Digital Breast Tomosynthesis QC Requirements

AAPM
Spring Clinical Meeting
March 8, 2015
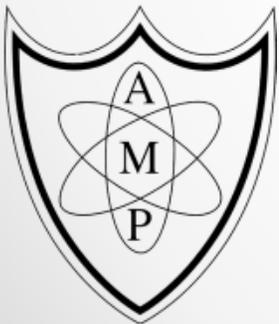
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Alliance Medical Physics, LLC
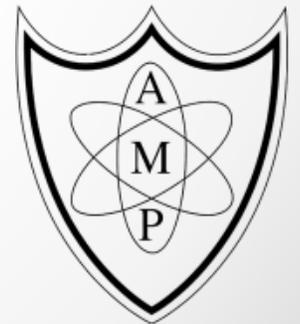
Learning Objectives

1. GE SenoClaire - Physicist & Technologist QC

2. Hologic Selenia Dimensions 3D- Physicist & Technologist QC

Disclosures

- **Funding Support- None**
- **Conflicts of Interest- None**
- **Disclosures- Yes, vendor QC slides**

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- **Razvan Iordache, PhD of GE Healthcare**
- **Nikos Gkanatsios ,PhD of Hologic**

Quality Control for SenoClaire (GE Breast Tomosynthesis)

SenoClaire (GE Breast Tomosynthesis)

SenoClaire Key Features

- 9 Projections
- Stop-and-shoot
- Sweep angle 25° (+/- 12.5)
- Sweep time <10 sec*
- Detector pixel size 100 um in 2D & 3D
- 2D/3D-grid for scatter reduction
- ASIR^{DBT} Iterative Reconstruction
- No dose increase (3D vs. 2D)
- BTO DICOM format
  (Breast Tomosynthesis Object)

Comment: *Exposure time depends on breast thickness, ; ≤ 10 sec for average breast of 4.5cm PMMA.

9

SenoClaire is an Upgrade for Senographe Essential

Senographe Essential
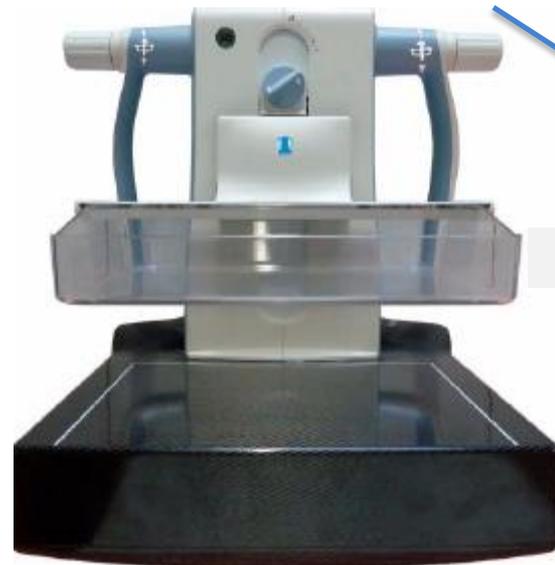
Motorized Tomosynthesis Device (MTD)

Senographe Essential Upgraded with SenoClaire

Imaging with the MTD
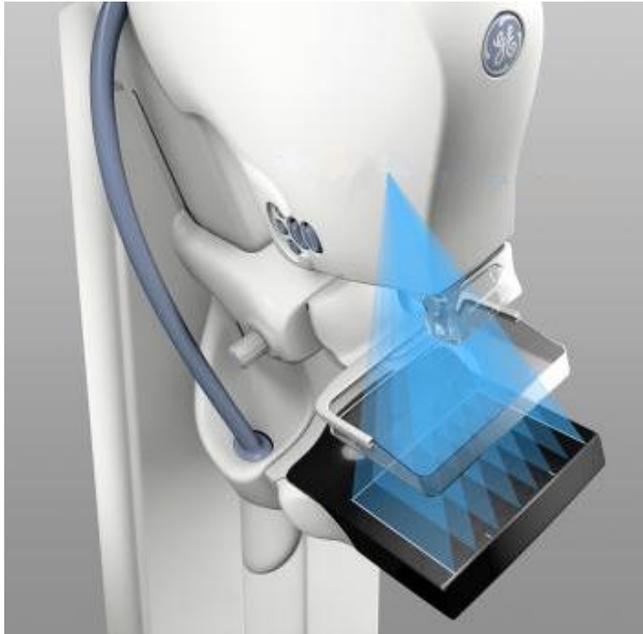
Traditional antiscatter grid - Essential
View of system positioned for a left MLO view
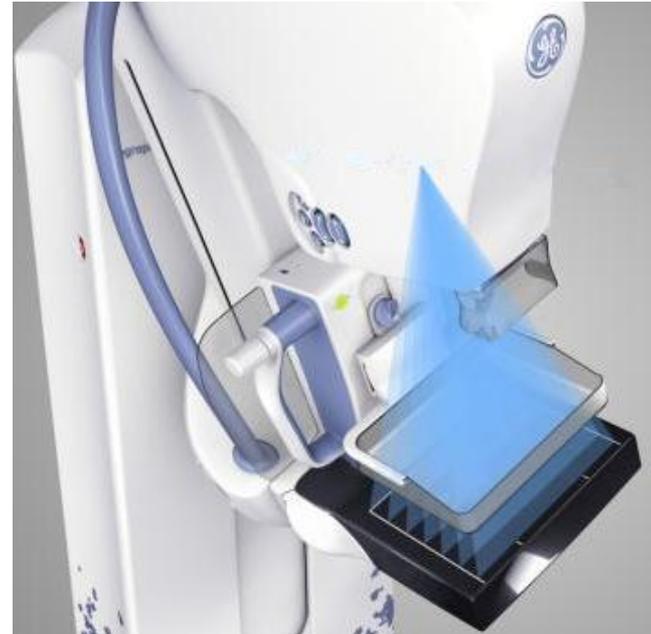
2D/3D antiscatter grid – SenoClaire's MTD
View of system positioned for a left MLO view

Both 2D & 3D imaging is performed with the MTD

SenoClaire QC Manual

This quality control (QC) manual **adds** tests specific to SenoClaire to those listed in the Senographe Essential QC manual

71 pages

SenoClaire

GE Breast Tomosynthesis
Quality Control Manual

Non-contractual image. Flowers on the Gantry are not delivered with the system as standard.

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Senographe Essential

Quality Control Manual

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SenoClaire QC – Radiologic Technologist

SenoClaire

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QC Tests for the Radiologic Technologist

Minimum frequency	Test	Essential	
		No X	2D
Daily	Monitor cleaning	X	
Weekly	Flat field		X
Weekly	Phantom IQ		X
Weekly	CNR & MTF		X
Weekly	Viewbox & Viewing	X	
Monthly	AOP Mode & SNR		X
Monthly	Visual Checklist	X	
Quaterly	Repeat Analysis	X	
Semi-anually	Compression Force	X	

QC Tests for the Radiologic Technologist

Minimum frequency	Test	Essential		SenoClaire (w/ MTD)		
		No X	2D	No X	2D	3D
Daily	Monitor cleaning	X				
Weekly	Flat field		X			X
Weekly	Phantom IQ		X		X	X
Weekly	CNR & MTF		X		X	
Weekly	Viewbox & Viewing	X				
Monthly	AOP Mode & SNR		X		X	X
Monthly	Visual Checklist	X		X		
Quaterly	Repeat Analysis	X				
Semi-anually	Compression Force	X		X		
Monthly	Grid Texture				X	

SenoClaire Tests ... same as Essential Tests

Minimum frequency	Test	Essential		SenoClaire (w/ MTD)		
		No X	2D	No X	2D	3D
Daily	Monitor cleaning	X				
Weekly	Flat field		X			X
Weekly	Phantom IQ		X		X	X
Weekly	CNR & MTF		X		X	
Weekly	Viewbox & Viewing	X				
Monthly	AOP Mode & SNR		X		X	X
Monthly	Visual Checklist	X		X		
Quaterly	Repeat Analysis	X				
Semi-anually	Compression Force	X		X		
Monthly	Grid Texture				X	

SenoClaire Tests ... specific Visual Checklist

Minimum frequency	Test	Essential		SenoClaire (w/ MTD)		
		No X	2D	No X	2D	3D
Daily	Monitor cleaning	X				
Weekly	Flat field		X			X
Weekly	Phantom IQ		X		X	X
Weekly	CNR & MTF		X		X	
Weekly	Viewbox & Viewing	X				
Monthly	AOP Mode & SNR		X		X	X
Monthly	Visual Checklist	X		X		
Quaterly	Repeat Analysis	X				
Semi-anually	Compression Force	X		X		
Monthly	Grid Texture				X	

Visual Checklist (monthly)

Objective

To assure that GE Breast Tomosynthesis indicator lights, displays, and mechanical locks and detents are working properly and that the system is mechanically stable.

Equipment required

Visual checklist Chart 5. Grid texture test, Visual Checklist and Compression Record of Checks (page 36).

