NHS
Cancer Screening Programmes

Routine quality control tests for full-field digital mammography systems

Equipment report 1303: fourth edition

October 2013

About the NHS Cancer Screening Programmes

The national office of the NHS Cancer Screening Programmes is operated by Public Health England. Its role is to provide national management, coordination, and quality assurance of the three cancer screening programmes for breast, cervical, and bowel cancer.

About Public Health England

Public Health England's mission is to protect and improve the nation's health and to address inequalities through working with national and local government, the NHS, industry and the voluntary and community sector. PHE is an operationally autonomous executive agency of the Department of Health.

www.gov.uk/phe

Lead authors:

Gill Baxter
Vivienne Jones
Vivien Milnes
Jenny Oduko
Vivien Phillips
Sarah Sellars
Zoe Vegnuti

PHE publications gateway number:

Document Information	
Title	Routine quality control tests for full-field digital mammography systems
Policy/document type	Equipment report 1303
Electronic publication date	October 2013
Version	4
Superseded publications	Versions 1-3
Review date	None
Author/s	Gill Baxter Vivienne Jones Vivien Milnes Jenny Oduko Vivienne Phillips Sarah Sellars Zoe Vegnuti
Owner	Comments may be sent to Sarah Sellars, sarah.sellars@phe.gov.uk in readiness for review.
Document objective (clinical/healthcare/social questions covered)	Updates previous guidance, removing a section on CR and updating tests to reflect current experience and new guidance.
Population affected	Women screened and assessed within the NHSBSP
Target audience	Radiographers, Assistant Practitioners and Physicists working in the NHSBSP

Contents

Executive summary

This document, *Routine quality control tests for full field digital mammography systems,* offers guidance for the quality control processes that ensure that all mammography equipment meets NHSBSP standards. It is designed to complement European and national NHSBSP guidance documents, as well as the guidance from manufacturers, to provide a full range of tests and checks and to ensure that equipment is working within agreed standards and parameters and functioning safely.

The tests covered comprise:

- monitor checks
- system checks with Perspex blocks
- weekly image quality tests
- detector flat-field calibration
- monthly mechanical safety and function tests
- analysis of repeat images
- printer checks
- tests to be run after mobile units are moved
- tests to be run after an engineer’s visit
- tests to be run after a software change
- tests for small field digital mammography systems used for biopsy
- tests for specimen cabinets

1. Introduction

Following a recommendation in the document *Improving Outcomes: A Strategy for Cancer*[1], direct digital (DR) mammography systems are being used for routine mammography in the NHS Breast Screening Programme (NHSBSP).

Routine quality control is essential to ensure that the equipment meets NHSBSP standards and is performing as expected. This guide describes the recommended routine QC tests that should be undertaken by radiographic staff. It was originally based on the European protocol for the quality control of the physical and technical aspects of mammography screening[2], but also incorporates current knowledge and understanding of digital systems.

Guidance on commissioning and the routine testing by physicists of full field digital mammography systems is given in NHSBSP Equipment Report 0604, version 3.[3] Baseline values need to be established at installation in conjunction with the local physicist[i] and must be re-established if conditions are changed.

For many tests it does not matter whether unprocessed[ii] images or processed (clinical) images are used. Manufacturers and the local physicist should be consulted as to which type of image is appropriate for each individual piece of equipment. The same type of image should be used each time a test is carried out. Manufacturers' tests can be used as long as they are equivalent to those described in this document. Local physicists must be consulted for advice, and test protocols agreed and accepted after commissioning.

The routine tests for the calibration or maintenance of systems recommended by the manufacturer of the X-ray set, workstation, or printer should be added to the local test protocol. Some systems have built-in tests for the detector and/or display, and it is hoped that manufacturers will continue to develop such automated QC systems. The local physicist should be asked to advise whether built-in tests are suitable for use in place of the tests described in this document.

The results of all tests must be recorded on paper, or electronically on spreadsheets (the latter is preferable) to facilitate data analysis and auditing. If results (for example baseline images) are kept on the X-ray set then these are likely to be removed when

[i] This is the person involved in provision of medical physics expert advice to the specific NHSBSP screening centre.
[ii] Different manufacturers have different terms for 'unprocessed' images e.g. raw (GE), QC-raw (Siemens), flatfield (Hologic).

software is upgraded. Relevant images[iii] must therefore be stored securely for a minimum of 8 months. Baseline images[iv] must be stored permanently.

All quantitative and qualitative data generated by routine tests and observations should be recorded. The routine QC tests for DR systems are summarised in Table 1. This guidance should be used in conjunction with *Routine Quality Assurance guidelines for mammography* (NHSBSP Publication no 63).[4] Screening Programmes must consider the interface intercompatibility of the different parts of the imaging chain e.g. workstations and modalities from different suppliers.

Table 1 Recommended routine QC tests for DR systems

Frequency	**Test**	**Section**
Daily	Checks on acquisition and reporting monitors	2.1
Daily	System check	3.1
Daily	Printer checks using test pattern	8.1
Weekly	Check of contrast-to-noise ratio	3.2
Weekly	Image quality tests	4
Weekly	Artefact and uniformity check	3.3
Monthly	AEC thickness check	3.4
Monthly	Test of acquisition and reporting monitors	2.2
Monthly	Mechanical safety and function checks	6
As required	Detector flat-field calibration	5
As required	Repeat analysis	7
As required	Printer checks following software upgrade	8.2
As required	Check after mobile unit moves	9
As required	Check after engineer's visit	10
As required	Check after software or any other changes to the imaging chain including rulers/callipers	11

[iii] This should be decided in consultation with the Superintendent and local physicist.
[iv] These are test images taken by the mammographer when the system was first commissioned or when the baselines are reset after significant changes

2. Monitor checks

Monitor checks should be performed on both the acquisition and reporting[v] monitors under recommended[vi] working conditions, as agreed with the local physicist.

