MAYO CLINIC

ACR ACCREDITATION REQUIRED ULTRASOUND QC TESTS

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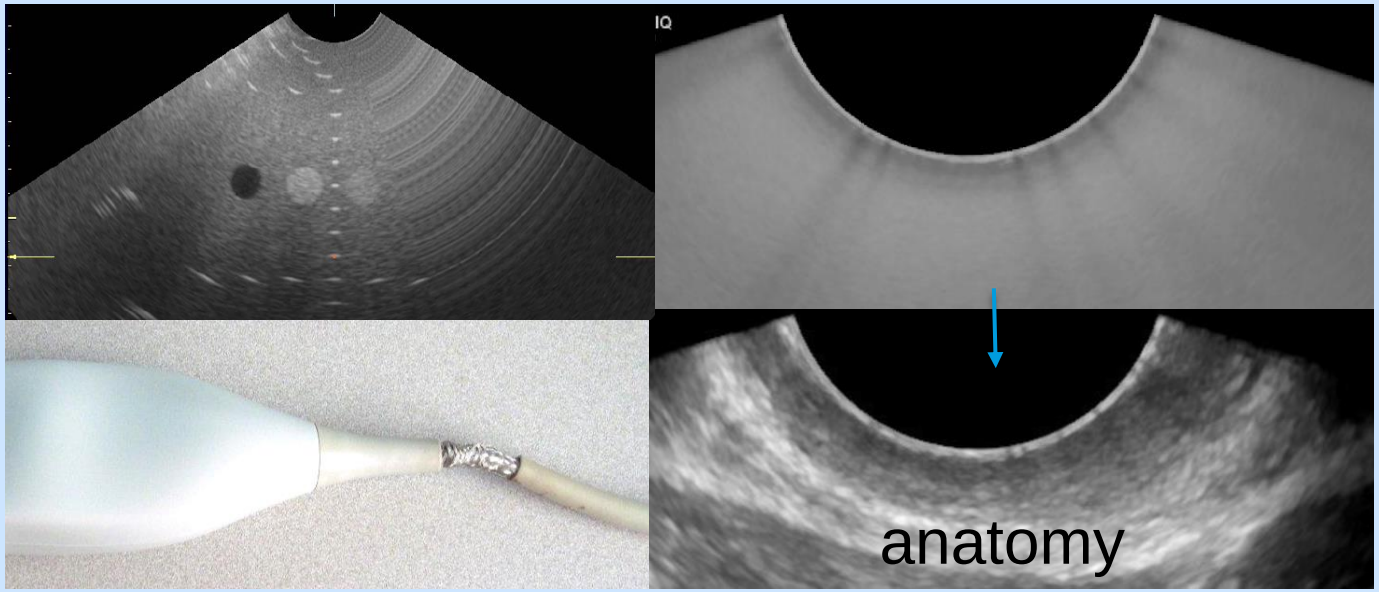
MOTIVATION

- Failures are being identified with fast/simple annual QC tests
  - 10% for scanner components, 14% for transducers [1]
  - Higher rates reported in the literature [2,3]
- Accreditation requirements
  - ACR, AIUM, etc.



1. Hangiandreou et al. 2011; 2. Martensson et al. 2010; 3. Dudley and Wooley 2016.

BEFORE GETTING STARTED WITH TESTING

- ACR recommends acceptance testing, and requires documented annual survey
  - Performed by or under the supervision of a qualified medical physicist
- No specific manual or required pass/fail criteria
  - Literature references such as Goodsitt et al. 1998
- Inventory establishment and verification
- Phantoms and testing methods
  - Material, acoustic properties, and care

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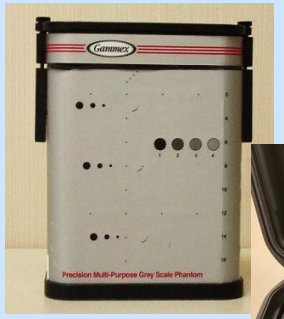
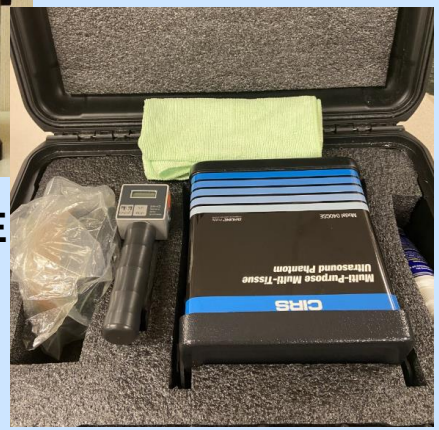