Procedure

- Review each item on the visual checklist and indicate its status

Action Limit

Each of the items listed in the Visual Checklist must pass (ie, receive a check mark)
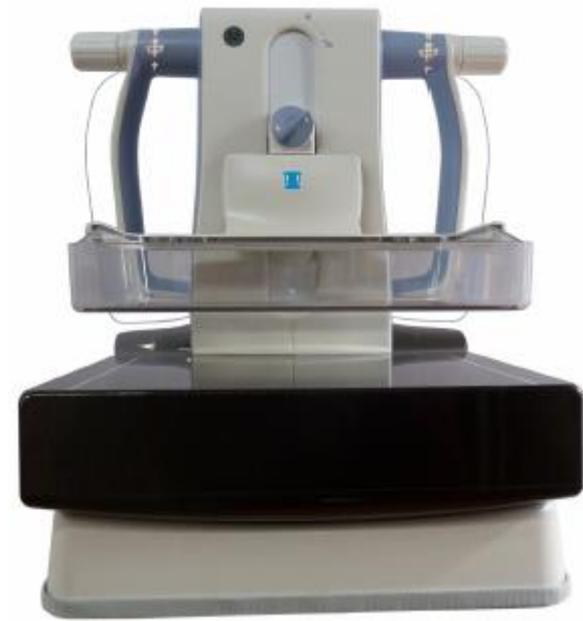
SenoClaire Tests … New Grid Texture Test

Minimum frequency	Test	Essential		SenoClaire (w/ MTD)		
		No X	2D	No X	2D	3D
Daily	Monitor cleaning	X				
Weekly	Flat field		X			X
Weekly	Phantom IQ		X		X	X
Weekly	CNR & MTF		X		X	
Weekly	Viewbox & Viewing	X				
Monthly	AOP Mode & SNR		X		X	X
Monthly	Visual Checklist	X		X		
Quaterly	Repeat Analysis	X				
Semi-anually	Compression Force	X		X		
Monthly	Grid Texture				X	

Grid Texture Test (monthly)

Objective
Measures the amount of grid texture in 2D images

Equipment required
Flat field test object

Procedure
- Automatic acquisition of 10 2D images with increasing mAs
- Record the dispayed test results

Action Limit
The texture level must not exceed 0.002
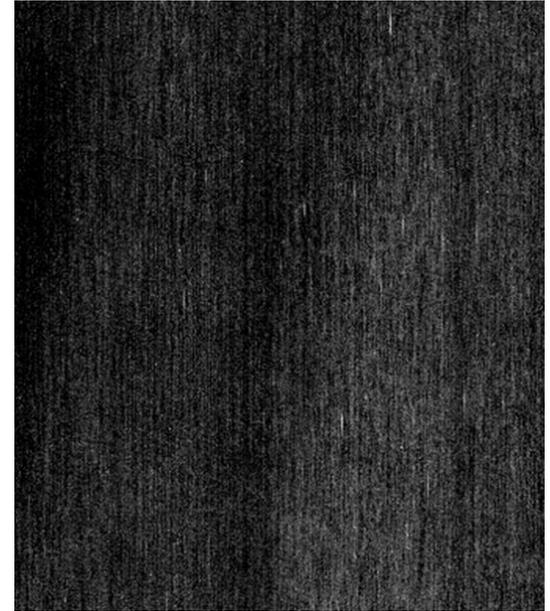
Grid Texture Test (monthly)

Image Quality Test Results 2014-04-03,15:08:42,GMT

Test	Measurement	LSL	USL	Status
Texture Level	0.1478	N/A	0.0020	FAIL

Intermediate values

Parameter	Values			
Electronic Noise	-0.8386	N/A	N/A	PASS
Quantum Noise	0.0681	N/A	N/A	PASS
Texture Noise	0.0101	N/A	N/A	PASS

Image Number	Acquisition Parameters	Average Detector Dose (nGy)	Noise Energy (counts)
1	MoMo 26 kV 5 mAs	12.7331	2.4922
2	MoMo 26 kV 8 mAs	21.0883	5.4698
3	MoMo 26 kV 13 mAs	34.8372	13.8806
4	MoMo 26 kV 25 mAs	68.1042	49.0433
5	MoMo 26 kV 40 mAs	110.7504	127.3293
6	MoMo 26 kV 60 mAs	166.9471	295.8159
7	MoMo 26 kV 90 mAs	251.0739	651.3262
8	MoMo 26 kV 120 mAs	334.8458	1149.3167
	MoMo 26 kV 240 mAs	668.7838	4551.0737
	MoMo 26 kV 400 mAs	1112.1067	12533.4037

OK

Noise vs dose

$y = 0.0101x^2 + 0.0681x - 0.8385$

Noise [counts] vs Detector dose [nGy]
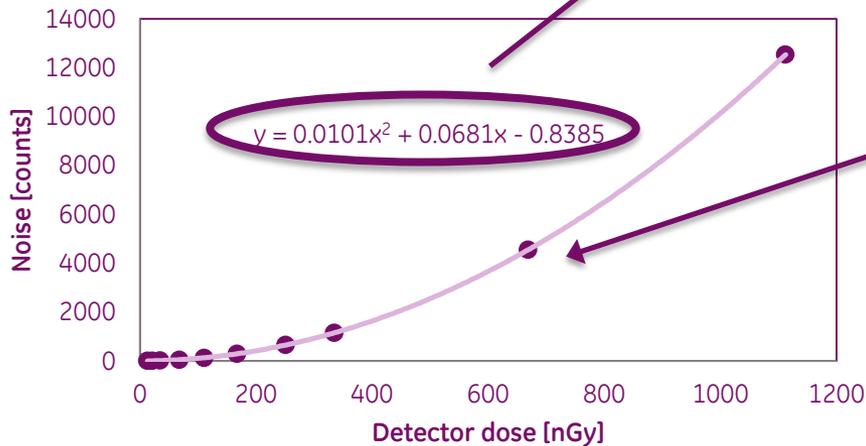
SenoClaire Tests ... 3D "Extensions"

Minimum frequency	Test	Essential		SenoClaire (w/ MTD)		
		No X	2D	No X	2D	3D
Daily	Monitor cleaning	X				
Weekly	**Flat field**		X			X
Weekly	**Phantom IQ**		X		X	X
Weekly	CNR & MTF		X		X	
Weekly	Viewbox & Viewing	X				
Monthly	**AOP Mode & SNR**		X		X	X
Monthly	Visual Checklist	X		X		
Quaterly	Repeat Analysis	X				
Semi-anually	Compression Force	x		x		
Monthly	Grid Texture				X	

Flat field 3D Test (Weekly)

Objective

Ensure flatness and homogeneity when reconstructing planes through a flat field phantom

Equipment required

Flat field test object

Procedure

- Automatic 3D acquisitiion
- Record the displayed test results
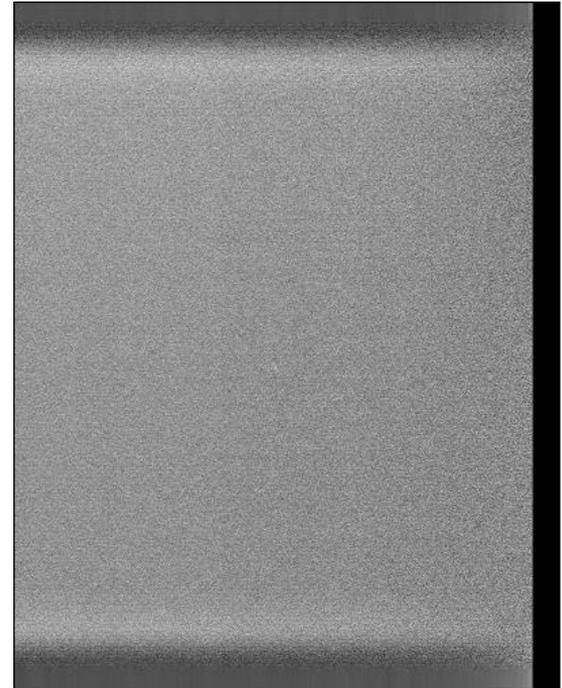

```
                Image Quality Test Results 2014-04-03,15:20:21,GMT

Test                              Measurement    LSL           USL           Status
Brightness Non Uniformity         14.17          N/A           15.00         PASS
SNR Non Uniformity                55.01          N/A           50.00         FAIL

Configuration                     3D
```

Action Limit

Both Brightness non-uniformity* and SNR non-uniformity* tests must pass

Calculated in the plane at 10 mm height

Phantom IQ 3D Test (Weekly)

Objective

Ensure adequate and consistent IQ of 3D images

Equipment required

ACR mammography accreditation phantom

Procedure

- 3D acquisitiion with Rh/Rh track/filter, 29 kV, 56 mAs
- Review the volumes; "score" the phantom

 Scroll through the volume to find the best in-focus plane for each structure!

