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TCO'99 – Mandatory and recommended requirements for Flat panel Visual Display Units (VDUs) and Portable computers concerning:

- Visual ergonomics
- Emissions and energy saving
- Electrical safety
- Acoustic noise
- Ecology

Introduction

The TCO'99 labelling scheme also covers CRT-type VDUs, System Units, Keyboards and alternatively designed keyboards. Separate reports for these items are already available. The ecology requirements are presented in a special report.

Definitions

- A Flat panel VDU can be a unit consisting only of a screen, usually LCD, but may alternatively be a combined unit with disk drive/s and/or CPU.
- The term Portable computer refers to devices that can work with power support from a battery and without any external units. The test measurements shall always be made with the Portable computer connected to the mains. The Portable computers are normally equipped with a built-in keyboard. The keyboards in these units are meant for occasional use and therefore have ecology requirements, but not any ergonomic requirements in this document.
- The principal use of a portable computer is not telecommunication in the frequency region of 0.5 – 2.0 GHz.
- Separate power supply units are covered by the same electrical safety requirements as parts of certified units of the above-mentioned types.

References

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

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

TCO'95, Personal computers, Report No. 1 and 2. Third Edition, 1996

TCO'95, Portable computers and flat panel VDUs, Amendment No. 1, Second Edition, 1997

TCO'99, Displays [flat], Report No. 2 and Ecology, Report No. 5, 1998

Mandatory and recommended requirements

	Mandatory requirement	Recommended requirement	
1 Visual ergonomics – Legibility			
1.1	Fill factor	X	-
1.5.1	Luminance level	X	R
1.5.2 A	Luminance uniformity	X	R
1.5.2 B	Luminance uniformity – angular-dependent	X	-
1.5.3 A	Luminance contrast – angular-dependent	X	-
1.5.3 B	Luminance contrast – characters	X	-
1.6	Front frame gloss and reflectance	X	R
2 Visual ergonomics – Image stability			
2.1	Periodic luminance variation	deleted	-
4 Emissions and energy saving			
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 Acoustic noise			
6.6	Acoustic noise from units with fans	X	R
7 Keyboard – Usability			
	Keyboard – Usability	-	R
8 Ecology			
	Ecology requirements	XM	-

Definitions

X or XM are characteristics required for certification.

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

XM = characteristics required for certification which shall be verified by accredited or other laboratories accepted by TCO Development or by the suppliers' own test reports or declarations

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 and TCO'99 as far as possible.

Requirements for Flat panel VDUs and Portable computers

A.1 Visual ergonomics – Legibility

A.1.1 Fill factor

Definition:	The fraction of the total area geometrically available to a pixel that can be altered to give information.
Reason:	Image quality considerations. Assessment of the degree of usability of the screen surface area.
Applicability:	Portable computers and Flat panel VDUs with a pixel density of less than 30 pixels per degree.
Method:	See test method section.
Mandate:	≥ 0.5
Recommendation:	–

A.1.5 Luminance

A.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 a defined 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.
Applicability:	Portable computers and Flat panel VDUs.
Method:	See test method section.
Note:	The measurement of the luminance level is made with the portable computer connected to the mains.
Mandate for Portable computers:	$\geq 100 \text{ cd/m}^2$
Mandate for Flat panel VDUs:	$\geq 125 \text{ cd/m}^2$
Recommendation:	$\geq 150 \text{ cd/m}^2$

A.1.5.2 A Luminance uniformity

Definition:	Luminance definitions according to A.1.5.1. The luminance uniformity is the ability of the VDU or the VDU as a part of a portable computer, 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.
Reason:	Image quality considerations. Visible unevenness can be irritating and can have a negative effect on screen legibility.
Applicability:	Portable computers and Flat panel VDUs.
Method:	See test method section.
Note:	The measurement of the luminance uniformity is made with the Portable computer connected to the mains.
Mandate:	Luminance variation $L_{\max} : L_{\min} \leq 1.7:1$
Recommendation:	Luminance variation $L_{\max} : L_{\min} \leq 1.5:1$

A.1.5.2 B Luminance uniformity – angular-dependent

Definition:	Luminance definitions according to A.1.5.1. The luminance uniformity is the ability of the VDU as a stand-alone unit or as a part of a portable computer, 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 in the specified measurement areas.
Reason:	The luminance of a flat panel VDU is often angularly dependent in a way that the more commonly used CRT-based types never are. A slight head movement when looking at various parts of the screen can cause a change in brightness that is similar to a brightness change according to 1.5.2 A Luminance uniformity. This can have a negative effect on screen legibility.
Applicability:	Portable computers and Flat panel VDUs with angular-dependent luminance.
Method:	See test method section.
Note:	The measurement of the luminance uniformity is made with the portable computer connected to the mains.