CIRS 040GSE

QC case

ACR ACCREDITATION REQUIRED TESTS

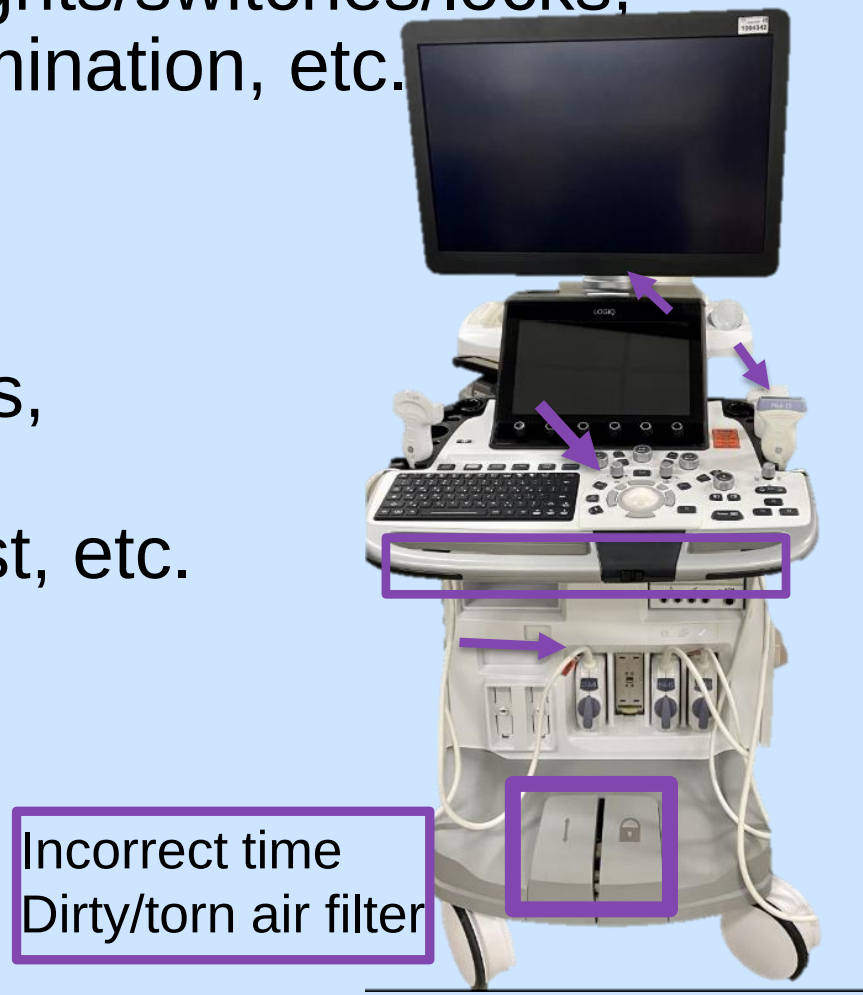
- Annual survey
  - Physical and mechanical inspection
  - Image uniformity and artifact survey
  - System sensitivity
  - Ultrasound scanner electronic image display performance

  - Geometric accuracy (optional) *still required by AIUM accreditation
  - Contrast resolution (optional)
  - Spatial resolution (optional)
  - Primary interpretation display performance (optional)
  - Evaluation of QC program (if applicable)

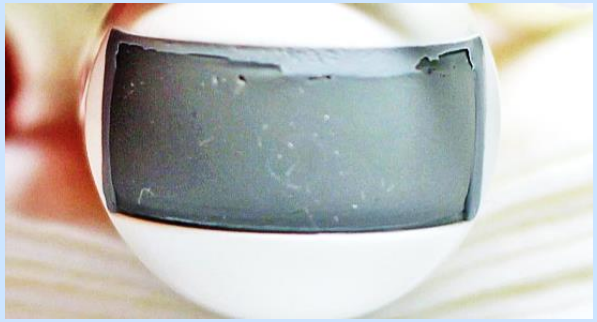
PHYSICAL AND MECHANICAL INSPECTION

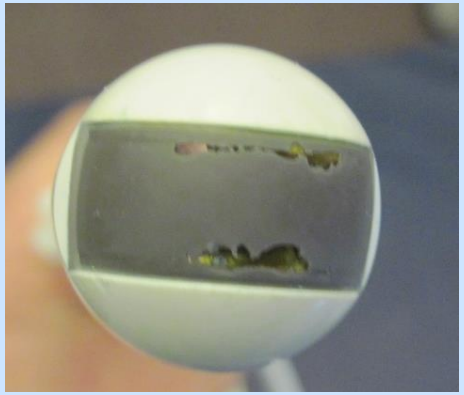
- Scanner and monitor: console cracks, missing/damaged buttons/transducer holders, dysfunctional lights/switches/locks, dirty air filter, damaged power cords, contamination, etc.
  - ~2-4 min

