# Appendix A:

ABBREVIATED PERFORMANCE TEST INSTRUCTIONS
ULTRASOUND QUALITY CONTROL

Perform quick scan tests (display monitor fidelity, depth of visualization, hardcopy fidelity, distance accuracy, and image uniformity) and physical and mechanical inspection every 3 months for mobile systems and every 6 months for others. Use only the most frequently employed transducer for these tests. Once a year, perform a more thorough examination of the system including all of its transducers. In addition to the tests listed above, perform tests of anechoic object imaging, axial and lateral resolution, dead zone, and slice thickness. Test the machines at the end of service visits while the serviceman is still present or at least as soon as possible thereafter.

MOST FREQUENTLY PERFORMED TESTS

1) Physical and Mechanical Inspection
   a) Transducers: Check cables, housing, & transmitting surfaces for cracks, separations & discolorations. Check mechanical real-time transducers for smooth vibration-free motion & for possible presence of air bubbles. Also check condition of connectors.
   b) Power cord: Check for cracks, discoloration & damage to cable & plug.
   c) Controls: Check operation of switches & knobs, note burnt out bulbs.
   d) Video monitor: Check for cleanliness & scratches & operation of controls
   e) Wheels & Locks: Verify proper operation of wheels & locks.
   f) Dust Filters: Check for cleanliness. Person responsible should clean or replace filters at regular intervals.
   g) Scanner housing: Check for dents and other damage.

2) Display Monitor Fidelity and Hardcopy Fidelity Part I.
   Procedure
   a) Verify that contrast and brightness knobs on display monitor are in baseline positions.
   b) Display grayscale stepwedge pattern on TV monitor.
   c) Note first and last steps that are visible as well as total number of steps that are visible. Compare with baseline values.
   d) Examine text on display for blur.
   e) Make a hardcopy of the image.
   f) Note first and last steps that are visible as well as total number of steps that are visible in hardcopy. (Should equal baseline values.)
   g) Measure OD's of 4 steps selected at baseline (e.g. lightest and darkest, and two in-between). Compare with baseline values.

3) Image Uniformity
   Setup: Use baseline settings on data sheet if available. Use cardboard template for TGC settings if created during baseline studies.
   <u>Suggested settings</u>:
   a) Generate images using both single and multiple focal zones
   b) Adjust gain and TGC to baseline values (should produce moderate image brightness, uniform with depth. Use cardboard template to set TGC if employed at baseline.
   Procedure:
   a) Scan across phantom & freeze image while moving.
   b) Examine image for streaking.
   c) If streaking is present, repeat scan at another phantom location to ensure streaking is not a result of poor coupling or phantom artifact.
   Also change focal zones or select fewer or more focal zones to

determine if this has an effect on the streaking.

d) If above does not eliminate streaking, store and/or photograph image displaying streak. Note gain setting & output settings & gray level of streak. Using stored or photographed image as reference, adjust gain or output to bring signals adjacent to streak to original gray level of streak.

Record image nonuniformity = new gain or output setting - original setting.

4) Maximum Depth of Visualization and Hardcopy Fidelity Part II

Setup:

Use baseline settings on data sheet if available. If not, adjust system output and gain, TGC, persistence and the focal zone so as to obtain a relatively uniformly bright image that displays background texture echoes to as great a depth as possible. Use cardboard template for TGC settings if template was created during baseline studies.

Suggested settings: (May need to be adjusted for desired image uniformity)

a) Deepest focal zone
b) Gain and output power at maximum
c) TGC at full gain where signal begins to falloff and beyond.
d) Reject off or at minimum.
e) Field of View to value that permits maximum depth of visualization.

Note: Record all settings for future use.

Procedure:

a) Scan phantom and freeze image (If possible, include gray bar along with image).
b) Measure and record penetration, which is distance from top of scan window to the deepest spherical or cylindrical anechoic object of a particular size that is barely visible, or to the depth at which the background texture can barely be seen reliably.
c) Photograph the display and process the film, leaving the display frozen.
d) Measure penetration visible on film.
e) Verify that weakest echoes on the display are visible on the film.
f) Verify that the small gaps of nearly-full brightness between very strong echoes are as visible on the film
g) Check and record whether the processor QC has been performed and processor is functioning properly.

