

INTERNATIONAL STANDARD

NORME INTERNATIONALE



**Medical electrical equipment – Medical image display systems –
Part 1: Evaluation methods**

**Appareils électromédicaux – Systèmes d'imagerie médicale –
Partie 1: Méthodes d'évaluation**



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Part 1: Evaluation methods**

**Appareils électromédicaux – Systèmes d'imagerie médicale –
Partie 1: Méthodes d'évaluation**

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**Medical electrical equipment – Medical image display systems –
Part 1: Evaluation methods**

**Appareils électromédicaux – Systèmes d'imagerie médicale –
Partie 1: Méthodes d'évaluation**

CONTENTS

FOREWORD.....	5
INTRODUCTION.....	7
INTRODUCTION to Amendment 1.....	7
INTRODUCTION to Amendment 2.....	7
1 Scope	8
2 Normative references	8
3 Terms, definitions, symbols and abbreviations.....	8
3.1 Terms and definitions	8
3.2 Symbols	11
3.3 Abbreviations	12
4 General	12
5 Prerequisites	12
6 Equipment and tools	13
6.1 LUMINANCE meter	13
6.2 ILLUMINANCE meter	13
6.3 Colour meter	13
6.4 TEST PATTERNS	14
7 Evaluation methods	15
7.1 General	15
7.2 Evaluation method table overview	15
7.3 Visual evaluation methods	17
7.3.1 General	17
7.3.2 Overall image quality evaluation	17
7.3.3 Greyscale resolution evaluation.....	18
7.3.4 LUMINANCE response evaluation.....	19
7.3.5 LUMINANCE uniformity evaluation.....	20
7.3.6 Chromaticity evaluation	20
7.3.7 Pixel faults evaluation	20
7.3.8 VEILING GLARE evaluation.....	21
7.3.9 Geometrical image evaluation	21
7.3.10 Angular viewing evaluation.....	22
7.3.11 Clinical evaluation.....	23
7.4 Quantitative evaluation methods	23
7.4.1 Basic LUMINANCE evaluation.....	23
7.4.2 Basic LUMINANCE evaluation without ambient light	24
7.4.3 LUMINANCE response evaluation.....	24
7.4.4 LUMINANCE evaluation of multiple displays	27
7.4.5 Chromaticity uniformity evaluation	27
7.4.6 Chromaticity evaluation ~~of~~ across multiple displays.....	27
7.4.7 LUMINANCE uniformity evaluation.....	27
7.4.8 Viewing angle evaluation.....	28
7.4.9 Greyscale chromaticity evaluation	28
Annex A (informative) Sample test reports.....	29
Annex B (informative) LUMINANCE measurement methods	48
Annex C (informative) Description of TEST PATTERNS	48

Annex D (informative) Evaluation methods for handheld display devices	60
Bibliography	70
Index of defined terms	72
Figure 1 – Overall image quality evaluation using the TG18-QC TEST PATTERN	17
Figure 2 – Overall image quality evaluation using the TG18-OIQ TEST PATTERN	18
Figure 3 – Magnified view of TG18-MP TEST PATTERN showing the 8-bit and 10-bit markers	19
Figure 4 – A close-up of the TG18-CT TEST PATTERN	20
Figure 5 – The TG18-GV TEST PATTERN is displayed (left), a close-up of the centre of the TEST PATTERN when covered with a mask (right)	21
Figure 6 – Geometrical evaluation using the GD pattern	22
Figure 7 – Visual evaluation of viewing angle response	23
Figure 8 – Example of the measured LUMINANCE in relation to the standard LUMINANCE response function according to GREYSCALE STANDARD DISPLAY FUNCTION (GSDF)	26
Figure 9 – An example of the CONTRAST response computed from 18 grey levels as related to the expected CONTRAST response associated with the DICOM 3.14 [2] standard LUMINANCE response with a given tolerance limit (e.g. 15 %) [10]	26
Figure B.1 – Method A, telescopic method	48
Figure B.2 – Method B, near-range LUMINANCE meter in combination with an ILLUMINANCE meter	49
Figure B.3 – Method C, frontal integrated LUMINANCE meter in combination with ILLUMINANCE meter	49
Figure B.4 – Method D, back integrated LUMINANCE meter in combination with ILLUMINANCE meter	50
Figure C.1 – Example of TG-18 QC pattern for a matrix size of 1536 × 2048	59
Figure D.1 – Hh-Ctr TEST PATTERN	64
Figure D.2 – Grey level emphasized angular target	64
Table 1 – Overview to the definitions of physical parameters	11
Table 2 – TEST PATTERNS used for display testing	14
Table 3 – List of the evaluation methods that can be used for testing medical IMAGE DISPLAY SYSTEMS	16
Table A.1 – Acceptance test sample report of a diagnostic display	30
Table A.2 – Constancy test sample report of a diagnostic display	35
Table A.3 – Acceptance test sample report of a monochrome reviewing display	38
Table A.4 – Constancy test sample report of a monochrome reviewing display	40
Table A.5 – Acceptance test sample report of a colour reviewing display	42
Table A.6 – Constancy test sample report of a colour reviewing display	45
Table C.1 – Description of multi-purpose TEST PATTERNS	52
Table C.2 – TG18-QC pattern: LUMINANCE levels with 8-bit and [12-bit] pixel values and CX ratings	55
Table C.3 – The blurring characteristics of the CX reference set utilized in TG18-QC TEST PATTERNS [16]	56
Table C.4 – Evaluation criteria for the examples of the CLINICAL REFERENCE IMAGES	57
Table C.5 – Example description of TG-18 QC pattern for a matrix size of 1536 × 2048	58

Table D.1 – Major characteristics of typical handheld devices compared to IMAGE DISPLAY SYSTEMS	60
Table D.2 – TEST PATTERNS for handheld device	61
Table D.3 – Recommended TEST ITEMS for handheld devices	63
Table D.4 – Description of TEST PATTERNS for handheld devices	65

INTERNATIONAL ELECTROTECHNICAL COMMISSION

MEDICAL ELECTRICAL EQUIPMENT – MEDICAL IMAGE DISPLAY SYSTEMS –

Part 1: Evaluation methods

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IEC 62563-1 edition 1.2 contains the first edition (2009-12) [documents 62B/743/CDV and 62B/768/RVC], its amendment 1 (2016-03) [documents 62B/983/CDV and 62B/995/RVC] and its amendment 2 (2021-07) [documents 62B/1168/CDV and 62B/1203/RVC].

In this Redline version, a vertical line in the margin shows where the technical content is modified by amendments 1 and 2. Additions and deletions are displayed in red, with deletions being struck through. A separate Final version with all changes accepted is available in this publication.

International Standard IEC 62563-1 has been prepared by subcommittee 62B: Diagnostic imaging equipment of technical committee 62: Electrical equipment in medical practice.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

In this standard, the following print types are used:

- requirements and definitions: roman type;
- informative material appearing outside of tables, such as notes, examples and references: in smaller type. Normative text of tables is also in a smaller type;
- TERMS DEFINED IN CLAUSE 3 OF THIS INTERNATIONAL STANDARD, OR AS NOTED: SMALL CAPITALS.

A list of all parts of the IEC 62563 series, published under the general title *Medical electrical equipment – Medical image display systems*, can be found on the IEC website.

The committee has decided that the contents of the base publication and its amendments will remain unchanged until the stability date indicated on the IEC web site under webstore.iec.ch in the data related to the specific publication. At this date, the publication will be

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- withdrawn,
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INTRODUCTION

This International Standard provides evaluation methods for testing IMAGE DISPLAY SYSTEMS used in MEDICAL ELECTRICAL EQUIPMENT and medical electrical systems for diagnostic imaging.

On site or after installation, two types of testing can be carried out. An acceptance test is carried out after a new IMAGE DISPLAY SYSTEM has been installed, or major modifications have been made to the existing IMAGE DISPLAY SYSTEM. Since an IMAGE DISPLAY SYSTEM may degrade over time, the constancy test is carried out by the user in a periodic cycle to verify that the performance is maintained for the intended use.

The standard describes various evaluation methods without dictating what particular tests shall be used for acceptance and/or constancy tests.

Rather, it is the intention of this standard to be a reference for other standards and guidelines specific to each modality or to be defined by national authorities who will refer to the evaluation methods of this standard and mention limiting values and frequencies for acceptance and constancy tests. Annex A shows sample reports of such a reference.

To maintain the homogeneity in the IEC standards for MEDICAL ELECTRICAL EQUIPMENT, IEC 61223-2-5, *Evaluation and routine testing in medical imaging departments – Part 2-5: Constancy tests – Image display devices* should be reviewed.

INTRODUCTION to Amendment 1

This amendment is published to introduce colour measurement.

Since publication of IEC 62563-1:2009, IEC 61223-2-5, *Evaluation and routine testing in medical imaging departments Part 2-5: Constancy tests – Image display devices* has been reviewed and withdrawn.

INTRODUCTION to Amendment 2

This amendment is intended to introduce evaluation methods for handheld display devices.

MEDICAL ELECTRICAL EQUIPMENT – MEDICAL IMAGE DISPLAY SYSTEMS –

Part 1: Evaluation methods

1 Scope

This part of IEC 62563 describes the evaluation methods for testing medical IMAGE DISPLAY SYSTEMS.

The scope of this International Standard is directed to practical tests that can be visually evaluated or measured using basic test equipment. More advanced or more quantitative measurements can be performed on these devices, but these are beyond the scope of this document.

This standard applies to medical IMAGE DISPLAY SYSTEMS, which can display ~~monochrome~~ image information ~~in the form of greyscale values on colour and~~ on greyscale and colour IMAGE DISPLAY SYSTEMS ~~(e.g. CATHODE RAY TUBE (CRT) monitors, FLAT PANEL DISPLAYS, PROJECTION SYSTEM)~~. This standard applies to medical IMAGE DISPLAY SYSTEMS used for diagnostic (interpretation of medical images toward rendering clinical diagnosis) or viewing (viewing medical images for medical purposes other than for providing a medical interpretation) purposes and therefore having specific requirements in terms of image quality. Head mounted IMAGE DISPLAY SYSTEMS and IMAGE DISPLAY SYSTEMS used for confirming positioning and for operation of the system are not covered by this standard. Handheld IMAGE DISPLAY SYSTEMS might require additional or modified versions of the procedures described in this standard.

It is not in the scope of this standard to define the requirements of acceptance and constancy tests ~~nor~~ the frequencies of constancy tests.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60788:2004, *Medical electrical equipment – Glossary of defined terms*

ISO 11664-1:2007, *Colorimetry – Part 1: CIE standard colorimetric observers*

CIE S 010/E:2004 *Photometry – The CIE system of physical photometry*

3 Terms, definitions, symbols and abbreviations

3.1 Terms and definitions

For the purpose of this document, the terms and definitions given in IEC 60788:2004 and the following apply.

3.1.1

accuracy

closeness of agreement between a test result and the accepted reference value



3.1.2
brightness

LUMINANCE as perceived by the human visual system

3.1.3
cathode ray tube
CRT

picture tube

component of an IMAGE DISPLAY SYSTEM in which images defined via electrical signals are visualized by means of an electron beam striking a phosphor

3.1.4
clinical reference image

specific medical image typical for the intended use of the IMAGE DISPLAY SYSTEM

NOTE The anatomical patterns reported in Annex C are examples of CLINICAL REFERENCE IMAGE.

3.1.5
clock artefact

artefact in form of distorted vertical bars or stripes, visible on the screens of fixed-pixel type IMAGE DISPLAY DEVICES (e.g. LCD), when the frequency of the internal dot clock is different from that of the incoming analogue signal

3.1.6
contrast

<IMAGE DISPLAY DEVICES> ratio of the difference of the LUMINANCE of two image areas, $L_1 - L_2$, divided by the average of the two LUMINANCE values:

$$\text{CONTRAST} = 2 \cdot (L_1 - L_2) / (L_1 + L_2)$$

3.1.7
digital driving level
DDL

digital value given as input to an IMAGE DISPLAY SYSTEM producing a LUMINANCE

3.1.8
display controller

electronic component of an IMAGE DISPLAY SYSTEM that provides the analogue or digital interface between the computer hardware and the IMAGE DISPLAY DEVICE

3.1.9
flat panel display

IMAGE DISPLAY DEVICE that is flat and thin

NOTE E.g. liquid crystal display (LCD), plasma display (PDP), field emission display (FED), surface-conduction electron-emitter display (SED), carbon-nano-tube display (CNT), organic light-emitting display (OLED).

3.1.10
flicker

perception of unintentional fluctuations of the LUMINANCE over time

3.1.11
greyscale standard display function
GSDF

mathematically defined mapping of input, DIGITAL DRIVING LEVEL (DDL) to LUMINANCE values based on the Barten model

[Source: DICOM PS 3.14:2007, see [2]¹⁾]

3.1.12

illuminance

measurement of the luminous flux incident on a surface per unit area (unit: Lux (lx), $\text{lx} = \text{lm}/\text{m}^2$)

3.1.13

image display device

monitor

specific hardware/medium used to display images presented through an analogue or digital interface

3.1.14

image display system

workstation consisting of an IMAGE DISPLAY DEVICE, DISPLAY CONTROLLER and computer hardware and software, capable of displaying images

3.1.15

luminance

ratio of luminous flux penetrating (impinging on) a surface area in a specified direction to the product of the irradiated solid angle and the projection of the surface area onto a plane perpendicular to the viewing direction (unit: candela per square meter (cd/m^2))

NOTE This definition has been derived from the term in DIN 5031-3:1982-03 [18] and is equivalent to the definition in the International Electrotechnical Vocabulary (IEV).

