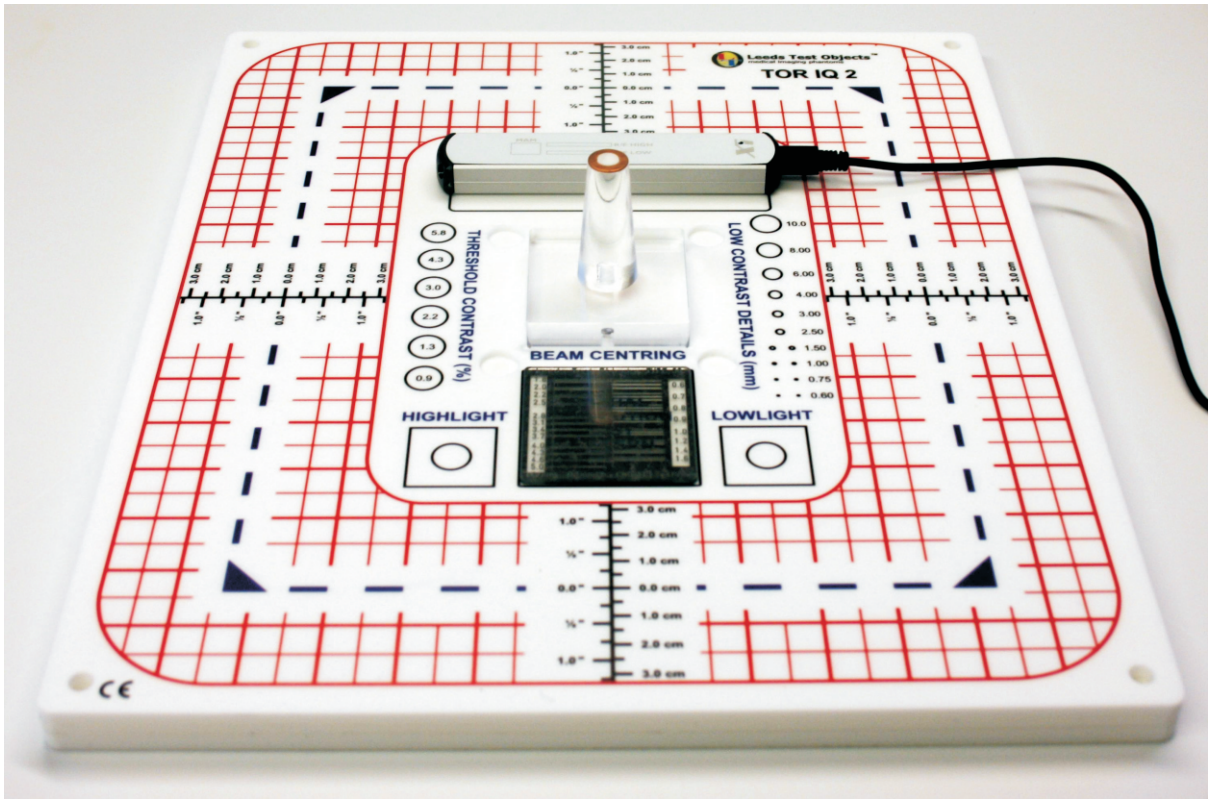
Leeds Test Objects
medical imaging phantoms

TOR IQII

USER MANUAL



Radiography & Fluoroscopy Image Quality Control

DESCRIPTION

Leeds Test Objects' TOR IQ II phantom has been designed to meet the quality assurance requirements of general radiography and fluoroscopy systems. Providing that the consistent performance of the image processor system has been verified, the phantom enables the user to perform the following tests in a robust, repeatable fashion:

- Focal spot size
- Homogeneity
- Contrast resolution (both high and low contrast details)
- Dynamic range
- Geometric distortion
- Artefacts
- Central beam alignment
- Patient dose / dose indicator check - requires additional dosemeter
- Limiting spatial resolution
- Light to x-ray field alignment
- Radiation field size

Test equipment included in the set:

