American College of Radiology CT Accreditation Program

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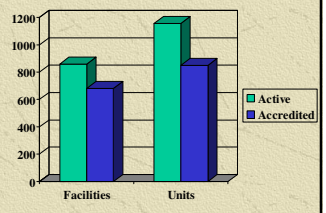
Outline

- CT Accreditation Program Overview
  - Statistics
  - Essentials
    - Personnel
    - Equipment
    - QA
- Technologist Level Testing
- Physicist Level Testing
- Site Scanning Instructions
  - Image Quality
  - Dose
    - CTDIw, CTDIvol, DLP, Effective Dose
    - Advanced Equipment

Current CTAP Statistics

- Facilities active (current and under review): **881**
- Facilities currently accredited: **682**
- Units active: **1157**
- Units accredited: **850**
- Failure rate: **37%**
  (6/1/2005 – 6/30/2006)
  - Clinical only: **44%**
  - Phantom only: **37%**
  - Clinical + phantom: **19%**



Physician Requirements

Radiologists

Initial	Board Certification, and 300 CT exams in past 36 months OR Completion of a diagnostic radiology residency, and 500 CT exams in past 36 months
Continuing Experience	100 CT exams per year (recommended)
Continuing Education	150 hours every three years (recommended)

Physician Requirements

Non-Radiologists

Initial	Completion of specialty residency 200 hours of Cat 1 CME 500 CT exams in past 36 months
Continuing Experience	100 CT exams per year (recommended)
Continuing Education	150 hours every three years (recommended)

Technologist Requirements

Initial	Current ARRT(R) or unlimited state license, and Documentation of training and experience in CT OR ARRT(R)(CT)
Continuing Education	24 credits in a two year period

Physicist Requirements

Initial	Board certification in Diagnostic Radiological Physics or Radiological Physics (recommended)
Continuing Education	150 CME every three years (recommended)

Personnel Requirements

- Note that physician, medical physicist requirements are mandatory as of July 2006
  - Starting with next accreditation/re-accreditation
  - Phase-in period
    - Individuals will not be required to have all of their continuing education completed at the time of re-accreditation
    - Pro-rated CE will be required

Equipment Requirements

- CT equipment specifications and performance shall meet state and federal requirements and applicable ACR Practice Guidelines and Technical Standards.

Quality Assurance

- Policies and Procedures
  - Quality
  - Patient education
  - Infection control
  - Safety
  - Per ACR Policy on Quality Control and Improvement, Safety, Infection Control and Patient Education Concerns

Quality Assurance

- Must include
  - Appropriateness/Outcomes analysis for CT-guided procedures
    - Diagnostic accuracy
    - Complication rate
    - Outcome
  - Equipment quality control
    - Continuing QC
    - Annual MP survey

Continuous QC Program

- Established with Medical Physicist
  - Frequency of each test
  - Who performs each test
- Should include
  - Alignment light accuracy
  - Slice thickness
  - Image quality
    - Spatial resolution
    - Low contrast resolution
    - Image uniformity
    - Noise
    - **Artifact evaluation**
  - CT number accuracy
  - Display devices

Continuous QC Program

- Written procedures and methods
- PM scheduled, performed, documented
- Results of QC program monitored annually by MP
- Corrective action
- Service records and QC follow-up documentation

Annual Medical Physics Survey

- Alignment light accuracy
- Alignment of table to gantry
- Table/gantry tilt
- Slice positioning from scout
- Table incrementation accuracy
- Slice thickness
- Image quality
  - Spatial resolution
  - Low contrast resolution
  - Image uniformity
  - Noise
  - Artifact evaluation
- CT number
  - Accuracy
  - Linearity
- Dosimetry

First Step: Table 1

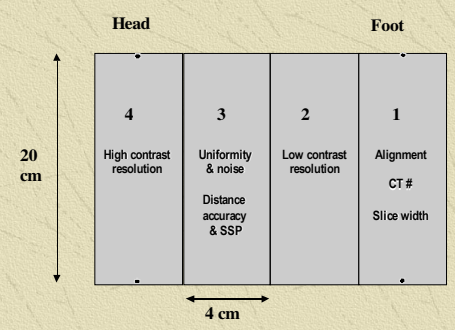
Table 1: Typical Image Acquisition Technical Parameters

