Japan Industries Association of Radiological Systems Standards (JESRA X－0093＊A^{-2010})
-English version-

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Quality Assurance (QA) Guidelines for Medical Imaging Display Systems

Japan Industries Association of Radiological Systems

Caution

1 Original document

This document is translated from Japanese JESRA X-0093*A^{-2010}. Please refer the Japanese version of JESRA if any contradiction between English and Japanese because English version is not official, just translation.

2 Keyword definitions

Several keywords are used to differentiate between different levels of requirements and optionality, as follows:

2.1 shall: A keyword indicating a mandatory requirement.

2.2 should: A keyword indicating flexibility of choice with a strongly preferred alternative.

2.3 may: A keyword indicating flexibility of choice with no implied preference.

Contents

Preface

The quality assurance of medical imaging display systems (hereafter display systems) is recognized as an important issue, and concerned organizations in the individual countries have compiled standards for acceptance tests and constancy tests. However, the generation of standards preceded everything else, and methodical investigation about how the standards should be followed has been generally insufficient. In addition, because the standards have been complied at foreign institutions' initiatives, the standards do not perfectly match the organizations and customs of Japanese medical institutions.

The "Quality Assurance (QA) Guidelines for Medical Imaging Display Systems" (hereafter the guidelines) have been compiled so that Japanese medical institutions can follow smoothly; the standards and guidelines generated by foreign institutions have been reflected as necessary. The guidelines have an appendix that allows medical institutions to implement test methods without referring to other standards. Some other appendixes show generated test patterns and formats of standard reports, so that the quality assurance of display systems will be widely recognized.[1]

1. Scope and purpose

1.1 Scope

The scope of the guidelines covers the color and monochrome display systems that are used for monochrome image display at medical institutions. The guidelines do not specify the color image, but they apply to the color monitors that are used for monochrome image display. When the guidelines are used to manage medical displays, the characteristics of display system[2] shall be GSDF characteristics specified by DICOM PS 3.14.

It is desirable for medical institutions to use display systems managed under the guidelines when performing image diagnosis. The guidelines cover only the evaluation methods and standards of display systems themselves. For clinical applications, refer to "the guidelines for handling digital images" issued by Japan Radiological Society. Medical institutions themselves should consult with physicians and decide what monitors should be used for image reading.

1.2 Purpose

The purpose of the guidelines is to keep or improve the precision of image reading through quality assurance activities for display systems.

2. Reference standards and guidelines

2.1 Reference standards

JIS Z 4752-1

Quality maintenance evaluation and routine testing methods in medical imaging departments--Part 1: General aspects

JIS Z 4752-2-5

Quality maintenance evaluation and routine testing methods in medical imaging departments--Part 2-5: Constancy tests -- Imaging display devices

DIN 6868-57

Image Quality Assurance in X-Ray Diagnosis -- Part 5-7: Acceptance testing for image display devices

Digital Imaging and Communications in Medicine (DICOM)

Part 14: Grayscale Standard Display Function

2.2 Reference Guidelines

AAPM On Line Report No. 03, April 2005

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[1] When users use the provided images, they shall understand the "obligations of users" described in the manual for test tool that is published in the home page of Japan Industries Association of Radiological Systems.

[2] The range of display systems is defined in section 3 in appendix 6.

Citation:

Samei E, Badano A, Chakraborty D, Compton K, Cornelius C, Corrigan K, Flynn MJ, Hemminger B, Hangiandreou N, Johnson J, Moxley M, Pavlicek W, Roehrig H, Rutz L, Shepard J, Uzenoff R, Wang J, and Willis C. Assessment of Display Performance for Medical Imaging Systems. Report of the American Association of Physicists in Medicine (AAPM) Task Group 18, Medical Physics Publishing, Madison, AAPM On Line Report No. 03, April 2005

Guidelines for handling digital images, Version 2.0, April 2006

The Electron Information Committee of the Japan Radiological Society

3. Definitions of terminology used in the guidelines

Acceptance tests

The tests having the objective of checking whether a purchased apparatus satisfies the required specifications. This test is usually conducted before such apparatus is installed and operated. However, the test is conducted also after the installation and operation if repair or adjustment affecting the characteristics is required or if environmental conditions change.

Artifact

Any problematic phenomenon that should not be present. The types of phenomenon include flicker, crosstalk, video characteristics (ghost and ringing), and color characteristics (convergence and landing characteristics).

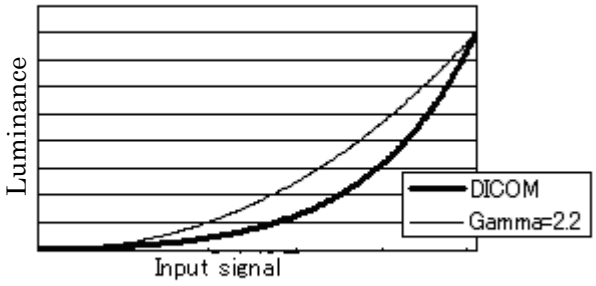
Aspect ratio, Aspect ratio of X/Y

The proportion of the display's width and its height. General 2M and 3M display systems of a horizontal type have an aspect ratio of 4:3 (for a vertical type, 3:4), and general 1M and 5M display systems of a horizontal type have an aspect ratio of 5:4 (for a vertical type, 4:5).

Characteristics curve

A curve representing the relationship between input signals and actual display luminance. An example of a characteristics curve is given below:

Characteristics curve



Color artifact

An artifact representing color characteristics. This often refers to color shift resulted from misconvergence or mislanding on a CRT display.

Color meter

A meter used to measure chromaticity, which should be expressed in u', v' chromaticity coordinate (UCS color system). The details are given in appendix 5.

Constancy tests

The tests aimed at maintaining the characteristics of the apparatus in use within the permissible range. In this test the specified items regarding the initial characteristics of an apparatus that underwent the acceptance tests are used as the reference, and the apparatus is periodically checked against the reference to ensure that the apparatus operates within the acceptable range. The test should be conducted by the actual user.

Contrast response

This index shows the deviation of the ideal GSDF curve and the actual characteristics curve against JND index. The smaller value means the proximity to the ideal GSDF curve. (The details are given in section 6 in appendix 6.)

Correlated

When one of multiple measuring instruments in use is designated for reference, correlated means compensated by the error factor for the measuring instrument relative to the reference measuring instrument.

Crosstalk

A phenomenon caused when signals interfere with a different electric circuit. On an LCD, driving signals interfere with a panel circuit which is not currently driven, generating shadows along characters and lines.

Edge

The borderline of circumference of the JIRA TG18-QC and the JIRA TG18-UNL80 patterns.

Flicker

A fluctuating image on a display screen. A display screen is refleshed several tens of times per second. In particular a CRT display causes flicker when the frequency of screen refreshing (vertical scanning frequency) is too low. Flicker appears different from person to person.

Ghost

A false image generated through reflection mainly attributable to circuit and cable factors; multiple images often result.

GSDF

An abbreviation for Grayscale Standard Display Function. This function is also referred to as the Barten curve from the name of the person who verified the function. DICOM PS 3.14 shows the GSDF’s table for the function of the Just Noticeable Difference (JND) index and luminance. The function is characterized by the uniform contrast resolution in the range from low to high luminance.

Horizontal/vertical crosshatch line

Grid pattern lines resulted from cross of multiple parallel horizontal and vertical lines equally spaced.

I/F

An abbreviation for interface. In a broad sense it designates a part of an apparatus or device to which another machine or device is connected for communication and/or control; it often refers to a connection part between a computer and a peripheral device. When used in the guidelines, it means a connection part between a display system and another type of apparatus.

Illuminance meter

A meter used to measure illuminance , which is expressed in lx. The details are given in appendix 5.

Image display terminal

This terminal contains the display system defined in section 3 in appendix 6, and the computer that drives the display system

Interlaced display

Method in which a single screen display is generated through two sets of line drawings, whereby the pixel clock is reduced. Because this method utilizes the residual-image characteristics of the human eye, it can cause such problems as appearance of flicker or the intervals between odd and even lines may not have a ratio of 1:1. The method in which a single screen display is generated through one set of line drawing is called a non-interlaced or progressive.

JND index

JND stands for Just Noticeable Difference. The JND index represents changes in input relative to changes of luminance levels in JND steps on the Grayscale Standard Display Function (GSDF).

Linearity

When QC patterns and other test patterns are displayed, if each grid is a square and each line is straight without curving or winding, then linearity is good.

Luminance meter

A meter used to measure luminance, which should be expressed in cd/m^2. The details are given in appendix 5.

Luminance ratio

The maximum luminance is called L_{max}. The minimum luminance is called L_{min}. The luminance observed on the surface of display system when the display system is switched off, is called L_{amb}. Then, the luminance ratio is expressed in $(L_{max} + L_{amb}) / (L_{min} + L_{amb})$. In the guidelines, in order to make the measurement values reproducible, $L_{amb} = 0$ in principle. In practice, therefore, the luminance ratio is used as L_{max} / L_{min}.

LUT

An abbreviation for Look Up Table that designates the conversion table of digital pixel values.

Maximum luminance

Luminance produced when the maximum value of input signals is input.

Minimum luminance

Luminance produced when the minimum value of input signals is input.

Misconvergence

A phenomenon on a color CRT such as bleared characters and color image blurring resulting from the fact that three electron beams (red, blue, and green) are not correctly sent to the fluorescent screen (are not focused on a single point on the fluorescent screen) because of the assembly variance of the deflection yoke and electron gun. This phenomenon can also be caused by changes in the installation environment (i.e. influence by magnetism).

Mislanding

A phenomenon whereby an electron beam of any color on a color CRT does not reach an appropriate fluorescent substance but lands upon an adjacent fluorescent substance, causing an incorrect color to be emitted; this happens because of physical shift between the shadow mask (aperture grill) and the fluorescent substances or because the incident angle of the beam relative the shadow mask has shifted. When a perfectly white image is displayed, this phenomenon causes the luminance of the white portion to be nonuniform or in a worst case causes some white part to be colored.

Multiple medical displays

In the guidelines, it refers to plural medical displays of the same type that are driven by a single computer.

Nyquist frequency

The maximum frequency used when lines of a screen display are drawn. This frequency is used when a display is drawn with one dot on and one dot off in the JIRA TG18-QC pattern and the JIRA SMPTE pattern.

Overshoot

A phenomenon presenting an excessive output relative to input of square waves in an electric circuit. This problem makes white appear enhanced at the borderline between black and white on a display screen.

p value

An input value for the standardized display system whose output presents GSDF characteristics.

Scoring scale

Cx images generated by spuriously deteriorating the focus characteristics that exist at the center of the JIRA TG18-QC test pattern, step by step (12 steps: minus 2 to zero to 9); this is used as the reference.

