# CT SCANNER PERFORMANCE EVALUATION

**GREEN LIGHT IMAGING, LLC**
Medical Mobile Diagnostics
8348 Rosemead Blvd
Pico Rivera, CA 90660

(562)222-1321

**CT Trailer #4**
GE Optima CT520
Gantry S/N: 377671HM3

**Survey Date:** July 3, 2020

**Khachig A. Jerjian, Ph.D.**
ABR Certified in Diagnostic Radiological Physics
California MQA-0061

(949)683-5215

# CT SCANNER PERFORMANCE EVALUATION SUMMARY

| | | | |
|---|---|---|---|
| **Site:** | **GREEN LIGHT IMAGING, LLC** | **Report Date:** | July 3, 2020 |
| | 8348 Rosemead Blvd | **Survey Date:** | July 3, 2020 |
| | Pico Rivera, CA 90660 | | |
| **X-Ray Unit Manufacturer:** | General Electric Medical Systems | **Model:** | Optima CT520 |
| **Date Manufactured:** | July 1, 2014 | **Room ID:** | CT Trailer #4 |
| **Medical Physicist:** | Khachig A. Jerjian, Ph.D. | **Signature:** | K. Jerjian, Ph.D. Digitally signed by K. Jerjian, Ph.D. DN: cn=K. Jerjian, Ph.D., o=AJMP, inc., email=kjmedicalphysics@gmail.com, c=US Date: 2021.05.19 16:11:22 -06'00' |

| | | PASS/FAIL/NA |
|---|---|---|
| 1. | Review of Clinical CT Protocols | PASS |
| 2. | Scout Prescription Accuracy Evaluation | PASS |
| 3. | Laser Light Alignment Accuracy Evaluation | PASS |
| 4. | Table Travel Accuracy Evaluation | PASS |
| 5. | Radiation Beam Width Accuracy Evaluation | PASS |
| 6. | Slice Thickness Accuracy Evaluation | PASS |
| 7. | High Contrast Spatial Resolution Evaluation | PASS |
| 8. | Low Contrast Performance Evaluation | PASS |
| 9. | CT Number Accuracy Evaluation | |
| | a. CT Number Accuracy and Linearity Evaluation | PASS |
| | b. CT Number Contrast Scale Evaluation | PASS |
| | c. CT Number Dependence on Slice Thickness Evaluation | PASS |
| | d. CT Number Dependence on kVp Evaluation | PASS |
| | e. CT Number and Image Uniformity Evaluation | PASS |
| 10. | Artifact Evaluation | PASS |
| 11. | Dosimetry Evaluation | PASS |
| 12. | Acquisition Display Device Evaluation | PASS |
| 13. | Radiation Protection Evaluation | |
| | a. Visual Inspection | PASS |
| | b. Audible/Visual Warning Signs | PASS |
| | c. Posting Requirements | PASS |
| 14. | Technologist Quality Control Program Evaluation | N/A |

## MEDICAL PHYSICS RECOMMENDATIONS & COMMENTS

1. CT scanner performance evaluation was found to be adequate. Performance evaluation test results were within ACR recommended action limits. Deviations in the indicated and measured $CTDI_{vol}$ dose values were within an acceptable range of ± 10%.

2. Select clinical protocols for adult and pediatric patients were reviewed. Protocols were found to be adequate with typical doses within ACR recommended Reference Dose Levels for both head and body protocols.

3. Brain Perfusion CT protocols were not reviewed. Brain CT Perfusions are not performed on this scanner.

4. CT number calibration dependence on kVp and Slice Thickness was found to be adequate for kVp stations used clinically. CT Number linearity and contrast scale were also found to be adequate.

5. The lowest kVp station (80 kVp) is generally not used clinically and is not properly calibrated. It is recommended that use of the 80 kVp setting be avoided until such time when system is calibrated by FSE.

6. This being a new unit, Technologist QC program could not be reviewed. Recommend establishing a Technologist QC Program consistent with ACR recommendations.

7. Detailed accounts of this performance evaluation may be obtained by contacting us directly at (949)683-5215 or by e-mail at kjmedicalphysics@gmail.com.

**Khachig A. Jerjian, Ph.D., DABR** **Date: July 3, 2020**
Medical Physicist

## 1. REVIEW OF ROUTINE CLINICAL CT PROTOCOLS

This CT scanner performance evaluation was performed using the ACR CT Accreditation Program Phantom and routine clinical head and abdomen protocols used at this facility. Test procedures were consistent with ACR CT Accreditation Program guidelines.

**Table 1.** Routine Protocols

| For this section, techniques used on an average patient or average technique calculated from several patient images is recorded. | **Adult Head** | **Adult Abdomen** | **Pediatric Head (1 Year Old)** | **Pediatric Abdomen (5 Year Old)** |
|---|---|---|---|---|
| kVp | 120 | 120 | 100 | 120 |
| mA | 270 | 275 | 190 | 85 |
| Time per Rotation (sec) | 1.0 | 1.0 | 0.8 | 0.8 |
| System Calculated mAs | 270 | 275 | 152 | 68 |
| Effective mAs (or mAs per slice) as displayed | 288 | 200 | 152 | 49 |
| Scan FOV (cm) | Head(25 cm) | Large(50 cm) | Ped(25 cm) | Large(50 cm) |
| Display FOV (cm) | 25 cm | 36 cm | 25 cm | 28 cm |
| Reconstruction Algorithm | Std Plus | Standard | Standard | Std Plus |
| Axial (A) or Helical (H) Scan | H | H | A | H |
| Acquisition Slice Thickness Z-Axis Collimation (T in mm) | 1.25 | 1.25 | 1.25 | 1.25 |
| Number of Slices per Tube Rotation - # of Data Channels Used (N) | 16 | 16 | 16 | 16 |
| Table Increment (mm) (axial scans) or Table Speed (mm/rot)(helical scans) (I) | 18.750 | 27.5 | 20.0 | 27.5 |
| IEC definition of Pitch for this protocol (Pitch = I / N * T) (calculated by the System) | 0.938 | 1.375 | 1.0 | 1.375 |
| Reconstructed Scan Width (mm) | 5.0 | 2.5 | 5.0 | 5.0 |
| Reconstructed Scan Interval (mm) | 5.0 | 2.5 | 5.0 | 5.0 |
| Dose Reduction Technique(s) used in routine patient scanning for these protocols (*Note: The ACR and CTDI phantoms are NOT scanned with dose reduction options.* ) | Auto mA 100-220 mA Noise Index 2.8 | Auto mA 75-350 mA Noise Index 15.86 | Auto mA 50-190 mA Noise Index 1.41 | Auto mA 50-200 mA Noise Index 11.57 |
| Indicated CTDIvol (mGy) | 49.74 mGy | 17.26 mGy | 17.24 mGy | 4.23 mGy |
| Reference Dose Phantom Size | Head 16 | Body 32 | Head 16 | Body 32 |

The facility clinical protocol acquisition and reconstruction parameters were reviewed for specific requirements of the diagnostic imaging task, adequate image quality and dose. The above listed protocols were found to be adequate. The High Resolution Chest protocol was also found to be adequate. Brain Perfusion protocols were not reviewed. Brain Perfusions are not performed on this scanner.

## 2. SCOUT PRESCRIPTION ACCURACY EVALUATION

**Phantom:** ACR CT Accreditation Phantom

**Technique:** 120 kVp, 160 mA, 0.8 sec Rotation Speed, 128 mAs, Axial Mode, 2x0.625 mm Detector Configuration, 1.25 mm Slice Thickness, Bone Reconstruction Algorithm, Large SFOV, 21 cm DFOV, 512x512 Image Matrix.

Following proper position and leveling of the phantom on the scan table at the center of the gantry and acquisition of scout images, 1.25 mm thick axial images were prescribed at the center of modules 1 and 4 of the ACR CT Accreditation phantom at table landmark position of +0 mm and at table location 120 mm superior to the landmark position. Slice localization from scout prescription accuracy was evaluated using images of embedded 1 mm diameter BBs at the surface of modules 1 and 4 of the ACR phantom.

| Detector Configuration | Nominal Position | Actual Location | Deviation (mm) |
|---|---|---|---|
| 1i 2x0.625 mm | Landmark Location | 0.0 mm | 0.0 mm |
| | Superior +120 mm | +120.0 mm | 0.0 mm |

**Conclusion:** Slice localization from scanned projection radiographs/scout was found to be adequate, accurate to within ± 1 mm.

## 3. LASER LIGHT ALIGNMENT ACCURACY EVALUATION

| Detector Configuration | Nominal Position | Actual Location | Deviation (mm) |
|---|---|---|---|
| 1i 2x0.625 mm | Landmark Location | 0.0 mm | 0.0 mm |
| | Azimuth 0° Laser | Left/Right | 0.0 mm |
| | Azimuth 90° & 270° | Vertical | 0.0 mm |

- Maximum discrepancy between the internal and external axial laser lights and the plane of radiation field was determined to be less than ± 1 mm. The sagittal and coronal laser light alignment accuracy was also found to be adequate, within ± 2 mm limits.

**Conclusion:** Bed positioning accuracy and congruence of the laser light beam localizer with the imaging plane was found to be adequate.

## 4. TABLE TRAVEL ACCURACY EVALUATION

| Detector Configuration | Nominal Position | Actual Location | Deviation (mm) |
|---|---|---|---|
| 1i 2x0.625 mm | Landmark Location | 0.0 mm | 0.0 mm |
| | Superior +120 mm | +120.0 mm | 0.0 mm |

- Maximum discrepancy in bed repositioning was determined to be less than ± 1 mm.

**Conclusion:** CT scanner table motion was accurate, reproducible and consistent with digital system indicators. Bed travel and indexing/incrementation accuracy was found to be adequate and reproducible to within ±1 mm.

## 5. BEAM WIDTH ACCURACY EVALUATION

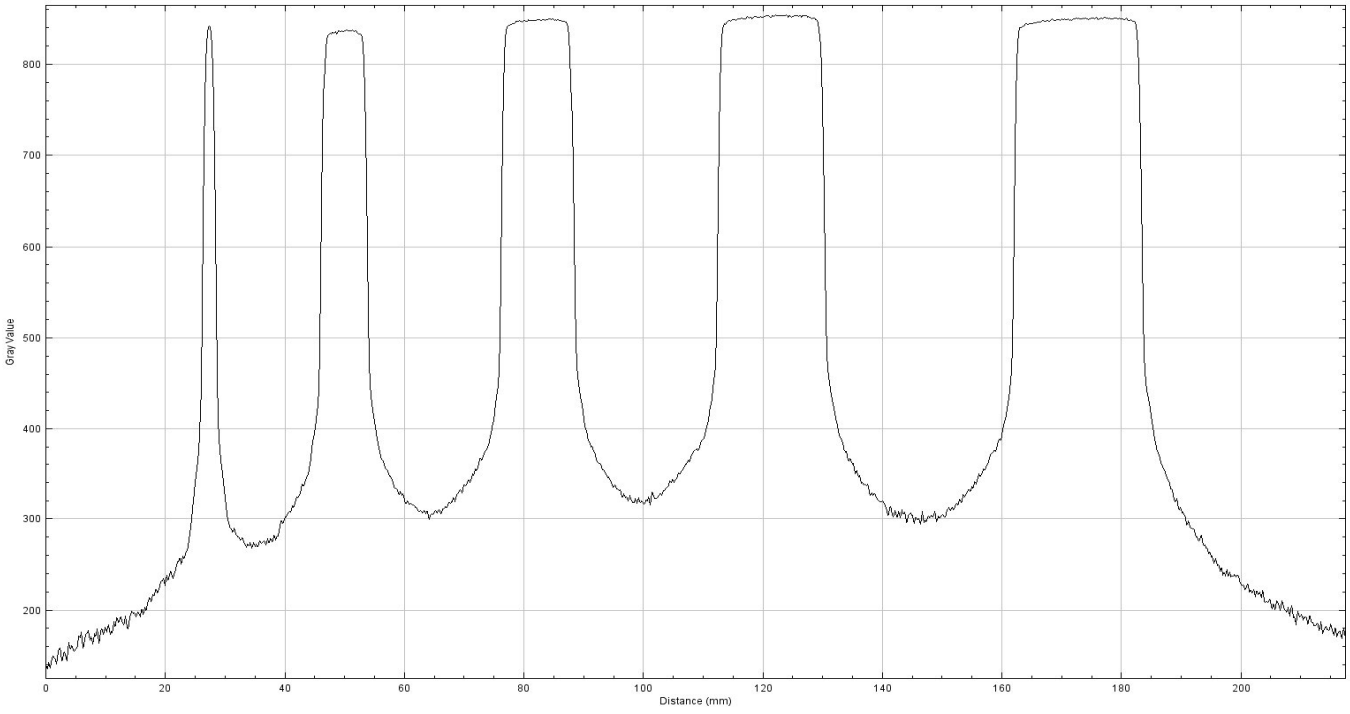
**Phantom:** CR Plate

**Technique:** 80 kVp, 10 mA, 0.8 sec Rotation Speed, 8 mAs, Axial Mode, Detector Configuration and Slice Thicknesses as indicated, Standard Reconstruction Algorithm, Large SFOV, 40 cm DFOV, 512x512 Image Matrix.

