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TCO Certified Displays 5.2



8 February 2011

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Introduction

TCO has, since the end of the 1980s, been involved in influencing the development of IT equipment, particularly Visual Display Units (VDUs). Today the TCO certification system is an international mark that makes it easy to choose IT and office equipment designed for the benefit of both the user and the environment.

The unique user-perspective on the products makes it logical to list the requirements in this document under two main headings “Usability” and “Environment”. “Usability” covers important quality aspects of the products such as Ergonomics, Emission and Electrical safety while “Environment” covers all major environmental aspects such as energy consumption, content of hazardous materials, preparation for recycling etc.

The first TCO label, TCO’92, was launched in 1992, and has since then been succeeded by TCO’95, TCO’99 and TCO’03 Displays. TCO’06 Media Displays is an adaptation of TCO’03 Displays intended for specific applications.

With every new TCO label we extend and tighten criteria in pace with technology innovation and development. The TCO certification system is now internationally recognised and products bearing the TCO label can be found throughout the world. More information can be found on www.tcodevelopment.com.

The publication of TCO Displays 5 marks the fifth version of TCO certification of displays. New versions that carry the number 5, such as 5.1, 5.2 etc, may eventually be released. However, these versions are to be considered only as updates that incorporate changes we felt were necessary to improve the precision of the mandates & test methods. Every updated TCO Certified Display 5 version is not to be considered as a greater challenge to achieve over earlier TCO Certified Displays 5 versions.

To quote parts of these criteria (e.g. in procurements) is allowed, provided the source is properly disclosed and the extent of the quotation is consistent with sound copyright practice.

Stockholm May 10, 2010

TCO Development

Stephen Fuller
Business Area Manager Displays

A Criteria

A.1 General information

This document contains requirements, test methods and references for Flat Panel Displays, herein referred to as “FPD” throughout. This means Visual Display Units (VDUs) of LCD type. However, the measuring procedures may in many cases be applied to other types of flat panels with fixed positions of the pixels. The term FPD covers the display and the stand as it is delivered to the end user, but not any peripherals.

The aim of this criteria document is to provide relevant test methods and criteria for the actual use of the product. This criteria document has an A- and a B-part. The A-part includes the mandated criteria and the B-part clarifications and test methods.

Compliance to the mandates in this criteria document can be achieved in one of two ways; either through a test report or through a verification report.

1. A test report is defined as a report based on:
 - Testing conducted by the laboratory issuing the test report on the product identified in the report.
2. A verification report is defined as a report based on:
 - A test report issued by a different laboratory.
 - Declarations from the Company applying for the certificate.

The alternatives accepted by TCO Development for each criterion can be found under each mandate respectively.

Media Displays

Some displays are specially designed for media content such as moving images and photo editing. To ensure high visual performance of these media displays there are some extra requirements which might be used to verify this. If these and all other requirements are met the product has shown compliance to TCO Displays 5 (media). If all except the media requirements are met the product fulfils TCO Displays 5.

A.1.1 TCO Document

Background

It is desirable that the purchaser of a product that has been certified in accordance with *TCO Displays* should receive information concerning the quality, features and capabilities of the product. This information is based on the viewpoint from the user's perspective that TCO Development represents.

Applicability

All FPDs.

References

The contract between TCO Development and the applicant company.

Mandate:

A TCO Document written in English shall accompany the product, describing why these particular requirements have been chosen for the products within the program of TCO Displays, and what is expected to be achieved by them. The document may be provided as an electronic file. The text can be obtained from TCO Development.

Examples of how the document can accompany the product are presented below:

- A separate printed document.
- As an electronic file or in the user manual.
- At the manufacturer's web site, together with the information about the product. A reference to the web site shall accompany the product

The following information shall be submitted to the verifier at the test laboratory:

A written guarantee that the above mandate is fulfilled. The document shall be signed by the responsible person at the applicant company.

The following information shall be submitted with the application to TCO Development:

A copy of a verification report from a test laboratory approved by TCO Development.

We hereby guarantee that the above mandate is fulfilled.

.....
Product brand and model name

.....
Signature

.....
Name and title in block capitals

.....
Date

.....
Company

A.2 Visual ergonomics

Today computer displays are an essential tool for users in all kinds of environments. Good visual ergonomics is a very important aspect of quality that can also have a direct effect on the health, comfort and performance of the user.

In developing requirements for visual ergonomics, the possible health effects of various parameters have been taken into account. Other features that characterise good quality displays have also been in focus for developing *TCO Displays*.

TCO Development used three main methodologies to determine the suitable level for each requirement and the test methods for the visual ergonomics part of the TCO labelling program. One is based on acceptable visual levels, as determined by scientific research. The second is based on statistics from tests carried out in accordance with TCO Development, ISO, MPR regulations and from specialized VDU tests. The third way is based on manufacturers' knowledge and experience, which is invaluable. Manufacturers, consumer groups and other organisations with interests in the visual ergonomics field have contributed a great deal of valuable information and ideas throughout the development process.

A.2.1 Image detail characteristics

A.2.1.1 Native display resolution requirement

Background

Image quality is negatively affected by a low fill factor, visible “jaggies”, poor rendering of details, etc. All of these parameters are related to the resolution of the display. For display resolution characteristics, it is important to take the viewing distance into account.

The viewing distance in this TCO display criteria document is defined as $1.5 \times$ the display diagonal, but no less than 500 mm which could be considered as an absolute minimum viewing distance for comfortable viewing. This means that the mandate on resolution is independent of the display size and viewing distance but dependent on the display format. Only the display format needs to be known.

Definition

A pixel is the smallest addressable imaging element of the FPD capable of reproducing a full range of luminance and colours.

The native display resolution is the number of pixels in the horizontal direction by the number of pixels in the vertical direction that the display can present.

Applicability

All FPDs.

Test procedure

See B.2.1.1.

References

Please see reference 2, 36 and 44.

Mandate:

The FPD shall have a pixel density ≥ 30 pixels/degree visual angle.

The following information shall be submitted with the application to TCO Development:

A copy of a test report from a test laboratory approved by TCO Development.

A.2.2 Video reproduction

A.2.2.1 Motion blur

Background

It has been recognised for some time now that LCD displays will introduce blur in the images when showing moving objects. Motion blur reduces readability and can cause eyestrain. There are two effects that contribute to the motion blur, slow response time and that the picture elements hold their light intensity until they are changed. The latter is referred to as sample-and-hold.

Definition

Motion blur is the perceptual effect that appears when the eyes are tracking a moving object on a display with too slow pixel updating and too long hold-time for the speed of the object. It shows itself as blurring or a reduction of the edge sharpness.

Applicability

Media FPDs.

Test procedure

See B.2.2.1.

References

2, 43, 75, 76, 77

Mandate: The mean value over all transitions between the grey levels 0, 63, 127, 191 and 255 of the blur edge time (BET) shall be $BET_{mean} \leq 25ms$

The following information shall be submitted with the application to TCO Development:

A copy of a test report from a test laboratory approved by TCO Development.

A.2.3 Luminance characteristics

A.2.3.1 Luminance level

Background

It shall be possible to set the luminance level according to the lighting conditions of the surroundings. Poor luminance can lead to low contrast and consequently affect legibility and colour discrimination and thus lead to misinterpretations. It shall be possible to set a sufficiently high luminance level with respect to the ambient lighting in order to present a comfortable viewing situation and to avoid eyestrain. It is also important that it is possible to set the luminance to a suitable level in low ambient light i.e. 100 cd/m^2 .

Definition

Luminance being emitted from a particular area is a measure of the luminous intensity per unit area of light travelling in a given direction and falls within a given solid angle.

The unit of luminance is cd/m^2 .

Applicability

All FPDs.

Test procedure

See B.2.3.1.

References

Please see reference 1, 2, 18, 21, 27, 31, 36 and 44.

Mandate:

For a FPD the following conditions shall be fulfilled:

- The luminance at default setting shall be $\geq 150 \text{ cd/m}^2$
- The maximum luminance shall be $\geq 200 \text{ cd/m}^2$
- The minimum luminance shall be $\leq 100 \text{ cd/m}^2$

The following information shall be submitted with the application to TCO Development:

A copy of a test report from a test laboratory approved by TCO Development.

A.2.3.2 Luminance uniformity

Background

Image quality is badly affected by non-uniform luminance. When poor luminance uniformity is visible, it can locally affect the contrast and consequently the legibility of information on the display. The areas of deviating luminance can have different sizes and cause varying contour sharpness.

Definition

Luminance uniformity is the capacity of the FPD to maintain the same luminance level over the whole active screen area. The luminance uniformity is defined as the ratio of maximum to minimum luminance within the fully active screen area.

Applicability

All FPDs.

Test procedure

See B.2.3.2.

References

Please see reference 1, 2, 16, 18, 21, 22, 27, 32, 33, 36 and 44.

Mandate:

Luminance variation across the active screen, $L_{max} : L_{min}$ shall be $\leq 1.53:1$

The following information shall be submitted with the application to TCO Development:

A copy of a test report from a test laboratory approved by TCO Development.

A.2.3.3 Black level

Background

It is important that a display can produce a black level dark enough to show shadow details in pictures at high and low white luminance levels.

Definition

Black level is the capacity of the display to maintain a good reproduction of black even when its luminance is high.

Applicability

All FPDs.

Test procedure

See B.2.3.3.

References

51

Mandate:

The luminance of black shall be $\leq 2 \text{ cd/m}^2$ at a white luminance setting of $\geq 200 \text{ cd/m}^2$.

The following information shall be submitted with the application to TCO Development:

A copy of a test report from a test laboratory approved by TCO Development.

A.2.3.4 Luminance uniformity - angular-dependence

Background

The luminance of an FPD is angular-dependent , i.e. screen luminance decreases when the FPD is viewed slightly from the side horizontally or vertically. This can have a negative effect on contrast and can affect the legibility of the display.

Definition

Luminance uniformity – angular dependence, is the capacity of the FPD to maintain a certain luminance level independently of the viewing direction. The angular-dependent luminance uniformity is defined as the ratio of maximum luminance to minimum luminance in the specified measurement areas.

Applicability

All FPDs.

Test procedure

See B.2.3.4.

References

Please see reference 1, 16, 22, 27, 31, 32 and 33.

Mandate:

- 1) For FPDs in landscape mode, when the screen is rotated around the vertical axis through the centre of the screen the mean value of the L_{max} to L_{min} ratios at $\pm 30^\circ$ shall be ≤ 1.73 .
- 2) For FPDs in landscape mode, when the screen is rotated around the horizontal axis through the centre of the screen, the largest value of the L_{max} to L_{min} ratios at $\pm 15^\circ$ shall be ≤ 1.73 .

The following information shall be submitted with the application to TCO Development:

A copy of a test report from a test laboratory approved by TCO Development.

A.2.3.5 Greyscale gamma curve

Background

TCO certified displays shall be delivered with a calibrated gamma curve in default preset since it makes it easier to distinguish between similar light levels. A well-tuned greyscale is the basis for accurate detail rendering of any imaging device. The greyscale rendering is measured via a number of steps in a greyscale in the test image. Each greyscale step, regardless of grey level, shall have a luminance level close to what is specified by the common standard sRGB in order to give accurate rendering of the greyscale of the original image. With special software or hardware calibration tools it may be possible to achieve a better calibrated gamma curve than the TCO criteria and also in other presets than the default one.

Definition

Greyscale gamma curve is the capability of the imaging device to maintain the original greyscale luminance or a greyscale pattern at all tested greyscale levels.

Applicability

All FPDs.

Test procedure

See B.2.3.5

References

11, 12, 13, 14, 20, 51, 52 and 74.

Mandate:

The different grey scale luminance levels shall be within the Max- and Min levels according to the table below, where 100% means the luminance level measured for white, RGB 255, 255, 255.

Grey level	L_{sRGB} %	L_{min} %	L_{max} %
255	100	100,0	100,0
225	75	70	93
195	55	46	68
165	38	29	49
135	24	17	36
105	14	8	24
75	7	3	14
45	3	1	7

The following information shall be submitted with the application to TCO Development:

A copy of a test report from a test laboratory approved by TCO Development.

A.2.4 Luminance contrast characteristics

A.2.4.1 Luminance contrast – characters

Background

The degree of contrast is important for legibility and for distinguishing one character from another.

Definition

Luminance contrast – characters is the capacity of the FPD to maintain a high luminance difference between a bright background and dark characters or parts of characters over the whole active area.

Luminance contrast – characters is expressed as the ratio of the L_{\max} to L_{\min} difference over the sum of L_{\max} and L_{\min} , in accordance with Michaelson's formula.

Applicability

All FPDs.

Test procedure

See B.2.4.1.

References

Please see reference 2, 16, 19, 20, 22, 23, 27, 32 and 44.

Mandate:

The FPD shall have a luminance contrast ≥ 0.70 measured orthogonally to the screen.

The following information shall be submitted with the application to TCO Development:

A copy of a test report from a test laboratory approved by TCO Development.

A.2.4.2 Luminance contrast – angular dependence

Background

For FPDs the luminance and consequently the contrast on the display is angular-dependent. The luminance variations can influence both the bright white and the dark areas of the screen, causing a change in contrast. This can have a negative effect on the legibility of the display.

Definition

Luminance contrast – angular dependence, is the capability of the FPD to maintain the same contrast regardless of the direction from which the screen is viewed. Luminance contrast – angular dependence, is expressed as the ratio of the L_{\max} to L_{\min} difference over the sum of L_{\max} and L_{\min} , in accordance with Michaelson's formula. It is measured at two different angles.

Applicability

All FPDs.

Test procedure

See B.2.4.2.

References

Please see reference 2, 16, 19, 20, 23, 28 and 33.

Mandate:

For FPDs in landscape mode, the luminance contrast-angular dependence shall be ≥ 0.80 at $\pm 30^\circ$ horizontally from the viewing direction (rotated around the vertical axis through the centre of the screen).

The following information shall be submitted with the application to TCO Development:

A copy of a test report from a test laboratory approved by TCO Development.

A.2.5 Reflection characteristics

A.2.5.1 Front frame gloss

Background

Front frame gloss may influence visual comfort and legibility by drawing attention away from the task at hand. The higher the gloss value the more likely it is that the surface will create specular reflections (mirror-like reflections) from ambient lighting and bright surfaces. If the gloss value and the ambient light are high enough, the problem of reflected images may occur.

However, in a controlled ambient light, reflections can be avoided by changing light intensity or moving light sources or the display, making the problem with a glossy frame less relevant.

Definition

Gloss is a measure of how a light beam, physically described as luminous flux, is scattered at the surface when incident against that surface. Gloss is a function of the directional reflectance properties of a surface.

Applicability

All FPDs

Test procedure

See B.2.5.1.

References

Please see reference 5, 6, 7 and 37.

Mandate:

For displays that have a gloss value G(60°) >30 gloss units the following consideration note for the placement of the FPD shall be given in the user manual .

“For displays with glossy bezels the user should consider the placement of the display as the bezel may cause disturbing reflections from surrounding light and bright surfaces.”

The following information shall be submitted to the verifier at the test laboratory:

If >30 gloss units a written guarantee that the above mandate is fulfilled must be provided. The document shall be signed by the responsible person at the applicant company.

The following information shall be submitted with the application to TCO Development:

A copy of a test report and a verification report from a test laboratory approved by TCO Development.

We hereby guarantee that the above mandate is fulfilled.

.....
Product brand and model name

.....
Signature

.....
Name and title in block capitals

.....
Date

.....
Company

A.2.6 Screen colour characteristics

A.2.6.1 Correlated colour temperature, CCT, variation

Background

Most FPDs are today equipped with a number of pre-set correlated colour temperature settings. These settings make it possible to more accurately evaluate the colour of an image on the FPD compared to real scenes or prints.

Physical measurements of colour stimuli can only give an indication of the colour appearance in a practical situation. The colour of the frame, the spectral composition of the lighting, the colour of various areas in the visual field, and the complexity of brightness variations in the visual field all influence the colour appearance of an FPD image.

Normal daylight has a correlated colour temperature in the range 5000 – 10000 K.

For the editing of photos or video, it is important to be able to set a colour temperature of 6500 K or sRGB, since most productions are made using that standard.

Definition

The correlated colour temperature is a measure of the perceived screen colour expressed in kelvin (K).

Applicability

All FPDs.

Test procedure

See B.2.6.1.

References

Please see reference 2, 3, 4, 8-12, 14, 15, 17, 24, 25, 26, 28, 30, 34, 36 and 38.

Mandate:

The FPD shall have at least two predefined possibilities for pre-set correlated colour temperatures between 5000K and 10000K and one possibility for the user to adjust the CCT (total of three settings).

Each pre-set correlated colour temperature shall have a colour difference $\Delta u'v' \leq 0.012$ when compared to CIE u' and v' chromaticity co-ordinates for corresponding correlated colour temperatures.

Extra for media displays

At least one of the predefined pre-set correlated colour temperatures shall be 6500 K or sRGB. If the pre-set CCT is named something different from the numeric value (e.g. "normal") the end-user shall be informed in the user manual of which pre-set CCT corresponds to 6500K or sRGB.

The following information shall be submitted to the verifier at the test laboratory:

If information about the CCT is given in the manual a written guarantee must be submitted. The document shall be signed by the responsible person at the applicant company.

The following information shall be submitted with the application to TCO Development:

A copy of a test report and a verification report from a test laboratory approved by TCO Development.

A.2.6.2 Colour uniformity

Background

The human visual system is very sensitive to changes in colour hue in white and grey areas. Since the white or grey colour hues are the background on which most colours are judged, the white or grey areas are the reference colours on the screen.

Patches of colour variation on an active white or grey screen could reduce the contrast locally, be disturbing and affect the legibility, colour rendering and colour differentiation.

Definition

The colour uniformity of an FPD is the capability to maintain the same colour in any part of the screen.

Applicability

All FPDs.

Test procedure

See B.2.6.2.

References

Please see reference 2, 8, 14, 15, 23, 25, 29, 35, 36 and 38.

Mandate:

$\Delta u'v' \leq 0.012$ for the maximum colour deviation between measured active areas on the screen that are intended to maintain the same colour.

The following information shall be submitted with the application to TCO Development:

A copy of a test report from a test laboratory approved by TCO Development.

A.2.6.3 RGB settings

Background

Accurate colour rendering is important when realistic colour images or colour presentations are presented on the FPD screen. Poor colour rendering can lead to poor legibility and misinterpretation. The u' and v' chromaticity co-ordinates of the primary colours red (R), green (G) and blue (B) of the screen shall aim at values given in international IEC, EBU and ITU standards. The u' and v' chromaticity co-ordinates of the primary colours R, G and B form a triangle in the CIE 1976 uniform chromaticity scale diagram. The larger the area of the triangle, the wider the range of colours the screen is capable of presenting.

Definition

The colour characteristics of an FPD are based on the visual appearance of the FPD primary colour stimuli, the R, G, B-stimuli.

Applicability

All FPD s.

Test procedure

See B.2.6.3.

References

Please see reference 3, 4, 8-15, 17, 25, 26, 28, 30, 34, 36 and 38.

Mandate:						
The minimum colour triangle shall have the following coordinates:						
	Red		Green		Blue	
Co-ordinate	u'	v'	u'	v'	u'	v'
Requirement	≥ 0.411	≥ 0.503	≤ 0.140	≥ 0.548	≥ 0.150	≤ 0.210
The following information shall be submitted with the application to TCO Development:						
A copy of a test report from a test laboratory approved by TCO Development.						

A.2.6.4 Colour uniformity – angular dependence

Background

The human visual system is very sensitive to changes in colour hue in white and grey areas. Since the white or grey colour hues are the background on which most colours are judged, the white or grey areas are the reference colours on the screen. Angular-dependent colour variations on an active white or grey screen could be disturbing and affect legibility, colour rendering and colour differentiation.

Definition

The colour uniformity – angular dependence of an FPD is the capability of the display to maintain constant colour over the screen surface depending of the direction from which the screen is viewed.

Applicability

All FPDs.

Test procedure

See B.2.6.4.

References

Please see reference 2, 8, 14, 15, 23, 25, 29 and 35.

Mandate:

For an FPD in landscape mode, the $\Delta u'v'$ between areas on the left side and the right side of the screen when it is positioned at $+30^\circ$ and at -30° horizontally to the screen normal (rotated around the vertical axis through the centre of the screen) shall be $\Delta u'v' \leq 0.025$.

The following information shall be submitted with the application to TCO Development:

A copy of a test report from a test laboratory approved by TCO Development.

A.2.6.5 Colour greyscale linearity

Background

A well-tuned colour greyscale is the basis for good colour rendering on the screen. This is measured via steps in a greyscale on the screen. Each greyscale step shall have similar colour hues in order to simplify colour interpretation and to avoid confusion for the user, only the luminance shall vary.

Definition

Colour greyscale linearity is the capability of the screen to maintain the same u',v' co-ordinates of a greyscale pattern at all greyscale levels, i.e. only the luminance shall change from one greyscale step to the next.

Applicability

All FPDs.

Test procedure

See B.2.6.5.

References

Please see reference 2, 8, 14, 15, 23, 25, 29 and 35.

Mandate:								
Greyscale	Maximum $\Delta u',v'$ difference							
	255	225	195	165	135	105	75	45
255	0							
225	0,015	0						
195	0,015	0,015	0					
165	0,020	0,020	0,020	0				
135	0,025	0,025	0,020	0,020	0			
105	0,025	0,025	0,025	0,025	0,020	0		
75	0,035	0,035	0,035	0,035	0,035	0,025	0	
45	0,035	0,035	0,035	0,035	0,035	0,035	0,035	0

The $\Delta u',v' \leq$ the maximum allowed difference for each step according to table 2.6.5.

The following information shall be submitted with the application to TCO Development:

A copy of a test report from a test laboratory approved by TCO Development.

A.3 Work load Ergonomics

Work load ergonomics refers to the adaptation of the task, tools, work place and physical environment where the product will be used. These requirements are put in place in order to meet and optimize the users' needs for a good work environment.

Computer equipment is, just as much as furniture, lighting and other equipment, an important part of the modern environment where IT products are used. TCO Development wants to contribute to the development of FPDs with good user characteristics, on the basis of work load ergonomics. This thereby enhances the possibility for users to be able to have good quality FPDs so that the best possible conditions for physical variation are created in the user's environment.

It is important for FPDs to offer users the possibility of variation between different work postures. An aesthetically appealing design should not restrict the work load ergonomics function.

Displays larger than 26" are not normally used on a work desk since the viewing distance is considered to be too close. They are also not considered to be easily movable on a normal display stand but are often placed on wall mounts. They are therefore excluded from these requirements.

As a further complement and support for users, ergonomic user instructions are available in "the Advisor" on TCO Development's webpage <http://www.tcodevelopment.com>.

A.3.1 Vertical tilt

Background

It is a benefit to be able to tilt the FPD in the vertical plane. This offers the possibility to tilt the FPD back in order to always have a 90 degrees viewing angle. This ability to tilt the display offers the user the option of altering work posture for maximum comfort and also to obtain and utilise the best visual ergonomics of the FPD.

Applicability

All FPDs ≤ 26”.

References

Please see references 39-48.