3.1.16

phase artefact

artefact in form of blurred edges of displayed objects (letters, lines, etc.), visible on the screens of fixed-pixel type IMAGE DISPLAY DEVICES (e.g. LCD), when the phase setting of the internal dot clock is different from that of the incoming analogue signal

3.1.17

precision

closeness of agreement between independent test results obtained under stipulated conditions

[ISO 5725-1:1994, definition 3.12]

3.1.18

projection system

large-screen IMAGE DISPLAY DEVICE which enlarges the small image generated on a plane by central projection to a second plane

3.1.19

resolution addressability ratio

RAR

measured pixel at 50 % point of LUMINANCE at peak or nominal rating expressed as a percentage of addressable space available

3.1.20

spatial resolution

measure of the ability of an IMAGE DISPLAY SYSTEM to distinguish spatial features of interest within an image

¹⁾ Figures in square brackets refer to the Bibliography.

NOTE Systems designed with adequate SPATIAL RESOLUTION characteristics are necessary to assure that spatial details of interest are preserved when a medical image is displayed. Portraying image data on a IMAGE DISPLAY DEVICE with insufficient resolution will compromise the ACCURACY of the radiological interpretation.

3.1.21

test image

test pattern

image for testing or verifying the IMAGE DISPLAY SYSTEMS

3.1.22

veiling glare

enhancement of the LUMINANCE measurable on the IMAGE DISPLAY DEVICE caused by internal scatter processes

NOTE The value of the LUMINANCE enhancement is dependent on the illuminated portion of the image displayed.

3.1.23

window setting

display of a subset of the pixel values existing in the digital image

NOTE The WINDOW SETTING is determined by the window width and level (centre) and serves for CONTRAST enhancement.

3.2 Symbols

The symbols of physical parameters used in this standard are listed in Table 1. All measurements referred to in Table 1 are in the centre of the IMAGE DISPLAY DEVICE. Note that LUMINANCE may also be measured at other locations according to the methodologies described in this document.

Table 1 – Overview to the definitions of physical parameters

Abbreviation	Mathematically derived	Definition and explanation
L_{amb}		LUMINANCE generated by the ambient light on the surface of an IMAGE DISPLAY DEVICE when the IMAGE DISPLAY DEVICE is off.
L_{min}		Minimum LUMINANCE generated by a IMAGE DISPLAY DEVICE at DIGITAL DRIVING LEVEL (DDL) = 0 measured at the centre of the screen. It includes VEILING GLARE specific to TEST PATTERN used for measurement. It is measured with ambient light totally switched off (in the dark).
L_{max}		Maximum LUMINANCE generated by a IMAGE DISPLAY DEVICE at DIGITAL DRIVING LEVEL (DDL) = max measured at the centre of the screen. It includes VEILING GLARE specific to TEST PATTERN used for measurement. It is measured with ambient light totally switched off (in the dark).
L'_{min}	$L_{min} + L_{amb}$	LUMINANCE that will be perceived by the human eye at the centre of the screen at DIGITAL DRIVING LEVEL (DDL) = 0. It contains VEILING GLARE and L_{amb} .
L'_{max}	$L_{max} + L_{amb}$	LUMINANCE produced by the IMAGE DISPLAY DEVICE at the maximum DIGITAL DRIVING LEVEL (DDL) measured at the centre of the screen. It contains VEILING GLARE and L_{amb} .
R_d		Diffuse reflection coefficient (provided by manufacturer with a specific measurement method, ideally following the methods described in Reference [10] using a CIE standard illuminant A and an aperture size 20 to 30 % larger than the diameter of the LUMINANCE meter).
r'	L'_{max}/L'_{min}	LUMINANCE ratio of an IMAGE DISPLAY DEVICE containing VEILING GLARE and ambient LUMINANCE.
E		ILLUMINANCE.
a	L_{amb}/L'_{min}	Safety factor.

Abbreviation	Mathematically derived	Definition and explanation
a_R	L_{amb}/L_{min}	Alternative safety factor. This factor is defined to provide consistency with other relevant documents (e.g. ACR–AAPM–SIIM Technical Standard For Electronic Practice Of Medical Imaging, Amended 2014, Resolution 39).
$\Delta u'v'$	$((u_1'-u_2')^2 + (v_1'-v_2')^2)^{1/2}$	~~Maximum~~ Distance in $u'-v'$ space.

3.3 Abbreviations

The following abbreviations are used in this standard.

CRT	cathode ray tube
CT	computed tomography
DDL	digital driving level
DICOM	digital imaging and communication in medicine
LCD	liquid crystal display
MR	magnetic resonance

4 General

In IMAGE DISPLAY SYSTEMS, every individual component can limit or reduce the image quality of the system. Therefore it is necessary to adopt suitable measures for quality monitoring. If IMAGE DISPLAY SYSTEMS are correctly adjusted and maintained, these devices can consistently generate similar images.

Simple test equipment is used (LUMINANCE meter, TEST IMAGES) with PRECISION appropriate for the purpose of a test. Before a test, all test equipment shall be checked for its functioning according to the manufacturer's specifications.

The manufacturer's data (e.g. requirements on operating voltage, humidity etc.) are required for the correct setting of the IMAGE DISPLAY SYSTEM and for correct installation. The manufacturer's data shall be enclosed with the technical documentation of the IMAGE DISPLAY SYSTEM.

The tests listed in this International Standard are a compilation of all the evaluation methods that may be used for testing an IMAGE DISPLAY SYSTEM. A subset of these test items or test methods may be selected and applied in any order depending on the intended purpose of the IMAGE DISPLAY SYSTEM.

For mobile systems, a fixed location for these tests shall be determined and used so that it is representative for the locations where such mobile systems may be used. Care should be taken to ensure that the ambient lighting in these areas can be adequately controlled.

5 Prerequisites

Prior to testing an IMAGE DISPLAY SYSTEM, the following shall be considered:

- The testing of an IMAGE DISPLAY SYSTEM shall include the complete system including software, hardware and settings involved in image handling.
- For all IMAGE DISPLAY SYSTEMS to be tested, all components including computer, IMAGE DISPLAY DEVICE, display card, display software, and software version shall be traceable.
- The TEST IMAGES and the clinical images shall be presented in the same way on the IMAGE DISPLAY SYSTEM.

- d) Before starting the tests, the front surface of the IMAGE DISPLAY DEVICE shall be cleaned according to the instructions for use.
- e) It shall be ensured that no prior nominal settings have been changed.
- f) Room lights, windows, viewing devices etc. shall not cause any disturbing reflections on the IMAGE DISPLAY DEVICE. Methods to prevent reflections are described in the standards ISO 9241-302, ISO 9241-303, ISO 9241-305 and ISO 9241-307.
- g) The ambient lighting in the room shall be maintained at normally used conditions.
- h) Before initiating a test, the IMAGE DISPLAY SYSTEM shall be installed and started up according to the manufacturer's recommendations; to ensure stable performance, the IMAGE DISPLAY DEVICE shall be switched on before the test for a period as specified by the manufacturer (e.g. 30 min). The IMAGE DISPLAY SYSTEM should be set to the desired display function. The GREYSCALE STANDARD DISPLAY FUNCTION (GSDF) is recommended and is a necessary prerequisite for some tests.

6 Equipment and tools

6.1 LUMINANCE meter

A LUMINANCE meter shall have the following specifications. The range of the LUMINANCE meter shall cover at least the range of LUMINANCE of the IMAGE DISPLAY SYSTEM with a PRECISION of at most 5 % (repeatability), and an ACCURACY of at most 10 %, with a calibration traceable to a primary standards laboratory. The manufacturer of the meter shall provide a clear calibration program. The aperture angle shall not exceed 5°. The relative spectral sensitivity shall correspond to the BRIGHTNESS CIE standard photopic spectral response (CIE S 010/E:2004). The influence of the photopic response shall be within the overall ± 10 % ACCURACY described in this paragraph.

For near range LUMINANCE meters, a predefined angle and distance of measurement result in a defined measurement field size. During a measurement, the area to be measured shall be displayed by a field (or patch) that is significantly bigger than the defined measurement field size.

A LUMINANCE meter can be integrated into the IMAGE DISPLAY SYSTEM or be a stand-alone device.

6.2 ILLUMINANCE meter

An ILLUMINANCE meter may be required for testing IMAGE DISPLAY SYSTEMS with a range of 1 to 1 000 lux with an ACCURACY of at most 10 % and a PRECISION of at most 5 % (repeatability). The device calibration shall be traceable to a primary standards laboratory and shall have a clear calibration program. It shall have a uniform response to a Lambertian light source.

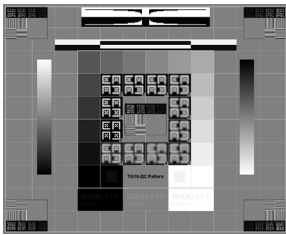
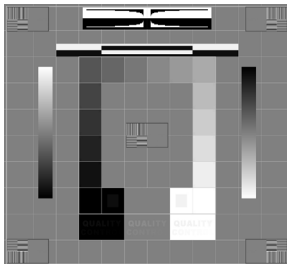
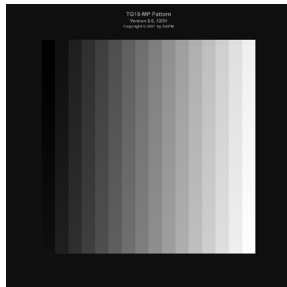
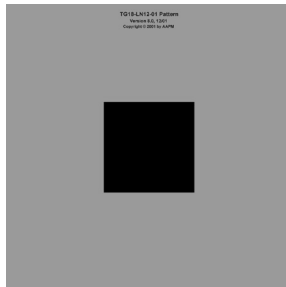
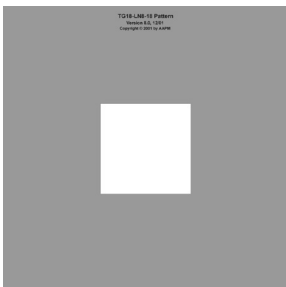
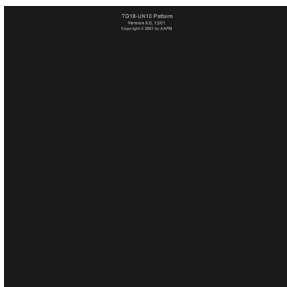
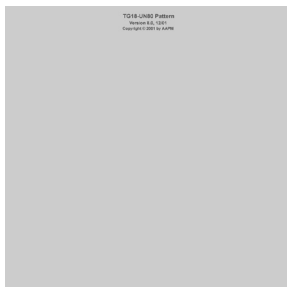
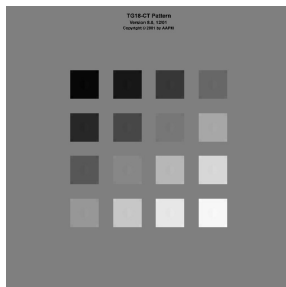
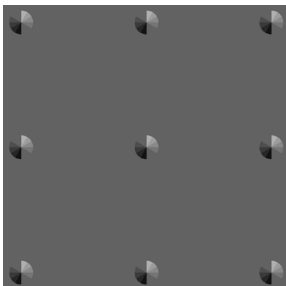
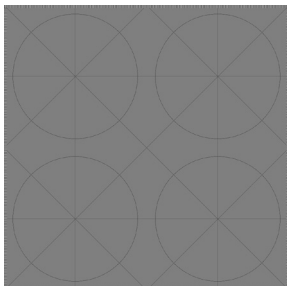
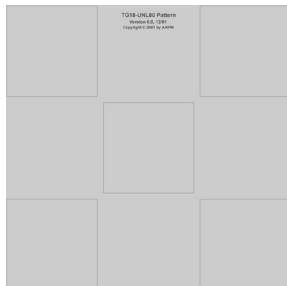
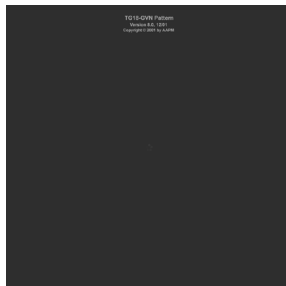
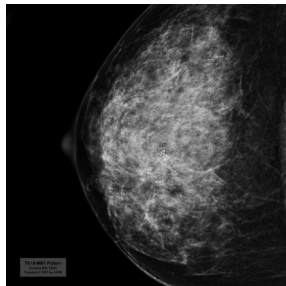
In measurement method B, C and D (described in Annex B), the ILLUMINANCE meter is ideally located at the centre of the screen facing outward. Side locations will also be acceptable as long as they provide similar measured values.

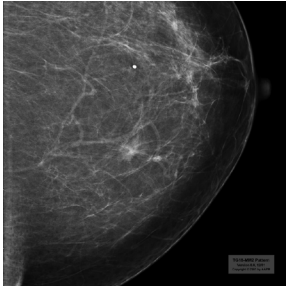
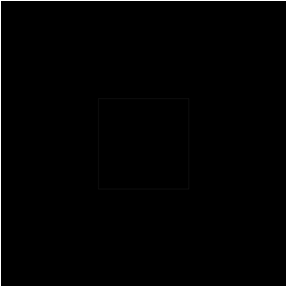
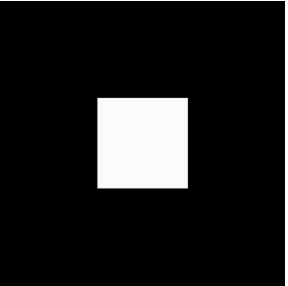
6.3 Colour meter

A colour meter may be required for testing IMAGE DISPLAY SYSTEMS. The meter shall be able to evaluate the CIE-specified (ISO11664-1:2007) colour coordinate with better than $\pm 0,004$ ACCURACY in the u',v' space (0,007 in the x,y space) for a standard illuminant, within the LUMINANCE range of the IMAGE DISPLAY SYSTEM. The device calibration shall be traceable to a primary measurement standard and shall have a clear calibration program.