- 1x TOR IQ II Base Section
- 1x Resolution Test Pattern (0.6 - 5.0 LP/mm)
- 2x 1mm Cu filter
- 1x Focal Spot Stand, comprising:
    - 4x Pillars
    - 1x Test Plate
- 1x Central Beam Alignment Tool, comprising:
    - 1x Tower
    - 1x Base

ACCEPTANCE TESTING

Baseline values should be determined when:

- A new X-ray system is brought into use (acceptance testing)
- A new detector/CR reader is brought into use
- Any other factor which may affect image quality is altered

The image obtained at acceptance testing should be retained and marked 'Reference Image' so that it can be compared with future images obtained during constancy testing. The baseline values and X-ray system settings used at acceptance should be recorded on the relevant test record sheet, and used in all subsequent tests.

CONSTANCY TESTING

Constancy tests should be carried out on a monthly basis, and when:

- Malfunction is suspected
- Immediately after maintenance on components which might affect the image quality.
- The test leads to results outside the established criteria, in order to confirm the test results.

The constancy values should be recorded on the relevant test record sheet.

TEST PROCEDURES

These tests should be performed using both manual and automatic exposure control, if both are used for patient scans.

Tube potential should be set at 70kV, however if this value is unavailable, then 100kV should be selected. In this case, additional filtration should be installed above the phantom.

The mAs parameter should be set as per manufacturer recommendations (manual control only).

Two scans are required to gain sufficient data for the tests listed on Page 1.

The phantom should be positioned centrally in the field of view in each scan.

The set-up for each is shown overleaf.

Set-up Instructions:

- Assemble Focal Spot Stand - screw 4x Pillars into Test Plate.
- Locate Focal Spot Stand in recesses in TOR IQ II Base Section.
- Place resolution test pattern (or star test pattern - not included) into recess in Test Plate.
- Centre in X-ray field by aligning the crosshair of the patient positioning system with the centre markers of the phantom
- Expose phantom.