5) Distance Accuracy

Setup: Use the same scanner setup as in the depth of visualization test.

Procedure:

a) Scan phantom so vertical column of filament targets appears towards the center of the image and a set of horizontal targets is also visible. Apply transducer to scanning membrane with little pressure. Freeze image, include depth markers and photograph.
b) VERTICAL DISTANCE ACCURACY: Use calipers to measure distance between most widely separated filament targets in vertical column displayed in image. (Place caliper cursors at tops of echoes.) Record measured distance on QC form.
c) Use normal method to measure corresponding distance on photographed image. Again record measured distance.
d) HORIZONTAL DISTANCE ACCURACY: Repeat above analysis in displayed and photographed images for horizontal row of filament targets. (Place caliper cursors above or below centers of echoes.)

LESS FREQUENTLY PERFORMED TESTS

6) Anechoic Object Imaging

Setup: Use baseline settings on data sheet if available.

Suggested Settings:

a) Multiple focal zones set at depths of multiple size cyst-like objects in phantom (e.g. 3 cm, 7 cm, 11 cm) (Or set single focus at these depths.)
b) Adjust gain, power & TGC to display maximum number of anechoic objects.

Note: Record settings for future use.

Procedure

a) Scan phantom. Record smallest anechoic object that can be visualized at specific depths (e.g. @ 3 cm, 7 cm, & 11 cm).

b) For anechoic object just larger than smallest perceived, measure and record height and width, and height/width ratio. Also record
cyst image quality (c = clear, f = filled in, J= ,jagged edge,
N= no enhancement)

c) For one or more of the larger anechoic objects with fill-in, reduce the gain until the fill-in disappears. Record the new gain value(s).

7) Axial Resolution

Setup: Use same settings as in anechoic object perception test.
Decrease gain so background texture is barely visible.

Procedure

a) Scan phantom, zooming maximum amount at each axial resolution
target group (See fig. 6.)

b) Record AXIAL RESOLUTION = smallest separation between targets that can be perceived at each depth or FWHM &/or FWTM of axial profile through a single target at a specific depth.

8) Lateral Resolution or Response Width

Setup: Use same setup as in axial resolution test.

Procedure:

a) Scan phantom in region containing vertical column of filaments.

b) Reduce FOV to just view either a single filament in the focal region or the set of lateral resolution filaments. If possible, zoom in on the filament(s).

c) Freeze the image.

d) Use calipers to measure the LATERAL RESOLUTION OR RESPONSE WIDTH = width of the filament in the focal region. (See Fig. 7) Record this value. Alternatively, have system generate a lateral profile through a target of interest, and compute the FWHM &/or FWTM of that profile.

e) Repeat for different focal regions.

9) Ring Down or Dead Zone

Setup: Use same setup as in axial resolution test. (Use shortest focal zone.)

Procedure:

a) Scan phantom in region containing dead zone test filaments (See Fig. 8)

b) Freeze image & determine closest filament that can be imaged.
Record DEAD ZONE = depth of this filament.

10) Slice Thickness or Elevational Focus

Setup: Use inclined plane phantom. Select as many focal zones as possible (center @ 3 cm for 5 MHz and up, center @ 7 cm for < 5 MHz). Gain, output & TGC same as anechoic perception test.

Procedure:

a) Turn inclined plane phantom upside down, orient transducer perpendicular to usual longitudinal direction & scan phantom from edge closest to incline.

b) Record depth at which bright rectangle echo from inclined plane first becomes smaller.

c) Continue scanning and move focal zones deeper.

d) Record depth at which rectangle spreads or becomes diffuse with no central intensity.

e) *Slice thickness focal range* = depth (d) - depth (b)

f) Find depth where rectangle is narrowest. Move single focal zone to this depth and measure thickness of rectangle at this depth. This is equal to the *slice thickness*.
Depth where this occurs is the *slice thickness focal depth*.

References

Goodsitt MM, Carson PL, Witt S, Hykes DL, Kofler JM. “Real Time B-mode ultrasound quality control test procedures: Report of AAPM Ultrasound Task Group No. 1”. Med Phys. 25 (8) 1998: 1385-1406.