Hands-on GE SenoClaire DBT: technical characteristics & quality control

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Imagination at work

Disclosures and Acknowledgements

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- Employee of GE Healthcare

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Our clinical collaborators for providing example cases

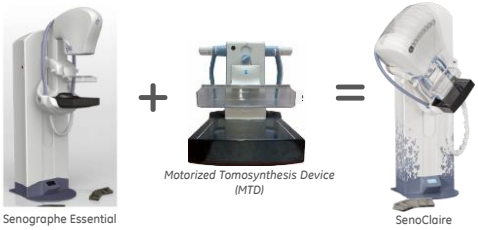
Tomosynthesis is analogous to a photography focus sweep

Outline

Technical datasheet
GE DBT (3D) technology
Clinical examples
Quality control

Datasheet

SenoClaire is an upgrade for Senographe Essential



Technical characteristics for 3D

Detector size [cm] & type	24 x 30 Indirect: a-Si + CsI(Tl) scintillator
Detector pixel size [um]	100
Detector motion	Static
X-ray tube target	Mo or Rh
X-ray tube filtration	0.03 mm Mo or 0.025 mm Rh
X-ray tube motion	Step-and-shoot
Anti-scatter grid	Linear, grid ratio: 5:1, grid pitch: 100 um
Angular range [deg] / Number of projections	25 / 9
Scan time [s]	<10*
AGD 3D : AGD 2D	1:1
Reconstruction algorithm	Iterative: ASiR^{DBT}
Volume representation	Planes & slabs
Planes geometrical characteristics	100 um pixel size, z-sampling 0.5 mm or 1 mm
Slabs geometrical characteristics	100 um pixel size, 10 mm thickness, z-sampling 5 mm
DICOM format for planes, slabs & V-Preview	DICOM Breast Tomosynthesis object (BTO)
Supported DICOM BTO syntax transfer	Uncompressed, lossless JPEG & lossy JPEG

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

GE DBT (3D) technology

Technology optimization strategy

Optimize …

- Projection images
- Acquisition configuration (number of projections dose distribution, angular range)
- Reconstruction algorithm
- Image coding and presentation

… while preserving the same AGD as in 2D

Projection images

Resolution

- Apparent focal spot
- Detector pixel pitch

Dose/IQ optimization

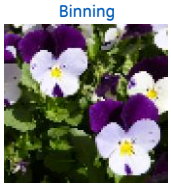
- Scatter management
- AEC & Beam quality

Resolution: detector pixel pitch

Native

Preserve resolution performace equal to 2D but requires fast read-out and high DQE at low dose

Binning



Trade resolution to accelerate read-out and increase SNR

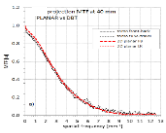
Resolution: apparent focal spot size

When the object (or the tube) moves during acquisition, the object is blurred in the direction of the motion (red arrow), but not in the direction orthogonal to the motion (blue arrow)

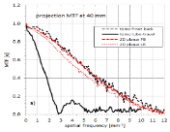
Step-and-shoot avoids motion blur
Spatial resolution is maintained in all directions

In the direction of motion: object is blurred – spatial resolution is reduced
Orthogonal to motion: object not blurred – spatial resolution maintained

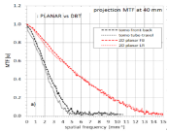
Resolution: MTF of projections



System A:
step & shoot tube motion,
detector native resolution
No loss in spatial resolution compared to 2D in all directions



System B:
continuous tube motion,
detector native resolution
Loss in spatial resolution in one direction compared to 2D in sweep direction only



System C:
continuous tube motion,
detector binning
Loss in spatial resolution compared to 2D in both directions

N.Marshall, H.Bosmans, 29th annual meeting of BHPA, Feb. 2014, "Application of the draft EUREF protocol for QC of digital breast tomosynthesis (DBT) systems", http://2014.bhpa.eu/wp-content/uploads/formidable/Marshall_Nicolas.pdf