Mandate:
 For FPD’s ≤26” it shall be possible to easily tilt the FPD in the vertical plane to the extent of 20 degrees or more in one of the height positions.

The following information shall be submitted to the verifier at the test laboratory:

A written guarantee that the above mandate is fulfilled. The guarantee shall be signed by the responsible person at the applicant company.

The following information shall be submitted with the application to TCO Development:

A copy of a verification report from a test laboratory approved by TCO Development.

We hereby guarantee that the above mandate is fulfilled.

.....
Product brand name and model name

.....
Signature

.....
Name and title in block capitals

.....
Date

.....
Company

A.3.2 Vertical height

Background

To maintain good posture and visual comfort it is important to maintain a downward viewing angle for long term display use. Therefore it is beneficial that the top of the active display area is not above the normal line of sight (0° -15° below horizontal) so users will not need to extend the neck backwards to look at the FPD when it is placed on a standard height (750 mm) table. A height adjustment function is recommended and beneficial for the possibility of work posture flexibility as well as to get the best visual ergonomics of the FPD.

Applicability

All FPDs ≤ 26”.

References

Please see references 39-49, 78, 79

Definition

Work top surface: the surface where the FPD is positioned.

Mandate:

FPD's ≤26” shall meet at least one of the following four mandates:

- 1- With the display aligned vertically in its lowest point of height adjustment, the distance measured from the underside of the display's foot (work top surface) to the upper edge of the active screen area shall be ≤ 42 cm.
- 2- The FPD shall have a height adjustment function as a standard feature.
- 3- The FPD shall have a mounting interface applicable to the VESA mounting interface standard.
- 4- The manufacturer or a third party shall provide the accessories necessary to achieve the height adjustment function. Information of where the accessories can be purchased and how they are to be installed shall be provided to the customer in the user's manual

The following information shall be submitted to the verifier at the test laboratory: A written guarantee that the FPD meets the above mandate. The guarantee shall be signed by the responsible person at the applicant company.

The following information shall be submitted with the application to TCO Development: A copy of a verification report from a test laboratory approved by TCO Development.

We hereby guarantee that the above mandate is fulfilled.

.....
Product brand and model name

.....
Signature Name and title in block capitals

.....
Date Company

A.4 Emissions

The amount of electrical equipment in our homes and workplaces is increasing tremendously, with a concomitant increase in the presence of electrical and magnetic fields. Users of IT equipment now have several nearby field sources placed on work surfaces that are constantly in use. The degree of exposure of users working with this equipment is increasing. The permanent relationship of the body to certain field sources, such as visual distance from displays, mobile telephone location next to the ear and the proximity of task-specific lighting are realities that exacerbate this trend.

When the first TCO label was introduced in 1992 one of the main interests was the requirements for electrical and magnetic fields. To this day scientists and experts are divided on the question if these fields pose any health risks to humans.

Due to continued public concern and the increasing amount of emissions surrounding us, TCO remains convinced that the criteria in our documents are still highly relevant, even with today's slim displays. TCO emission criteria are created to ensure that internal shielding is used to make sure a TCO certified product's emissions are at a technically achievable low level and will not raise normal background levels when the product is used in a working environment.

TCO criteria cover emissions around the product since it may be placed there persons, other than the user, are working in close proximity. Large displays may be wall mounted so emission consideration must be taken to what may be lying on the other side of that wall.

A.4.1 Alternating electric fields

Background

Electrical alternating fields are created between objects that have different levels of electrical potential which change over time. When the potential changes in a periodic manner, an electrical alternating field is set up, with a field strength and a frequency. A display contains many sources of electrical alternating fields. The field characteristics depend on the actual electrical potential difference and the distance from the FPD.

Display users are often concerned about a possible health risk arising from electrical alternating fields generated by equipment. Quite a large number of users also report various kinds of symptoms that cannot completely be attributed to the influence of other factors in their environment or to medical reasons.

The mandatory requirements are based on the ambition to reduce the electrical alternating fields to such a low level so as not to burden the work and home environment with unnecessary factors. The mandatory requirements shall not be regarded as hygienic limit values.

Applicability

All FPDs.

Test procedure

See B.4.1.

References

-

Mandate:

Band I: 5 Hz to 2 kHz, ≤ 10 V/m

FPDs ≤ 26 " are measured at 0.3 m and 0.5 m in front of the FPD.

FPDs > 26 " are measured at 0.5 m in front of the FPD.

Band II: 2 kHz to 400 kHz, ≤ 1.0 V/m

FPDs ≤ 26 " are measured at 0.3 m in front of- and 0.5 m around the FPD.

FPDs > 26 " are measured at 0.5 m from the surface of the product around the FPD.

The following information shall be submitted with the application to TCO Development:

A copy of a test report from a test laboratory approved by TCO Development.

A.4.2 Alternating magnetic fields

Background

Magnetic alternating fields are created when an electrical alternating current flows through a conductor. Like other electrical equipment, displays are surrounded by magnetic alternating fields. These magnetic alternating fields are generated by different parts of the product, e.g. power supply unit, voltage inverters and other electrical circuits. The field strength depends on the actual electric current and on the distance from the FPD.

Display users are often concerned about a possible health risk arising from electrical alternating fields generated by equipment. Quite a large number of users also report various kinds of symptoms that cannot completely be attributed to the influence of other factors in their environment or to medical reasons.

The mandatory requirements are based on the ambition to reduce the magnetic alternating fields to such a low level as not to burden the work and home environment with unnecessary factors. The mandatory requirements shall not be regarded as hygienic limit values.

Applicability

All FPDs.

Test procedure

See B.4.2.

References

-

Mandate:

Band I: 5 Hz to 2 kHz, ≤ 200 nT

FPDs $\leq 26''$ are measured at 0.3 m in front of- and at 0.5 m around the FPD.

FPDs $> 26''$ are measured at 0.5 m from the surface of the product around the FPD.

Band II: 2 kHz to 400 kHz, ≤ 25 nT

FPDs $\leq 26''$ are measured at 0.5 m around the FPD.

FPDs $> 26''$ are measured at 0.5 m from the surface of the product around the FPD.

The following information shall be submitted with the application to TCO Development:

A copy of a test report from a test laboratory approved by TCO Development.

A.4.3 Noise

FPDs equipped with fans shall fulfil the requirements regarding noise found in the latest version of the labelling document for Desktop computers. This document can be found on the TCO Development home page (www.tcodevelopment.com).

A.5 Electrical safety

A.5.1 Electrical safety

Background

Electrical safety concerns the electrical design of apparatus with respect to its electrical insulation and other arrangements that are intended to prevent accidents resulting from contact with live components, and the risk of fire or explosion as a result of electrical flash-over due to inadequate or faulty electrical insulation.

Applicability

All FPDs with built-in power supplies as well as any separate power supply intended to be used together with the FPD.

References

Please see reference 50.

Mandate:

The FPD shall be certified according to EN/IEC 60 950 or EN/IEC 60 065.

The following information shall be submitted with the application to TCO Development:

A copy of a CB certificate or a national certificate from a CB member (NCB) shall be submitted.

A.6 Environmental requirements

The TCO Development label requirements combine a unique integrated balance of indoor and outdoor environmental issues. Achieving a good working environment should not be at the expense of the natural environment. This document details the environmental requirements of the TCO Certified label.

The Environmental requirements are divided into the following sections:

1. Organisation – requirements focusing on the production phase, environmental management and social responsibility.
2. Climate – energy consumption, one of the most important issues in the environmental impact of IT products.
3. Hazardous Substances – heavy metals, flame retardants, plastics.
4. Product Lifetime – factors to extend the life of the product.
5. Preparation for Recycling – factors to stimulate recycling.
6. Packaging – hazardous substance content and recycling.

Potential environmental effects are evident at each stage of the product life cycle. Due to the complexity of the production of ICT products, it is often most effective to refer to indirect requirements on the production such as requirements for an environmental management system. Should a more direct quality-assured system for manufacturing processes become possible, TCO would consider that option for future requirements. The environmental requirements TCO has focused on in this criteria document are those that we consider most relevant to the product group. They have also proved to be attainable in volume production and are verifiable. Future updates of the criteria document will likely focus on hazardous substances, social responsibility and climate issues.

All requirements except section A.6.3 *Climate* shall be verified by sending the requested information to an eco-verifier at a test laboratory approved by TCO Development. The energy consumption requirements in section A.6.3 shall be tested at a test laboratory approved by TCO Development.

A.6.1 Product description

Background

The aim of this product description is to provide information about the product that is to be reviewed for compliance with the environmentally related requirements of Section A.6 and also for information collection.

Definitions

Marking plate /Marking label is the label that contains the display's electrical rating in terms of voltage, frequency, current and the manufacturer's name, trademark or identification mark together with the manufacturer's model or type reference. The label shall be in accordance with IEC 60 950:1 clause 1.7.1.

Applicability

All FPDs.

Clarification

B.6.1

References

53.

Mandate:

A product declaration shall be provided for the FPD.

The following information shall be submitted to an approved eco-verifier:

1. The declaration below, completed where applicable.
2. A copy of the marking plate for the FPD.

The information submitted shall be signed by the responsible person at the applicant company.

The following information shall be submitted with the application to TCO Development:

A copy of a verification report from an eco-verifier at a laboratory approved by TCO Development and a copy of the marking label.

Display	
Manufacturer	
Brand name	
Brand Owner	
Type/Model name	
Screen size (inch)	

Panels	
Manufacturer	
Type/Model name	
Brand name	
Technology	

TCO Certificate holder.....

We hereby guarantee that the above mandate is fulfilled.

.....
Product brand name and model name

.....
Signature

.....
Name and title in block capitals

.....
Date

.....
Company

A.6.2 Organisation

A.6.2.1 Environmental management system certification

Background

A certified environmental management system is proof that the company shows concern for the environment and has chosen to work in a systematic way with constant improvement of the environmental performance of the company and its products in focus. A certified environmental management system includes external independent reviews.

Definitions

Manufacturing plant is the site where the final assembly of the product is taking place.

Applicability

The company or companies which manufacture the FPD.

Clarification

B.6.2.1

References

54 and 55.

Mandate:

Each *manufacturing plant* must be certified in accordance with ISO 14001, or EMAS registered. If the product is manufactured by a third party, it is this company that shall be certified or registered.

If the *manufacturing plant* does not have an ISO 14001 certificate or EMAS registration at the time of application, the *manufacturing plant* is given a 12-month grace period to obtain ISO14001 certification or EMAS registration.

The following information shall be submitted to an approved eco-verifier:

1. A document showing the names and addresses of the manufacturing plants.
2. Copy of the ISO 14001 certificate or EMAS registration or, when not available, an estimated date of certification/registration.
3. A written guarantee that the certificate/registration is valid and that the mandate above is fulfilled, signed by the responsible person at the applicant company.

The following information shall be submitted with the application to TCO Development:

A copy of a verification report from an eco-verifier approved by TCO Development.

We hereby guarantee that the above mandate is fulfilled.

.....
Product brand name and model name

.....
Signature

.....
Name and title in block capitals

.....
Date

.....
Company

A.6.2.2 Social Responsibility

Background

Expectations for social and environmental performance are increasing from customers and organisations. An important step towards a sustainable business is control of the effects the business has on both the natural environment and the workforce, throughout the supply chain. TCO Development is therefore introducing a requirement aimed at the situation in the production facilities.

TCO Development is accepting several ways of demonstrating commitment to corporate social responsibility.

Definitions

Brand owner is the company that owns the brand name visible on the product.

Applicability

The *Brand owner*.

Clarification

B.6.2.2

References

56, 57, 58 and 59.

Mandate:

The *brand owner* shall demonstrate that it has working practices that promote good labour relations and working conditions in the production phase.

This can be validated by any one of the following:

- 1) The *brand owner* submits a report according to the GRI Sustainability Reporting Guidelines, G3 level C or higher. The report shall be a maximum of one year old at the time of application.
- 2) The *brand owner* submits a Communication on Progress (COP) report demonstrating active participation in the Global Compact initiative. The report shall be a maximum of one year old at the time of application.
- 3) The *brand owner* is a member of the Electronic Industry Citizenship Coalition.
- 4) The *brand owner* is SA8000 certified or is carrying out the production in SA8000 certified factories.
- 5) The *brand owner* is a member of other relevant initiative(s) proving commitment to social responsibility or is in any other way implementing working practices that promote good labour relations and working conditions in the production phase that correspond with internationally recognised human rights and the laws in the country of production.

If the *brand owner* is not able to meet the requirement according to the alternatives above, the *brand owner* is given a 12- month grace period to obtain this.

The following information shall be submitted to an approved eco-verifier:

- 1. Copy of the report/certificate/membership according to the above mandate. When not yet available, an estimated date when the report/certificate/membership will be available.
- 2. Information on which of option 1-5 above is fulfilled and date of report (in list below).
- 3. A written guarantee that the above mandate is fulfilled. The guarantee shall be signed by the responsible person at the applicant company.

The following information shall be submitted with the application to TCO Development:

A copy of a verification report from an eco-verifier approved by TCO Development.

- Option (to be verified):
- 1. GRI Sustainability Reporting Guidelines
 - 2. Global Compact: Communication on Progress report
 - 3. Member of the Electronic Industry Citizenship Coalition
 - 4. SA8000 certified
 - 5. Own work

Date of report/verification documents sent in:.....

We hereby guarantee that the above mandate is fulfilled.

.....
Product brand name	Model name(s) or "All products"

.....
Signature	Name and title in block capitals

.....
Date (Declaration valid 1 year from date)	Brand Owner Company

A.6.3 Climate

A.6.3.1 Energy consumption

Background

Energy is the single most important topic in the issue of climate change. Energy efficient equipment is an important and effective way to fight climate change. With an ever-increasing volume of IT equipment in use, the efficiency of each product is vital.

This requirement and test method is based on the most recently published Energy Star standard for displays.

Definitions

In accordance with the most recently published Energy Star® standard for displays.

Applicability

All FPDs.

Test procedure

B.6.3.1

References

60.

Mandate:

The most recently published Energy Star standard for displays on the date of application shall be fulfilled and verified through testing by a test laboratory approved by TCO Development

The following information shall be submitted with the application to TCO Development:

A copy of a test report from a test laboratory approved by TCO Development.

A.6.3.2 Energy consumption – external power supply

Background

Energy is the single most important topic in the issue of climate change. Energy efficient equipment is an important and effective way to fight climate change. With an ever-increasing volume of IT equipment in use, the efficiency of each product is vital.

This requirement is based on the **International Efficiency Marking Protocol for External Power Supplies**

Definitions

In accordance with the International Efficiency Marking Protocol for External Power Supplies

Applicability

All external power supplies.

Test procedure

B.6.3.2

References

61.

Mandate:

The external power supply shall meet at least the International Efficiency Protocol requirement for level V

The following information shall be submitted with the application to TCO Development:

A copy of a test report from a test laboratory approved by TCO Development.

A.6.4 Environmentally hazardous substances

A.6.4.1 Cadmium (Cd), mercury (Hg), lead (Pb) and hexavalent chromium (CrVI)

Background

The effects of the listed substances are well documented as environmental hazardous substances. EU regulated these substances in the RoHS directive (2002/95/EC).

Applicability

All FPDs.

Clarification

B.6.4.1

References

62 and 63.

Mandate:

1. The FPD shall not contain cadmium, mercury, lead and hexavalent chromium. The requirement applies to components, parts, and raw materials in all assemblies and sub-assemblies of the product e.g. paint, surface treatment, plastics and electronic components.
2. The maximum level of mercury in background lighting systems allowed is 3,5 mg Hg/lamp. See B.6.4.1 for exemptions.
3. The total amount of mercury in the lamps shall be declared in the "Mercury declaration template" below.

The following information shall be submitted to an approved eco-verifier:

1. A written guarantee that the above mandate is fulfilled. The guarantee shall be signed by the responsible person at the applicant company.
2. A declared "Mercury declaration template" below.

The following information shall be submitted with the application to TCO Development:

A copy of a verification report from an eco-verifier approved by TCO Development.

We hereby guarantee that the above mandate is fulfilled.

.....
Product brand name and model name

.....
Signature

.....
Name and title in block capitals

.....
Date

.....
Company

Mercury declaration template

Display brand name:.....

Display type/model name:.....

FPD size:

Panel manufacturer:.....

Panel identification code:

Panel technology

Mercury lamp supplier:	Lamp ID code:	Lamp length (mm)	Max. mg Hg/lamp:

We hereby guarantee that the above mandate is fulfilled.

.....
Product brand name and model name

.....
Signature

.....
Name and title in block capitals

.....
Date

.....
Company

A.6.4.2 Halogenated substances

Background

Brominated and chlorinated flame retardants and other halogenated substances are often persistent, can bioaccumulate in living organisms and have been detected in flora and fauna.

A series of international elimination activities in respect to brominated and chlorinated flame retardants is currently in progress within several national and international bodies, e.g EU, OECD, North Sea Conference.

Definitions

Plastic parts are parts made mainly of plastics, e.g. the housing. Parts containing other materials in any significant amounts, e.g. cables with metal conductors, are not included in the definition.

Printed wiring board laminate is a printed board that provides point-to-point connections but not printed components in a predetermined configuration on a common base.

Applicability

All FPDs.

Clarification

B.6.4.2

References

64.

Mandate:

1. *Plastic parts* weighing more than 25 grams shall not contain flame retardants or plasticizers that contain organically bound bromine or chlorine. The requirement applies to plastic parts in all assemblies and sub-assemblies. Exempted are *printed wiring board laminates*, electronic components and all kinds of cable insulation.

2. The FPD shall not contain PBB and PBDE. The requirements apply to components, parts and raw materials in all assemblies and sub-assemblies of the product e.g. batteries, paint, surface treatment, plastics and electronic components.

The following information shall be submitted to an approved eco-verifier:

A written guarantee that the above mandate is fulfilled. The guarantee shall be signed by the responsible person at the applicant company.

The following information shall be submitted with the application to TCO Development:

A copy of a verification report from an eco-verifier approved by TCO Development.

We hereby guarantee that the above mandate is fulfilled.

.....
Product brand name and model name

.....
Signature

.....
Name and title in block capitals

.....
Date

.....
Company

A.6.4.3 Non-halogenated substances

Background

Recently it has been common practice to replace hazardous substances with new substances with unknown effects. This is one important focus of the new European chemical legislation, REACH. This mandate focuses on ensuring that the phase out of halogenated flame retardants doesn't risk a shift towards substances with unknown effects.

Definitions

Plastic parts are parts made mainly of plastics, e.g. the housing. Parts containing other materials in any significant amounts, e.g. cables with metal conductors, are not included in the definition.

Printed wiring board laminate is a printed board that provides point-to-point connections but not printed components in a predetermined configuration on a common base.

Applicability

All FPDs.

Clarification

B.6.4.3

References

65 and 66.

Mandate:

Flame retardants used in plastic parts weighing more than 25 grams shall not have been assigned one or more of the following risk phrases at the time of application (according to EU Directive 67/548/EEG (/EU Directive 1272/2008)):

R40(/H351) (limited evidence of a carcinogenic effect)

R45(/H350) (may cause cancer)

R46(/H340) (may cause heritable genetic damage)

R48(/H372) (danger of serious damage to health by prolonged exposure)

R50/53(/H400 and H410) (very toxic to aquatic organisms / may cause long-term adverse effects in the aquatic environment)

R60(/H360F) (may impair fertility)

R61(/H360D) (may cause harm to the unborn child)

Exempted are *printed wiring board laminates*, electronic components and all kinds of cable insulation.

The following information shall be submitted to an approved eco-verifier:

A written guarantee that the above mandate is fulfilled. The guarantee shall be signed by the responsible person at the applicant company.

The following information shall be submitted with the application to TCO Development:

A copy of a verification report from an eco-verifier approved by TCO Development.

We hereby guarantee that the above mandate is fulfilled.

.....
Product brand name and model name

.....
Signature

.....
Name and title in block capitals

.....
Date

.....
Company

A.6.4.4 Plastics with chlorine and bromine as part of the polymer

Background

PVC is by far the most common halogen containing plastic. There are however other plastics that contain chlorine or bromine in the plastic itself. As the requirement concerning permissible flame retardants tightens, the risk increases that halogenated plastics will become more common. TCO Development sees a future environmental risk with such a development.

PVC is a much-debated plastic that can pose environmental problems in most parts of its life cycle. The magnitude of the environmental problems relating to PVC differs depending on the environmental status of a particular manufacturing facility and the uses of additives. At present there are very limited possibilities to distinguish between harmful and less harmful production facilities for PVC.

Definitions

Plastic parts are parts made mainly of plastics, e.g. the housing. Parts containing other materials in any significant amounts, e.g. cables with metal conductors, are not included in the definition.

Printed wiring board laminate is a printed board that provides point-to-point connections but not printed components in a predetermined configuration on a common base.

Applicability

All FPDs.

Clarification

B.6.4.4

References

63 and 67.

Mandate:
Plastic parts in the FPD weighing more than 25 grams shall not contain chlorine or bromine as a part of the polymer.
 Note that *printed wiring board laminates*, and all kinds of internal and external cable insulation are not considered to be part of *plastic parts* and are therefore not included in the mandate.

The following information shall be submitted to an approved eco-verifier:
 A written guarantee that the above mandate is fulfilled. The guarantee shall be signed by the responsible person at the applicant company.

The following information shall be submitted with the application to TCO Development:
 A copy of a verification report from an eco-verifier approved by TCO Development.

We hereby guarantee that the above mandate is fulfilled.

.....
Product brand name and model name

.....
Signature

.....
Name and title in block capitals

.....
Date

.....
Company

A.6.4.5 Information regarding plastics and flame retarding agents

Background

This requirement is intended to give information about the plastics and flame retarding agents in the product to be reviewed for compliance with the environment requirements in this criteria document.

Definitions

Plastic parts are parts made mainly of plastics, e.g. the housing. Parts containing other materials in any significant amounts, e.g. cables with metal conductors, are not included in the definition.

Printed wiring board laminate is a printed board that provides point-to-point connections but not printed components in a predetermined configuration on a common base.

Applicability

All FPDs.

References

64, 68, 69 and 70.

Mandate:

The material specifications shall be provided for *plastic parts and printed wiring board laminates* weighing more than 25 grams and which have flame retardant concentrations above 1% by weight, in line with ISO 1043-4.

The following information shall be submitted to an approved eco-verifier:

The table below shall be completed and the guarantee signed by the responsible person at the applicant company.

Manufacturers of plastic materials who consider such information confidential may submit the information to an eco-verifier approved by TCO Development.

The following information shall be submitted with the application to TCO Development:

A copy of a verification report from an eco-verifier approved by TCO Development.

Plastic part and PWB name	Weight in grams	Type of plastic	Plastic manufacturer name	Plastic model name	Flame retardant/ plasticizer type	Flame retardant/plasticizer CAS number*)	Plastic label code (**)

*) Chemical Abstract Service number www.cas.org

**) Labelling according to ISO 11469

We hereby guarantee that the above mandate is fulfilled.

.....
Product brand name and model name

.....
Signature

.....
Name and title in block capitals

.....
Date

.....
Company

A.6.5 Product lifetime

A.6.5.1 Warranty and spare parts

Background

A longer product lifetime has a significant positive contribution to resource use as well as the reduction of air and water pollution. A pre-condition for prolonged lifetime is that the product is of high quality, which is supported by good guarantees. Another requirement is the availability of spare parts for the product once it is taken out of production.

