TCO´99 – Mandatory and recommended requirements for CRT-type Visual Display Units (VDUs) concerning:

- Visual ergonomics
- External disturbance factors
- Emissions
- Energy saving
- Electrical safety
- Miscellaneous characteristics

Introduction

The TCO'99 labelling scheme will also cover Flat Panel Displays, Laptop and Notebook Computers, System Units and Keyboards. Separate sections for these items will be issued.

The characteristics included in the TCO'99 scheme originate from TCO´95, ISO, IEC and EN-standards, as well as EC Directive 90/270/EEC, but also from such national specifications as the Swedish MPR 1990:8 (MPRII) and TCO Screen Facts 1991.

Definitions

A VDU is normally a CRT-type VDU with or without USB Hub but it can also be a combined unit with disc drive/s and/or CPU.

References

CIE Publication 69, 1987, Methods of characterising illuminance meters and luminance meters. Performance characteristics and specifications.

CIELUV (1976) Colour space.

EC Directive 90/270/EEC - Minimum safety and health requirements for work with display screen equipment, 1990.

EN 60 950 (IEC 60 950), Safety of information technology equipment, including electrical business equipment.

MPR 1990:8, Test methods for Visual Display Units

TCO, Screen Facts, 1991

Mandatory and recommended requirements

		Mandatory requirement	Recommended requirement
1 Visual ergonomics - Legibility			
1.3	Linearity	X	-
1.4	Orthogonality	X	-
1.5.1	Luminance level	X	R
1.5.2	Luminance uniformity	X	R
1.5.3	Luminance contrast	X	R
1.6	Front frame reflectance and gloss	X	R
1.7.1	Colour temperature variation	X	R
1.7.2	Colour uniformity and characteristics	X	R
2 Visual ergonomics - Image stability			
2.1	Periodic luminance variation	X	R
2.2	Positional instability (jitter)	X	R
3 External disturbance factors			
3.1	External alternating magnetic fields	X	R
4 Emissions and energy saving			
4.1	X-Ray radiation	X	R
4.2	Electrostatic potential	X	-
4.3	Alternating electric fields	X	-
4.4	Alternating magnetic fields	X	-
4.5	Energy saving	X	R
5 Electrical safety			
5.1	Electrical safety	X	-
6 Miscellaneous characteristics			
6.1	Vertical tilt	-	R
6.2	Height adjustment	-	R
6.3	Horizontal swivelling	-	R
6.4	Luminance and contrast adjustment	-	R
6.5	Refresh rate indication	-	R
6.6	Acoustic noise (VDUs with fan)	X	R

Definitions

X = characteristics required for certification that shall be verified by accredited or other laboratories accepted by TCO.

R = characteristics that are not required for certification at present, or characteristics that might be required in the future.

Numbering = The numbering follows TCO´95 as far as possible.

Requirements for Visual Display Units of CRT-type

1 Visual ergonomics - Legibility

1.3 Linearity

Definition: Positional conformity in picture elements that form horizontal or vertical lines such that they appear straight and continuous.

Reason: Quality considerations. Poor linearity can lead to poor legibility.

Method: See test method section.

Mandate: ≤ 1 % of half the active screen width and height respectively.

Recommendation: –

1.4 Orthogonality

Definition: Geometric alignment or perpendicularity between vertical and horizontal lines.

Reason: Quality considerations. Poor orthogonality can lead to poor legibility.

Method: See test method section.

Mandate:

Horizontal deviation	$\Delta H / H_{mean} \leq 0.02$
Vertical deviation	$\Delta V / V_{mean} \leq 0.02$
Diagonal deviation	$\Delta D / D_{mean} \leq 0.03$

Recommendation: –

1.5 Luminance

1.5.1 Luminance level

Definition: Luminance characterises the physical amount of projected light. Luminance can be defined for a point on a surface of a light source, in a light beam or on a lit surface. For screen and character luminance an average is taken over an area.

Reason: It shall be possible to set a sufficiently high luminance level with respect to the ambient lighting in order to avoid eye strain.

Method: See test method section.

Mandate: ≥ 100 cd/m^2

Recommendation: ≥ 125 cd/m^2

1.5.2 Luminance uniformity

Definition: Luminance definition according to 1.5.1. Luminance uniformity is the ability of the VDU to maintain the same luminance over the whole active screen area. The luminance uniformity is defined as the ratio of maximum luminance to minimum luminance within the active screen area. Luminance uniformity is measured with the entire screen activated.

Reason: Quality considerations. Visible unevenness can be irritating and thus affect legibility.

Method: See test method section.

Mandate: Luminance variation $L_{max} : L_{min} \leq 1.5:1$

Recommendation: Luminance variation $L_{max} : L_{min} \leq 1.25:1$

1.5.3 Luminance contrast

Definition:	The luminance contrast between a character and its surrounding areas that have a bearing on legibility. Luminance contrast is the relationship between the luminance of the test character and the luminances of the adjacent areas.
Reason:	The degree of contrast is important for legibility and for the capability to distinguish one character from another.
Note:	The area for evaluation is larger than in TCO´95
Method:	See test method section.
Mandate:	Luminance contrast modulation $C_m \geq 0.5$
Recommendation:	Luminance contrast modulation $C_m \geq 0.7$

1.6 Front frame reflectance and gloss

Definition:	Reflectance is defined as the quotient between the luminance of the front frame surface of the VDU and the luminance of a white reference standard. Gloss is based on a physical measurement of how a light beam, physically described as luminous flux, is scattered when incident against a given surface. The higher the gloss value the more likely is the surface to produce irritating reflexes from ambient lighting. If the gloss value is high enough, the problem of reflection images can occur.
Reason:	The front frame reflectance value and the gloss influences visual comfort and legibility.
Method:	See test method section.
Mandate:	Reflectance ≥ 20 % Gloss ≤ 30 gloss units
Recommendation:	Reflectance ≥ 25 % to ≤ 75 % Gloss ≤ 30 gloss units

1.7.1 Colour temperature variation

Definition: The hue of white light is often expressed physically in terms of the colour temperature of the light. The reddish white light from an incandescent lamp indoors has a low colour temperature, while the bluish white light of a cloudy sky has a high colour temperature. The light of a cloudy sky is said to be cooler than the warm light of an incandescent lamp. The colour temperature is expressed in degrees Kelvin (K). Normal daylight has a colour temperature of about 5000 – 10000 K but CIE recommends for example 6500 K. Incandescent lighting indoors is about 2800 K.

Reason: Most VDUs come with a number of pre-set correlated colour temperature (CCT) settings. This means that it is possible to set the hue of the white active area of the screen in comparison to the hue of the working surrounding areas. More importantly it makes it possible to more accurately evaluate the colour of an image on the VDU compared with the real scenes or prints.

If the VDU has a number of pre-set correlated colour temperatures, it should be expected that the measured CCTs are not too far from what is declared by the manufacturer.

Applicability: All multicolour VDUs.

References: CIELUV (1976) colour space.

Method: See test method section.

Mandate: $\Delta u'v' \leq 0.01$ in the CIELUV (1976) colour space.

It is not required that there must be a particular number of pre-set CCTs on a VDU. The mandatory value corresponds to the colour temperature intervals shown in the table below.

Pre-set CCT in K	Corresponding interval in K
9300	8500 – 10250
7500	6980 – 8100
6500	6100 – 6950
5000	4700 – 5350

As the default pre-set CCT, the 6500 K or 9300 K colour temperature should be used, depending on the preferences set by the client.

