INDEPENDENT X-RAY
QUALITY ASSURANCE

RAD-DIGIX-4

USER MANUAL

Radiography Image Quality Control

There are no special safety requirements associated with the use of this phantom.

SET-UP

Position the RAD-DIGIX-4 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.

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.

The RAD-DIGIX-4 has been designed to meet the quality assurance requirements of digital radiography systems, as set out in DIN 6868-13. The phantom enables the user to perform the following tests in a robust, repeatable fashion:

- Patient dose - requires additional dosemeter
- Optical density - requires additional densitometer
- Light intensity - requires additional lux meter
- Dynamic range
- Limiting spatial resolution - requires test pattern (optional)
- Contrast resolution
- Homogeneity
- Geometry / Scale
- Light field to X-ray field alignment
- Beam Centring

Test equipment included in the set:

RAD-DIGIX-4 object

- Optional patient-equivalent filter (25mm Al)
- Optional 1.0mm Cu plate for use at 100kV

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.

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

Place the test object directly on top of the image detector.

Place the Al attenuator into the rails of the X-ray tube head, with optional 1.0mm Cu filter if 100kV is selected.

Expose the dosemeter into 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 ±25% from baseline value
AEC (100 kV) Al attenuator – maximum ±20% from baseline value
Manual exposure adjustment (70 kV) Al attenuator – maximum ±30% from baseline value
Manual exposure adjustment (100 kV) Al attenuator – maximum ±30% from baseline value

AEC (70 kV) PMMA/Cu attenuator – maximum ±30% from baseline value
AEC (100 kV) PMMA/Cu attenuator – maximum ±25% from baseline value
Manual exposure adjustment (70 kV) PMMA/Cu attenuator – maximum ±30% from baseline value
Manual exposure adjustment (100 kV) PMMA/Cu attenuator – maximum ±30% from baseline value

Acceptance Test Tolerance

Refer to DIN 6868-58

OPTICAL DENSITY

This test is only required where x-ray films are used in a clinical setting.

Use a densitometer to measure the optical density in the region 'D_{OPT}' on the test image. Compare this with previously recorded values using the same exposure settings.

Constancy Test Tolerance

Deviation from the baseline should be no greater than 0.30

Acceptance Test Tolerance

Should be in the range $1.0 < D_{OPT} < 1.5$
Variation in measurements should be < 0.20

LIGHT INTENSITY

Please note this test is not required if the Optical Density test has been carried out on the test system as above.

Use a lux meter (or equivalent) to measure the light intensity in the region 'D_{OPT}' on the viewing monitor.

Constancy Test Tolerance

Maximum value should be no greater than +50% of the baseline value
Minimum value should be no less than -200% of the baseline value

Acceptance Test Tolerance

Measured value should not deviate from the value specified by the manufacturer by more than 58%

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.

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.

Constancy Test Tolerance

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

Acceptance Test Tolerance

Where the image receptor dose is:
up to 5 μGy the minimum resolution should be 2.4 LP/mm
up to 10 μGy the minimum resolution should be 2.8 LP/mm

CONTRAST RESOLUTION

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

Constancy Test Tolerance

The number of resolved details should be no fewer than that observed on the baseline reference image. For the step wedge all 7 steps should be resolved.

Acceptance Test Tolerance

The number of resolved details should be no fewer than 3. For the step wedge all 7 steps should be resolved.

Threshold Contrast	
Disc	**Contrast (%)**
1	5.6
2	4.0
3	2.8
4	2.0
5	1.2
6	0.8

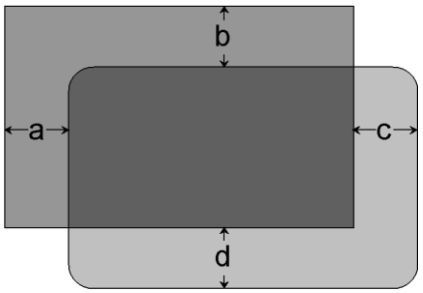
Visual inspection of the alignment markings on the test image.

Measurements can be made simply using the 5mm markings along the phantom, and geometry can be assessed using the corner and central T-markers.

Measurements should be approximately made from the centre of each edge of the image, to the corresponding marker. Opposite deviations will be summed as follows:

Key:

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



Summations:

$|a| + |c|$
$|b| + |d|$

Figure 1: Illustration of the fields not aligned correctly: misalignments shown by labelled arrows

Constancy Test Tolerance

Must not exceed 2% of the focal-spot : image receptor distance

Acceptance Test Tolerance

The ratio of the summations (see above) should be in the range 0.97 – 1.03

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.

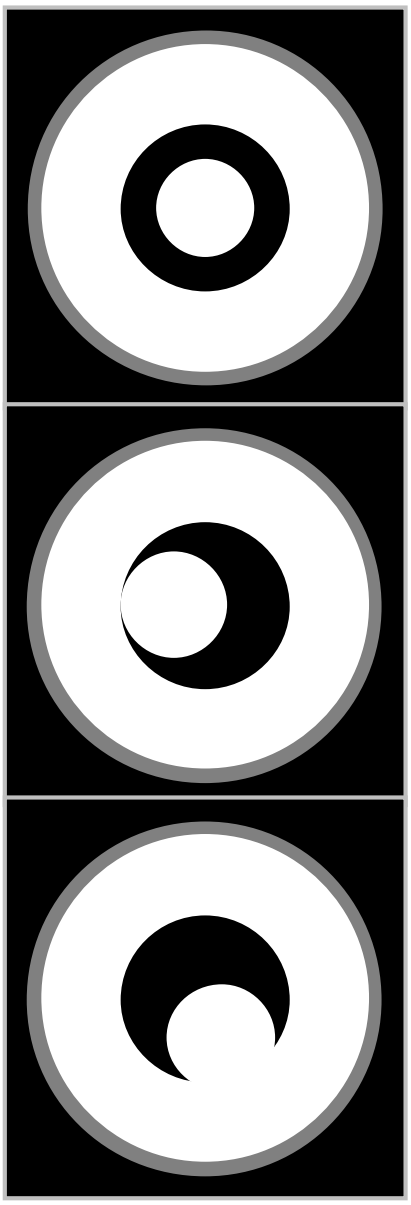


Figure a: Central detail imaged in centre of annulus. PASS

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

GEOMETRY / SCALE (ACCEPTANCE ONLY)

Measure the distances between all 4 film markings (either on a film or on a monitor).

Acceptance Test Tolerance

The distances should not vary by more than 3% of the true value (taking care to account for the image scale).

HOMOGENEITY (ACCEPTANCE ONLY)

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 (~30mm from the edge, between the film markers).

Acceptance Test Tolerance

When testing on film, all D_{OPT} readings should be within 20% of the central reading.

When testing on a monitor, light intensity shall not vary by more than 58% of the central reading.

The following suggested remedial and suspension levels are recommended by DIN 6868-13

Test Record Sheet

Phantom:

RAD-DIGI-X-4 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.

Warranty
Any defects should be notified within three months of delivery and the defective product returned to Leeds Test Objects Ltd at the purchaser's expense. When Leeds Test Objects Ltd accepts that the defect is due to faulty workmanship or materials Leeds Test Objects Ltd will have the option either to repair or replace the defective product. The warranty given above will not apply to defects which are due to: fair wear and tear, accidental damage or failure by the purchaser to adhere to Leeds Test Objects Ltd's recommendations.

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 6868-13 protocol
	Results must be compared to the acceptance test values	Consult the test record sheet

Automatic scoring software is not currently available from RTI.