Shadow

A phenomenon generating shadows along characters and lines at parts presenting contrast changes.

SI vendor (System Integration vendor)

This stands for a system integration vendor producing and supplying medical systems.

Video artifact

An artifact caused by video signals such as ghost or shadow.

4. Management Grade Classification

Display systems that have been managed shall be classified into the following two categories:

Table 1 Display system management grade

Management grade	Maximum luminance $L_{max}(cd/m^2)$	Luminance ratio L_{max}/L_{min}	Contrast response Kδ(%)
1	≧170	≧250	≦±15
2	≧100	≧100	≦±30

5. Operation Framework

5.1 Frameworks of Medical Institutions

The framework of a medical institution should be structured according to JIS Z 4752-1.

It is desirable to establish a Quality Assurance Committee (tentatively so named) within a medical institution upon the request of the head of the medical institution and causes the committee to carry out works concerning overall quality maintenance activities. Ideally, works relating to quality assurance should be carried out on the authority and responsibility of the Quality Assurance Committee (tentatively so named).

The Quality Assurance Committee (tentatively so named) should appoint a display system quality administrator.

5.2 Display System Quality Administrator

5.2.1 Works of display system quality administrator

A display system quality administrator should carry out the following works in order to assure the display system's stable display capability needed for diagnosis.

The generation of procedures concerning quality maintenance

Determination of the set values for acceptance tests and constancy tests (especially determination of the set values of maximum luminance[3])

Training of acceptance tests and constancy tests

Implementation of acceptance tests and constancy tests

Evaluation of results and countermeasures

Storage of records, which are test histories

Repair, renewal of display systems etc.

[3] The details for the set values of maximum luminance are described in section 3 in appendix 4.

5.2.2 Display system quality administrator

It is desirable for the display system quality administrator to be fully informed of acceptance and constancy tests.

5.3 Regarding Outsourcing

Some of the works concerning the quality assurance of display systems may be carried out by organizations outside the medical institution.

6. Test Methods

The display system quality administrator shall, before the test, determine the set value of the operative maximum luminance. After that, the administrator shall use the calibrated measurement instrument, conduct the acceptance tests and constancy tests of display systems, generate and store a report about the test results that become the test history.[4] The outline of acceptance tests, the outline of constancy tests, and the details of both tests are described in section 6.1, section 6.2, and appendix 1 respectively, so that the tests will be thoroughly understood.

6.1 Acceptance Tests

6.1.1 Test conditions and timing

The display system quality administrator should conduct the acceptance tests and generate a report about the test results. In a case where the reproducibility of the evaluation data on the display system has been confirmed[5], the display system quality administrator may omit the acceptance tests by checking and approving the display system's outgoing inspection report presented by the system supplier. In order to prevent variations attributable to image reading environments and to maintain the reproducibility of test results, acceptance tests at medical institutions and outgoing inspections by system suppliers shall be conducted in an environment not exposed to ambient light.

6.1.2 Preparation

The acceptance tests should be conducted according to the preparation procedure; for details, see section 1 in appendix 1.

6.1.3 Check items and judgment criteria

The outline is shown in table 2, and the details are given in section 2 to 10 in appendix 1.

6.1.4 Keeping test results

Acceptance test result reports (samples are shown in Table 4) should be kept for the period during which display systems remain in use.

6.2 Constancy Tests

6.2.1 Test conditions and timing

The constancy tests should be conducted on the responsibility of the display system quality administrator.

Visual check for the constancy tests shall be performed under ordinary ambient light for image reading. Measurement shall be performed in an environment free from ambient light in order to prevent variations attributable to image reading environments and to maintain the reproducibility of test results.[6]

The constancy tests comprise the following three items (① to ③).

[4] The storage format of test result report is not specified.
[5] Application examples are given in section 4 in appendix 6.
[6] The details for the use in a bright room are given in section 2 in appendix 4.

① Generation of reference values

The initial values for the constancy tests should be measured using the image display terminal and luminance meter actually used at the medical institution at the earliest possible time after the display system has been installed. The initial values then should be compared with the outgoing inspection data and the set value to check the grade and be used as the reference for constancy tests.

② Overall evaluation tests on each usage day

The overall evaluation test on each usage day should be conducted by a user who is designated by the display system quality administrator. The test shall be implemented under ambient light conditions actually used for image reading as preparation for using the display system.

③ Periodical tests

Periodical constancy tests should be conducted under the same (or nearly the same) environment as when the reference values are generated. For CRT display systems, tests should be conducted every three months at least; for LCD display systems, every six months at least. For LCD display systems containing a luminance stabilizing circuit, tests may be implemented once a year.

6.2.2 Preparation

The constancy tests should be conducted according to the preparation procedure; for details, see section 1 in appendix 1.

6.2.3 Check items and judgment criteria

The outline is shown in table 3, and the details are given in section 2 to 9 in appendix 1.

6.2.4 Procedures to be adopted when the test is not passed

When a constancy tests are not passed, repeat the test. If the system still does not meet the judgment criteria, perform calibration[7] and then conduct the test once again. If the calibration does not allow the system to meet the criteria, contact the display system quality administrator and take appropriate procedures.

6.2.5 Keeping test results

The results of constancy tests should be described in a constancy test result report (samples are shown in tables 5 and 6) and kept for the period during which display systems remain in use.

[7] The details are given in section 5 in appendix 6.

Table 2　Check items and judgment criteria for acceptance tests

Judgment method	Category	Test pattern measuring instrument	Judgment criteria		Check item Formula[8]	Unit	Test No.[9]
			Grade 1	Grade 2			
Spec	Specifications		≧1k*1k		Resolution	Pixel	
Visual check	Overall evaluation	JIRA TG18-QC [JIRA SMPTE][10]	The patches' luminance differences among 16 (11) steps should be clearly recognized. 5% and 95% patches should be visible.				2
		Judgment-use clinical image or reference clinical image	The judgment-use positions on the judgment-use clinical image or the reference clinical image should be visible without any problem.[11]				
	Grayscale	JIRA TG18-QC [8-bit gray scale at least]	Smooth, stable and continuous display should be presented.				3
	Geometric distortion：CRT only	JIRA TG18-QC [JIRA SMPTE]	The entire screen should allow visual check and provide linearity. The aspect ratio of the width and height should be appropriate.				4
	Resolution：CRT only	JIRA TG18-QC [JIRA SMPTE]	0≦Cx≦4 Nyquist lines should be visible.		Cx score	－[12]	5
	Artifact	JIRA TG18-UNL80 [JIRA TG18-UN80, Entirely white]	Artifacts should not be present.		Flicker		6
		JIRA TG18-QC [JIRA SMPTE]			Crosstalk Video artifact		
					Color artifact：CRT only		
Measurment	Luminance uniformity	JIRA TG18-UNL80 [JIRA TG18-UN80, Entirely white] Luminance meter	≦30		{(Lmax－Lmin)÷(Lmax＋Lmin)}×200	%	7
	Contrast response	JIRA TG18-LN or JIRA BN Luminance meter	≦±15	≦±30	Kδ of 18 points	%	8
	Maximum luminance		≧170	≧100	Lmax	cd/m^2	9
			Between multiple displays ≦10		$\{(Lmax_1－Lmax_2)÷Lmax_2\}×100$	%	
	Luminance ratio		≧250	≧100	Lmax/Lmin	－	
	Chromaticity	JIRA TG18-UNL80 [JIRA TG18-UN80, Entirely white] Color meter	Inside the screen ≦0.01	－	$\{(u'_1－u'_2)^2+(v'_1－v'_2)^2\}^{1/2}$	－	10
			Between multiple displays ≦0.01		$\{(u'm_1－u'm_2)^2+(v'm_1－v'm_2)^2\}^{1/2}$	－	

8 The meanings of L_{max} and L_{min} differ among test items. For details, refer to the relevant sections in appendix 1.

9 Test No designate section numbers in appendix 1, "Acceptance and Constancy Tests for Display Systems."

10 The content of [　] shows an alternate test pattern when a standard test patterns cannot be displayed; there is no evaluation of Cx patterns.

11 The reference values for the window width and window level of the display software should be determined at the medical institution.

12 The dash (－) designates that no test and unit is provided.

Table 3　Check items and judgment criteria for constancy tests

1. Items to be checked on each usage day prior to use and their judgment criteria

Judgment method	Category	Test pattern measuring instrument	Judgment criteria		Check item Formula	Unit	Test No.
			Grade 1	Grade 2			
Visual check	Overall evaluation	JIRA TG18-QC [JIRA SMPTE]	The patches' luminance differences among 16 (11) steps should be clearly recognized. 5% and 95% patches should be visible.				2
		Judgment-use clinical image or reference clinical image	The judgment-use positions on the judgment-use clinical image or the reference clinical image should be visible without any problem.				
	Alternate overall evaluation	JIRA CHEST-QC	The patches' luminance differences among 16 steps should be clearly recognized. 5% and 95% patches should be visible. The judgment-use positions on the chest image should be visible without any problem				2

2. Items to be checked every three months for CRT display systems, and every six or twelve months for LCD display systems, and their judgment criteria

Judgment method	Category	Test pattern measuring instrument	Judgment criteria		Check item Formula	Unit	Test No.
			Grade 1	Grade 2			
Visual check	Overall evaluation	JIRA TG18-QC [JIRA SMPTE]	The patches' luminance differences among 16 (11) steps should be clearly recognized. 5% and 95% patches should be visible.				2
		Judgment-use clinical image or reference clinical image	The judgment-use positions on the judgment-use clinical image or the reference clinical image should be visible without any problem.				
	Grayscale	JIRA TG18-QC [8-bit gray scale at least]	Smooth, stable and continuous display should be presented.				3
	Geometric distortion：CRT only	JIRA TG18-QC [JIRA SMPTE]	The entire screen should allow visual check and provide linearity. The aspect ratio of the width and height should be appropriate.				4
	Resolution：CRT only	JIRA TG18-QC [JIRA SMPTE]	0≦Cx≦4 Nyquist lines should be visible.		Cx score	－	5
	Artifact	JIRA TG18-UNL80 [JIRA TG18-UN80, Entirely white]	Artifacts should not be present.		Flicker		6
		JIRA TG18-QC [JIRA SMPTE]			Crosstalk Video artifact		
					Color artifact：CRT only		
	Luminance uniformity	JIRA TG18-UNL80 [JIRA TG18-UN80, Entirely white]	Excessive nonuniformity should be absent.				7
Measurement	Contrast response	JIRA TG18-LN or JIRA BN Luminance meter	≦±15	≦±30	Kδ of 18 points	%	8
	Maximum luminance		≧170	≧100	Lmax	cd/m^2	9
			Luminance deviation ≦±10		$\{(Lmax_n－Lmax_0)÷Lmax_0\}×100$	%	
			Between multiple displays ≦10		$\{(Lmax_1－Lmax_2)÷Lmax_2\}×100$	%	
	Luminance ratio		≧250	≧100	Lmax÷Lmin	－	
	Illuminance (value for reference)				Screen vertical Illuminance	lx	

Appendix 1.　Acceptance and Constancy Tests for Display Systems

1. Preparation

1.1 Measuring instruments

The detailed expressions of each measuring instruments are shown in appendix 5.