Mandate for Portables computers:

The mean value of the luminance variation
 $L_{\max} : L_{\min} \leq 2.2:1$ at $\pm 15^\circ$ horizontally from the viewing direction.

Mandate for Flat panel VDUs:

The mean value of the luminance variation
 $L_{\max} : L_{\min} \leq 1.7:1$ at $\pm 30^\circ$ horizontally from the viewing direction.

Recommendation: –

A.1.5.3 A Luminance contrast – angular-dependent

Definition: Luminance definitions according to A.1.5.1. The minimum contrast for a character and its surrounding areas that has a bearing on legibility. Luminance contrast is the relationship between the luminance of the test pattern and the luminances of the adjacent areas.

Reason: The luminance of a flat panel VDU is often angularly dependent in a way that the more commonly used CRT-based types never are. This luminance variation 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 screen legibility.

Applicability: Portable computers and Flat panel VDUs with angular-dependent contrast within $\pm 30^\circ$ horizontally from the viewing direction.

Method: See test method section.

Note: The measurement of the luminance contrast is made with the portable computer connected to the mains.

Mandate: Luminance contrast modulation ≥ 0.5 at $\pm 30^\circ$ horizontally from the viewing direction.

Recommendation: –

A.1.5.3 B Luminance contrast – characters

Definition: See the definition for A.1.5.3 A.

Reason: The degree of contrast is important for legibility and for the capability to distinguish one character from another. On flat panel VDUs, stripes of lower contrast may occur anywhere on the screen, dependent on various time settings of the VDU.

Applicability:	Portable computers and Flat panel VDUs with noticeable stripes of lower contrast. If it is not possible to adjust such factors as time and phase settings of the VDU in order to remove unwanted low contrast stripes or patches, then testing in accordance with this section shall be carried out. Therefore it is vital that appropriate time and phase settings are described in the users manual.
Method:	See test method section.
Note:	The measurement of the luminance contrast is made with the portable computer connected to the mains.
Mandate:	Luminance contrast modulation ≥ 0.5 at 90° .
Recommendation:	–

A.1.6 Front frame gloss and reflectance

Definition:	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 the surface is to produce irritating reflections from ambient lighting. If the gloss value is high enough, the problem of reflection images can occur.
Reason:	The front frame gloss influence visual comfort and legibility.
Applicability:	The gloss parameters are applied for Flat panel VDUs and portable computers.
Method:	See test method section.
Mandate for Portables computers:	Gloss ≤ 30 gloss units
Mandate for Flat panel VDUs:	Gloss ≤ 30 gloss units

A.2 Visual ergonomics – Image stability

A.2.1 Periodic luminance variation

The requirement is deleted.

A.4 Emissions and energy saving

A.4.3 Alternating electric fields

Definition: Alternating electric fields arise between objects with different electrical potentials. Portable computers and Flat panel VDUs contain 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 their equipments. 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.

Applicability: Portable computers and Flat panel VDUs.

Method: See test method section.

Note: Positive polarity shall be used.

The electric fields are measured with the test object connected to the mains. Screened mains power supply cord may not be used in order to comply with the mandatory requirement. If, however, such a non-detachable cord is supplied with the product 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, ≤ 10.0 V/m, measured at 30 cm and at 50 cm in front of the VDU.
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: –

A.4.4 Alternating magnetic fields

Definition:	Portable computers and Flat panel VDUs, like other electrical apparatus, are surrounded by magnetic fields. Various parts in the equipment, such as the power supply unit, deflection coils, high-voltage transformer and other circuits generate these magnetic fields.
Reason:	<p>Some VDU users are concerned about the possible danger to health from magnetic fields in the vicinity of their equipments.</p> <p>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.</p>
Applicability:	Portable computers and Flat panel VDUs.
Note:	<p>Positive polarity shall be used.</p> <p>The magnetic fields are measured with the test object connected to the mains.</p>
Method:	See test method section.
Mandate:	<p>Band I: 5 Hz to 2 kHz, ≤ 200 nT, measured at 50 cm around the VDU and at 30 cm in front of it.</p> <p>Band II: 2 kHz to 400 kHz, ≤ 25 nT, measured at 50 cm around the VDU.</p>
Recommendation:	–

A.4.5 Energy saving

Definition:	The electric energy consumed by a portable computer 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 electric energy consumption, it is important for all electric equipment, the cooling system included, to consume as little energy as possible.

Applicability: Portable computers and Flat panel VDUs.

Method: See test method section.

Mandate for Portable computers:

	Energy saving position A1	Energy saving position A2
Power	$\leq 15\text{ W}$	$\leq 5\text{ W}$
Readable screen within	$\leq 5\text{ s}$	-

If the first step (A1) is $\leq 5\text{ W}$ and $\leq 5\text{ s}$, then a second step is not required.