Definitions

Brand owner is the company that owns the brand name visible on the product.

Spare parts are those parts which have the potential to fail during the normal use of the product. Product parts whose life cycle usually exceeds the average usual life of the product need not be provisioned as spare parts.

Applicability

All FPDs.

Clarification

B.6.5.1

Mandate:

The *brand owner* shall provide a product warranty for a period of at least one year.

The *brand owner* shall guarantee the availability of *spare parts* for at least three years from the time that production ceases.

The following information shall be submitted to an approved eco-verifier:

A written guarantee that the above mandate is fulfilled. The guarantee shall be signed by the responsible person at the *brand owner* company.

The following information shall be submitted with the application to TCO Development:

A copy of a verification report from an eco-verifier approved by TCO Development.

We hereby guarantee that the above mandate is fulfilled.

..... Product brand name Model name(s) or "All products"
..... Signature Name and title in block capitals
..... Date (Declaration valid 1 year from date) Brand Owner Company

A.6.6 Preparation for Recycling

A.6.6.1 Material coding of plastics

Background

Recycling of used electronic products is an important environmental issue. Material recycling and reuse are the best options from an environmental point of view. With material coding there is a better possibility for plastics to be recycled and used in new IT equipment.

Definitions

Plastic parts are parts made mainly of plastics, e.g. the housing. Parts containing other materials in any significant amounts, e.g. cables with metal conductors, are not included in the definition.

Printed wiring board laminate is a printed board that provides point-to-point connections but not printed components in a predetermined configuration on a common base.

Applicability

All FPDs.

Clarification

B.6.6.1

References

65, 70 and 71.

Mandate:

Plastic parts weighing more than 25 grams shall be material coded in accordance with ISO 11469 and ISO 1043-1, -2, -3, -4. Such parts shall be listed in the table at Section A.6.4.5.

Exempted are *printed wiring board laminates*.

The following information shall be submitted to an approved eco-verifier:

A written guarantee that the above mandate is fulfilled. The guarantee shall be signed by the responsible person at the applicant company.

The following information shall be submitted with the application to TCO Development:

A copy of a verification report from an eco-verifier approved by TCO Development.

We hereby guarantee that the above mandate is fulfilled.

.....
Product brand name and model name

.....
Signature

.....
Name and title in block capitals

.....
Date

.....
Company

A 6.6.2 Variety of plastics

Background

Recycling of used electronic products is an important environmental issue. Material recycling and reuse are the best options from an environmental point of view. Therefore TCO Development presents requirements that facilitate material recycling.

Applicability

All FPDs.

Clarification

B.6.6.2

Definitions

Types of *plastic material* (using the abbreviation terms, symbols and concepts for plastics in ISO 1043 Part 1, 2, 3, and 4) are:

- Basic polymers
- Mixtures of polymers
- Basic polymers with flame retardants
- Mixtures of polymers with flame retardants

Product units are:

- Display case and foot
- LCD panel in FPDs
- External power supply

References

70 and 71.

Mandate:
No more than two different types of *plastic materials* are accepted for parts weighing more than 100 grams in each *product unit*.
The light guide in FPD panels are exempted.

The following information shall be submitted to an approved eco-verifier:
A written guarantee that the above mandate is fulfilled. The guarantee shall be signed by a responsible person at the applicant company.

The following information shall be submitted with the application to TCO Development:
A copy of a verification report from an eco-verifier approved by TCO Development.

We hereby guarantee that the above mandate is fulfilled.

.....
Product brand name and model name

.....
Signature

.....
Name and title in block capitals

.....
Date

.....
Company

A.6.6.3 Moulded-in metal parts and metallization of plastic housing

Background

Recycling of used electronic products is an important environmental issue. Material recycling and reuse are the best options from an environmental point of view. Therefore TCO Development presents requirements that facilitate material recycling.

Definition

Metallization is a surface deposition process whereby a metallic layer is applied to the surface of a completed shaped plastic part. Examples of metallization processes are chemical coating and ion vapour deposition.

Applicability

All FPDs.

Clarification

B.6.6.3

Mandate:

1. There shall be no internal or external *metallization* of the FPD outer plastic casing.
2. Moulded-in or glued metal parts are not accepted.

The following information shall be submitted to an approved eco-verifier:

A written guarantee that the above mandate is fulfilled. The guarantee shall be signed by the responsible person at the applicant company.

The following information shall be submitted with the application to TCO Development:

A copy of a verification report from an eco-verifier approved by TCO Development.

We hereby guarantee that the above mandate is fulfilled.

.....

Product brand name and model name

.....
Signature

.....
Name and title in block capitals

.....
Date

.....
Company

A.6.6.4 Preparation for recycling - Mercury lamps

Background

During the dismantling and recycling of flat panel displays, lamps containing mercury present one of the greatest environmental problems. By setting the requirement that the lamps must be easily detachable and dealt with separately, Mercury can be handled in an environmental secure way and the process of material recycling of the rest of the display is facilitated.

Applicability

All FPDs which contain mercury lamps for background lighting systems.

Clarification

B.6.6.4

Mandate:

Connections to be separated during the disassembly of FPD must be easy to take apart in order to not damage the mercury lamps. This means that gluing and welding must not be used to bond parts of the casing and complicate removal of the lamps.

The following information shall be submitted to an approved eco-verifier:

A written guarantee that the above mandate is fulfilled together with an adequate description of the method by means of which the lamps shall be removed. The description shall be signed by the responsible person at the applicant company.

The following information shall be submitted with the application to TCO Development:

A copy of a verification report from an eco-verifier approved by TCO Development.

We hereby guarantee that the above mandate is fulfilled.

.....
Product brand name and model name

.....
Signature

.....
Name and title in block capitals

.....
Date

.....
Company

A.6.6.5 Take back system

Background

The amount of electronic waste in the world today is enormous and a growing environmental problem. It is important that manufacturers provide mechanisms to take back their equipment at end-of-life under the principle of individual producer responsibility wherein each producer must be financially responsible for managing its own brand products at end-of-life. Currently much electronic waste is being exported to developing countries where it is managed unsustainably and disproportionately burdens developing countries with this global environmental burden. The Basel Convention and its decisions govern the export of many types of electronic waste. However not all countries have properly implemented these decisions. With this mandate TCO Development aims to put more influence into spreading better electronic waste management practice to more countries.

Definition

Brand owner is the company that owns the brand name visible on the product.

Take back system is a system that makes sure that the customer can return used products to be recycled. The system can be with or without a fee.

Environmentally acceptable recycling methods are:

- Product and component reuse
- Material recycling with secured handling of hazardous chemicals and heavy metals
- Pollution-controlled energy recovery of parts of the Display

Applicability

All FPDs.

Clarification

B.6.6.5

References

72.

Mandate:
The *brand owner* (or its representative, associated company or affiliate) shall offer their customers the option to return used products for *environmentally acceptable recycling methods* in at least one market where the product is sold and where electronics take back regulation is not in practice at the date of application.

The following information shall be submitted to an approved eco-verifier:
The information stated in the list below shall be submitted and the guarantee signed by the responsible person at the *brand owner* company.

The following information shall be submitted with the application to TCO Development:
A copy of a verification report from an eco-verifier approved by TCO Development.

The requirement can be fulfilled by one of three options (to be verified):

- 1. Product only sold on markets with WEEE legislation or similar
- 2. World-wide product take back*
- 3. One additional market lacking WEEE legislation where product take back is offered*
Name of market.....

*The brand owner shall also submit a short description, to an approved eco-verifier, of the take back system or reference to the representative, associated company or affiliate taking care of the take-back system

We hereby guarantee that the above mandate is fulfilled.

..... Product brand name Model name(s) or "All products"
..... Signature Name and title in block capitals
..... Date (Declaration valid 1 year from date) Brand Owner Company

A.6.7 Product packaging

A.6.7.1 Hazardous substances in product packaging

Background

Packaging constitutes a well known environmental problem and is regulated in many countries worldwide. Packaging material has a short lifetime and generates large volumes of waste.

There are three main areas of concern, content of hazardous substances, use of resources and transport volume.

Applicability

All packaging material.

Definition

Brand owner is the company that owns the brand name visible on the product.

Clarification

B.6.7.1

References

73.

Mandate:

The packaging material shall not contain lead (Pb), cadmium (Cd), mercury (Hg) or hexavalent chromium (Cr6).

Plastic packaging material shall not contain organically bound halogens.

The following information shall be submitted to an approved eco-verifier:

A written guarantee that the mandate above is fulfilled. The guarantee shall be signed by the responsible person at the *brand owner* company.

The following information shall be submitted with the application to TCO Development:

A copy of a verification report from an eco-verifier approved by TCO Development.

We hereby guarantee that the above mandate is fulfilled.

.....
Product brand name

.....
Model name(s) or "All products"

.....
Signature

.....
Name and title in block capitals

.....
Date (Declaration valid 1 year from date)

.....
Brand Owner Company

A.6.7.2 Preparation for recycling of product packaging material

Background

Packaging constitutes a well known environmental problem and is regulated in many countries worldwide. Packaging material has a short lifetime and generates large volumes of waste.

There are three main areas of concern, content of hazardous substances, use of resources and transport volume.

Applicability

All packaging material.

Definition

Brand owner is the company that owns the brand name visible on the product.

Mandate:

Non-reusable packaging components weighing more than 25 grams shall be possible to separate into single material types without the use of tools.

Exempted is reusable packaging.

The following information shall be submitted to an approved eco-verifier:

A written guarantee that the mandate above is fulfilled. The guarantee shall be signed by the responsible person at the *brand owner* company.

The following information shall be submitted with the application to TCO Development:

A copy of a verification report from an eco-verifier approved by TCO Development.

We hereby guarantee that the above mandate is fulfilled.

.....
Product brand name

.....
Model name(s) or "All products"

.....
Signature

.....
Name and title in block capitals

.....
Date (Declaration valid 1 year from date)

.....
Brand Owner Company

R References

International standard organisations referred to in the reference list below and their home pages.

- ASTM, American Society for Testing and Materials, <http://www.astm.org/>
- CIE, Commission Internationale de l'Eclairage, International Commission on Illumination, www.cie.co.at/cie/
- DIN, Deutsches Institut für Normung e. V., www2.din.de
- EBU, European Broadcasting Union, http://www.ebu.ch/tech_info.html
- IEC, International Electrotechnical Commission, www.iec.ch
- ISO, International Organization for Standardization, <http://www.iso.org/>
- ITU, International Telecommunication Union www.itu.int/home/index.html
- SMPTE, Society of Motion Picture Television Engineers, www.smppe.org
- VESA, Video Electronics Standards Association, www.vesa.org

1. CIE Publication 69 (1987), Methods of characterizing illuminance meters and luminance meters: performance characteristics and specifications.
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3. <http://www.w3.org/Graphics/Color/sRGB.html>
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5. ASTM gloss standard D523.
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7. DIN 67 530.
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16. ISO 3664:1999, Viewing conditions for graphic technology and photography, p. 9 Uniformity of screen luminance.

17. ISO 3664:1999, Viewing conditions for graphic technology and photography, p. 5, 4.2.4 Surround and backing for reflection viewing, Note 1 p. 8.
18. ISO 3664:1999. Viewing conditions for graphic technology and photography, p. 10 Monitor luminance.
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26. www.srgb.com
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37. ISO 9241-7 Ergonomic requirements for office work with visual display terminals (VDTs) - Part 7: Requirements for display with reflections. International Organisation of Standardisation.

38. ISO 9241-8 Ergonomic requirements for office work with visual display terminals (VDTs) - Part 8: Requirements for displayed colours. International Organisation of Standardisation.
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41. EC Directive 90/270/EEC EU Directive 90/270/EEC Minimum safety and health requirements for work with display screen equipment.
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57. United Nations Global Compact (UNGC), <http://www.unglobalcompact.org/>
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59. SA8000, <http://www.sa-intl.org>
60. ENERGY STAR® Program Requirements for Displays, Eligibility Criteria (Version 5.0) DRAFT 2
61. International Efficiency Marking Protocol for External Power Supplies
62. EU Directive 2006/66/EG on batteries and accumulators containing certain dangerous substances
63. EU Directive 2002/95/EC on the restriction of the use of certain hazardous substances in electrical and electronic equipment
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B Test methods and clarifications

The following definitions, test conditions, requested specifications from clients, and other information apply for test methods described in this document.

Test results are valid only for the presentation form(s) and configuration(s) tested.

B.0 General test conditions

B.0.1 Definition of a test object

- Test objects covered by this document are flat panel visual display units, henceforth called FPDs (Flat Panel Displays) with fixed positions of the pixels.
- A test object is defined as the FPD or the FPD plus necessary equipment in order to generate a test image. Any accessory, such as a graphic card, a video generator or a character generator that can affect the test result can be considered part of the test object if the client so specifies and it is delivered as a part of the product to the end user.
- A test object with all necessary information for its operation shall be delivered to the test laboratory in test ready condition including any required accessories. All necessary information about how to operate and adjust the test object shall be provided.
- The performance of the test object shall in all aspects be fully in accordance with the performance of the final product.
- The client shall inform the test laboratory if any image enhancement software or hardware is used for the FPD and which input ports that have image enhancement.

B.0.2 Required test object information

- The client shall specify the name(s), type designation(s) and manufacturer for all different exchangeable parts of the test object.
- The client shall specify if a particular graphic card or video generator shall be used for testing (see B.0.3).
- The client shall specify the display resolution of the FPD and the vertical and horizontal frequencies for testing.

B.0.3 Graphic card (Video adapter)

- The client shall specify if a particular graphic card shall be used for testing. In this case the graphic card shall be representative of the common use of the FPD, for example included in the motherboard of associated equipment. Non-standard graphic cards shall not be accepted for testing, unless they are for a special purpose relevant for the product and sold together with it. If the client does not specify a graphic card, a high quality standard graphic card from the testing laboratory shall be used. This shall be reported in the test report and the client shall be informed. The graphic card shall be easily commercially available or supplied with the display and be of recent model, in order to give the tested combination a more general validity and to give any user of the FPD the possibility of purchasing the same graphic card as used in the testing. The most recent versions of graphic cards and drivers are recommended. The graphics board shall offer a typical output voltage on RGB of $0.7 \text{ V} \pm 10\%$.
- A character generator or video generator shall only be used to operate the FPD if it is not possible to use a standard graphic card. This is because a character generator is not representative of the usual way an FPD is run.
- The graphic card used for testing shall not be used for more than the test object during the test, if not stated by the client.
- The computer or similar devices used to run the test object in the test shall not use any unnecessary software or hardware that could influence the test.
- All settings in the operating systems shall be the default ones as delivered to the end user or the default as it appears directly after the installation of the operating system.

B.0.4 Conditions for the equipment under test

- The FPD being tested shall be physically prepared for testing and shall be warmed up until it is fully stabilised, but at least for 30 minutes.
- The FPD screen surface shall be clean when tested.
- The FPD shall be tested under nominal conditions of input voltage, current, etc. If sold on different markets, one setup shall be chosen by the manufacturer which shall represent the conditions of the country in where it will be sold the most.
- When possible testing shall be done with the digital signal input. In the case of several digital inputs the one with the lowest bandwidth which can still support the native resolution shall be used. The same signal input shall be used for testing of all parameters. The signal input used shall be specified in the test report.
- If the product relies on network connection to function a network connection must be established. Otherwise the FPD shall be tested without load on any peripheral interface such as USB, firewire or network hub, memory card slot, loudspeakers or similar.

B.0.5 FPD alignment for testing

The FPD screen front shall be aligned vertically with the possibility to rotate the screen $\pm 30^\circ$ around a vertical axis through the centre-point of the screen front. It shall also be possible to rotate the screen forwards and backwards $\pm 15^\circ$ around a horizontal axis through the same centre-point.

B.0.6 Instruments used for testing

All instruments used for testing of a FPD shall be of good quality and validated by a recent test certificate from a certified testing laboratory. Any necessary instrument calibration shall be done before the tests are performed. Calibrations shall be traceable to national standards.

B.0.7 Settings of the FPD

- Pivot screens shall only be measured in the usual landscape mode.
- The FPD resolution shall be set to the native resolution
- The FPD shall be put in its factory default mode. The CCT of the default mode shall be used.
- All tests shall be performed with the FPD in the factory default mode if not stated otherwise in the test methods.
- Testing may be done with a preset instead of the default mode if the user is informed in the user manual which preset is used for TCO compliance. In this case this preset shall be treated as the default mode in the criteria document and noted in the test report.
- All measurements shall be taken with no adjustments made between the measurements, if not specified otherwise in the test method.
- An external control unit that is not a standard part of the FPD is not allowed.
- The colour depth of the source signal shall be 24 bits (8 bits per colour channel) or more.
- In Windows/Display Properties/Settings/Advanced the Windows “Small fonts” option shall be used.
- In Windows/Display Properties/Appearance the “Windows standard” colour scheme option shall be used.

B.0.8 Test image/test character

- All test images can be found on the home page of TCO Development, www.tcodevelopment.com.

- The default testing 12 point Arial font and 100% “zoom/magnification” shall be used. The latest version of MS Windows operating system is the default user interface, if not otherwise stated. For Macintosh displays, Mac OS can be used during the testing.
- The default testing polarity is positive polarity (black characters on a white background).
- Another possibility is to use a testing program that shall consist of software commonly used in office and home computer work. The word processor should be able to produce the text and graphics required for the test procedures.
- All parts of the tests for a test object shall be conducted using the same font, character size, correlated colour temperature, resolution, operating system and other settings of the FPD controls etc., unless otherwise stated in the test procedure.

B.0.9 Test Image and Test Luminance setting

The test image in Figure B.0.9.1, referred to as the TCO default test image, has an 80 % image loading. It shall be used for testing unless otherwise specified:

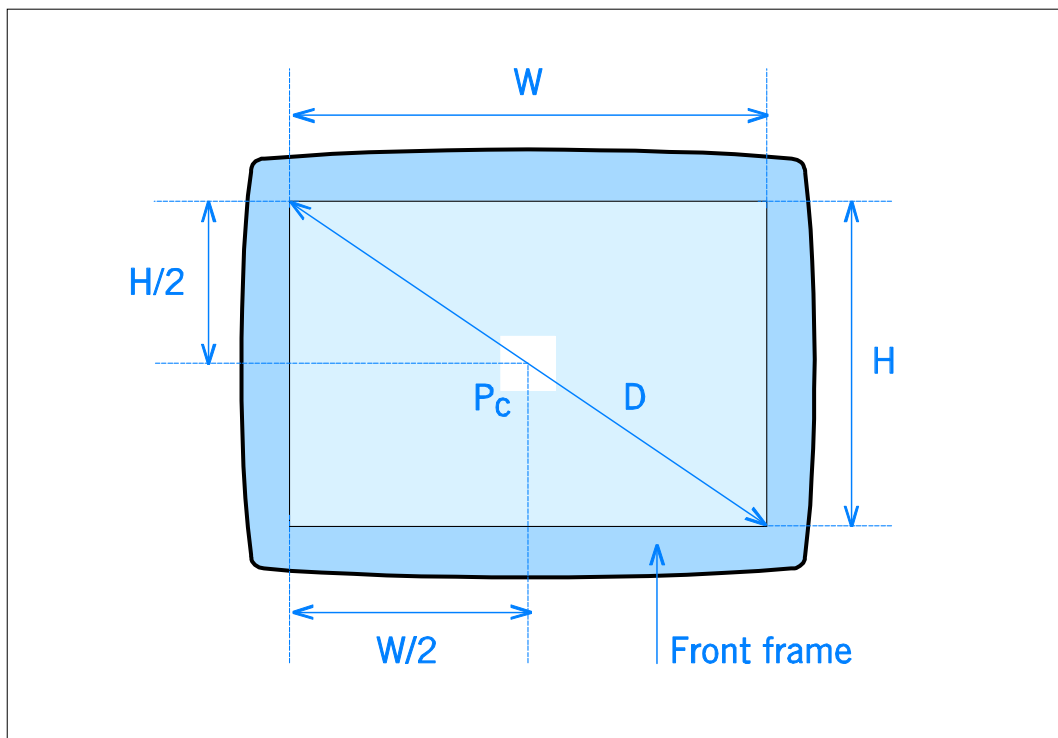


Figure B.0.9.1. The TCO default test image.

Procedure:

- The background colour shall be set to RGB 204, 204, 204 (i.e. equal to 80 % image loading).

- An active white square at the centre of the screen shall be $4^{\circ} \times 4^{\circ}$ in size and have an RGB setting of 255, 255, 255. The $4^{\circ} \times 4^{\circ}$ corresponds to an area of about 34.9 mm \times 34.9 mm at a measuring distance of 500 mm or 69.8 mm \times 69.8 mm at 1 meter. For a 15" display measured at 57 cm, the $4^{\circ} \times 4^{\circ}$ corresponds to a square of 40 mm \times 40 mm.

Test Luminance setting:

- Reset the product to its default mode (as intended to be delivered to the end user). If the product has an automatic adjustment this can be activated once. In the default mode the luminance of the FPD shall be at least 150 cd/m². If the luminance is lower than that the product can not be TCO certified.

B.0.10 Test report

The test results are valid only for the presentation form(s) and configuration(s) tested. If other configurations are accepted by the laboratory based on the results of the tested ones it shall be clearly specified in the test report that these configurations have not been tested.

The test report shall include the following information:

- Any changes to the test methods.
- The manufacturer, brand name, model type and serial number (if available).
- The panel brand, full panel number, if the screen is Pivot stand type and if it has a LED backlight.
- The mode(s) (i.e. horizontal and vertical scan frequency and resolution) used during the test and the aspect ratio.
- The supply voltage and frequency used during the test and whether it is a CLASS I or CLASS III type. If CLASS III the AC adapter brand and model number shall also be stated.
- The degree of uncertainty for each given measurement result.
- The setting of contrast, brightness and CCT preset at the reset default setting.
- Four photographs of the product taken: Front, rear, open panel and a legible panel marking label

B.1 General information

B.1.1 TCO Document

The TCO document shall accompany the product as provided by TCO Development. No editorial changes without TCO's consent are accepted. The TCO Document is available at the TCO Development web site www.tcodevelopment.com.

If the TCO Document is part of a User's Manual or is provided as an electronic file the TCO Document must be separated from other text portions so that it is obvious that the TCO Document is not accountable for the content of the other texts.

The brand name owner may post the TCO Document on its web site, e.g. by showing TCO logos or icons that redirect the visitor by links to the TCO Document

If the product that is to be TCO labelled is branded differently from the applicant name, the applicant company signing the guarantee shall be sure that the brand name holder agrees with the requirement.

B.2 Visual ergonomics

B.2.0 General test conditions for visual ergonomics

B.2.0.1 Basic test requirements

As described in section B.0.
For all tests, the FPD screen shall be clean.

B.2.0.2 Photometric laboratory general requirements

Photometric measurements shall be performed under darkroom conditions. This means that measurement data shall in no way be affected by direct light from sources or light reflected from interiors, equipment, clothes etc.