A lower pre-set CCT setting will not be permitted to have measured correlated colour temperatures higher than the next closest higher pre-set CCT. For example the CCT 7500 K will not be allowed to have a higher measured CCT than CCT 9300 K and not lower than 6500 K, if the pre-set CCTs are 9300 K, 7500 K and 6500 K respectively.

If the VDU lacks pre-set CCT settings, it will be measured at the default CCT and the results will be given in measured CCT and trichromatic co-ordinates.

It is also possible for the manufacturer to specify the RGB-settings for different correlated colour temperatures in the VDU manual for the user to set manually and store for further use.

At present there is no mandate that all pre-set colour temperature settings shall have the same luminance of 100 cd/m^2.

Recommendation: $\Delta u'v' \leq 0.005$ in the CIELUV (1976) colour space.

The recommended value corresponds to the colour temperature intervals shown in the table below.

Pre-set CCT in K	Corresponding interval in K
9300	8900 – 9750
7500	7200 – 7800
6500	6300 – 6700
5000	4850 – 5150

It is recommended that at least 9300 K and 6500 K shall have a luminance close to 100 cd/m^2.

1.7.2 Colour uniformity and characteristics

Definition:

The colour uniformity of a VDU is a visual appearance of the uniformity of a programmed/pre-set uniform white colour of the whole active area of the VDU.

The colour uniformity is physically established using the CIELUV (1976) colour space using the u´, v´ chromaticity co-ordinates and calculate $\Delta u´v´$ for the worst locations of visual colour non-uniformity.

The colour characteristics of a VDU are based on the visual appearance of the VDU primary colour stimuli such as R,G,B.-stimuli.

The R,G,B stimuli or other VDU primary stimuli are measured using u´, v´ chromaticity co-ordinates.

It should be noted that physical measurements of colour stimuli are only able to 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 a VDU.

Reason:

Patches of colour variations on an active white screen could be disturbing and affect the readability, the colour rendering and colour differentiation.

The u´, v´ chromaticity co-ordinates of the R,G,B primaries of a VDU give an indication of the VDUs colour rendering, especially in a comparison between VDUs.

References:

CIELUV (1976) colour space.

Method:

See test method section.

Mandate:

$\Delta u´v´ \leq 0.01$ for the worst white active area locations on the screen.

Recommendation:

$\Delta u´v´ \leq 0.005$ for the worst white active area locations on the screen.

2 Visual ergonomics - Image stability

2.1 Periodic luminance variation

Definition: Time-dependent unintended variations in character or background luminance.

Reason: Noticeable periodic luminance variations, i.e. changes in brightness can cause visual tiredness and eyestrain. Periodic luminance variation may also distract the user.

Method: See test method section.

Mandate:

CRT size	Vertical frequency	Resolution
14-15”	≥ 85 Hz	≥ 800 x 600
17”	≥ 85 Hz	≥ 1024 x 768
19-21”	≥ 85 Hz	≥ 1280 x 1024
> 21”	≥ 85 Hz	≥ 1280 x 1024

For “widescreens” or other special VDU sizes the mandatory requirements are ≥ 85 Hz and a resolution that corresponds to the above given resolutions.

If viewing size is used instead of the CRT size, the corresponding viewing sizes should be used in the above table.

Recommendation: Vertical frequency ≥ 100 Hz

2.2 Positional instability (jitter)

Definition: Positional instability (jitter) is a perceptible and unintended variation in the geometric properties of a picture element.

Reason: Unstable images can cause visual tiredness and eyestrain. Positional instability (jitter) can also distract the user.

Method: See test method section.

Mandate: The positional instability shall be ≤ 0,10 mm.

Recommendation: The positional instability shall be ≤ 0,08 mm.

3 External disturbance factors

3.1 External alternating magnetic fields

Definition: The electron beam in a VDU of CRT-type is controlled by magnetic fields from the deflection coils. If there are certain levels of magnetic flux density in the vicinity of the VDU, interference may arise between the external magnetic field and the vertical deflection magnetic field. The result of such interference can be a positional instability (jitter) of the same type as described in 2.2. Also other types of interference can occur.

Reason: Unstable images can cause eyestrain.

Method: See test method section.

Mandate: The positional instability shall be ≤ 0,10 mm at a field of 200 nT RMS with a frequency of 80 Hz.

Recommendation: The positional instability shall be ≤ 0,10 mm at a field of 400 nT RMS with a frequency of 80 Hz.

4 Emissions and energy saving

4.1 X-Ray radiation

Definition: X-ray radiation is produced inside cathode ray tubes (CRTs) due to the collision of the electron beam with the inside of the front glass. The CRT glass is normally non-transparent to this radiation. Levels measurable above the permanently present natural background radiation do not exist for a normally operating VDU of CRT-type. X-rays radiated from a VDU are measured as the kerma rate in air in units of Gray per hour (Gy/h).

Reason: To verify that no harmful X-ray radiation exists on the outside of a VDU.

Method: See test method section.

Mandate: ≤ 5000 nGy/h

Recommendation: ≤ 300 nGy/h

4.2 Electrostatic potential

Definition: Electrostatic potential arises at the front face of a VDU of CRT-type, due to the potential difference between the tube cathode and the inside of the tube, which is used to accelerate the electrons in the electron beam. This generates in turn the visible light on the screen that is used to create characters and graphic images.

Reason: The external surface of the VDU shall have a low electrostatic potential in order to prevent dust particles, due to differences in potential, being attracted by or moving to the user or to the VDU screen.

The mandatory requirement is based on the ambition of reducing the electrostatic potential to as low a level as it is technically possible to achieve, so as not to burden the working environment with unnecessary factors. The mandatory requirement shall however not be taken as representing a hygienic limit value.

Method: See test method section.

Mandate: The equivalent surface potential shall be within $\pm$ 0,5 kV.

Recommendation: –

4.3 Alternating electric fields

Definition: Alternating electric fields arise between objects with different electrical potentials. A VDU contains several sources of alternating electric fields. The strength of the field depends on both distance and on the actual electrical potential.

Reason: Some VDU users are concerned about the possible danger to health of alternating electric fields in the vicinity of VDUs. Quite a large number of users also report various forms of skin ailment that cannot be entirely ascribed to the influence of other working environment factors or to medical reasons.

The mandatory requirement is based on the ambition of reducing the alternating electric fields to as low a level as it is technically possible to achieve, so as not to burden the working environment with unnecessary factors. The mandatory requirement shall however not be taken as representing hygienic limit values.

Method: See test method section.

Note: Positive polarity shall be used and at least one mode shall be the same for emission testing as for the testing of visual ergonomics.

Screened power cord may not be used in order to comply with the mandatory requirement. If, however, the cord is non-detachable it will be used for the test. An optical filter may not be used in order to comply with the mandatory requirement.

Mandate: Band I: 5 Hz to 2 kHz, ≤ 10 V/m, measured at 30 cm in front of the VDU and at 50 cm in front of it. Band II: 2 kHz to 400 kHz, ≤ 1.0 V/m, measured at 50 cm around the VDU and at 30 cm in front of it.

Recommendation: –

4.4 Alternating magnetic fields

Definition: VDUs, like other electrical apparatus, are surrounded by magnetic fields. Various parts in the VDU, such as the power supply unit, deflection coils, high-voltage transformer and other circuits generate these magnetic fields.

Reason: Some VDU users are concerned about the possible danger to health from magnetic fields in the vicinity of VDUs.

The mandatory requirement is based on the ambition of reducing the magnetic fields to as low a level as it is technically possible to achieve, so as not to burden the working environment with unnecessary factors. The mandatory requirement shall however not be taken as representing hygienic limit values.

