Digital Mammography Quality Control

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Quality Control

- Quality Control are simple checks that ensure the digital system is operating to the standards that is was designed to do.
- The system is designed to detect any changes in settings that could compromise image quality, and deterioration in the equipment performance over a period of time.

Quality Assurance

- **All-encompassing management program used to ensure excellence in healthcare through the systematic collection and evaluation of data.**
- **Patient scheduling, management techniques, departmental policies and procedures, technical effectiveness and efficiency, in -service education and image interpretation**

How is QC broken down for FFDM

- Indirect Conversion/Direct Conversion
- Also per each manufacturer specific
- FDA approved QC manual per Manufacturer.
- Updated version # of QC Tests
- State specific also

Quality Control

- Quality control is the part of the quality assurance program that deals with techniques used in monitoring and maintenance of the technical elements of the systems that affect the quality of the image.
- Level I – Noninvasive and Simple
- Level II – Noninvasive and Complex
- Level III – Invasive and Complex

Why Quality Control

- Reduce exposure to patients and personnel
- Consistent image quality
- Detect and correct for potential problems, before they impact image quality

Why quality control?

- Determination of what is "Normal"
- Detection of what is "Abnormal"
- Understanding of how to return to"Normal" from "abnormal".
- In particular, in FFDM, how do you know you are seeing is what it is suppose to be.

- Flat Field uniformity – is an analysis of the homogeneity of the detector field
- MTF Modulation Transfer Function – is a measure of image sharpness.
- CNR – Contrast to noise ratio is a measure of the detectors ability to distinguish between objects in an image and the image noise.
- 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.
- Contrast Resolution is the ability of an imaging

Universal QC for Digital Mammography

Not currently available

ACR is working on a universal manual FFDM

Currently manufacturer specific

We will discuss this at the end of class

Technologists Quality Control Procedures GE

- 1. Monitor Cleaning
- 2. Viewing Conditions for the RWS
- 3. Flat field and Image Quality Checks
- 4. Phantom Image Quality and CNR
- 5. Viewbox and Viewing Conditions Test
- 6. MTF Measurement
- 7. AOP Mode and SNR Check

That was then…..this is now

Old Terms	New Terms
Film screen contact	Flat Field Uniformity
Screen cleaning	MTF
Darkroom Fog	CNR
Fixer Rentention	SNR

Technologists Quality Control Procedures Lorad Selenia

- 1. Laser Printer Quality Assurance
- 2. Viewboxes and Viewing Conditions
- 3. Softcopy Workstation QC
- 4. Artifact Evaluation
- 5. Signal-to-Noise and Contrast-to-Noise Measurements

Lorad Selenia™

- 6. Phantom Image
- 7. Detector Flat-Field Calibration
- 8. Visual Checklist
- 9. Repeat Analysis
- 10. Compression

Hologic

If the facility has both tungsten and moly systems, they must use the QC manual applicable to their model

Hologic has confirmed this understanding with the FDA and if a facility is told by an inspector they must have and follow the latest revision they should ask the inspector to call the FDA hotline for clarification

Siemens Mammomat Novation QC

- 1. Detector Calibration-Weekly and as needed
- 2. Artifact Detection-Weekly and as needed
- 3. Phantom image quality-daily-image phantom and score
- 4. SNR and CNR Measurements-Weekly
- 5. Printer Check-when clinical images are to be printed-Daily
- 6. Repeat Analysis-quarterly
- 7. Compression force-semi-annually

GE Senograph DS/ESSENTIAL Quality Control Procedures

- Same as done on GE Senograph 2000D

EXCEPT

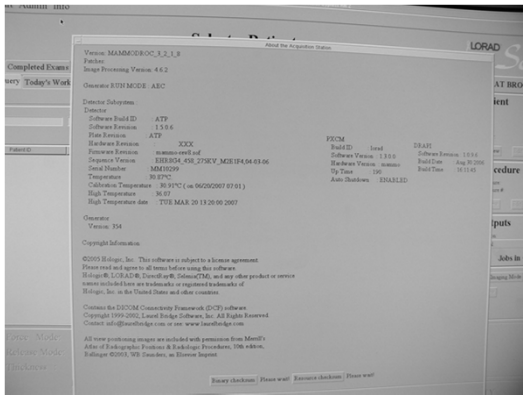
All QC tests are done internally- there is not mathematical calculations done by the technologist, just documentation of results.

Technologists Quality Control Procedures Fischer Senoscan

- 1. Detector Calibration and Flat Field Test
- 2. Phantom Image Acquisition Test
- 3. Phantom Image Quality Test
- 4. System Resolution/Scan Speed Uniformity
- 5. Image Display Monitor(s) Test
- 6. System Operations
- 7. Repeat Rate
- 8. Compression
- 9. Printer

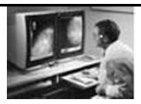
Prior to QC Procedures

- The detector temperature must be stabilized.
- The unit must be turned on for a period of time to get the detector temperature appropriate.

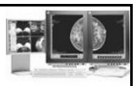


Monitor Cleaning

- Do not use cleaning agents which attack the surface, such as petroleum (mineral) spirits.
- The front panel is extremely sensitive to mechanical damage. Avoid all scratches, knocks, etc.
- Do not apply the cleaning liquid directly to the monitor housing or screen.
- Do not allow the cleaning liquid to enter the monitor housing; be sure to dampen the cloth sparingly



Monitor Cleaning-GE



- **Frequency:** Daily/days when clinical image acquisition or reviews are planned

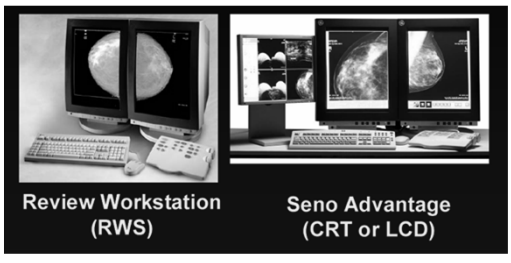
Viewing Conditions Check for RWS-GE

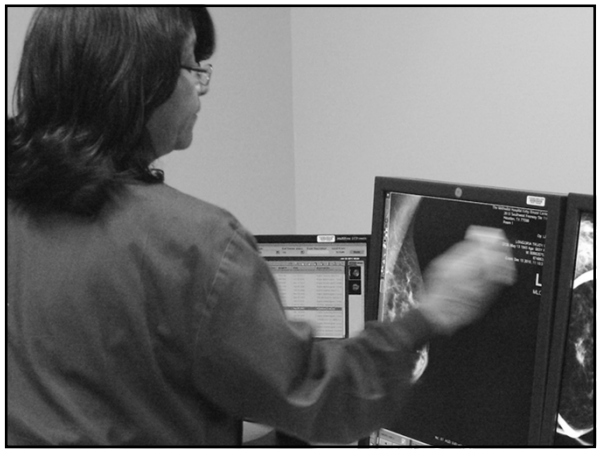
Frequency: Daily/days when image reviews are planned

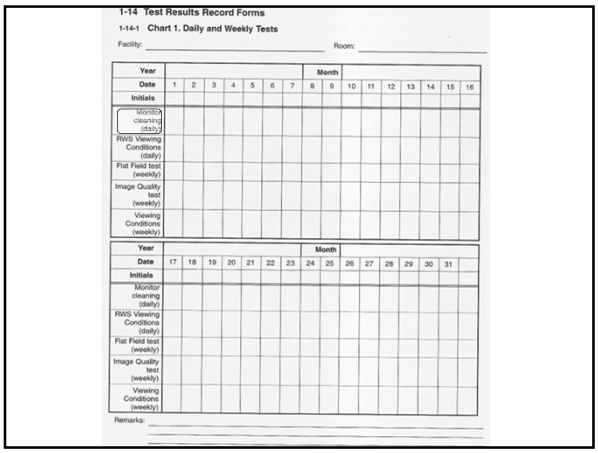
Objective: Ensure optimal viewing conditions

Monitor Cleaning

- Daily
- Ensures good image review conditions
- Lightly dampen cloth with water/solution
- Clean with cloth or cleaning tissue to remove dust, finger prints and other marks
- Record completion in book







1-14 Test Results Record Forms

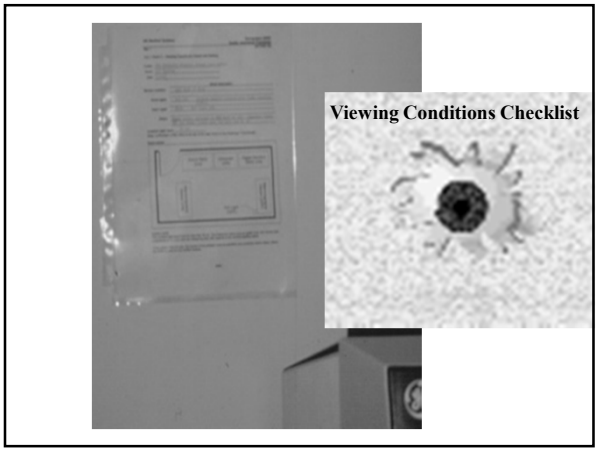
1-14-1 Chart 1. Daily and Weekly Tests

Facility: _____ Room: _____

Year								Month							
Date	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Initials																
Monitor cleaning (daily)																
RWS Viewing Conditions (daily)																
Flat Field test (weekly)																
Image Quality test (weekly)																
Viewing Conditions (weekly)																

Year								Month							
Date	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Initials															
Monitor cleaning (daily)															
RWS Viewing Conditions (daily)															
Flat Field test (weekly)															
Image Quality test (weekly)															
Viewing Conditions (weekly)															

Remarks: _____



Viewing Conditions Check For The Reading Rooms

- Each room has a data form that is filled out by the Medical Physicist for the room configuration.
- The medical physicist looks at the normal value of the ambient light in the room and measures it.
- If changes are made in the room such as small lamp, new doors, room curtains, blinds, etc…

MAMMOGRAPHY QUALITY CONTROL CHECKLIST – FULL-FIELD DIGITAL
GENERAL ELECTRIC MODEL: Pristina

Monthly, Quarterly, and Semi-Annual
(date, initial and enter number where appropriate)

Year / Month	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Acquisition Station Monitor Check (monthly)												
AOP and SNR Check (monthly)												
Visual Checklist (monthly)												
Repeat Analysis Check (52% change) (quarterly)												
Compression Force (25-45 lb) (semi-annually)												
AOP 3D Check - DBT (monthly)												
Review Workstation QC (See QC Manual)												
Film Printer (if applicable)												
Mobile Unit Quality Control (if applicable)												

Date: Test: Comments:

Flat Field-GE

- **Frequency:** Weekly
- **Objective:** Five tests performed during Flat Field test.
- 1)brightness uniformity, 2) high frequency modulation (HFM), 3) SNR uniformity, 4) bad ROI, 5) bad pixel verification.
- First day of week/ first thing in the morning- image receptor retains ghost images taken during the week.
- Technical factors-automatic
- Two exposures

Signal-to-noise ratio (SNR)

- Uniformity, which is the variation of the SNR over the whole image

Brightness Uniformity

- Checks the magnitude of low frequency structures or large shapes in defects

Bad Pixel Verification

- Measures the number of pixels having signals much different from those of their neighbors and the density of the bad pixels

High Frequency Modulation(HFM)

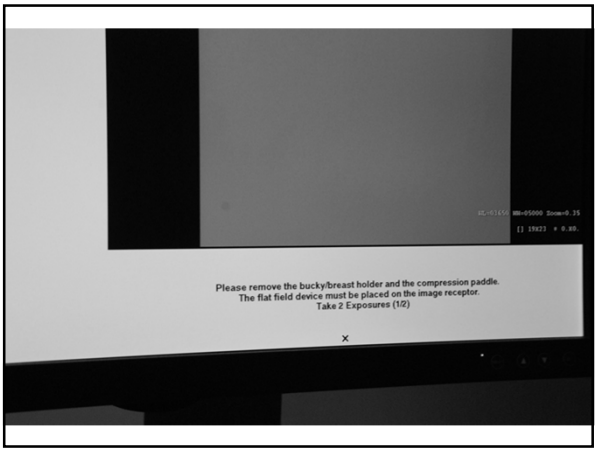
- Looks at the magnitude of high frequency structures or small defects

Bad Regions Of Interest (ROI)

- Counts the number of regions of interest containing more than two bad pixels

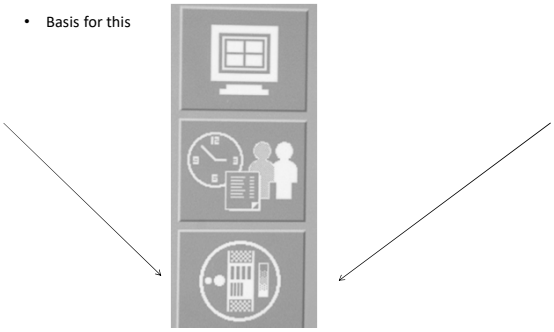
The Ideal response of the Detector is a uniform image with the following…

- No large or small defects
- No pixel having a signal much higher or much lower than its neighbors.
- A uniform signal-to-noise ratio



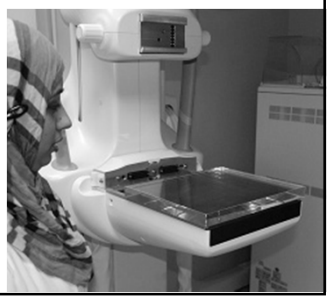
Start the Test By clicking on QAP button on Monitor

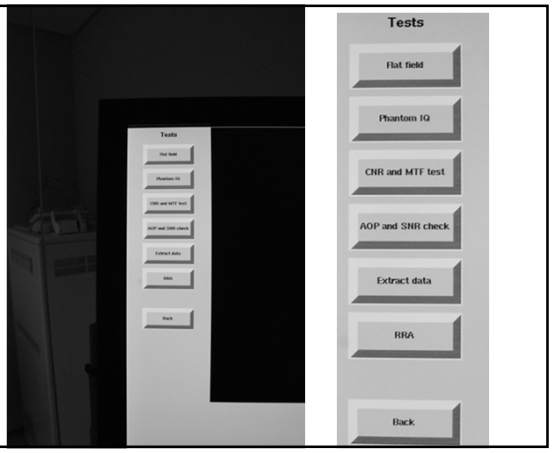
- Basis for this



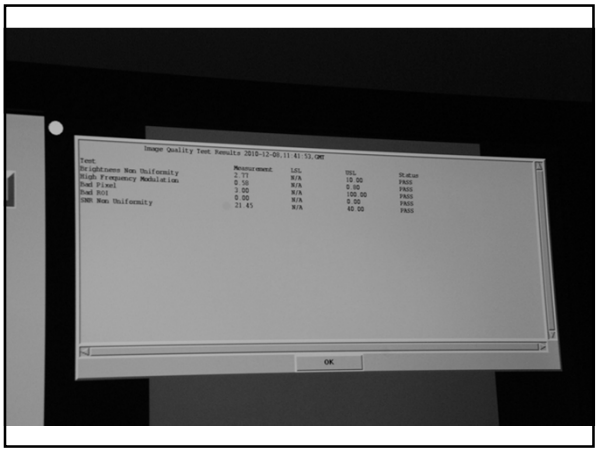
Flat Field-GE

Detector w/o grid





Flat Field Printed Image GE



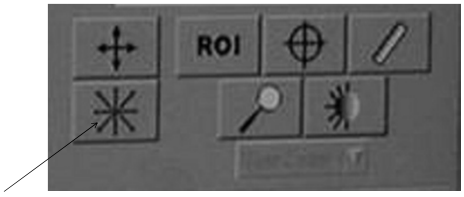
Artifact Evaluation

- Select the First Flat Field view from the examination screen window on the Acquisition Workstation.
- Acquired an exposure
- Make sure to change the Center and Width numbers to make it darker
- Do two exposures with Mo Filter and the second in Rhodium Filter or one with Rhodium filter and second image with Ag. Depends on what system you have.
- Pan across the whole image to look for artifacts. Move zoom/pan like your mowing the lawn.
- When image displays record the mAs value

If Test Fails look at the following…

- The compression paddle and grid cover have been removed
- No object except the Flat Field test object is in the field
- The collimator is open to the largest field size
- The tube arm angle is at "O" degrees
- The Flat field test object is clean and free from scratches or other imperfections
- The surface of the image receptor is clean
- The Flat Field test object fully covers the FOV of the image receptor

Activate the Full Zoom/pan function on the preview screen

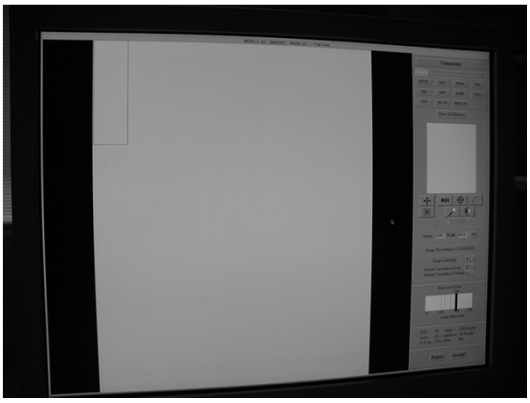


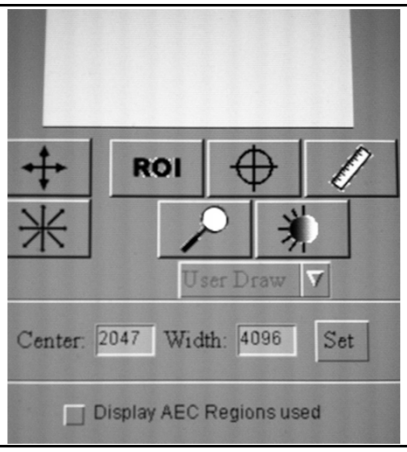
Artifact Evaluation-Hologic

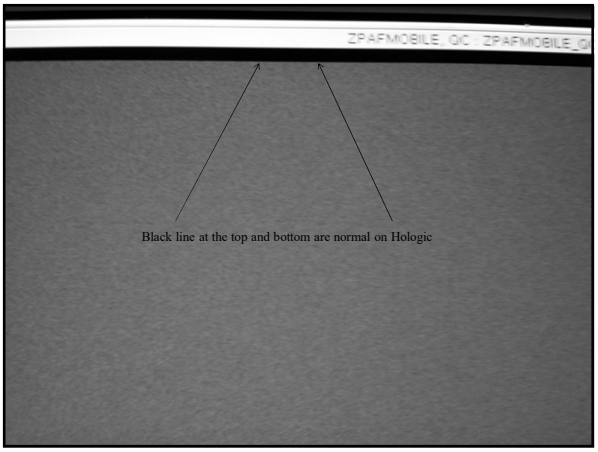
TO MAKE SURE THAT THE IMAGE IS FREE OF UNDESIRABLE ARTIFACTS

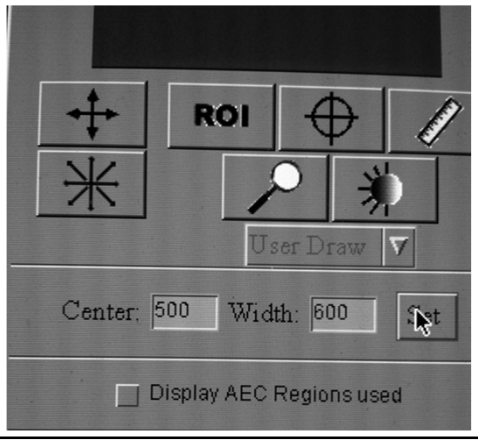
If you want to establish a Mean Pixel Value, click the ROI in preview tools and click User draw. Then choose 64 X 64 from the dropdown list. Click the center of the flat field image and the ROI Statistics dialog box will appear. Take the Mean Pixel Value with the first three numbers for a start for the Center Setting.