Action Limit

The score must be: Fibers $\geq$ 4, Speck groups $\geq$ 3, Masses $\geq$ 3
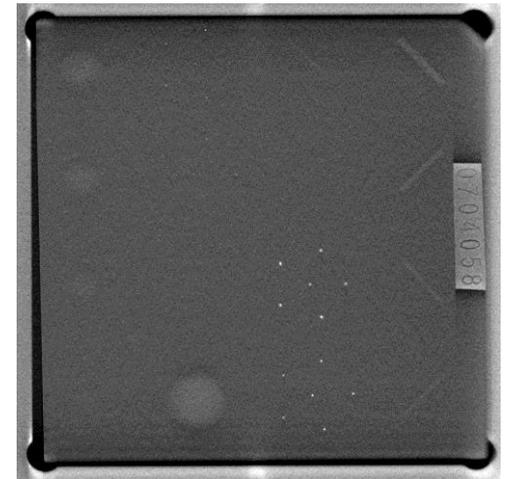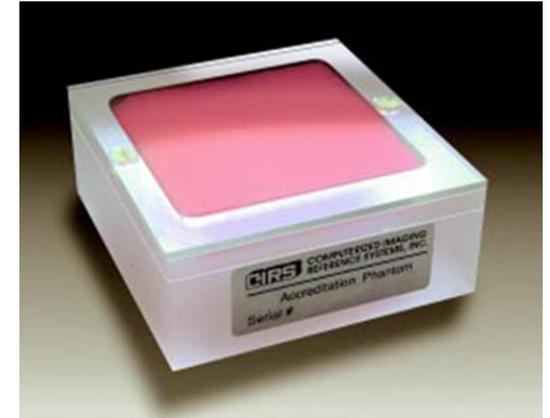
Same technique & action limit as for the 2D test

AOP 3D Check (Monthly)

Objective

Check that the correct parameters are selected in AOP 3D mode

Equipment required

Set of acrylic plates (same as for the AOP 2D Check)

Procedure

- 3D AOP acquisition on 25mm, 50mm, and 60 mm of acyrlic
- Record the exposure parameters

Action Limit

Acrylic Thickness (mm)	Exposure parameters		
	Track/Filter	mAs	kV
25	Mo/Mo or Mo/Rh	20-70	26
50	Rh/Rh	40-90	29
60	Rh/Rh	50-120	30 or 31

AOP 3D Check (Monthly)

Displayed results

Image Quality Test Results 2014-04-03,15:23:05,GMT

Test	Acrylic Thickness	Measurement	LSL	USL	Status
AOP	25mm	Mo/Mo/26kv	{Mo/Mo/26kv,Mo/Rh/26kv}		PASS
MAS	25mm	45.00	20.00	70.00	PASS

OK

Image Quality Test Results 2014-04-03,15:25:05,GMT

Test	Acrylic Thickness	Measurement	LSL	USL	Status
AOP	50mm	Rh/Rh/29kv	Rh/Rh/29kv		PASS
MAS	50mm	72.00	40.00	90.00	PASS

OK

Image Quality Test Results 2014-04-03,15:26:21,GMT

Test	Acrylic Thickness	Measurement	LSL	USL	Status
AOP	60mm	Rh/Rh/31kv	{Rh/Rh/30kv,Rh/Rh/31kv}		PASS
MAS	60mm	72.00	50.00	120.00	PASS

OK

SenoClaire QC Tests for the Technologist

- 2D Tests:
    - Section 3: Phantom IQ Test with MTD - Checks for consistency of image quality.
    - Section 4: CNR and MTF Measurement with MTD - Checks for consistent production of good contrast images.
    - Section 8: AOP 2D and SNR Check with MTD - Checks for correct operation of AOP mode with MTD.
- MTD Test: Section 7: Grid Texture Test - Checks for consistency of image quality regarding grid texture.
- 3D Tests:
    - Section 5: Flat-field 3D Test - Checks for consistency of image quality.
    - Section 6: Phantom IQ 3D Test - Checks for consistency of image quality.
    - Section 9: AOP 3D Test - Checks for correct operation of AOP mode in 3D.
- Section 10: Visual Checklist (page 27).
- Section 11: Compression Force Test - Checks for the correct level of compression force.
- Section 12: Test Results Forms - Provides charts for use in recording test results. It is recommended that you copy these chart pages to record test results.

For record keeping and further analysis, data generated on the Acquisition Workstation (AWS) for Flat-field, CNR, MTF, AOP and SNR tests can be exported as text files to a CD-R.

SenoClaire QC – Medical Physicist

SenoClaire

GE Breast Tomosynthesis
Quality Control Manual

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QC Tests for the Medical Physicist

Test	Essential	
	noX	2D
Flat field		X
Phantom IQ		X
CNR & MTF		X
AOP Mode & SNR		X
Artifact Eval & Flat field Unif		X
Collimation (2 alternatives)		X
Sub-system MTF or Focal Spot Perf		X
Breast Entrance Expose, AGD, Reproducibility		X
Flexible paddle deflection	X	
kVp Accuracy and Reproducibility		X
HVL		X
Mammo Unit Assembly Eval	X	

QC Tests for the Medical Physicist

Test	Essential		SenoClaire (w/ MTD)		
	noX	2D	noX	2D	3D
Flat field		X			X
Phantom IQ		X		X	X
CNR & MTF		X		X	
AOP Mode & SNR		X		X	X
Artifact Eval & Flat field Unif		X		X	
Collimation (2 alternatives)		X			
Sub-system MTF or Focal Spot Perf		X			
Breast Entrance Expose, AGD, Reproducibility		X		X	X
Flexible paddle deflection	X				
kVp Accuracy and Reproducibility		X			
HVL		X			
Mammo Unit Assembly Eval	X				
Grid Texture				X	
Compression paddle border to chestwall alignment				X	
Volume Coverage					X

Test Intervals – **all** at acceptance and at least annually

7 tests from radiologic technologist's section

Table 1   Radiologic Technologist's QC tests

	Radiologic Technologist's QC section	Minimum Frequency	Section
1.	Phantom IQ Test with MTD	Annually	*Chapter 1* section 3 *Phantom IQ Test with MTD* on page 13
2.	CNR and MTF Measurement with MTD	Annually	*Chapter 1* section 4 *CNR and MTF Measurement with MTD* on page 15
3.	Flat field 3D Test	Annually	*Chapter 1* section 5 *Flat field 3D Test* on page 18
4.	Phantom IQ 3D Test	Annually	*Chapt...*
5.	Grid texture Test	Annually	
6.	AOP 2D and SNR Check with MTD	Annually	
7.	AOP 3D Check	Annually	

5 additional only for medical physicists

Additional tests that must be performed by the Physicist are listed below.

Table 2   QC tests specific to Digital Mammography

	Specific to Digital Mammography	Minimum Frequency	Section
8.	Compression paddle border to chest wall alignment with MTD	Annually	*Job Card VF-DBT01 - Compression paddle to MTD chest wall alignment test* on page 39
9.	Breast Entrance Exposure and Average Glandular Dose with MTD	Annually	*Job Card VF-DBT02 - Breast Entrance Exposure and Average Glandular Dose with MTD* on page 45
10.	Breast Entrance Exposure and Average Glandular Dose in 3D mode	Annually	*Job Card VF-DBT05 - 3D Breast Entrance Exposure and Average Glandular Dose* on page 49
11.	Artifact Evaluation and Flat field Uniformity with MTD	Annually	*Job Card VF-DBT03 - Artifact Evaluation and Flat field Uniformity with MTD* on page 55
12.	Volume coverage	Annually	*Job Card VF-DBT04 - Volume Coverage* on page 59

SenoClaire Tests … same as Essential Tests

Test	Essential		SenoClaire (w/ MTD)		
	noX	2D	noX	2D	3D
Flat field		X			X
Phantom IQ		X		X	X
CNR & MTF		X		X	
AOP Mode & SNR		X		X	X
Artifact Eval & Flat field Unif		X		X	
Collimation (2 alternatives)		X			
Sub-system MTF or Focal Spot Perf		X			
Breast Entrance Expose, AGD, Reproducibility		X		X	X
Flexible paddle deflection	X				
kVp Accuracy and Reproducibility		X			
HVL		X			
Mammo Unit Assembly Eval	X				
Grid Texture				X	
Compression paddle border to chestwall alignment				X	
Volume Coverage					X

Compression paddle to MTD chest wall alignment test

Objective

Assure that the paddle chest wall side border aligns with the chest wall side of the MTD

Same test as "Compression Paddle Chest Wall Test" from the Collimation Assessment tests for Essential (541589-3-1EN)
- *Job Card VF-P01A - Collimation Assessment with X-Ray Cassette, OR*
- *Job Card VF-P01B - Collimation Assessment with Radiation Sensitive Strips*

Tape the coin to the underside of the compression paddle as illustrated below. The coin must be as close as possible to the tangent of the inner, vertical surface of the compression paddle at the chest wall edge. Position the coin near the center of the chest wall edge.