- Transducer: delamination, holes, air bubbles, separation, cable damage, exposed wiring, connector damage/bent pins, excessive dust, etc.
  - ~1-2 min per transducer



PHYSICAL AND MECHANICAL INSPECTION

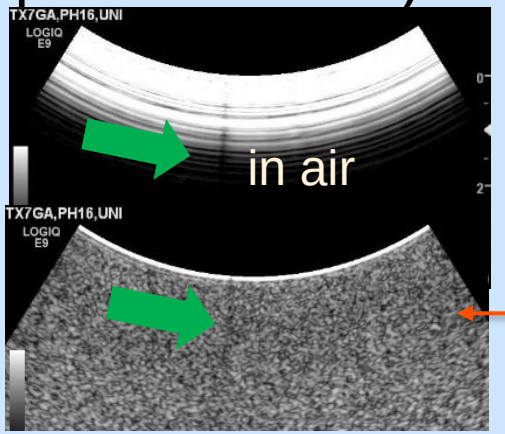




UNIFORMITY AND ARTIFACT SURVEY

- Multi-purpose or uniformity phantom
  - Shallower imaging depth, lower dynamic range, turn off spatial compounding, max frame averaging

- Common findings during QC, can negatively impact grayscale and Doppler quality, as well as accuracy of velocity measurement [1-2]
- Factors to consider when artifact(s) identified
  - Location, number, and severity (could use computerized tool)
  - Check impact of cable and port
  - Clinical practice reality
- New vendor automatic probe check

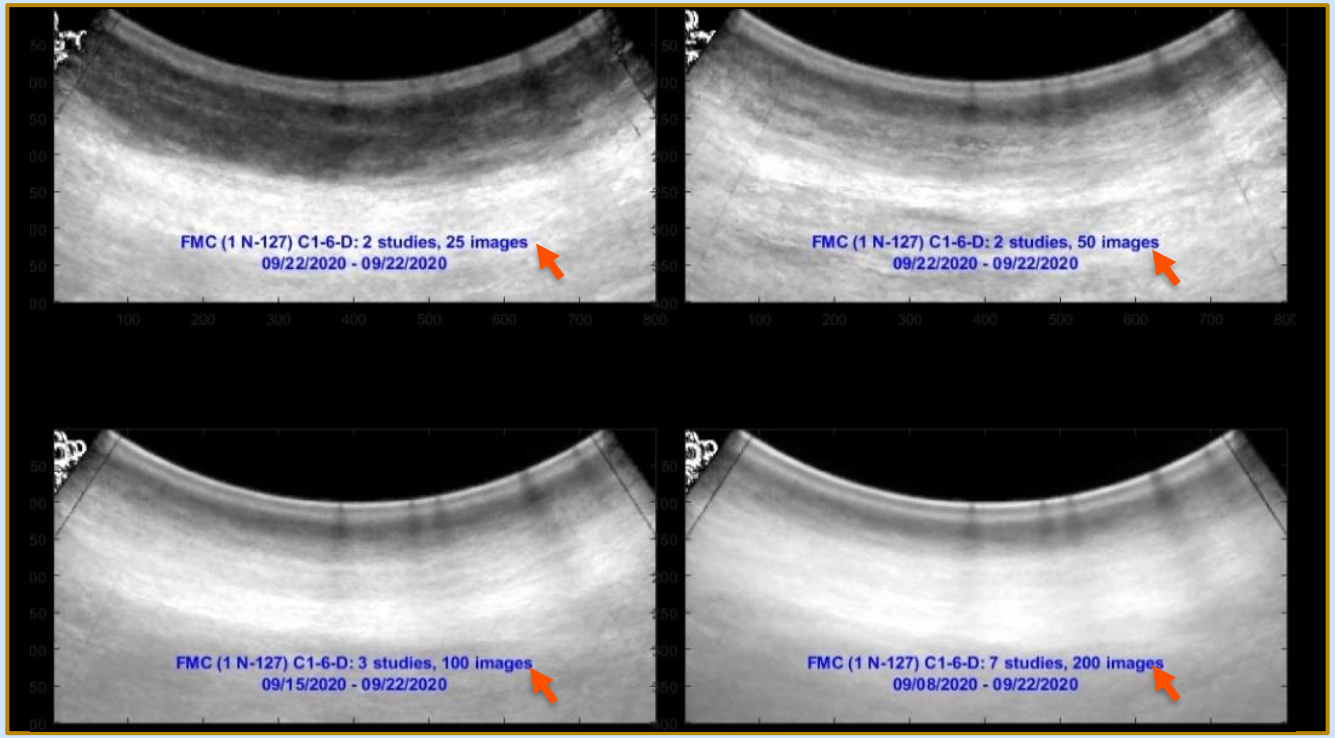


“snow globe”[3]

