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1. QUALITY ASSURANCE PROGRAM

1.1 INTRODUCTION

This manual has been established to document the functions of various Departments and individuals in maintaining quality assurance in diagnostic and therapeutic radiology. The purpose of a quality assurance program is to provide a quality image and reduced radiation exposure to both patients and workers to a level As Low As is Reasonably Achievable (ALARA). This is achieved through a formalized program of Quality Control testing, documentation of the efforts, evaluating the records and correcting programs as they are detected. The test procedures documented in this manual are general guidance and variations from those procedures may be used so long as the means and results conform to the NY State Sanitary Code (10NYCRR16) and other statutory guidance.

The Quality Assurance Program was mandated by the NYS Health Department as required by Section 16.5 of the NY State Sanitary Code (10NYCRR16.5). Since this part of the radiation safety program, the Radiation Safety Unit of the University of Rochester is responsible for coordinating the program in all Departments using X-ray machines on humans. The Radiation Safety Unit will ensure that the tests are being performed and that follow-up action is taken when necessary.

The Quality Assurance Committee for Medical X-ray will review the records and reports that are generated. The Radiation Safety Unit will prepare quarterly trending reports of selected data.

Each Department represented on this committee may perform additional specific tests and have a departmental QA Procedure Manual that documents these additional tests.

1.2 QUALITY ASSURANCE COMMITTEE

A Quality Assurance Committee has been established as follows:

1. Chief X-ray Technologist, Diagnostic Radiology
2. Staff Radiologist, Diagnostic radiology
3. Chief Clinical Engineer, Clinical Engineering
4. QA Technologist, Radiation Safety
5. QA Medical Physicist, Radiation Safety
6. Radiation Safety Officer, Radiation Safety
7. Chairman, Department of Radiology
8. Chief Therapist, Radiation Oncology
9. Medical Physicist, Radiation Oncology

10. Representative of Dental Clinic

11. Representative of the Cardiac Catheterization Laboratory

12. Representative of Nuclear Cardiology Department

13. Chief of Nuclear Medicine Department

14. Medical Physicist of the Nuclear Medicine Department

15. Representative of Magnetic Resonance Imaging (MRI) Department

The Committee shall meet quarterly for the purpose of reviewing the records of testing in the previous year. A summary report of this meeting and the findings shall be forwarded to the University Radiation Safety Committee. Minutes of the meetings shall be kept for a minimum of three years.

1.3 THE FUNCTIONS OF THE COMMITTEE

1. Provide direction to the URMC Quality Assurance program.

2. Assure that proper documentation and testing is maintained.

3. Review trending reports and effectiveness of corrective actions.

4. Review the effectiveness of the program and make changes in the hospital QA program as needed.

2. RADIATION SAFETY UNIT'S ROLE IN QA PROGRAMS ASSOCIATED WITH RADIATION

2.1 INTRODUCTION

The Radiation Safety Unit of the University of Rochester is responsible for maintaining radiation safety throughout the University and Medical Center. This responsibility includes working with State Regulatory Agencies and coordinating compliance procedures.

The purpose of this chapter is to establish the guidance that Radiation Safety Unit will provide and how it relates to the other parts of total radiological program. Radiation Safety Unit (RSU) will test standard protocol which has been mandated by the NY State Department of Health within their regulations and guidelines (Part 16). Test will include, but not be limited the settings to address the major functions such as filtration, timer reproducibility, kVp accuracy, mA linearity and timer accuracy.
In addition, each department is responsible to submit the maintenance and required QA reports to the Radiation Safety Unit for their review. The RSU and the specific departments maintain these records consistent with NY State record requirements.

The purpose of the Radiation Safety Unit QA program is not to duplicate the efforts of departments, but to give an independent check of the performance of the radiological devices. The Radiation Safety Unit ensures the maintenance and corrective actions are being performed when discrepancies are noted. **Typically, Clinical Engineering will be contacted to start a work order to fix any non-compliance of specifications as soon as possible.**

In the event that the Radiation Safety Unit detects a problem which is inconsistent with 10NYCRR16 or other regulations, a report will be sent to the responsible person with instructions to address the issues within 30 days or less, based on the severity of the concern. If more than 30 days is required to complete the actions, then a corrective action plan will be provided as a part of the response to the finding.

If the problem persists without correction after 30 days passed and there is no reasonable justification (such as awaiting a part), the Radiation Safety Officer, or in their absence, the Chairman of the Radiation Safety Committee may suspend the use of the radiation producing equipment in question.
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* Except Panorex used for non-dental medical exams, which requires annual testing
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<thead>
<tr>
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<th>Frequency, Daily, weekly, monthly, quarterly, semi-annual or annual.</th>
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<td>Annual</td>
<td>Qualified Medical Physicist, Radiologist, CT Technologist</td>
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<td>Qualified Medical Physicist</td>
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<tr>
<td>Artifact Evaluation</td>
<td>Annual</td>
<td>Qualified Medical Physicist</td>
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<td>Qualified Medical Physicist (New Unit) Monthly test will be done by Clinical Engineering upon tube replacement (tube replace).</td>
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*These are New York State Department of Health Requirements. All other requirements are for the American College of Radiology, and/or the Joint Commission.
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<td><strong>Acceptance Testing</strong></td>
<td>As Needed</td>
<td>Qualified Medical Physicist</td>
</tr>
<tr>
<td><strong>View Box Re-lamping</strong></td>
<td>Annual</td>
<td>Clinical Engineering</td>
</tr>
<tr>
<td><strong>Technique Charts</strong></td>
<td>As Needed</td>
<td>Qualified Medical Physicist / Imaging Science</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>MRI QA</strong></th>
<th><strong>Imaging Science</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Visual Checklist</td>
<td>Weekly</td>
</tr>
<tr>
<td>Table Positioning</td>
<td>Weekly</td>
</tr>
<tr>
<td>Center Frequency</td>
<td>Weekly</td>
</tr>
<tr>
<td>Transmission Gain</td>
<td>Weekly</td>
</tr>
<tr>
<td>Geometric Accuracy</td>
<td>Weekly</td>
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<tr>
<td>High Contrast Resolution</td>
<td>Weekly</td>
</tr>
<tr>
<td>Low Contrast Resolution</td>
<td>Weekly</td>
</tr>
<tr>
<td>Image Artifact Assessment</td>
<td>Weekly</td>
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<tr>
<td>Film Quality Control</td>
<td>Weekly</td>
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<tr>
<td>RF Coils</td>
<td>Quarterly</td>
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<tr>
<td>Magnetic Field Homogeneity</td>
<td>Semi-annual</td>
</tr>
<tr>
<td>Slice Position Accuracy</td>
<td>Semi-annual</td>
</tr>
<tr>
<td>Slice Thickness Accuracy</td>
<td>Semi-annual</td>
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<tr>
<td>Inter-slice Interference</td>
<td>Semi-annual</td>
</tr>
<tr>
<td>Soft Copy Displays</td>
<td>Semi-annual</td>
</tr>
<tr>
<td>General Imaging QA</td>
<td>Frequency, Daily, weekly, monthly, quarterly, semi-annual or annual.</td>
</tr>
<tr>
<td>--------------------------------------------------------</td>
<td>---------------------------------------------------------------------</td>
</tr>
<tr>
<td><strong>Diagnostic Work Station</strong></td>
<td></td>
</tr>
<tr>
<td>Weekly Image Quality</td>
<td>Weekly</td>
</tr>
<tr>
<td>Quarterly Image Quality check</td>
<td>Quarterly</td>
</tr>
<tr>
<td>Annual Full Calibration of Diagnostic Workstation</td>
<td>Annual</td>
</tr>
<tr>
<td><strong>CR/DR Testing</strong></td>
<td></td>
</tr>
<tr>
<td>Test CR System, TQT</td>
<td>Semi-Annual</td>
</tr>
<tr>
<td>CR Processor Safety Check and Preventative Maintenance</td>
<td>Semi-Annual</td>
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<tr>
<td>CR cassette TQT</td>
<td>50% per quarter</td>
</tr>
<tr>
<td>CR cassette erasing</td>
<td>Weekly</td>
</tr>
<tr>
<td>Dry View Laser Printer</td>
<td>Weekly</td>
</tr>
<tr>
<td>Image Quality (Artifact) and Storage</td>
<td>Daily</td>
</tr>
<tr>
<td>DR Detector calibrations</td>
<td>Per Vender requirements</td>
</tr>
<tr>
<td>Reject Analysis</td>
<td>Quarterly</td>
</tr>
</tbody>
</table>
2.2 X-RAY OUTPUT MEASUREMENTS

2.2.1 Instrumentation:
- Calibrated R/F Meter Kit
- Lap Top Computer
- Calibrated R/F meter software
- Several Protective aprons
- Tape measure

**Note:** Calibrated R/F Meter Kit is calibrated annual by the manufacturer.
**Note:** For the purposes of this document inch only indicators are converted to cm by multiplying the number of inches x 2.54 cm and then rounded to the nearest cm. For SID indicators 40 inches = 100 cm and 10 inches = 25 cm.

2.2.2 Positioning
- Log out and log in under service.
- Set the X-ray tube at a 77 cm Source to Image Detector (SID). Remove any padding or linen from table top. The R/F dosimeter probe is placed on the table. If mobile x-ray position, make source to detector distance 77 cm from focal spot.
- Fully open the collimator and center the detector in the light field.

2.2.3 If using Unfors meter the settings are:
- Units mR/R
- Trigger delay set to “0”
- kVp delay to “0”
- Calc. Delay to 0.5
- Check AMX+4 setting to “on” for AMX+4 machines (GE)
- For non-AMX machines AMX is unchecked

2.2.4 kVp Accuracy
   a. Take four exposures each at 2 kVp values < 100 kVp
      - Typical values:
        - Group 1: 60 kVp, 50 mA, 100 ms
        - Group 2: 80 kVp, 100 mA, 200 ms
   b. Take four exposures ≥ 100 kVp
      - Typical values:
        - 102 kVp, 160 mA, 250 ms
   c. Acceptance:
      Unless otherwise specified in the manufacturer’s specifications, all equipment shall meet:
      - ± 2 kVp of the indicated for < 30 kVp
      - ± 3 kVp of the indicated for 31 kVp – 100 kVp
      - ± 6 kVp of the indicated for ≥ 100 kVp
Note: the data collected in this step is also used for **manual timer accuracy and time (dose) reproducibility**.

**Acceptance:**
- Manual timer accuracy
  - Measured time must be within 5% of displayed
- Time (dose) reproducibility
  - \((\text{mR max} - \text{mR min}) / \text{mR Ave} \leq 10\%\)

### 2.2.5 mA(s) Linearity

a. Four (4) exposures per mA Group.
- Each mA setting should be double the previous setting.
- Typical values;
  - Group 1: 50 mA
  - Group 2: 100 mA
  - Group 3: 200 mA
  - Group 4: 400 mA

b. kVp and time settings are kept constant
- Typical values: 120 kVp, 200 ms

c. Acceptance:

The average ratios of exposure to the indicated mAs product (mR/mAs) obtained at any two consecutive tube current settings shall not differ by more than 0.10 times their sum. The generator should be capable of maintaining the above linearity across all the available mAs settings.

### 2.2.6 Half Value layer

- Automatically calculated by Calibrated R/F meter and populates spreadsheet.
- Acceptance:

For certified equipment, the minimum HVL shall not be less than:

<table>
<thead>
<tr>
<th>X-ray Tube Voltage Operating Range</th>
<th>kVp</th>
<th>HVL Al (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Below 50 kVp</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>30</td>
<td>0.3</td>
</tr>
<tr>
<td></td>
<td>40</td>
<td>0.4</td>
</tr>
<tr>
<td></td>
<td>49</td>
<td>0.5</td>
</tr>
<tr>
<td>50-70 kVp</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>50</td>
<td>1.2</td>
</tr>
<tr>
<td></td>
<td>60</td>
<td>1.3</td>
</tr>
<tr>
<td></td>
<td>70</td>
<td>1.5</td>
</tr>
</tbody>
</table>
Above 70 kVp

<table>
<thead>
<tr>
<th>kVp</th>
<th>Exposure (mAs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>71</td>
<td>2.1</td>
</tr>
<tr>
<td>80</td>
<td>2.3</td>
</tr>
<tr>
<td>90</td>
<td>2.5</td>
</tr>
<tr>
<td>100</td>
<td>2.7</td>
</tr>
<tr>
<td>110</td>
<td>3.0</td>
</tr>
<tr>
<td>120</td>
<td>3.2</td>
</tr>
<tr>
<td>130</td>
<td>3.5</td>
</tr>
<tr>
<td>140</td>
<td>3.8</td>
</tr>
<tr>
<td>150</td>
<td>4.1</td>
</tr>
</tbody>
</table>

### 2.2.7 Automatic Exposure Control (AEC) Timers

a. Reproducibility of the Output, Accuracy and testing of AEC and Backup Timer.
   1. Indicated time (milliseconds) must be manually recorded under SET column for accuracy test.
   2. Take four exposures with AEC at a specific kVp (Typical value: 72 kVp).
   3. For testing Output and Accuracy, use a lead apron to protect the photo cell, and provide some attenuation for the AEC, by covering them partially.
   4. For Back up timer cover all AEC cells with several lead apron layers.
   5. Repeat test for photo-times on wall bucky if equipped.

b. Acceptance:
   - Passing criteria limits: Measured Time must be within 5% of displayed
   - Backup Timer: Message on screen indicates backup timer and exposure shut off. The backup time should be within 10% of setting if one exists.

### 2.2.9 Entrance Skin Exposure Data:

- Take six more additional exposures set to standard protocols standard as in the example in Fig 2.2.9-1.

<table>
<thead>
<tr>
<th>Entrance Skin Exposure</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>University of Rochester Radiation Safety Unit</strong></td>
</tr>
<tr>
<td>Device: 0</td>
</tr>
<tr>
<td>ORS # CN #: 0</td>
</tr>
<tr>
<td><strong>Projection</strong></td>
</tr>
<tr>
<td>A/P L Spine 100 cm</td>
</tr>
<tr>
<td>P/A Chest 183 cm</td>
</tr>
<tr>
<td>ABD (KUB) 100 cm</td>
</tr>
<tr>
<td>Full Spine 183 cm</td>
</tr>
<tr>
<td>Cervical Spine 100 cm</td>
</tr>
<tr>
<td>Lat Skull 100 cm</td>
</tr>
</tbody>
</table>

*Note: At present there is no guidance comparing CR or DR index to film speed. A 400 film speed is assumed for testing purposes.*
Not all machines will be set at the same techniques. The techniques should be specified by the clinical department using them. These should be recorded on the test spreadsheet. This will be used for Entrance Skin Exposure posting for each machine.

Note: This test is required for acceptance testing and these charts must be updated when new x-ray tubes or calibrations change the baseline data from which the charts were developed.

2.3 Collimation, Centering and Positive Beam Limitation (PBL)

Instrumentation:

1. 8 U.S. mint pennies tapped together in pairs
2. 1 single penny
3. CR or DR cassettes
4. Tape measure

A. All images are sent to PACS.
Typical parameters are below. Check with the clinical department where the test is being performed for their particular details:

1. Last name: Xrayrm
2. First name: Machine designation (i.e. C39, P21 or RM5)
3. Accession number: Test Date
4. MR or MRN: Clinical Engineering Control Number
5. DR images are set to corner before accepting to PACS.

B. Collimation and Dial Accuracy (devices with marked graduation) and Centering for table, fixed chest rooms or mobile units

1. If the X-ray unit is fixed (X-ray room) and uses CR cassettes or DR wireless cassettes, load the cassette into the table bucky and center the tube. For mobile x-ray, place cassette on table top.
2. Set Source to Image (SID) to 100 cm (183 cm for fixed chest room).
3. Collimate beam to 25 cm x 25 cm.
4. Place two pennies together on each side such that the edge of the light field splits where the pennies touch each other.

5. Place a single penny in middle of light field crosshairs.

6. Set exposure to 60 kVp and 5 mAs (typical) and make exposure.

7. If using DR process image. If using CR, pull out cassette tray and push back in to reset collimator and X-ray generator. Be careful not to disturb the pennies.

8. Open collimation to outside the edge of the pennies and make an exposure using 50 kVp and approximately 1.5 – 2 mAs. This will create some contrast making the pennies outside the 25 cm x 25 cm field more visible when processing cassette.
C. Centering for wall bucky

1. If the X-ray unit is fixed (X-ray room) and uses CR cassettes or DR wireless cassettes, load the cassette into the table bucky and center the tube. For mobile x-ray, place cassette on table top.
2. Set Source to Image (SID) to 100 cm (183 cm for fixed chest room).
3. Collimate beam to 25 cm X 25 cm.
4. Place a single penny in middle of light field crosshairs.
5. Use 70 kVp and 10mAs (typical).
7. Acceptance:
   a. Collimation (Light Field to X-ray Field):
      The inside pennies closest to the center of the field shall lay partially or completely in the radiation field. The outside pennies may lie partially in the exposed field but no outside positioned penny may be fully covered by the radiation field.

      **Note:** If SID is other than 100 cm (such as a dedicated chest room): The misalignment in either dimension of the edges of the light field versus the x-ray field shall not exceed 2% of the SID.

   b. Dial Accuracy:
      Each dimension of the x-ray field should not exceed 2% of the SID.

   c. Centering (X-ray Field to Image Receptor Alignment):
      Find centers of the x-ray field and image receptor by drawing lines from corner to corner of both the x-ray field and full image receptor. Measure the distance between the intersections of the 2 sets of lines (centers).

      The misalignment of the center of the x-ray field as compared to the center of the image receptor shall not exceed 2% of SID.
D. Positive Beam Limitation (PBL)

1. If the X-ray unit is fixed (X-ray room) and uses CR cassettes or DR wireless cassettes, load the cassette into the table bucky and center the tube. For mobile x-ray, place cassette on table top.
2. Set Source to Image (SID) to 100 cm (183 cm for fixed chest room).
3. Set (PBL) and note indicated measurements.
4. Turn collimator 45 degrees.
5. Take an exposure at 60 kVp, 5 mAs (typical)
6. Process image
7. Acceptance: The indicated x-ray beam size shall not differ from the receptor size by more than 3% of SID in any one dimension or by a total of more than 4% of the SID in both dimensions.
8. Repeat for wall bucky, if available

2.4 ILLUMINATION TEST (OPTIONAL)

2.4.1 Equipment:
- Calibrated R/F Meter Kit with Illumination Probe

2.4.2 Steps:
1. Connect light meter to Calibrated R/F meter base and set measurement to Foot Candles
2. Set SID to 100 cm table top and collimate to 25 cm X 25 cm. If collimation controls are not graduated adjust light field to the above mentioned light field by using a tape measure.
3. With the area as dark as possible and collimator light off measure, record ambient light with meter directly below x-ray tube.
4. Turn collimator lights on and starting in upper left quadrant measure light fields of all four quadrants in a clock wise direction.

```
Q11 Q2
Q4 Q3
```

5. Subtract measured ambient light from each measurement in all four quadrants.

2.4.3 Acceptance:
- Average for all for quadrants must be greater than 15 foot candles.
2.5 FLUOROSCOPIC EXPOSURE RATE MEASUREMENTS AND IMAGE EVALUATION

2.5.1 Instrumentation:
- Calibrated R/F Meter Kit,
- Laptop computer,
- Calibrated R/F meter (excel) software
- Two ea. 18 cm x 18 cm of Type 1100 Aluminum with 2 cm inches thickness,
- One 18 cm x 18 cm of copper with 0.5 mm thickness,
- One 18 cm x 18 cm of copper with 2 mm thickness and
- One 18 cm x 18 cm of 3 mm lead sheet
- Approved 1.0 mm aluminum sheet with two sets of four test holes
- Spatial resolution test tool (0.1 mm maximum lead foil thickness)

2.5.2 Positioning
1. Remove any padding or linen so that imaging table is clear
2. If the system has variable source to image detector (SID) set to 100 cm.
3. Center detector 30 cm below image intensifier facing X-ray source.
4. Collimate to an appropriate border.
5. Place wooded blocks or protection device around detector to protect chamber from phantom.