The laboratory shall have a routine for the control of the stray-light level at the FPD screen (see also B.2.0.6).

B.2.0.3 Power supply and test room climate requirements for testing

- AC mains voltage* 230 VAC RMS, tolerance $\leq 1 \%$
- AC mains frequency* 50 Hz, tolerance $\leq 2 \%$
- Test room temperature $23 \pm 3 \text{ }^\circ\text{C}$
- Humidity 20-75 % RH (non condensing)

* – or other voltage and frequency combination specified by the client.

B.2.0.4 Photometric and spectrometric measurements

Several instruments are to be used when carrying out measurements for visual ergonomics. All instruments shall be recently calibrated and carry a calibration certificate from a certified testing laboratory.

The following instrument types are to be used for testing:

- **Gloss meter.** An instrument for measuring gloss as a function of the directionally selective reflecting properties of a material at angles near to and including the direction giving specular reflection.

- **Luminance meter.** A luminance meter shall have a sufficiently good V_{λ} -sensitivity (Requirements for luminance meters are covered by CIE Publication 69 (1987). Luminance meters of CIE Class L(aboratory) with a combined performance characteristic $\leq 3\%$ shall be used) and integrate luminance over a finite measuring field during a finite time. The meter shall be equipped with adjustable optics and always be focused on the measured area. The luminance meter must incorporate a sufficiently long time constant of integration in order to ensure averaging of the pulsation of the light emitted by FPDs. The sensitivity shall be independent of the polarization of the measured light (often referred to as f_8 error).

The luminance meter measuring field shall be one degree for all measurements, except for the micro-photometric luminance measurements, see below.

An automated instrument using collimating optics may be used for testing although the measurement area will differ somewhat from the area covered by the luminance meter. When the luminance measurement in this case is done at a shorter distance than $1.5 \times$ the screen diagonal (D) because of instrumental constraints, the laboratory shall verify that the results are equal to those done at $1.5 \times D$.

- **Micro-photometer.** Micro-photometric registration of the luminance distribution of test patterns shall be performed with an array photo detector device capable of resolving structures of ≤ 0.02 mm. A scanning device shall not be used because it is sensitive to jitter and other variations that may occur during a scanning.
- **Spectro-radiometer.** An instrument for the measurement of radiant flux as a function of wavelength shall be used. A spectro-radiometer for the measurement of light and colour is normally equipped with a microprocessor that makes it possible to obtain luminance and colour co-ordinates directly from raw measurement data. A spectro-radiometer can replace the luminance meter when suitable. The wavelength resolution shall be ≤ 4 nm for accurate colour measurements. The sensitivity shall be independent of the polarization of the measured light (often referred to as f_8 error).

B.2.0.5 Measurement distance

All measurements shall be carried out through a point, simulating the eye position of the operator, at a distance of $1.5 \times$ “diagonal of the screen” from the centre-point of the FPD screen but no less than 500 mm which could be considered as an absolute minimum viewing distance for comfortably viewing the display. The instrument shall be focused on the presented test image for all measurements.

B.2.0.6 Stray light

Stray light may cause errors which can negatively affect measurement of luminance, contrast and chromaticity coordinates. It is therefore necessary to make an evaluation of stray light influence for the different measurement procedures described in this document.

If it is verified that stray light affect the measurement result it is necessary to take actions to eliminate the source of error. Two possible ways to solve the problem are to equip the luminance meter with a well designed screening attachment, a frustum or to use a black screening sheet at the FPD surface.

B.2.0.7 Overall uncertainty

The overall uncertainty of the test laboratory shall be calculated for each measurement procedure in this document and presented in the test report. The uncertainty shall be within the required levels for each criterion. All measurement uncertainties claimed for used instruments shall be referred to traceable calibration reports.

B.2.1 Image detail characteristics

B.2.1.1 Native display resolution requirement

B.2.1.1.1 Preparation of the FPD for testing

No specific preparation of the FPD is needed.

B.2.1.1.2 Equipment

Calculator and product manual or similar information about the display resolution.

B.2.1.1.3 Test method

The maximum resolution and frequencies of the display are found in the manual or similar information from the manufacturer.

B.2.1.1.4 Test evaluation

The viewing distance is defined as $1.5 \times$ the display diagonal, but no less than 500 mm. This means that the mandate is independent of the display size and viewing distance but dependent on the display format. Only the display format needs to be known.

The minimum resolution to fulfil the criteria can be calculated for any display format in the following way:

Minimum amount of pixels in the vertical direction

Half the display height at the viewing distance expressed in degrees is:

- $\arctan(\text{width}/2/\text{viewing distance})$

The whole display height expressed in degrees is:

- $2 \times \arctan(\text{width}/2/\text{viewing distance})$

The requirement is 30 pixels/degree which gives the amount of pixels needed in the vertical direction to:

- $30 \times 2 \times \arctan(\text{width}/2/\text{viewing distance})$

Example:

For the format 5:4:3 and viewing distance 1.5 this gives the formula:

- $30 \times 2 \times \arctan(4/2/(1.5 \times 5)) = 896 \text{ pixels}$

The principle is the same in the horizontal direction.

For the most common display formats the mandates are:		
<u>Display format</u>	<u>Min amount of horizontal pixels</u>	<u>Min amount of vertical pixels</u>
5:4:3	896	679
18.36:16:9	972	557
6.4:5:4	875	706
18.87:16:10	947	601
Note: Display format is a ratio between [Diagonal : Width : Height]		
For or other aspect ratios the min display resolution shall be calculated.		

B.2.1.1.4 Overall uncertainty

Uncertainty is not applicable in this case. Product data information is sufficient.

B.2.2 Video Reproduction

B.2.2.1 Motion blur

B.2.2.1.1 Preparation of the FPD for testing

- All necessary preparations described in B.0 and B.2.0 shall be done.
- The TCO default test image with an 18-step greyscale as shown in Figure B.2.3.1 shall be used for luminance level measurement.
- The measurement shall be made in the centre of the screen.

A test image for motion blur shall be a homogeneous area of one grey level g_1 , which is an area that is at least twice the size in each dimension compared to area covered by the sensor, so that no interference is introduced from the surrounding area. The test image is at a certain point in time changed to another grey level g_2 . The grey levels used shall be 0, 63, 127, 191 and 255 (or corresponding levels if other colour depth is used). This makes 20 transitions when switching between all combinations.

B.2.2.1.2 Equipment

Luminance meter or photo diode connected to an oscilloscope with ≤ 0.1 ms resolution connected to a computer with suitable evaluation software. A data logger is usually needed to record all the data. The response time of the sensor must be ≤ 0.1 ms. The sensor should cover a small vertical dimension, so that the measurements are not affected by the vertical frame update. It shall cover $\leq 1\%$ of the vertical dimension of the display.

B.2.2.1.3 Test method

The luminance transition between two greyscale steps shall be recorded with a sampling frequency ≥ 10 kHz. The output is normalized by

$$\bar{E}(t) = \frac{E(t) - E(0)}{E(\infty) - E(0)}$$

so that the values are ranging between 0 and 1. The time values are given in ms. The recording shall be repeated at least 5 times for each greyscale transition and stored in the data logger. This procedure will reduce the random noise and other temporal variations of the signal. In all at least 100 transitions must be recorded. The 5 repetitions will be used for the averaging in order to reduce any temporal noise. The input port used for testing shall be the same as the port used for the other parameters and must be specified, since not all ports will have the same characteristics and consequently will not give the same results.

B.2.2.1.4 Test evaluation

The eyes are moving continuously tracking the moving object i.e. smooth pursuit, trying to keep the target stable on the retina. A moving edge on a CRT is flashed in each location for a short period of time and black periods in between. If the eyes are able to perfectly track the edge, it will be flashed on the same location on the retina each time and no blur will be introduced. On an LCD the eyes will also try to stabilize the object on the retina, but the object on the screen will be shown at the old location until it jumps ahead to the new location and this will give rise to a non-continuous motion on the screen and the image of the object on the retina will, therefore, move around the stabilization location, which is perceived as a blur.

Temporal step-response: A pixel is changing its intensity from a start greyscale level g_1 to a final grey level g_2 e.g. black (g_1) to white (g_2). The considered grey-to-grey transition is written $g_1 \rightarrow g_2$. The temporal step-response is the luminance profile of the pixel as a function of time

$$R_{N_j \rightarrow N_i}(t)$$

Blur Edge Width (BEW): The spatial profile of the moving edge E is written

$$E_{N_{right} \rightarrow N_{left}}(x).$$

It corresponds to the luminance profile of the blurred edge as a function of space.

$\bar{E}_{N_{right} \rightarrow N_{left}}(x)$ is the normalized spatial profile between 0 and 1.

Then BEW is defined:

$$BEW_{g_{right} \rightarrow g_{left}} = |x_{90\%} - x_{10\%}| \text{ with } x_{10\%} \text{ and } x_{90\%} \text{ such as } \begin{cases} \bar{E}_{g_{right} \rightarrow g_{left}}(x_{10\%}) = 0.1 \\ \bar{E}_{g_{right} \rightarrow g_{left}}(x_{90\%}) = 0.9 \end{cases}$$

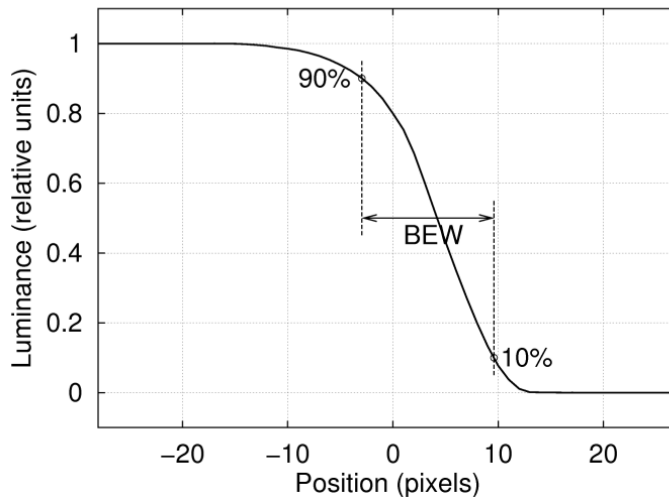


Figure 1: Example of blurred edge profile $\bar{E}_{g_i \rightarrow g_j}(x)$ $\bar{E}_{N_i \rightarrow N_j}(x)$. BEW is measured between 10% and 90% of the edge dynamic

$${}^1 \bar{E}(t) = \frac{E(t) - E(0)}{E(\infty) - E(0)}$$

Blur Edge Time (BET): We consider an edge moving from left to right. Each pixel of the screen will initially have the grey level of the right part of the edge

g_{right} and then have the grey level of the left part of the edge g_{left} . Thus the grey-to-grey transition is $g_{right} \rightarrow g_{left}$, and each pixel will undergo a the temporal step-response $R_{N_{right} \rightarrow N_{left}}(t)$. It has been shown that the blurred edge profile can be obtained directly from this temporal step response:

$$E_{g_j \rightarrow g_i}(x) = R_{g_j \rightarrow g_i} \left(\frac{-xT}{v} \right) * \text{rect} \left(\frac{xT}{v} \right)$$

These studies have also given that the BEW value is proportional to the velocity of the edge v . Then it is possible to express the blur width independently of the speed, the value obtained has a unit of time and is referred as the BET:

$$\text{BET} = \text{BEW}/v$$

$$\text{BET} = \text{BEW} / v$$

where v is the velocity of the edge.

Mean Blur Edge Time (BET_{mean}): The mean or the average Blur Edge Time of all 20 transitions ($5 \times 5 - 5 = 20$) made by the 5 grey levels $g_i = \{0, 63, 127, 191, 255\}$ and $g_j = \{0, 63, 127, 191, 255\}$

The blur edge luminance profile i.e Blur Edge Width (BEW) is obtained by convolving the temporal step response with a window, which width is one frame-period.

The Blur Edge Time (BET) can then be measured directly on the obtained luminance profile, in unit of time (e.g. in frames). The BEW value, in unit of space (e.g. in pixels), is obtained by multiplying the BET value with the motion speed v of the moving object in space per time units (e.g. in pixels/frame), i.e.:
 $\text{BEW (in pixels)} = \text{BET (in frames)} \times v \text{ (in pixels/frame)}$

The BET should be expressed in milliseconds (ms) by multiplying with the period T of one frame (usually T is about 16.67 ms at present for computer displays) i.e
 $\text{BET (in ms)} = \text{BET (in frames)} \times T \text{ (in ms/frame)}$

Matlab code for computing BET could be as follows

```
window = 1/round(Fs/Fr).*ones(1,round(Fs/Fr));
Edge = filter2(window, SampledResponseData');
Edge = Edge(numel(window):numel(Response)-numel(window));
NEdge = Normalize(Edge);
BET = ComputeCrossing10to90Level(NEdge);
```

B.2.2.1.5 Overall uncertainty

$\leq \pm 0.5\text{ms}$.

See B.2.0.7.

B.2.3 Luminance characteristics

B.2.3.1 Luminance level

B.2.3.1.1 Preparation of the FPD for testing

- All necessary preparations described in B.0 and B.2.0 shall be done.
- The TCO default test image with an 18-step greyscale as shown in Figure B.2.3.1 shall be used for luminance level measurement.

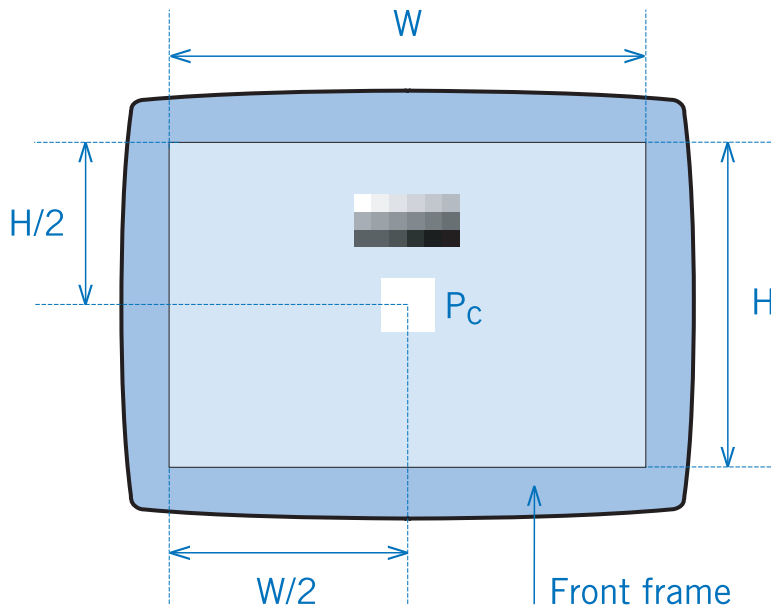


Figure B.2.3.1. TCO default test image with the 18-step greyscale inserted.

- The measurement position P_C shall be at the centre of a $4^\circ \times 4^\circ$ square without line borders, having an RGB setting of 255, 255, 255, and positioned at the centre of the screen. The background shall be RGB 204, 204, 204.
- Reset the display to its default setting. Check that the luminance is ≥ 150 cd/m^2 .

The following evaluations shall be carried out orthogonally to the screen surface.

- To achieve the maximum luminance proceed as follows:
Use the TCO default test image with an 18-step grey scale pattern presented on the screen. From the default setting, adjust the controls on the display to achieve as high luminance as possible with an acceptable image quality. The image quality is considered acceptable if at least 15 of the 18 grey scale steps are visible. At this maximum luminance, test that the display has a luminance ≥ 200 cd/m^2 .
- Reset the display to its default setting. From the default setting, adjust the controls on the display to achieve as low luminance as possible with an acceptable image quality. The image quality is considered acceptable if at

least 15 of the 18 grey scale steps are visible. At this minimum luminance check that the display has a luminance $\leq 100 \text{ cd/m}^2$.

- If it difficult to visually determine if 15 of the 18 grey scale steps are visible, then the display shall comply with the gamma curve criteria (A.2.3.5) in the max and min luminance setting.
- After this test is completed the display shall be put back in its default mode by pressing a reset button or similar. After each reset the display has to stabilize before other test measurements are made.

B.2.3.1.2 Equipment

Luminance meter.

B.2.3.1.3 Test method

The luminance at the centre of the white test area shall be measured with the luminance meter directed orthogonally to the test area as described in B.2.0.5.

B.2.3.1.4 Test evaluation

The measured luminance is the required value. The luminance shall be reported with no decimal places.

The measured luminance, Contrast and Brightness settings for all conditions shall be noted in the test report. The preset CCT in default setting shall also be noted.

B.2.3.1.5 Overall uncertainty

$\leq \pm 10 \%$ in luminance.

See B.2.0.7.

B.2.3.2 Luminance uniformity

B.2.3.2.1 Preparation of the FPD for testing

- All necessary preparations described in B.0 and B.2.0 shall be done.
- The entire active area of the screen shall be white and the FPD colour setting shall be RGB 255, 255, 255.

B.2.3.2.2 Equipment:

Luminance meter.

B.2.3.2.3 Test method:

The luminance shall be measured orthogonally to the FPD screen plane at 9 points. The 4 corner positions (1, 3, 7 and 9) are measured 1° from the edges of the screen as shown in Figure B.2.3.2.1. The 4 side positions (2, 4, 6 and 8) are measured on the middle of the side 1° from the edge. Finally the centre position (5) is measured. This means that all measurement points have $1/2^\circ$ marginal to the edges if the measurement area of the instrument is 1° .

The luminance uniformity shall also be evaluated visually by the technician in order to find any dark or bright areas except from the 9 default positions. If a significantly bright or dark area is found these measuring points shall also be measured and used to evaluate the luminance uniformity.

The conditions for luminance measurement in the corner positions and the distribution of other measurement points are illustrated in figure B.2.3.2.1.

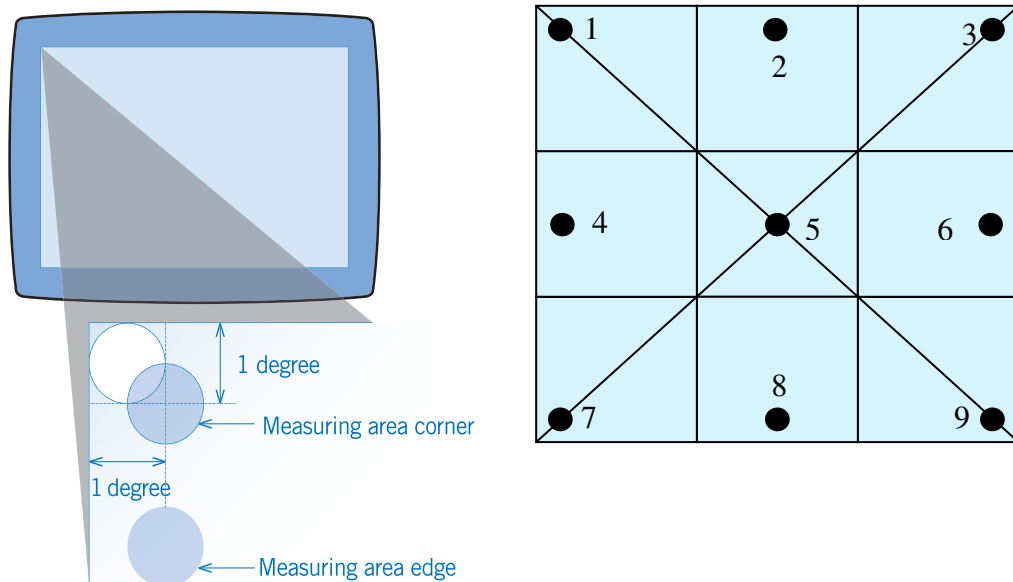


Figure B.2.3.2.1. Measurement positions for the measurement of luminance and colour uniformity.

B.2.3.2.4 Test evaluation

The luminance uniformity shall be reported as the ratio between the highest and the lowest measured luminance values.

The result shall be presented to 2 decimal places.

B.2.3.2.5 Overall uncertainty

$\leq \pm 10 \%$ in luminance.

$\leq \pm 0.1$ unit in luminance uniformity.

See B.2.0.7.

B.2.3.3 Black level**B.2.3.3.1 Preparation of the FPD for testing**

- All necessary preparations described in B.0 and B.2.0 shall be done.
- The TCO default test image with an 18-step greyscale as shown in Figure B.2.3.1 shall be used for luminance level measurement.
- The measurement position P_C shall be at the centre of a $4^\circ \times 4^\circ$ square without line borders, having an RGB setting of 0, 0, 0, and positioned at the centre of the screen.
- The black level shall be tested at maximum luminance. This is considered to be $\geq 200 \text{ cd/m}^2$.
- To achieve the maximum luminance proceed as follows:
Use the TCO default test image with an 18-step grey scale pattern presented on the screen. From the default setting, adjust the controls on the display to achieve as high luminance as possible with an acceptable image quality. The image quality is considered acceptable if at least 15 of the 18 grey scale steps are visible. This maximum luminance shall be $\geq 200 \text{ cd/m}^2$.
- If it difficult to visually determine if 15 of the 18 grey scale steps are visible, then the display shall comply with the gamma curve criteria (A.2.3.5) in the max luminance setting.
- Change the colour of the white square in the test image to black (RGB: 0,0,0) and measure the luminance of the black square check that it is $\leq 2 \text{ cd/m}^2$.

B.2.3.3.2 Equipment

Luminance meter.

B.2.3.3.3 Test method

The luminance at the centre of the black test area shall be measured with the luminance meter directed orthogonally to the test area as described in B.2.0.5.

B.2.3.3.4 Test evaluation

The measured luminance is the required value. The luminance shall be reported to one decimal place.

B.2.3.3.5 Overall uncertainty

$\leq \pm 10 \%$ in luminance.

See B.2.0.7.

B.2.3.4 Luminance uniformity – angular dependence

B.2.3.4.1 Preparation for the FPD testing

- All necessary preparations described in B.0 and B.2.0 shall be done.
- Luminance values shall be measured at five different positions on the screen as shown in Figure B.2.3.4.1. Each measurement position shall consist of white RGB 255, 255, 255 squares sized $4^\circ \times 4^\circ$ without line borders.
- The background shall be RGB 204, 204, 204.
- The luminance meter shall be positioned and directed orthogonally to the screen centre-point as described in B.2.0.5.

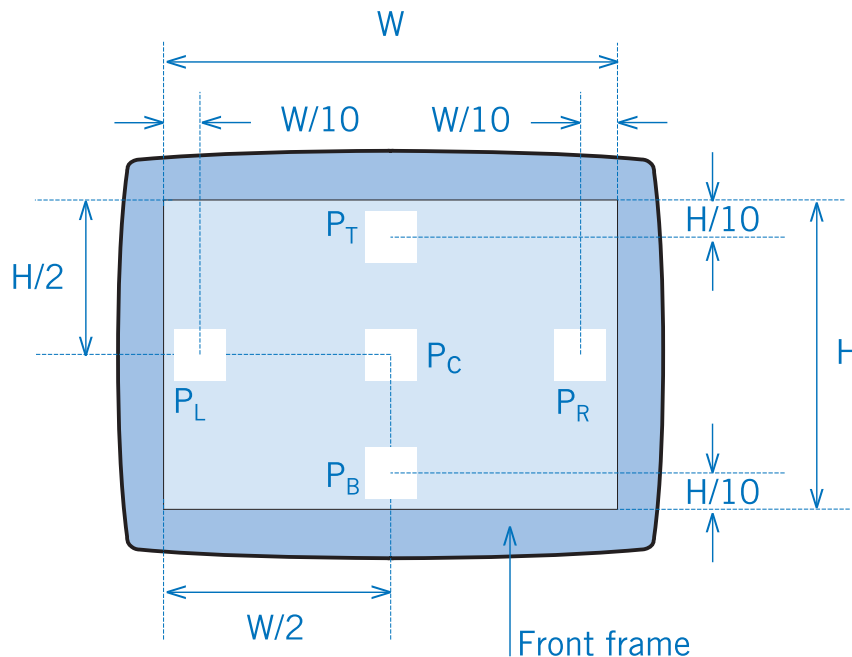


Figure B.2.3.4.1. Measurement positions for angular dependent luminance uniformity.

