

**FLUKE®**

**Biomedical**

# **Nuclear Associates**

## **76-823, 76-824 & 76-825**

**PET/SPECT Phantom Source Tank,  
Phantom Inserts and Cardiac Insert**

**Users Manual**

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## Section 1

# Introduction

### 1.1 Introduction

This manual provides information on the Model 74-823\*, 74-824 and 74-825. Photon emission computed tomography (PET/SPECT systems, like any imaging apparatus, require periodic performance testing. This modular phantom helps provide the data for such evaluations. It permits measurements of the resolution of "hot" lesions in a cold field, "cold" lesions in a "hot" (or radioactive) field, linearity, uniformity of response to a uniform field, and a simple way to find the center of rotation. In addition, a more sophisticated test suitable for acceptance testing may be done by measuring the point spread function, from which the MTF may be calculated.



Figure 1-1 PETISPECT

### 1.2 Components

#### Tank

Acrylic, 8 ½" OD x 8" ID x 12 ½" long. Has an o-ring sealed cover with fill and drain ports. One of the port plugs will accept a micro-hematocrit capillary tube that is used to get a point-spread function for MTF measurements. Includes supports for holding the tank in a horizontal position.

#### "Hot" Lesion Resolution Insert

Acrylic, 7-7/8" OD x 2 ½" thick. Eight pairs of holes are drilled through the block, each pair separated by a distance equal to the hole diameters (4.7, 5.9, 7.3, 9.2, 11.4, 14.3, 17.9 and 22.4 mm). The diameter of each pair is 25% larger than that of the preceding pair.

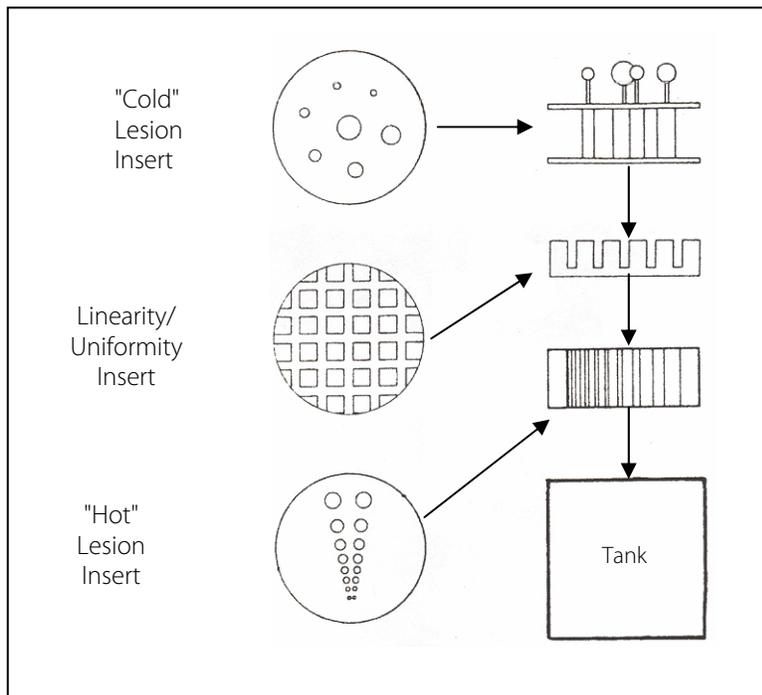
#### "Cold" Lesion Resolution Insert

7-7/8" OD x 3" thick. Contains 7 plastic rods whose diameters are 5.9, 7.3, 9.2, 11.4, 14.3, 17.9 and 22.4 mm. Each rod is 25% larger in diameter than the preceding one. Plastic spheres of the same diameter as the rods can be attached on standoff supports to the outside of this insert. The centers of all the spheres fall into a single plane.

