

**Upstate Medical Physics**  
**CT Quality Assurance Test Procedures**  
**Rev 5-11-2012**

**1) Introduction**

The New York State Department of Health (NYSDOH) and ACR CT Accreditation program (CTAP) requires periodic quality assurance testing of ionizing radiation producing equipment. For CT imaging facilities, our testing consists of an annual evaluation of image quality and patient dosimetry.

Generally, four imaging protocols are selected (Adult Brain, Adult Abdomen, Pediatric Brain, Pediatric Abdomen). Image quality is evaluated through the use of a multi sectional phantom manufactured by Gammex (RMI). This is also the phantom used for ACR Accreditation (CTAP).

**2) Table Indexing and Travel**

Prior to making any exposures, the Gammex RMI is set up on the table (using the phantom holder), leveled, and centered. One measurement is made to evaluate table travel and indexing. Using the positioning laser and indexing display, a comparison of the known distance of the phantom length to the displayed table travel length is made and documented.

**3) Image Quality Evaluation Process**

The Gammex RMI phantom is centered in the gantry, and a pilot (Topogram, Sureview, Scout) acquisition is made of the appropriate phantom sections or Modules. Confirmation of technique and slice thickness is made with the technologist. To determine optimal phantom positioning, making an exposure through the center of Module 1 should result in the ability to visualize four small BB's mounted at 12, 3, 6, and 9 o'clock positions on the exterior of the phantom.

For modules of the CTAP phantoms are evaluated for various image quality parameters using site's most commonly used Adult Brain, Adult Brain, Pediatric Brain and Pediatric Abdomen protocols. These modules are also evaluated using the range of kVp selections available and clinically used on the CT scanner by keeping rest of the technique parameters as the Adult Abdomen protocol.

- a) The first section (Module 1) contains tools for evaluation of slice thickness, CT Number Accuracy, CT Number Scaling. An exposure is made through the center of the first section. Slice thickness is evaluated by counting the number of ramp lines visible and dividing by two, and then comparing against the reconstructed slice thickness. Manufacturer's specifications (if available) are used to determine acceptability.
- b) For CT Number Accuracy, the phantom contains 5 materials with nominal CT numbers. A region of interest (ROI) is prepared and placed inside each of the materials, and CT number (mean) is recorded and compared against the nominal values. Limits of acceptability for the solid water material are +7 to -7 HU.

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- a) For High Contrast evaluation, the last phantom section (Module 4) contains a number of high contrast resolution test patterns (from 4-12 lp/cm). An image (slice) is made through the center of these test patterns. The image is optimally adjusted (window and level) to visualize the highest line pair pattern, and results documented. There are 4 small (1mm) BB's positioned at 12, 3, 6, and 9 o'clock around the center of Module 4. Visualization of these 4 BB's in the High Contrast resolution section of the phantom indicates you are positioned in the center of the section. Note that these BB's are precisely 120mm from the BB's located in Module 1. Evaluation of table travel accuracy can be evaluated.
- b) Low Contrast performance is evaluated as follows. Module 2 of the Gammex CT phantom contains a low contrast evaluation tool. This consists of low contrast targets or spheres (4 in a group). The size of the low contrast targets range from 2mm up to 6mm. An image is obtained through the center of the module, using the site's Adult Abdomen and Adult Brain protocols. The image is optimally adjusted to visualize the targets. Results for the low contrast objects are documented. Contrast-to-Noise Ratio (CNR) is also calculated using the same image. Two ROIs are drawn: one on the 25 mm diameter cylinder and one in the background region of the phantom next to the cylinder. CNR is calculated as:  $[\text{Mean HU}(\text{disk}) - \text{Mean HU}(\text{background})] / \text{Std. Dev. (background)}$ . CNR is also calculated and documented for next consecutive slice. Minimum CNR required for the Adult protocols is 1. For the Pediatric Brain protocol minimum CNR of 1 and for the Pediatric Abdomen protocol minimum CNR of 0.5 is recommended.
- c) Module 3 of the Gammex RMI CT phantom is used to evaluate uniformity and artifacts. An Adult Abdomen protocol is used for image acquisition. Once the image is optimized, regions of interest (ROI) are made in the center, 12 o'clock, 3 o'clock, 6 o'clock, and 9 o'clock locations. CT number and standard deviation is documented for the center ROI only. CT number is documented for the remaining ROI's. Also contained in this module are two metal BB's spaced exactly 100 mm apart. The distance measuring device of the CT scanner can be evaluated by measuring the distance between the objects and comparing against the known distance. Once uniformity is evaluated, all ROI's are deleted and the image is optimally adjusted for evaluation of any artifacts, such as streaking or ring.
- d) Do not remove the Gammex CT image quality phantom from the table until you are certain that all evaluations have been performed and results documented.

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**6) Patient Dosimetry Evaluation**

Using the 16 cm and 32 cm CIRS dosimetry phantom, scans are made to measure the patient dose in the center and 12 o'clock positions. The CT chamber is connected to the Radcal electrometer, and the Radcal unit is set to "Auto Dose". The dose is displayed in mR and entered into the Excel CT spreadsheet. Results are compared against the NYSDOH (or ACR) reference values. If the manufacturer's estimated dose is presented, our measured results are compared, when appropriate.

**a) Adult Brain Protocol**

The Adult Head protocol (axial or axial equivalent) is evaluated first. If a head holder is used, the phantom should be placed and secured in the head holder. It is important to center the ion chamber laterally, vertically, and coronally using the positioning laser. A pilot scan (Scout, Topogram, Sureview) is made of the entire phantom. Place the slice positioning laser in the center of the phantom. The table increment should be set to 0, so that the same region of the phantom and ion chamber is imaged for each exposure. Three exposures are measured at the center position, and three exposures are made with the probe/detector at the 12 o'clock position.

**b) Pediatric Brain Protocol**

The Pediatric Brain protocol (axial or axial equivalent) is evaluated. Keep the phantom placement same as described above. Three exposures are measured at the center position, and three exposures are made with the probe/detector at the 12 o'clock position.

**c) Pediatric Abdomen Protocol**

Place the 16 cm phantom on the table, center and secure the phantom so that the ion chamber is at isocenter. Convert the typically used Pediatric Abdomen technique into a comparable axial technique (kVp, mAs, time, slice thickness). Any automatic exposure control features (CareDose, Auto mA) should be disabled or turned off. Repeat the scans as above, using three scans in the center, and three scans at the 12 o'clock position. Table increment should be set to 0.

**d) Adult Abdomen Protocol**

The 16 cm dosimetry phantom will be placed inside of the 32 cm phantom, forming a solid 32 cm phantom for evaluation of Adult Abdomen patient dosimetry. The axial technique developed for the image quality evaluation should be used. Any automatic exposure control features (CareDose, Auto mA) should be disabled or turned off. Center the phantom using the positioning lasers, so that the ion chamber is located as isocenter.

The table increment should be set to 0. Make and record three exposures with the ion chamber in the center, and three exposures with the chamber positioned at the 12 o'clock position. Dosimetry results are compared against the NYSDOH CT reference values specified in the NYSDOH CT QA Guide and ACR CTAP Requirements.

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**7) QC Program Review**

At the conclusion of our testing, a review of those QC tests specified in the NYSDOH CT QA Guide (10/04) is performed with the CT technologist. Records of the daily, monthly, semi-annual, and annual QC tests are reviewed for accuracy and completion.