6.4 TEST PATTERNS

Table 2 – TEST PATTERNS used for display testing

 TG18-QC for overall testing CATHODE RAY TUBE (CRT and LCD)	 OIQ for overall testing (LCD)	 TG18-MP for LUMINANCE resolution	 TG18-LN8-01 for LUMINANCE
 TG18-LN8-18 for LUMINANCE	 TG18-UN10 for LUMINANCE uniformity	 TG18-UN80 for LUMINANCE uniformity	 TG18-CT for LUMINANCE response
 ANG for angular response	 GD for geometrical properties	 TG18-UNL80 for LUMINANCE uniformity	 TG18-GVN for VEILING GLARE
 TG18-GV for VEILING GLARE	 TG18-CH as example chest radiograph	 TG18-KN as example extremity radiograph	 TG18-MM1 as example mammogram

 TG18-MM2 as example mammogram	 BN01 for LUMINANCE (LCD)	 BN18 for LUMINANCE (LCD)	
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A subset of these examples or elements from these examples may be used to form composite TEST PATTERNS depending on the intended use of each modality being tested (see Annex C for more information).

7 Evaluation methods

7.1 General

This clause describes a number of evaluation methods (tests) that can be used for testing medical IMAGE DISPLAY SYSTEMS. The number and order of these evaluation methods are not mandatory; a modality standard can refer to a subset of these tests in any order with a preference for limiting values and evaluation criteria.

7.2 Evaluation method table overview

Table 3 shows an overview of all evaluation methods described in this standard. Not all of these tests may be required or be appropriate for a specific IMAGE DISPLAY SYSTEM. A subset of test items or test methods to be performed can be chosen from these lists that are relevant to a particular IMAGE DISPLAY SYSTEM. These tests can be performed in any appropriate order.

**Table 3 – List of the evaluation methods that can be used
for testing medical IMAGE DISPLAY SYSTEMS**

Evaluation method	Equipment, tools
Visual evaluation methods	
Overall image quality evaluation – Verify overall performance.	TG18-QC TEST PATTERN
Greyscale resolution evaluation – Verify sufficient greyscale resolution based on 8- and 10-bit markers	TG18-MP TEST PATTERN
LUMINANCE response evaluation (more complete solution than overall image quality evaluation)	TG18-CT TEST PATTERN
LUMINANCE uniformity evaluation – Look for non-uniformities	TG18-UN80 TEST PATTERN
Chromaticity evaluation – Verify colour uniformity	TG18-UN80 TEST PATTERN
Pixel faults evaluation – Look for dark (TG18-UN80) and bright (TG18-UN10) pixel defects	TG18-UN10 and TG18-UN80 TEST PATTERN
VEILING GLARE evaluation – Look for low CONTRAST objects on 2 TEST PATTERNS	TG18-GVN and TG18-GV TEST PATTERN, mask
Geometrical image evaluation – Verify geometry, phase/clock correction, clipping	GD TEST PATTERN, ruler (CATHODE RAY TUBE (CRT) only)
Angular viewing evaluation – Verify viewing angle	ANG TEST PATTERN
Clinical evaluation	Clinical TEST PATTERNS (examples see TG18-CH, TG18-KN, TG18-MM1 and TG18-MM2)
Quantitative evaluation methods	
Basic LUMINANCE evaluation	LUMINANCE meter, ILLUMINANCE meter
Basic LUMINANCE evaluation without ambient light	LUMINANCE meter
LUMINANCE response evaluation The GREYSCALE STANDARD DISPLAY FUNCTION (GSDF) is prerequisite for this test	LUMINANCE meter, ILLUMINANCE meter
LUMINANCE evaluation of multiple displays	LUMINANCE meter
Chromaticity uniformity evaluation	Colour meter
Chromaticity evaluation of across multiple displays	Colour meter
LUMINANCE uniformity evaluation	LUMINANCE meter
Viewing angle evaluation	(Provided by manufacturer)
Greyscale chromaticity evaluation	Colour meter

7.3 Visual evaluation methods

7.3.1 General

All visual tests shall be performed from the customary viewing distance unless specified differently.

7.3.2 Overall image quality evaluation

The elements in the TG18-QC TEST IMAGE may be used to assess the overall performance of IMAGE DISPLAY SYSTEMS as described in Figure 1.

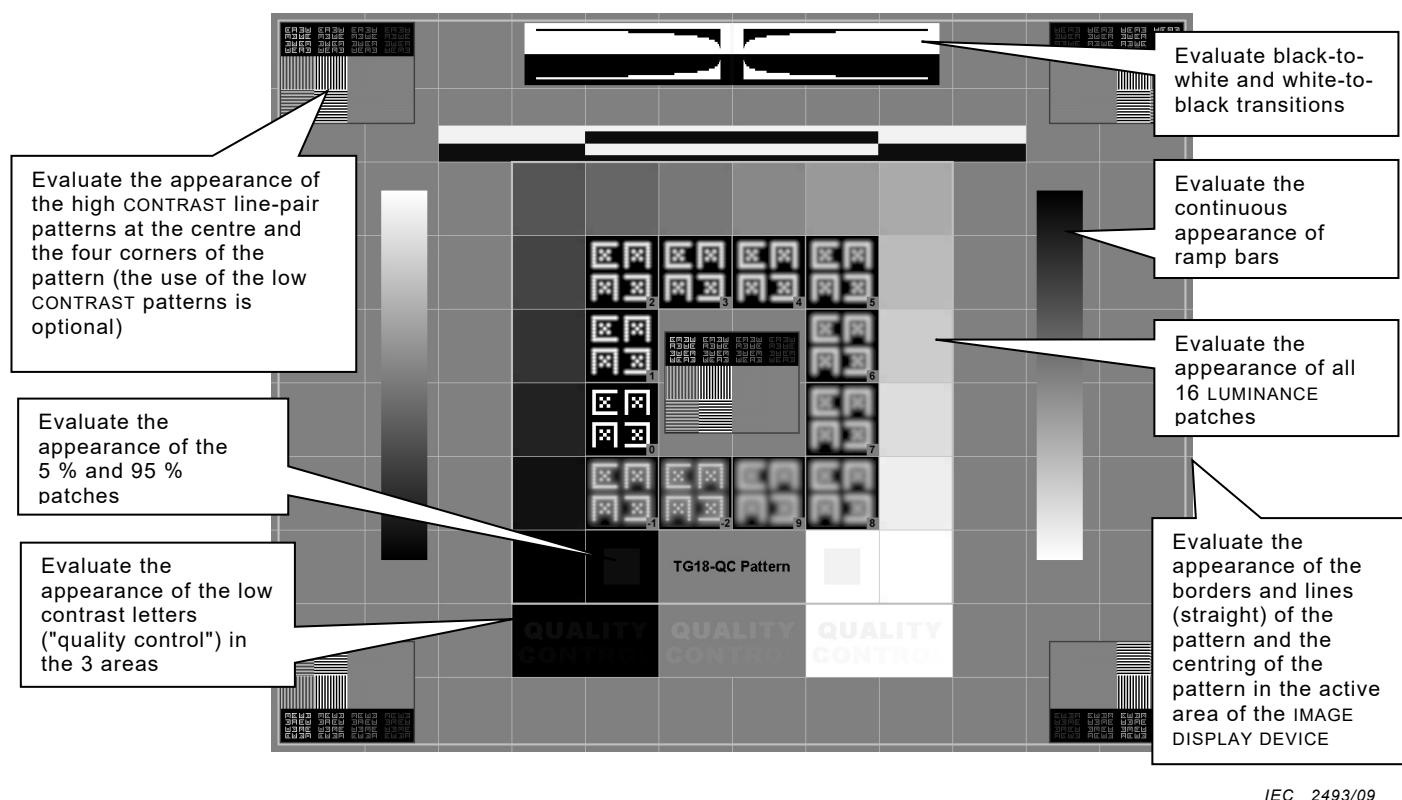
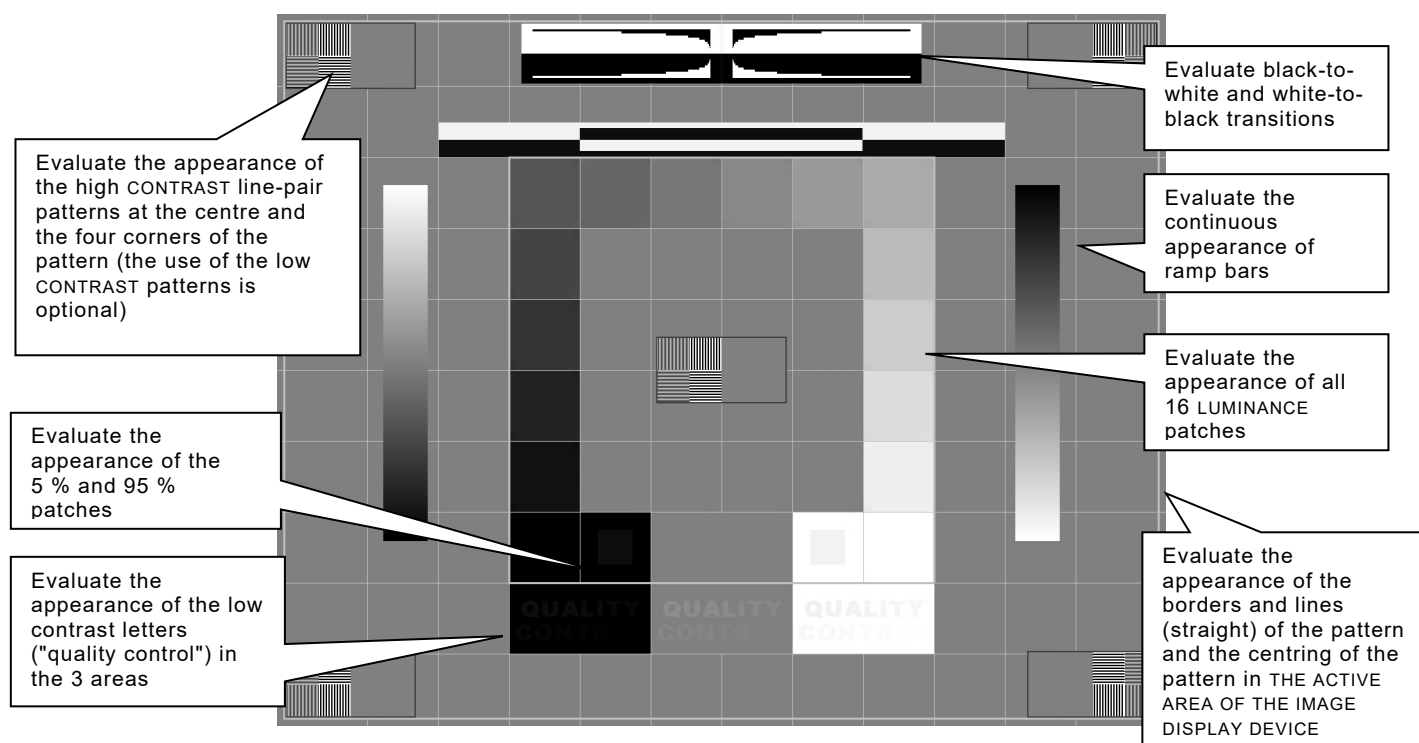


Figure 1 – Overall image quality evaluation using the TG18-QC TEST PATTERN

For CATHODE RAY TUBES (CRT) the SPATIAL RESOLUTION shall be included: Evaluate the CX patterns at the centre and corners of the pattern and grade them compared to the reference score (see Annex C).

As an alternative, the OIQ (overall image quality) TEST IMAGE may be used to assess overall performance of LCDs as described in Figure 2.