\* Designed and developed by Ray A. Carlson, Hutzel Hospital, Detroit, MI, and Jeffrey T. Colvin, Texas Oncology PA, Dallas, TX

### **Linearity Insert**

Acrylic, 7-7/8" OD x 2" thick. Crossed grid of channels are cut out in a 1 1/2" deep square pattern.



*Figure 1-1 Exploded View of Phantom*

## **1.3 General Instructions**

- A. Remove the cover of the tank by unscrewing all the thumbscrews. Check the packing material inside the phantom tank carefully for the plugs, o-ring and additional thumbscrews. Replace the inserts as desired.
- B. Place a small amount of silicone grease on a paper towel (s topcock or vacuum grease is acceptable), and lightly coat the entire o-ring. Also lightly grease the o-ring groove in the tank, using a cotton swab. Place the ring in the groove, being careful not to over-stretch the o-ring. The sloped inner side of the groove will hold the o-ring in place.
- C. Whenever the tank is opened, inspect the o-ring. Re-grease it when it appears dry (once or twice per year).

## Section 2 Operation

### 2.1 Preparing Phantom For Use

- A. Stand the tank upright (with the three inserts inside) on a level surface in a sink or tray. Fill with water to approximately  $\frac{1}{4}$ " from the top. Replace the cover and hand-tighten all the thumbscrews. Using a funnel through one of the small holes in the cover, add water to fill completely.
- B. Screw two thumbscrews into the outer holes on the cover. The small o-rings on these screws need not be greased.
- C. Let the phantom stand overnight to allow dissolved air to dissipate from the water. Add more water if needed to retain proper level.
- D. Fill a syringe with 5 to 10 mCi of the desired isotope (usually technetium). With another syringe, remove a volume of water from the tank (through the center hole) equal to that of the amount in the technetium syringe. Now add the technetium through the center hole; and screw in the remaining thumbscrew. If done carefully, there should be no spillage of radioactive solution. Make sure that all screws are secure. Mix thoroughly by repeated inversion of the tank. The phantom is now ready for use. A small air bubble remaining in the tank is of no importance.

### 2.2 Performance Measurements

The following procedures describe simple techniques for checking the performance of SPECT and PET systems. You may prefer to alter these procedures for your own purposes.

Place the phantom on the imaging table, its axis perpendicular to the plane of rotation. Carry out the data acquisition, using the normal number of views and counts per view for a patient study. The results will thus be equivalent to those obtained in normal patient imaging. The entire phantom is imaged in one acquisition.

To test maximum system performance, high-resolution data can be obtained at the operator's option by increasing the number of views and/or counts per view.

As in planar patient imaging, very high-count rates should be avoided because of dead-time losses.

Reconstruction should be performed, using the method typically appropriate for patients. Phantom results, using several reconstruction and filter parameters, may serve as an aid in determining the method best used for patients.

#### A. Resolution - Hot lesions in a Cold Field

Resolution measurements can be made in two ways. Measurements on hot lesions in a cold field simulate brain and bone scans, for example. Cold lesions in a hot (radioactive) lung and liver scans, among others.

#### Procedure

Perform a reconstruction of the Hot Lesion Insert (the acrylic block with the 8 pairs of graded-sized holes). The largest holes can be seen individually. A blurred image resembling the letter "V" is created by the holes too small to be distinguished separately. The smallest set of holes seen individually is a measure of the system's resolution.

## **B. Resolution - Cold lesions in a Hot Field**

In general, for lesions of equal size and contrast, cold lesions in a hot field are less visible to the eye than hot lesions in a cold field. Compare, for example, the visibility of a star in a black sky with that of a high-flying airplane against the face of the moon.

### **Procedure**

Make a reconstruction of the Cold Lesion Insert (the one with seven rods logarithmically-graded in size). The image of the smaller rods may not be visible in the reconstruction slice. The smallest rod visible is the measure of the resolution.

## **C. Plastic Spheres (Installed on Cold Lesion Insert)**

The slice images are used to evaluate the cold lesion visibility and resolution with partial volume effects controlling the contrast. To vary the contrast, move the reconstructed slice position longitudinally so that the slice contains different-sized portions of the spheres and background activity.