	Adult Head (skullbase portion)	High Resolution Chest	Adult Abdomen	Pediatric Abdomen (5 y.o.)
kVp				
mA				
Time per rotation (s)				
Scan FOV(cm or name)				
Display FOV (cm)				
Reconstruction Algorithm				
Axial (A) or Helical (H)				
Z-axis collimation (T, in mm)[1]				
# data channels used [1] (N)				
A: Table increment (mm) or H: Table Speed (mm/rot) (I)				
Pitch[1]				
Reconstructed Scan Width (mm)				
Reconstructed Scan Interval (mm)				
Dose Reduction Techniques[1]				

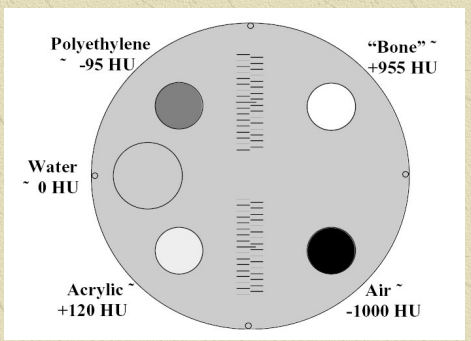
- Ensure that you have this
- Ensure that the data matches what they do clinically
- Verify that default protocol matches
- Evaluate to ensure that all entries are appropriate

The ACR CT Accreditation Phantom – RMI Model 464

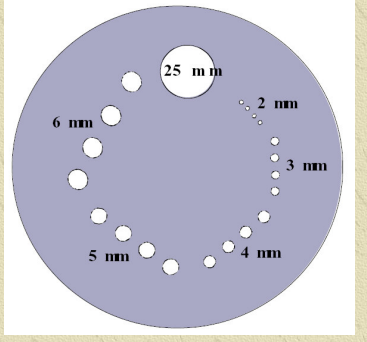
The ACR CT Accreditation Phantom – RMI Model 464



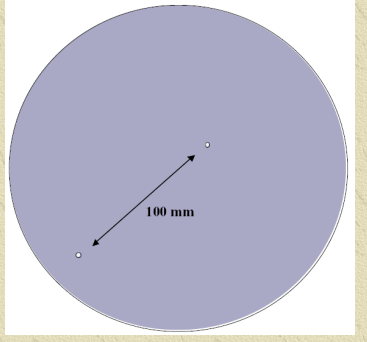
The ACR CT Accreditation Phantom – Module 1



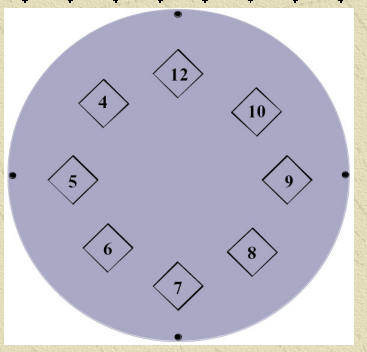
The ACR CT Accreditation Phantom – Module 2



The ACR CT Accreditation Phantom – Module 3

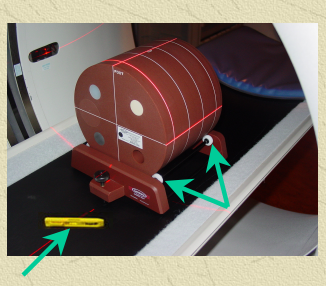


The ACR CT Accreditation Phantom – Module 4



Phantom Positioning

- Use CT alignment lasers
- Optional base can make life easier
- Use bubble level to verify pitch and roll
- Ensure teflon rings off module centers



Alignment Light/Scout Accuracy

- At 0, HRC slice thickness (<1.5 mm)
- Accurate to within 1 mm (4 BBs)
- Biopsy

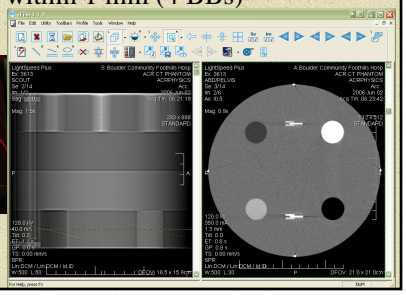
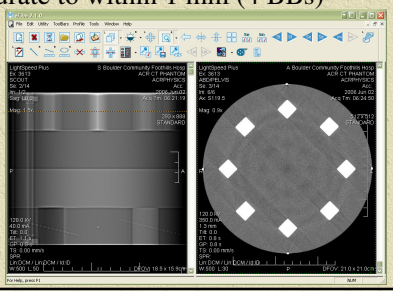