1. Weigang et al. 2003; 2. Vachutka et al. 2013; 3. King et al. 2010.

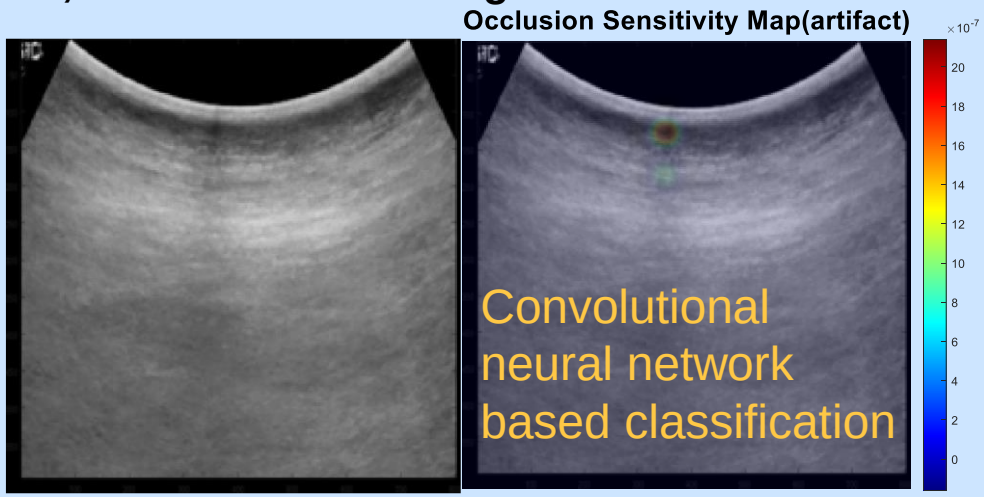
UNIFORMITY AND ARTIFACT SURVEY

Capture % Failures found in QC	Scanner Physical and Mechanical	Uniformity and Artifact
2011 [1]	25%	66%
Current	60%	35%



Potentially more frequent test based on clinical images [2-4]. May not capture extremely subtle or intermittent artifact

C1-6, from 50 clinical images artifact 100%

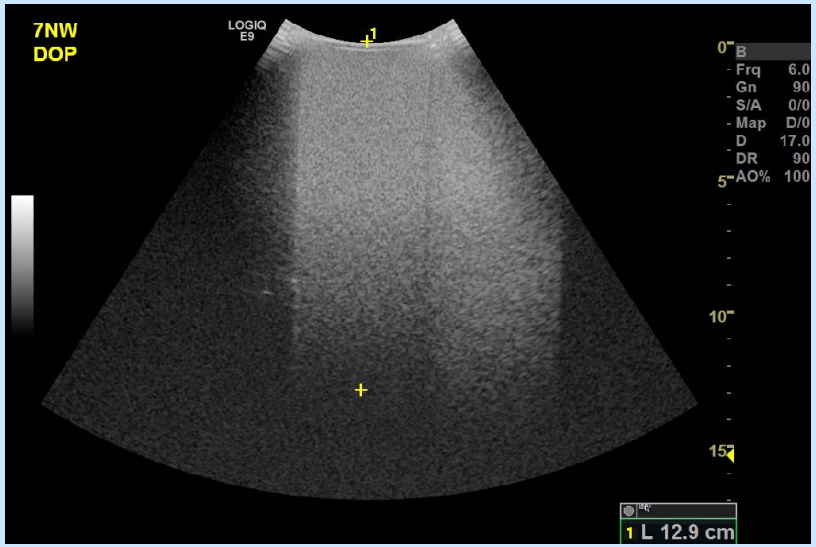


1. Hangiandreou et al. 2011; 2. Lorentsson et al. 2018; 3. Ferrero et al. 2019 AAPM Annual Meeting; 4. Long et al. 2021 AIUM Annual Meeting.

