Ontario Breast Screening Program

Digital Mammography Quality Control for the Mammographic Technologist

Authors: G.E. Mawdsley, A.K. Bloomquist, M.J. Yaffe

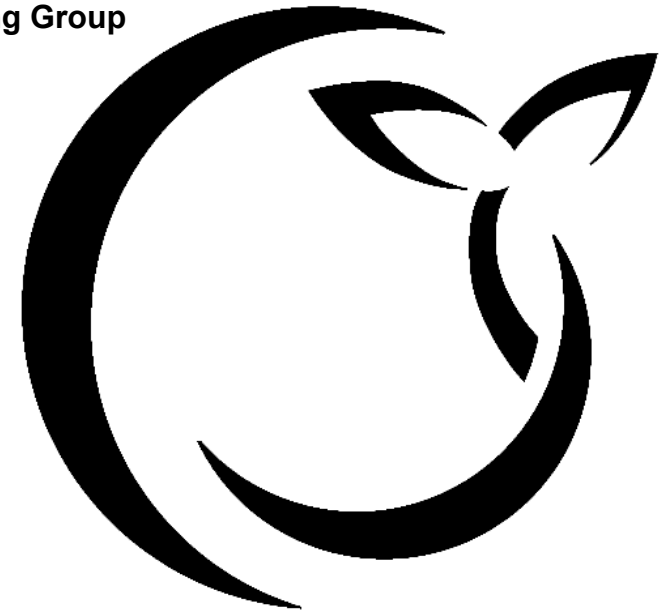
September 2008
Revision 2.6b

Mammographic Physics Consulting Group
Ontario Breast Screening Program

Main:
Room S6-32
Sunnybrook Health Sciences Centre
2075 Bayview Avenue
Toronto, ON M4N 3M5

QC Support:
Sunnybrook Imaging Research
OBSP.Physics@Sunnybrook.ca

Telephone: 416.480.5705
Fax: 416.480.6719



The latest version of this manual can be downloaded from:
http://www.sunnybrook.utoronto.ca/~yaffegrp/OBSP/

or from: obsp.webexone.com Documents(Physics-Quality Control)

ontario breast screening program
a cancer care ontario program
programme ontarien de dépistage du cancer du sein
un programme de action cancer ontario

Blank page

Table of Contents

I. INTRODUCTION

This document lists the quality control (QC) procedures, their frequencies, and action limits that should be used for clinical Digital Mammography (DM) systems used in the Ontario Breast Screening Program. DM includes systems previously identified as: Full-Field Digital Mammography (FFDM), computed radiography (CR), and digital radiography (DR). All QC procedures listed here must be performed at the required intervals or more frequently if the individual situation dictates. The tests in this manual are those required by the OBSP, and form a set of comprehensive tests performed in a standardized manner that can be compared across machines and facilities. These tests must be done by OBSP sites. Some manufacturers have QC tests in their manuals which are similar to tests in this manual; since those tests provide essentially the same information, they do not need to be performed by the site to maintain CAR accreditation. There are some manufacturer specific tests which a site could perform in addition to the OBSP required tests, as well as some tests that must be done in order to use the equipment, but are not required by OBSP. The site should continue to perform any additional manufacturer tests that are required for their unit.

This QC Manual for the mammographic technologist has procedures with frequencies ranging from daily to semi-annually. There is also a Medical Physicist's Manual which has tests that are to be performed upon installation, semi-annually or when significant changes or repairs have been made to the unit.

The data charts used to record test results are provided in this manual in paper form. In addition, each chart is downloadable from the OBSP Physics website (http://www.sunnybrook.utoronto.ca/~yaffegrp/OBSP/) or from OBSP.webexone.com Documents(Physics-Quality Control) in an Excel format. The use of the Excel spreadsheets will simplify procedures significantly, since many plots and calculations are done automatically.

An automatic software package called "Gladys" is being evaluated for use by the OBSP. This package was developed for use in the Flemish part of Belgium, and has a number of important features, greatly reducing the effort (recording and plotting) required for the QC program. The mammographic acquisition system automatically sends images of a patient named QC Mammo to this program that performs a complete analysis of the image quality, reporting the results to OBSP Physics through the internet. This greatly reduces the effort involved in regular QC, and enables detection of subtle problems. This will allow the physics group to detect problems quickly, and intervene before a problem becomes critical as well as reduce clerical and technologist time requirements.

The tests described in this manual are designed to verify the correct operation of the entire imaging chain by evaluating the three components of digital mammography systems: image acquisition (x-ray generation and detection, flat-field correction), image processing (dynamic range adjustment, sharpening, peripheral equalization), and image display (softcopy and printed gray-scale calibration and display resolution). When problems are detected, further tests may be required to diagnose and isolate the cause of the problems so that they can be corrected. Depending on the resources available at the facility and the nature of the problems, such diagnostic testing may be performed by the quality control technologist, the facility's medical physicist, equipment service personnel, or other suitably trained and qualified personnel.

The mammographic technologist must understand that the CAR accreditation requirements require the medical physicist either perform a mammography equipment evaluation "whenever a new unit or processor is installed, a unit or processor is disassembled and reassembled at the same or a new location, or major components of a mammography unit or processor equipment are changed or repaired", or review the results of the testing performed by another qualified individual. This includes the replacement of detectors, as well as moving the machine from one room to another. For new mammography units, this equipment evaluation is essentially an "acceptance test" and involves more complete testing and evaluation than that required for the annual survey. ***All tests must pass before the equipment may be used for the mammography of patients*** and the report must be sent by the facility to the Ontario X-ray Inspection Unit, Ministry of Health and Long Term Care, 5700 Yonge St, 3rd Floor, Toronto, On, M2M4K5 within 60 days of the test, in order to comply with HARP regulations. In addition, the facility can minimize costly mistakes by involving the medical physicist in the purchase decision, siting, viewing room design and computer requirements well in advance of installation.

The importance of involving the medical physicist in the purchase decision and the value of his or her equipment evaluation prior to equipment use is even more critical for digital mammography as facilities rapidly depart from a single-vendor environment where appropriate communication among system components was assured by design. It is not uncommon for a facility to install several different acquisition systems, interface them with review workstations from different vendors, and share the images over an existing picture archiving and communications system (PACS). The medical physicist must perform an equipment evaluation on the review workstations and it must pass the softcopy tests described in the medical physicist's section of this manual, using test images emulating those produced by each acquisition system. If the workstation properly displays

test images emulating those from a given acquisition device, that workstation would pass the equipment evaluation. However, this does not confirm that hanging protocols will be properly followed, or that a given manufacturer's image processing will be properly applied.

As in screen-film mammography, DM QC is only effective if the procedures are performed correctly, results are charted and compared to previous results and to action limits ***as data are collected***, and appropriate corrective actions are taken when needed. QC is ineffective if procedures are not performed regularly, if tests are performed but results are not charted, or if the charted results are not reviewed carefully to determine if corrective actions are needed. To aid in recognizing when corrective actions should be taken, specific action limits are given for all QC test results.

Because these action limits have been developed based on the performance of only a few units of each design from the earlier DM systems, some of the action limits may need to be revised as systems improve over time. These will be periodically reviewed by OBSP Physics and updates will be provided by your OBSP hub site, and will also be available on the OBSP website.

Some tests specify that corrective action must be taken immediately; this means that the device must not be used for patients until the problem is corrected. For example, if the monitor being evaluated is on a review workstation, the interpreting physicians may not use it for interpretation until the problem is satisfactorily repaired. However, the facility is not required to immediately cease mammography; they may continue to acquire patient images for a reasonable length of time. In this example, a "reasonable length of time" would be 3 working days since acceptable medical practice involves notifying health care providers of positive examinations as soon as possible (as guidance, within 3 business days).

Images are generally provided to PACS systems in a "For Presentation" or "processed" form. Most of the tests in this quality control program require images in the "For Processing" or "raw" format. In order to properly evaluate signal levels and noise in the system using phantoms, edge enhancement and dynamic range compression (thickness equalization) must not be applied to the images. It may also be important to ensure that the "auto-push" DICOM server is set to the appropriate state at the completion of the testing.

The mammographic technologist's Procedures for DM for all units are shown in

Table 1 and Table 2 below. Most evaluations can be recorded directly on the checklists (Daily and Weekly Tests and Monthly, Quarterly and Semi-Annual Tests). Note that the tests and frequencies may vary with the type of processing used (wet vs. dry) with the laser printer.

Table 1: DM Radiologic Technologist's QC Procedures and Minimum Frequencies without Laser Printer

Test #	Test	DM Systems	Minimum Frequency	Corrective Action Timeframe	Charts
1.	Monitor Cleaning and Daily Checklist	All	Daily	Immediately, before checked component is used for patients	Chart A, Chart 1
3.	Phantom Image Quality	All	Weekly	Immediately	Chart 4
4.	Display Monitor QC	All	Weekly	Immediately: workstation-before patient images interpreted; acquisition station monitor- before patients imaged	Chart 5, Chart 6
5.	Viewbox Cleanliness	All where prior films are hardcopy	Weekly	Immediately, before patient images interpreted or comparison films reviewed	Chart A
6.	Full Field Artefacts	All	Monthly	Immediately	Chart 7
7.	Monthly Checklist	All	Monthly	Immediately or within 30 days, depending on check	Chart 8
9	Resolution/ Modulation Transfer Function (MTF)	All with scanned image acquisition	Monthly	Immediately	Chart B
10.	Repeat Analysis	All	Quarterly	Within 30 days of the test date	Chart 10, Chart 11
13.	Compression Force	All	Semi-Annually	Immediately	Chart B

Table 2: DM Radiologic Technologist's QC Procedures and Minimum Frequencies including Laser Printer

Test #	Test	DM Systems	Minimum Frequency	Corrective Action Timeframe	Charts
1.	Monitor Cleaning and Daily Checklist	All	Daily	Immediately, before checked component is used for patients	Chart A, Chart 1
2.	Laser Printer Sensitometry	All hardcopy	Daily (wet) or Monthly (dry)	Immediately, before patient images printed	Chart **2**, Chart 3
3.	Phantom Image Quality	All	Weekly	Immediately	Chart 4
4.	Display Monitor QC	All	Weekly	Immediately: workstation-before patient images interpreted; acquisition station monitor- before patients imaged	Chart 5, Chart 6
5.	Viewbox Cleanliness	All hardcopy	Weekly	Immediately, before patient images interpreted or comparison films reviewed	Chart A
6.	Full Field Artefacts	All	Monthly	Immediately	Chart 7
7.	Monthly Checklist	All	Monthly	Immediately or within 30 days, depending on check	Chart 8
8	Laser Printer Artefacts	All hardcopy	Monthly	Immediately, before patient images printed	Chart 9
9	Resolution/ Modulation Transfer Function (MTF)	All with scanned image acquisition	Monthly	Immediately	Chart B
10.	Repeat Analysis	All	Quarterly	Within 30 days of the test date	Chart 10, Chart 11
11.	Printed Image Quality	All hardcopy	Quarterly	Immediately, before patient images printed	Chart 12
12.	Analysis of Fixer Retention	All hardcopy with wet processors	Quarterly	Within 30 days of the test date	Chart B
13.	Compression Force	All	Semi-Annually	Immediately	Chart B

QC TEST IMAGES - SUGGESTED NAMES AND PATIENT ID:

Patient ID numbers assigned to the test images should be chosen so they fall outside the range used for imaging real patients, so as not to create difficulties with any PACS, radiology information system (RIS) or health information system (HIS) in use. The numbers assigned should also be unique to each test. Below we suggest possible ID numbers for the technologist's QC test images, which can be used, provided they meet the above criteria. The following table (Table 3) lists the images generated by the technologist's QC tests along with a suggested patient naming convention. Suggested Patient IDs are given, in the following format: 990XUYYMMDD where X is the test number, U is the mammography unit or room number and YYMMDD is the date the images are acquired.

Table 3: Mammographic Technologist's QC Test Images and Suggested Names and Patient ID

Test #	Test	Patient Name	Images Required	Suggested Patient ID	# of Images Expected
1.	Monitor Cleaning and Daily Checklist	NA	No	NA	NA
2.	Laser Printer Sensitometry	NA	Yes	NA	1 film/day (wet) or 1 film/month (dry)
3.	Phantom Image Quality	Phantom, Test	Yes	9903UYYMMDD	1/week
4.	Display Monitor QC	NA	No	NA	NA
5.	Viewbox Cleanliness	NA	No	NA	NA
6.	Full Field Artefacts	Phantom, Test	Yes	9906UYYMMDD	4+ for CR
7.	Monthly Checklist	NA	No	NA	NA
8.	Laser Printer Artefacts	NA	Yes	NA	1 film/month
9.	Resolution/MTF	Phantom, Test	Yes	9909UYYMMDD	1
10.	Repeat Analysis	NA	No	NA	NA
11.	Printed Image Quality	NA	Yes	NA	1 film/quarter
12.	Analysis of Fixer Retention	NA	Yes	NA	1 film/quarter (wet)
13.	Compression Force	NA	No	NA	NA

MAMMOGRAPHY QC TEST IMAGE AND RECORD RETENTION

As with screen-film mammography QC, the medical physicist will review the facility's DM QC data, results and images during their annual inspection. Table 4 summarizes the length of time these records must be maintained at the facility.

HARP regulations require that quality control records be "maintained for at least six years from the time of their making in the facility in which the x-ray machine to which the records referred is operated". These records must include type and result of test, frequency of testing and actions taken to correct each deficiency identified, but do not include the actual images.

Table 4: OBSP Requirements for Mammography QC Test Image Retention

QC Images / Records	Retention
Daily QC	Images -previous 60 days.
Weekly QC	Previous 12 weeks.
Monthly QC	Until the next semi-annual inspection has been completed and it has been determined that the facility is in compliance with the quality assurance requirements.
Quarterly QC	Until the next semi-annual inspection has been completed and it has been determined that the facility is in compliance with the quality assurance requirements.
Semi-annual QC tests	Until the next semi-annual inspection has been completed and it has been determined that the facility is in compliance with the quality assurance requirements or until the test has been performed two additional times at the required frequency, whichever is longer.
Mammography Equipment Evaluations	Images documenting test failures be provided to the facility to assist them in making corrective actions. These should be kept for 12 months.

Monthly QC Report Cover Sheet

Facility Name: _____

Address: _____

_____

_____

Phone: _____

Email address: _____

Prepared by: _____

Date: _____

Attention: OBSP Physics Consulting Group

Email Address: obsp.physics@sunnybrook.ca

Re: ☐ Monthly QC for _____

☐ Equipment Downtime/Service Report

☐ Other

Message: _____

_____

_____

Please contact the HEAD QC TECHNOLOGIST as soon as possible if you do not receive all pages.

Name: _____

Phone: _____ ext. _____

Department: _____

Confidentiality Statement:

The documents accompanying this transmission contain confidential information intended for a specific individual and purpose. The information is private and protected by law. If you are not the intended recipient, you are hereby notified that any disclosure, of the contents of this information is strictly prohibited. If you have received this information in error, please notify us immediately by telephone and return the original to us by regular mail at our expense. THANK YOU.

END-OF-MONTH QC REPORTS FOR DIGITAL MAMMOGRAPHY SYSTEMS

To be sent by email to: obsp.physics@sunnybrook.ca, or through the hub sites.

All charts are available in Excel format from the physics group.

Please prefix the **Monthly QC Report Cover Sheet** to the submission.

Information to be submitted includes:

- **Monthly QC Report Cover Sheet** – requires an email address and phone number for QC contact at site as essential information.
- **Chart 2** - Laser printer sensitometry (only if hardcopy reading is performed)
- **Chart 4** - Phantom measurements
  - signal level in region of interest (ROI) - this gives a measure of sensitivity
  - noise level (standard deviation) in same ROI.
  - signal-difference (SD) - provides a measure of contrast
  - signal-difference to noise ratio - an index of image quality
  - mAs ties the results to dose
- **Chart 5** and **Chart 6** - Display monitor QC summary – replaces processor QC
- **Chart 11** Retake analysis for digital images

PHANTOMS FOR DIGITAL QC

The only phantom required to perform OBSP and CAR QC at the site is a phantom provided by the OBSP Physics group which covers the entire image receptor and is provided with a 1mm thick disc which is placed on the top of the phantom and used to measure the system "speed" and "contrast" (see Figure 1). This phantom is also used to evaluate the uniformity of the image, and the presence of artifacts. If the phantom is damaged through misuse or lost, the cost of replacement is $750 (less than a CAR phantom). The disc has a $10. replacement fee.

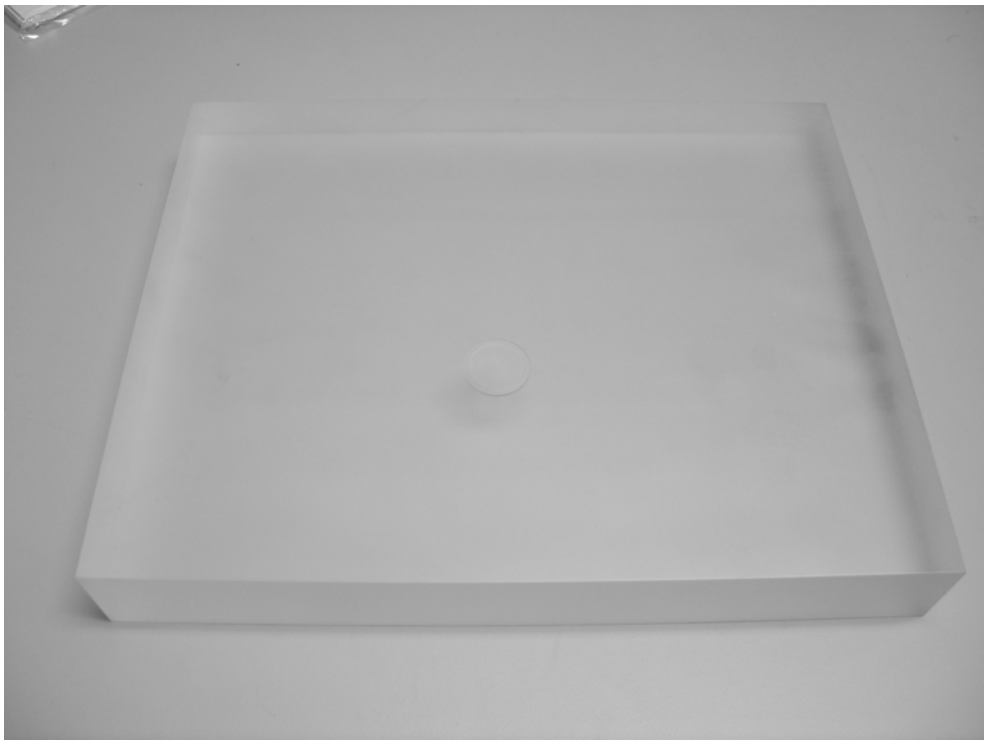


Figure 1: OBSP Digital Mammography Uniform Phantom (DMUP) with 1mm disc on top

Until this phantom is available, the site can use a uniform phantom of any thickness from 2 cm to 5 cm thick PMMA, with a 1.0 mm thick PMMA disk placed in the middle of the phantom. The 1.0 mm disk will be provided by your OBSP physicist. Please do not lose this disk as there is a $10 replacement fee which must be paid by the site.

