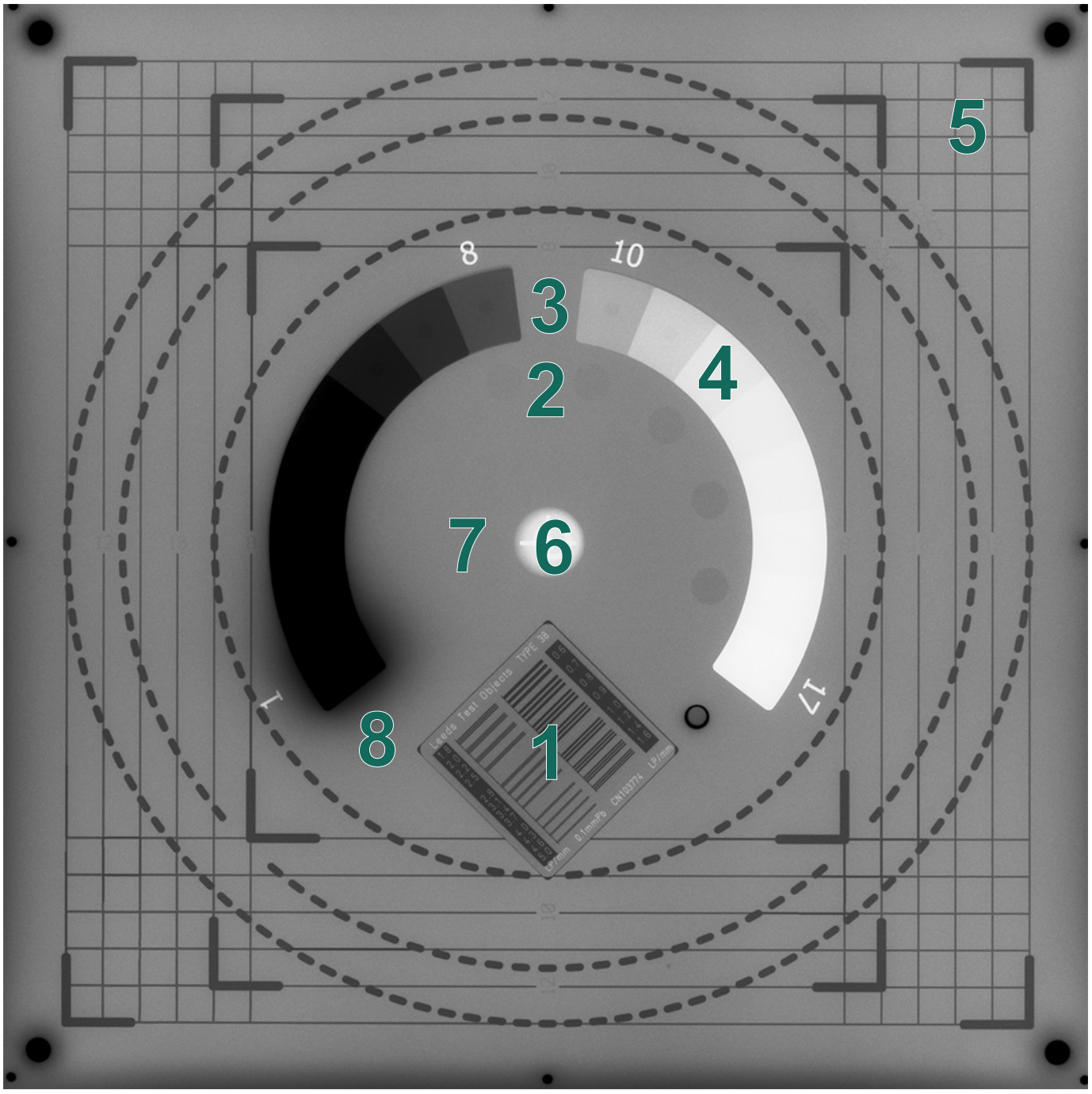
INDEPENDENT X-RAY
QUALITY ASSURANCE

FLUORO-X-4-150

USER MANUAL

Fluoroscopy Image Quality Control



1 - Spatial resolution (line pair test pattern up to 5 line pairs per millimetre (LP/mm))
2 - Contrast resolution (8 discs)
3 - Dynamic range (17 steps)
4 - Contrast resolution (on 17 different backgrounds of the step wedge)
5 - Field size and congruence markers
6 - Beam centring
7 - Uniformity
8 - Dose detector area

