

Digital Mammography Quality Control – The Role of the Technologist

**Presented By:
Mark Liddington**

Objectives:

Introduce you to QC terminology in digital mammography

Introduce you to the different vendors in the marketplace

Review the quality control programs and testing protocols of a digital mammography program with focus on General Electric and Hologic FFDM units.

FDA Facility / FFDM Statistics

As of August 1, 2007

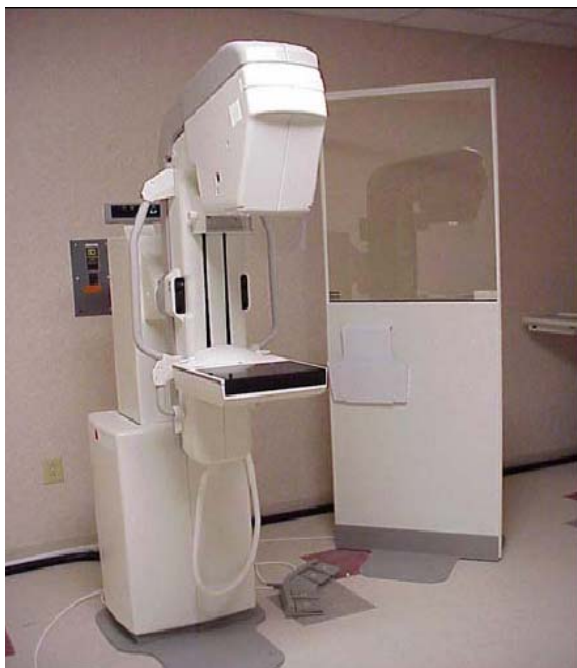
- Total certified facilities: 8,825
- Total accredited units 13,402
- Certified facilities with FFDM units: **2,090 (24%)**
- Accredited FFDM units: **3,077 (23%)**

As of August 1 2006

- Total certified facilities: 8,829
- Total accredited units: 13,556
- Certified facilities with FFDM units: **1,130 (13%)**
- Accredited FFDM units: **1,604 (12%)**

Digital Mammography Manufacturers

- General Electric
- Hologic
- Siemens
- Fuji – CR
- Fischer
- Sectra



GE 2000D
19cm x 23 cm
detector



GE Essential
24cm x 30.7cm
detector



GE
SenoAdvntage
Workstation

General Electric

- 2000D – Approved January 28, 2000
- Softcopy Review – Approved November 16, 2000
- DS – Approved February 19, 2004
- ES – Approved April 11, 2006

Hologic – (LoRad)

- Lorad Digital Breast Biopsy System approved March 15, 2002
- Hologic Selenia™ Amorphous Selenium Direct-Capture System approved October 2, 2002

Hologic



Hologic Selenia™

Amorphous Selenium Direct-Capture System

Siemens

Siemens Mammomat Novation DR Approved August 20, 2004

Uses the same detector as the Hologic Selenia™



Novation



Review and Acquisition
Workstations



Mammo Report ^{Plus}

Fischer

Fischer Senoscan
Approved September 25, 2001



Fuji

Fuji Computed Radiography for Mammography (FCRm) Approved July 10, 2006



Clear View – Single
Plate Reader



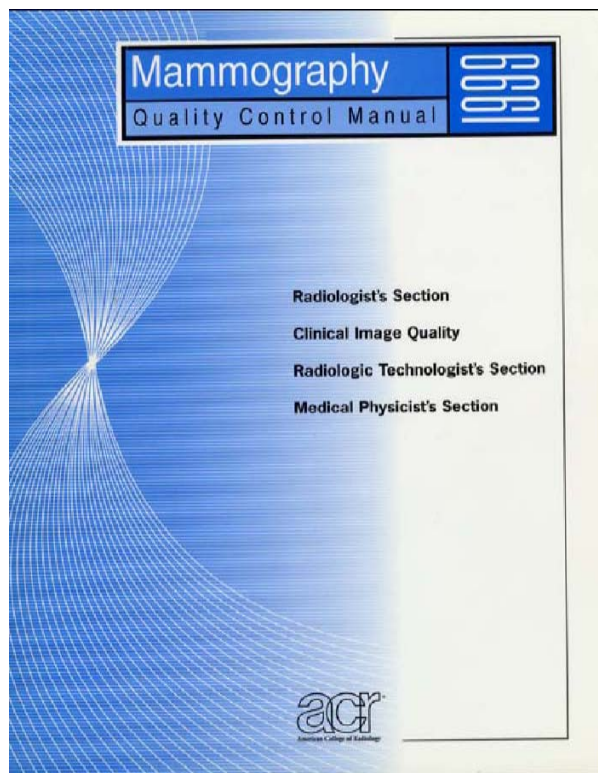
Clear View – Multi-
Plate Reader

Laser Printer Manufacturers

Agfa

Kodak

Fuji



The 1999 ACR QC Manual does not apply to Full Field Digital Mammography (FFDM) units.

The FDA requires you to follow the manufacturer's QC manual for your machine.

21 CFR 900.12(e)(6)

“For systems with image receptor modalities other than screen-film, the quality assurance program shall be **substantially** the same as the quality assurance program recommended by the image receptor manufacturer, except that the maximum allowable dose shall not exceed the maximum allowable dose for screen-film systems in paragraph (e)(5)(vi) of this section.”

That was then...this is now!

Film Screen QC

Machine

Film Cassettes

Processor

Digital QC

Machine

Review Workstation

Printer

That was then...this is now!

Old Terms

New Terms

Film Screen Contact

Flat Field Uniformity

Screen Cleaning

MTF

Darkroom Fog

CNR

Fixer Retention

SNR

Digital Mammography Terminology

FFDM – Full field digital mammography

Flat Field uniformity is an analysis of the homogeneity of the detector field

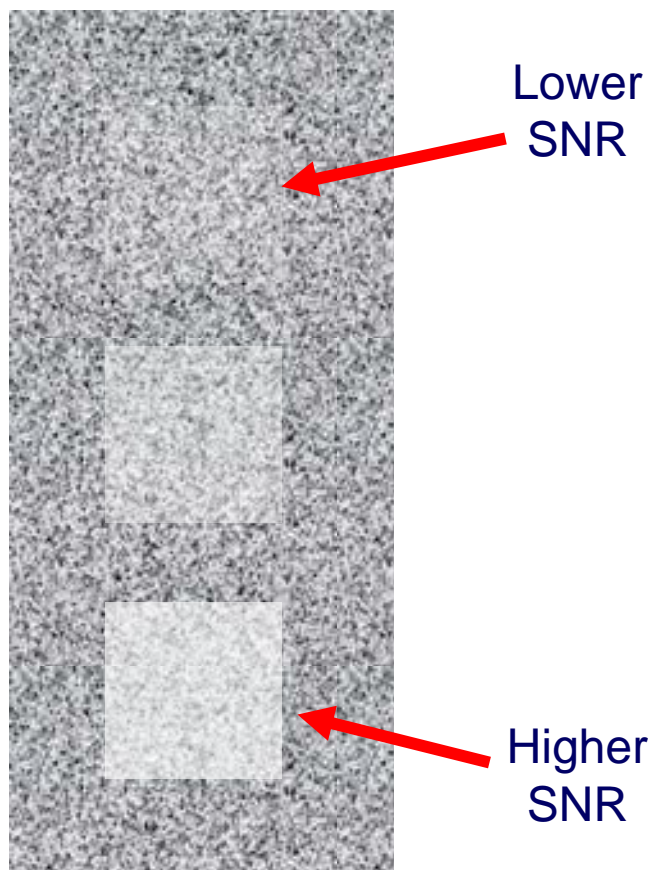
MTF (Modulation Transfer Function) is a measure of image sharpness.