2.1 Daily checks on acquisition and reporting monitors

The following method must be followed:

- check for obvious faults such as dirty screens, artefacts (see Appendix 1)
- for CRT monitors only: check for flicker, distortion, and whether text and lines on the screen are sharp and straight
- check general condition
- clean if necessary (follow the supplier's instructions)

An additional optional test is to display a test pattern or standard clinical mammogram and check its appearance. A record must be kept of all checks. Problems must be noted, and action taken to correct them.

2.2 Monthly test of acquisition and reporting monitors

The test uses the TG18-QC test pattern[5] shown in Figure 1 (this is the preferred pattern). Refer to the supplier or local physicist for advice on how to display this.

The following method must be followed:

- check that the room brightness is as recommended, with no glare from other monitors, light boxes, or windows
- clean the monitors (follow the supplier's instructions)
- display the TG18-QC pattern on each monitor in turn
- examine the image carefully under working conditions, and check that:
    - there are no significant reflections on the monitor
    - borders are completely visible
    - lines are straight
    - the active display area is centred on the screen
    - the 5% square is visible within the larger 0% square (area A)
    - the 95% square is visible within the larger 100% square (area B)

[v] The term 'acquisition monitor' is used here to denote a monitor used by the mammographer when performing the mammogram (also known as a review or secondary monitor). The term 'reporting monitor' is used to denote a monitor in the workstation used by the film reader when reporting the mammogram (also known as a diagnostic or primary monitor).
[vi] Ambient light should be less than 20 lux (LCD monitors) or 10 lux (CRT monitors) for primary display devices.[6]

- each grey scale step from 0% to 100% can be distinguished from the adjacent squares (see dotted arrows)
- the text on the pattern is sharp and in focus

- record the results for each monitor

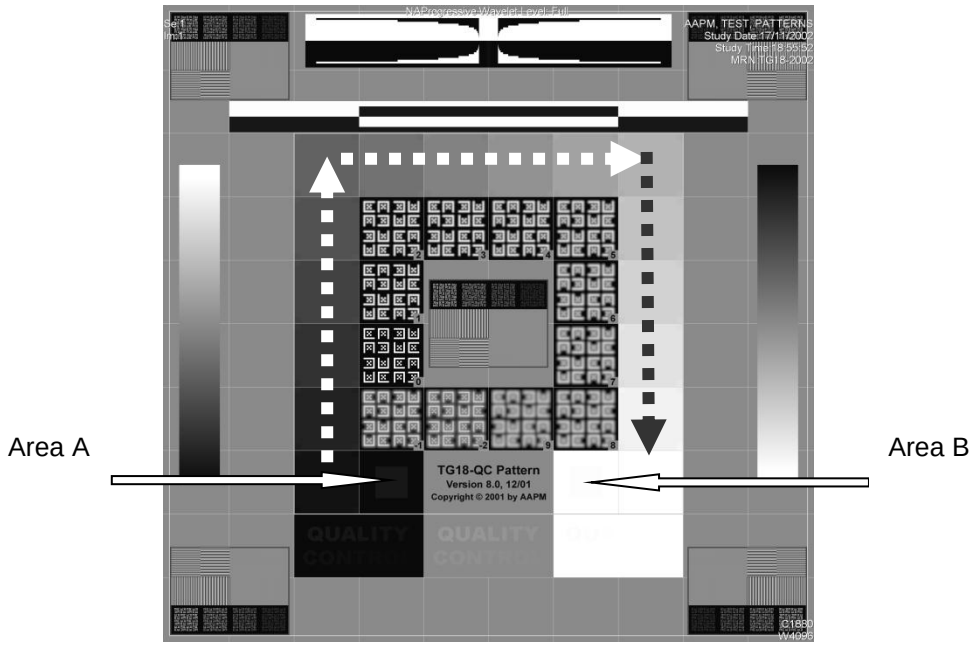


Figure 1 TG18-QC test pattern

2.2.1 Remedial level

If the system fails any of the above checks then take action to correct the problem.

2.3 Optional monthly test

Send a TOR(MAM) image (or equivalent image quality phantom image) to all workstations to which clinical images are sent from the X-ray unit being tested. Score the image on all monitors at each workstation (see section 4). These images should be stored to enable future review.

2.3.1 Remedial level

Significant variation between TOR(MAM) scores on different workstations (this would be decided locally) or significant deterioration of scores on all workstations from previous months' values.

3. System checks with Perspex blocks

These tests will detect changes in the performance of the X-ray set or the image receptor. See Appendix 2 for suggested details of the test object design.

3.1 Daily system check

The following method must be followed:

- position the test object on the unit (see Appendix 2). Always use a dedicated QC paddle. Add further thicknesses of Perspex if necessary to give a total thickness of 4.0 or 4.5 cm
- compress to a consistent compression force or thickness (chosen so as to give the same kV, target and filter every day in normal circumstances). If using thickness, compression should not be greater than a set value, for example not more than 60 newtons, to avoid possible damage to the plastic paddle
- select either a processed or an unprocessed image; the same type of image should always be used
- expose using automatic exposure control
- record post-exposure factors (kV, target/filter, mAs)
- record an indicator of dose to detector (e.g. displayed dose, mean pixel value)
- inspect the image for artefacts and variations in the noise pattern using a narrow window width, for example of about 20% of window level. (See Appendix 1 for a discussion of the type of artefacts that may be seen)
- draw a ROI as shown in Figure 2 and record the mean (M) and standard deviation (SD) of the pixel value, or the SNR as given by the system
- divide M by SD to calculate the signal-to-noise ratio (SNR) as in Equation 1 (see Appendix 3 for an example of the calculation):