2.5.3 kVp Accuracy
- Exposure ≤ 100 kVp
- Exposure > 100 kVp

2.5.3.1 Acceptance: Unless otherwise specified in the manufacture’s specification, all equipment shall meet:
- ± 2 kVp of the indicated for < 30 kVp
- ± 3 kVp of the indicated for 31 kVp – 100 kVp
- ± 6 kVp of the indicated for > 100 kVp

2.5.4 Dose Output
2.5.4.1 Phantom configurations:
- Pediatric Phantom: 2 cm of aluminum (25 Kg)
- Small Adult Phantom: 4 cm of aluminum (50 Kg)
- Average Adult Phantom: 4 cm of aluminum and 0.5 mm copper (75 Kg)
- Large Adult Phantom: 4 cm of aluminum and 2.0 mm copper (100 Kg)
- Max Phantom: 4 cm of aluminum and 3 mm of lead.

2.5.4.2 Steps:
1. Set the fluoroscopic machine controls on automatic exposure mode and set to continuous fluoro.
2. Set fluoroscopic device to largest field of view setting.
3. Place Pediatric configuration phantom between the Calibrated R/F meter detector and the image intensifier.
4. Collimate to phantom border around Calibrated R/F meter detector.
5. Expose using “automatic” and “Continuous” fluoro settings and record output to Calibrated R/F meter spreadsheet. If testing fixed room use highest output setting.
6. If Fluoroscopic device is equipped for pulse or boost, collimate and make exposure. Record output to Calibrated R/F meter spreadsheet.

Note: An Audible beeping may be heard during pulse or boost mode.

7. Repeat steps 1 through 4 for all field of view settings.
8. Repeat 1 through 35 for all phantom configurations except MAX
9. Repeat 1 through 5 only for largest field of view for MAX phantom configuration.

2.5.4.3 Acceptance:
- The fluoroscopic exposure rate in automatic and /or manual mode must not exceed 5R/min for Average Adult phantom. Otherwise Max phantom limit 10R/m automatic mode or 20 R/min in High Level Control (boost mode).

Note: See more details in Appendix E of the New York State Department of Health, Bureau of Environmental Protection Guide for Radiation Safety/Quality Assurance Programs.

2.5.5 Spatial Resolution

Note: If the system has variable source to image detector (SID) then SID should not exceed 100 cm

2.5.5.1 Steps:
1. Set distance of table top to image intensifier (30 cm for most devices except mini c-arms).
2. Place one 2 cm type 1100 aluminum centered under the image intensifier.
3. Place spatial resolution test tool on top of the aluminum block.

Note: If device is mobile C-arm Set C-arm kvp mode to “Automatic” and fluoro mode to “Continuous”.

4. Choose largest field of view setting.
5. Set room lights to low if possible
6. Collimate to aluminum block.

Note: Allow enough fluoro for Automatic Brightness Control to level off.

7. Record of the highest number of the test pattern that gives visible separation lines between of each line pair.
8. Repeat steps 4.6 and 4.7 for all field of view settings.
9. Acceptance: The minimum spatial resolution for all field of views shall be determined by the following equation: \(2 \text{ lp/mm} \times (15\text{cm} / \text{size of field of view used}) = \text{minimum number of line pair}\)

### 2.5.6. Low Contrast Performance

**Note:** If the system has variable source to image detector (SID) then SID should not exceed 100 cm.

#### 2.5.6.1 Steps:

1. Set Image intensifier 30 cm above table top
2. Place the 1 mm sheet of aluminum with holes between the two blocks of type 1100 aluminum.
3. Place the aluminum centered under the image intensifier.

**Note:** If device is mobile C-arm Set C-arm kVp mode to “Automatic” and fluoro mode to “Continuous”.

4. Expose and collimate to the aluminum blocks. Be sure and allow the Automatic Brightness control to level off.
5. Record the smallest hole size visible, kVp and mA
6. End exposure
7. Repeat 5.4 through 5.6 for all field of view sizes.
8. Acceptance: The low contrast performance of the fluoroscopic system shall resolve a minimum hole size of 3mm.

### 2.6 FLUOROSCOPIC BEAM DEFINITION

#### 2.6.1 Instrumentation:

- Fluoroscopic Alignment Device
- Four brass strips
- Tape
- CR cassettes

**Note:** All inch indicators are converted to approximate cm by number of inches x 2.54 and then rounded to nearest cm.

#### 2.6.2 Steps

1. Remove any padding from the surface of the table or remove the elevating device from the previous test.
2. Place the fluoroscopic Alignment Device on the table centered under the image intensifier at one half of the SID and tape into place. Machine SID should be at full distance.
3. Set output to lowest dose.
4. Starting with the largest field of view and collimators open, expose the fluoroscopic alignment device and the brass plates so that the brass plate circles inner edge with the edge of the X-ray field displayed on the monitor.
5. Place a cassette on top of the alignment device and expose it. The spacer posts are to be in place on the device for this test.
7. Repeat process for all fields of view.
8. Measure the length of the brass strips on each side that protrude into the center of the radiation field using PACS.

2.6.3 Acceptance:
- The X-ray beam shall not exceed the visible area of the image receptor by more than 3% of the SID in one dimension or by a total of more than 4% of the SID in both dimensions.

2.7 EOS SYSTEM
Please refer to published EOS manual.

2.8 EXPOSURE GUIDE
2.8.1 Purpose: To ensure that the entrance skin exposure to the patient is within a range of recommended exposures that is commonly used in the facilities.

2.8.2 Procedure:
1. Determine the machine settings for an average patient for any of the following projections with in the room:
   - AP Abdomen
   - AP Cervical Spine
   - AP Pelvis
   - AP Retrograde Pyelogram
   - AP Shoulder
   - AP Thoracic Spine
   - Hand
   - Lateral Knee
   - Lateral Skull
   - Lumbosacral Spine
   - PA Chest
2. Phototimer shall be off and put ion chamber 9 inches (simulate patient body thickness) above tabletop.
3. Using the output measurements determine the mR output at 31 inches for the projection used.

Note: If photo timing is used exclusively, an estimate of the actual exposure will be needed.
2.8.3 Acceptance Limits:
- Any exposures marked higher than those listed in Appendix G of the New York State Department of Health, Bureau of Environmental Protection Guide for Radiation Safety/Quality Assurance Programs are unacceptable.
- This out range exposure (HIGH) shall be investigated to determine the cause.
- For exposures marked LOW, only a confirmation that acceptable radiographs are being obtained, is necessary.
- The exposure dose is higher or lower depend on X-ray processor used in the room.

2.9 RADIATION SAFETY SURVEY (Scatter Test)

2.9.1 Instrumentation:
- Two pieces of 12 x 12 x 6 inches Masonite phantom or approved phantom and a survey meter

2.9.2 Purpose:
- To measure the quantity of the scattered radiation exposure to the operator and personnel around the x-ray room.

2.9.3 Procedure:

1. Set up the x-ray machine as normally used. For standard overhead tubes, this will be 40 inches SID.
2. Document the SID in any case. A 12x12x6 inches Masonite phantom or CT body phantom is placed in the beam and the field size is set at 10x10 inches. Smaller phantoms may be used for skull and other special units.
3. Set the x-ray machine for kVp, mAs where possible. A low mA and high time is acceptable and any kVp may be used. For equipment that is normally operated at higher than 100 kVp, use the highest kVp used. For equipment that never operates at 100 kVp, use the highest that is normally used. Document all settings used.
4. An ionization chamber type survey meter is used to measure the scattered radiation. Use more commonly positioned distance between sources and measurement (distance form x-ray tube and where staff stands). If a shorter time is used, time constant corrections are needed.
5. Measurements are to be made at the position of the operator and any other personnel associated with the procedure. Occupied areas around the room are also surveyed except where previous surveys have demonstrated safe levels. Other measurements may be made to document the level to the side of the control booth or in the open door to the room to demonstrate the safety factor in standing in the shielded area.
6. All measurements are recorded and calculated using an estimated weekly workload for the unit. The workload is obtained using the number of exposures per week and the average mA and time for each exposure. The kVp is ignored, since a higher kVp is used and the results are considered to be worst case.
7. Make a sketch of the room showing the locations of the measurements and all areas around the room. The control and tube locations should also be indicated. Measure the distance in feet from the center of the phantom to the point of measurement and...
record this distance on the sketch if there are no clear landmarks such as a wall where the measurement can be taken

8. The procedure for fluoroscopy and some special units will vary from this standard protocol. For fluoro, the Masonite or 1.5 inch thickness of Type 1100 Aluminum and 0.5 mm copper phantom is placed on the table and the intensifier head is lowered to two inches above the top of the phantom. The unit is operated in the ABC mode if applicable and the shutters are positioned wide open. Lead drapes and shields are positioned as normally used. Measurements are made at occupied locations at eye, chest, and waist level if they vary due to shields. A protective apron factor is established by measuring one location with and without a protective apron.

9. The results of this test are to be posted at or in the x-ray room to provide instruction to employees in the radiation levels that are encountered in their work.

2.9.4 Acceptance Limits:
- Weekly exposure levels of up to 2 mR for non-controlled areas and 10 mR for controlled areas are acceptable.
- The protective apron reduction factor is to be used where applicable and the number of operators may be a factor in allowing greater than 10 mR/wk in fluoroscopy rooms.

2.10 CT DOSE MEASUREMENT (Air Kerma)

2.10.1 Instrumentation:
- Calibrated R/F Meter Kit with CT Probe Ionization Chamber
- Standard CT and Head and Body Phantom

2.10.2 Purpose:
- To assure long term consistency of the dose delivered by the CT system.

Note: Outputs from meter may be recorded in ACR spreadsheet. The spreadsheet will automatically calculate CDTI\text{w}, CTDI\text{vol}, DLP and Effective Dose. See spreadsheet for input directions.

Per NYSDOH Guide for Radiation/Quality Assurance Program Computed Tomography Equipment:

2.10.3 Patient dose
URMC shall have available dose measurements based on the most common conditions of operation of their CT units. Since the advent of CTDI\text{FDA}, the International Electrotechnical Commission (IEC) has defined a new standard for dose index. This standard is called the CTDI\text{100}. CTDI\text{100} utilizes measurements made with a 16cm diameter (head/pediatric body) or a 32cm diameter (body) acrylic phantom. The measurements are made utilizing a 100 mm long pencil ionization chamber. Readings are made with the ion chamber in both the center (axial or central dose) position and near surface slots of the phantom (the peripheral dose).
CTDI\textsubscript{W}, the weighted or blended dose, is calculated by adding together two-thirds of the CTDI\textsubscript{100} peripheral dose with one-third of the CTDI\textsubscript{100} axial or center dose.

\[(\text{CTDI}_W = \frac{2}{3} \text{CTDI}_{100} \text{ peripheral} + \frac{1}{3} \text{CTDI}_{100} \text{ axial or center})\]

It is important to remember that CTDI\textsubscript{W} represents an average dose in the x and y planes. With multiple slice helical scanning, the dose is better represented by CTDI\textsubscript{VOL}, which takes into account the effect of pitch and averages over the x, y, and z planes. CTDI\textsubscript{VOL} represents the integrated dose over the total volume that is irradiated.

\[
\text{CTDI}_{\text{VOL}} = \frac{1}{\text{PITCH}} \times \text{CTDI}_W
\]

**2.10.3.1 Procedure:**

1. Center the head phantom with the Lucite rods in place as described in section 3.15 CT Laser Alignment.
2. Select a technique which represents an average patient, and record the factors used (i.e. kVp, mA, sec, slice thickness [in mm]).
3. Insert the CT ionization chamber in the center hole and using the laser alignment, align the probe such that it is iso-centered.
4. Record the exposure (mR), and the time (in seconds).
5. Repeat for center holes and upper holes (12 o’clock position) 3 times in the phantom.
6. (Use 16-cm diameter head dose phantom for Adult head (in head holder), Pediatric head (on table), and Pediatric abdominal (on table). Use the 32cm diameter body dose phantom for Adult abdominal. Use the Calibrated R/F meter CT Detector (or initialized MDH in the Pulse Exposure Mode).
7. Take average
8. Calculate the Multiple Slice Average Dose (MSAD) from the Multiple Slice Average Exposure (MSAE) using the following equation:

\[
\text{MSAD} = (C \times L \times \frac{E}{I}) \times f
\]

Given:
- \(C\) = Energy response correction factor for volume considerations. (Radical 2x5-10.3 Ct pencil chamber correction factor = 2, Calibrated R/F meter correction factor = 1)
- \(L\) = length of pencil chamber = 10 cm
- \(E\) = exposure reading, Roentgens
- \(I\) = scan width (full collimation) = \(n \times T\)
  - \(n\) = # data channels used
  - \(T\) = Z axis collimation per data channel (mm)
- \(f\) = 0.87 rad/R for gamma rays in air

**Note:** CTDI\textsubscript{100} (Computed Tomography Dose Index) = MSAD for pitch =1 (using a 100 mm pencil chamber)
2.10.3.2 Acceptance Limits:
Per ACR effective July 1, 2013:

<table>
<thead>
<tr>
<th>Examination</th>
<th>Pass/Fall Criteria CTDI$_{vol}$ (mGy)</th>
<th>Reference Levels CTDI$_{vol}$ (mGy)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adult Head</td>
<td>80</td>
<td>75</td>
</tr>
<tr>
<td>Adult Abdomen</td>
<td>30</td>
<td>25</td>
</tr>
<tr>
<td>Pediatric Head (1 year old)</td>
<td>40</td>
<td>35</td>
</tr>
<tr>
<td>Pediatric Abdomen (5 year old, 40-50 lb)</td>
<td>20</td>
<td>15</td>
</tr>
</tbody>
</table>

Note: Per NYSDOH:
The resultant measurements should not exceed the following:

<table>
<thead>
<tr>
<th>Examination</th>
<th>CTDI VOL (mGy)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adult Head</td>
<td>75</td>
</tr>
<tr>
<td>Adult Abdomen</td>
<td>25</td>
</tr>
<tr>
<td>Pediatric Abdomen (5 yr. Old)</td>
<td>20</td>
</tr>
</tbody>
</table>

And the measurements shall not exceed:

<table>
<thead>
<tr>
<th>Examination</th>
<th>CTDI VOL (mGy)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adult Head</td>
<td>80</td>
</tr>
<tr>
<td>Adult Abdomen</td>
<td>30</td>
</tr>
<tr>
<td>Pediatric Abdomen (5 yr. Old)</td>
<td>25</td>
</tr>
</tbody>
</table>

or as listed in the manufacturer’s CTDI specification.

2.11 CT BEAM HALF VALUE LAYER

2.11.1 Purpose:
- To determine the amount of inherent filtration in a CT unit.

Note: If using a meter that has automatic HVL output, the aluminum and calculations unnecessary.

2.11.2 Procedure:

1. Set the CT scanner at 120 kVp and the commonly used mA setting.
2. Set the scanner such the tube is on the top of the gantry (Scout position).
3. Align the CT Ionization chamber in the beam.
4. Initialize the Calibrated R/F meter Dosimeter or MDH in the Pulse Exposure Mode.
5. Take an exposure, and record the mR.
6. Add 3.5 mm Aluminum between tube and chamber.
7. Take second exposure and record the mR.
8. Calculate the Half Value Layer (HVL) using the equation:

   \[ I = I_0 e^{-\mu x} \]

   Where:

   \( I \) = exposure reading with added filtration

   \( I_0 \) = exposure reading with no added filtration

   \( \mu \) = mass attenuation coefficient of Aluminum (cm²/gram)

   Using the above equation, and solving for \( \mu \), the HVL is calculated by:

   \[ \text{HVL} = \frac{0.693}{\mu} \]

2.11.3 Acceptance Limits:

- For a CT Unit operating at 120 kVp, the HVL should exceed 3.2 mm Al. (Reference: "QA and Radiation Exposure Levels in CT", CRC Handbook of Medical Physics Vol. II, page 325).

2.12 CALCULATION AND MEASUREMENT OF ENTRANCE SKIN EXPOSURE

2.12.1 Purpose:

- To be able to calculate the patient’s Entrance Skin Exposure for various examination projections.

2.12.2 Procedure:

- When possible all measurements are to be taken table top with a distance of 100 cm between focal spot and table top.
- Ion chamber must be placed 23 cm above table top.
- Techniques should be set to produce radiation outputs less than the 400 speed Max column of Appendix G of the New York State Department of Health, Bureau of Environmental Protection Guide for Radiation Safety/Quality Assurance Programs, but not more than twice the average per conference call with New York Department of Health February 25, 2013.
Radiation Output Measurements (mRem)

<table>
<thead>
<tr>
<th>Projection</th>
<th>SID</th>
<th>Average</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>A/P Lumbar Spine (100 cm)</td>
<td>100 cm</td>
<td>350</td>
<td>700</td>
</tr>
<tr>
<td>P/A Chest (183 cm)</td>
<td>183 cm</td>
<td>15</td>
<td>50</td>
</tr>
<tr>
<td>Abdomen Kidney Bladder (100cm)</td>
<td>100 cm</td>
<td>300</td>
<td>600</td>
</tr>
<tr>
<td>Full Spine (180 cm)</td>
<td>183 cm</td>
<td>145</td>
<td>290</td>
</tr>
<tr>
<td>Cervical Spine (100 cm)</td>
<td>100 cm</td>
<td>95</td>
<td>190</td>
</tr>
<tr>
<td>Lateral Skull (100 cm)</td>
<td>100 cm</td>
<td>70</td>
<td>140</td>
</tr>
</tbody>
</table>

*Exposure may not exceed 2 times the average except for chest which may not exceed 50 mR max.

**Note:** The techniques for the above provided by the department which is being tested.

2.13 COMPUTED RADIOGRAPHY (CR) QUALITY ASSURANCE

2.13.1 Equipment Monitoring

URMC has quality control tests to monitor equipment performance and maintain records of data collected. The tests performed vary from manufacturer to manufacturer but include those quality control checks specified by the manufacturer. If, at the time of inspection, significant equipment malfunctions are found URMC will perform more frequent testing to ensure good diagnostic image quality.

Appropriate quality control testing is conducted whenever major maintenance or a change in equipment operation (software change) occurs.

The CR cassettes are tested per manufacturer’s recommendations/directions. Computed Radiography quality control is maintained by performing the quarterly Total Quality Tool (TQT) on the cassettes, and the daily image checks documented using Fig. 2.13-1. All cassettes used in our system are tested twice per year using the CR Total Quality Tool’s cassette testing feature.

The following are evaluated from analysis of the flat-field image using the TQT:

- Field Uniformity
- Line Position
- Banding
- Chatter and Streaks

In addition, the cassette used for the flat-field test is re-read to evaluate the erase and system noise functions.
2.13.2 Frequency:

- Quarterly:
  - Perform a flat field (uniformity, streak, speed) TQT on a sampling of the cassettes.
  - Test 50% of the cassettes every quarter to ensure all cassettes are tested twice per year
- Semi Annual:
  - Perform preventative maintenance (PM) and checks on every CR reader per the specific PM procedure for the CR reader

In order to assure image quality on both the cassettes and CR readers the following are done:

- Daily:
  - all images are checked for quality/artifacts (documented in E-view)
- Weekly:
  - CR cassettes are erased.
- Quarterly:
  - Reject Analysis is performed – reasons for rejects are reviewed and corrective action is taken when necessary

Note: For other details, see:

- 3.7 CR PROCESSOR SAFETY CHECK AND PREVENTIVE MAINTENANCE
- 4.11 CR CASSETTE QA TEST PROCEDURES
- 4.18 ERASED SCREEN OF COMPUTED RADIOGRAPHY
- APPENDIX A: X-RAY QUALITY ASSURANCE USING COMPUTED RADIOGRAPHY AND PACS
Fig 2.13-1. Screenshot of an example technologist verification of image quality

Fig. 2.13-2. Screenshots of an example of a findings log
2.14 CT PATIENT DOSE CALCULATION

According to NYSDOH, CTDI\textsubscript{w} will be:

\[ \text{CTDI}_w = \frac{2}{3} \text{CTDI}_{100} \text{ peripheral} + \frac{1}{3} \text{CTDI}_{100} \text{ axial or center dose.} \]

Important: CTDI\textsubscript{w} represents an average dose in the X and Y plane.