Mandate for Flat panel VDUs:

VDU	Alternative 1		Alternative 2
	1st step (A1)	2nd step (A2)	One step
Power	$\leq 15\text{ W}$	$\leq 5\text{ W}$	$\leq 5\text{ W}$
Readable screen	$\leq 3\text{ sec}$	No wake-up time requirement	No wake-up time requirement

For alternative 1, if the first step (A1) is $\leq 5\text{ W}$ and $\leq 3\text{ s}$, then a second step is not required.

Flat panel VDUs with built in USB Hub will be permitted to have only one step where (A1) is $\leq 15\text{ W}$ and $\leq 3\text{ s}$. During the power saving test there will be no devices connected to the USB Hub connectors.

Mandate: The applicant shall submit an energy declaration showing power consumption 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 portable computer is brought into the energy saving condition. This description shall always be available in English.

Recommendation: (A1) is $\leq 5\text{ W}$ energy consumption and readable screen within $\leq 3\text{ s}$ in all power saving positions.

A.5 Electrical safety

A.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.
Application:	The requirements are applicable to Portable computers and Flat panel VDUs with built-in power supplies as well as to any separate power supplies that are intended to be used together with the products covered by this publication.
References:	EN 60 950 (IEC 60 950). Safety of information technology equipment including business equipment.
Mandate:	The Portable computer, the Flat panel VDU and, if a separate power supply exists, it shall be certified according to EN 60 950.

A.6 Acoustic noise

A.6.6 Acoustic noise from units with fans

Definition:	<p>A measure of the total amount of sound power emitted by a machine (sound source) when it is operating. The A-weighted sound power level for a sound source is given in bels, B (1 B = 10 dB). The reference sound power is 1 pW.</p> <p>A measure of the total amount of sound emitted by a machine (sound source) when it is operating. The A-weighted sound pressure level for a sound source is given in decibels, dB. The reference sound pressure is 20 µPa.</p>
Reason:	Noise from fans, hard disks etc. can be annoying. To prevent such annoyance, the aim is to have as little unintentional sound generation as possible from portable computers where they are used.
Application:	Portable computers and Flat panel VDUs with built-in fans.

References: ISO 7779, Acoustics - Measurement of airborne noise emitted by computer and business equipment and ISO 9296, Acoustics - Declared noise emission values of computer and business equipment.

Method: See ISO 7779 and ISO 9296. The measurements shall be performed according to ISO 7779 with the modification that sound power measurements only have to be performed in six microphone positions. The measurements can also be performed according to another standardized method with equal or higher precision.

Mandate: **Sound pressure level**
The declared A-weighted sound pressure level at the operator position shall be reported for the following modes of operation:

Idling and operating with, respectively: hard disk, diskette drive, CD drive, DVD drive etc. (if applicable).

It should also be reported if the equipment emits broad band noise or if there are any significant discrete frequency components. If so, these frequencies shall be reported.

Sound power level

The declared A-weighted sound power level in bel (1 B = 10 dB) shall be reported and shall not exceed:

	Operating*	Idling*
Unit with fan	5.5	4.8

* with the component in operation which gives the highest sound pressure level at the operator position.

Additional information: For the sound pressure level measurements the sound source shall be placed on top of a standard test table according to ISO 7779.

The sound pressure level obtained in practice will depend on the conditions of the room and the location of the sound source.

Recommendation: It is recommended that the declared A-weighted sound power level in bel does not exceed:

	Operating*	Idling*
Unit with and without fan	5.0	4.5

* see text above.

7. Keyboard - Usability

Portable computers refer to devices that can work without any external units and are normally equipped with a built-in keyboard. The keyboards in these units are meant for occasional use and therefore do not have any mandatory ergonomic requirements but have mandatory ecology requirements.

8. Ecology

The mandatory Ecology requirements for and Flat panel VDUs and Portable computers are found in the booklet:

TCO'99 CERTIFICATION. Requirements and test methods for environmental labelling of Ecology for Displays, System Units and Keyboards. Report No. 5, Edition 2.

Contents

- General Criteria: §§ 1.1 – 1.4
- Manufacturing Processes: §§ 2.1 – 2.2
- Environmental Hazards: §§ 3.1 – 3.4
- Preparation for Recycling: §§ 4.1 – 4.3 and 4.5.
§ 4.4 Metallization of Plastic Housings is valid for Flat panel VDUs but is excluded from the requirements for Portable computers. The reason for this cancellation is the severe difficulty in meeting the special electrical and safety qualities inside such a compact product as a portable computer is today.