Compression Paddle outer vertical surface

Compression Paddle inner vertical surface

Compression Paddle inner vertical surface

Chest Wall Edge

Coin

The large coin must be as close as possible, but inside of the tangent to the inner vertical suface

Coin

Chest Wall Edge

Compression Paddle Side View

Compression Paddle Plan View

SenoClaire Tests ... New Grid Texture Test

Test	Essential		SenoClaire (w/ MTD)		
	noX	2D	noX	2D	3D
Flat field		X			X
Phantom IQ		X		X	X
CNR & MTF		X		X	
AOP Mode & SNR		X		X	X
Artifact Eval & Flat field Unif		X		X	
Collimation (2 alternatives)		X			
Sub-system MTF or Focal Spot Perf		X			
Breast Entrance Expose, AGD, Reproducibility		X		X	X
Flexible paddle deflection	X				
kVp Accuracy and Reproducibility		X			
HVL		X			
Mammo Unit Assembly Eval	X				
Grid Texture				X	
Compression paddle border to chestwall alignment				X	
Volume Coverage					X

SenoClaire Tests … 3D "Extensions"

Test	Essential		SenoClaire (w/ MTD)		
	noX	2D	noX	2D	3D
Flat field		X			X
Phantom IQ		X		X	X
CNR & MTF		X		X	
AOP Mode & SNR		X		X	X
Artifact Eval & Flat field Unif		X		X	
Collimation (2 alternatives)		X			
Sub-system MTF or Focal Spot Perf		X			
Breast Entrance Expose, AGD, Reproducibility		X		X	X
Flexible paddle deflection	X				
kVp Accuracy and Reproducibility		X			
HVL		X			
Mammo Unit Assembly Eval	X				
Grid Texture				X	
Compression paddle border to chestwall alignment				X	
Volume Coverage					X

3D Breast Entrance Exposure and AGD

Objective

Measure the typical entrance exposure in 3D mode on a "standard breast" (42-mm 50% fibroglandular); calculate the delivered AGD

Equipment required

Dosimeter & ACR Mammography accreditation phantom

Procedure

- 3D *stationary** acquisition in manual mode
- acquisition technique should be as close as possible to technique clinically used on a "standard breast"
- From the measured Entrance exposure compute the AGD …

Action Limit

The AGD for a "standard breast" must not exceed 3 mGy per 3D acquisition

Same procedure as for the 2D test … but entrance dose measured over a sequence of 9 low-dose acquisitions

* "3D" acquisitions with the tube non-moving (at zero degree)

SenoClaire Tests … New 3D Specific Test

Test	Essential		SenoClaire (w/ MTD)		
	noX	2D	noX	2D	3D
Flat field		X			X
Phantom IQ		X		X	X
CNR & MTF		X		X	
AOP Mode & SNR		X		X	X
Artifact Eval & Flat field Unif		X		X	
Collimation (2 alternatives)		X			
Sub-system MTF or Focal Spot Perf		X			
Breast Entrance Expose, AGD, Reproducibility		X		X	X
Flexible paddle deflection	X				
kVp Accuracy and Reproducibility		X			
HVL		X			
Mammo Unit Assembly Eval	X				
Grid Texture				X	
Compression paddle border to chestwall alignment				X	
Volume Coverage					X

Volume Coverage

Top aluminum sheet

Bottom aluminum sheet

Acrylic plates

Objective
Ensure that the entire imaged object is reconstructed on the Z-axis (perpendicular to the detector)

Equipment required
Set of acrylic plates; 2 1-mm Al sheets

Procedure
- "Sandwich" 25 mm of acrylic plates in between the 2 Al sheets *as showed in the picture*
- Manual 3D exposure, clinically used compression force
- Search for the focal planes for the 2 Al sheets
- Repeat with 60 mm acrylic

Action Limit
The focal planes for the 2 Al planes must be in the reconstructed volume
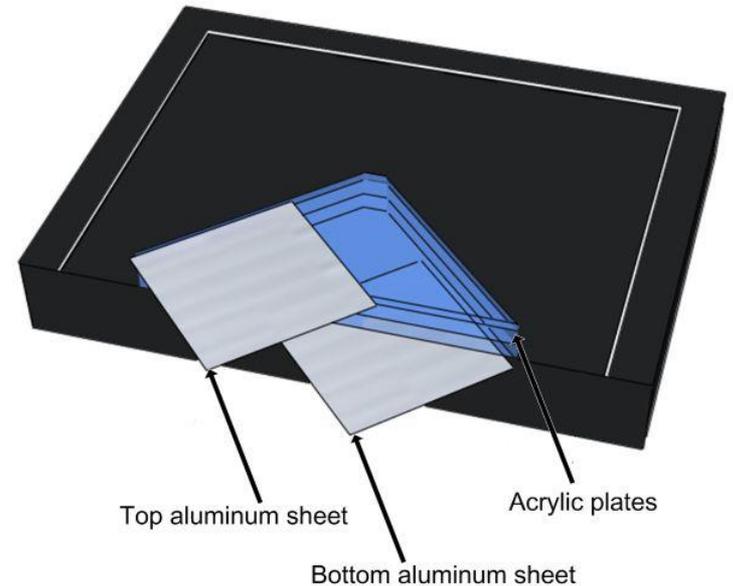
Volume Coverage
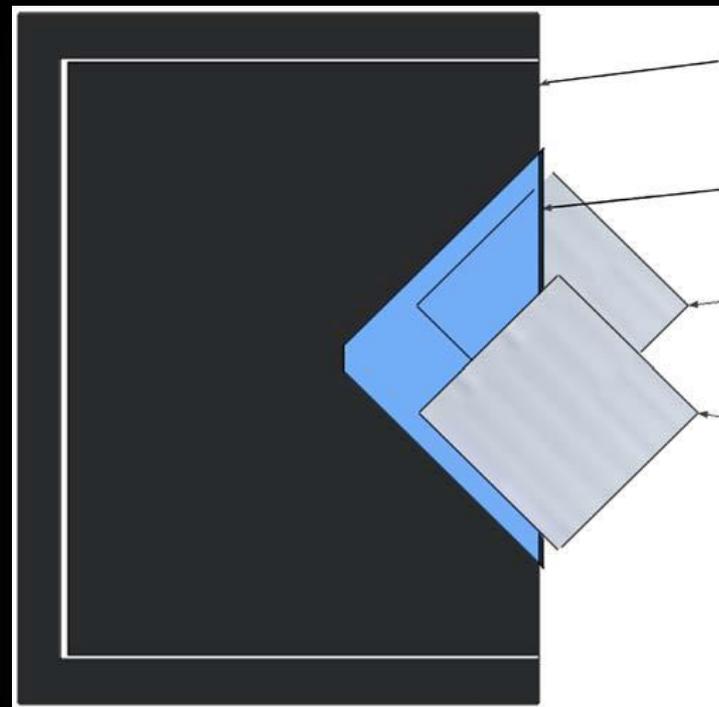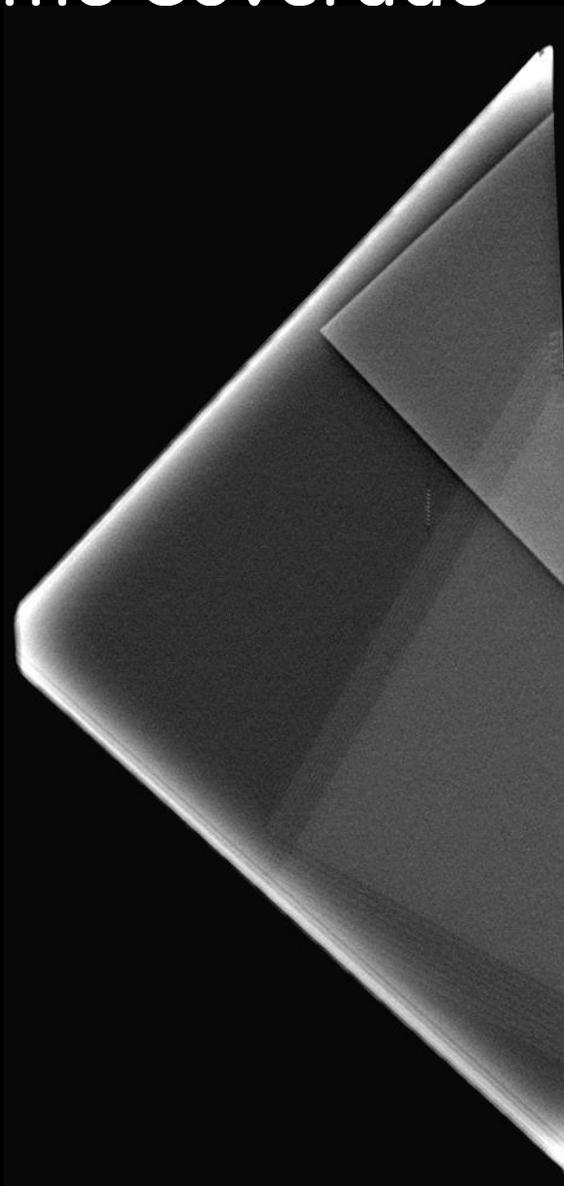
SenoClaire Quality Control Forms

SenoClaire

GE Breast Tomosynthesis
Quality Control Forms

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Conclusion

Additional QC Tests for SenoClaire (with MTD installed)

Technologist Tests

1. Phantom IQ 2D Test with MTD
2. CNR and MTF Measurement with MTD
3. Flat-field 3D Test
4. Phantom IQ 3D Test
5. MTD Grid Texture Test
6. AOP 2D and SNR Check with MTD
7. AOP 3D Check
8. Visual Checklist
9. Compression Force Test

Weekly

Monthly

Semi-annually

Medical Physicist Tests (in addition to repeating those above)

1. Compression paddle to chest wall alignment with MTD
2. Breast Entrance Exposure and AGD in 2D with MTD
3. Breast Entrance Exposure and AGD in 3D Mode
4. Artifact Evaluation and Flat-field Uniformity with MTD
5. Volume Coverage of DBT