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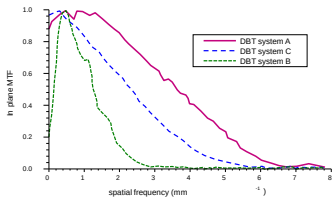
Resolution: MTF of planes (slices)



N.Marshall, H.Bosmans, 29th annual meeting of BHPA, Feb. 2014, "Application of the draft EUREF protocol for QC of digital breast tomosynthesis (DBT) systems", http://2014.bhpa.eu/wp-content/uploads/formidable/Marshall_Nicolas.pdf

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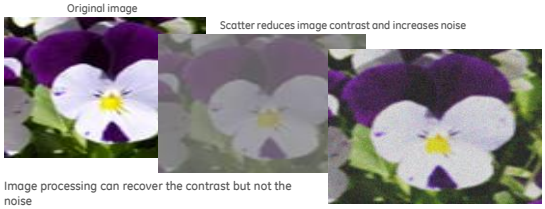
Scatter mgt: grid or no grid?

Original image



Scatter reduces image contrast and increases noise

Image processing can recover the contrast but not the noise

For thick breasts that create a lot of scatter, image quality is deteriorated or higher dose is needed to overcome the increased noise

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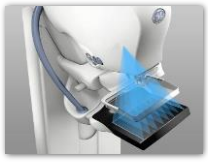
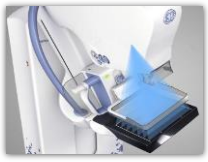
Scatter mgt: 2D/3D antiscatter grid (1/3)



Traditional 2D grid

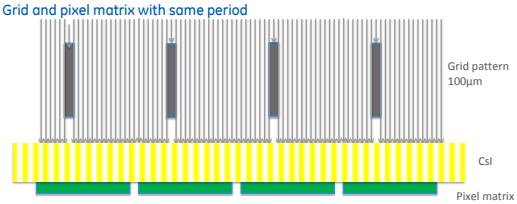


2D/3D grid

GE SenoClaire uses an antiscatter grid for 2D & 3D imagng

Scatter mgt: 2D/3D antiscatter grid (2/3)

Grid and pixel matrix with same period



Each pixel coincides with one grid line
Therefore each pixel gets the same signal
First order grid structure is eliminated in the image
Some additional oscillation will totally remove grid structure

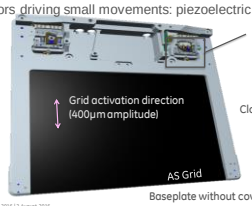
Scatter mgt: 2D/3D antiscatter grid (3/3)

Challenge: rotating the grid leaves very little space for the grid to move

Solution:

- match the grid line frequency to the detector pitch
- compact, high precision actuators driving small movements: piezoelectric transducers

Motorized Tomosynthesis Device

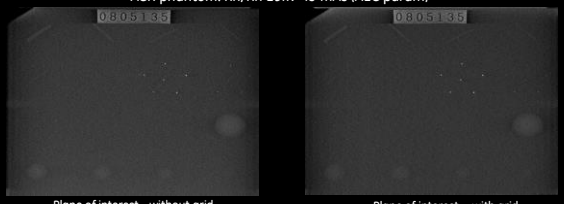


Baseplate without covers

Close Up of Piezo Actuator

Scatter mgt: grid impact for moderate thickness (4.4 cm) in 3D

ACR phantom: Rh/Rh 29kV 45 mAs (AEC param)

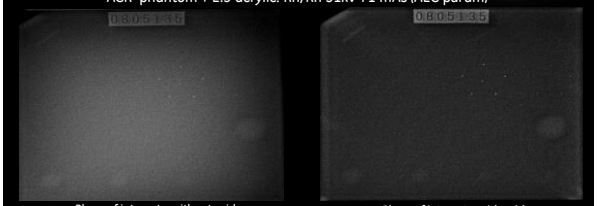


Plane of interest - without grid

Plane of interest - with grid

Scatter mgt: grid impact for high thickness (6.9 cm) in 3D

ACR phantom + 2.5 acrylic: Rh/Rh 31kV 71 mAs (AEC param)