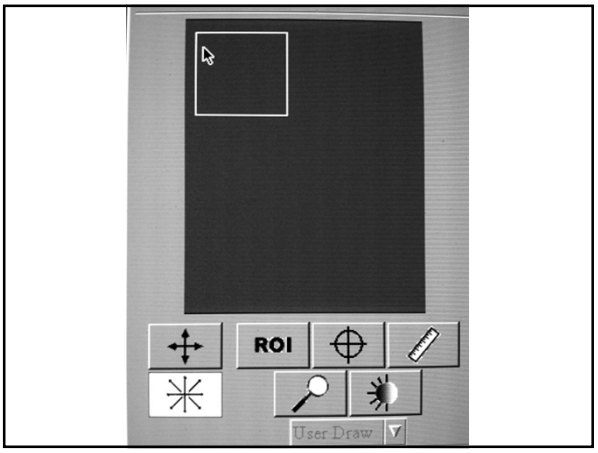
An average center number is around 500 and the average width setting is around 600. But make sure it isn't too dark or too light because there will be artifacts that are missed. So you want a dark gray look to the image

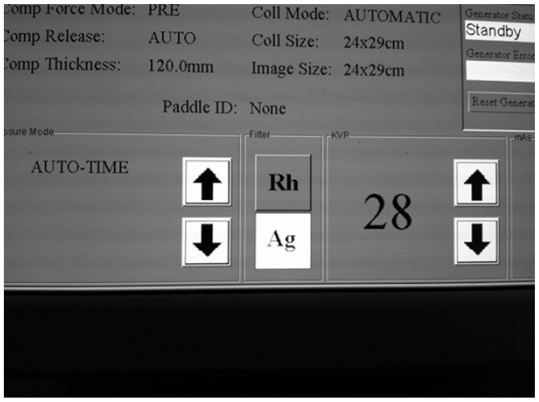






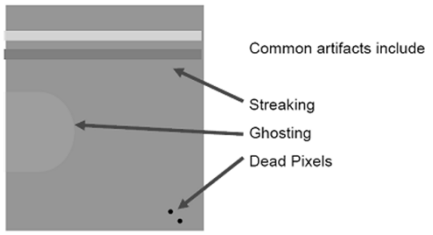


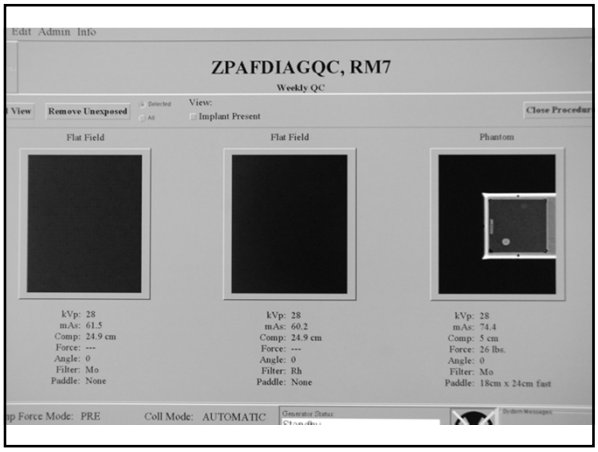




Weekly QC Tests – Hologic Selenia

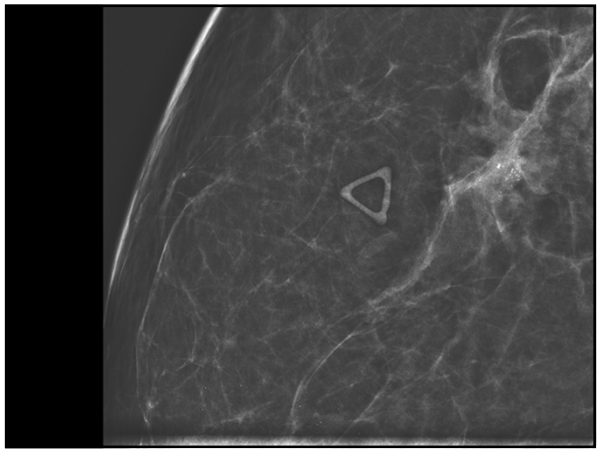
Artifact Evaluation – Detector

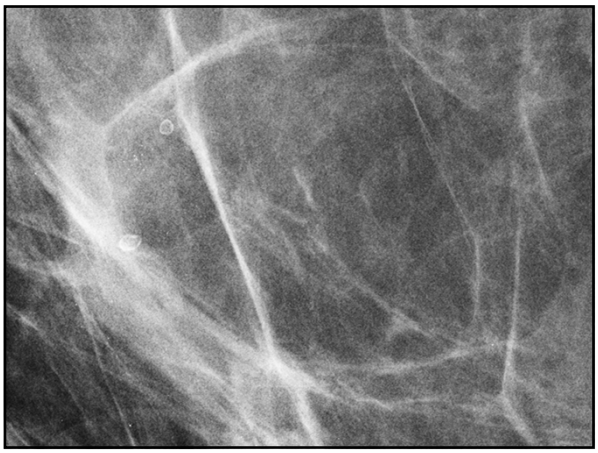


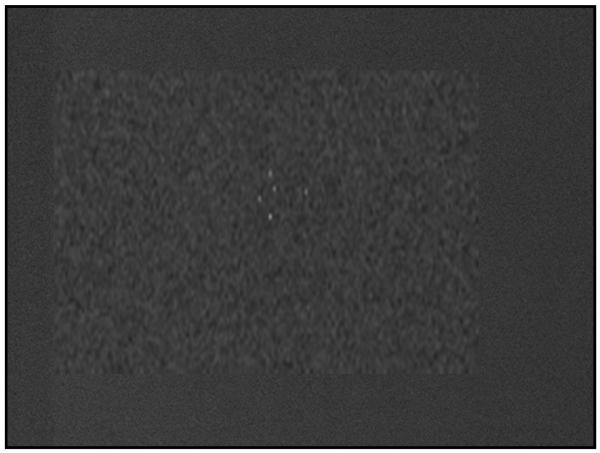


Case Study for
Flat field check……

- If artifacts are present rotate the acrylic 180° and repeat procedure
- If the appearance of the artifacts changes location between the two images they are in the acrylic phantom and there is not a system problem.
- If the artifacts persist in the same location there is a problem in either the x-ray system or the digital receptor

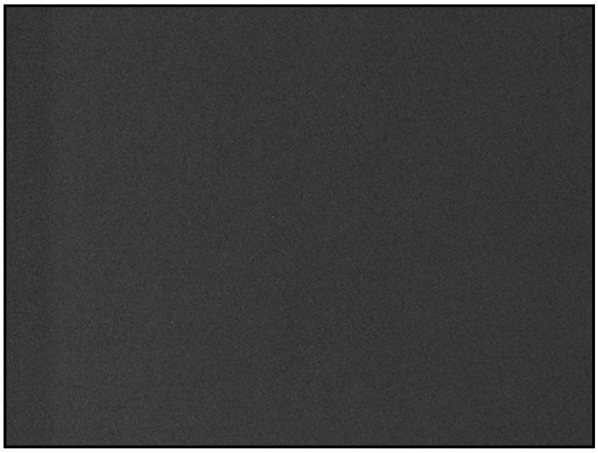




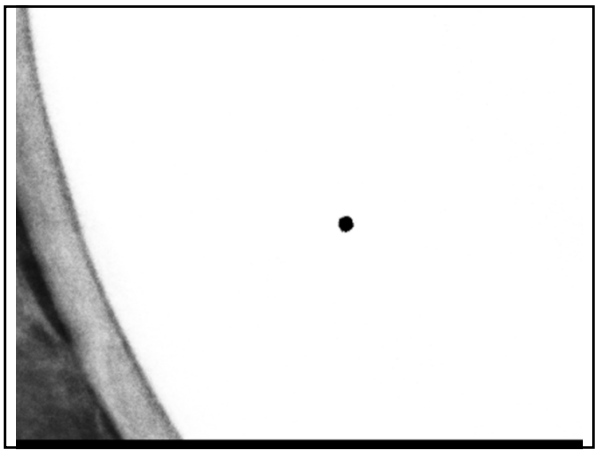


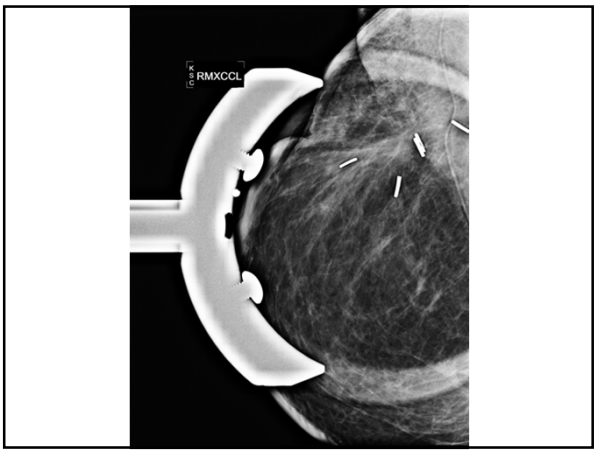
Performed a flat field test

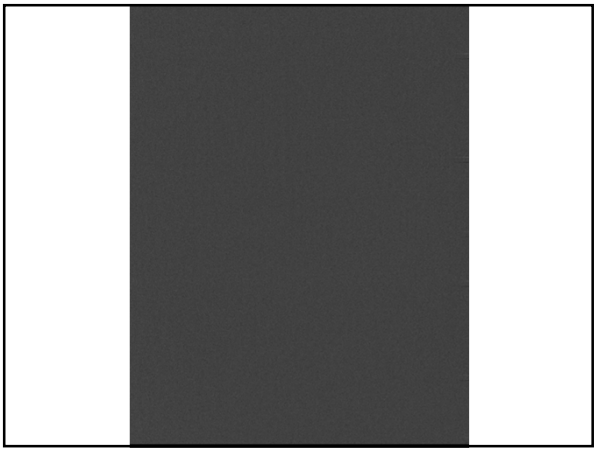
Results, Detector going bad. Had to replace it.
It wasn't reading all the pixel information

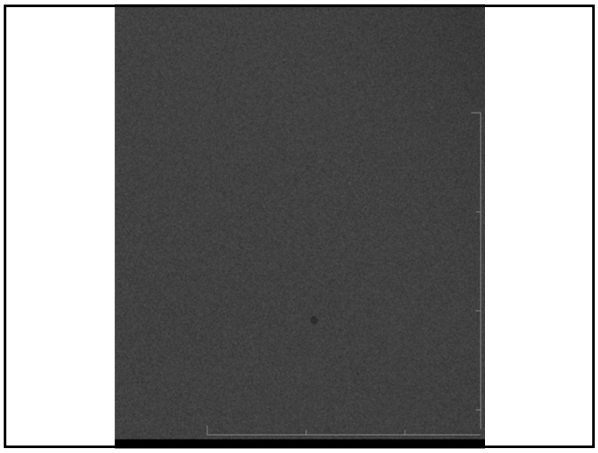


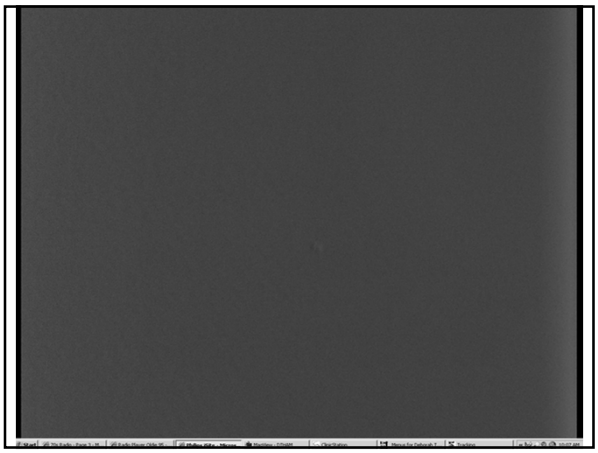
Another artifact with flatfield Test

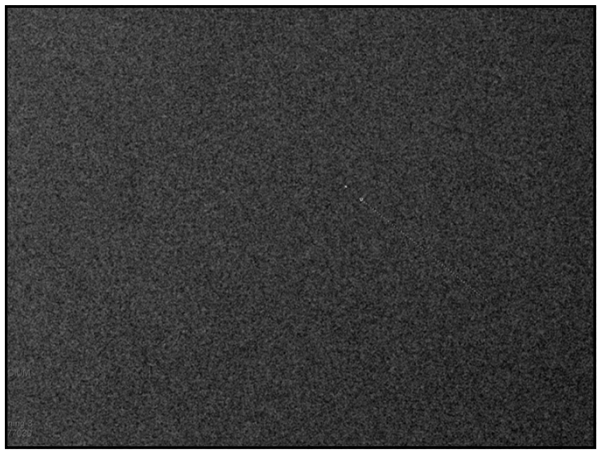



RMXCCL



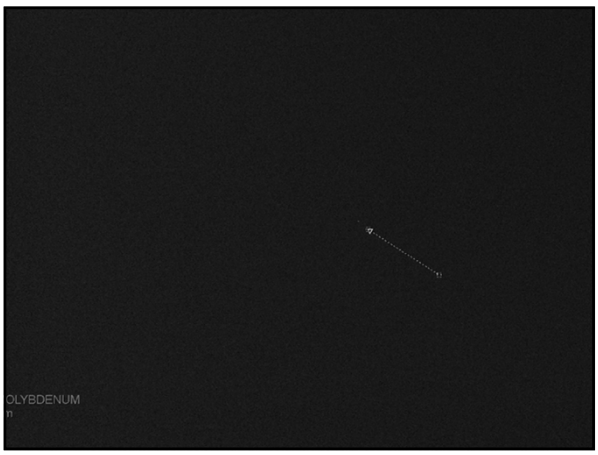


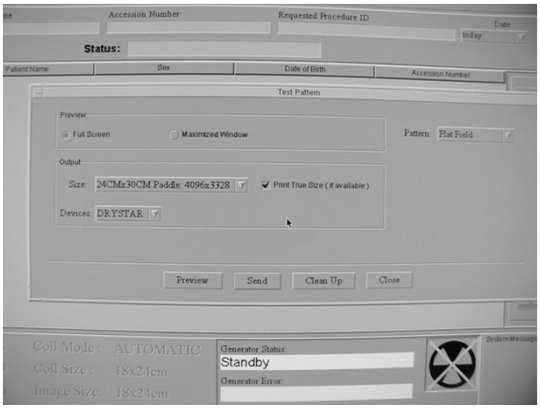


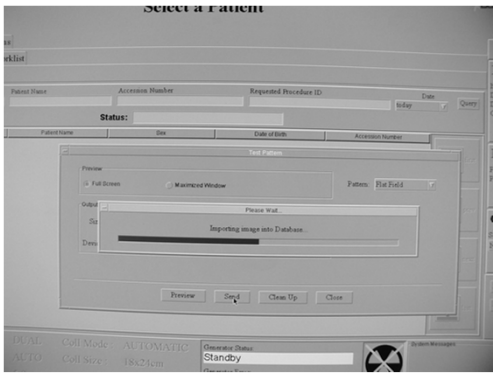


DICOM Printer Artifact Evaluation

- Print a flat field pattern to the printer. Do not take a flat field image is not appropriate for this test.
- Inspect the film for artifacts
- If multiple FFDM's only do this test from one of the machines and use the same machine every time for consistency.
- After you have looked for artifacts on the film, then record on the form.

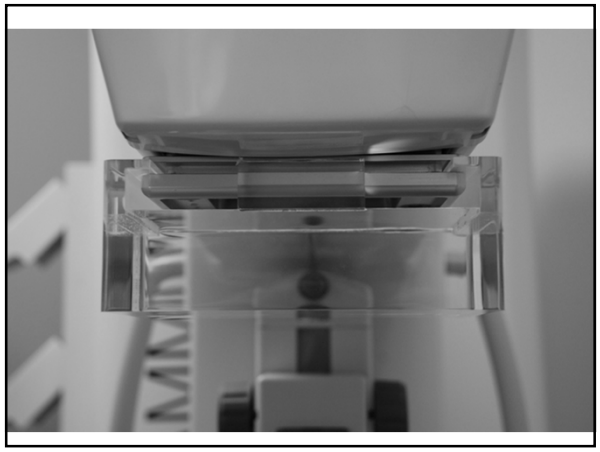






Performance Criteria

- Artifacts traced to the digital image receptor or the x-ray unit shall be eliminated by a qualified service engineer within 30 days of the test



Siemens Artifact Detection

Objective-to determine if the detector is dusty, damaged or has other artifacts

- Insert collimator mounted plexi phantom (40 mm thick)
- Insert compression plate simulator
- Choose procedure QC raw
- 28 kVp 90 mAs
- Look at image for clinical relevant artifacts by magnifying to full resolution
- If the image has artifacts do calibration and repeat

Phantom Image Quality on AWS, RWS, and Printer and CNR Test-GE

- **Frequency:** Weekly after establishing the baseline for the Contrast-to-Noise Ratio (CNR) test.
- Only after successful completion of the Flat Field test.
- Phantom Image quality test of the printer-run only after successful completion of the daily QC test for the printer

Analog Phantom QC/Digital Phantom QC Differences

- In film-screen mammography imaging systems the phantom image test is for the consistency of image contrast as represented by the density difference (DD) between the image of an added test object (4mm thick acrylic disk) and the background density of the phantom.

Phantom Image Quality

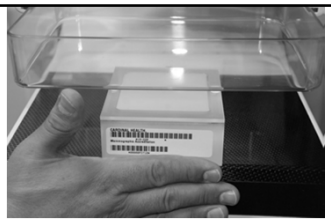
- Objective: CNR (Contrast to Noise Ratio) is a measure of the detectors ability to distinguish between objects in an image and the image noise
- Ensure adequate/consistent quality of images acquired by the detector and displayed on the AWS and RWS monitors and the printer.

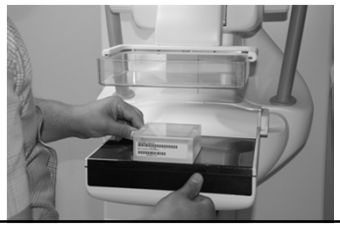
Analog Phantom QC/Digital Phantom QC Differences

- In GE's digital imaging the relative level of A signal or contrast to the image noise is the more relevant measure of image quality. Therefore, the measure of consistency of CNR is used as a replacement for the measure of consistency of DD that was in film/screen

GE

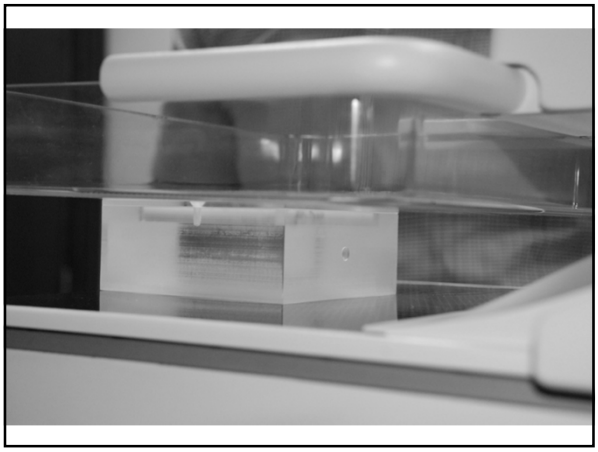
Image Acquisition
Image acquired on the AWS.

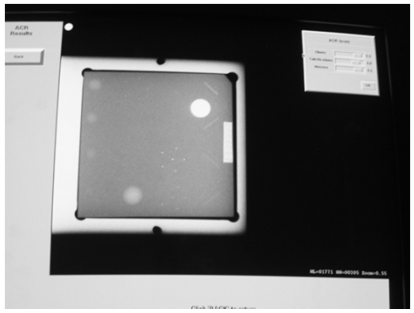




CNR

- **The following events require re-establishment of the CNRoI:**
- replacement of the x-ray tube
- replacement of the Mo x-ray beam filter
- replacement of the compression paddle
- replacement of the phantom
- replacement of the anti-scatter grid
- replacement of the detector
- re-calibration of detector gain





Open Raw Image of the Phantom

- **B. Change in CNR Measurement**

- Operating level for the CNR ratio measurement must be established, CNR_{ol}.
- 5 consecutive days to determine a 5 day average and a CNR operating level.
- Subsequent weekly measurements are compared to this operating level.

Why the raw image?

- Tests depend on using numerical values that are proportional to the amount of x-rays detected.
- Raw images provide image numbers that behave in the above manner.
- Processed images are good for viewing but are useless for the numerical tests.
- The values used are ones that best represent the incidental x-ray beam and the response of the detector when raw image is used.