FLUORO-X-4-150

Fluoroscopy Phantom

DESCRIPTION

The FLUORO-X-4-150 phantom has been designed to meet the quality assurance requirements of fluoroscopy systems, as set out in DIN 6868-4 and 6868-150. The phantom enables the user to perform the following tests in a robust, repeatable fashion:

- Patient dose - requires additional dosemeter
- Dose indicator
- Limiting spatial resolution
- Contrast resolution
- Effective radiation field
- Light field to X-ray field alignment
- Beam Centring
- Artifacts

Test equipment included in the set:

- FLUORO-X-4-150 test object
- Beam centring tower
- 25 mm Al attenuator (patient-equivalent)
- 1.0 mm Cu attenuator
- 0.5 mm Cu attenuator
- Vertical hanger-type holder
- Fluoroscopy stand

SET-UP

Position the FLUORO-X-4-150 phantom on the patient couch using the patient positioning system and centre markers on the phantom such that the test features are centred in the field of view and the light field matches one of the field sizes marked on the phantom. If using a vertical bucky position the phantom on the hanger-style holder (left, below). If using a system without an accessory rail for the patient equivalent filter use the fluoroscopy stand (right, below).

TEST

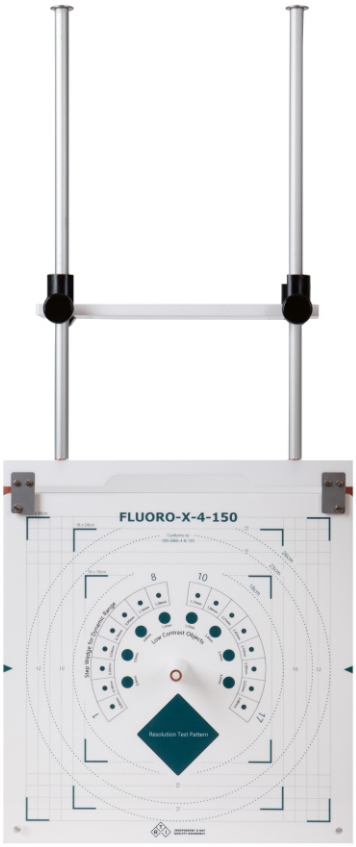
Obtain an image using standard machine settings.

RESULTS

Count the number of resolvable contrast discs, dynamic steps, line pair groups and record and compare to the baseline value.

Determine the congruence between the light field and radiation field by checking the x-ray image to see the edge of the radiation field matches the field size markers to which the light field was set.

Determine whether the beam centring is within tolerance by checking whether the disc on the beam centring tower breaks out of the ring.



DOSE

Expose the dosemeter in the position marked ‘Dose-Detector Area’. Note: the dosemeter should be exposed in the same position/orientation each time the test is carried out.

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

Constancy Test Tolerance:

AEC (70 kV) Al attenuator – maximum ±30% from baseline value

DOSE INDICATOR

Compare the recorded reading, with the estimate given by the system under test.
Calculate the percentage deviation as follows:

$$\frac{\text{Dose(Indicator)} - \text{Dose(Dosemeter)}}{\text{Dose(Indicator)}}$$

Constancy Test Tolerance

Percent Deviation should be no greater than 50%

EFFECTIVE RADIATION FIELD

Open the lamellae fully, such that the edges can be seen on two adjacent sides. If less than two edges are visible, test the function of the lamellae.

Constancy Test Tolerance

No electric mask should cover any area of the effective radiation field.