Where “w” means weighted or blended dose.

The resultant measurements should not exceed the following:

<table>
<thead>
<tr>
<th>Examination</th>
<th>CTDI\textsubscript{VOL} (mGy)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adult Head</td>
<td>75</td>
</tr>
<tr>
<td>Adult Abdomen</td>
<td>25</td>
</tr>
<tr>
<td>Pediatric Abdomen (5 yr. Old)</td>
<td>20</td>
</tr>
</tbody>
</table>

And the measurements shall not exceed:

<table>
<thead>
<tr>
<th>Examination</th>
<th>CTDI\textsubscript{VOL} (mGy)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adult Head</td>
<td>80</td>
</tr>
<tr>
<td>Adult Abdomen</td>
<td>30</td>
</tr>
<tr>
<td>Pediatric Abdomen (5 yr. Old)</td>
<td>25</td>
</tr>
</tbody>
</table>

or as listed in the manufacturers CTDI specification.

**Also, per ACR:**

**CT pediatric head should not exceed: 35 mGy**

**And shall not exceed: 40 mGy**

With multiple slice helical scanning, the dose is better represented by CTDI\textsubscript{VOL} which takes into account the effect of pitch and averages over the X, Y, and Z plan. CTDI\textsubscript{VOL} represents the integrated dose over the total volume that is irradiated.

\[ \text{CTDI}_{\text{VOL}} = \frac{1}{\text{Pitch}} \times \text{CTDI}_w \]

Where VOL means total volume irradiated.
2.15 FILTRATION OR HALF-VALUE-LAYER CALCULATION USING MANUAL TECHNIQUES

2.15.1 Instrumentation:

- Calibrated R/F meter,
- Dosimeter/ kVp Readout.
- Ion Chamber,
- Sheets of aluminum of various thicknesses

*Note:* For CT half value testing, the Calibrated R/F meter chamber is parallel and iso-centered to the gantry. Aluminum is used only if Calibrated R/F meter does not output HVL measurements.

2.15.2 Procedure:

1. Use General Protocol 2.2, and remove any filters that can be casually removed.

2. Set the X-ray equipment at 100 kVp, 100 mA, and 0.1 sec. Or any other similar setting that gives about 300 to 400 mR with no filters added.

3. Position the R/F Ion Chamber at a SID of 100 cm, with the Calibrated R/F meter 22.9 cm above the table top (as noted in paragraph 2.2 above in the iso-center of the beam. Connect to the computer and turn power on.

4. Take two or three exposures and verify using the computer software that the kVp, mA and time output is within acceptable limits for the selected settings. The value displayed by the Calibrated R/F meter for half value layer is acceptable for the test result.

5. For manual measurement of the HVL, take another exposure adding the minimum HVL (Half Value Layer) of aluminum and record it. The output value must be greater than minimum HVL aluminum set.

6. Take two more exposures without filters to determine the precision of output measurements.

7. HVL data may be taken directly from the Calibrated R/F meter output. Manual calculation is performed at the user’s discretion. See the below method for appropriate calculations.
Calculate the HVL using the equation:

\[ I = I_o e^{-\mu x} \]

The equation, rearranged to solve for the HVL,

\[ -\frac{1}{X} \ln \left( \frac{I}{I_o} \right) = \mu \]

Where:

- \( I \) = final intensity, after adding filtration
- \( I_o \) = initial intensity with no filtration.
- \( X \) = thickness of aluminum filter added.
- \( \mu = 0.693/HVL \)
- \( HVL = 0.693/\mu \)

Solve the equation for HVL to obtain the HVL (beam quality).

Acceptance Limits:

<table>
<thead>
<tr>
<th>X-ray Tube Voltage Operating Range</th>
<th>kVp</th>
<th>HVL Al (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Below 50 kVp</td>
<td>30</td>
<td>0.3</td>
</tr>
<tr>
<td></td>
<td>40</td>
<td>0.4</td>
</tr>
<tr>
<td></td>
<td>49</td>
<td>0.5</td>
</tr>
<tr>
<td>50-70 kVp</td>
<td>50</td>
<td>1.2</td>
</tr>
<tr>
<td></td>
<td>60</td>
<td>1.3</td>
</tr>
<tr>
<td></td>
<td>70</td>
<td>1.5</td>
</tr>
<tr>
<td>Above 70 kVp</td>
<td>71</td>
<td>2.1</td>
</tr>
<tr>
<td></td>
<td>80</td>
<td>2.3</td>
</tr>
<tr>
<td></td>
<td>90</td>
<td>2.5</td>
</tr>
<tr>
<td></td>
<td>100</td>
<td>2.7</td>
</tr>
<tr>
<td></td>
<td>110</td>
<td>3.0</td>
</tr>
<tr>
<td></td>
<td>120</td>
<td>3.2</td>
</tr>
<tr>
<td></td>
<td>130</td>
<td>3.5</td>
</tr>
<tr>
<td></td>
<td>140</td>
<td>3.8</td>
</tr>
<tr>
<td></td>
<td>150</td>
<td>4.1</td>
</tr>
</tbody>
</table>

For uncertified equipment, State law requires 2.5 mm Al for equipment that operates above 70 kVp.
3. TESTING PERFORMED BY CLINICAL ENGINEERING OR PRODUCT VENDOR

3.1 INTRODUCTION

The testing described in the following section is performed by assigned staff members in Clinical Engineering Department.

3.2 RELAMPING VIEW BOX FOR FILM

Purpose: To assure consistency of light output of all film viewers.

Procedure:

1. Disassemble unit and clean.

2. Replace the entire lamp and reassemble it.

3.3 MANUAL AND VISUAL CHECKS

Purpose: To check radiographic units for any visible deficiencies that are not covered in the other QC checks. These include any electrical or mechanical malfunctions in the system as well as equipment related to patient safety and comfort.

Performed by radiologic technologist.

Procedure:

Check the following items as they relate to the radiographic system:

1. SID Indicator marks – Check the accuracy of the SID indicator using a tape measure. Measure this from the spot mark on the tube housing to the Bucky tray. If the spot is not indicated, measure from a point 1” above bottom of the tube housing.

2. Perpendicularity – While the tube head is in position for Bucky radiography, check to see if the tube head, collimator, and crane appear to be perpendicular.

3. Angular Indicator – Use a level to make sure that the tube and collimator are level when angle indicator is set in the zero degree position.

4. Locks – Check to make sure that all tube crane locks lock in properly and release easily.

5. Field Light – Check to see that the field light is operational and that it is bright enough to see under normal operating conditions. Check for dirt and other debris.
6. Bucky Center Light – Center the tube to the center of the Bucky tray by using the Bucky centering light. Pull the overhead tube crane over the tray and inspect to make sure that the light beam center falls over the same location as the Bucky centering light.

7. Cables – Visually inspect all cables to insure there are no bare or frayed wires, that all are properly supported, and that none are kinked when head is moved to extreme positions. Additionally, check any or all foot switches to insure they are in good working condition and all ground lines are intact.

8. Overhead Crane Movement – Move the crane around the room to ensure the crane moves easily and encounters no obstructions.

9. Bucky Lock – Examine Bucky lock for smooth operation and make certain the cassette lock functions properly.

10. Table Angulation & Center Stop – For tilting tables, check that the table is level in the zero degree position and that it stops in the center position.


12. Doors – Inspect all doors for proper seals by closing the door. If there is more than one door, lock the door furthest from the control panel when doing a survey or taking an exposure to avoid any possible incidents.

13. Panel Lights – Visually inspect all panel and crane lights for any that may be burned out. Report any failures to the department lead. Make sure all switches function properly.

14. Aprons, Gloves, Gonad Shielding – Inspect all gloves, aprons, and gonad shielding for any apparent tears or holes and report as necessary.

Acceptance Limits: These items are spot checked daily by the technologists. If there are any identified problems, rectify them as necessary through the maintenance work order process. A formal safety check is performed semi-annual by technologist. Serious problems may need to be brought to the attention of Clinical Engineering or Radiation Safety Unit.
3.4 DIAGNOSTIC MONITOR QUALITY CONTROL CHECK FOR IMAGING SCIENCE DIAGNOSTIC WORKSTATIONS

Purpose:
To assure the Imaging Science Diagnostic Workstation’s diagnostic monitors are uniform in color (if capable) and brightness and free of dead pixels so they provide a diagnostic high quality image.

A. Radiation Safety/Quality Assurance Responsibility
The term “Primary Diagnostic Monitor” or PDM is used to describe monitors that are used by practitioners to make primary diagnosis. Monitors that are used by teleradiology services for off hour’s interpretations are considered PDMs. Testing of PDMs is of primary importance to reduce radiation exposure and optimize diagnostic image quality. This is based on the ALARA principle to ensure that the benefits of the use of ionizing radiation exceed the risks to the individual and the public health and safety.

This PDM QC program oversight is the responsibility of the Radiation Safety Officer. The responsibility for performing PDM equipment preventive Maintenance/testing falls upon several different groups (medical physicists, radiologic technologists, and in-house engineering) for various aspects of equipment evaluation and/or performance. The medical physicist at the radiation Safety Unit should be consulted and maintain technical oversight of the PDM QC program.

Each department that has PDMs shall have quality control tests to monitor equipment performance and maintain records of data collected. The tests performed may vary from manufacturer to manufacturer but must include those quality control checks specified by the manufacturer and be modeled after the program below.

Departments with equipment under warranty or service contract with an Original Equipment Manufacturer (OEM) or an Independent Service Organization (ISO) must follow the testing and preventive maintenance schedule required by the OEM or ISO to keep the warranty or contract valid. The OEM or ISO testing and maintenance schedule must be included in the manual. Departments with equipment not under warranty or service contract must follow the testing frequency stated in this section. Departments must perform all the QC tests which their manufacturer-supplied phantom will allow. Appropriate quality control testing must be conducted whenever major maintenance or a change in equipment operation (software change) occurs.
Note: “PACS IT” is identified as the group that performs each test.

Note: Radiation Safety Officer or a Licensed Medical Physicist will test 10% of the monitors, including a sampling of Barco monitors, per year.

Note: Per NYSDOH, 10% of monitor evaluation by a medical physicist at an institution is acceptable if:
- There is oversight of the process by the medical physicist, e.g. the PACS IT team is reporting results on a regular basis (quarterly is acceptable)
- Physicians are still responsible for cleaning, and that the weekly cleaning and test is performed.

Note: A memo of understanding will be developed and sent to each physician that says that physicians do not do a final diagnostic interpretation from their home.

B. Records
1. Manual
The manual includes the following items:
- List of tests to be performed and the frequency of performance;
- List identifying which individual or group will be doing each test;
- Written description of the procedure that will be used for each test;
- List of all the variables which comprise the operating conditions for each test procedure;
- Acceptability limits for each test;
- List of the equipment to be used for testing;
- Sample records to be used for each test.

2. Equipment Records
Records shall be maintained for each monitor currently in operation and include:
- Initial test results (acceptance testing and other documentation as appropriate);
- QC test results for the current year;
- One set of QC test results from each intervening year to show changes over time.

Records of repairs and other pertinent data shall also be available.

3. QC Records for Test Equipment
Records shall be maintained and available for review for QC test equipment that requires calibration. QC records may be maintained in either a hardcopy or softcopy format, but must be available for review during inspections and whenever else they are needed.

C. Equipment Monitoring

Frequency:
- Weekly: Visual image quality checks
- Quarterly: Image quality check
- Annual: Full calibration
Definitions:

1. **Weekly Image quality check** (see special note below)

Radiologist - are being prompted **weekly** to perform visual checks for SMTP, all white screen, all black screen, and three color blocks (red, green, blue). Check if the monitor is capable of displaying color, their name is recorded within the QA tracking database. It has not been fully deployed and is still a work in progress; the Radiologists will be prompted to clean the monitor and must respond they did. Our current instance of RadinetPro and QAWeb tracks the visual check activities for reporting.

**Note:** If monitor is not regularly used, then this test must be done before clinical use.

**(Special Note:** New York State requires only a **bi-weekly** check. The **weekly** check is currently weekly because of vendor supported software requirements).

**Test details:**

a. Using the software provided by your PACS/PDM vendor, display a SMPTE test pattern. Evaluate the SMPTE test pattern considering the following criteria:
   - Grayscale squares should be easily differentiated at each step, 0% through 100%
   - High and low contrast resolution patterns should be of high integrity in the center and all four corners. -95% -100% and 0% -5% patches should be easily visible
   - Grid lines should be straight with no distortion.

b. Each monitor must be thoroughly cleaned with an appropriate cleaning solution and cloth. The PDM vendor should be able to provide recommendations for an appropriate cleaning solution and cloth.

c. Display an all-white image, either using PACS/PDM software, or by using window width and window level adjustments to make a clinical image all-white. On visual inspection, brightness should appear uniform on each PDM. If two or more PDMs are grouped to form a PDM workstation, there should be no noticeable difference in brightness between individual PDMs in the workstation.

d. Display an all-black image, either using PACS/PDM software, or by using window width and window level adjustments to make a clinical image all-black. On visual inspection, the black should appear uniform on each PDM, and each PDM should have the same color tone. If two or more PDMs are grouped to form a PDM workstation, there should be no noticeable difference in brightness between individual PDMs in the workstation.

e. If the PDM is capable of displaying color, an appropriate test pattern must be displayed and evaluated for color trueness. The test pattern should contain objects of three colors, displaying shades of red, green, and blue. Objects should not be distorted.
II. Quarterly Image quality check

- PACS IT every 3 months will perform Luminance and Grayscale tests on each of the candidate diagnostic monitors.
- Quarterly time example; October is the first month of the QA quarter, the last month of this quarter is December. January is the first month of the next QA quarter.
- Workstations equipped with Barco diagnostic monitors have auto (non-manual) quality assurance checks performed on them, a server application controls and tracks results. Manual inspection is not required.
- Non-Barco equipped diagnostic workstations need to have the quarterly diagnostic monitor QA performed on them.
- All manually inspected workstations need to have (quality control) QA performed on their diagnostic monitors once each quarter.
- The suggested process is to perform manual checks on approximately one third of the candidate monitors per quarter month, at the end of the quarter all workstations will be complete.

Test details:

a. If the workstation and PDM has software allowing verification of DICOM calibration of the Grayscale Standard Display Function (GSDF) to be performed, GSDF verification should be performed at quarterly intervals, with full GSDF calibrations recommended annually.

b. If the PDM does not have software allowing verification of DICOM GSDF calibration, full GSDF calibrations should be performed quarterly.

c. DICOM GSDF calibration verifications and calibrations will typically be made using the vendor-supplied photometer (often called a “puck” or inherent in the display device itself) and software resident on the workstation.

   i. For PDMs not used for mammography, the maximum luminance output of each PDM must be no less than 171 cd/m², with a luminance ratio (defined as the ratio of maximum luminance to minimum luminance) no less than 170 (ref. ACR Technical Standard for Electronic Practice of Medical Imaging, 10/01/07; AAPM Task Group 18 OR-03). Maximum luminance of at least 200 cd/m² and a luminance ratio of 250 or greater are recommended.

   ii. For PDMs used for mammography, the maximum luminance output of each PDM must be no less than 250 cd/m², with a luminance ratio no less than 250. Maximum luminance of 450 cd/m² and a luminance ratio of 500 or greater are recommended.
Equipment needed:

- Diagnostic workstation
- Monitor cleaning wipe
- Quality control software
- Photometer calibration sensor

Quarterly Image Quality Check Procedure

For both monochrome and color monitors:
1. Launch the quality control application by clicking the RadiCS icon in the system tray and choosing Advanced Mode.
2. After the RadiCS menu appears choose luminance check.
3. Input Tester Name (enter your initials or name into the box that appears).
4. Attached the photometer calibration sensor to a USB port on the desktop.
5. Hold the photometer calibration sensor in the center of the white crossed square.
6. Reply ok to start the luminance check.
7. If a message appears indicating “Luminance check failed”, reposition the calibration puck and repeat the same process.
8. If repeated luminance checks still fail, follow on screen prompts and perform a calibration on the monitor (use Annual Calibration Procedure that appears below in this document).
9. If the calibration fails contact the vendor if the monitor is under warranty. If no warranty, the monitor must be replaced. The system should not be used diagnostically until the monitor issue is resolved.
10. Continue to the next step if the luminance check passes.
11. Using the RadiCS menu again click on task and choose grayscale check.
12. When prompted verify your initials and click ok.
13. Hold the photometer sensor in the center of the white crossed square.
14. Reply ok to start the grayscale check.
15. Reply Exit to the grayscale check passed message.
16. Repeat as needed for additional monitors, this process is complete.
17. If a message appears indicating “Grayscale check failed”, reposition the calibration puck and repeat the same process.
18. If repeated Grayscale checks still fail, follow on screen prompts and perform a calibration on the monitor (use Annual Calibration Procedure that appears below in this document).
19. If the calibration fails contact the vendor if the monitor is under warranty. If no warranty, the monitor must be replaced. The system should not be used diagnostically until the monitor issue is resolved.
III. Annual Full Calibration

- Once a year PACS IT will perform a manual full calibration on all non-Barco diagnostic monitors using an approved calibrated photometer. Yearly Barco monitor calibrations will be facilitated by the Barco QAWeb server utilizing the monitor’s built-in I-Guard photometer.
- The URMC Radiation Safety Officer or someone from his group that is a Licensed Medical Physicist will support 10 percent of these calibrations.
- Along with full calibration, Luminance and Grayscale tests are perform on each of the diagnostic monitors.
- The documentation associated with the testing of the monitors will be reviewed annual during one of the quarterly radiology QA meetings and be recorded as a part of the meeting minutes.

Test details:
To verify the accuracy of the vendor-provided photometer and software, PDMs should be evaluated annually by a Licensed Medical Physicist. Using an external calibrated photometer, the following represents the minimum set of tests to be performed:

- Perform a DICOM Grayscale Standard Display Function (GSDF) verification using a stand-alone photometer and compare with the results obtained using the vendor-supplied photometer.
- Review of all facility QC documentation and procedures for PDMs.
- Quantitative assessment of the brightness (luminance) uniformity of each PDM.
- Quantitative determination of the luminance ratio.
- Quantitative assessment of the viewing conditions.
- Analysis of all test results, including comparison with specifications provided by the vendor and applicable technical standards from professional societies.
- Document recommendations for quality improvement and corrective actions.

Equipment needed:
- Diagnostic workstation
- Monitor cleaning wipe
- Quality control software
- Photometer calibration sensor

Annual Calibration Procedure

For both color and monochrome monitors:
1. Launch the quality control application by clicking the RadiCS icon in the system tray and choosing Advanced Mode.
2. After the RadiCS menu appears left click the Calibration icon and click proceed.
3. Input Tester Name (enter your initials into the box that appears).
4. Click ok to proceed.
5. Attached the photometer calibration sensor to a USB port on the desktop.
6. Tilt the monitor back slightly and hang the photometer on the monitor using the counterweight to allow the photometer to be centered in the small square in the center of the monitor (or using masking tape, securely tape the photometer centered in the small square).
7. Follow the onscreen test information and prompts.
8. Reply Exit to the Calibration check passed message.
9. When calibration is complete, results are shown graphically.
10. View graph, confirm that the actual values (dots) are in-line with the expected values (line).
11. Repeat for each additional monitor as needed.
12. If a message indicates “Calibration failed”.
20. If the calibration fails contact the vendor if the monitor is under warranty. If no warranty, the monitor must be replaced. The system should not be used diagnostically until the monitor issue is resolved.