$$\mathrm{SNR} = \frac{\mathrm{M}}{\mathrm{SD}} \qquad (1)$$

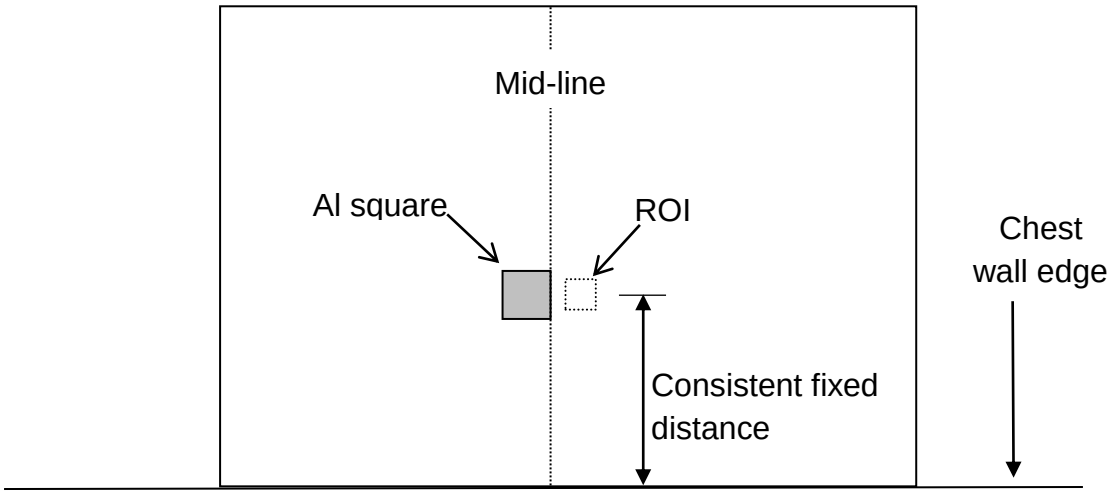


Figure 2 ROI for SNR measurement.

3.1.1 Remedial level

mAs	baseline ± 10% (provided kV and target/filter are the same as for the baseline measurement)
Detector dose indicator	baseline ± 10%
SNR	baseline ± 10%

If any of the above levels are exceeded then action must be taken to correct the problem. If the problem persists after checking, action must be taken, in line with local protocols, before the equipment is put back in use.

3.2 Weekly check of contrast-to-noise ratio (CNR)

The following method must be followed:

- use the image of the test object from the daily test (see 3.1)
- draw two ROIs, as shown in Figure 3
- record the mean (M1) and standard deviation (SD) of the pixel value in ROI 1
- record the mean (M2) of the pixel value in ROI 2
- subtract M2 from M1 and divide by the standard deviation of the pixel value (SD) to calculate the contrast-to-noise ratio (CNR) as shown in Equation 2 (see Appendix 3 for an example of the calculation)

$$\mathrm{CNR} = \frac{\mathrm{M1} - \mathrm{M2}}{\mathrm{SD}} \qquad (2)$$

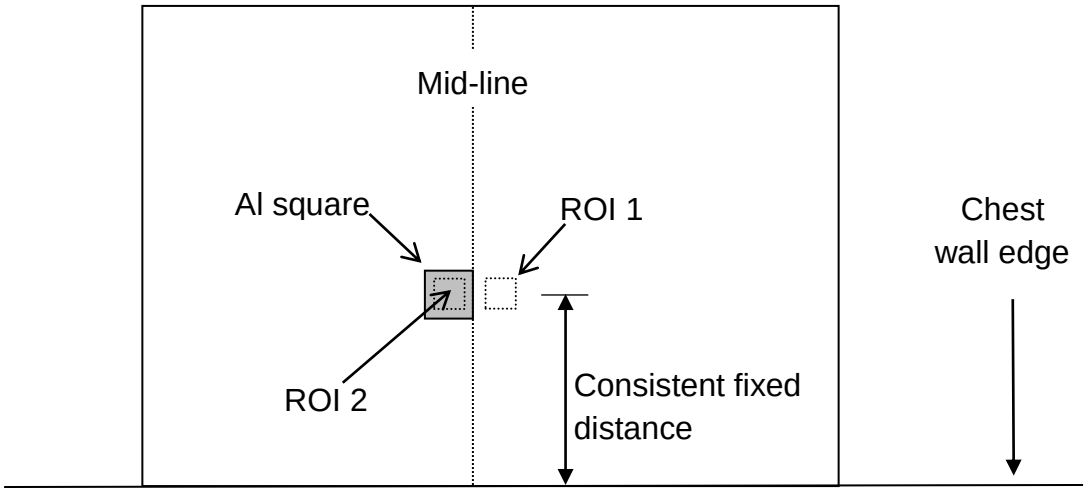


Figure 3 ROIs for CNR measurement

3.2.1 Remedial level

CNR	baseline ± 10%

If this level is exceeded then action must be taken to correct the problem. If the problem persists after checking, action must be taken, in line with local protocols, before the equipment is put back in use.

3.3 Weekly artefact and uniformity check

Uniformity should be visually checked on a weekly basis using an image of the maximum field size, with Perspex covering the whole field. Before testing, clean any dust from the top surface of the paddle, the breast table and the Perspex. Set a narrow window width of about 20% of window level to show up any areas of non-uniformity. Magnify or zoom the image electronically and inspect it in a systematic fashion to look for artefacts such as faulty clusters of pixels or areas of unusually low noise (where the background mottle appears blurred or smoother than other areas of the image).

