ACR MRI Accreditation Update

1. ACR MRI Accreditation Program
   (Purpose, Status and Role of the Medical Physicist)

2. Impact of CMS/MIPPA and JC Requirements

3. ACR MRI Application Specifics
   (Whole-body modular, Extremity and Breast)

4. 2015 ACR MRI Quality Control Manual
   (Technologist and Medical Physicist Responsibilities)

5. MRI Safety Requirements: ACR/Joint Commission

ACR MRI Accreditation Program

Goals of the ACR MRI Accreditation Program are to set quality standards for “best practice” and to help continuously improve the quality of patient care. Primary components of the ACR program are the evaluation of:

1. Qualifications of all personnel (Physicians, Physicists and Technologists)
2. Equipment performance
3. Effectiveness of quality control and patient safety measures
4. Quality of clinical images

Accreditation Milestones

- 1996: Voluntary Whole-body/Cardiac MRI accreditation with “Large” QA phantom
- 2000: Modular program (Head, Spine, MSK, Body, MRA, Cardiac)
- 2008: “Small” phantom for dedicated extremity systems
- 2010: Breast MRI Accreditation (Mammography program not MRI program)
- 2015: Revised Requirements for Diagnostic Imaging Services

ACR Status (6/29/15)

- 7,021 Accredited Facilities (8,666 Units): Pending (148 Facilities, 290 Units)
- ~20% Fully Electronic Submissions

Impact of CMS/MIPPA Requirements

The Centers for Medicare and Medicaid Services (CMS/MIPPA) requires that all facilities providing Advanced Diagnostic Imaging (ADI) services that are billed under Part B of the Medicare Physician Fee Schedule must be accredited by one of the (4) CMS approved accreditation organizations by January 1, 2012.

ACR Medical Physics Requirements


I. Qualifications and Responsibilities

II. Performance Monitoring Responsibilities

A. Acceptance Testing (AAPM Report No. 100)
B. Annual Equipment Performance Testing
C. Quality Control and Safety Program
D. Written Performance Reports and Follow-up

MRI Accreditation Program Requirements (10/28/13)


Impact of CMS/MIPPA and JC Requirements

(Similar to current ACR standards.)
ACR Accreditation Application Specifics

The accreditation process consists of two phases:

Phase 1: Account Activation (Must be completed online.)

Phase 2: Application (Image submission either online or mailed CDs.)

Modular whole-body and extremity magnets the application requirements:

- Phantom and Clinical images
- Physicist’s Equipment Performance Report for each magnet (<1 year), documentation of corrective actions and most recent quarter of technologist’s weekly QC documents

Breast MRI application requirements. Note: currently no phantom images.

- Clinical Images
- Physicist’s Equipment Performance Report for each magnet (<1 year), documentation of corrective actions and most recent quarter of technologist’s weekly QC documents

https://acredit.acr.org/

Accreditation Submission: ACR Large Phantom

Five sequences: ACR T1, Dual-Echo T2, and Site T1 and T2

1) ACR Sagittal (20/200)
2) ACR T1 SE (20/500)
3) ACR T2 SE (20/2000)
4) Site T1 (knee)
5) Site T2 (knee)

FOV x 12 cm, multi-slice (7 @ 5mm), 192 x 152 matrix

Sag localizer: Z-Axis accuracy
#1: Slice thickness and position, high contrast resolution
#3: X-Y geometric accuracy
#5: Pillow ghosting (PSG)
#6-7: LCD

1 sag 20 mm slice
7 axial 5mm slices w/ 5mm gap

FOV 12 cm 192 x 152 matrix

Localizer: Geometric Accuracy (z)

#1: Slice thickness and position, geometric accuracy, high contrast resolution
#3: Geometric accuracy (x,y)
#7: Percent image uniformity (PIU), Percent signal ghosting (PSG)
#8-11: Low contrast object detectability (LCD), and slice position (in #11)

ACR Submission: Small Phantom (Extremity Systems)

Five Sequences

1) ACR Sagittal (20/200)
2) ACR T1 SE (20/500)
3) ACR T2 SE (20/2000)
4) Site T1 (knee)
5) Site T2 (knee)

FOV x 12 cm, multi-slice (7 @ 5mm), 192 x 152 matrix

Sag localizer: Z-Axis accuracy

#1: Slice thickness and position, high contrast resolution
#3: X-Y geometric accuracy
#5: Pillow ghosting (PSG)
#6-7: LCD