Facilities which have CR systems will need to have the phantom specified by the manufacturer to perform the quarterly MTF (resolution) test or an MTF test square (available from OBSP Physics).

Monitor test patterns (AAPM TG-18) should be loaded on your acquisition workstation and onto your review workstations by your physicist, and

should not be removed. The images will also be available for download from the Webex site or on DICOM compliant CD from OBSP Physics.

ACR/CAR Mammographic Accreditation phantom

This phantom was a cornerstone of accreditation programs in the US and Canada for film mammography and while not designed for QC has been used for that purpose for film. It has been demonstrated, however, that this phantom is of little value for QC in digital mammography and is therefore not recommended for that purpose in the OBSP program. Nevertheless, since these phantoms are available in most sites as a holdover from film mammography, some facilities may choose to image them periodically.

Imaging of the CAR phantom weekly is at the discretion of the facility, but is not required to meet OBSP QC requirements.

As well, at the time of writing, the submission of an image of this phantom is still part of the CAR Mammography Accreditation Program, so that facilities should be prepared to submit such images at the time of renewal of accreditation.

II. IMPORTANT POINTS

1. TIME FOR QUALITY ASSURANCE PROCEDURES

Each of the elements of a facility's quality assurance program must be assigned to individuals who are qualified for their assignments and the ***facility must allow these individuals adequate time*** to perform these duties. The approximate times to implement, analyze, and document the DM quality control tests described in this manual are listed in Table 5. Additional time must be allocated for retesting, corrective action and retesting again if the initial results do not meet performance criteria.

Table 5: Responsibilities of the QC Technologist and Typical Amount of Time Required

Nature of Procedure/Task and Minimum Performance Frequency	Time Required*
Daily	
Daily Checklist	2 min
Monitor Cleaning	2 min
Laser Printer Sensitometry Check	3 min
Total Time Daily	**7 min**
Weekly	
Phantom Image Quality Test (SDNR and Flat-Field)	6 min
Display Monitor	6 min
Viewbox Cleanliness	5 min
Total Time Weekly	**17 min**
Monthly Checklist	2 min
Laser Printer Artefacts	4 min
Total Time Monthly	**6 min**
Quarterly	
MTF	4 min
Repeat analysis	20 min
Printed Image Quality	8 min
Analysis of Fixer Retention	4 min
Meetings with radiologist	45 min
Total Time Quarterly	**81 min**
Semiannually	
Compression Force Test	5 min
Darkroom Fog	10 min
Total Time Semiannually	**15 min**
Total Time for QC per Year (5-day week)	**51 hours Hard Copy** **32 hours Soft Copy**

*Estimated times include setup, testing, and recording of results for a facility with two mammography units, one "wet" laser printer and one processor.

All of the routine QC must be performed by the quality control technologist or by other personnel qualified to perform the tasks. When other personnel are utilized for these tasks, the quality control technologist must ensure that the tasks are completed properly. The laser printer sensitometry test must be conducted daily for systems with wet processing of printed images; monthly for systems with dry processing. Daily darkroom cleaning need not be performed by the mammographic QC technologist if it is being performed adequately by other qualified facility personnel, however, darkroom cleanliness and monitor cleanliness must be checked on a daily basis.

2. INFORMATION STORAGE AND MAMMOGRAPHY UNIT IDENTIFICATION

In addition to quality requirements already in place for digital mammography, we point out that it is important to ensure that certain key information is automatically transferred from the digital mammography image acquisition system to the stored DICOM image.

This information is required for several purposes: 1) qc, 2) to enable review of images by other facilities and head office, 3) the estimation of patient dose, 4) tracking of imaging parameters, and 5) for use in retrospective studies.

Specifically, systems MUST provide all information fields listed in Table 6 below without additional manual entry by the operator. In addition, it is DESIRABLE that systems also provide the information listed in Table 7.

The Institution Address must include at least the city, province and postal code of the institution. The Station Name would preferably be the CAR Unit number.

Table 6: **DICOM header required tags**

Tag Number	Tag Description
0008,0080	Institution Name
0008,0022	Acquisition Date
0008,0032	Acquisition Time
0008,0081	Institution Address
0008,1010	Station Name
0008,1070	Operator
0010,0010	Patient Name
0010,0020	Patient ID
0018,0060	kV
0018,1152	Exposure or tags as below
0018,1150	Exposure Time **and**
0018,1151	X-ray Tube Current
0018,1191	Anode Target Material
0018,5101	View Position
0018,7050	Filter Material
0020,0020	Patient Orientation
0020,0062	Image Laterality

To fully document the imaging technique used, either tag 0018,1152 (Exposure) or both tags 0018,1150 and 0018,1151 (Exposure time and x-ray tube current) must be included.

Table 7: DICOM header desirable tags

0018,1114	Radiographic Magnification factor **or tags as below**
0018,1111	Distance Source to Patient **and**
0018,1110	Distance Source to Detector
0018,1400	Image Processing
0018,1401	Acquisition Device Processing Code

To know the magnification factor used (i.e. when imaging on a magnification stand), either tag 0018,1114 (Estimated Radiographic Magnification Factor) or both tag 0018,1400 (Distance Source to Patient) and tag 0018,1401 (Distance Source to Detector) should be included.

To the best of our knowledge, all current DM systems are capable of providing this information, however it has come to our attention that for some CR systems, additional hardware or software might be required to achieve this functionality.

CAR and OBSP both require that if there is more than one mammography unit in a facility, the Unit Number be clearly identified on the image. Properly operating and configured software will provide all of the required information in the DICOM header. For computed radiography (CR) systems, radio-opaque markers may be needed to identify the ***unit*** and view.

In addition, systems should have the capability of exporting DICOM images to a portable external medium such as: DVD or USB flash disk.

As we become more familiar with digital mammography and as more new systems are introduced, additional requirements may become evident.

3. ESTABLISHING OPERATING LEVELS AND CONTROL LIMITS

Control limits are established by the medical physicist at equipment evaluation, when the equipment is known to be operating correctly.

When a quality control program is started or equipment is newly installed, it is necessary to establish operating levels and control limits. The operating level is that level which is normally expected. For example, the background pixel value or optical density measured on a phantom image would be expected to be at, or close to, some particular value that is the standard operating level. The control limits are performance criteria established based on operating levels which, if reached or exceeded by subsequent measurements, require additional action. If wet processing of

hardcopy film is performed in the testing procedure, this should be done using seasoned chemistry in the processor.

If repairs or changes are made to the equipment such that new baselines need to be established, the medical physicist will come and acceptance test the repaired/modified equipment and determine the new operating levels or work with the site by telephone to guide how establish the baselines.

The only baselines that may be established by the site without consulting OBSP Physics are for the laser printer, where new baselines may need to be set when the film emulsion changes.

4. TEST FREQUENCIES

The frequency of tests specified in this manual (

Table 1 and Table 2) is the minimum frequency. The actual frequency that the QC tests should be conducted may vary with factors such as the age and stability of the imaging equipment and the number of problems being encountered.

After the operating levels have been determined, the tests should be run more frequently than specified in this document for a few test periods. For example, if the recommended frequency is weekly, then the test should be performed daily for a few weeks. This provides a large amount of data quickly to determine whether rapid changes are occurring and allows for an accurate determination of operating levels, where appropriate. It also allows the individual performing the tests to gain more experience in a shorter period of time.

The frequency of the tests may be modified in consultation with the consulting medical physicist. It may be prudent to increase the frequency of the tests if problems are frequently detected.

NOTE: If problems are seldom detected, DO NOT discontinue testing or reduce the frequencies below the OBSP/CAR minimums for any of the tests in the quality control program! The lack of problems indicates that the process is "in control" at the present time but does not predict the stability of the process in the future.

The control limits should not be widened to accommodate varying performance. If the equipment produces results which are consistently

outside of the control limits specified in this manual, then it will be necessary to have the appropriate repairs made or the equipment replaced.

5. CONTROL CHARTS

The QC technologist will be monitoring quantitative performance of DM systems in a number of QC tests (e.g., laser printer sensitometry, phantom image quality, etc.). Plotting the results on a quality control chart will enable the technologist to quickly and visually determine if the system is performing as it should (i.e., within "control"), if trends are occurring which may eventually lead to an out-of-control system, and if performance variations are related to other events (e.g., service, calibration, etc). The QC technologist must immediately plot the data on the control chart (either by hand or by computer) for reliable monitoring of the measurements in the QC program. For example, the film density, region of interest (ROI) mean value, SDNR and exposure time or mAs should be plotted on a control chart. The date should be indicated, along with the initials of the individual performing the test. Notes regarding changes in operating conditions (e.g., recent service, new flat-field maps or replacement of detector) should also be recorded.

Normally, if the control limits are reached or exceeded, the test procedure should be reviewed to determine if human error contributed to the result and the test should be immediately repeated to confirm the problem. If a repeat of the test gives the same measurement, then corrective action is required. In this case, the out-of-control data point should be circled or annotated, the cause of the problem noted, the corrective action documented and the in-control data point plotted. Corrective action may include contacting the medical physicist to investigate the problem and recommend corrective actions or contacting a service engineer to correct a confirmed problem.

If the performance criteria, or control limits, from this manual are consistently exceeded, then it will be necessary to determine the cause of the problem. The cause may be the measurement technique. For example, if a CR plate is processed immediately after exposure one time and after a delay the next, such variations in technique may be responsible for results that vary beyond control limits. All of these "human variables" should be eliminated and data collected for another period of time before making a decision. If the control limits are still consistently exceeded, then the measurement equipment, e.g., the densitometer should be evaluated. If the measurement equipment is found to be functioning properly and all "human variables" have been eliminated, then equipment repair, or in extreme situations, replacement should take place. All of the problem data

should be reviewed by the medical physicist, and recommendations regarding correction of the problem.

NOTE: If the action limits are consistently exceeded, then it is necessary to improve the quality control procedures, or repair or replace the appropriate equipment. DO NOT widen the action limits since the data are indicating that the process is "out of control" and corrective action is essential.

Control charts also allow the detection of trends that indicate an unstable process or drifting equipment calibration. A trend is an upward or downward change in the measured data when three data points move in the same direction. The cause of a trend should be investigated before the control limits are reached or exceeded.

Finally, there may be situations when operating levels and action limits need to be re-established. Typical examples are when the detector is recalibrated or changed or when new x-ray equipment is installed. This should be done in consultation with the medical physicist.

6. MAMMOGRAPHY QC CHECKLISTS

In order to assist in the oversight of the quality control tests, two DM quality control checklists are provided (**Chart A** and **Chart B**). These checklists provide a quick reminder of when quality control tasks are due and also provide a record indicating that the appropriate tasks have been completed in a timely manner. All dates should be filled in prior to use of the checklist. Each time a task is completed, the individual carrying out the task should initial the appropriate area on the checklist.

Record all daily and weekly DM QC procedure results on **Chart A**. Record the performance of all monthly, quarterly and semi-annual DM QC tests on **Chart B**. Monthly, quarterly and semi-annual DM QC tests should be conducted on the same day each week. It is suggested that approximately one-half hour be set aside to conduct these procedures. Allow the system to stabilize before acquiring phantom images. It may be helpful to conduct these weekly procedures for the first time with your medical physicist present to answer any questions that arise.

Each CAR Accredited facility has a lead interpreting physician who has the general responsibility of ensuring that the quality assurance program meets all CAR requirements. The CAR recommends that the lead interpreting physician reviews the QC technologist's test results at least once every 3 months. In addition, the medical physicist must review the results of the technologists' QC at least semi-annually. Spaces are provided in the monthly, quarterly and semi-annual DM QC checklist

(**Chart B**) for the lead interpreting physician and medical physicist to initial their reviews.

Chart A: Digital mammography quality control checklist: daily and weekly tests.

	Room:			Month/Year:		

Checkmark (√) = Pass/Adequate; x = Fail; initial when complete

Test	Date	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
	Initials																															
1	Monitor Cleaning																															
1	Daily Checklist (Chart 1, daily)																															
2	Laser Printer Sensitometry-wet (daily)																															
3	Phantom Image Quality (weekly)																															
4	Display Monitor QC (weekly)																															
5	Viewbox Cleanliness (weekly)																															

Date:	Test:	Comments:

Chart B: Digital mammography quality control checklist: monthly, quarterly and semi-annual tests.

	Room:			Year:		Minimum Resolution:

Checkmark (√) = Pass/Adequate; x = Fail; enter number where appropriate; initial box when complete

Test	Month	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
2	Laser Printer Sensitometry-dry (monthly)												
6	Full-Field Artefacts (CR-monthly)												
7	Monthly Checklist (chart 8-monthly)												
8	Laser Printer Artefact (monthly)												
9	Resolution/MTF Horizontal Bars (scanning-quarterly)												
	Resolution/MTF Vertical Bars (scanning -quarterly)												
10	Repeat Analysis (quarterly)												
11	Printed Image Quality (quarterly)												
12	Analysis of Fixer Retention (quarterly)												
13	Compression Force (semi-annual)												
Radiologist Review (quarterly)													
Medical Physicist Review (semi-annually)													

Date:	Test:	Comments:

7. TECHNIQUE CHARTS

Ideally, digital mammography units should expose all breasts optimally; however there are cases where the breast shapes or compositions do not fit within the expectations of the equipment designer. This problem may be reduced by using a Digital Mammography Technique Chart (**Chart C**) that should be developed by the mammographic technologist in consultation with the medical physicist.

Some mammography units offer the selection of an anode target material and x-ray beam filter. In cases where the choices of target and filter are prescribed by the mammographic technologist, those choices should be included on the technique chart.

It may be necessary to use manual techniques to obtain appropriate exposures on images of breasts containing implants. The appropriate information can be recorded on the technique chart.

Once the technique chart has been filled out, it should be posted on the DM unit adjacent to the control panel and followed by every technologist using the equipment when indicated. The manufacturer's recommendations should be followed, but the medical physicist, applications specialist and radiologist should be involved in optimizing this chart, and in setting appropriate aim values.

Chart C : Digital mammography technique chart.

No Implants							
Compressed Breast Thickness (cm)	Mammographic Density	AEC Setting	Target	Filter	kVp	mAs	Aim Value (S#, EI or ADU)
Implants							
Compressed Breast Thickness (cm)	Mammographic Density	AEC Setting	Target	Filter	kVp	mAs	Aim Value (S#, EI or ADU)

8. IMAGE VIEWING CONDITIONS

Viewing conditions are extremely critical in mammography. The information for the procedures entitled "Viewing Conditions" and "Display Monitor" should be read and followed with great care. The higher optical density mammograms needed to maximize lesion detection require high-luminance viewboxes, proper masking of each film, and low ambient room light. All mammograms and mammography test **images must be completely masked** when being viewed, i.e., no light should come directly from the viewbox surface or monitor to the eye of the observer. These viewing conditions apply to the technologist QC area as well as the area where the radiologist interprets images. If printed digital mammograms are viewed on the viewbox, it should be understood that the printer is calibrated for use with a viewbox with a given intensity, and that the diagnostic quality of the image may not be as expected.

The correct calibration of monitors used to view digital mammograms takes into account the effect of ambient room light on the final appearance of the image. Thus, ambient room light should be kept to a minimum during initial setup of the monitors, and the initial viewing conditions should be maintained for all future use and testing of the monitors. If the ambient illumination changes, it will be necessary to have the monitor calibration adjusted.

Whenever mammograms or phantom images are viewed, they should be viewed under identical conditions. For example, phantom images should be viewed on the same viewbox or monitor, with the same lighting conditions, and using the same magnifier as used for viewing clinical mammographic images and at the same time of day, for example, first thing in the morning. In addition, the same viewbox masking should be used for both clinical and phantom images.

Whenever it is necessary to make subjective judgments about phantom images, e.g., determining resolution in test images, the perception of low contrast changes or the detection of artefacts, the evaluation should be carried out by the same person using conditions identical to those used for previous evaluations.

9. THIRD PARTY PRINTING

If your site uses a third party (a different mammography facility or separate entity) to print digital mammograms onto films, it is the responsibility of your site to verify that appropriate quality control of the printer(s) used is being carried out, and that the printed image quality is acceptable. Your facility's QC technologist must provide oversight of the laser printer QC. This may be done by obtaining the monthly QC records

from the printing service and evidence that problems are corrected when detected. Please forward the third party's monthly QC records to the OBSP Mammographic Physics Consulting Group along with your monthly QC package. In addition, printed films of a uniform image should be provided monthly and films of an appropriate test pattern should be provided quarterly so that test procedures 8 and 11 (Laser Printer Artefacts Test and Printed Image Quality Test) can be performed. Periodically, clinical cases should also be reviewed.

III. DIGITAL MAMMOGRAPHY QUALITY CONTROL TESTS

The QC test procedures required by the mammographic technologist are listed in this next section. Each test is numbered in order to coordinate with

Table 1, Table 2, Table 3, **Chart A** and **Chart B**.

1. DAILY QUALITY CONTROL TEST PROCEDURES

Performance of daily monitor cleaning and the daily checklist (Chart 1) should be recorded on Chart A. Daily laser printer sensitometry should be recorded on Chart 2. Baselines can be established using Chart 3.

TEST #1: MONITOR CLEANING AND DAILY CHECKLIST

Objective

To keep monitor screens free of dust, fingerprints and other marks that might interfere with image interpretation.

Frequency

Daily

Required Test Equipment

Dry, soft, lint-free cloth or lens tissue
Water or approved monitor face cleaner
Daily checklist (Chart 1)

Test Procedure Steps

1. Clean all monitor screens gently with the cloth lightly dampened with water if required.

2. If the facility has Gladys software, perform the MoniQA tests.

3. Record the monitor cleaning on the daily and weekly checklist (**Chart A**).

4. Ensure that appropriate cleaning solutions are in the examination room.

5. Complete the daily checklist (Chart 1). Ensure that the mammography unit has no loose or broken parts, and is clean. Check that the compression paddles are not cracked and that all hoses and cabling are unobstructed. If you have a CR system, erase all the imaging plates and ensure the CR reader and environment are clean (see the manufacturer's manual for more detailed cleaning information).

6. Record performance of this check on the daily and weekly checklist (**Chart A**).

Precautions and Caveats

Abrasive materials or alcohols should not be used on monitor faces, since the anti-glare surface on the display might be destroyed.

Performance Criteria and Corrective Action

1. Monitor screens must be free of dust, fingerprints and other marks that might interfere with image interpretation. There should be no "shiny" patches or obvious non-uniformities on the surface.

2. Both review monitors must pass MonQA tests if performed.

3. The lighting conditions and room configuration must match what is described on the medical physicist's worksheet. Sources of bright light must not be present in the room and must not be reflected from the viewbox and/or monitor surfaces.

4. See the manufacturer's manual for criteria for their recommended daily checks.

Timeframe for Corrective Action

Before patient films are interpreted.

Chart 1: Daily Checklist

	Facility:																															
	Room:																Month/Year:															
Checkmark (√) = Pass/Adequate; x = Fail; initial when complete																																
Date	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	
Initials																																
No Loose Parts																																
Overall Integrity																																
Cleanliness																																
No Cracks in Paddles																																
Housing and Cabling unobstructed																																
CR Reader Cleanliness																																
Imaging Plate Erasure																																

Date:	Comments:

TEST #2: LASER PRINTER SENSITOMETRY

Objective

To confirm and verify that the laser film processing system used to print patient images is working in a consistent manner according to pre-established specifications (manufacturer's specifications) so that printed image quality is consistently high.

