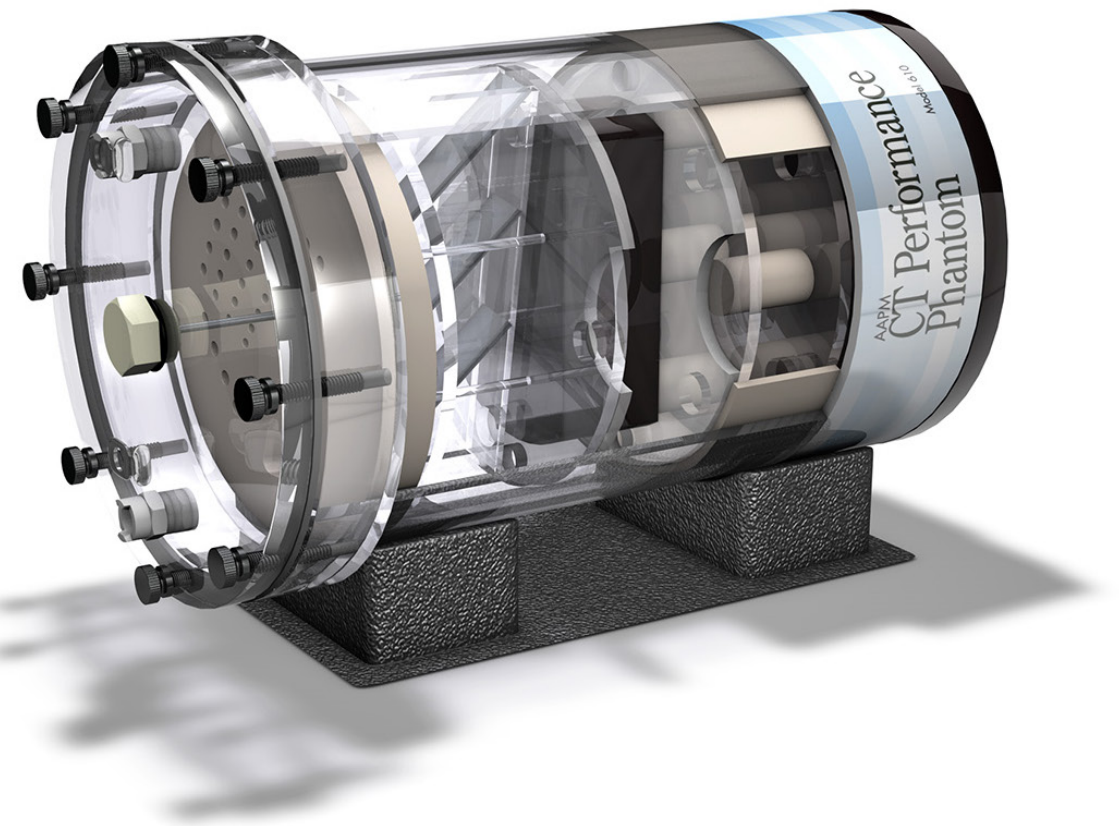
AAPM CT Performance Phantom

Model 610



USER GUIDE

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INTRODUCTION

MODEL 610 AAPM CT PERFORMANCE PHANTOM PRODUCT DESCRIPTION

With the increasing use of computerized tomography as a diagnostic tool, the need has arisen for an efficient means of evaluating the performance of the CT scanners now in use. Recognizing this requirement, the American Association of Physicists in Medicine (AAPM), established a Task Force on CT scanner phantoms. Its goals were to define CT scanner performance and present practical methods of performance testing through the utilization of special phantoms. The phantom described here is based on the guidelines presented in Report #1 of the Task Force and approved by the AAPM.

The modular CT Performance Phantom offers the CT user a single system with which to measure nine performance parameters. One phantom does it all. It permits the routine standardization of alignment, beam width, spatial uniformity, linearity/contrast, spatial resolution, linespread, noise, size independence, and absorbed dose.

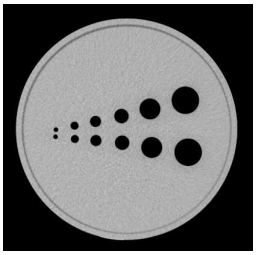
All components of the phantom are housed in a compact, transparent tank (to be filled with water), which holds the system together in the correct orientation.

COMPONENTS

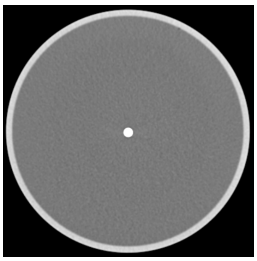
Overall dimensions of phantom
8.5” OD x 15.5” L
Empty weight
17.25 lb

Phantom Housing:
PMMA cast tubing 8.5” OD, 8” ID x 12.75” L with removable lid.