① Luminance meter

In order to measure luminance of display systems, a luminance meter shall be prepared. It shall be used for acceptance tests and constancy tests.

② Color meter

In order to measure chromaticity of display systems, a color meter shall be prepared. It shall be used for acceptance tests.

③ Magnifying glass

In order to test the resolution of CRT display systems, a magnifying glass shall be prepared. It shall be used for acceptance tests and constancy tests. It is not needed for LCD display systems.

④ Illuminance meter

In order to measure the ambient illuminance at the center of the screen of display systems, an illuminance meter shall be prepared. In the guidelines, however, illuminance is merely an informative value. Therefore, an illuminance meter need not be prepared.

1.2 Test patterns and clinical images for judement

It is necessary to prepare the three kinds of test patters shown in figure 1 and the judgment use clinical image corresponding to usage of each display systems. If it is impossible to prepare the judgment use clinical image, the reference clinical image shown in figure 3 can be replaced. For alternate overall evaluation on each usage day, it is necessary to prepare the JIRA CHEST-QC pattern shown in figure 4. If it is impossible to prepare one of the standard test patterns shown in figure 1, the patterns shown in figure 2 can be replaced.[13] Each pattern shall be displayed on the entire screen with an appropriate aspect ratio.

The observation points for test pattern, the Reference Clinical Image and the JIRA CHEST-QC pattern are shown in appendix 2.

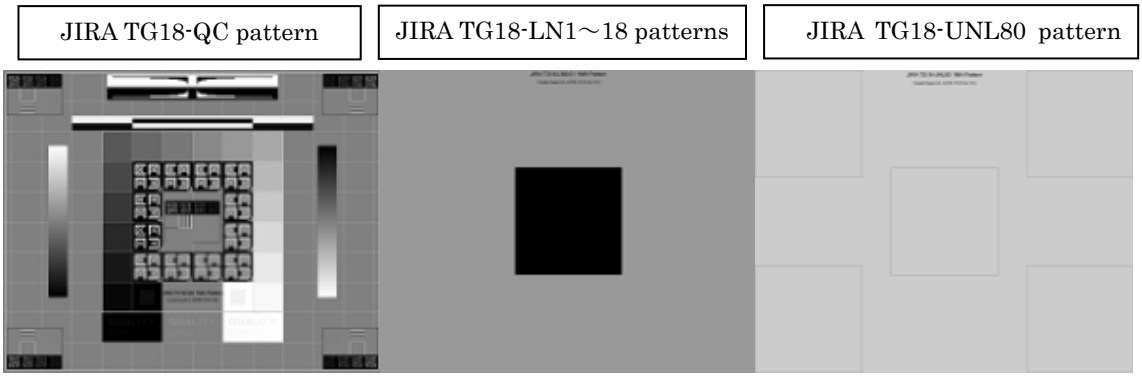


Figure 1　Standard test patterns

[13] As luminance measurement by using JIRA TG18-LN patterns are affected by the background of TG18-LN Patterns, it is recommended to use JIRA BN luminance measurement patterns.

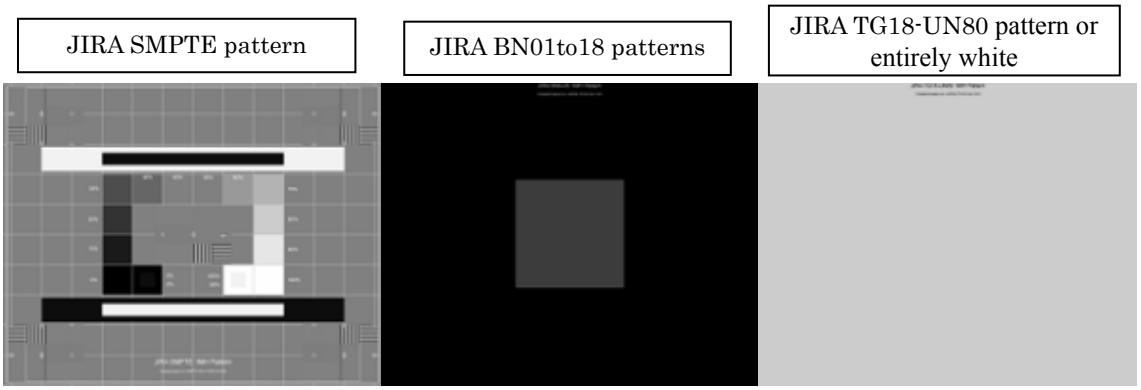


Figure 2 Alternate test patterns

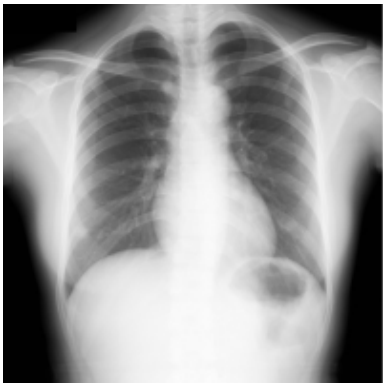


Figure 3 Reference clinical image

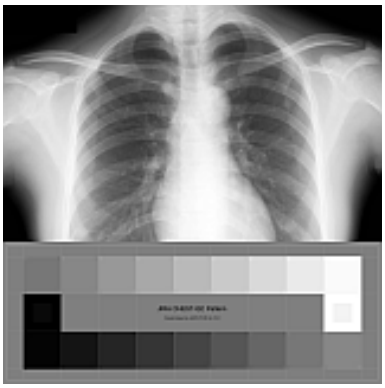


Figure 4 JIRA CHEST-QC pattern

1.3 Preparation and Precautions for Tests

① Prepare the result data of acceptance tests and constancy tests.

② Prepare the measuring instruments, test patterns, and the Clinical Image for judgment or the Reference Clinical Image.

③ Turn on the power to the display system for the period recommended by manufacturers (in operation manuals, specifications etc.)[14] before evaluation in order to stabilize its electronic components. Condensation occurs when the image display is quickly moved from a cold to a warm and humid place. Note that it is not desirable to turn on the display system when condensation is present.

14 While the display system is in the power-save mode, its electronic components are not stabilized.

④ Calibration

Perform calibration at the time of the acceptance tests if necessary. Calibration here means precisely setting such parameters as the luminance of the display system, characteristics curve, and chromaticity, using a sensor. The details of calibration are given in section 5 of appendix 6.

⑤ It is essential to generate reference values for constancy tests and conduct constancy tests in a finally installed environment at medical institutions. The placement of the display system and the condition of illumination shall have been finalized, and the image display terminal and a correlated luminance meter actually used at the medical institution shall be used for the tests. The display system shall have been placed so that the direct light from overhead illumination, sunlight, or viewing box shall not be present at a usual image reading position at the front of the display system under actual ambient conditions.

⑥ For a CRT display system, check if it is affected by magnetic fields. Using the JIRA TG18-QC (or the JIRA SMPTE) pattern, check if ambient magnetic fields cause image distortion, fluctuation, or color shift.

⑦ A LCD display system has angular dependence characteristics. When visually checking a LCD display system, view the image on the screen from the front.

⑧ Before conduction the test, clean the screen so that it is free from dust and dirt. When cleaning the screen, follow the procedure presented by the system supplier.

2. Overall Evaluation Tests (Visual Evaluation)

Before starting individual tests, make the JIRA TG18-QC pattern and the judgment-use clinical images or reference clinical images, and check the overall image quality of the display system. If the JIRA TG18-QC pattern cannot be prepared, the JIRA SMPTE pattern may be used instead.

For the overall evaluation test on each usage day, the JIRA CHEST-QC pattern may be used to conduct an alternate overall evaluation test.

2.1 Overall Evaluation Test Using the JIRA TG18-QC Pattern

・Check items

① Differences in luminance among 16-step patches

② Recognition of 5% and 95% patches

・Judgment criteria

① Differences in luminance should be clearly recognizable.

② Visual recognition should be possible.

2.2 Overall Evaluation Test Using the JIRA SMPTE Pattern

・Check items

① Differences in luminance among 11-step patches

② Recognition of 5% and 95% patches

・Judgment criteria

① Differences in luminance should be clearly recognizable.

② Visual recognition should be possible.

2.3 Overall Evaluation Tests Using Judgment-use Clinical Images or Reference Clinical Images

Medical institutions should prepare judgment-use clinical images suitable for the usage of a display system, and determine the check items and judgment criteria.

If the medical institution can not itself prepare judgment-use clinical images suitable for the usage of a display system, it is recommend to use reference clinical images shown in “1) Guidelines for handling digital images” listed under the bibliography.

・Check items of reference clinical images

Check how nodules to be recognized appear on reference clinical images.

・Judgment criteria of reference clinical images

Points for judgment should be visible without problems.

2.4 Alternate Overall Evaluation Tests on Each Usage Day Using the JIRA CHEST-QC Pattern

・Check items

① Differences in luminance among 16-step (step 1 to 9 and step 8 to 16) patches

② Recognition of 5% and 95% patches

③ Check how nodules to be recognized appear on chest images.

・Judgment criteria

① Differences in luminance should be clearly recognizable.

② Visual recognition should be possible.

③ Points for judgment should be visible without problems.

3. Grayscale Test (Visual Evaluation)

・Check items

Display the JIRA TG18-QC test pattern (or another 8 bit or higher grayscale as an alternative) and check that the grayscale bars are continuous.

・Judgment criteria

Smooth, even and continuous display should be presented.

4. Geometric Distortion Test (Visual Evaluation): CRT Display Systems Only

・Check items

Visually check geometric distortion using the JIRA TG18-QC test pattern (or alternatively the JIRA SMPTE test pattern). Make the pattern cover the entire display area. Visually check the linearity of the pattern over the entire display area and at the borderlines of the pattern's periphery.

・Judgment criteria

The pattern should not present a significant geometric distortion, and the entire pattern should be displayed. The pattern should be displayed with an appropriate aspect ratio, and each grid should be square. Each line should be straight and present an appropriate linearity; it should not be curved or winding. Extreme barrel or pincushion distortion should not be present; presence of minimal barrel or pincushion distortion is not a problem.