Printing should be conducted from ***each workstation*** that is normally used to submit patient films for printing. Testing of all image sources is performed during the quarterly Printed Image Quality test.

Frequency

Systems with ***wet*** processing: ***daily*** or on each day before clinical images are to be printed, or when changes in sensitometry are suspected.

Systems with ***dry*** processing: ***monthly***, or when changes in sensitometry are suspected.

Required Test Equipment

Densitometer

TG18-QC pattern (use one specific to one of your DM units-Figure 2) or printer-produced sensitometry strip (gray-scale step wedge)

Chart 2 and Chart 3

A. Laser Printer Sensitometry

Test Procedure Steps

1. Expose and process a single TG18-QC film or a gray-scale step wedge. Always use the same window width and level settings.

2. If using the TG18-QC pattern, note that the box numbers run from darkest (#1) to brightest (#18) (see Figure 2). Read and record the densities on the pattern as follows:

   a) Maximum density area (Dmax) – box #1

   b) Density difference (DD) – box #16 (DD1) minus box #5 (DD2)

   c) Mid-density (MD) – box #11

d) Base+fog (B+F) – box #18

3. If using a gray-scale step wedge, choose step numbers as follows:

   a) Dmax – the darkest step

   b) DD – the step closest to 2.20 (DD1) minus the step closest to but not less than 0.45 (DD2)

   c) MD – the step closest to but not below an optical density of 1.20 or your working optical density

   d) B+F – the lightest step

Record and plot these four 4 values (Dmax, DD, MD, and B+F) on Chart 2.

4. Record completion of the sensitometry procedure on the daily and weekly checklist (**Chart A**).

Performance Criteria and Corrective Action

1. If the ***Dmax*** falls below the ***control limit of -0.15*** of its respective operating level or is less than ***3.50***, the source of the problem must be determined and corrected before digital mammograms are printed. (Note that there is no upper control limit; darker Dmax values are desired.) If the Dmax falls below -0.10 of its respective operating level but is still above -0.15, the test should be repeated immediately. If the same result is obtained it is acceptable to print films, but the printer or processor should be monitored closely. If the Dmax is above -0.10 of its respective operating level, the printer or processor is in control and no further action is required.

2. If the ***DD or MD*** exceeds the ***control limit of ±0.15*** from its operating level, the source of the problem must be determined and corrected before digital mammograms are printed. If the DD or MD fall outside of the ±0.10 control limit but are within a range of ±0.15, the test should be repeated immediately. If the same result is obtained it is acceptable to print films, but the printer or processor should be monitored closely. If the DD and MD are within ±0.10 of their respective operating levels, the printer or processor is in control and no further action is required.

3. If the ***B+F*** exceeds the ***control limit of +0.03*** from its operating level, the source of the problem must be determined and corrected before digital mammograms are printed. If the B+F is within +0.03 of its

operating level, the printer or processor is in control and no further action is required.

4. If a change in the Dmax, DD, MD or B+F exceeds the performance criteria, it will be necessary to determine the source or sources of this change and the problems should be corrected immediately. In addition, the out-of-control data point should be circled, the cause of the problem noted in the "Remarks" section of the control chart. After correction, the in-control data point should be plotted on the same date. On wet processors, the most likely sources of change are processing chemistry, replenishment, and temperature changes. For example: if few films have been printed for some time, the processing chemistry may have oxidized and may not have been properly replenished. On dry processors, a likely source of change might be the drum temperature. On either processor, a change in film emulsion batches may lead to a change in film optical densities, and should initiate an internal re-calibration of the printer.

Timeframe for Corrective Action

Immediately, before any further patient images are printed.

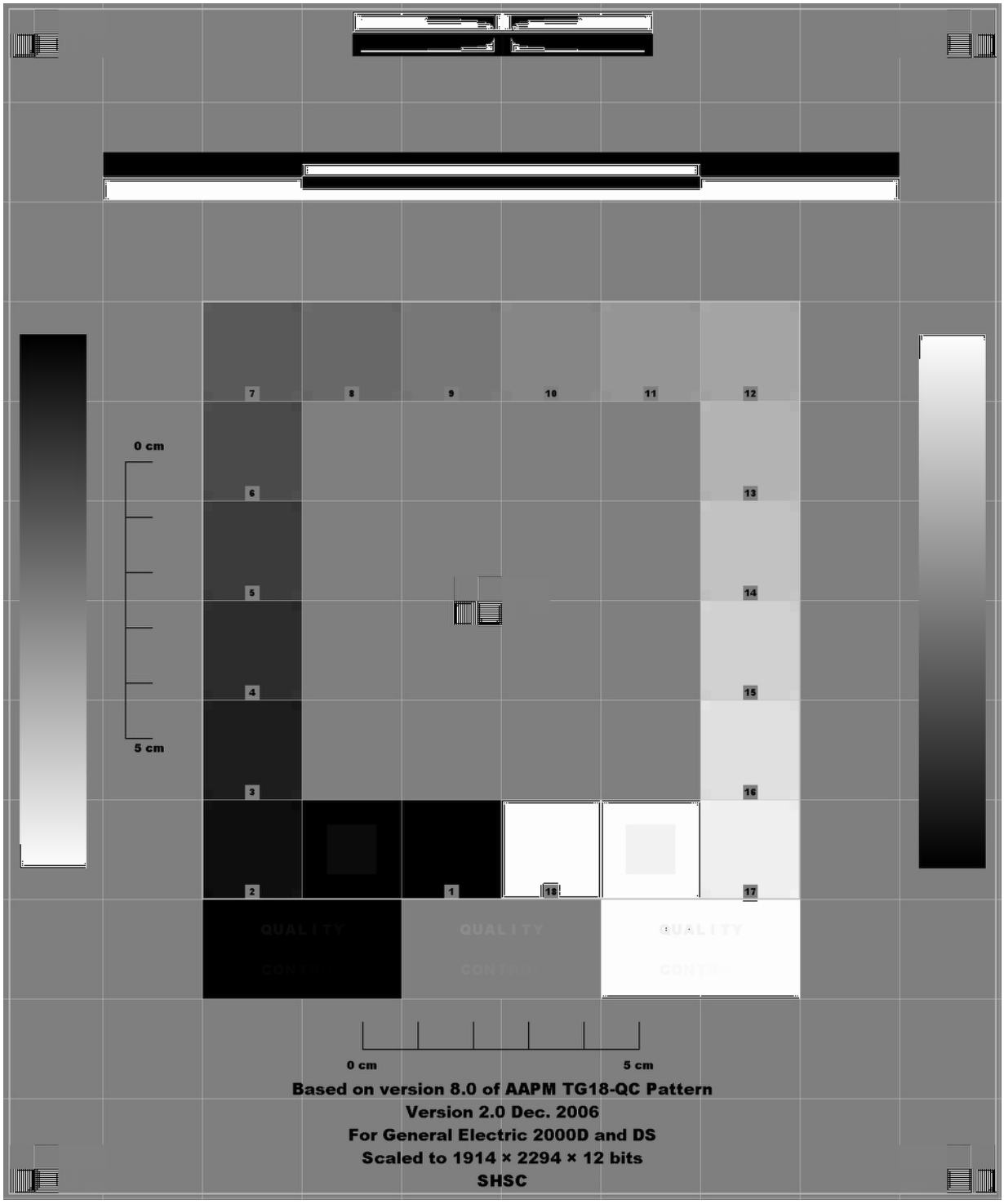
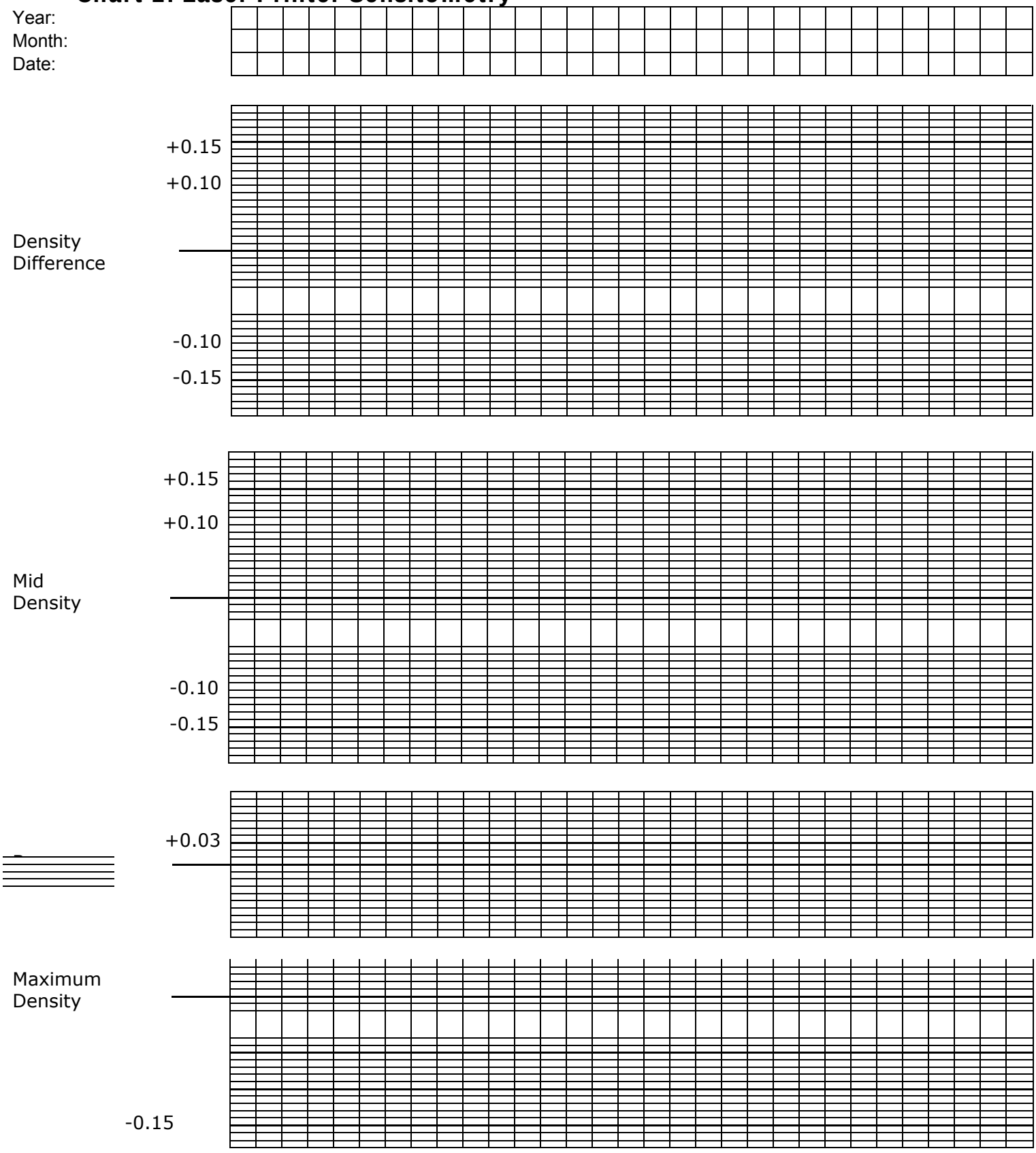


Figure 2: TG18-QC Pattern

Chart 2: Laser Printer Sensitometry



B. Establishing Laser Printer Sensitometry Operating Levels

Test Procedure Steps

1. Print and process a TG18-QC film or a gray-scale step wedge. Record the window width and level settings used if printing the TG18-QC pattern.

2. Repeat step 1 for 5 days, obtaining 5 films. Ensure that the window width and level settings are the same each time.

3. If using the TG18-QC pattern, read and record the densities on Chart 3 as follows:

4. Dmax – box #1 contrast square (may not be less than 3.5)

5. DD – box #16 (DD1) minus box #5 (DD2)

6. MD – box #11

7. B+F – box #18

8. If using a gray-scale step wedge, read and record the densities on Chart 3 as follows:

   a) Dmax – the darkest step (may not be less than 3.5)

   b) DD – the step closest to 2.20 (DD1) minus the step closest to but not less than 0.45 (DD2)

   c) MD – the step closest to but not below an optical density of 1.20 or your working optical density

   d) B+F – the lightest step

Determine the averages for these four values (Dmax, DD, MD, and B+F) over the first week. Use these averages as the operating levels on Chart 2.

9. Record the date the operating levels were calculated on Chart 3.

NOTE: New operating levels should not need to be set except when major changes are made to equipment. The printer should be re-calibrated to meet the expected operating levels when film or chemistry is changed. Consult your medical physicist.

Chart 3: Setting Operating Levels: Laser Printers

Date Values Valid From: _____

	Step / Box #	Date					
							Average
D Max							
DD 1							
Mid Density							
DD 2							
Base + Fog							

	Target Value
Density Difference (DD1-DD2)	
Mid Density	
D Max	
Base + Fog	

Reason for setting new target value:

2. WEEKLY QUALITY CONTROL TESTS

These procedures should be conducted on the same day each week. It is suggested that approximately one-half hour be set aside to conduct these procedures. Allow the system to stabilize before acquiring phantom images. It may be helpful to conduct these weekly procedures for the first time with your medical physicist present to answer any questions that arise.

Record the performance of all weekly DM QC tests on **Chart A**. Record the data from the phantom image quality test on Chart 4, and the data from the display monitor QC on Chart 5 and Chart 6.

TEST # 3: PHANTOM IMAGE QUALITY

Objective

To ensure that the image acquisition chain is working in a consistent manner, and that there are no obvious artefacts.

Frequency

Weekly

Required Test Equipment

OBSP Digital Mammography Uniform Phantom (DMUP)

and

1 mm thick 25mm diameter contrast disc

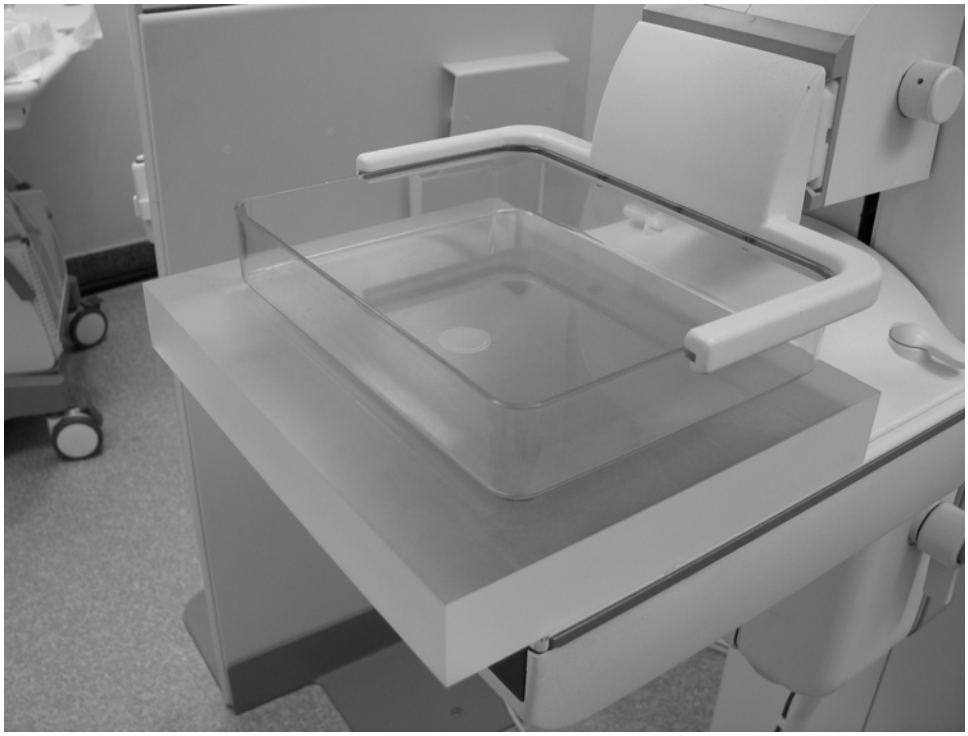


Figure 3: OBSP Digital Mammography Uniform Phantom (DMUP) in position for imaging

Test Procedure Steps

1. Open a test patient exam named QC Mammo at the acquisition workstation and give it an ID number specific to the date (Use an ID number such as 9903UYYMMDD), with U being the unit identifier. Using an image numbering system that tracks your QC images over time in a consistent manner will allow you to find your QC records in an easy way.

2. a) Place the DMUP phantom so that it covers the entire breast support plate, extending beyond the chest wall edge of the digital image receptor.

   b) Place the 1mm thick disc about 50mm from the chest wall, on the centerline of the image detector. This should be located at the same place each time, so if there is an AEC detector mark on the paddle, it would be a good position to select. Because the location of the disc is not the same for both large and small image fields, the disc cannot be glued in place.

   c) Compress the phantom at between 5-10 decaNewtons (about 11-22 lbs.) of compression force. Record the compression force used

and thickness indicated at the top of Chart 4. Use that same amount of compression force each time the DMUP is imaged.

3. Acquire an image of the phantom using the same technique settings that you would used for a clinical exposure of a 4.2 cm thick breast of 50% glandular and 50% adipose tissue (standard breast). If you routinely use automatic exposure control, then use it for this exposure. Some systems (e.g. Lorad/Hologic or Siemens) may require prescribing a "raw" or "for processing" image. For CR, process the imaging plate using a mode suitable for phantoms (for FUJI, use Anatomical Region: "Test", EDR: "Semi"; for Kodak, use the "Pattern" setting). For FUJI CR record the S number used. For Kodak CR record the exposure index or EI.

4. Record the technique used to acquire the image at the top of the form. This exposure mode should be used for all subsequent phantom exposures. For systems using automatic exposure control (AEC or AOP), the target material, filtration and kVp should not change from one week to the next. If target, filtration and kVp are unchanged, plot the mAs on Chart 4. If the kVp or filter changes, repeat the exposure using a slightly different compression force.

5. If patient images are interpreted in softcopy, view the processed image on the radiologist's softcopy display station. Use the window width (WW) as determined by your physicist at the most recent testing of the unit and a window level (WL) that results in the background of the phantom being displayed with a mid-gray. The same WW and WL settings (+/- 10 ADUs) should be used each time an image is evaluated.

6. With the same WW and WL as used above, evaluate the entire phantom image for artefacts. Examine the entire phantom for both broad area artefacts, such as non-uniformities, blotches, and streaks, and for detailed artefacts, such as black or white pixels, clusters of pixels, lines, or dust particles. Broad area artefacts are typically best seen while observing the phantom image as a whole, not in pieces. Detailed artefacts are typically best seen while observing the phantom image at full spatial resolution, where one pixel on the display matches one pixel in the image, or even in magnified form (with a magnification greater than 1.0) Record the absence or presence of artefacts at the bottom of Chart 4.

An artefact is considered significant if it may mimic or obscure anatomic features.

7. If patient images are interpreted on hard-copy, print the image, using the WW and WL that would be used for a patient image. View the image on a mammographic quality viewbox, preferably the one used by the radiologist. Evaluate the entire phantom image for artefacts, recording the absence or presence of artefacts on Chart 4.