SYSTEM SENSITIVITY (DEPTH OF PENETRATION, DOP)

- Subjective assessment
  - Consistent imaging mode and transmit frequency, 100% power output, higher dynamic range, one focal zone (if relevant) deeper than expected DOP, turn off speckle reduction/smoothing
  - Visually define the deepest depth with consistent presentation of speckles during live scan and measure this depth
  - Compare with acceptable range or previous data

Phantom	Zone	Attenuation (dB/ MHz/cm)
A	Low	0.59
	High	0.94
B	Low	0.68
	High	0.90

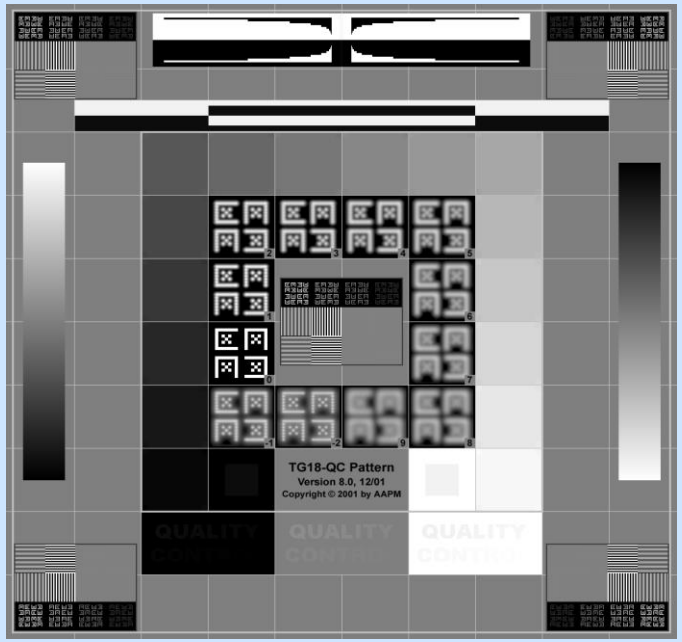


- Objective method using a pair of uniform-gel image and in-air image (IEC 61391-2) (optional)

SCANNER DISPLAY PERFORMANCE

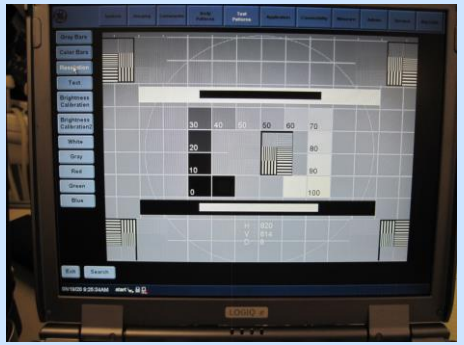
- Clean display
- Use test patterns to visually check luminance, contrast, spatial resolution, pixel defect and other non-uniformities, etc.