Note: Positive polarity shall be used and at least one mode shall be the same for emission testing as for the testing of visual ergonomics.

Method: See test method section.

Mandate: Band I: 5 Hz to 2 kHz, ≤ 200 nT, measured at 50 cm around the VDU and at 30 cm in front of it. Band II: 2 kHz to 400 kHz, ≤ 25 nT measured at 50 cm around the VDU.

Recommendation: –

4.5 Energy saving

Definition: The electrical energy consumed by a VDU can be considered as being completely converted into heat energy, that warms up the room in which it is placed. Apart from the conversion in this way of electric energy to heat energy, high power consumption wastes electricity.

Reason: If the additional heat is more than can be handled by the capacity of the normal room ventilation, an undesired increase of room temperature may result. Also, taking into account the general desire to reduce electrical energy consumption, it is important for all electrical equipment, the cooling system included, to consume as little energy as possible.

Method: See test method section.

Mandate:

	Energy saving position A1	Energy saving position A2
Power	≤ 15 W	≤ 5 W
Readable screen within	≤ 3 s	-

If the first step (A1) is ≤ 5 W and ≤ 3 s, then a second step is not required.

For VDUs with built in USB Hub it will be accepted to use only one step (A1) ≤ 15 W and ≤ 3 s. For VDUs with USB Hub there will be no devices connected to the USB Hub connectors during the power saving testing.

The applicant shall submit an energy declaration showing power in normal use and for the different energy saving modes. There shall also be a complete description, from the users' point of view of how the VDU is brought into the energy saving condition. This description shall always be available in English.

Recommendation: ≤ 5 W energy consumption and readable screen within ≤ 3 s in all power saving positions.

5 Electrical safety

5.1 Electrical safety

Definition: 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.

Reason: To prevent personal injury and/or fire.

References: EN 60 950 (IEC 60 950). Safety of information technology equipment including business equipment.

Mandate: The VDU shall be certified according to EN 60 950.

6 Miscellaneous characteristics

6.1 Vertical tilt

Definition: The facility to tilt the VDU vertically relative to the horizontal plane is indicated in degrees, positive and negative.

Reason: Affects the work posture

References: EC Directive 90/270/EEC.

Method: See test method section.

Mandate: –

Recommendation: It shall be possible to tilt VDU between -5° and +20° in steps or continuously. The VDU shall be stable in the different adjustment positions.

6.2 Height adjustment

Definition:	The facility to adjust the height of the VDU above the working surface it is standing on.
Reason:	Affects the work posture.
References:	EC Directive 90/270/EEC.
Method:	See test method section.
Mandate:	–
Recommendation:	It shall be possible to raise or lower the VDU by at least 110 mm in total. There shall be no danger of pinching fingers accidentally (no scissor mechanism). The height adjustment shall be lockable in all positions and be possible in steps or continuously.

6.3 Horizontal swivelling

Definition:	The possibility to adjust the VDU horizontally relative to the working surface it is standing on.
Reason:	Affects the work posture. A swivelling capability facilitates client communication via the VDU e.g. in bank premises.
References:	EC Directive 90/270/EEC.
Method:	See test method section.
Mandate:	–
Recommendation:	It shall be possible to swivel the VDU by a minimum of 45 degrees in each direction in steps or continuously. The VDU shall be stable in the different adjustment positions.

6.4 Luminance and contrast adjustment

Definition: The facility to change the luminance and the contrast on the screen of the VDU.

Reason: Affects visual ergonomics and reading errors when working with VDUs.

Reference: EC Directive 90/270/EEC.

Method: See test method section.

Mandate: –

Recommendation: There shall be a luminance and contrast adjustment facility that shall be easily accessible e.g. via “on screen display”.

6.5 Refresh rate indication

Definition: The facility for the user to be able to inspect the refresh rate while the VDU is being used in a normal way.

Reason: It is difficult for users to find out if their VDU is being operated at a refresh rate that does not give any noticeable periodic luminance variations.

Method: See test method section.

Mandate: –

Recommendation: There shall be a possibility for the user to easily inspect the refresh rate in use, e.g. via “on screen display”.

6.6 Acoustic noise from VDUs with fan

Mandate: VDUs with built-in fan shall comply with relevant parts of the requirements for system units. See the publication for system units.

Test methods for Visual Display Units of CRT-type

General test conditions for visual ergonomics

For the test methods for visual ergonomics described in this document the following definitions, test conditions, requested information from client etc., apply.

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

1 Definition of the test object

- The test object is defined as the VDU.
- All kinds of accessories, if specified by the client, that could affect the test in any way, are also parts of the test object.
- The test object shall be delivered to the test laboratory in test ready condition including any required accessories. This includes that all VDU controls etc. shall be working correctly and that necessary information about how to run and adjust the test object shall be provided.
- If the test object is a terminal, the client shall provide appropriate technical devices, manuals and other information to facilitate the necessary presentation.

2 Required test object information

- The client shall specify the name(s), type specification(s) and manufacturer for the test object as well as the CRT tube.
- The client shall specify if a particular graphic card shall be used for testing. In this case the graphic card shall be representative for the common use of the VDU, for example included in the motherboard of an associated equipment. Non-standard graphic cards are not recommended for testing, unless they are for a special purpose relevant for the client.
- The client shall specify the default colour temperature of the VDU for testing. The default colour temperature is recommended to be 9300 K or 6500 K. If only one setting is possible and/or no specific default colour temperature is selectable, a colour temperature between 6000 K and 9300 K is recommended.
- The client shall specify the horizontal and vertical resolution of the VDU and the vertical and horizontal frequency for testing. The minimum resolutions and vertical frequencies for testing can be found in a table in section 2.1 Periodic luminance variation.

3 Settings of the VDU controls

- The settings of the VDU controls are specified in 1.5.1 Luminance.
- The standard controls of the test VDU shall be used to configure and adjust the screen, e.g. brightness, contrast, linearity, orthogonality, colour temperature. An external control unit, that is not a standard part of the VDU, is not allowed and shall not be used.

4 Graphic card (Video adapter)

- A default standard graphic card of high quality, specified by the testing laboratory, shall be used if the client specifies no other graphic card. The graphic card shall be easily commercially available and up to date, in order to give the tested combination a more general validity and to give any user of the VDU the possibility of purchasing the same graphic card as used in the testing. The latest versions of the graphic cards are recommended.
- 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 test should not use any unnecessary software or hardware that could influence the test.
- Character generator shall only be used to operate the test VDU if using a standard graphic card is not possible. The reason for this is that a character processor is not representative of the usual way to run a VDU in office and home computer work.

5 Test image/test character

- The default testing typeface is Arial 12 points and 100% “zoom/magnification” shall be used. MS Windows 95 or NT4.0 or later is the default user interface.
- The default testing polarity is positive polarity (black characters on white background).
- The default testing program shall consist of commonly used software, for example a word processor that can produce text and graphics required for the test procedures. The reason for this is that the test should be valid for software most commonly used in office and home computer work.
- All parts of the tests for a test object shall be conducted using the same typeface, character size, resolution, operating system and other settings of the VDU controls etc., unless otherwise stated in the test procedure.

6 Conditions for the equipment under test

The VDU being tested shall be physically prepared for testing and it shall be warmed up for at least 20 minutes. It shall be tested under nominal conditions of input voltage, current, etc. After switching on, any integral manual degaussing device shall be activated.

7 Lighting conditions and measured dimensions

Photometric measurements shall be taken under dark room conditions. All dimensions shall be measured parallel to the plane tangential to the screen surface.