Repeat the uniformity check for all other target/filter combinations used clinically, in case there is any debris in the system or damage to one of the filters.

The following method must be followed:

- position the test object on the unit
- compress to a consistent thickness or compression (if exposing under AEC) or use a Perspex block at the tube head

- select either a processed or unprocessed image, the same image type should always be used
- expose using automatic exposure control, or manual exposure if following the manufacturer's or local physicist's recommendations
- record post-exposure factors (kV, target/filter, mAs). Inspect for uniformity and artefacts. Set a narrow window width of about 20% of window level to show up any areas of non-uniformity. Magnify or zoom the image electronically and inspect it in a systematic fashion to look for artefacts, such as faulty clusters of pixels or areas of unusually low noise (where the background mottle appears blurred or smoother than other areas of the image)
- expose and record exposure factors for alternative target/filter combinations and inspect the images (manual exposures may be required in order to test the range of combinations available)
- for the first image only, draw ROIs as shown in Figure 4
- record the mean pixel value (Mcentre) in the central ROI
- record the mean pixel values in the other ROIs and find the one that is most different from Mcentre – call this Medge
- calculate the maximum percentage deviation from the central value using Equation 3:

$$MaxDev = \frac{Mcentre - Medge}{Mcentre} \times 100 \qquad (3)$$

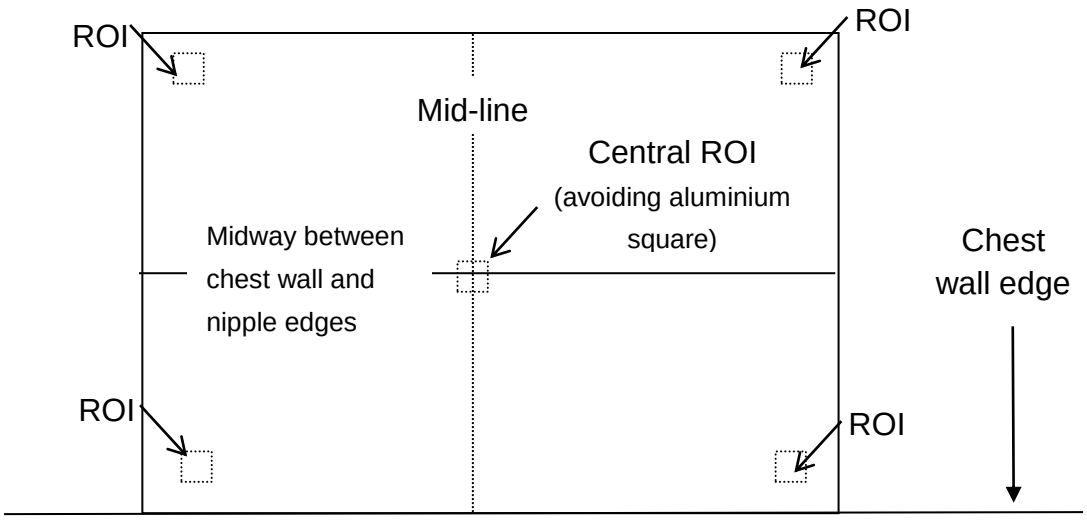


Figure 4 ROIs for uniformity check

3.3.1 Remedial level

>10% maximum deviation from the value at the centre or value specified by the manufacturer. If an artefact is observed, first check the Perspex, breast table, grid and paddle for marks, scratches or debris then repeat the test with the test object in a different orientation, if possible. If the artefact remains visible then seek further advice from the manufacturer or local physicist.

3.3.2 Suspension level

If no improvements are achievable then this should be discussed with the local physicist

3.4 Monthly AEC thickness check

This should be checked with at least three thicknesses of Perspex, covering the clinical range used and including the test object described in Appendix 2. The range of thicknesses used must ensure that all clinically used target/filters are tested. Ensure that the aluminium square is always positioned at the same height. The following method must be followed:

- position the Perspex blocks on the unit
- compress to a consistent force or thickness
- expose using automatic exposure control
- record post-exposure factors (kV, target/filter, mAs)
- record an indicator of dose to the detector (e.g. displayed dose, mean pixel value)
- inspect image for artefacts and variations in the noise pattern using a narrow window setting (high contrast), see Appendix 1
- measure SNR and compare with baseline values (see section 3.1)
- measure CNR and compare with baseline values (see section 3.2)
- repeat for the other thicknesses

3.4.1 Remedial level

mAs	Baseline for that thickness ± 10% (provided kV and target/filter are the same as for the baseline measurement)
Detector dose indicator	Baseline for that thickness ± 10%
SNR	Baseline for that thickness ± 10%
CNR	Baseline for that thickness ± 10%

No disturbing artefacts should be visible.

If any of the levels are exceeded, action should be taken to correct the problem. If the problem persists after checking, action must be taken, in line with local protocols, before the equipment is put back in use.

4. Weekly image quality tests

4.1 Method for weekly image quality test

A suitable test object, such as the TOR (MAM) on 3 cm of Perspex, should be used under AEC control. Since this test object has features similar to a breast, a clinical image processing algorithm should be used. The TOR (MAX) and TOR (MAS) are not suitable for this test.

The following method must be followed:

- compress to a consistent force or thickness
- record post-exposure factors (target, filter, mAs, kV)
- record an indicator of dose to detector
- send the image to a designated reporting workstation (the same workstation should always be used)
- examine each image, using standard window width and level and image processing, and view under standard conditions. Ensure that the image is displayed at the same size that it would be displayed at clinically
- score according to the agreed documented instructions

When evaluating the results, inter-observer variations should be taken into account.