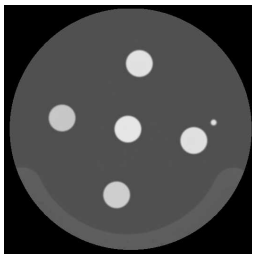
INSERT DESCRIPTIONS



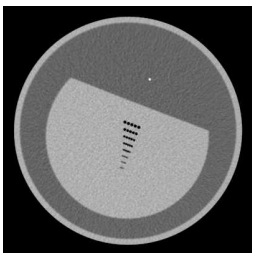
PART NO. 610-01-02
CONTRAST TEST OBJECT
(This option is only available with the purchase of a phantom body)
8.5” OD x 2.5” L solid acrylic equivalent disk block with12 fillable cavities 2.25” deep. Two of each cavity with diameters: 1,0.75,0.50, 0.375,0.25, and 0.125 inches, spaced twice their diameter apart from a centerline. Cavities can be easily filled from the outside with dextrose or sodium chloride solutions of various concentration.



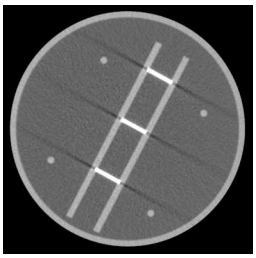
PART NO. 610-01-05
ALIGNMENT PIN
0.25” Ø x 3” L aluminum pin with threaded attachment to housing cover plate.



PART NO. 610-02
CT NUMBER LINEARITY INSERT
7.5” OD x 2.5” L includes 1” Ø. Rods of polyethylene, PMMA (acrylic), polycarbonate, polystyrene and nylon. Density values (g/cc) : polyethylene - 0.95, polystyrene - 1.05, nylon - 1.1, acrylic, - 1.19, polycarbonate, - 1.20.

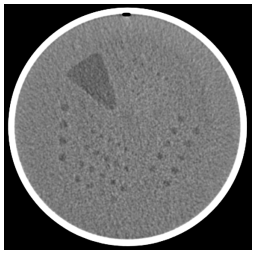


PART NO. 610-03
RESOLUTION INSERT
7.5” OD x 2.5” L with acrylic equivalent test object with eight sets of air thru holes (five holes per set) : Diameter of holes is 1.75, 1.5, 1.25, 1.00, 0.75, 0.61, 0.50, and 0.40 mm. Distance between each hole equal to hole diameter. Each row is 5mm apart. Insert also contains a 0.009” stainless steel wire positioned longitudinally for calculation of line-spread function.



PART NO. 610-04
SLICE THICKNESS INSERT
7.5” OD x 3.5” L contains three 0.02 x 1.00” aluminum strips angled at 45°, positioned on center and aligned vertically.

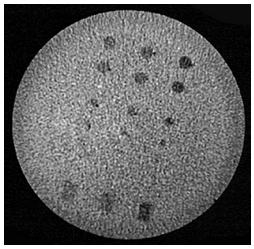
PART NO. 610-05
BONE RING
7.65” ID x 0.2” wall thickness x 2.8” long cortical bone ring. Fits over linearity, resolution and slice thickness insert to harden the beam.



PART NO. 610-06
OPTIONAL - LOW CONTRAST INSERT
8” OD x 1.18” L proprietary epoxy with CT density 6-10 HU above water. The test object contains a series of water-filled holes from 2.5 to 7.5 mm in Ø, in 0.5 mm steps. For each target size, the center-to-center distance between holes is twice the hole diameter.

PART NO. 610-07
OPTIONAL - WHOLE BODY RESOLUTION AND NOISE RING
12” OD x 8.5” ID x 2” L fits over phantom housing and contains the same test object as the Resolution Insert, at two locations 90° apart.

PART NO. 610-08
OPTIONAL - TLD INSERT
0.5” Ø x 3.5” L PMMA rod drilled 3 inch deep to accept TLD’s. Can be swapped with alignment pin in housing cover without removing the cover.



PART NO. 610-10
OPTIONAL - LOW CONTRAST
INSERT - SPHERICAL TARGETS
8” OD x 1.18” Plastic Water® LR equivalent background. The test object contains spheres 5, 10 & 20 CTU below background and 3 reference plugs for each material used as spheres.

PART NO. 9504
OPTIONAL - CUSTOM CARRY CASE FOR MODEL 610
Custom carry case for easy storage and handling of complete Model 610.