B.2.3.4.2 Equipment

Luminance meter.

B.2.3.4.3 Test method

1. The luminance meter shall always be directed towards a measurement point and rotated around a fixed vertical axis, (or horizontal axis for the tilt measurement) through the focal point of its front lens with a distance as described in B.2.0.5.
2. In landscape mode the display shall be rotated $+30$ degrees around a vertical axis through the display-glass centre-point and the luminance at positions P_L and P_R , ($L_{P_L/+30/0}$ and $L_{P_R/+30/0}$ respectively) shall be recorded. See Figure B.2.3.4.2.
3. In landscape mode the display shall then be rotated -30 degrees around the vertical axis through the display-glass centre-point and the luminance at positions P_L and P_R ($L_{P_L/-30/0}$ and $L_{P_R/-30/0}$ respectively) shall be recorded. See Figure B.2.3.4.2.

4. In landscape mode the display shall then be tilted +15 degrees backwards around a horizontal axis through the display-glass centre-point and the luminance at positions P_T and P_B ($L_{PT/0/+15}$ and $L_{PB/0/+15}$ respectively) shall be recorded. See Figure B.2.3.4.3.
5. In landscape mode the display shall then be tilted -15 degrees forwards around a horizontal axis through the display-glass centre-point and the luminance at positions P_T and P_B ($L_{PT/0/-15}$ and $L_{PB/0/-15}$ respectively) shall be recorded. See Figure B.2.3.4.3.
6. The measurements to be carried out are summarised in Table B.2.3.4.1. The step numbers in the step column correspond with the test method paragraphs.

Table B.2.3.4.1.

Reference above test method step	Landscape mode	Screen rotation	Screen tilt	Measuring points			
				P_L	P_R	P_T	P_B
Step 2	Horizontal direction (turned around vertical axis)	+30°	0°	X	X		
Step 3	Horizontal direction (turned around vertical axis)	-30°	0°	X	X		
Step 4	Backwards tilt = (turned around the horizontal axis)	0°	+15°			X	X
Step 5	Forwards tilt = (turned around the horizontal axis)	0°	-15°			X	X

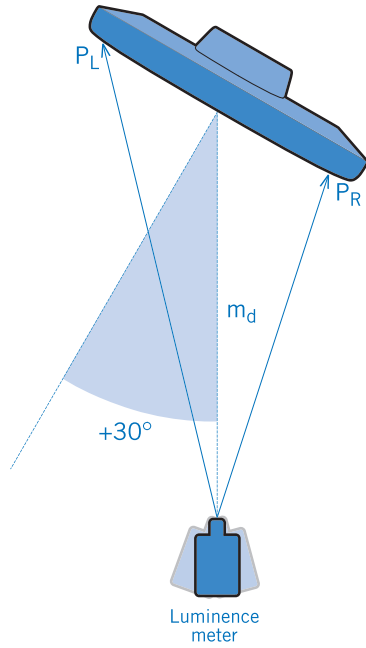


Figure B.2.3.4.2. Top view of test set-up when the display is rotated ± 30 degrees. The + rotation is defined clockwise.

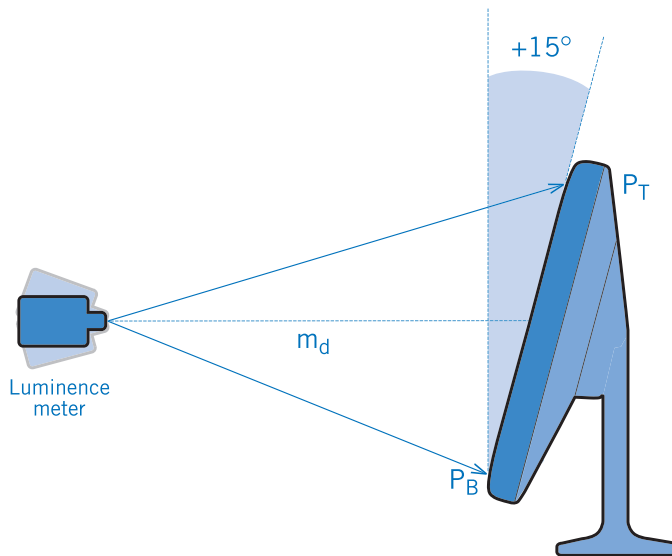


Figure B.2.3.4.3. Side view of the test set-up when the display is tilted ± 15 degrees. The + rotation is defined as backwards.

B.2.3.3.4 Test evaluation

The luminance uniformity for angular dependence shall be calculated as follows. In landscape mode, for the horizontal direction, (turned around the vertical axis) measurement presented in Table B.2.3.4.1 (test step 2 and 3). A ratio between the two measured luminances shall be calculated. This ratio, or its inverse if it has a higher value, shall be reported as the requested L_{\max} to L_{\min} luminance uniformity in **mandate 1**. The requirement is on the mean value of the two ratios $+30^\circ$ and -30° . The result shall be presented to 2 decimal places.

In landscape mode, for the vertical direction (turned around the horizontal axis). Tilt backwards and tilt forwards $\pm 15^\circ$ test step 4 and 5. A ratio between the two measured luminances shall be calculated. This ratio, or its inverse if it has a higher value, shall be reported as the requested L_{\max} to L_{\min} luminance uniformity in **mandate 2**. The requirement is on the larger of the two ratios $+15^\circ$ and -15° . The result shall be presented to 2 decimal places.

B.2.3.4.5 Overall uncertainty

$\leq \pm 10\%$ in luminance.

$\leq \pm 0.3^\circ$ in rotation angle.

$\leq \pm 0.1$ unit in luminance uniformity.

See B.2.0.7.

B.2.3.5 Greyscale gamma curve**B.2.3.5.1 Preparation of the projector for testing**

- All necessary preparations described in B.0 and B.2.0 shall be done.
- A TCO default test image, as shown in Figure B.0.9.1, shall be used for this measurement.
- The 4° × 4° square shall have each of the following RGB settings:
R=G=B=255, 225, 195, 165, 135, 105, 75 and 45.

B.2.3.5.2 Equipment

Luminance meter.

B.2.3.5.3 Test method

Measure the luminance at the centre of the 4° × 4° square for each greyscale setting specified above. Change the greyscale of the square for each measurement.

B.2.3.5.4 Test evaluation

The different greyscale luminance levels shall be within the max- and min levels according to the equation or the table below, where 100% means the luminance level measured for white, RGB 255, 255, 255.

Comments on the limits tolerance from the sRGB curve

A linear tolerance has been applied symmetrically around the sRGB gamma curve. However, as most displays on the market today have S-shaped gamma curves a “S-correction” has been added to the linear tolerance on the gamma level 225 and 195.

This correction is added since this is a new requirement and the industry needs time to adapt to a gamma curve which is not S-shaped. This correction has been determined based on statistics from measured displays. TCO Development may decide to remove this “S-correction” in the next version of this criteria document.

Table 2.3.5.4

Grey level	L_{sRGB}	L_{min}	L_{max}
	%	%	%
255	100	100,0	100,0
225	75	70	93
195	55	46	68
165	38	29	49
135	24	17	36
105	14	8	24
75	7	3	14
45	3	1	7

B.2.3.5.5 Overall uncertainty

≤ ± 10 % in luminance.

See B.2.0.6.

B.2.4 Luminance contrast characteristics

B.2.4.1 Luminance contrast – characters

B.2.4.1.1 Preparation of the FPD for testing

- All necessary preparations described in B.0 and B.2.0 shall be done.
- A micro-photometer for luminance measurement shall be aligned orthogonally to the FPD screen.
- The test image shall be filled with rows of the regular capital letter “H” in 12 point Arial font.

B.2.4.1.2 Equipment

A micro-luminance meter such as an array photo detector capable of measuring luminance on structures ≤ 0.02 mm. Measurement requirements are given in clause B.2.0.2.

B.2.4.1.3 Test method

- By visual evaluation of the standard test measurement position the technician shall search for and locate visual stripes, or patches, that clearly influence the contrast of characters or even parts of characters. Once the patches are visually identified as having significantly lower contrast they shall be geometrically referenced from the upper left corner of the active image and measured, see below. If one position is found that does not fulfil the mandate, there is no need to make further measurements.
- With a micro-luminance meter or a luminance scanner the luminance signal of and around a vertical stroke of a capital H of 12 point Arial font shall be measured. The optical axis of the luminance meter shall be aligned with the normal of the screen surface at the measuring point. The misalignment between the screen surface normal and the optical axis of the luminance meter shall be less than 0.3° .
- The height (h) of the measuring windows shall be $1/3$ of the actual height (H) of the character “H”. The window shall be positioned symmetrically between the horizontal stroke and the lower ending of the vertical stroke (see Figure B.2.4.1.1).

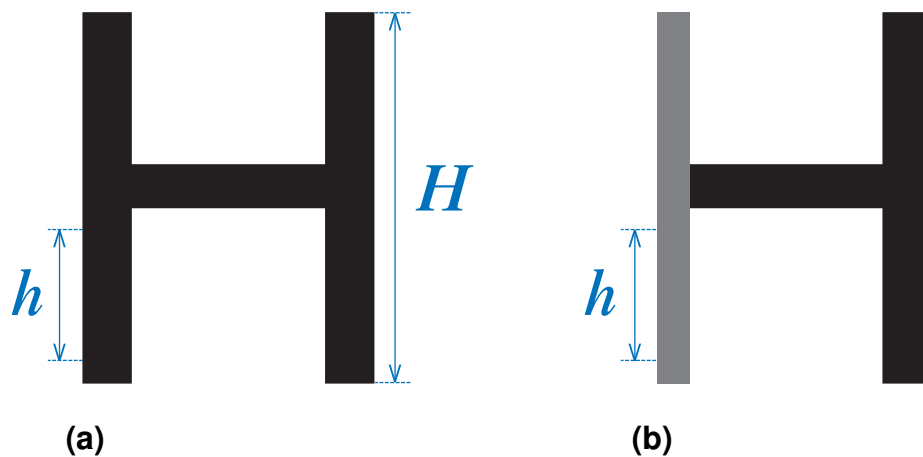


Figure B.2.4.1.1. Example of one capital “H” with (a) good contrast and one with (b) low contrast due to a paler and thinner left vertical stroke. The measuring window having height h shall be positioned symmetrically between the horizontal stroke and the lower ending of the vertical stroke of the H.

- The physical width of each measuring window or the matrix element shall be less or equal to $1/8$ of the pixel size, but not more than 0.02 mm (cf. Figure B.2.4.1.2).

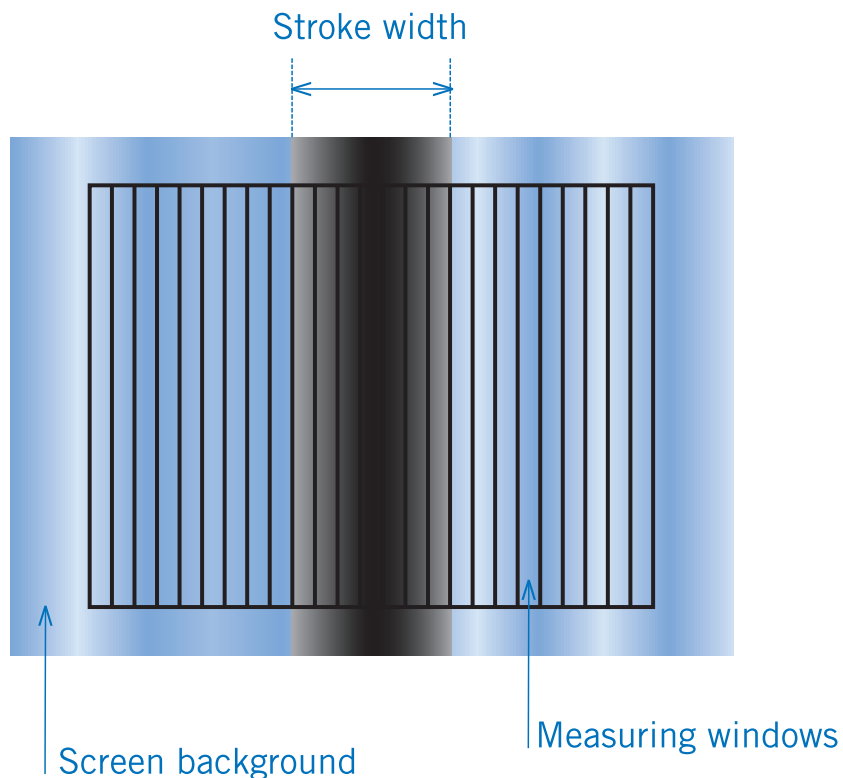


Figure B.2.4.1.2. Magnification of the vertical stroke in Figure B.2.4.1.1(a) showing a number of sampling windows.

- The basic luminance signal scanned from left to right in Figure B.2.4.1.2 could for example be as shown in Figure B.2.4.1.3.

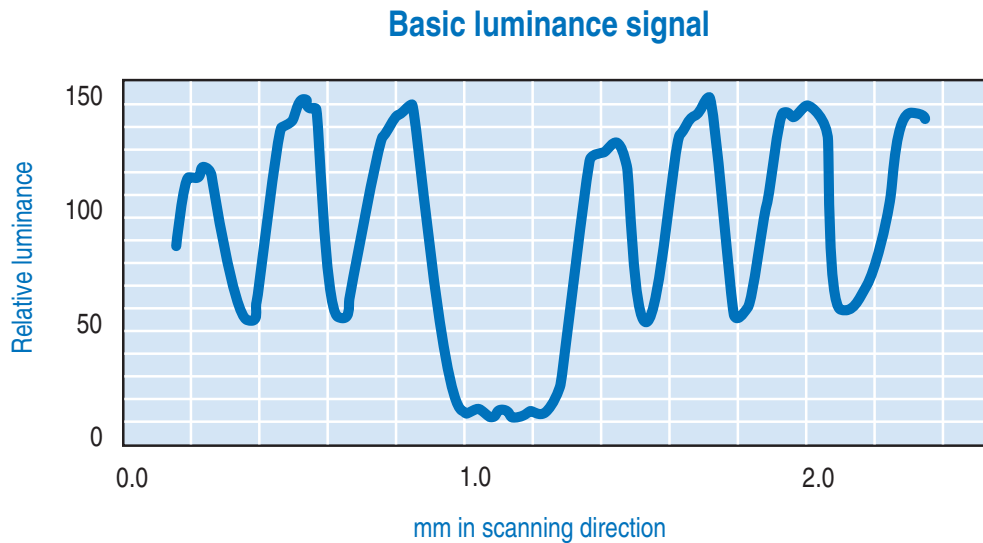


Figure B.2.4.1.3. Example of a basic luminance signal of a vertical stroke of H.

B.2.4.1.4 Test evaluation

- The basic luminance signal received from the micro-luminance meter depends on the resolution (sampling window size) of the sensor and the pixel size of the display. It is likely that the sampling window size differs between laboratories depending on photometer brand.

- The luminance contrast C shall be calculated using the formula

$$C = \frac{L_{\max} - L_{\min}}{L_{\max} + L_{\min}}$$

with the maximum and minimum luminances determined as described below.

- The photometer produces a basic luminance signal which can be filtered to a resolution of either 1 or 4 minutes of arc. These filtered signals shall be used for the calculation of C .
- To find the L_{\min} proceed as follows: The basic luminance signal shall be filtered to correspond to the 1 minute of arc resolution of the human visual system. This is equal to a sampling window size of 0.145 mm at 500 mm viewing distance. The filtering shall be done by applying a moving average to the basic input data. For example, the 1 minute of arc filtering applied to the luminance signal in Figure B.2.4.1.3 gives the signal in Figure B.2.4.1.4.

1 minute of arc filtered luminance signal used for L_{\min} calculation

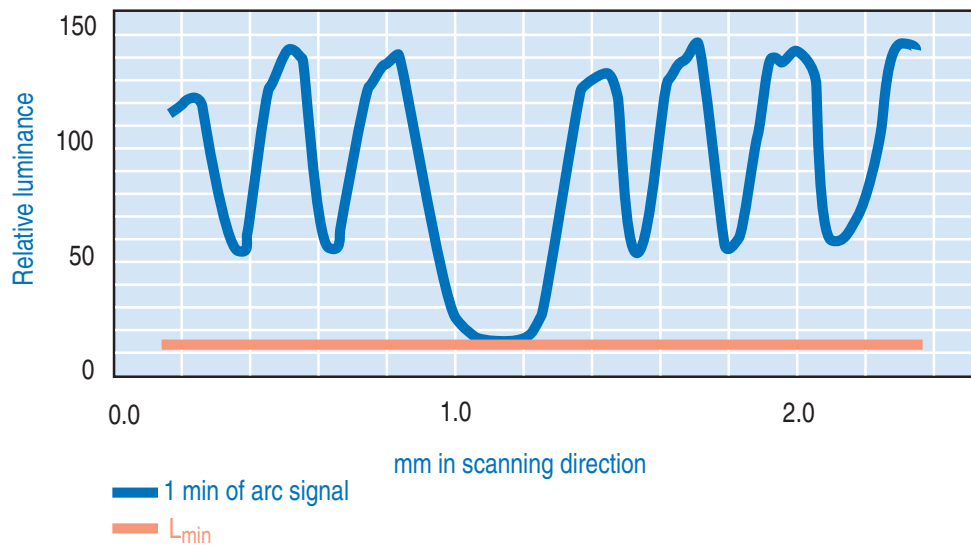


Figure B.2.4.1.4. The luminance signal filtered to 1 minute of arc and showing L_{\min} .

- The lowest relative luminance in the vertical stroke in the 1 minute of arc signal is L_{\min} .
(In the example of Figure B.2.4.1.4, the L_{\min} value is 14 cd/m^2).
- To find the L_{\max} proceed as follows: The 4 minute of arc signal filtering shall be obtained by applying a moving average to the 1 minute of arc signal. This corresponds to a more comfortable viewing condition. The filtered luminance signal is shown in Figure B.2.4.1.5.

4 minutes of arc filtered luminance signal used for L_{\max} calculation

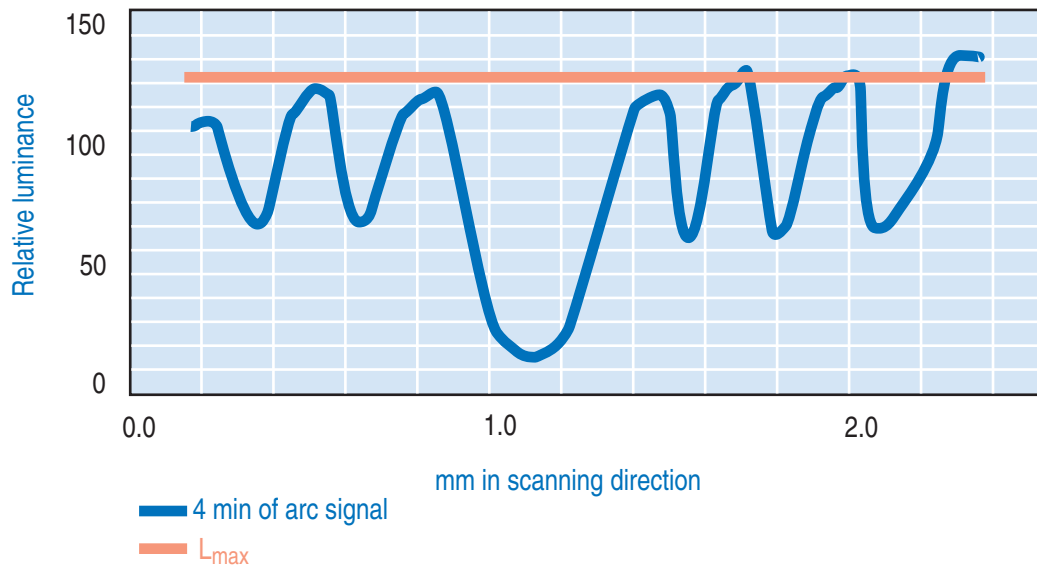


Figure B.2.4.1.5. The 1 minute of arc luminance signal filtered to 4 minutes of arc and showing L_{\max} .

- The maximum luminances may be different on the two sides of the H stroke. Select the lower one as L_{\max} .

(In the example of Figures B.2.4.1.4 and B.2.3.1.5 the luminance is lower on the left side than the right side and thus

$L_{\max} = 127 \text{ cd/m}^2$. With $L_{\min} = 14 \text{ cd/m}^2$ the contrast is $C = (127 - 14) / (127 + 14) = 0.80$).

The lowest luminance contrast found shall be reported.

The result shall be presented to 2 decimal places.

B.2.4.1.5 Overall uncertainty $\leq \pm 0.05$ in contrast.

See B.2.0.7.

B.2.4.2 Luminance contrast – angular dependence**B.2.4.2.1 Preparation of the FPD for testing**

- All necessary preparations described in B.0 and B.2.0 shall be done.
- A TCO default test image, as shown in Figure B.0.9.1, shall be used for this measurement.
- The 4° × 4° square shall have each of the following RGB settings: (RGB 255, 255, 255) and (RGB 0, 0, 0).

B.2.4.2.2 Equipment

Luminance meter.

B.2.4.2.3 Test method

- The luminance meter shall be positioned and directed orthogonally to the screen centre-point as described in B.2.0.5.
- The FPD shall be rotated around a vertical axis through the screen front centre, changing the azimuth angle to + 30°. The luminance of the white square L_{W+30} and the luminance when the square is black L_{B+30} at the centre shall be recorded.
- Finally the azimuth angle of the screen shall be changed to -30° and the new measurements $L_{W/-30}$ and $L_{B/-30}$ taken.

B.2.4.2.4 Test evaluation

The luminance contrast values C_{+30} and C_{-30} shall be calculated using the formula

$$C = \frac{L_W - L_B}{L_W + L_B}$$

Of C_{+30} and C_{-30} , only the lowest value shall be reported as the luminance contrast.

B.2.4.2.5 Overall uncertainty

≤ ± 10% in luminance.

≤ ± 0.05 in contrast.

See B.2.0.7.