8 Photometric measurements

A luminance photometer integrates luminance over a finite measuring field and during a finite time. The photometer must incorporate a sufficiently long time constant of integration in order to ensure averaging of the pulsation of the light emitted by most VDUs. The photometer measuring field shall be one degree for the measurements being made except for microphotometric luminance measurements.

9 Microphotometric measurements

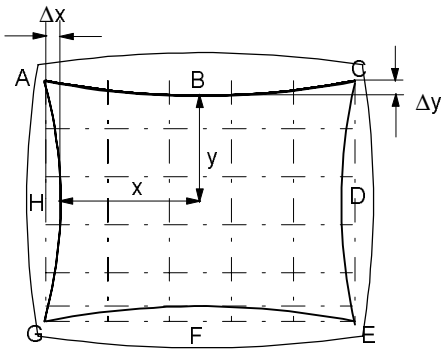
The registration of the luminance distribution of the test pattern shall be performed with a scanning luminance measuring device or a video luminance measuring device. The physical width of the slit or the matrix element shall be $\leq$ 1/8 of the smallest part of the character (e or m), but not more than 0.05 mm. The length of the slit shall be at least 4 times the width of a single pixel.

1 Visual ergonomics - Legibility

1.3 Linearity

Method:

Linearity shall be determined with a travelling microscope (or equivalent instrument) that can determine the length of the measured portion, relative to a measuring scale. The microscope or instrument shall be aligned parallel to the test pattern that shall fill the whole active area as much as possible.



$\Delta X/X$ respectively $\Delta Y/Y \leq 0.01$

Uncertainty: $\leq \pm 0.2$ % of the measured lengths.

1.4 Orthogonality

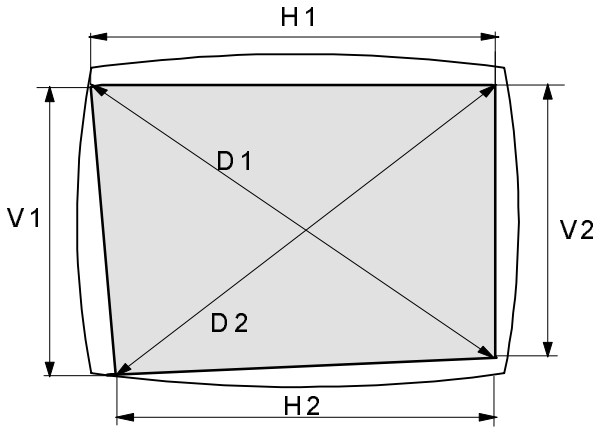
Method:

Orthogonality shall be determined with a travelling microscope (or equivalent instrument) that can determine the length of the measured portion, relative to a measuring scale. The microscope or instrument shall be aligned parallel to the test pattern that shall fill the whole active area as much as possible.

The following conditions apply

$$\frac{|H_1 - H_2|}{0.5\,(H_1 + H_2)} \leq 0.02 \qquad \frac{|V_1 - V_2|}{0.5\,(V_1 + V_2)} \leq 0.02 \qquad \frac{|D_1 - D_2|}{0.5\,(D_1 + D_2)} \leq 0.03$$

where V_1 and V_2 are the shorter sides in the figure on the next page.
The outer frame corresponds to the total active area of the VDU.



Uncertainty: ≤ ± 0.2 % of the measured lengths.

1.5 Luminance

1.5.1 Luminance level

Method:

The brightness and contrast controls of the VDU are set to maximum. If the image quality of the VDU becomes very bad the controls shall be adjusted to lower values (so that an acceptable image is achieved). In this case, first the brightness control shall be used to lower the luminance of the VDU, and secondly the contrast control.

Test image for maximum luminance

An image with an image loading of 80 ± 5 % (80 % white/20 % black) shall be used when measuring the maximum luminance of the VDU. In the centre of the screen a white area, 3 by 3 cm, is created. The maximum luminance is measured in the centre of this white area.

Test luminance setting

Using the same image, as described for maximum luminance, the brightness control is first used to reduce the luminance to the test luminance level of 100 cd/m^2. If necessary, the contrast control may in addition be used to achieve 100 cd/m^2. **These brightness and contrast settings shall be used for all of the visual ergonomic testing**.

Uncertainty: ≤ ± 10 % of the measured luminance.

1.5.2 Luminance uniformity

Method:

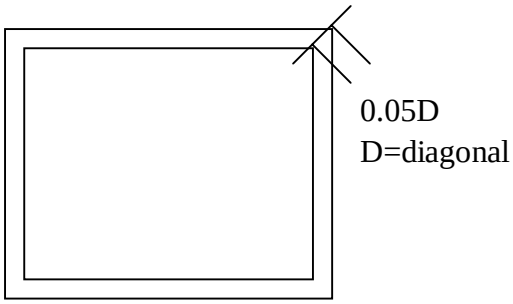
The luminance uniformity is measured within the whole active area. The luminance uniformity is presented as the ratio between the maximum luminance and the minimum luminance. See also 1.7.1 note 1 and note 2.

Uncertainty: ≤ ± 10 % of the measured luminance.

1.5.3 Luminance contrast

Method:

The image details that are to be seen as separated shall be used to measure luminance contrast. Two characters (e and m) shall be used and each shall be measured in the worst positions within the area defined by the following figure. The outer rectangle represents the total active area. Luminance contrast is calculated as luminance contrast modulation C_m.

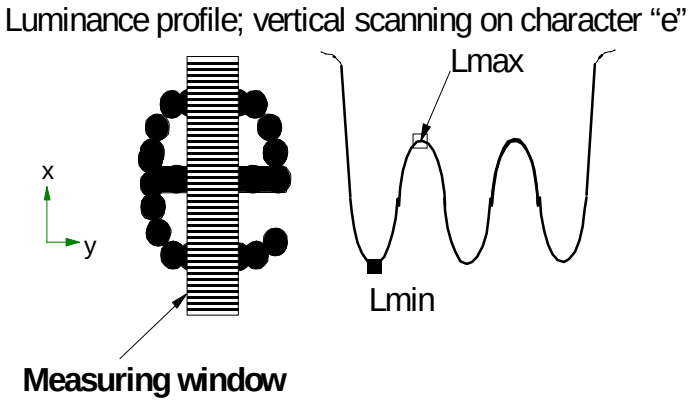


The characters (Arial 12 points is recommended) are the lower case “e” (for contrast between vertically adjacent character features) and “m” (for contrast between horizontally adjacent character features). The path of the microphotometer travel when measuring the luminance profile of the characters is shown for “e” in the following figure. Modulation shall be calculated by obtaining a luminance profile along the prescribed path.

The luminance contrast modulation is determined in both horizontal and vertical directions. The most unfavourable value is reported. See also “Microphotometric measurements”. The integration of luminance in the scanning direction shall be made over a distance corresponding to 1 min of arc (≈ 0.15 mm at a viewing distance of 500 mm) in the dark area of the character, L_{min}.

The relationship between the higher (L_{max}) and lower (L_{min}) luminances that define the test pattern to be detected, is expressed as luminance contrast modulation(C_m) defined by

$$C_m = \frac{(L\,max - Lmin)}{(Lmax + Lmin)}$$



Uncertainty: ≤ ± 10 % of the measured luminance.

1.6 Front frame reflectance and gloss

Method for reflectance:

The VDU front frame is illuminated with uniform diffuse white light. The luminance is measured perpendicular to the surface at the upper mid point of the VDU front frame.