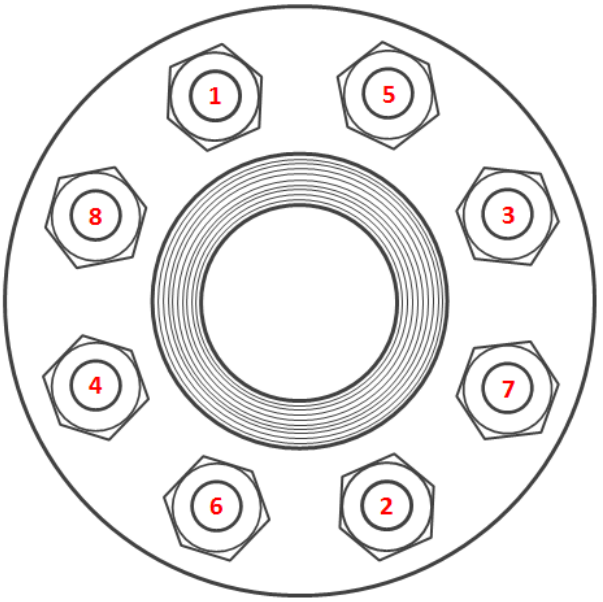
INITIAL SET UP

The Phantom is shipped partially assembled. However, it may contain packing material that must be removed before filling the systems with water. Proceed as follows:

1. Remove the top cover by unscrewing all the shipping screws.

2. Remove the packing materials. Separate the two gate valves, aluminum alignment pin, TLD insert pin and insert pin mounting plug. Replace the inserts.

3. Re-install the cover. Tighten all thumbscrews securely by hand. Leaking can occur when the top plate is not secured in an alternating sequence methodology (shown in diagram).



FILLING PROCEDURE - QUICK CONNECT FITTINGS

1. Stand the Phantom on end on a level surface. Insert the gate valves into their respective ports located on the cover plate.

2. Insert male fittings with tubes.

3. Fill the phantom slowly with warm water via syphon process or attach to water source. Air will be displaced as the water level rises.

5. When all the air is displaced, water will flow out of the vent valve. Turn off the water flow.

6. Let the phantom stand for 3-4 hours to allow dissolved air to disassociate from the water.

7. Add more water until all the air in the phantom has been displaced and water flows from the valve.

8. Detach both hoses. The phantom is now ready for use.

ADJUSTING RESOLUTION INSERT

The 0.009 stainless steel wire used for linespread functions can loosen due to vibrations during transit and use. To tighten, use an Allen wrench to loosen one of the set screws securing the wire in the cover plates. Squeeze the two plates together, grasp the wire with a pair of needle-nosed pliers, and draw tight. Retighten the set screw, and then release the pressure on the two plates.

LOW-CONTRAST INSERT — FILLING INSTRUCTIONS

Make up appropriate solutions of sodium chloride and water, or dextrose and water, to the desired density differentials. Using allen keys provided, remove the plugs in the Low-Contrast Insert. With a syringe, carefully fill each section to the top of the threaded portion of each cavity. Carefully re-insert the filler plugs. Advance the thread slowly so that no displaced air is trapped.

PERFORMANCE MEASUREMENTS

The following procedures describe simple techniques for checking the performance of CT systems. The user may choose to adjust these procedures for his own particular scanner.

BEAM ALIGNMENT AND NOISE

Beam alignment measurements are performed by scanning the aluminum pin, which is mounted axially on the inside of the phantom cover plate.

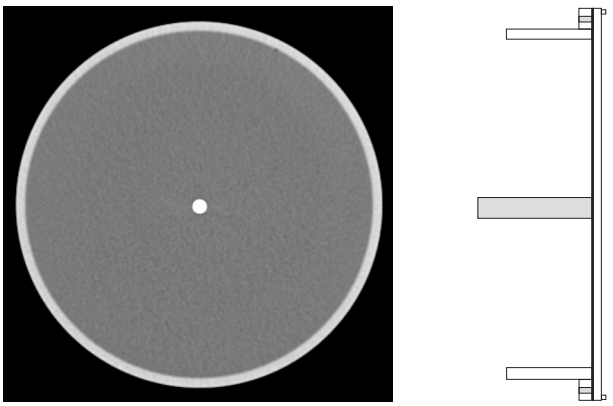


Image of horizontal alignment pin showing true cut alignment.