A CR plate was positioned at the iso-center and axial images were acquired at selected location. Beam widths were measured at the FWHM of the slice profiles.

| Detector Configuration (Prescribed Width NxT) | Prescribed Beam Width | Measured Beam Width | Difference | Status (Pass/Fail Criteria) |
|---|---|---|---|---|
| 2i 2x0.625 mm | 1.25 mm | 2.4 mm | 1.2 mm | PASS (≤ 3.0 mm) |
| 4i 4x1.25 mm | 5.0 mm | 7.8 mm | 2.8 mm | PASS (≤ 3.0 mm) |
| 16i 16x0.625 mm | 10 mm | 12.1 mm | 2.1 mm | PASS (≤ 3.0 mm) |
| 4i 4x3.75 mm | 15 mm | 17.7 mm | 2.7 mm | PASS (≤ 4.5 mm) |
| 16i 16x1.25 mm | 20 mm | 21.3 mm | 1.3 mm | PASS (≤ 6.0 mm) |

**Conclusion:** Measured beam widths were found to be in good agreement with indicated beam widths. Measured beam widths have to be within the larger of ± 3 mm or 30% of prescribed total nominal collimated beam width.



## 6. SLICE THICKNESS ACCURACY EVALUATION

**Phantom:** ACR CT Accreditation Phantom Module 1

**Technique:** 120 kVp, 250 mA, 1.0 sec Rotation Speed, 250 mAs, Axial Mode, Detector Configuration and Slice Thicknesses as indicated, Standard Reconstruction Algorithm, Large SFOV, 21 cm DFOV, 512x512 Image Matrix.

Axial images were acquired at the center of Module 1 of the ACR CT Accreditation phantom. Slice widths were assessed by counting the visible wires on the two ramps containing wires arranged in 0.5 mm z-axis increments.

| Detector Configuration (Prescribed Beam Width NxT) | Prescribed Slice Width | Measured Slice Width | Difference |
|---|---|---|---|
| 16i 16x0.625 mm | 0.625 mm | 1.0 mm | < 0.5 mm |
| 16i 16x1.25 mm | 1.25 mm | 1.5 mm | < 0.5 mm |
| 8i 8x2.5 mm | 2.50 mm | 2.5 mm | 0.0 mm |
| 4i 4x3.75 mm | 3.75 mm | 4.0 mm | < 0.5 mm |
| 4i 16x1.25 mm | 5.0 mm | 5.0 mm | 0.0 mm |
| 2i 4x3.75 mm | 7.5 mm | 7.5 mm | 0.0 mm |

**Conclusion:** Observed slice widths were found to be in good agreement with the nominal slice widths. Slice widths must be within ± 1.5 mm of the prescribed slice thickness.

## 7. HIGH CONTRAST SPATIAL RESOLUTION EVALUATION

**Phantom:** ACR CT Accreditation Phantom

**Technique:** Routine Adult Head, Adult Abdomen and HR Chest Protocols

The high contrast resolution insert, Module 4 of the ACR Phantom, contains eight bar patterns representing spatial frequencies corresponding to 4, 5, 6, 7, 8, 9, 10 and 12 lp/cm, respectively.

| Protocol | High Contrast Spatial Resolution |
|---|---|
| Routine Adult Brain Protocol | 7 lp/cm |
| Routine Adult Abdomen protocol | 7 lp/cm |
| HR Chest Protocol | 10 lp/cm |

**Conclusion:** The limiting high contrast spatial resolution is adequate. The ACR Pass/Fail criteria are 6 lp/cm for standard resolution head and body protocols and 8 lp/cm for the high resolution chest protocol.

## 8 (a). CONTRAST TO NOISE EVALUATION

**Phantom:** ACR CT Accreditation Phantom Module 2
**Technique:** Routine Head and Abdomen Protocols

The low contrast resolution insert, Module 2 of the ACR phantom, contains five different size rod sets with diameters equal to 6 mm, 5 mm, 4 mm, 3 mm, and 2 mm, respectively. The rod sets are considered to be resolved if all four rods of the same size can be clearly visualized .

**Contrast to Noise (CNR) Evaluation:**

The low contrast resolution insert, Module 2 of the ACR Phantom, was evaluated using a ROI of about 100 $mm^2$. Image noise was represented by the ROI standard deviation of the background area.

| Protocol | Rod Insert ROI (H.U.) | Background ROI (H.U.) | Background ROI (Std. Dev.) | CNR |
|---|---|---|---|---|
| Adult Brain 5.0 mm | 92.1 | 86.2 | 4.5 | 1.3 |
| Adult Abdomen 2.5 | 91.6 | 85.5 | 6.3 | 1.0 |
| Pediatric Brain | 82.6 | 77.2 | 7.0 | 0.8 |
| Pediatric Abd | 92.3 | 86.1 | 10.1 | 0.6 |

**Conclusion:** Routine Brain and Body protocol contrast to noise ratios were found to be adequate. The CNR must be greater than 1.0 for the adult Brain and adult Abdomen protocols. CNR must be greater than 0.7 for Pediatric Brain and greater than 0.4 for Pediatric Abdomen protocol.

## 8 (b). LOW CONTRAST RESOLUTION EVALUATION

**Phantom:** ACR CT Accreditation Phantom Module 2
**Technique:** Routine Adult Head and Adult Abdomen Protocols

The low contrast resolution insert, Module 2 of the ACR phantom, contains five different size rod sets with diameters equal to 6 mm, 5 mm, 4 mm, 3 mm, and 2 mm, respectively. The rod sets are considered to be resolved if all four rods of the same size can be clearly visualized .

| Protocol | Contrast Level | $CTDI_{vol}$ (mGy) | Low Contrast Resolution |
|---|---|---|---|
| Adult Brain | 0.6% | 49.74 mGy | 4 mm |
| Adult Abdomen | 0.6% | 17.26 mGy | 6 mm |
| Pediatric Brain (1 Year old) | 0.5% | 17.24 mGy | 5 mm |
| Pediatric Abdomen (5 Year old) | 0.6% | 4.23 mGy | 6 mm |

**Conclusion:** The ACR Pass/Fail criteria indicate a resolution of 6 mm diameter rods with both adult abdomen and adult brain protocols. The scanner Low Contrast Resolution is estimated to better than 4.0 mm @ 0.6 % contrast at a dose of 50 mGy $CTDI_{vol}$.

## 9 (a). CT NUMBER ACCURACY AND LINEARITY EVALUATION

**Phantom:** ACR CT Accreditation Phantom Module 1
**Technique:** Routine Brain and Abdomen Protocols

Module 1 of the ACR phantom is used to assess CT number accuracy and linearity. There are five cylinders of different materials including a bone mimicking material ("Bone"), polyethylene, water equivalent material, acrylic and air. Each cylinder, except the water cylinder, has a diameter of 25 mm and a depth of 4 cm. The water cylinder has a diameter of 50 mm and a depth of 4 cm. ROI measurements were performed in each insert with an ROI area of ~ 200 $mm^2$.

**Technique:** Routine Adult Abdomen Protocol

| ACR Phantom Insert | Mean CT Number (HU) | Acceptable CT Number Range | | |
|---|---|---|---|---|
| Polyethylene | -94 | -107 HU | to | -84 HU |
| Water Equivalent | -0.7 | -7 HU | to | 7 HU |
| Acrylic | 118 | 110 HU | to | 135 HU |
| Bone | 892 | 850 HU | to | 970 HU |
| Air | -970 | -1005 HU | to | -970 HU |

**Technique:** Routine Adult Brain and Pediatric Brain and Abdomen Protocols

| PROTOCOL | Adult Brain | Pediatric Brain | Pediatric Abdomen |
|---|---|---|---|
| Polyethylene Insert CT Number (HU) | -93 | -105 | -94 |
| Water Equivalent Insert CT Number (HU) | 0.8 | 0.8 | -0.4 |
| Acrylic Insert CT Number (HU) | 119 | 111 | 118 |
| Bone Insert CT Number (HU) | 956 | **1094** | 896 |
| Air CT Number (HU) | -971 | -973 | -970 |

**Conclusion:** CT number calibration accuracy is adequate. Mean CT number of tested inserts are within ACR recommended ranges.

## 9 (b). CT NUMBER CONTRAST SCALE EVALUATION

**Phantom:** ACR CT Accreditation Phantom Module 1
**Technique:** Routine Adult Brain and Adult Abdomen Protocols

CT number contrast scale was evaluated using the Water and Acrylic inserts in Module 1 of the ACR Phantom. Acrylic/Water CT number contrast scale was represented by the difference in Acrylic and Water CT numbers.

| PROTOCOL | Acrylic CT Number | Water CT Number | Contrast Scale | |
|---|---|---|---|---|
| Routine Adult Brain protocol | 118.0 | -0.7 | 119 | HU |
| Routine Adult Abdomen protocol | 118.6 | 0.8 | 118 | HU |

**Conclusion:** Contrast scale is adequate. The acrylic and water CT number difference should be within 120 ± 12 HU.

## 9 (c). CT NUMBER DEPENDENCE ON SLICE THICKNESS EVALUATION

**Phantom:** ACR CT Accreditation Phantom Module 1

**Technique:** Adult Abdomen equivalent axial protocol at 120 kVp, 275 mA, 1.0 sec Rotation Time, Small SFOV, 21 cm DFOV, Standard Body Algorithm, slice thicknesses as indicated and ROI areas of ~ 200 $mm^2$.

| Slice Thickness | Mean CT Number (HU) | Acceptable CT Number Range | | |
|---|---|---|---|---|
| 0.625 mm | 1.1 | -7 HU | to | 7 HU |
| 1.25 mm | -0.2 | -7 HU | to | 7 HU |
| 2.5 mm | -0.3 | -7 HU | to | 7 HU |
| 3.75 mm | -0.1 | -7 HU | to | 7 HU |
| 5.0 mm | -0.6 | -7 HU | to | 7 HU |
| 7.5 mm | -0.5 | -7 HU | to | 7 HU |

**Conclusion:** CT number dependence on slice thickness is adequate. Mean CT numbers should be within the ACR recommended range of ± 7 HU, and preferably within ± 5 HU.