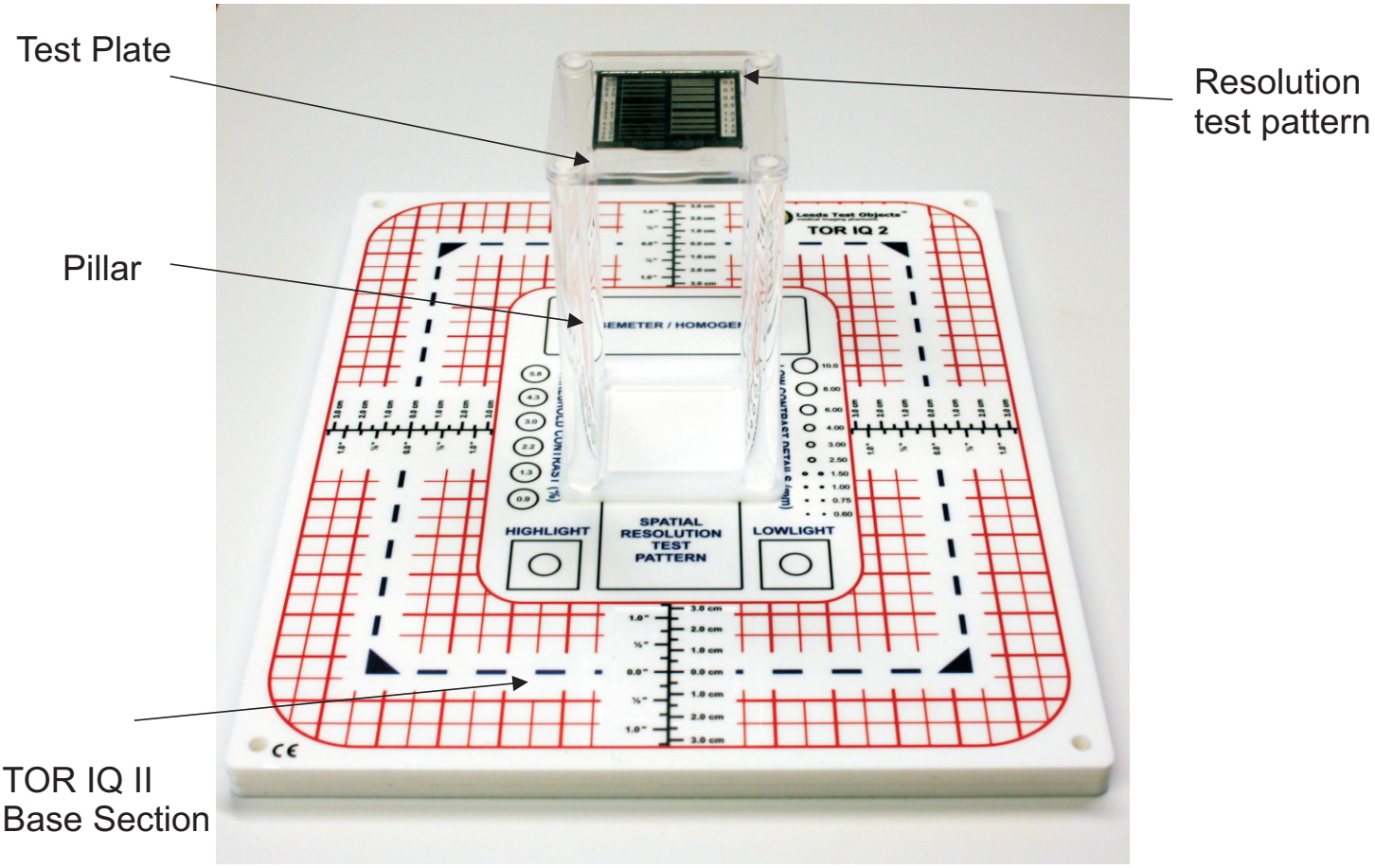


Figure 1: Scan 1 Set-Up

Tests which can be performed using SCAN 1:

- Focal spot
- Homogeneity
- Contrast resolution (high & low)
- Dynamic range
- Geometric distortion
- Artefacts
- Light to x-ray field alignment
- Radiation field size

Set-up Instructions:

- Assemble Central Beam Alignment Tool: screw Tower into Base.
- Check Tower is Fully screwed in using paper (attempt to push a sheet of paper under the Tower - if it goes under, tighten Tower until tight).
- Locate Central Beam Alignment Tool into central recess in TOR IQ II Base Section.
- Place resolution test pattern on TOR IQ II Base Section, inside “Spatial Resolution Test Pattern” position.
- Place dosemeter (not included with phantom) onto TOR IQ II Base Section. NOTE: dosemeter should be exposed in same position & orientation each time.
- Centre in X-ray field by aligning the crosshair of the patient positioning system with the centre markers of the phantom
- Expose phantom.