Large and Small Phantom Test Guidance Document

Available at www.acr.org
ACR Guidelines for Phantom Scans

**Large Phantom**

- FOV = 25 cm, 256x256
- Dimensional accuracy (Sagittal) = 148 ± 2 mm
- Dimensional accuracy (Axial) = 190 ± 2 mm
- Slice Thickness = 5 mm ± 0.7 mm
- Slice Position = ≤ 5 mm
- Image Uniformity (PIU) = ≥ 87.5% (< 3T)
- Percent Signal Ghosting = ≤ 2.5%
- High-contrast Resolution = 1 mm
- Low-contrast Detectability Score = ≥ 9 (<3T)

**Small Phantom**

- FOV = 12 cm, 152x192
- Dimensional accuracy (Sagittal) = 100 ± 2 mm
- Dimensional accuracy (Axial) = 100 ± 2 mm
- Slice Thickness = 5 mm ± 0.7 mm
- Slice Position = ≤ 5 mm
- Image Uniformity (PIU) = ≥ 87.5% (< 3T)
- Percent Signal Ghosting = ≤ 2.5%
- High-contrast Resolution = 0.8 mm
- Low-contrast Detectability Score = ≥ 37 (3T)

ACR Limits: Unchanged

Note: Because of the specific and detailed requirements for the clinical image acquisition parameters, the Medical Physicist has an important role in the submission process to confirm that the images meet the technical requirements.

Medical Physicist Assistance with Clinical Images

Examination choices for MR Accreditation by module (specialty examinations denoted by asterisk)

- **Head/Neck**: Brain, Spine, Head and/or Neck
- **Cardiac**: Brain, Chest, Coronary arteries, Intervertebral discs, Pelvis, Abdomen, Small bowel, Rectum, Thyroid, Parathyroid, Kidneys, Adrenal, Liver, Pancreas, Stomach, Ovaries, Testicles, Pelvic fractures

MRI Accreditation Program

Clinical Image Quality Guide

The physicist should confirm that the submitted clinical sequences meet the required acquisition parameters defined in the ACR Quality Guide.

Typical requirements: 4-8 exams per scanner, depending upon the number of modules. Exams must include a "specialty" exam.

ACR Breast Accreditation Clinical Images (review DICOM header)

The Medical Physicist will need to help the site determine some of the required information, e.g. slice thickness, phase and frequency-encoding steps and FOV.

Breast Magnetic Resonance Imaging (MRI)

Accreditation Program Requirements

1. Application requires submission of the clinical images from one biopsy-proven CA patient study. (There is currently no requirement for submission of phantom images.)
2. Application requires submission of entire most recent (within 12 months) Annual System Performance Evaluation REPORT that includes Evaluation of Site’s Technologist QC Program and corrective actions taken.

The specifics of the QC program and the phantom to be used is the responsibility of the Medical Physicist.

Weekly/Daily QA with the ACR small Phantom

Note: Because of the specific and detailed requirements for the clinical image acquisition parameters, the Medical Physicist has an important role in the submission process to confirm that the images meet the technical requirements.

ACR Breast Accreditation Clinical Images

- **Pre-contrast T1-weighted**: Brain, Spine, Head and/or Neck
- **Post-contrast T1-weighted**: Brain, Spine, Head and/or Neck

Maximum Recommended In Plane FOV:

<table>
<thead>
<tr>
<th>Sequence</th>
<th>Slice Thickness</th>
<th>Gap</th>
<th>Dimension for Phase and Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sagittal, Axial and/or Coronal</td>
<td>≤3 mm</td>
<td>0 mm</td>
<td>≤1 mm</td>
</tr>
</tbody>
</table>
Field Homogeneity

Additional methods described in the 2015 manual.

- **Spectral FWHM with large sphere** (Only global sensitivity)
- **Phase-Difference Method** (2D or 3D homogeneity maps)
- **Phase-Map Method** (2D or 3D homogeneity maps)
- **Bandwidth-Difference Method** (Only global sensitivity)
  (Chen, et al Med. Phys. 33 (11), 2006. Note: only sensitive along frequency axis.)

Spherical phantoms are recommended for all methods. Homogeneity should be specified for largest spherical volume (DSV) available.

Alternative: For systems that do not allow any of these methods. One may use the service engineer’s most recent shim report (< 6 month).