## 9 (d). CT NUMBER DEPENDENCE ON kVp EVALUATION

**Phantom:** ACR CT Accreditation Phantom Module 1

**Technique:** Routine Adult Abdomen equivalent protocol in axial mode 2.5 mm Slice Thickness, 275 mA, 1.0 sec Rotation Time, and kVp values as indicated with ROI areas of ~ 200 $mm^2$.

| kVp | Mean CT Number (HU) | Acceptable CT Number Range | | |
|---|---|---|---|---|
| 80 | **-8.0** | -7 HU | to | 7 HU |
| 100 | -0.6 | -7 HU | to | 7 HU |
| 120 | 0.1 | -7 HU | to | 7 HU |
| 140 | -0.5 | -7 HU | to | 7 HU |

**Conclusion:**

CT number dependence on kVp is adequate at 100, 120 and 140 kVp settings. Mean CT numbers should be within the ACR recommended range of ± 7 HU, and preferably within ± 5 HU.

## 9 (e). IMAGE UNIFORMITY EVALUATION

**Phantom:** ACR CT Accreditation Phantom Module 3

**Technique:** Routine Adult Abdomen Protocol

The uniformity section insert, Module 3 of the ACR phantom, contains Teflon beads embedded in a uniform water equivalent background. ROI measurements were performed at the center and periphery of the phantom. Area of ROI used was ~ 400 mm2. Image spatial uniformity was depicted by the edge-to-center mean CT number differences.

| ACR Phantom | Location | Mean ROI CT Number (H.U.) | ROI Standard Deviation (H.U.) | Difference Center to Edge ROI (H.U.) |
|---|---|---|---|---|
| ROI ~ 400 $mm^2$ | Center | -2.0 | 7.3 | --- |
| | 3 O'Clock | -2.4 | | 0.4 |
| | 6 O'Clock | -1.8 | | 0.2 |
| | 9 O'Clock | -2.5 | | 0.5 |
| | 12 O'Clock | -3.0 | | 1.0 |

**Conclusion:** Mean CT number and image spatial uniformity is adequate. The measured mean CT numbers should be in the range of 0 ± 7 Hounsfield Units (HU) and preferably within 0 ± 5 HU. Image spatial uniformity, depicted by the edge-to-center mean CT number differences is also within recommended limits. Edge-to-center mean CT number differences must be less than 5 HU for all four edge positions.

## 10. ARTIFACT EVALUATION

**Phantom:** ACR CT Accreditation and CTDI Dose Phantoms

**Technique:** Routine Adult Brain and Adult Abdomen Protocols

With all graphics turned off and with reduced room lighting, images were viewed for artifacts, such as ring or streak artifacts.

**Conclusion:** No significant ring, streak or other equipment related artifacts were noted.

## 11. CT DOSIMETRY EVALUATION

### A. CT SCANNER INDICATED COMPUTED TOMOGRAPHY DOSE INDEX ($CTDI_{VOL}$) EVALUATION

| | |
|---|---|
| **Phantom:** | 16 cm CTDI Acrylic Head and 32 cm CTDI Acrylic Body Phantom |
| **Dosimeter Used:** | Radcal Accu-Pro Model 9096 S/N 96-0544 |
| **Ion Chamber:** | Radcal 10X6-3CT Ion Chamber |
| **Technique:** | Axial Brain and Abdomen Protocols |

**Weighted $CTDI_{w,100}$ Dose Measurements using CTDI Dose Phantoms:**

| Scan Protocols | kVp | mA | Scan Time (sec) | SFOV (cm) | Scan Type | Indicated $CTDI_{vol}$ (mGy) | Measured $CTDI_{w}$ (mGy) | Percent Difference |
|---|---|---|---|---|---|---|---|---|
| **Adult Brain** (16x0.625 mm) | 120 | 270 | 1.0 | Head (25 cm) | Axial | 46.63 (Head16) | 46.83 | 0% |
| **Adult Abdomen** (16x1.25 mm) | 120 | 275 | 1.0 | Large (50 cm) | Axial | 23.74 (Body32) | 24.01 | 1% |
| **Pediatric Brain** (16x1.25 mm) | 100 | 190 | 0.8 | Ped Head (25 cm) | Axial | 17.24 (Head16) | 16.10 | -7% |
| **Pediatric Abdomen** (16x1.25 mm) | 120 | 85 | 0.8 | Large (50 cm) | Axial | 5.81 (Body 32) | 5.84 | 1% |

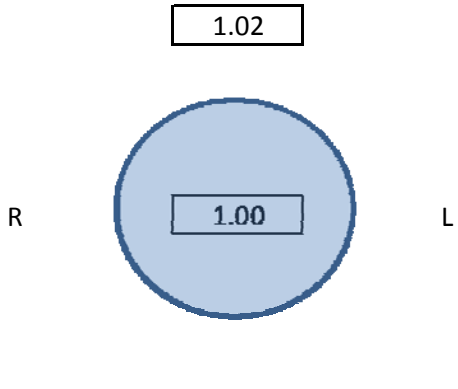
**CONCLUSION:** Measured $CTDI_{w}$ values were found to be consistent with indicated $CTDI_{vol}$ values. Percent differences were within an acceptable range of ± 20.0%.

### RADIATION DOSE UNIFORMITY*

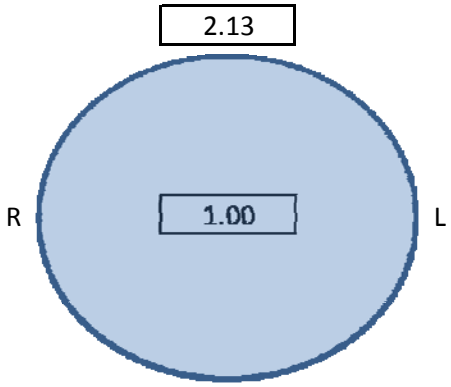
**Note: Phantom surface dose factors normalized relative to the value at the center location*

| | |
|---|---|
| **Technique:** | 120 kVp Adult Techniques as indicated in table above |

**16 cm CTDI Head Dose Phantom**




**32 cm CTDI Body Dose Phantom**



## 11. CT DOSIMETRY EVALUATION (Continued)

**B. PATIENT DOSE EVALUATION FOR REPRESENTATIVE CT EXAMINATIONS**

**Phantom:** 16 cm CTDI Acrylic Head and 32 cm CTDI Acrylic Body Phantom
**Technique:** Routine Brain and Abdomen Protocols

**Correspondence of Measured and Indicated $CTDI_{vol}$** Doses for Select Clinical Protocols:

| Protocols | Measured $CTDI_{vol}$ (mGy) | Indicated $CTDI_{vol}$ (mGy) | Reference CTDI Dose Phantom | Percent Difference |
|---|---|---|---|---|
| Adult Brain | 49.95 mGy | 49.74 mGy | Head 16 cm | 0% |
| Adult Abdomen | 17.46 mGy | 17.26 mGy | Body 32 cm | 1% |
| Pediatric Brain | 16.10 mGy | 17.24 mGy | Head 16 cm | -7% |
| Pediatric Abdomen* | 4.25 mGy | 4.23 mGy | Body 32 cm | 0% |

**CONCLUSION:** Measured $CTDI_{vol}$ dose values were found to be consistent with indicated $CTDI_{vol}$ values. Percent differences were within an acceptable range of ± 20%.

*Note: Pediatric Abdomen dose measured using the Large (32 cm Diameter) CTDI Phantom.

**C. PATIENT DOSE EVALUATION FOR REPRESENTATIVE CT EXAMINATIONS**

**Effective Dose Estimates for Select Clinical Protocols**

| Protocols | Measured $CTDI_{vol}$ (mGy) | Scan Length | Dose Length Product DLP (mGy.cm) | Effective Dose (mSv) |
|---|---|---|---|---|
| Adult Brain | 49.95 mGy | 17.5 cm | 874 mGy.cm | 1.8 mSv |
| Adult Abdomen (SSDE**) | 17.89 mGy | 25.0 cm | 447 mGy.cm | 6.7 mSv |
| Pediatric Brain | 16.10 mGy | 12.0 cm | 193 mGy.cm | 1.3 mSv |
| Ped Abdomen (SSDE**) | 7.98 mGy | 15.0 cm | 120 mGy.cm | 2.4 mSv |

**CONCLUSION:** $CTDI_{vol}$ dose values and Effective Dose estimates are well within the ACR recommended limits. Attached, please find dose calculator spreadsheets for further details. Measured $CTDI_{vol}$ values should be less than the ACR Pass/Fail Criteria tabulated below, and preferably less than the ACR Reference Dose Levels.

**SSDE: Size Specific Dose Estimate

**ACR $CTDI_{vol}$ Pass/Fail Criteria and CT Dose Reference Levels**

| CT Examination | ACR Pass/Fail Criteria $CTDI_{vol}$ (mGy) | ACR Reference Levels $CTDI_{vol}$ (mGy) |
|---|---|---|
| Adult Head | 80 mGy | 75 mGy |
| Adult Abdomen | 30 mGy | 25 mGy |
| Pediatric Head (1 year old) | 40 mGy | 35 mGy |
| Pediatric Abdomen (40-50 lb) - 16 cm Diameter CTDI Phantom | 20 mGy | 15 mGy |
| Pediatric Abdomen (40-50 lb) - 32 cm Diameter CTDI Phantom | 10 mGy | 7.5 mGy |

## 12 (a). ACQUISITION DISPLAY DEVICE EVALUATION

**Luminance Meter Make/Model:** Unfors Xi Photometer

**Acquisition display devices were evaluated using a standard SMPTE test pattern:**

1. The 5% and the 95% square contrast patterns were properly resolved and visualized.
2. Each gray-level step from 0% to 100% was uniform and distinct from the adjacent step.
3. The borders and lines of the SMPTE pattern were straight.
4. No spatial distortions or misalignments were noted in the grids across the screen.
5. Alphanumeric characters looked sharp and focused.
6. The high contrast line-pair resolution patterns in the center and corners of the display area were linear, properly resolved and adequately visualized without any magnification.
7. No streaking was noted in and around the white and black rectangular patterns.

The overall appearance of the SMPTE pattern was found to be adequate.
The soft copy display monitor resolution and spatial accuracy was found to be adequate.
No significant distortions or any kind of non-linearities were noted in any of the target patterns.

| Monitor<br>NEC MultiSync LCD 1980SXi | Minimum Luminance<br>(Black Level) | Maximum Luminance<br>(White Level) | % Luminance<br>Non-Uniformity |
|---|---|---|---|
| Acquisition Workstation Display | 0.2 cd/$m^2$ | 123 cd/$m^2$ | 18% |

The minimum luminance (Black Level) should be less than 1.2 cd/$m^2$.
The maximum luminance (White Level) should be greater than or equal 100 cd/$m^2$ for diagnostic workstations.
The display luminance uniformity is considered adequate if percent luminance non-uniformity is less than 30%.

**CONCLUSION:** The display monitor minimum & maximum luminances and uniformity were found to be adequate.

## 12 (b). SPATIAL DISTORTION EVALUATION

**Phantom:** ACR CT Accreditation Phantom Module 3
**Technique:** Routine Adult Abdomen Protocol
Spatial distortion and distance measurement accuracy was evaluated by measuring the known dimensions of the ACR phantom and set distance between the Teflon BB's in Module 3.

***A. Distance Gauge Check:***

| Orientation of BB's | Actual Distance Between BB's | Scanner Measured Distance | Percent Difference |
|---|---|---|---|
| 45° | 10.0 cm | 10.0 cm | 0.0% |

***B. Aspect Ratio of Video Monitor and Imager (if available):***

| ACR Phantom | Aspect Ratio |
|---|---|
| Ratio of Horizontal to Vertical Dimensions of Circular Phantom Object | 1.00 |
| Ratio of Horizontal to Vertical Dimensions of Object on the Monitor | 1.00 |
| Ratio of Horizontal to Vertical Dimensions of Object on Film | N/A |

**CONCLUSION:** The scanner distance measurement accuracy is adequate. There are no significant spatial distortion of the image on the monitors.