It is not necessary to view the image on all available softcopy monitors. This is a test of image acquisition, not display. Monitor performance is assessed in test 4.

8. If it is possible, display the unprocessed ("raw" or "for processing") image on a workstation that provides region of interest analysis.

.

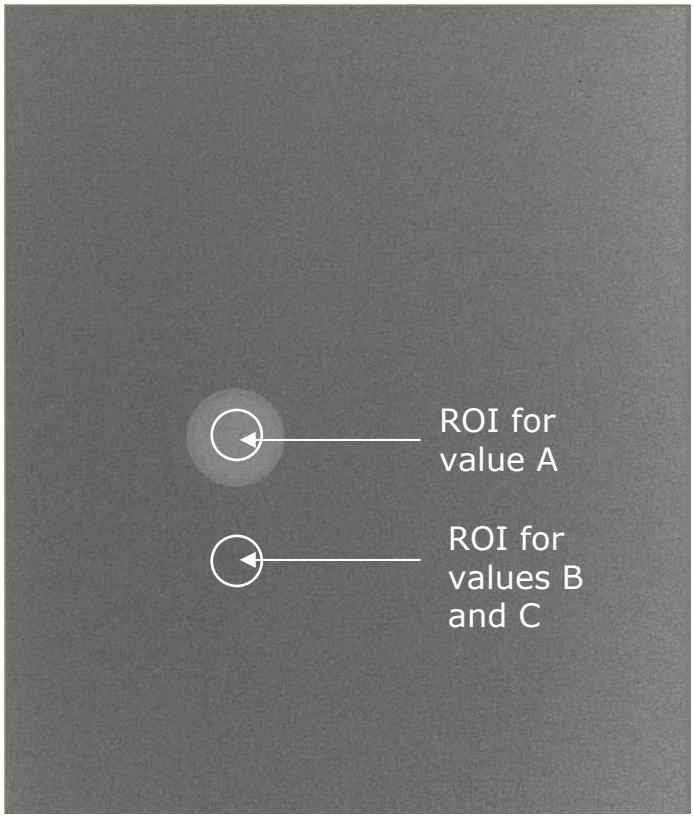


Figure 4: ROIs in the image of the weekly QC phantom used to calculate the signal difference to noise ratio.

9. With the image displayed so that the signal difference to noise ratio (SDNR) contrast disc is clearly visible (see Figure 4), place a circular ROI of approximately 1 cm in diameter (approximately 0.8 cm^2) over, and entirely contained within the disc area. Record the mean signal value (or mean ADU) and label this value "A". This number will be recorded on Chart 4 and will be used to calculate SDNR.

10. In a region outside, but immediately adjacent to the disc, record the mean and standard deviation within a similarly sized ROI as used above as B and C, respectively, on Chart 4.

11. Calculate the Signal Difference-Noise-Ratio (SDNR) as:

SDNR = (B-A)/C

12. An alternative method would be to use software built into the mammography system or workstation to automatically calculate SDNR, once the manufacturers incorporate this test into their software. If Gladys software is running, this test will automatically be performed, and recorded.

13. Record the SDNR and mean pixel value on Chart 4.

Precautions and Caveats

The ROI placed over the 25 mm diameter contrast area should not touch or extend beyond the edges of the disc. The ROI placed outside the disc should be to the left or right of the disc (looking at the image receptor).

When recording signal mean and standard deviation values, it is not necessary to write down all of the digits seen on the screen. Four significant digits (1234) are sufficient for the signal value. Three significant digits are sufficient for the noise (standard deviation) value. For example, if 123.4567 is displayed for the signal, record 123.4; if 9.87654 is displayed for the standard deviation, record 9.88.

Note: Operating levels should only be recalculated when changes are made to equipment such as replacement of tube or detector or re-calibration of detector, AEC or generator. If the unit is serviced, new operating levels may need to be calculated. **Almost all of these conditions require an equipment evaluation by the medical physicist.**

Performance Criteria and Corrective Action

1. The phantom exposure mAs should be within ±10% of the baseline mAs value.

2. The measured signal (or ADU) value should be within ±10% of the average baseline signal (or ADU) value.

3. The calculated SDNR value should be within ±10% of the average baseline SDNR value.

4. For CR systems, the S number or EI value should be within ±10% of the average baseline value

5. If any of these three quantities is "out of control", meaning that it is outside the action limits stated above, the ***test should be repeated***. Make sure you are using the correct image type ("raw" or "for processing") for signal measurements. You might also check to see if service adjustment, ambient or detector temperature, recalibration of the detector system, or software changes might be responsible for the readings appearing out of control. If no service adjustment has occurred, and if any of the values are still out of control on a repeat test, contact your authorized service representative.

6. If any artefacts are visible which might mimic or obscure anatomic information or if any patterns are seen, a recalibration or flat-fielding of the digital detector is needed, or there may be a foreign material on the compressor paddle, breast support or detector face. After you, your medical physicist, or your service person performs the recalibration or flat-fielding, repeat the artefact phantom test. If artefacts persist, contact your authorized service representative. Do not image patients until the artefacts are removed.

7. There should be no blotches or regions of altered noise appearance

8. There should be no observable grid lines or table top structure.

9. There should be no "bright" or "dark" pixels evident.

Time Frame for corrective action

If this test fails, do not image patients until the failure is resolved.

Chart 4: OBSP DM QC Phantom control chart.

Facility: _____ Room / Unit: _____

Target/Filter _____ Year: _____

kV _____

Compression Thickness _____ Compression Force: _____

Window Width _____ Window Level _____

Month																							
Day																							
Init.																							
EI or S																							
L																							

Weekly mAs Value

+10 %

Baseline

-10 %

Weekly Signal Value (A)

+10%

Baseline

-10%

Weekly SDNR Value ((B-A)/C)

+10%

Baseline

-10%

Artefacts (Y/N)																							
Pass/Fail																							

CHART 4 – PHANTOM IMAGE QUALITY, CONTINUED

Facility: _____ Room / Unit: _____

Target/Filter Year: _____

kV _____

Compression Thickness _____ Compression Force: _____

Window Width _____ Window Level _____

Month																						
Day																						
EI or S																						

Weekly S/EI Value (CR Only)

+10 %																						
Baseline																						
-10 %																						
Pass/Fail																						

Remarks

Date	Action

TEST #4: DISPLAY MONITOR QC

Objective

To ensure that images on the acquisition workstation monitor and on the monitor used for interpretation are displayed at adequate contrast and resolution.

Applicability

This test should be performed on ***all*** primary medical display devices used to interpret digital mammograms (radiologist's workstations), and on ***all*** secondary display devices as indicated. Secondary display devices include the monitor(s) attached to the acquisition workstation that is used to verify patient image quality and/or the monitor used to manipulate and print the images (technologist's workstations). If the interpreting physicians provide final interpretations from hardcopy ***only***, the tests will only apply to the secondary display devices.

Frequency

Weekly

Required Test Equipment

Modified AAPM TG18-QC test patterns with DICOM header to match processed images produced by each acquisition system used at the site. (This test pattern may be obtained from the DM unit's or the workstation's manufacturer.) For your convenience "right" and "left" versions of the test pattern are provided so that the display software on the radiologist's workstation can display the image on both monitors simultaneously. The "right" and "left" versions of the image are identical except for the mammographic projection (view) information contained in the header. The images can be loaded as patient images in the same manner that previous images would be reviewed on the system. The images should be loaded onto your PACS system or workstation by the medical physicist when they perform the equipment evaluation. The images are also available on a DICOM compliant CD from OBSP Physics. These images should not be deleted.

Patient images

A. Test pattern Check

Test Procedure Steps

1. First, review the acceptable viewing conditions sheet posted by your medical physicist in the room where the radiologist's workstation is kept before this test, or whenever a significant change in viewing conditions is perceived.

   a) Ensure that the lighting conditions and room configuration match what is described on the worksheet. Ensure that sources of bright light are not present in the room, and are not being reflected from viewbox and/or monitor surfaces.

   b) If differences exist between the acceptable configuration and the current configuration, adjust the room appropriately to ensure acceptable viewing conditions (i.e., turn off lights that should be off, close curtains, etc.).

2. If Gladys is running at the facility, perform the MoniQA test for each monitor of the review workstation, and for the acquisition workstation, and proceed to Section B "Clinical Image check". The MoniQA program automatically records and analyzes the test.

3. Display the AAPM TG18-QC test pattern image in the normal manner (as you would for a clinical image). Ensure that the window-width is set to maximum and the window-level is set to half of maximum. Use the same window-width and window-level settings each time. See Table 8 for the window-width and window-level settings applicable to each acquisition system image type.

Table 8: Window width and Level Settings for viewing AAPM TG18-QC images

Acquisition System	Window-Width	Window-Level
Fuji CR	1024	512
GE 2000D, Essential	4096	2048
IMS Giotto Image SDL	4096	2048
Hologic Selenia	16384	8192
Kodak CR	4096	2048
Siemens Novation	4096	2048

4. For each primary and secondary display device view the TG18-QC pattern on each monitor used to display digital mammograms. For primary display devices there are typically two monitors used to display digital mammograms.

5. For reference, refer to figure 5 and evaluate subjectively the following:

   a. General image quality

      i. There should be no evidence of smearing.

      ii. There should be no evidence of other artefacts.

      iii. The vertical grayscale ramps that go from black to white along the sides of the pattern (regions A on figure 5) should be smooth and continuous.

   b. Geometric distortion

      i. The lines on the pattern should be straight.

      ii. The image should be centered on the screen.

      iii. The boxes should appear square.

   c. Luminance

      i. The luminance squares frame the central portion of the pattern (regions B on Figure 5). They are numbered 2 through 17. Each should be a distinct shade of gray, different from the other patches.

      ii. Examine the 0%-5% and the 95%-100% contrast squares (Figure 6) located at the ends of the luminance square frame. Note if the patches are visible on Chart 5 for radiologists' review workstations or Chart 6 for acquisition stations, as applicable.

   d. Lettering (only required for radiologist's workstations) - Examine the text areas below the central region of the pattern (regions C on figure 5). Letters spelling "QUALITY CONTROL" are printed in fainter and fainter text over the backgrounds. Record the number of letters visible over the following backgrounds on Chart 5.

      i. Dark

      ii. Mid-gray

      iii. Light

Currently it may not be possible to install and display the AAPM TG-18 QC pattern on all secondary display monitors. If that is the case at your site, follow the manufacturer's recommended monitor QC test for the monitor until it becomes possible to perform this test. Consult your physicist for more information.

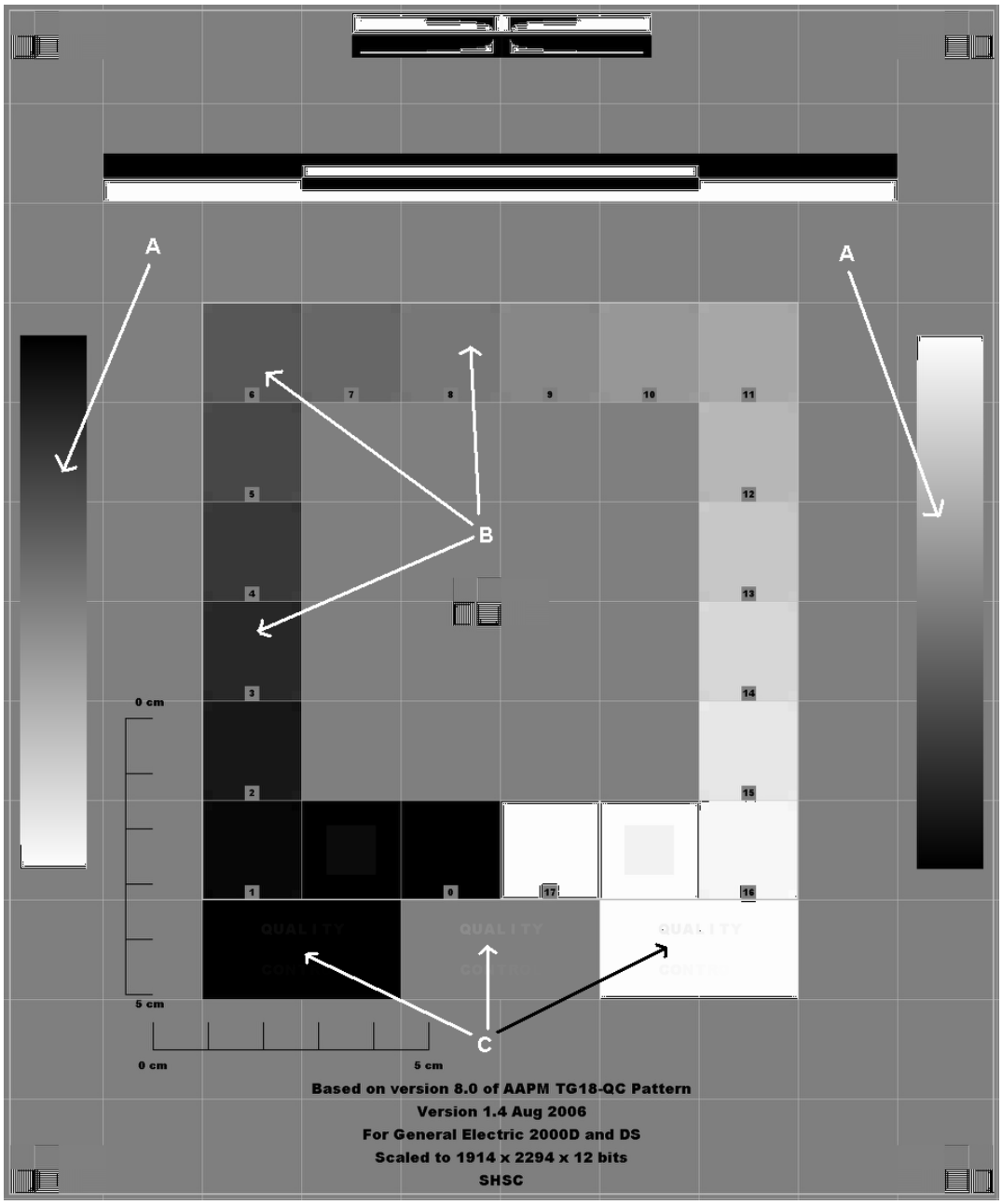


Figure 5: TG18-QC Pattern with vertical gray-scale bars (A), luminance patches (B), and lettering (C) indicated.

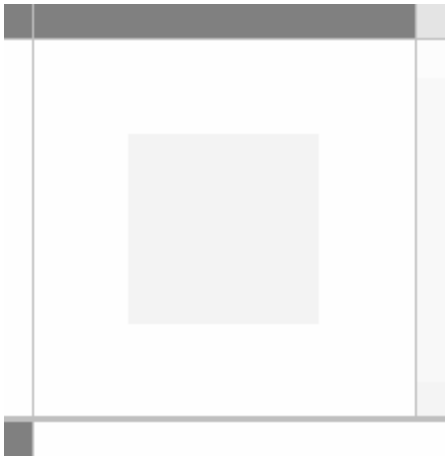


Figure 6: 95% / 100% contrast square from the TG18-QC test pattern.

B. Radiologist's Workstation Clinical Image Check

Test Procedure Steps

1. From the radiologist's workstation used for interpretation, locate a random clinical patient file on the menu and open the file for viewing. Load the same clinical image on all monitors for viewing (Figure 7). DO NOT change the default window width and window level settings.

NOTE: You do not have to use the same clinical image each week for this test. Simply choose a random image and place the same image on each monitor.

2. Evaluate the following items and record a pass/fail for each on Chart 5.

   a). Verify that the background (non-breast) areas appear black and not gray.

   b). Verify that the background (non-breast) areas have the same level of blackness on all monitors.

   c). Verify that corresponding areas of dense breast tissue have the same brightness on all monitors.

   d). Verify that corresponding areas of dense breast tissue have the same contrast on all monitors

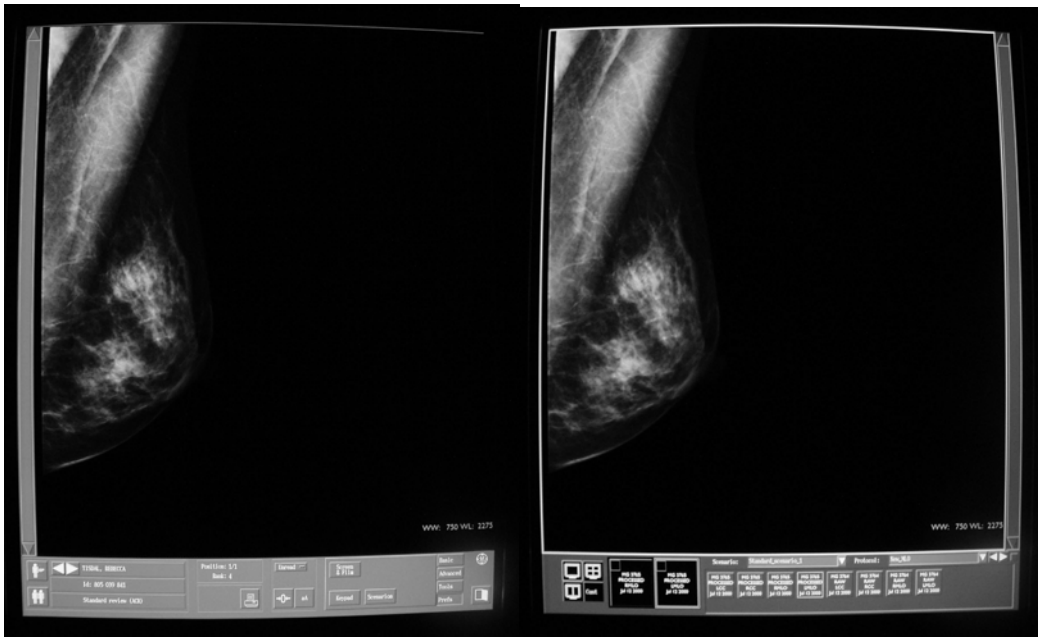


Figure 7: Radiologist's workstation with the same clinical image displayed on both monitors.

Precautions and Caveats

Viewing conditions for the secondary display devices should be as close as possible to those used for interpretation so that proper assessment of image quality may be made by the technologist.

Once the window width and level settings are correctly set, it is often possible to "save" how the image is displayed so that next time the image is called up the settings are already correct. (Consult your applications training person for instructions.)

Performance Criteria and Corrective Action

1. The accuracy of the diagnosis and the efficiency of the radiologist are influenced by the conditions under which the mammograms are viewed. Viewing conditions may affect the diagnostic potential of even the best quality mammograms. These conditions are determined by the luminance and calibration of the monitors used for softcopy interpretation, the luminance of the viewboxes used for hardcopy interpretation, the ambient room illumination or the amount of light falling on the monitor and/or viewbox surface, and good masking of films on the viewbox.

2. Contrast is extremely important in the mammography image and is degraded by extraneous light. Consequently, monitors and viewboxes

should be positioned to avoid light from windows, other monitors or viewboxes, and other sources of bright light, either direct or reflected. General lighting in the room should be at a low level and diffuse. Refer to your acceptable viewing conditions sheet posted by your medical physicist in the reading room.