5. Resolution Test (Visual Evaluation): CRT Display Systems Only

・Check items

Visually check how the Cx pattern included in the JIRA TG18-QC test pattern appears. It is important to check that image pixels match display pixels one for one. A digitally enlarged display does not allow its actual resolution to be evaluated. With the JIRA TG18-QC test pattern and a magnifying glass, check the Cx patterns displayed at the center and four corners of the screen, and perform evaluation using the appropriate scoring scale where the clearest reference pattern is 0, and the least clearest reference pattern is 9. In addition, check if lines are visible for the horizontal and vertical line pair patterns at the Nyquist frequency on the JIRA TG18-QC and the JIRA SMPTE patterns.

・Judgment criteria

The result of the Cx evaluation should be between 0 and 4 (clearer than score 4). The horizontal and vertical line pair patterns at the Nyquist frequency should be recognizable at all positions and in every direction.

6. Artifact Test (Visual Evaluation): For □Color Artifact Test, CRT Display System Only

・Check items

① Flicker

Visually check the artifact using the JIRA TG18-UNL80 test pattern (or alternatively the JIRA TG18-UN or the entirely white pattern).

② Crosstalk

Visually check the crosstalk element of the JIRA TG18-QC test pattern (or alternatively the low contrast Nyquist lines of the JIRA SMPTE pattern).

③ Video artifact

Visually check the white-to-black and black-to-white signal change of the JIRA TG18-QC test pattern (or alternatively the JIRA SMPTE pattern).

④ Color artifact

Visually check the crosshatch lines and background of the JIRA TG18-QC pattern (or alternatively the JIRA SMPTE pattern).

・Judgment criteria

① Flicker

No flicker should be visible; this test does not apply to display system with an interlace display technique.

② Crosstalk

Crosstalk elements should be properly displayed; the low contrast lines of the JIRA SMPTE pattern should be properly displayed.

③ Video artifact

There should be no extreme tailing, overshoot, shadow or ghosting.

④ Color artifact

Horizontal and vertical crosshatch lines should not present significant misconvergence. The pattern background should not present significant mislanding.

7. Luminance Uniformity Test

7.1 Acceptance Test Evaluation (Quantitative Evaluation)

・Check items

Using a calibrated luminance meter and the JIRA TG18-UNL80 pattern, measure the luminance of the center of each of the displayed five patches. (Even when using alternatively the JIRA TG18-UN80 or the

entirely white pattern, the measurement points should be the same as for the JIRA TG18-UNL80.) The following formula allows the luminance deviation of the display pattern to be obtained.

*Formula 1　　Formula = ｛(Lmax－Lmin)/(Lmax＋Lmin)｝*200%*

where Lmax is the maximum luminance value among the measured five points ,

and; Lmin is the minimum luminance value among the measured five points .

・Judgment criteria

The luminance deviation shall be within 30%.

7.2 Constancy Test Evaluation (Visual Evaluation)

・Check items

In order to visually check the luminance uniformity of display system, use the JIRA TG18-UNL80 test pattern (or alternatively the JIRA TG18-UN80 or the entirely white pattern). Display the pattern and visually check its uniformity.

・Judgment criteria

The pattern should not present a significant non-uniformity from the center to the edges.

8. Contrast Response Tests (Quantitative Evaluation)

・Check items

Using a calibrated luminance meter and the JIRA TG18-LN or the JIRA BN test patterns, measure the luminance inside the test area for 18-step digital drive levels. In the luminance measurement, when the JIRA TG18-LN luminance measurement patterns are used, the measured values are affected by the background luminance. Therefore, the guidelines recommend the use of the JIRA BN luminance measurement patterns.

・Judgment criteria

Using the measured luminance values and the DICOM PS 3.14 standard luminance response curve, calculate the contrast response relative to the JND index.[15] For grade 1 display systems, the calculated contrast response values shall be within ±15% of the standard values at all measurement points; for grade 2 display systems, within ±30%.

9. Maximum luminance and luminance Ratio Tests

9.1 Acceptance Test Evaluation (Quantitative Evaluation)

・Check items

Using a calibrated luminance meter and the JIRA TG18-LN or the JIRA BN test patterns, measure the maximum luminance (white luminance, Lmax) and the minimum luminance (black luminance, Lmin) and calculate the luminance ratio (Lmax / Lmin). In the luminance measurement, when the JIRA TG18-LN luminance measurement patterns are used, the measured values are affected by the background luminance. Therefore, the guidelines recommend the use of the JIRA BN luminance measurement patterns.

Among multiple displays for the same usage, the deviation of the maximum luminance shall be calculated by the following formula. When the outgoing inspection data are used as the acceptance test data, the deviation value shall be calculated from the outgoing inspection data of the targeted display systems.

15 The details are given in section 6 in appendix 6.

Formula 2　Formula $= \{(Lmax_1 - Lmax_2) / Lmax_2\} * 100\%$

where $Lmax_1$ is the maximum luminance of the display system presenting the maximum luminance, and;$Lmax_2$ is the maximum luminance of the display system presenting the minimum luminance.

・Judgment criteria

The Lmax shall be 170 cd/m^2 or higher for grade 1 display systems and 100 cd/m^2 or higher for grade 2 display systems.

The luminance ratio shall be 250 or higher for grade 1 display systems and 100 or higher for grade 2 display systems.

The maximum luminance deviation among multiple displays shall be within 10%.

9.2 Constancy Test Evaluation (Quantitative Evaluation)

・Check items

Besides the acceptance tests, check the deviation from the reference value of the maximum luminance.

Formula 3　Formula $= \{(Lmax_n - Lmax_0) / Lmax_0\} * 100\%$

where $Lmax_n$ is the maximum luminance obtained through a periodic constancy tests, and; $Lmax_0$ is the maximum luminance of the reference value for a constancy tests.

・Judgment criteria

The deviation shall be within ±10% from the reference value.

10. Chromaticity Deviation Tests (Quantitative Evaluation): Applicable to grade 1 display systems only

・Check items

Using a calibrated color meter and the JIRA TG18-UNL80 pattern, measure the chromaticity (u', v') of the center of each of the displayed five patches. (Even when using alternatively the JIRA TG18-UNL80 or the entirely white pattern or alternative pattern, the measurement points should be the same as for the JIRA TG18-UNL80.) Use the following formula to calculate the chromaticity deviation between the measured points and perform judgment by using the maximum value.

Formula 4　Formula $= \{(u'_1 - u'_2)^2 + (v'_1 - v'_2)^2\}^{1/2}$

where u'_1 and v'_1 are the u' and v' values of measurement point 1, and; u'_2 and v'_2 are the u' and v' value of measurement point 2.

With the mean value of the five points set to (u'm, v'm), the following formula allows the calculation of the chromaticity deviation between multiple display systems. Perform judgment by using the maximum value. When the outgoing inspection data are used as the acceptance test data, the deviation value shall be calculated from the outgoing inspection data of the targeted display systems.

Formula 5　Formula $= \{(u'm_1 - u'm_2)^2 + (v'm_1 - v'm_2)^2\}^{1/2}$

where $u'm_1$ and $v'm_1$ are the u'm and v'm value of display system 1, and; $u'm_2$ and $v'm_2$ are the u'm and v'm value of display system 2.

・Judgment criteria

The chromaticity deviation shall be 0.01 or less.

The chromaticity deviation between multiple displays shall be 0.01 or less.

Appendix 2.　Detailed explanation of Test Patterns and Reference Clinical Images

1. JIRA TG18-QC Test Pattern (alternatively, JIRA SMPTE Test Pattern)

This pattern should be used for comprehensive judgment.

