MODEL L-823
PET/SPECT PHANTOM

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Overview

The Ludlum PET/SPECT Performance Phantom is designed to measure resolution, linearity, and the uniformity of PET (Positron Emission Tomography) and SPECT (Single Photon Emission Computed Tomography) systems.

The Model L-823 Source Tank is the basic component of this phantom. When combined with the source tank, the Model L-824 Resolution Insert Set and the Model L-825 Cardiac Insert, the PET/SPECT Performance Phantom provides the user with a comprehensive test tool. The phantom can be filled with a ^{99m}Tc or ^{201}Tl and water solution to simulate cold and hot lesions and for measuring linearity and uniformity performance of the PET/SPECT system. MTF (Modulation Transfer Function) and PSF (Point Spread Function) may also be calculated using a micro-hematacrit tube, attached to the plug in the center of the cover. The procedures for the latter are described further in the following pages.

Specifications

Material: acrylic; sections are sealed with O-rings for leak-proof assembly

Source Tank Dimensions: 21.6 x 20.3 x 30.5 cm (8.5 x 8 x 12 in.) (Outside Dia x Inside Dia x L)

Linearity/Uniformity: 19.1 x 5.1 cm (7.5 x 2 in.)(Outside Dia x Inside Dia); cross grid of channels (waffle shape) are cut in a 1.5-inch square pattern

Hot Lesion: 19.1 x 6.5 cm (7.5 x 2.5 in.) (Outside Dia x Inside Dia); each of the eight pairs of holes is 25% larger than the previous pair

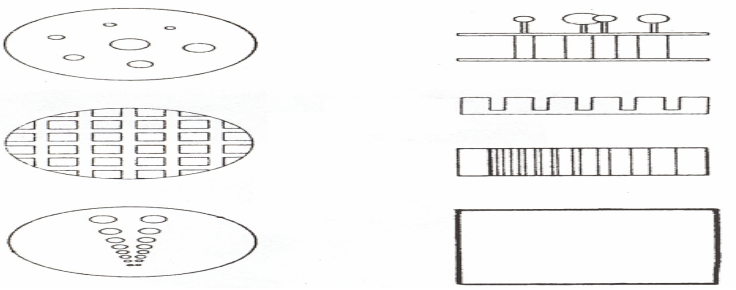
Hole Diameters: 4.7 mm, 5.9 mm, 7.3 mm, 9.2 mm, 11.4 mm, 14.3 mm, 17.9 mm, and 22.4 mm

Cold Lesion: 19.1 x 7.6 cm (7.5 x 3 in.) (Outside Dia x Inside Dia) plastic rods, each of the seven rods are 25% larger than the rod preceding it

Rod Diameters: 5.9 mm, 7.3 mm, 9.2 mm, 11.4 mm, 14.3 mm, 17.9 mm, and 22.4 mm

Plastic spheres the same diameter as the rods can be attached on standoff supports. Centers of all the spheres fall into a single plane.

Optional Cardiac Insert Dimensions: 8 x 8 cm (Dia x H), with a variable height of 15.3 to 25.4 cm



Initial Inspection and Preparation of Phantom

- Check the packing material within the source tank carefully for the remaining plugs, O-ring, and additional thumbscrews.
- Be sure to apply silicone, stopcock, or similar grease to the O-rings. Inspect the O-rings every time the tank is opened.

When filling the tank, stand the tank upright with the selected inserts installed. Fill with water to within 0.64 cm (a quarter-inch) of the top. Replace the lid and fill the remaining volume with a funnel. Allow the phantom to stand overnight so the remaining air bubbles will dissipate from the water. Add more water as needed. Seal the fill holes using the provided thumbscrews.

In preparation for testing, fill a syringe with 5-10 mCi of technetium or desired isotope. Using another syringe, remove an amount of water equal to the isotope solution that will be injected into the phantom. Inject the prepared radioisotope and reseal the fill hole. Mix the solution well by several inversions of the tank.

General Imaging Procedure

Start by placing the filled phantom on the imaging table, ensuring the central axis of the phantom is perpendicular to the plane of rotation of the camera. Proceed with a normal imaging sequence. (The entire phantom is imaged in a single acquisition.)

- **Resolution measurements can be made as follows:**

  For example, make a reconstruction of the hot lesion insert (eight pairs of holes). The largest holes should be easily identified. The smallest set of holes seen individually is a measure of the system's resolution. This will simulate hot lesions in a cold field like brain and bone scans.

  Next, make a reconstruction of the cold lesion insert (seven rods). The smallest rods visible will be a measure of the resolution. This will simulate cold lesions in a hot field like lung and liver scans.

  By adding the plastic spheres to the cold lesion insert, you can evaluate the effect of partial volumes on system contrast. To vary the contrast, move the reconstructed slice position along a longitudinal line so that each slice contains a different sized portion of the sphere against the background activity.

- **Check linearity using the waffle-cut linearity/uniformity insert.**

  Make a reconstruction of the center of the linearity/uniformity insert. Look for circular distortions of the crosshatch pattern. These are typically caused by X and Y amplification errors. Visible distortion should be adjusted accordingly.

  A uniformity evaluation is made by making a transverse slice reconstruction about seven and one-half centimeters (three inches) above the insert. Look for reconstruction artifacts, typically from uncompensated radiation self-absorption in the radioisotope solution. If ring artifacts are seen, the center of rotation is likely incorrect. If the center of the field is lighter than the rest, there is no compensation for self-absorption.

- **Check for center of rotation, point-spread function, and MTF.**

  By using the source tank (without inserts), center of rotation and point-spread function can be measured. This can also be accomplished with the tank filled with water only (again no inserts). Begin by filling a micro-hematacrit tube with Technetium. Each end should be sealed with wax. The radioisotope solution should be approximately 20 μCi in one-fifteenth cc of water.

  Next, insert the tube into the hole in the center of the central cover plug. Re-insert the cover plug so that the tube extends into the tank along the long axis of the tank. Image the tank. If the tank does not appear circular, the computed center of rotation factor is wrong and should be recalculated. If the system is well centered, calculations will produce a PSF that can be used to calculate the system MTF.

- **Utilizing the optional cardiac insert:**

  The cardiac insert simulates a heart wall that is approximately 12 to 14 mm thick. The heart wall chamber has a fill capacity of about 240 cc and is typically filled with water and a mixture of 0.1 mCi of ^{201}Tl. (Other isotopes may be substituted.) After insertion into the source tank, the insert can be adjusted to the desired angle. To provide a reasonable imaging background for the insert, a mixture of water and 200-400 μCi of ^{201}Tl is suggested for the source tank. The phantom may be scanned in a variety of positions to provide the best heart position (relative to the gamma camera).

  Heart wall defects can be simulated by placing some 0.3 cm thick radiopaque bolus material (like Superflab ®) on the inside walls of the phantom. The latter is not included but may be purchased optionally. Imaging of these defects can help determine lesion resolution of the system.