Table Incrementation Accuracy

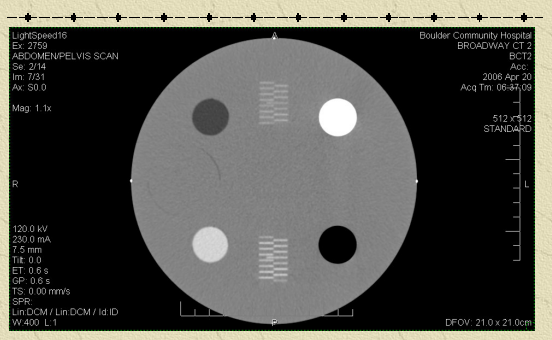
- Superior 120 mm, HRC slice thickness
- Accurate to within 1 mm (4 BBs)



Slice Thickness - Detected

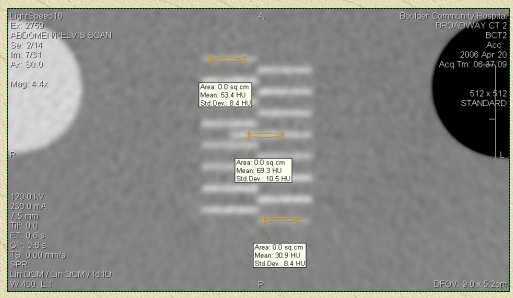
- WW = 400, WL = 0
- Accurate to within 1.5 mm
- Measure for
  - 7 mm
  - 5 mm
  - 3 mm
  - 1 mm (HRC)
- If not available, use the size closest to the nominal value

Slice Thickness - Detected



Slice Thickness - Detected

- Count if half the brightness of the brightest



CT Number Accuracy

- 200 mm^2 ROI
- ROIs must be placed within the cylinders
  - Polyethylene: –107 and –87 HU
  - Water: –7 and +7 HU (± 5 HU preferred)
  - Acrylic: +110 and +130 HU
  - Bone: +850 and +970 HU
  - Air: –1005 and –970 HU
- Must use axial version of clinical adult abdomen protocol

CT Number Accuracy

CT Number Accuracy

- Water CT # must be measured vs. kVp
- All kVp stations available on the scanner must be operable
- All kVp stations available on the scanner must be calibrated
- Water CT # must be = 0 ± 7 HU (0 ± 5 HU preferred)

Image Quality – Low Contrast

- Head and Abdomen protocols
- WW=400, WL=100
- Must visualize at least 6 mm rod group
- Must visualize all four rods in the group to count.
- Measure 100 mm^2 ROI inside and outside the 25 mm rod
- Record difference = contrast

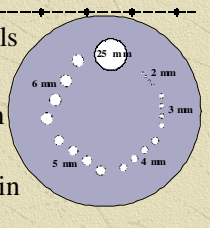


Image Quality – Low Contrast

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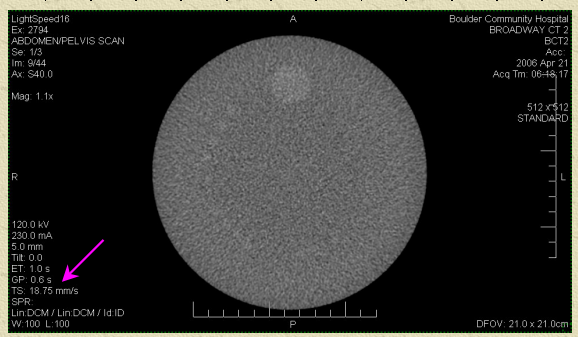