Test methods for Flat panel VDUs as stand alone units or as parts of Portable computers

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 the requirement 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.
- 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 associated equipment. Non-standard graphic cards are not recommended for testing, unless they are needed for a special purpose relevant for the client.
- The client shall specify the horizontal and vertical resolution of the VDU and the vertical and horizontal frequency for testing.
- The client shall supply a Users Manual or a preliminary version of such a document if any instructions concerning the adjustment of time and phase directed to the user are important for the correct functioning of the VDU screen. If such instructions are present they shall be followed by the laboratory before testing according to item 1.5.3 B is considered.

3. Settings of the VDU controls

- The settings of the VDU controls are specified in B.1.5.1 Luminance.
- The standard controls of the test VDU shall be used to configure and adjust the screen, e.g. brightness, contrast. 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 anything other than the test object during the test, unless stated otherwise by the client.
- The computer or similar devices used to run the test object in test shall not use any unnecessary software or hardware that could influence the test.
- A character generator shall only be used to operate the test VDU if the use of a standard graphic card is not possible. The reason for this is that a character generator is not representative of the usual way to run a VDU in office, home computer work nor portable use.

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 the text and graphics required for the test procedures. The reason for this is that the test shall be valid for software most commonly used in office, home computer work and portable use.
- 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. This has shown to be very important also for flat panel VDUs. The test object shall be tested under nominal conditions of input voltage, current, etc.

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 centre of 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 subtend 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.

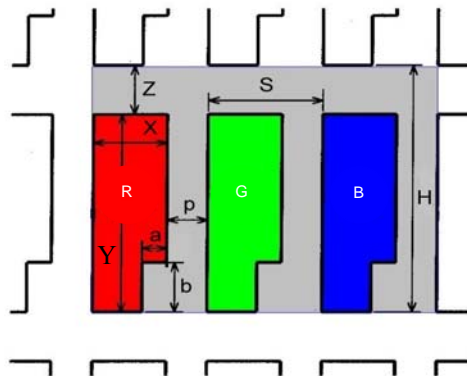
B.1 Visual ergonomics – Legibility

B.1.1 Fill factor

Method:

Fill factor shall be calculated by multiplying the height of a pixel times its width, and dividing by the area allocated to the pixel. Pixel size shall be decided by the 50 % luminance difference contours between the pixel and its background based on a luminance profile obtained in accordance with the requirements for microphotometric luminance measurements.

Many LCD technologies may have the fill factor calculated from the electro-optical producing artwork.



$$\text{Active area/sub pixel} = (X \cdot Y) - (a \cdot b)$$

$$\text{Fill factor} = (\text{Area}_{\text{red}} + \text{Area}_{\text{green}} + \text{Area}_{\text{blue}}) / (3S \cdot H) = 3 \cdot (X \cdot Y - a \cdot b) / (3S \cdot H)$$

Uncertainty: $\leq \pm 10 \%$ of the measured luminance
 $\leq \pm 0.1 \text{ mm}$ for measured size

B.1.5 Luminance

B.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 adjusted as necessary.

Test image for maximum luminance

An image with an image loading of $80 \pm 5 \%$ (80 % white/20 % black) shall be used when measuring the maximum luminance of the VDU. In the centre of the screen a white area, 4 by 4 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 125 cd/m^2 for Flat panel VDUs and 100 cd/m^2 for Portable computers. If necessary, the contrast control may in addition be used to achieve 125 cd/m^2 and 100 cd/m^2 , respectively.

These brightness and contrast settings shall be used for all the remaining visual ergonomic testing.

Uncertainty: $\leq \pm 10 \%$ of the measured luminance.

B.1.5.2 A Luminance uniformity

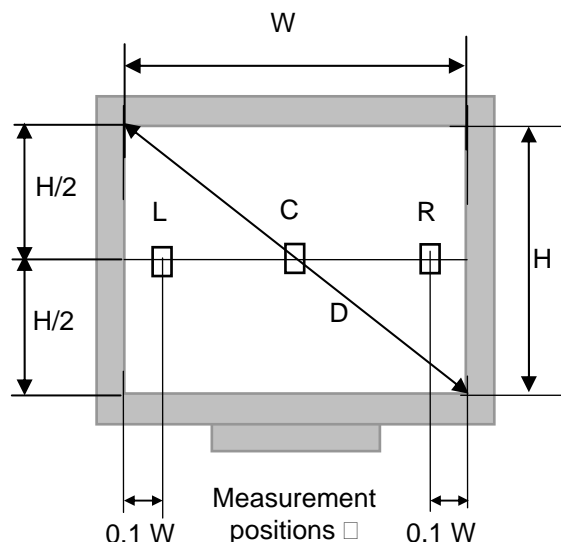
Method:

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.

Uncertainty: $\leq \pm 10 \%$ of the measured luminance.