Digital Mammography Terminology

CNR (Contrast to Noise Ratio) is a measure of the detectors ability to distinguish between objects in an image and the image noise



Digital Mammography Terminology



SNR (Signal to Noise Ratio) compares the level of the desired signal to the level of background noise.

A higher SNR provides a better image

Daily QC Tests – General Electric

FFDM Machine

2000D

Monitor Cleaning

Workstation Viewing Conditions

DS and Essential

Monitor Cleaning

Workstation Viewing Conditions

Daily QC Tests – General Electric

Review Workstations

Seno Advantage

Monitor Cleaning

Viewing Conditions Check

Centricity PACS Mammo Module

Monitor Cleaning

Viewing Conditions Check

Daily QC Tests – General Electric Seno Advantage and Centricity

Monitor Cleaning

Objective:

To ensure good image review conditions by keeping the monitor screens free of dust, finger prints, and other marks.

Equipment required:

Dry, soft, lint-free cloth or cleaning tissue. If necessary, the cloth or tissue may be lightly dampened with water before use. Never apply water or other fluids directly to electronic equipment.

Note: Any other cleaning methods may lead to damage of the anti-reflective screen coating.

Daily QC Tests – General Electric Seno Advantage and Centricity

Monitor Cleaning

Procedure:

Clean all monitor screens using the cloth or cleaning tissue to remove dust, finger prints, and other marks

Check the screen to verify that it is free from dust, fingerprints, and other marks.

Action Limit:

After the monitor is cleaned, the screen must be free from dust, fingerprints, and other marks.

Monitor Cleaning (Any Monitor!!!)

Check for fingerprints, dirt, scratches
Brush with nylon brush to remove dirt/dust

Use a Soft Cloth Only!

Old Tee Shirt

Camera – Microfiber Cloth

NO WINDEX!!!

Removes protective anti-glare coating on monitor

If Dirty and/or Greasy, clean with mild detergent solution
1 drop dishwashing liquid to 8 oz Warm Water

If a monitor needs to be replaced, both monitors should/will be replaced

Daily QC Tests – General Electric

Seno Advantage and Centricity

Viewing Conditions Check for the Workstation

Objective—to ensure optimal viewing conditions

Procedure:

Review the data form "Viewing Conditions Check and Setting" posted in the reading room during the most recent Medical Physicist's evaluation. In this data form you will find the reading room conditions established as optimal during this evaluation.

Compare the reading room configuration to the one described in the data form.

If differences exist between this configuration and the actual one, adjust the room configuration as described in the data form. For example, if desk lights were described to be turned off, turn them off, or, if the curtains were described to be closed, close them.

GE Medical Systems		Seno Advantage	
Revision 1		QC Manual 2391082-100	
Chart 3 - Site and System Summary			
Facility Name	St. Luke's Hospital (North Facility Seno Advantage)		
Address	Broadhead Road		
	Bethlehem, PA		
Date of Installation	3/11/04	Room ID	SL North Reading Room
Date of Survey	6/1/2007		
Serial Numbers			
Mammographic Unit	5544	Workstation CPU	45512GE1
Left Monitor	HXU300072	Right Monitor	HXU300033
Chart 4 - Viewing Conditions Check and Setting			
Monitor Position	See diagram below		
Room Lights	Off		
Desk Lights	Off		
Others	Clinical films on viewer are masked to size (if needed)		
Ambient Light value	3	lux	
Note: confirmation of this value is not part of the daily check by the Radiologic Technologist.			
Room Layout			
	<p>The diagram shows a schematic of the room layout. On the left is a shaded area representing a wall. To the right, there is a desk area. On the desk, two monitors are labeled 'Mammo Monitors/'. Below the desk, a vertical rectangular area is labeled 'Film Viewer'. Arrows point from the text labels to the corresponding components in the diagram.</p>		
Action Limit:			
<p>The ambient light level must not exceed 20 lux. The measured value must be stable over one minute (with a tolerance of ± 5 lux over the measuring time with regards to the nominal lighting value). If the system fails the test, the source of the problem must be identified and corrective action taken, before any further mammographic images are reviewed or interpreted using the Seno Advantage.</p>			

Daily QC Tests – General Electric

Seno Advantage and Centricity

Viewing Conditions Check for the Workstation

Action Limit:

On the "Viewing Conditions Check and Setting" data form posted by your Medical Physicist, you will find the nominal value of the ambient light. This is a record of the most recent measure and provides a comparison value for the next Medical Physicist survey. The Radiologic Technologist is not required to measure the ambient light level as part of the Viewing Conditions Check.

If the reading room configuration has changed, the source of the problem must be identified, and corrective action taken, before any further mammographic images are reviewed or interpreted using this specific Centricity Workstation.

Ideal Conditions in Digital Reading Rooms

Room light levels

Keep lights off or low -- < 5 lux
» 1 to 2 lux preferred

Equipment positioning

View boxes and Softcopy displays should be parallel to one another ... not at an angle or back to back

Need to avoid “crosstalk” between light sources

Daily QC Tests – Siemens

Novation

Image Quality (Phantom Image)

Procedure is nearly identical to film screen phantom testing

Exposure technique: Opdose program 2

Criteria: 5 fibers, 4 specks, 4 masses

MammoReportplus

Monitor Cleaning

Weekly QC Tests – General Electric

2000D

- Flat Field Test
- Phantom Image Quality (4, 3, 3)
(Technique specified by manufacturer: 26 kVp, 125 mAs, Mo/Mo)
- CNR
- Viewbox and Viewing Conditions Test

• DS

- Flat Field Test
- Phantom Image Quality (4, 3, 3)
- MTF and CNR
- Viewbox and Viewing Conditions Test

• Essential –Same as DS

Weekly QC Tests – General Electric Flat Field Test – Similar for all GE models



Hit QAP icon & bring
up Flat Field

Place 25mm acrylic
directly on the detector
with no compression

Follow directions

Record on Image
Quality chart

Weekly QC Tests – General Electric Flat Field Test – Similar for all GE models

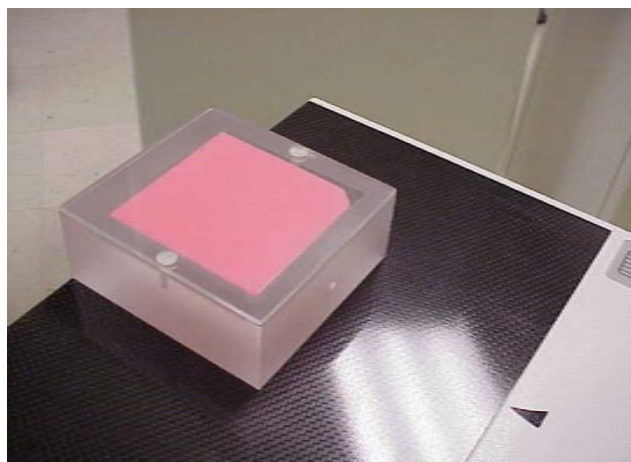
The most common failure on this test is the “Bad Pixel ROI” measurement

If this fails, run the collimator through a cycle of all sizes and repeat the test

If it fails again, contact your service engineer

Weekly QC Tests – General Electric

Phantom Image Quality – Similar for all GE models



Position the phantom the same as you do for film screen evaluation

(Select the 9 x 9 cm X-ray field size and use the light localizer to center the phantom laterally.)