3. There should be no noticeable artefacts in the image. This might include electronic interference, diagonal lines, flicker, blotches, non-uniform gray scale ramps, curved "straight" lines and bright or dark pixels. If artefacts are evident, contact the monitor service person.

4. All 16 luminance patches should be distinct from each other in shade. If the luminance patches are not distinct, the monitors may need to be recalibrated. If recalibration fails to correct the problem, contact the monitor service person.

5. The smaller, 5% contrast squares (see Figure 6) should be visible in both the dark (0-5%) and light (95-100%) squares. If the luminance 5% difference squares are not visible, the monitors may need to be recalibrated. If recalibration fails to correct the problem, contact the monitor service person.

6. You should be able to see at least "QUALITY CONT" in each of the three regions on the primary display devices (radiologist's workstations).

7. The images on all primary display monitors (i.e., radiologist's workstations) should appear to be visually identical (the same brightness and contrast). If the images do not appear similar, the monitors may need to be recalibrated. If recalibration fails to correct the problem, contact the monitor service person (PACS support or a qualified service engineer).

8. If the clinical image check reveals that the background is not black, that image contrast is inadequate, or that the brightness or contrast settings of the two monitors do not match, the source of the problem must be identified, and corrective action taken, before any clinical examinations are interpreted from the review workstation. (See Figure 8 for an example.) A qualified service engineer may be needed to make brightness and contrast adjustments on radiologist's workstation monitors and to recalibrate monitors.

9. All corrective actions should be recorded on Chart 5 or Chart 6 as appropriate.

Timeframe for Corrective Action

Immediately, before any further patient images are interpreted on the review workstation, before any further patient images are acquired using the acquisition workstation, or before the technologist's workstation is used for patient images.

NOTE: Failure of a review workstation monitor to pass this test does not mean that patient image acquisition must cease, only that interpretation of patient images using that monitor must cease until the problem is corrected.

Failure of the acquisition station monitor requires the cessation of patient imaging; unless the review workstation is located close enough to the acquisition station, so that each image can be checked before the next is taken.

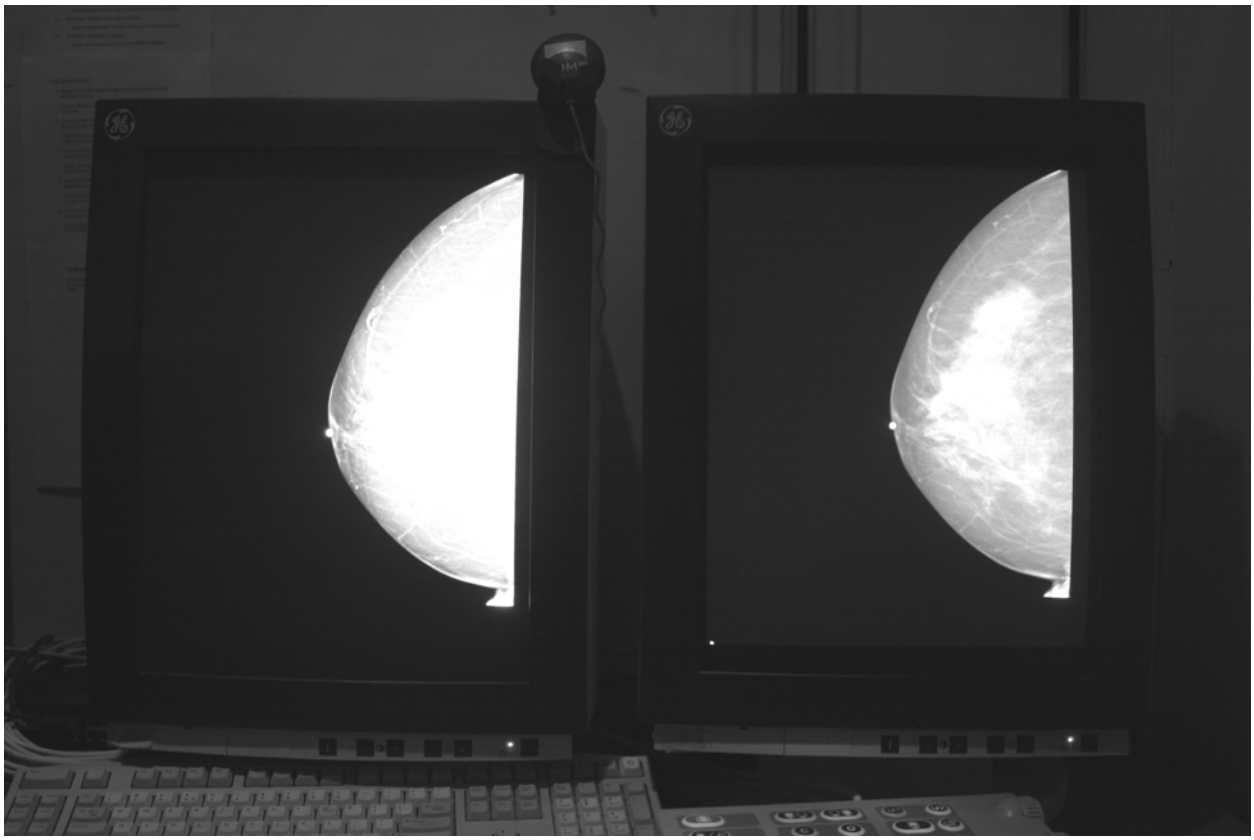


Figure 8: Unacceptable monitors: significant differences noted in the background blackness, brightness and contrast.

Chart 5: Weekly Display Monitor QC – Review Workstation

Facility: _____ Room: _____

Workstation Mfr.: Monitor Mfr.:

Year												
Month												
Day												
Initials												
Monitor	Left	Right	Left	Right	Left	Right	Left	Right	Left	Right	Left	Right
General Image Quality (P/F)												
No smearing												
No artefacts												
Ramps cont.												
Geometric Distortion (P/F)												
Lines Straight												
Pattern Centered												
Boxes square												
Luminance (P/F)												
Patches Distinct												
0-5% Visible												
95-100% Visible												
# of Letters Visible (at least 11 or "QUALITY CONT")												
Dark												
Mid-gray												
Light												
Clinical Image Check (P/F)												
Background (non-breast) area is black												
Background areas on 2 monitors match												
Dense breast tissues on 2 monitors match												
Contrast on 2 monitors matches												
Overall Pass/Fail												

Remarks:	
Date:	Action:

Chart 6: Weekly Display Monitor QC – Acquisition Monitor

Facility: _____ Room: _____

Workstation Mfr.: Monitor Mfr.:

Year												
Month												
Day												
Initials												
General Image Quality (P/F)												
No smearing												
No artefacts												
Ramps cont.												
Geometric Distortion (P/F)												
Lines Straight												
Pattern Centered												
Boxes square												
Luminance (P/F)												
Patches Distinct												
0-5% Visible												
95-100% Visible												
Overall Pass/Fail												

Remarks:	
Date:	Action

TEST #5: VIEWBOX CLEANLINESS

Objective

To ensure that viewboxes are clean and uniform and that masking is available.

Frequency

All viewboxes that are use for interpreting hard copy or screen-film images (previous films or referrals): at least ***weekly***

Required Test Equipment

Window cleaner, e.g., Windex or Glass Plus
Soft towels

Test Procedure Steps

1. Clean viewbox surfaces using window cleaner and soft paper towels.

2. Assure that all marks have been removed.

3. Visually inspect the viewboxes for uniformity of luminance.

4. Assure that all viewbox masking equipment is functioning properly and easily.

5. Record performance of this task on **Chart A**.

Precautions and Caveats

Viewboxes are a vital link in the process of interpreting a mammogram yet receive little attention even after extensive efforts have been invested in producing high-quality mammograms.

Particular attention should be paid to the uniformity of the luminance of the viewbox and the luminance level. Viewboxes used in mammography should have luminance levels of at least 3,000 candela/m^2 (nit).

It is essential to mask the area around the mammograms to exclude extraneous light which reduces image contrast and limits the maximum densities that can be seen without "bright-lighting" each film.

Fluorescent tubes decrease in brightness with time, although not rapidly, i.e., about 10% in 2,000 hours. It is advisable to replace fluorescent tubes every 18 to 24 months. All tubes should be replaced at one time. In

addition, all of the replacement tubes should be of the same type and color. If it is necessary to replace any fluorescent tubes due to decreased light output or for any other reason, such as flickering, then all tubes should be replaced at the same time to assure uniformity in color and luminance.

Performance Criteria and Corrective Action

1. Viewboxes should be free from dirt, grease pencil marks, marker etc. Any marks that are not easily removed with window cleaner should be removed with a safe and appropriate cleaner.

2. Viewboxes should appear uniformly bright and of the same hue. If viewboxes appear non-uniform, all of the fluorescent lamps should be replaced as soon as possible.

3. Masking materials should be available and easy to use. If masking materials are missing, they should be replaced. If viewbox masks are difficult to use, appropriate service or modifications should be requested.

4. Viewboxes should be located so that they do not produce glare on soft-copy reading monitors.

Timeframe for Corrective Action

Immediately, before any further patient films are interpreted or reviewed for comparison with current digital images.

3. MONTHLY QUALITY CONTROL TEST PROCEEDURES

A uniform image should be taken using all applicable focal spots, filters and magnification modes. This is to evaluate whether dirt has become lodged on the filter or mirror, the flat-field calibration or detector characteristics has changed or if there is deterioration in the detector plate. Results are recorded on Chart 7. The technologist must evaluate the safety and mechanical stability of the x-ray unit on a monthly basis. This is accomplished using the monthly checklist of the exam room Chart 8. A test for laser printer artefacts should also be performed, and the results recorded on Chart 9. Performance of the necessary monthly QC tests should be recorded on **Chart B**.

TEST #6: FULL FIELD ARTEFACTS TEST

Objective

To ensure that there are no artefacts in the image which might mimic structures in the breast, or which might increase the difficulty of interpretation.

Frequency

All computed radiograph (CR) systems only- Monthly

Required Test Equipment

OBSP DMUP Phantom.

Procedure

1. Open the patient QC Mammo at the acquisition workstation and give it an ID number specific to the date (Use an ID number such as 9906UYYMMDD), with U being the unit identifier.

2. Place the DMU phantom covering the entire breast support plate, extending beyond the chest wall edge of the digital image receptor.

3. Do NOT place the disc on the phantom.

4. Compress the DMUP phantom at between 5-10 decaNewtons (about 11-22 lbs.) of compression force. Record the compression force used and thickness indicated at the top of Chart 7. Use that same amount of compression force each time the DMUP phantom is imaged.

5. Acquire an image of the phantom on every one of the CR cassettes used for mammography, using the same settings used for the weekly QC image.

6. Record the technique used to acquire the image at the top of the form. This exposure mode should be used for all subsequent phantom exposures. For systems using some type of automatic exposure control (AEC or AOP), the target material, filtration and kVp should not change from one exposure to the next.

7. If patient images are interpreted in softcopy, view the raw (for processing) image on the radiologist's softcopy display station. Use the window width (WW) and window level (WL) settings (+/- 10 ADUs) as determined by your physicist at the most recent acceptance testing of the unit and a window level (WL) that results in the background of the phantom being displayed as a mid-gray.

8. With the same WW and WL as used above, evaluate the entire phantom image for artefacts. Examine the entire phantom for both broad area artefacts, such as non-uniformities, blotches, and streaks, and for detailed artefacts, such as black or white pixels, clusters of pixels, lines, or dust particles. Broad area artefacts are typically best seen while observing the phantom image as a whole, not in pieces. Detailed artefacts are typically best seen while observing the phantom image at full spatial resolution, where one pixel on the display matches one pixel in the image, or even in magnified form (with a magnification greater than 1.0) Record the absence or presence of artefacts at the bottom of Chart 7.

An artefact is considered significant if it may mimic or obscure anatomic features.

9. If patient images are interpreted on hard-copy, print the image, using the WW and WL that would be used for a patient image. View the image on a mammographic quality viewbox, preferably the one used by the radiologist. Evaluate the entire phantom image for artefacts, recording the absence or presence of artefacts on Chart 7. Record at the bottom of Chart 7 whether the phantom image was evaluated on hardcopy (H), softcopy (S), or both (B).

10. Repeat steps 4 through 8 for all cassettes.

11. Record the completion of the test on the monthly, quarterly and semi-annual checklist (**Chart B**).

Precautions and Caveats

The contrast must be set appropriately so that artefacts are not missed, or so that minor imperfections are not over-emphasized.

Performance Criteria and Corrective Action

1. There should be no conspicuous linear structures.
2. There should be no artefacts mimicking mass objects.
3. There should be no blotches or regions of altered noise appearance
4. There should be no observable grid lines or table top structure.
5. There should be no “bright” or “dark” pixels evident.

Timeframe for Corrective Action

Immediately, before any further patient images are acquired.

Chart 7: CR Full field artefacts.

Facility: _____ **Room:** _____
Window Width: _____ **Year:** _____
Window Level: _____
Compression Force _____ **AEC Mode:** _____

Month												
Day												
Initials												
Cassette ID												
Target												
Filter												
kV												
mAs												
No Undue Artefacts												
Hardcopy (H)/ Softcopy(S)/ Both(B)												

Date: **Remarks:**

_____ _____

_____ _____

_____ _____

_____ _____

_____ _____

TEST #7: MONTHLY CHECKLIST OF EXAM ROOM

Objective

To ensure that the unit is safe and that the image acquisition information is correct. To assure that mammographic x-ray system indicator lights, displays, mechanical locks and detents are working properly and that the mechanical rigidity and stability of the equipment is optimum. Hoses and cables should not be crimped and/or knotted, and should not present a trip hazard. No hazards should be presented to the client or operator.

Frequency

Monthly or after any service or maintenance on the mammographic x-ray system.

Required Test Equipment

Chart 8 - Monthly Mechanical Inspection Checklist
Thermometer mounted on wall of digital mammography room.

Test Procedure Steps

1. Measure the temperature in the room containing the acquisition unit.

2. Visually inspect the unit for loose parts, cracks in the compression paddles, compressor and bucky cleanliness and overall integrity.

3. Check that all hoses and cables are free from breaks, crimps, or knots. Hoses and cables should not be under other heavy equipment.

4. Verify that the angulation indicator is working correctly.

5. Verify that the interlocks are working correctly.

6. Ensure that the gantry is moving smoothly, and that the field light, panel switches, lights and meters are functioning.

7. Ensure that the current technique chart is posted.

8. On the review workstation, display a recent clinical image, and verify that the time and date as well as the facility identification are correct in the image annotation.

9. Ensure that the cleaning solution for the breast support plate and compressor is available.

10. Verify other functions that are specified for monthly monitoring by the equipment's manufacturer.

11. Record each item on Chart 8**,** and initial.

12. Record completion of the inspection on the monthly, quarterly and semi-annual checklist (**Chart B).**

Precautions and Caveats

Some of the items on the mechanical inspection checklist are operator convenience features. Many of the items, however, are essential for patient safety and high-quality diagnostic images. It may be necessary to add additional items to the list that are specific to particular equipment or procedures. These should be included on the checklist and in each evaluation.

Performance Criteria and Corrective Action

1. Items that are hazardous, inoperative, out of alignment or operate improperly should be repaired by appropriate service personnel before any patients are imaged.

2. Each of the items listed in the Monthly Checklist should pass or receive a check mark.

3. Items missing from the room should be replaced immediately. Malfunctioning equipment should be reported to the service engineer for repair or replacement as soon as possible.

4. Room temperature should be in the range recommended by the manufacturer.

Timeframe for corrective action

Immediately. Before any further patients are imaged, failures of any of the following tests should be corrected:

- Room temperature
- Loose parts
- Cleanliness
- Cracked or damaged paddles
- Overall integrity

- Hoses or cables kinked or damaged
- Interlocks
- Time and date
- Facility identification
- Cleaning solution
- Facility ID on images correct

Within 30 days of the item first being identified as out of control, failures of the following tests should be corrected:

- Angulation indicator
- Field light
- Smoothness of motion
- Panel lights
- Technique chart

Chart 8: Monthly mechanical inspection.

Facility: _____ Room #: _____ Unit: _____

Year: _____

	J	F	M	A	M	J	J	A	S	O	N	D
Date												
Initials												
Room temperature												
No loose parts												
Cleanliness												
No cracks in paddle												
Overall integrity												
Hoses and cabling unobstructed												
Angulation indicator												
Locks (all)												
Field light												
Smoothness of motion												
Panel switches / lights / meters												
Time and date on images correct												
Facility ID on images correct												
Technique charts												
Cleaning solution												
PASS = P												
FAIL = F												
Not Applicable = NA												

IF failure of a test listed above, document resolution:

_____

_____

_____

TEST #8: LASER PRINTER ARTEFACTS TEST

Objective

To ensure there are no objectionable artefacts on printed films.

Frequency

All sites interpreting from hardcopy (film): ***monthly***, or when the presence of artefacts is suspected.

Required Test Equipment

Uniform test image such as the "AAPM Test UNL" (available from OBSP Physics on CD) or a uniform mid-grey image generated by the printer.
Densitometer
Magnifying glass

Test Procedure Steps

1. Print the uniform test image with a window level that gives an optical density between 1.5 and 2.0. The window width should be set to maximum.

2. Examine the resulting film on the radiologist's viewbox using a magnifying glass. Ensure that the image is of uniform optical density, with no streaks, lines, specks or blotches.

3. Record the test results on Chart 9**.**

4. Record the performance of the test on the monthly, quarterly and semi-annual checklist (**Chart B**).

Performance Criteria and Corrective Action

1. The resulting film should be of uniform optical density.

2. There should be no streaks, lines, specks, blotches or other objectionable artefacts on the film, which in the opinion of the radiologist could interfere with the interpretation of a mammogram.

NOTE: If these criteria are not met, the printer should be serviced to correct the problem.

Timeframe for Corrective Action

Immediately, before any further patient films are printed.

Chart 9: Laser printer artefacts.

Laser Printer Artefacts	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Date												
Initials												
OD												
Uniform OD												
No Streaks?												
No Lines?												
No Specks?												
No Other Artefacts?												
Overall Pass/Fail												
PASS = P												
FAIL = F												
Not Applicable = NA												

Printer: _____ Date:_____

IF failure of a test listed above, document resolution: _____

_____

_____

_____

_____

4. QUARTERLY QUALITY CONTROL TESTS

On systems with moving parts in the imaging chain (slot scanning, or CR laser readers and printers), the resolution must be evaluated in order to catch problems which may occur and degrade image quality. Every quarter the rate at which patient films are repeated should be examined. This can be done with Chart 10 and Chart 11. The printed image quality should be verified and the results recorded on Chart 12. Sites using wet process printers should also measure the amount of fixer retained in their films. Performance of all these tests can be recorded on **Chart B**.

TEST #9: RESOLUTION / MTF

Objective

To ensure that the system is not causing any blur and that contrast transfer is adequate over the spatial frequency range used by the detector.

Frequency

All systems which use scanned image acquisition (including CR systems): ***at least quarterly or whenever something seems wrong with the system resolution***

Required Test Equipment

DM MTF tool (MTF square) or Manufacturer recommended bar pattern
OBSP DMUP phantom.

Procedure

1. Open a patient exam called QC MTF at the acquisition workstation and give it an ID number specific to the date (9909UYYMMDD), with U being the unit identifier.