B.1.5.2 B Luminance uniformity – angular-dependent

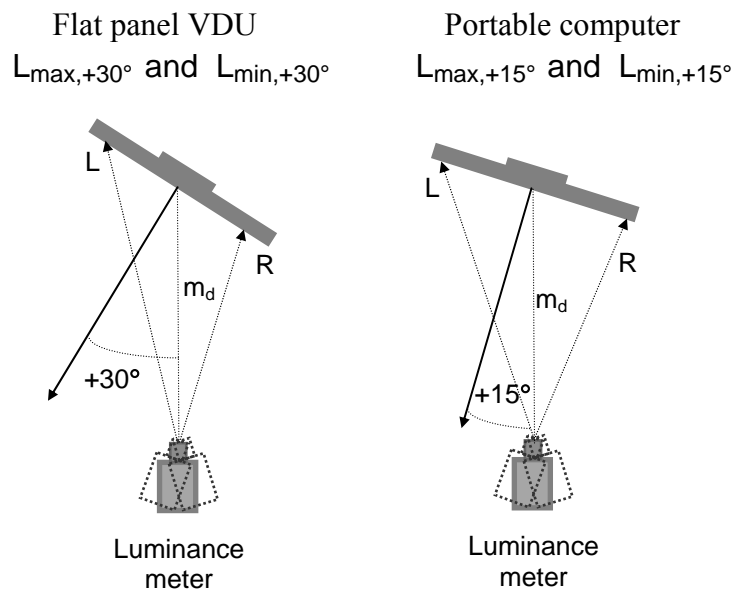
Method:



- Luminance is measured at the centre measurement position “C” on the screen. The measurement positions shall consist of active white squares of size 4 by 4 cm. The optical axis of the luminance meter shall be aligned with the normal of the screen surface in measuring point “C”.
- The measuring distance “ m_d (cm)” between the luminance meter and the VDU screen is set to:

$$m_d \text{ (cm)} = D \times 1.5 \text{ with a minimum distance: } m_d = 50 \text{ cm.}$$
 (D is the diagonal of the screen in centimetres)
- The luminance at position L and R is measured and the luminance shall not differ more than $\pm 15\%$.
- The display is rotated around a vertical axis through the centre of the display changing the azimuth angle to $+30^\circ$ for Flat panel VDUs and $+15^\circ$ for Portable computers. The distance between the display and the luminance meter is not altered and the luminance meter is directed at exactly the same measuring point as prior to the display rotation.

The luminance meter is then rotated varying only the azimuth angle of the luminance meter with a fixed distance to the display. Luminances are measured at measuring points “L” and “R” giving:



- The display is then rotated to an azimuth angle of -30° and -15° , respectively.
 $L_{\max, -30^\circ}$ and $L_{\min, -30^\circ}$ for Flat panel VDU and $L_{\max, -15^\circ}$ and $L_{\min, -15^\circ}$ for Portable computer are measured using the same procedure.

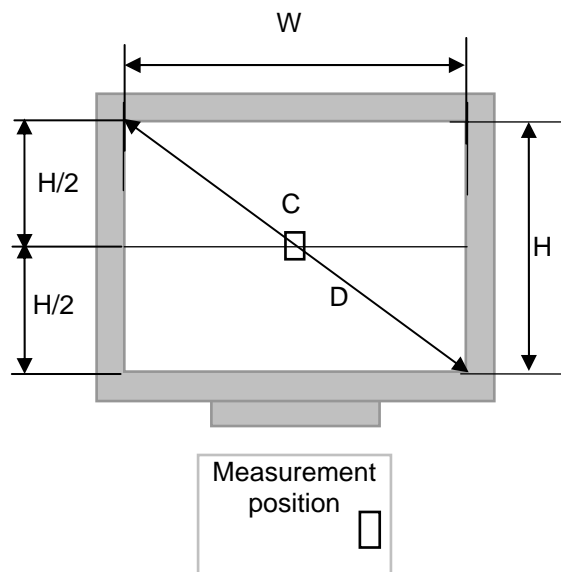
6. The variation in luminance ratio is calculated as the ratio:

$$L_R = ((L_{\max,+30^\circ} / L_{\min,+30^\circ}) + (L_{\max,-30^\circ} / L_{\min,-30^\circ})) / 2 \text{ and}$$
$$L_R = ((L_{\max,+15^\circ} / L_{\min,+15^\circ}) + (L_{\max,-15^\circ} / L_{\min,-15^\circ})) / 2, \text{ respectively}$$

Uncertainty: $\leq \pm 10\%$ in the measured luminances.

B.1.5.3 A Luminance contrast – angular-dependent

Method:



1. Luminance contrast modulation is measured at the centre measurement position "C" of the screen. The measurement position shall consist of an active white square of size 4 by 4 cm, and a black square of size 4 by 4 cm. The luminance meter shall be aligned with the normal of the screen in measuring point "C".