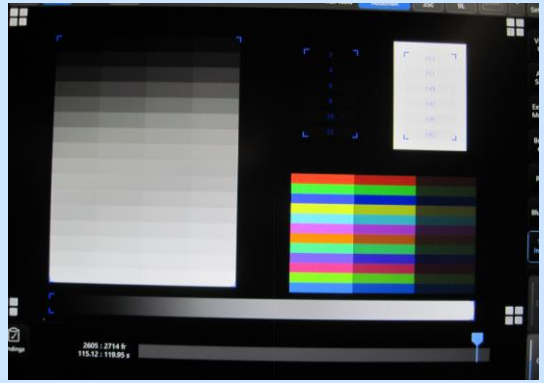
TG18-QC



TG18-LN

TG18-UN80

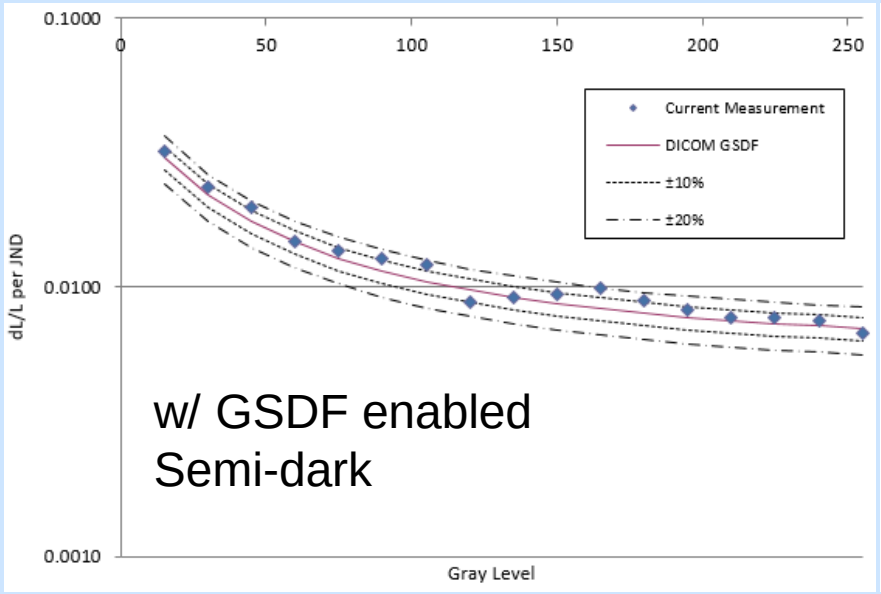




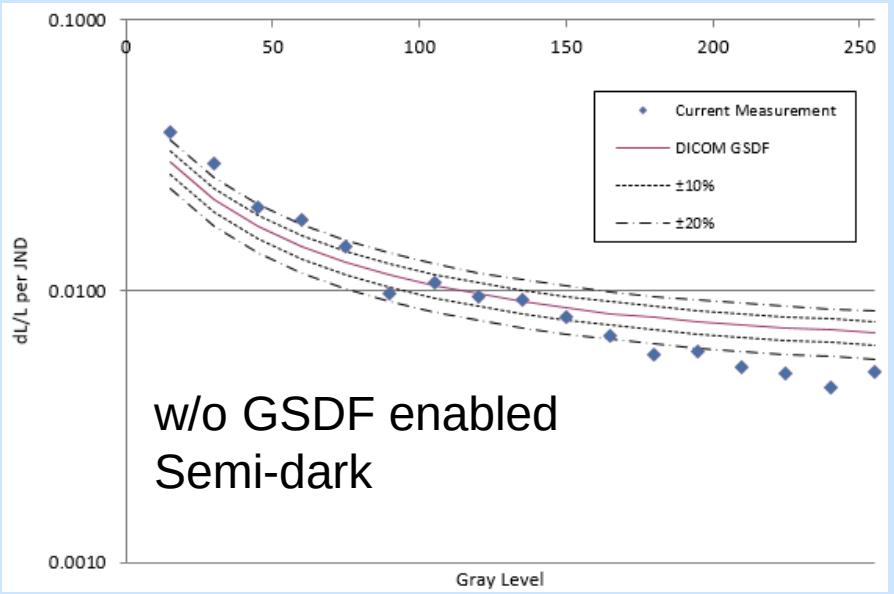
Limited patterns on some scanners. May be able to import patterns as DICOM images as a patient

SCANNER DISPLAY PERFORMANCE

- Some scanners have “GSDF enabled” feature, or settings for different ambient light conditions
- Measure luminance response (optional)
  - Maximum and minimum luminance
  - If necessary and available, adjust monitor output and re-measure



w/ GSDF enabled
Semi-dark



w/o GSDF enabled
Semi-dark

Ongoing AAPM TG316 effort

SUMMARY FORM

Ultrasound/Breast Ultrasound Equipment Annual Survey Summary

Facility Name:		
UAP/BUAP #:	Unit #:	Report Date:
Serial Number:		Survey Date:
System Manufacturer:		Model:
Medical Physicist or designee (Print name):		
Medical Physicist or designee (Signature):		

Equipment Evaluation Tests

Required	Pass/Fail *	Comments
1. Physical and Mechanical Inspection		
2. Image Uniformity and Artifact Survey		
3. System Sensitivity		
4. Scanner Electronic Image Display Performance		

Were all clinically used transducers tested? ☐ YES ☐ NO

Optional		
1. Primary Interpretation Display Performance		
2. Contrast Resolution		
3. Spatial Resolution		
4. Geometric Accuracy		

Overall comments:

ACR

Documentation of corrective action

*If any Fail result is indicated above, documentation of corrective action is required.

Revised 10/27/2020

Medical Physics Annual Equipment Performance Summary

(v2.3)

Services for: _____

Modality: Ultrasound TMS Asset #: _____

Manufacturer: _____ Model: _____

Equipment ID: _____ Serial Number: _____

UAP ID #: _____

WARS Location: _____ Room ID: _____

Survey Date: _____ Report Date: _____

Service Provider: _____ Service Provider Number: _____

Service Provider: _____ Service Provider Number: _____

Test Description (P = Pass F=Fail NA=Not Applicable)	
1. US System Inventory Transducer Inventory Verification	
2. US Scanner Evaluation Basic connectivity Physical & Mechanical Inspection -- Safety Evaluation Image Uniformity and Artifact Survey, for each port	
3. Electronic Image Display Performance Ultrasound Scanner Displays for primary interpretation of ultrasound exams	
4. US Transducer Evaluation (Summary For All Assigned Transducers) Physical & Mechanical Inspection -- Safety Evaluation Image Uniformity and Artifact Survey System Sensitivity (Depth of Penetration)	
5. Evaluation of QC Program Review of routine US QC program	

Comments and Recommendations (Additional information may be found on the Notes Page)