**Note:** The I-guard only needs to be calibrated if the LCD panel is replaced. Refer to email from Barco Service Representative:

-----Original Message-----
From: Barco Service Representatives [mailto:service.medical.usa@barco.com]
Sent: Tuesday, January 06, 2015 10:04 AM
To: Mistretta, Richard; Forrester, James; aditya.seth@barco.com
Cc: Mis, Frederic; MacDougall, Kevin; Conover, David
Subject: RE: Barco monitor internal calibration photometer question [ref:_00D207r5g.50020hGLix:ref ]

Good Morning Richard,
I have heard back from the engineers. We do not have any think in writing. They say the I-guard only needs to be calibrated if the LCD panel is replaced otherwise there is no requirement to calibrate the I-guard.

John
3.5 PORTABLE UNIT CENTERING ALIGNMENT

Purpose: To assure that the x-ray field is accurately aligned with the light field.

Procedure:
1. Place a commonly used size of cassette on a tabletop. Make sure x-ray head is centered. Adjust x-ray head to give 40 inches to tabletop.

2. Turn on collimator field light and place four radio-opaque rulers on the four sides of the light field as in any normal collimation test (see section 2.10 Collimation Alignment). Place an object in the upper right hand corner to designate orientation, and place another object in the center of the cross-hairs to serve as a center marker.

3. Expose film at 50 kVp and 3 to 6 mAs.


5. Draw a diagonal line through the x-ray field of corners 1 to 4 and 2 to 3. The distance between the intersection of the lines and the center marker is recorded as the centering alignment.

Acceptance limits: The centering alignment shall be within 2% of the SID. For 40 inches this is 0.8 inches.

(For acceptance limits regarding field length and width see section 2.10 COLLIMATOR ALIGNMENT).

3.6 CT LASER ALIGNMENT

Purpose: To assure the accuracy of the laser alignment guides.

Procedure:
1. Insert the Lucite rods into the holes of the phantom (the rods should be pushed in no further than the edge of the phantom).

2. Center the Lucite head phantom in the beam using the laser alignment guides.

3. Take a trial scan.

4. The small holes in the Lucite rods appear as a "crow's foot" pattern on the scan when the phantom is centered.

5. If not centered, move the table in 5mm increments, and repeat the scan until centered. Acceptance Limits: The "crow's foot" pattern must be evident on the scan.

Note: See more detail in Appendix J: CT Imaging Performance QC – page J7.
3.7 CR PROCESSOR SAFETY CHECK AND PREVENTIVE MAINTENANCE

Purpose: To ensure the CR processor is mechanically sound, free of light leaks and calibrated according to manufacturer’s recommendations.

PURPOSE: To ensure the CR processor is mechanically sound, free of light leaks and calibrated according to manufacturer’s recommendations.

FREQUENCY: Performed per manufacturer’s recommendations. See reference below. In addition, if the Radiologic Technologist finds artifacts/inconsistencies on processed images, Imaging Engineering evaluates and repairs the system. The processor is taken out of service until image quality and functionality are determined.

PROCEDURE: Performed by SMH Imaging Engineers

1. All aspects of the Cassette Handling System are inspected and cleaned.

2. Using the Diagnostic software, perform the following tests:
   - light test
   - slow scan current calibration
   - slow scan current and velocity test
   - Laser Power
   - Glavo Test
   - MPT test
   - Glavo Plot

RESULTS: If all internal tests pass and the PM are completed, a “pass” result is entered in the Imaging Engineering Reporting System. If a test fails, Imaging Engineers trouble shoot the equipment and make necessary repairs contacting the vendor for assistance as needed. CR Process is taken out of service until repairs are made and image quality is tested. CR Processor is taken out of service until repairs are made and image quality is tested.

References:
- Preventative Maintenance for the Kodak DirectView CR 800, System Service Code 3519, April 2009;
- Preventive Maintenance for the DirectView CR 825/850, Systems Service Codes 4825, 5634. June 2011,
- Preventative Maintenance for the Kodak DirectView CR 900, System Service Code 3520. March 2002
3.8 INSTALLATION OF NEW EQUIPMENT/ TUBE OR OUTPUT CHANGE

Install new X-ray equipment, changing a new tube or X-ray dose output changed significantly, when it happen following things shall be done:

1. Radiation Protection Surveys

2. Acceptance testing

3. Average patient’s exposures for common X-ray examinations


4. POLICIES OF THE IMAGING SCIENCE DEPARTMENT

Purpose:
All medical x-ray equipment on NYS registration is included in this QA program. A complete up to date listing of the specific equipment is maintained in Clinical Engineering and Radiation Safety.

All standard radiographic and fluoroscopic units including portables and C-arms are to be tested using the standard protocols where applicable. Special equipment such as CT scanners and medical accelerators will be maintained under contract or by in-house service.

All view-boxes and laser film processors are to be tested using the standard protocols. A complete up to date list of specific equipment is maintained by Clinical Engineering.

4.1 PROCEDURES FOR PREGNANT WORKERS

It is the policy of the University of Rochester to allow radiation workers to make an individual decision regarding exposure to radiation. When a worker becomes pregnant, special provisions may be considered on an annual basis.

The University Radiation Safety Manual Section 7.2, the dose to the embryo or fetus shall not exceed 500 mR in the nine months gestation period (monthly total effective dose equivalent no more than 50 mR) according to the Nuclear Regulatory Commission in Regulatory Guide 8.13, Instruction Concerning Prenatal Radiation Exposure and NYSDOH 16.6(h), Dose to an embryo/fetus.

New employees at the University of Rochester are trained using the guidance from Regulatory Guide 8.13 and are advised to consult Radiation Safety if they have special concerns at the time of pregnancy. This is also discussed in periodic in-service training sessions in the Diagnostic Radiology Department.
4.2 USE OF GONADAL SHIELDING

At least 0.5mm lead equivalent of shielding is to be used on all patients not past the reproductive age during any procedure in which the gonads may be in the direct x-ray beam as required in part 16 of NYSDOH section 16.53(b)(6), 16.56(c)(3) and 16.57(c)(2).

Such shielding should be provided when following conditions exist:

1. The gonads will lie within the primary x-ray field, or within close proximity (about 5 cm or 2 inches), despite proper beam limitation.

2. Specific area testicular shielding shall be used during those examinations in which the testes usually are in the primary x-ray field, such as examinations of the pelvis, hip, and upper femur.

3. Specific area testicular shielding may also be warranted during other examinations of the abdominal region in which the testes may lie within or in close proximity to the primary x-ray field, depending upon the size of patient and examination techniques and equipment employed. As basis for judgment, Specific area testicular shielding should be considered for all examinations of male patients in which the pubic symphysis will be visualized on the film. The only exceptions are examinations where the shielding would interfere substantially with the diagnosis.


4.3 SHIELDING DURING SCOLIOSIS EXAMINATIONS

A protective “stole” type shield of at least 0.5 mm lead equivalency is to be used on all adolescent and adult patients during radiographic studies to protect sensitive breast tissue.

4.4 PREGNANT PATIENTS

1. Purpose:
To ensure female patients receiving Imaging Sciences Radiologic Exams, utilizing ionizing radiology (x-ray, CT, nuclear medicine), and/or any exam that requires IV contrast (CT, MRI, Angio/Interventional) are not pregnant prior to receiving said exams.

1.1 Any exams of the abdomen/pelvis/femurs and/or exams with IV contrast require a urine pregnancy test to be performed on females from menses to menopause.

2.0 Exclusion criteria
2.1 In general x-ray & CT- exams that are performed from the diaphragm up and from the knees down
2.2 total hysterectomy
2.3 IUD in place (intrauterine device)
2.4 Un-reversed tubal ligation
2.5 Implantable or intramuscular contraception (Norplant-subcutaneous, Depo-Provera IM injection)
2.6 Post menopause (1 year without menstruation)

Notes:
- **Any plain film image from diaphragm up** is excluded from requiring pregnancy test; however appropriate patient shielding is required.
- **For X-ray, CT or fluoro:** Refusal by a patient to have a pregnancy test performed requires signing of non-pregnancy waiver, call to Radiologist/resident/PA and patient education on the risks associated with fetal radiation exposure and fetal IV contrast exposure.
- **For MRI:** Refusal by a patient to have a pregnancy test performed requires signing of a non-pregnancy waiver, call to Radiologist/resident/PA to change protocol and patient education on the risks associated with fetal radiation exposure. MRI will be performed without gadolinium contrast.
- **In life threatening situations** or in Level I/ Level II trauma patients, IV contrast/images may proceed without pregnancy testing.

4.5 HOLDING OF PATIENTS

1. No person shall be exposed to radiation unnecessarily when there is an alternative way of restraining a patient, such as the use of restraining devices.

2. A person who works regularly with radiation shall never be subjected to unnecessary radiation exposure by holding patients.

3. No person shall be habitually exposed to radiation by holding patients.

Reference: Guidelines from Radiation Technologist Licensure Law, Article 35, Part 89

4. Rules for holding patients
   - Hold only when restraining devices will not work
   - Technologists may not hold
   - Fertile women may not hold
   - Individuals under 18 years of age may not hold
   - Protect holding individual with apron and gloves
   - Monitor the individuals’ exposure with a dosimeter
   - Record the results of monitoring in the log book that is kept with the dosimeter
4.6 EQUIPMENT MAINTENANCE

A pink service request form for the maintenance of x-ray equipment and ancillary equipment (film processors, alternator [film viewer]) is completed by the X-Ray Technologist requesting service. The sheet is attached to the defective machine after the user calls Ext. 55501 for service. The user is asked to provide an equipment ID number and a description of the problem. When corrective action is taken, the service engineer completes the pink form and returns it to the Chief Technologist. Engineers maintain records of all service performed in a database as wells as the Chief Technologist’s paper records. Service records are kept by Clinical Engineering electronically.

When a certified component is installed on existing x-ray equipment, the in-house installer will notify Radiation Safety that they need to test the corrected device. Radiation Safety will test the unit and verify compliance.

4.7 IMAGING SCIENCE PURGE CRITERIA FOR RADIOGRAPHIC FILMS

IMAGING POLICY.

1. Six years after the last exam, a patient’s x-ray file including all sub-files, such as nuclear medicine and angiography, will be purged.

The only exceptions are:

a) Pediatric patient films that must be retained until age 25 and six years after the last exam.

b) Mammography films are never purged. If the patient’s folder is “purge able”, remove the mammography films from the patient’s folder and file them in the designated filing area specifically for mammography films.

2. When film files are purged, the reports will be separated from the films and disposed of using the Iron Mountain confidential bins. The films will be processed through the silver recovery program.

3. If any faculty member outside Imaging Sciences has a need for the films after the purge date, it will be their responsibility to store them.

4. If a patient has multiple master film jackets and the date of the last insert is older than eight years, the jackets may be purged. All mammography films will be moved forward to the most recent retained jacket at the time of purging.

4.8 TECHNIQUE CHARTS

Technique charts are posted at each x-ray control unit. Data provided includes:

1. Part to be imaged
2. Distance
3. mA/time or mAs and kVp factors to be used
4. Automatic exposure (photo timing, ionization chambers) technique data as to correct detectors and kVp levels to be utilized per body part
4.9 PURCHASE SPECIFICATIONS AND ACCEPTANCE TESTING

Purpose: To assure that the appropriate equipment is specified and that the installed equipment meets the specifications.

Procedure:

1. Specifications for equipment involve input from two major sources. The Purchasing Department attaches all legal and warranty requirements of the University. The Radiology Department supplies data for performance criteria.

2. Through conversations with involved radiologists, physicians, physicists, clinical engineering and Radiologic Technologists, the requirements of the room are determined. This data includes:
   - maximum kVp and mA
   - type of generator
   - table requirements
   - number of tubes
   - fluoro magnification
   - timer requirements
   - phototiming needed
   - type and number of tube hangers
   - fluoro requirements
   - recording devices
   - electrical considerations
   - any other special needs

3. A number of manufacturers are asked to provide specification sheets on equipment that would meet the basic requirements of the room.

4. The Clinical Engineering Department has stored a number of previous specifications on an excel processor. By selecting a room closely associated with the desired room, a printout is obtained as a worksheet. The worksheet may be modified to meet the specific needs of the new room.

5. Using this worksheet, manufacturers’ data and information from staff, a final version of the room specifications is prepared. These are minimum requirements to allow as many companies as possible to quote on them.

6. Before acceptance of any unit for use and payment, Clinical Engineering and a Physicist perform testing of all parameters to ensure that the requirements of the specifications are met. The records of this testing is maintained for the life of the equipment to allow comparison testing in future years.

7. All Federal Compliance Certification Forms shall be submitted to Radiation Safety as a part of the Acceptance Testing Report. Prior to installation, Radiation Safety will be requested to complete a “Physicist’s Report” specific to the location and equipment, as required by Part 16.
4.10 IMAGE CONSTANCY QC PROCEDURE for KODAK DRY VIEW LASER IMAGERS

Purpose: To ensure the constancy of density of the Dry View Laser Printers.

Procedure (written by Kodak):

1. From the local panel, select the green button with two asterisks’
2. Verify the contrast and Dmax values are equal to 3.0
3. Use the next, pink, button to scroll down the menu to Density Test, select print, grey, button to print SMPTE film.
4. Use the return, yellow, button to return back to the main menu.
5. Record densities from, 0% patch, 10% patch, 40% patch, and 90% patch.
6. Compare each patch density to its baseline for each Dry View Laser.

Acceptance Limits: Patch Densities must be within + or – 0.15 of the baseline.

Corrective Action: If any of the patch densities are not within the baseline limits call Clinical Engineering for a service request.


4.11 CR CASSETTE QA TEST PROCEDURES

4.11.1 CR Cassette Flat Field Image Testing Procedure

Purpose:
To assure the CR screens are uniform and free of scratches, artifacts and dust in order to provide a diagnostic high quality image. The testing data is compiled using information gathered from Kodak’s TQT application for performing Flat Field Test. The Kodak TQT software tests for uniformity, fast streaks, slow streaks and speed deviation.

Frequency:
a) Report results annually.
b) Test 100% annually but with an ongoing, quarterly 10 % sampling per NYSDOH Bureau of Environmental Radiation Protection, Guide for Radiation Safety/Quality Assurance Programs Computed Radiography.

Equipment Needed:

1. Instadose dosimeter
2. Kodak Quality Tool Test Kit – includes phantom, phantom tray and filters.
3. Kodak CR Reader
4. Kodak TQT software loaded in CR
5. X-ray Equipment
Procedure:
Performed by Radiologic Technologist

Preparation

1. Clean the Phosphor screen in each cassette to be tested
2. Run all cassettes to be tested thru the CR and “erase”
3. Move the x-ray tube to 72” above a clean floor.

4. Place the phantom tray on the floor and tape the tray to the floor so that it can be kept in place.
5. Collimate the beam of light so that the edges of the light are on the outer edges of the tray.
6. Use tape to fasten the copper and aluminum filters together.
7. Slide the filters into the collimator box with the copper on top, nearest to the x-ray tube. Use tape to attach to the collimator box.

Note: In order to assure that the correct technique is used, proceed with the following prior to performing initial test:

- Place a protective lead apron on the phantom tray.
- Place a dosimeter on top of the protective lead apron.
- Procedure for the 14” x 17” cassette: Set the equipment to make an exposure level of 5mR +/- .2. Start with 80 kVp at 20 mAs. If the exposure level is outside this range adjust your mAs up or down as needed.
- Procedure for the 10” x 12” cassettes. Set the equipment to make an exposure level of 10 mR +/- .2. Start with 80 kVp at 40 mAs. If the exposure level is outside this range, adjust your mAs up or down as needed.
- Expose the dosimeter three more times to ensure a consistently correct exposure level.
- Remove the protective apron and dosimeter from the phantom tray.

EXPOSING THE CASSETTE.

1. Place a 14” x 17” cassette on the phantom tray with the ID indicator in the upper right corner. Expose the cassette using the predetermined settings. Turn the cassette so that the ID is in the lower left corner. Expose the cassette again.

2. Place a 10” x 12” cassette on the phantom tray with the ID indicator in the upper right corner. Expose the cassette once using twice the mAs as you used in a single exposure on the 14” x 17” cassette.

3. Continue exposing as many cassettes as needed to be tested as above.

4. Wait 5 minutes between exposure and CR reading.
**PROCESSING THE CASSETTES**
1. From the CR system main menu,
   a. Touch Key Operator, touch quality tool, touch cassette test, touch flat field image test.
2. When you see LOAD Cassette, load the Cassette. When the message changes to “Processing Complete”, check the results.
3. Continue testing cassettes as above.

**EXPORTING THE TEST DATA SUMMARY**
1. On the Cassette Screen Test page, touch Test Data.
2. Open the CR system door and insert a blank formatted floppy disk into the disk drive and close the door.
3. Touch Export

**FAILED CASSETTE**
1. If a cassette fails, set the cassette aside for a minimum of 5 minutes and retest it. Before retesting, open the cassette and clean the screen.
2. If cassette passes, set aside for another 5 minutes and then re-test again to ensure 2 consecutive passes. If cassette fails a second time send out for service.

**4.11.2 LONG LEG IMAGING (LLI) CR CASSETTE QA PROCEDURE**

**PURPOSE:** To assure the LLI CR screens are artifacts and stitching is uniform in order to provide a diagnostic high quality image.

**FREQUENCY and PROCEDURE:** - performed by Radiologic Technologist
1. Erase the LLI cassettes prior to use to remove any scatter and/or dust artifacts.
2. If artifacts are noticed, remove the screen and visually inspect and clean.
3. Inspect clinical images prior to accepting/sending to PACS. If stitching offset is noted, report to vendor for evaluation/repair.


Procedure Revisions made on 7/12/06, by Mary Ellen Wilson, R.T.R.M.- Revised 2/2/2007, 9/28/2011 mew, 6/7/12ajz, 3/30/15 mew
4.12 QC – REPEAT / REJECT ANALYSIS

The testing described in this section is performed by assigned staff members in The Radiology Department.

Purpose: To provide a method for the analysis of the rejected exposures

Procedure:

1. Once per quarter collect data pertinent to the incidence of rejected exposures from the CR readers and DR units throughout the department of Imaging Sciences.

2. Analyze this data by determining the reasons that these exposures were rejected.

3. Determine the overall reject rate by calculating, the total number of rejected exposures compared to the total amount of exposures taken.

4. Determine the percentage of rejects for each reason category that is utilized.

5. The results are trended and compared with previous reports

6. The section Chief Technologist and QA technologist review the results, write a report and implement any corrective action. A complete report is sent to the Radiation Safety Department, and also retained within the department of Imaging Sciences.

Corrective Action: Overall results are trended and any discrepancies are addressed. Equipment issues are reported to Clinical Engineering and repairs are requested. Technologist image quality is monitored and remedial training is provided as necessary. Technique charts are reviewed to assure proper image quality and exposure indexes are maintained.

Note: In addition to the quarterly reject analysis the section supervisors and the radiologists constantly monitor image quality looking for artifacts, uniformity, exposure index and patient positioning. Equipment repairs are made and additional technologist training is provided as necessary.