Procedure

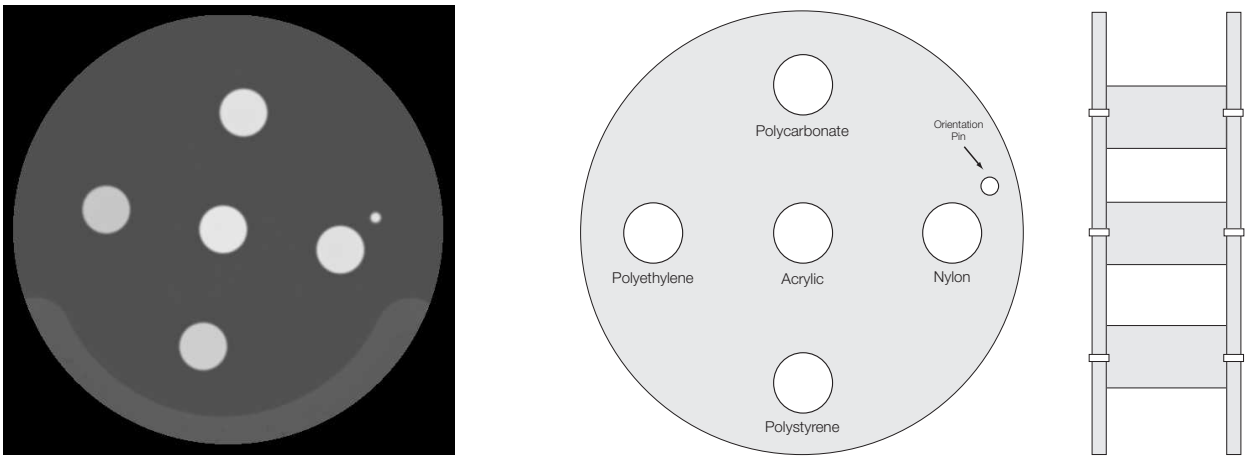
1. Position the phantom in the scan circle so that it is parallel to the axis of the circle and perpendicular to the circle plane. Use a bubble level to set up these parameters for best results.
2. Position the scanner table so that the center of the pin is in the scan zone.
3. Scan the alignment pin and photograph for medium contrast (window width of 50 to 150).
4. Proper alignment yields a round and true image of the pin. If the CT scanner alignment is incorrect, the pin appears elliptical in shape or produces tuning-fork type artifacts.
5. The image of the water surrounding the tank should be uniform and should show no major “streaking” artifacts.

LINEARITY AND CONTRAST

The CT Number Insert consists of five pins, each 1" in diameter, fabricated of the following materials:

Material	Density
Acrylic	1.19
Polystyrene	1.05
Polycarbonate	1.20
Polyethylene	0.95
Nylon	1.10

Although only polyethylene is less dense than water, radiographic densities (linear-absorbent coefficients) differ greatly. Both polystyrene and polyethylene exhibit CT numbers less than water. Depending on your CT system's computational program and effective beam energy, the CT numbers may vary somewhat from published results.



Example of a high-contrast linearity measurement, showing different radiographic densities of test pins.