4.1.2 Remedial level

Significant change from baseline (this should be decided locally).

5. Detector flat-field calibration

Some DR detectors may have a non-uniform response (for example, due to variations in sensitivity, or faulty pixels). Also, there are non-uniformities in the X-ray beam due to the anode heel effect and X-ray beam divergence.

DR systems correct for these inherent non-uniformities by a process of flat-fielding. Flat-field correction maps are obtained using a standard beam attenuator (usually a Perspex block) for one or more exposure conditions (e.g. different target/filter combinations and focal spot sizes). Some systems require the user to carry out this flat-fielding process periodically, and it is therefore included here, although it is not strictly a QC test. On other systems the check is carried out by the service engineer at routine service visits.

The following method must be followed:

- carry out the flat field calibration according to the manufacturer's protocols. Ensure that the top surface of the paddle is clean to avoid incorporating the image of any dense particles in the calibration
- record and initial that the procedure has been performed

6. Monthly mechanical safety and function tests

The safety and function of the system must be checked on a monthly basis. It is recommended that a local checklist is drawn up for each system to identify relevant features to be checked (for example items that are safety-critical, or areas known to be prone to faults). This should be based on the guidance in *Quality assurance guidelines for mammography including radiographic control* (NHSBSP Publication number 63)[4], plus additional items specific to the local system, for example:

- environmental checks (some digital systems are particularly sensitive to environmental conditions, such as temperature and humidity)
- checks relating to the reporting workstation (ergonomics)

Keep a record of all checks carried out, and note any problems and the action taken to have them corrected.

7. Analysis of repeat images

Early experience of changing from analogue to digital has shown that the number of repeat images may increase initially. A log of all repeat examinations must therefore be kept and regularly audited. The design of the PACS/digital systems should allow for repeat and reject analysis.

Relevant repeat and recall data must be collected and input onto the breast screening IT system (NBSS). NHSBSP guidance on collecting, monitoring and reporting repeat examinations must be followed.[7]

The NHSBSP minimum standard for repeat and recall examinations is < 3% of total examinations.

8. Printer checks

When a printer is installed, the installation engineer should ensure that the hard copy matches the soft copy image. Hard copy quality can be checked subjectively by using a standard mammography test object, such as TOR(MAM).

8.1 Daily printer checks using test pattern

On each day that a printer is used, a printer check must be carried out using standard viewing conditions. Print the TG18-QC test pattern (see section 2.2) or the manufacturer-supplied test pattern and perform the following checks:

- *geometrical distortion:* check that the image is printed without geometrical distortion; the borders should be completely visible and straight lines should be straight
- *contrast visibility:* in the TG18-QC test pattern, the 5% and 95% squares should be clearly visible
- *printer artefacts:* check the test pattern for printer artefacts (see Appendix 1); no disturbing artefacts should be visible
- if a densitometer is available, measure densities and compare with baseline values.

8.2 Printer checks following a software upgrade

After software changes or an upgrade, it may be advisable to print both a test pattern and a clinical image to confirm that the hard copy remains similar to the soft copy display.

9. Tests after mobile units are moved

When mobiles are moved to new sites appropriate tests should be performed on the mammography equipment, as agreed with the local physicist.

10. Tests after an engineer's visit

There should be clear handover procedures to follow after an engineer has performed routine preventative maintenance or as a call-out. Appropriate tests should be performed, as agreed with the local physicist, after an engineer's visit or changes to any parts of the imaging chain (including software), e.g. workstations.

11. Tests to be performed after software changes to the imaging chain, including rulers and callipers

Relevant checks, including displayed image quality and the accuracy of rulers/callipers, must be undertaken at commissioning and at appropriate intervals thereafter e.g. change of software, changes of monitors. These checks should be made in both contact and magnification modes. Further advice will be sought on standard testing and this document will be updated in due course.

12. Small field digital mammography systems used for biopsy, including stereo

There are some small field systems in use in the NHSBSP. The medical physics service should perform tests on small field digital systems on a six-monthly basis and whenever a new digital detector is installed, according to the guidance provided in *Commissioning and routine testing of small field digital mammography systems* (NHSBSP Report 01/09).[8] The tests that must be run include checks of the detector, the display monitor, and the hard copy system as for full field systems. It is recommended that local protocols are developed for more frequent testing by radiographic staff, in conjunction with the local physicist and taking account of the equipment manufacturer's recommendations.

The tests that are appropriate will depend on the system, but prone table systems require the full QC protocol. These system tests should be agreed with the local physicist.

Where a lateral arm facility is used, testing should be undertaken according to the equipment manufacturer's guidance and the recommendations for full field digital testing.

Needle positioning accuracy should be tested according to *Quality assurance guidelines for mammography including radiographic quality control* (NHSBSP Publication 63)[4] and all of the recommended tests for full field digital attachments should be followed.

13. Specimen cabinets

These should be set up and calibrated as per the manufacturer's instructions to ensure accuracy of images. An occasional check that calcifications are clearly visible must be recorded.

Appendix 1: Examples of artefacts

To inspect an image of a uniform test object on a monitor, adjust the window width (WW) to about 20% of the window level (WL) and use magnification if required.