References: New York State Department of Health, Bureau of Environmental Radiation Protection, Guide for Radiation Safety/Quality Assurance Programs, Appendix D. Data collection is dependent on utilizing Carestream Health CR and DR software.
4.13 PERIODIC TESTING OF PROTECTIVE DEVICES

Purpose: Aprons, gonad shields, gloves and other protective devices are evaluated periodically to determine if there are any defects in the lead (cracks, tears, etc) that may affect the ability to shield radiation.

Procedure:

Note: Each department or unit that possesses protective aprons, gloves, gonad shields, or other protective devices is responsible for inspecting these devices twice a year. Department personnel or unit designated staff will perform these inspections.

1. Each item is inventoried, and then visually and manually inspected for any defects such as holes, cracks, or tears. If the integrity of the lead is uncertain it may be discarded.

2. Lead shields found to be defective or no longer needed are discarded through the Radiation Safety Unit to ensure proper disposal of lead.

3. Each item shall be assigned a unique identifying number and a log shall be maintained to account for all items and inspections.

4. A copy of the Final Report is retained by the Department where the lead resides and a copy is also sent to the Radiation Safety Unit indicating the results of the inspection and the point of contact.

4.14 MAMMOGRAPHY QUALITY ASSURANCE

4.14.1 PHANTOM IMAGE

Purpose: To assure that image quality due to the x-ray imaging system, and DICOM printer, are maintained at optimal level.

Instrumentation:

i. 18 x 24 cm compression paddle

ii. ACR mammographic accreditation phantom that approximates 4.5 cm compressed breast of 50-50 tissue composition (i.e., RMI 156 by Radiation Measurement, inc)

iii. Acrylic disc, 4mm thick with 1.0 cm diameter, placed on the top of the mammographic Accreditation phantom as per the 1999 ACR mammography Quality Control Manual as phantom imaging section.

iv. Magnifying lens, same as used clinically. Previous and original mammographic accreditation phantom images.
Procedure:

Simplified AEC Method

1. It is important for performing this test that the kVp and Filter selection is done at a thickness of 4.5 cm.

2. Re-open the Weekly QC examination created for the artifact or SNR/ CNR test or create a test patient on the acquisition Work station.

3. In case the previously acquired ACR image is used, move to Data Analysis and interpretation section of test.

4. Install the 18 x 24 cm compression paddle in the compression device.

5. Follow the next steps or move to the Alternate Equivalent AEC Test Method to complete this procedure.

6. Center the phantom laterally on the image receptor and position it so the chest wall edge of the phantom is aligned with the chest wall side of the image receptor.

7. Lower the compression device so that the compression paddle sits on the phantom trying to achieve compression thickness as close to 4.5 cm as possible.

8. Select the phantom view from Patient View screen on the Acquisition Workstation.

9. Select AEC Sensor poison 2 and make an exposure at the clinically used exposure setting (for example, Auto-Filter).

10. Accept the image in the preview window of the Acquisition Workstation monitor.

11. Close the procedure.

Alternate equivalent AEC Method – Clinically equivalent technique to acquire a phantom image under 4.5 cm compressions in clinically used AEC mode without using compression

1. Set the system to the clinically used AEC mode (for example, Auto-Filter).

2. Lower compression paddle, without the phantom in place, until the compression device reads 4.5cm.

3. Record kV and filter indicated on the AWS screen.

4. Raise the compression paddle.
5. Center the phantom laterally on the image receptor and position it so the chest wall edge of the phantom is aligned with the chest wall side of the image receptor.

6. Lower the compression paddle to barley touch the phantom.

7. Change the AEC Mode to Auto-Time.

8. Change the kV and filter to the values recorded in step 3 of this alternate test procedure.

9. Select the Phantom view from the examination screen window on the Acquisition Workstation.

10. Select AEC Sensor position 2 and make an exposure.

11. Accept the image in the preview window of the Acquisition Workstation monitor.

12. Close the procedure.

**4.14.2 RECORD FORMS**

Use the Phantom Control Chart in this manual to record the phantom scores

**4.14.3 DATA ANALYSIS AND INTERPRETATION**

**Note:** The 1999 ACR Mammography Quality Control Manual, Phantom Images section must be consulted to perform data analysis and interpretation of the phantom image quality. Numerous points made in the ACR Mammography Control Manual apply in digital mammography.

Use one of the following two methods to score the phantom image quality, as it best applies to your practice. In the case of a Mobile Selenia with no access to a DICOM printer or a diagnostic review workstation, the third method may be used as an alternative.

Scoring the Phantom Image on a Film Printout

1. Select Image Management from the Admin Menu

2. Search for the patient name with the mammographic accreditation phantom image previously acquired.

3. Select the thumbnail image of the mammographic accreditation phantom.

4. Select the DICOM printer as the output device under the drop-down list in the Resend Tab.

5. Ensure that the Apply Mammo Image Processing and Print True Size options are checked and click on Resend.

7. Record the results in the record form and in the Phantom Control Chart


Scoring the Phantom Image on a Diagnostic Review Workstation

1. Select Image Management from the Admin Menu.

2. Search for the patient name with the mammographic accreditation phantom image previously acquired.

3. Select the thumbnail image of the mammographic accreditation phantom.

4. Select the diagnostic review workstation as the output device under the drop-down list in the Resend Tab.

5. Score the phantom image on the workstation display, using the procedure described in the 1999 ACR Mammography Quality Control Manual, Phantom Image Section.

6. Record the results in the Phantom Control Charts.

Scoring the Phantom Image on the Mobile Lorad Selenia Acquisition Workstation

In the event that the Mobile Lorad Selenia does not have access to a printer or a diagnostic review workstation, it is appropriate in this case to score the phantom image on the display of the acquisition workstation following the procedure below. Since the display used on the acquisition workstation is of lesser quality compared to the display of the diagnostic review workstation, a passing score on the acquisition workstation will guarantee a passing score on a diagnostic review workstation (true for Lorad Selenia FFDM systems, only). A failing score on the acquisition workstation will be interpreted as a failure unless overruled by a passing score on a printed film or a diagnostic workstation. A failing score on the acquisition workstation may be used as a passing score only if that particular failing score has been previously confirmed as a passing score on either a printed film or on a diagnostic workstation.

1. Click the phantom image thumbnail to review the image if the preview window is already closed.

2. Click the Zoom/Pan icon to go into the “zoom and pan” to display the phantom image in full resolution.

3. Score the phantom image on the acquisition workstation display using the procedure described in the 1999 ACR Mammography Quality Control Manual, Image Quality Evaluation section.
4. Record the results in the record form and in the Phantom Control Chart (1999 ACR Mammography Quality Control Manual, Phantom Image section).

**Note:** Critical evaluation of mammographic phantom images may reveal subtle artifacts or variances on phantoms that are not visible with screen-film image receptors. Artifacts associated with the phantom may be identified by repeating the phantom image with the phantom slightly rotated. Artifacts that move with the rotation of the phantom are caused by the phantom and not the imaging system. It is strongly recommended that the same phantom be used to evaluate phantom image quality over time. Should a different phantom (serial number) be used for this QC test, the medical physicist must be consulted to determine the possibility of manufacturing variability in the phantom itself when evaluating these images, even if the phantoms have the identical manufacturer model number.

**Note:** The phantom image evaluation shall be done per Selenia FFDM system either by using a hard copy image (digitally printed film) from a single printer or by reviewing the phantom image on a single diagnostic review workstation. Since the purpose of this test is to qualify the image quality of the Selenia FFDM system, a single evaluation per Selenia is adequate. For a Mobile Selenia the instructions given above shall be followed.

### 4.14.4 RECOMMENDED PERFORMANCE CRITERIA AND CORRECTIVE ACTION

The phantom image quality shall meet the minimum passing score shown below.

**ACR Mammography Accreditation Phantom**

<table>
<thead>
<tr>
<th>Component</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fibers</td>
<td>5.0</td>
</tr>
<tr>
<td>Speck Groups</td>
<td>4.0</td>
</tr>
<tr>
<td>Masses</td>
<td>4.0</td>
</tr>
</tbody>
</table>

**Minimum Passing Score**

There may be small fluctuations in scoring of the fibers and masses due to phantom variations. If the fiber score is 4.5 and or the mass score is 3.5 then examine the SNR and high contrast resolution of the system. If both those exceed recommended criteria, then a total score of 4.5 fibers, 4.0 specs, and 3.5 masses is acceptable.

If the Phantom score fails to meet recommended criteria as specified above, a qualified service engineer shall correct the problem before using the system for clinical imaging.
4.14.5 EVALUATION OF SYSTEM RESOLUTION

Objective

To evaluate imaging performance, using system limiting spatial resolution as a performance indicator, this may be easily measured in the field.

Required Equipment

- 18 x 24 cm compression paddle
- High contrast resolution pattern providing a test up to 15 cycle/mm (c/mm, or lp/mm) with 1 c/mm steps in the range 5-15 c/mm.
- 4 cm thick acrylic or BR-12 attenuating block

Test Procedure

1. Create a test pattern on the acquisition Workstation.

2. Place the attenuation block on top of the image receptor to cover its entire surface. If the attenuation block is not wide enough to cover the digital image receptor from direct exposure, tape the blocks under the collimator window.

3. Install the 18 x 24 cm compression paddle in the compression device.

4. Raise the compression paddle to a height of 4.5 cm as indicated by the thickness display on the compression device. Use a ruler to verify the height and adjust accordingly, if necessary.

5. Place the resolution test pattern on top of the compression paddle. Position the pattern within 1 cm of the chest wall edge of the image receptor, centered laterally. The test pattern lines shall be at 45° to the anode-cathode axis.

6. Select the Flat Field view from the examination screen window on the acquisition workstation and make a manual exposure at 28 kVp, 65 mAs, Mo/Mo target-filter combination, LFS.

Record Forms

Use System Limiting Spatial resolution form to record the results

System Limiting Spatial Resolution

X-ray Tube Manufacturer

Model #
Nominal focal spot size (mm)

Target material

Nominal kVp setting

Nominal mA setting

mAs

Limiting resolution in cycles per mm

Action Limit:

If limiting resolution with the bars at 45° relative to the anode-cathode axis is not greater than 7 cycles/mm, contact a qualified service engineer.

Data Analysis and interpretation

1. Click on the zoom/Pan icon to go into “zoom and pan” to display the resolution pattern in full resolution.

2. Move the pattern to the center of the preview display.

3. Determine the highest frequency lines that are distinctly resolved (and ensure the correct number of lines is visualized) across some part of the resolution pattern. There are likely to be regions where the pattern fades from being resolved, due to imperfect alignment of the bar pattern with the image matrix. Once the blur is seen across the entire length of the lines, a phase shift (bright lines shift to dark, and vice versa), or aliasing (fewer bars are visualized), record this frequency as the limiting spatial resolution.

4. Accept the image in the preview window of the acquisition workstation monitor.

Recommend Performance Criteria and Corrective Action

The system limiting spatial resolution must be greater than 7 c/mm (lp/mm)

If these criteria are not met, a qualified service engineer must correct the problem before using the system for clinical imaging.
4.15 QUALITY CONTROL GUIDANCE

MQSA and Manufacturer’s requirement for the Radiologic Technologist

Propose: Assure quality control of printer (DICOM) preserved as manufacture recommended

Regulation Action Level

Control Values

SMPTE Grayscale Patch

Control Limits

Mid Density
40% ± 0.15

Density Difference
10% - 40% ± 0.15

Low Density
90% ± 0.15

If the test results fall outside the control limits, the source of the problem shall be identified and corrective actions shall be taken before printing any more clinical or phantom films. Breast Imaging Department has the complete Quality Control Guidance.

KODAK CARESTREAM MAMMOGRAPHY WORKSTATION QC

TEST FREQUENCY PERSON RESPONSIBLE

Monitor cleaning Daily Mammography Tech

Viewing Conditions Check Daily Mammography Tech

Image Quality Monthly Mammography Tech

Viewing Conditions Check and Settings Annual Medical Physicist

Monitor Luminance / Gray Scale Calibration Annual Medical Physicist

Image Quality Annual Medical Physicist
Kodak Dry View 6800 Laser Imager QC Tests

TEST FREQUENCY PERSON RESPONSIBLE

Density Constancy Weekly Mammography Tech
Low Contrast Visibility Semi-annual Mammography Tech
Spatial Resolution Semi-annual Mammography Tech
Artifact Annual Mammography Tech
Grayscale Response Annual Medical Physicist
Geometry Annual Medical Physicist
Phantom Image Quality Annual Medical Physicist

Selenia QC Test

4.16 CT QUALITY ASSURANCE

A) For Philips (Brilliance)
Use Quick IQ test phantom and procedure

Test 1: CT Number Uniformity (system phantom calibrations and check)
Propose: Assure calibrated as manufacture recommendation

Test 2: Imaged Slice Thickness
Propose: Slice width measurement. Measure slice thickness at 10.0 +/- 1.0mm, at 5.0 +/- 0.5mm, at 0.050 +/- 0.05mm

Test 3: Slice Positioning Accuracy
Purpose: Laser Alignment / Table Incrementation Allowed Misalignment of +/- 1mm

Test 4: CT Number Scale Accuracy
Purpose: Contrast Linearity.
Typical values (depends on version of Software installed):
Water 0 +/- 4, Polyethylene -75 +/- 15, Teflon 1017 +/- 51, Lexan 116 +/- 15, Acrylic 140 +/- 15
Test 5: Hardcopy Output Device

Purpose: Grayscale Linearity

Test 6: Spatial Resolution

Purpose: Impulse / Response. Standard 1.50 +/- 0.20, High 0.685 +/- 0.115, Ultra High 0.49 +/- 0.11

Test 7: Low Contrast Detectability

Purpose: Low Contrast Resolution Must visualize 5 of the 6 pins within the Aculon circle

New X-Ray tube Installation: Perform test 1,2,3,4 & 5 (Use Quick IQ test phantom and procedure)

Within 30 days: Full acceptance test including tests 6 & 7

Film Measurement of Radiation Beam Profile with Gafchromic Film.

Note: See manufacture specs for passing criteria.
Note: See ACR CT Accreditation Program for testing and criteria for dose and image quality.

4.17 MAINTENANCE REVIEW

Purpose: To assure that equipment is being maintained in a timely fashion and to detect any trends or problem areas.

Procedure:

1. A maintenance log shall be established for each x-ray generator. This log will be maintained on the Clinical Engineering Computer System.

2. When a problem with an x-ray machine is found, the technologist shall call 275-5501 or 273-5084, notifying to the Clinical Engineering about the problem. The service request will be entered into the computer log.

3. When the problem is corrected the service engineer will record the date corrected or note the parts needed to be ordered or explain why correction has not been made. This will be entered computer log.

4. Any outstanding problems that are related to the State Code will be reported to the Department Chairman and if uncorrected after 30 days, the details will be reported to the Chairman of the Radiation Safety Committee with the recommendation that the equipment be temporarily removed from service until corrections are made.
4.18 ERASED SCREEN OF COMPUTED RADIOGRAPHY (CR)

**Purpose:** To verify screens are being adequately erased and that there are no sources stray light entering the light entering the cassette

**Frequency:** Weekly

**Procedure:**

*Note:* These are typical steps for a CR reader. They may not apply to all models of CR readers. Follow your specific CR reader’s instructions for erasing cassettes.

1. Each section supervisor collects CR cassettes in their specific section.
2. Use the cassette erase button on the main menu screen. Select the erase button. Follow prompt to insert cassette to be erased. When it finishes, continue to insert all the cassettes to erase. The reader will post the number of the cassette being erased.
3. When done, go back to the main menu.
4. Record in the Log Book
5. Pick one cassettes out of the group erased and process it to verify it was erased/has a low index

**Acceptance Limits:**
The processed, erased image / cassette index should be low – less than 100

**Corrective action:**
Cassettes that don’t seem to be erasing properly are taken out of service

**Note:**
- In addition to weekly procedure, - on a daily basis the section supervisor collects any cassettes that are not put back where they belong and processes the cassettes. This practice reduces the chance of making an inadvertent double exposure.
- **LOW VOLUME CR** areas where cassettes are used less than once per week: No need to erase the cassettes every week if they weren’t used.
  **Perform Cassette Erase Process prior to patient use.**

Mew 8/2011
4.19 FLUOROSCOPIC DOSE MONITORING & TRACKING POLICY

After all fluoroscopy exams, both the air kerma (Gy) and Dose Area Product (DAP) (Gy cm$^2$) will be recorded in the patient record. If the fluoroscopy equipment does not display air kerma or DAP then the total fluoroscopy time for the exam time is recorded.

5. QUALITY ASSURANCE OF MRI PROGRAM

5.1 INTRODUCTION

This manual was developed based on the MRI Quality Control Manual published in 2004 by the American College of Radiology (ACR). Test procedures and acceptance limits have been adapted for the MRI systems at the University. Daily SNR test, echo planar imaging (EPI) stability test and additional tests for RF coils built at the University are added. Dr. Edmund Kwok developed this chapter.

5.2 QUALITY ASSURANCE COMMITTEE

• Supervising radiologist

• QC technologist

• MRI physicist

The committee shall meet quarterly for the purpose of reviewing the records of testing in the previous year. A summary report of this meeting and the findings shall be forwarded to the University Radiation Safety Committee. Minutes of the meetings shall be kept for a minimum of three years.

5.3 THE FUNCTIONS OF THE QA COMMITTEE

1) The supervising radiologist is to:

a) Conduct initial assessment of image quality at the establishment of QC program

b) To regularly monitor QC results

2) The QC technologist’s role includes:

a) Regularly performing a set of short QC procedures

b) Recording the procedure results in a QC notebook

c) Initiating appropriate correction actions
A designated QC technologist should be assigned to each particular piece of equipment to improve consistency.

3) The role of MRI physicist includes:

a) Baseline performance test
b) Define action limits for weekly QC tests
c) Identify and initiate correction actions
d) Conduct review of the QC notebook maintained by the technologist every 3 months.
e) Review and sign completed data form
f) Semi-annual system performance evaluation
g) RF coil evaluation every three months
h) Acceptance testing

5.4 QUALITY CONTROL PROCEDURES

5.4.1 INTRODUCTION

Quality control of MRI includes:
• Acceptance testing
• Baseline performance
• Detection of changes
• Verification of correction

5.4.2 GE SNR TEST

Instrumentation: GE head phantom, standard head coil

Purpose: To conduct daily SNR test according to GE recommendation.

Procedure:

1. Use “QA SCAN-DAILY” protocol under “site protocol” list.

2. Acquire the single scan series and save the image data.
Acceptance Limits: Data to be used by GE.
Protocol Parameters: Spin echo sequence, TR/TE=300/20ms, bandwidth 15.6kHz, FOV 24x24cm, slice thickness 10mm, space 10mm, 3 slices (S50-S10), image matrix 256x256, 1 NEX, and acquisition time 1:23 minutes.

5.4.3 VISUAL CHECKLIST

Purpose: To ensure the MRI system patient bed transport, alignment indicator lights, RF room integrity, safety lights, signage and monitors are present and working properly and are mechanically and electrically stable.

Procedure: Visual inspection of the above listed item.

Acceptance Limits: Each of the items listed in the visual checklist should pass or receive a check mark. (See more detail: Appendix O- MRI Quality Control Manual, ACR, page 59)

5.4.4 TABLE POSITIONING

Instrumentation: ACR MRI phantom, standard head coil

Purpose: To determine the setup and positioning accuracy.

Procedure:

Follow the ACR Phantom Imaging Procedures in Appendix 5 - Section A, and acquire the sagittal localizer T1 series.

Note: the position of the central grid structure on the phantom on the sagittal image.

Acceptance Limits: Center of the sagittal image of the phantom is within +/- 2mm of the central grid structure on the phantom. See more detail: Appendix O- MRI Quality Control Manual, ACR, page 35

5.4.5 CENTER FREQUENCY

Instrumentation: ACR MRI phantom, standard head coil.