## 13. RADIATION SAFETY EVALUATION

A. Visual Inspection
A visual safety inspection of the CT Trailer and surroundings was conducted. No unsafe conditions were noted.

B. Audible and Visual Warning Signs
System audible and visual warning signs are functional and performing adequately. Dose Notification and Dose Alert features are activated and functioning properly.

C. Posting Requirements
CT scanner room was appropriately posted with a "Caution X-Ray" warning sign.

## 14. TECHNOLOGIST QUALITY CONTROL PROGRAM

A. Technologist QC program is to be established. Recommend performing Daily and Monthly QC tests consistent with ACR recommendations.

| Quality Control Procedures | Responsible Individual | Frequency | STATUS |
|---|---|---|---|
| 1. Water CT Number Accuracy Eval | CT Technologist | Daily | TBE* |
| 2. Image Noise Evaluation | CT Technologist | Daily | TBE* |
| 3. Artifact Evaluation | CT Technologist | Daily | TBE* |
| 4. Visual Checklist | CT Technologist | Monthly | TBE* |
| 5. Dry Laser QC | CT Technologist | N/A | N/A |
| 6. Acquisition Display QC | CT Technologist | Monthly | TBE* |

*TBE: To be Established

B. Preventive maintenance program is well established. Regular PMs will be performed periodically and documented by qualified field service engineers.

# ACR CT ACCREDITATION DOSE SPREADSHEET

IMPORTANT NOTE: This Excel Workbook contains formulae essential to accurate reporting of dose for ACR CT Accreditation. It is intended to be used with both Windows and Mac operating systems. Please note, ANY alteration of the formulae will very likely result in errors of reported data, and could adversely affect our accreditation results. You must enter accurate data from this workbook into the ACRedit online testing package. Please check the results from this workbook against the results shown in the ACRedit database online testing package before submission.

## Dose Calculator Spreadsheet (Exposure)

**CTAP ID Number**

## Radiation Dosimetry (Adult Head)

| CTDI Head Phantom (16-cm diameter PMMA Phantom) | Measured | Calculated |
|---|---|---|
| kV | 120 | |
| mA | 270 | |
| Exposure time per rotation (s) | 1 | |
| # data channels used (N)[1] | 16 | |
| Z-axis collimation (T)[1] | 1.25 | |
| Axial (A): Table Increment (mm) = (I)[1]<br>OR<br>Helical (H):Table Speed (mm/rot) = (I)[1] | 18.75 | |
| Active Chamber length (mm) | 100 | |
| Chamber correction factor | 1 | |
| **Center** | | |
| Measurement 1 (mR) | 1069 | |
| Measurement 2 (mR) | 1058 | |
| Measurement 3 (mR) | 1063 | |
| Average of above 3 measurements (mR) | | 1063.3 |
| Head CTDI at isocenter in phantom (mGy) | | 46.3 |
| **12 o'clock position** | | |
| Measurement 1 (mR) | 1097 | |
| Measurement 2 (mR) | 1078 | |
| Measurement 3 (mR) | 1074 | |
| Average of above 3 measurements (mR) | | 1083.0 |
| Head CTDI at 12 o'clock position in phantom (mGy) | | 47.1 |
| | | |
| CTDIw (mGy) | | 46.83 |
| **Clinical exam dose estimates** (using measured CTDIw and site's Adult Head Protocol from Table 1) | | |
| CTDIvol (mGy) | =CTDIw*N*T/I | 49.95 |
| CTDIvol reported by scanner (mGy) for the protocol entered in the phantom site scanning data form (using 16-cm diameter PMMA phantom) | 49.74 | |
| Percent difference between calculated CTDIvol and CTDIvol reported by scanner | | 0% |
| Dose Notification Value (mGy) as described in XR-29 (if applicable) | | |
| DLP (mGy-cm) | =CTDIvol*17.5 | 874 |

[1]See definitions in the CT Accreditation Testing Instructions.

# ACR CT ACCREDITATION DOSE SPREADSHEET

IMPORTANT NOTE: This Excel Workbook contains formulae essential to accurate reporting of dose for ACR CT Accreditation. It is intended to be used with both Windows and Mac operating systems. Please note, ANY alteration of the formulae will very likely result in errors of reported data, and could adversely affect our accreditation results. You must enter accurate data from this workbook into the ACRedit online testing package. Please check the results from this workbook against the results shown in the ACRedit database online testing package before submission.

## Dose Calculator Spreadsheet (Exposure)

**CTAP ID Number**

## Radiation Dosimetry (Adult Abdomen)

| CTDI Body Phantom (32-cm diameter PMMA Phantom) | Measured | Calculated |
|---|---|---|
| kV | 120 | |
| mA | 275 | |
| Exposure time per rotation (s) | 1 | |
| # data channels used (N)[1] | 16 | |
| Z-axis collimation (T)[1] | 1.25 | |
| Axial (A): Table Increment (mm) = (I)[1] OR Helical (H):Table Speed (mm/rot) = (I)[1] | 27.5 | |
| Active Chamber length (mm) | 100 | |
| Chamber correction factor | 1 | |
| **Center** | | |
| Measurement 1 (mR) | 314.4 | |
| Measurement 2 (mR) | 315.0 | |
| Measurement 3 (mR) | 313.6 | |
| Average of above 3 measurements (mR) | | 314.3 |
| Body CTDI at isocenter in phantom (mGy) | | 13.7 |
| **12 o'clock position** | | |
| Measurement 1 (mR) | 659.3 | |
| Measurement 2 (mR) | 665.3 | |
| Measurement 3 (mR) | 686.7 | |
| Average of above 3 measurements (mR) | | 670.4 |
| Body CTDI at12 o'clock position in phantom (mGy) | | 29.2 |
| | | |
| CTDIw (mGy) | | 24.01 |
| **Clinical exam dose estimates** (using measured CTDIw and site's Adult Abdomen Protocol from Table 1) | | |
| CTDIvol (mGy) | =CTDIw*N*T/I | 17.46 |
| CTDIvol reported by scanner (mGy) for the protocol entered in the phantom site scanning data form (using 32-cm diameter PMMA phantom) | 17.26 | |
| Percent difference between calculated CTDIvol and CTDIvol reported by scanner | | 1% |
| Dose Notification Value (mGy) as described in XR-29 (if applicable) | 35 | |
| DLP (mGy-cm) | =CTDIvol*25 | 436 |
| SSDE for 35 cm water equivalent diameter (mGy) | =SSDE(35 cm) | 17.89 |

[1]See definitions in the CT Accreditation Testing Instructions.

# ACR CT ACCREDITATION DOSE SPREADSHEET

IMPORTANT NOTE: This Excel Workbook contains formulae essential to accurate reporting of dose for ACR CT Accreditation. It is intended to be used with both Windows and Mac operating systems. Please note, ANY alteration of the formulae will very likely result in errors of reported data, and could adversely affect our accreditation results. You must enter accurate data from this workbook into the ACRedit online testing package. Please check the results from this workbook against the results shown in the ACRedit database online testing package before submission.

## Dose Calculator Spreadsheet (Exposure)

**CTAP ID Number**

## Radiation Dosimetry (Pediatric Head, 1 year old)

| CTDI Head Phantom (16-cm diameter PMMA Phantom) | Measured | Calculated |
|---|---|---|
| kV | 100 | |
| mA | 190 | |
| Exposure time per rotation (s) | 0.8 | |
| # data channels *used* (N)[1] | 16 | |
| Z-axis collimation (T)[1] | 1.25 | |
| Axial (A): Table Increment (mm) = (I)[1] OR Helical (H):Table Speed (mm/rot) = (I)[1] | 20 | |
| Active Chamber length (mm) | 100 | |
| Chamber correction factor | 1 | |
| **Center** | | |
| Measurement 1 (mR) | 338.2 | |
| Measurement 2 (mR) | 336.9 | |
| Measurement 3 (mR) | 335.4 | |
| Average of above 3 measurements (mR) | | 336.8 |
| Head CTDI at isocenter in phantom (mGy) | | 14.7 |
| **12 o'clock position** | | |
| Measurement 1 (mR) | 386.0 | |
| Measurement 2 (mR) | 385.8 | |
| Measurement 3 (mR) | 388.1 | |
| Average of above 3 measurements (mR) | | 386.6 |
| Head CTDI at 12 o'clock position in phantom (mGy) | | 16.8 |
| | | |
| CTDIw (mGy) | | 16.10 |
| **Clinical exam dose estimates** (using measured CTDIw and site's Pediatric Head (1 year old) Protocol from Table 1) | | |
| CTDIvol (mGy) | =CTDIw*N*T/I | 16.10 |
| CTDIvol reported by scanner (mGy) for the protocol entered in the phantom site scanning data form (using 16-cm diameter PMMA phantom) | 17.24 | |
| Percent difference between calculated CTDIvol and CTDIvol reported by scanner | | -7% |
| Dose Notification value as desciribed in XR-29 (if applicable) | | |
| DLP (mGy-cm) | =CTDIvol*12 | 193 |

[1]See definitions in the CT Accreditation Testing Instructions.

# ACR CT ACCREDITATION DOSE SPREADSHEET

IMPORTANT NOTE: This Excel Workbook contains formulae essential to accurate reporting of dose for ACR CT Accreditation. It is intended to be used with both Windows and Mac operating systems. Please note, ANY alteration of the formulae will very likely result in errors of reported data, and could adversely affect our accreditation results. You must enter accurate data from this workbook into the ACRedit online testing package. Please check the results from this workbook against the results shown in the ACRedit database online testing package before submission.

## Dose Calculator Spreadsheet (Exposure)

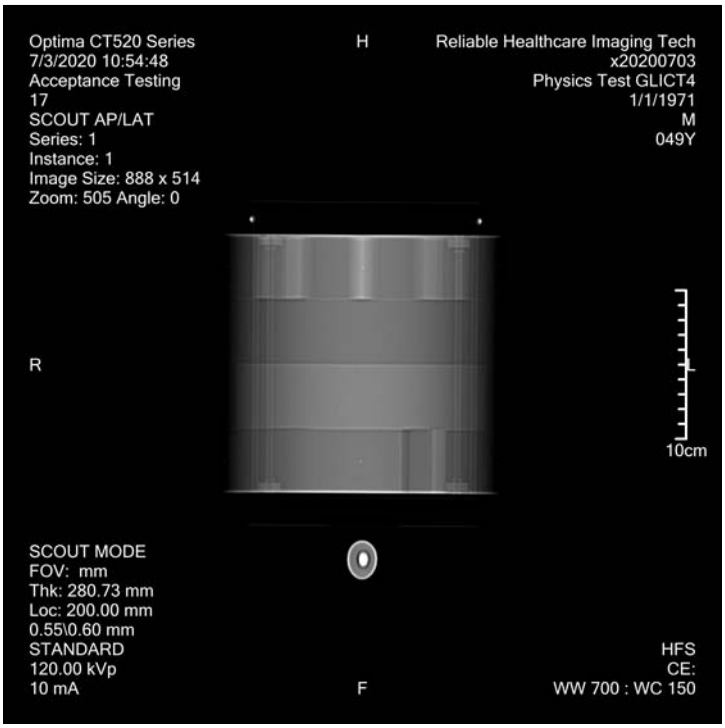
**CTAP ID Number**

## Radiation Dosimetry (Ped Abdomen, 40-50 lb)

**Note: For pediatric abdomen (40-50 lb.)protocols, some CT scanners report CTDIvol using the 16 cm phantom, while others use the 32 cm phantom. The physicist should use the phantom (16 or 32 cm ) that is used by the scanner to report CTDIvol.**