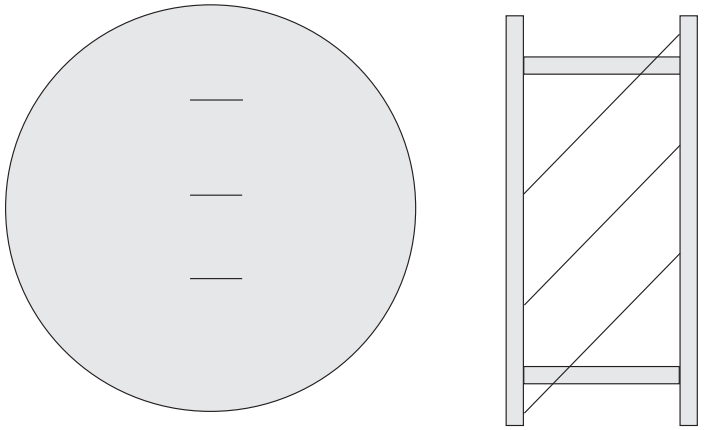
Procedure

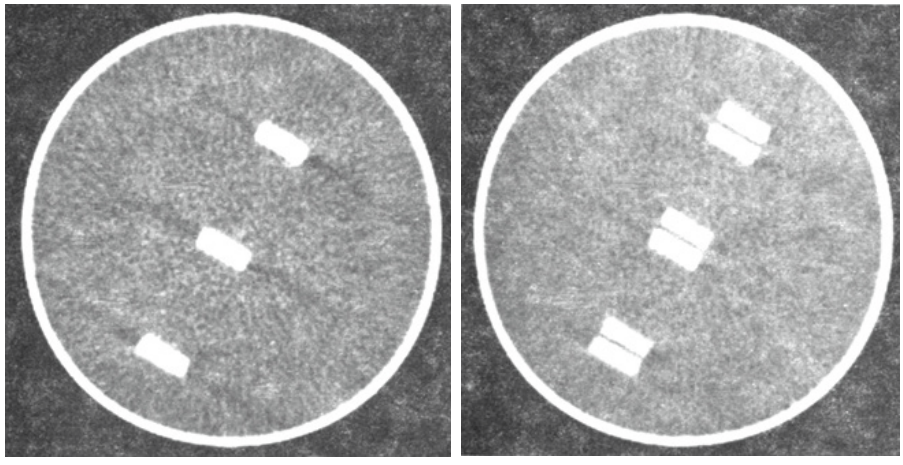
1. Position the phantom in the scan circle so that is parallel to the axis of the circle and perpendicular to the circle plane.
2. Position the scanner table so that the center of the high-contrast insert is in the scan zone.
3. Scan the insert.
4. Using the window and level control, or the "area of interest" system, measure the CT scan number of each pin, using at least 25 pixels for the determination. Typically, polystyrene and polyethylene will display CT numbers less than water. The acrylic and polycarbonate pins, although close in density, will exhibit different CT values. The nylon pin, with a density of 1.10, provides a control value as found in dense tissue.
5. A typical "Hounsfield" CT number scale may yield the following results. Please be advised that results vary from scanner to scanner. These numbers are only for reference.

Material	± 1000 number scale	± 500 number scale
Polyethylene	-92	-46
Polystyrene	-24	-12
Water	0	0
Nylon	+92	+46
Polycarbonate	+102	+51
Acrylic	+120	+60

SLICE THICKNESS INSERT

The Slice Thickness Insert allows the use to effectively measure both the slice thickness (cut) width and the adjacency of successive cuts.





Beam width and adjacency of cut

Procedure A – No Line Printer

1. Position the Phantom in the scan circle, parallel to the axis of the circle and perpendicular to the circle plane.
2. Position the scanner table so that the slice thickness insert is in the scan zone.
3. Scan and photograph once.
4. Remove or advance the film system and re-photograph at 1/2 the exposure time. Leave this exposure in the camera.
5. Step the scanner table for the next adjacent cut, and scan. Photograph in the frame of step 4 and process the film.
6. The first image obtained (step 3) is evaluated for beam width by taking the ratio of the film image diameter to that of the phantom (8.5") to obtain a reduction factor.
7. Measure the widths of the aluminum ramps as shown on the image, and divide by the reduction factor. Then divide the result by 1.414 to obtain true entrance, middle and exit cut width.
8. The second frame (steps 4 & 5 adjacency measurement) should display the image of the three aluminum strips with the second cut image adjacent to them. Any excessive separation or overlap indicates the need to adjust the table stepping mechanism.

SAMPLE BEAM WIDTH MEASUREMENT

Phantom diameter on film = 2.125”

Reduction Factor = $\frac{2.125}{8.50} = 0.25$

Measured Ramp Width = 3.5 mm

Adjusted Width= $\frac{3.5}{0.25} = 14.0$ mm

“Slice Thickness” = 14.0 mm

Procedure B – With Line Printer

1. Position the phantom in the scan circle, parallel to the axis of the circle and perpendicular to the circle plane.
2. Position the scanner table so that the slice thickness insert is in the scan zone.
3. Scan and photograph once.
4. Step the scanner table for the next adjacent cut, and scan. Photograph in the frame of step 3 and process the film.
5. The first image obtained (step 3) is evaluated by taking the ratio of the film image diameter to that of the phantoms (8.5") to obtain a reduction factor.
6. The second frame (steps 4 & 5 adjacency measurement) should display the image of the three aluminum strips with the second cut image adjacent to them. Any excessive separation or overlap indicates the need to adjust the table stepping mechanism.