SPATIAL RESOLUTION

Visually inspect and note those line pair groups where the bars and spaces are all visible (i.e. resolved), and determine the highest spatial frequency that can be resolved in this way.

The groups are marked with values of 0.6, 0.7, 0.8, 0.9, 1.0, 1.2, 1.4, 1.6, 1.8, 2.0, 2.2, 2.5,2.8, 3.1, 3.4, 3.7, 4.0, 4.3, 4.6, 5.0 LP/mm

Constancy Test Tolerance

The number of resolved groups should be no fewer than that observed on the baseline reference image.

CONTRAST RESOLUTION

Visual inspection of the step wedge and the low contrast circular details.

A 17-step stepwedge with the values as shown below:

Step Number	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Copper (mm)	0.00	0.18	0.36	0.54	0.74	0.95	1.16	1.38	1.50
PMMA (mm)	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	17.00
Step Number	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	
Copper (mm)	1.73	1.96	2.21	2.45	2.70	2.96	3.22	3.48	
PMMA (mm)	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	

Each of the steps 1-8 and 10-17 of the stepwedge contains a contrast detail:

Detail Number	**1 to 17**
Depth (mm)	2.50
Diameter (mm)	4.00

A row of 8 low contrast details with the values shown below:

Detail Number	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Depth (mm)	0.40	0.60	0.80	1.20	1.70	2.40	3.40	4.00
Contrast (%)	0.90	1.30	1.80	2.80	4.00	5.60	8.00	9.40

Constancy Test Tolerance

The number of resolved details (steps or circular details) should be no fewer than that observed on the baseline reference image. For the 17 step stepwedge, at least step 4 - 12 should be resolved.

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.

LIGHT FIELD TO X-RAY FIELD ALIGNMENT

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 5a illustrates where these settings are accurate. However, over time, mechanical misalignment of the mirrors and/or collimators can occur as shown below. 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:

$|a| + |c| < 2\%$ FFD; $|b| + |d| < 2\%$ FFD

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

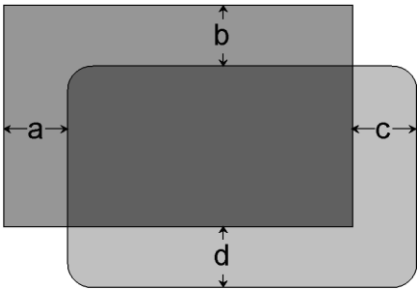


Figure B: Illustration of the fields not aligned correctly: misalignments shown by labelled arrows

KEY:

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

This test is purely visual, and the test is illustrated in the figure (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.

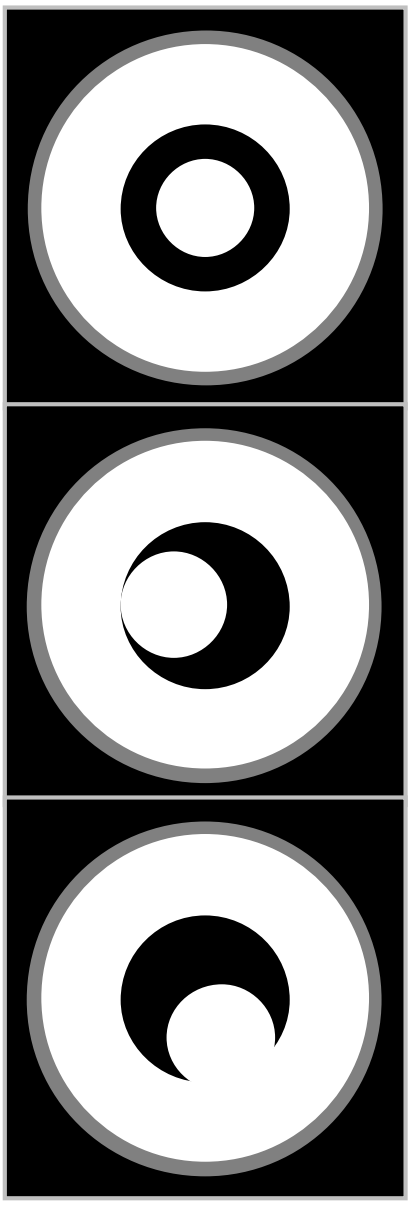


Figure a: Central detail imaged in centre of annulus. PASS

Figure b: 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 c: 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