| CTDI Phantom (16 or 32 cm diameter PMMA Phantom) | Measured | Calculated |
|---|---|---|
| Size of phantom the scanner uses to report CTDIvol for routine pediatric abdomen protocol (40-50 lb.) | **32 cm** | |
| kV | 120 | |
| mA | 85 | |
| Exposure time per rotation (s) | 0.8 | |
| # data channels *used* (N)[1] | 16 | |
| Z-axis collimation (T)[1] | 1.25 | |
| Axial (A): Table Increment (mm) = (I)[1] OR Helical (H):Table Speed (mm/rot) = (I)[1] | 27.5 | |
| Active Chamber length (mm) | 100 | |
| Chamber correction factor | 1 | |
| **Center** | | |
| Measurement 1 (mR) | 76.8 | |
| Measurement 2 (mR) | 76.7 | |
| Measurement 3 (mR) | 76.4 | |
| Average of above 3 measurements (mR) | | 76.6 |
| Ped Body CTDI at isocenter in phantom (mGy) | | 3.3 |
| **12 o'clock position** | | |
| Measurement 1 (mR) | 159.9 | |
| Measurement 2 (mR) | 169.0 | |
| Measurement 3 (mR) | 160.3 | |
| Average of above 3 measurements (mR) | | 163.1 |
| Ped Body CTDI at12 o'clock position in phantom (mGy) | | 7.1 |
| | | |
| CTDIw (mGy) | | 5.84 |
| **Clinical exam dose estimates** (using measured CTDIw and site's Pediatric Abdomen (40-50 lb.) Protocol from Table 1) | | |
| CTDIvol (mGy) | =CTDIw*N*T/I | 4.25 |
| CTDIvol reported by scanner (mGy) for the protocol entered in the phantom site scanning data form | 4.23 | |
| Percent difference between calculated CTDIvol and CTDIvol reported by scanner | | 0% |
| Dose Notification Value as described in XR-29 (if applicable) | | |
| DLP (mGy-cm) | =CTDIvol*15 | 64 |
| SSDE for 18.5 cm water equivalent diameter (mGy) | =SSDE(18.5 cm) | 7.98 |