Image Quality – Low Contrast

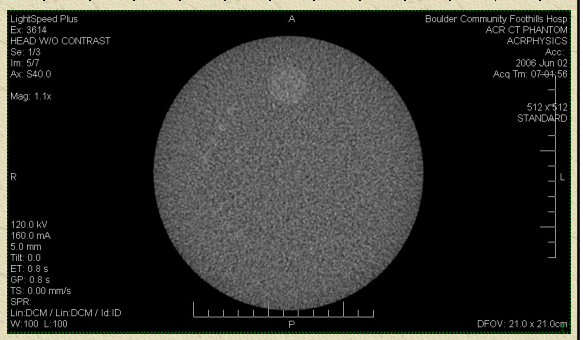


Image Quality - Image Uniformity

- Measure 5 circular ROIs, 400 mm^2
  - Central axis
  - 12:00, 3:00, 6:00, 9:00
- Central ROI
  - Must be 0 ± 7 HU
  - Preferably 0 ± 5 HU
- Locate peripheral ROIs 1 ROI diameter from the edge of the phantom
- Peripheral ROIs must be Central ± 5 HU

Image Quality – Image Uniformity

Image Quality – Artifact Evaluation

- WW = 100, WL = 0
- Mainly rings, streaks

Image Quality – Spatial Resolution

- Abdomen and High Res. Chest protocols
- WW=100, WL=1100±*100*
- Must visualize at least 6 lp/mm

Image Quality – Spatial Resolution

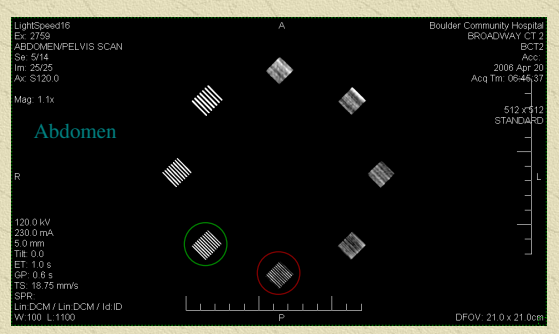
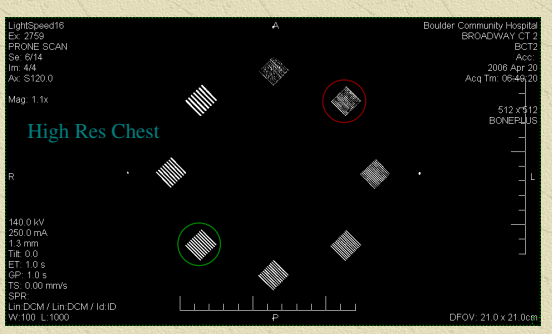


Image Quality – Spatial Resolution



Dosimetry

- **Clinical** adult head
- **Clinical** adult abdomen
- **Clinical** pediatric abdomen (5 y.o., ~20 kg)
- **Must measure dose in axial mode**
- **Must convert helical to axial**
- **Table 1**
- FDA phantoms:
  - 16 cm head
  - 32 cm body
  - Non-chamber holes must be filled
  - For pediatric abdomen, use head phantom ON TABLE

Axial Conversion

- Note actual z-axis (detector) collimation and number of data channels used
  - Siemens Emotion 6 scanner
    - Pitch = I/NT
    - 1.2 = 14.4 mm/rot / (6 data channels * 2 mm)
- Do not confuse z-axis collimation with nominal slice thickness!
- May not be able to achieve the same detector configuration in axial as used in helical

Axial Conversion

- Determine NT of detector configuration underlying the clinical helical protocol
- Select axial detector configuration most closely matching the helical NT
- Use the axial configuration in all subsequent calculations

Axial Conversion

- ***If an axial acquisition cannot be made using that selection of N and T, keep T the same as described in Table 1 and use the next smallest allowed value of N.***

  Example: Siemens Sensation 16 system with N = 16 and T = 1.5 mm and reconstructed helical scan width = 5 mm. Axial images cannot be acquired using N = 16. Use the same value of T (1.5 mm) but the next lowest allowed value of N, which would be 12. Thus the 12 x 1.5 mm detector configuration would be used for the axial version of the spiral adult abdomen protocol with N = 16 and T = 1.5 mm. This is similarly true for the 16 x 0.75 mm detector configuration (use an axial 12 x 0.75 mm detector configuration).