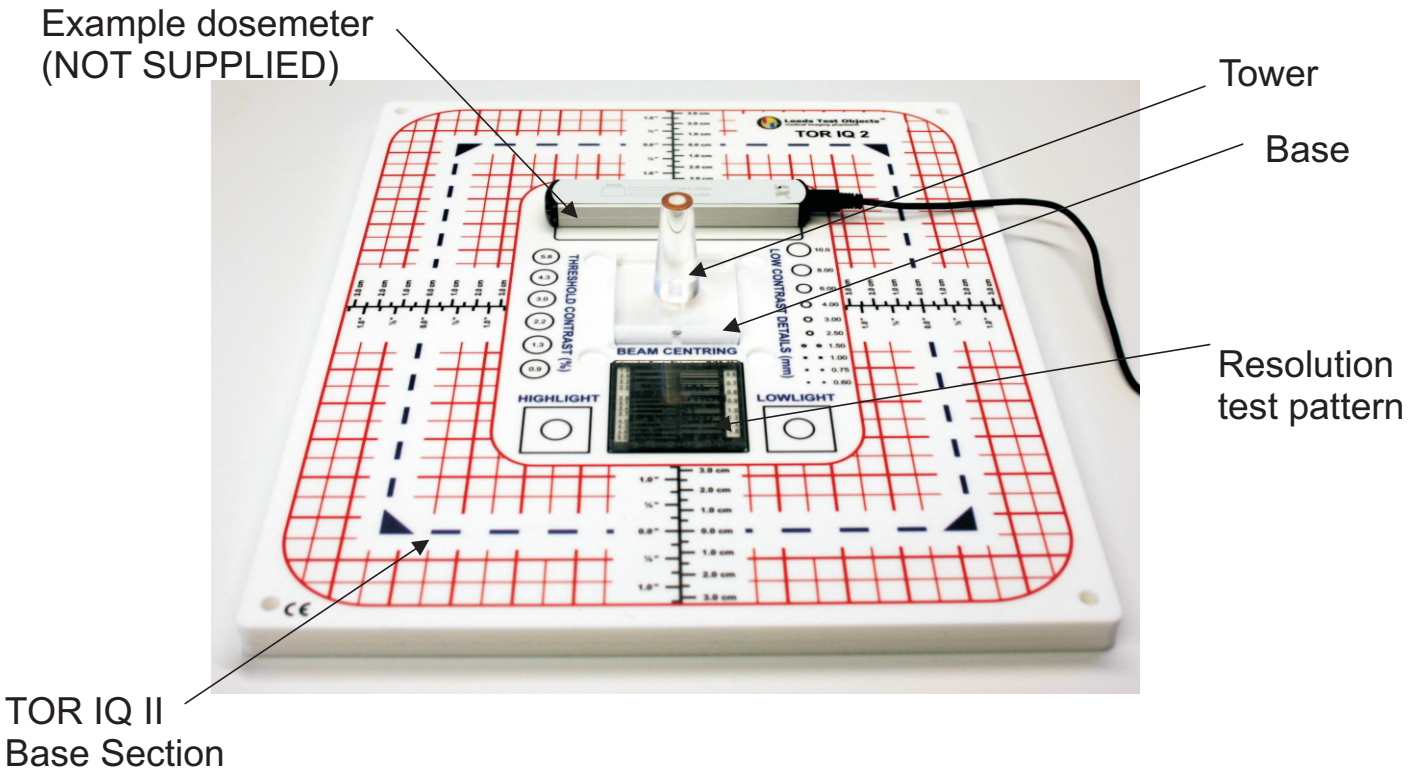


Figure 2: Scan 2 Set-Up

Tests which can be performed using SCAN 2:

- Central beam alignment
- Patient dose / dose indicator
- Limiting spatial resolution
- Contrast resolution
- Geometric distortion
- Dynamic Range
- Artefacts
- Light to x-ray field alignment
- Radiation field size

This procedure refers only to the use of test pattern type 38-010 when used with TOR IQ II to measure focal spot size in film/screen general radiography and fluoroscopy equipment. For CR/DR systems use a star pattern. When measuring focal spot size using a star test pattern, please refer to the Leeds Test Objects star test patterns user manual.

Visually inspect the image of the test pattern (using a 5-10x magnifier), and determine the highest LP/mm group which is resolved (all bars and spaces must be visible). Refer to Table 1 below for the corresponding focal spot size.

CONVERSION FROM LP/MM TO FOCAL SPOT SIZE				NOMINAL FOCAL SPOT SIZE (R=MUST BE RESOLVED)								
Group	LP/mm	Focal Spot Diameter /mm	Focal Spot (actual)	2.00	1.80	1.50	1.30	1.00	0.80	0.70	0.60	0.50
1	0.60	6.67	2.60 x 3.64	R	R	R	R	R	R	R	R	R
2	0.70	5.71	2.60 x 3.64	R	R	R	R	R	R	R	R	R
3	0.80	5.00	2.60 x 3.64	R	R	R	R	R	R	R	R	R
4	0.90	4.44	2.60 x 3.64	R	R	R	R	R	R	R	R	R
5	1.00	4.00	2.60 x 3.64	R	R	R	R	R	R	R	R	R
6	1.20	3.33	2.34 x 3.28			R	R	R	R	R	R	R
7	1.40	2.86	2.34 x 3.28				R	R	R	R	R	R
8	1.60	2.50	1.95 x 2.73					R	R	R	R	R
9	1.80	2.22	1.95 x 2.73					R	R	R	R	R
10	2.00	2.00	1.50 x 2.18					R	R	R	R	R
11	2.20	1.82	1.40 x 1.96						R	R	R	R
12	2.50	1.60	1.12 x 1.57						R	R	R	R
13	2.80	1.43	1.12 x 1.57							R	R	R
14	3.10	1.29	1.12 x 1.57								R	R
15	3.40	1.18	1.12 x 1.57									R

Table 1: Calculated focal spot diameters (Rao, G.U.V. (1971) 'A New Method to Determine the Focal Spot Size of X-Ray Tubes', Johns Hopkins University and Hospital, Baltimore, Maryland.)