Plane of interest - without grid

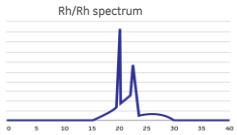
Plane of interest - with grid

AEC & beam quality

Take advantage of the Mo&Rh dual track tube to optimize CNR/dose ratio

- Low patient dose
- Dense breast penetration

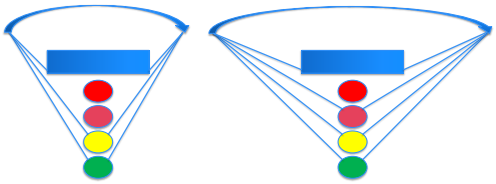
Same beam quality used for all projections



3D acquisition configuration

Sweep angle
Number of projections
… and uniform dose distribution

Sweep angle



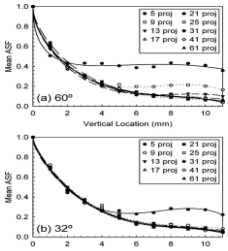
With a wider sweep angle you can separate closer objects

Number of projections

Objectives:
- Increase vertical resolution
- Reduce artifacts

- Vertical resolution is limited by the angular range, and the number of projections should be the minimum required to obtain the best possible ASF
- Increasing the number of projections beyond that required to minimize out-of-plane artifacts does not further improve the vertical resolution
- In-plane image quality is inversely proportional to the number of projections (constant dose)

For typical DBT sweep angles, relatively few projections are required



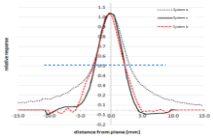
Ioannis Sechopoulos and C. Ghetti. "Optimization of the acquisition geometry in digital tomosynthesis of the breast." *Medical Physics* **36**:4 (2009): 1199-1207.

Z-resolution (using 1 mm Al sphere)

Artefact Spread Function (ASF):

$$ASF(z) = \frac{\bar{\mu}_S(z) - \bar{\mu}_B(z)}{\bar{\mu}_S(z_0) - \bar{\mu}_B(z_0)}$$

$\bar{\mu}_S$: Mean DU values of the sphere
$\bar{\mu}_B$: Mean DU values of the background
z_0: Off-focus plane
z: Off-focus plane

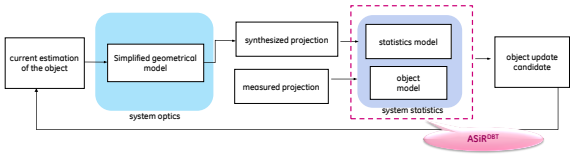


For real DBT systems, z-resolution is larger for larger sweep angle

Geometry	
System a	15 projections over 15°
System b ----	9 projections over 25°
System c ——	25 projections over 50°

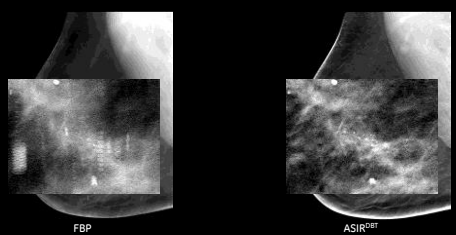
N.Marshall, H.Bosmans, 29th annual meeting of BHPA, Feb. 2014, "Application of the draft EUREF protocol for QC of digital breast tomosynthesis (DBT) systems", http://2014.bhpa.eu/wp-content/uploads/formidable/Marshall_Nicolas.pdf