Keeping the diffuse lighting conditions constant, the VDU surface is replaced by a white reference standard and the luminance of this reference standard is measured. The ratio between the VDU surface luminance and the reference standard luminance is calculated.

The uniform diffuse lighting that is required can be obtained by lighting up a diffuse white surface and using this surface as a reflector, to reflect light against the VDU front frame.

The uniformity of the diffuse lighting can be tested by measuring vertical illuminances: in the left upper corner of the upper front frame, in the middle of the upper front frame (the measuring point) and in the right corner of the upper front frame.

Equipment:	Luminance meter with good V (λ) calibration. Calibrated white reference standard.
Uncertainty:	$\leq \pm$ 10 % of the measured luminance.

Method for gloss:

Measurement of gloss shall be made on the front frame of the VDU. The gloss measurement instrument may need an absolutely flat surface to function properly. If the front frame of the VDU in all parts have a curvature, then a measurement could be made elsewhere on the housing given that the measured surface microstructure and colour is the same as the surface of the front frame.

The measurement of gloss shall be made using an angle of 60 degrees between the normal of the surface to be measured and the direction of the incident light beam.

Measurement shall be made in dark room thus avoiding the problem of ambient light leaking into the measurement instrument.

Equipment:	Gloss meter of good quality
Uncertainty:	$\leq \pm$ 2 units of the measured gloss.

1.7.1 Colour temperature variation

Method:

The colour temperature variation is determined using a test pattern consisting of a white square 3 by 3 cm in size surrounded by an area of about 80 % image loading. The luminance of the white square shall be 100 cd/m^2 at the default colour temperature setting (9300 K or 6500 K). The u´, v´ co-ordinates of the default colour temperature setting are measured with a spectrophotometer in the minimum spectral range of 380 to 730 nm. The spectrophotometer shall be accurate enough to give readings of 0.001 in u´ and v´. The difference between the measured u'_m and v'_m values and the u'_K and v'_K values for the correlated colour temperature (CCT) in question are calculated as follows:

$$((u'_K - u'_m)^2 + (v'_K - v'_m)^2)^{0.5}$$

The other pre-set correlated colour temperature settings are tested without changing the brightness or contrast settings of the VDU.

Most VDUs are delivered with one or more pre-set correlated colour temperatures (CCTs) for a white screen. These pre-set CCTs are often one or more of the following; 9300 K, 7500 K, 6500 K, 5000 K. The pre-set CCTs are tested and the mandatory requirements set limits on the maximum permitted colour temperature variations.

- The number of pre-set CCTs is left to the client to decide.
- As the default pre-set CCT, a value of 6500 K or 9300 K is used depending on the preferences set by the client.
- Testing is carried out under dark room conditions.
- The chromaticity co-ordinates x, y, u´, and v´, according to CIE1931 and CIELUV (1976) colour space, are calculated by means of a formula for the CCT of daylight as recommended by CIE (“Measuring colour” R. W. G. Hunt, 1987, and others):

  $x = -2.0064(10^9/CCT^3)+1.9018(10^6/CCT^2)+0.24748(10^3/CCT)+0.244063$

  for CCT ≥ 7000 K to 25000 K and

  $x = -4.607(10^9/CCT^3)+2.9678(10^6/CCT^2)+0.09911(10^3/CCT)+0.237040$

  for CCT ≥ 4000K and ≤ 7000 K.

  $y = -3x^2 + 2.87x - 0.275$ in both cases.

$u' = \frac{4x}{-2x+12y+3}, \quad v' = \frac{9y}{-2x+12y+3}$ according to CIELUV (1976) colour space

The formulae produce the following co-ordinates for the most common pre-set CCTs.

CCT in K	X	Y	u'_K	v'_K
9300	0.283	0.297	0.189	0.446
7500	0.299	0.315	0.194	0.459
6500	0.313	0.329	0.198	0.469
5000	0.346	0.359	0.209	0.488

Equipment: Spectrophotometer

Uncertainty: $\leq \pm$ 0.002 in u´ and v´.

1.7.2 Colour uniformity and characteristics

Method:

The colour uniformity will be measured on a white screen in a similar way as for Item 1.5.2 Luminance uniformity, and at the default pre-set CCT at the testing luminance of 100 cd/m^2. A visual evaluation of the darkest and brightest areas and the most coloured areas of a white screen is done. If no such areas could be found, the four corners and the centre of the active area shall be measured. The u´, v´ co-ordinates of a white area in the four corners, in the centre and in the visually worst positions of the screen will be used to calculate the Δu´v´ according to CIELUV (1976) colour space.

For the RGB measurements, the red, green and blue areas should measure 3 by 3 cm in the centre of the screen. The RGB settings are defined as red 255, 000, 000, green 000, 255, 000, and blue 000, 000, 255. Note that in MS Word97 the RGB setting 000 255 000 is called “bright green”.
The u´, v´ co-ordinates are measured with a spectrophotometer in the minimum spectral range of 380 to 730 nm. The spectrophotometer shall be accurate enough to give readings of 0.001 in u´ and v´.

The testing shall be carried out under dark room conditions.

Note 1

The measured white area shall be about 9 – 10 mm in diameter, corresponding to 1 degree at 500 mm viewing distance. A clean white area around the measured area shall be used in order to ensure a high accuracy in the measurements.

Note 2

A white screen covering the whole active area is used as the test pattern. This corresponds to about 100 % image loading. Due to the image loading the luminance of the VDU can fall below the 100 cd/m^2 set at the image loading of 80%. However, the luminance reduction is usually very small at 100 % image loading compared to 80 % image loading at 100 cd/m^2 and will not affect the luminance uniformity or the colour uniformity. It is important to perform a degauss operation before testing the colour uniformity.

Usually a spectrophotometer measures the luminance at the same time as u´ and v´. Hence, the luminance uniformity can be measured simultaneously.

The u'_{max}, u'_{min}, v'_{max} and v'_{min} are identified and
the $\Delta u'v' = ((u'_{max} - u'_{min})^2 + (v'_{max} - v'_{min})^2)^{0.5}$ is calculated.

RGB measurements

The u´ and v´ co-ordinates are measured in a coloured (red, green or blue) area of 3 by 3 cm in the centre of the screen. The u´, v´ co-ordinates of red, green and blue will form a triangle that should be as large as possible in a u´, v´ diagram.

Equipment: Spectrophotometer

Uncertainty: $\leq \pm$ 0.002 in u´ and v´.

2 Visual ergonomics - Image stability

2.1 Periodic luminance variation

Method:

Measurement of the image refresh frequency is carried out in a suitable way, e.g. with a luminance meter connected to an oscilloscope or with other suitable refresh frequency test equipment.

Uncertainty: $\leq \pm$ 2 % of the measured frequency

2.2 Positional instability (jitter)

Method:
The maximum variation of the geometric position of the character (jitter), is measured using a microscope with at least 20x magnification or in an equivalent manner. The positional instability (jitter) is determined by visual alignment of the microscope cursor or comparator reticle with the extreme positions of an edge of a character or test pattern during an observation period of at least 4 seconds.

Positional instability (jitter) shall be expressed in mm.

A special measuring device may be used. This device shall determine, on a scan-by-scan basis, the relative location of a character or test pattern. If a device is used that determines the positional instability (jitter) along the horizontal and vertical axes only, the extent of the positional instability (jitter) shall be defined as the square root of the sum of the squares of the maximum horizontal and vertical distances.

Equipment: Microscope or suitable special device.

Uncertainty: ≤ ±10 % of the measured value.