A

Mayo Clinic Rochester/Midwest

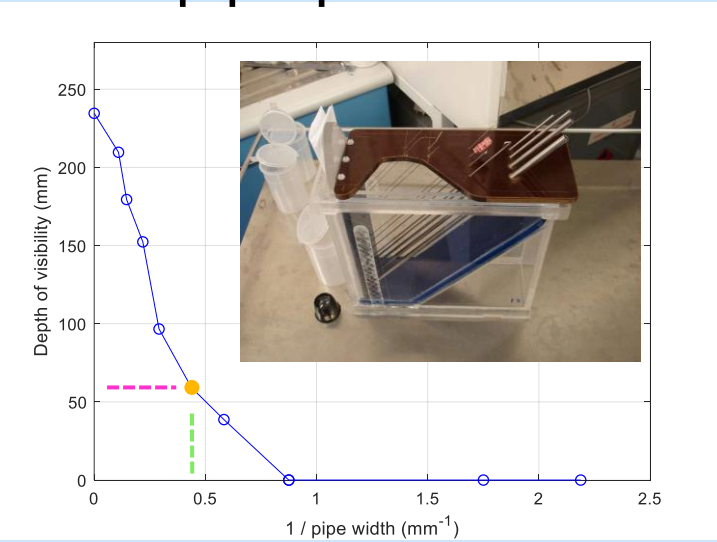
Signature _____ Date _____

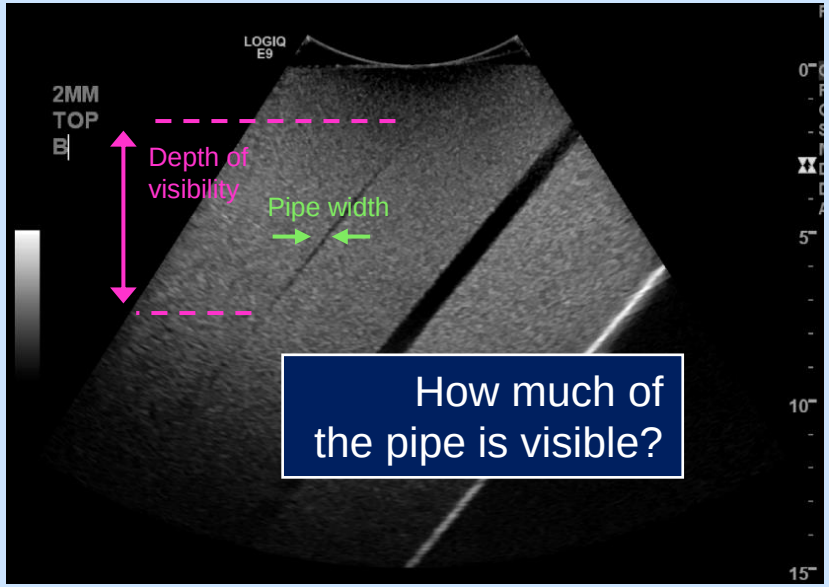
AAPM ultrasound subcommittee upcoming effort on multi-institution QC review

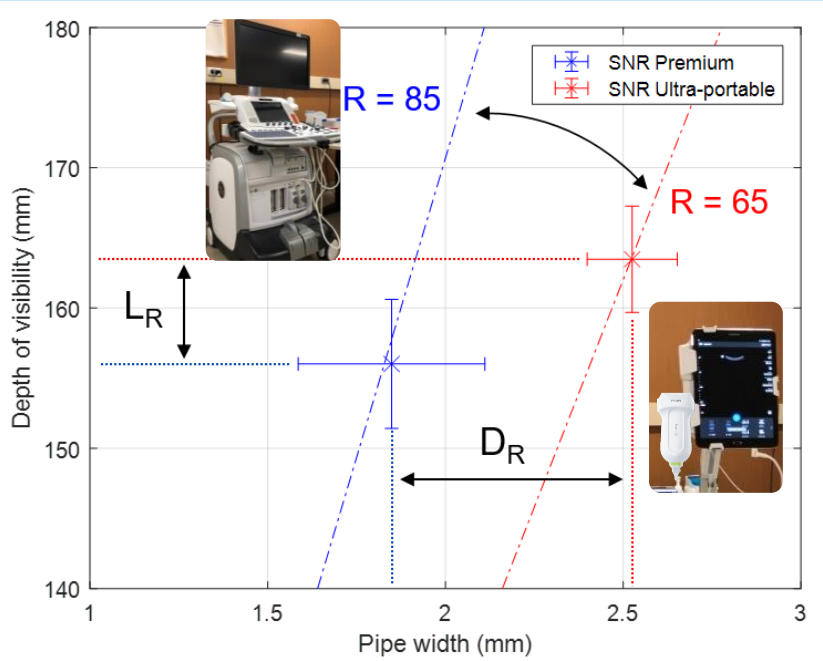
PERFORMANCE ASSESSMENT OR TROUBLE SHOOTING