Note: Careful attention to precise positioning of the phantom is critical to the reproducibility of the measurement.

Install the full-size compression paddle and apply about 5 daN of compression force to the phantom.

Select the following parameters: large focal spot, Mo/Mo track/filter, 26 kV, 125 mAs.

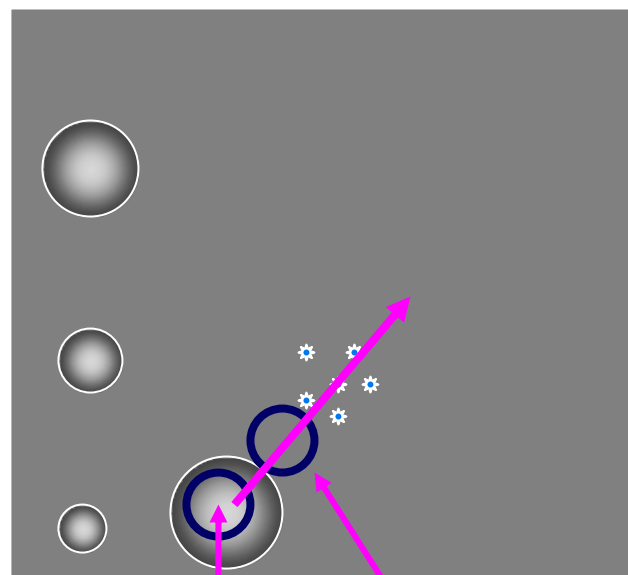
Score the processed phantom image on the AWS and RWS

Weekly QC Tests – General Electric

CNR (Contrast to Noise Ratio) 2000D

Similar to phantom density difference (Does not use acrylic disk)

Use RAW Data and default ROI.



ROI #1

ROI #2

Measure mean of mass with ROI 1.

Measure mean and SD of background with ROI 2.

Difference of means measures contrast.

Std. Dev. of background measures noise.

Weekly QC Tests – General Electric

CNR,MTF, and SNR Worksheet

Note: All measurements must be made from **Raw** images.

CNR Test

Object	Mean	Std. Dev.
Mass	865.43	12.5
Background	913.36	11.89

$$\text{CNR} = \frac{\text{mean_background} - \text{mean_mass}}{\text{sd_background}}$$

CNR_{ol} = 3.70

CNR = 4.03

Change in CNR = 0.089

Change in CNR = $1 - \frac{\text{CNR}}{\text{CNR}_{ol}}$; for CNR ≤ CNR_{ol}

Change in CNR = $\frac{\text{CNR}}{\text{CNR}_{ol}} - 1$; for CNR > CNR_{ol}

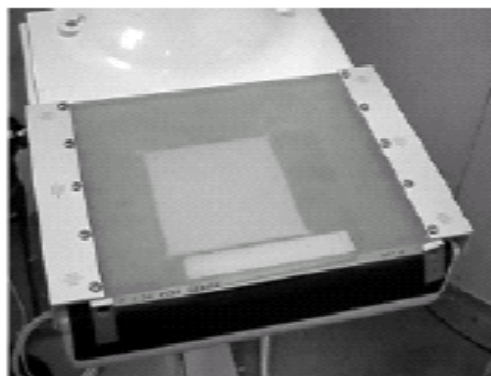
To establish **Operating Level**, repeat this measurement once a day for five consecutive days and average the five values to determine CNR_{ol}.

Action Limit:

Change in CNR cannot exceed 0.2

Weekly QC Tests – General Electric

CNR – DS and Essential



Uses a special (IQST) phantom supplied by GE

Position the IQST device on top of the Bucky.
*(The following parameters are selected automatically:
 Rh/Rh/30kV/56mAs.)*



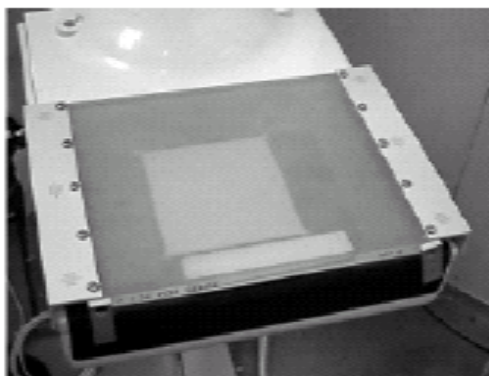
Perform one exposure.

After the image has been captured, the results of the tests are displayed

Weekly QC Tests – General Electric

MTF – DS and Essential

Uses (IQST) phantom supplied by GE



Position the IQST device on top of the Bucky.
*(The following parameters are selected automatically:
 Rh/Rh/30kV/56mAs.)*

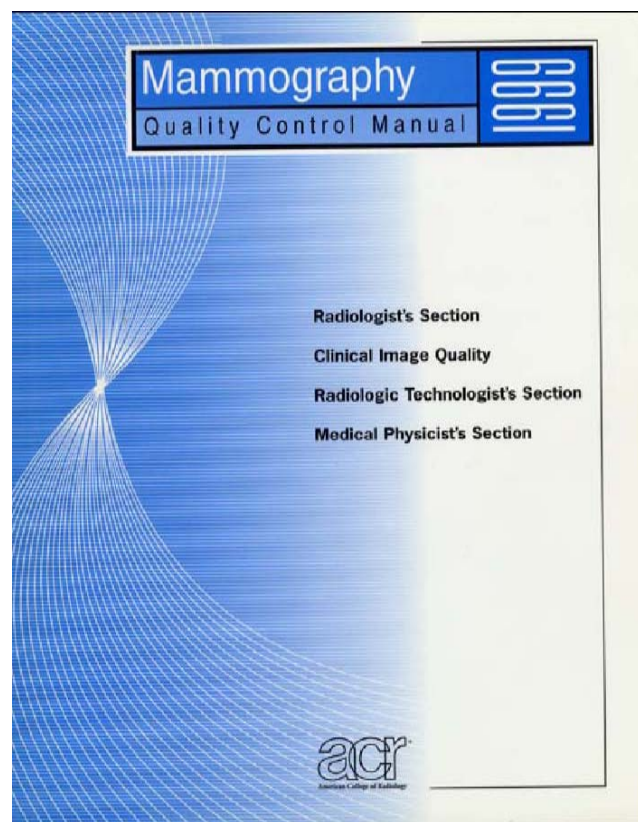
Perform one exposure.

After the image has been captured, the results of the MTF tests are displayed

Record Results



Weekly QC Tests – General Electric



Viewboxes and Viewing
Conditions Check - all
units and workstations

This is the same test
that you perform for a
film screen
mammography
program

Monthly QC Tests – General Electric

2000D

- MTF
- AOP SNR
- Visual Checklist
- Monitor Calibration Test

• DS

- AOP SNR
- Visual Checklist

• Essential –Same as DS

Monthly QC Tests – General Electric 2000D

MTF Test

Frequency: Monthly

Objective: Monitor the contrast delivered by the detector

Contrast at low frequencies (1–2 lp/mm) aids detection of masses and fibers.