Reconstruction algorithm

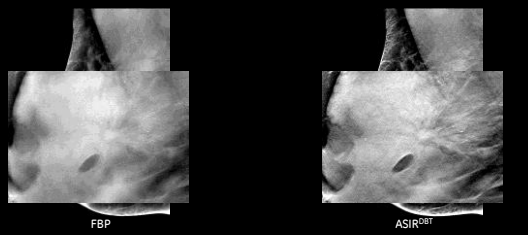


ASiR^{DBT} (Adaptive Statistical Iterative Reconstruction) enables dose reduction and mitigation of artefacts

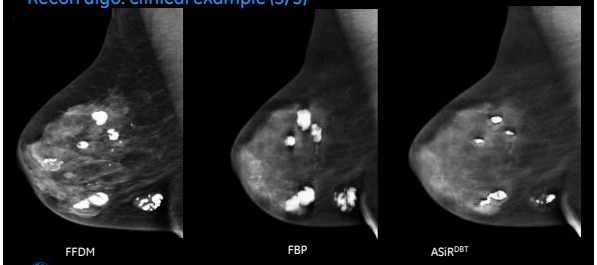
Recon algo: clinical example (1/3)



Recon algo: clinical example (2/3)



Recon algo: clinical example (3/3)



SenoClaire Clinical Atlas | 2014

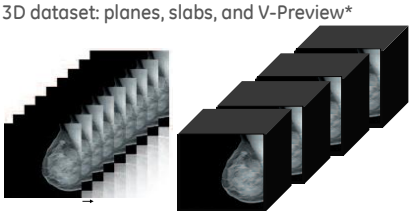
Image Coding & Presentation

3D dataset
- Volumes (planes & slabs)
- 2D synthetic view (V-Preview*)

DICOM format
- Breast tomosynthesis objects (BTO)

**for navigation use only, not a replacement to FFDM*

3D dataset: planes, slabs, and V-Preview*



Planes (slices)
0.5mm or 1.0mm distance

Slabs:
1 cm thick, 5mm overlap

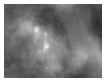
V-Preview* Synthetic 2D
** for navigation use only, not a replacement to FFDM*

3 data files in BTO DICOM format

Slabs: why?

Calcifications in a cluster are spread over several consecutive planes

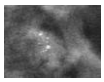
Need to aggregate information from consecutive planes in slabs to see all calcifications in the cluster in the same image



State of the art MIP SLABS

GE slabs

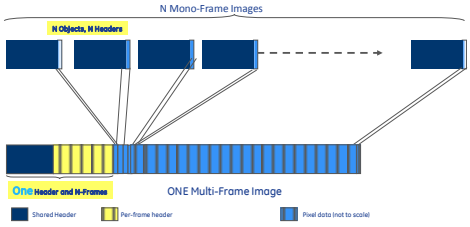
- GE developed a specific slabbing algorithm able to render calcifications as if each of them were in their optimal plane
- GE slabs mitigate DBT artifacts not well managed by standard slabbing techniques (average and MIP)



GE SLABS

Breast Tomo Object

It is a multi frame object = *One DICOM object with several 2D images*



SenoClaire exam size

Exam = (9 projections + planes + slabs) x 2 + (2D raw + 2D processed) x 2
Size of each 3D frame -> Cropping ratio -> Breast size

Consider 3 case examples:

	Thickness	Cropping Ratio	No. Of slabs	No. of planes (0.5mm)	No. of planes (1mm)
Small Breast	14mm	10:1	4	39	20
Medium Breast	44mm	3:1	10	99	50
Large Breast	80mm	1:1	18	171	86

Exam size depends on:
Number of 3D frames -> Z-Sampling (1 mm vs 0.5 mm) & breast thickness

Exam size
Small breast exam (1.0 mm z-sampling): ~390 MB
Medium breast exam (1.0 mm z-sampling): ~900 MB
Large Breast exam (1.0 mm z-sampling): ~3,300 MB