IEC 2494/09

Figure 2 – Overall image quality evaluation using the TG18-OIQ TEST PATTERN

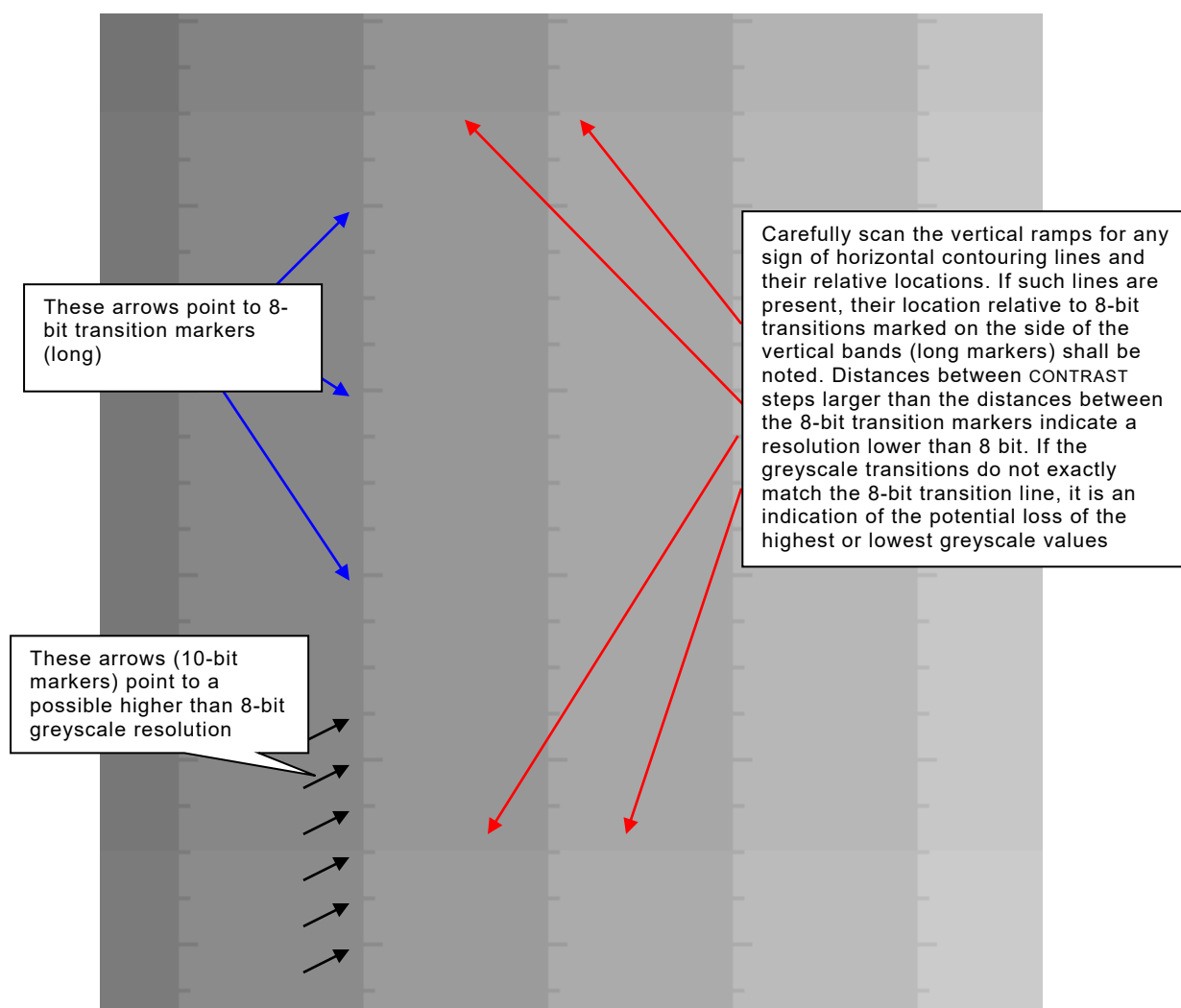
During this test, also evaluate the overall appearance of the TEST PATTERN. Look for sufficient SPATIAL RESOLUTION details, possible FLICKER, cross-talk, noise and video artefacts. Note that a TEST PATTERN specifically designed to evaluate each of these items may also be used.

For the overall image quality evaluation the SMPTE TEST PATTERN can also be used with similar criteria.

NOTE While not yet considered to be crucial for general display performance characteristics of medical displays, dynamic display performance (also called temporal response) might be important for certain medical applications. Other relevant documents may be consulted for applicable procedures to test the dynamic performance of medical displays [15].

7.3.3 Greyscale resolution evaluation

The greyscale resolution of the IMAGE DISPLAY DEVICE shall be evaluated using the TG18-MP TEST PATTERN as described in Figure 3. It might be good to magnify the pattern about 200 % when doing the test.

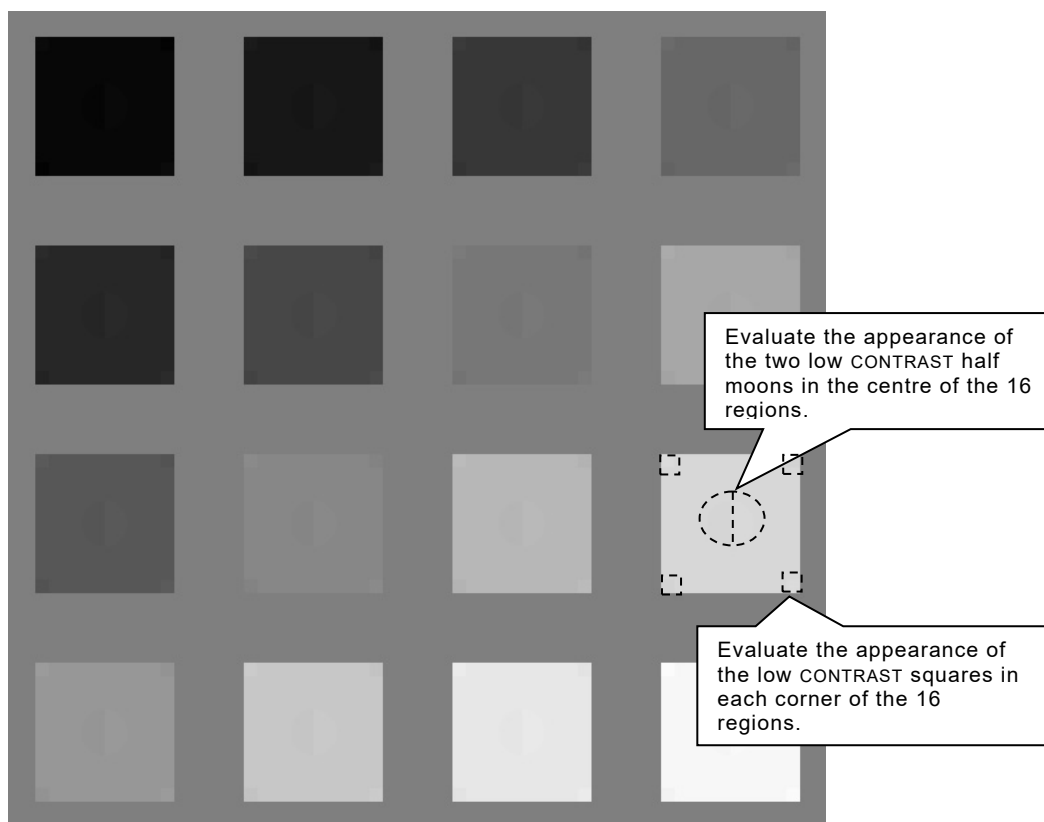


IEC 2495/09

Figure 3 – Magnified view of TG18-MP TEST PATTERN showing the 8-bit and 10-bit markers

7.3.4 LUMINANCE response evaluation

The LUMINANCE response of the IMAGE DISPLAY DEVICE can be evaluated using the TG18-QC TEST PATTERN as part of the overall image quality evaluation (7.3.2). However using the TG18-CT TEST PATTERN is a more complete solution for a visual LUMINANCE response evaluation, as described in Figure 4.



IEC 2496/09

Figure 4 – A close-up of the TG18-CT TEST PATTERN

7.3.5 LUMINANCE uniformity evaluation

Verify the TG18-UN80 TEST PATTERN and look for gross non-uniformities from the centre to the edges. Typical CATHODE RAY TUBES (CRT) show symmetrical non-uniformities and LCDs are associated with non-symmetrical ones. Since the human visual system is generally not sensitive to very low spatial frequencies, gradual non-uniformity extending over the full display surface is not a problem unless the variation is very pronounced. Smaller scale non-uniformities that have dimensions in the order of 1 cm are of more significance and should not be visible when viewing a uniform TEST PATTERN. Non-uniformities of smaller dimension are classified as noise (evaluated in 7.3.2).

7.3.6 Chromaticity evaluation

The visual assessment of chromaticity is performed using the TG18-UN80 TEST PATTERN. Verify the colour uniformity of the displayed pattern across the screen.

The test can also be performed on multiple IMAGE DISPLAY DEVICES of the same type associated with a particular IMAGE DISPLAY SYSTEM. Check perceivable colour differences amongst different IMAGE DISPLAY DEVICES of a system.

7.3.7 Pixel faults evaluation

Pixel faults are evaluated by displaying the TEST PATTERNS TG18-UN10 and TG18-UN80. The number of defects shall be counted. The fault type shall be identified by using a magnifying glass according to the error type definitions below.

Type A fault: sub-pixel (an addressable part of a greyscale pixel or one of the base colour parts of a colour pixel) is stuck at high state - count bright sub-pixels in TG18-UN10.

Type B fault: sub-pixel is stuck at low state - count dark sub-pixels in TG18-UN80.

Type C fault: abnormal sub-pixel not of type A or B - count in TG18-UN10 and TG18-UN80 (e.g. stuck at intermediate state, blinking sub-pixel).

Cluster: Two or more sub-pixels with faults within a block of 5×5 pixels.

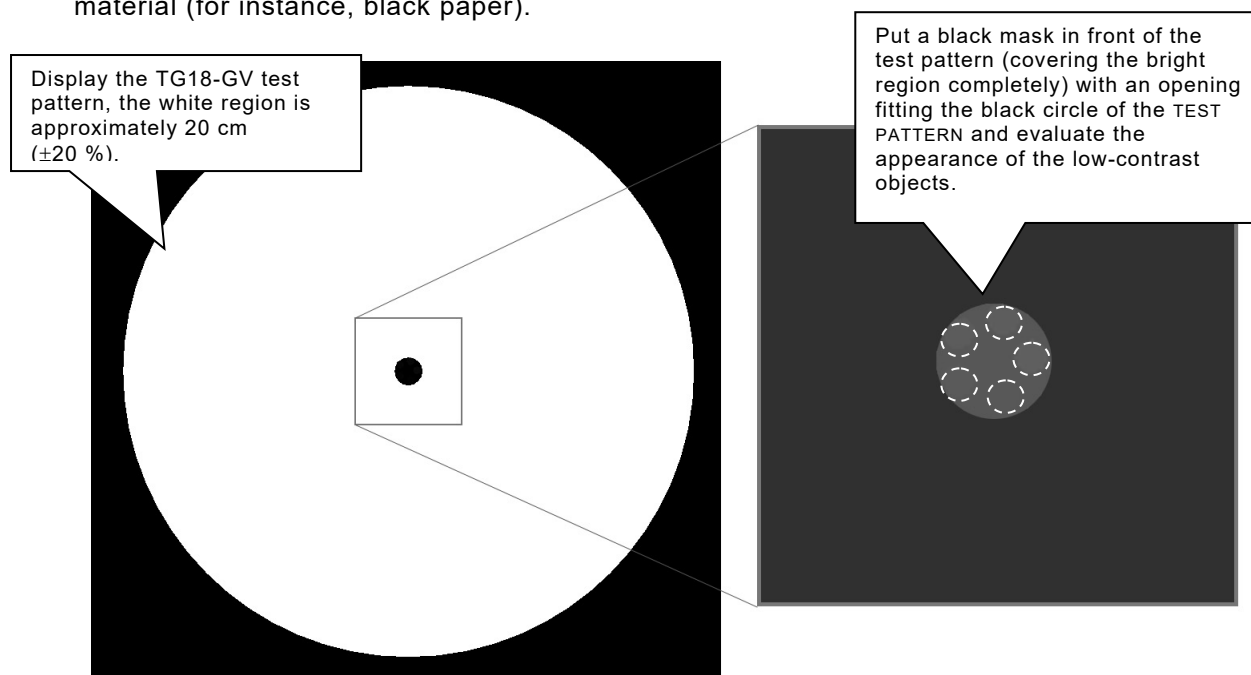
The types above or similar types would also apply to other point artefacts such as scratches, dust, and point defects in analogue IMAGE DISPLAY SYSTEMS such as CATHODE RAY TUBES (CRT).

7.3.8 VEILING GLARE evaluation

This test only applies to CATHODE RAY TUBES (CRT) and some FLAT PANEL DISPLAYS with thick protective covers. The visual assessment of VEILING GLARE can be accomplished using the TG18-GV and TG18-GVN TEST PATTERNS.

The observer shall discern the appearance of the low CONTRAST objects in sequential viewing of the TG18-GV and TG18-GVN patterns with the bright region masked (Figure 5).

The mask shall be made of black, non-transparent, light-absorbing, and non-reflective material (for instance, black paper).