Contrast at high frequencies (4–5 lp/mm) aids detection of microcalcifications.

Method: Measure the fluctuation of a bar pattern signal in a region of interest (ROI)

The greater the signal fluctuation, the greater the MTF.

Monthly QC Tests – General Electric 2000D

MTF Test



Position resolution bar pattern with open on left

Align along the chest wall edge without the compression paddle

Make an exposure: 30 kVp, 28 mAs, Rh/Rh and LCC

Examine the RAW image

Monthly QC Tests – General Electric 2000D

MTF Test



Set the ZOOM factor to 1
Use ROI to measure

2.09 Standard Deviation

3.93 Standard Deviation

Mean space

Mean bar

Monthly QC Tests – General Electric 2000D

MTF Measurement – Sample Calculation

MTF Test

Object	Mean	Std. Dev.
2 lp/mm bars	4191.84	2876.92
4 lp/mm bars	3906.14	1829.08
Space	8798.99	
Bar	136.64	

$$MTF_{2lp/mm} = 73.73$$

$$MTF_{4lp/mm} = 46.88$$

Formula:

$$MTF = \frac{SD \text{ lp/mm}}{\text{Mean Space} - \text{Mean Bar}} \times 222$$

MTF (2 lp/mm) must be > 58%
 MTF (4 lp/mm) must be > 25%

Monthly QC Tests – General Electric All Units

AOP and SNR Test



Tested for 2.5cm, 4cm, 6cm thicknesses with the supplied acrylic tests phantoms

Position on image receptor as shown

Apply 5dNa compression

Make exposures in the STD mode

Record techniques on AOP Mode chart

Close exam & bring up raw data

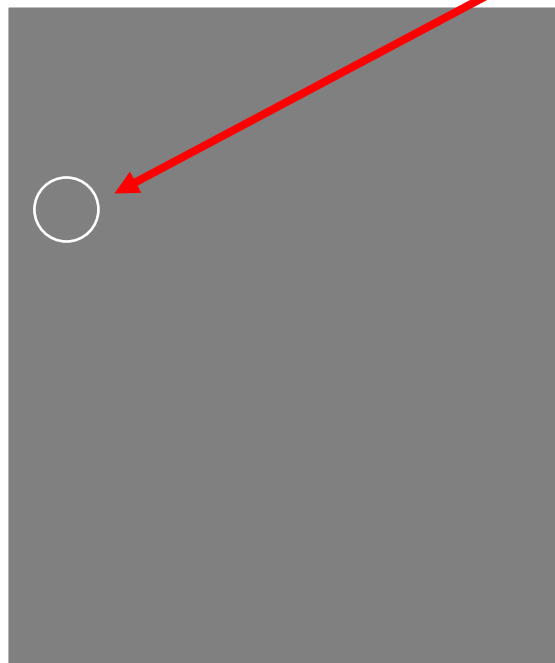
Monthly QC Tests – General Electric All Units

AOP and SNR Test

Place ROI at chest wall on all 3 images

$$\text{SNR} = \text{mean}/\text{sd}$$

Record results on AOP Mode chart



AOP and SNR Test

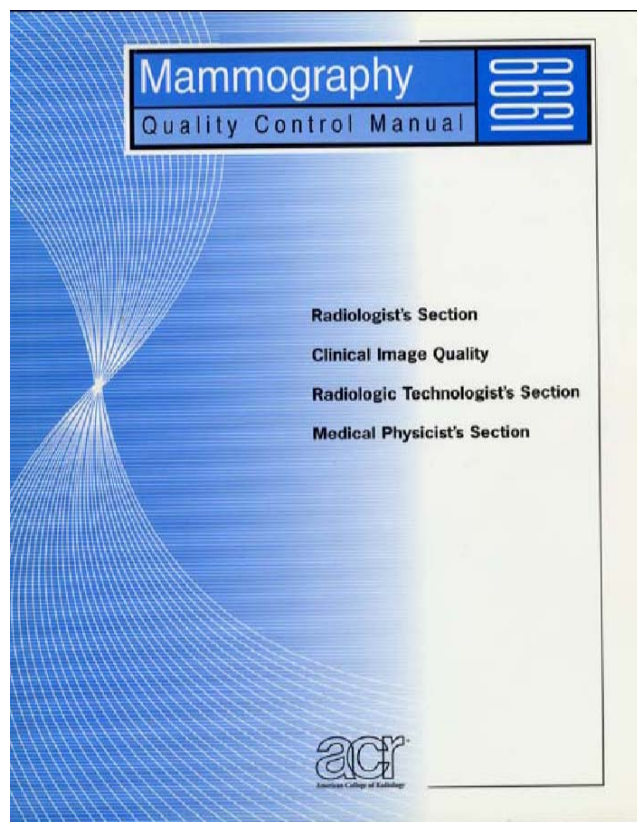
$$\text{SNR} = \frac{\text{Mean}}{\text{Std. Dev.}}$$

Thick	kVp	Track	Filter	mAs	Mean	Std. Dev.	SNR
25 mm	27	Mo	Mo	26	764.55	10.93	69.95
40 mm	28	Mo	Rh	55	799.57	11.61	68.87
60 mm	32	Rh	Rh	59	749.05	12.07	62.06

Requirement:

Acrylic Thickness (mm)	Track/Filter	mAs	kV	SNR
25	Mo/Mo	20 - 60	27	> 50
40	Mo/Rh	35 - 90	28	> 50
60	Rh/Rh	35 - 90	32	> 50

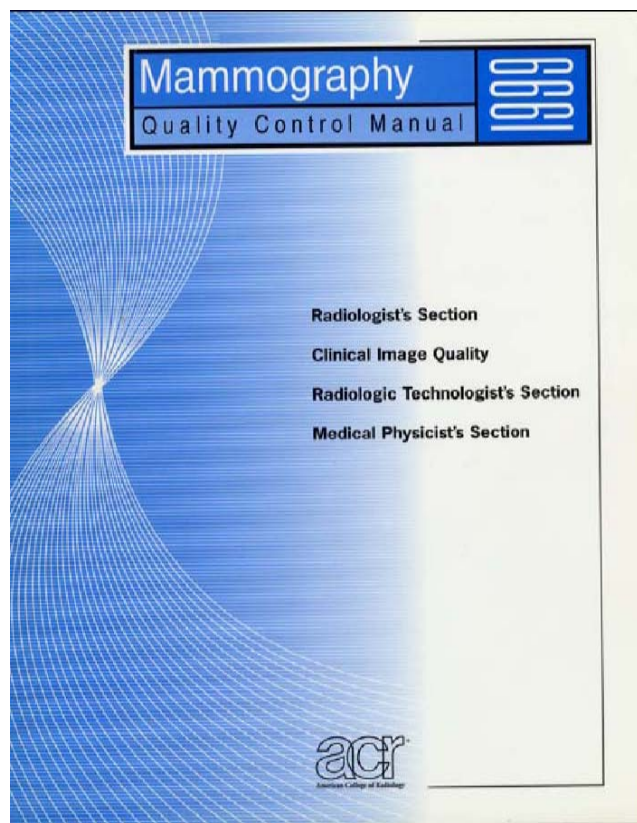
Monthly QC Tests – General Electric All Units Visual Checklist