2. Position the MTF square on top of the uniform phantom, with the outer square edges parallel to the edges of the bucky. If using a resolution bar pattern follow the positioning described in the manufacturer's QC manual.

3. Acquire an image of the resolution bar pattern or MTF square on top of your uniform phantom using the same technique as used for the weekly DMUP phantom test.

4. You may use the manufacturer's recommended test, use the QC software program provided by OBSP Physics to run the MTF calculation or simply record the minimum resolution seen on the resolution pattern in each direction. If using the OBSP software to run the MTF calculation skip to step 8. To determine the minimum resolution seen, follow steps 5-7.

5. On a suitable workstation view the high-contrast resolution pattern images with appropriate zoom (see Figure 9; in this image the limiting resolution for the horizontal bars is 6 line pairs/mm, and the limiting resolution for the vertical bars is 6 line pairs/mm).

6. Window and level the image to best visualize the resolution test pattern.

7. Starting from the lowest frequency (wide end of the wedge) of the pattern note the highest frequency pattern whose lines are distinctly visible. Note that the lines may entirely blur out and then reappear at a higher frequency, with a reversal in the light and dark bars in the image. This "spurious resolution", demonstrated in Figure 10 should not be interpreted as system resolution. Using this criterion, record the highest frequency visible for each test image on the monthly, quarterly and semi-annual checklist (**Chart B**).

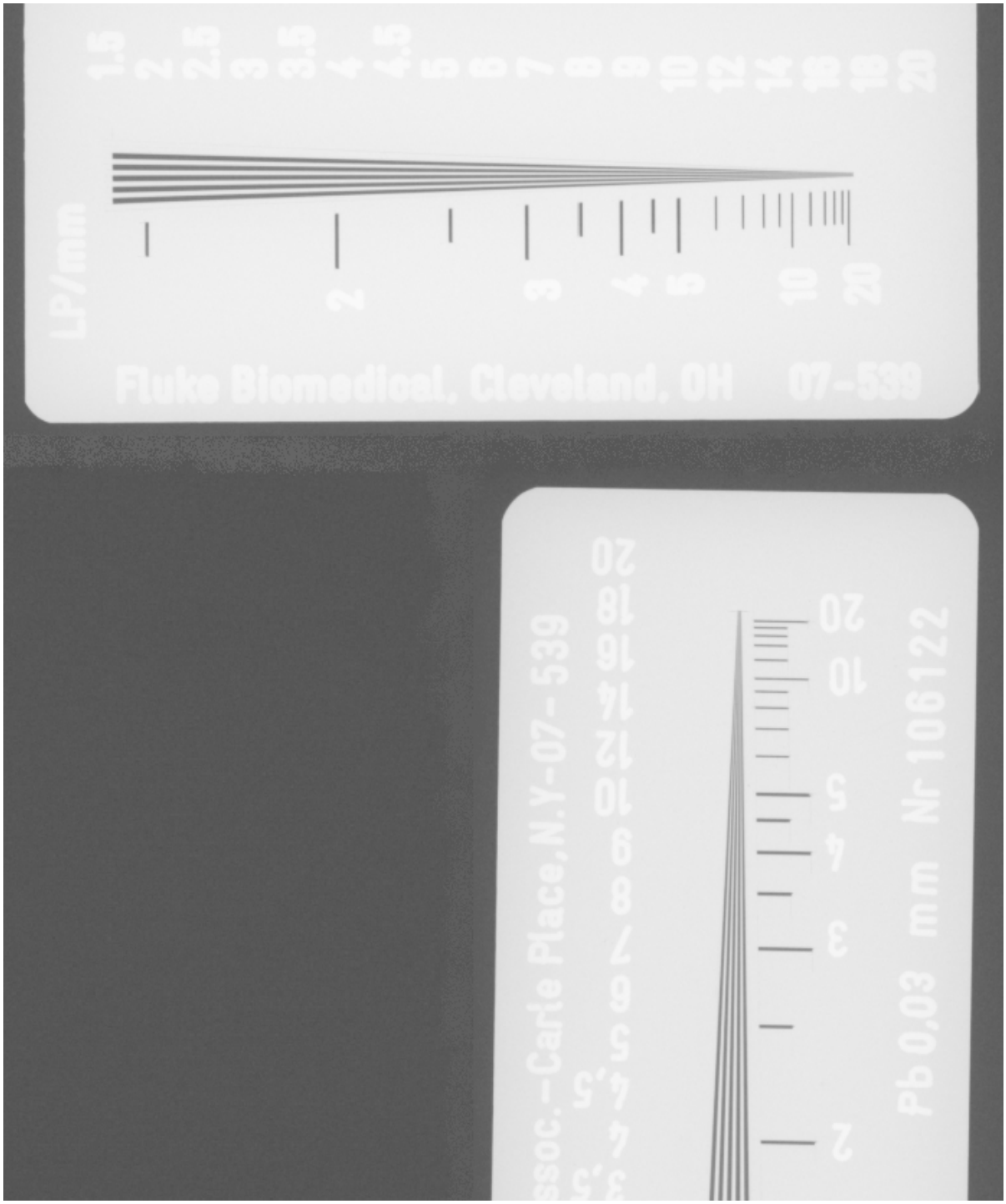


Figure 9: Radiograph of a resolution test pattern. In this image the limiting resolution for the horizontal bars is 4.5 line pairs/mm, and the limiting resolution for the vertical bars is 4.5 line pairs/mm.

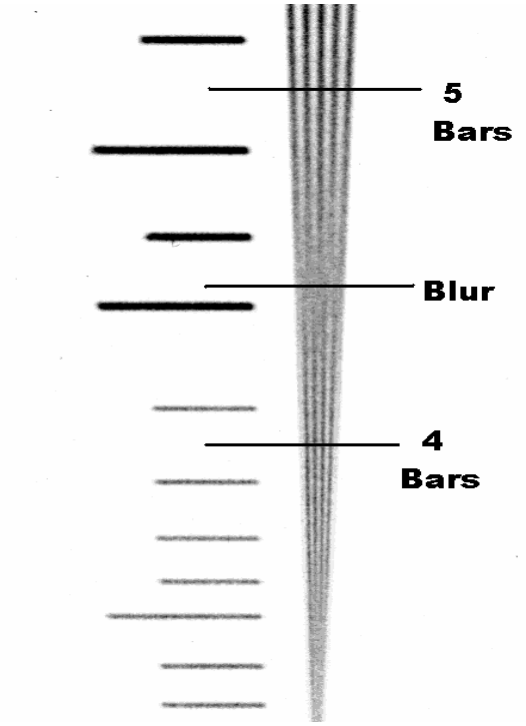


Figure 10: Aliasing. This image was taken on the magnification stand, using the large focal spot to show the effect of aliasing. There should be 5 bars, and 4 spaces. The image gets blurry as the bars get closer together, and then it looks like bars can be seen again. This aliasing causes "spurious" resolution, as there are 4 bars seen, when really there should be 5.

8. If you are using software to calculate the MTF, ensure that the limiting resolution measured is higher than that set by the medical physicist as the operating level.

9. Print the plot for your QC records, or save the plot to the QC records directory.

10. Record the performance and overall pass or fail of the test on the monthly, quarterly and semi-annual checklist (**Chart B**).

Precautions and caveats

The limiting resolution is the first time the pattern goes blurry, and does not include the aliased bars that can be seen beyond that point.

Performance Criteria and corrective action

1. The MTF curves or the limiting resolution should fall within the "acceptable" range for the machine type.

2. If the MTF curves or limiting resolution drop below the acceptable range, repeat the test to verify there is a problem.

NOTE: If the test fails on the second attempt, contact your authorized service representative. No patients should be imaged until the problem is corrected.

Timeframe for Corrective Action

Immediately, before any further patient images are acquired.

TEST #10: RETAKE ANALYSIS

Objective

To determine the number and cause of repeated digital mammograms. Analysis of these data should help identify ways to improve system performance, reduce digital image retakes, associated increased patient dose, and costs.

Frequency

At least every 3 months (***quarterly***). In order for the retake rates to be meaningful, a patient volume of at least 250 patients is needed, if possible.

Note: The analysis is carried out for each individual acquisition station, rather than for the combined department as is done in screen-film mammography.

Required Test Equipment

Chart 10 **-** Digital Mammography Retake Record or retake log obtained from the acquisition workstation, provided it complies with this manual.

Chart 11 - Quarterly Digital Mammography Retake Analysis.

A method to count or estimate the total number of clinical images acquired during the test period

A repeated image is one that is taken for reasons of inadequate quality. It does not include additional views required to image selected tissue seen on the first image. It also does not include images taken for the purposes of including tissue that could not be positioned on the image receptor due to size of the breast.

Repeats include images that are rejected at the acquisition workstation and images that are aborted before the exposure is complete. Repeat causes include problems with positioning, blurred images due to patient motion, detector under or over exposure, unacceptable artefacts, x-ray equipment failures (such as generator faults), software failures (such as the acquisition software freezing or crashing), blank images, no image ever appearing on the acquisition station, although an exposure was made, and other miscellaneous problems.

Test Procedure Steps

1. Record each repeated exposure on Chart 10, entering the cause of repeated exposure, date, etc. Some acquisition systems allow for the logging of the causes of repeated exposures by the acquisition software. This may be an acceptable means of recording the majority of repeats, provided the log can be easily retrieved for any specified date range and the causes provided match those shown on Chart 10. Note that repeated exposures taken on a different date (i.e. because the radiologist remarked that the image was blurry) may not be logged by such software, and thus the OBSP currently recommends maintaining a Chart 10 for such repeats, even if repeat-logging software is used.

A "blank image" (cause 7) occurs when an exposure is made, and the resulting image file is empty (all pixels the same value) such that the image displayed is all one shade. "No Image" (cause 8) occurs when an exposure is made, and no image at all comes up on the screen – there is no image file; no digital record of the exposure exists.

2. Chart 11 to summarize the number of repeats in each category.

3. Estimate the total number of clinical exposures taken during the quarter. This can be done by subtracting the patient number at the beginning of the quarter from the patient number at the end of the quarter and multiplying by 4. This method assumes sequential patient numbering of all patients and an average of 4 exposures per patient. It may also be possible to obtain the number of exposures from a log maintained by the acquisition work-station (varies with manufacturer and model). Be sure not to include images taken for quality control purposes.

4. Calculate the overall retake rate as the total of repeated exposures divided by the total number of patient exposures during the analysis period, multiplied by 100%.

5. Determine the percentage of retakes in each category by dividing the retakes in that category by the total number of repeated exposures from all categories.

6. Record completion of the Repeat Analysis on the monthly, quarterly and semi-annual checklist (**Chart B**).

Precautions and Caveats

All images that are repeated should be included in the repeat analysis, not just those that the radiologist asked to have repeated. Some facilities may keep repeated images in the patient study along with good images, rather

than rejecting them. These repeated images must be included in the repeat analysis.

At a minimum, the retake analysis must be done at least quarterly. This process of reviewing the rejected images provides mammographic technologists with an educational benefit. Many higher workload facilities choose to conduct a retake analysis monthly.

Including examinations on at least 250 patients (approximately 1000 exposures) allows for a minimum number of rejected images so that reasonable statistics can be obtained for the analysis. Collecting rejected images from a larger number of patients is encouraged because it will yield more reliable data when evaluating causes for retakes. Facilities that do not examine 250 patients in a quarter should still assess retake images at least quarterly to determine the primary causes of repeated images and reap the educational benefit of the process.

There is a real danger that technologists may alter their routine procedures or criteria for accepting images if they know their repeated images will be analyzed. This should be avoided.

Many digital mammography acquisition stations include some facility for logging the causes for rejecting images in software and generating a summary report. This can simplify the process of retake analysis, however caution is needed. The logs generated by the software may not catch all retakes – potentially missed areas may include aborted exposures, retakes due to equipment malfunction, and retakes where the original image is not rejected. Also, the reject logging software may not group the causes for rejection in the same manner as suggested in this manual.

Performance Criteria and Corrective Action

1. The overall repeat rate ideally should be 2% or less, but a rate of 5% or less is probably adequate if the radiologist and medical physicist agree that this is a reasonable level. These rates should be based on an image volume of at least 250 patients to be meaningful. A "Reason for Repeat" that is significantly higher than the others indicates an area for potential improvement.

2. If the repeat rate exceeds the selected acceptance level of either 2% or 5%, or if the repeat or reject rate changes from the previously measured rate by more than 2%, the change should be investigated and corrective action taken if necessary. For example, if the previous repeat rate was 1.8% and the new repeat rate is 4.2%, then the follow-up described above is required. A repeat rate of below 0.5% can indicate that the radiologists are accepting/interpreting sub-standard images for

sake of expediency, since there will always be a number of patients that will not allow proper positioning.

3. Any corrective actions should be recorded on the bottom of the Repeat Analysis chart. In addition, the effectiveness of the corrective actions shall be assessed by performing another repeat analysis after the corrective actions have been implemented.

4. If the primary cause of excessive repeated exposures is an equipment or detector problem it should be brought to the attention of the service engineer.

5. If the primary cause of excessive repeated exposures is a positioning or other motion problem, corrective actions such as additional training on positioning and compression should be taken.

Timeframe for Corrective Action

Within 30 days of the repeat analysis date.

Chart 10: Retake analysis: digital repeat record.

ENTER ANY REPEATED EXPOSURES THAT REQUIRED THE PATIENT TO HAVE ADDITIONAL DOSE BEYOND THAT OF THE NORMAL EXAM.

Facility: _____ Room: _____ Unit: _____

Date From: _____
Date To: _____

Study #	Causes	# of Times	Date	Initiated by: Physician	Technologist	Technologist

Causes:

1 Positioning
2 Patient Motion
3 Improper Detector Exposure
4 Artefact
5 X-Ray Equipment Failure
6 Software Failure
7 Blank Image
8 No Image
9 Other

Chart 11: Quarterly Digital Mammography Retake Analysis

Facility _____ Room # _____ Unit: _____
Date From: _____ Date To: _____

Total Patient Exposures in Quarter: | |

	Cause	No. of Exposures	Percentage of Repeats
1	Positioning		
2	Patient Motion		
3	Improper Detector Exposure		
4	Artefact		
5	X-Ray Equipment Failure		
6	Software Failure		
7	Blank Image		
8	No Image		
9	Other		
		Total #	% Repeat Rate

Repeat Exposures (sum 1 through 9)		

TEST #11: PRINTED IMAGE QUALITY TEST

Objective

To ensure that the printed image quality is high.

Frequency

All sites printing hardcopy: ***quarterly***, or when reduced printed image quality is suspected.

Required Test Equipment

Digital mammography unit specific TG18-QC test pattern (provided by OBSP Physics)
Magnifying glass
Ruler

Test Procedure Steps

1. Print the TG18-QC test pattern appropriate for each type of digital mammography unit used to generate images for interpretation from the acquisition station and from the radiologist's review workstation(s).

2. Examine the resulting films carefully on the radiologist's view-box, using the magnifying glass.

3. Record the visibility of the different test objects (see Figure 11 and figure 12) on Chart 12.

4. Record the performance of the test on the monthly, quarterly and semi-annual checklist (**Chart B**).

5. Measure the length of the 5 cm long calibration lines in horizontal and vertical directions and record on Chart 12.

Performance Criteria and Corrective Action

1. The 0-5% contrast squares and 95-100% contrast squares should be distinguishable.

2. The finest horizontal and vertical line pairs shall be visible in all four corners.

3. The squares of different shades from black to white shall be distinct.

4. Lines shall appear straight and even, without apparent distortions.

5. There shall be no distracting artefacts.

6. The 5 cm lines will be between 4.7 and 5.3 cm long on the printed image.

If these criteria are not met, the printer should be serviced to correct the problem.

Timeframe for Corrective Action

Immediately, before any further patient films are printed if there is no other means for primary interpretation.

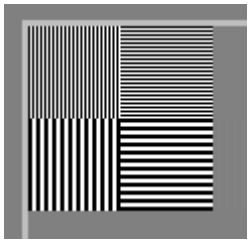


Figure 11: Detail of horizontal and vertical line pairs from TG18-QC test pattern.

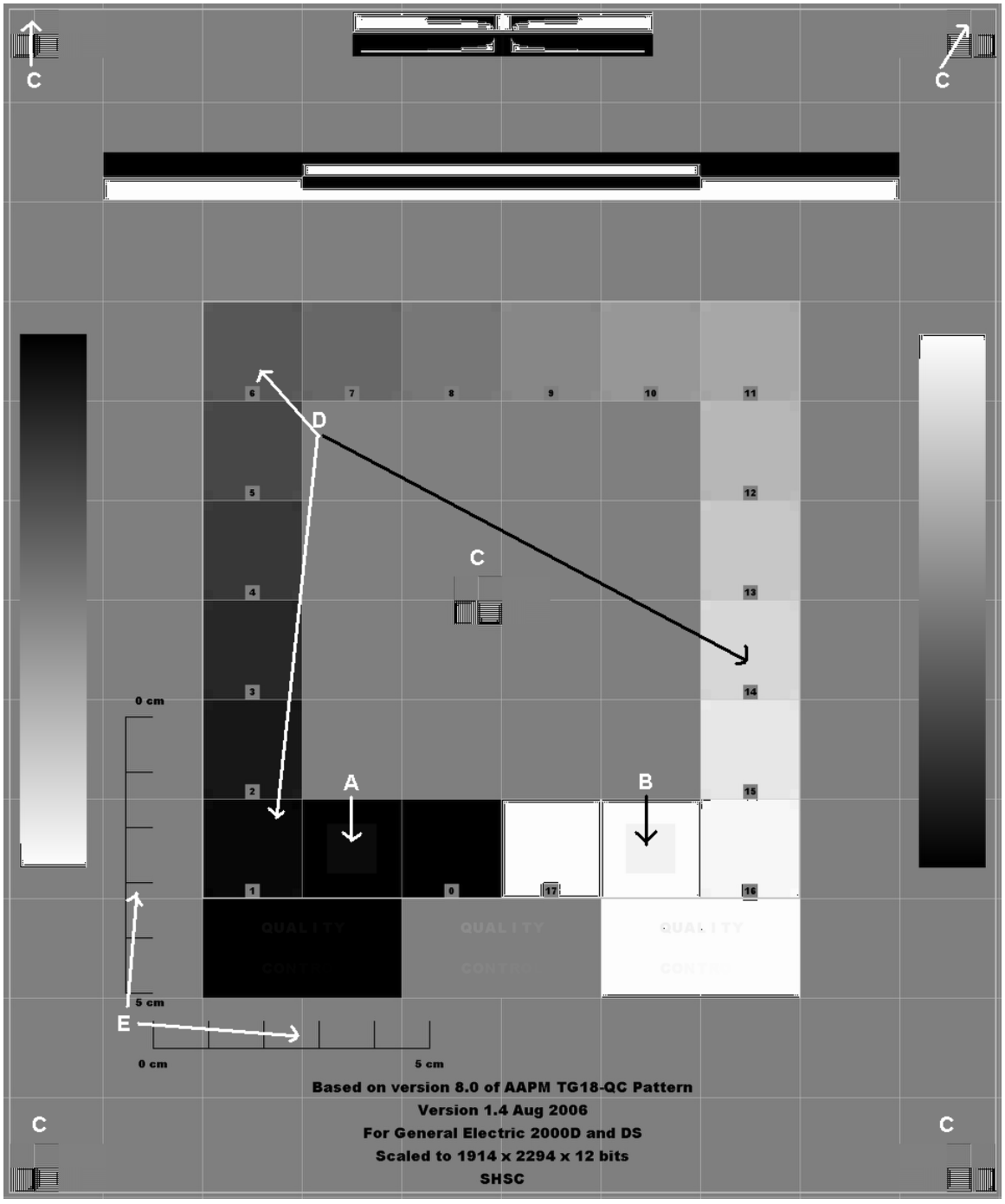


Figure 12: TG18-QC Image with test objects indicated. A – 0-5% contrast square, B – 95-100% contrast square, C – horizontal and vertical line pairs, D – squares going from black to white, E – 5 cm lines

Chart 12: Printed Image Quality

Printer: _____

Printed From: _____

Date												
Initials												
0-5 % Square												
95-100% Square												
Horizontal Line Pairs												
Vertical Line Pairs												
Grey Patches												
Lines Straight												
No Artefacts												
Length of 5 cm Horizontal Ruler (between 4.7 and 5.3 cm)												
Length of 5 cm Vertical Ruler (between 4.7 and 5.3 cm)												
Overall Pass/Fail												
PASS = P												
FAIL = F												
Not Applicable = NA												

IF failure of a test listed above, document resolution:

_____

_____

_____

_____

TEST #12: ANALYSIS OF FIXER RETENTION

Objective

To determine the quantity of residual fixer (hypo) in processed film as an indicator of keeping quality. Residual hypo indicates insufficient washing and considerably degrades image stability.