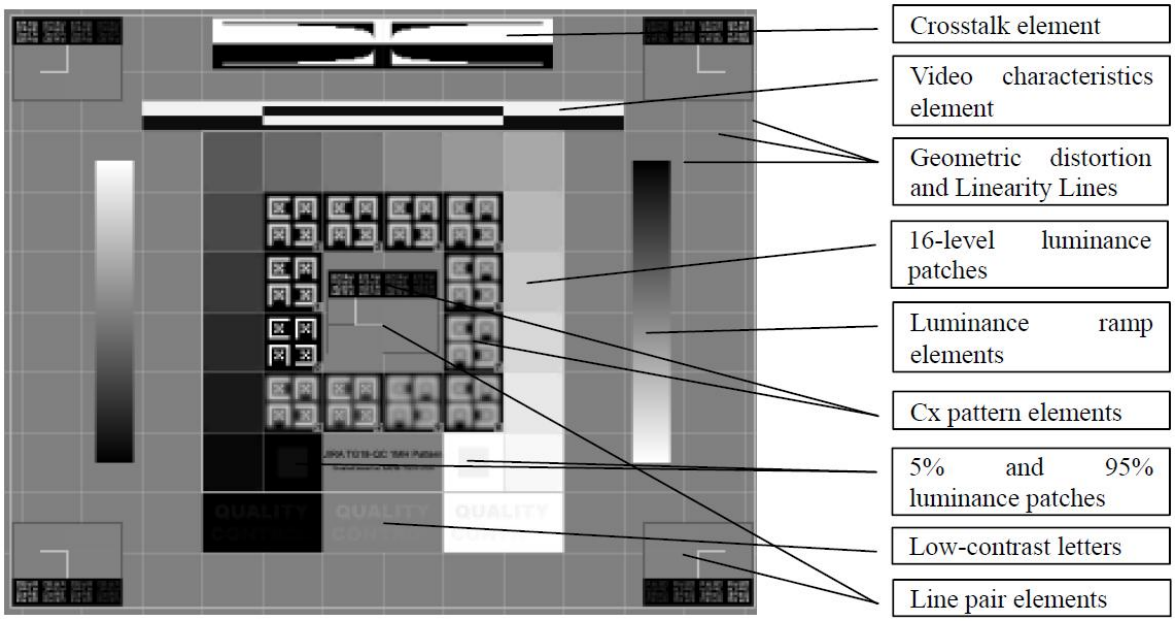


Figure 5　JIRA TG18-QC pattern

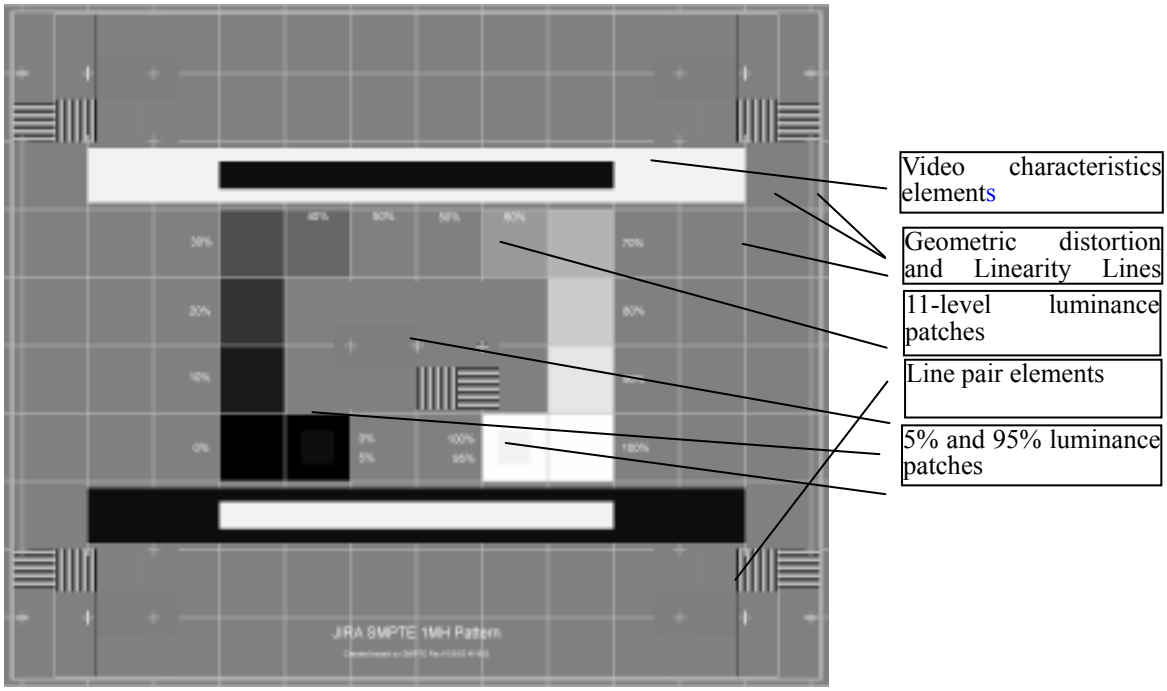
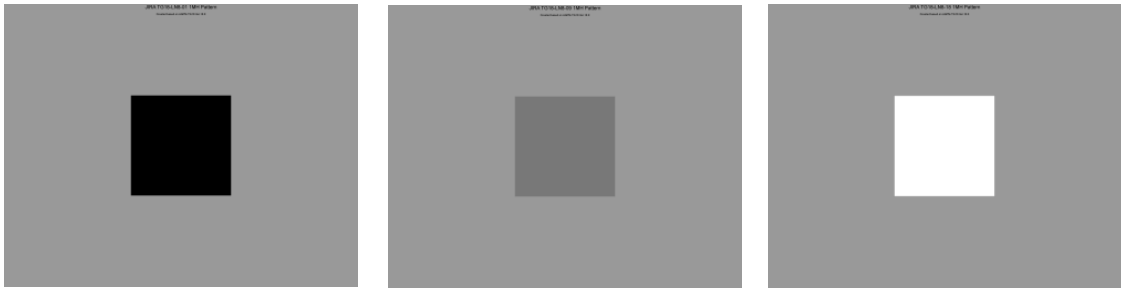


Figure 6　JIRA SMPTE pattern

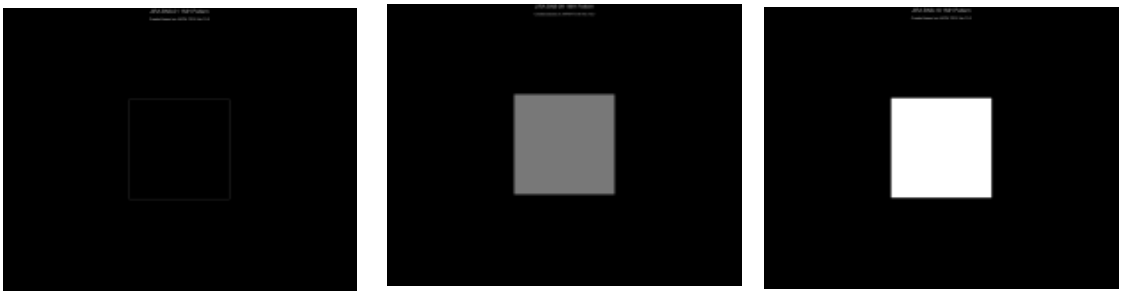
2. JIRA TG18-LN8-nn Test Patterns or JIRA BN8-nn Test Patterns[16]

The patterns should be used for luminance measurement. The patterns consist of 18 different versions (01 to 18) with p values divided at even intervals. Each pattern has been specified so that the area of the patch to be measured is 10% of the entire area, and the luminance of the background is 20% of the maximum



TG18-LN8-01 *TG18-LN8-09* *TG18-LN8-18*

Figure 7　JIRA TG18-LN8 01 to 18 patterns



JIRA BN8-01 *JIRA BN8-09* *JIRA BN8-1 8*

Figure 8　JIRA BN8-01 to 18 patterns

[16] When luminance is measured with a telescopic-type luminance meter, the JIRA TG18-LN luminance measurement patterns are affected by the background luminance. So, the guidelines recommend the use of the JIRA BN luminance measurement patterns.

3. JIRA TG18-UNL80 Test Pattern (alternatively, JIRA TG18-UN80 Test Pattern, entirely white pattern)

This pattern should be used to measure the uniformity of the luminance and chromaticity, and to observe flicker. Measurement should be performed at the center of the five patches located at the center and four corners of the display area: five positions in all. It has been specified that the area of each patch to be measured is 10% of the entire area, and the brightness is 80% of the maximum digital drive level.

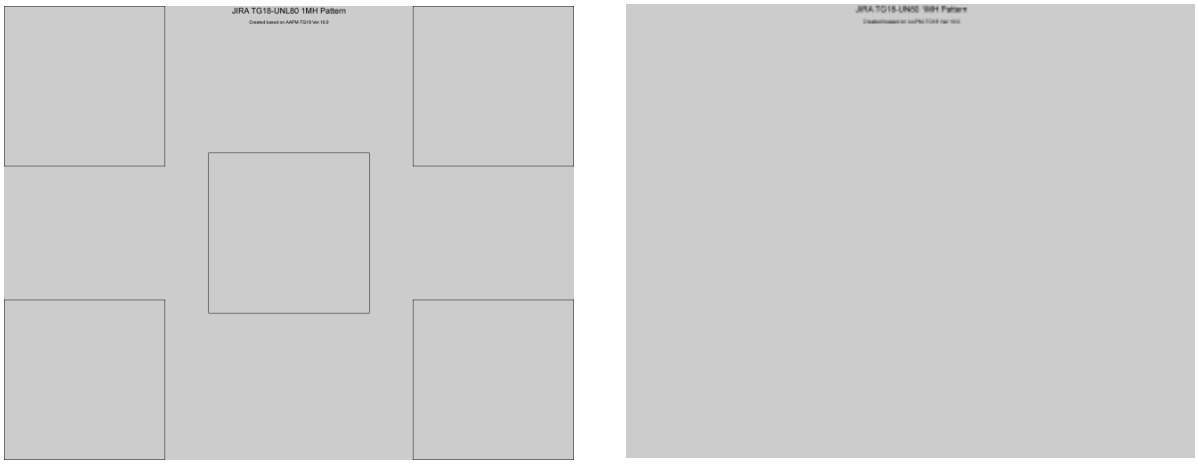


Figure 9　JIRA TG18-UNL80 pattern and JIRA TG18-UN80 pattern

4. Reference Clinical Image

The reference clinical image is specified in the Guidelines for Handling Digital Images prepared by The Electron Information Committee of the Japan Radiological Society.

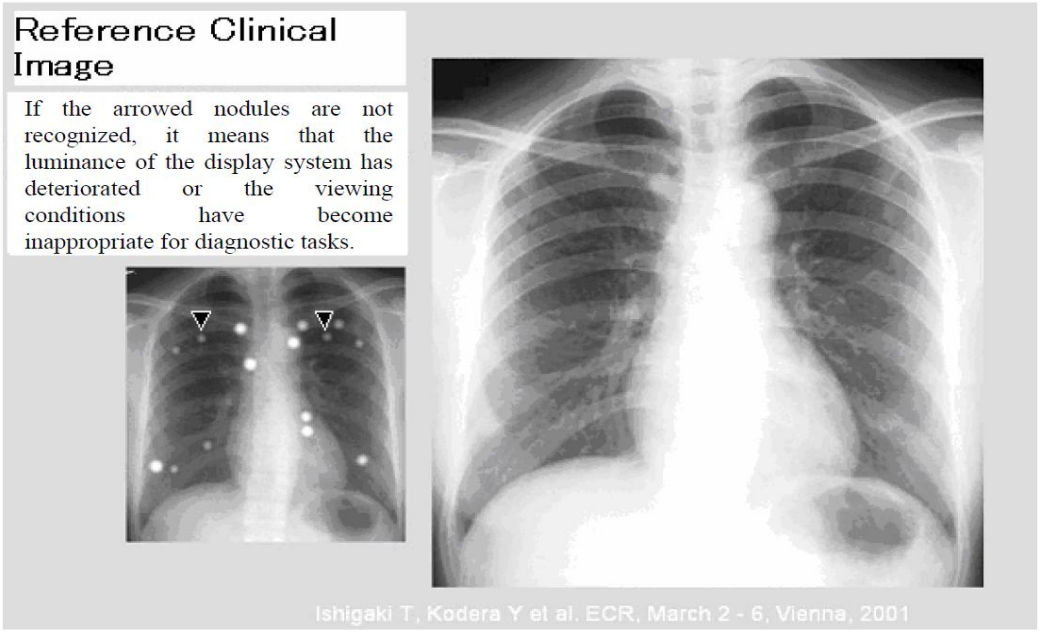


Figure 10　Reference clinical image

5. JIRA CHEST-QC pattern

The JIRA CHEST-QC pattern is a composite pattern consisting of the reference clinical image and the JIRA TG18-QC pattern judgment portion. A single image can perform an alternate overall evaluation.