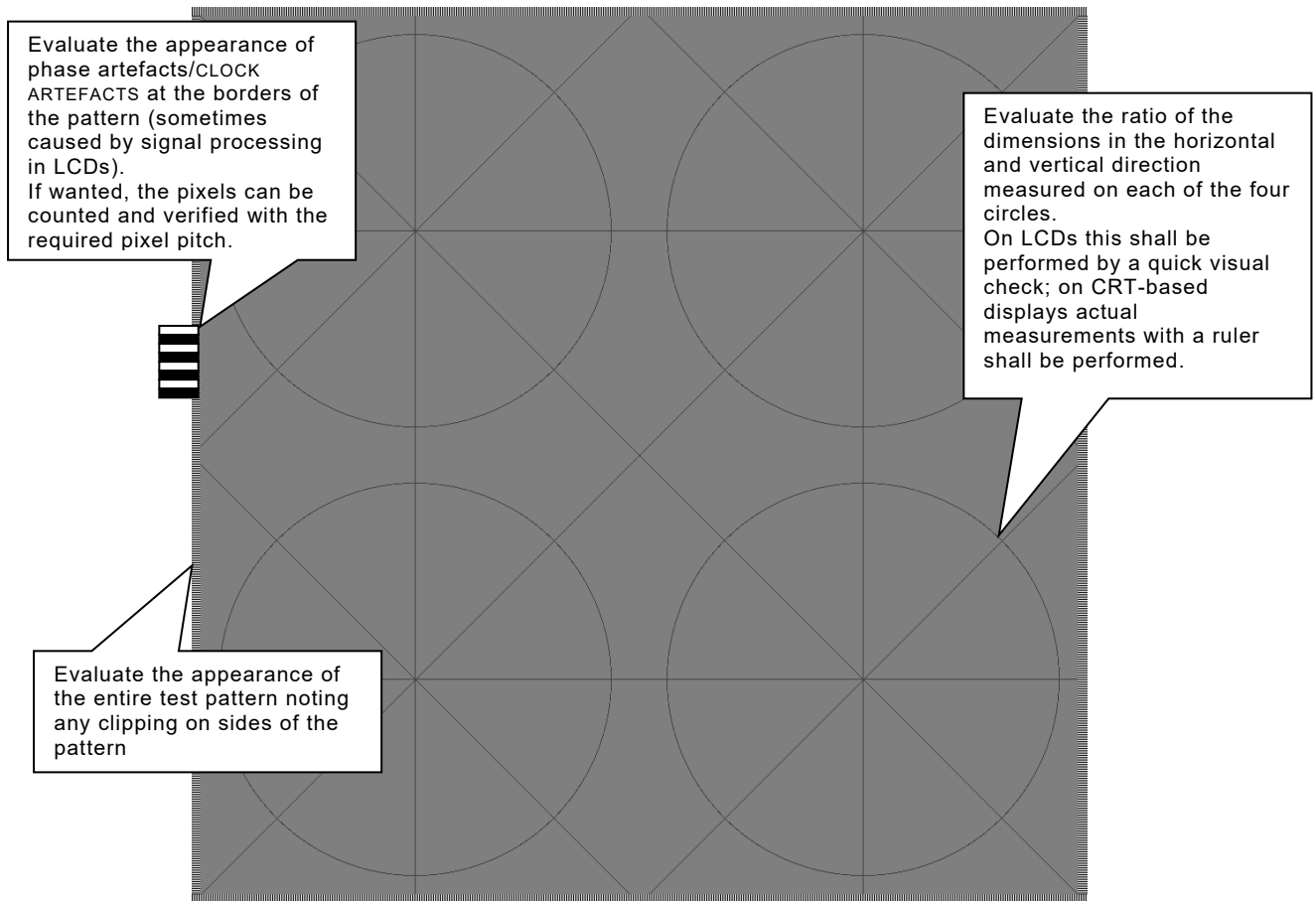


IEC 2497/09

Figure 5 – The TG18-GV TEST PATTERN is displayed (left), a close-up of the centre of the TEST PATTERN when covered with a mask (right)

7.3.9 Geometrical image evaluation

The TG18-QC TEST PATTERN is used for the geometrical image evaluation as part of the overall image quality evaluation (7.3.2). However using the geometric distortion TEST PATTERN (GD pattern) is a more complete solution for this evaluation (Figure 6).



IEC 2498/09

Figure 6 – Geometrical evaluation using the GD pattern

7.3.10 Angular viewing evaluation

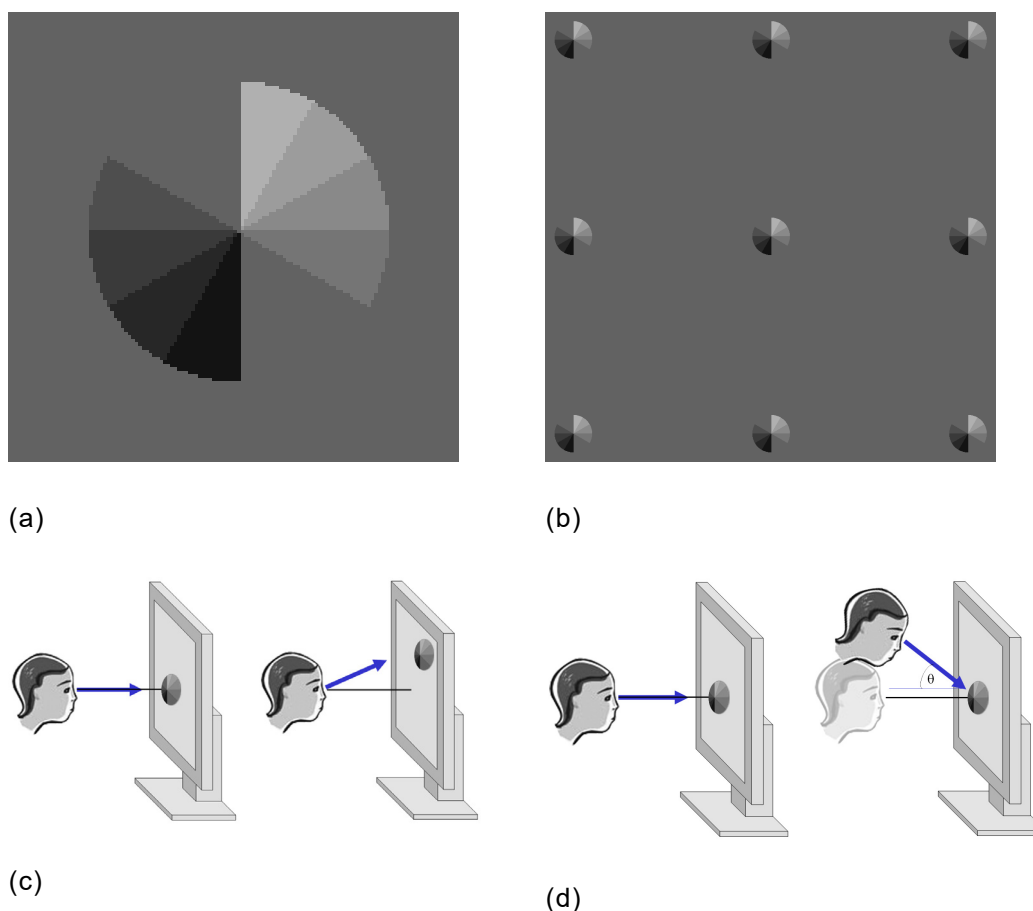
The characterization may be performed visually using methods described in the following paragraphs.

The TEST PATTERN used in the visual study, depicted in Figure 7a, consists of nine equally spaced circles in a 3 by 3 array and is fully described in Annex C.

The reading procedure can be done in two ways: (1) fixed observer, and (2) moving observer. In the case of fixed observer (option 1), the procedure requires viewing the pattern with the centre of the middle circle lined up with the centre point between the eyes at the normal viewing distance. The reader is then asked how many edges or transition lines between the slices are visible in the circle located at the centre of the screen. The inspection is then repeated for the circles at the eight other locations (top-centre, top-left, top-right, centre-left, centre-right, bottom-left, bottom-centre, and bottom-right). The reported score (S) is calculated by computing the ratio of the number of lines seen in an off-normal target (average of all non-centre scores) to the number of lines seen in the centre target. Both numbers are always between 0 and 10.

In the case of a moving observer (option 2), the procedure requires reading only the target in the centre of the pattern at perpendicular viewing, and then determining the maximum angle in off-normal directions (for example, in the horizontal and vertical directions) that provides a similar (or equal) score to that obtained in the perpendicular viewing direction.

An alternative, modified method with the same or similar TEST PATTERN in which the tester accommodates the viewing direction to be representative of conditions of use might be employed if a scientific evaluation demonstrates that the method is robust and sensitive to the expected or typical changes of LUMINANCE and CONTRAST with angle of view.



- (a) Single target
(b) Full ANG TEST PATTERN
(c) Diagram showing reading procedure for option 1; with fixed position for observer
(d) Diagram showing reading procedure for option 2; with moving observer

IEC 2499/09

Figure 7 – Visual evaluation of viewing angle response

7.3.11 Clinical evaluation

CLINICAL REFERENCE IMAGES or anatomical images as those reported in Annex C may be used for this test. The images shall be evaluated in terms of their clinical efficacy.

7.4 Quantitative evaluation methods

7.4.1 Basic LUMINANCE evaluation

The LUMINANCE ratio r' ($= L'_{\max}/L'_{\min}$) shall be evaluated for the IMAGE DISPLAY DEVICE.

Measure the values $L'_{\min}$, $L'_{\max}$ and L_{amb} using one of the measurement methods described in Annex B.

For a given minimum required LUMINANCE ratio the corresponding maximum value of $L'_{\min}$ can be determined by:

$$L'_{\max}/r'$$

Evaluating the safety factor “a”:

$a = L_{\text{amb}}/L'_{\text{min}}$ where $L_{\text{amb}} = \text{ILLUMINANCE } E * R_d$ and $0 < a < 1$

The accommodation of ambient ILLUMINANCE can be accomplished in one of two ways depending on the environment and the LUMINANCE ratio range of the IMAGE DISPLAY DEVICE. For example, a safety factor equal or less than 0,4 implies a L_{min} of at least 1,5 times L_{amb} . However, in cases in which the implementation of this rule might negatively impact the desired LUMINANCE ratio (e.g. certain modality displays), the safety factor may have a value close to unity (1) provided that the desired display function (e.g. GREYSCALE STANDARD DISPLAY FUNCTION (GSDF)) calibration of the IMAGE DISPLAY DEVICE takes the ranges of the ILLUMINANCE in the environment into consideration.

The following relationship between L_{min} and L_{amb} can be useful:

$$L_{\text{min}} = L_{\text{amb}} \left(\frac{1}{a} - 1 \right)$$

Optionally in this test the L_{max} can be evaluated against a target value as

$$\Delta L_{\text{max}} = (L_{\text{max}} - L_{\text{target}})/L_{\text{target}}$$

where L_{target} is the target LUMINANCE at maximum DIGITAL DRIVING LEVEL (DDL) being the IMAGE DISPLAY DEVICE vendor default value or the value used during calibration.

In addition, L_{max} can be evaluated and compared to a minimum required value to be defined by modality-specific or national organization standards.

7.4.2 Basic LUMINANCE evaluation without ambient light

This evaluation method should be used only for establishing the IMAGE DISPLAY SYSTEM basic LUMINANCE response without considering ambient lighting conditions.

This method should not be used if the IMAGE DISPLAY SYSTEM is calibrated to GSDF taking ambient light conditions into account.

The LUMINANCE ratio $r (= L_{\text{max}}/L_{\text{min}})$ shall be evaluated for the IMAGE DISPLAY DEVICE.

Measure the values L_{min} , L_{max} using one of the measurement methods described in Annex B.

Optionally in this test the L_{max} can be evaluated against a target value as

$$\Delta L_{\text{max}} = (L_{\text{max}} - L_{\text{target}})/L_{\text{target}}$$

where L_{target} is the target LUMINANCE at maximum DIGITAL DRIVING LEVEL (DDL) being the IMAGE DISPLAY DEVICE vendor default value or the value used during calibration.

In addition, L_{max} can be evaluated and compared to a minimum required value to be defined by modality-specific or national organization standards.

7.4.3 LUMINANCE response evaluation

The GREYSCALE STANDARD DISPLAY FUNCTION (GSDF) is a prerequisite for this test. Using a calibrated LUMINANCE meter and the TG18-LN TEST PATTERNS, the LUMINANCE L in the test region shall be measured for all 18 DIGITAL DRIVING LEVEL (DDL) P -values, $L(P)$, by the measurement methods described in Annex B.

The IMAGE DISPLAY SYSTEM shall be calibrated to the GREYSCALE STANDARD DISPLAY FUNCTION (GSDF). If the value of L_{amb} cannot be determined because of some practical reason, the value of L_{amb} (or $E * R_d$) used during the calibration shall be used for the LUMINANCE response evaluation. If the purpose is to evaluate the IMAGE DISPLAY SYSTEM response independently of ambient light conditions then this method is still valid with L_{amb} set to zero. However the GREYSCALE STANDARD DISPLAY FUNCTION (GSDF) as referred in [2] clearly quotes: "The GREYSCALE STANDARD DISPLAY FUNCTION explicitly includes the effects of the diffused ambient ILLUMINANCE".

The measured values shall be related to the GREYSCALE STANDARD DISPLAY FUNCTION (GSDF). First, they shall be transformed to just noticeable difference indices (J -values) based on the characteristics of the human visual system (J -values versus LUMINANCE). The J -values for the measured L'_{min} and L'_{max} , J_{min} and J_{max} shall be identified. The intermediate J -values shall then be evenly spaced within the range of J_{min} to J_{max} , ΔJ , and linearly related to the actual P -values used, P , as

$$J_i = J_{min} + \frac{P_i \Delta J}{\Delta P}$$

where P is the digital input to the system, ΔP is the range of digital input values from P_{min} to P_{max} , and i refers to the index of the 18 TEST IMAGES used for this test.

CONTRAST response is then calculated using the slope of the LUMINANCE response. The slopes based on measured values δ_i (measured CONTRAST) and GREYSCALE STANDARD DISPLAY FUNCTION (GSDF) values δ_i^d (target CONTRAST for the GREYSCALE STANDARD DISPLAY FUNCTION (GSDF)) are calculated as

$$\delta_i = \frac{2(L'_i - L'_{i-1})}{(L'_i + L'_{i-1}) \cdot (J_i - J_{i-1})}$$

$$\delta_i^d = \frac{2(L'^d_i - L'^d_{i-1})}{(L'^d_i + L'^d_{i-1}) \cdot (J_i - J_{i-1})}$$

where L'_i is the luminance value at index i , and L'^d_i is the corresponding target luminance value according to GREYSCALE STANDARD DISPLAY FUNCTION (GSDF).

δ_i and δ_i^d are plotted against $0,5(J_i + J_{i-1})$ (the average of the J values that relate to the LUMINANCE measurements).

The values for δ_i shall not deviate from δ_i^d beyond a certain threshold criterion. Figure 8 shows an example of the measured LUMINANCE for 18 display levels, plotted in relation to the target LUMINANCE response, which in this case happens to be the GREYSCALE STANDARD DISPLAY FUNCTION (GSDF). Figure 9 shows the CONTRAST response associated with the data shown in Figure 8.