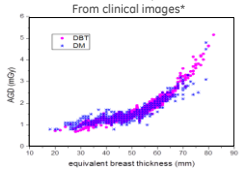
BTO lossless compression

DICOM default lossless compression supported

- Decompressed image is identical to original
- JPEG Lossless, Non-Hierarchical, First-Order Prediction (Process 14 [Selection Value 1]) 1.2.840.10008.1.2.4.70

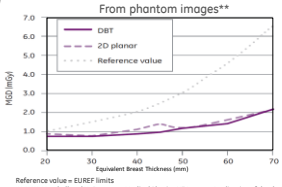
AGD for a 3D acquisition (1/2)

From clinical images*

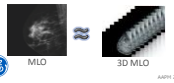


*700 DBT and DM acquisitions of same breast in same view

From phantom images**



Reference value = EUREF limits
** N.W. Marshall and H. Bosmans, Medical Physics UZ Leuven, Application of the draft EUREF protocol for Quality Control of digital breast tomosynthesis (DBT) systems", BHPA 2014.



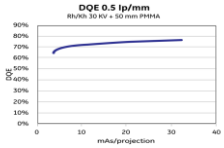
MLO 3D MLO

The dose of a single view DBT acquisition on SenoClaire is equivalent to the dose of a 2D standard acquisition of the same vie

AGD for a 3D acquisition (2/2)

Enabling factors

- Detector DQE at low dose
- Use of an antiscatter grid
- ASiR^{DBT} reconstruction algorithm



Clinical aspects

GE SenoClaire indications for use*

SenoClaire acquires 2D images and also acquires multiple projection views to produce 3D DBT images suitable for screening and diagnosis of breast cancer. The SenoClaire option can be used for the same clinical applications as traditional mammography for screening mammography.

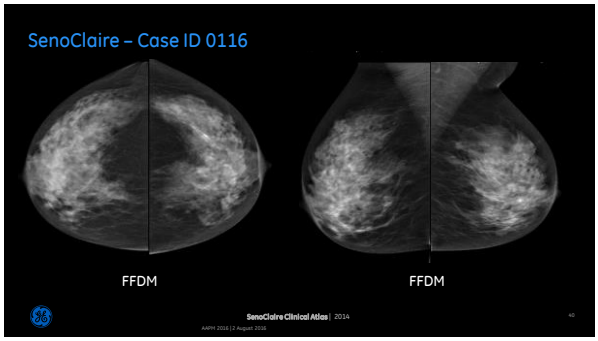
A screening examination will consist of:

- A 2D image set consisting of a craniocaudal view and of a mediolateral oblique view, or

- A 2D craniocaudal view and 3D mediolateral oblique image set.

The SenoClaire Digital Breast Tomosynthesis (DBT) option to Senographe Essential FFDM system may also be used for additional diagnostic workup of the breast.