Detector artefacts: DR systems

- faulty individual pixels, clusters of pixels or lines of pixels may be observed. They may be always black, always white, or randomly fluctuating, and they may or may not disappear after “flat fielding”. Their significance depends on how many pixels are involved and where they are located. This should be discussed with the local physicist
- in scanning-type DR systems, faulty pixels may give rise to linear artefacts perpendicular to the scan direction
- loss of resolution (blurring) may occur in one or both directions, in one part of the detector or all over. This may be seen as a subtle change in the background noise pattern. The image will appear smoother (less noisy) where it is blurred
- ghosting/image retention is characterised by a faint image of a previously imaged breast or test object, or of collimation to the smaller field size when using the whole detector
- fine lines may appear, close together, on part of the image

Monitor artefacts: cathode ray tube (CRT)

- distortion may occur, possibly due to interference from other electrical devices
- note that some monitors have one or more fine horizontal black lines, which form part of the monitor’s calibration system. These are not artefacts

Monitor artefacts: flat panel display (FPD)

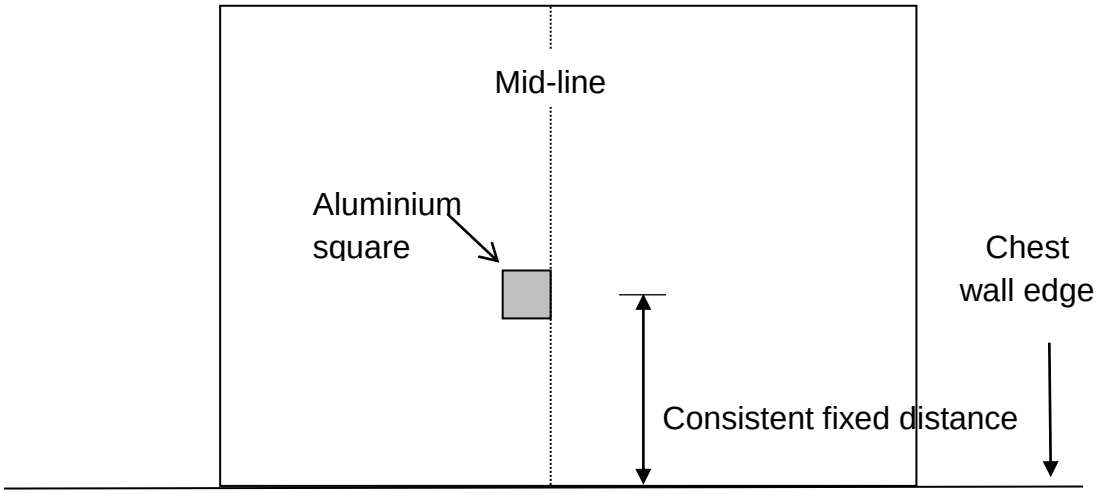
- faulty pixels may appear

Printer artefacts

- if an artefact is only seen on hard copy, then it is caused by the printer
- banding and streaking may occur
- a fine line in the direction of film travel may be seen
- pick off (damage to the film)

Appendix 2: Design of test object

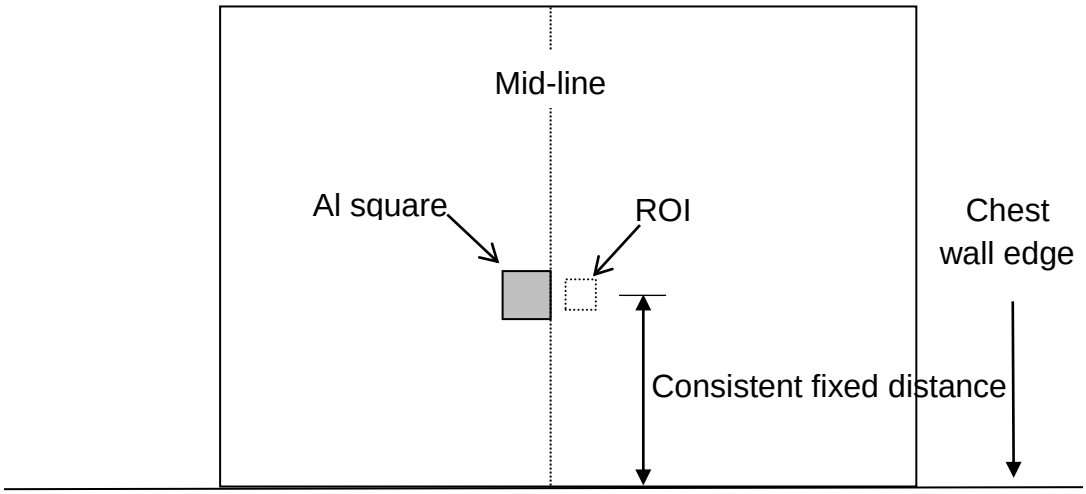
Perspex block(s) are used, with 0.2 mm of aluminium foil to provide contrast. Blocks of size 18 x 24 cm are suitable; blocks of other sizes or shapes may be used if the local physicist confirms that they provide suitable coverage of the AECs of all the X-ray sets in use. A suitably sized piece of aluminium should be used, with one edge on the midline. This needs to be fixed to the Perspex to prevent movement, but uneven layers of glue must be avoided. The height of the aluminium above the breast platform is not critical, and it can be sandwiched between Perspex layers.



Appendix 3: Examples of SNR and CNR calculations

The SNR and CNR are usually calculated in a spreadsheet.

SNR example



Baseline value of SNR is 50 for this example. 10% of 50 is 5.

Lower remedial level = 50-5 = 45
Upper remedial level = 50+5 = 55

Measurement 1:

Mean pixel value in ROI = M = 397.1
Standard deviation of pixel values in ROI = SD = 8.1

$$SNR = \frac{M}{SD} = \frac{397.1}{8.1} = 49.0$$

This is between the lower and upper remedial levels, so this measurement passes the test.