### **Procedure**

The first reconstructed image should be made with the plane of the sphere centers coinciding with the plane at the center of the slice. Subsequent images at different points along the phantom axis will show the partial volume effects. The spheres are mounted on screw pins so that their positions can be interchanged, if desired.

## **D. Linearity**

To check linearity, use the acrylic block with the crosshatch pattern.

### **Procedure**

- 1) Position the reconstructed slice near the center of the cutout section of the block.
- 2) Among the common problems are "pincushion" or "barrel" distortion. An elliptical appearance of the circular pattern is caused by unequal X and Y amplifications. Noticeable distortion requires adjustment of the apparatus.

## **E. Uniformity**

Examine a slice image of the region of uniform activity. About 3" of such uniform space exists above the inserts. The purpose is to detect uncompensated radiation self-absorption in the radioactive solution, and reconstruction artifacts of various kinds.

### **Procedure**

- 1) Reconstruct a transverse slice of a uniform area.
- 2) If ring artifacts are seen, the center of rotation offset may be incorrect, or there are uncorrected nonuniformities in the flood field. If the center of the image is lighter than the rest, self-absorption is not being compensated.

## **F. Center of Rotation, Point-Spread Function and MTF**

With the tank empty, the center of rotation error and a pointspread function (PSF) can be measured. A similar measurement in the presence of radiation absorption can be made with the tank filled with water only.

### **Procedure**

- 1) Fill a micro-hematocrit capillary tube with a technetium solution (about 20 uCi in 1/15 cc water). Plug the ends with wax.
- 2) Insert the tube into the hole in the center of the inner face of the central cover plug. Screw the plug into the tank cover so that the hematocrit tube extends into the tank, along the tank axis.
- 3) As in Section E, image and examine a reconstruction of part of the tank, empty of inserts. If the reconstructed image of the tank is not circular, the center of rotation factor calculated by the computer is wrong and should be recalculated. A well-centered system will render a PSF that can be used to calculate the system's MTF.

## 2.3 76-825 Cardiac Insert

A. The chamber simulates a heart wall that is approximately 12 to 14 mm thick. SUPERFLAB bolus material (supplied with this unit) is used to simulate "defects." The bolus may be cut to any desired size using a scalpel or X-Acto knife and the metric template supplied. The bolus material is somewhat tacky and will "stick" for a short period of time.

Remove the eight screws holding the chamber together. At this point, the outer wall-sealing flange should be lightly coated with hi-vacuum grease or Vaseline to seal the chamber walls. Place up to 3 previously cut "defects" into the outer chamber wall. Note that large defects cannot be placed near the apex of the chamber. Reassemble the inner chamber wall to the outer wall and tighten all eight screws. As you tighten the screws, grease will change from translucent to transparent, indicating a perfect seal.

### **B. Filling**

The "heart wall" chamber has a capacity of about 240 cc, and should be filled with water and about 0.1 mCi of Thallium-201. (Other isotopes, c.f. Tc-99m may be used instead, if desired.) The insert may then be adjusted to the angle desired, and placed into the PET/SPECT tank. If desired, the Linearity/Uniformity insert may be placed into the tank below, but not above, the Cardiac Insert. The tank may then be closed in the usual manner, filled with water and activated with about 200 to 400 uCi of Tl-201, to provide reasonably realistic background radiation.

### **C. Procedure**

Instructions for use of the Linearity/Uniformity block may be found in Section 2.2, D and E. For the Cardiac Phantom Insert, make a reconstruction in the usual way, including the defect in the slice reconstructed. In general, use the smallest defects that can be visualized under the best of conditions. Defects either larger or smaller than these are not as useful. The phantom may be scanned in any position or attitude, but one approximating the position of the human heart relative to the isotope camera will usually be the most useful, both for teaching purposes and for quality assurance.

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