peo MEDICAL SYSTEMS

ULTRASOUND

Tissue Mimicking QC Phantom Model 411LE

User's Guide

Gammex

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Introduction

The 411 LE phantom is designed to measure the image quality needs of a small ultrasound laboratory. The phantom provides a standard of Quality Assurance required for routine testing of ultrasound scanning systems. This Tissue Mimicking QC Phantoms permits precise measurements of resolution for testing the following image indicators:

1) dead zone
2) axial and lateral resolution at various depths
3) cyst imaging
4) depth of penetration
5) image uniformity

This phantom offers one mid-depth axial resolution target at 6 cm with pins spaced at 2, 1 and 0.5 mm and a single 6 mm diameter anechoic cyst at 5 cm. All pin targets are constructed of 0.3 mm nylon.

The phantom uses the latest technology in Tissue Mimicking gel which provides a very smooth background texture. The composite film scanning surface has been developed to allow more of the ultrasonic beam to be transmitted and received. The phantom is fully compatible with the latest tissue harmonics equipment and technology.

Limitations of Use

The 411 LE is designed to be used to aid in the Quality Control testing and monitoring of ultrasound instruments only. The 411 LE is not to be used to make diagnostic decisions.

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Caring for your 411 LE

Phantom comes ready to scan. Do not remove surface material.

Store your 411 LE out of direct sunlight when it is not in use. Store in the plastic bag provided or in an air and water-tight container

Store your 411 LE at 35º-105ºF (2º-40ºC).
Freezing temperatures will damage the phantom and high temperatures will accelerate desiccation.

Weigh your 411 LE to monitor desiccation.
Weigh the phantom when you first receive it and then every 6 months. Record the values on the data sheet.

Do not drop or damage the phantom.
Return the phantom for inspection and/or repair if it has been dropped or damaged. Physical damage to the case will cause premature desiccation.

Gammex recommends annual servicing of your 411LE to ensure proper operation. Our qualified service technicians will check for desiccation and provide any needed rejuvenation, scanning/certification to original specifications, and repairs.

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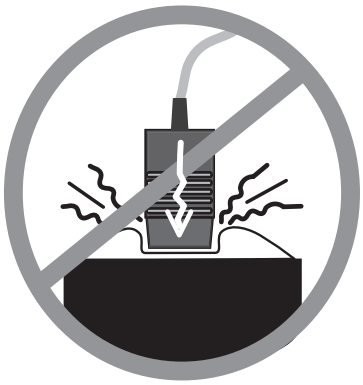
Scanning your 411 LE

- Always place the phantom on a stable, level surface for scanning.
- **The phantom comes ready to scan. Do not peel off the surface material.**
- **Do not press the transducer into the scanning surface.** This damages the scanning surface and will shorten the life of the phantom. For curved transducers, use water or a thick layer of gel.
- Use water or a generous amount of coupling gel to ensure good transmission. Do not use mineral oil, baby oil or lanolin-based gels as a coupling medium. Poor transmission is a result of insufficient coupling.
- Clean the scanning surface immediately after use. Use a soft cloth or paper towel and soap and water, if needed.



Caution:
Do not press the transducer into the scanning surface.

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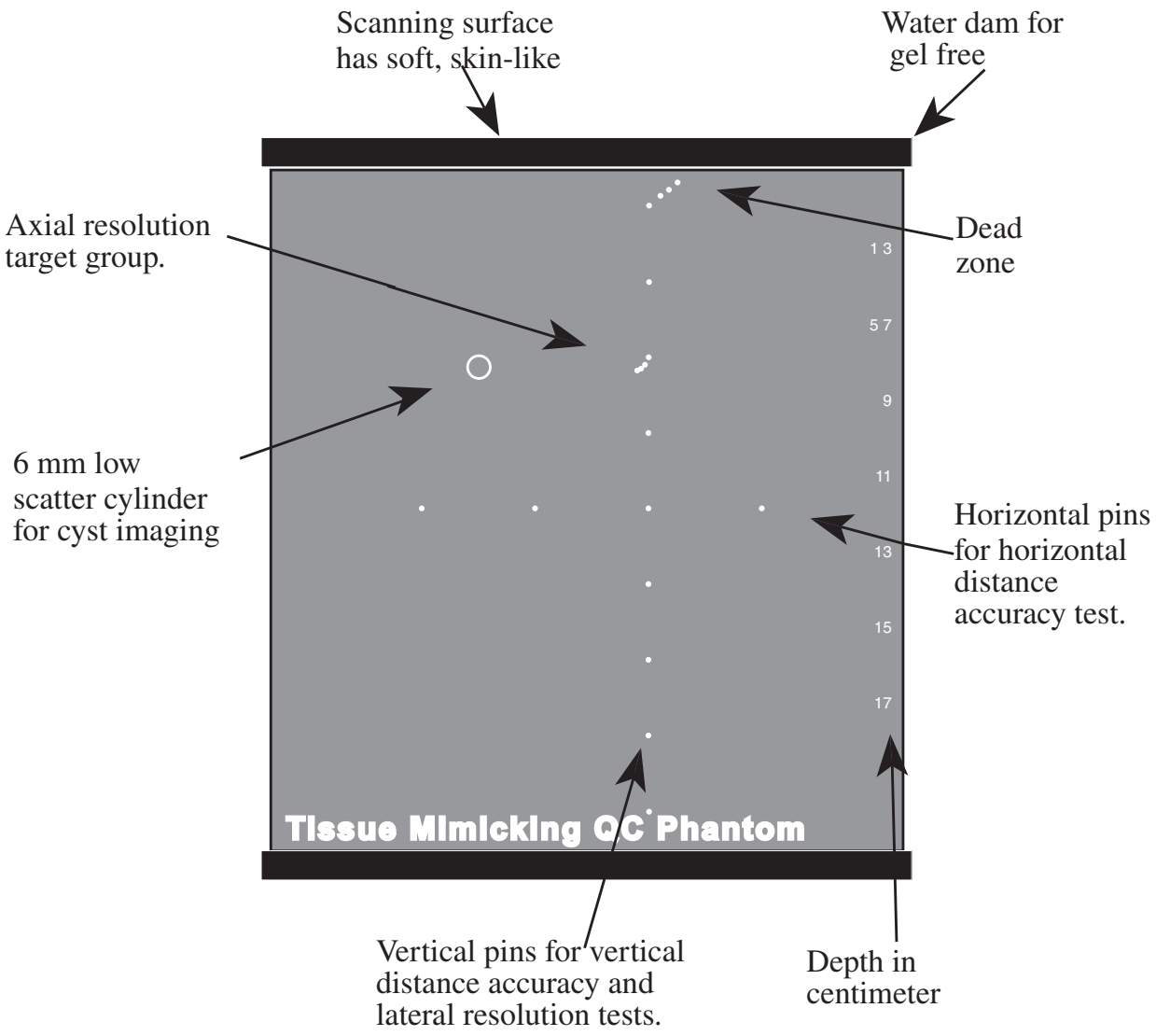
A Guided Tour of your 411 LE

The 411 LE Tissue Mimicking QC Phantom is a precision tool for measuring the image quality of ultrasound scanners. The Tissue Mimicking (TM) gel in the phantom is ultrasonically similar to human tissue. The speed of sound, attenuation, and the nonlinearity parameter (B/A) all correspond very well to measured values seen in human tissue. These qualities give the phantom its smooth appearance and allow the use of normal scanner control settings, which mimic a realistic scanning situation that one might come across clinically. This makes the 411 LE phantom an invaluable tool for training.

Scanning is the best way to familarize yourself with the features and functions of the 411 LE. A guided tour of the phantom is provided on the following pages.



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Evaluating the Phantom

Remember

- **The phantom comes ready to scan. Do not peel off the surface material.**
- **Never press the transducer into the scanning surface.**
- Always clean and dry the scanning surface after each use. Never leave coupling gel or water on the scanning surface for more than a few hours.
- **Do not** use mineral oil, baby oil, or lanolin-based gels as a coupling medium.

A 4.5MHz probe will provide a good overall view of the phantom for this demonstration.

1. To couple with water, fill the dam with distilled water. For a better image quality, use gel.

2. Rest the transducer on the scanning surface. Adjust the scanner to display the full depth of the phantom. You may notice how the echoes near the bottom of the phantom fade into noise. The depth at which usable echoes disappear is called the ***depth of penetration***. The depth markers on the phantom label will help you determine the depths of targets.

2. Move the transducer across the scanning surface while observing the locations of the targets. Notice how the smooth texture of the TM gel emphasizes image non-uniformities and artifacts, making them easier to detect. Scanning an area without targets is a good way to test for ***image uniformity***.

   Decrease gain controls to highlight pin targets.

3. Scan the group of vertical pin targets and freeze the image. Use the electronic calipers to measure the distance between two of the vertical pin targets. Repeat for two of the horizontal pin targets. The vertical pins have 2 cm spacing while the horizontal pins have 3 cm spacing.

   Use the pin targets to determine *vertical distance accuracy* and *horizontal distance accuracy.* Note that the highest dead zone pin you can see should be the point of reference, not the scanning surface.

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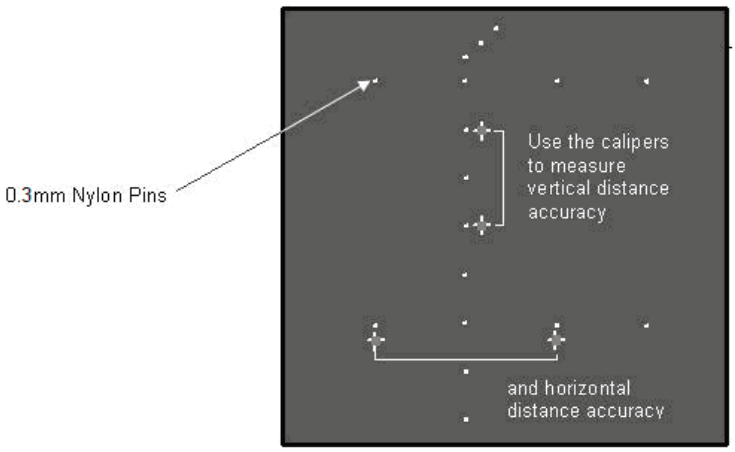
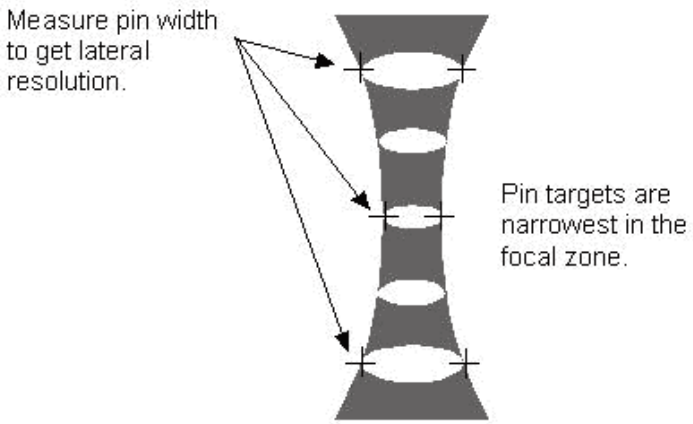


4. Freeze an image of the vertical pin targets. Use the electronic calipers to measure the horizontal width of the pin targets in the near, mid and far field of the image. Notice how the pins are narrowest in the focal zone. The pin width demonstrates the width of the ultrasound beam at that depth and approximates the ***lateral resolution*** of the scanner.



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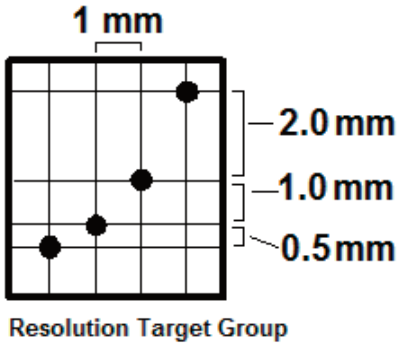
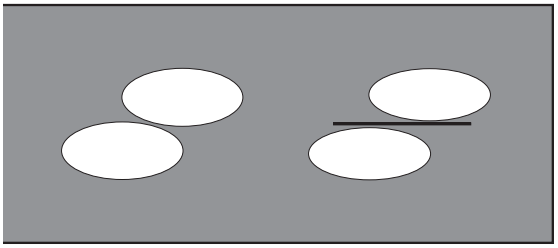
5. Decrease the image depth and examine the axial resolution target group at 5cm. Notice how the images of the lower pin targets may begin to merge. The smallest distance between the two pins that can be clearly resolved with no vertical overlap is called the scanner's ***axial resolution***.



Resolution Target Group



Pin targets are resolved axially if an imaginary horizontal line can be drawn between the targets without touching either target. The targets on the left are not resolved. The targets on the right are resolved.

6. Scan the low scatter cylinder. This "cyst" image should be round, with a clear black texture and well defined edges. Measure its dimensions to check the image geometry. Bright specular echoes at the top and bottom of the target are normal.

7. Finally, decrease the image depth to the minimum and examine the dead zone target group. The dead zone targets can also be used to measure ***lateral resolution*** in the extreme near field of the transducer.

   Note: The highest dead zone pin you can see should be the point of reference for all measurements – not the scanning surface.

8. When you are done scanning the phantom, empty the water dam or completely clean off the coupling gel with a soft cloth or paper towel.

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Phantom Specifications

Physical Specifications

Weight . . . . . .Aprox. 2.7 kg (5 lbs. 15 oz.)
Dimensions . . . . . .16.8x7.6x21.6 cm
. . . . . .(6.63x3x8.5 in.)
Scanning surface . . . . . .Composite film
Case material . . . . . .ABS plastic

Tissue Mimicking Background Material

Water-based gel with appearance of human tissue.

Speed of sound . . . . . .1540 ± 10 m/s at 22°C
Temperature dependence of speed of sound . . . . . .1.5 m/s/°C
Attenuation coefficient . . . . . .0.7 ± 0.05 dB/cm/MHz
. . . . . .0.5 ± 0.05 dB/cm/MHz
. . . . . .refer to phantom side label
Nonlinear parameter (B/A) . . . . . .6.6 ± 0.3 (411 LE)
. . . . . .6.7 (Accepted value for human liver tissue)

Low Scatter Anechoic Cysts

Placement . . . . . .5 cm deep
Diameter 6mm
Speed of sound . . . . . .1540 ± 10 m/s at 22°C
Temperature dependence of speed of sound . . . . . .1.5 m/s/°C
Attenuation coefficient . . . . . .0.05 ± 0.01 dB/cm/MHz

Pin Targets

Nylon monofilament . . . . . .0.3mm diameter
Vertical spacing . . . . . .20mm at 1 to 17 cm deep
Horizontal spacing . . . . . .30 mm at 9 cm deep

Axial Resolution Target Group . . . . . .at 5 cm deep

All acoustic measurements made at 4.5 MHz, 22°C.

Due to our philosophy of continuous quality improvement, all specifications are subject to change.

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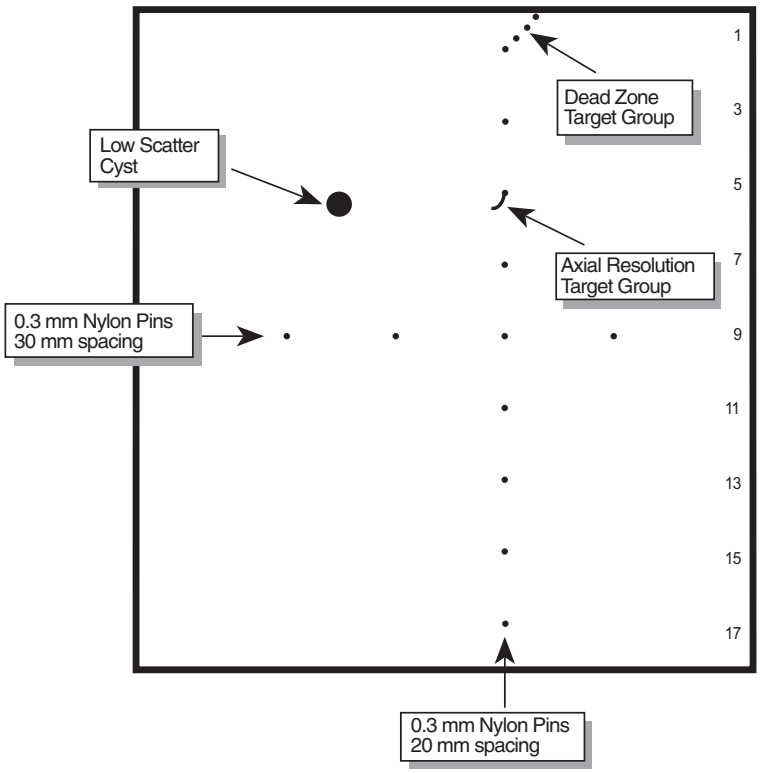
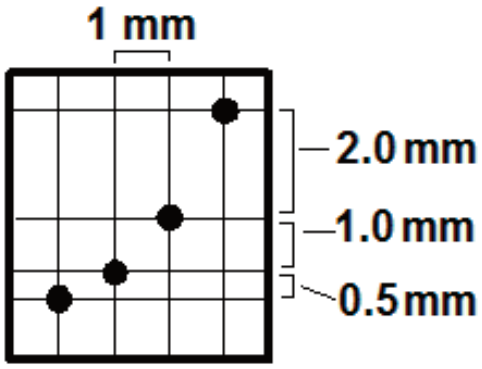
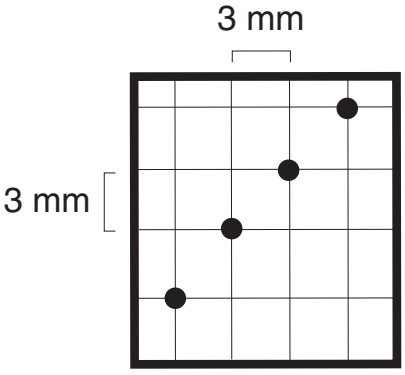
Target Configuration