Annually

Quality Control Procedures: Digital Breast Tomosynthesis

Selenia® Dimensions® Digital Breast Tomosynthesis Systems

HOLOGIC®

The Women's Health Company

System Description

Image Acquisition Modes

- Conventional
  - Acquires 2D images, only
- Tomo
  - Acquires tomosynthesis images, only
- TomoHD
  - Acquires tomosynthesis images, only
  - Produces C-View images
- Combo
  - Acquires 2D images
  - Acquires tomosynthesis images
- ComboHD
  - Acquires 2D images
  - Acquires tomosynthesis images
  - Produces C-View images

QC Modes

- Quality control procedures test
  - Conventional
  - Tomo
  - Combo
  - iView
- The following modes do not require separate QC testing
  - TomoHD
  - ComboHD

AWS Configurations

With AWS-8000
(premium version)

With AWS-5000
(standard version)

Identical gantry

X-Ray Generation

X-Ray Tube
- Tungsten (W) Anode
- LFS: 0.3 mm; SFS: 0.1 mm

X-Ray Filtration
- Conv: 50 µm Rh; 50 µm Ag
- Tomo: 0.7 mm Al

X-Ray Generator
- 200 mA max for LFS
- 50 mA max for SFS
- Max mA varies with kVp
- mA adjusts to target time range

Selenia Dimensions: Techniques

Conventional 2D Imaging

- a-Se detector, 24 × 29 cm area
- 70 µm pixel size
- Rh and Ag filters
- HTC grid in contact mode;
- HTC (High Trans. Cellular)

- 20-39 kVp

Tomosynthesis Imaging

- a-Se detector, 24 × 29 cm area
- 140 µm pixel size
- Al filter
- No anti-scatter grid
- Moving tube, 15° sweep
- Moving detector
- 15 projections
- ~4 seconds acquisition
- Reconstruction
  - ~100 µm pixel size
  - 1 mm slice spacing
- 20-49 kVp

Table 1-2: Quality Control Tests to be Performed by the Medical Physicist on Selenia Dimensions 2D FFDM and Selenia Dimensions DBT Systems

Quality Control Test	Frequency	Action Criteria	Chapter 2
Mammographic Unit Assembly Evaluation	Annually	Category C	Section 1.0, page 10
Collimation Assessment	Annually	Category C	Section 2.0, page 11
Artifact Evaluation	Annually	Category C	Section 3.0, page 18
kVp Accuracy and Reproducibility	Annually	Category C	Section 4.0, page 22
Beam Quality Assessment—HVL Measurement	Annually	Category C	Section 5.0, page 24
Evaluation of System Resolution	Annually	Category A	Section 6.0, page 26
Automatic Exposure Control (AEC) Function Performance	Annually	Category C	Section 7.0, page 29
Breast Entrance Exposure, AEC Reproducibility, and Average Glandular Dose	Annually	Category A Category C	Section 8.0, page 33
Radiation Output Rate	Annually	Category C	Section 9.0, page 39
Phantom Image Quality Evaluation	Annually	Category A	Section 10.0, page 42
Signal-To-Noise and Contrast-To-Noise Measurements	Annually	Category A	Section 11.0, page 45
Diagnostic Review Workstation Quality Control	Annually	Category B	Section 12.0, page 50
Detector Ghosting (troubleshooting use only)	—	Category A	Section 13.0, page 52

Table 1-3: Quality Control Tests with Tomosynthesis-Specific Options

Quality Control Test	Frequency	Action Criteria	Chapter 2
Collimation Assessment	Annually	Category C	Section 2.0, page 11
Artifact Evaluation	Annually	Category C	Section 3.0, page 18
Beam Quality Assessment—HVL Measurement	Annually	Category C	Section 5.0, page 24
Evaluation of System Resolution	Annually	Category A	Section 6.0, page 26
Automatic Exposure Control (AEC) Function Performance	Annually	Category C	Section 7.0, page 29
Breast Entrance Exposure, AEC Reproducibility, and Average Glandular Dose	Annually	Category A Category C	Section 8.0, page 33
Phantom Image Quality Evaluation	Annually	Category A	Section 10.0, page 42

DBT
Quality Control

Selenia Dimensions QC Manual

- http://www.hologic.com/support/dimensions-3d-breast-tomosynthesis-dimensions-2d-full-field-digital-mammography

- http://www.hologic.com/support/selenia-digital-mammography

The QC manual covers:
- Selenia Dimensions 2D FFDM system
- Selenia Dimensions DBT system
- Current revisions:
    - MAN-01965 R008, Jul 2014
    - MAN-03706 R002, Aug 2014

Medical Physics QC Tests

12 tests to be performed by the medical physicist

7 of them have DBT components/requirements

Table 1-2: Quality Control Tests to be Performed by the Medical Physicist on Selenia Dimensions 2D FFDM and Selenia Dimensions DBT Systems

Quality Control Test	Frequency	Action Criteria	Chapter 2
Mammographic Unit Assembly Evaluation	Annually	Category C	Section 1.0, page 10
Collimation Assessment	Annually	Category C	Section 2.0, page 11
Artifact Evaluation	Annually	Category C	Section 3.0, page 18
kVp Accuracy and Reproducibility	Annually	Category C	Section 4.0, page 22
Beam Quality Assessment—HVL Measurement	Annually	Category C	Section 5.0, page 24
Evaluation of System Resolution	Annually	Category A	Section 6.0, page 26
Automatic Exposure Control (AEC) Function Performance	Annually	Category C	Section 7.0, page 29
Breast Entrance Exposure, AEC Reproducibility, and Average Glandular Dose	Annually	Category A Category C	Section 8.0, page 33
Radiation Output Rate	Annually	Category C	Section 9.0, page 39
Phantom Image Quality Evaluation	Annually	Category A	Section 10.0, page 42
Signal-To-Noise and Contrast-To-Noise Measurements	Annually	Category A	Section 11.0, page 45
Diagnostic Review Workstation Quality Control	Annually	Category B	Section 12.0, page 50
Detector Ghosting (troubleshooting use only)	—	Category A	Section 13.0, page 52

Table 1-3: Quality Control Tests with Tomosynthesis-Specific Options

Quality Control Test	Frequency	Action Criteria	Chapter 2
Collimation Assessment	Annually	Category C	Section 2.0, page 11
Artifact Evaluation	Annually	Category C	Section 3.0, page 18
Beam Quality Assessment—HVL Measurement	Annually	Category C	Section 5.0, page 24
Evaluation of System Resolution	Annually	Category A	Section 6.0, page 26
Automatic Exposure Control (AEC) Function Performance	Annually	Category C	Section 7.0, page 29
Breast Entrance Exposure, AEC Reproducibility, and Average Glandular Dose	Annually	Category A Category C	Section 8.0, page 33
Phantom Image Quality Evaluation	Annually	Category A	Section 10.0, page 42

Tomosynthesis Option

- Tomosynthesis specific tests are marked with an icon

- Icon indicates that a special action is required under tomosynthesis

NOTE: *When testing FFDM only, these instructions are ignored*

Quality Control Tests

MP Tests for Dimensions 2D

Quality Control Test	Frequency	Action Criteria
Mammographic Unit Assembly Evaluation	Annually	Category C
Collimation Assessment	Annually	Category C
Artifact Evaluation	Annually	Category C
kVp Accuracy and Reproducibility	Annually	Category C
Beam Quality Assessment—HVL Measurement	Annually	Category C
Evaluation of System Resolution	Annually	Category A
Automatic Exposure Control (AEC) Function Performance	Annually	Category C
Breast Entrance Exposure, AEC Reproducibility, and Average Glandular Dose	Annually	Category A Category C
Radiation Output Rate	Annually	Category C
Phantom Image Quality Evaluation	Annually	Category A
Signal-To-Noise and Contrast-To-Noise Measurements	Annually	Category A
Diagnostic Review Workstation Quality Control	Annually	Category B
Detector Ghosting (troubleshooting use only)	—	Category A

MP Tests with Tomosynthesis Option

Quality Control Test	Frequency	Action Criteria
Collimation Assessment	Annually	Category C
Artifact Evaluation	Annually	Category C
Beam Quality Assessment—HVL Measurement	Annually	Category C
Evaluation of System Resolution	Annually	Category A
Automatic Exposure Control (AEC) Function Performance	Annually	Category C
Breast Entrance Exposure, AEC Reproducibility, and Average Glandular Dose	Annually	Category A Category C
Phantom Image Quality Evaluation	Annually	Category A

Technologist Tests – Dimensions 2D

Quality Control Test	Frequency	Action Criteria
DICOM Printer Quality Control	Weekly	Category B
Detector Flat Field Calibration	Weekly	Category A
Geometry Calibration (Tomosynthesis Option)	Semiannually	Category A
Artifact Evaluation	Weekly	Category C
Phantom Image	Weekly	Category A
Signal-To-Noise and Contrast-To-Noise Measurements	Weekly	Category A
Compression Thickness Indicator	Biweekly	Category C
Diagnostic Review Workstation Quality Control	Weekly	Category B
Viewboxes and Viewing Conditions	Weekly	Category B
Visual Checklist	Monthly	Category C
Repeat/Reject Analysis	Quarterly	Category C
Compression	Semiannually	Category A