* Premarket Approval Application (PMA) Number: P130020


SenoClaire – Case ID 0116
FFDM
FFDM
SenoClaire Clinical Atlas | 2014
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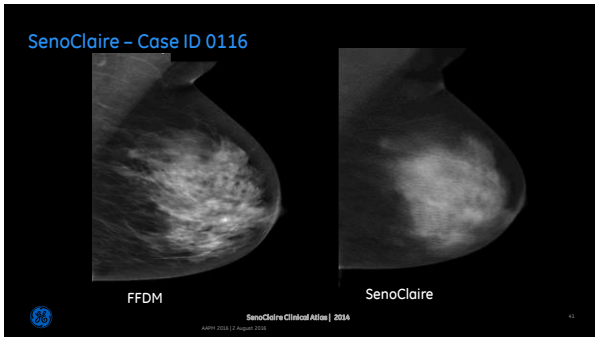
SenoClaire – Case ID 0116
FFDM
SenoClaire
SenoClaire Clinical Atlas | 2014
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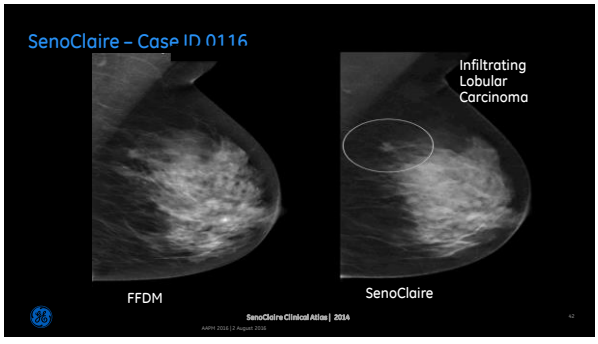
SenoClaire – Case ID 0116
Infiltrating
Lobular
Carcinoma
FFDM
SenoClaire
SenoClaire Clinical Atlas | 2014
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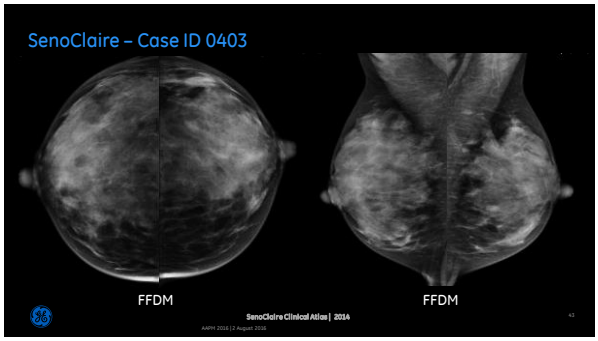
SenoClaire – Case ID 0403
FFDM
FFDM
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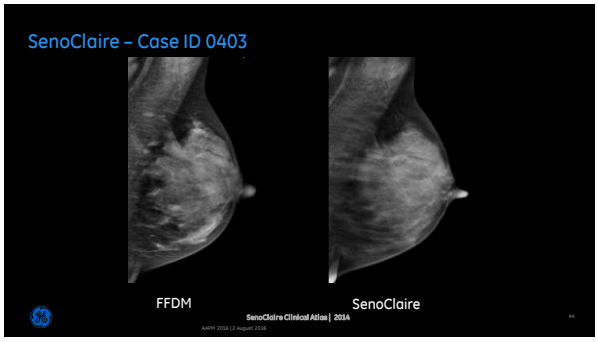
SenoClaire – Case ID 0403
FFDM
SenoClaire
SenoClaire Clinical Atlas | 2014
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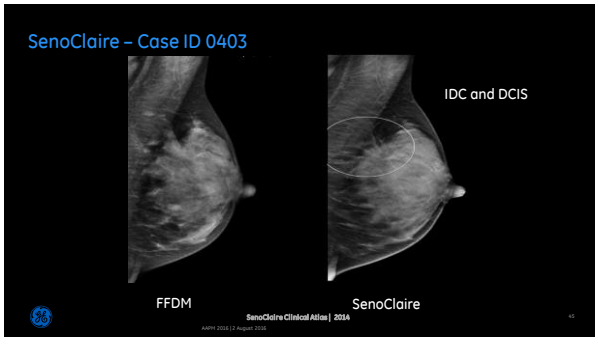
SenoClaire – Case ID 0403
IDC and DCIS
FFDM
SenoClaire
SenoClaire Clinical Atlas | 2014
AAPM 2016 | 2 August 2016
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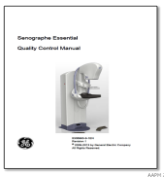
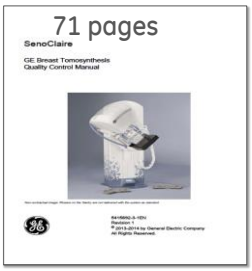
Quality control

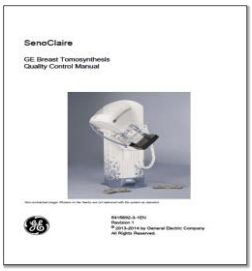
SenoClaire QC manual

Adds specific tests to be executed in addition to those from Senographe Essential QC