The following suggested remedial and suspension levels are recommended by DIN 6868-150

SPATIAL RESOLUTION
The value obtained for image intensifiers in NORMAL MODE must be.
- No less than 1.0 LP/mm for 25cm detector size
- No less than 0.8 LP/mm for 30cm detector size
- No less than 0.7 LP/mm for 36cm detector size
- No less than 0.7 LP/mm for 38cm detector size

The value obtained for image intensifiers in SERIAL MODE must be.
- No less than 1.2 LP/mm for 25cm detector size
- No less than 1.0 LP/mm for 30cm detector size
- No less than 0.8 LP/mm for 36cm detector size
- No less than 0.8 LP/mm for 38cm detector size

The value obtained for flat panel systems in NORMAL MODE must be.
- No less than 1.0 LP/mm

The value obtained for flat panel systems in SERIAL MODE must be.
- No less than 1.2 LP/mm

The value obtained for flat panel systems in DIGITAL RADIOGRAPHY MODE must be.
- No less than 2.8 LP/mm @ dose level ≤ 10 µGy
- No less than 2.4 LP/mm @ dose level ≤ 5 µGy

CONTRAST RESOLUTION
The value obtained for image intensifiers in NORMAL MODE must be.
- No less than 12 dynamic range steps, and no less than 3 contrast discs resolved

The value obtained for image intensifiers in HIGH-LEVEL MODE must be.
- No less than 12 dynamic range steps, and no less than 4 contrast discs resolved

The value obtained for image intensifiers in SERIAL MODE must be.
- No less than 12 dynamic range steps, and no less than 5 contrast discs resolved

The value obtained for flat panel systems in NORMAL MODE must be.
- No less than 14 dynamic range steps, and no less than 3 contrast discs resolved

The value obtained for image intensifiers in HIGH-LEVEL MODE must be.
- No less than 14 dynamic range steps, and no less than 4 contrast discs resolved

The value obtained for flat panel systems in SERIAL MODE must be.
- No less than 14 dynamic range steps, and no less than 5 contrast discs resolved

The value obtained for flat panel systems in DIGITAL RADIOGRAPHY MODE must be.
- No less than 16 dynamic range steps, and no less than 5 contrast discs resolved

LIGHT TO X-RAY FIELD ALIGNMENT
Must be within 2% of the focus to image detector distance (FID)

Test Record Sheet

Phantom:

FLUORO-X-4-150 serial number _____

Machine Details:

Manufacturer_____

Model_____

Serial Number_____

Location_____

Image Quality Parameter	Acceptance Test	Constancy Tests							
		Date	Date	Date	Date	Date	Date	Date	Date
Number of dynamic range steps resolved									
Number of low contrast details resolved									
Number of high contrast LP/mm resolved									
Central Beam alignment ok?									
Radiation Field Size									
Light to X-ray Field Alignment									
Homogeneity									
Geometric Distortion									

Storage
Always keep the phantom in its protective case when not in use to prevent accidental damage.

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

Maintenance
Observe the phantom for physical damage over time. Action is required only in the event that damage is observed. In such a case, the phantom needs to be replaced/repaired.

Transport
Always transport the phantom in its protective case to prevent accidental damage.

Service
No service is required for this phantom.

Calibration
This tool does not require calibration.

PROBLEM	CAUSE	SOLUTION
I can't see the test features on my images	Incorrect positioning of the phantom	Re-position the phantom as per the set-up instructions
	Incorrect exposure settings	Check the correct exposure settings, and patient equivalent filtration are present
How do I know if my results are acceptable?	Results must be compared to the expected values	Consult the machine manufacturer's user manual Consult the DIN 6868-150 protocol
	Results must be compared to the acceptance test values	Consult the test record sheet