Similar to Visual checklist for film screen mammography

Quarterly QC Tests – General Electric 2000D

Repeat Analysis



Similar to repeat analysis for film screen mammography

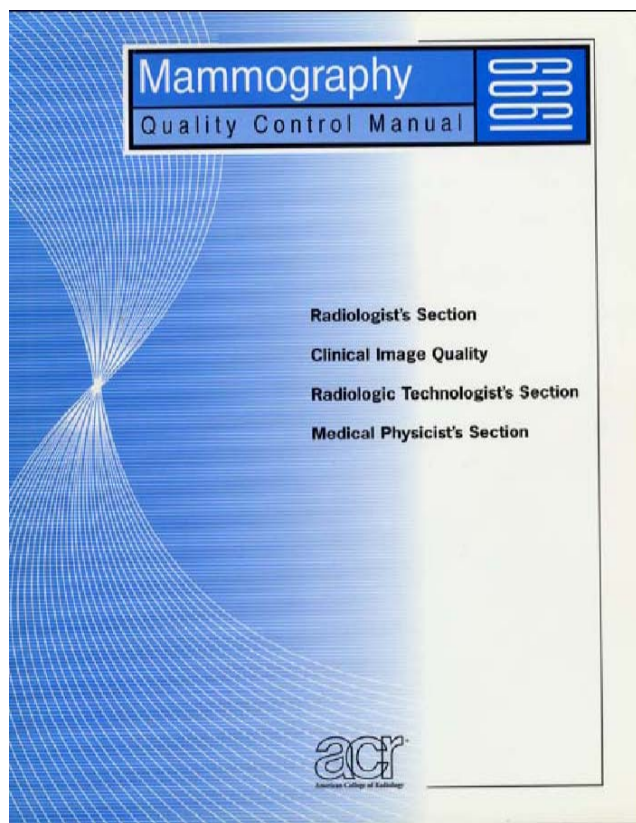
Must manually record retakes and estimate number of exposures

Manually calculate retake percentages

Quarterly QC Tests – General Electric DS & ES

Repeat Analysis

Procedure is automated

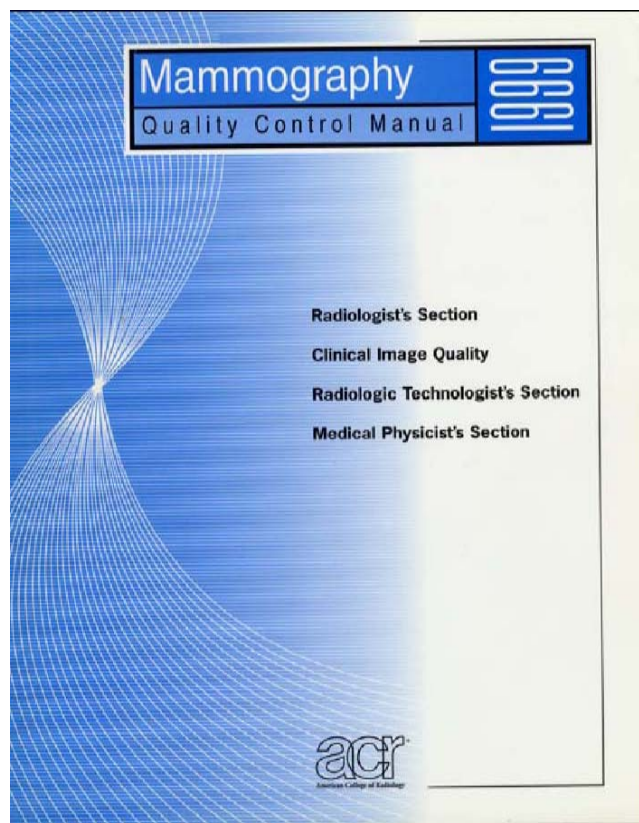


Select the QAP icon in the browser, then click the *RRA* button to display the *Repeat and Reject Analysis* window.

In the *Repeat and Reject Analysis* window, select *From* and *To* dates for the analysis, then click *Preview analysis* to display the *Repeat Reject Exposures Analysis* table

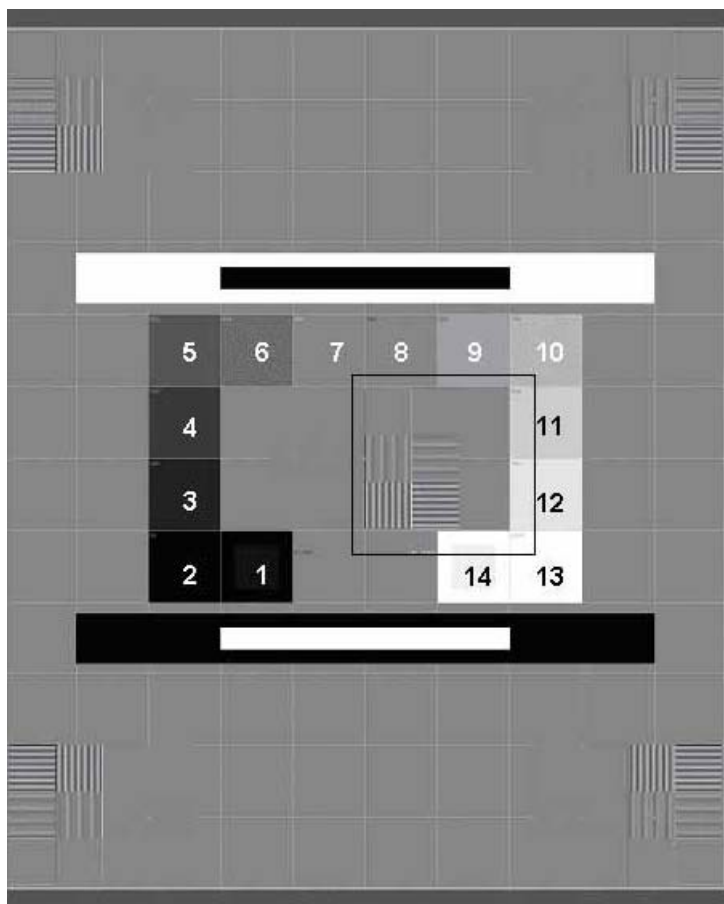
The table summarizes all exposures made during the chosen period, and gives the percentages for Repeated and Rejected exposures, together with their respective causes.

Semi-Annual QC Tests – General Electric All Compression Units



Procedure is the same as a film screen unit

QC Tests – General Electric Seno Advantage Review Workstations Monitor Calibration (Monthly)



Verify that the 0%-5% contrast is visible

Verify that the 95%-100% contrast is visible

Verify that each gray level step from 0% to 100% can be distinguished from the adjacent squares.

Verify that the alphanumeric characters that appear on the pattern are sharp and in focus.