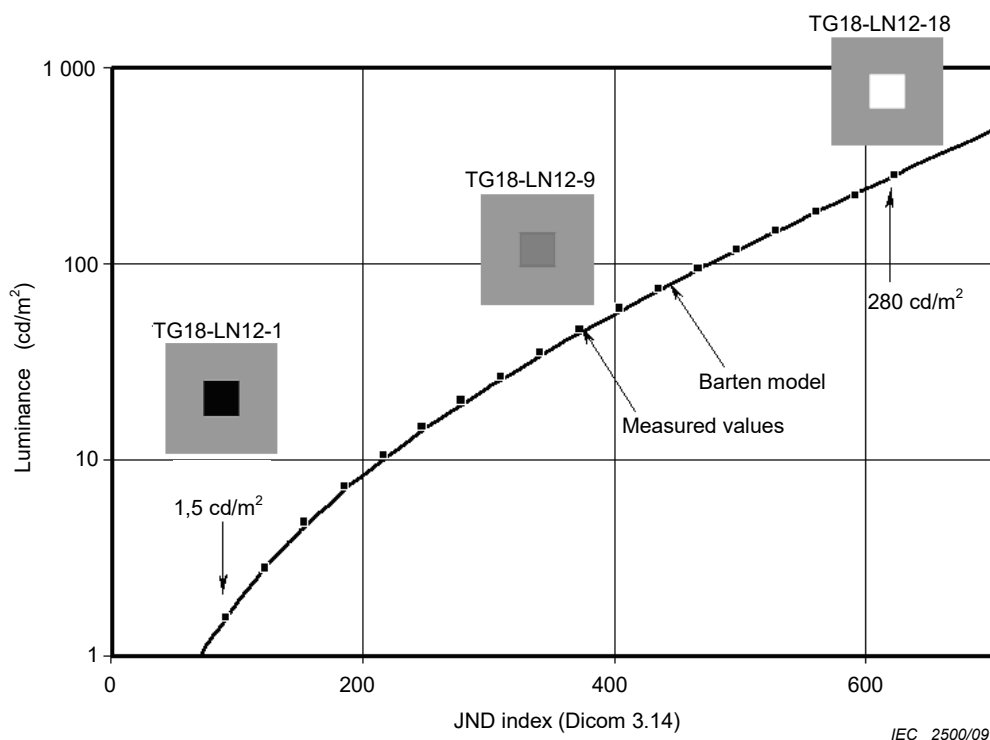


Figure 8 – Example of the measured LUMINANCE in relation to the standard LUMINANCE response function according to GREYSCALE STANDARD DISPLAY FUNCTION (GSDF)

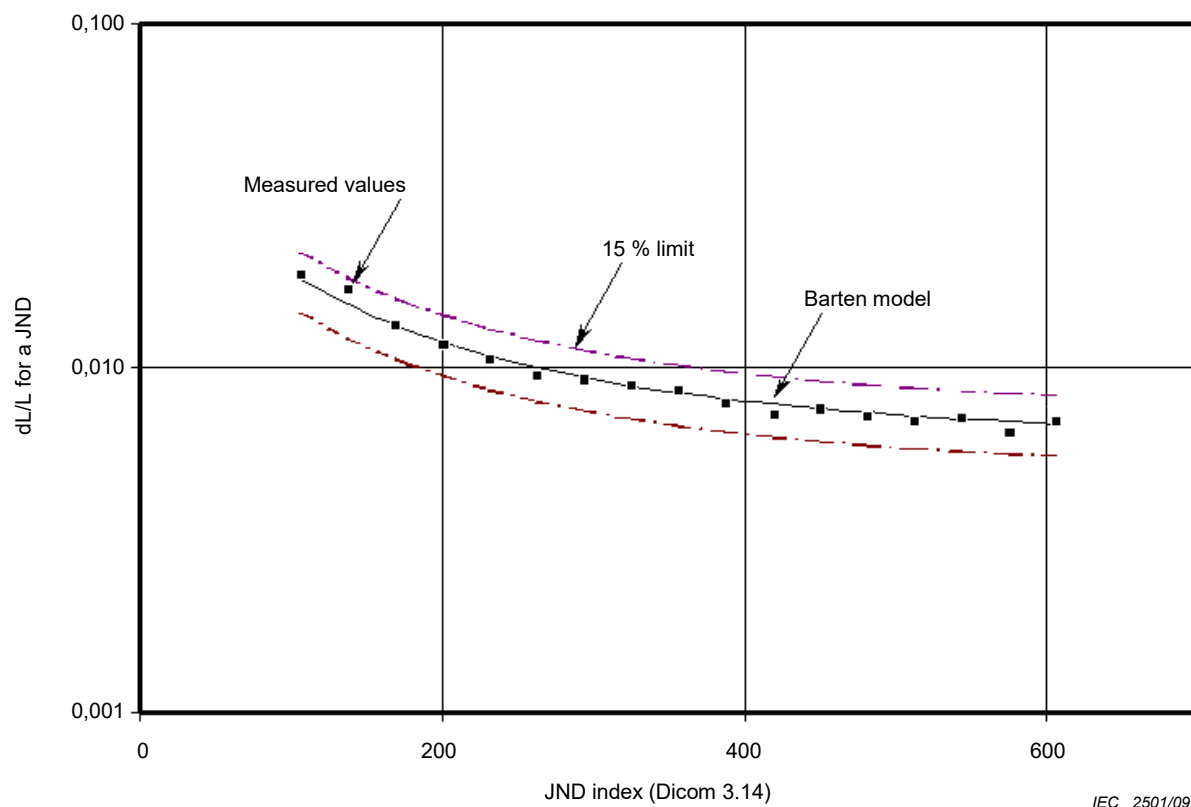


Figure 9 – An example of the CONTRAST response computed from 18 grey levels as related to the expected CONTRAST response associated with the DICOM 3.14 [2] standard LUMINANCE response with a given tolerance limit (e.g. 15 %).

7.4.4 LUMINANCE evaluation of multiple displays

If multiple image displays devices are associated with the same IMAGE DISPLAY SYSTEM, the white LUMINANCE values as measured in the basic LUMINANCE evaluation (7.4.1) of all IMAGE DISPLAY DEVICES shall be compared. The values to be compared are $L'_{\max}$ or $L_{\max}$. Also all measurement methods A, B, C and D (Annex B) can be used for these measurements. The maximum LUMINANCE deviation is calculated as a percent difference between the highest and lowest LUMINANCE values relative to their ~~average~~ lowest value, $100 \cdot (L_{\text{highest}} - L_{\text{lowest}})/L_{\text{lowest}}$.

7.4.5 Chromaticity **uniformity** evaluation

Display the TG18-UNL80 TEST PATTERN on the IMAGE DISPLAY DEVICES. Using a colour meter, measure the (u', v') colour coordinates at the centre and at the four corners of the screen and compute the distance $\Delta u'v'$, as the maximum distance in $u'-v'$ space between any possible pairs of (u', v') points using the following formula:

$$\Delta u'v' = ((u'_1 - u'_2)^2 + (v'_1 - v'_2)^2)^{1/2}$$

The distance is calculated as the maximum for any two locations within the display screen. If a colour meter outputs its values in x,y coordinate, those can be converted to u', v' using the following conversion formulas:

$$u' = 4x/(-2x + 12y + 3)$$

$$v' = 9y/(-2x + 12y + 3)$$

7.4.6 Chromaticity evaluation ~~of~~ **across** multiple displays

If multiple IMAGE DISPLAY DEVICES are associated with the same IMAGE DISPLAY SYSTEM the (u', v') chromaticity in the centre of every IMAGE DISPLAY DEVICE shall be compared. These central measurements for all IMAGE DISPLAY DEVICES can also be retrieved from the chromaticity evaluation of each IMAGE DISPLAY DEVICE (7.4.5). Compute the distance $\Delta u'v'$, as the maximum distance in $u'-v'$ space between any possible pair of central measurements as

$$\Delta u'v' = ((u'_1 - u'_2)^2 + (v'_1 - v'_2)^2)^{1/2}$$

If this distance $\Delta u'v'$, is calculated to more than two IMAGE DISPLAY DEVICES, the two with the biggest ~~deviation in~~ (u', v') distance shall be used.

Optionally (in order to keep consistency with other standards), an averaged (u', v') chromaticity coordinate of 5-location measurements in each IMAGE DISPLAY DEVICE described in 7.4.5 can be used instead of the central measurement. Compute the distance $\Delta u'v'$ as the maximum distance in $u'-v'$ space between any possible pair of the averaged coordinates using the same formula above.

7.4.7 LUMINANCE uniformity evaluation

Measure the LUMINANCE at five locations on the faceplate of the IMAGE DISPLAY DEVICE (centre and four corners) using the TG18-UNL80 TEST PATTERN and techniques A or B in Annex B. The maximum LUMINANCE deviation is calculated as a percent difference between the highest and lowest LUMINANCE values relative to their average value,

$$200 \times (L_{\text{highest}} - L_{\text{lowest}})/(L_{\text{highest}} + L_{\text{lowest}}).$$

7.4.8 Viewing angle evaluation

The quantitative viewing angle evaluation of the IMAGE DISPLAY DEVICE may be performed by the manufacturer according to the “viewing-cone thresholds” method proposed in reference [15].

The manufacturer may provide this information to the user at acceptance testing. This test is performed as a type test, where typical values for an IMAGE DISPLAY DEVICE model are given.

NOTE 1 A possible setup for a quantitative assessment of the viewing angle response is: arrange the LUMINANCE meter to measure the LUMINANCE and chromaticity at the IMAGE DISPLAY DEVICE centre from the normal direction; use a goniometric positioning device such as a rotating platter or motorized positioning system to assure an accurate angular alignment between the LUMINANCE meter and the screen normal for incremental increases in off-normal viewing directions (use a 5° maximum increment size for inclination and a 10° maximum increment for azimuth).

NOTE 2 The viewing angle should be evaluated using the degree of contrast ratio degradation in % from the on-axis direction [10].

7.4.9 Greyscale chromaticity evaluation

With a colour meter, luminance and colour coordinates (u' , v') are measured using TG18-LN test patterns (TG18-LNx-i, $i = 01, 02, \dots, 18$). Measurements shall be performed without ambient light. With only the measurements corresponding to recorded luminance values higher than or equal to 5 cd/m², the distances in the u', v' plane with respect to the measurement at full white (i.e. from TG18-LNx-18) are computed as

$$\Delta u'_i v'_i = ((u'_i - u'_{18})^2 + (v'_i - v'_{18})^2)^{1/2}$$

The number of discarded measurements (luminance values less than 5 cd/m²) will vary depending on the calibrated display function. For this reason, reporting greyscale chromaticity results should be accompanied by the calibrated display function used for the display device being measured.

The greyscale chromaticity is quantified as the maximum deviation in the computed values. The greyscale chromaticity evaluation method described in 7.4.9 is applicable to both colour and monochrome display devices.

Annex A (informative)

Sample test reports

This annex provides several sample test reports, as follows:

- Table A.1: Acceptance test of a diagnostic display;
- Table A.2: Constancy test of a diagnostic display;
- Table A.3: Acceptance test of a monochrome reviewing display;
- Table A.4: Constancy test of a monochrome reviewing display;
- Table A.5: Acceptance test of a colour reviewing display;
- Table A.6: Constancy test of a colour reviewing display.

Table A.1 – Acceptance test sample report of a diagnostic display

General
Date of test: Jan 23 2007
Test performed by: John
Facility: St. John's facility, Jonathan Street 55, John's City, John's Country
Location: Radiology, Reading Room 4, Workstation Rad44
Display: ~~Brand Monochrome~~ LCD, Type 3MP Portrait, S/N-983300444 (first display of dual head)
Application: Diagnostic, multi-modality (RX,CT, MR) workstation

Evaluation method	Equipment, tools	Requirement	Conclusion
		Test result	
Global test result:			OK
Visual evaluations			
Overall image quality evaluation – Verify overall performance	TG18-QC TEST PATTERN	All appearances OK and no defects found	OK
		No	
Greyscale resolution evaluation – Verify sufficient greyscale resolution based on 8- and 10-bit markers	TG18-MP TEST PATTERN	> 8 Bit	OK
		Resolution matches the 8-bit markers	
LUMINANCE response evaluation (more complete solution than the corresponding evaluation within overall image quality evaluation)	TG18-CT TEST PATTERN	All squares and half moons are visible	OK
		Yes	
LUMINANCE uniformity evaluation – Look for non-uniformities	TG18-UN80 TEST PATTERN	No visual non-uniformities detected	OK
		No	
Chromaticity evaluation – Verify colour uniformity	TG18-UN80 TEST PATTERN	No visual non-uniformities on colour detected	OK
		None	

Evaluation method	Equipment, tools	Requirement	Conclusion
		Test result	
Pixel faults evaluation – Look for dark (TG18-UN80) and bright (TG18-UN10) pixel defects	TG18-UN10 and TG18-UN80 TEST PATTERN	type A: <=1 type B: <=1 type C: <=2 None in the same cluster	OK
		Detected pixel faults: 0 type A (<=1), 1 type B (<=1), 1 type C (<=2), none in the same cluster	
Angular viewing evaluation – Verify viewing angle	ANG TEST PATTERN	SCORE: >= 0,9	OK
		Centre score: 10 Top-left score: 8 Top-centre score: 10 Top-right score: 9 Centre-right score: 10 Bottom-right score: 9 Bottom-centre score: 10 Bottom-left score: 8 Centre-left score: 10 SCORE: 9,25/10	
Clinical evaluation	Clinical TEST PATTERNS TG18-CH, TG-18-KN	Clinical images appear OK	OK
		Yes	
Quantitative evaluations			
Basic LUMINANCE evaluation	LUMINANCE meter	$L_{\max}$ deviation < ±5 % of 500 cd/m ² $r' > 250$ $a < 0,4$ $L_{\max} > 170$ cd/m ²	OK
		Measured with method A (B.2.1) $L'_{\max} = 504,97$ cd/m ² $L'_{\min} = 1,28$ cd/m ² $L_{\text{amb}} = 0,5$ cd/m ² $L_{\max} = 504,47$ cd/m ² $r' = 394$ $a = 0,39$	