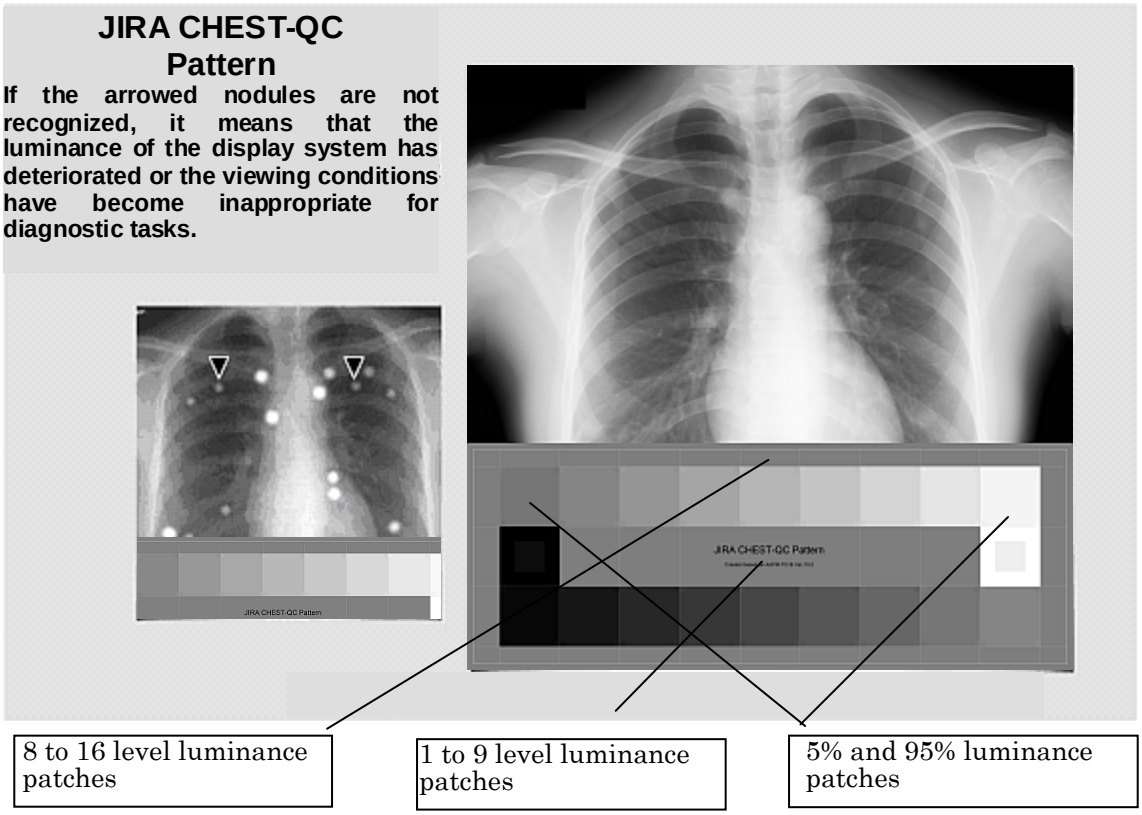


Figure 11　JIRA CHEST-QC pattern

Appendix 3. Standard reports

Table 4 Acceptance test result report (sample)

Medical institution	JIRA Hospital	Luminance meter model		Approved by	Conducted by	
Department	Radiology	Sr. No.		Taro JIRA	Jiro JIRA	
Model name	xxx-xxx	Illuminance meter model				
Sr. No.	0001	Sr. No.				
Test date	Feb. 22, 2010					

Judgment method	Category	Judgment criteria		Check item Formula	Unit	Judgment
		Grade 1	Grade 2			
Spec	Specifications	≧1k*1k		Resolution	Pixel	OK
Visual check	Overall evaluation	The patches' luminance differences among 16 (11) steps should be clearly recognized. 5% and 95% patches should be visible. The judgment-use positions on the judgment-use clinical image or the reference clinical image should be visible without any problem.				OK
	Grayscale	Smooth, stable and continuous display should be presented.				OK
	Geometric distortion： CRT only	The entire screen should allow visual check and provide linearity. The aspect ratio of the width and height should be appropriate.				－
	Resolution： CRT only	0≦Cx≦4 Nyquist lines should be visible.		Cx score	－	－
	Artifact	Artifacts should not be present.		Flicker Crosstalk Video artifact Color artifact：CRT only		OK
Measurement	Luminance uniformity	≦30		{(Lmax－Lmin) / (Lmax ＋Lmin)}*200	%	Measured value
	Contrast response	≦±15	≦±30	Kδ of 18 points	%	Measured value
	Maximum luminance	≧170	≧100	Lmax	cd/m^2	Measured value
		Between multiple displays ≦10		$\{(Lmax_1－Lmax_2) / Lmax_2\}*100$	%	Calculated value
	Luminance ratio	≧250	≧100	Lmax / Lmin	－	Measured value
	Chromaticity	Inside the screen ≦0.01	－	$\{(u'_1－u'_2)^2 ＋(v'_1－v'_2)^2\}^{1/2}$	－	Measured value
		Mean value inside screen at the time of outgoing inspection				u'm: measured value v'm: measured value
		Between multiple displays ≦0.01		$\{(u'm_1－u'm_2)^2 ＋(v'm_1－v'm_2)^2\}^{1/2}$	－	Calculated value

Table 5 Constancy test result report for each usage day (sample)

Medical institution	JIRA Hospital	Luminance meter model		Approved by	Conducted by
Department	Radiology	Sr. No.		Taro JIRA	Jiro JIRA
Model name	xxx-xxx	Illuminancemeter model			
Sr. No.	0001	Sr. No.			
Test month	March 2010				

Judgment method	Category	Judgment criteria	
		Grade 1	Grade 2
Visual check	Alternate overall evaluation	The patches' luminance differences among 16 (11) steps should be clearly recognized. 5% and 95% patches should be visible. The judgment-use positions on the chest image should be visible without any problem.	

Sun	Mon	Tue	Wed	Thu	Fri	Sat
–	3/1 ✓	3/2 ✓	3/3 ✓	3/4 ✓	3/5 ✓	
–	3/8 ✓	3/9 ✓	3/10 ✓	3/11 ✓	3/12 ✓	3/13 ✓
–	3/15 ✓	3/16 ✓	3/17 ✓	3/18 ✓	3/19 ✓	–
–	–	3/23 ✓	3/24 ✓	3/25 ✓	3/26 ✓	3/27 ✓
–	3/29 ✓	3/30 ✓	3/31 ✓	–	–	–

Table 6　Periodic constancy test result report (sample)

Medical institution	JIRA Hospital	Luminance meter model		Approved by	Conducted by	
Department	Radiology	Sr. No.		Taro JIRA	Jiro JIRA	
Model name	xxx-xxx	Illuminance meter model				
Sr. No.	0001	Sr. No.				
Test date	Feb. 21, 2011					
Judgment method	Category	Judgment criteria		Check item Formula	Unit	Judgment
		Grade 1	Grade 2			
Visual check	Overall evaluation	The patches' luminance differences among 16 (11) steps should be clearly recognized. 5% and 95% patches should be visible. The judgment-use positions on the judgment-use clinical image or the reference clinical image should be visible without any problem.				OK
	Grayscale	Smooth, stable and continuous display should be presented.				OK
	Geometric distortion : CRT only	The entire screen shall allow visual check and provide linearity. The aspect ratio of the width and height should be appropriate.				－
	Resolution : CRT only	0≦Cx≦4 Nyquist lines should be visible.		Cx score	－	－
	Artifact	Artifacts should not be present.		Flicker Crosstalk Video artifact Color artifact : CRT only		OK
	Luminance uniformity	Excessive non-uniformity should be absent.				OK
Measurement	Contrast response	≦±15	≦±30	Kδ of 18 points	%	Measured value
	Maximum luminance	≧170	≧100	Lmax	cd/m^2	Measured value
		Luminance deviation ≦±10		$\{(Lmax_n - Lmax_0) / Lmax_0\}*100$	%	Measured value
		Between multiple displays ≦10		$\{(Lmax_1 - Lmax_2) / Lmax_2\}*100$	%	Measured value
	Luminance ratio	≧250	≧100	Lmax÷Lmin	－	Measured value
	Illuminance (value for ref.)			Screen vertical Illuminance	lx	Measured value

Appendix 4. About the test environment and the constancy tests

1. Background

The Softcopy Display System Committee has continued to discuss, with the advisors, the ambient environment (especially luminance) for conducting the acceptance and constancy tests. The Committee has reached the following conclusion. In Japan, the environment for use of display systems is not ready unlike in Europe and America. Various cases are considered. Even when the environment changes, the evaluation results must be reproducible. The operational standard are to be specified to ensure the reproducibility.

Specifically, the operational criteria are as follows.

① Item about measurement tests

Evaluation should be performed without including ambient light.

For outgoing inspection by suppliers and acceptance tests/ constancy tests by medical institute, evaluation should be performed without ambient light.

② Item about visual tests

For outgoing inspection by suppliers and acceptance tests by medical institute, evaluation should be performed without ambient light.

(In order to prevent discrepancy between outgoing inspection and acceptance tests, conditions should be the same.)

For constancy tests, evaluation should be performed with ambient light.

(In order to prevent nonconformity in the actual operating environment, evaluation should be performed with ambient light.)

2. The use in a bright room

When displays are used in medical institutions, the low level of grayscale on the screen may be affected by the ambient light or the location of a room. In that case, displays should be calibrated according to ambient condition.. Specifically, the reflective luminance (Lamb) due to the ambient light should be added to Lmin measured at darkroom. At this time, Lamb is usually defined as the luminance at the screen center measured with a telescopic-type luminance meter or its equivalent value.[17] Measurement shall be performed under usual ambient condition with display systems being switched off.

When calibration has been performed including Lamb, the reference values for constancy tests must be generated. At this time, luminance may be measured in either of the following two methods.

① The method where a telescopic-type luminance meter measures luminance with ambient light.

② The method where a luminance meter measures luminance without ambient light, and Lamb should be added to each measured value.

In either case, a measured value is L', which is used to calculate each item of luminance (contrast response, maximum luminance, luminance ratio). Especially, if addition of Lamb has prevented the luminance ratio from meeting the judgement criteria, then the ambient light should be decreased to reduce Lamb.

In addition, the constancy tests through visual inspection and the measurement tests with Lamb are affected by the ambient light. It is important that the ambient light has remained unchanged since the reference values for constancy tests were taken.

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[17] How to obtain the equivalent value should be addressed upon consultation with suppliers.

3. The preset value of maximum luminance and the renewal timing of displays

In acceptance tests and constancy tests, the preset values of the maximum luminance are especially important. That is because the maximum luminance of display systems is related to the luminance ratio and the durable years. In order to recognize the difference for each grayscale, the luminance ratio should be set to be higher. For that purpose, the maximum luminance should be set to be higher, and the minimum luminance should be set to be lower.

However, if the maximum luminance is set to be high, then the durable years of displays become short. Moreover, if the maximum luminance is set to be low, then the ambient light has more influence, the contrast response becomes changeable, and the grayscale characteristics become shifted. If the maximum luminance is set to be low, the durable years become long. But, if you want to keep a sufficient luminance ratio, then you should lower the minimum luminance. In this way, each setup influences each other. Therefore, the present value must be determined with full consideration.