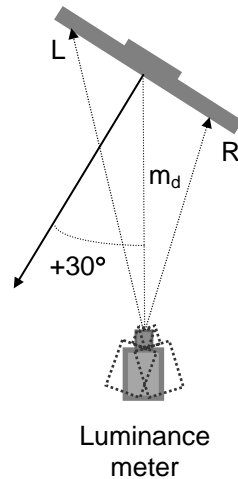
2. The measuring distance " m_d (cm)" between the luminance meter and the VDU screen is set to:

$$m_d \text{ (cm)} = D \times 1.5 \text{ with a minimum distance: } m_d = 50 \text{ cm.}$$

(D is the diagonal of the screen in centimetres)

3. The display is rotated around a vertical axis changing the azimuth angle to $+30^\circ$. The distance between the display and the luminance meter is not altered and the luminance meter is directed at exactly the same measuring point as prior to the display rotation. Luminances are measured on the two squares placed in the centre measuring point "C" giving:

$L_{\text{white},+30^\circ}$ and $L_{\text{black},+30^\circ}$



- The display is then rotated to an azimuth angle of -30° and $L_{\text{white},-30^\circ}$ and $L_{\text{black},-30^\circ}$ are measured with the same procedure. Changing azimuth angle to 0 degrees (the optical axis of the luminance meter aligned with the normal of measurement point "C") W_{white} and B_{black} are measured.

- The luminance contrast modulation C_m is calculated as:

$$C_m = (L_{\text{white}} - L_{\text{black}}) / (L_{\text{white}} + L_{\text{black}})$$

for $+30^\circ$ and -30° azimuth angles. The lowest value for C_m is reported. C_m is also calculated and reported for 0 degree azimuth angle as a reference.

Uncertainty: $\leq \pm 10\%$ of the measured luminance.

B.1.5.3 B Luminance contrast - characters

Method:

- LCDs sometimes show visual bands, stripes or patches with significant lower contrast. The setting of various timing and phase controls as well as the setting of image geometry controls can cause such serious defects to occur. For example the contrast over a single character can vary substantially as an effect of such stripes of low contrast.

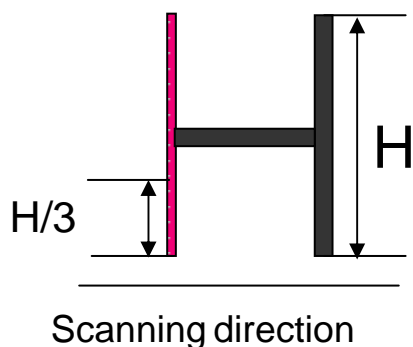
Correct settings of timing, phase and geometry controls can remove this effect but sometimes it is not possible for the VDU operator to find the proper control settings, and the testing procedure B.1.5.3 B shall be carried out.

- The measurement position for this luminance level shall consist of an active white square of size 4 by 4 cm in the centre of the screen. The

luminance meter shall be aligned normal to the screen. The screen shall be filled with capital "H" giving an image load of 80 %. Font Arial 12 shall be used.

3. By the use of visual evaluation the testing engineer shall visually search for and geometrically locate visual stripes, or patches, that clearly influence the contrast of characters or even parts of characters. The viewing angle of the testing engineer shall be aligned with the normal of the screen surface. Once the patches are visually located as having significant low contrast they are geometrically referenced to the upper left corner of the active image. The dimension of the active image is reported.
4. With a micro-video luminance meter or a luminance scanner the luminance profiles are measured as indicated in the figure below. The optical axis of the luminance meter is aligned with the normal of the screen surface at the measuring point. Deviation in alignment between the screen surface normal and the optical axis of the luminance meter shall be less than 2° in every angular direction. The height of the measuring area, as indicated in the figure, shall be $1/3$ of the actual height of the character "H" using font Arial 12.

Separate measurements shall be made at various locations and each measurement shall be geometrically referenced to the upper left corner of the area image. Based on the luminance profile a calculation of the luminance contrast modulation (C_m) is made.



Uncertainty: $\leq \pm 10\%$ of the measured luminance.

B.1.6 Front frame gloss

Method for reflectance:

The requirement is deleted.

Note! The Portable computers do not have any mandatory requirement for reflectance.

Method for gloss:

Measurement of gloss shall be made on the front frame of the VDU as a stand alone unit or as a part of a Portable Computer. The gloss measurement instrument may need an absolutely flat surface to function properly. If all parts of the front frame of the VDU are curved, then a measurement could be made elsewhere on the housing given that the measured surface microstructure and colour are the same as those of the surface of the front frame.

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

The measurement shall be made under dark room conditions, 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.

B.2 Visual ergonomics – Image stability

B.2.1 Periodic luminance variation

The requirement is deleted.