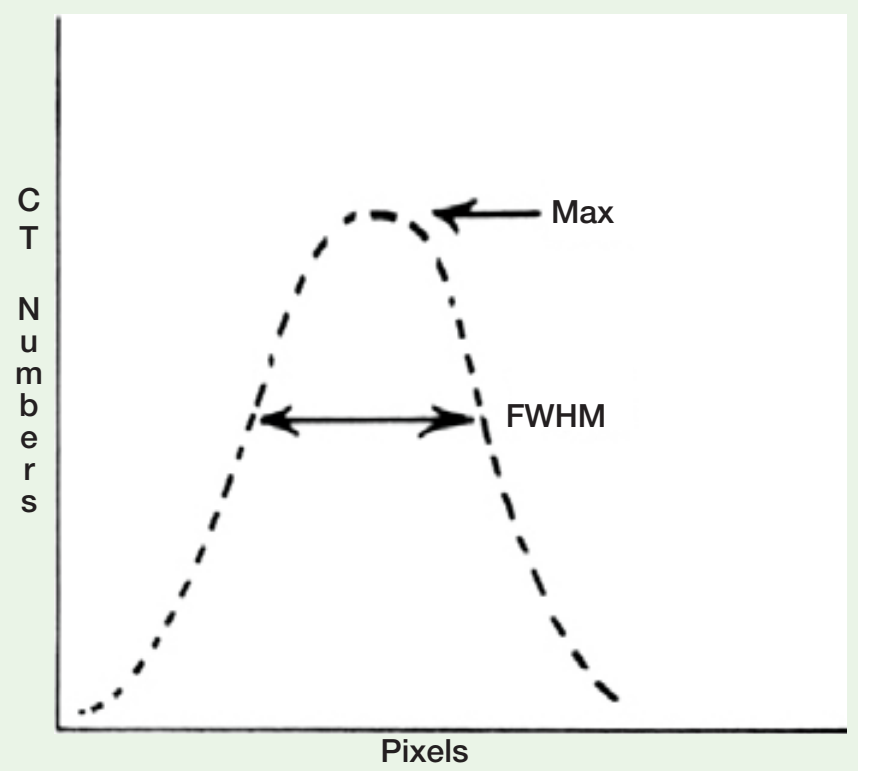
7. To measure the widths of the aluminum ramps as shown on the image, obtain a CT number printout of each aluminum ramp.

8. From the CT number printout of the aluminum ramps, plot the numbers versus individual pixels (see example below).

CT Print-Out
(one-ramp)

4
6
8
12
24
83
121
128
147
173
195
194
184
164
118
70
61
39
17
7
6

Plot



9. From the plot determine the full width at half maximum (FWHM) in terms of pixels.

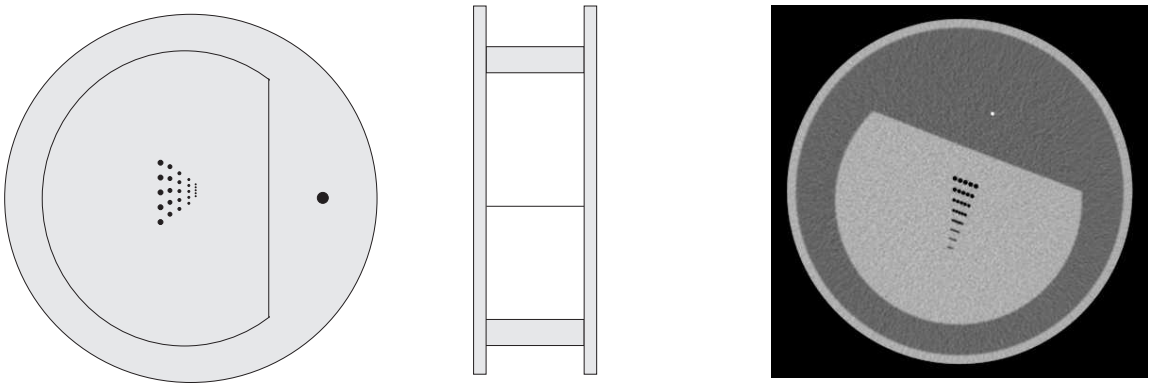
10. Convert the FWHM in terms of pixels to dimensions of millimeters by multiplying by the length of each pixel.

Example
FWHM in pixels = 10 pixels
1 pixel length = 1.5 mm (varies with model of CT scanner – obtain from CT mfr.)
FWHM in dimensions of length
(10 pixels) x 1.5 mm / pixel = 15 mm
“Slice thickness” = 15 mm

SPATIAL RESOLUTION AND SIZE UNIFORMITY (RESOLUTION INSERT)

The High-Resolution Insert allows the measurement of system resolution on both small and large scan circles.

Resolution limits of small scan circles are easily defined. Linespread function can be calculated directly.