3 External disturbance factors

3.1 External magnetic fields (not final method)

Method:

A large Helmholz coil, which gives a uniform magnetic field, shall be used. The coil shall be supplied from a generator that can supply a sinusoidal waveform of a magnitude that gives the described magnetic fields of 200 or 400 nT RMS respectively. The amplitude and frequency of the magnetic field shall be verified with a magnetic field meter of the kind that is used for verifying the magnetic fields in the relevant section of this publication. The worst case of directions X, Y, Z shall be evaluated.

For the positional instability (jitter) measurements – See section 2.2 of this publication.

If necessary this method will be amended after a trial period.

General test conditions for emissions

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

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

1 Extra measurement distances for TCO'99 emission

In order to comply with the mandates, additional measurements must be made for alternating electric fields and magnetic fields in front of the VDU at 30 cm distance. This is not required for magnetic fields in band II.

2 Condition for the test object and set up

- The tests shall be performed with the full screen size activated.
- When the VDU is connected via a detachable cable the measurement shall be performed with a non-shielded grounded cable of normal type.
- The mode(s) (i. e. horizontal and vertical scan frequency and resolution) used during the test shall be stated in the report.
- The supply voltage and frequency used during the test shall be stated in the report.
- Positive polarity shall be used, meaning dark or black characters on a white background.
- The VDU control settings shall be the same as for visual ergonomics. This means that 100 cd/m^2 at an image loading of 80 $\pm$ 5 % shall be used for the emission testing of alternating electric and magnetic fields. See the luminance measurement section for details concerning this setting. For electrostatic field a white screen with H-pattern may be used.
- At least one mode or resolution shall be the same for visual ergonomics and for emissions. This means that the VDU must comply with the emission mandates for at least one mode or resolution with picture frequency $\geq$ 85 Hz for alternating electric and magnetic fields. This is not required for electrostatic field.
- The CRT-type and manufacturer shall be stated in the test reports.

4 Emissions and energy saving

4.1 X-Ray radiation

Method:

According to IEC 60 950 (Appendix H).

The background radiation in the test laboratory shall not exceed 100 nGy/h.

Equipment:

As specified in IEC 60 950.

Results:

In cases where no X-ray radiation is detected the result "≤ 100 nGy/h" shall be stated.

Measurement uncertainty:

The test shall be performed in such a way that the total uncertainty of the test result will be better than ± (40 % of reading + 30 nGy/h).

4.2 Electrostatic potential

Method:

Test Laboratory

The test laboratory shall conform to the following environmental conditions during the measurement of the equivalent surface potential of the VDU.

The ambient temperature shall be 21 ± 2 degrees Centigrade at a distance of 1 m or more from the test object.

The relative humidity shall be 20 ± 5 %. The velocity of the air shall be less than 0.30 m/s within the perimeter of the test set-up.

The concentration of positive or negative ions in the air shall be less than $1 \cdot 10^9$ ions/m^3.

Preparation of the test object

The screen and front bezel of the VDU shall be washed with low conductivity water, i.e. having a conductivity of less than 200 µS/m.

The VDU shall then be placed in a room meeting the specifications for the test laboratory for at least 6 hours. The VDU shall be left switched OFF during this period. After the six hour period the VDU shall be wiped with a conductive brush, for example a carbon fibre brush, which is connected to earth.

Measurement instructions

The VDU shall display a full screen of capital “H” pattern in dark/black letters on a white background.

For this testing it is not required to set the VDU luminance to 100 cd/m^2 and 80 % image loading. The H-pattern shall be clearly visible.

The measuring plate shall be placed 100 mm away from and parallel to the tangential plane of the VDU with a tolerance of ± 2 mm at the centre and ± 5 mm at the edges of the screen. The centre-centre point of the VDU shall be horizontally in line with the field strength meter on the measuring plate as in figure A.

Switch ON the VDU and note the reading, R, on the field strength meter after twenty minutes.

If the measurement limit ± 500 V is reached in a time shorter than 20 minutes, the measurement may be terminated at that time.

The field strength, E, is calculated using the following expression:

$$E = R \cdot F \text{ Volts/metre}$$

Where R is the field strength meter reading and F is the calibration factor (see “Equipment”). The electrostatic (or equivalent surface) potential, U, is calculated using the following expression:

$$U = E \cdot d \cdot [1 + (0.12/D)^3] \text{ Volts}$$

Where E is the field strength in V/m, d is the distance in metres to the measuring plate (0.1 metres in this case), D is the diagonal of the VDU screen in metres.

Equipment:

Figure A illustrates the test set-up for measuring electrostatic potential. The measuring plate shall be made of a square piece of metal 0.5 m by 0.5 m. This plate shall be connected to earth on the mains supply and must be common with the earth on the VDU.

A field strength meter, for example a field mill, shall be placed at the centre of the measuring plate. The measuring probe of the field strength meter shall be flush with the surface of the measuring plate. The ground point of the probe shall be electrically connected to the measuring plate.

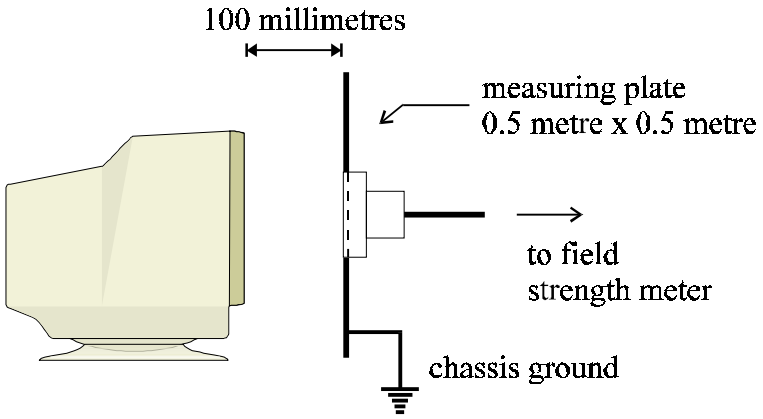


Figure A Test equipment and set-up

The calibration of the measuring equipment shall be performed as illustrated in figure B. The calibration plate shall be made from a square piece of metal measuring 0.5 m by 0.5 m. This plate shall be separated from the measuring plate by 100 ± 0.5 mm at the centre and 100 ± 2.0 mm at the edges. A D.C. voltage of 500 ± 10 V shall be applied to the calibration plate, as illustrated in figure B. The nominal reading of the field strength meter should be 5000 V/m. Therefore, the calibration factor, F, is:

$$F = \frac{5000\ (V/m)}{\text{Reading on field strength meter (V/m)}}$$

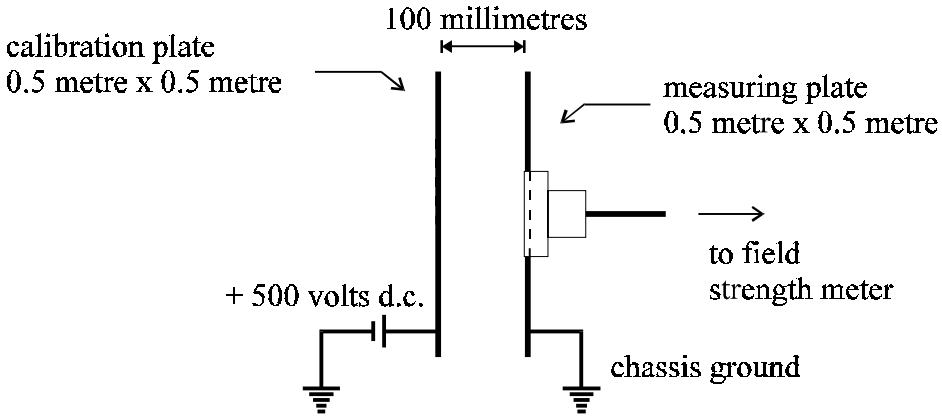


Figure B. Calibration set-up.