Verify that the high contrast line-pair images at the center and corners of the SMPTE pattern are distinguishable

QC Tests – General Electric Centricity Review Workstations

Monitor Calibration (Weekly)



Monitor Calibration is automated after the program is set up

Tests:

- I-Guard
- Calibration Settings
- Measure Display White Field

Review Last Results log and record results

QC Tests – General Electric Centricity Review Workstations

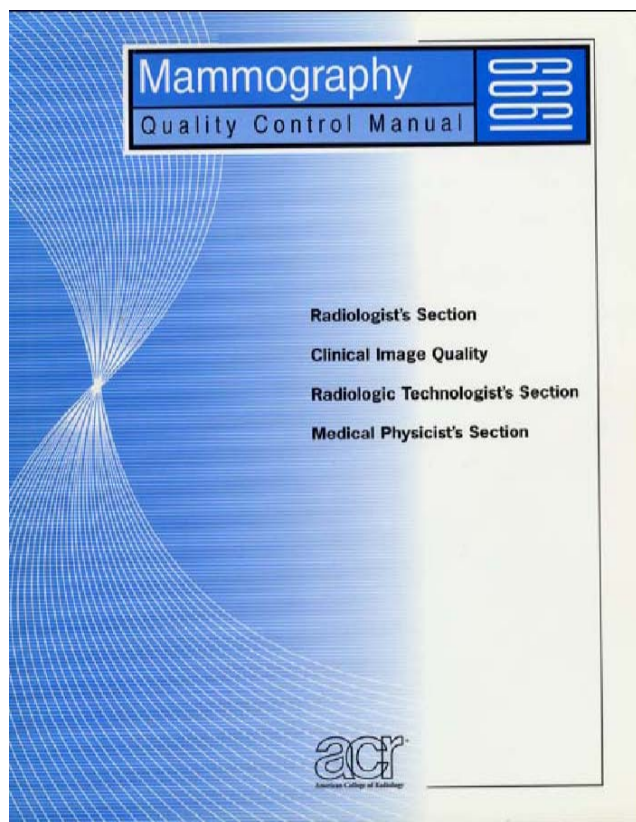
Measure Quality Level (Monthly)



Quality Level is automated after the program is set up

Review Last Results log and record results

Daily QC Tests – Hologic



Note: If wet processing is used the following tests must be performed:

Darkroom cleanliness

Processor QC

Tests will follow the 1999 ACR manual

Weekly QC Tests – Hologic Selenia

Laser Printer QC (dry laser)

(follow manufacturer's manual)

Viewbox and Viewing Conditions

(follow 1999 ACR manual)

Diagnostic Review Workstation QC

Artifact test – Detector and Printer

Phantom with SNR and CNR

Weekly QC Tests – Hologic Selenia

Diagnostic Review Workstation QC

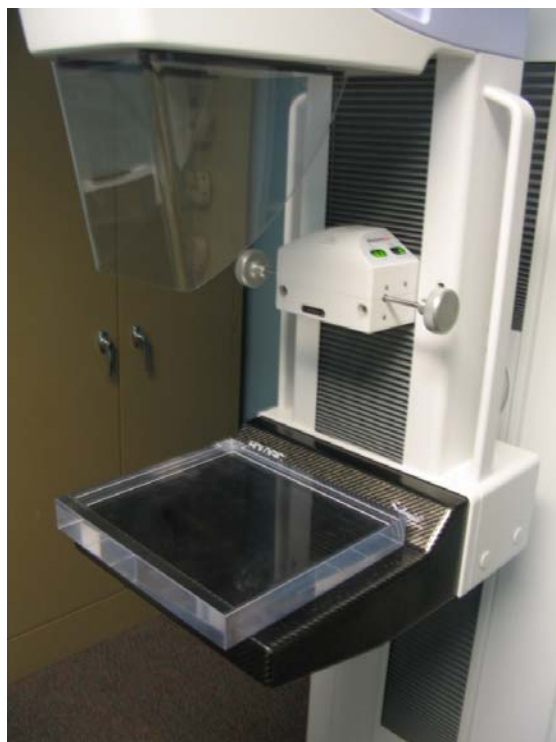
Workstations with CRT monitors use a photometer that is attached to the monitor. After following the on-screen instructions, the process is automated

QC tests for workstations with flat panel monitors is automated. Technologists must retrieve the results and record them in the QC logbook.

Hologic workstations use MediCal Pro software. The same software that is used on the GE Centricity PACS workstations.

Weekly QC Tests – Hologic Selenia

Artifact Evaluation – Detector



Performed before the phantom test

Place acrylic on image receptor

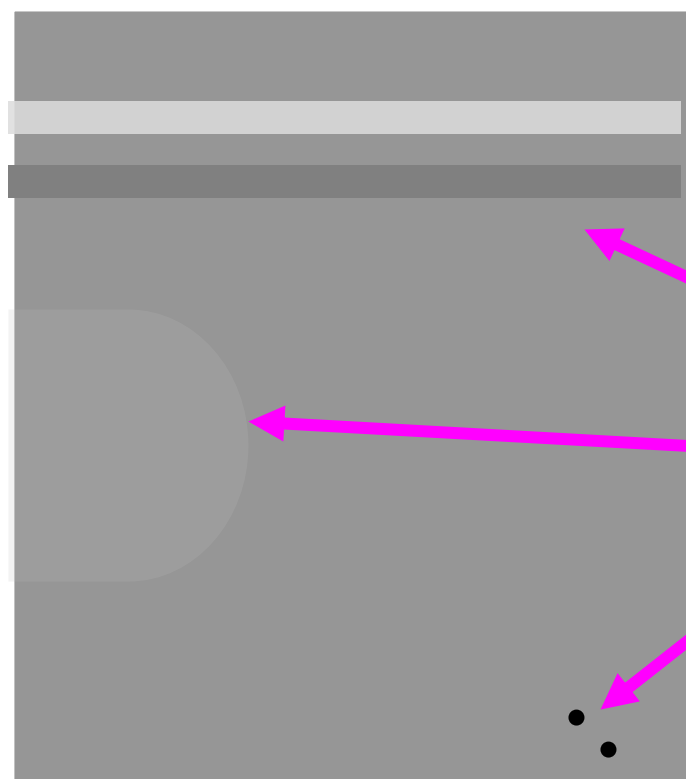
Make exposure at 28 kVp, 65 mAs, Mo/Mo LFS

Rotate Acrylic 180° and repeat exposure

Using the Pan/Zoom feature, analyze the image for artifacts

Weekly QC Tests – Hologic Selenia

Artifact Evaluation – Detector



Common artifacts include

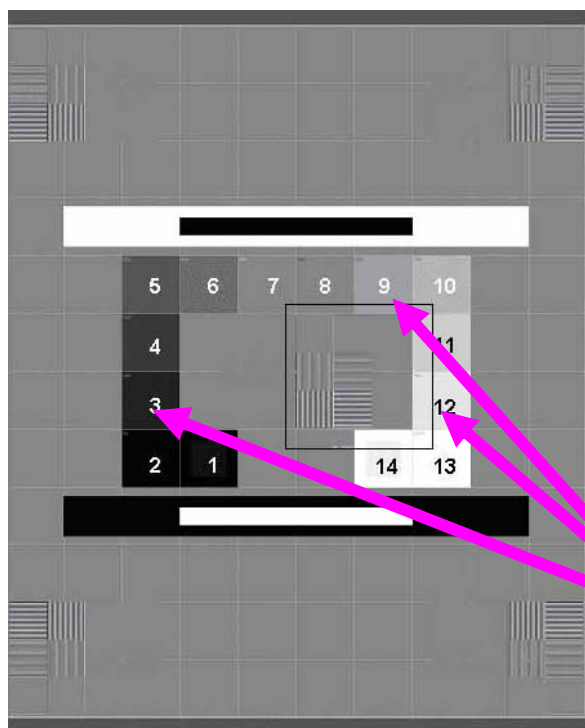
Streaking

Ghosting

Dead Pixels

Weekly QC Tests – Hologic Selenia

Artifact Evaluation – Printer



Select test patterns from the Admin menu

Select SMPTE pattern from the drop down list

Send image to printer

Evaluate SMPTE patterns visually

Using a densitometer, measure the 40%, 10% and 90% contrast patches.