[1]See definitions in the CT Accreditation Testing Instructions.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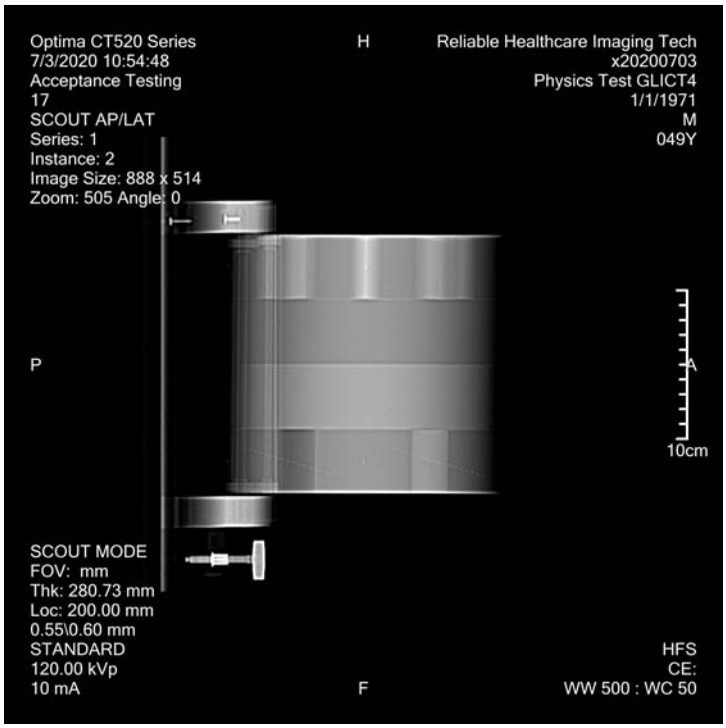
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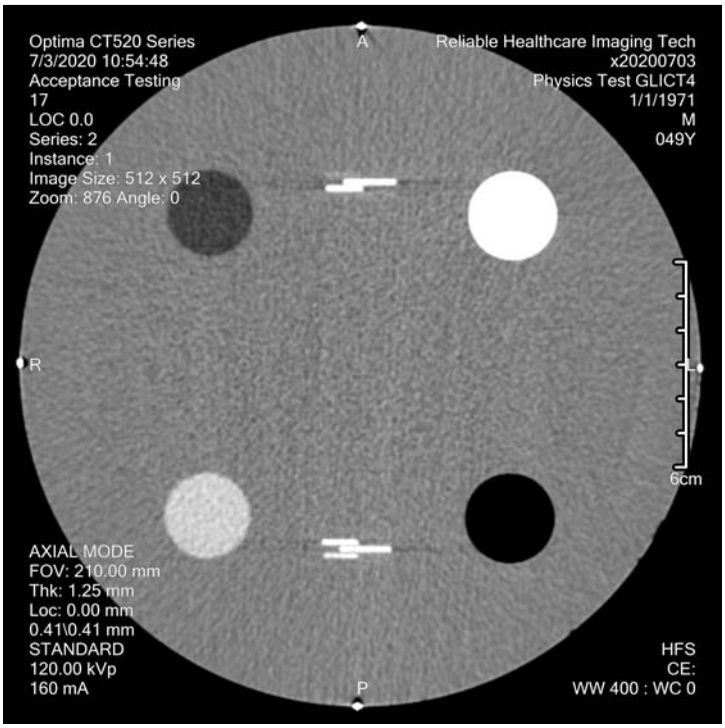
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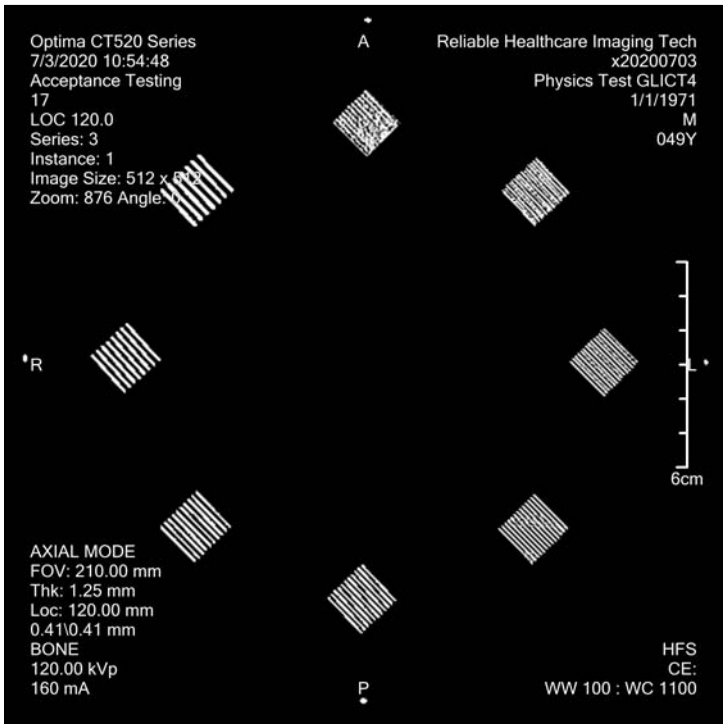
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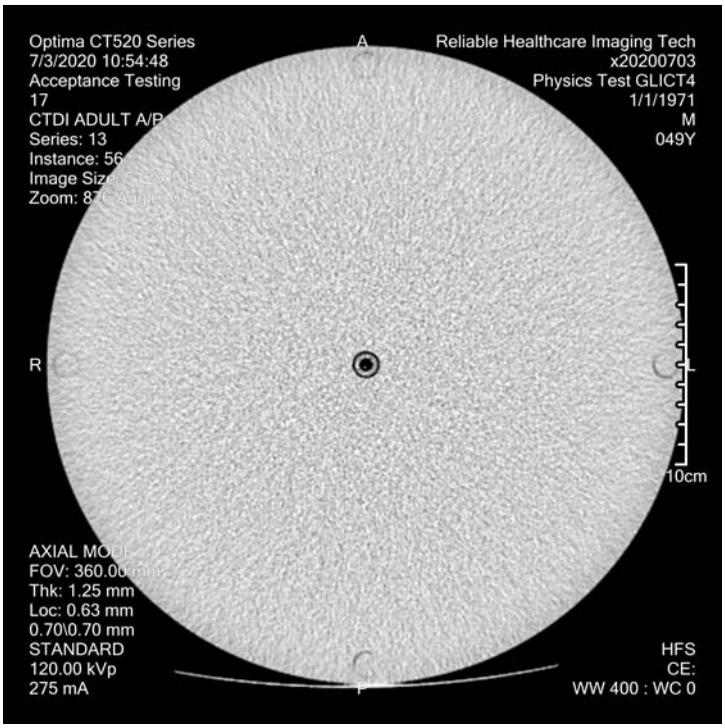
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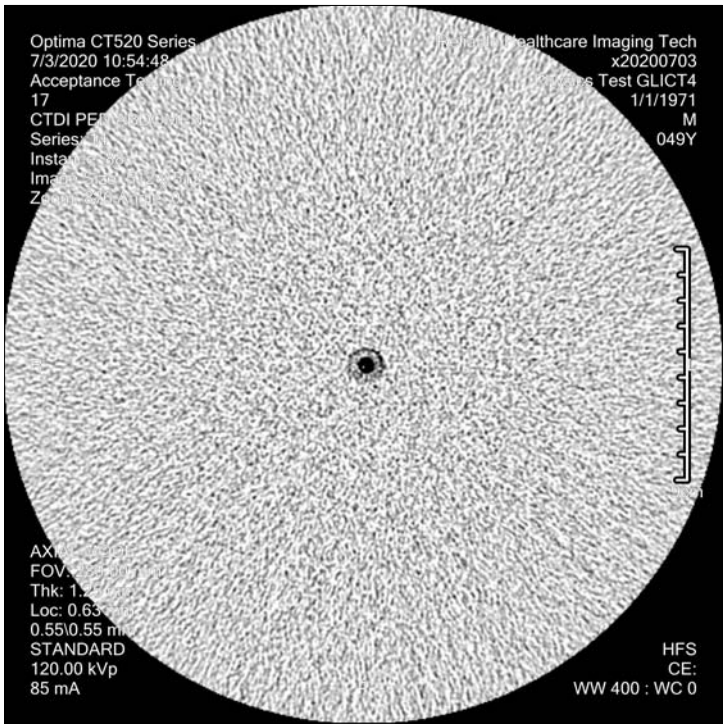
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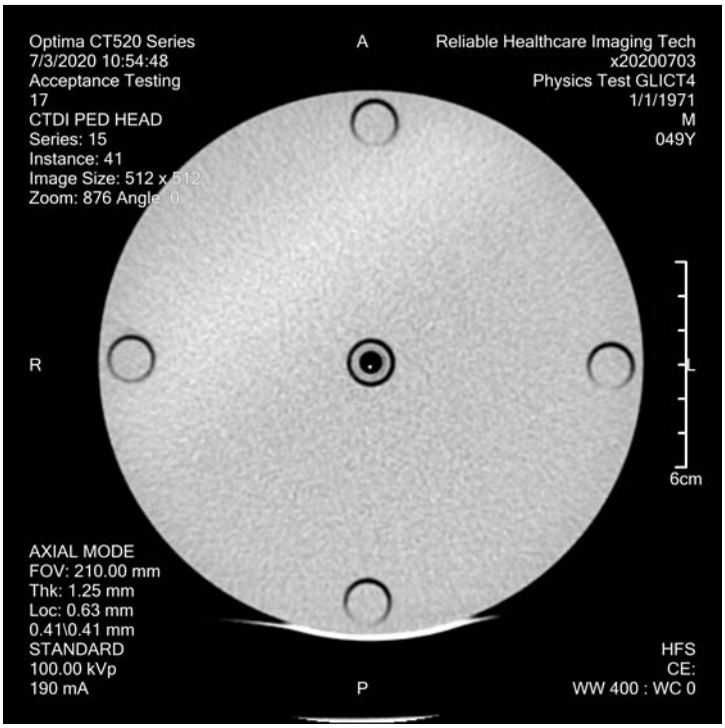
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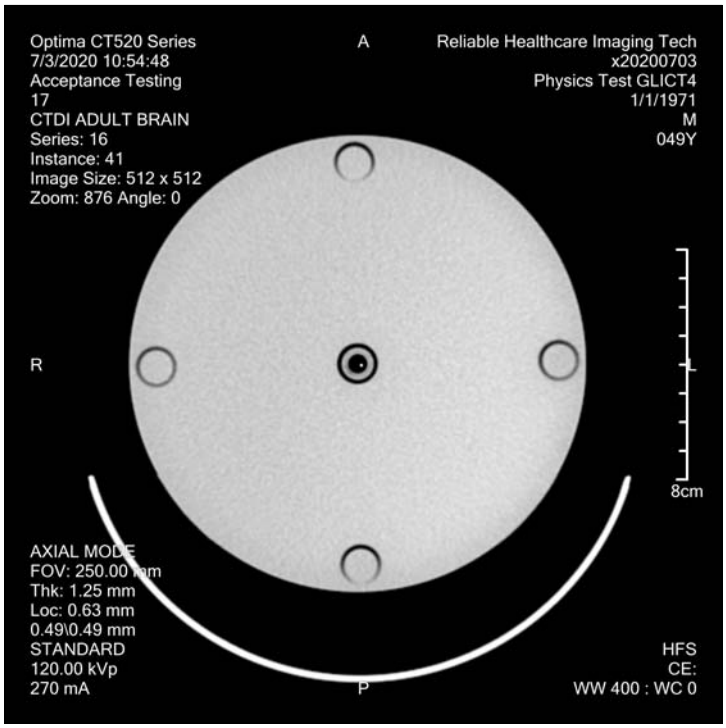
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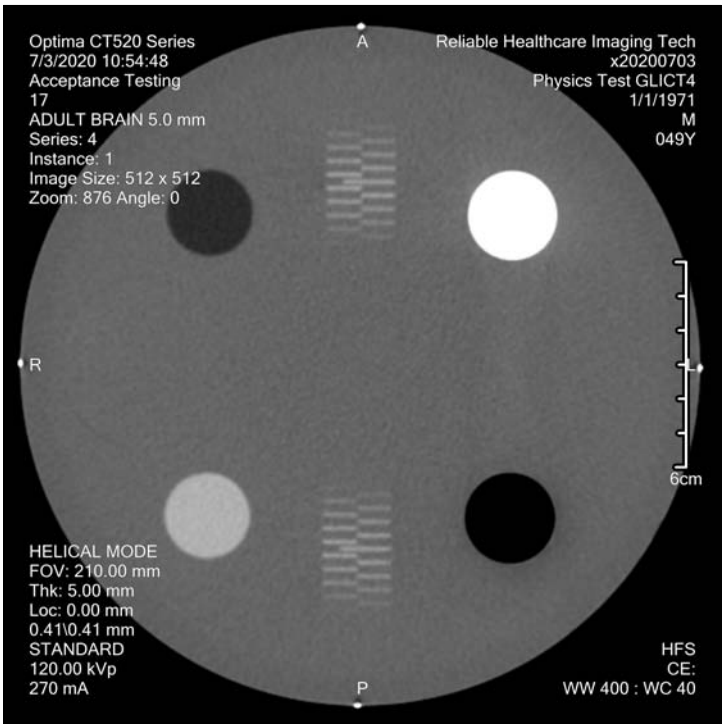
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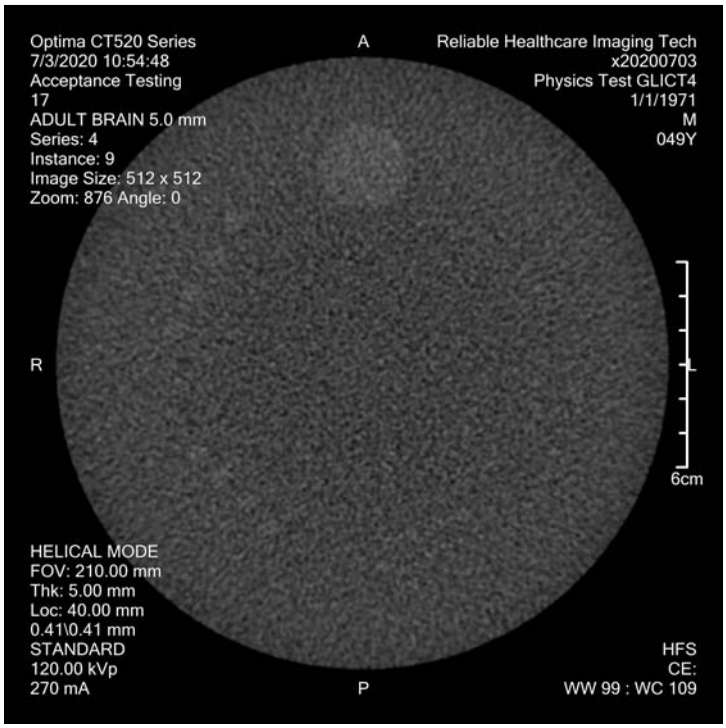
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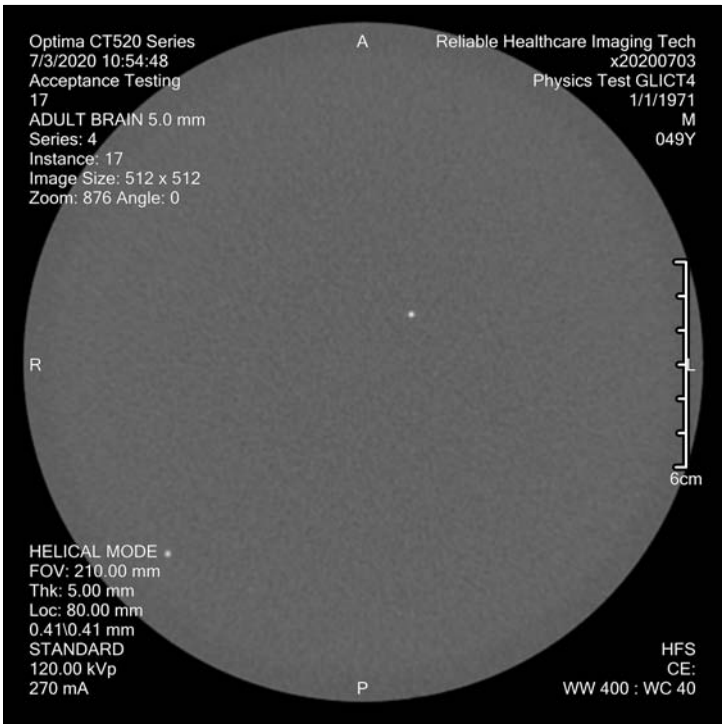
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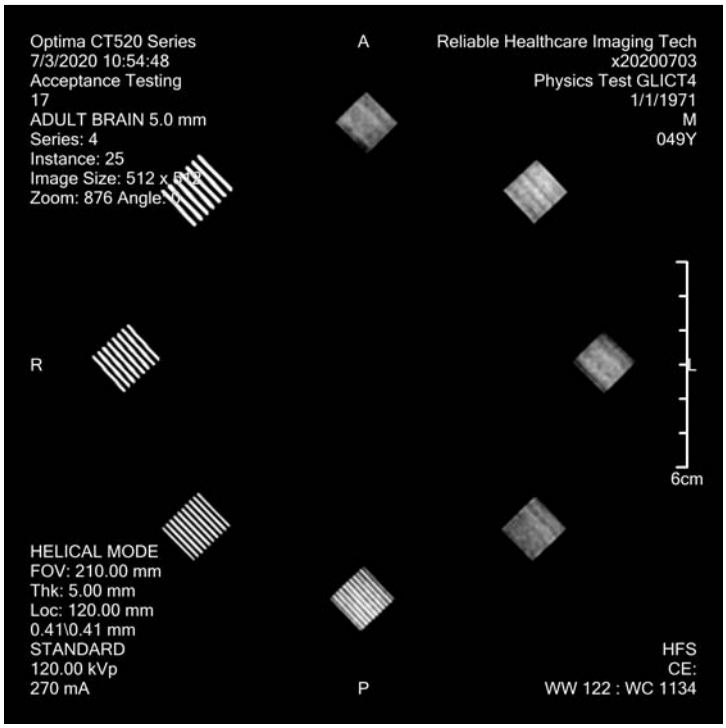
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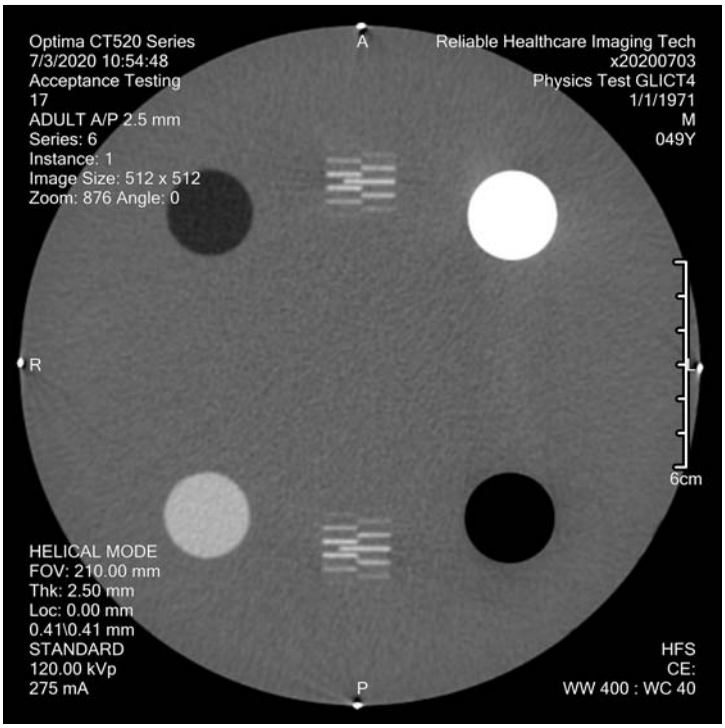
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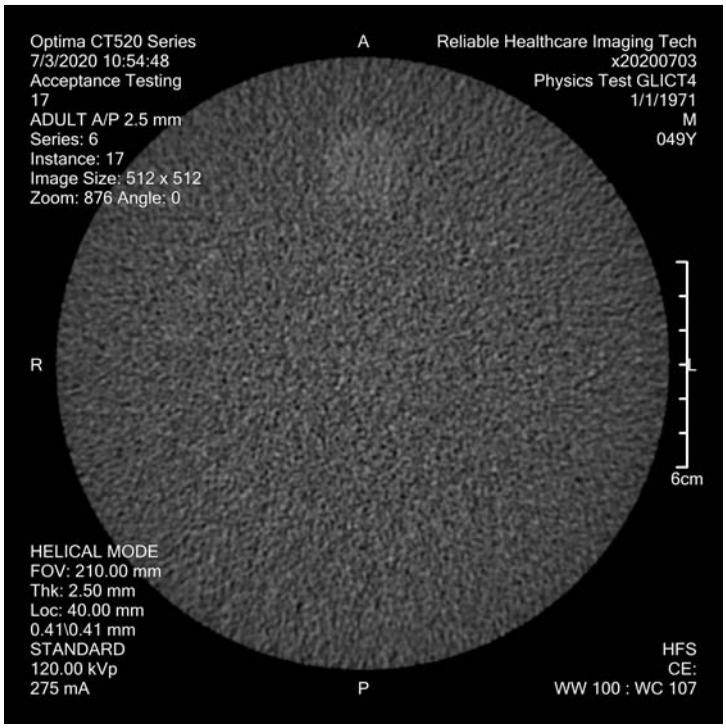
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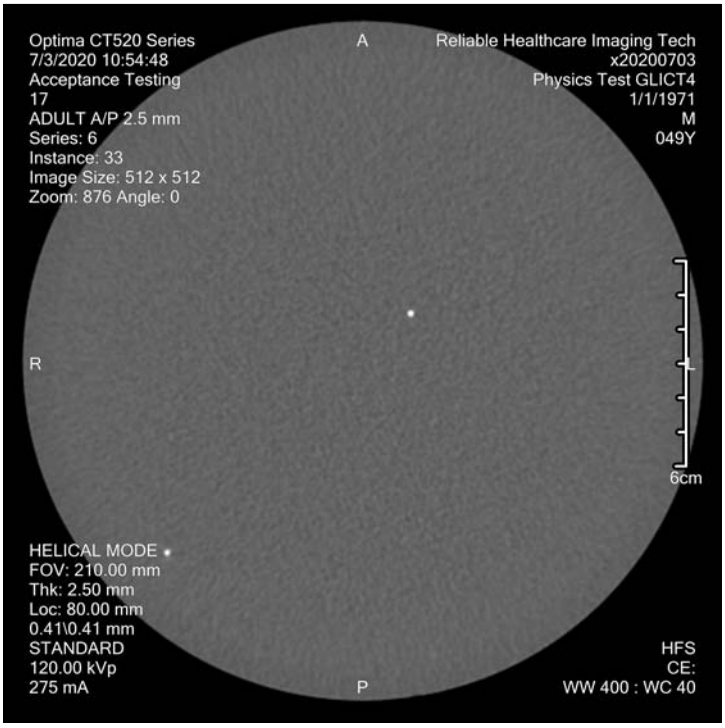
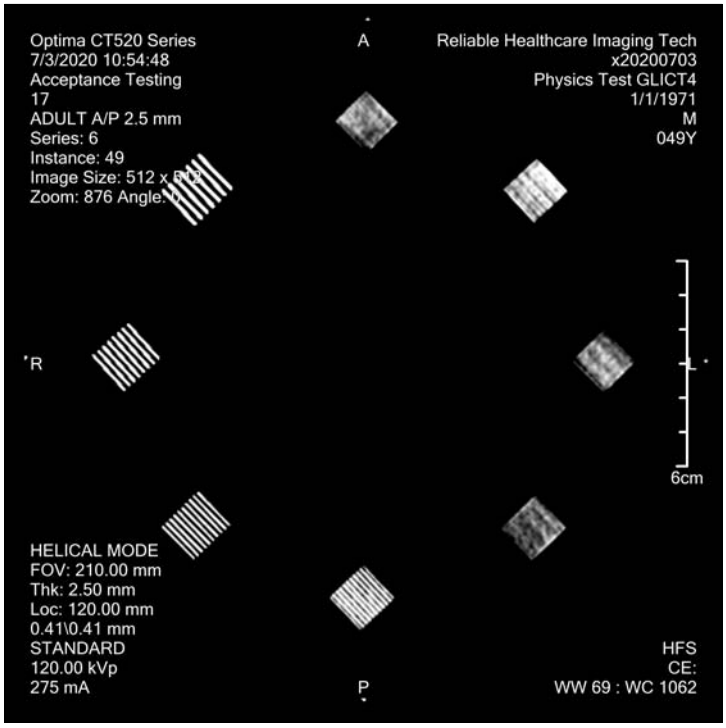
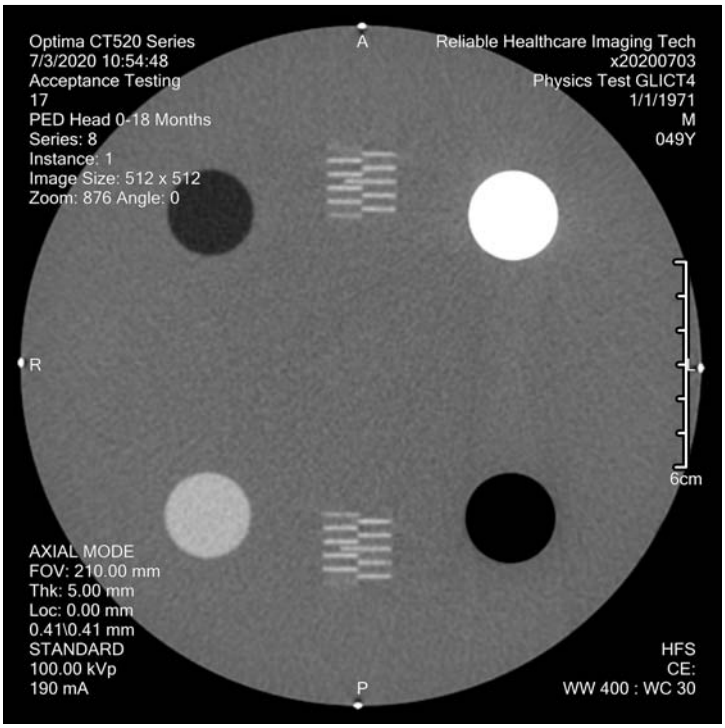
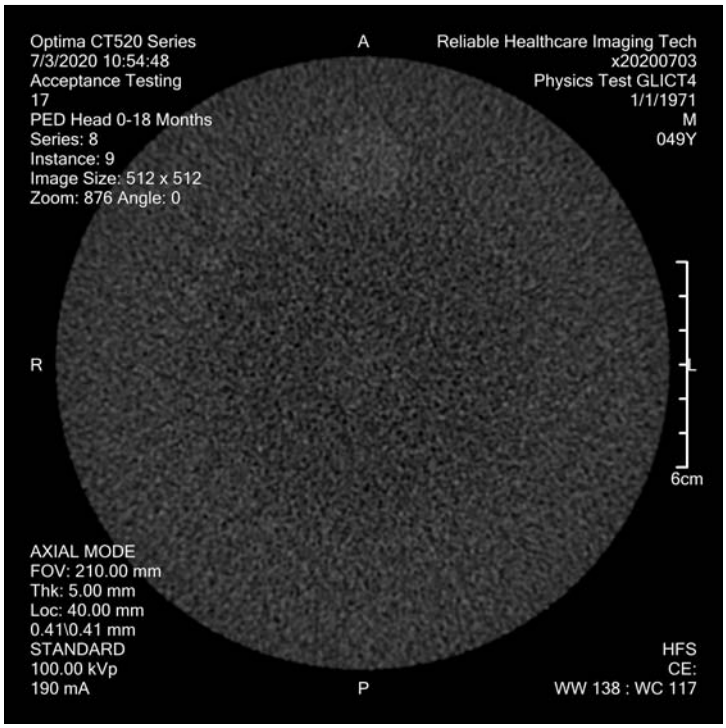
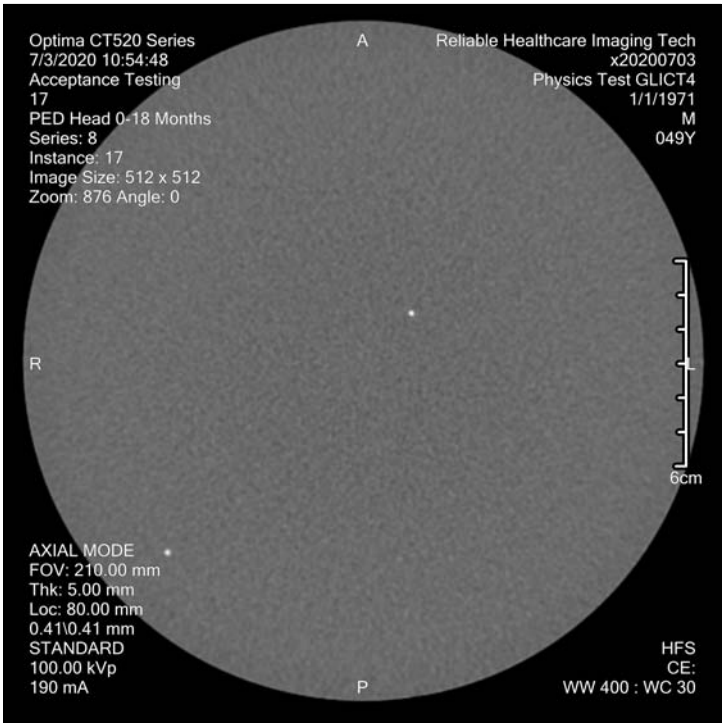
CE:
WW 100 : WC 107