Results:

The equivalent surface potential U shall be given. If the value of U is less than 500 volts, the result shall be noted as:

Electrostatic potential within ± 0.5 kV (kilovolts)

Measurement uncertainty:

The test shall be performed in such a way that the total uncertainty of the test result will be less than ± (10 % of reading + 100 V).

4.3 Alternating electric field

Method:

The true RMS-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.

The VDU shall be positioned such that the tangential plane is at a right angle to the horizontal plane. The largest right angle distance along the normal to the tangential plane through the centre-centre point between the screen surface and the back of the VDU 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 VDU and with co-ordinates according to:

z = 0
r = L/2 + 0.5
ϑ = 0 for band I
ϑ = 0, 90, 180 and 270 for band II

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 ± 5 degrees, to the radial axis.

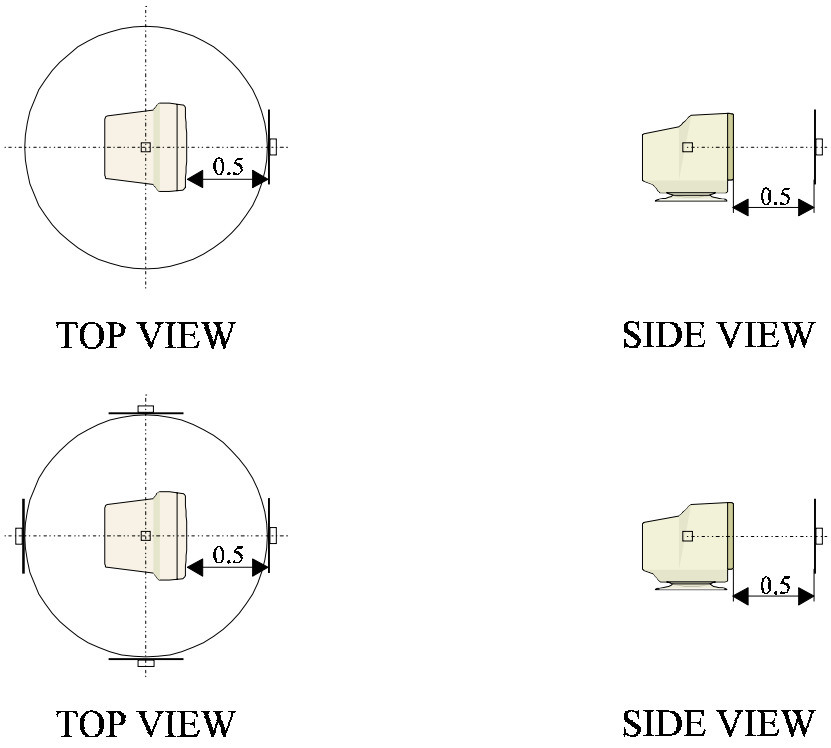


Figure A. Measurement geometry for band I (top) and band II (bottom).

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

Additional units and connecting cables necessary for the operation of the VDU, but which are not part of the test, shall be placed so far away from the measuring set-up 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. The cables between the measuring probe and the measuring instrument shall be positioned in such a way that they do not influence the measured value.

The VDU shall display a full screen of capital “H” pattern in dark/black letters on a white background.

For VDU luminance settings – see General test conditions for emission.

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 V/m in band I and 0.2 V/m in band II.

The mains voltage of the VDU under test shall be within ± 3 % of its nominal value. The nominal value of the main voltage used shall be specified in the test report.

The power cable of the test object shall be connected to the phase and the neutral conductors of the mains. If the mains 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.

The VDU under test shall be connected to the mains via a cable that shall be laid horizontally 0.1 m out from the test object and then vertically downwards for at least 1 m.

Equipment:

The alternating electrical field emission from the VDU 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. 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 earth. 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 $U = \varepsilon \cdot E \cdot A/C$ where C is the capacitance in the feedback loop of the operational amplifier and ε is the permittivity for a vacuum.

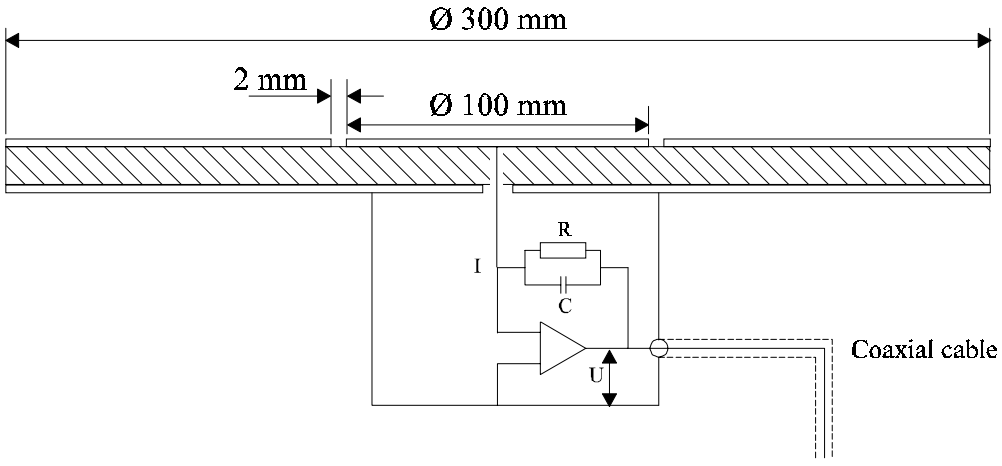


Figure B Sketch and circuit principle of the measuring probe for alternating electrical field measurements. The feedback circuit of the operational amplifier is a capacitance C in parallel with a high value resistor R to ensure that there is no DC voltage across the plates of the capacitor C.

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 A.

Table A. 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 RMS-value of the electric field strength in both frequency bands.

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

The measuring system shall be capable of measuring 2 V/m in band I and 0.2 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 with at least 300 mm diameter. The distance between the surface of the probe and the plate shall not exceed 30 mm.

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

Table B Calibration frequencies and amplitudes

	Frequencies	**Amplitudes**
Band I	50, 100, 500, 1000 Hz	25, 250 V/m
Band II	15, 30, 60, 120 kHz	2.5, 10, 25 V/m

Recorded values at these calibration points shall be within ± 5% of the nominal value. Due to the nature of the specified filters the deviation shall be calculated at 1 kHz from 22.5 and 225 V/m and at 120 kHz from 2.4, 9.5 and 24 V/m.

Results:

Results shall be presented as RMS-values of the alternating electric field expressed in volts per meter (V/m). For band I, results shall be presented as the measured value for normal and stand-by operations if they differ. For band II, the measured values in front of the VDU and the maximum value shall be presented for normal and stand-by operations if they differ.

If the measured values are less than 10 V/m in band I or less than 1 V/m in band II the result shall be reported as "≤ 10 V/m" or "≤ 1 V/m", respectively.

Measurement uncertainty:

The test shall be performed in such a way that the total uncertainty in the test result will be better than ± (10% of reading + 1. 5 V/m) for band I and ± (10% of reading + 0. 1 V/m) for band II.

4.4 Alternating magnetic fields

Method:

Test laboratory

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.

The true RMS 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 measuring equipment.

The measuring geometry is illustrated in figure A and the measurement points are mathematically defined in the following way.