B.2.5 Reflection characteristics

B.2.5.1 Front frame gloss

B.2.5.1.1 Preparation of the FPD for testing

- No special preparation of the FPD is needed.
- FPD frame surfaces to be tested shall be clean.
- A gloss measurement instrument needs an absolutely flat surface to function properly.
- If the front frame of the display is curved, a measurement could be made elsewhere on the housing, provided that the measured surface microstructure, texture and colour are the same as the surface of the front frame.
- If no absolutely flat test surface can be found on the display frame, the manufacturer can also supply a flat piece of material with optical properties fully equivalent to the front frame material.

B.2.5.1.2 Equipment

A gloss meter that is in accordance with ISO2813, ASTM D 523 or DIN 67 530, and a calibrated reference standard.

The measurement of gloss shall be made using an instrument with an incident light beam angle of 60° to the normal of the measured surface.

B.2.5.1.3 Test method

Measurement of gloss shall be made at several locations on the front frame of the display. Logos, brand names, type marks, control buttons, webcam and other small markings are excluded from the measurements and the requirements.

B.2.5.1.4 Test evaluation

The gloss results shall be presented in gloss units with no decimal places.

The highest recorded gloss value shall be reported.

B.2.5.1.5 Overall uncertainty

$\leq \pm 2$ gloss units.

See B.2.0.7.

B.2.6 Screen colour characteristics

B.2.6.1 Correlated colour temperature (CCT) variation

B.2.6.1.1 Preparation of the FPD for testing

- All necessary preparations described in B.0 and B.2.0 shall be done.
- A TCO default test image, as shown in Figure B.0.9.1, shall be used for this measurement.

B.2.6.1.2 Equipment

Spectro-radiometer capable of presenting CIE u' and v' chromaticity co-ordinates with at least three decimals.

B.2.6.1.3 Test method

The spectral properties at the centre of the test square shall be measured with a spectro-radiometer.

The spectral data shall then be processed, which is normally done directly in the instrument microprocessor, to give chromaticity co-ordinates. In this case the CIE co-ordinates u' and v' are needed for the test evaluation and are often presented directly by the spectro-radiometer used.

If the client has stated more than two pre-set CCTs, preparation and testing shall be repeated for the additional CCTs.

The following rules shall apply:

- Only CCTs with exactly specified numerical values have to fulfil the requirements.
- CCTs lower than 5000 K shall not be tested.

B.2.6.1.4 Test evaluation

The measured u'_m and v'_m values of the screen for the pre-set CCT and the CIE reference chromaticity co-ordinates u'_{CCT} and v'_{CCT} values for the reported CCT shall be used to calculate the colour difference as follows:

$$\Delta u'v' = \sqrt{(u'_{CCT} - u'_m)^2 + (v'_{CCT} - v'_m)^2}$$

This calculation shall be done for all tested pre-set CCTs.

Most FPDs are delivered with two or more pre-set CCTs for a white screen. These pre-set CCTs are often one or more of the following; 9300 K, 7500 K, 6500 K, 5500 K and 5000 K. The CIE 1976 u' and v' reference chromaticity co-ordinates for the five mentioned CCTs are given in Table B.2.6.1.1.

Table B.2.6.1.1

CCT in K	u'_{cct}	v'_{cct}
9300	0.1888	0.4457
7500	0.1935	0.4586
6500 (sRGB)	0.1978	0.4684
5500	0.2044	0.4808
5000	0.2091	0.4882

If preset CCTs other than those given in Table B.2.6.1.1 are used in the test, u'_{CCT} and v'_{CCT} can be found by using CIE tabulated data or by using CIE formulae presented in CIE Publication 15.2 (1986), Colorimetry, p.11, p. 27-28 and p. 53-54, Table 1.3.

If the spectro-radiometer used only can produce CIE 1931 x and y chromaticity co-ordinates these can be transformed to u' and v' chromaticity co-ordinates by using the formulae in the CIE Publication 15.2 mentioned above.

The relevant CIE material – conversion formulae and tabulated data for u'_{CCT} and v'_{CCT} – can also be found on the TCO homepage, www.tcodevelopment.com. A computer program based on the given equations can be supplied by TCO.

The resulting colour difference calculation shall be presented to 3 decimal places.

B.2.6.1.5 Overall uncertainty

$\leq \pm 0.003$ in u' and v' .

See B.2.0.7.

B.2.6.2 Colour uniformity**B.2.6.2.1 Preparation of the FPD for testing**

- All necessary preparations described in B.0 and B.2.0 shall be done.
- The entire active area of the screen shall be white and the FPD colour setting shall be RGB 255, 255, 255.

B.2.6.2.2 Equipment

Spectro-radiometer with a capacity to present u' and v' co-ordinates with at least 3 decimals.

B.2.6.2.3 Test method:

The colour uniformity shall be measured orthogonally to the FPD screen plane at 9 points. The 4 corner positions (1, 3, 7 and 9) are measured 1° from the edges of the screen as shown in Figure B.2.3.2.1. The 4 side positions (2, 4, 6 and 8) are measured on the middle of the side 1° from the edge. These measurement points have a $1/2^\circ$ margin to the edges if the measurement area of the instrument is 1° (see figure B.2.3.2.1). Finally the centre position (5) is measured.

The colour uniformity shall also be evaluated visually by the technician in order to find those areas where the colour varies the most except from the 9 default positions. If a significant difference within the 1° from the edge area is found these measuring points shall also be measured and used to evaluate the colour uniformity.

The conditions for colour measurement in the corner positions and the distribution of other measurement points are illustrated in Figure B.2.3.2.1.

B.2.6.2.4 Test evaluation

$\Delta u'v'$ according to the CIE (1976) uniform chromaticity scale diagram shall be calculated for each measured position using the formula

$$\Delta u'v' = \sqrt{(u'_A - u'_B)^2 + (v'_A - v'_B)^2}$$

where A and B are the two points found to have the largest colour difference between them.

The largest difference in $\Delta u'v'$ value shall be reported.

The result shall be presented to 3 decimal places.

(The evaluation procedure is exemplified below)

- Make a table of colour chromaticity values for each measured position

Measurement position no.	u'	v'
1	0.190	0.447
2	0.186	0.441
3	0.186	0.437
-	-	-
-	-	-
n-1	0.185	0.434
n	0.186	0.432
Largest difference	0.005 in this example	0.015 in this example

- The largest u' difference, $\Delta u'$, is 0.005 (between 0.190 and 0.185) at measurement positions 1 and n-1.
- The largest v' difference, $\Delta v'$, is 0.015 (between 0.447 and 0.432) at measurement positions 1 and n.
- Since $\Delta v'$ (= 0.015) is much larger than $\Delta u'$ (= 0.005), the $\Delta v'$ value shall be used for the calculation of $\Delta u'v'$.
- The corresponding two pairs of u' and v' to be used for the calculation are thus the values found at position 1 and position n and thus become the values used for points A and B such that

$$u'_1 = u'_A = 0.190 \text{ and } v'_1 = v'_A = 0.447 \text{ for point A in this example}$$

and

$$u'_n = u'_B = 0.186 \text{ and } v'_n = v'_B = 0.432 \text{ for point B in this example}$$

Hence $\Delta u'v' = \sqrt{0.000016 + 0.000225} = 0.01552$, which shall be reported as 0.016.)

B.2.6.2.5 Overall uncertainty

$\leq \pm 0.003$ in u' and v' .

See B.2.0.7.

B.2.6.3 RGB settings**B.2.6.3.1 Preparation of the FPD for testing**

- All necessary preparations described in B.0 and B.2.0 shall be done.
- A TCO default test image, as shown in Figure B.0.9.1, shall be used for this measurement.
- The $4^\circ \times 4^\circ$ square shall have each of the following RGB settings:
(255, 0, 0) for red,
(0, 255, 0) for green,
(0, 0, 255) for blue.

B.2.6.3.2 Equipment

Spectro-radiometer with a capacity to present u' and v' co-ordinates with at least 3 decimals.

B.2.6.3.3 Test method

The instrument shall be directed orthogonally towards the different test square centres at the measurement distance described in B.2.0.5. Measure the chromaticity co-ordinates at the centre of the $4^\circ \times 4^\circ$ square for each colour setting specified above. Change the colour of the square for each measurement.

B.2.6.3.4 Test evaluation

The recorded chromaticity co-ordinates u' and v' for the red, green and blue squares shall be reported.

The u' and v' shall be presented to 3 decimal places.

B.2.6.3.5 Overall uncertainty

$\leq \pm 0.003$ in u' and v' for red and green.

$\leq \pm 0.007$ in u' and v' for blue.

See B.2.0.7.

B.2.6.4 Colour uniformity – angular dependence

B.2.6.4.1 Preparation of the FPD for testing

- All necessary preparations described in B.0 and B.2.0 shall be done.
- The screen background shall be RGB 204, 204, 204.
- Chromaticity co-ordinates u' and v' shall be measured at three different positions on the screen as shown in Figure B.2.6.4.1. Each measurement position shall consist of white RGB 255, 255, 255 squares sized $4^\circ \times 4^\circ$.
- The spectro-radiometer shall be positioned and directed orthogonally to the screen centre-point as described in B.2.0.5.

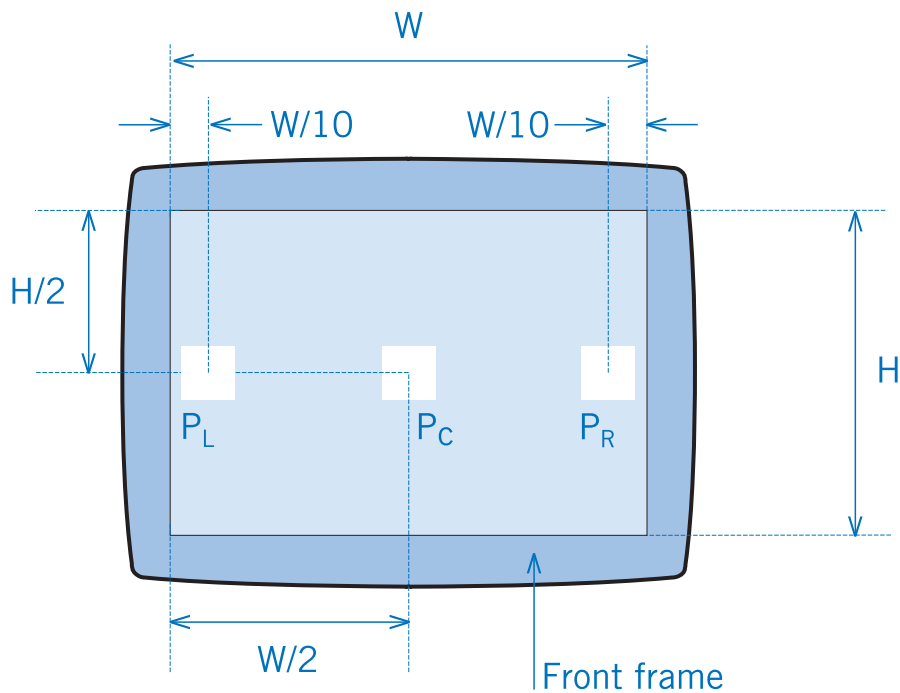


Figure B.2.6.4.1. Measurement positions for colour uniformity-angular dependence.

B.2.6.4.2 Equipment

Spectro-radiometer with a capacity to present u' and v' co-ordinates with at least 3 decimals.

B.2.6.4.3 Test method

- The spectro-radiometer shall always be directed towards a measurement point and rotated around a fixed vertical axis, (or horizontal axis for the tilt measurement) through the focal point of the front lens with a distance as described in B.2.0.5.
- The spectro-radiometer shall be turned towards positions P_L and P_R and focused. The colour co-ordinates at positions P_L and P_R ($u'_{PL/0}$, $v'_{PL/0}$ and $u'_{PR/0}$, $v'_{PR/0}$ respectively) shall be recorded.
- The screen shall then be rotated $+30$ degrees around a vertical axis through the screen centre-point and the chromaticity co-ordinates at positions P_L , P_R , ($u'_{PL/+30}$, $v'_{PL/+30}$ and $u'_{PR/+30}$, $v'_{PR/+30}$ respectively) shall be recorded.

- The screen shall finally be rotated -30 degrees around a vertical axis through the screen centre-point and the chromaticity co-ordinates at positions P_L, P_R, (u'_{PL/-30}, v'_{PL/-30} and u'_{PR/-30}, v'_{PR/-30} respectively) shall be recorded.
- Pivot screens shall only be measured in the usual landscape mode.

B.2.6.4.4 Test evaluation

$\Delta u'v'$ according to the CIE (1976) uniform chromaticity scale diagram shall be calculated for each measured position using the formula

$$\Delta u'v' = \sqrt{(u'_A - u'_B)^2 + (v'_A - v'_B)^2}$$

where A and B are the two points found to have the largest colour difference between them.

The largest difference in $\Delta u'v'$ value shall be reported

The result shall be presented to 3 decimal places.

(The evaluation procedure is exemplified below)

- Make a table of chromaticity values for each measurement position and calculate $\Delta u'v'$ for +30° for and -30°

Measurement position no.	Example value u'	Example value v'
PL /+30	0.190	0.447
PR /+30	0.187	0.442
Difference at +30°	0.003	0.005
$\Delta u'v'$ at +30°	0.0059	
Measurement position no.	Example value u'	Example value v'
PL /-30	0.182	0.436
PR /-30	0.189	0.432
Difference at -30°	0.007	0.004
$\Delta u'v'$ at -30°	0.0081	
Largest difference $\Delta u'v'$	0.0081 in this example	

The largest calculated $\Delta u'v'$ difference is 0.0081 when the screen is rotated -30°. The test value to be reported is this value, reported to 3 decimal places, thus 0.008.

B.2.6.4.5 Overall uncertainty

≤ ± 10% in luminance.

≤ ± 0.003 units for u' and v'.

≤ ± 0.3° in rotation angle.

See B.2.0.7.

B.2.6.5 Colour greyscale linearity

B.2.6.5.1 Preparation of the FPD for testing

- All necessary preparations described in B.0 and B.2.0 shall be done.
- A TCO default test image, as shown in Figure B.0.9.1, shall be used for this measurement.
- The 4° × 4° square shall have each of the following RGB settings: R=G=B= 255, 225, 195, 165, 135, 105, 75, 45.

B.2.6.5.2 Equipment

Spectro-radiometer with a capacity to present u' and v' co-ordinates with at least 3 decimals.

B.2.6.5.3 Test method

The instrument shall be directed orthogonally towards the different test square centres at the measurement distance described in B.2.0.5. Measure the chromaticity co-ordinates at the centre of the 4° × 4° square for each greyscale step specified above. Change the greyscale of the square for each measurement.

B.2.6.5.4 Test evaluation

The evaluation procedure is exemplified below

- TCO will provide an excel spreadsheet at the TCO website www.tcodevelopment.com which will calculate the $\Delta u' v'$ differences between all the greyscale levels according to the equation:

$$\Delta u' v' = \sqrt{(u'_A - u'_B)^2 + (v'_A - v'_B)^2}$$

- Fill in the chromaticity values of u' and v' for each measured greyscale step into the corresponding cells of the spread sheet.

The table below contains coloured cells indicating difference requirements. The principle is that the darker the greyscale the more difficult it is to see a colour difference.

Examples on how to use the table: By using the column 255 (greyscale 255) and go down to line 165 (greyscale 165) you find that the maximum allowed colour difference $\Delta u' v'$ is 0.020 (orange cell). For the greyscales 225 and 75 the maximum allowed difference is 0.035 (green cell).

Greyscale	Maximum $\Delta u' v'$ difference							
	255	225	195	165	135	105	75	45
255	0							
225	0,015	0						
195	0,015	0,015	0					
165	0,020	0,020	0,020	0				
135	0,025	0,025	0,020	0,020	0			
105	0,025	0,025	0,025	0,025	0,020	0		
75	0,035	0,035	0,035	0,035	0,035	0,025	0	
45	0,035	0,035	0,035	0,035	0,035	0,035	0,035	0

Table 2.6.5.4

B.2.6.5.5 Overall uncertainty

$\leq \pm 10\%$ in luminance.

$\leq \pm 0.003$ units for u' and v' .

See B.2.0.7.

B.3 Workload ergonomics

B.3.2 Vertical height

The height requirement level under mandate 1 is set on documented Anthropometric data for the eye height variance for 2.5-97.5 percentile of adults. The shortest distance between eye and working surface level is taken from the 2.5 percentile of adults. The distance is from the operator's elbow (work surface height) to eye level. With a maximum height measurement set for displays that can not be height adjusted these operators will avoid the need to extend the neck backwards when scanning the screen.

The height of the population in the US and Europe has been documented in the “humanscale”

- The 2.5 percentile of the population in these regions is 145cm. According to the “humanscale” this gives a eye height of 42cm from the table top surface.
- The height measurement shall be taken with the display in normal (non-tilted) position standing directly on a flat surface and at the lowest point of height adjustment. The measurement shall be taken from the table surface to the upper edge of the active screen area – see figure B.3.2
- For the moment the criterion is based on the “humanscale” but as more relevant Anthropometrical data becomes available the criterion may be revised.

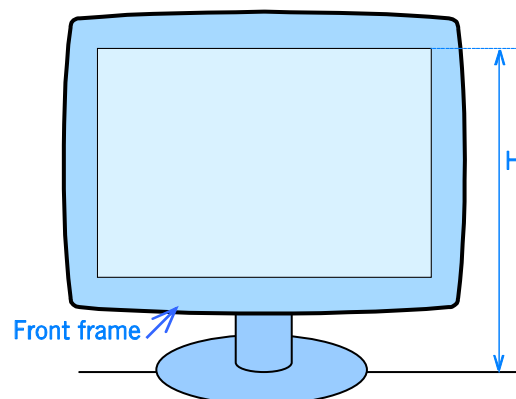


Figure B.3.2 vertical height measurement

B.4 Emissions

B.4.0 General test conditions for emissions

B.4.0.1 Basic test requirements

As described in section B.0.

For the test methods for emissions described in this document the following conditions apply:

- AC mains voltage* 230 VAC RMS, tolerance $\leq 1 \%$
- AC mains frequency* 50 Hz, tolerance $\leq 2 \%$

The equipment shall be connected to phase and neutral.

* – or other voltage and frequency combination specified by the client.

B.4.0.2 Conditions and set up for the test object

The tests shall be performed with the full screen size activated.

The FPD control settings shall be the same as for visual ergonomics. This means that the default setting at reset shall be used for the emission testing of alternating electric and magnetic fields the luminance at this setting shall be $\geq 150 \text{ cd/m}^2$. See section B.0.9 for details concerning this setting.

The FPD shall during the measurements show a full screen of capital “H” pattern in dark/black Arial letters on a luminated background (positive polarity), see section B.0.8 for details concerning this setting.

Any pivot FPD that can be used in both normal landscape position and portrait position (turned 90°) shall have measurements taken in both positions. The worst case shall be reported.

Any FPD equipped with a height-adjustable stand shall have measurements taken in both the lowest and highest positions. Both measurements shall be done with the measurement instrument positioned to the centre-centre point of the screen surface. The worst case shall be reported.

The FPD must comply with the mandatory requirements without having to rely on an earth connection via the signal cable. In order to test a FPD without an earth connection via the power cable, a battery operated computer, with no connection to earth, can be used to operate the FPD.

If the FPD is connected to mains via a detachable mains cord, the measurement shall be performed with a non-shielded mains cord of normal type, (connected to earth for CLASS I device). A shielded power cord may be used if the cord is permanently attached to the FPD or adapter. By permanently we mean that tools are necessary to remove and change the cord.

An FPD without an external power supply shall be connected to mains via the above mentioned power cable, which shall run from the point of its connection on

the FPD and then horizontally straight to a point 0.4 m behind the screen surface. The cable shall then from this point run downwards at least 1 m. – see figure B.4.0.2.1.

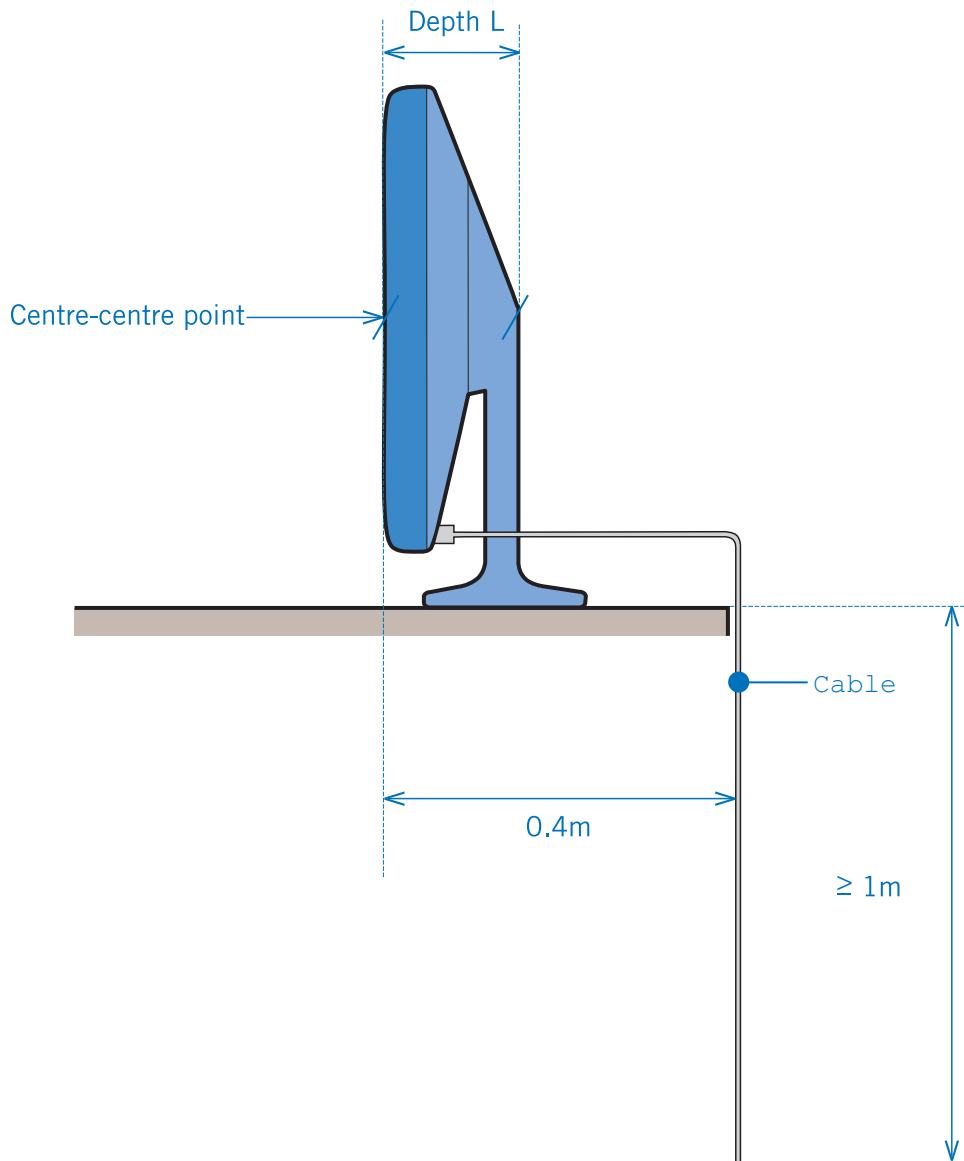


Figure B.4.0.2.1 FPD without external power supply unit.