SenoClaire QC – Radiologic technologist



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)

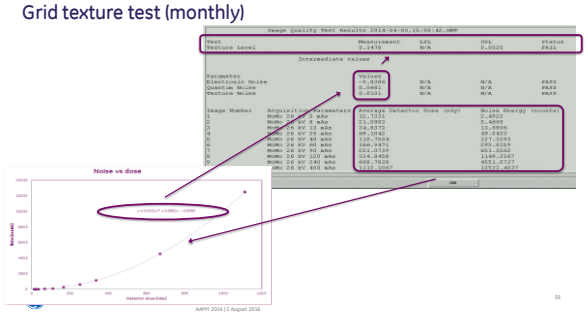
Objective
Measures the amount of grid texture in 2D images

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

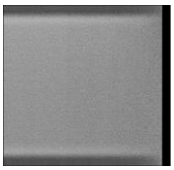
Grid texture test (monthly)



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 of 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

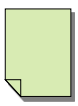
Equipment required
ACR mammography accreditation phantom

Procedure
- 3D acquisitiion with Rh/Rh track/filter, 29 kV, 56 mAs
- Score both planes and slabs

Action limit
The score must be: Fibers ≥ 4, Speck groups ≥ 3, Masses ≥ 3

Same technique & action limit as for the 2D test

SenoClaire DBT ACR phantom softcopy submission to FDA



Option 1 (on IDI Mammo Workstation)
E-Print the plane of interest and send it by email

Option 2 (on IDI Mammo Workstation 4.7 MR4b / Build 401 or newer)
Save the set of planes on a DICOM CD/DVD with GE Media Viewer installed on the CD/DVD

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)

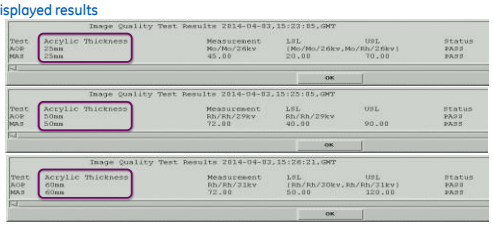
Procedure
- 3D AOP acquisition on 25mm, 50mm, and 60 mm of acyrlic
- Record the exposure parameters

Action limit

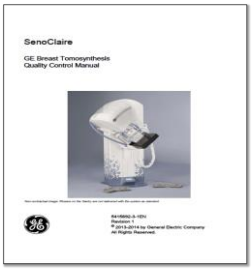
Acrylic Thickness (mm)	Exposure parameters		
	Track/Filter	mAs	kV
25	Mo/Mo or Mo/Rh	20-70	26
50	Rh/Rh	40-90	29
60	Rh/Rh	50-120	30 or 31

AOP 3D check (monthly)

Displayed results



SenoClaire QC – Medical physicist



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 exposure, 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 exposure, 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 – MEE 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 7* section *3 Phantom IQ Test with MTD* on page 13
2.	CNR and MTF Measurement with MTD	Annually	*Chapter 7* section *4 CNR and MTF Measurement with MTD* on page 15
3.	Flat field 3D Test	Annually	*Chapter*
4.	Phantom IQ 3D Test	Annually	*Chapt*
5.	Grid texture Test	Annual	
6.	AOP 2D and SNR Check with MTD	Annual	
7.	AOP 3D Check	Annual	

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

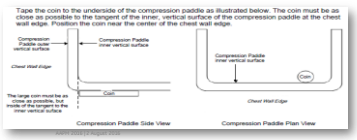
Test	Essential		SenoClaire (w/ MTD)		
	noX	2D	noX	2D	3D
Flat-field		X			X
Phantom IQ		X		X	X
CNR & MTF		X		X	
AOP Mode & SNR		X		X	X
Artifact eval & flat-field unif		X		X	
Collimation (2 alternatives)		X			
Sub-system MTF or Focal spot perf		X			
Breast entrance exposure, AGD, reproducibility		X		X	X
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)



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 exposure, 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 exposure, 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 as close as possible to technique clinically used on a "standard breast"
- Measured cumulated entrance exposure from the 9 projections to 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)

Dose in 3D – how can it be measured?