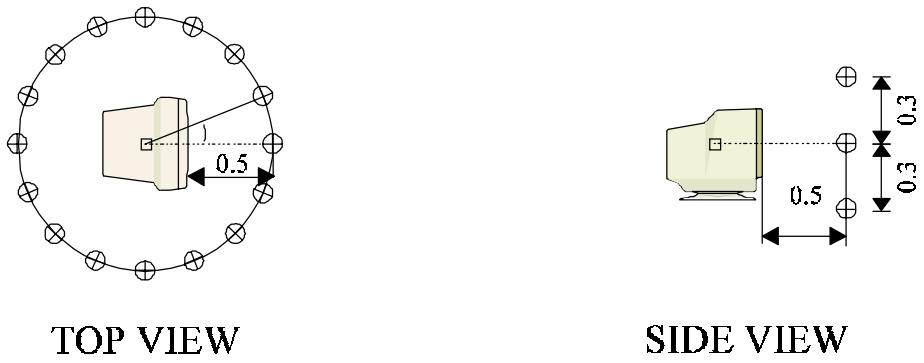


Figure A Measurement geometry for the test object (distances in m).

The VDU shall be positioned such that the tangential plane is at a right angle to the horizontal plane. The largest perpendicular distance along the normal to the tangential plane through the centre-centre point between the screen surface and the back of the VDU 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 to be at right angles 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 VDU and with co-ordinates according to:

z = -0.3, z = 0 and z = 0.3
r = L/2 + 0.5
ϑ = p • 22.5 where p represents all integers in the range 0 < p < 15.

Distances are given in metres and angles in degrees.

The measuring coils shall be stationary during the measurements.

The VDU shall display a full screen of capital “H” pattern in dark/black letters on a white background.

For VDU luminance settings – see General test conditions for emission.

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 plug permits an interchange of the live and neutral conductors, measurements shall be taken with that connection which gives the highest reading in band I.

Equipment:

The magnetic field shall be measured with two coil systems, one covering band I and the other band II. Each coil system shall consist of three mutually perpendicular concentric circular coils each with an area of 0.01 m^2. 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 be greater than 12 kHz for band I and greater than 2.5 MHz for band II. The resonances shall be suppressed by resistive loading of each coil.

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 A.

Table A. 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	> 400 kHz
Attenuation	> 80 dB/decade	3 dB	0 dB	3 dB	> 40 dB/decade

After amplification, integration and filtering, the signals from the three coils in each coil set shall be used as input values for calculating the RMS-value of the amplitude of the magnetic flux density vector in both frequency bands. It is permissible to calculate the RMS-value for each of the coil signals and use the root of the squared sum of those RMS-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 measuring system shall be capable of measuring 40 nT in band I and 5 nT in band II.

The measuring system shall be calibrated using a Helmholtz-type calibration coil as shown in figure B. Calibration shall be performed with sinusoidal fields at the amplitudes and frequencies specified in Table B.

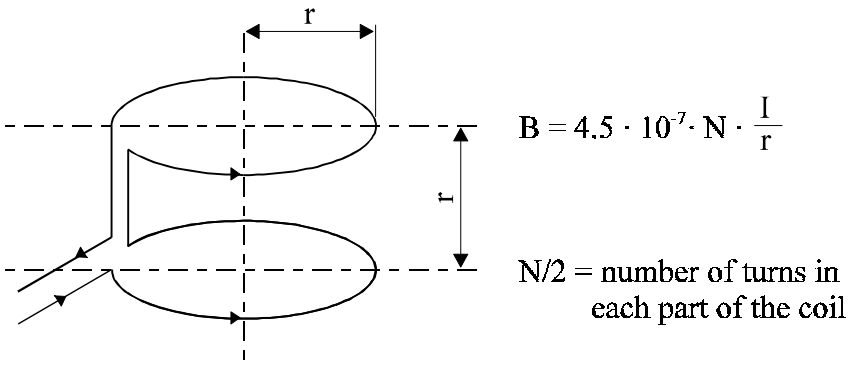


Figure B Calibration set-up.

Table B 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 ± 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.

Results:

Results shall be presented as RMS-values of the magnetic flux density expressed in nanotesla (nT) for the two frequency bands. The values in front of the VDU 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 nT in band II the result shall be reported as "≤ 200 nT" and "≤ 10 nT" respectively.

Measurement uncertainty:

The test shall be performed in such a way that the total uncertainty in the test result will be better than ± (10% of reading + 30 nT) for band I and ± (10% of reading + 1.5 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.

4.5 Energy saving

Energy Saving Position A1

The VDU shall enter Energy Position A1 after an adjustable time interval following the last use of the keyboard, a mouse operation or a message received. Readable screen shall occur not more than 3 seconds from the moment when the keyboard or mouse is touched again or when a message comes from the computer.

It is recommended to wait at least 5 minutes before the testing of the recovery time is made.

Energy Saving Position A2

Energy Saving Position A2 shall occur when the keyboard has not been touched for an additional time. This time may be fixed relative to the start of the Energy Saving Position A1. Readable screen shall occur again when the keyboard or mouse is touched again or when a message comes from the computer. The recovery time may in this case be similar to a normal cold start.

It is assumed that the total time (A1 + A2) shall be set to maximum one hour in the set up of the computer used.

Indicator lamp

It is desirable that the energy saving positions are indicated on the VDU.

Energy declaration

The energy declaration shall specify power consumption under the following conditions:

- Normal operation (maximum) with white background
- Energy Saving Position A1 and A2 respectively.

The energy declaration shall also include an instruction to the user to switch off the VDU when leaving it for longer periods.

Special testing conditions for energy saving

- Line impedance	≤ 0.25 ohm
- Total harmonic distortion (voltage)	≤ 5 %
- AC mains voltage *1	230 VAC RMS tolerance ≤ 1 %
- AC mains frequency *1	50 Hz tolerance ≤ 2 %

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

5 Electrical safety

5.1 Electrical safety

Method: The certification shall be made by a recognised testing laboratory within the CB scheme.

6 Miscellaneous characteristics

6.1 Vertical tilt

Method: The VDU as delivered is examined for vertical tilting. The angles that are attainable are given related to the vertical position of the screen surface. When the upper front of the VDU is tilted backwards the angle towards the vertical direction is defined to be positive.

Equipment: Protractor, spirit level.

Uncertainty: ≤ ± 2 degrees.

6.2 Height adjustment

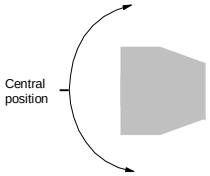
Method: The VDU, equipped with recommended stand, support or feet, is placed on a table. The adjustment limits are given in relation to the bottom edge of the highest line of text from the working surface.

Equipment: Measuring rule. Ocular inspection.

Uncertainty: ≤ ± 5 mm.

6.3 Horizontal swivelling

Method: The VDU as delivered is examined for horizontal turning. The angles that are attainable are given related to the central position of the VDU as shown below.



Equipment: Protractor.

Uncertainty: ≤ ± 5 degrees.

6.4 Luminance and contrast adjustment

Method: Inspect the existence, function and position of luminance and contrast controls.

Equipment: Manual and ocular inspection.

Uncertainty: Not applicable

6.5 Refresh rate indication

Method: Inspect the existence and function of any provided refreshes rate indication. Also judge accessibility and the presentation of refresh rate values.

Equipment: Manual and ocular inspection.

Uncertainty: Not applicable

6.6 Acoustic noise from VDUs with fan

Method: See the publication for system units.

Contents