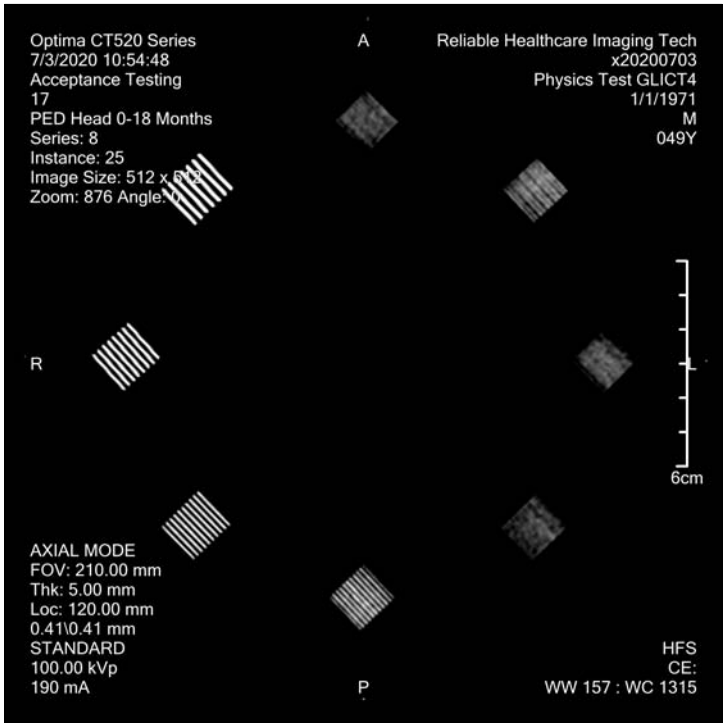

Optima CT520 Series
7/3/2020 10:54:48
Acceptance Testing
17
ADULT A/P 2.5 mm
Series: 6
Instance: 33
Image Size: 512 x 512
Zoom: 876 Angle: 0
A
Reliable Healthcare Imaging Tech
x20200703
Physics Test GLICT4
1/1/1971
M
049Y
R
L
6cm
HELICAL MODE
FOV: 210.00 mm
Thk: 2.50 mm
Loc: 80.00 mm
0.41\0.41 mm
STANDARD
120.00 kVp
275 mA
P
HFS
CE:
WW 400 : WC 40