Record values on control sheet (*similar to processor QC*)

Weekly QC Tests – Hologic Selenia

Artifact Evaluation – Printer



Select test patterns from the Admin menu

Select flat field pattern from the drop down list

Send image to printer

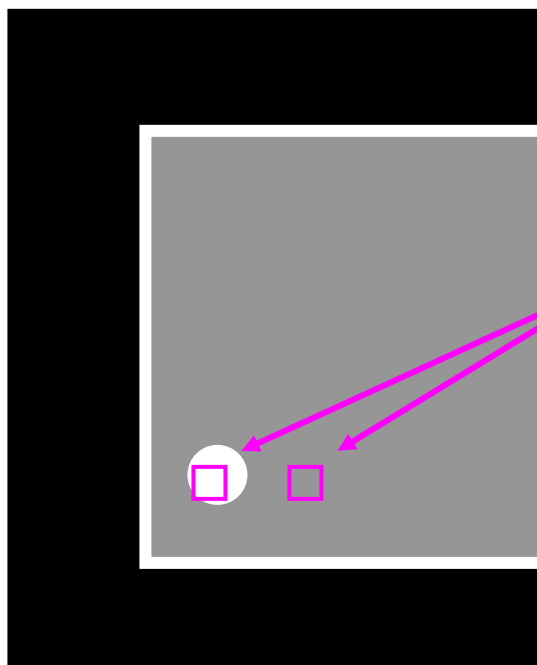
Analyze the image for artifacts

Common artifacts are streaks and repeat lines

Weekly QC Tests – Hologic Selenia

SNR (signal to noise ratio)

CNR (signal to noise ratio)



Position the phantom and make an exposure using the clinical setting (Hologic requires the acrylic disk)

Make ROI measurements on the disk and in the background

Record the mean and standard deviation of the ROIs

Artifacts



Weekly QC Tests – Hologic Selenia

SNR (signal to noise ratio)

Compute the SNR using the SNR formula

$$\text{SNR} = \frac{\text{Mean (bkg)} - 50}{\text{STD (bkg)}}$$

The measured SNR must be greater than or equal to 40

Weekly QC Tests – Hologic Selenia

CNR (signal to noise ratio)

$$\text{CNR} = \frac{\text{Mean (bkg)} - \text{Mean (disk)}}{\text{STD (bkg)}}$$

Compute the CNR using the CNR formula

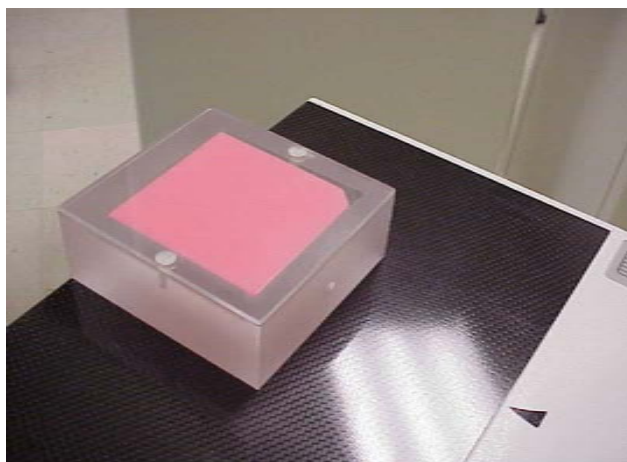
Compute the deviation from the original CNR using the CNR_(diff) formula

$$\text{CNR}_{(\text{diff})} = \frac{\text{CNR}_{(\text{base})} - \text{CNR}_{(\text{meas})}}{\text{CNR}_{(\text{base})}} \times 100\%$$

The deviation should not exceed $\pm 15\%$ of original CNR

Weekly QC Tests – Hologic Selenia

Phantom Image Evaluation



Position the phantom the same as you do for film screen evaluation (you can use the phantom image from the CNR and SNR tests)

Print a film of the phantom

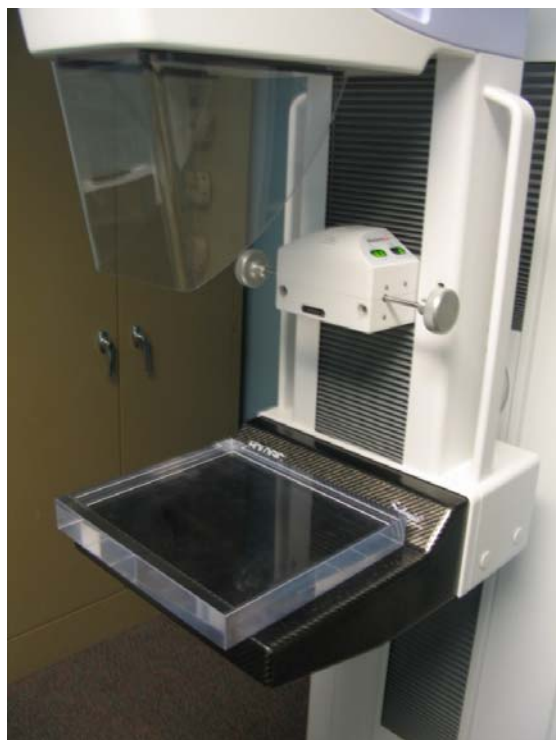
Score the phantom on film and the diagnostic review workstation

Make measurements with a densitometer on the film

Record the results on the QC forms

Bi-Weekly QC Tests – Hologic Selenia

Detector Flat Field Calibration



Select Calibrate from the Admin drop down menu (directions are displayed on the monitor)

Remove compression paddle, place the acrylic block on the image receptor and make a manual exposure

Review the image for foreign objects and collimation interference

Rotate the acrylic block 180° and press the Accumulate Calibration button.

Follow the remaining instructions

Bi-Weekly QC Tests – Hologic Selenia Detector Flat Field Calibration

The calibration is performed automatically by software on the AWS

Review the image for foreign objects and collimation interference

If artifacts are seen, contact your medical physicist, radiologist and or service engineer to determine the cause of the artifact

Bi-Weekly QC Tests – Hologic Selenia Compression Thickness Indicator

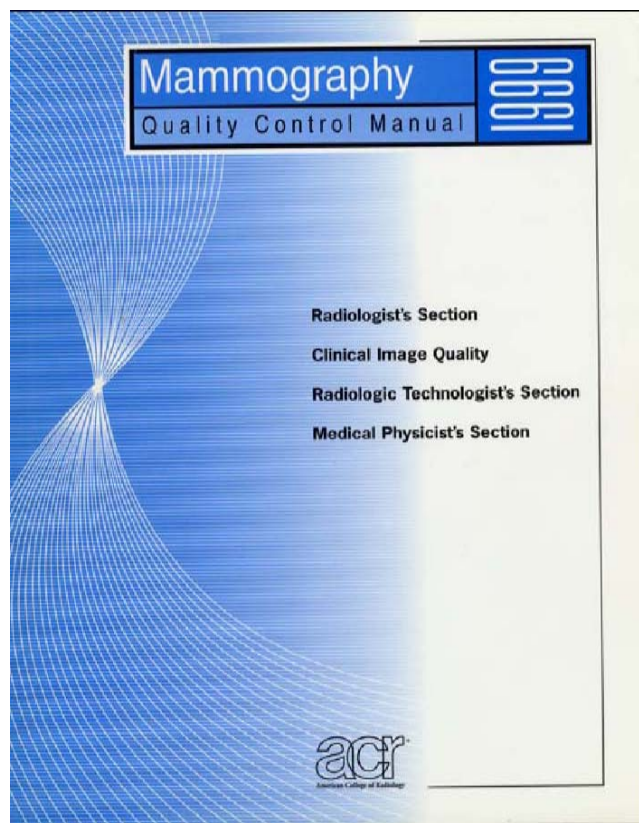
Position the ACR phantom on the image receptor and compress it with ~30 lbs. using the 7.5 cm spot compression paddle