Purpose: To determine the center frequency (water proton resonance frequency)

Procedure:

1. Follow the ACR Phantom Imaging Procedures in Appendix A, and acquire the sagittal localizer T1 series.
2. Download the ACR T1 series, and use auto-prescan to automatically check and display the center frequency.

3. Record the center frequency in the fourth column of the Data Form for Weekly MRI Equipment Quality Control (see appendix R).

Acceptance Limits: Resonance frequency should not deviate by more than 1.5ppm (95.8 Hz for 1.5T and 192 Hz for 3.0 T) between successive weekly measurements for GE and Siemens MR scanners. For Philips MR scanners, it should not derivate by more than 0.1ppm/hour (150 Hz/day for 1.5T and 100 Hz/day for 1.0 T) as specified by Philips Health Care. The center frequency is checked and adjusted to proper value during periodic maintenance service (every 2 to 3 month) by the system field engineers. (For more details see Appendix O-MRI Quality Control Manual, ACR, page 36-38)

5.4.6 TRANSMISSION GAIN

Instrumentation: ACR MRI phantom, standard head coil

Purpose: To determine the transmission gain

Procedure:

1. Follow the ACR Phantom Imaging Procedures in Appendix A, and acquire the sagittal localizer T1 series.

2. Download the ACR T1 series, and use auto-prescan to automatically check and display the transmission gain (TG) value.

3. Record the TG value in the fifth column of the Data Form for Weekly MRI Equipment Quality Control (see appendix R).

Acceptance Limits: Transmission gain should be less than 120 for GE scanners and less than 336 for Siemens 3.0T TRIO scanner, less than 0.7 for Philips 1.0T Panorama scanner and less than 1.05 for Philips 1.5T Achieva scanner (For more details see: Appendix O-MRI Quality Control Manual, ACR, page 39)

5.4.7 GEOMETRIC ACCURACY

Instrumentation: GE head phantom, GE standard head coil

Purpose: To test the degree of geometrical distortion present in images produced by the MRI system
Procedure:

1. Geometric accuracy is checked with the ACR MRI accreditation phantom using the sagittal localizer image and image slice #5 from the T1-weighted ACR axial series.

2. Display the sagittal image of the phantom. Set the display window and level so that the edges of the phantom are approximately at the half-maximum value of the signal intensity.

3. Using the distance measuring function, measure the length from one end of the signal-producing region to the other. Ensure that the length is measured along a line that runs vertically from one end of the phantom to the other and is close to the center of the phantom.

4. Enter the resulting length (in millimeters) in column #6 of the Data Form for Weekly MRI Equipment Quality Control (see appendix R).

5. Display slice #5 of the Axial T1-weighted images. Set the display window and level so that the edges of the phantom are approximately at the half-maximum value of the signal intensity.

6. Use the scanner’s distance measuring function to determine the diameter of the signal-producing circular phantom, measured vertically through the center of the phantom.

7. Enter the resulting length (in millimeters) in column #7 (y-direction) of the Data Form for Weekly MRI Equipment Quality Control.

Acceptance Limits: Length measurement in the sagittal image: 148+/- 2mm; length measurements in the axial T1 weighted: 190+/- 2mm. (For more details see: Appendix O-MRI Quality Control Manual, ACR, pages 40 - 43)

5.4.8 HIGH CONTRAST RESOLUTION

Instrumentation: ACR MRI phantom, standard head coil

Purpose: To assess the scanner’s ability to resolve small objects.

Procedure:

1. Display the image of slice #1 of the ACR T1-weighted axial series. On the image, there is a resolution insert with three array pairs: for the left pair the hole diameter is 1.1mm, for the center pair it is 1.0mm and for the right pair it is 0.9mm.

2. Magnify the image by a factor of two to four, keeping the resolution insert visible in the display.

3. Begin with the left most pair of hole arrays, which is the pair with the largest hole size, 1.1mm.
4. Look at the rows of holes in the upper left (UL) array, and adjust the display window and level to best show the holes as distinct from one another.

5. If all four holes in any single row are distinguishable from one another, the image is considered resolved right-to-left at this particular hole size.

6. Enter the smallest hole-size (1.1, 1.0 or 0.9) that can be resolved in UL array in column #9 of the Data Form for Weekly MRI Equipment Quality Control (see appendix R). That is the measured right-left resolution.

7. Look at the rows of holes in the lower right (LR) array and adjust the display window and level to best show the holes as distinct from one another.

8. If all four holes in any single column are distinguishable from one another, the image is considered resolved top-to-bottom at this particular hole size.

9. Enter the smallest hole size (1.1, 1.0, 0.9) that can be resolved in LR array in column #10 of the Data Form for Weekly MRI Equipment Quality Control (see appendix R). That is the measured top-bottom resolution.

Acceptance Limits: Image resolution of 1.0mm or better in both right-left and top-bottom directions. (For more details see: Appendix O-MRI Quality Control Manual, ACR, pages 44 – 46).

5.4.9 LOW CONTRAST RESOLUTION

Instrumentation: ACR MRI phantom, standard head coil

Purpose: To assess the extent to which objects of low-contrast are discernible in the images.

Procedure:

1. Low-contrast detectability is checked with the ACR MRI accreditation phantom using one of the image slices 8-11 from the T1-weighted ACR axial series.

2. Display the slice to be scored. Adjust the display window width and level settings for best visibility of the low-contrast objects.

3. Count the number of complete spokes. Begin counting with the spoke having the largest diameter holes; this spoke is at 12 o’clock or slightly to the right of 12 o’clock, and is referred to as spoke 1. Count clockwise from spoke 1 until a spoke is reached where one or more of the holes are not discernible from the background.

4. The number of complete spokes counted is the score for this slice. Record the score in column #11 of the Data Form for Weekly MRI Equipment Quality Control.
5. If the action criteria are exceeded, recheck the phantom positioning. Tilting in the head-foot direction can be particularly troublesome. Ensure that the slices 8-11, are actually positioned over the thin plastic sheets in the phantom that contain the holes. Acquire the axial series again.

Acceptance Limits: For 1.0T and 1.5T systems, total score not less than 9 spokes for each image series. For the 3.0T system, total score should not be less than 37 spokes for each image series. (For more details see: Appendix O-MRI Quality Control Manual, ACR, pages 47 – 50)

5.4.10 IMAGE ARTIFACT ASSESSMENT

Instrumentation: ACR MRI phantom, standard head coil

Purpose: To assess image artifacts.

Procedure:

1. Image artifacts are checked with the ACR MRI accreditation phantom using the image slices from the T1-weighted ACR axial series.

2. On each slice, adjust the display window and level to show the full range of pixel values in the image. The easiest way to get it right is to find the approximate pixel value for the bright areas, which can be done with a region-of-interest (ROI) measurement of the mean value in a bright area. Then, set the window to that value and the level to approximately half of that value.

3. Check that the following are true:

   a) The phantom appears circular, not elliptical or otherwise distorted.

   b) There are no ghost images of the phantom in the background or overlying the phantom image.

   c) There are no streaks or artifactual bright or dark spots in the image.

   d) There are no unusual or new features in the image.

4. If any of the foregoing items are false, then enter “Yes” in column 13 of the weekly QC data form; otherwise enter “No”.

Acceptance Limits: Center of the sagittal image of the phantom is within +/- 2mm of the central grid structure on the phantom. (For more details see: Appendix O-MRI Quality Control Manual, ACR, page 51)
5.4.11 LASER FILM QUALITY CONTROL

Instrumentation: Densitometer, Laser Imager Printer, SMPTE pattern

Purpose: To ensure artifact-free laser films are produced with consistent grey levels that match the image appearance on the filming console.

Procedure:

1. On the “Image Browser” page, put the cursor on an empty space and click on the right mouse button. From the list displaced, select “Service Tool” then “install SMPTE”. A study named “SMPTE” is generated. From the browser list, display the SMPTE test pattern on the console. Do not change the display window and level.

2. Set the DMAX of the Kodak DryView 8700 Laser Imager to 2.60. Film the SMPTE pattern. Use a 6-on-1 format and capture the pattern into all six frames.

3. Using a film densitometer, measure the optical density of the 0, 10%, 40% and 90% gray level patches of the SMPTE pattern in the upper left frame of the film.

4. Plot these optical densities in the appropriate places on the Laser Film QC chart. Circle any points that fall outside the control limits.

5. Put the film on a light box and inspect it for streaks, uneven densities and other artifacts.

Acceptance Limits:

SMPTE Patch Optical Density Control limits

0%  2.95 +/- 0.15
10% 2.00 +/- 0.15
40% 1.00 +/- 0.15
90% 0.30 +/- 0.08

(For more details see: Appendix O-MRI Quality Control Manual, ACR, pages 53 - 57)
5.4.12 SLICE POSITION ACCURACY

Instrumentation: ACR MRI phantom, standard head coil

Purpose: To check the accuracy with which axial slices are positioned at specific locations utilizing a sagittal localizer image.

Procedure:

1. Measurements are made for slices #1 and slices #11 of the ACR T1-weighted axial series.

2. Display the slice magnified on the monitor by a factor of two to four. Keep the vertical bars of the crossed wedges within the displayed portion of the magnified image.

3. Adjust the display window so that the ends of the vertical bars are not fuzzy using a fairly narrow display window. The display level should be set to a level roughly one half that of the signal in the bright portions of the phantom.

4. Use the viewer’s length measurement tool to determine the difference in length between the left and right bars. If the left bar is longer, then assign a minus sign to the length.

5. Enter the measured data on the MRI Equipment Performance Evaluation Data Form (see appendix Q).

Acceptance Limits: Bar length difference no more than 5mm. (For more details see: Appendix O-MRI Quality Control Manual, ACR, pages 95 – 96).

5.4.13 SLICE THICKNESS ACCURACY

Instrumentation: ACR MRI phantom, standard head coil

Purpose: To determine the accuracy of a specified slice thickness.

Procedure

1. Measurements are made for each of the ACR axial series.

2. Display slice #1 magnified by a factor of two to four while keeping the slice thickness insert (two thin opposed inclined ramps) fully visible on the screen.

3. Adjust the display level so that the signal ramps are well visualized.

4. Place a rectangular ROI at the middle of each signal. Note the mean signal values for each of these two ROI’s, then average those two values together. The result is a number approximating
the mean signal in the middle of the ramps. Be careful not to allow any portion of the ROI’s to be located outside of the ramps.

5. Lower the display level to one half of the average ramp signal calculated in step 3. Leave the display window set to its minimum.

6. Use the on-screen length measurement tool of the display station to measure the lengths of the top and bottom ramps. Record these lengths. Enter the values measured on the MRI Equipment Performance Evaluation Data Form (see appendix Q).

Acceptance Limits: Slice thickness = 0.2 x (top x bottom)/(top + bottom). Measured slice thickness should be 5.0mm +/- 0.7mm. (For more details see: Appendix O-MRI Quality Control Manual, ACR, pages 97 – 99).

5.4.14 INTER-SLICE RF INTERFERENCE

Instrumentation: ACR MRI phantom, standard head coil

Purpose: To evaluate inter-slice RF interference in multi-slice imaging.

Procedure:

1. Use the ACR T1-weighted axial multi-slice spin echo sequence and the ACR MRI accreditation phantom, setting gaps as indicated in Step #4 below.

2. Select the ACR T1-weighted axial series: FOV = 25cm, 256 X 256 matrix, 5mm slices, TR = 500, TE = 20, NSA = 1.

3. Position the slices so that they are centered on the uniform signal producing volume of the ACR phantom (slices #7 and #8 in the standard ACR series).

4. Repeat measurements altering the slice gap and the number of slices as indicated below:

Series # 1, 2, 3, 4

   No. Slices 11, 11, 11, 11

   Slice Gap (mm) 0, 0.5, 1.0, 5

5. Record the mean signal intensity and standard deviation of the background signal (noise).
6. Divide the average signal in the image of the phantom by the standard deviation of the background signal (noise). Measure the SNR for each of the image sets. Enter this value on the MRI Equipment Performance Evaluation Data Form.

7. Plot the data as a function of the percentage slice gap, normalized to the SNR obtained with the slice gap equal to 100% of the slice thickness.

Acceptance Limits: Cross talk effects should not reduce the SNR by more than 20% when comparing 100% gap to 0 gap images. (For more details see: Appendix O-MRI Quality Control Manual, ACR, pages 113–115).

5.4.15 SOFT COPY DISPLAYS

Instrumentation: Precision luminance meter, SMPTE pattern

Purpose: To verify that the display device meet the manufacturer’s published specifications for (1) maximum and minimum luminance, (2) luminance uniformity, (3) resolution, and (4) spatial accuracy.

Procedure:

1. Maximum and minimum luminance

a) Measure monitor luminance using a precision luminance meter. Record the data for the luminance meter on the MRI Equipment Performance Evaluation Data Form.

b) Measurements are performed on a monitor screen when the image displays are at their brightest levels. Set the window width and window level to their minimum values so that the monitor is uniformly at its brightest value.

c) Measure the luminance in the center of the image display area. Record this value on the MRI Equipment Performance Evaluation Data Form (see appendix Q).

2. Luminance uniformity

a) Measure the luminance at each of the four corners of the image display area. Record these values on the MRI Equipment Performance Evaluation Data Form.

b) Calculate the average of the luminance values measured in the four corners of the image display area. Record this value on the MRI Equipment Performance Evaluation Data Form (see appendix Q).

c) Calculate the percent difference of the luminance values measured in the image display area, using the following equations: \( \% \text{ difference} = 200 \times \frac{L_{\text{max}} - L_{\text{min}}}{L_{\text{max}} + L_{\text{min}}} \), where
Lmax and Lmin are the maximum and minimum measured luminance values, respectively. Record this value on the MRI Equipment Performance Evaluation Data Form (see appendix Q).

3. Resolution

a) Display the SMPTE pattern, and examine the pattern using a magnifying glass.

i) To display the SMPTE pattern on the GE 1.5T systems, select the “Image Browser” page, put the cursor on the background space and click the right mouse button. From the list displayed, select “Service Tool” then “install SMPTE”. A study named “SMPTE” is generated. From the browser list, display the SMPTE test pattern on the console.

ii) To display the SMPTE pattern on the Siemens 3.0T systems, copy the file “ServiceImage6.dcn” from c:\MedCom\service\testimages to c:\temp. From the “viewing” task card, click on “Transfer” tab, select “import from offline”, and then “ServiceImage6.dcm” from the list. Open examination “ServiceImages” to display the SMPTE pattern

iii) To display the SMPTE pattern on the Phillips systems, select “System” on the main menu user page. From the pop-up list, select “Advanced Tools” and then select “Service”.

b) The test is repeated with the pattern displayed in the corners of the monitor. Record observations as “comments” on the MRI Equipment Performance Evaluation Data Form (see appendix Q).

4. Spatial accuracy

a) Display the SMPTE pattern with 1 on 1 magnification. Overlay the screen with a similar grid pattern, and compare to the displayed image. Record observations as “comments” on the MRI Equipment Performance Evaluation Data Form (see appendix Q).

Acceptance Limits:

Maximum and minimum luminance: The maximum brightness of diagnostic quality monitors should exceed 90 Cdm-2 and the minimum brightness should be less than 1.2 Cdm-2.

Luminance uniformity: Each of the values obtained in the four corners of the screen should be within 30% of the maximum brightness measured in the center of the screen.

Resolution: The monitor should display a resolution bar pattern of 100% contrast when the spatial frequency of the bar phantom is equal to one half the monitor line frequency in both the vertical and horizontal directions. The monitor should pass the test in all regions.

Spatial accuracy: The monitor should not depict any noticeable changes in image intensity over the entire usable part of the screen. Lines depicted on the monitor should be straight to within ± 5mm. (For more details see: Appendix O-MRI Quality Control Manual, ACR, pages 116–117).
5.4.16 RADIO FREQUENCY (RF) COIL CHECKS

Instrumentation: Uniform phantoms that simulate the body part for each RF coil tested

Purpose: To evaluate the RF properties and imaging performance of RF coils

Procedure:

1. Position the RF coil in its normal clinical orientation. Place the phantom in an orientation that most closely represents the position of the body part of interest in the clinical scan. The center of the RF coil should be positioned as close to the center of the phantom as is practical.

2. Positioning aids, such as external references on both the coil and the phantom, should be noted and described in the QC procedures manual. The phantom should be marked to indicate the position of the RF coil with respect to the phantom.

3. Allow about 5 minutes for the solution in the phantom to settle down.

4. Run the ACR T1-weighted sequence with a slice positioned near the center of the RF coil and with the uniform signal-producing volume positioned in the image plane most often used in clinical practice.

5. Note the transmission gain on the MRI Equipment Performance Evaluation Data Form.

6. Record all pulse sequence and hardware parameters in their appropriate boxes on the MRI Equipment Performance Evaluation Data Form.

7. Volume Coil Tests

   a) Select an image depicting the center of the phantom that lies along the central axis of the phantom.

   b) Create a “mean signal region of interest” that covers 80% of the cross-sectional area of the phantom, as viewed in the image. This “mean signal ROI” defines the range in which measurements will be performed.

   c) Record the Mean Signal in the MRI Equipment Performance Evaluation Data Form.

   d) Set the window width to a small value. Adjust the window level so that the region of greatest signal intensity is depicted.

   e) Create a “measurement ROI” that is approximately 0.15% of the area of the FOV.

   f) Move the “measurement ROI” to the position of greatest signal intensity that is within the “mean signal ROI”.

80
g) Determine the mean signal value of all the pixels in the “measurement ROI”. This is the Maximum Signal. Record the value on the MRI Equipment Performance Evaluation Data Form.

h) Move the measurement ROI to the position of lowest signal intensity that is within the measurement range ROI.

i) Record the mean signal value of all the pixels in the measurement ROI. The ROI should be positioned in the center of the image and should not include any obvious artifacts. This is the Minimum Signal. Record the value on the MRI Equipment Performance Evaluation Data Form.

j) Move the measurement ROI to a position that is away from the phantom volume in the frequency encoding direction. This is the “noise ROI”. Be careful not to position the “noise ROI” in a region where the effects of the RF receiver filter are noticeable.

k) Determine the Background Signal as the mean value of all pixel intensities in the “Noise ROI” located on the image background. Record this value in the MRI Equipment Performance Evaluation Data Form.

l) Determine the Noise Standard Deviation as the root mean square value of all the pixel intensities in the “Noise ROI” located on the image background. Record the value in the MRI Equipment Performance Evaluation Data Form.

m) Move the measurement ROI to a position that is away from the phantom volume in the phase encoding direction. This is the “Ghost ROI”.

n) Record the Ghost Signal as the mean value of all the pixel intensities in the “Ghost ROI”, this is located on the image background.

o) SNR = Mean Signal / Noise Standard Deviation. Enter this value in the column labeled “Signal-to-Noise Ratio” of the MRI Equipment Performance Evaluation Data Form.

p) The percent image uniformity (PIU) = 100 x [1- (Maximum Signal – Minimum Signal) / (Maximum Signal + Minimum Signal)]. Enter this value in the column labeled “Percent Image Uniformity” of the MRI Equipment Performance Evaluation Data Form.

q) The percent signal ghosting (PSG) = 100 x | (Ghosts Signal – Background Signal) / (2 x Mean Signal)|. Enter this value in the column labeled “Percent Signal Ghosting” of the MRI Equipment Performance Evaluation Data Form.