Evaluation method	Equipment, tools	Requirement	Conclusion
		Test result	
LUMINANCE response evaluation	LUMINANCE meter	Max. deviation < 15 %	OK
		Measured with method A (B.2.1) $L'(LN01) = 1,58 \text{ cd/m}^2$ $L'(LN02) = 3,16 \text{ cd/m}^2$ $L'(LN03) = 5,48 \text{ cd/m}^2$ $L'(LN04) = 8,7 \text{ cd/m}^2$ $L'(LN05) = 12,9 \text{ cd/m}^2$ $L'(LN06) = 18,8 \text{ cd/m}^2$ $L'(LN07) = 26,4 \text{ cd/m}^2$ $L'(LN08) = 36,4 \text{ cd/m}^2$ $L'(LN09) = 48,9 \text{ cd/m}^2$ $L'(LN10) = 65,5 \text{ cd/m}^2$ $L'(LN11) = 86,2 \text{ cd/m}^2$ $L'(LN12) = 112,7 \text{ cd/m}^2$ $L'(LN13) = 144,8 \text{ cd/m}^2$ $L'(LN14) = 186,7 \text{ cd/m}^2$ $L'(LN15) = 240,2 \text{ cd/m}^2$ $L'(LN16) = 309,8 \text{ cd/m}^2$ $L'(LN17) = 395,5 \text{ cd/m}^2$ $L'(LN18) = 504,9 \text{ cd/m}^2$ Max. deviation = 5,10 %	
LUMINANCE evaluation of multiple displays	LUMINANCE meter	Deviation < 10 %	OK
		Measured with method A (B.2.1) $L'_{\max} = 504,97 \text{ cd/m}^2$ $L'_{\max} = 493,65 \text{ cd/m}^2$ Deviation = 2,27 %	

Evaluation method	Equipment, tools	Requirement	Conclusion
		Test result	
Chromaticity evaluation	Colour meter	Max. deviation < 0,02	OK
		Measured with method B (B.2.2) Top-left $u' = 0,2025$ $v' = 0,4699$ Top-right $u' = 0,2051$ $v' = 0,4688$ Centre $u' = 0,2024$ $v' = 0,4680$ Bottom-right $u' = 0,2052$ $v' = 0,4695$ Bottom-left $u' = 0,2009$ $v' = 0,4706$ Max. deviation = 0,0046	
Chromaticity evaluation of multiple displays	Colour meter	Deviation < 0,02	OK
		Measured with method B (B.2.2) Centre $u' = 0,2024$ $v' = 0,4680$ Other display: Centre $u' = 0,2046$ $v' = 0,4699$ Deviation = 0,0029	
LUMINANCE uniformity evaluation	LUMINANCE meter	Max. deviation < 30 %	OK
		Measured with method B (B.2.2) Top-left $L = 191,5$ cd/m ² Top-right $L = 176,4$ cd/m ² Centre $L = 197,2$ cd/m ² Bottom-right $L = 202,5$ cd/m ² Bottom-left $L = 195,8$ cd/m ² Max. deviation = 13,8 %	

Evaluation method	Equipment, tools	Requirement	Conclusion
		Test result	
Greyscale chromaticity evaluation NOTE This device was calibrated according to the GSDF	Colour meter	Max. deviation < 0,01	OK
		Discarded measurements: ($L < 5 \text{ cd/m}^2$) LN01: $L = 0,64 \text{ cd/m}^2$ $u' = 0,193 \text{ 6}$ $v' = 0,427 \text{ 6}$ LN02: $L = 2,03 \text{ cd/m}^2$ $u' = 0,200 \text{ 3}$ $v' = 0,449 \text{ 1}$ LN03: $L = 4,17 \text{ cd/m}^2$ $u' = 0,203 \text{ 9}$ $v' = 0,464 \text{ 9}$ Remaining measurements: LN04: $u' = 0,204 \text{ 6}$ $v' = 0,469 \text{ 5}$ LN05: $u' = 0,204 \text{ 8}$ $v' = 0,471 \text{ 5}$ LN06: $u' = 0,204 \text{ 9}$ $v' = 0,472 \text{ 7}$ LN07: $u' = 0,205 \text{ 0}$ $v' = 0,473 \text{ 5}$ LN08: $u' = 0,205 \text{ 1}$ $v' = 0,474 \text{ 0}$ LN09: $u' = 0,205 \text{ 1}$ $v' = 0,474 \text{ 3}$ LN10: $u' = 0,205 \text{ 1}$ $v' = 0,474 \text{ 4}$ LN11: $u' = 0,205 \text{ 3}$ $v' = 0,474 \text{ 3}$ LN12: $u' = 0,205 \text{ 1}$ $v' = 0,474 \text{ 1}$ LN13: $u' = 0,205 \text{ 2}$ $v' = 0,473 \text{ 8}$ LN14: $u' = 0,205 \text{ 3}$ $v' = 0,473 \text{ 3}$ LN15: $u' = 0,205 \text{ 0}$ $v' = 0,472 \text{ 4}$ LN16: $u' = 0,204 \text{ 9}$ $v' = 0,471 \text{ 5}$ LN17: $u' = 0,204 \text{ 9}$ $v' = 0,470 \text{ 8}$ LN18: $u' = 0,205 \text{ 0}$ $v' = 0,470 \text{ 8}$ Max. deviation = 0,003 6	

Table A.2 – Constancy test sample report of a diagnostic display

General
Date of test: Apr 23 2007 (QUARTERLY TEST)
Test performed by: John
Facility: St. John's facility, Jonathan Street 55, John's City, John's Country
Location: Radiology, Reading Room 4, Workstation Rad44
Display: ~~Brand Monochrome~~ LCD, Type 3MP Portrait, S/N ~~983300444 (first head of dual head)~~
Application: Diagnostic, multi-modality (RX,CT, MR) workstation

Evaluation method	Equipment, tools	Requirement	Conclusion
		Test result	
Global test result:			OK
Visual evaluations			
Overall image quality evaluation – Verify overall performance	TG18-QC TEST PATTERN	All appearances OK and no defects found	OK
		No	
LUMINANCE uniformity evaluation – Look for non-uniformities	TG18-UN80 TEST PATTERN	No visual non-uniformities detected	OK
		No	
Clinical evaluation	Clinical TEST PATTERNS TG18-CH, TG-18-KN	Clinical images appear OK	OK
		Yes	

Evaluation method	Equipment, tools	Requirement	Conclusion
		Test result	
Quantitative evaluations			
Basic LUMINANCE evaluation	LUMINANCE meter, ILLUMINANCE meter	$r' > 250$ $a < 0,4$	OK
		Measured with method C (B.2.3) $L_{\max} = 520,9 \text{ cd/m}^2$ $L_{\min} = 0,64 \text{ cd/m}^2$ $E = 24 \text{ lux}$ $Rd = 0,017$ $L_{\text{amb}} = 0,408 \text{ cd/m}^2$ $r' = 497$ $a = 0,389$	
LUMINANCE response evaluation	LUMINANCE meter, ILLUMINANCE meter	Max. deviation < 15 %	OK
		Measured with method C (B.2.3) $L(\text{LN}01) = 0,64 \text{ cd/m}^2$ $L(\text{LN}02) = 2,03 \text{ cd/m}^2$ $L(\text{LN}03) = 4,17 \text{ cd/m}^2$ $L(\text{LN}04) = 7,11 \text{ cd/m}^2$ $L(\text{LN}05) = 11,12 \text{ cd/m}^2$ $L(\text{LN}06) = 16,75 \text{ cd/m}^2$ $L(\text{LN}07) = 24,07 \text{ cd/m}^2$ $L(\text{LN}08) = 33,67 \text{ cd/m}^2$ $L(\text{LN}09) = 46,24 \text{ cd/m}^2$ $L(\text{LN}10) = 63,12 \text{ cd/m}^2$ $L(\text{LN}11) = 83,94 \text{ cd/m}^2$ $L(\text{LN}12) = 110,6 \text{ cd/m}^2$ $L(\text{LN}13) = 144,9 \text{ cd/m}^2$ $L(\text{LN}14) = 190,1 \text{ cd/m}^2$ $L(\text{LN}15) = 246,3 \text{ cd/m}^2$ $L(\text{LN}16) = 317,8 \text{ cd/m}^2$ $L(\text{LN}17) = 406,4 \text{ cd/m}^2$ $L(\text{LN}18) = 520,9 \text{ cd/m}^2$ Max. deviation = 8,10 %	

Evaluation method	Equipment, tools	Requirement	Conclusion
		Test result	
Greyscale chromaticity evaluation NOTE This device was calibrated according to the GSDF.	Colour meter	Max. deviation < 0,01	OK
		Discarded measurements: ($L < 5$ cd/m ²) LN01: $L = 0,64$ cd/m ² $u' = 0,193\ 6$ $v' = 0,427\ 6$ LN02: $L = 2,03$ cd/m ² $u' = 0,200\ 3$ $v' = 0,449\ 1$ LN03: $L = 4,17$ cd/m ² $u' = 0,203\ 9$ $v' = 0,464\ 9$ Remaining measurements: LN04: $u' = 0,204\ 6$ $v' = 0,469\ 5$ LN05: $u' = 0,204\ 8$ $v' = 0,471\ 5$ LN06: $u' = 0,204\ 9$ $v' = 0,472\ 7$ LN07: $u' = 0,205\ 0$ $v' = 0,473\ 5$ LN08: $u' = 0,205\ 1$ $v' = 0,474\ 0$ LN09: $u' = 0,205\ 1$ $v' = 0,474\ 3$ LN10: $u' = 0,205\ 1$ $v' = 0,474\ 4$ LN11: $u' = 0,205\ 3$ $v' = 0,474\ 3$ LN12: $u' = 0,205\ 1$ $v' = 0,474\ 1$ LN13: $u' = 0,205\ 2$ $v' = 0,473\ 8$ LN14: $u' = 0,205\ 3$ $v' = 0,473\ 3$ LN15: $u' = 0,205\ 0$ $v' = 0,472\ 4$ LN16: $u' = 0,204\ 9$ $v' = 0,471\ 5$ LN17: $u' = 0,204\ 9$ $v' = 0,4708$ LN18: $u' = 0,205\ 0$ $v' = 0,470\ 8$ Max. deviation = 0,003 6	

Table A.3 – Acceptance test sample report of a monochrome reviewing display

General
Date of test: Feb 14 2007
Test performed by: John
Facility: St. John's facility, Jonathan Street 55, John's City, John's Country
Location: East Wing, Room 405, Workstation WS_405_1
Display: ~~Brand Monochrome~~ LCD, Type 2MP Portrait, S/N ~~44820922 (first display of dual head)~~
Application: Reviewing, multi-modality (CT, MR) workstation

Evaluation method	Equipment, tools	Requirement	Conclusion
		Test result	
Global test result:			OK
Visual evaluations			
Overall image quality evaluation – Verify overall performance	TG18-QC TEST PATTERN	All appearances OK and no defects found	OK
		No	
Greyscale resolution evaluation – Verify sufficient greyscale resolution based on 8- and 10-bit markers	TG18-MP TEST PATTERN	> 8 bit	OK
		Resolution matches the 8-bit markers	
LUMINANCE response evaluation (more complete solution than the corresponding evaluation within overall image quality evaluation)	TG18-CT TEST PATTERN	All squares and half moons are visible	OK
		Yes	
LUMINANCE uniformity evaluation – Look for non-uniformities	TG18-UN80 TEST PATTERN	No visual non-uniformities detected	OK
		No	
Chromaticity evaluation – Verify colour uniformity	TG18-UN80 TEST PATTERN	No visual non-uniformities on colour detected	OK
		No	
Angular viewing evaluation – Verify viewing angle	ANG TEST PATTERN	SCORE $\geq 0,75$	OK
		Centre score: 10 Top-left score: 8 Top-centre score: 9 Top-right score: 8 Centre-right score: 10 Bottom-right score: 8 Bottom-centre score: 10 Bottom-left score: 9 Centre-left score: 8 SCORE: 8,75/10	
Clinical evaluation	Clinical TEST PATTERNS TG18-CH, TG-18-KN	Clinical images appear OK	OK
		Yes	