General test conditions for emissions

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

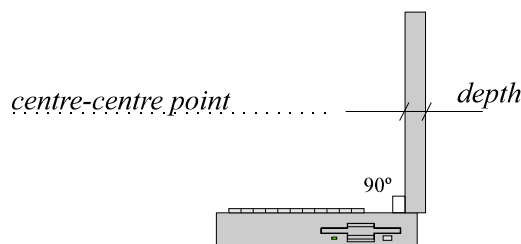
The test results are valid only for the presentation form(s) and configuration(s) tested.

1. Extra measurement distances for TCO'99 emission characteristics

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. Conditions and set up for the test object

- The tests shall be performed with the full screen size activated.
- When the Flat panel VDU/Portable computer 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 test report.
- The supply voltage and frequency used during the test shall be stated in the test 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 125 cd/m^2 for Flat panel VDUs and 100 cd/m^2 for Portable computers at an image loading of $80 \pm 5 \%$ (80 % white and 20 % black) shall be used for the emission testing of alternating electric and magnetic fields. See the luminance measurement section for details concerning this setting.
- When testing Flat panel VDUs and Portable computers, the screen shall be in an upright position and the centre of rotation shall be calculated from half the depth at the centre-centre point of the screen.



3. Positioning of external power supply units

- The external power supply unit, if any, will contribute to the electromagnetic fields around the equipment.
- The power supply unit shall be positioned directly behind the test sample. If this is not possible, then the positioning shall be described in the test report.

B.4 Emissions and energy saving

B.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 25 cm to the outer surface of the VDU and with co-ordinates according to:

$$\begin{aligned}z &= 0 \\r &= L/2 + 50 \quad (\text{In the front also } 30 \text{ cm}) \\ \vartheta &= 0^\circ \text{ for band I} \\ \vartheta &= 0^\circ, 90^\circ, 180^\circ \text{ and } 270^\circ \text{ for band II}\end{aligned}$$

Distances are given in centimetres 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.

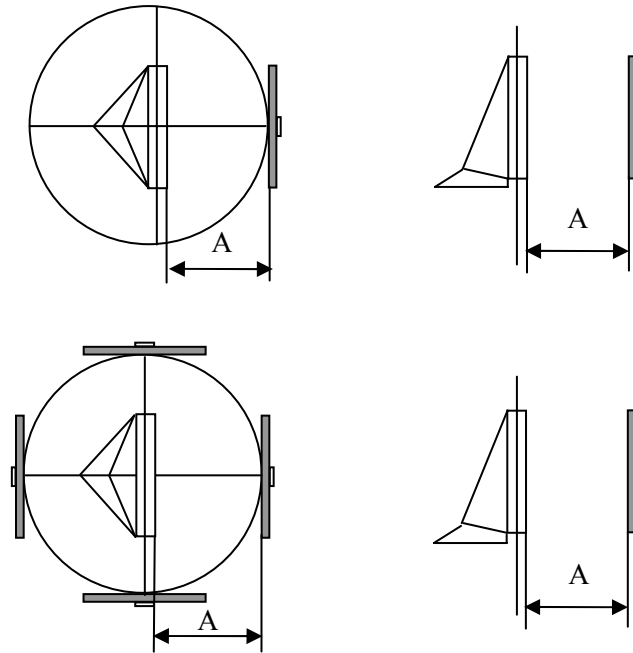


Figure: Measurement geometry for band I (top) and band II (bottom). A is the measurement distance 50 cm. In front of the test sample the testing must be made also at 30 cm distance.

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 is 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 2.0 V/m in band I and 0.20 V/m in band II.

The mains voltage of the VDU under test shall be within $\pm 3\%$ 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 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.

The VDU under test shall be connected to the mains power supply via a cable that shall be laid horizontally 40 cm out from the test object, measured from the screen surface, 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 below. 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 is 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.