An example of the setting method is as follows. First, preset the minimum luminance value that is suitable for the ambient light to be used. Next, consult with the radiologists and preset the maximum luminance value in order to obtain the contrast ratio required for diagnosis.

If display systems have failed in constancy tests, the display quality administrator should adopt procedures required at the time of failure.[18] One of appropriate procedures is to renew a display. The guidelines specify the lowest value of maximum luminance as 170 cd/m^2 and 100 cd/m^2 for grade 1 and grade 2, respectively.[19] The guidelines, however, consider neither the influence/fluctuation of the ambient light nor the luminance ratio required for various fields of diagnosis. The display performance has made a significant progress. Especially, the maximum luminance value tends to be larger than the lowest value of maximum luminance specified in the guidelines. When the display quality administrators preset the maximum luminance, they should decide the value required for diagnosis. If the maximum luminance does not reach the specified reference value and a display fails in constancy tests, then that display systems must be renewed justifiably. .

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[18] The details are given in "6.2.4 Procedures to be adopted when the test is not passed".

[19] The values of 170 cd/m^2 and 100 cd/m^2 are described in AAPM On-Line Report No. 03, April 2005.

Appendix 5. Measuring instruments used

1. Luminance meter

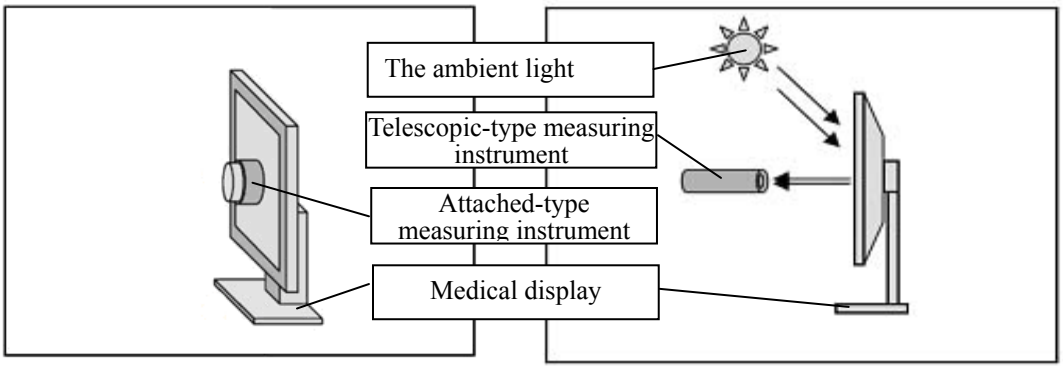
It is used in order to measure the luminance of the display system. A luminance meter must have the measurement range required to measure the luminance of medical displays, and the accuracy required to control the quality.

The SI unit of luminance is cd/m^2 (candela/square meter). The guidelines express the judgment criteria in cd/m^2. Luminance may be expressed in nit or ft-L (foot Lambert). The relation is as follows. 1 nit=1 cd/m^2, and 1 ft-L=3.426 cd/m^2.

Depending on the measurement distances, a luminance meter is available in two types: a telescopic type and an attached type (figure 12).

An attached-type: This type is placed in close contact with a display screen. The gap should not be present. But, refrain from pressing the meter on the screen too strongly. It is not influenced by the ambient light and capable of measuring only the display luminance.

A telescopic-type: This type is placed far away from a display screen. It is necessary to measure luminance from a suitable distance. The measurement result is influenced by the ambient light. It is possible to measure the display luminance with the reflective luminance caused by the ambient light. (If measurement is performed in a dark room, then it is possible to measure only the display luminance.) If measurement is performed with a display power being switched off, then it is possible to measure the reflective luminance caused by the ambient light. In order to obtain the display luminance, the reflective luminance caused by the ambient light may be subtracted from the measured luminance value..



Attached type　　Telescopic type

Figure 12　Example of (a) attached-type and (b) telescopic-type measuring instruments

2. Color meter

It is used in order to measure the chromaticity of the display systems. Generally a color meter can also measure luminance simultaneously. Even when a color meter is used at the maximum luminance of display systems, it must have the measurement range required to measure the chromaticity, and the accuracy required to control the quality.

In the guidelines, the judging criteria are expressed in u' and v' chromaticity coordinate (UCS color system). For this reason, a color meter should display in u' and v' chromaticity coordinate. However, high popularity is achieved by a color meter that displays in x and y chromaticity coordinate (XYZ color system). For conversion, use the following formula.

[Conversion formula] : u'=4x/(-2x+12y+3)、v'=9y/(-2x+12y+3)

Like a luminance meter, a color meter is also available in two types: a telescopic-type and an attached-type. The characteristics of each type of color meter are the same as those for a luminance meter.

3. Illuminance meter

It is used in order to measure the illuminance of the ambient light that strikes the center of monitor screen. Hold an illuminance meter so that a photoreceptor shall face outward on axis of the front center of the monitor. An illuminance meter shall measure the ambient illuminance in the required range. In the guidelines, the illuminance due to the ambient light is merely informative reference. On an illuminance meter, the unit of illuminance is displayed in lx.

4. Precautions during operation

The measuring instruments are characterized with their accuracy and usage, depending on their kinds. So, it is necessary to operate instruments by consult with manufacturers and SI vendors. The precautions during operation are as follows.

- The measuring instrument used for the acceptance and constancy tests shall be calibrated periodically in accordance with calibration standards specified by the measuring instrument manufacturers.
- The same and single measuring instrument should be used. If operation requires use of plural instruments, then consider the error of each instrument. Select a reference instrument and correlate the instruments used. Confirm correlation periodically.
- An instrument with high accuracy should be used. If operation requires use of a simple instrument for displays(for example, which does not operate itself, and whose photoreceptor contacts a display, and which use software for measurement), then correlation with a high-accuracy instrument should be confirmed.
- Except the uniformity test, the luminance at display center is to be measured. If operation requires use of a display whose center cannot be measured, then measure the center with a reference instrument, and correlate each measured value with the result of a reference meter. Correlation with the display center should be confirmed periodically.

Appendix 6. Explanation

1. Purpose and Intent of Enactment (Especially Consistency with JIS Standards)

Section 1 details the description of the preface.

The existing standard for the constancy tests of display systems has been presented in JIS Z 4752-2-5 “Quality maintenance evaluation and routine testing methods in medical imaging departments-Part 2-5: Constancy tests - imaging display devices.” This standard has been generated through translation of IEC 61223-2-5:1994 “Evaluation and routine testing in medical departments-Part 2-5: Constancy tests-imaging display devices” enacted in 1994. The standard was drawn up when LCD display systems, which are widely used at present were unavailable in the market.

In addition, no Japan Industrial Standard’s (JIS) standard exists for acceptance tests.

The IEC is currently working for enactment of IEC 61223-3-6 “Evaluation and routine testing in medical imaging departments Part 3-6: Acceptance Tests-Imaging Display systems”, that covers acceptance and constancy tests. However, the JIS standard based on IEC standard will not be enacted soon enough; a considerable time will be needed to complete the process. Because of an increasing quantity of diagnosis with display systems also in Japan, there is an urgent need to conclude the management standards for display systems.

In addition, because Japanese and overseas medical institutions differ in systems and image reading environments, applying standards and guidelines generated for foreign institutions to Japanese institutions can cause operational problems.

For the above reasons, the guidelines have been concluded with domestic situations taken into account, based on both the IEC61223-3-6 standard to be newly enacted and the AAPM TG18 guideline that underlie the IEC61223-3-6 standard. The IEC61223-3-6 standard and AAPM TG18 guideline are still in process of drafting. If changes are made to reflected in those guidelines, the guidelines as on JESRAX-0093^{-2005} will be revised as necessary.

1.1. About changes of the reference standards

The AAPM TG18 Guideline was issued as On-Line Report No. 03 in April 2005.

On the other hand, IEC 61223-3-6 Evaluation and routine testing in medical imaging departments Part 3-6: Acceptance Tests-Imaging Display Systems was rejected after CD voting. It was changed into the standard that specified only the evaluation methods. It was IEC 62563-1 Ed. 1.0 MEDICAL ELECTRICAL EQUIPMENT - Medical image display systems - Part 1: Evaluation methods, which was issued in December 2009.

IEC 62563-1 Ed. 1.0 specifies only the evaluation methods, and does not specify the actual operation methods. The evaluation methods in the guidelines in this document are consistent with IEC 62563-1 Ed. 1.0.

2. About revision of QA guidelines

Since QA guidelines were enacted in 2005, five years have passed. In the meantime, many questions and requests received by Japan Industries Association of Radiological Systems, the Softcopy Display System Committee. In order to make QA guidelines easier to use, the Committee considered the questions and requests, cooperated with JRS and JSRT, and reviewed QA guidelines. The previous test pattern was Bitmap format. In line with a review of QA guidelines, we added DICOM format, which was requested by many users. The following points were important, and they were reviewed and implemented.

- To clarify the scope. To specify that the display system of the characteristics is included in the scope.
- To impose the following tasks to a monitor quality administrator. The tasks are to determine the preset value of the maximum luminance, to repair and renew a monitor.
- To specify that medical institutions should prepare the judgment-purpose clinical images. To specify that, if they cannot do so, then they shall use the reference clinical images.
- To use the JIRA CHEST-QC pattern as the alternate overall evaluation test on each usage day.
- To recommend the JIRA BN8 test patterns for luminance measurement.

・ To specify precautions for use in a bright room.
・ Concerning the monitor renewal timing, the present values of maximum luminance are important. To add the text to state the importance.
・ To add the detailed explanation about the measuring instruments used.
・ To change the definition of the retention period of constancy test result report.
・ To renew the reference standards. To unify terminology. To make other corrections.

3. The Range of Display Systems

Section 3 defines the range of display systems mentioned in 6.1 Acceptance Tests and 6.2 Constancy Tests. The display systems referred in the guidelines are systems that can display the GSDF curve.

① If a medical display contains the LUT and can set the GSDF curve of itself, the display system consists of only the medical display.

② If a video board that contains the LUT allows the GSDF curve to be set, the display system consists of the medical display and video board.

③ If the GSDF curve cannot be set without using viewer's functions, the display system consists of the medical display, video board, and display software. Because the settings of the viewer are daily changed, the viewer should be preset with a point for setting the GSDF curve, and tests should be conducted with the preset status recalled.