Technologist Tests – Tomosynthesis Option

Quality Control Test	Frequency	Action Criteria
Geometry Calibration (Tomosynthesis Option)	Semiannually	Category A
Artifact Evaluation	Weekly	Category C
Phantom Image	Weekly	Category A

Follow the *1999 ACR Mammography Quality Control Manual*

1. MAMMOGRAPHIC UNIT ASSEMBLY EVALUATION

TOMO

Follow the *Hologic Selenia Dimensions Quality Control Manual*

2. COLLIMATOR ASSESSMENT

2a. X-Ray Field to Light Field
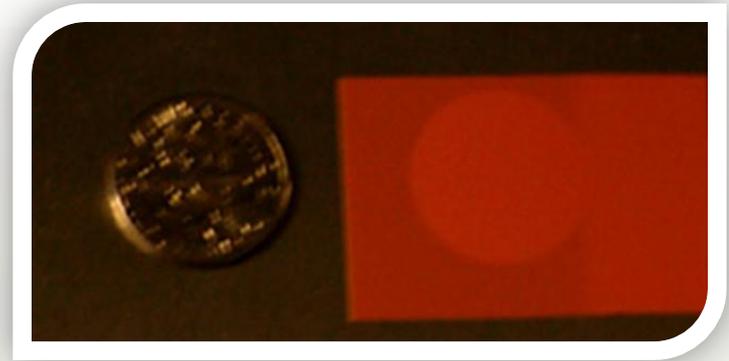
- ONLY use the 24x29 cm compression paddle
- Cover the image receptor if repeated, high exposures are required (i.e. self-developing film)

2b. X-Ray Field to Image Receptor
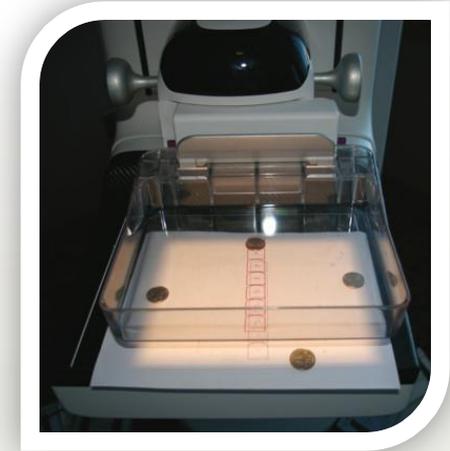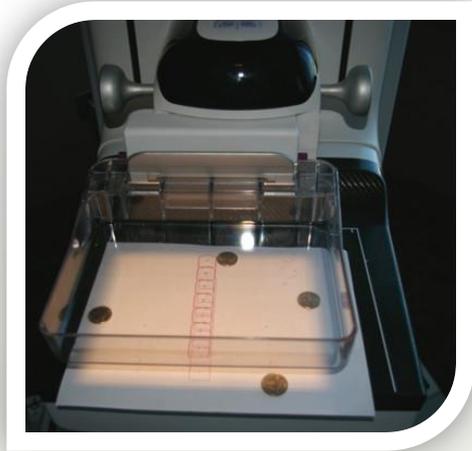
- Test with the 24x29 cm compression paddle
- Test left, center and right x-ray fields with the 18x24 cm compression paddle
- Use the *Zero-Degree Tomo* view to test under tomosynthesis
- Follow the directions in the QC manual

2c. Compression Paddle to Image Receptor
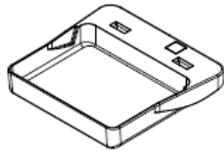
18 x 24 cm Frameless Screening Paddle
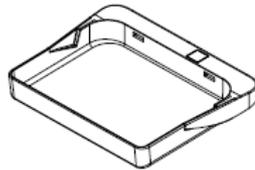
24 x 29 cm Frameless Screening Paddle
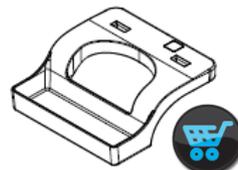
Small Breast Frameless Paddle

- Compression paddles
  - Manufactured as single pieces
  - Do not have adjusting parts
  - Designed to comply with the regulations
  - Design assumes mild compression (~10lb) to remove play
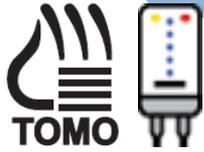
Follow the *Hologic Selenia Dimensions Quality Control Manual*

3. ARTIFACT EVALUATION
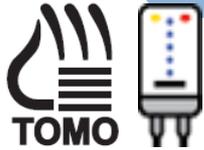
Procedure Highlights

- DICOM printer
  - Send an artificial flat field image to the printer
- FFDM testing
  - Test all focus/filter combinations (LFS/Rh; LFS/Ag; SFS/Rh; SFS/Ag)
  - Preview image in full resolution
- DBT testing
  - Test using middle projection
  - Preview image in full resolution

Follow the *1999 ACR Mammography Quality Control Manual*

4. KVP ACCURACY AND REPRODUCIBILITY

Procedure Highlights

Conventional   Tomo   Station. Tomo
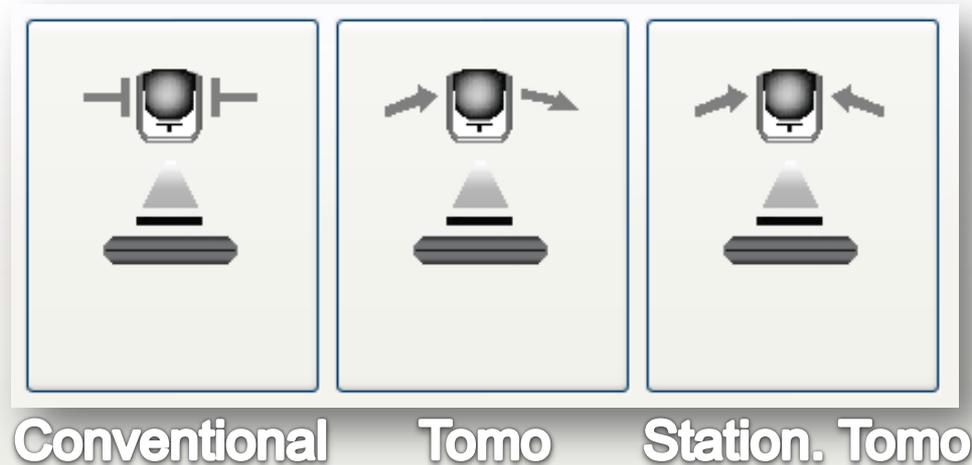
- Cover the image receptor to protect it from radiation exposure
- FFDM extends to 39 kVp; DBT extends to 49 kVp
- Use the *Zero-Degree Tomo* mode to test beyond 39 kVp, if needed
- Non-invasive meters must be calibrated to the specific filters and energy range used
- Hologic Service can assist with equipment
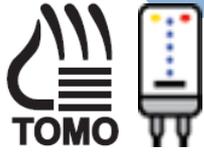
Follow the *1999 ACR Mammography Quality Control Manual*

5. BEAM QUALITY ASSESSMENT—HVL MEASUREMENT
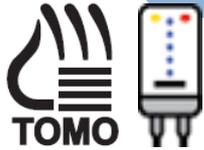
Procedure Highlights
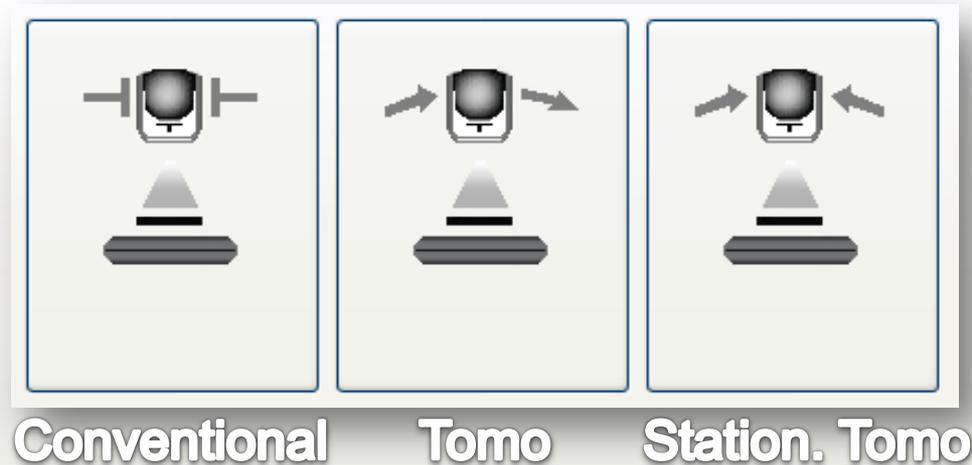
Conventional   Tomo   Station. Tomo

- Cover the image receptor to protect it from radiation exposure
- Use the *Zero-Degree Tomo* mode to measure HVL under DBT (Al filter)
- NOTE: compression thickness should be <24cm for the system to allow exposure
- Non-invasive meters must be calibrated to the specific filters and energy range used
- [HVL > (kVp/100) + 0.03] in mm Al

Follow the *Hologic Selenia Dimensions Quality Control Manual*

6. EVALUATION OF SYSTEM RESOLUTION

Procedure Highlights

- Place the line pair phantom on top of the 4 cm acrylic c
- Rotate the line pair phantom 45°
- Apply 15-20 lb of compression to avoid vibration during DBT
- Use the Flat Field view (no image processing)
- Resolution guidelines:
  - FFDM: > 7 lp/mm @ 45°
  - DBT: > 3 lp/mm @ 45°