Acceptance Limits: SNR within +/- one standard deviation. For regular head coil, PIU >= 90% at 1.5T and PIU >= 82% for 3.0T. Ghosting ratio < 3%.
5.4.17. SURFACE COIL TESTS

a) Select an image depicting the center of the phantom that lies along the central axis of the phantom.

b) Set the window width to a small value. Adjust the window level so that the region of greatest signal intensity is depicted.

c) Create a “measurement ROI” that is approximately 0.15% of the area of the FOV.

d) Move the “measurement ROI” to the position of greatest signal intensity that is within the phantom.

e) Determine the mean signal value of all the pixels in the “measurement ROI”. The ROI should be positioned so that it does not include any obvious artifacts. This is the Maximum Signal. Record the value in the MRI Equipment Performance Evaluation Data Form.

f) Move the “measurement ROI” to a position that is away from the phantom in the frequency encoding direction. This is the “noise ROI”. Be careful not to position the “noise ROI” in a region where the effects of the RF receiver filter are noticeable.

g) Determine the Noise Standard Deviation as the root mean square value of all the pixel intensities in the “noise ROI” located on the image background. Record the value in the MRI Equipment Performance Evaluation Data Form.

h) Maximum SNR = Maximum Signal / the Noise Standard Deviation. Enter this value in the column labeled “Maximum Signal-to-Noise Ratio” of the MRI Equipment Performance Evaluation Data Form.

i) Observe the signal intensity distribution and note on the MRI Equipment Performance Evaluation Data Form whether it generally appears the same as when previous measurements were performed on this coil. Save a hard copy of the image and record the window width and window level settings for future reference.

j) Observe the image and note on the MRI Equipment Performance Evaluation Data Form whether the image ghosting appears unusually high. If the ghosting does appear high, measure the PSG as described above Section 5.4.7.q.

9. Phased-array RF coils

a) Perform similar tests as for surface coils, with the signal obtained from all the coil elements in a phased-array coil.
10. Additional Tests for Coils built at U of Rochester

a) Visual inspection of the physical conditions of coils, paying particular attention to cables and connectors.

b) Check the resonance frequency and impedance of the coil using a network analysis.

Acceptance Limits: The resonance frequency of coil should be within ¼ of peak FWHM from the proton Larmor frequency, and the coil impedance should be between 30 and 150 Ohms. (For more details see: Appendix O-MRI Quality Control Manual, ACR, pages 100–112).

Procedure:

1. Select and acquire the multiple slice scan.

2. Display the “Stability Plot” series.

3. Note the peak-to-peak value and the standard deviation value from the central slice.

Acceptance Limits: peak-to-peak variation < 1.0%, standard deviation <0.15%


5.5 ACCEPTANCE TESTING

Acceptance testing should be conducted at new installation and after major upgrade.

In additional to the tests listed in Section 5.4, acceptance test also includes testing of all RF coils and verifying manufacturer’s test data to be within the system specifications.

5.6 BASELINE PERFORMANCE

Baseline performance of the weekly QC tests should be evaluated for each MRI system. Baseline performance data should be acquired over 10 days, from which action limits will be defined. The tests that require baseline performance are center frequency, transmission gain, film quality control, magnetic field homogeneity, and RF coil check.
5.7 TEST PROCEDURES AND RESULTS ACCESSIBILITY

All test procedures and results should be kept in a QC notebook at a central location near the MRI scanners.

A QC notebook includes:

1. Facility’s QC policies and procedures
2. The Data form where QC procedure results are recorded
3. Recording notes on QC problem & corrective actions

It should be accessible to all members of QC team and service engineers.

5.8 ACR PHANTOM IMAGING PROCEDURE

1. Select “ACR PHANTOM” protocol under “site protocol” list (Protocol pulse sequences and imaging parameters are listed in 5.9).

2. Obtain the sagittal localizing scan in series 1.

3. Position the 11 slices of the “ACR AXIAL T1” scan using the sagittal localizing scan, starting at the vertex of the crossed 450 wedges at the inferior end of the ACR phantom and ending at the vertex of the crossed 450 wedges at the superior end of the phantom.

4. Set up the acquisition of the axial slices through the length of the phantom, making sure that the slice prescription is referenced to structures in the phantom in a reproducible way.

5. Acquire the axial ACR T1-weighted scan.

6. Using the same slice positions as in the ACR AXIAL T1 series, acquire the ACR AXIAL T2 series in the protocol.

5.9 ACR PHANTOM PULSE SEQUENCE PROTOCOL

1. Sagittal Localizer

Spin echo sequence, 2D

TR = 200ms, TE = 20ms

Bandwidth = scanner default value
FOV = 25cm, 256 x 256 matrix
Slice thickness = 20mm, number of slices = 1
Frequency encoding direction = superior/inferior
Signal average = 1, scan time = 0:56 minutes

2. ACR Axial T1-weighted scan
Spin echo sequence, 2D
TR = 500ms, TE = 20ms
Bandwidth = Scanner default value
FOV = 25cm, 256 x 256 matrix
Slice thickness = 5mm, spacing = 5mm, number of slices = 11
Frequency encoding direction = anterior/posterior
Signal average = 1, scan time = 2:16 minutes

3. ACR Axial T2-weighted scan
Spin echo sequence, 2D
TR = 2000ms, TE1 = 20ms, TE2 = 80ms
Bandwidth1 = Scanner default value
Bandwidth 2 = same as bandwidth 1
FOV = 25cm, 256 x 256 matrix
Slice thickness = 5mm, spacing = 5mm, number of slices = 11
Frequency encoding direction = anterior/posterior
Signal average = 1, scan time = 8:56 minutes
(Evaluation form in Appendix Q and R)
6. NUCLEAR MEDICINE: QUALITY CONTROL GAMMA CAMERAS

6.1 PHILIPS SKYLIGHT DAILY:
- Bring camera heads together as close as possible
- Place C0-57 sheet source centered on camera head
- On computer select QC uniformity icon
- Acquire image to 15,000K
- Acquire BKG to 2K
- View image for uniformity
- Use QC tools program to calculate UFOV % and CFOV %
- Record data in quality control book
- Values should fall in the acceptable range
- If values outside the range, contact clinical engineering

6.2 PHILIPS SKYLIGHT WEEKLY:
- Bring camera heads together as close as possible
- Place C0-57 sheet source centered on camera head
- On computer select QC uniformity icon
- Acquire image to 25,000K
- Acquire BKG to 2K
- View image for uniformity
- Use QC tools program to calculate UFOV % and CFOV %
- Record data in quality control book
- Values should fall in the acceptable range
- If values outside the range, contact clinical engineering

6.3 PHILIPS SKYLIGHT MONTHLY RESOLUTION
- Place trihole resolution phantom on detector 1
- Acquire image to 1000K using 512X512 matrix
- Repeat for detector 2
- Review for resolution and linearity
- Record information in quality control book
- If any decrease in resolution and or linearity contact clinical engineering

6.4 PHILIPS SKYLIGHT MONTHLY COR
- Obtain 1mci Tc99m point source
- Place Tc99m source and cor holder on table
- Center source within fov of both detectors
- Select QC cor icon
- Follow requested directions
- Press start
- Once finished, select tools, diagnostics, cor
- Select the acquired cor data
- Calculation of pass/fail will be shown on screen
- Record pass in qc book
- If values failed, repeat
- If values still failed, contact clinical engineering

6.5 TRIONIX BIAD DAILY

- Remove table
- Bring camera heads together as close as possible
- Place C0-57 sheet source centered on camera head
- On computer select FLD 1&2
- Acquire image to 3000k
- Acquire BKG to 2K
- View image for uniformity
- If acceptable, record information in quality control book
- If not acceptable, contact clinical engineering

6.6 TRIONIX BIAD WEEKLY

- Remove table
- Bring camera heads together as close as possible
- Place C0-57 sheet source centered on camera head
- On computer select FLD 1&2
- Acquire image to 12000K
- Select user programs, uniformity check
- Record valves in quality control book
- Values should fall within acceptable limits
- If not acceptable, contact clinical engineering

6.7 TRIONIX BIAD MONTHLY RESOLUTION

- Place adac detector mask on camera head
- Place trihole resolution phantom on detector
- Acquire image to 1000K using 512X512 matrix
- Repeat for other detector
- Review for resolution and linearity
- Record information in quality control book

6.8 TRIONIX BIAD MONTHLY COR

- Obtain 1mCi point source
- Place Spect table
- Place source in head holder of Spect table
- Center source on table using cursor crosshairs
- Bring detectors to a radius of 20CM
- Set detector to 0 degrees
- Press enable
- Select CAL from computer
- Select COR
- Open MCA window
- Take off XY align oval
- Press set create and acquire data
- Print result page on place in QA book
- If values not acceptable, contact clinical engineering

6.9 QC PHILIPS BRIGHTVIEW DAILY

- Bring camera heads together as close as possible
- Place C0-57 sheet source centered on camera head
- On computer select QA uniformity icon
- Acquire image to 12,000K
- Acquire BKG to 2K
- View image for uniformity
- Use QC tools program to calculate UFOV % and CFOV %
- Record data in quality control book
- Place CT phantom on table in designated area
- Perform daily CT of phantom
- Use hybrid CAL icon to obtain HU on phantom
- Record CT phantom data in quality control book
- Values should fall in the acceptable range
- If values outside the range, contact clinical engineering

6.10 QC PHILIPS BRIGHTVIEW WEEKLY

- Obtain approx 1mCi TC99M source
- Place source in designated holder on floor
- Remove collimators and place cart out of the FOV
- Select intrinsic QA button to position detectors
- On computer select QC intrinsic icon
- Acquire to 25000K
- Use QC tools program to calculate UFOV % and CFOV %
- Record data in quality control book
- Values should fall in the acceptable range
- If values outside the range, contact clinical engineering
6.11 QC PHILPS BRIGHTVIEW MONTHLY RESOLUTION

- Obtain approx 1mCi TC99M source
- Place source in designated holder on floor
- Remove collimators and place cart out of the FOV
- Select intrinsic QA button to position detectors
- Place resolution bar phantom on detector 1
- On computer select QC resolution icon
- Acquire image to 1,000 K counts
- Repeat for detector 2
- View images for resolution and linearity
- If loss of resolution or linearity, contact clinical engineering

6.12 QC PHILIPS BRIGHTVIEW MONTHLY COR

- Obtain 1mCi TC99M point source
- Place TC99M source and COR holder on table
- Center source within FOV of both detectors
- Select QC COR icon
- Follow requested directions
- Press start
- Once finished, select TOOLS,DIAGNOSTICS,COR
- Select the acquired COR DATA
- Calculation of pass/fail will be shown on screen
- Record pass in QC book
- If values failed, repeat
- If values still failed, contact clinical engineering

NOTE: QC data stored for review

6.13 QC SIEMENS ECAM DAILY

- Remove collimators
- Place approx 20uCi - 30uCi in plastic vial
- Rotate camera to 0 degrees
- Raise table to 3.0 cm
- Pull source holder out and place vial in the holder
- Set up computer using QC daily program
- Acquire to 25000K
- Use intrinsic CALC
- Record values in quality control book
- If values unacceptable, contact clinical engineering
- Replace collimators, acquire BKG to 2K
- Record BKG values

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6.14 QC SIEMENS ECAM RESOLUTION MONTHLY

- Place trihole resolution phantom on detector 1
- Place CO57 sheet source on top of phantom
- Acquire image to 1000K 512 X 512 matrix
- Repeat for detector 2
- Record results in quality control book
- If loss of resolution or linearity, contact clinical engineering

6.15 QC SIEMENS ECAM COR

- Place approx 1mCi TC99M in 5 vials
- Align vials in MRH holder
- Position holder on ECAM table
- Acquire COR using MRH protocol
- Store data and record in quality control book

NOTE: QC data stored for review

6.16 OC DIGIRAD DAILY

- Place small CO57 sheet source on detector
- Setup acquire data to 12000K, using CO57 daily protocol
- Run QC program
- Acquire BKG count 2000K
- Record values in quality control book
- If values unacceptable contact clinical engineering

6.17 OC DIGIRAD WEEKLY

- Place small CO57 sheet source on detector
- Setup and acquire data to 25000K using CO57 protocol
- Run OC program
- Record values in quality control book
- If values unacceptable, contact clinical engineering
7. DENTAL CLINIC

7.1 INTRODUCTION

Radiography is an essential component of a dental diagnosis. Data demonstrates if delivered in sufficient doses, radiation may produce biological damage. However, it is not clear if radiation in doses required for dental radiography presents any risk. It is neither clear that these small doses are free of risk. For the practitioner, it is important to assure:

1) The dental radiographic examination is clinically indicated and justified.

2) The technique is optimized to ensure high-quality diagnostic images.

3) Proper technique used to minimize exposure to the patient, staff and the public.

4) That dose to operators and public are within limits established by NYSDOH.

5) That dose levels should keep to the ALARA principle.

7.2 ROLE OF THE DENTAL PERSONNEL OF RADIATION PROTECTION

The Dental facility RSO is responsible for:

1) Establishing, reviewing, and documenting radiation protection.

2) Instructing staff in radiation protection.

3) Implementing radiation surveys, recording results and corrective actions.

4) Implementing ALARA principle.

7.3 DENTAL X-RAY DEVICES

The dental x-ray must:

1) The operating potential of dental X-ray machines shall not be less than 60 kVp and shall not be more than 80 kVp.

2) Position-indicating devices shall be open-ended.

3) Source-to-imaging receptor distance for intraoral radiography shall not be less than 20 cm (7 inches) and should not be less than 40 cm (16 inches).

4) Panoramic radiography shall be capable of high speed (400 or greater) rare-earth screen film systems or digital image receptors.
5) Cephalometric radiography: only the fastest screen-film shall be used and shall be collimated to the area of clinical interest.

7.4 DENTAL FILM PROCESSING

Normalizing. Quality control is first started by establishing a baseline comparison film. The normalizing process should be carried out using normal bitewing technique settings and new developer solutions.

Instrumentation: X-ray densitometer

Procedure:

1) Place test tool on a flat surface.

2) The same flat surface should be used each time the test is performed to maintain the same amount of backscatter.

3) Insert an inter-oral film under the copper square and center the copper square under tube head cone.

4) The cone should be in contact with test tool (densitometer)

5) Expose the film and develop it as usual.

6) Insert developed film into the designated area and placed and the device on a view box.

7) Using the sliding seven-step filmstrip, match the density on the exposed film to a step on the sliding filmstrip.

The chart below from FDA

<table>
<thead>
<tr>
<th>kVp: 50</th>
<th>“D” Speed Film</th>
<th>“E” Speed Film</th>
<th>“F” Speed Film</th>
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</thead>
<tbody>
<tr>
<td>Lower Limit</td>
<td>425</td>
<td>220</td>
<td>170</td>
</tr>
<tr>
<td>Upper Limit</td>
<td>575</td>
<td>370</td>
<td>260</td>
</tr>
</tbody>
</table>

<p>| kVp: 55 | Lower Limit | 350          | 190            | 150            |
| Upper Limit | 500          | 270            | 220            |</p>
<table>
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<tr>
<th>kvp</th>
<th>lower limit</th>
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<td>180</td>
<td>90</td>
</tr>
</tbody>
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7.5 DENTAL X-RAY REPRODUCIBILITIES

Instrumentation: MDH (Radical Corporation) - model 1015 radiation monitor, Ionization Chamber (10 x 5-6) and Ionization Chamber (10 x 5-180).

Purpose: To assure x-ray dose and timer can reproducible.

Frequency 5 years, except Panorex used for non-dental medical exams, which requires annual testing.

Procedure:

1) Select dental radiography use adult bitewing technique.

2) Set kVp (or fixed kVp) used in dental office.

3) mA and time (pulse) are set by console.

4) Position the detector probe at least 4 inches (10 cm) above the table or other support surface to minimize backscatter.

5) Bring the tip of the cone into contact with the probe.

6) Make four exposures recording the output and exposure time for each.

7) If all the output measurements are within 10% of each other, the unit is reproducible and in compliance.

8) If all readings are not within 10% of each other, make six additional exposures and record those also. If the majority of the ten exposures are within 5% of each other the unit is considered reproducible and in compliance.
Acceptance Limits: Limits:

1) 4 dose measurements less than 10%.

2) If first 4 dose output measurements are more than 10% need to 6 additional measurements and shall be satisfy $s/x = 0.05$, where $s$ = standard deviation and $x$= average of the ten exposure measurements.

3) Unless otherwise stated in the manufacture’s specification.

7.6 DENTAL SCATTER MEASUREMENTS

Instrumentation: Calibrated Ion chamber (example: Inovision Pressurized Ion Chamber 451P-RYR), 5 inches x 5 inches x 4 inches of Masonite tooth phantom

Procedure:

1) Draw a room and mark where survey test will be done.

2) Place tooth phantom in head rest of dental chair

3) Exposure X-ray against 3 neighbor walls of both directions.

4) Measure dose at entrance door and X-ray switch area.

5) Find out how many images are exposed per week.

6) Calculate Workload = #exposure/week X mA used room X # second /exposure

7) Scatter dose= mR/hr X 1hr/60 min X 1 min / 60 sec X 1/mA used X time correction factor X meter dose correction factor

Exposure time (Second)

Dose Rate (µR/hr)

Correction Factor
See specific model user manual
8. RADIATION ONCOLOGY

8.1 PERIODIC QUALITY ASSURANCE OF VARIAN OBI IMAGERS

PURPOSE: To establish a policy and procedure for ensuring the safe and accurate use of the Varian On-Board Imager system in patient image-guided radiation therapy.

SOURCE(S). Varian OBI Instructions for Use.

ELIGIBILITY: n/a

APPLICABILITY: Radiation therapy technologists (R.T.T.), medical physicists.

SCOPE: This policy shall apply only to the quality assurance of the Varian On-Board Imager.

BACKGROUND: The Varian OBI consists of a collimated x-ray source (tube) and a flat panel detector each mounted on robotic arms. The beam axis of the OBI is in the plane of rotation of the linac’s gantry but mounted perpendicular (i.e. rotated 90º) to the axis of the therapy beam.

The overall function of the OBI system for IGRT may be broken down into three phases with associated failure modes:

a. Mechanical accuracy of the kV imager, kV detector, and treatment couch.
   i. inaccurate kV source position.
   ii. inaccurate kV detector position.

b. Radiographic quality of the obtained images.
   i. insufficient image brightness, contrast or image quality.
   ii. missing pixels.

c. Network and image analysis application performance.
   i. patient data transfer network failure.
   ii. failure of image analysis software.

The quality assurance tests established here must detect each of these failure modes.
POLICY

1. Daily QA

a. kV radiographic imaging

   i. Each day before IGRT patient treatment and when judged necessary by the physics staff the position accuracy and function of the kV imager shall be tested. The imager shall be used for IGRT only if all test results fall within established specifications.

   ii. Specifications:

      (1) Linear alignment, (Ant/Post, Left/Right, Sup/Inf): ± 0.1 cm.

      (2) Rotational alignment: ± 1º.

      (3) Image quality: sufficient to resolve internal structure of QA phantom

b. CBCT

   i. Each day before IGRT patient treatment and when judged necessary by the physics staff the position accuracy and function of the CBCT imager shall be tested. The imager shall be used for patient positioning only if all test results fall within established specifications.

   ii. Specifications:

      (1) Linear alignment, (Ant/Post, Left/Right, Sup/Inf): ± 0.1 cm.

      (2) Rotational alignment: ± 1º.

      (3) Image quality: sufficient to resolve internal structure of QA phantom.

2. Monthly QA

a. kV radiographic imaging

   i. The OBI radiographic mode shall be tested monthly for:

      (1) Beam centering

      (2) image symmetry

      (3) collimator blade position accuracy
b. CBCT
   i. The OBI CBCT mode shall be tested monthly for:

   (1) Image acquisition function

   (2) Automatic couches repositioning accuracy.