Frequency

All sites printing hardcopy with wet processing: every 3 months (quarterly)

Required Test Equipment

Hypo estimator comparison tool (e.g., Kodak Hypo Estimator, Publication No. N-405, or equivalent) as used for screen- film processors.

Hypo test solution

Test Procedure Steps

1. Process one sheet of unexposed film in the photographic processor.
2. Place one drop of the hypo test solution on the ***emulsion (less shiny) side*** of the film.
3. Allow the solution to stand for two minutes.
4. Blot off the excess solution.
5. Place the film on a sheet of white paper
6. Compare the stain with a hypo estimator strip (see Figure 13) by observing the radiographic film on a sheet of white paper. The comparison should be made with the estimator over the film sample to help compensate for differences in the color of the base of the film and with the hypo estimator strip in its sleeve for protection.
7. Record the results on the Monthly, Quarterly and Semi-Annual Checklist (**Chart B**).

Precautions and Caveats

The comparison should be made immediately after the excess test solution has been removed from the film. Direct sunlight causes the spot to darken rapidly and a prolonged delay between the blotting of the solution and comparison also allows the spot to darken.

The test hypo estimator solution has a shelf life of about two years, provided that it is stored in a dark, airtight bottle and away from light.

Both acetic acid and silver nitrate are dangerous and must be handled with caution. If either of these chemicals comes in contact with your skin, wash the area with cold water immediately. For more information, consult the Material Safety Data Sheets (MSDS) provided by the manufacturer or supplier.

Performance Criteria and Corrective Action

The hypo estimator provides estimates of the amount of residual hypo in the film in units of grams per square meter. The estimated amount of residual hypo should be 0.05 gram per square meter (5 micrograms per square cm) or less.

If the stain indicates that there is more than 0.05 gram per square meter residual hypo in the film, the test should be repeated. If the same result is obtained, then corrective action is necessary.

The processor wash water tank should be checked to assure that it is full of water, if appropriate. The wash water flow rate should be verified to determine that it meets the specifications of the processor manufacturer. Also, the fixer replenishment rate should be checked to determine that it is close to the recommended rate because the efficiency of the wash water in removing fixer from the film is dependent on the correct fixing of the film. If these items appear to be correct, a technical representative of the film manufacturer should be consulted to assist in resolving the problem of excessive fixer retention.

Timeframe for Corrective Action

Within 30 days of the test date.

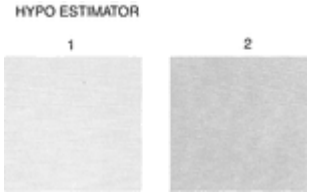


Figure 13: Hypo estimator comparison tool. Step 1 indicates an acceptable amount of retained fixer.

5. SEMI-ANNUAL QUALITY CONTROL TESTS

TEST #13: COMPRESSION FORCE

Objective

To assure that the mammography system can provide adequate compression in the manual and powered mode and that the equipment does not allow too much compression to be applied.

Adequate compression is essential for high-quality mammography. Compression reduces the thickness of tissue that must be penetrated by radiation, thereby reducing scattered radiation and increasing contrast, while reducing radiation exposure to the breast. Compression improves image sharpness by reducing the breast thickness, thereby minimizing focal spot blurring of structures in the image, and by minimizing patient motion. In addition, compression makes the thickness of the breast more uniform, resulting in more-uniform image densities and an image which is easier to interpret.

Frequency

Initially, then every 6 months (***semi-annually***), and when reduced compression is suspected

Required Test Equipment

Bathroom scale. The scale should be a flat, conventional, analog type. Household digital scales sample the data and may not respond properly as additional pressure is applied slowly to the scale. Digital scales designed specifically to measure compression force may be used.

Several towels.

Test Procedure Steps

Power Mode

1. Place a towel on the cassette holder (to protect the cassette holder), then place the bathroom scale on the towel with the dial or read-out positioned for easy reading. Locate the center of the scale directly under the compression device (Figure 14).

2. Place one or more towels on top of the scale to prevent damage to the compression device.

3. Using the **initial** power drive, activate the compression device and allow it to operate until it stops automatically.

4. Read and record the compression force on the monthly, quarterly and semi-annual checklist (**Chart B**).

5. Release the compression device.

Manual Mode

1. Using the initial manual drive, move the compression device downward until it stops.

2. Read and record the compression force on the monthly, quarterly and semi-annual checklist (**Chart B**).

3. Release the compression device.

NOTE: 1 decanewton (daN) = 10 newton = 2.2 lbs force.

Precautions and Caveats

If the safety mechanism is not properly adjusted, it may be possible to damage the compression device and associated components. If the compression exceeds 200 N (20 daN or approximately 45 pounds) in the power drive mode, immediately release the compression device and ask a service engineer to make the appropriate adjustments.

Performance Criteria and Corrective Action

1. In the initial power driven mode, a maximum compression force of 11.1 daN (25 lbs) to 20.0 daN (45 lbs) must be available.

2. Under manual adjustment of compression, a compression force of at least 11.1 daN (25 lbs) should be achievable.

3. If the performance criteria are not met in both the manual and power driven modes, a service engineer should make the appropriate internal adjustments of compression force.

Timeframe for Corrective Action

Immediately, before any further patients are imaged.

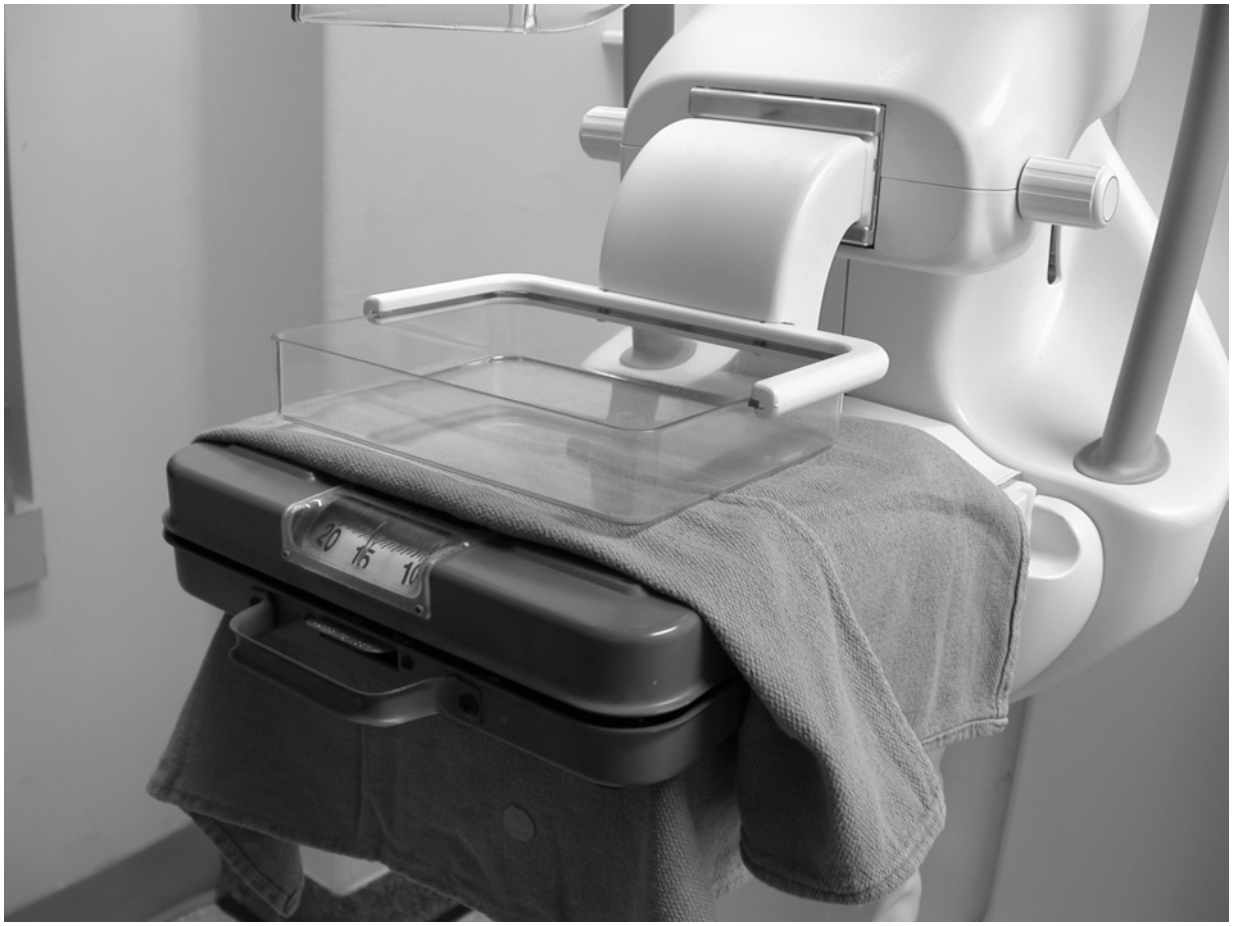


Figure 14: Positioning of bathroom scale to perform compression force measurement.

IV. REVISION CHANGES FROM 2.0

Added this revision section.

A number of minor spelling changes as well as formatting of charts, and removal of redundant charts. Updated photographs have been added.

Definition of Digital mammography clarified to include CR and DR

Clarified which tests must be performed.

Added a chart for performance of the daily checklist. This resulted in renumbering the other charts.

Added the requirement for acceptance testing when a machine is moved or a detector replaced.

Added the websites for digital download of documents and monitor test patterns (OBSP Physics and Webex).

A section on Phantoms for Digital QC has been added including a picture of the only phantom required.

A discussion on the irrelevance of the CAR phantom has been added.

The address of the X-Ray Inspection Unit has been added.

Additional information has been added on DICOM headers and PACS storage requirements.

The calculation of operating points and limits for the Signal value and SDNR has been removed – it is now done by the Medical Physicist on the Technologist Baselines sheet. The conditions under which new baselines need to be established and who can establish them have been clarified.

The monthly Full-field artifacts test has been eliminated for all systems except CR, where a step has been added to perform the test on every cassette. This test is performed weekly on a single detector.

Repeat analysis has been changed to retake analysis.

V. REFERENCES

1. American Association of Physicists in Medicine, Task Group 18. Assessment of Display Performance for Medical Imaging Systems (Pre-print draft version 9.0). AAPM, 2002

2. Bloomquist AK, Yaffe MJ, Pisano ED, Hendrick RE, Mawdsley GE, Bright S, Shen SZ, Mahesh M, Nickoloff EL, Fleischman RC, Williams MB, Maidment ADA, Beideck DJ, Och J, Seibert JA. Quality Control for Digital Mammography in the ACRIN DMIST Trial - Part I. Med. Phys. 2006

3. Destouet JM, Bassett LW, Yaffe MJ, Butler PF, Wilcox PA. The American College of Radiology Mammography Accreditation Committee – 10 Years of experience since MQSA. J. American College of Radiology. 2, 585-594, 2005

4. Haus AG, Yaffe MJ (ed). Syllabus: a categorical course in physics: technical aspects of breast imaging. Chicago: Radiologic Society of North America, 1993

5. R. E. Hendrick et al., American College of Radiology (ACR) Mammography Quality Control Manual for Radiologists, Medical Physicists and Technologists, (American College of Radiology, Reston, VA, 1999)

6. National Electrical Manufacturer's Association, DICOM Imaging and Communication in Medicine (DICOM) Part 14: Grayscale Standard Display Function, PS 3.14-2004, (National Electrical Manufacturer's Association, Rosslyn, VA, 2004)

7. Pisano, E.D., Gatsonis C, Hendrick E, Yaffe M, Baum JK, Acharyya S, Conant EF, Fajardo LL, Bassett L, D'Orsi C, Jong R, Rebner M. Diagnostic accuracy of digital versus film mammography for breast cancer screening - The results of the American College of Radiology Imaging Network (ACRIN) Digital Mammographic Imaging Screening Trial (DMIST). NEJM, 353, 1773-1783, 2005

8. E. Pisano, R. E. Hendrick, S. Masood and C. Gatsonis, American College of Radiology Imaging Network - ACRIN 6652 - Digital vs. Screen-Film Mammography, ACRIN 2001

9. E. Samei, et al, Assessment of Display Performance for Medical Imaging Systems, Pre-print Draft (version 9.0). American Association of Physicists in Medicine, Task Group 18, 2002

10. Yaffe MJ, Bloomquist A, Mawdsley GE, Pisano, Hendrick RE, Fajardo LL, Boone JM, Kanal K, Mahesh M, Fleischman RC, Och J, Williams MB, Beideck DJ, Maidment ADA. Quality control for digital mammography: Part II Recommendations from the ACRIN DMIST trial. Med. Phys. 2006

VI. APPENDIX – SAMPLE CHARTS

Monthly QC Report Cover Sheet

Facility Name: Anywhere X-Ray and Mammography

Address: 123 Somestreet
Anywhereville, ON

Phone: 416-123-4567

Email address: JaneDoe@anywhereXray.com

Excel File Submission

Prepared by: Jane Doe

Date: 30-Jan-08

Attention: OBSP Physics

Email Address: obsp.physics@sunnybrook.ca

Number of Files: _____

Re: [x] Monthly QC for

[ ] Equipment Downtime/Service Report

[ ] Other

Message: Here is our month end QC!

Please contact the HEAD QC TECHNOLOGIST as soon as possible if you do not receive all pages.

Name: Jane Doe

Phone: 416-123-4567 Ext. 123

Department: Mammography

Confidentiality Statement:

The documents accompanying this transmission contain confidential information intended for a specific individual and purpose. The information is private and protected by law. If you are not the intended recipient, you are hereby notified that any disclosure, of the contents of this information is strictly prohibited. If you have received this information in error, please notify us immediately by telephone and return the original to us by regular mail at our expense. THANK YOU.

Full Field Digital Mammography Quality Control Checklist
Daily and Weekly Tests

Room: 1 **Month/Year:** Jan-08

Checkmark (√) = Pass/Adequate; x = Fail; initial when complete

Test	Date	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
	Initials	JD	JD	JD	JD			JD	JD	JD	JD	JD			JD	JD	JD	JD	JD			JD	JD	JD	JD	JD			JD	JD	JD	JD
1	Monitor Cleaning	√	√	√	√			√	√	√	√	√			√	√	√	√	√			√	√	√	√	√			√	√	√	√
1	Daily Checklist (daily)	√	√	√	√			√	√	√	√	√			√	√	√	√	√			√	√	√	√	√			√	√	√	√
2	Laser Printer Sensi-tometry-wet (daily)																															
3	Phantom Image Quality (weekly)	√	√	√	√			√	√	√	√	√			√	√	√	√	√			√	√	√	√	√			√	√	√	√
4	Display Monitor QC (weekly)	√	√	√	√			√	√	√	√	√			√	√	√	√	√			√	√	√	√	√			√	√	√	√
5	Viewbox Cleanliness (weekly)	√	√	√	√			√	√	√	√	√			√	√	√	√	√			√	√	√	√	√			√	√	√	√

Date: **Test:** **Comments:**

Digital Mammography Quality Control Checklist
Monthly, Quarterly and Semi-Annual Tests

Room: 1 **Year:** 2008 **Minimum Resolution:** _____

Test	Month	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
	Initials	JD											
2	Laser Printer Sensitometry - dry (monthly)	P											
6	Full-Field Artifacts (monthly)	P											
7	Monthly Checklist (CR-monthly)	P											
8	Laser Printer Artifacts (monthly)	P											
9	Resolution/MTF Horizontal Bars (scanning-quarterly)												
	Resolution/MTF Vertical Bars (scanning-quarterly)												
	Overall Pass/Fail												
10	Repeat Analysis (quarterly)	P											
11	Printed Image Quality (quarterly)	P											
12	Analysis of Fixer Retention (quarterly)												
13	Compression Force (semi-annual)	**30 lb**											

Date: **Test:** **Comments:**

Full Field Digital Mammography Technique Chart

No Implants

Compressed Breast Thickness (cm)	Mammographic Density	AEC Setting	Target	Filter	kVp	mAs	Aim Value (S#, EI or ADU)
2 cm	average	CNT	Mo	Mo	25	30	700
4 cm	average	CNT	Mo	Rh	28	80	700
6 cm	average	CNT	Rh	Rh	28	200	700
8 cm	average	CNT	Rh	Rh	30	225	700

Implants

Compressed Breast Thickness (cm)	Mammographic Density	AEC Setting	Target	Filter	kVp	mAs	Aim Value (S#, EI or ADU)
2 cm	average	CNT	Mo	Mo	25	30	700
4 cm	average	CNT	Mo	Rh	28	80	700
6 cm	average	CNT	Rh	Rh	28	200	700
8 cm	average	CNT	Rh	Rh	30	225	700

CHART 1: DAILY CHECKLIST

Facility: Anywhere X-Ray Room: 1

Month: Jan Year: 2008

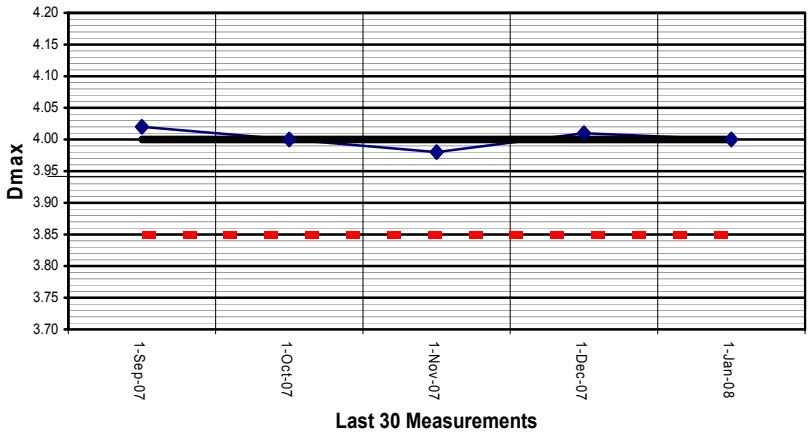
Checkmark (√) = Pass/Adequate; x = Fail; initial when complete