Pitch

- Must use IEC definition
  - Pitch = I/N*T
    - I = table increment/speed
    - N = number of data channels used
    - T = z-axis collimation
  - Not always stated correctly on the CT system
- Must know underlying detector configuration

Dosimetry Calculations

- CTDI at central axis and periphery

$CTDI_{100} = f \bullet C \bullet E \bullet L / (N \bullet T)$

where

f = 0.87 rad/R
C = electrometer/chamber correction factor
E = measured exposure
L = active chamber length
N = number of data channels
T = z-axis collimation

Dosimetry Calculations

- $CTDI_W$ = weighted axis and periphery

$CTDI_W = 1/3\ CTDI_{axis} + 2/3\ CTDI_{periph}$

- ***Reference values:***

Head	***Abdomen***	***Ped. Abd.***
60 mGy	***35 mGy***	***25 mGy***

- ***NOTE: reference values will***
  - ***Become pass/fail criteria***
  - ***Change (lower)***
  - ***Be evaluated against $CTDI_{vol}$, not $CTDI_W$***

Dosimetry Calculations

- $CTDI_{VOL}$ = $CTDI_W * N * T / I$ (axial)
  = $CTDI_W$ / pitch (helical)

$CTDI_W$		N	T	I	Pitch	$CTDI_{VOL}$	
58	Pass	4	5	20	--	58	Pass
58	Pass	4	5	10	--	116	FAIL
24	Pass	--	--	--	1	24	Pass
27	Pass	--	--	--	0.75	36	FAIL
38	FAIL	--	--	--	1.5	25	Pass

Dosimetry Calculations

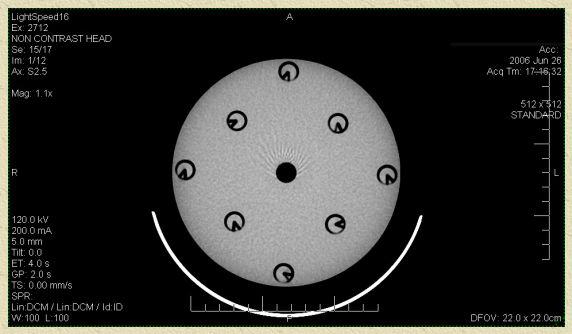
- ***DLP (mGy-cm) = $CTDI_{VOL}$ (mGy) • total scan length (cm)***
  - ***For ACR, assume total scan length = 17.5 cm for head***
    = 25.0 cm for adult abd.
    = 15.0 cm for ped. abd.

- ***Effective Dose (E) = k (mSv/mGy-cm) * DLP (mGy-cm)***
  - ***Where k = 0.0023 for head***
    = 0.015 for adult abd.
    = 0.0081 • 2.6 for ped. abd.

Reference Values

- Current values derived from EUROPEAN GUIDELINES ON QUALITY CRITERIA FOR COMPUTED TOMOGRAPHY
  http://www drs.dk/guidelines/ct/quality/mainindex.htm
- New values will be based on experience derived through the ACR CT Accreditation Program

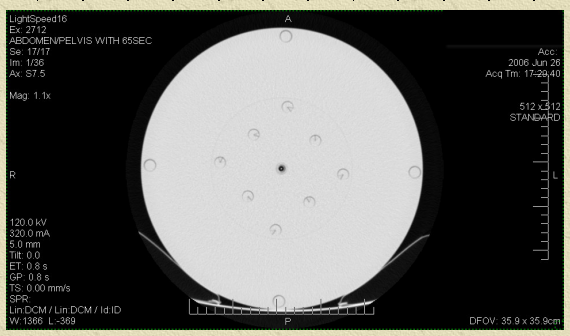
Head Dosimetry



CTDI Head Phantom (16-cm diameter PMMA Phantom)	Measured	Calculated
kVp	120	
mA	200	
Exposure time per rotation (s)	2	
Z axis collimation T (mm)1	5	
# data channels used (N)1	2	
Axial (A): Table Increment (mm) = (i)1	10	
Active Chamber length (mm)	100	
Chamber correction factor	1	
Center		
Measurement 1 (mR)	941.3	
Measurement 2 (mR)	942.9	
Measurement 3 (mR)	944	
Average of above 3 measurements (mR)		942.7
Head CTDI at isocenter in phantom (mGy)		82.0
12 o'clock position		
Measurement 1 (mR)	961.6	
Measurement 2 (mR)	963.9	
Measurement 3 (mR)	966.1	
Average of above 3 measurements (mR)		963.9
Head CTDI at 12 o'clock position in phantom (mGy)		83.9
CTDIw (mGy)		83.2
Clinical exam dose estimates (using measured CTDIw and site's Adult Head Protocol from Table 1		
CTDIvol (mGy)	=CTDIw*N*T/I	83.2
DLP (mGy-cm)	=CTDIvol*17.5	1456.8
Eff Dose (mSv)	=DLP*0.0023	3.4