EXCEPTION(S): n/a
CONFIDENTIALITY: n/a
DEFINITION(S):

CBCT Cone-beam CT
IGRT Image-Guided Radiation Therapy
linac linear accelerator
OBI On-Board Imager

PROCEDURE(S):

1. Daily QA kV radiographic imaging

   a. Staff: Radiation Therapy Technologist

   b. Setup

      i. Position the gantry and collimator at IEC 0°.

      ii. Place the Penta-Guide phantom (figure 1.) on the couch and align the “bull’s-eyes” 
          (Sup, Inf, etc.) with the collimator cross hairs and the room lasers.

      (1) If the field cross-hairs do not align with the room lasers a physicist shall be immediately 
          notified. IGRT may not be delivered until the physicist has resolved the issue.

      iii. Select quality assurance test patient on the 4DTC.

   c. Alignment Test

      i. Acquire both kV images (AP and lateral).

      (1) The internal spheres and their respective rings should align as in figure 2.

      (2) If the spheres and rings do not align properly a physicist shall be notified immediately. 
          IGRT shall not be delivered until the physicist has resolved the issue.
d. Couch Repositioning Test
   
i. Fuse both images with their respective reference images.
   
ii. Apply the resulting couch shifts.
   
iii. Verify that the couch moved such that the room lasers now fall on the secondary target mark.

(1) If the lasers do not coincide properly with the secondary target mark a physicist shall be notified immediately. IGRT shall not be delivered until the physicist has resolved the issue.

e. Collision Detection Test
   
i. While moving each of the arms press the collision detectors. Verify that pressing the collision detectors properly stopped arm motion.
   
ii. Reset the collision detector by pressing the touch guard button.

8.2. DAILY QA CBCT

a. Staff: Radiation Therapy Technologist

b. Setup
   
i. Position the gantry and collimator at IEC 0°.
   
ii. Place the Penta-Guide phantom (figure 1.) on the couch and align the “bull’s-eyes” (Sup, Inf, etc.) with the collimator cross hairs and the room lasers.

(1) If the field cross-hairs do not align with the room lasers a physicist shall be immediately notified. IGRT may not be delivered until the physicist has resolved the issue.

iii. Select quality assurance test patient on the 4DTC.

c. CBCT Function Test
   
i. Acquire a CBCT.
   
ii. Verify that the CBCT system is functional for clinical use.
   
iii. Verify that the CBCT image quality is acceptable for clinical use.
   
iv. Save the reconstruction.
8.3. MONTHLY QA kV RADIOGRAPHIC IMAGING

a. Staff: Medical Physicist

b. Image Centering Test
   i. Turn on the graticule, and select the measure from the toolbar.
   ii. Using the electronic ruler, measure the distance from the center pixel of the image (the cross-hair in the fluoro image) to the graticule (the red computer-drawn lines). See figure 5.
   iii. The center of the blade check tool should be within ± 1 mm of the digital graticule.

(1) If the difference in position is > 2 mm the imaging unit shall not be used for delivery of IGRT. Service shall be notified as soon as possible.

c. Image Magnification Test
   i. Reset the zoom, and measure the distance from the center pixel to the 10 cm mark. See figure 6.
   ii. The distance should be within ± 1 mm.

(1) If the difference in position is > 2 mm the imaging unit shall not be used for delivery of IGRT. Service shall be notified as soon as possible.

4. Monthly QA CBCT

a. Staff: Medical Physicist

b. Setup
   i. Position the gantry and collimator at IEC 0°.
   ii. Place the Penta-Guide phantom (figure 1.) on the couch and align the “bull’s-eyes” (Sup, Inf, etc.) with the collimator cross hairs and the room lasers.

Note: If the field cross-hairs do not align with the room lasers a physicist shall be immediately notified. IGRT may not be delivered until the physicist has resolved the issue.

   iii. Select quality assurance test patient on the 4DTC
c. CBCT Function Test
   i. Acquire a CBCT.
   ii. Verify that the CBCT system is functional for clinical use.
   iii. Verify that the CBCT image quality is acceptable for clinical use.

d. CBCT automatic couch repositioning test
   i. Select the quality assurance test patient in the 4DTC.
   ii. Acquire a CBCT.
   iii. Fuse the image with the reference image.
   iv. Apply the resulting couch shifts.
   v. Verify that the couch moved such that the room lasers now fall on the secondary target mark. (Figure 4)

   (1) If the lasers do not coincide properly with the secondary target mark an IGRT shall not be delivered until the physicist has resolved the issue.
   vi. Save the reconstruction

5. Annual QC OBI CBCT
   • CTDIw for typical techniques for head and body
   • Beam quality
     o kVp accuracy
     o Half Value layer

CROSS-REFERENCE(S): n/a

ADDITIONAL INFORMATION: See figures below (Available from Radiation Oncology)

Figure 1. Penta-Guide Phantom.

Figure 2. Alignment of internal spheres and matching rings.

Figure 3. Misalignment of spheres and rings resulting from 2º rotation.
Align to these marks.

Figure 4. Location of secondary target marks.

Figure 5. Measuring the alignment of the kVD’s center pixel.

Figure 6. Measuring the magnification of the fluoro image.

8.4 CT SIMULATOR QUALITY ASSURANCE

1. Purpose: To establish a quality assurance policy for the radiation therapy CT simulators at the University of Rochester Medical Center.


3. Eligibility: n/a


5. Scope: This policy shall apply only to the radiation therapy CT simulators located in the department of radiation oncology at URMC, HH and PR.

6. Background: Current radiation therapy treatment planning systems are capable of accounting for patient tissue heterogeneity when calculating dose. This greatly increases the accuracy of dose calculations. Tissue heterogeneity information is inferred from CT Hounsfield unit numbers on a voxel-by-voxel basis. It is therefore critical that accurate and precise CT Hounsfield units are reported by the CT simulator. Similarly, it is critical that both relative and absolute geometric information about the patient are accurately reported by the CT simulator. Lastly, it is necessary for the resolution of scanned images to be sufficient to identify critical structures in patient images for treatment. This policy seeks to test these aspects of CT operation and ensure function within acceptable limits.

7. Policy:

7.1. Daily QA: Each day that the CT simulator is to be used for patient simulation the following shall be tested:

7.1.1. Image contrast scale.

7.1.2. Laser alignment.

7.1.3. Image noise and uniformity.
7.2. Monthly QA: Each month that the CT simulator is in commission the following shall be tested:

7.2.1. Image contrast scale

7.2.2. Image high contrast resolution

7.2.3. Image slice thickness

7.2.4. Alignment light accuracy

7.2.5. Image low contrast detectability

7.2.6. Image noise and uniformity

7.3. Annual QA: Annual QA shall be established by the department of radiation safety.

8. Exception(s): none

9. Confidentiality: All URMC QA test results shall remain confidential.

10. Definition(s):

10.1. CT Computed tomography

10.2. HH Highland Hospital

10.3. PR Park Ridge Hospital

10.4. URMC University of Rochester Medical Center

11. Procedure(s)

Procedures for the various tests are maintained by the CT/Simulation Therapists, with direction and approval given by the Division of Medical Physics.

12. Annual QC CT Simulator

- CTDI\textsubscript{w}
- Beam width profile

13. Cross-Reference(s) n/a

14. Additional Information: n/a
8.5 EXAC-TRAC QUALITY ASSURANCE

PURPOSE: To set down the policy related to quality assurance activities associated with the ExacTrac image guidance system.

SOURCE(S). Vendor recommendations.

ELIGIBILITY. n/a

APPLICABILITY. Medical Physicists and Radiation Therapists.

SCOPE. All ExacTrac image-guidance systems in operation within the Strong Health system.

BACKGROUND. All image guidance systems have calibration issues, and thus it is prudent to validate the accurate guidance of the system on a routine basis. The ExacTrac system is set up to allow efficient verification of operations on a daily basis.

POLICY.
It is the policy of the Department of Radiation Oncology to verify the accurate and reliable operation of the ExacTrac systems daily before use, on any day that the system will be employed as an image-guidance system for actual patients. Any deviation of performance outside of tolerance will be communicated to an appropriate member of the Division of Medical Physics for evaluation, and no patient treatments will occur until the system is subsequently released for clinical use. Annual tests related to tube performance will be designed and performed by the Department of Radiation Safety.

EXCEPTION(S). n/a

CONFIDENTIALITY. All quality assurance records are confidential records.

DEFINITION(S).

PROCEDURE(S). The procedure for performing the quality assurance tests are described in the document:

a. S:\Policies and Procedures\Quality Assurance\QA Documents\Treatment Machines\Daily\Procedure-Daily Linac QA-Novalis.doc

Annual QC Exac-Trac
  • kVp accuracy
  • Half value layer
  • mA linearity

CROSS-REFERENCE(S): N/A

ADDITIONAL INFORMATION: N/A
9. GLOSSARY

ALARA: The principle of limiting the radiation dose of exposed persons to levels as low as is reasonably achievable, economic and social factors being taken into account.

Aluminum equivalent: The thickness of type 1100 aluminum alloy affording the same attenuation, under specified conditions, as the material in question.

Annual: One calendar year ± 60 days. Must fall within current calendar year.

Aperture: (e.g., for computed tomography) - the opening in the collimation that allows radiation to reach the detector.

Attenuation: The reduction of radiation intensity upon passage of radiation through matter.

Attenuation block: A block or stack of material with a gross section larger than the beam with a total thickness equivalent to 1.5 inches (3.8 cm) of type 1100 aluminum.

Barrier: See protective barrier.

Beam limiting device: (beam defining device). A device which provides a means to restrict the dimensions of the useful beam.

Bold fMRI: Abbreviation of Blood Oxygenation-Level Dependent functional MRI.

Collimator: See beam limiting device.

CT: Computed tomography-An imaging procedure that uses multiple x-ray transmission measurements and a computer program to generate tomographic images of the patient.

Controlled area: A defined area in which the occupational exposure of personnel to radiation is under the supervision of the Radiation Safety Officer. This area designation is equivalent to a “Restricted area” as defined by the U.S. Nuclear Regulation Commission (NRC, 1988)

Densitometer: An instrument using a photocell to determine the degree of darkening of developed radiographic film.

Dose equivalent: A quantity, defined for radiation protection purposes, which is the product of the absorbed dose to the tissue and a quality factor ”Q” determined by the properties of the radiation that produced absorbed dose.

Exposure: A measure of the ionization produced in a specified mass of air by X or gamma radiation which may be used as a measure of the radiation to which one is exposed. The unit of exposure is the Roentgen.
Filtration: Material in the useful beam which usually absorbs preferentially the less penetrating radiation.

Added filter: Filter in the addition to the inherent filtration.

Fluorography: The production of a photographic record of the image formed on the output phosphor of an image intensifier by the action of the X-rays transmitted through the patient.

Focal spot: The apparent size of the radiation source region in a source assembly when viewed from the central axis of the useful radiation beam.

Half-value layer: Thickness of a specified substance which, when introduced into the path of a given beam of radiation, reduces the kerma rate by one-half.

Image intensifier: An X-ray image receptor which increases the brightness of a fluoroscopic image by electronic amplification and image magnification.

Interlock: A device used to assure proper and safe use of a radiation installation by monitoring the status, presence or position of various associated devices such as source position, collimator opening, beam direction, door closure, filter presence and preventing the production or emission of radiation if the potential for an unsafe condition is detected.

Kerma: Kinetic Energy Released In a Material. The sum of the initial kinetic energies of all the charged ionizing particles liberated by uncharged ionizing per unit mass of a specified material. KERMA equals dose under conditions of electronic equilibrium.

Lead equivalent: The thickness of lead affording the same attenuation, under specified conditions, as material in question.

Mammography: Use of radiography of the breast to diagnose breast cancer and other conditions.

MRI: Abbreviation for Magnetic Resonance Imaging.

Pediatrics: Medical science relating to care of children and treatment of their diseases.

Phantom: An object used to simulate the absorption and scatter characteristics of the patient’s body for radiation measurements purposes.

Pixel: A two-dimensional picture element in the presented image.

Quarterly: 90 days ± 20 days.

Radiation: Any electromagnetic or particulate radiation capable producing ions, directly or indirectly, by interaction with matter.

Radiation survey: An evaluation of the radiation safety in and around an installation that includes radiation measurements, inspections, evaluations, and recommendations.
Radiography: The production of images on the image receptor or other record by the action of the X-rays transmitted through the patient.

RCBI: Abbreviation of Rochester Center of Brain Imaging.

Semiannual: 180 days ± 30 days

SID: Source–to–image–distance. The distance measured along the central ray from the center of the front of the surface of the source to the image detector.

SSD: Source-surface distance. The distance measured along the central ray from the center of the front of the surface of the source to the surface of the irradiated object or patient.

STTD: Source to Table Top Distance. The distance measured along the central ray from the center of the front of the surface of the source to the surface of the table.

Spot image: A radiography taken during a fluoroscopic examination for the purpose of providing a permanent record of an area of interest or to verify the filling of a void with contrast media.

Target: The part of X-ray tube anode assembly impacted by the electron beam to produce the useful X-ray beam.

Tomograph: A special X-ray unit that demonstrates the organ or tissue at a particular depth.

Useful beam: See radiation.

http://www.health.ny.gov/environmental/radiological/radiation_safety_guides/
APPENDIX A

X-RAY QUALITY ASSURANCE USING COMPUTED RADIOGRAPHY & PAC'S

Step 1

Expose the CR cassette in the normal manner that you would a standard CR cassette.

Step 2

Take the cassette to an ROP or CR reader.

Step 3

On the main menu press “Study Data”

Step 4

On the Study Data page press “New Patient”

Step 5

Enter “XRAYRM” as the patient’s last name.

Enter the room number as the patient’s first name. Spell the room number (IE: CATHONE).

Enter your name or Tech Code for Tech ID.

Enter the equipment control number for the Patient ID.

Enter a description of the QA procedure and include the SID (IE: Fluoro Collimation, Wall Bucky, Table Bucky, etc.) into the procedure block.

Step 6

Scan the cassette in the barcode reader.

Select a body part (IE: Chest).

Select an orientation. (AP, Lateral, etc.)

Press “Submit” and an icon of the cassette will appear on the screen. You are now ready to scan the cassette.
Step 7
Insert the cassette into the CR unit.

Step 8
If scanning does not start automatically, press “Scan Cassette” and then “Start”.

Step 9
The cassette will now be scanned by the system.

When the cassette is scanned the raw image will appear on the CR monitor. Then press the cassette icon on the ROP.

Step 10
The image will finally arrive at the ROP and is ready for processing.

Press the “Image Processing” graph to begin processing the image.

First remove the black surround mask by pressing the check box labeled “Black Surround Mask”.

Then press “Reprocess Image”

When the reprocessed image appears press “Back”.

Then adjust the brightness and contrast until the image appears the way you want it.

Step 11
When the image looks the way you want it, press “Select Destination”.

Make sure that one of the archives is selected with a “1”

If you want a hard copy, put a “1” after the printer of your choice.

Make sure that the image is not being sent to Clinical Access.

After all destinations are selected press “Back” and then “Accept Image”

The image is now on its way to the PACS system and will soon be available for QA measurements to be taken.
You are now ready to expose another cassette and may scan the cassette barcode and start at Step 6. If you are changing receptors or SID go back to Step 5 and make the necessary changes to the “Procedure” block.

Step 12

After all the necessary images have been taken and transmitted to the archive it is now time to make the necessary measurements using the Image Cast system.

First start at the Medical Center Home Page. Click on Physician Services.

Click on Image Cast (Stentor) in the left hand column.

You will now see the Login Screen. Enter your user name and password.

Now you will see the IDXrad worklist page. Now click on “Worklist”.

Enter “Xrayrm” in the Patient Name and press “enter”.

Find the room that you did your QA test on and select the test you just performed. A tab labeled “Xrayrm” will show up in the upper right corner. Click on the tab and bring up the images.

Clicking on the maximize button in the upper right corner of the image will maximize the image and make it easier to work with.

Rotate the wheel on wheel mouse to magnify the image. Press “control” and the left mouse button to move the image to the position that you want it to take measurements.

A right click on the mouse will bring up your options menu. You can use Annotations to draw lines to help you in your measurements or write text.

“Measurement” will bring up measurement options.

“Measurement Palette” will bring up a window with measurement buttons for ruler and calipers, etc. You can click on the ruler button to activate the ruler. With the ruler activated, when you press on the left mouse button and then drag the cursor between the points you wish to measure. The measurement will now appear on the screen. Repeat the process for each measurement you wish to take.

After you have taken all of the measurements that you want to take, click on the box next to the “X” box in the upper left hand corner of the image. This will minimize the image. Now move the mouse cursor over the image and right click on the mouse. Select “Save Image” and “To Clipboard”. You may now paste the image into the appropriate form and record the measurements.
APPENDIX B

DOCUMENTATION OF QC CHECKS ON RADIOGRAPHY EQUIPMENT

Fig. Appendix B-1. Screenshot of an example technologist daily verification of image quality.
Fig. Appendix B-2. Screenshots of an example of a findings log
Fig. Appendix B-3. An example of the radiographic calibration log and equipment visual check sheet
APPENDIX C

Carestream Digital Radiography (DR) Detector Calibration Procedure

PURPOSE: To assure the Digital Radiography (DR) Detectors are consistently providing a diagnostic high quality image, suitable for diagnostic interpretation.

FREQUENCY: Daily calibrations are performed and documented in a logbook located in each section. Additional Calibration frequencies are dependent on vendor supplied specific software.

EQUIPMENT NEEDED:
1. Copper Filter
2. Detector holder (optional)
3. DR Detector

PRECAUTIONS:
1. Detector should remain within an ambient temperature range of 65-85 F.
2. Calibrations of the detector should be performed only after the system has powered on for at least 4 hours
3. DO NOT move or touch the detector during any calibration process.

PROCEDURE:

Offset Refresh Calibration
1. Login as “tech”
2. Press the utilities menu
3. Choose detector calibration
4. Choose the detector, (wall or table)
5. Select “offset refresh”
6. Press “begin calibration” button to start the calibration process
7. The offset refresh calibration sequence will then run automatically
8. Record date, name and results in the Calibration Log Book

Dark Calibration
1. Login as “tech”
2. Press the Utilities Menu
3. Choose detector calibration
4. Choose the detector (wall or table)
5. Select “dark calibration”
6. Press “begin calibration” button to start the calibration process.
7. The dark Calibration sequence will then run automatically
8. Record date, name and results in the Calibration Log Book
**X-Ray Calibration**

1. X-ray calibration cannot be performed until dark calibration has completed successfully.
2. Set SID to 183 cm to the wall stand and remove the grid and/or pull out the detector from the table and set 122 cm of SID.
3. Ensure nothing is in the beam path and open both collimator blades completely
4. Ensure DAP is inserted (if applicable)
5. Place the internal collimation filters to 0.0 mmAl
6. Insert the 0.5mm copper/1.0mm aluminum filter onto the collimator with the copper side facing the tube. (Filters are stored inside the console door)
7. Press the *begin calibration* button to start the calibration process
8. Follow the prompts as to when Press and hold or Release the exposure button (prep is not required, fully depress the exposure button for entire countdown)
9. When calibration is complete, remove the filter from the collimator
10. Record date, name and results in the Calibration Log Book

*Notify Vendor and/or Imaging Engineering if problems occur while testing or if calibrations fail. Follow vendor and/or imaging engineering recommendations as to room usage. Notify Radiation Safety for any/all radiation concerns/questions.*


9/22/11 mew

1/5/2015 mew/sam (reviewed and revised)
APPENDIX D

For those satellite offices which do not perform all of the procedures listed in this document, the following letter must be included in their QA manual. At which point, those studies in the QA manual which are not applicable for the respective satellite office may be lined out with a single line, and “N/A” noted at the end of the line.

NOT ALL CONTENTS APPLICABLE TO THIS SITE

PLEASE REFER TO THE TABLE OF CONTENTS FOR APPLICABLE CONTENTS

APPROVED BY:

[Signature]