Evaluation method	Equipment, tools	Requirement	Conclusion
		Test result	
Quantitative evaluations			
Basic LUMINANCE evaluation	LUMINANCE meter Manufacturer X Instrument Y – S/N 98832	$L_{\max}$ deviation < ± 10 % of 400 cd/m ² $r' > 100$	OK
		Measured with method A (B.2.1) $L'_{\max} = 418,2$ cd/m ² $L'_{\min} = 2,01$ cd/m ² $L_{\text{amb}} = 1,5$ cd/m ² $r' = 208$ $a = 0,746$	
LUMINANCE response evaluation	LUMINANCE meter Manufacturer X Instrument Y – S/N 98832	Max. deviation < 30 %	OK
		Measured with method A (B.2.1) $L'(\text{LN01}) = 2,012$ cd/m ² $L'(\text{LN02}) = 3,324$ cd/m ² $L'(\text{LN03}) = 5,236$ cd/m ² $L'(\text{LN04}) = 7,488$ cd/m ² $L'(\text{LN05}) = 10,396$ cd/m ² $L'(\text{LN06}) = 14,9$ cd/m ² $L'(\text{LN07}) = 20,756$ cd/m ² $L'(\text{LN08}) = 28,436$ cd/m ² $L'(\text{LN09}) = 38,492$ cd/m ² $L'(\text{LN10}) = 51,996$ cd/m ² $L'(\text{LN11}) = 68,652$ cd/m ² $L'(\text{LN12}) = 89,98$ cd/m ² $L'(\text{LN13}) = 117,42$ cd/m ² $L'(\text{LN14}) = 153,58$ cd/m ² $L'(\text{LN15}) = 198,54$ cd/m ² $L'(\text{LN16}) = 255,74$ cd/m ² $L'(\text{LN17}) = 326,62$ cd/m ² $L'(\text{LN18}) = 418,22$ cd/m ² Max. deviation = 14,72 %	
LUMINANCE evaluation of multiple displays	LUMINANCE meter Manufacturer X Instrument Y – S/N 98832	Deviation < 10 %	OK
		Measured with method A (B.2.1) $L'_{\max} = 418,2$ cd/m ² $L'_{\max} = 389$ cd/m ² Deviation = 7,2 %	
LUMINANCE uniformity evaluation	LUMINANCE meter Manufacturer X Instrument Y – S/N 98832	Max. deviation < 30 %	OK
		Measured with method B (B.2.2) Top-left $L = 144$ cd/m ² Top-right $L = 159,1$ cd/m ² Centre $L = 149,8$ cd/m ² Bottom-right $L = 168,2$ cd/m ² Bottom-left $L = 153,7$ cd/m ² Max. deviation = 15,5 %	

Table A.4 – Constancy test sample report of a monochrome reviewing display

General
Date of test: Aug 23 2007 (TWICE A YEAR TEST)
Test performed by: John
Facility: St. John's facility, Jonathan Street 55, John's City, John's Country
Location: East Wing, Room 405, Workstation WS_405_1
Display: ~~Brand Monochrome~~ LCD, Type 2MP Portrait, S/N ~~44829923 (second display of dual head)~~
Application: Reviewing, multi-modality (CT, MR) workstation

Evaluation method	Equipment, tools	Requirement	Conclusion
		Test result	
Global test result:			OK
Visual evaluations			
Overall image quality evaluation – Verify overall performance	TG18-QC TEST PATTERN	All appearances OK and no defects found	OK
		No	
LUMINANCE uniformity evaluation – Look for non-uniformities	TG18-UN80 TEST PATTERN	No visual non-uniformities detected	OK
		No	
Clinical evaluation	Clinical TEST PATTERNS TG18-CH, TG-18-KN	Clinical images appear OK	OK
		Yes	
Quantitative evaluations			
Basic LUMINANCE evaluation	LUMINANCE meter, ILLUMINANCE meter	$r' > 100$	OK
		Measured with method C (B.2.3) $L_{\max} = 430,6 \text{ cd/m}^2$ $L_{\min} = 0,6 \text{ cd/m}^2$ $E = 53 \text{ lux}$ $Rd = 0,025$ $L_{\text{amb}} = 1,325 \text{ cd/m}^2$ $r' = 224$ $a = 0,688$	

Evaluation method	Equipment, tools	Requirement	Conclusion
		Test result	
LUMINANCE response evaluation	LUMINANCE meter, ILLUMINANCE meter	Max. deviation < 30 %	OK
		Measured with method B (B.2.3) $L(LN01) = 0,6 \text{ cd/m}^2$ $L(LN02) = 1,9 \text{ cd/m}^2$ $L(LN03) = 4 \text{ cd/m}^2$ $L(LN04) = 7 \text{ cd/m}^2$ $L(LN05) = 11 \text{ cd/m}^2$ $L(LN06) = 16,1 \text{ cd/m}^2$ $L(LN07) = 23 \text{ cd/m}^2$ $L(LN08) = 31,9 \text{ cd/m}^2$ $L(LN09) = 42,8 \text{ cd/m}^2$ $L(LN10) = 57,4 \text{ cd/m}^2$ $L(LN11) = 75,6 \text{ cd/m}^2$ $L(LN12) = 97,7 \text{ cd/m}^2$ $L(LN13) = 127 \text{ cd/m}^2$ $L(LN14) = 163,1 \text{ cd/m}^2$ $L(LN15) = 209,7 \text{ cd/m}^2$ $L(LN16) = 266,6 \text{ cd/m}^2$ $L(LN17) = 340,1 \text{ cd/m}^2$ $L(LN18) = 430,6 \text{ cd/m}^2$ Max. deviation = 11,6 %	

Table A.5 – Acceptance test sample report of a colour reviewing display

General
Date of test: Mar 21 2007
Test performed by: John
Facility: St. John's facility, Jonathan Street 55, John's City, John's Country
Location: West Wing, Room 1109, Workstation WS_1109_4
Display: ~~Brand-Colour~~ LCD, Type 2MP Landscape, S/N ~~56698221 (first display of dual head)~~
Application: Reviewing workstation

Evaluation method	Equipment, tools	Requirement	Conclusion
		Test result	
Global test result:			OK
Visual evaluations			
Overall image quality evaluation – Verify overall performance	TG18-QC TEST PATTERN	All appearances OK and no defects found	OK
		No	
Greyscale resolution evaluation – Verify sufficient greyscale resolution based on 8- and 10-bit markers	TG18-MP TEST PATTERN	> 8 bit	OK
		Resolution matches the 8-bit markers	
LUMINANCE response evaluation (more complete solution than the corresponding evaluation within overall image quality evaluation)	TG18-CT TEST PATTERN	All squares and half moons are visible	OK
		Yes	
LUMINANCE uniformity evaluation – Look for non-uniformities	TG18-UN80 TEST PATTERN	No visual non-uniformities detected	OK
		No	
Chromaticity evaluation – Verify colour uniformity	TG18-UN80 TEST PATTERN	No visual non-uniformities on colour detected	OK
		No	
Clinical evaluation	Clinical TEST PATTERNS TG18-CH, TG-18-KN	Clinical images appear OK	OK
		Yes	
Quantitative evaluations			
Basic LUMINANCE evaluation	LUMINANCE meter	$L_{\max}$ deviation < ±10 % of 300 cd/m ² $r' > 100$	OK
		Measured with method A (B.2.1) $L'_{\max} = 285$ cd/m ² $L'_{\min} = 1,95$ cd/m ² $L_{\text{amb}} = 1,2$ cd/m ² $L_{\max} = 283,8$ cd/m ² $r' = 146$ $a = 0,615$	

Evaluation method	Equipment, tools	Requirement	Conclusion
		Test result	
LUMINANCE response evaluation	LUMINANCE meter	Max. deviation < 30 %	OK
		Measured with method A (B.2.1) $L'(LN01) = 1,95 \text{ cd/m}^2$ $L'(LN02) = 3,15 \text{ cd/m}^2$ $L'(LN03) = 4,8 \text{ cd/m}^2$ $L'(LN04) = 7,1 \text{ cd/m}^2$ $L'(LN05) = 9,85 \text{ cd/m}^2$ $L'(LN06) = 14,05 \text{ cd/m}^2$ $L'(LN07) = 18,68 \text{ cd/m}^2$ $L'(LN08) = 24,66 \text{ cd/m}^2$ $L'(LN09) = 31,99 \text{ cd/m}^2$ $L'(LN10) = 40,87 \text{ cd/m}^2$ $L'(LN11) = 51,4 \text{ cd/m}^2$ $L'(LN12) = 65 \text{ cd/m}^2$ $L'(LN13) = 83,8 \text{ cd/m}^2$ $L'(LN14) = 108,3 \text{ cd/m}^2$ $L'(LN15) = 139 \text{ cd/m}^2$ $L'(LN16) = 177,9 \text{ cd/m}^2$ $L'(LN17) = 224 \text{ cd/m}^2$ $L'(LN18) = 285 \text{ cd/m}^2$ Max. deviation = 13,62 %	
LUMINANCE evaluation of multiple displays	LUMINANCE meter	Deviation < 10 %	OK
		Measured with method A (B.2.1) $L'_{\max} = 285 \text{ cd/m}^2$ $L'_{\max} = 306 \text{ cd/m}^2$ Deviation = 7,1 %	
LUMINANCE uniformity evaluation	LUMINANCE meter	Max. deviation < 30 %	OK
		Measured with method B (B.2.2) Top-left $L = 95,3 \text{ cd/m}^2$ Top-right $L = 90,8 \text{ cd/m}^2$ Centre $L = 110,6 \text{ cd/m}^2$ Bottom-right $L = 101,1 \text{ cd/m}^2$ Bottom-left $L = 112 \text{ cd/m}^2$ Max. deviation = 20,9 %	

Evaluation method	Equipment, tools	Requirement	Conclusion
		Test result	
Greyscale chromaticity evaluation NOTE: This device was calibrated according to the GSDF.	Colour meter	Max. deviation < 0,01	OK
		Discarded measurements: ($L < 5 \text{ cd/m}^2$) LN01: $L = 0,7 \text{ cd/m}^2$ $u' = 0,192\ 7$ $v' = 0,458\ 3$ LN02: $L = 1,92 \text{ cd/m}^2$ $u' = 0,193\ 5$ $v' = 0,461\ 5$ LN03: $L = 3,48 \text{ cd/m}^2$ $u' = 0,193\ 5$ $v' = 0,464\ 0$ Remaining measurements: LN04: $u' = 0,192\ 7$ $v' = 0,462\ 0$ LN05: $u' = 0,193\ 5$ $v' = 0,464\ 1$ LN06: $u' = 0,192\ 7$ $v' = 0,464\ 7$ LN07: $u' = 0,193\ 0$ $v' = 0,464\ 8$ LN08: $u' = 0,193\ 0$ $v' = 0,464\ 9$ LN09: $u' = 0,192\ 8$ $v' = 0,465\ 0$ LN10: $u' = 0,193\ 3$ $v' = 0,465\ 1$ LN11: $u' = 0,193\ 1$ $v' = 0,465\ 5$ LN12: $u' = 0,193\ 1$ $v' = 0,465\ 5$ LN13: $u' = 0,193\ 1$ $v' = 0,465\ 3$ LN14: $u' = 0,193\ 3$ $v' = 0,465\ 5$ LN15: $u' = 0,193\ 4$ $v' = 0,465\ 4$ LN16: $u' = 0,193\ 4$ $v' = 0,465\ 4$ LN17: $u' = 0,193\ 5$ $v' = 0,465\ 7$ LN18: $u' = 0,193\ 9$ $v' = 0,466\ 1$ Max. deviation = 0,004 3	

Table A.6 – Constancy test sample report of a colour reviewing display

General
Date of test: Jul 23 2007 (QUARTERLY)
Test performed by: John
Facility: St. John's facility, Jonathan Street 55, John's City, John's Country
Location: West Wing, Room 1109, Workstation WS_1109_4
Display: ~~Brand-Colour~~ LCD, Type 2MP Landscape, S/N ~~56698221 (first display of dual head)~~
Application: Reviewing workstation

Evaluation method	Equipment, tools	Requirement	Conclusion
		Test result	
Global test result:			OK
Visual evaluations			
Overall image quality evaluation – Verify overall performance	TG18-QC TEST PATTERN	All appearances OK and no defects found	OK
		No	
LUMINANCE uniformity evaluation – Look for non-uniformities	TG18-UN80 TEST PATTERN	No visual non-uniformities detected	OK
		No	
Clinical evaluation	Clinical TEST PATTERNS TG18-CH, TG-18-KN	Clinical images appear OK	OK
		Yes	
Quantitative evaluations			
Basic LUMINANCE evaluation	LUMINANCE meter, ILLUMINANCE meter	$r' > 100$	OK
		Measured with method B (B.2.2) $L_{\max} = 280,3 \text{ cd/m}^2$ $L_{\min} = 0,7 \text{ cd/m}^2$ $E = 45 \text{ lux}$ $Rd = 0,029$ $L_{\text{amb}} = 1,305 \text{ cd/m}^2$ $r' = 140$ $a = 0,651$	

Evaluation method	Equipment, tools	Requirement	Conclusion
		Test result	
LUMINANCE response evaluation	LUMINANCE meter, ILLUMINANCE meter	Max. deviation < 30 %	OK
		Measured with method B (B.2.2) $L(LN01) = 0,7 \text{ cd/m}^2$ $L(LN02) = 1,92 \text{ cd/m}^2$ $L(LN03) = 3,48 \text{ cd/m}^2$ $L(LN04) = 5,56 \text{ cd/m}^2$ $L(LN05) = 8,06 \text{ cd/m}^2$ $L(LN06) = 11,85 \text{ cd/m}^2$ $L(LN07) = 16,55 \text{ cd/m}^2$ $L(LN08) = 22,84 \text{ cd/m}^2$ $L(LN09) = 29,65 \text{ cd/m}^2$ $L(LN10) = 37,2 \text{ cd/m}^2$ $L(LN11) = 49,1 \text{ cd/m}^2$ $L(LN12) = 63,7 \text{ cd/m}^2$ $L(LN13) = 82,5 \text{ cd/m}^2$ $L(LN14) = 107 \text{ cd/m}^2$ $L(LN15) = 137,7 \text{ cd/m}^2$ $L(LN16) = 176,6 \text{ cd/m}^2$ $L(LN17) = 225,5 \text{ cd/m}^2$ $L(LN18) = 280,3 \text{ cd/m}^2$ Max. deviation = 14,76 %	