- SNR based on spherical lesion phantom, resolution integral with Edinburgh pipe phantom, low contrast detectability, etc. [1-5]

pipe phantom







Resolution integral (R)
Characteristic depth of visibility (L_R)
Characteristic spatial resolution (D_R)
Gomez-Cardona et al. RSNA 2020

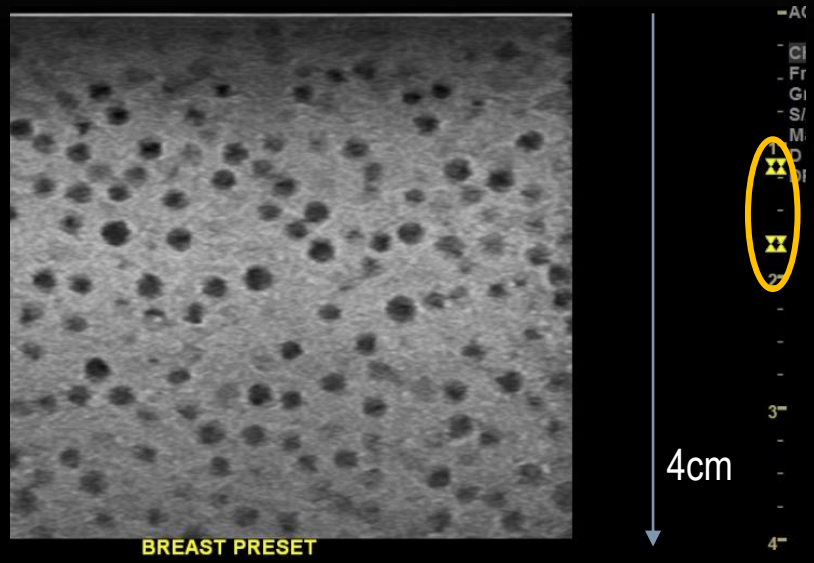
1. Madsen et al. 2014; 2. Kofler et al. 2005; 3. Pye and Ellis, UK Patent GB2396213, 2002;
4. Moran et al. 2008; 5, Lorentsson et al. 2016;

Higher Volume Fraction (20%), Random Sphere Phantoms

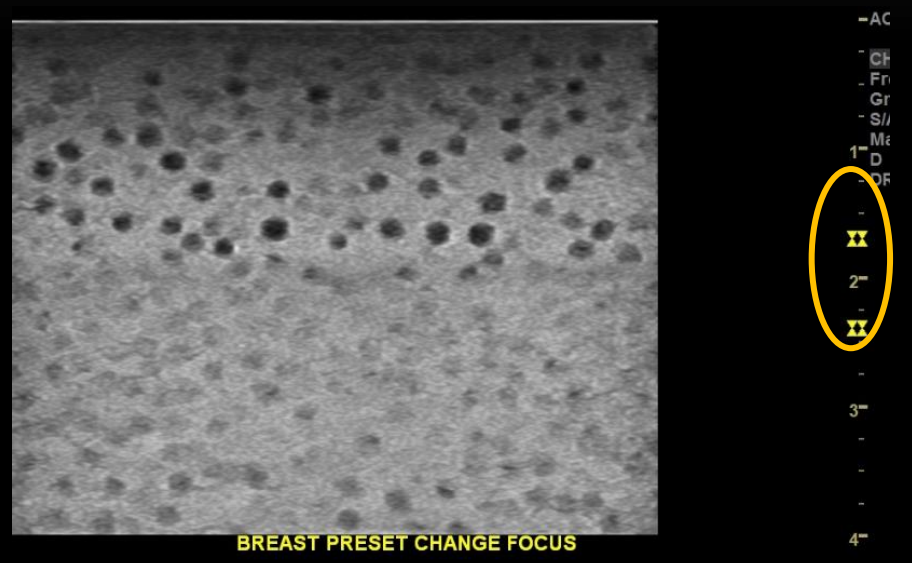
Prototype Random Hypoechoic Sphere phantom, (courtesy of Cristel Baiu, Sun Nuclear)

- Spheres are ~2mm in diameter, -40 dB relative to background

Prototype, 2 mm hypoechoic sphere phantom, built to IEC 62791 Ed 2 (draft) specifications



4cm



Task: evaluate imaging presets of scanners when a breast preset is used with a multi-D transducer.

Expect better imaging at the transmit focal depths ≠ visual assessment

Sonographers were advised NOT to vary the transmit focus from that in the original preset on this scanner.

Slide Courtesy of Dr. James Zagzebski

ACKNOWLEDGEMENTS

- Donald Tradup, Scott Stekel, Drs. Nicholas Hangiandreou, James Zagzebski, and Zheng Feng Lu

Thank you for your attention!