If the FPD is provided with a fixed holder for the power and signal cables, to secure them together, then this holder is to be used during the test.

The external power supply unit, if any, will contribute to the electromagnetic fields around the FPD. Power supply units, which are connected via a primary cable to the outlet, shall be positioned centrally, directly behind the test sample, on the (turn)table, with the secondary side towards the FPD, see Figure B.4.0.2.2. The primary cable shall extend horizontally, on the (turn)table to a point 0.4 m behind the screen surface. The cable shall then, from this point run downwards at least 1 m. If the power supply can be positioned with different sides up, it shall be tested in all positions and the worst case shall be used. However, if it is obvious

which side is intended to be the top side or bottom side by the placement of LED indicator or integrated supports to stand on, it is enough to test the power supply in the one intended position.

The secondary cable of the power supply shall run the shortest distance from the point of its connection on the FPD to the secondary side of the power supply. The unused portion of the secondary cable, if any, shall be bundled together with the power supply unit. The bundle loops shall have a length equal to the longest dimension of the power supply. For supply units with dimensions less than 0.1 m, a 0.1 m bundle loop length shall be used.

For power supply units which are designed to be put directly in the outlet, without a primary cable, the secondary cable shall run vertically down to the (turn)table from the point of its connection on the FPD and then horizontally straight to a point 0.4 m behind the screen surface. The cable shall then, from this point, run downwards at least 1 m.

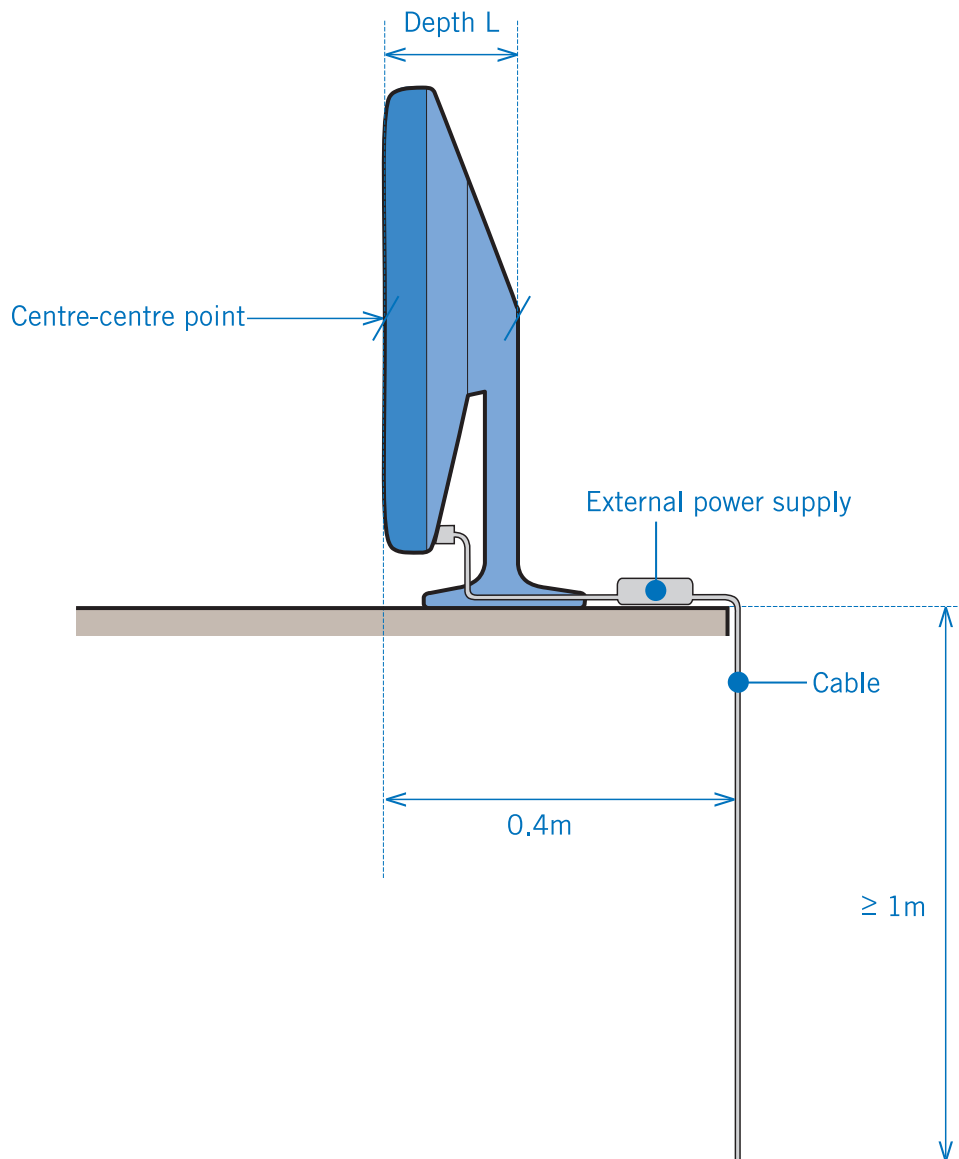


Figure B.4.0.2.2 FPD with external power supply units.

Note! For pivot FPDs and FPDs equipped with height-adjustable stands, the cable has to be adjusted for the different positions.

For measurements of alternating magnetic fields (B.4.2) the power cable may be positioned in another way, as the cable contributes a negligible amount to the magnetic field. However external power supplies must be correctly positioned, as they may give rise to magnetic fields.

If positioning according to the above rules is not possible, then the positioning of the supply unit and cables shall be described in the test report.

If a monitor is delivered without a stand (e.g. for wall mounting) it is possible that the monitor will not pass TCO requirements for emission if not a shielded power cord is used. In this special case it is allowed to use a shielded power cord if it is delivered with the FPD and it is indicated in the user manual that the product only fulfills TCO criteria with this shielded cable. The power cord shall hang straight down from the monitor and if the monitor has an external ac adapter, the adapter shall be positioned below the test sample on the floor if possible.

B.4.0.3 Emission measurement instruments

The instruments used for emission testing shall comply with the requirements and calibration procedures described below:

Alternating electric field meter

The alternating electrical field emission from the FPD under test shall be determined by measuring the displacement current passing a given surface of the measuring probe. The probe consists of a disc of double sided printed circuit board laminate with a diameter of 300 mm. On the front of the board the copper layer is removed in the annulus between radii 50 and 52 mm, see Figure B.4.0.3.1.

The copper foil surrounded by the annulus is the active measuring surface. It is connected to one input terminal of an operational amplifier, with capacitive feedback. The other input terminal of the operational amplifier, the copper ring outside the active surface, and the back of the board are connected to ground. The output voltage (U) from the probe (active surface with area (A)) is related to the incident electrical field, E , averaged over the active surface according to $U = \epsilon \cdot E \cdot A/C$ where C is the capacitance in the feedback loop of the operational amplifier and ϵ is the permittivity for a vacuum.

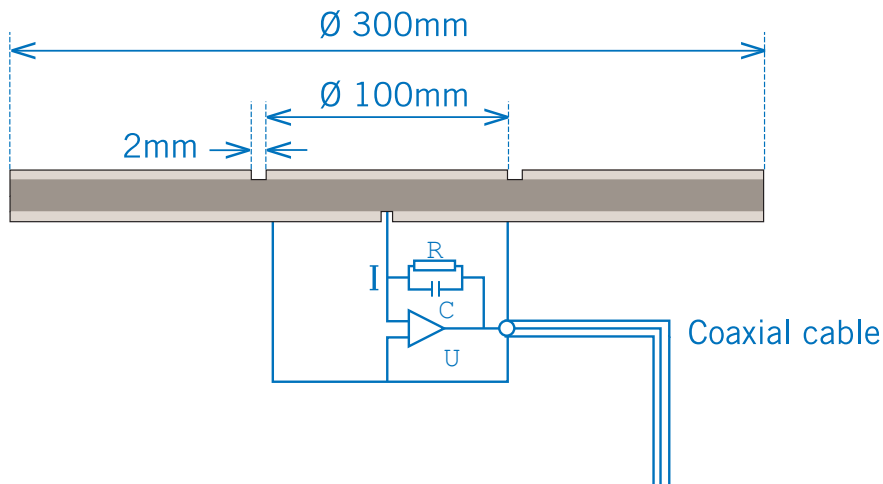


Figure B.4.0.3.1 Sketch and circuit principle of the Alternating electric field meter for alternating electrical field measurements. The feedback circuit of the operational amplifier is a capacitance C in parallel with a high value resistor R to ensure that there is no DC voltage across the plates of the capacitor C .

The specifications for the frequency response of the measuring probe are given by the calibration procedure. The signals from the probe shall be filtered by high-pass and low-pass filters. The specification of the filters is given in Table B.4.0.3.1.

Table B.4.0.3.1 Filter specifications

Frequency Band I					
Frequency	< 5 Hz	5 Hz	100 Hz	2 kHz	> 2 kHz
Attenuation	> 80 dB/decade	3 dB	0 dB	3 dB	> 40 dB/decade

Frequency Band II					
Frequency	< 2 kHz	2 kHz	30 kHz	400 kHz	> 400 kHz
Attenuation	> 80 dB/decade	3 dB	0 dB	3 dB	> 40 dB/decade

After amplification and filtering the output voltage of the measuring probe shall be used to determine the r.m.s. value of the electric field strength in both frequency bands.

The measuring time shall be sufficiently long to enable measurements with an accuracy of $\pm 5\%$ at 50/60 Hz.

The measuring system shall be capable of measuring at least down to 2.0 V/m in band I and down to 0.20 V/m in band II.

The measuring probe shall be calibrated using a parallel plate capacitor (air dielectric) consisting of the measuring probe and a metal plate of at least 300 mm diameter. The distance between the surface of the probe and the plate shall be 30 mm.

The calibration shall be performed with sinusoidal fields at the amplitudes and frequencies specified in Table B.4.0.3.2.

Table B.4.0.3.2 Calibration frequencies and amplitudes

	Frequencies	Amplitude
Band I	50, 100, 500, 1000 Hz	10, 25 V/m
Band II	15, 30, 60, 120 kHz	1.0, 2.5, 10 V/m

Recorded values at these calibration points shall be within $\pm 5\%$ of the nominal value. Due to the nature of the specified filters the deviation shall be calculated at 1 kHz from 9.5 and 22.5 V/m and at 120 kHz from 0.95, 2.4 and 9.5 V/m.

Alternating magnetic field meter in band I and band II

The magnetic field shall be measured using coil systems that shall consist of three mutually perpendicular concentric circular coils each with an area of 0.01 m². The coils may depart from a circular shape where they intersect. The minimum inner diameter shall be 110 mm and the maximum outer diameter 116 mm. The measuring coils shall not be sensitive to electric fields.

The resonance frequency of each coil appropriately connected to cables and amplifiers shall not be so low that it may influence the specified frequency response according to table B.4.0.3.1.

Amplifiers and integrating networks to make the output voltage proportional to the magnetic flux density and independent of frequency shall follow each coil. The specifications in respect of the frequency response are given in the calibration procedure.

High-pass and low-pass filters shall filter the signals from the coil systems. The specifications of the filters are given in Table B.4.0.3.1.

After amplification, integration and filtering, the signals from the three coils in each coil set shall be used as input values for calculating the r.m.s. values of the amplitudes of the magnetic flux density vectors in both frequency bands. It is permissible to calculate the r.m.s. value for each of the coil signals and use the root of the squared sum of those r.m.s. values as the test result.

The measuring time shall be sufficiently long to enable measurement with an accuracy of $\pm 5\%$ at 50/60 Hz.

The alternating magnetic field meter in band I and band II shall be capable of measuring down to at least 40 nT in band I and down to 5.0 nT in band II.

The alternating magnetic field meter in band I and band II shall be calibrated using a Helmholtz-type calibration coil as shown in the Figure B.4.0.3.2. Calibration set-up. Calibration shall be performed with sinusoidal fields at the amplitudes and frequencies specified in Table B.4.0.3.3.

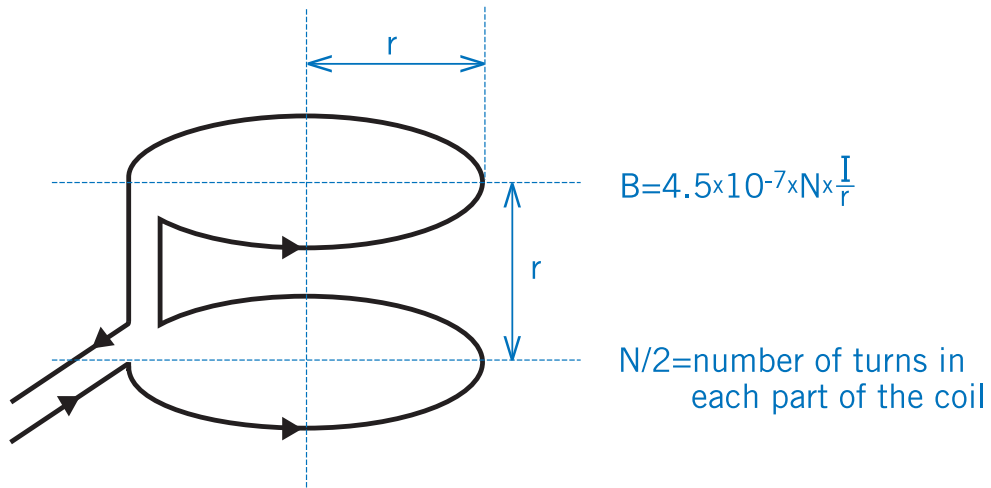


Figure B.4.0.3.2. Calibration using a Helmholtz-type calibration coil.

Table B.4.0.3.3 Calibration frequencies and amplitudes

	Frequencies	Amplitudes
Band I	60, 100, 500, 1000 Hz	200, 2000 nT
Band II	15, 30, 60, 120 kHz	25, 250 nT

Recorded values for these calibrations shall not deviate more than $\pm 5\%$ from the nominal value. Due to the nature of the specified filters the deviation at 1 kHz shall be calculated from 180 nT and 1800 nT and at 120 kHz from 24 nT and 240 nT.

The calibration shall be performed for each of the three individual coils separately exposed and for one situation where approximately the same flux density passes through all three coils.

B.4.1 Alternating electric fields

B.4.1.0 Test laboratory requirements

Background electric field strengths in the test laboratory, including disturbances transmitted by power lines and internally generated noise in the measuring system, shall together not exceed 2.0 V/m in band I and 0.20 V/m in band II.

The mains voltage to the FPD under test shall be within $\pm 3\%$ of its nominal value.

B.4.1.1 Preparation of the FPD for testing

All necessary preparations described in B.0 and B.4.0 shall be done.

An external optical filter may not be used in order to comply with the mandatory requirement.

B.4.1.2 Equipment

Alternating electric field meter

B.4.1.3 Test Method

The true r.m.s.-value of the amplitude of the electric field strength, at the surface of the measuring probe, is measured in front of the test object in band I and in four azimuths in band II. The frequency ranges are selected by means of filters in the measuring equipment.

Screens smaller or equal to 26"

The FPD shall be positioned such that the tangential plane, to the centre-centre point of the screen surface, is at a right angle to the horizontal plane. The distance between the centre-centre points of the screen surface and the back of the FPD, including an eventual part of a stand holder, along the normal to this tangential plane is called L, see Figure B.4.1.3.1.

The origin of the cylindrical co-ordinate system is chosen to be situated at a distance $L/2$ behind the screen surface on the normal to the tangential plane through the centre-centre point. The z-axis is chosen to be at a right angle to the horizontal plane. The angular reference direction is along the above mentioned normal in the direction pointing outwards from the screen. An angle (ϑ) is positive in the counter-clockwise direction.

Measurements shall be made at all points which have a minimum clearance of 0.25 m to the outer surface of the FPD and with co-ordinates according to:

$$z = 0$$

$$r = (L/2 + 0.5) \text{ m (at the front also } (L/2 + 0.3) \text{ m)}$$

$$\vartheta = 0^\circ \text{ for band I}$$

$$\vartheta = 0^\circ, 90^\circ, 180^\circ \text{ and } 270^\circ \text{ for band II}$$

In case of less than 0.25 m clearance the instrument shall be moved out radial until 0.25 m clearance is achieved.

Distances are given in metres and angles in degrees. The co-ordinates are given for the centre of the measuring probe. The surface of the probe shall be perpendicular, within $\pm 5^\circ$, to the radial axis.

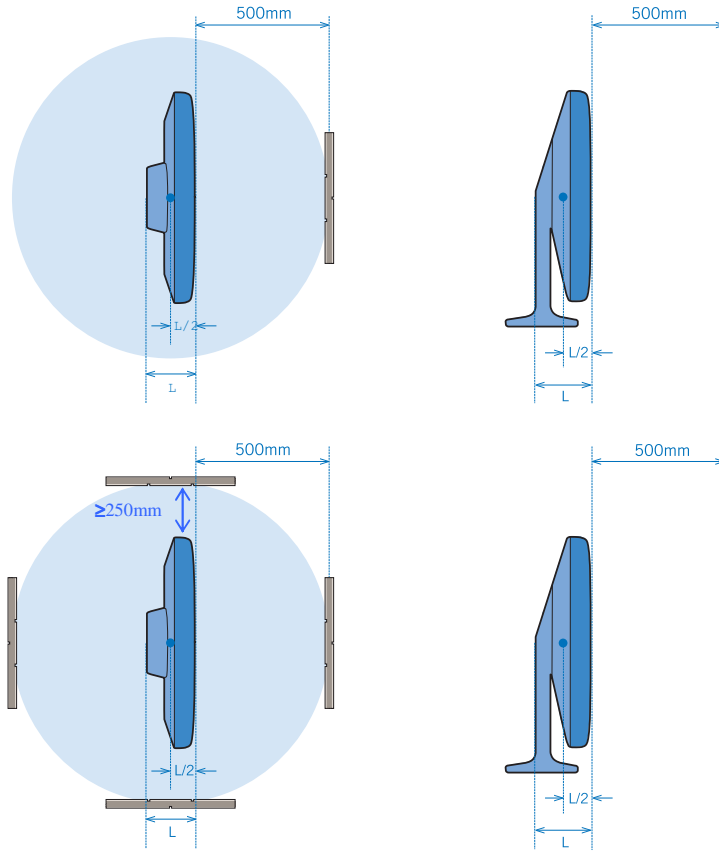


Figure B.4.1.3.1. Measurement geometry for band I (top) and band II (bottom).

Screens larger than 26"

For screens larger than 26" measurements shall be taken in four directions around the product at 0°, 90°, 180°, 270°. All measurements shall be taken at 0.5 m from the surface of the product.

For products that have a width or height ≥ 1 m additional measuring positions for front, rear and sides are required. The width and height of the screen does not include the frame but only the viewable screen area. The amount of positions depends on the size of the screen and is given in horizontal and vertical direction by the width and height in metres of the screen divided by 0.5 rounded to the closest integer. The positions shall be equally divided over the screen surface. See figure B.4.1.3.2.

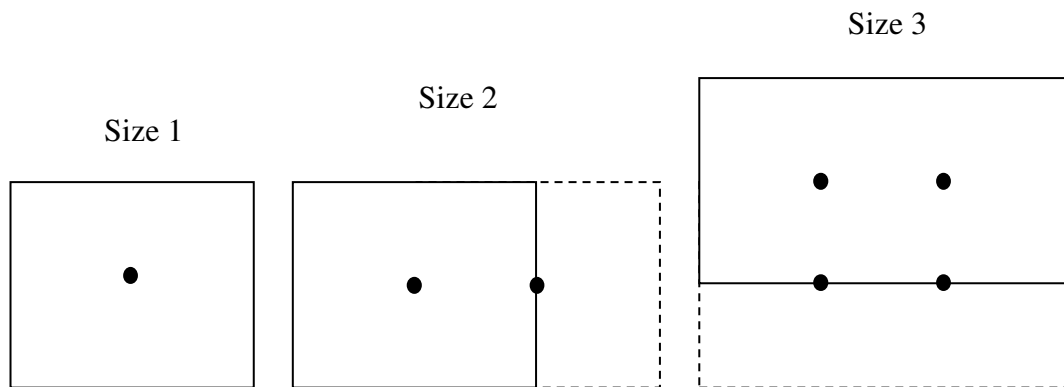


Figure B.4.1.3.2. Measurement point on different screen sizes. The dotted lines indicate a screen increase from size 1 by 0.5 m in width and then 0.5 m in height.

The FPD under test and the measuring probe shall be positioned at least 1 m from all significant metallic structures and objects apart from the test object.

Additional units and connecting cables necessary for the operation of the FPD, which are not part of the test, shall be placed so far away from the measuring setup that the fields they emit do not influence the measurement. Shielding may be added to these units and cables, as long as the 1 m clearance is maintained.

The measuring probe shall be connected to ground. Any eventual cables running between the measuring probe and the measuring instrument shall be positioned in such a way that they do not influence the measured value.

The power cable of the test object shall be connected to the phase and the neutral conductors of the mains power supply. If the mains power supply plug permits an interchange of the live and neutral conductors, measurements shall be taken with the connection that gives the highest reading in band I.

B.4.1.4 Test evaluation

Results shall be presented as r.m.s. values of the alternating electric field expressed in volt per meter (V/m). For band I, results shall be presented as the measured values at 0.3 m and 0.5 m for normal and stand-by operations if they differ. For band II, the measured values in front of the FPD and the maximum value at rotation shall be presented for normal and stand-by operations if they differ.

If the measured values are less than 10.0 V/m in band I or less than 1.0 V/m in band II the result shall be reported as “< 10.0 V/m” or “<1.0 V/m”, respectively.

If measuring more than one position on the front, rear or sides of the screen the worse case shall be given in the report.

B.4.1.5 Overall uncertainty

The test shall be performed in such a way that the total extended uncertainty in the test result will be less than $\pm (10 \% \text{ of the reading} + 1.5 \text{ V/m})$ for band I and $\pm (10 \% \text{ of the reading} + 0.1 \text{ V/m})$ for band II.

B.4.2 Alternating magnetic fields

B.4.2.0 Test laboratory requirements

Background magnetic fields in the test laboratory, including disturbances transmitted along the power line and internally generated noise in the measuring system, shall together not exceed 40 nT in band I and 5 nT in band II.

B.4.2.1 Preparation of the FPD for testing

All necessary preparations described in B.0 and B.4.0 shall be done.

B.4.2.2 Equipment

Alternating magnetic field meter in band I and band II

B.4.2.3 Method

Screens smaller or equal to 26"

The true r.m.s. value of the amplitude of the magnetic flux density vector is measured at 48 points on a cylindrical surface around the test object in the two frequency ranges, band I and band II. The frequency ranges are selected by specified filters in the alternating magnetic field meter.

The measuring geometry is illustrated in Figure B.4.2.3.1. The measurement points are mathematically defined in the following way.