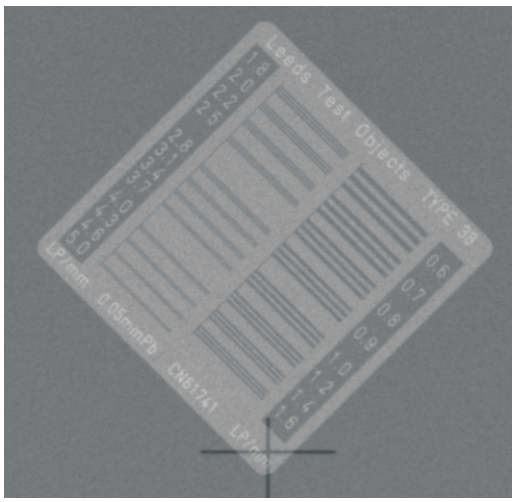


Figure 2: LP/mm pattern

RADIATION FIELD SIZE

The radiation field size can be measured by setting the collimation to a particular size using the scale markings on the front of the phantom. On taking an exposure, the corresponding radiopaque cross scale is visible, marked in centimeters (cm) and inches (“), and can be measured using a ruler or digital callipers.

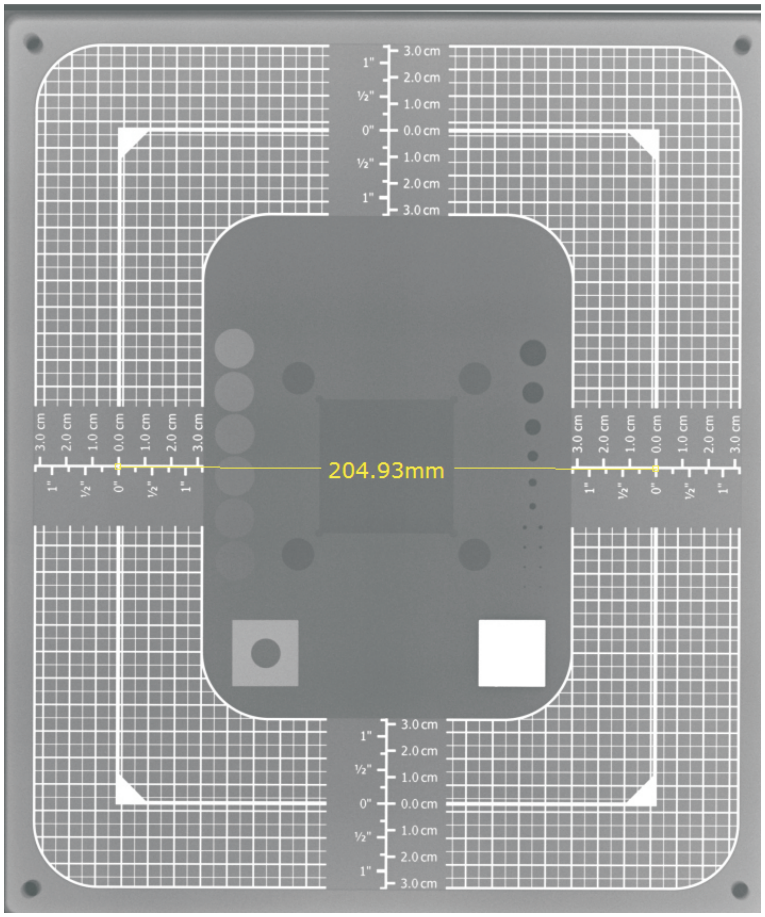


Figure 3: field size measurement

GEOMETRIC DISTORTION

As per above, measure the grid around the border of TOR IQ II Base Section, and compare with actual dimensions:
Track Separation (centre to centre) - 5.0 and 10.0mm
Track Width for 5.0mm grid - 0.25mm
Track Width for 10.0mm grid - 0.60mm
Innermost Width - 138.70mm
Outermost Width - 267.70mm
Innermost Length - 189.50mm
Outermost Length - 318.50mm

DYNAMIC RANGE

Observe both highlight and lowlight details. Both circles (central to these details) should be visible.