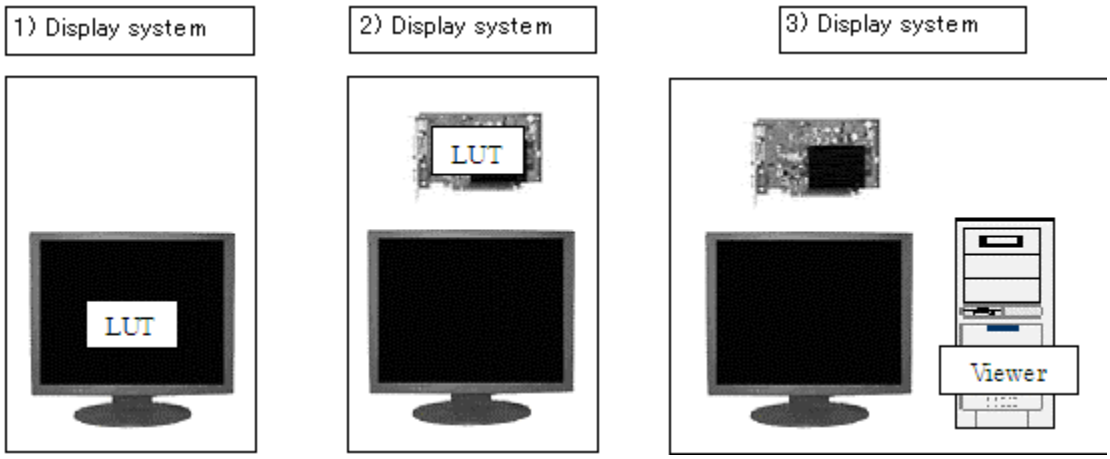


Figure 13 Three different display system configurations

4. When Outgoing Inspection Data can be Used as Acceptance Test Data

Section 4 describes the conditions that the outgoing inspection report provided with a display system by a supplier can be used as acceptance test data as mentioned in 6.1 Acceptance Tests.

① The SI vendors shall prepare outgoing inspection data of the display system defined in section 3 in appendix 6.

② The video board and medical display shall be connected through a digital interface.

If the above conditions are satisfied, outgoing inspection data can be used as acceptance test data.

If the conditions are not met, the medical institution is required to conduct an acceptance tests.

Example: An intended display system consists of a medical display, video board, and viewer software to make the LUT available, but all of them are purchased separately.

5. Calibration

Section 5 explains the definition and the concrete implementation methods of calibration mentioned in 6.2 Constancy Tests and in section 1.3 in appendix 1.

Calibration here means precisely setting the maximum luminance, minimum luminance, characteristics curves, and chromaticity of display systems by using sensors. It is desirable for display systems to be calibrated at the status of final installation.

Pattern locations for tests should conform to recommendation in DICOM PS 3.14. That is, the test area which is 10% of the entire image area is located at the center of the screen. The remaining area is a uniform background, which presents 20% of the maximum luminance. When performing calibration with a sensor attached to a position outside the center of the screen, it is necessary to correlate with the calibration of the standard pattern.

Usually with a sensor attached to the screen of the display system, automatic setting is performed by the application software.

Figure 14 shows the typical calibration example.

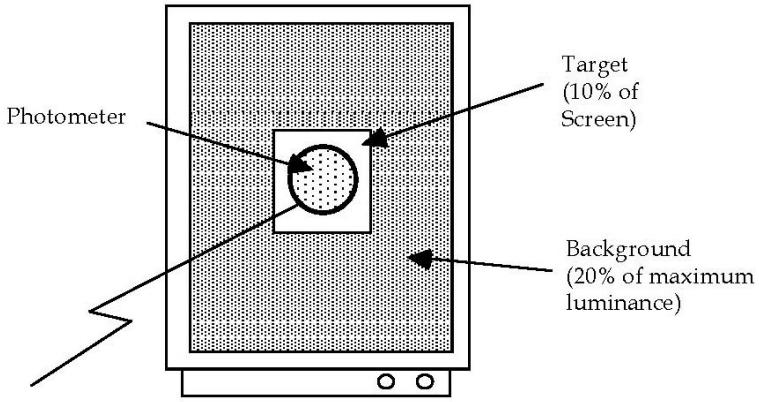


Figure 14　Test pattern and sensor placement example

6. Contrast response

Section 6 describes the concrete calculation procedure for Contrast Response Test (Evaluation through Measurement) mentioned in section 8 in appendix 1.

In order to obtain the contrast response, use a calibrated luminance meter, the JIRA TG18-LN or the JIRA BN test patterns, measure the luminance inside the test field for 18-step digital drive levels. Converse the measured value of luminance (Luminance, L) into JND indices (J) using the following The JND indices relative to the mean value are divided at even intervals within the JND range, so that linear relationships with p values are presented.

Formula 6　J（L）＝71.498068＋94.593053*log10(L)＋41.912053*log10(L) 2＋9.8247004*log10(L)3
＋0.28175407*log10(L)4－1.1878455*log10(L)5－0.18014349*log10(L)6
＋0.14710899*log10(L)7－0.017046845*log10(L)8、

where L is the measured value of luminance.

In the example in figure 15, a display system has a maximum luminance of 280cd/m^2 and a minimum luminance of 1.5cd/m^2. The measured values of luminance of display system are conversed to JND indices and plotted together with GSDF curve.

Next the measured data shall be converted into the contrast value $(L_{n+1}-L_n)/\{(L_{n+1}+L_n)/2\}$ that corresponds to JND indices $(JND_{N+1}+JND_N)/2$. The contrast response at the individual points can be obtained by dividing the dL/△L/L by the difference between the JND indices $JND_{N+1}-JND_N$.

Figure 16 shows the relation between the contrast response of data in figure 15 and the GSDF contrast response.

If 18-step luminance measurement and contrast response calculation are manually conducted, then they need a considerable time. Usually, auxiliary software is used to automatically conduct measurement and calculation.

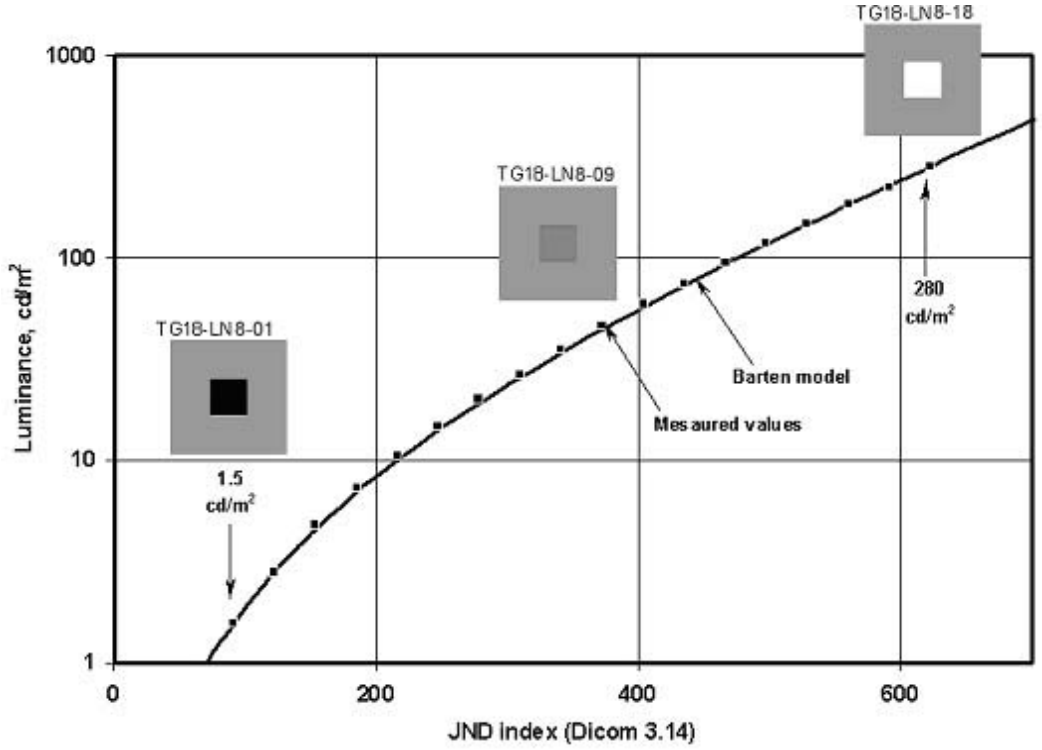


Figure 15　Relation between the luminance measurement values of 18-step display levels and GSDF curve (Example of plots)

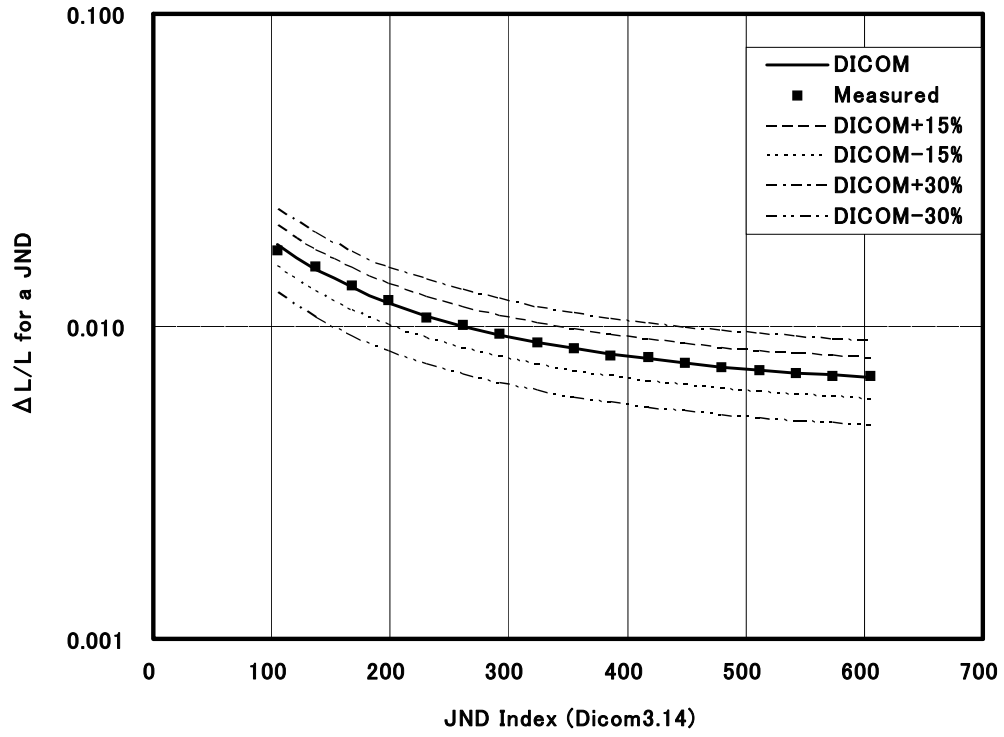


Figure 16　Relation between the contrast response calculated from 18-step gray levels and the GSDF contrast response (Example). Lines of allowable ranges are also shown.

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