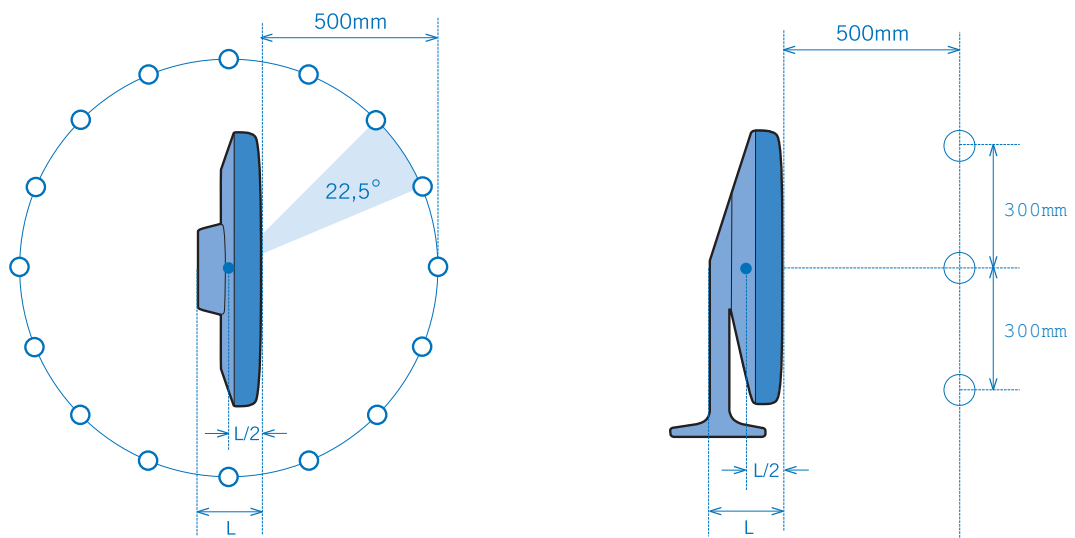


Figure B.4.2.3.1. Measurement geometry for the test object.

The FPD shall be positioned such that the tangential plane, to the centre-centre point of the screen surface, is at a right angle to the horizontal plane. The distance between the centre-centre points of the screen surface and the back of the FPD, including an eventual part of a stand holder, along the normal to this tangential plane is called L.

The origin of the cylindrical co-ordinate system is chosen to be situated at a distance $L/2$ behind the screen surface on the normal to the tangential plane through the centre-centre point. The z-axis is chosen to be at a right angle to the horizontal plane. The angular reference direction is along the above-mentioned normal in the direction pointing outwards from the screen. An angle (ϑ) is

positive in the counter-clockwise direction. Measurements shall be made at all points which have a minimum clearance of 0.25 m to the outer surface of the FPD and with co-ordinates according to:

$z = - 0.3 \text{ m}, z = 0 \text{ and } z = + 0.3 \text{ m}$

$r = (L/2 + 0.5) \text{ m}$ (at the front also $(L/2 + 0.3) \text{ m}$ in band I)

$\vartheta = p \cdot 22.5^\circ$ where p represents all integers in the range $1 \leq p \leq 15$.

In case of less than 0.25 m clearance the instrument shall be moved out radial until 0.25 m clearance is achieved.

Screens larger than 26"

For screens larger than 26" measurements shall be taken in four directions around the product at $0^\circ, 90^\circ, 180^\circ, 270^\circ$. All measurements shall be taken at 0.5 m from the surface of the product.

For products that have a width or height $\geq 1 \text{ m}$ additional measuring positions for front, back and sides are required. The width and height of the screen does not include the frame but only the viewable screen area. The amount of positions depends on the size of the screen and is given in horizontal and vertical direction by the width and height in cm of the screen divided by 0.5 rounded to the closest integer. The positions shall be equally divided over the screen surface see figure B.4.1.3.2.

Distances are given in metres and angles in degrees.

The measuring coils shall be stationary during the measurements.

For FPD luminance settings – see General test conditions for emissions.

The power cable of the test object shall be connected to the phase and the neutral conductors of the mains power supply. The FPD does not need to be measured with the phase and neutral interchanged in this case, as the magnetic fields are not influenced by such a change.

B.4.2.4 Test evaluation

Results shall be presented as r.m.s. values of the magnetic flux density expressed in nanotesla (nT) for the two frequency bands. The values in front of the FPD and the maximum value and its position shall be given both for normal and for standby operation if they differ. If measured values are less than 200 nT in band I or less than 10.0 nT in band II the result shall be reported as "< 200 nT" and "< 10.0 nT" respectively.

B.4.2.5 Overall uncertainty

The test shall be performed in such a way that the total extended uncertainty in the test result will be less than $\pm (10 \% \text{ of the reading} + 30 \text{ nT})$ for band I and $\pm (10 \% \text{ of the reading} + 1.5 \text{ nT})$ for band II.

Note

The uncertainties given are worst case limits. In many cases it will be possible to obtain better accuracy, especially in band II.

B.6 Environmental requirements

B.6.0 General clarification

B.6.0.1 Signatures

The templates in the ecological declaration shall be sent either with original signatures or as copies of original documents with original signatures. “Copies” are for example telefaxes or pdf-files of scanned signed documents. TCO Development and/or the responsible laboratory may later request the original signed document.

However, copies will not be accepted where the signature has been scanned and pasted into the document.

TCO accepts digital signature as an alternative to traditional signature on test reports and declarations submitted as pdf files. To approve a digital signature it is necessary to also submit a digital key to the eco-verifier to facilitate identification.

B.6.1 Product description

The brand name of the display unit must always be submitted.

The type key for unidentified characters, if any, in the model name and panel identification name shall be submitted. The type key must include two or more options.

B.6.2 Organisation

B.6.2.1 Environmental management system certification

The certificate shall be issued by a certification body that is accredited by an accreditation body covered by the International Accreditation Forum, www.iaf.nu, Multilateral Arrangement on Environmental Management Systems.

For applicants submitting several applications, it is enough to attach an ISO 14001 certificate or EMAS registration with the first application.

The certificate or an appendix to the certificate shall show the scope of the certification.

B.6.2.2 Social responsibility

The Displays criteria document of 2009 is the first to include requirements of social responsibility. At this stage we recognise that the level of implementation often is limited to first-tier suppliers. Although we see the ambition as covering all production we will for now not demand active engagement further down the chain.

To ensure that the document(s) sent in are really implemented and used, the report/certificate/membership or other document used as verification of this requirement must have a signature by a person at the brand owner company (approved to sign such documents by the brand owner company). All documents must also be dated to ensure that the documentation is up-to-date. The document(s) sent in by the brand owner is valid and verifies requirement A.6.2.2 one year from the signature date.

The different alternatives of verifying social responsibility, described below, are:

1. Global Reporting Initiative (GRI)
2. Global Compact
3. Electronic Industry Citizenship Coalition (EICC)
4. SA8000
5. Other relevant initiative and / or Own work

B.6.2.2.1 Global Reporting Initiative (GRI)

– a reporting standard

The Global Reporting Initiative (GRI) produces a standard in sustainability reporting guidelines. Sustainability reporting is the action where an organization publicly communicates their economic, environmental, and social performance. The GRI's mission is to make sustainability reporting by all organizations as routine and comparable as financial reporting.

The guideline consists of a set of Profile Disclosures and Disclosures of Management Approach as well as 79 *performance indicators*, divided into the following six categories:

1. Environmental

Indicators on materials, energy, water, biodiversity, emissions, effluents, waste, transport, products, services etc

2. Human rights

Indicators on Investment and procurement practices, non-discrimination, freedom of association, collective bargaining, child labour, forced and compulsory labour etc

3. Labour practices and decent work

Indicators on Employment, occupational health and safety, labour/management relations, training, diversity and equal opportunity etc

4. Social

Indicators on Community, corruption, public policy etc.

5. Product responsibility

Indicators on Customer health and safety, product and services labelling, customer privacy etc

6. Economic

Indicators on Economic performance, market presence, indirect economic impacts etc

There are 3 Application Levels: A, B and C. These levels can be self-declared, third-party-checked and/or GRI-checked, each with the option of recognizing external assurance (“+”).

Reporting according to “level C” includes reporting on some of the Profile Disclosures and also reporting of a minimum of 10 Performance Indicators, including at least one of each Indicator Dimension (Economic, Environmental, and Social). Reporting on Disclosures of Management Approach is not needed.

Accepted documentation:

A report according to the GRI Sustainability Reporting Guidelines, G3 level C or higher. The report shall be a maximum of one year old at the time of application.

More information:

<http://www.globalreporting.org/Home>

B.6.2.2.2 Global Compact

– an initiative stating principles for sustainable business

The United Nations Global Compact (UNGC) is a United Nations initiative to encourage businesses worldwide to adopt sustainable and socially responsible policies, and to report on their implementation. The Global Compact is a principle based framework for businesses, stating ten principles in the areas of human rights, labour, the environment and anti-corruption:

1. Human Rights

Businesses should:

- Principle 1: Support and respect the protection of internationally proclaimed human rights;
- Principle 2: Make sure that they are not complicit in human rights abuses.

2. Labour Standards

Businesses should uphold:

- Principle 3: the freedom of association and the effective recognition of the right to collective bargaining;
- Principle 4: the elimination of all forms of forced and compulsory labour;
- Principle 5: the effective abolition of child labour; and
- Principle 6: the elimination of discrimination in employment and occupation.

3. Environment

Businesses should:

1. Principle 7: support a precautionary approach to environmental challenges;
2. Principle 8: undertake initiatives to promote environmental responsibility; and
3. Principle 9: encourage the development and diffusion of environmentally friendly technologies.

4. Anti-Corruption

Businesses should:

- Principle 10: work against corruption in all its forms, including extortion and bribery.

The Global Compact is not a performance or assessment tool. It does not provide a seal of approval, nor does it make judgements on performance.

Participants are expected to publish in their annual report or similar corporate report (e.g. sustainability report) a description of the ways in which they are supporting the Global Compact and progress on implementing its ten principles. This is known as the "Communication on Progress" (COP). The Global Compact believes that this sort of openness and transparency encourages good practices by participants. The COP is an important demonstration of a participant's commitment to the Global Compact and its principles. Failure to provide a COP will result in a non-communicating or inactive status for a participant.

Accepted documentation:

A Communication on Progress (COP) report demonstrating active participation in the Global Compact initiative. The report shall be a maximum of one year old at the time of application.

More information:

<http://www.unglobalcompact.org/>

B.6.2.2.3 Electronic Industry Citizenship Coalition (EICC)

– a business cooperation on implementation of social responsibility

The Electronic Industry Citizenship Coalition (EICC) is a group of companies working together to create a comprehensive set of tools and methods that support credible implementation of the Electronic Industry Code of Conduct throughout the Electronics and Information and Communications Technology (ICT) supply chain.

The Electronic Industry Code of Conduct is a code of best practices adopted and implemented by some of the world's major electronics brands and their suppliers. The goal is to improve conditions in the electronics supply chain. Development of the Code was a multi-stakeholder effort, influenced by internationally-recognized standards.

By consolidating and standardizing compliance, audit and reporting efforts, suppliers can focus on achieving the high standards of performance set forth by the Code. This approach is also conducive to fostering a culture of social responsibility throughout the global electronics supply chain.

EICC sets forth performance, compliance, auditing and reporting guidelines across five areas of social responsibility:

- Labour
- Health and Safety
- Environmental
- Management System
- Ethics

Accepted documentation:

Proof of Brand owner being an active member of the EICC initiative.

More information:

<http://www.eicc.info/>

B.6.2.2.4 SA8000

– a certifiable standard for social accountability

SA8000 is a global social accountability standard for decent working conditions, developed and overseen by Social Accountability International (SAI). SAI contracts with a global accreditation agency, Social Accountability Accreditation Services (SAAS) that licences and oversees auditing organisations to award certification to employers that comply with SA8000.

SA8000 is based on the UN Universal Declaration of Human Rights, Convention on the Rights of the Child and various International Labour Organization (ILO) conventions. SA8000 covers the following areas of accountability:

- **Child labour:** No workers under the age of 15; minimum lowered to 14 for countries operating under the ILO Convention 138 developing-country exception; remediation of any child found to be working
- **Forced labour:** No forced labour, including prison or debt bondage labour; no lodging of deposits or identity papers by employers or outside recruiters
- **Workplace safety and health:** Provide a safe and healthy work environment; take steps to prevent injuries; regular health and safety worker training; system to detect threats to health and safety; access to bathrooms and potable water
- **Freedom of Association and Right to Collective Bargaining:** Respect the right to form and join trade unions and bargain collectively
- **Discrimination:** No discrimination based on race, caste, origin, religion, disability, gender, sexual orientation, union or political affiliation, or age; no sexual harassment
- **Discipline:** No corporal punishment, mental or physical coercion or verbal abuse
- **Working hours:** Comply with the applicable law but, in any event, no more than 48 hours per week with at least one day off for every seven day period; voluntary overtime paid at a premium rate and not to exceed 12 hours per week on a regular basis; overtime may be mandatory if part of a collective bargaining agreement
- **Remuneration:** Wages paid for a standard work week must meet the legal and industry standards and be sufficient to meet the basic need of workers and their families; no disciplinary deductions
- **Management system for Human Resources:** Facilities seeking to gain and maintain certification must go beyond simple compliance to integrate the standard into their management systems and practices.

Accepted documentation:

Valid SA8000 certificate documenting compliance with the standard. Accepted is either a Brand Owner certificate or if the production is carried out in SA8000 certified production facilities.

More information:

<http://www.sa-intl.org/>

B.6.2.2.5 Other relevant initiative and / or Own work

If the Brand Owner is not doing any of the above but in any other way is implementing working practices that promote labour relations and working conditions that correspond with internationally recognised human rights and the laws in the country of production, TCO Development accepts documentation of these practices.

Accepted documentation:

Alternative 1. Proof of Brand owner being an active member of a relevant initiative proving commitment to social responsibility.

Alternative 2. Documentation of one or several of the following:

- An implemented **code of conduct** referring to internationally recognised human rights, labour standards and relevant laws in the country of production.
- Appropriate **records of suppliers/subcontractors commitments to social accountability**, including but not limited to, contractual agreements.
- Appropriate **procedures to evaluate and select suppliers/subcontractors** (and, where appropriate, sub-suppliers) taking into account their performance and commitment to meet the requirements of the code of conduct.
- **Procedures to communicate** regularly to all interested parties data and other information regarding **compliance with the requirements of the code of conduct**.

B.6.3 Climate

B.6.3.1 Energy consumption – FPD

TCO require testing by a test laboratory approved by TCO Development. Testing shall be done according to the most recently published version of the Energy Star standard for displays. However, the product does not have to be certified according to that standard.

The “Power supply efficiency requirement”

If the product has an Energy Star certificate, the TCO accepted test laboratory can base the test report on this certificate to show compliance with the Energy Star “Power supply efficiency requirement”. For products without Energy Star certificate the “Power supply efficiency requirement” may be tested by any laboratory accredited according to ISO 17025 and considered acting as a third party.

Test conditions, Supply Voltage

If the product has an Energy Star certificate TCO Development only require that one of the voltages is tested at a laboratory accepted by TCO Development. Other supply voltages may be verified through the existing Energy Star certificate. For products without Energy Star certificate all supply voltages must be tested at a laboratory accepted by TCO Development. The Supply Voltage shall be recorded in the test report.

The “Power management requirements”

The TCO accepted test laboratory can base the test report on a declaration from the manufacturer that the Energy Star “Power management requirements” are fulfilled.

B.6.3.1.1 Exemptions from the Energy Star standard

Amounts of samples for testing

According to the TCO criteria the manufacturer is responsible that the whole batch fulfil the demands. Furthermore, that the test is performed at a third party laboratory. Therefore TCO accept the test of only one sample even if the result is very close to the limit value.

B.6.3.2 Energy consumption – external power supply

The U.S. Environmental Protection Agency's (EPA) has implemented their decision to retire the ENERGY STAR® programs for External Power supplies and End use products using EPSs as of December 31, 2010 and now demands compliance with The International Efficiency Protocol requirement for level V, which is equivalent to the Energy Star version 2.0 for external adapters.

The international efficiency mark consists of a Roman numeral (I – VI) that corresponds to specific minimum Active and No-Load efficiency levels (as well as a power factor requirement for level V) and is printed/applied by the manufacturer on the external power supply nameplate.

TCO Development recognises that The International Efficiency Protocol requirement for level V is equivalent to our previous A.6.3.2 demand for Energy Star compliant External Power Supplies for displays. Therefore, TCO now demand that at least Efficiency level V be fulfilled. This means that a TCO laboratory will require to see a copy of the display's external adapter nameplate there The International Efficiency Protocol requirement for level V symbol is visible as proof of compliance.

B.6.4 Environmentally hazardous substances

B.6.4.1 Cadmium (Cd), mercury (Hg), lead (Pb) and hexavalent chromium (CrVI)

Exemptions are according to EU Directive 2002/95/EC (RoHS) and the documents supporting the directive.

Limit values for cadmium, lead and hexavalent chromium are according to EU Directive 2002/95/EC (RoHS) and the documents supporting the directive. Limit value for mercury in lamps is maximum 3,5 mg Hg/lamp.

Note that 3,5 mg Hg/lamp is the maximum level allowed per lamp and not an average level calculated on a batch of lamps. This concerns lamps < 500 mm in length. For lamps between 500 mm and 1500 mm in length 5 mg Hg is allowed and for lamps over 1500 mm in length 13 mg Hg is allowed.

The limit value for batteries are according to the is 0,0005 % for mercury and 0,002 % for cadmium per listed part, according to EU Directive 2006/66/EG.

TCO Development supports the use of recycled plastic. To avoid making it more difficult to use recycled plastic, exceptions to this requirement can be accepted. If recycled plastic is used in the product please contact TCO Development for further instructions.

B.6.4.2 Halogenated substances

1. Plastic components weighing more than 25 g shall not contain flame retardants or plasticizers that contain organically bound chlorine or bromine.

LCD panels are included in the requirements.

2. The **whole FPD** (for definition see above) shall not contain PBB and PBDE.

Printed Wiring Boards are included.

The limit value will be according to EU Directive 2002/95/EC (RoHS), the following amendments to the Directive and other documents supporting the Directive. The limit value for all PBBs and PBDEs, including decaBDE is 0.1 % by weight in homogeneous materials.

TCO Development supports the use of recycled plastic. To avoid making it more difficult to use recycled plastic, exceptions to this requirement can be accepted. If recycled plastic is used in the product please contact TCO Development for further instructions.

B.6.4.3 Non-halogenated substances

There are currently two EU directives describing classification of chemicals. Classification, Labelling and Packaging of Substances and Mixtures, known as the CLP Regulation, EC 1272/2008 will replace directives 67/548/EEG and 1999/45/EG.

To determine if a substance has been assigned a specific R-phrase, please check the substance against the information in the European chemical Substance Information System (<http://ecb.jrc.ec.europa.eu/esis/>).

See below for a restricted substances list matching:

R-phrase (according to 67/548/EEG)	Phrase	H-statement (according to EC 1272/2008)	Statement
Human health hazards			
R40	Limited evidence of a carcinogenic effect	H351	Suspected of causing cancer
R45	May cause cancer	H350	May cause cancer
R46	May cause heritable genetic damage	H340	May cause genetic defects
R48	Danger of serious damage to health by prolonged exposure	H372	Causes damage to organs through prolonged or repeated exposure
R60	May impair fertility	H360F	May damage fertility
R61	May cause harm to the unborn child	H360D	May damage the unborn child
Environmental hazards			
R50/53	Toxic to aquatic organisms/may cause long-term adverse effects in the aquatic environment	H411	Toxic to aquatic life with long lasting effects

TCO Development supports the use of recycled plastic. To avoid making it more difficult to use recycled plastic, exceptions to this requirement can be accepted. If recycled plastic is used in the product please contact TCO Development for further instructions.

B.6.4.4 Plastics with chlorine and bromine as part of the polymer

TCO Development supports the use of recycled plastic. To avoid making it more difficult to use recycled plastic, exceptions to this requirement can be accepted. If recycled plastic is used in the product please contact TCO Development for further instructions.

B.6.4.5 Information regarding plastics and flame retarding agents

PWB laminates contained in LCD panels shall be listed if the conditions set out by the mandate are met.

B.6.5 Product lifetime

B.6.5.1 Warranty and spare parts

That spare parts shall be available for three years from “the time that production ceases” is only applicable to the production of the specific FPD, certified by the brand owner.

Regarding spare parts:

1. If a part of a product is broken (eg bezel, stand) the end user shall not need to replace the whole product, only the broken part. The broken part shall be possible to replace with an equivalent part (this part does not have to be identical to the broken part).
2. If the cost of replacing the broken part (eg panel) is not economically reasonable for the end user, it is acceptable to replace the whole product.

B.6.6 Preparation for Recycling

B.6.6.1 Material coding of plastics

If the amount of flame retardant exceeds 1 % by weight the coding shall be complemented in accordance with ISO 1043-4.

The requirements also apply to plastics in the LCD panel, however labelling of the light guide may instead consist of the application of a label in close proximity, for example PLASTIC LIGHT GUIDE:>*plastic type(s)*< or >PLASTIC LIGHT GUIDE:*plastic type(s)*<. Labelling of Plate diffuser (not thin plastic film diffuser) shall follow the same rules as for the light guide.

The requirement does not cover other thin plastic films in the panel due to difficulties in labelling these.

B.6.6.2 Variety of plastics

Clarification: A different additive marking will not make the plastic a different plastic type. For example ABS with FR40 and ABS with FR50 is considered *one* plastic type (two are still allowed).

B.6.6.3 Metallization of plastic housing and metal parts

The requirement applies to the outer plastic casing and the foot of the display. Housings for electronic components inside the outer casing are not included in the requirement.

When the virgin plastic already in its granulated form contains additives, consisting for example of metal oxides in the form of pigment or metal flakes, this is not considered to be metallization and is not included in the prohibitions defined in A.6.6.3.

Metallized plastic control buttons for the adjustment of screen contrast, brightness, colour, etc. are accepted.

Metal parts and metallized plastics parts are acceptable if they are of snap-fastening type or can be easily removed using standard tools. Moulded-in or glued metal parts are not accepted. Strong double-sided tape, difficult to separate is not accepted.

Clarification: All exceptions on metallised parts described above must fulfil the RoHS Directive.

B.6.6.4 Preparation for recycling - Mercury lamps

The panel technology shall be reported as LCD (TFT, NT, DSTN, etc.), plasma, or other (specified).

A disassembly description for every specified LCD panel shall be submitted.

Not applicable to LED technology.

B.6.6.5 Take back system

Tick the box of the option chosen.

If the applicant chooses **option 1** (*Product only sold on markets with WEEE legislation or similar*) and signs the declaration, the requirement is fulfilled.

If **option 2 or 3** (*World-wide product take back or One additional market lacking WEEE legislation where product take back is offered*) is chosen, the declaration must be signed and the applicant must provide a short description of how the take-back system on that market works. This can also be done by giving a reference (for example a link to a website) to the representative, associated company or affiliate taking care of the take-back system on that market.

In case of option 3 the applicant must also provide the name of the market (country) where a take back system is provided.

TCO Development has no requirement on the take-back system being free of charge.

It is important to point out that any recycling and waste export control legislation in countries where the applicant company operates must always be met.

B.6.7 Product packaging

B.6.7.1 Hazardous substances in product packaging

Limit values are according to Directive 94/62/EC on packaging and packaging waste.