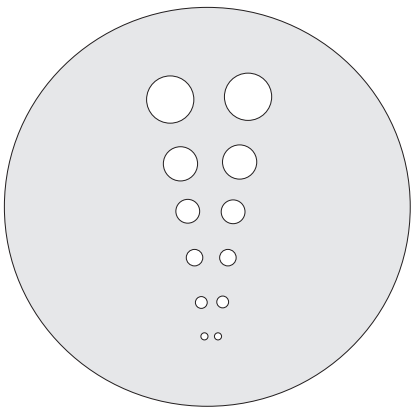


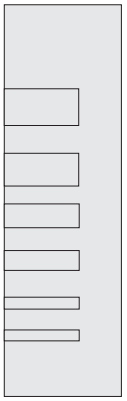
Procedure

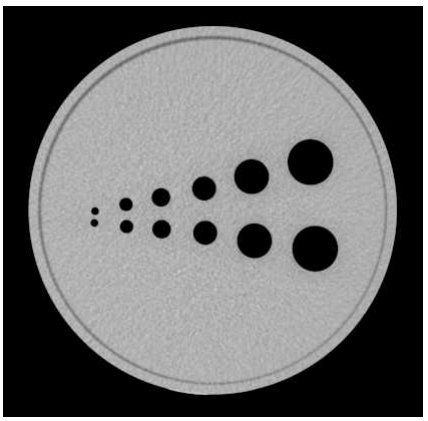
1. Position the phantom in the scan circle so that it is parallel to the axis of the circle and perpendicular to the circle plane. The bone ring should be positioned over the insert to simulate the beam hardening of bone as encountered in brain studies. The matrix of holes should be aligned to the vertical and horizontal axes.
2. Position the scanner table so that the center of the resolution insert is in scan zone.
3. Scan the insert. Adjust the level and window width for the best image, and photograph (scan circle approx. 30 cm diameter).
4. Rotate the phantom so that resolution hole matrix is at a 45° angle, and re-scan.
5. Adjust the level and window for the best image, and photograph.
6. Evaluate both images for resolution. Compute the linespread function, if desired.

CONTRAST SENSITIVITY (LOW-CONTRAST EXTENSION BLOCK)

The Low-Contrast Extension Block, mounted at the end of the phantom tank, allows the user to evaluate a scanner's ability to detect small differences in density. Solutions of dextrose or NaCl & H2O, prepared on a weight percent basis and differing by 1%, 2%, or 3% from the acrylic density, can be used to fill these cavities.







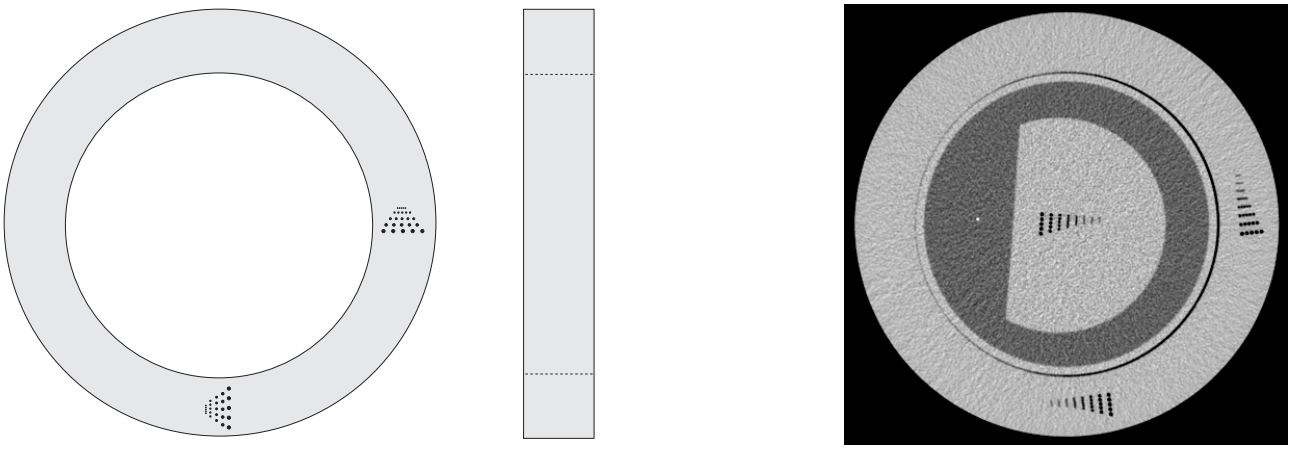
Low-contrast detectability is easily determined by using solutions whose densities differ by a known percentage in adjacent cavities in the test block

Procedure

1. Position the Low-Contrast Extension Block in the scan circle so that it is parallel to the axis of the circle and perpendicular to the circle plane, and the scan zone is over the center of the block.
2. Scan the block. Adjust the level and window setting for the best image, and photograph.
3. Using the “region of interest” program, or the window and level, evaluate the cavities for CT number value as a function of cavity diameter. The smallest cavity set with discernibly different CT numbers defines the limit of low-contrast detectability.

WHOLE-BODY SCANNER RESOLUTION, SIZE UNIFORMITY AND NOISE (NOISE RING)

The Whole-Body Annulus allows resolution and noise measurements to be performed on “whole-body scanners. This 12 “ OD x 8.5” ID ring is designed to slip over the phantom tank so that the scan circle is filled. By positioning the ring over any of the internal or external sections, all performance parameters may be measured.