Displayed CTDIvol = 84.0 mGy

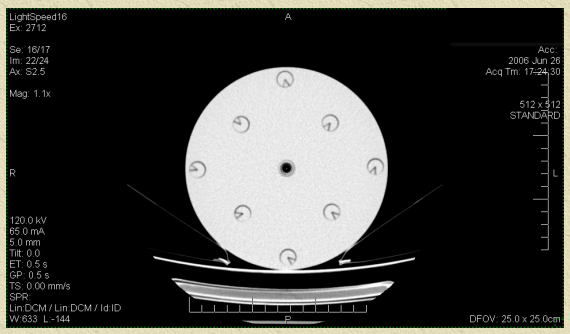
Adult Abdomen Dosimetry



CTDI Body Phantom (32-cm diameter PMMA Phantom)	Measured	Calculated
kVp	120	
mA	320	
Exposure time per rotation (s)	0.8	
Z axis collimation T (mm)1	5	
# data channels used (N)1	4	
Axial (A): Table Increment (mm) = (I)1	27.5	
Active Chamber length (mm)	100	
Chamber correction factor	1	
Center		
Measurement 1 (mR)	313.4	
Measurement 2 (mR)	314.8	
Measurement 3 (mR)	315.4	
Average of above 3 measurements (mR)		314.5
Body CTDI at isocenter in phantom (mGy)		13.7
12 o'clock position		
Measurement 1 (mR)	653.2	
Measurement 2 (mR)	620.5	
Measurement 3 (mR)	620.5	
Average of above 3 measurements (mR)		631.4
Body CTDI at12 o'clock position in phantom (mGy)		27.5
CTDIw (mGy)		22.9
Clinical exam dose estimates (using measured CTDIw and site's Adult Abdomen Protocol from Ta		
CTDIvol (mGy)	=CTDIw*N*T/I	16.6
DLP (mGy-cm)	=CTDIvol*25	415.9
Eff Dose (mSv)	=DLP*0.015	6.2

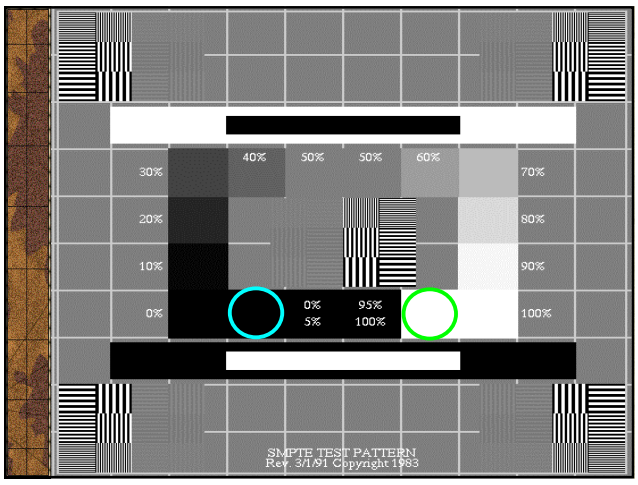
Displayed CTDIvol = 16.9 mGy

Pediatric Abdomen Dosimetry



SMPTE Pattern

- This pattern, or an equivalent, must be submitted (automatic failure)
- SHOULD be present on scanner
- Should demonstrate good contrast and resolution
- Must be able to see the 5% and 95% patches



For More Information

- Highly recommend:

The phantom portion of the American College of Radiology (ACR) Computed Tomography (CT) accreditation program: Practical tips, artifact examples, and pitfalls to avoid

Med. Phys. 31 (9), September 2004, pp. 2423 - 2442.

Roles and Responsibilities

- Oversee QC
- Annual testing
- Technology changes/utilization
  - 5 mm, 4i with a 10 mm table increment!
- Protocol optimization
  - Detector configuration
  - kVp
  - Reconstruction algorithm (spatial resolution vs. noise visibility)