Figure 4: highlight and lowlight

ARTEFACTS

Visual inspection of the image to check for dust, alias details, scratches, missing pixels/lines, interference with scatter grid, raster errors, Moiré interference patterns, line offset, directory errors, etc. which might hinder visualisation of structures critical to diagnosis.

HOMOGENEITY

Depending on imaging system used, the user should measure either pixel intensity, luminance or optical density. This should be performed at 5 locations around the phantom: central, and once central at each edge (~60mm from the edge of the phantom, between the film markers).

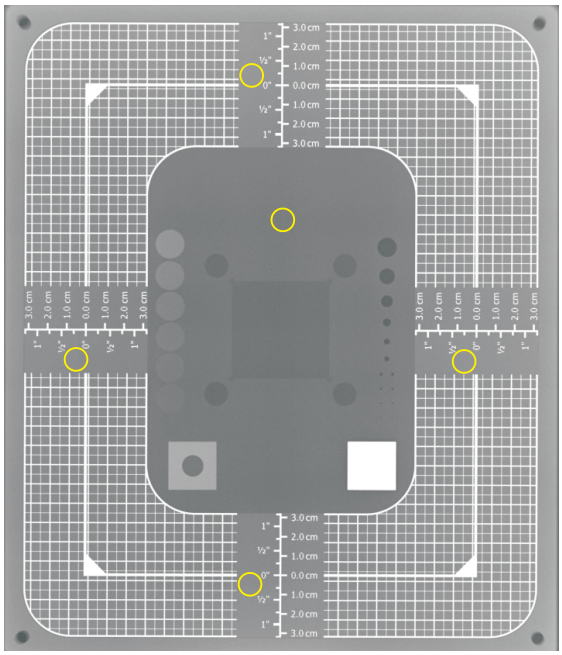


Figure 5: ROIs for homogeneity

This test is purely visual, and the test is illustrated in Figure 6 (below). The phantom has been designed such that if the circular detail appears to be just touching the annulus detail, then the unit just passes this constancy test as per IEC 61223-2-11: this implies angular deviation of 1.5º from normal.

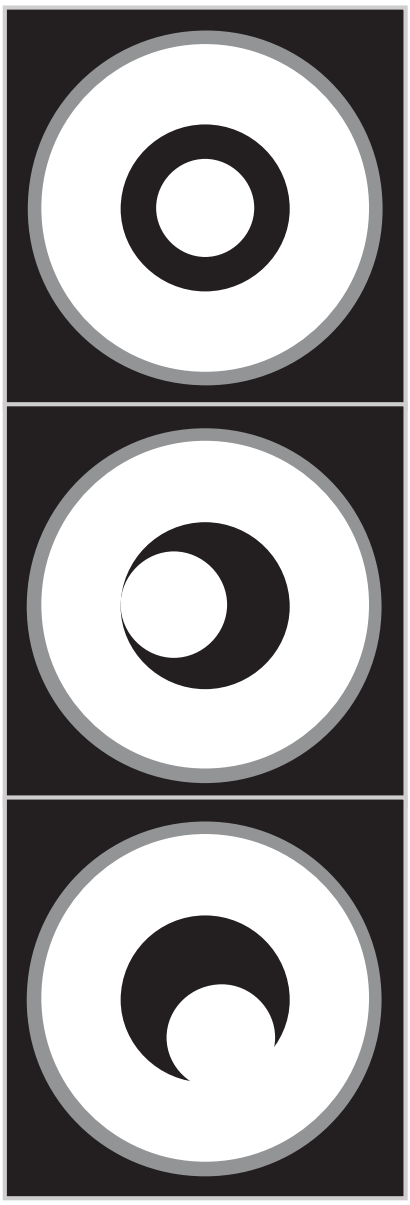


Figure 6a: Central detail imaged in centre of annulus. PASS

Figure 6b: Central detail imaged with horizontal displacement from centre of annulus (~1mm). This amounts to an angular deviation of approx. 1.5° from normal. The detail just touches the annulus. PASS