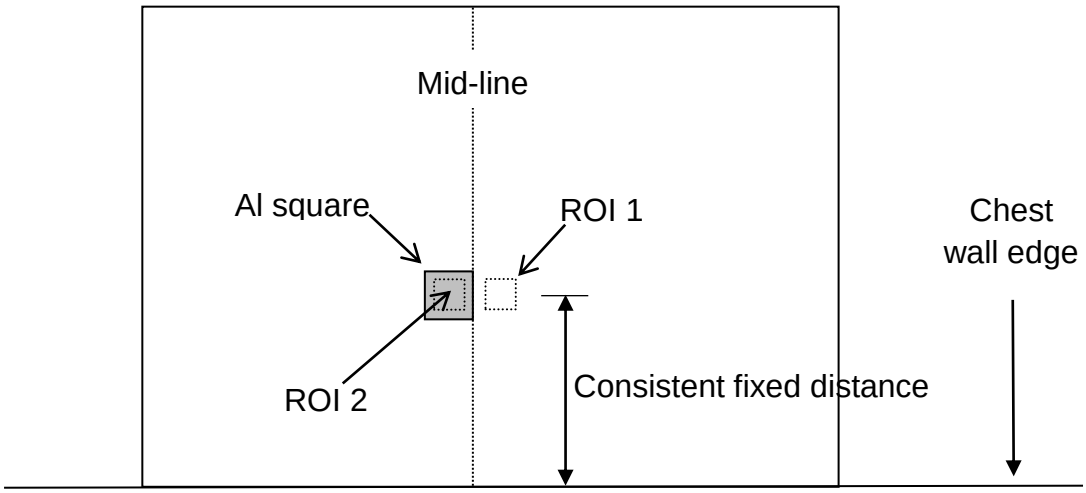
Measurement 2:

Mean pixel value in ROI = M = 405.2
Standard deviation of pixels values in ROI = SD = 6.3

$$SNR = \frac{M}{SD} = \frac{405.2}{6.3} = 64.3$$

This is above the upper remedial level, so this measurement fails the test.

CNR example



Baseline value of CNR is 7.7 for this example. 10% of 7.7 is 0.77.

Lower remedial level = 7.7-0.77 = 6.93
Upper remedial level = 7.7+0.77 = 8.47

Measurement 1:

Mean pixel value in ROI 1 (Perspex) = M1 = 386.7
Standard deviation of pixel values in ROI 1 = SD = 7.5
Mean pixel value in ROI 2 (Perspex plus aluminium) = M2 = 328.3

$$CNR = \frac{M1 - M2}{SD} = \frac{386.7 - 328.3}{7.5} = \frac{58.4}{7.5} = 7.8$$

This is between the lower and upper remedial levels, so this measurement passes the test.

Measurement 2:

Mean pixel value in ROI 1 (Perspex) = M1 = 386.7
Standard deviation of pixel values in ROI 1 = SD = 7.5
Mean pixel value in ROI 2 (Perspex plus aluminium) = M2 = 341.2

$$CNR = \frac{M1 - M2}{SD} = \frac{386.7 - 341.2}{7.5} = \frac{45.5}{7.5} = 6.1$$

This is below the lower remedial level, so this measurement fails the test.

Appendix 4: Example data collection forms

Ideally the QC results should be directly entered into spreadsheets, which facilitates error-free calculations, enables automatic checks against tolerances and can provide graphical display of the data to assist with trend analysis. Acceptable ranges could be entered into the spread sheet to help with analysis; also the compression force to be used could be recorded.

Example results sheets follow.

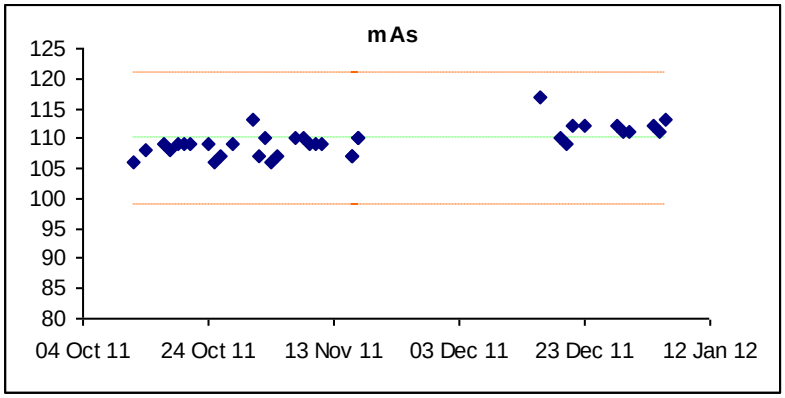
Daily and weekly system checks with Perspex blocks (sections 3.1, 3.2)