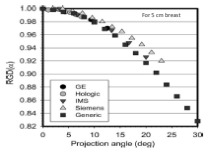
Relative Glandular Dose (RGD):

$$RGD(\alpha) = \frac{D_g N(\alpha)}{D_g N(0°)}$$

Average Relative Glandular Dose (RGD):

$$D_g N_{TOMO} = D_g N_{MAMMO} \cdot \frac{1}{N_\alpha} \cdot \sum_{\alpha=\alpha_{min}}^{\alpha=\alpha_{max}} RGD(\alpha)$$

$$D_g N_{TOMO} = D_g N_{MAMMO} \cdot \overline{RGD}$$



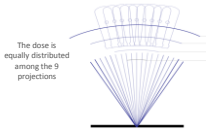
$$\overline{RGD} \cong 1\,, \quad \Delta < 5\%$$

Hence, mammography (0°) glandular dose values can be used to estimate tomosynthesis acquisition dose

http://www.aapm.org/pubs/reports/RPT_223.pdf

Dose in 3D – why it can be measured in stationary mode on SenoClaire?

Thickness (cm)	Angle 0°	6.25°	12.5°	RGD
2	1.000	0.996	0.982	0.994
3	1.000	0.994	0.979	0.992
4	1.000	0.993	0.974	0.990
5	1.000	0.992	0.970	0.989
6	1.000	0.993	0.969	0.989
7	1.000	0.991	0.966	0.987
8	1.000	0.991	0.963	0.986
9	1.000	0.991	0.961	0.986

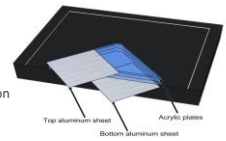


Sechopoulos, I., Sabol, J. M., Berglund, J *et al*, (2014). Radiation dosimetry in digital breast tomosynthesis: Report of AAPM Tomosynthesis Subcommittee Task Group 223. ***Medical Physics, 41***(9), 091501.

SenoClaire tests … 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 exposure, 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



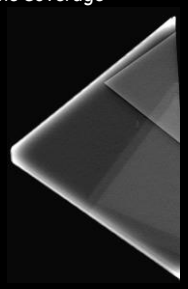
Objective
Ensure that the entire imaged object is reconstructed on the Z-axis (perpendicular to the detector)

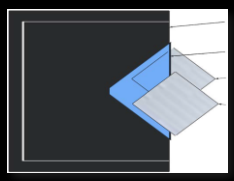
Equipment required
Set of acrylic plates; 2 1-mm Al sheets

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





With SenoClaire …
9 additional tests for the technologist

Minimum frequency	Test
Weekly	Phantom IQ test with MTD
	CNR and MTF measurement with MTD
	Flat-field 3D test
	Phantom IQ 3D test
Monthly	Grid texture test
	AOP 2D and SNR check with MTD
	AOP 3D check
	Visual checklist
Semi-annually	Compression force

With SenoClaire …
12 additional tests for the medical physicist

Minimum frequency	Test
Annually / MEE	Phantom IQ test with MTD
	CNR and MTF measurement with MTD
	Flat-field 3D test
	Phantom IQ 3D test
	Grid texture test
	AOP 2D and SNR check with MTD
	AOP 3D check
	Compression paddle border to chest wall alignment with MTD
	Breast entrance exposure and AGD with MTD
	Breast entrance exposure and AGD in 3D mode
	Artifact evaluation and flat-field uniformity with MTD
	Volume coverage


Thank You for your attention