Figure 6c: Central detail imaged with displacement in both x and y directions of approx. 2mm (~3°) from normal. Thus, the detail image overlaps the annulus. FAIL

LIMITING SPATIAL RESOLUTION

Visually inspect (using a magnifier 5-10x) and note those line pair groups where the bars and spaces are all visible (i.e. resolved). The highest LP/mm group that is resolved is the limiting spatial resolution.

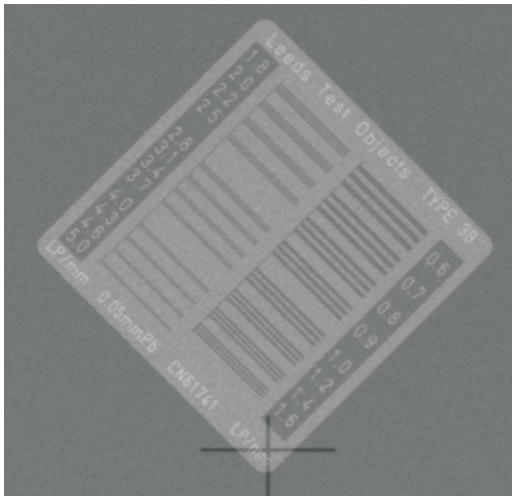


Figure 7: LP/mm pattern

CONTRAST RESOLUTION

Visual inspection of the threshold contrast & low contrast details to determine visibility.

Threshold Contrast Details		Low Contrast Details (10% Contrast)			
Disc	**Contrast (%)**	**Disc**	**Diameter (mm)**	**Disc**	**Diameter (mm)**
1	5.8	1	10.0	6	2.5
2	4.3	2	8.0	7	1.5
3	3.0	3	6.0	8	1.0
4	2.2	4	4.0	9	0.75
5	1.3	5	3.0	10	0.6
6	0.9				

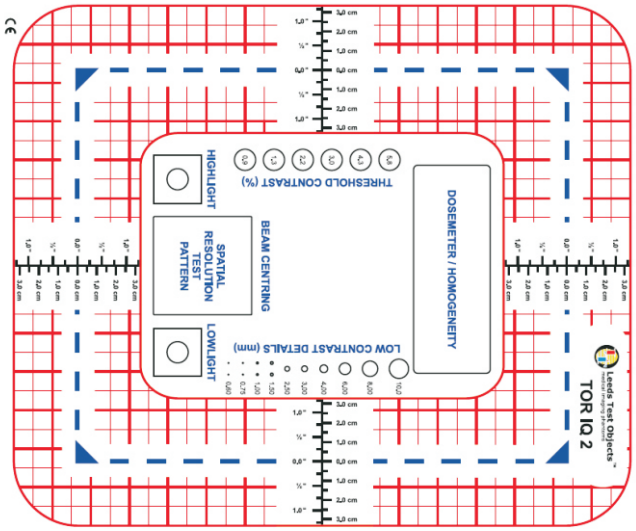
Table 2: contrast values and diameters.

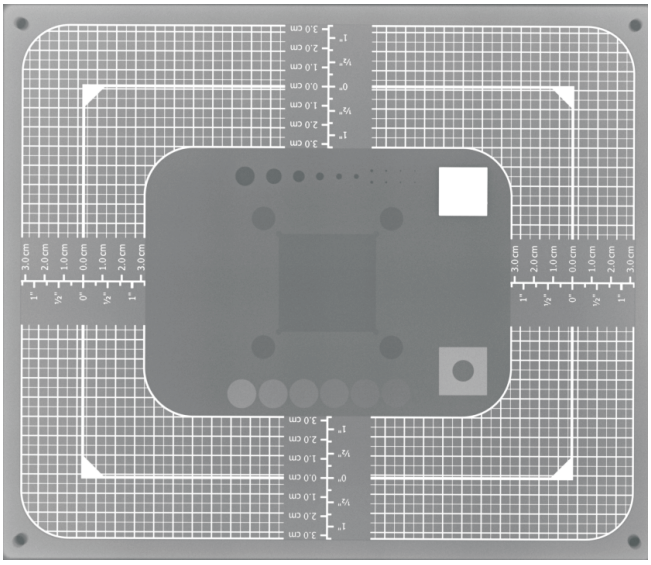
Threshold contrast: The same number of details (or greater) should be visible as at baseline.