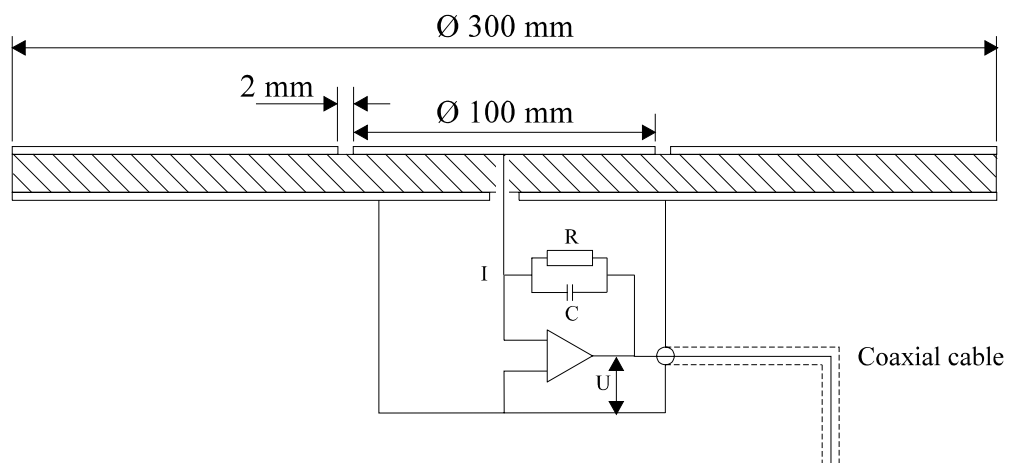


Figure: Sketch and circuit principle of the measuring probe for alternating electrical field measurements. The feedback circuit of the operational amplifier is a capacitance C in parallel with a high value resistor R to ensure that there is no DC voltage across the plates of the capacitor C.

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 $\pm 5\%$ at 50/60 Hz.

The measuring system shall be capable of measuring 2.0 V/m in band I and 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 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 $\pm 5\%$ 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 values at 30 cm and 50 cm for normal and stand-by operations if they differ. For band II, the measured values in front of the VDU 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.

Measurement uncertainty:

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

B.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 below and the measurement points are mathematically defined in the following way.

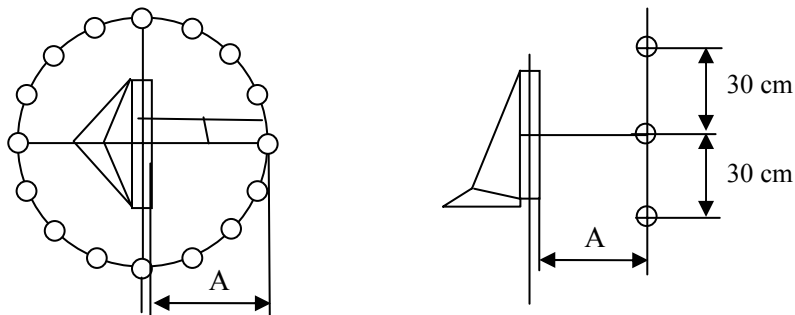


Figure: Measurement geometry for the test object (distances in m). A is the measurement distance 50 cm. In front of the test sample the testing must be made also at 30 cm distance.

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 25 cm to the outer surface of the VDU and with co-ordinates according to:

$$z = - 30 \text{ cm, } z = 0 \text{ and } z = + 30 \text{ cm}$$

$$r = L/2 + 50 \text{ cm} \quad (\text{In the front also } 30 \text{ cm})$$

$$\vartheta = p \cdot 22.5^\circ \text{ where } p \text{ represents all integers in the range } 0 \leq p \leq 15.$$

Distances are given in centimetres 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 power supply 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 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 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 kHz	> 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-values of the amplitudes of the magnetic flux density vectors 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 5.0 nT in band II.

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

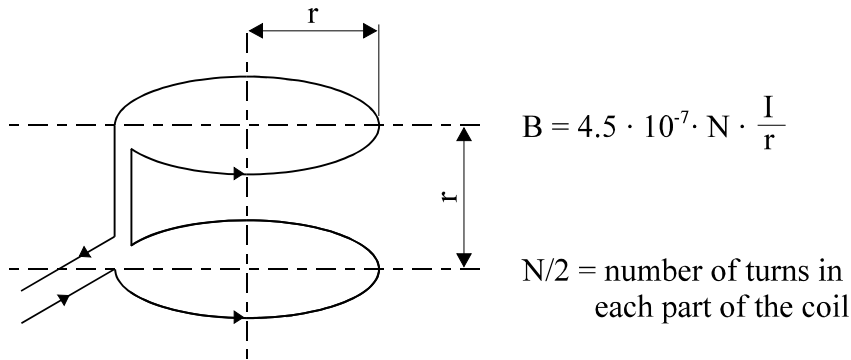


Figure: Calibration set-up.

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 $\pm 5\%$ 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.

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 10.0 nT in band II the result shall be reported as “ ≤ 200 nT” and “ ≤ 10.0 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 $\pm (10\% \text{ of reading} + 30 \text{ nT})$ for band I and $\pm (10\% \text{ of reading} + 1.5 \text{ nT})$ 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.

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 allow at least 5 minutes to elapse before the recovery time is tested.

Energy Saving Position A2

Energy Saving Position A2 shall occur when the input device has not been activated 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 a maximum of one hour in the set up routine of the computer used together with the VDU by the user.

Indicator lamp

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

Energy declaration

The energy declaration shall specify the 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 long 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.

B.5 Electrical safety

B.5.1 Electrical safety

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

B.6 Accoustic noise

B.6.6 Acoustic noise from units with fans

Method: See the text under section A.6.6 Accoustic noise from units with fans.