Procedure Highlights
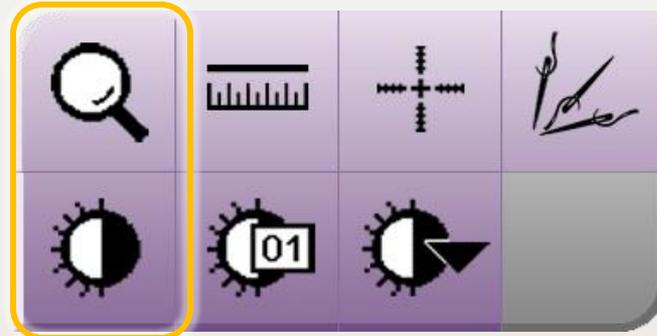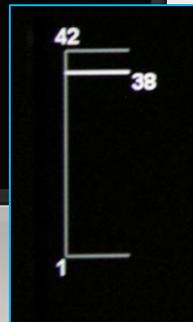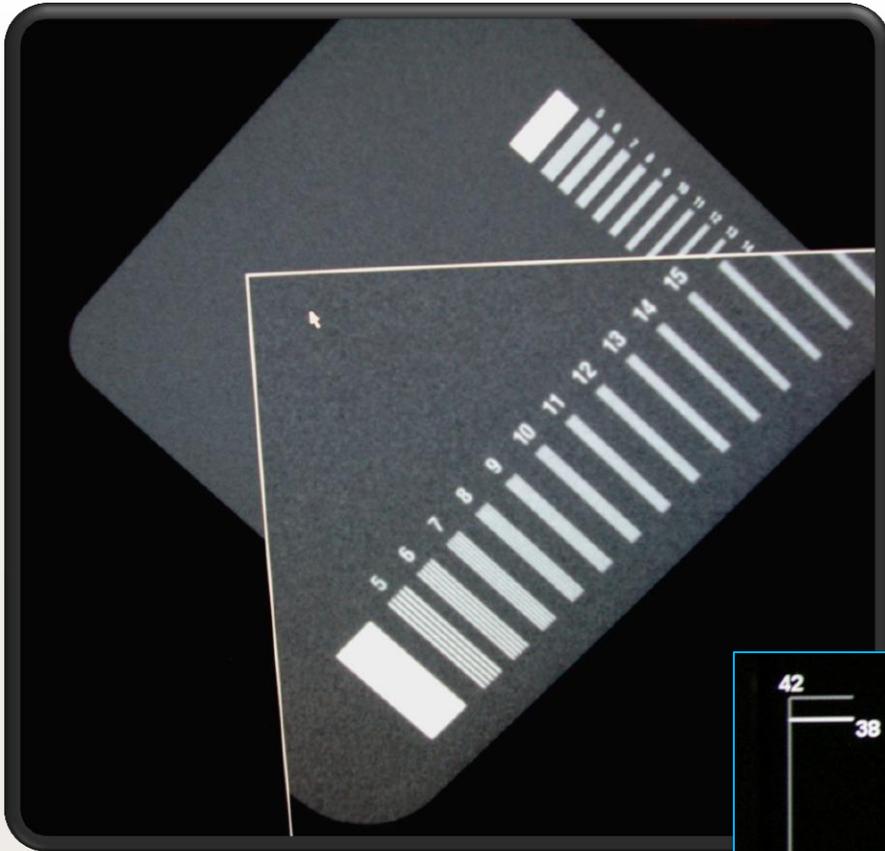
Follow the *Hologic Selenia Dimensions Quality Control Manual*

7. AEC FUNCTION PERFORMANCE

AEC Function Description

- AEC modes
  - Auto-Filter
  - Auto-kV
  - Auto-Time
- AEC positions
  - Auto AEC: 2, 1cm^2 floating sensors at 5x14cm^2 area
  - One of seven manual positions (marked on compression paddle)
- AEC function
  - kVp and filter parameters are determined by compression thickness and AEC technique tables
  - Starting mAs is determined from short pre-exposure targeting a specific exposure index (EI)
  - Final mAs is adjusted by CNR correction factor

Procedure Highlights

- Compression thickness must be set using the compression display
- FFDM testing
  - Range of phantom thickness
  - Different operating modes (i.e. mag)
  - Exposure compensation steps
- DBT testing
  - Range of phantom thickness

Compression Thickness

Exposure Index (EI)

- EI is defined as the *digital value of a detector element*
- "Raw" EI values need to be corrected by
  - Subtracting the DC offset (value of 50)
  - Normalizing by the CNR correction factor (given in *Appendix D* of the *Hologic QC Manual*)

$$Pixel\ Value = \frac{ROI\ mean\ - DC\ Offset}{CNR\ Correction\ Factor}$$

CNR Correction Factors, FFDM

LFS

1.0 CNR Correction – Conventional (Contact)

Note

System default setting is AEC Table 4 for imaging under contact mammography.

AEC Table 4 (Uniform CNR Screening Dose)

Compression Thickness	Prior to Software Rev 1.7.x — All Detectors	After Software Rev 1.7.x — Detectors Serial #: XX6xxxxx	Detectors Serial #: XX8xxxxx
2.0 cm	1.00	1.00	1.00
4.0 cm	1.00	1.00	1.00
6.0 cm	1.30	1.30	1.35
8.0 cm	1.70	1.70	1.82

CNR Correction Factors, FFDM

SFS
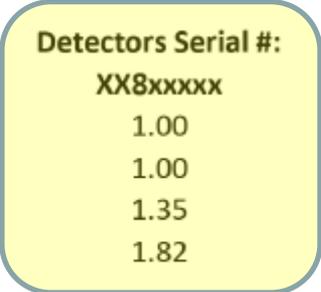
2.0 CNR Correction - Conventional (Magnification)

Note

> System default setting is AEC Table 0 for software prior to rev 1.7.x and AEC Table 4 for software after rev 1.7.x when imaging under magnification mammography.

AEC Table 4 (Enhanced Magnification Dose)

Compression Thickness	Prior to Software Rev 1.7.x — All Detectors	After Software Rev 1.7.x — Detectors Serial #: XX6xxxxx	After Software Rev 1.7.x — Detectors Serial #: XX8xxxxx
2.0 cm	N/A	1.50	1.50
4.0 cm	N/A	1.50	1.50
6.0 cm	N/A	1.50	1.55
8.0 cm	N/A	1.50	1.67

CNR Correction Factors, FFDM

LFS
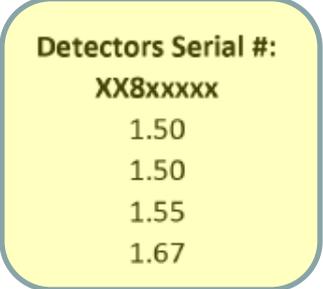
3.0   CNR Correction - Tomosynthesis Option

Note

System default setting is AEC Table 0 for imaging under digital breast tomosynthesis.

AEC Table 0 (Standard Tomosynthesis Dose)

Compression Thickness	Prior to Software Rev 1.7.x — All Detectors	After Software Rev 1.7.x — Detectors Serial #: XX6xxxxx	Detectors Serial #: XX8xxxxx
2.0 cm	0.70	0.70	0.70
4.0 cm	0.91	0.91	0.91
6.0 cm	1.46	1.46	1.55
8.0 cm	2.37	2.37	2.78

Calculation Example

Contact Imaging, Tomo								
Phantom thickness	AEC				Exp Comp	ROI	CNR	Pixel
	Mode	Filter	kVp	mAs	Step	Mean Value	Factor	Value
2 cm	Auto filter	Al	26	32	0	207	0.7	224
4 cm	Auto filter	Al	29	45	0	252	0.91	222
6 cm	Auto filter	Al	33	61	0	365	1.46	216
8 cm	Auto filter	Al	38	74	0	566	2.37	218

Mean Pixel Value	Pixel Value Range				Allowed Pixel Value		
220	216	to	224		198	to	242
Pass/Fail	Pass		Pass				

Pixel Value = (ROI mean - DC offset (50))/(CNR Correction Factor)

Action Limit: If the pixel value of each individual image corresponding to a breast thickness between 2 and 8 cm at any operating mode varies more than 10% of the mean pixel value computed for all tested breast thicknesses and operating modes, seek service.