Figure 8: Threshold contrast details

Low contrast details: the 3mm detail should be resolved on the image.

Figure 9: Low contrast details





Align the light field to a landmark on the cover of the phantom (e.g. the blue marker). The corresponding radiopaque marker should be visible in the resulting image. The light field and collimators should be set such that the two fields are the same size and, according to the settings, correspond spatially (as for patient imaging). Figure 10a illustrates where these settings are accurate. However, over time, mechanical misalignment of the mirrors and/or collimators can occur as shown in Figure 10b. The convention for measuring such misalignment is to sum the moduli of the displacements ('a' + 'c') and ('b' + 'd') and compare the results with a tolerance level:

$$|a| + |c| < 2\%\ \text{FFD}; \qquad |b| + |d| < 2\%\ \text{FFD}$$

Figure 10a: Illustration of the effective radiation field and light fields aligned correctly.

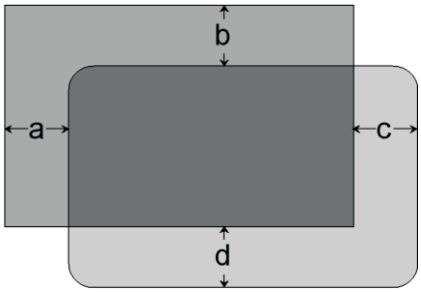


Figure 10b: Illustration of the effective radiation field and light fields aligned incorrectly.

KEY:

- Light grey area represents light field
- Mid-grey area represents effective radiation field
- Dark grey area represents field overlap

Record the reading and compare it with previous values for the same exposure settings.

RECOMMENDED PERFORMANCE STANDARDS

The following suggested remedial and suspension levels are recommended by IPEM (UK Institute of Physics and Engineering in Medicine) report 91, AAPM report 74, IEC 60336:2005 and IEC 61223-2-11.

Test	Frequency	Remedial Level	Suspension Level
Light to x-ray field alignment	1-2 monthly	any one side ±1cm misalignment at 1m SID	any one side >3cm misalignment at 1m SID
Central beam alignment	1-2 monthly	-	test failure
Limiting spatial resolution	weekly	baseline ±2 groups	-
Contrast resolution	weekly	baseline ±2 groups	-
Geometric distortion	at least 12 monthly	>2%	-
Focal spot size	at least 12 monthly	-	see table 1
Dynamic range	weekly	-	test failure
Homogeneity	1-2 monthly	-	D_{OPT} of peripheral readings differ by >20% from central reading
Dose	at least 12 monthly	-	baseline ±30%
Field Size	at least 12 monthly	> 2%	-
Dose indicator	1-2 monthly	baseline ±20%	baseline ±50%

Table 3: test frequencies.

MAINTENANCE

This tool does not require calibration.

The maintenance includes observation of physical damage(s) to the components/unit over time. Action is required only if the component(s)/unit are physically damaged. In such a case, the component(s)/unit needs to be replaced/repaired.

Clean the components using a soft, dry, clean cloth, do not use solvents.

Test Record Sheet

Phantom:

Leeds Test Objects TORIQ2 serial number _____

Machine Details:

Manufacturer_____

Model_____

Serial Number_____

Location_____

Image Quality Parameter	Acceptance Test	Constancy Tests							
		Date	Date	Date	Date	Date	Date	Date	Date
Highlight disc resolved?									
Lowlight disc resolved?									
Number of threshold contrast details resolved									
Number of low contrast details resolved									
Number of high contrast LP/mm resolved									
Focal Spot Size									
Central Beam alignment ok?									
Radiation Field Size									
Light to X-ray Field Alignment									
Homogeneity									
Geometric Distortion									

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