CNR

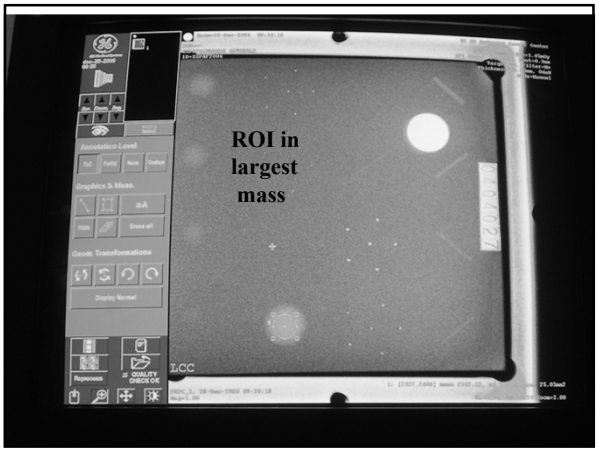
- **B. CNR measurement change continued**
- **Open the acquired raw image, zoom factor of 1, adjust the WW and WL between 125 and 175 to achieve the best contrast/object detectability.**

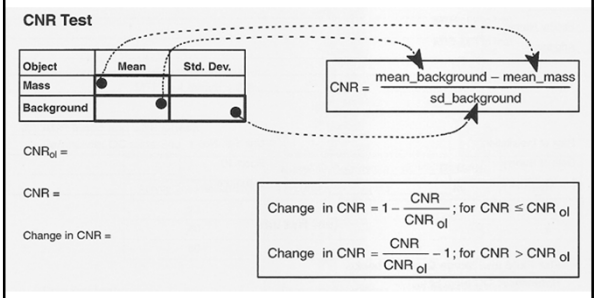
Raw Image

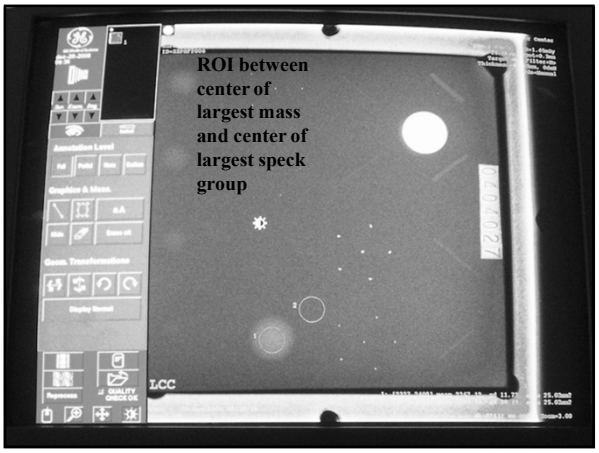
Adjusted Image

CNR

- **Now do the math:**
- Calculate the CNR as
- (mean_background-mean_mass)/sd-background
- Calculate the change in the CNR:
- If the new CNR is smaller than or equal to the CNR operating level (CNR_{ol}), then calculate :
- Change in CNR=1-(CNR/CNR_{ol})
- If the new CNR is larger than the CNR operating level (CNR_{ol}), then calculate
- Change in CNR=(CNR/CNR_{ol})-1







- Example:
- CNR_{ol} = 3.92
- Mean_mass = 921.26
- Mean_background= 969.43
- sd_background=12.01
- (mean_background-mean_mass)/sd-background
- 969.43-921.26=48.17 = 4.01
- 12.01
- Change in CNR=(CNR/CNR_{ol})-1
- 4.01 - 1 = .02 change in CNR
- 3.92

Why use the number 1 in the formulas

- Change if less in CNR=1-(CNR/CNR_{ol})
- Change if more in CNR=(CNR/CNR_{ol})-1

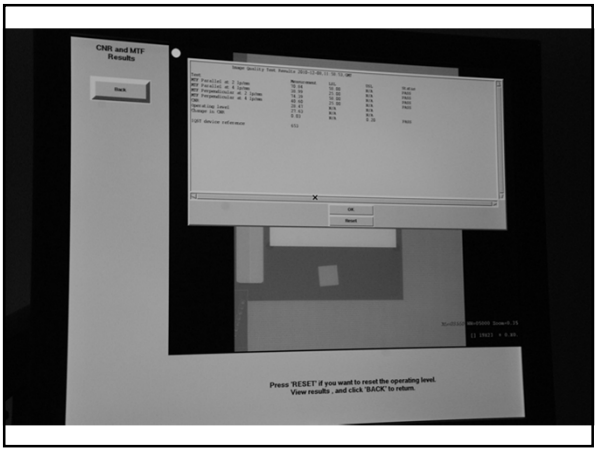
So you end up with a whole positive number

- **Action Limit:**
- The change in CNR must not exceed 0.2
- System fails- the source of the problem must be identified and corrective action taken before any further examinations are performed.
- Passes-proceed to next step…… ⇨

Contrast to Noise

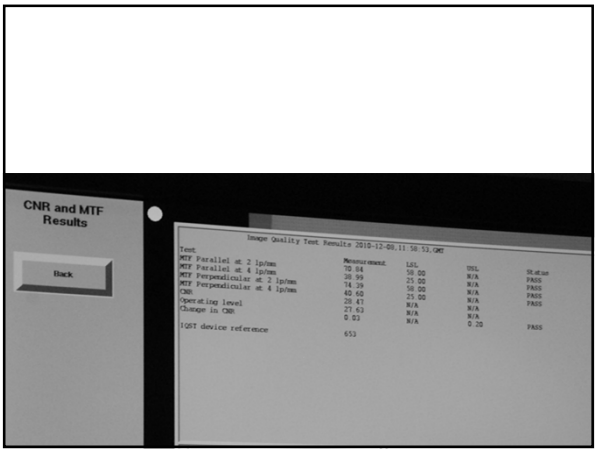
- Define contrast to be the signal difference between two tissues A and B

  CAB=SA-SB
- We are assuming that SA > SB so that contrast is always positive.

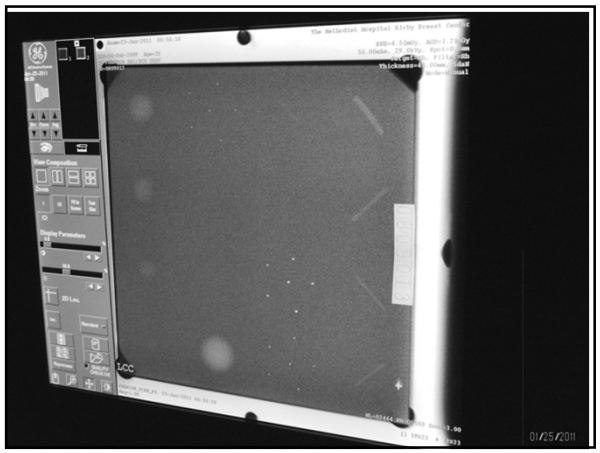


Mean

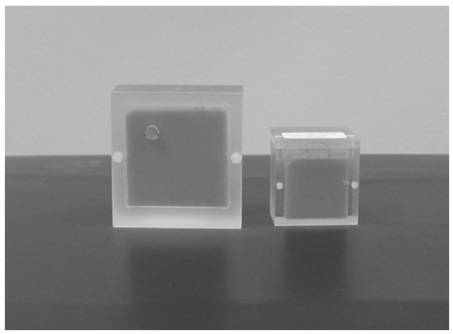
- An average of a group of numbers or data points.

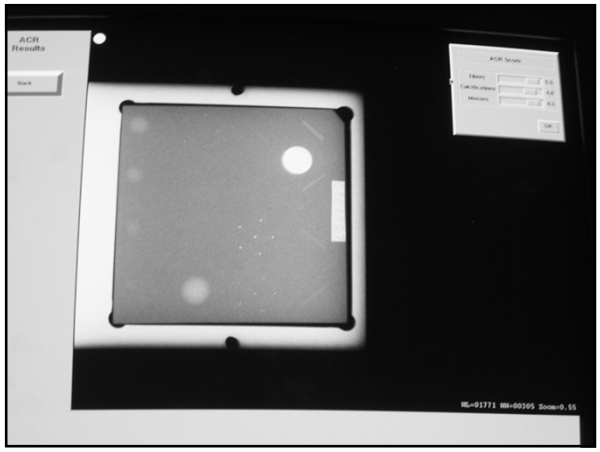


Phantom Image Quality	Phantom Used:										
AWS											
Zoom											
Window Width(WW)											
Window Level (WL)											
No. of fibers											
No. of speck groups											
No. of masses											
Contrast--to--Noise Ratio(CNR)											
Change in CNR											



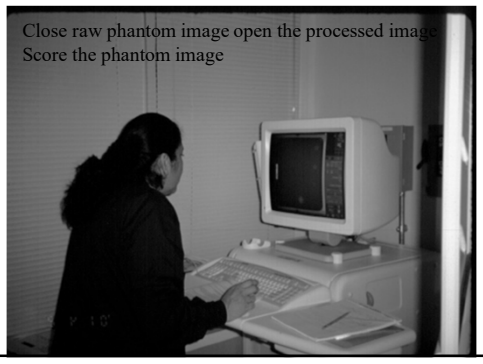
Phantoms

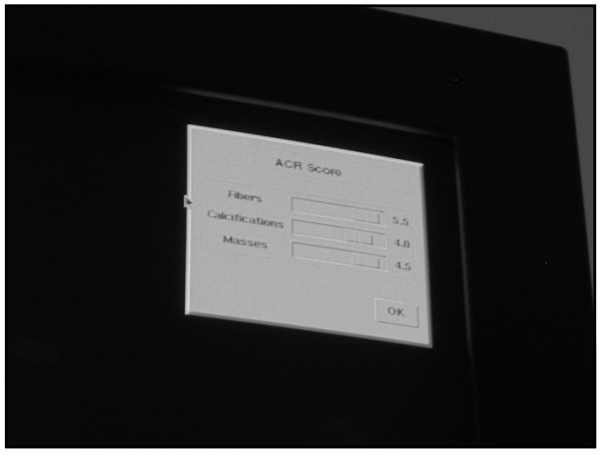




Phantom IQ Test on AWS

Close raw phantom image open the processed image
Score the phantom image





How do you score the Phantom

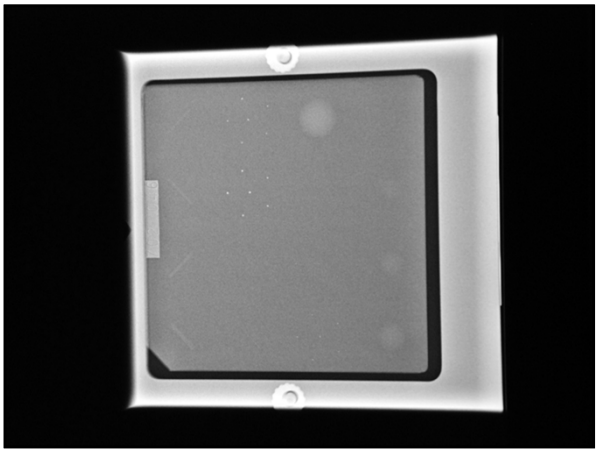
Phantom Hardcopy

- Background density center of phantom no less than 1.20 if CR
- Density difference in disc and adjacent to disk and subtract
- Plot on chart and plot mAs
- Score subtracting for artifacts

1. When scoring the image of one of the ACR-approved accreditation phantoms, e.g., Radiation Measurement, Inc. (RMI 156) or Nuclear Associates (18-220), each object type is scored separately. Always count the number of visible objects from the largest object of a given type (i.e., fiber, speck group, or mass) downward until a score of 0 or 0.5 is reached, then stop counting for that object type.
2. Count each fiber as one point if the full length of the fiber is visible and the location and orientation of the fiber are correct. Count a fiber as 0.5 point if not all, but more than half, of the fiber is visible, and its location and orientation are correct. Add each full or partial fiber to the total score, from largest down to smallest visible, until a score of 0 or 0.5 is reached (Figure 9A).
3. After determining the last fiber to be counted, look at the overall background for artifacts. If a fiber-like artifact appears anywhere in the wax insert area of the image, but not in an appropriate location or orientation, deduct the "artifactual" fiber from the last "real" half or whole fiber scored if the artifactual fiber is equally or more apparent. Deduct only from the last real fiber, not from additional fibers. (Figures 9A and B). Record the final score after artifact deduction in the appropriate space on the chart (Figure 7A).
4. Use a large field-of-view magnifying lens (approximately 2× or higher) to assist in the visualization of specks. Starting with the largest speck group, count each speck group as 1 point if four or more of the six specks in the group are visible in the proper locations. Count a speck group as 0.5 if two or three of the six specks in the group are visible in the proper locations. Add each full or partial speck group to the total speck group score, from largest down to smallest visible group, until a score of 0 or 0.5 is reached (Figure 9C).

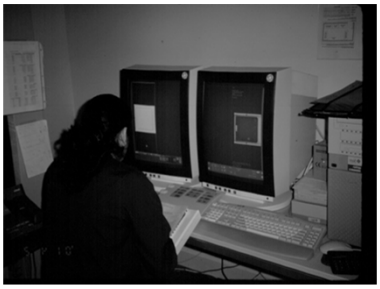
GE Senographe DS and Essential Phantom Scoring

- Only on AWS



GE

Phantom Scoring on Review Workstation



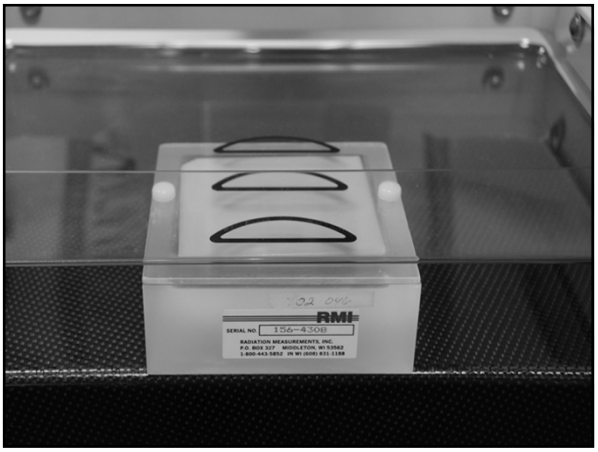
Phantom IQ Test on The Printer

- **Action Limit:**
- Fibers-4
- Masses-3
- Calcifications-3
- less than above-failed
- Identify source of problem
- Corrective action taken before any further examinations are performed.

Siemens Phantom-<u>Daily</u>

Objective-to ensure that adequate image quality is achieved

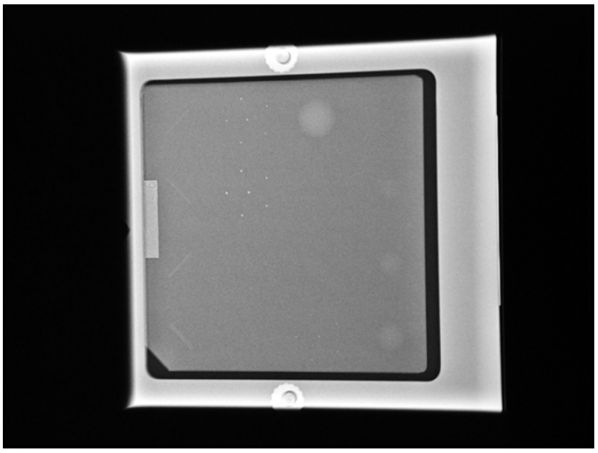
- Phantom-no disk
- Record mAs
- Program 4.5cm breast technique
- Score on monitor
- If there is a problem send it to the review workstation and printer and examine.



Performance Criteria

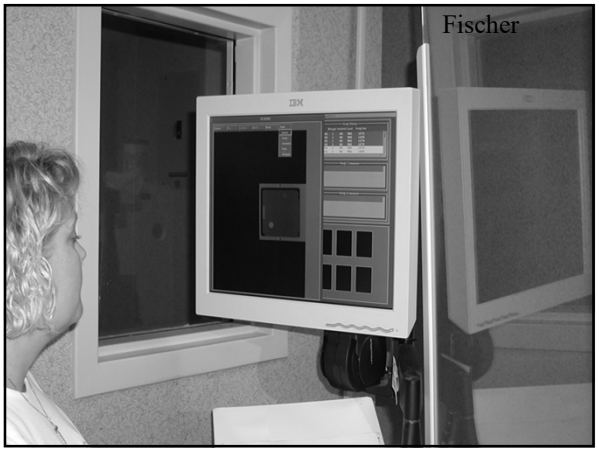
- Must score 5-4-4

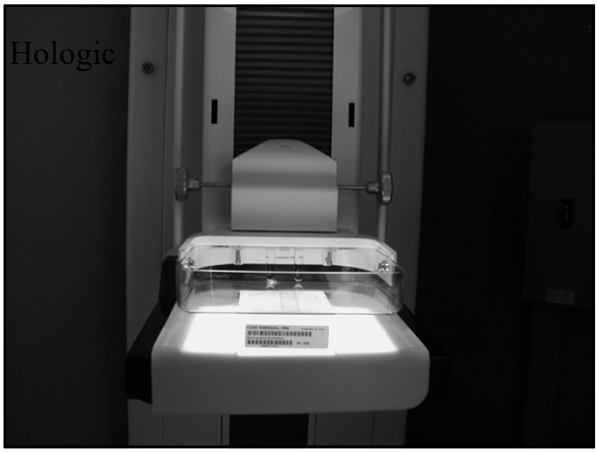
Correction required before examinations if failed

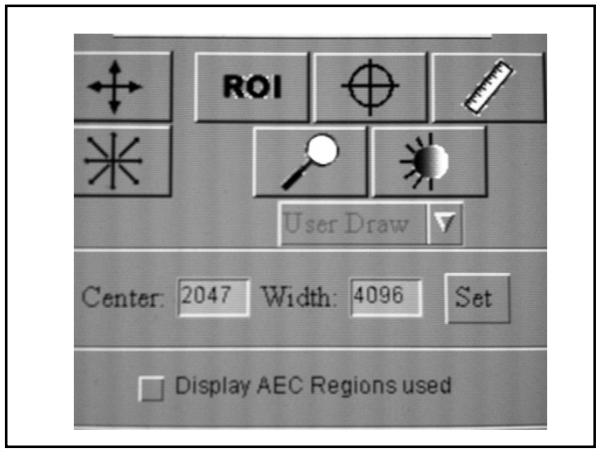


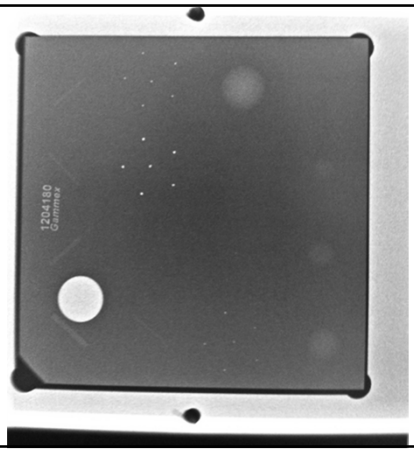

Fischer
Procedure:
Phantom and disk imaged


AUTO
AEC
22
5.0
NEWTONS/LBS
CM


Fischer

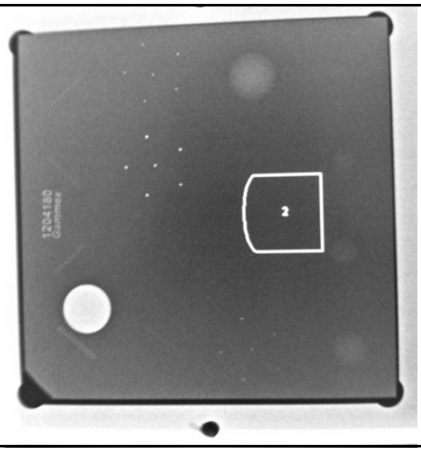

Hologic


ROI
User Draw
Center: 2047
Width: 4096
Set
Display AEC Regions used



Signal to Noise

- The power ratio between a signal (meaningful information) and the background noise.
- Both signal and noise power must be measured at the same or equivalent points in the system and within the same bandwidth (width or range of frequencies that an electronic signal uses on a given transmission medium).



Signal to Noise

- Bandwidth-in computer networks it is a synonym for data transfer rate-the amount of data than can be carried from one point to another in a given time period (bits of data per second).
- SNR=the ratio of the mean pixel value to the standard deviation of the pixel values.

SNR

- Lets talk about SNR
- Remember what SNR is – Signal to noise Ratio compares the level of the desired signal to the level of background noise.

Standard Deviation

- In statistics-(the number you get for the standard deviation is considered statistics) a measure of how much the data in a certain collection are scattered around the mean.

Siemens SNR and CNR

Objective-to assure proper functioning of the solid-state detector by evaluating the SNR and the CNR of the detector

Use the baseline values for SNR and CNR for weekly testing consistency

.

Signal-to-Noise and Contrast-to-Noise Measurements-Hologic

- **Frequency: weekly**
- Objective: To assure consistency of the digital image receptor
- SNR (Signal to Noise Ratio) compares the level of the desired signal to the level of background noise
- phantom and disk
- 18x24 compression paddle-on phantom as close to 4.5 cm as possible
- Use clinically used exposure factors: (i.e. Auto Filter)

Siemens SNR and CNR

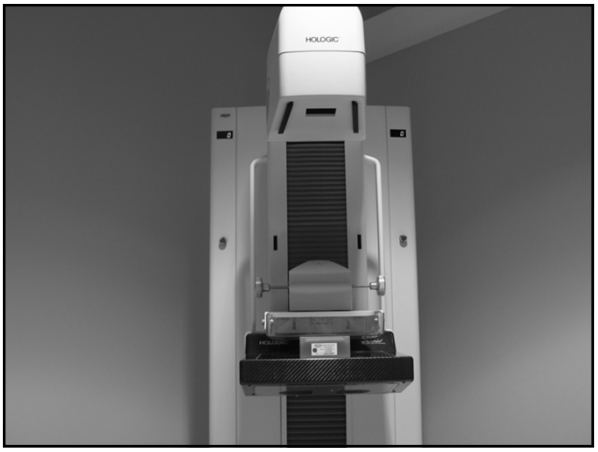
- Choose procedure QC raw
- Compress phantom
- Program 2-4.5 cm average breast technique
- Select AEC sensor 2 at the AWS
- Acquire phantom image
- Draw ROI in largest mass and record mean value
- Draw ROI in background and record mean value and standard deviation

Calculate:

$$SNR = \frac{\text{mean (bg)} - \text{DC (offset-always 50)}}{\text{std (bg)}}$$

Calculate:

CNR= (mean_background-mean_mass)/sd-background



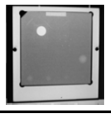
Performance Criteria

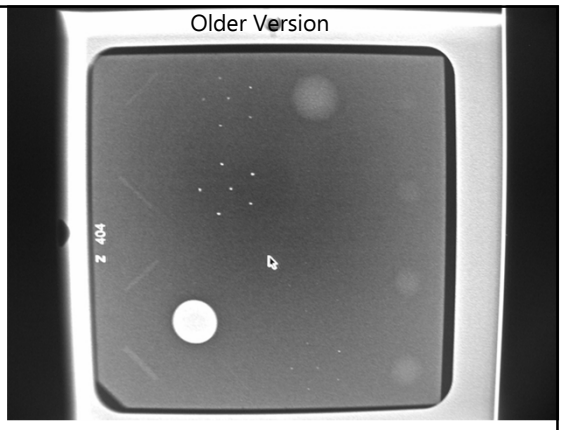
SNR ≥ 40

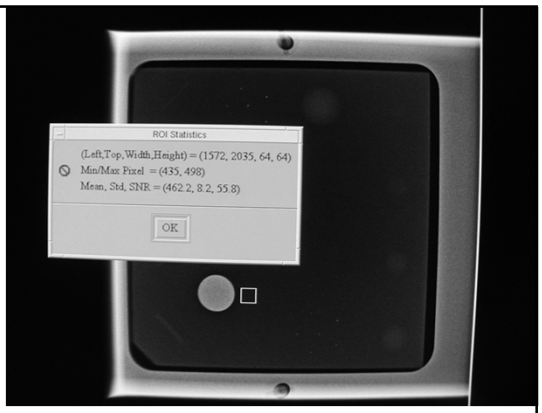
Deviation SNR ± 15%

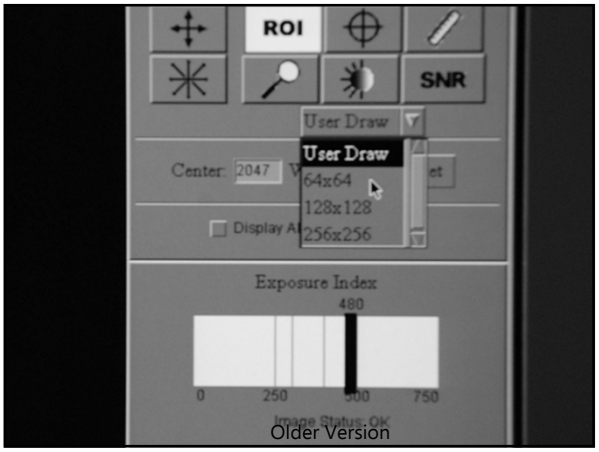
Deviation CNR ± 15%

SNR and CNR Lorad

- Phantom image will appear on monitor.
- ROI over disk slightly smaller than the disk-record Mean Value (Mean)
- Drag the previously drawn ROI next to the disk toward the chest wall-record the Mean Value (Mean) and standard deviation (STD). Do not use the Signal-to-Noise ratio given by the ROI statistics box.
- Accept Image…….. 







The SNR shall be computed using the mean and standard deviation values obtained from the ROI next to the acrylic disk.

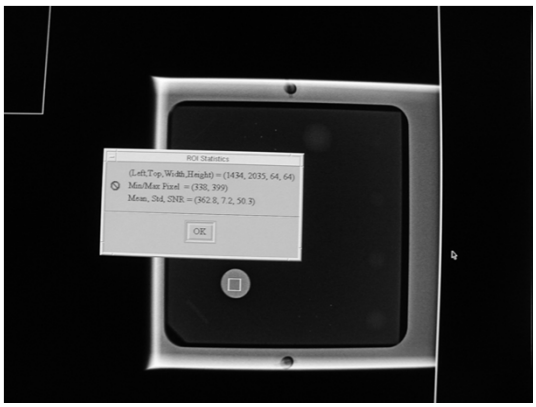
1. Compute the SNR of the detector according to:

SNR =

$$\frac{\text{mean background - DC offset}}{\text{std deviation}}$$

mean background and std background=the mean and standard deviation obtained from the ROI statistics dialog for the ROI next to the acrylic disk.

DC offset is a DC offset added to the detector signal and is equal to 50.



CNR = _____

2. Compute the CNR of the detector according to:

$$\frac{\text{mean } \textit{background} - \text{mean } \textit{disk}}{\text{std } \textit{background}}$$

mean disk= the mean value obtained from the ROI statistics dialog for the ROI on the acrylic disk.

3. Compute the deviation from the original CNR measurements according to:

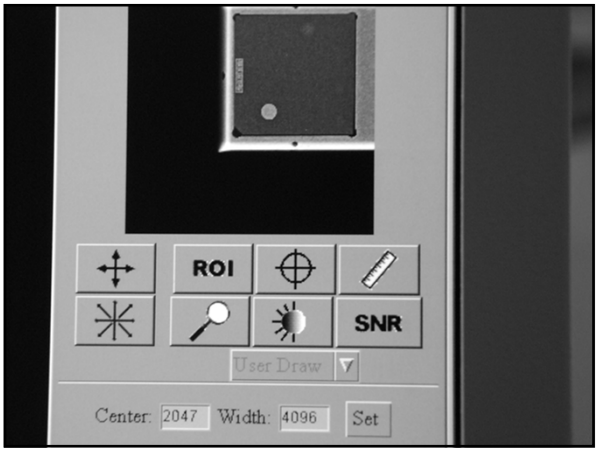
$$\frac{\text{CNR } \textit{base} - \text{CNR } \textit{measured}}{\text{CNR } \textit{base}} \times 100$$

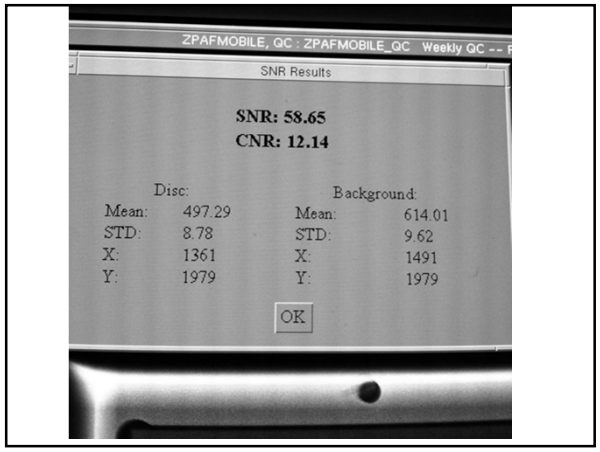
CNR base=the CNR base value established by the medical physicist during acceptance testing of the digital detector

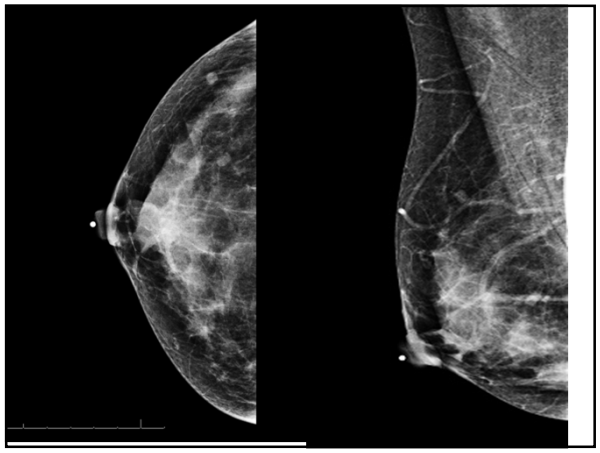
This is recorded in the Signal-to-Noise Ratio (SNR) and Contrast-to-Noise Ratio (CNR) Control Chart

CNR *measured* is the new CNR computed in step 2.

Now with the updated version SNR is automatic with the SNR button on monitor







SNR and CNR

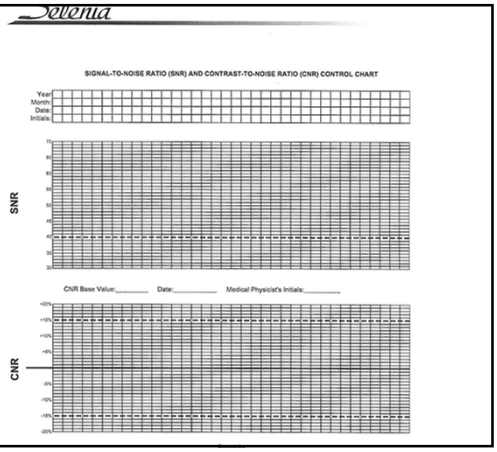
- Performance Criteria

The measured SNR must be equal to or greater then 40.

The computed CNR must be within ± 15% of the value determined by the medical physicist

Noise

- Radiographic noise or mottle
  - –The unwanted random (uncorrelated), nonrandom (correlated), or static level in a radiograph that has been given a uniform x-ray exposure



Noise – Quantum Mottle

- The random spatial variation of x-ray absorbed in the image receptor
- Fewer x-rays = ↑ noise or ↓ SNR & ↓ visibility of subtle contrasts
- Microcalcifications that can be the first sign of cancer may not be visible in a noisy or underexposed image

Noise

Noise – SNR & DQE

- The ratio of the magnitude of the image signal to the noise
- Detective quantum efficiency
  - –SNR transfer efficiency (good information transfer)
  - –High DQE – good information transfer & more dose efficient
  - –Low DQE – poor information transfer & less dose efficient

Noise – SDNR

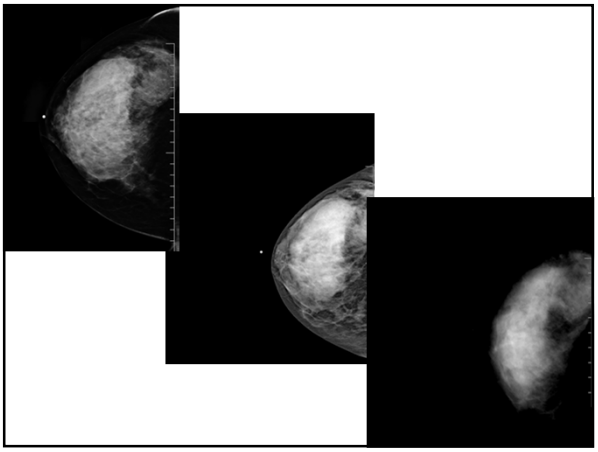
- SDNR
  - Signal difference-to-noise ratio
  - A measure of the difference between a signal & its background divided by the noise
  - Indicator of reliably depicting a structure in the breast in the presence of noise
  - Radiation dose depends on desired SDNR

Spatial Resolution

- The ability of an imaging system to allow 2 adjacent structures to be visualized as being separate, or the distinctness of an edge of the image (ie. Sharpness)

Viewbox and Viewing Conditions

- **Frequency:**
- Weekly
- **Objective:**
- To ensure good image review conditions by keeping the viewboxes free of dust, finger prints, and other marks and the viewing conditions optimized.
- **Procedure:**
- This test is not unique to digital mammography systems.
- Follow accepted mammographic QC procedures
- and action limits to complete this test.



Spatial Resolution

High Contrast

Spatial Resolution

- Loss most easily observed when imaging fine detail
  - Speculations radiating from a mass
  - Microcalcifications

Spatial Resolution - Qualitative Measurement

- Achieved with a bar pattern of alternating radio-opaque "bars" & radiolucent "spaces" of equal width
- Determines limiting resolution in lp/distance or lp/mm

Spatial Resolution – Detector Specific Blurring

- Direct flat panel detectors
  - Voltage or electric field across the direct conversion material must be adequate

Spatial Resolution – Geometric Blurring

- Minimized by using small FS for contact imaging (e.g., 0.3 nominal size)
- Minimized by using an even smaller FS for magnification (e.g., 0.1 nominal size)
- Minimized by ↓ OID as much as possible
- ↑ SID (e.g., 60-65 cm)(70cm dimension)

Spatial Resolution – Motion Blurring

- Caused by movement of the breast during exposure
- Minimized by
  - Short exposure time
  - Compressing the breast

Spatial Resolution – Detector Specific Blurring

- Occurs in x-ray converter material
- Scintillator-based converters
  - First source of blur = spreading of emitted light within the scintillator material
  - Determined by
    - Material thickness
    - Crystal structure
    - Reflective & absorptive properties

Spatial Resolution – Motion Blurring

- kVp may be ↑ to ↓ exposure time
  - Image processing compensates for contrast losses to the extent allowed by
    - Background noise
    - Image SNR

Spatial Resolution – Motion Blurring

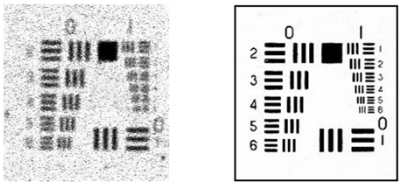
- SSCCD - scan slot charge-coupled device systems
  - –Misregistration artifacts between the anatomy imaged before motion occurs & that imaged after

MTF Measurement-GE

- Contrast is evaluated by measuring the fluctuation of a bar pattern signal in a region of interest.
- The bar pattern provides a signal to the detector, which is essentially alternating bars and spaces.
- The test determines how close to black the signal at the position of the bars is and how close to white the signal at the position of the spaces is.

Spatial Resolution – Motion Blurring

- Movement of the breast during exposure
- Minimized by a short exposure time & compression



MTF Measurement-GE

- **Frequency:**
- Monthly (only after successful completion of the Flat Field Test)
- **Objective:** Monitor the contrast delivered by the detector
- Ensure contrast is adequate over the 0-5 lp/mm spatial frequency range by obtaining an estimate of the MTF (Modulation Transfer Function) values near 2 and 4 lp/mm.

MTF Measurement-GE

- The closer the output signal is to black and white, the more contrast there is in the image and the more variation is recorded in the region of interest during the MTF Test.

MTF Measurement-GE

- Spatial resolution is the ability to see the difference in detail between adjoining objects, which is why we look at the spatial frequency groups. Attention is given to both low and high spatial frequency,
- Contrast at low spatial frequencies, which we measure at 2 lp/mm, aids in detection of masses and fibers.
- Contrast at high spatial frequencies, which we measure at 4 lp/mm, aids in detection of microcalcifications.
- The greater the signal fluctuation, the greater

MTF Measurement-GE-2000D

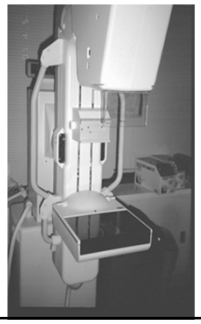
- **Procedure:**
- Resolution bar pattern including spatial frequency groups of 2 ± 0.1 and 4 ± 0.1 lp/mm and a thickness of at least 0.1 mm of lead.
- Positioning the pattern on the bucky and expose using the supplied technical factors.
- Measurements made on "raw image"
- Zoom image to 1, adjust the brightness and contrast for optimum visibility of the test object.
- Using the ellipse tool, measurements are made.

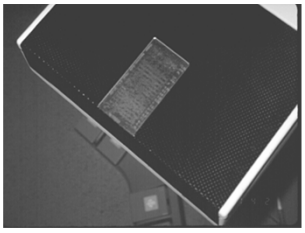
MTF Measurement-GE

- 100 micron => 5 lp/mm
- 70 micron => 7.14 lp/mm
- 54 micron / standard resolution => 9.26 lp/mm
- 27 micron => 18.5 lp/mm

- Film screen 15 lp/mm and film screen mag is 18 lp/mm

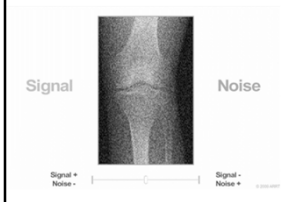
GE



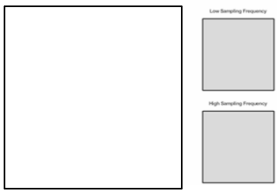


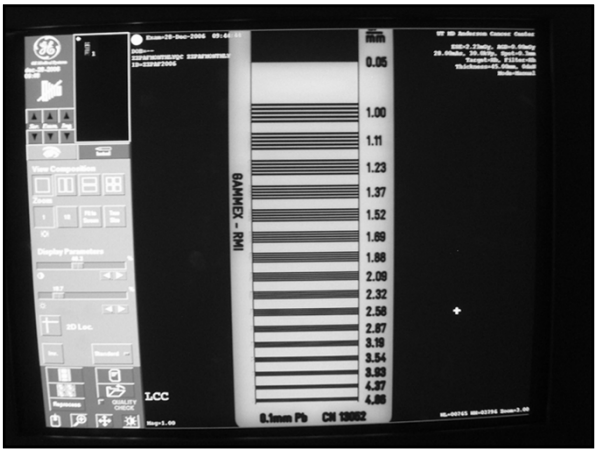
MTF Measurement

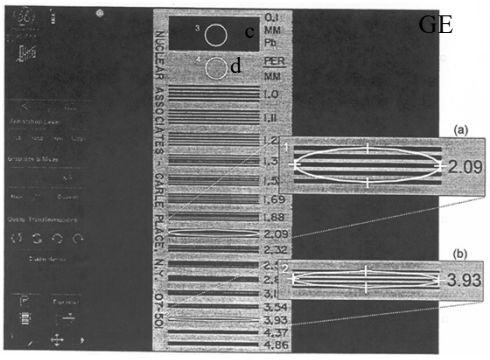
When pixel size decreases
Spatial resolution improves
but the Noise increases
SNR decreases



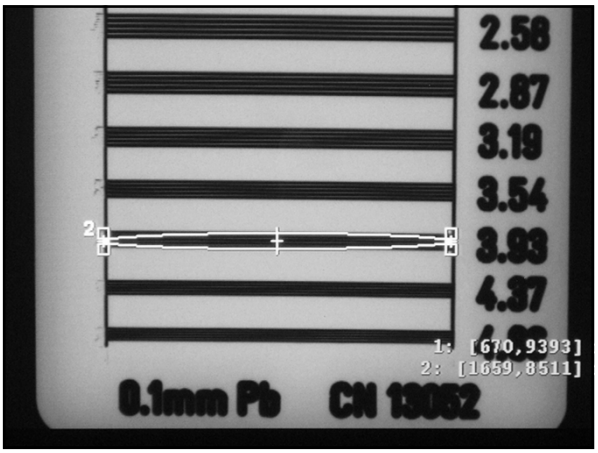
Example Noise





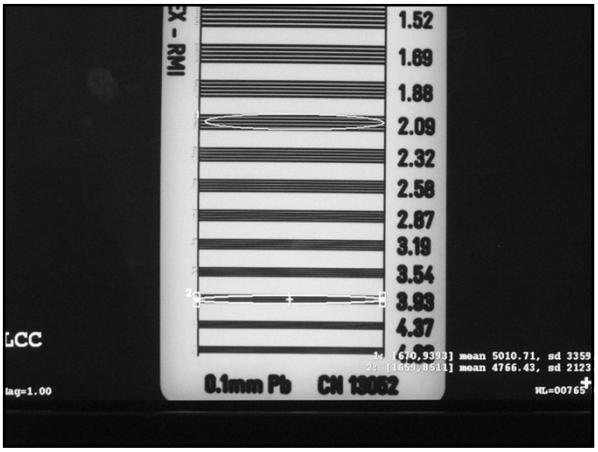


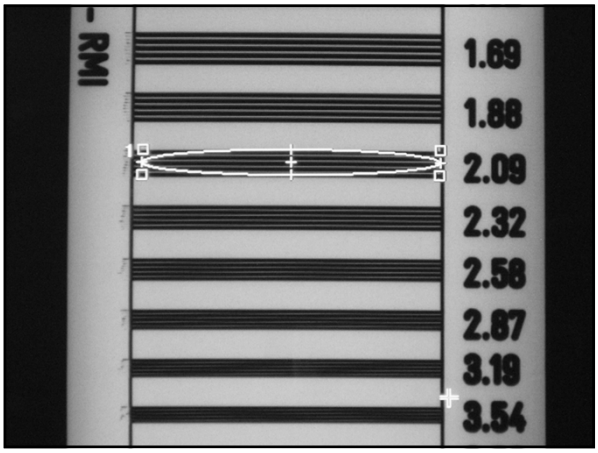
a. 2 lp/mm b. 4 lp/mm c. space d. bar

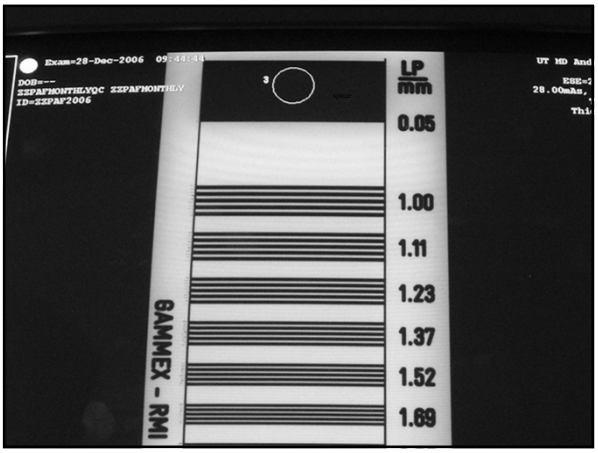


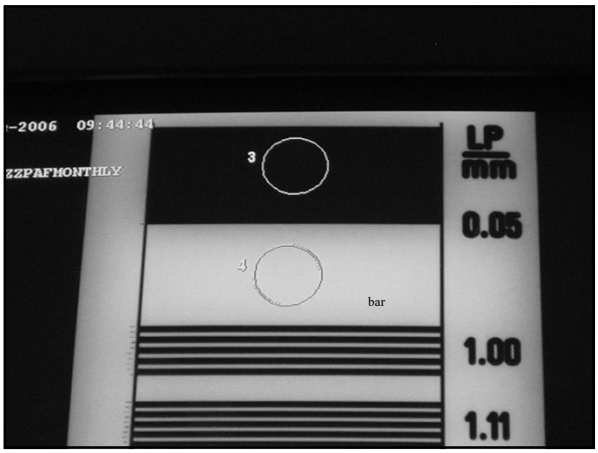
MTF Measurement-GE

- Measurements:
- "2 lp/mm" pattern
- "4 lp/mm" pattern
- "space" material-mean_space
- "bar" material-mean_bar
- A line pair consists of two elements-a bar and a space. The bar is the highly attenuating element and the space is the low-attenuating element.
-









MTF Measurement Test

- Example:
- Estimate the MTF expressed in % at 2 lp/mm:
- 2lp/mm
- 3335.74 (sd) X 222 = 740534.28 = 77%
- mean space-mean bar
- 9864.99-295.81 = 9569.18

MTF Measurement Test

MTF is always expressed in %

Estimate the MTF expressed in % at 2 and 4 lp/mm:

$$MTF_{2lp/mm} = \frac{sd_{2lp/mm}}{mean_{space} - mean_{bar}} \times 222$$

$$MTF_{4lp/mm} = \frac{sd_{4lp/mm}}{mean_{space} - mean_{bar}} \times 222$$

MTF Measurement Test

-
- Example:
- Estimate the MTF expressed in % at 4 lp/mm:
- 4lp/mm
- 1274.42 (sd) X 222 = 282921.24 = 29.5%
- mean space-mean bar
- 9864.99-295.81 = 9569.18
-

MTF Measurement Test

The test is successful if:

MTF $2_{lp/mm}$ > 58% and

MTF $4_{lp/mm}$ > 25%

What does the 222 represent in the formula?

- A decision based on a dilemma. Mathematically it is

[100 x π x Square Root(2)/2].

It is based on a method of obtaining MTF estimates from images of bar patterns.

- Using a calculation with pi and a square root in it would have perplexed the technologists and is a waste of time for the tech to recalculate every time.
- A simple constant (222) was decided to be used in place of.

MTF Measurement Test

- **Action Limit:**
- The test is successful if:

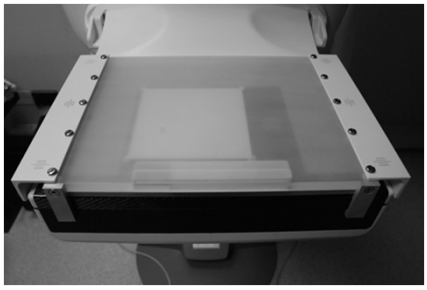
- MTF $2_{lp/mm}$ > 58%
- MTF $4_{lp/mm}$ > 25%

- If these results are not obtained, the source of the problem must be identified, and corrective action taken, before any further examinations are performed.

CNR and MTF Measurement Senograph DS and Essential

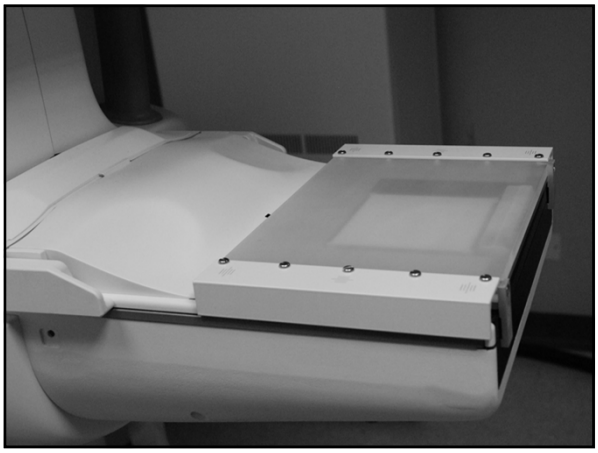
- Frequency:
- Weekly.
- The measurement must be made only after successful completion of the Flat Field Test
- • Objective:
- The test is designed to check the consistency of the contrast to noise ratio (CNR) and to ensure that
- contrast is adequate over the 0-5 lp/mm spatial frequency range by obtaining an estimate of the MTF
- (Modulation Transfer Function) values at 2 and 4 lp/mm.
- CNR measurement is done in two steps:
- - Establishment of a baseline operating level CNRoI

Senograph DS/Essential IQST
(Image Quality Signature Test) Automates MTF and CNR



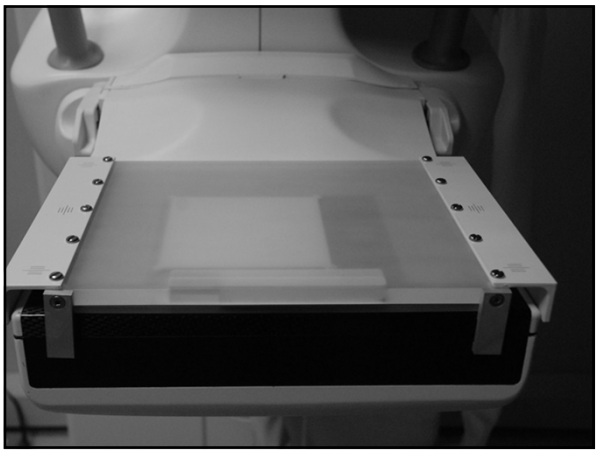
CNR and MTF Measurement Senograph DS and Essential

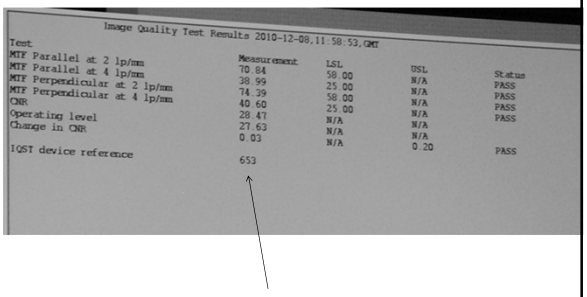
- 1. Click on the QAP button on the right column of the Browser window. A list of tests is displayed.
- Select the CNR and MTF test.
- 2. Enter or verify the reference of the IQST device (Serial Number or SN, written on the side of the
- device) on the AWS screen, then click Start .
- Note:
- If the device reference entered is different from the previous one, you will be asked if you want to
- restart the calibration process with this new reference.
- 3. Install the Bucky on the digital detector if it is not already installed.
- 4. Remove the compression paddle.
- 5. Position the IQST device on top of the Bucky.

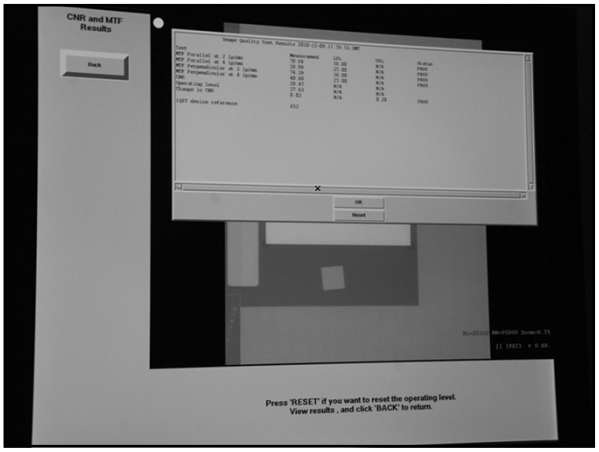


CNR and MTF Measurement Senograph DS and Essential

- 6. The following parameters are selected automatically: Rh/Rh/30kV/56mAs.
- 7. Perform one exposure.
- 8. After the image has been captured, the results of the tests are displayed:
- - The values of MTF at 2 lp/mm and MTF at 4 lp/mm.
- - The value of the change in CNR, computed as follows:
- Change in CNR = |CNR - CNRoI| / CNRoI
- where CNRoI = the CNR Operating Level as described above.
- If CNRoI has not been calculated yet, the change in CNR is computed as follows:
- Change in CNR = |CNR - mean| / mean
- where mean = the mean of the CNR values previously stored

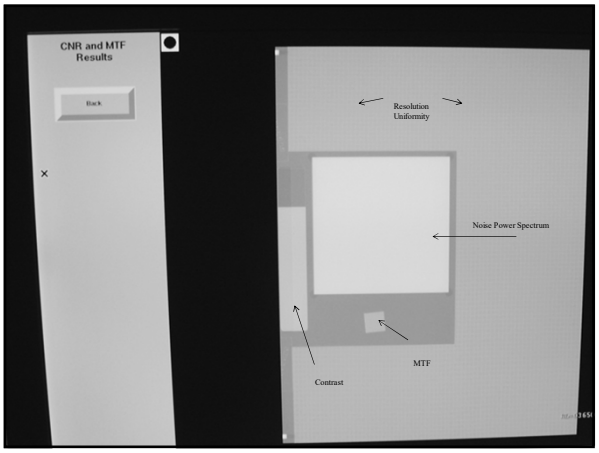




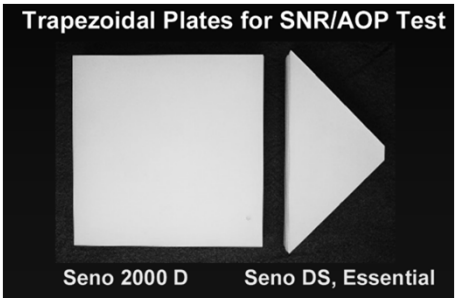


AOP Mode and SNR Check-GE

- **Frequency:**
- Monthly
- **Objective:**
- Checks the following aspects of system operation:
- -correct choice of parameters in AOP (Automatic Optimization of Parameters) mode
- -correct level of SNR (Signal-to-Noise Ratio) in the image
- -Correct thickness indicator is in limits

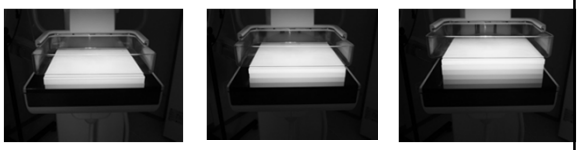


AOP Mode and SNR Check-GE



AOP Mode and SNR Check for GE Senograph 2000D

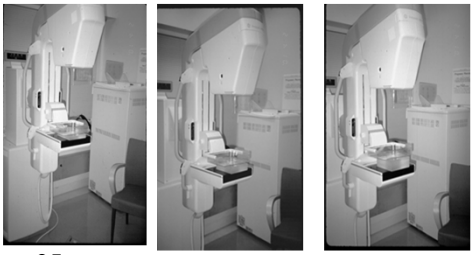
- This test is done with a set of acrylic plates allowing 25+/-- 0.1mm and 40+/-- 0.1mm and 60+/-- 0.1mm used with 5 deca Newtons compression force.



AOP Mode and SNR Check for GE Senograph 2000D

- Three exposures: one for each of the three thicknesses of acrylic in the field of view using the AOP STD mode.
- Record the exposure parameters after each exposure.
- Open each raw image for review and view it with the default zoom ("true size").

AOP-GE Senograph 2000D



25 mm 40 mm 60 mm

AOP Mode and SNR Check for GE Senograph 2000D

- Use the ellipse ROI tool:
- Measure the mean value
- Standard deviation, sd, of the image in the region close to the chest wall edge and laterally centered.
- Calculate the SNR:
- mean= SNR
- sd
- Document results.

AOP Mode and SNR Check

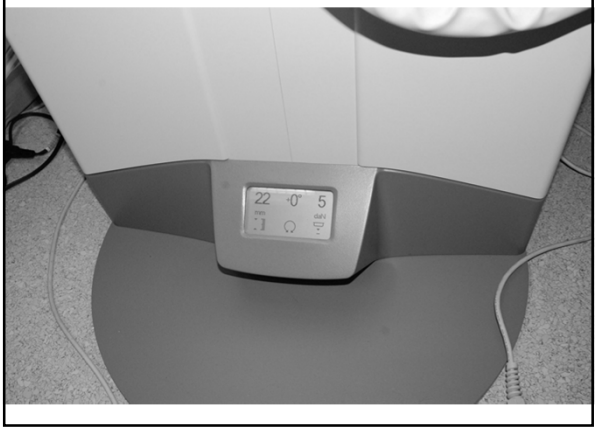
Reference: QC tests Sec. 1-8

	Exposure Parameters – AOP, STD Mode			
Acrylic Thickness(mm)	Track/filter	mAs	kV	SNR
25				
40				
60				

Requirement:

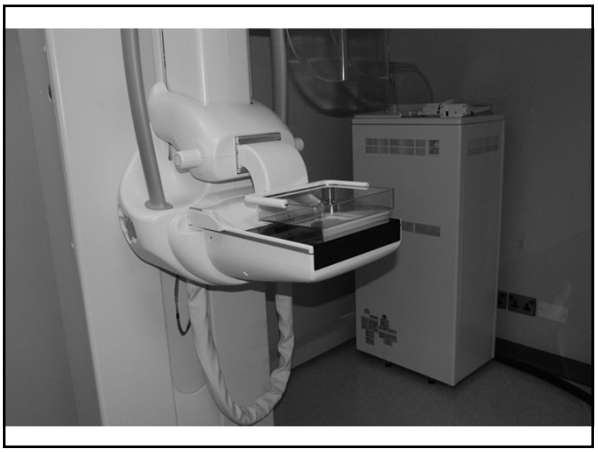
	Exposure Parameters – AOP, STD Mode			
Acrylic Thickness(mm)	Track/filter	mAs	kV	SNR
25	Mo/Mo	20 – 60	27	> 50
40	Mo/Rh	35 – 90	28	> 50
60	Rh/Rh	35 – 90	32	> 50

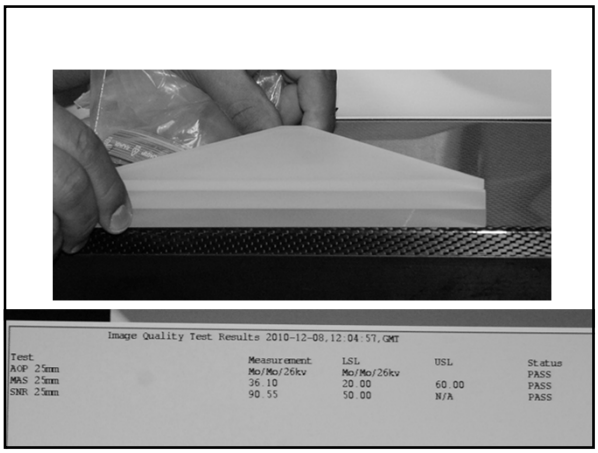
AOP-GE
ROI moved to chest wall

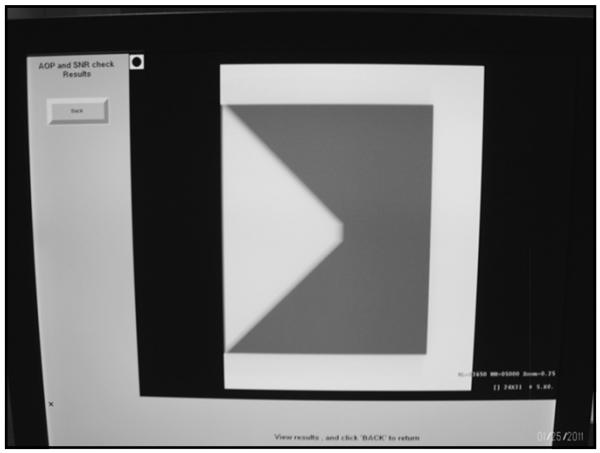


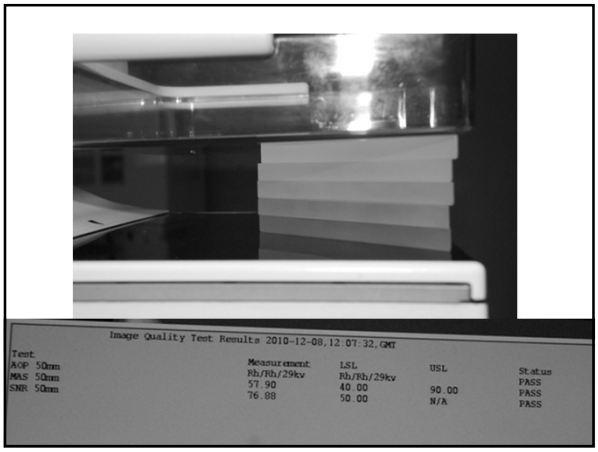
-
- Action Limit:
- AOP Mode Test successful:
- Exposure parameters are in accord with the values specified by the manufacturer.
- If the system fails the test, the source of the problem must be identified, and corrective action taken, before any further examinations are performed.

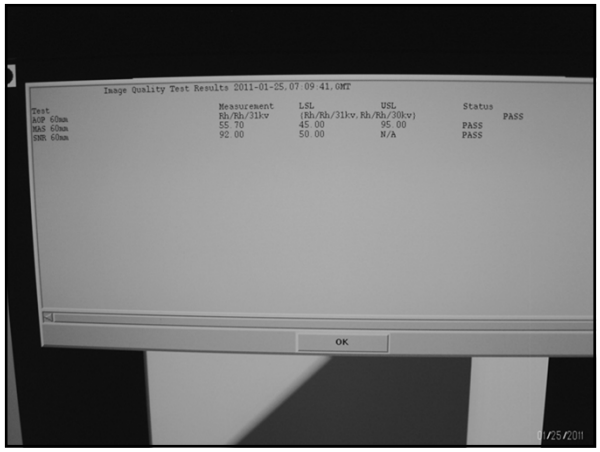
GE Senograph DS
and
GE Essential

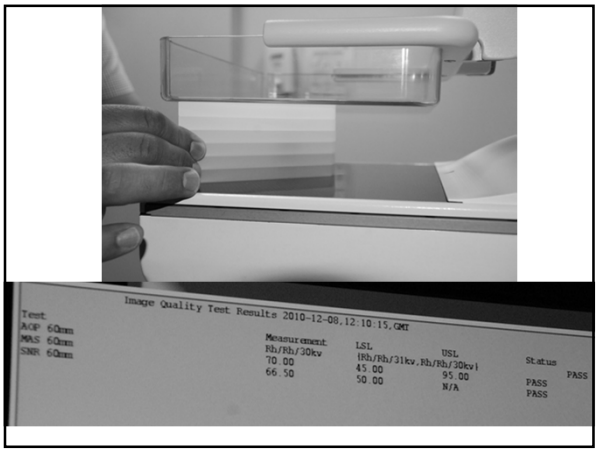












Manufacturers parameters in following table:

Acrylic Thickness (mm)	Exposure Parameters For AOP STD mode only		
	Track/filter	mAs	kVp
25	Mo/Mo	20-60	27
40	Mo/Rh	50-100	28
60	Rh/Rh	50-100	32

The value of SNR must exceed 50
For the senograph DS, Essential

MAMMOGRAPHY QUALITY CONTROL CHECKLIST – FULL-FIELD DIGITAL
GENERAL ELECTRIC MODEL Pristina

Monthly, Quarterly, and Semi-Annual
(date, initial and enter number where appropriate)

Year / Month	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Acquisition Station Monitor Check *(monthly)*												
AOP and SNR Check *(monthly)*												
Visual Checklist *(monthly)*												
Repeat Analysis Check (≤2% change) *(quarterly)*												
Compression Force (25-45 lb) *(semi-annually)*												
AOP 3D Check - DBT *(monthly)*												
Review Workstation QC (See QC Manual)												
Film Printer *(if applicable)*												
Mobile Unit Quality Control *(if applicable)*												

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

Visual Checklist-GE

- Frequency:
- Monthly and after any service or maintenance on the mammography system.
- Objective:
- To assure that the mammographic x-ray system indicator lights, displays, and mechanical locks and detents are working properly and that the system is mechanically safe.

Compression Thickness Indicator

Objective

To assure that the indicated compression thickness is within tolerance.

Frequency

Biweekly (every two weeks.)

Required Equipment

- ACR mammographic accreditation phantom that approximates 4.5 cm compressed breast of 50-50 tissue composition (i.e., RMI 156 by Radiation Measurement, Inc.; 18-220 by Nuclear Associates).
- 7.5 cm spot contact compression paddle

Test Procedure

1. Center the ACR phantom laterally on the image receptor and position it so the chestwall edge of the phantom is aligned with the chest wall side of the image receptor.
2. Install the 7.5 cm spot contact compression paddle in the compression device.
3. Apply Full Automatic Compression of approximately 30 pounds to the attenuation block.
4. Record the thickness indicated on the compression device.

Records Forms

Use the Compression Thickness Indicator form to track the results.

Recommended Performance Criteria and Corrective Action

The compression thickness indicator shall always be accurate to ±0.5 cm from the actual thickness.

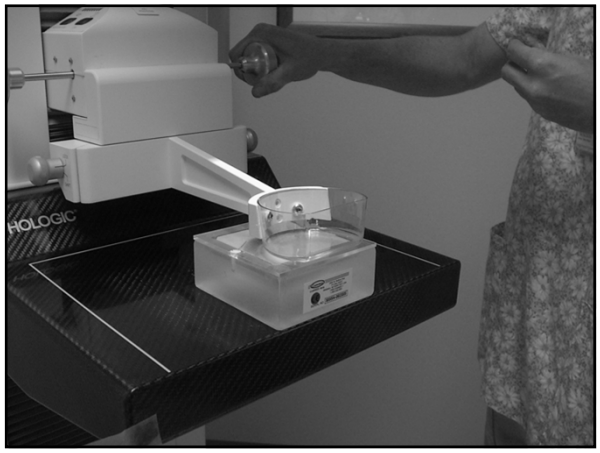
If the recommended performance criteria are not met, the source of the problem shall be identified and corrective action shall be taken within thirty days of the test date.

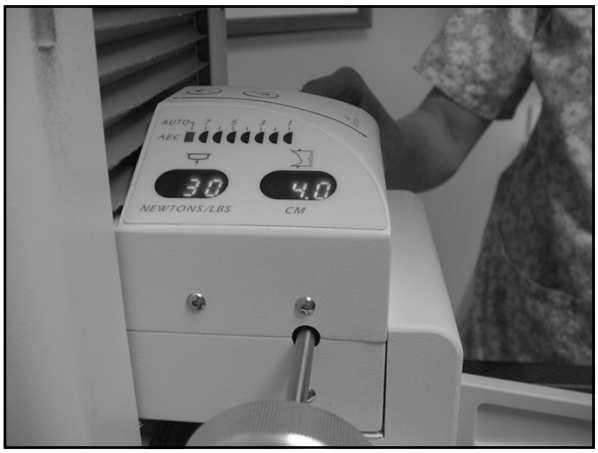
Frequency: *Monthly*

Room: . . . . . Unit: . . . . . .

Year:												
Month												
Day												
Initials												
Gantry:												
Angulation Indicator												
Locks (all)												
Field Light												
Smoothness of motion												
Inspect all paddles for cracks												
Control Panel:												
Switches/indicators												
Display												
Technique charts												
Other:												
Cleaning fluid												

Pass: P
Fail: F
Does not Apply: N/A





Detector Flat-Field Calibration

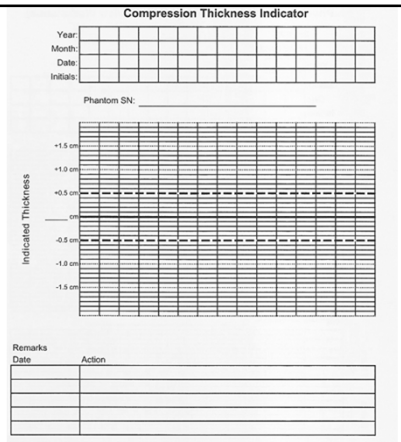
- **Do test bi-weekly and ensure the system is calibrated properly (weekly, new version 7&8)**
- **Use a 4 cm thick block of acrylic large enough to cover digital image receptor**
  surface should be clean do not leave compression paddle on.
  Newer version last 4 images with mag stand on the machine
- **Note - a dark band at the anterior side of the detector is normal**

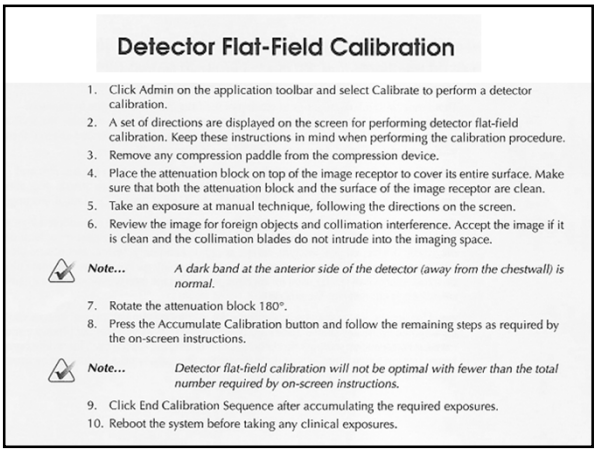
Remember….

- **The compression Thickness indicator shall always be accurate to +/- .5cm from the actual thickness.**

Calibration

- **calibration** - the act of checking or adjusting
- The words "calibrate" and "calibration" entered the English language during the American Civil War
- Started with description with Artillery





Detector Flat-Field Calibration

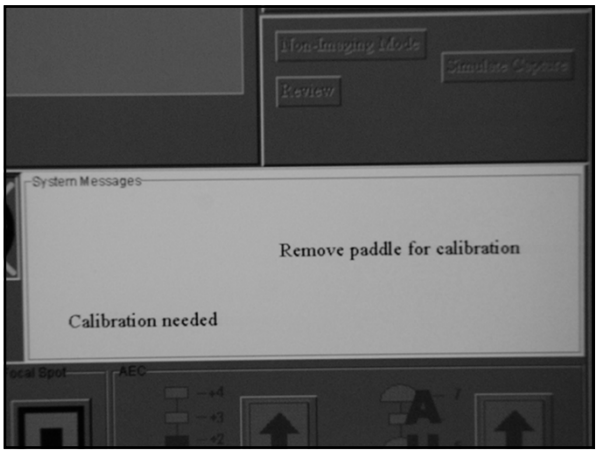
1. Click Admin on the application toolbar and select Calibrate to perform a detector calibration.
2. A set of directions are displayed on the screen for performing detector flat-field calibration. Keep these instructions in mind when performing the calibration procedure.
3. Remove any compression paddle from the compression device.
4. Place the attenuation block on top of the image receptor to cover its entire surface. Make sure that both the attenuation block and the surface of the image receptor are clean.
5. Take an exposure at manual technique, following the directions on the screen.
6. Review the image for foreign objects and collimation interference. Accept the image if it is clean and the collimation blades do not intrude into the imaging space.

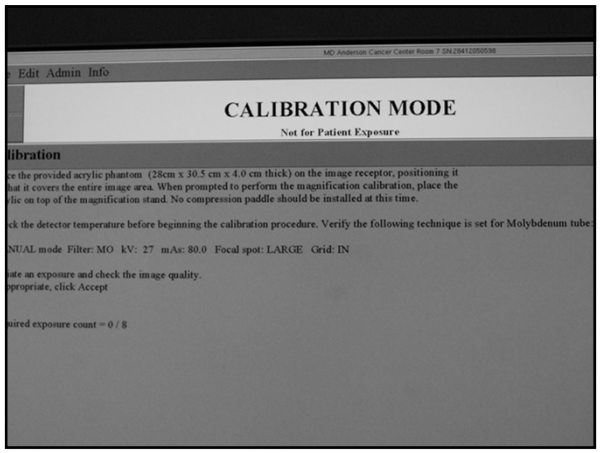
Note… *A dark band at the anterior side of the detector (away from the chestwall) is normal.*

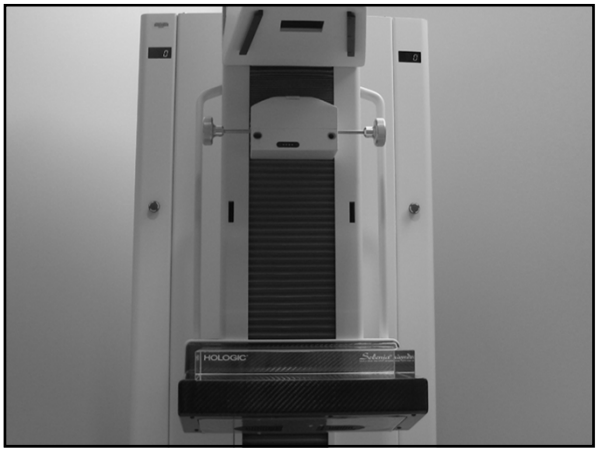
7. Rotate the attenuation block 180°.
8. Press the Accumulate Calibration button and follow the remaining steps as required by the on-screen instructions.

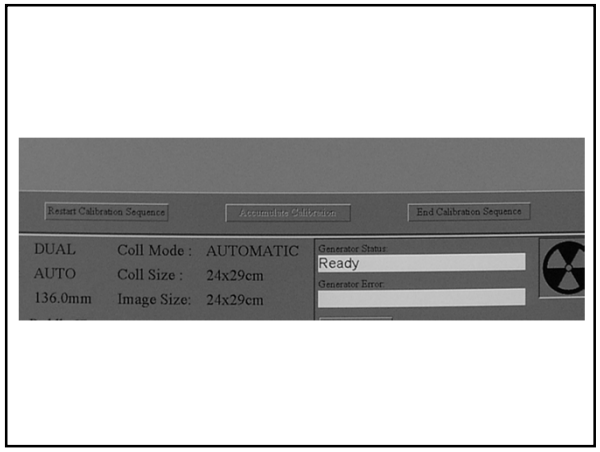
Note… *Detector flat-field calibration will not be optimal with fewer than the total number required by on-screen instructions.*

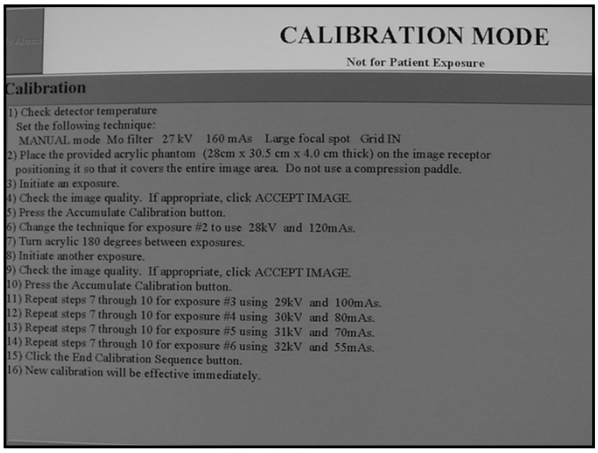
9. Click End Calibration Sequence after accumulating the required exposures.
10. Reboot the system before taking any clinical exposures.

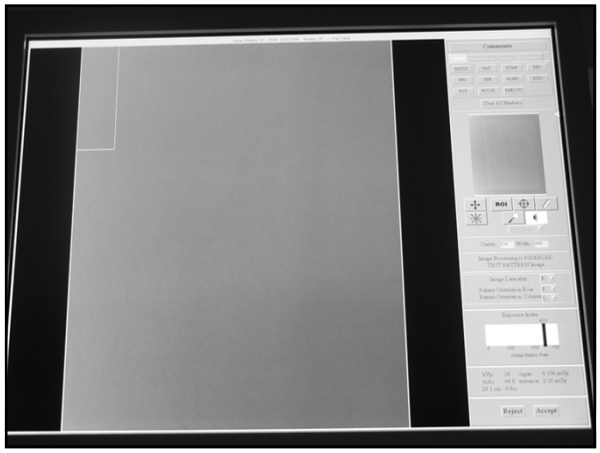

Non-Imaging Mode
Review
System Messages
Remove paddle for calibration
Calibration needed
AEC

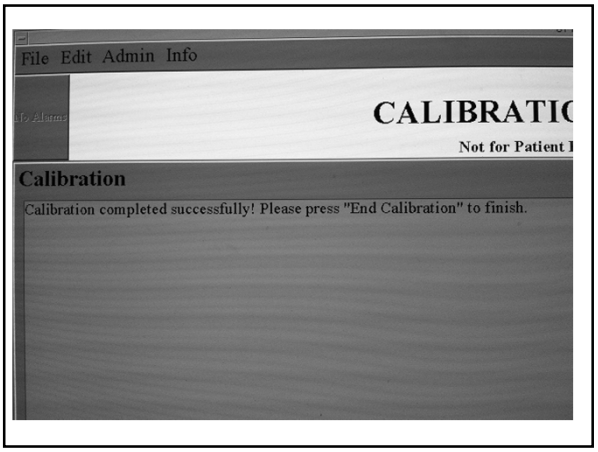

Edit Admin Info
CALIBRATION MODE
Not for Patient Exposure
ibration
ce the provided acrylic phantom (28cm x 30.5 cm x 4.0 cm thick) on the image receptor, positioning it
hat it covers the entire image area. When prompted to perform the magnification calibration, place the
lic on top of the magnification stand. No compression paddle should be installed at this time.
ck the detector temperature before beginning the calibration procedure. Verify the following technique is set for Molybdenum tube:
NUAL mode Filter: MO kV: 27 mAs: 80.0 Focal spot: LARGE Grid: IN
ate an exposure and check the image quality.
propriate, click Accept
uired exposure count = 0 / 8

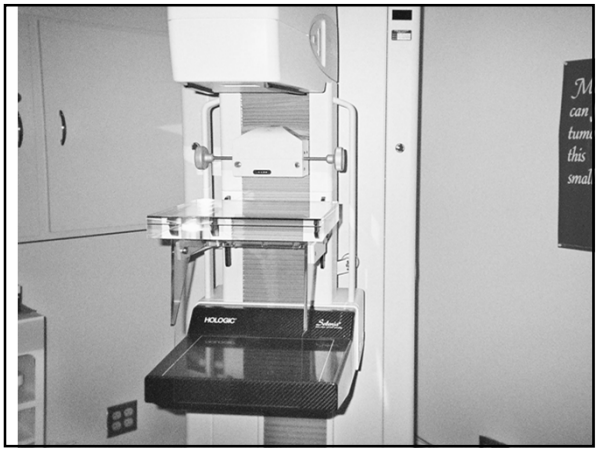

HOLOGIC


Restart Calibration Sequence
Accumulate Calibration
End Calibration Sequence
DUAL
AUTO
136.0mm
Coll Mode : AUTOMATIC
Coll Size : 24x29cm
Image Size: 24x29cm
Generator Status
Ready
Generator Error:

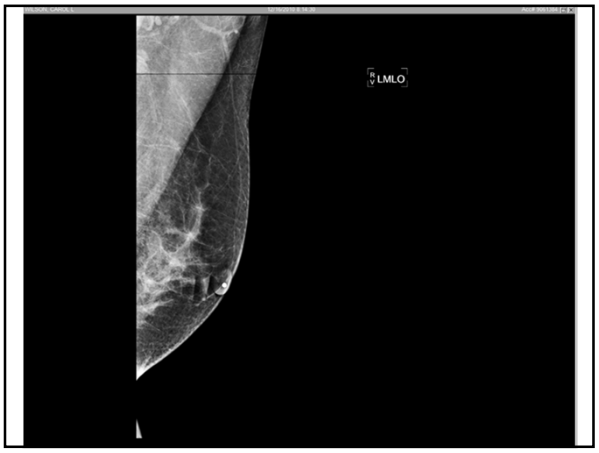

CALIBRATION MODE
Not for Patient Exposure
Calibration
1) Check detector temperature
Set the following technique:
MANUAL mode Mo filter 27 kV 160 mAs Large focal spot Grid IN
2) Place the provided acrylic phantom (28cm x 30.5 cm x 4.0 cm thick) on the image receptor
positioning it so that it covers the entire image area. Do not use a compression paddle.
3) Initiate an exposure.
4) Check the image quality. If appropriate, click ACCEPT IMAGE.
5) Press the Accumulate Calibration button.
6) Change the technique for exposure #2 to use 28kV and 120mAs.
7) Turn acrylic 180 degrees between exposures.
8) Initiate another exposure.
9) Check the image quality. If appropriate, click ACCEPT IMAGE.
10) Press the Accumulate Calibration button.
11) Repeat steps 7 through 10 for exposure #3 using 29kV and 100mAs.
12) Repeat steps 7 through 10 for exposure #4 using 30kV and 80mAs.
13) Repeat steps 7 through 10 for exposure #5 using 31kV and 70mAs.
14) Repeat steps 7 through 10 for exposure #6 using 32kV and 55mAs.
15) Click the End Calibration Sequence button.
16) New calibration will be effective immediately.


Reject
Accept





No record forms needed for this test, if any problems, consult the medical physicist



Softcopy Display Monitors

Monitor – Primary Display (RWS)

- Display workstations used for official interpretation of mammographic images
- FDA recommends primary display monitors be cleared for FFDM by the FDA
- ACR strongly recommends only FDA –cleared medical monitors

Monitor – Primary Display (RWS)

- Ability to select image sequence & display format (hanging protocols)
- Ability to accurately associate the patient & study demographic information with the images of the study performed
- Eyeglasses specifically for viewing distances for radiologist (15 – 60 cm)

Monitor – Primary Display (RWS)

- Once a display has been purchased & calibrated, it should be tested regularly by the medical physicist to maintain compliance
- 5 megapixel monitor (2,000 x 2,500 Pixel samples in the horizontal & vertical directions for portrait orientation) preferred

Monitor – Primary Display (RWS)

- During readout all images should be viewed at 1:1 or 100% size
- Pixel size (or pitch) should be less than ~200microns
- Display device specifications should match as closely as possible the acquisition matrix size

Monitor – Primary Display (RWS)

- Maximum luminance of grayscale monitors @ least 450 cd/m^2
- Reflected ambient light from the display surface should be included in luminance measurement
- Minimum of 8 bit luminance resolution (bit depth) is required
- Two-monitor portrait set up

Monitor – Primary Display (RWS)

- Window & level adjustment tools must be available
- Zoom (magnification) & pan (roaming) capabilities must be available
- Rotation & Flipping tools are essential
- Calculation & display of linear measurements, ROI & pixel value determination should be possible

Monitor – Primary Display (RWS)

–All images acquired in the study need to be fully accessible during interpretation

Required by Federal Law On Name Label

- Facility Name
- Facility Location (City,State,ZIP code)(street not required unless you have AB of State of Texas)
- Patient Name (First and Last)
- Patient Medical Number (Not SSN)
- Date of birth
- Date of Examination
- Laterality like Left or Right.
- Projection view as in CC or MLO, etc...
- The Technologist who performed the examinations, may be technologist initials or a technologist number.

Monitor – Primary Display (RWS)

– Clinically relevant technical parameters of the acquired image data should be accessible especially through header inf.
  - mAs
  - kVp
  - Bit depth
  - Exposure time
  - Matrix size
  - Exposure values to assess technique for dose, quality, & feedback for technologists

Recommended

- **Technical factors**
- **Target filters**
- **KvP**
- **mAs**
- **Exposure Time**
- **Compression force**
- **Compressed breast thickness**
- **Degree of obliquity**

Monitor – Primary Display (RWS)

– Sufficient for viewing all types of CR/DR images

Monitor – Primary Display (RWS)

- Reflections from ambient light sources should be kept at a minimum
  - Indirect & backlight incandescent lights with dimmer switches rather than fluorescent
  - Color tint should be uniform across the display area
  - Monitor pairs should be color matched from the same manufacturing batch

Softcopy Display Monitors – Other Guidelines

- Displays must be able to
  - Display mammography CAD marks when CAD is implemented
  - Apply marks on the displayed image corresponding to all findings encoded in the DICOM mammography CAD structred reporting (SR) objects
  - Display images in "true" size

Monitor – Primary Display (RWS)

- Optimize viewing conditions
  - Control reading room lighting
  - Eliminate reflection on the monitor
  - Lower ambient lighting level as much as feasible

Display Device Calibration Check-GE

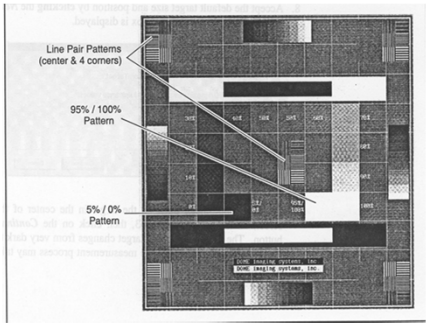
- Frequency:
- Monthly
- Objective:
- Assure the monitor is calibrated
- Brightness and contrast settings are at an appropriate level for the reading of the images on the review workstation.
- Procedure:
- At the RWS the "Start Calibration" is selected.

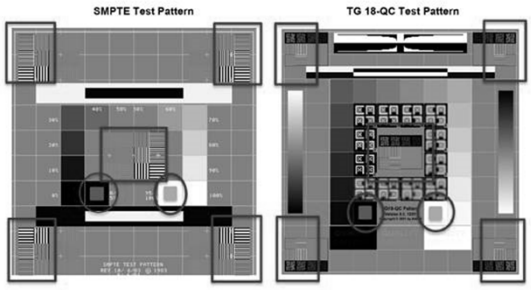
Monitor – Primary Display (RWS)

- Ambient lights should NOT be turned off completely nor turned up completely
- 20 lux is generally sufficient and is the recommendation

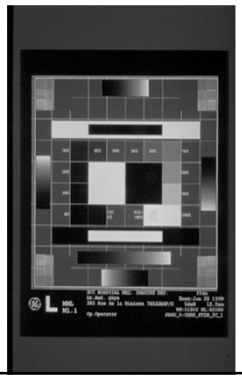
Display Device Calibration Check-GE

- The SMPTE pattern is examined carefully for the following features:
- 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. For example, that you can distinguish the 0% square from the 10% square , etc.
- verify that the line-pair images at the center and corners of the SMPTE pattern are distinguishable.





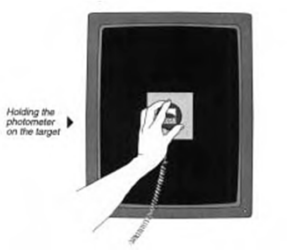
SMPTE PATTERN

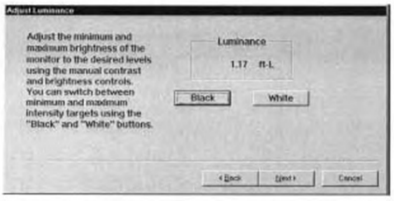


Society of Motion Picture and Television Engineering

GE-RWS(Review workstation)

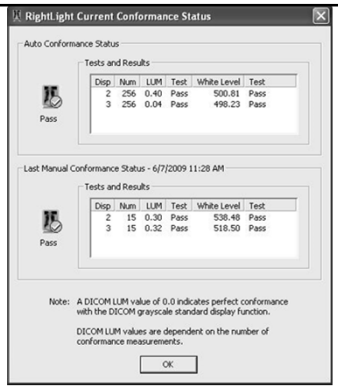
- Place and hold the photometer on the monitor's center target.
- **Note: The photometer must remain on the monitor throughout the**
- **calibration process. Keep the felt lining clean and dust free.**





As displays age, luminance and color temperature are apt to change. TOTOKU's Medivisor will keep your displays performing to DICOM standards. Medivisor is i

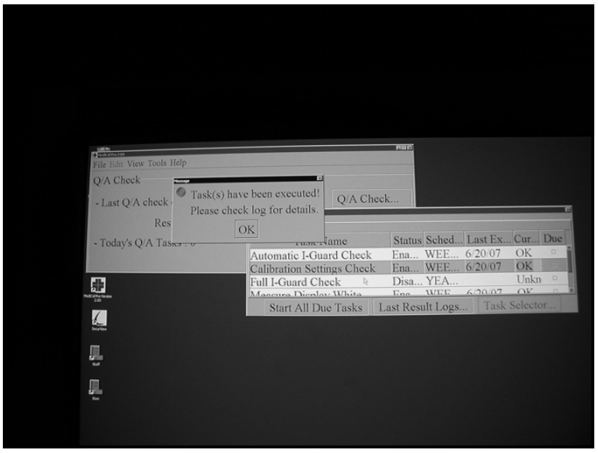
As displays age, luminance are apt to change. Monitor testing will keep your displays performing to DICOM standards. The calibration kit, along with photo sensor or "puck" for luminance testing and adjustment is included.

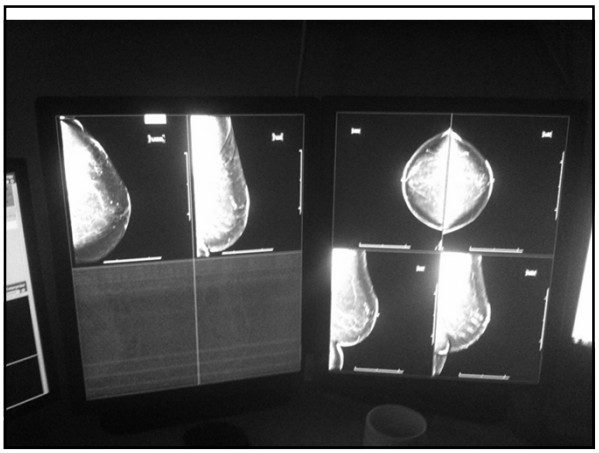


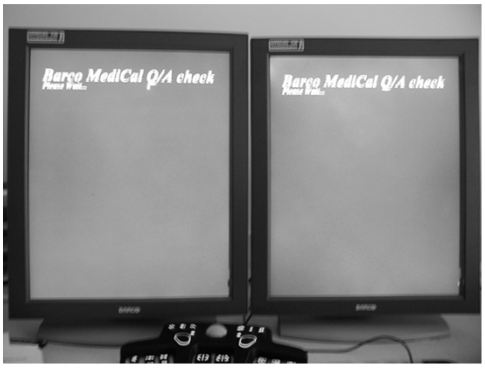
Luminance level should be below 1.0 (Black)
White Levels should be 500 +/- 10% or +/- 50

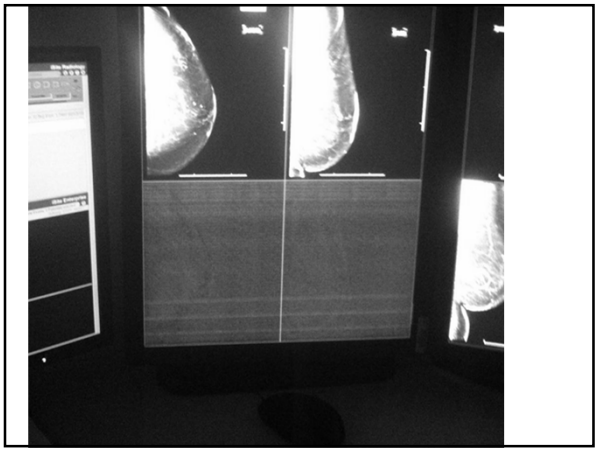
- If necessary, adjust the minimum and maximum luminance or the monitor's brightness and contrast controls to attain the desired black and white levels, according to the manufacturer's recommendations.

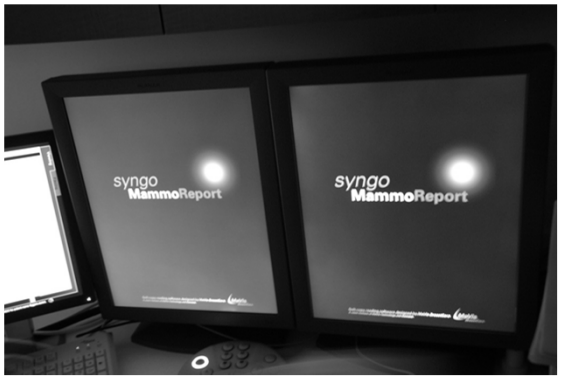
- For SenoScan review station monitors, adjust the Contrast and Brightness controls on the back of the monitor to achieve a luminance value of 0.2 ft L when the *Black button* is clicked and 87 ft L when the *White button is clicked.* Repeat as many times as necessary to achieve the minimum and maximum values











Digital Image Presentation Issues

- Time required to display an image on the WS – 3 seconds or less
- Displays should be able to accommodate fast & easy navigation between old & new studies

Digital Image Presentation Issues

- Hanging protocols should be
  - Flexible
  - Tailored to user preferences
  - Specifically for mammography with proper labeling & orientation of images

Monitor – Secondary Display (TWS)

- Technologist's workstations used to judge image quality during acquisition should be as similar as possible to the RWS
  - Resolution (may have less)
  - Maximum & minimum luminance
  - Contrast ratio
  - Ambient lighting
  - Conformance to DICOM
  - Zoom & pan

Digital Image Presentation Issues

- WS software tools must include
  - Window/level
  - Zoom/pan
- Specific recommendations regarding types of tools to be used & how to use them most effectively do not exist

Monitor – Clinician WS

- Used to review images as an adjunct to the official interpretation by a radiologist
- May not need as high resolution as RWS

Digital Image Presentation Issues

- WS should accommodate & display images from several modalities

Repeat Analysis Check

- Frequency:
- Quarterly. For the repeat rate to be meaningful, an analysis period that yields a patient volume of at least 250 patients or 1,000 exposures is needed.

- Objective:
- To determine the number and cause of repeated digital mammograms. Analysis of this data can help identify ways to improve system efficiency and reduce digital retakes and patient exposure.

Repeat Analysis check

- The applicable MQSA Quality Mammography Standard is: 900.12(e)(3)(ii)
- Quarterly quality control tests. Facilities with screen-film systems shall perform the following quality
- control tests at least quarterly:
- (ii) Repeat analysis. If the total repeat or reject rate changes from the previously determined rate by more than 2.0 percent of the total films included in the analysis, the reason(s) for the change shall be determined. Any corrective actions shall be recorded and the results of these corrective actions shall be assessed.

Compression Force Test

- Frequency:
- Initial installation and then every 6 months.
- Objective:
- To assure that the mammographic system can provide adequate compression in power driven and manual modes and that the equipment does not allow too much compression to be applied.

- Action Limit:
- If the total repeat rate changes from the rate determined for the previous analysis period by more than 2.0% of the total exposures included in the analysis, the reasons for the change must be determined. Any corrective actions taken must be recorded and an assessment must be made of their effectiveness.

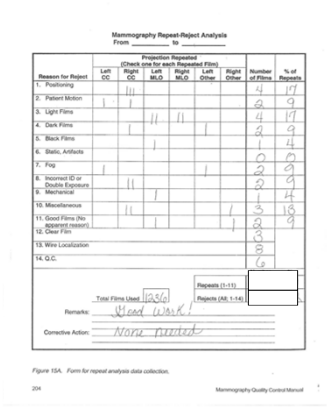
Breast Compression

- Breast compression is equally important for digital mammography as it is for film screen. It contributes to digital image quality by immobilizing the breast (reduces motion unsharpness), producing a more uniform, thinner tissue (lowers scatter radiation, more even penetration of x-rays, less magnification or geometric blurring, less anatomical superimposition), and lowering dose

23/1236

40/1236

4/23


Mammography Repeat-Reject Analysis
From _____ to _____

Reason for Reject	Projection Repeated (Check one for each Repeated Film) Left CC	Right CC	Left MLO	Right MLO	Left Other	Right Other	Number of Films	% of Repeats
1. Positioning		III					4	17
2. Patient Motion	I	I					2	9
3. Light Films			II	II			4	17
4. Dark Films		I			I		2	9
5. Black Films			I				1	4
6. Static, Artifacts							0	0
7. Fog	I				I		2	9
8. Incorrect ID or Double Exposure		II					2	9
9. Mechanical			I				1	4
10. Miscellaneous		II				I	3	13
11. Good Films (No apparent reason)			I			I	2	9
12. Clear Film							3	
13. Wire Localization							3	
14. Q.C.							6	

Total Films Used: 1236 | Repeats (1-11): | Rejects (All: 1-14):

Remarks: Need work!

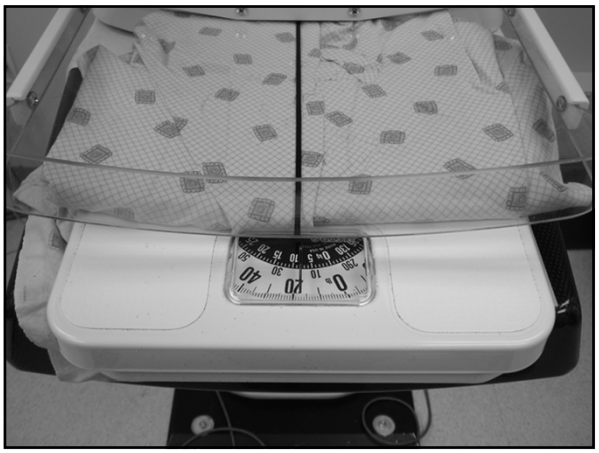
Corrective Action: None needed

Figure 15A. Form for repeat analysis data collection.

204 Mammography Quality Control Manual

Compression force test

- Procedure:
- This test is not unique to digital mammography systems.
- Follow accepted mammographic QC procedures to perform this test.
- Record the results.
- Action Limit-GE &Lorad
- The maximum compression force for the initial power drive must be between 11 and 20 daN
- (25-45 lb.)



Hardcopy Printing - Considerations

- FDA recommends only printers specifically cleared for FFDM by the FDA's ODE (Office of Device Evaluation)
- MQSA does allow other printers to be used
- ACR strongly recommends only FDA -cleared printers be used for digital mammography

Hardcopy Printing - Considerations

- FDA requires the ability to print FFDM images of final interpretation quality to film
- Manufacturer's guidelines should be followed

Printer

- Objective:
- To ensure optimal quality of the film printer output, follow the QC developed by the manufacturer of the device.
- If the printer is used with a film processor incorporating wet chemistry processing, follow the QC program developed by the manufacturer of the printer.

Hardcopy Printing - Considerations

- FDA requires all printers used with an FFDM unit
  - Comply with a quality assurance program that is substantially the same as that recommended by the FFDM manufacturer
  - That they pass the phantom & clinical image review process of the facility's accreditation body

Hardcopy Printing - Considerations

- At present, no accreditation body reviews softcopy images
- FDA recommends
  - Softcopy images be of such quality that if they were submitted they would pass the phantom & clinical image review process of the facility's accreditation body

FFDM System	QC Manual	Weekly/Daily	Annual	MEE	QC Procedures - Comments
GE- All systems	All	Yes*	No	No	*Per printer mfr. QC manual
Fischer	Rev.10-10/07	Daily check	No	No	Follow printer mfr. QC manual
Selenia	Rev. 7–8/07, **Chapter 1 Sec. 2	Yes	No	Yes**	Follow the Selenia QC manual
Siemens	Rev. 5–4/07	Before clinical use	No	Yes	Follow printer mfr. QC manual
Fuji	3 rd Edit.–4/07	Yes	Yes	Yes	Follow applicable printer QC manual

- Procedure:
- Follow the manufacturers recommended quality control procedure.
- Chart results.

Same printer or monitor with FFDM units from different manufacturers

For facilities using FFDM units from different manufacturers, each with its own QC requirements for printers and monitors, there is some uncertainty regarding the QC tests to perform on these components.

QC testing for printers and monitors without QC manuals

- In some cases the QC manual for the digital mammography unit instructs the facility to test monitors and printers according to the component's QC manual.
- In these cases, it is the responsibility of the facility to ensure that it obtains and follows the component's QC manual for its monitors and printers

DICOM Printer Quality Control

- For Lorad Selenia's

DICOM Laser Printer Quality Control

Objective

To assure consistency of laser printer performance. This procedure is analogous to film processor QC, performed on traditional film processors used to process mammograms.

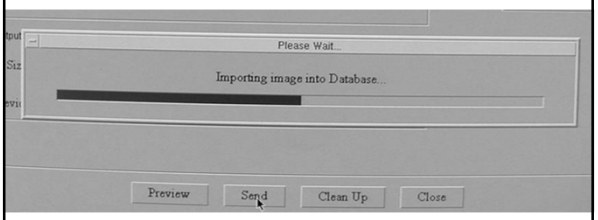
Frequency

Weekly for those facilities that use a dry laser printer.

Daily, at the beginning of the workday and before printing any clinical or phantom films for those facilities that use a wet laser printer.

Required Equipment

- Densitometer.
- SMPTE test pattern stored at the Acquisition Workstation of the LORAD Selenia FFDM System.

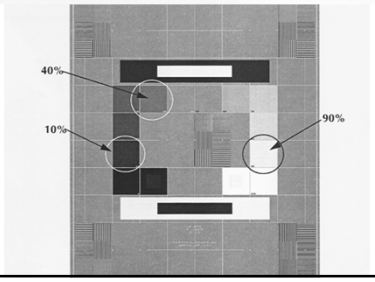


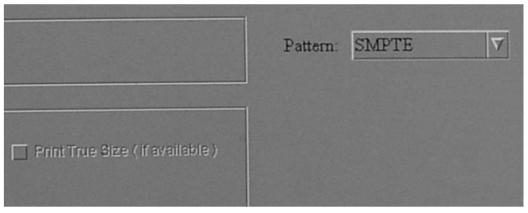
- Close any open examinations
- Select test patterns from the Admin Menu
- Select SMPTE from the Pattern drop-down menu
- Select from the Output Size drop-down menu the image size 18X24cm paddle
- Uncheck the "Print true size"
- Select the printer from the Output Devices drop-down menu
- Click Send to print the SMPTE pattern on the selected printer
- An image Queued dialog box appears informing you that the image is being sent. Click on OK to close it.
- Click close to exit the Test Pattern dialog

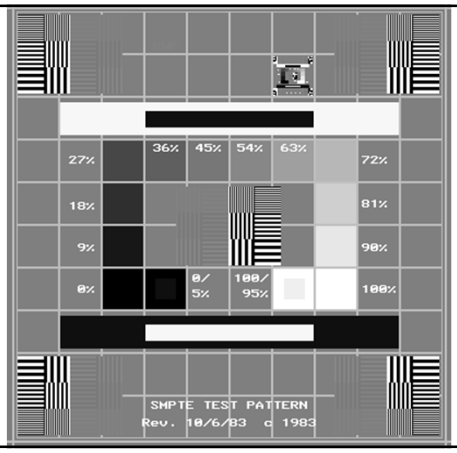
Use the densitometer to measure the density of the 10%, 40% and 90% patches on the SMPTE test pattern. Record the results on the test film and date the film.

Determine and plot the Mid Density (MD), Density Difference (DD) and Lower Density (LD) values on the *Laser Printer Control Chart*.

- For MD, use the density measured for the 40% patch, as shown in Figure 1-3.
- For LD, use the density measured for the 90% patch.
- For DD, subtract the density of the 10% patch from the density of the 40% patch.



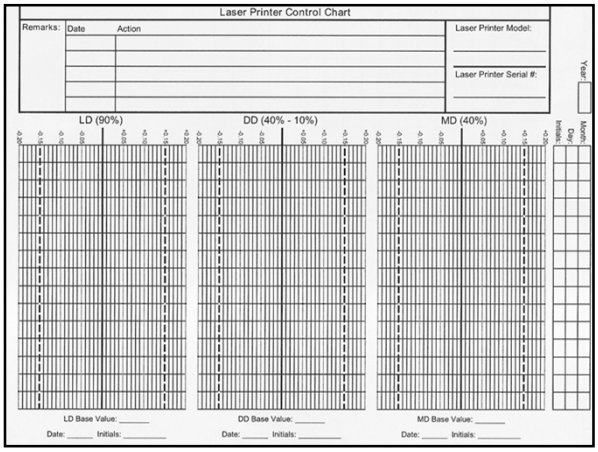


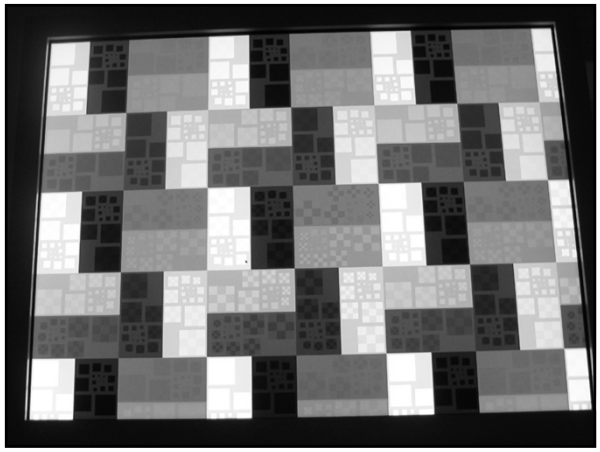


Control Value	SMPTE Grayscale Patch	Control Limits
MD	40%	±0.15
DD	40% - 10%	±0.15
LD	90%	±0.15

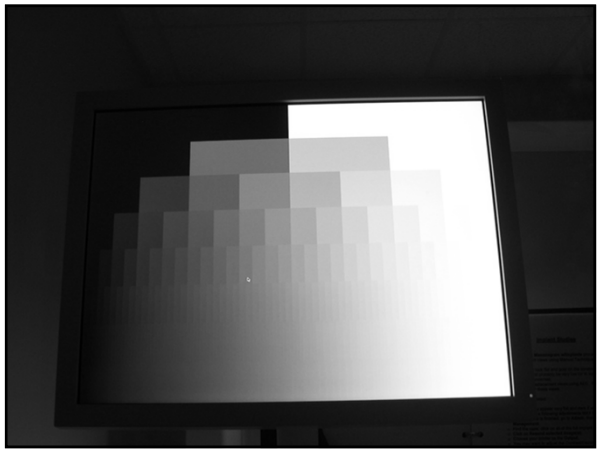
MD- Speed, DD- Contrast, LD- B&F, DC- Direct Current

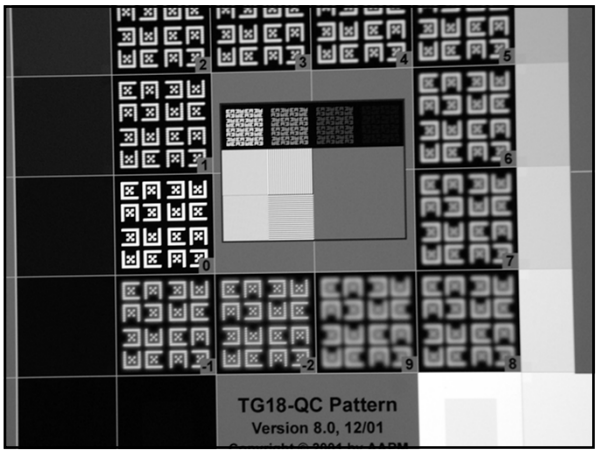
- The film is exposed with a scanning laser. After exposure, the film is heated to a temperature of 120 degree's for 24 seconds to process the image.
- After the image has been recorded, the film, immediately after it is ejected from the printer, is still in the processing image development.
- Light from the viewbox illuminator can cause slight changes in the optical density.