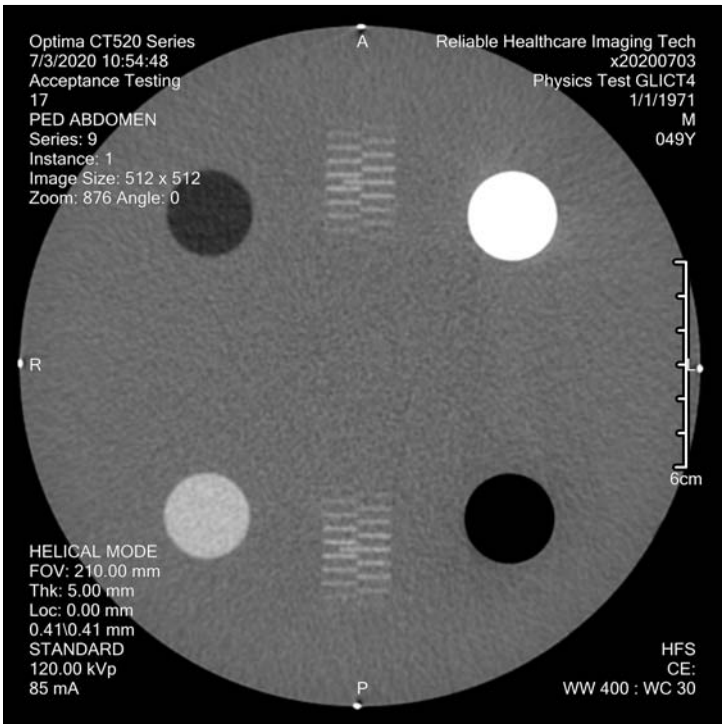

Optima CT520 Series
7/3/2020 10:54:48
Acceptance Testing
17
ADULT A/P 2.5 mm
Series: 6
Instance: 49
Image Size: 512 x 512
Zoom: 876 Angle: 0
A
Reliable Healthcare Imaging Tech
x20200703
Physics Test GLICT4
1/1/1971
M
049Y
R
L
6cm
HELICAL MODE
FOV: 210.00 mm
Thk: 2.50 mm
Loc: 120.00 mm
0.41\0.41 mm
STANDARD
120.00 kVp
275 mA
P
HFS
CE:
WW 69 : WC 1062

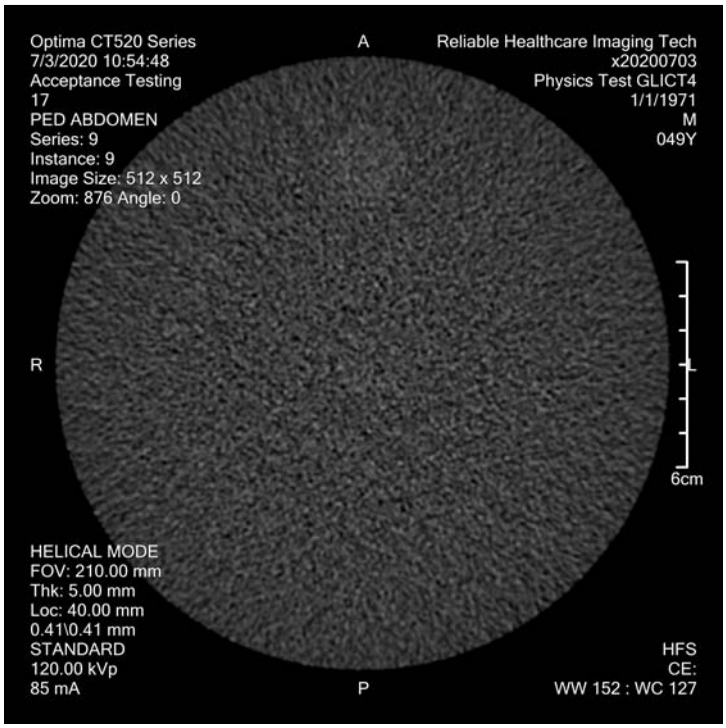

Optima CT520 Series
7/3/2020 10:54:48
Acceptance Testing
17
PED Head 0-18 Months
Series: 8
Instance: 1
Image Size: 512 x 512
Zoom: 876 Angle: 0
A
Reliable Healthcare Imaging Tech
x20200703
Physics Test GLICT4
1/1/1971
M
049Y
R
L
6cm
AXIAL MODE
FOV: 210.00 mm
Thk: 5.00 mm
Loc: 0.00 mm
0.41\0.41 mm
STANDARD
100.00 kVp
190 mA
P
HFS
CE:
WW 400 : WC 30

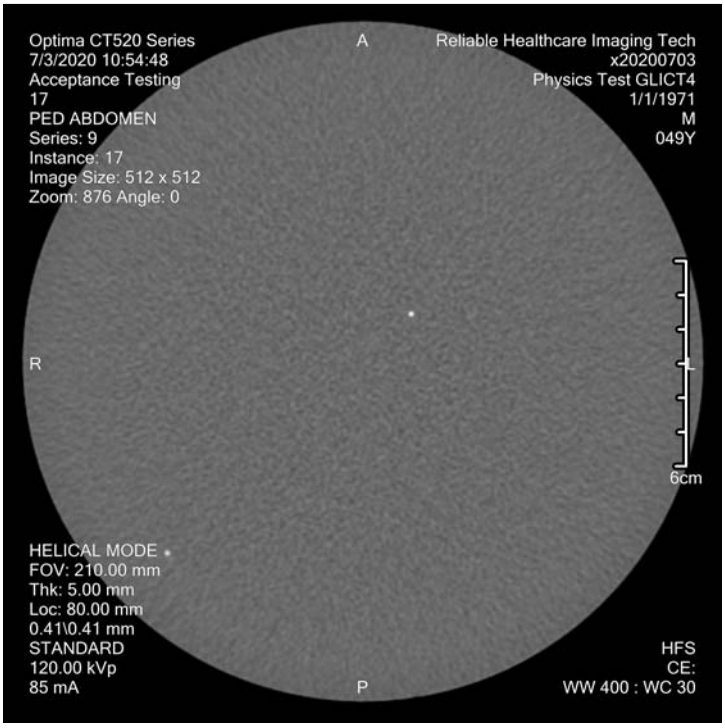

Optima CT520 Series
7/3/2020 10:54:48
Acceptance Testing
17
PED Head 0-18 Months
Series: 8
Instance: 9
Image Size: 512 x 512
Zoom: 876 Angle: 0
A
Reliable Healthcare Imaging Tech
x20200703
Physics Test GLICT4
1/1/1971
M
049Y
R
L
6cm
AXIAL MODE
FOV: 210.00 mm
Thk: 5.00 mm
Loc: 40.00 mm
0.41\0.41 mm
STANDARD
100.00 kVp
190 mA
P
HFS
CE:
WW 138 : WC 117

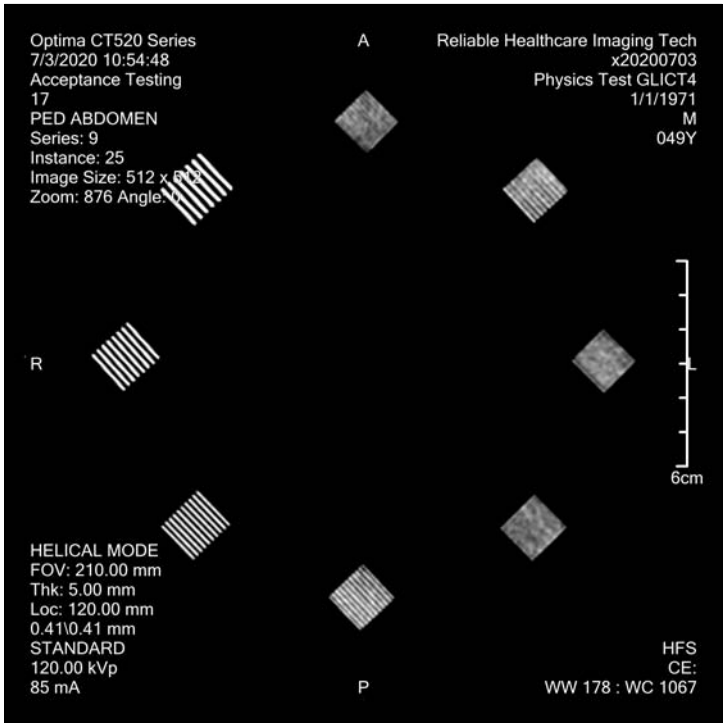

Optima CT520 Series
7/3/2020 10:54:48
Acceptance Testing
17
PED Head 0-18 Months
Series: 8
Instance: 17
Image Size: 512 x 512
Zoom: 876 Angle: 0
A
Reliable Healthcare Imaging Tech
x20200703
Physics Test GLICT4
1/1/1971
M
049Y
R
L
6cm
AXIAL MODE
FOV: 210.00 mm
Thk: 5.00 mm
Loc: 80.00 mm
0.41\0.41 mm
STANDARD
100.00 kVp
190 mA
P
HFS
CE:
WW 400 : WC 30


Optima CT520 Series
7/3/2020 10:54:48
Acceptance Testing
17
PED Head 0-18 Months
Series: 8
Instance: 25
Image Size: 512 x 512
Zoom: 876 Angle: 0
A
Reliable Healthcare Imaging Tech
x20200703
Physics Test GLICT4
1/1/1971
M
049Y
R
L
6cm
AXIAL MODE
FOV: 210.00 mm
Thk: 5.00 mm
Loc: 120.00 mm
0.41\0.41 mm
STANDARD
100.00 kVp
190 mA
P
HFS
CE:
WW 157 : WC 1315


Optima CT520 Series
7/3/2020 10:54:48
Acceptance Testing
17
PED ABDOMEN
Series: 9
Instance: 1
Image Size: 512 x 512
Zoom: 876 Angle: 0
A
Reliable Healthcare Imaging Tech
x20200703
Physics Test GLICT4
1/1/1971
M
049Y
R
L
6cm
HELICAL MODE
FOV: 210.00 mm
Thk: 5.00 mm
Loc: 0.00 mm
0.41\0.41 mm
STANDARD
120.00 kVp
85 mA
P
HFS
CE:
WW 400 : WC 30


Optima CT520 Series
7/3/2020 10:54:48
Acceptance Testing
17
PED ABDOMEN
Series: 9
Instance: 9
Image Size: 512 x 512
Zoom: 876 Angle: 0
A
Reliable Healthcare Imaging Tech
x20200703
Physics Test GLICT4
1/1/1971
M
049Y
R
L
6cm
HELICAL MODE
FOV: 210.00 mm
Thk: 5.00 mm
Loc: 40.00 mm
0.41\0.41 mm
STANDARD
120.00 kVp
85 mA
P
HFS
CE:
WW 152 : WC 127


Optima CT520 Series
7/3/2020 10:54:48
Acceptance Testing
17
PED ABDOMEN
Series: 9
Instance: 17
Image Size: 512 x 512
Zoom: 876 Angle: 0
A
Reliable Healthcare Imaging Tech
x20200703
Physics Test GLICT4
1/1/1971
M
049Y
R
L
6cm
HELICAL MODE
FOV: 210.00 mm
Thk: 5.00 mm
Loc: 80.00 mm
0.41\0.41 mm
STANDARD
120.00 kVp
85 mA
P
HFS
CE:
WW 400 : WC 30


Optima CT520 Series
7/3/2020 10:54:48
Acceptance Testing
17
PED ABDOMEN
Series: 9
Instance: 25
Image Size: 512 x 512
Zoom: 876 Angle: 0
A
Reliable Healthcare Imaging Tech
x20200703
Physics Test GLICT4
1/1/1971
M
049Y
R
L
6cm
HELICAL MODE
FOV: 210.00 mm
Thk: 5.00 mm
Loc: 120.00 mm
0.41\0.41 mm
STANDARD
120.00 kVp
85 mA
P
HFS
CE:
WW 178 : WC 1067