TOMO
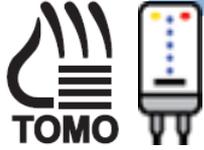
Follow the Hologic *Selenia Dimensions Quality Control Manual*

8. BREAST ENTRANCE EXPOSURE, AEC REPRODUCIBILITY AND AGD

Procedure Highlights

- Wait until the image receptor goes from *Warming* to *Ready* status

- Use *ACR Phantom* view to overwrite compression thickness to 4.2 cm
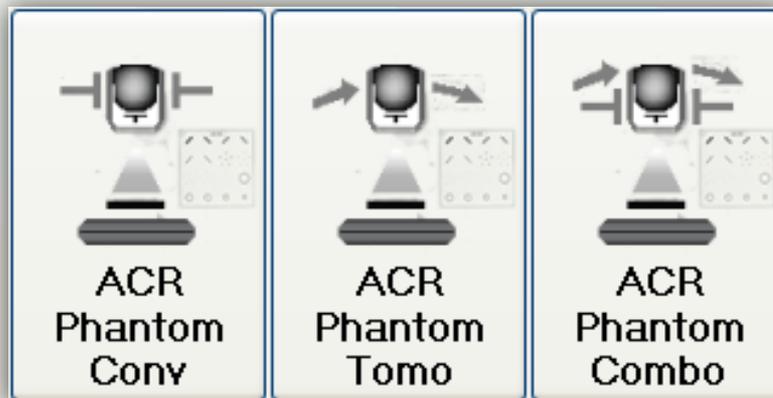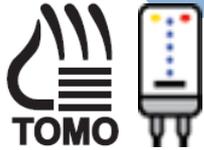
Procedure Highlights

- Test AGD in all three modes
  - FFDM
  - DBT
  - Combo
- Hologic AGD recommended dose for ACR phantom
  - FFDM: 1.2 mGy
  - DBT: 1.45 mGy
- Performance criteria
  - AGD < 3 mGy

ACR Phantom Conv

ACR Phantom Tomo

ACR Phantom Combo

TOMO
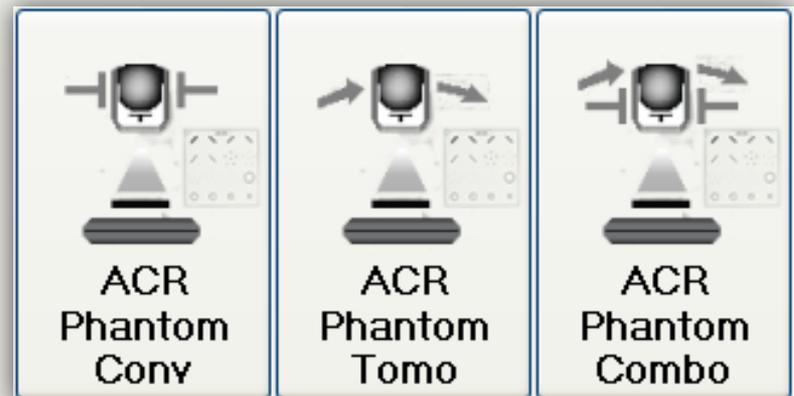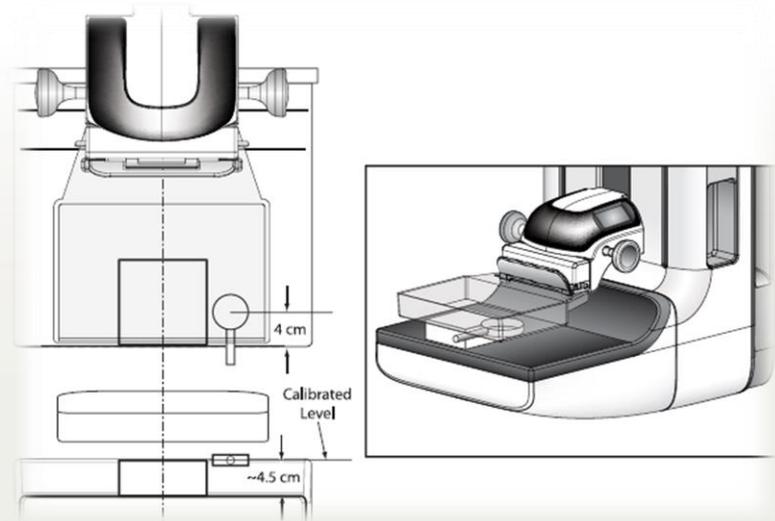
Follow the Hologic *Selenia Dimensions Quality Control Manual*

10. PHANTOM IMAGE QUALITY EVALUATION

Procedure Highlights

- Wait until the image receptor goes from *Warming* to *Ready* status

- Use *ACR Phantom* view to overwrite compression thickness to 4.2 cm
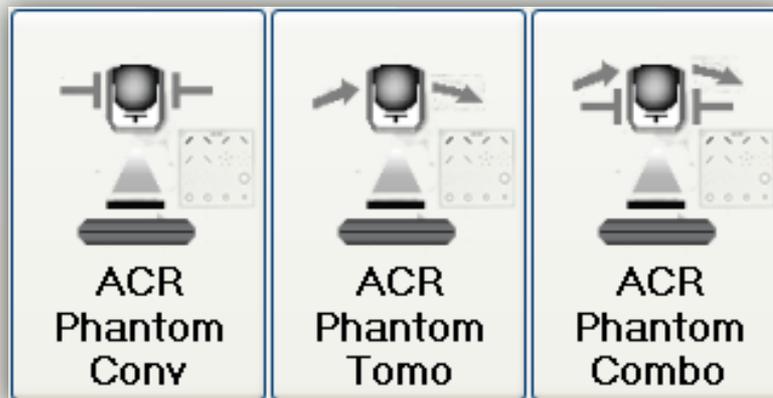
Phantom Scoring

- Score phantom on AWS display
- Review image in full resolution
- FFDM scoring
  – 5 fibers, 4 specs, 4 masses
  – Due to phantom variations a score of 4.5/4.0/3.5 is acceptable providing SNR and high contrast resolution tests pass
- DBT scoring
  – Scroll to the slice that puts the different elements in focus
  – 4 fibers, 3 specs, 3 masses
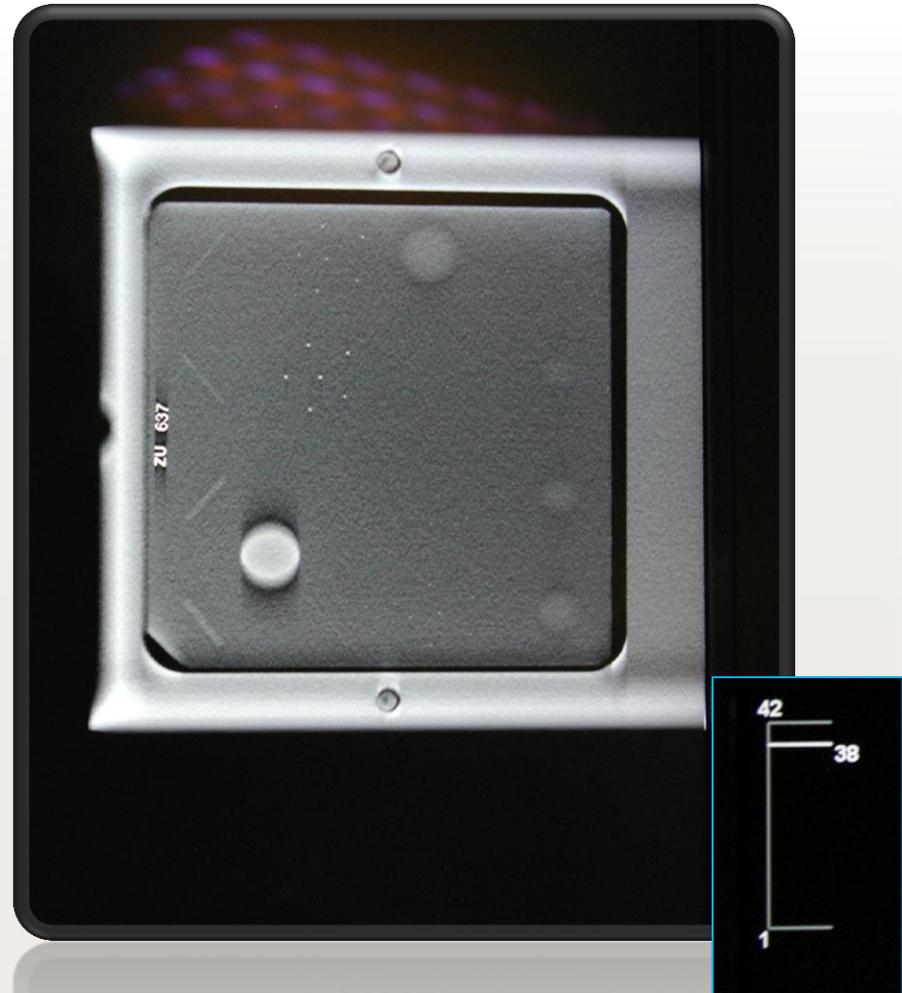
Follow the Hologic *Selenia Dimensions Quality Control Manual*

11. SNR AND CNR MEASUREMENTS

Procedure Highlights

- Wait until the image receptor goes from *Warming* to *Ready* status
- Use *ACR Phantom* view to overwrite compression thickness to 4.2 cm
- ACR Phantom view allows automatic SNR/CNR calculations
- Test is performed under FFDM mode only
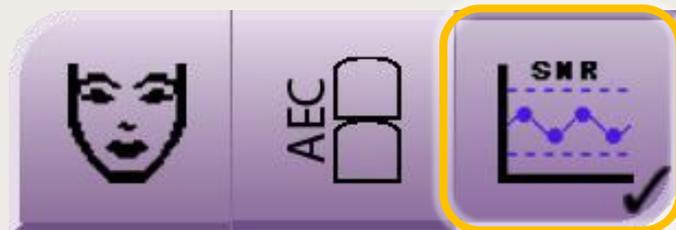
Automatic Computation

Geometry Calibration