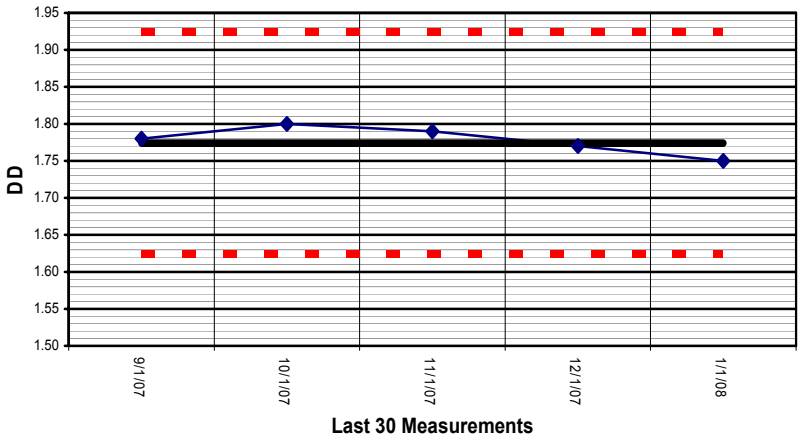
Day -->	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Initials		JD	JD	JD			JD	JD	JD	JD	JD			JD	JD	JD	JD	JD			JD	JD	JD	JD	JD			JD	JD	JD	JD
No Loose Parts		√	√	√			√	√	√	√	√			√	√	√	√	√			√	√	√	√	√			√	√	√	√
Overall Integrity		√	√	√			√	√	√	√	√			√	√	√	√	√			√	√	√	√	√			√	√	√	√
Cleanliness		√	√	√			√	√	√	√	√			√	√	√	√	√			√	√	√	√	√			√	√	√	√
No Cracks in Paddles		√	√	√			√	√	√	√	√			√	√	√	√	√			√	√	√	√	√			√	√	√	√
Hoses and Cabling Unobstructed		√	√	√			√	√	√	√	√			√	√	√	√	√			√	√	√	√	√			√	√	√	√
CR-Reader Cleanliness																															
Imaging Plates Erased																															

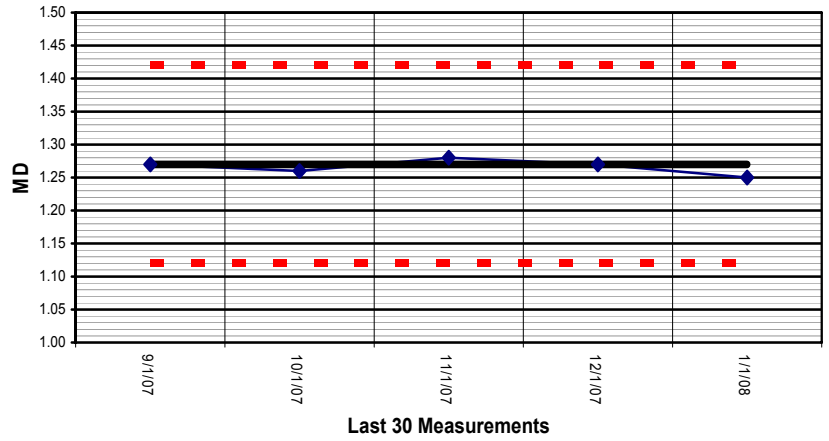
Date: **Comments:**

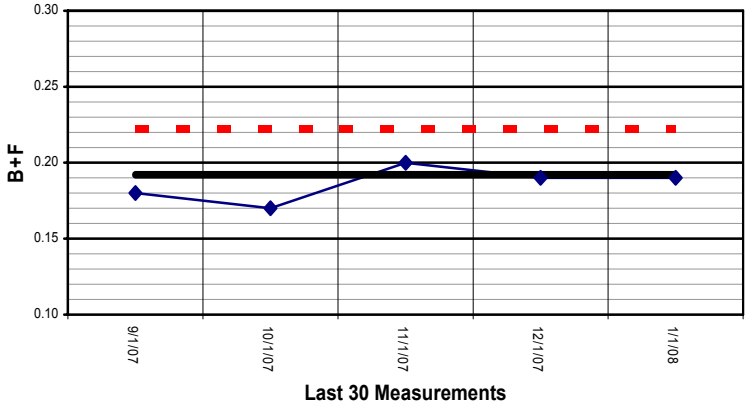
CHART 2: LASER PRINTER SENSITOMETRY

Laser Printer: Kodak Film: Laser Mammo Emul#: 1234567 Workstation: PACS1









Digital Mammography Quality Control

TG-18 QC	Box #18	Box #16	Box #11	Box #5	Box #16 - Box #5	Box #1	WW: 4096	WL: 2048
Gray-Scale Step Wedge	Step #:	Step #:	Step #:	Step #:	DD1-DD2	Lightest		
Op Levels	4.00	2.24	1.27	0.46	1.77	0.19		
Date	Dmax	DD1	MD	DD2	DD	B+F	Remarks	
1-Sep-07	4.02	2.24	1.27	0.46	1.78	0.18		
1-Oct-07	4.00	2.25	1.26	0.45	1.80	0.17		
1-Nov-07	3.98	2.23	1.28	0.44	1.79	0.20		
1-Dec-07	4.01	2.24	1.27	0.47	1.77	0.19		
1-Jan-08	4.00	2.25	1.25	0.50	1.75	0.19		

CHART 3: SETTING OPERATING LEVELS FOR LASER PRINTER

Date operating levels valid from: 20-Aug-07

TG-18 QC Pattern: Window Width 4096 Window Level 2048

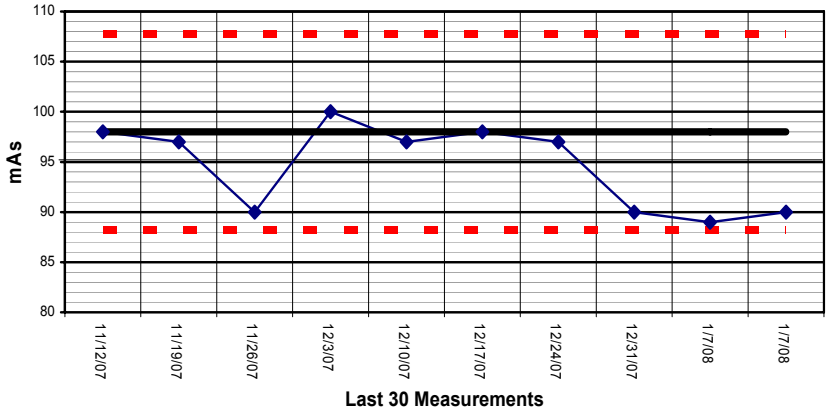
	Box#/ Step	Dates					Average	Operating Level
		16-Aug-07	17-Aug-07	18-Aug-07	19-Aug-07	20-Aug-07		
Maximum Density	18	4.00	3.95	3.99	4.01	4.05	4.00	4.00
DD1	16	2.22	2.26	2.22	2.26	2.22	2.24	
Mid-Density	11	1.25	1.30	1.25	1.30	1.25	1.27	1.27
DD2	5	0.47	0.45	0.49	0.45	0.45	0.46	
Base+Fog	1	0.19	0.18	0.19	0.20	0.20	0.19	0.19
							DD	1.77

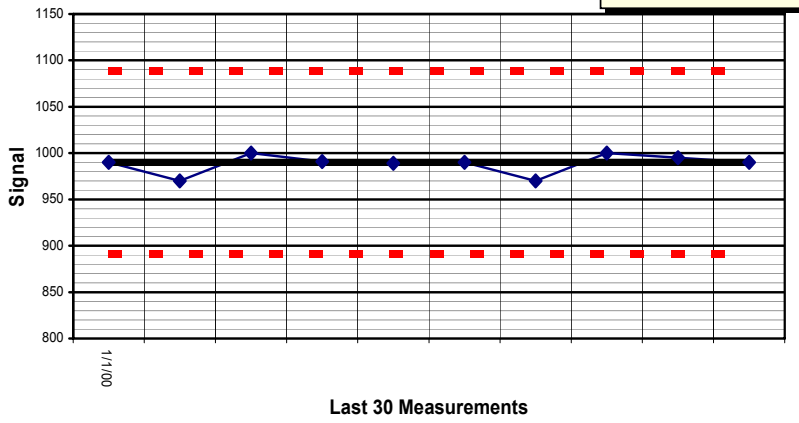
Reason for setting new operating levels:
Printer recalibrated by service.

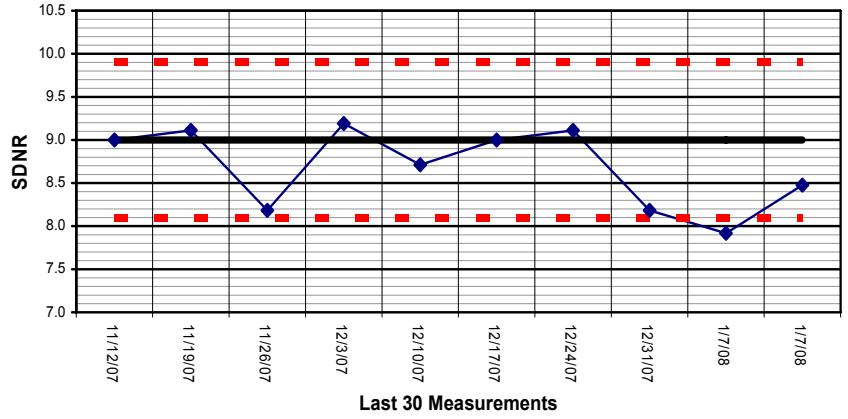
CHART 4: WEEKLY PHANTOM

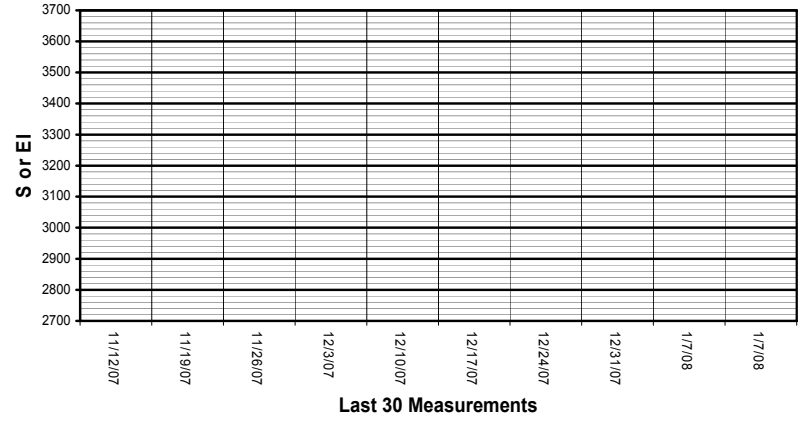
Albert Tyson:
To force excel to calculate or update plots, hit the F9 key.

Facility: Anywhere X-Ray
Room: 1 Manuf: GE Model: 2000D









Digital Mammography Quality Control

	mAs	Disk Signal (A)	Background Signal (B)	Background St. Dev. (C)	SDNR (B-A)/C	Artefacts (Y/N)	El or S (CR only)	WW: 200 WL: 700
Op Levels	98	900	990	10.0	9.0			
Date	**mAs**	**Disk Sig**	**Backgd. Sig.**	**Std. Dev.**	**DD**	**Artefacts**	**El or S**	**Remarks**
12-Nov-07	98	900	990	10.0	9.0	N		
19-Nov-07	97	888	970	9.0	9.1	N		
26-Nov-07	90	910	1000	11.0	8.2	N		
3-Dec-07	100	900	991	9.9	9.2	N		
10-Dec-07	97	901	989	10.1	8.7	N		
17-Dec-07	98	900	990	10.0	9.0	N		
24-Dec-07	97	888	970	9.0	9.1	N		
31-Dec-07	90	910	1000	11.0	8.2	N		
7-Jan-08	89	900	995	12.0	***7.9***	N		Room too warm. Turned down heater and re-shot 2 hrs later.
7-Jan-08	90	901	990	10.5	8.5	N		

CHART 5: WEEKLY DISPLAY MONITOR QC - REVIEW WORKSTATION

Facility: Anywhere X-Ray | Room: 3
Workstation Mfr: GE | Monitor Mfr: Barco
Year: 2008

Month	Jan											
Day	1											
Initials	JD											
Monitor	Left	Right	Left	Right	Left	Right	Left	Right	Left	Right	Left	Right
General Image Quality (P/F)												
No Smearing	P	P										
No Artifacts	P	P										
Ramps cont.	P	P										
Geometric Distortion												
Lines straight	P	P										
Pattern Centered	P	P										
Boxes square	P	P										
Luminance												
Patches distinct	P	P										
Patch corners visible	P	P										
0-5%	P	P										
95-100%	P	P										
# of Letters Visible (at least 11 or "QUALITY CONT")												
Dark	12	12										
Mid-Gray	12	12										
Light	12	12										
Clinical Image Check												
	P	P										
Background (non-breast) area is black												
Background areas on 2 monitors match	P											
Dense breast tissues on 2 monitors match	P											
Contrast on 2 monitors matches	P											
Overall Pass/Fail	P	P										

Remarks:

Date	Action

Under "General Image Quality" enter "Y" or "N" to indicate presence or absence of smearing or other artifacts.
Enter "Y"if the grayscale ramps appear continuous, "N" if they do not.
Under "Geometric Distortion" enter "Y" or "N" to indicate if the lines and borders appear straight, if the pattern is centered and if the boxes appear square.
Under "Luminance" enter "Y" or "N" to indicate the visibility of each item.
Under "Lettering" record the number of letters visible at each luminance level.

CHART 6: WEEKLY DISPLAY MONITOR QC - ACQUISITON MONITOR

Facility: Anywhere X-Ray Room 1
Workstation Mfr: GE Monitor Mfr: Barco
Year: 2008

Month	Jan											
Day	1											
Initials	JD											
General Image Quality (P/F)												
No Smearing	P											
No Artifacts	P											
Ramps cont.	P											
Geometric Distortion												
Lines straight	P											
Pattern Centered	P											
Boxes square	P											
Luminance												
Patches distinct	P											
Patch corners visible	P											
0-5%	P											
95-100%	P											
Mid-Gray	P											
Light	P											
Overall Pass/Fail	P											

Remarks:

Date	Action

Under "General Image Quality" enter "Y" or "N" to indicate presence or absence of smearing or other artifacts.
Enter "Y"if the grayscale ramps appear continuous, "N" if they do not.
Under "Geometric Distortion" enter "Y" or "N" to indicate if the lines and borders appear straight, if the pattern is centered and if the boxes appear square.
Under "Luminance" enter "Y" or "N" to indicate the visibility of each item.
Under "Lettering" record the number of letters visible at each luminance level.

CHART 7 - CR MONTHLY FULL-FIELD ARTEFACT EVALUATION

Facility: Anywhere X-Ray Room: 1

Window Width: 200 Year: 2008

Window Level: 700

Compression Force 5 AEC Mode: CNT

Month	Jan.											
Day	2											
Initials	JD											
Cassette ID	1	2	3	4	5	6	7	8				
Target	Mo											
Filter	Mo											
kV	26											
mAs	99	100	98	101	97	99	100	101				
mean Pixel Value (ADU)	990	1000	980	1010	970	990	1000	1010				
No Undue Artefacts	P	P	P	P	P	P	P	P				
Hardcopy/Softcopy/ Both	S	S	S	S	S	S	S	S				

Date: **Remarks:**

CHART 8: MONTHLY MECHANICAL INSPECTION

Facility: Anywhere X-Ray Room: 1

Unit: 1 Year: 2008

Month	J	F	M	A	M	J	J	A	S	O	N	D
Date	1											
Initials	JD											
Room temperature	P											
No Loose Parts	P											
Cleanliness	P											
No Cracks in Paddle	P											
Overall Integrity	P											
Hoses and Cabling Unobstructed	P											
Angulation Indicator	P											
Locks (all)	P											
Field Light	P											
Smoothness of Motion	P											
Panel switches /lights/meters	P											
Time and Date on images correct	P											
Facility ID on images correct	P											
Technique charts	P											
Cleaning solution	P											

IF failure of a test listed above, document resolution:

Enter "Y" or "N" for each section

CHART 9: MONTHLY LASER PRINTER ARTEFACT EVALUATION

Facility: Anywhere X-Ray Year: 2008

Printer Kodak

Month		J	F	M	A	M	J	J	A	S	O	N	D
Date		1											
Initials		JD											
OD		1.50											
Uniform OD	P												
No Streaks?	P												
No Lines?	P												
No Specks?	P												
No Other Artefacts?	P												
Overall Pass/Fail	P												

IF failure of a test listed above, document resolution:

Enter "Y" or "N" for each section

CHART 10: DIGITAL MAMMOGRAPHY RETAKE RECORD

(Enter any repeated exposures that required the patient to have additional dose beyond that of the normal exam)

Facility: Anywhere X-Ray Room: 1 Unit: 1

Date From: 01-Jan-08

Date To: 31-Jan-08

Study #	Causes	Number of Times	Date	Initiated by:		Technologist
				Physician	Technologist	
201	1	1	01-Jan-08		x	JD
212	1	1	09-Jan-08		x	JD
220	2	1	14-Jan-08		x	JD
231	2	1	17-Jan-08		x	JD
243	1	1	22-Jan-08		x	JD
258	1	1	31-Jan-08	x		JD

Causes:

1 Positioning
2 Patient Motion
3 Improper Detector Exposure
4 Artefact
5 X-Ray Equipment Failure
6 Software Failure
7 Blank Image
8 No Image
9 Other

CHART 11: QUARTERLY RETAKE ANALYSIS

Facility: Anywhere X-Ray Room # 1
Date From: 01-Jan-08 Unit: 1
Date To: 31-Jan-08

Total Patient Exposures in Quarter-------> 250

	Cause	No. of Exposures	Percentage of Repeats
1	Positioning	4	67%
2	Patient Motion	2	33%
3	Improper Detector Exposure	0	0%
4	Artifact	0	0%
5	X-Ray Equipment Failure	0	0%
6	Software Failure	0	0%
7	Blank Image	0	0%
8	No Image	0	0%
9	Other	0	0%

	Total	% Repeats
Repeat Exposures (1-9)	6	2.4%

CHART 12: QUARTERLY PRINTED IMAGE QUALITY TEST

Printer Kodak Year 2008

Printed From: PACS 1

Date	01-Jan											
Initials	JD											
0-5% Square	P											
95-100% Square	P											
Horizontal Line Pairs	P											
Vertical Line Pairs	P											
Grey Patches	P											
Lines Straight	P											
No Artefacts	P											
Length of 5 cm Horizontal Ruler (between 4.7 and 5.3 cm)	4.9											
Length of 5 cm Vertical Ruler (between 4.7 and 5.3 cm)	5.0											
Overall Pass/Fail	P											

IF failure of a test listed above, document resolution: