Nuclear Associates 84-350

Near Field Ultrasound Phantom

Users Manual

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Section 1
Introduction

1.1 Introduction

This phantom is constructed from a patented solid elastic material called Zerdine™. Zerdine, unlike other phantom materials on the market, is not affected by changes in temperature. It can be subjected to boiling or freezing conditions without sustaining significant damage. Zerdine is also more elastic than other materials and allows more pressure to be applied to the scanning surface without subsequent damage to the material. At normal or room temperatures, the Zerdine material found in the Near Field Phantom will accurately simulate the ultrasound characteristics found in human breast tissue. The 84-350 contains low scatter masses in a range of sizes and depths, a calibrated volumetric test object and an assortment of nylon monofilament target groups. The phantom is protected by an acrylic case and plastic membrane to facilitate scanning and minimize desiccation. The 84-350 was designed to allow for assessment of linearity, axial and lateral resolution, depth calibration, dead-zone measurement, volumetric calibration and registration.

The Nuclear Associates series of ultrasound phantoms, unlike human subjects or random scannable materials, offers a reliable medium that contains specific, known test objects for repeatable qualitative assessment of ultrasound scanners over time.

1.2 Description

Background Material

The manufacturer maintains specific proprietary fabrication procedures that enable close control over the homogeneity of Zerdine and the reliability of its acoustic characteristics from batch to batch. The speed of sound in Zerdine can be adjusted between 1430 and 1650 meters per second. The acoustic attenuation can be adjusted between .05dB/cm/MHz and 1.50 dB/cm/MHz. The relation between the acoustic attenuation A and the acoustic frequency F is of the form $A = A^{\circ}F^{n}$ with values of the power coefficient n in the range of .8 to 1.10, indicating the proportional increase of the acoustic attenuation with frequency. Backscatter characteristics can be adjusted through the addition of predetermined amounts of calibrated scatter material. Zerdine can be molded into very intricate shapes and the material can be cured in layers, allowing the production of "multi-tissue" phantoms. Zerdine, like most other phantom materials will desiccate if unprotected, but Zerdine has a sponge-like property. Any moisture lost to evaporation will be reabsorbed when the material is immersed in water. Barring any damage to the case or scanning membrane, the phantom should lose only minimal amounts of moisture over time.

Near Field Resolution Target

The target consists of parallel 0.1 mm nylon wires horizontally spaced 6 mm apart from center to center. Vertical distance from the center of each wire to the top edge of the scanning surface ranges from 9 mm down to 1 mm in 1 mm increments (see Figures 1-1 and 1-5). This target is designed to measure a transducer's dead zone, otherwise referred to as the "ring-down distance."

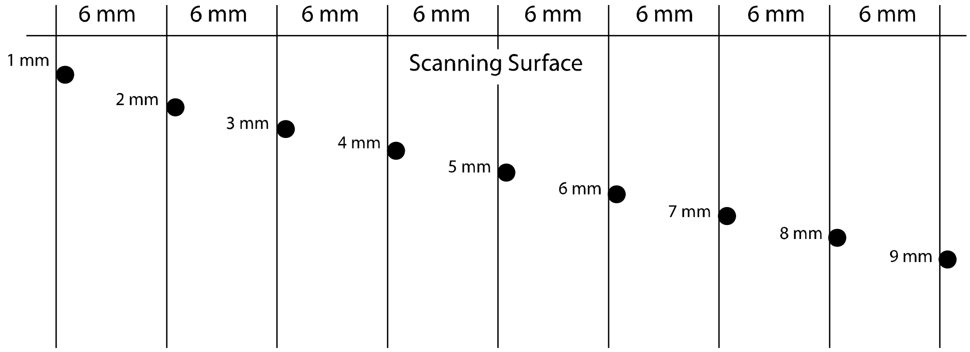

Figure 1-1.

Lateral Resolution Target

The target is positioned 1.5 cm deep to allow testing of short distance transducers. Extremely fine monofilament wires with a diameter of. 1 mm are used to avoid any possibility of one wire acoustically shadowing another. Five parallel wires are horizontally spaced precisely 5, 4, 3, 2 and 1 mm distances apart from center to center (see Figures 1-2 and 1-5).

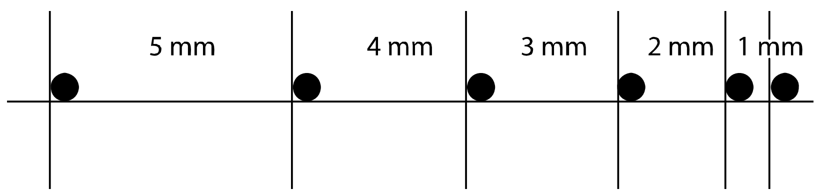

Figure 1-2.

Vertical Resolution Target

The target consists of six pairs of parallel .1 mm wires, horizontally spaced 6 mm apart from center to center. The lower wire in each pair is horizontally offset from the upper wire by 1 mm to further reduce any acoustic shadowing effects. The vertical distance between each pair of wires is 5, 4, 3, 2, 1 and .5 mm from center to center (see Figures 1-3 and 1-5). This garget is designed to accurately assess vertical resolution capabilities at a depth of 2 cm.

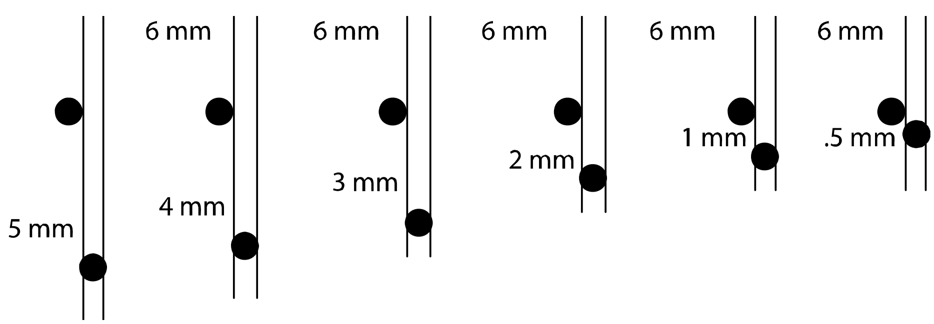

Figure 1-3.

Vertical Plane Target

A group of 0.1 mm parallel wires are positioned 1 cm apart down the center of the phantom in a vertical plane (Figure 1-5). When scanned from the top, this target enables measurement of vertical linearity, depth calibration and gain as a function of depth**.**

Scatter Targets

Three groups of cylinders with diameters of 1.6, 2.0 and 2.4 mm are arranged in a specified pattern at a designated position in the phantom. The cylinders have a backscatter that is approximately 15 dB lower than the background, and enable the identification of a system's anechoic mass detectability threshold.

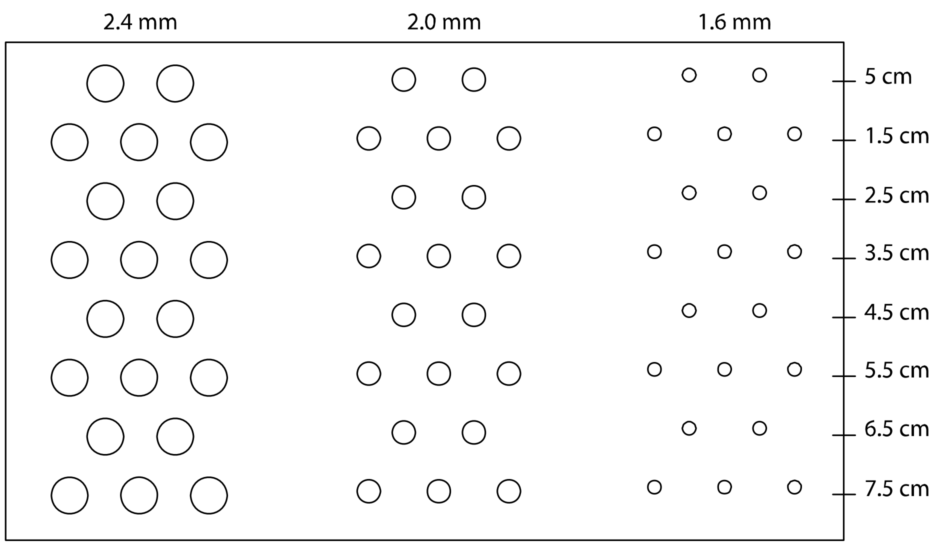

Figure 1-4.

Calibrated Volumetric Test Object

One mass with a specific calibrated volume is embedded at one end of the phantom approximately 3 cm deep. The backscatter within the test subject is approximately 9dB lower than the background. This target is designed for evaluation of spatial measurements and volumetric calculations.

1.3 Testing Procedures

Dead-Zone Identification

The transducer should be placed firmly above the near field resolution target and perpendicular to the wires. Dead zone or the ring down distance can be defined as that distance between the transducer's face and the closest wire target to be resolved from the reverberation. If the first target to be resolved is at 4 mm, then the dead zone distance is "something less than 4 mm."

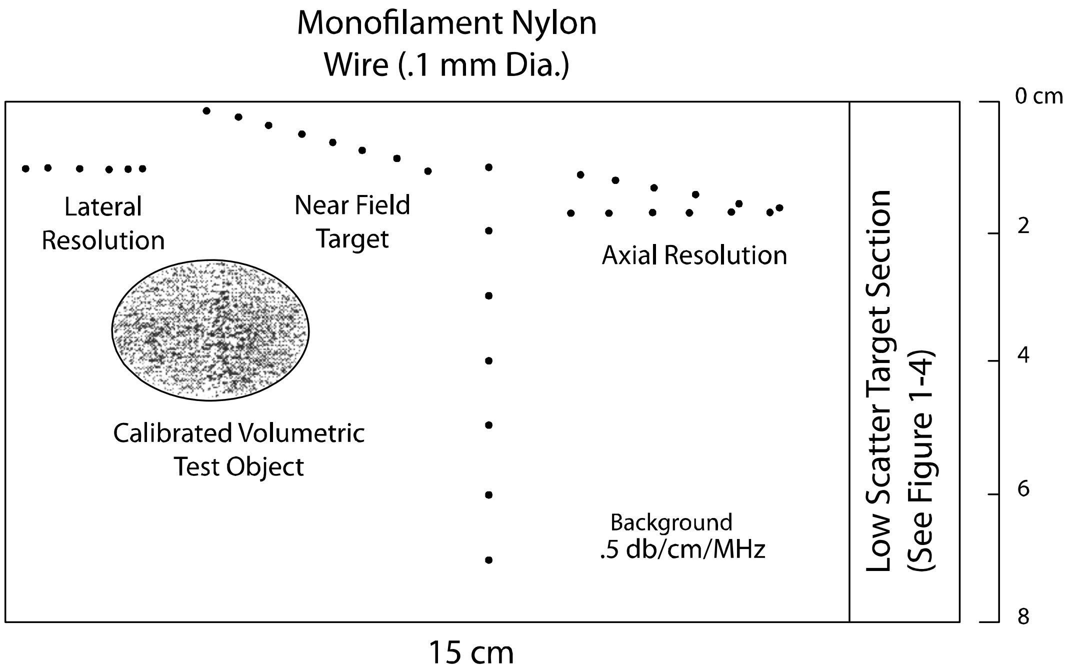

Figure 1- 5.

Assessment of Resolution

These measurements should be done at several sensitivities and depth levels to facilitate a thorough evaluation. As defined by the AIUM standards committee, lateral resolution "at specified control settings and range is the minimum lateral distance between two identical reflectors or scattering volumes at which separate registrations can be clearly distinguished on the display." A simple measurement can be taken at a depth of 1.5 cm using the lateral resolution target. A more thorough evaluation can be done using the vertical plane target (refer to section on beam width measurement). Closer positioning of the transducer's focal point to each target group should result in better resolution. Assessment of vertical resolution should be done in the same manner as assessment of lateral resolution using the vertical resolution target that is located approximately 30 mm from the scanning surface.

Depth Calibration

This measurement should be performed using the vertical plane targets. This group of wires should be scanned linearly and to the target plane. All wires should be displayed simultaneously. Measure the distance between two targets using the display markers and plot the values as a function of true distance that is known to be 20 mm. Or, more simply, align the echoes to the display markers for comparison.

Beam Width Measurement

A linear scan should be performed perpendicular to the vertical plane target. Some of the monofilament wires are displayed as lines rather than points. The determined length of these displayed lines demonstrates beam width as a function of depth in 1 cm increments.

Anechoic Mass Detectability

Optimize imaging conditions for anechoic masses through adjustment of TGC, gain, output, focal depth, etc., and record settings. Image each set of targets and determine the diameter and/or depth at which the masses can no longer be faithfully resolved.

Volumetric Measurements

Each phantom will identify the specific size dimensions and volume of the embedded test object. Use standard measurement procedures and compare results with known values.

NOTE

Time-gain properties and sector scanner errors can be evaluated using the vertical plane target in accordance with suggested AIUM techniques. For targets with minimum scattering, lower gain levels can be used, however, higher gain settings enable evaluation at more clinical-type settings. When evaluating any machine, settings should be recorded and remain consistent over time. For further instruction on measuring performance, refer to Standard Methods for Measuring Performance of Pulse-Echo Ultrasound Imaging Equipment AIUM Standards Committee, July, 1990.

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Section 2
Handling Instructions

2.1 Handling Instructions

1. Remove acrylic cover which protects the scanning membrane.
2. Fill the scanning cavity with water or suitable coupling material.
3. Apply the appropriate transducer to the membrane using normal pressure. The phantom material and membrane are semi-elastic but can be damaged if excessive pressure is used.
4. Test ultrasound equipment in accordance with procedures suggested above or AIUM recommendations.
5. When all testing is complete, remove excess coupling material and replace the protective acrylic cover.
6. It is suggested that the phantom be stored at room temperature, avoid extreme temperatures.
7. Zerdine will desiccate over time if the watertight envelope is compromised. If there is a noticeable change in the phantom or the case and/or membrane are damaged, the phantom should be returned immediately for repair or replacement

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