Resolution Target Group



Dead Zone Target Group

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Harmonic Imaging

Harmonic imaging has become an important addition to the medical ultrasound community. Harmonic imaging is when a pulse is sent from the transducer at a nominal (fundamental) frequency, but the signal received by the transducer is twice that frequency, which is the second harmonic. The result is that better resolution is attained at any given depth than if the reception had been at the fundamental frequency, as in conventional ultrasound.

There are three tissue properties that determine the effectiveness of harmonic imaging:

1. pulse propagation speed
2. attenuation (rate of pulse energy loss with depth)
3. the value of the nonlinearity parameter: B/A

In order for phantoms to present valid resolution results for harmonic imaging, these three properties must adequately correspond to human tissue. Attenuation increases with frequency and much of the propagation involves the fundamental frequency, so in harmonic imaging, there is enhanced resolution without as much attenuation as there would be if the higher frequency were used to generate the pulses at the transducer. So, higher frequency resolution occurs for greater depths within the subject than if conventional ultrasound was used.

The ratio of B/A quantifies the rate of transfer with respect to propagation distance of ultrasonic fundamental frequency energy to harmonic frequencies. The greater the amplitude, the greater the energy transfer rate; thus, the beam profile for the harmonic is smaller than for the fundamental, which means better lateral and elevational resolution.

Tissue-mimicking phantoms will be appropriate for assessing harmonic imaging only if B/A for the tissue-mimicking material in the phantom adequately approximates that of soft tissues. Recently, we have developed the capacity to measure the value of B/A for the tissue-mimicking materials in Gammex phantoms and have found it to lie in the range for human soft tissue, meaning B/A is between 6 and 7[1].

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[1]Gong, X. F., Zhu, Z. M., Shi, T., Huang, J. H. (1989) Determination of the acoustic nonlinearity parameter in biological media using FAIS and ITD methods, J. Acoust. Soc. Am. 86 (1), pp 1-5.

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Phantom Desiccation

Over time, the phantom's water-based gel will slowly lose moisture. This process is accelerated by high temperatures, incorrect storage, and damage to the case or scanning surface. Consistently storing the phantom in an airtight container will contribute greatly to long phantom life. Properly storing your phantom will reduce the amount of moisture lost per year.

For most climate-controlled environments, the phantom weight should be checked every six months. Phantoms used in high temperature/low humidity environments or in mobile situations should be tested more frequently. As the phantom desiccates, the scanning surface may flatten out. It is suggested that the phantom be sent in for rejuvenation once it has lost 10-15 grams of its original weight. If the phantom has lost more than 20 grams, Gammex cannot guarantee that the phantom will be able to rejuvenate successfully.

Charts and Graphs

Refer to the Charts and Graphs section of the manual CD to find the appropriate charts and graphs for your 411 LE phantom, which include:

Phantom Weight Chart
Data Sheet

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