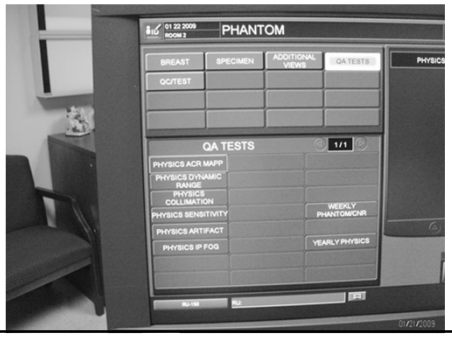




- Most printers are dry laser printers compared to wet chemistry printers. These devices were introduced in 1996. They require specialty film which is photothermographic that uses silver behenate rather than silver halide to produce the image and is processed thermally rather than with liquid developer and fixer.







FUJI CR QC

Baseline Tests-first measurement for each test

- Printer QC
- Monitor QC
- Phantom and CNR Weekly Check
- Image Quality
- S Value Confirmation
- System Resolution
- CR Reader Scanner performance
- AEC system performance assessment
- Imaging plate fog
- System artifact evaluation
- Dynamic range
- Primary erasure
- Inter-plate consistency
- Dose

Fuji CNR Check

Objective:

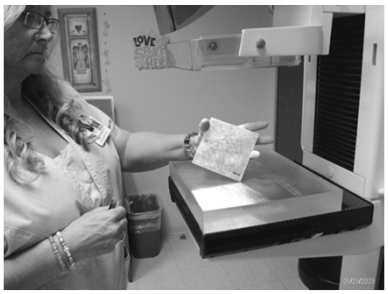
To establish an operating level of Contrast-to-Noise Ratio (CNR) at a specific exposure and weekly confirm that the CNR remains consistent, within limits over time at the same exposure setting.

Image Plate Erasure

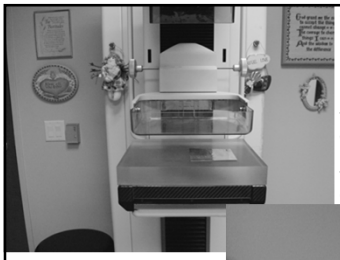
- Using secondary erasure erase each plate first thing each morning

Establish a baseline CNR with 5 day average of the CNR values…when doing the 5 day average remove and replace the aluminum between exposures since positioning of it may have some effect on the calculated CNR from week to week.

- Erase dedicated QC cassette using secondary erasure

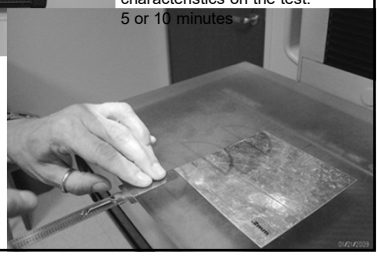


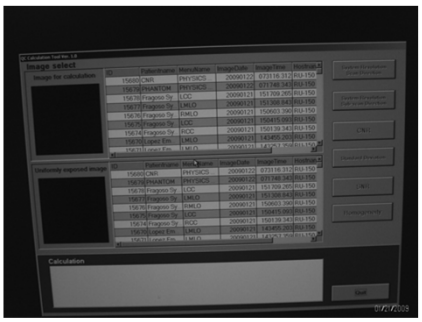
4 cm acrylic on bucky with 0.2 mm thick aluminum object on top positioned as shown in diagram.

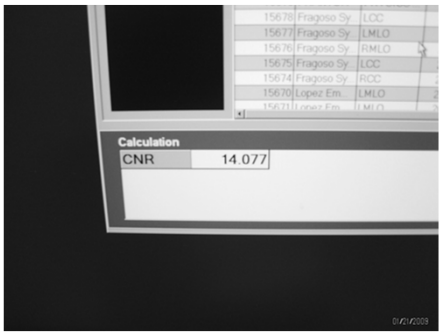


Compression paddle in contact
Exposure: Mo/Mo 26 kVp @125 mAs

Interval processing time-control time interval between X-ray exposure and reading of the IP. It must be consistent to Reduce the influence of IP fading characteristics on the test.
5 or 10 minutes







Fuji Phantom Image

Objective:

To assure that contrast, uniformity and image quality (due to the x-ray exposure system, image reader and printer and workstation) are maintained at optimum levels.

Done hardcopy and softcopy……

Reestablish (5 day average) new baseline if:

- X-ray tube replacement
- Filter replacement
- Replacement of compression paddle
- Change in phantom used
- Change of IP/and or cassette used
- Change of grid
- Change of x-ray generator
- Change of CR reader calibration

Phantom and disk-disk not used for softcopy test but can be on phantom for it.

Performance Criteria CNR

- Must be within ± 20% of the baseline image (CNR) established
- If failed must be corrected before any further examinations

- Expose on technique used for 50/50 breast (this was auto filter-LoRad unit)
- Photocell in center of wax insert and in same place every time
- Same compression thickness every time
- Send to printer once processed

Phantom Hardcopy

- Background density center of phantom no less than 1.20
- Density difference in disc and adjacent to disk and subtract
- Plot on chart and plot mAs
- Score subtracting for artifacts

Phantom Softcopy

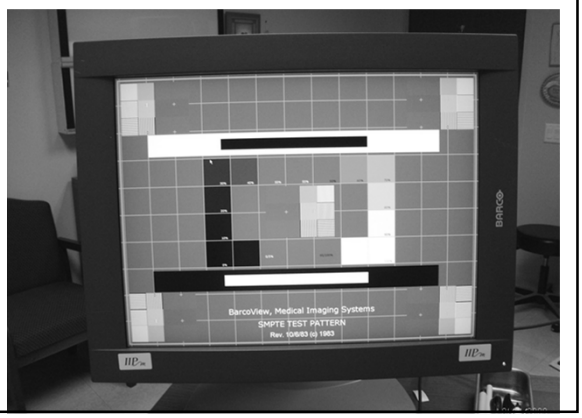
- Plot the S value from the exposure on the S value range line on chart
- Score subtracting for artifacts

Fuji Printer QC

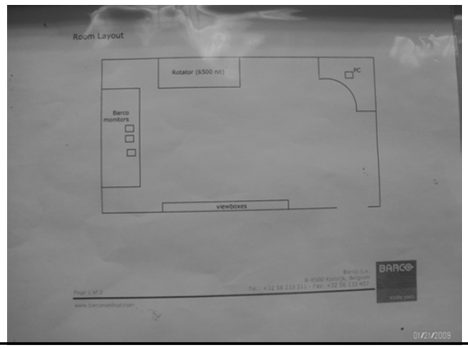
Objective- to assure the printer used for final interpretation is performing according to the manufacturers specifications

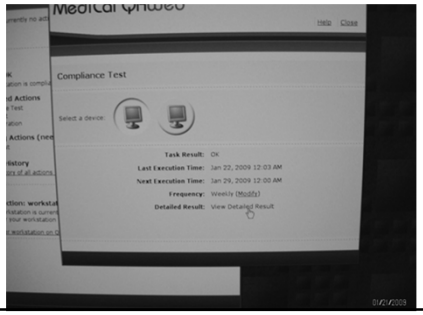
Performance Criteria

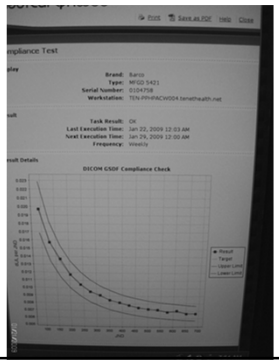
- Score 4-3-3
- If hard copy are used for final interpretation the OD must be within ± .20 of the established OL and the DD must be within ± .05
- If softcopy images are used for final interpretation the S value must not vary by greater than ± 20% (the S value of the phantom confirms the exposure unit output and the FCRm reader sensitivity setting)
- If criteria is not met for either must be corrected before any further examinations are performed.

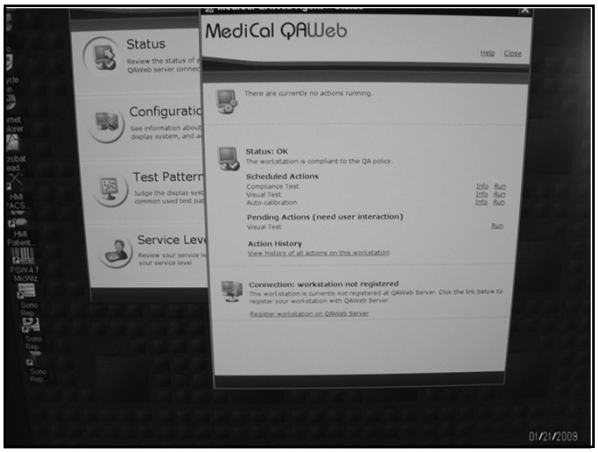


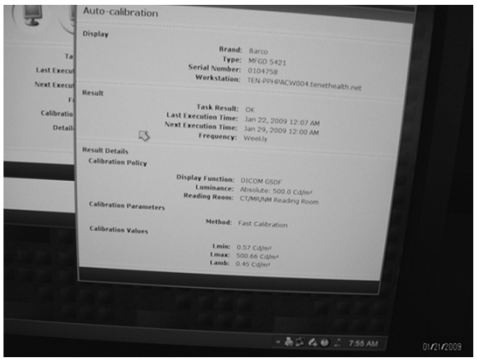
Review Workstation Room

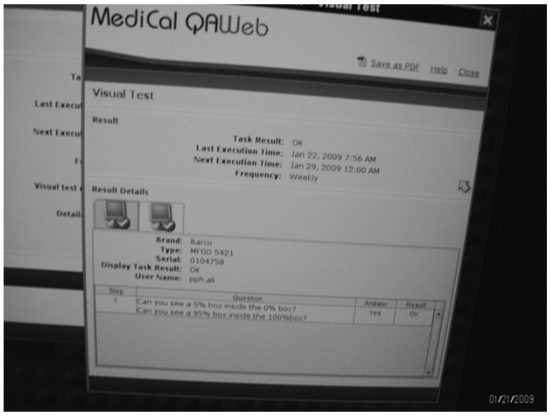






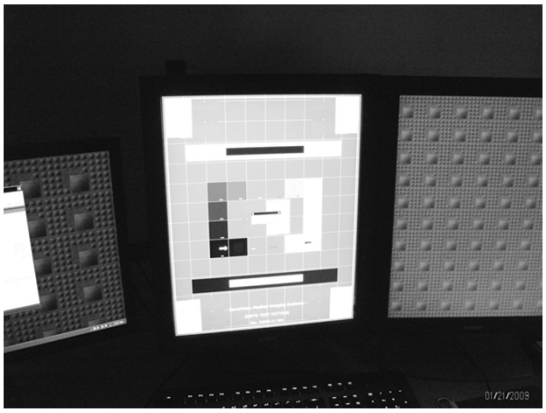






Changes in QC for FFDM

- New BI-RAD's and lexicon changes
- New ACR FFDM QC Control Manual
- New Digital Phantom for FFDM
- Possibly a new Phantom for DBT



About the new ACR Digital manual

- Q. When will the new ACR Digital Mammography QC Manual be available? A. The manual will be available in late spring of 2016. Q. How will the new ACR Digital Mammography QC Manual be distributed? It was out in August 2016.
- A. The manual will be provided, at no charge, to all ACR-accredited mammography facilities (and to those applying for accreditation) in a PDF format.
  Medical physicists associated with ACR-accredited facilities will also be allowed to download the manual at no charge. All others may purchase the manual PDF from the ACR catalog. Hard copies will not be available.

New Changes

- Lets move on to newer changes……..

More questions….

- Our facility has a mammography unit that performs 2D imaging using computed radiography (CR). Will we be allowed to use the new ACR Digital Mammography QC Manual instead of our CR manufacturer's QC manual for QC on this unit?
- A. Yes.

- Q. Our facility would like to begin using the new ACR Digital Mammography QC Manual. Can we do so as soon as we receive our new manual?
- A. Before the facility QC technologist may start using the new DMQC Manual on a particular unit, the medical physicist must first conduct an annual survey of the digital mammography unit and display devices using the new manual and phantom. This is important to provide testing techniques and procedures for the QC technologist to use during routine QC. After this is done, the QC technologist may start performing routine QC using the new manual.

ACR FFDM QC Manual Project

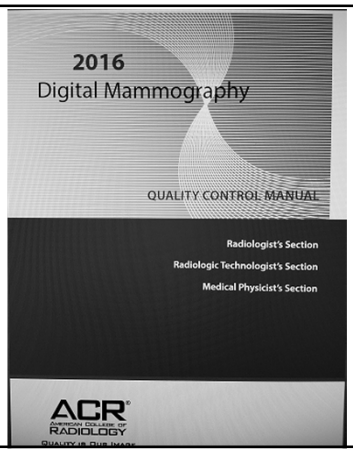
- ACR Subcommittee on Quality Assurance
- –Clinical Representatives
- – MITA Representatives
- –ACR Representatives
- Information written by

…….Et al. Eric Berns, PhD

- Q. May I use our old ACR phantom to perform the tests in the new ACR Digital Mammography QC Manual instead of obtaining the new ACR Digital Mammography Phantom?
- A. No. The new ACR Digital Mammography QC Manual procedures were designed around the new ACR Digital Mammography Phantom. The old ACR phantom cannot be used to conduct the tests in the new manual.

ACR FFDM QC Manual Project

- Subcommittee Charge:
- – Design ACR Accreditation Phantom for FFDM
- – Write QC Manual for ACR FFDM Mammography
- Accreditation Program



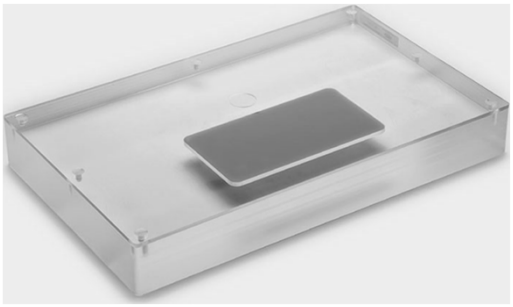
ACR Digital QC Manual

- Structure of Manual:
- – Radiologist's Section
- – Clinical Image Quality Section
- – Radiologic Technologist's Section
- – Medical Physicist's Section
- – Educational, Guidance, and Troubleshooting Section
- – Glossary
- – References
- – Index

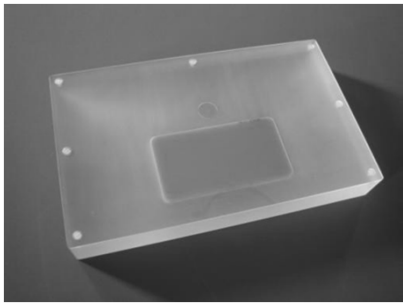
What will be New?

- Tech Section
- – Enhanced positioning and image quality section
- – New Test: Monitor QC for the Radiologist
- – New Test: Facility QC Review
- – New Format: Corrective Action Log
- – New Documentation: Facility Equipment Inventory
- – Instructions for Mobile Units
- – Eliminating calculations (Yet to be determined)

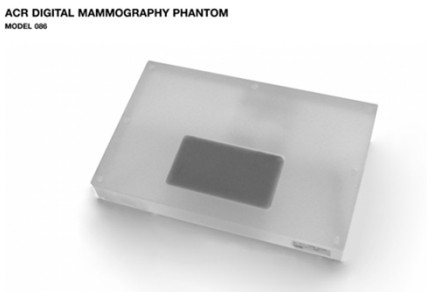
Gammex



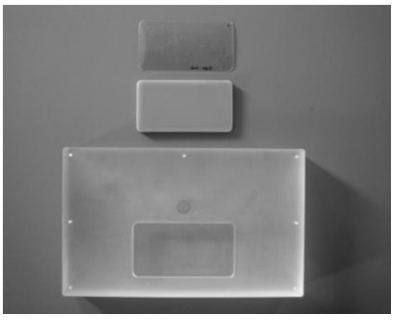
The ACR FFDM Phantom 24 X 30

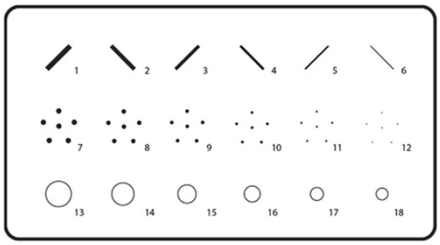


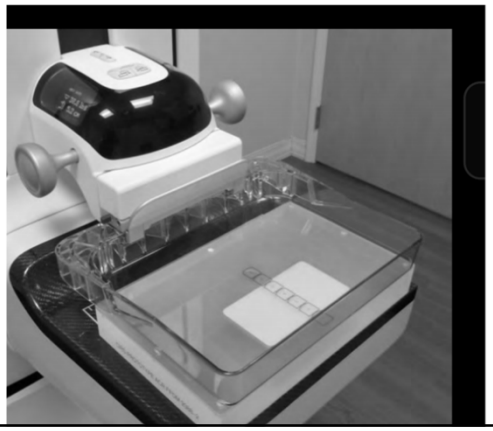
CIRS



The ACR FFDM Phantom

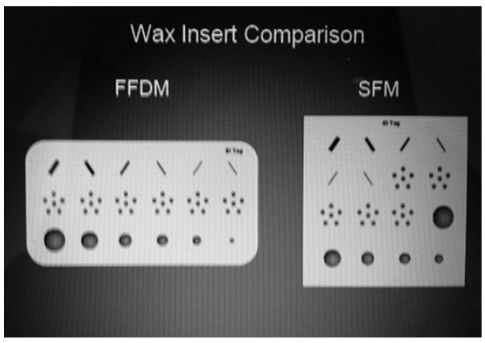






The ACR FFDM Phantom

http://www.acraccreditation.org/~/media/ACRAccreditation/Documents/Resources/DMQC/2016-DMQC-Manual-Tech-Webinar.pdf?la=en



Design Summary

Differences from screen-film phantom

- • Eliminate subtraction for artifacts
- • Add "Fail" for artifacts
- • Improve specific rules for scoring
- • Change pass/fail criteria from
- – 4,3,3 to 2,3,2
- – **But, objects are the same (effective) size as SFM Phantom

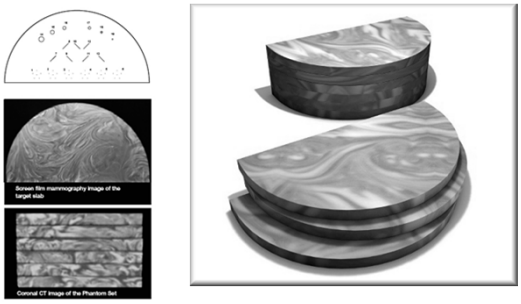
ACR Digital QC Manual

- • Benefits of Phantom Design
- – Provides view of entire detector – artifact evaluation
- – W/L optimized for test objects optimizes for artifact eval
- – Finer gradations of test objects
- – Test objects go to smaller sizes
- – AGD measurement & limit same as SFM – Meets MQSA
- – Provides single image/exposure for evaluation(s)
- – Minimal training (~ 25,000 Techs currently trained)
- – Provides basis for monitor and laser printer QC
- – ACR Physics Reviewers
- • Can see scores and artifacts on single submitted film (or image)
- • Do not need different WW/WL settings

CIRS Model 020 BR3D Mammography Phantom

- The phantom consists of a set of six (6) slabs made of heterogeneous breast equivalent material that exhibits characteristics of real breast tissue and demonstrates how underlying targets can be obscured by varying glandularity. Each slab contains two tissue equivalent materials mimicking 100% adipose and gland tissues "swirled" together in a approximate 50/50 ratio by weight. One of the slabs contains an assortment of micro-calcifications, fibrils and masses.

CIRS Model 020 BR3D Mammography Phantom
Used on FFDM, Breast Tomo, and Breast CT Internationally
Will this be used in U.S.?



That's enough QC!!

- The CIRS Model 020 BR3D Mammography Phantom was designed to assess detectability of various size lesions within a tissue equivalent, complex, heterogeneous background. This phantom provides more realistic challenges for standard screen and FFDM mammography systems as well as Tomosynthesis and breast Computed Tomography.