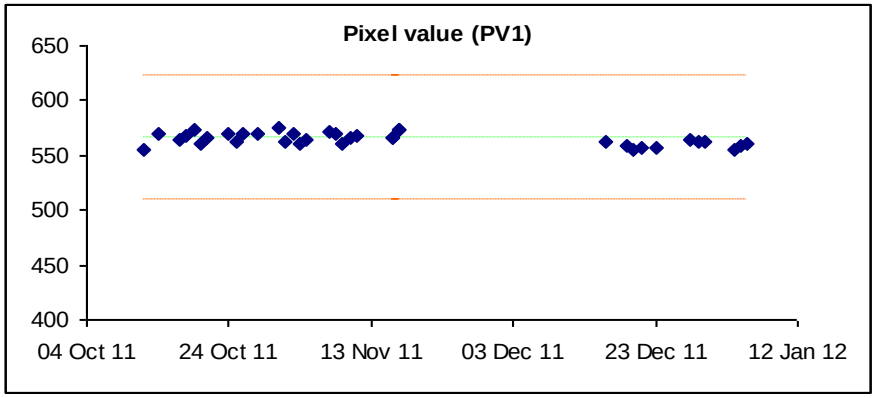
Unit/Location, Model, Identifying Code

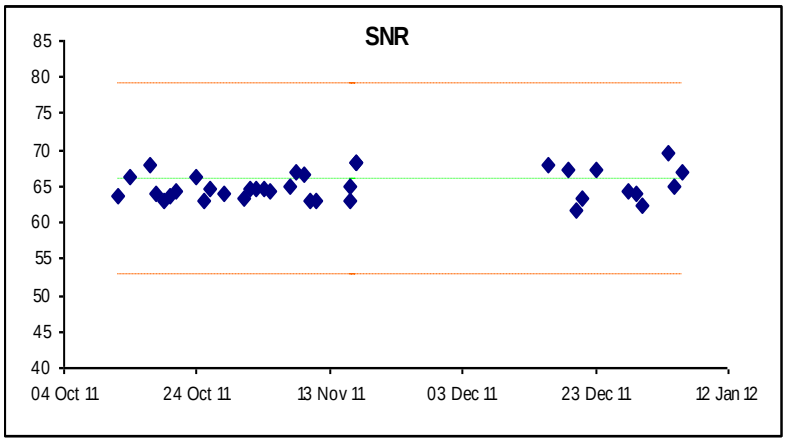
Perspex (cm)		**Compression paddle**		**Exposure mode**	
Perspex size (cm)		**Compression force**		**Processing**	

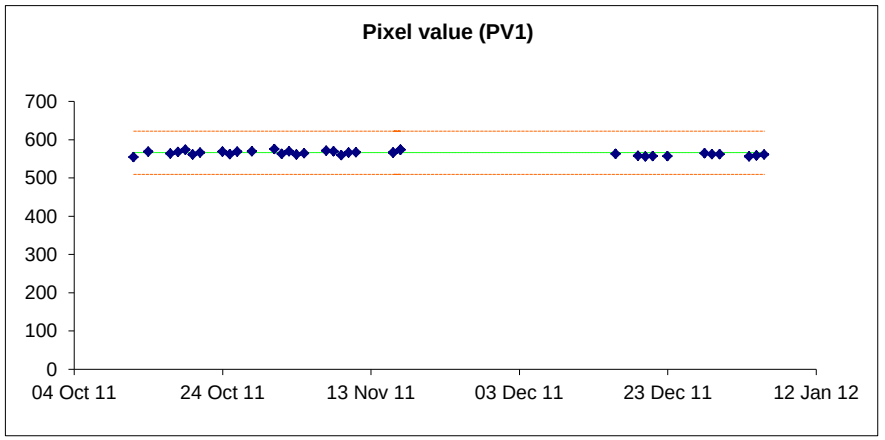
					Daily			**Weekly**				
Date	**Detector temp (°C)**	**kV**	**Target/ Filter**	**mAs**	**Pixel value (PV1)**	**Standard deviation (sd1)**	**SNR (PV1 / sd1)**	**Pixel value (PV2)**	**CNR (PV1-PV2) / sd1**	**Initial**	**Any visible artefacts?**	**Comments**

Example results charts from sample datasets, including limiting tolerance





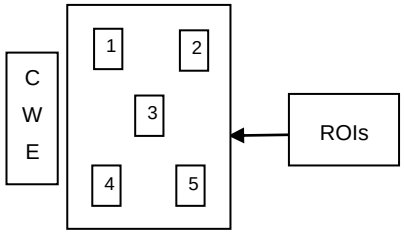




Example results charts for weekly uniformity test (section 3.3)

Unit/Location, Machine, Identifying Code

Perspex (cm)		**Compression paddle**	24x30	**Exposure mode**	
Perspex size (cm)		**Compression force**		**Processing**	



				Mean pixel value									
Date	**kV**	**TargetFilter**	**mAs**	**ROI 1**	**ROI 2**	**Centre (ROI 3)**	**ROI 4**	**ROI 5**	**Any visible artefacts?**	**Comments**	**Initial**	**Max deviation from centre**	**(Limit 10%) Acceptable?**

Monthly AEC thickness check (section 3.4)

Unit/Location, Machine, Identifying Code																											
	2 cm								**4.5 cm**								**7 cm**										
Date	kV	Target-filter	mAs	PV1	sd1	PV2	SNR	CNR	kV	Target-filter	mAs	PV1	sd1	PV2	SNR	CNR	kV	Target-filter	mAs	PV1	sd1	PV2	SNR	CNR	Initial	Comment

Add range of tolerances

References

1. *Improving Outcomes: A Strategy for Cancer*. London: Department of Health, January 2011

2. European protocol for the quality control of the physical and technical aspects of mammography screening. Part 2b: Digital mammography. In: *European guidelines for quality assurance in breast cancer screening and diagnosis,* 4th edition. Luxembourg: European Commission, 2006.

3. *Commissioning and routine testing of full field digital mammography systems* (NHSBSP Equipment Report 0604, Version 3). Sheffield: NHS Cancer Screening Programmes, 2010.

4. *Quality assurance guidelines for mammography including radiographic quality control* (NHSBSP Publication No. 63). Sheffield: NHS Cancer Screening Programmes, 2006.

5. *Assessment of display performance for medical imaging systems.* American Association of Physicists in Medicine (AAPM). Online report 03, 2005 (available at www.aapm.org/pubs/reports/OR_03.pdf).

6. *Supplement to the European Guidelines 4th Edition.* Nijmegen: EUREF, 2011

7. *Collecting, monitoring and reporting repeat examinations* (NHSBSP Good Practice Guide No 4, Version 2). Sheffield: NHS Cancer Screening Programmes 2006

8. *Commissioning and routine testing of small field digital mammography systems* (NHSBSP Equipment Report 0705). Sheffield: NHS Cancer Screening Programmes, 2007