Record the thickness indicated on the compression device

The compression indicator should be accurate to within ± 0.5 cm from the actual thickness. *(Should read 3.7 to 4.7 cm for standard phantom)*

Monthly QC Tests – Hologic Selenia

Visual Checklist



Follow the procedure listed in the 1999 ACR Quality Control Manual

Use the visual checklist form in the 1999 ACR Quality Control Manual

Quarterly QC Tests – Hologic Selenia

Repeat Analysis

The Procedure is automated

Minimize the Selenia Application and double click the terminal shortcut icon

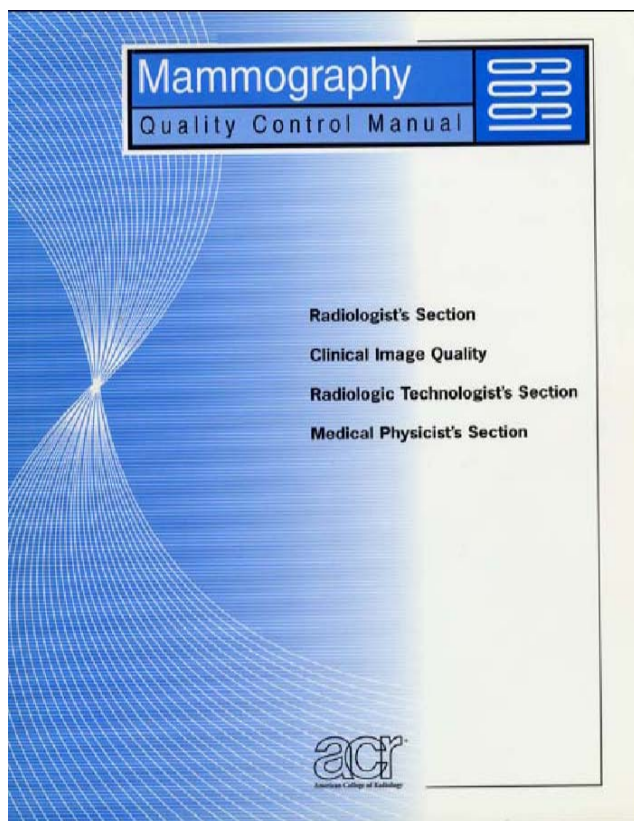
Enter the password and select repeat-reject analysis from the options list

Enter the start and end date of the monitoring period and submit the request.

Action levels are the same as stated in the 1999 ACR QC manual

Quarterly QC Tests – Hologic Selenia

Fixer Retention

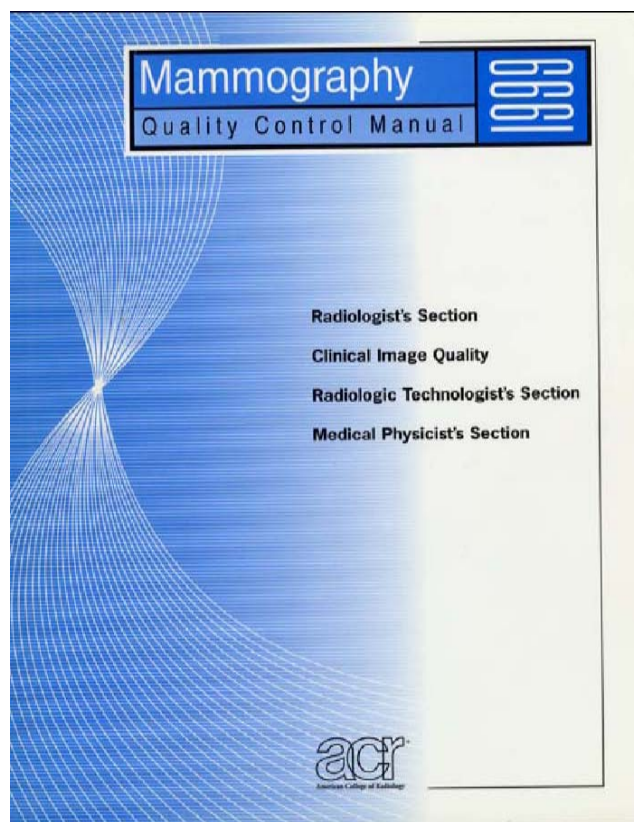


Applies to those facilities printing digital mammo films to a wet laser printer.

Follow the 1999 ACR QC manual

Semi-annual QC Tests – Hologic Selenia

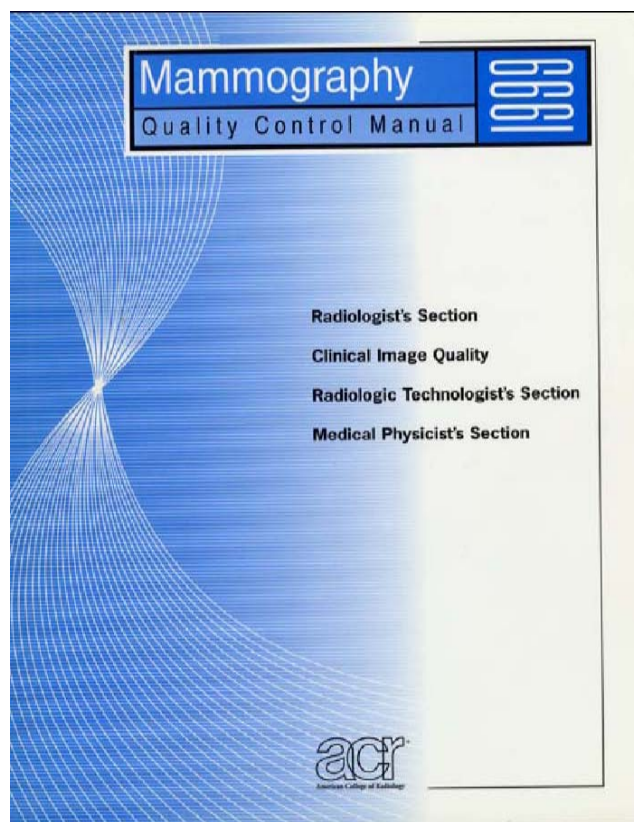
Compression



Follow the 1999 ACR QC manual

Semi-annual QC Tests – Hologic Selenia

Darkroom Fog



Follow the procedure listed in the 1999 ACR Quality Control Manual

Use the visual checklist form in the 1999 ACR Quality Control Manual

At this time, Siemens uses the same detector as the Hologic Selenia. Therefore, the detector-related QC tests are similar to the Hologic QC program

References:

GE Senographe 2000D QAP, QC Manual 2371472-100, Rev 0

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If you'd like to review this presentation, it will be available at
www.WalterRobinson.com

Questions?