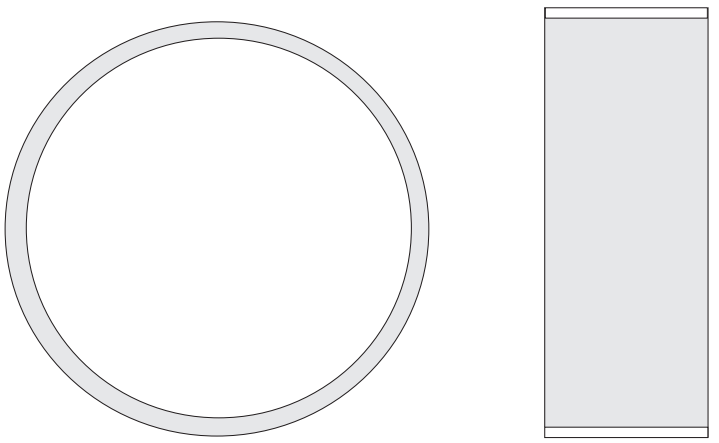
Whole body scanner resolution is easily evaluated, using the noise ring and tank sections.

Procedure

1. Position the CT Phantom in the scan circle so that is parallel to the axis of the circle and perpendicular to the circle plane.
2. Place the noise ring over the phantom, and position it so that is rests over the inner high-resolution insert. Both inner and outer hole patterns should be perpendicular to the table plane.
3. Scan and adjust window and level settings for optimum image. Photograph.
4. Evaluate both inner and outer resolution patterns on the film. Evaluate MTF from the inner insert.
5. Rotate both the phantom and the noise ring so that the hole patterns are at a 45° angle.
6. Scan and photograph as in Step 3.
7. Evaluate for performance as in Step 4. Note any difference in the resolution capability between the images (i.e., parallel to or angulated to the pixel matrix).
8. The image of the two hole patterns should be uniform in size. The relative noise level in the noise ring and internal tank water should be the same.

BEAM HARDENING (BONE RING)

The Bone Ring may be positioned over any of the internal inserts to harden the beam, simulating a clinical condition. The ring has been designed to slide easily over any of the internal inserts throughout the Phantom.



WARRANTY

All standard CIRS products and accessories are warranted by CIRS against defects in material and workmanship for a period as specified below. During the warranty period, the manufacturer will repair or, at its option, replace, at no charge, a product containing such defect provided it is returned, transportation prepaid, to the manufacturer. Products repaired in warranty will be returned transportation prepaid.

There are no warranties, expressed or implied, including without limitation any implied warranty of merchantability or fitness, which extend beyond the description on the face hereof. This expressed warranty excludes coverage of, and does not provide relief for, incidental or consequential damages of any kind or nature, including but not limited to loss of use, loss of sales or inconvenience. The exclusive remedy of the purchaser is limited to repair, recalibration, or replacement of the product at manufacturer's option.

This warranty does not apply if the product, as determined by the manufacturer, is defective because of normal wear, accident, misuse, or modification.

NON-WARRANTY SERVICE

If repairs or replacement not covered by this warranty are required, a repair estimate will be submitted for approval before proceeding with said repair or replacement.

RETURNS

If you are not satisfied with your purchase for any reason, please contact your local distributor prior to returning the product. Visit https://www.cirsinc.com/distributors/ to find your local distributor. If you purchased your product direct through CIRS, call Customer Service at 800-617-1177, email rma@cirsinc.com, or fax an RMA request form to 757-857-0523. CIRS staff will attempt to remedy the issue via phone or email as soon as possible. If unable to correct the problem, a return material authorization (RMA) number will be issued. Non-standard or "customized" products may not be returned for refund or exchange unless such product is deemed by CIRS not to comply with documented order specifications. You must return the product to CIRS within 30 calendar days of the issuance of the RMA. All returns should be packed in the original cases and or packaging and must include any accessories, manuals and documentation that shipped with the product. The RMA number must be clearly indicated on the outside of each returned package. CIRS recommends that you use a carrier that offers shipment tracking for all returns and insure the full value of your package so that you are completely protected if the shipment is lost or damaged in transit. If you choose not to use a carrier that offers tracking or insure the product, you will be responsible for any loss or damage to the product during shipping. CIRS will not be responsible for lost or damaged return shipments. Return freight and insurance is to be pre-paid.

WITH RMA NUMBER, ITEMS MAY BE RETURNED TO:

CIRS
Receiving
900 Asbury Ave,
Norfolk, Virginia, 23513 USA

PRODUCT	WARRANTY PERIOD
Model 610 - AAPM CT Performance Phantom	60 Months

COMPUTERIZED IMAGING REFERENCE SYSTEMS, INC.
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Norfolk, Virginia 23513 USA

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