Medical Physicist’s Annual Performance Testing

1. Annual Physics Report must include 
   verification of technologist weekly QC measurements (repeated at 
   annual visit)
2. Annual Physics Report must include evaluation of all 
   pulse sequences required for accreditation submission.
3. Additional methods for field homogeneity:
   - Spectral Peak
   - Phase-angle Difference
   - Phase-Map
   - Bandwidth-Difference
5. Optional slice cross-talk assessment
6. Additional methods (NEMA) for SNR, PIU and PSG
7. Additional information on testing multi-element coils
8. Required review of site safety program

Medical Physics Annual Performance Report Must Include

1. Field homogeneity assessment
2. Acquisition monitor assessment
3. Assessment of coil performance (comparison to prior year or reference)

ACR Annual Performance Tests

<table>
<thead>
<tr>
<th>Test</th>
<th>Technologist QC (Weekly)</th>
<th>Medical Physician/MR Scientist (Annually)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>2</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>3</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>4</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>5</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>6</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>7</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>8</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>9</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>10</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>11</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>12</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>13</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>14</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>15</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>

Physicist must repeat and evaluate the weekly Tech QC measurements and the sequences required for accreditation submission. Annual report should assess coil performance by comparison with previous year’s results or other performance reference.

Note: Interslice RF cross-talk test is at the discretion of the medical physicist.

ACR Annual Performance Excel Form

[Link to Excel Form]

Field Homogeneity

Additional methods described in the 2015 manual.

- **Spectral FWHM with large sphere** (Only global sensitivity)
- **Phase-Difference Method** (2D or 3D homogeneity maps)
- **Phase-Map Method** (2D or 3D homogeneity maps)
- **Bandwidth-Difference Method** (Only global sensitivity)
  (Chen, et al Med. Phys. 33 (11), 2006. Note: only sensitive along frequency axis.)

Spherical phantoms are recommended for all methods. Homogeneity should be specified for largest spherical volume (DSV) available.

Alternative: For systems that do not allow any of these methods. One may use the service engineer’s most recent shim report (< 6 month).

Phase-Map Method

Gradient Echo Sequence: $TE = 1/\text{resonance frequency (ppm)}$  
(e.g. 1 ppm @ 1.5T = 1.63 Hz = 15.6 ms)

- $TE = 10\ms$ ~ 0.8 ppm/transition  
- $TE = 20\ms$ ~ 0.4 ppm/transition

The field homogeneity ($\Delta B_0$) is determined by counting the number of transitions and then multiplying by the ppm/transition for the specific TE.
**Bandwidth-Difference Method**

For single-image SNR methods, to improve reproducibility image intensity correction should be **off** e.g. SCIC, CLEAR and PURE. Algorithms can significantly affect the background noise ($s_{air}$) estimate and thus the calculated SNR.

**Volume Coil SNR (Annual Performance Testing)**

Annual requirement to assess all coils used clinically.

1. Single-Image Methods

   Note: Image correction algorithms should be off
   a. ACR 2004 Original: ($SNR = \frac{\text{Mean Signal}}{s_{air}}$)
   b. NEMA Method 4: ($SNR = 0.655 \times \frac{\text{Mean}}{s_{air}}$)

2. Image-Difference Method

   Image-Difference Method: NEMA Method 1

**Surface Coil SNR Measurements: (Annual Testing)**

Original manual recommendation was to use phantom geometry that best matched the coil and to measure the **Maximum SNR**. In order to improve year-to-year reproducibility, recommendation is to measure the **Mean SNR** and to use the largest ROIs possible for both signal and background.

**Testing Coil Arrays (Annual Performance Testing)**

The 2015 ACR MRI Manual recommends that the images from each coil be reconstructed and evaluated individually (if possible) to check for malfunctioning elements.

This is increasingly important with high-density arrays.

**Image-Difference Method (NEMA Method 1')**


*NEMA MS 1-2008: Determination of Signal-to-Noise Ratio in Diagnostic Magnetic Resonance Images (Method 1)*

$\sqrt{2}$ corrects for error propagation.
MRI Safety
(Recommended Components of Annual Site Safety Assessment)

- Site Access Restrictions (MR Zones)
- Documented MR Safety Education/Training for all personnel
- Patient and non MR Personnel Screening
- MRI Safety policies as recommended by ACR guidance documents


Criteria for Compliance
1. Written policies are present, available to staff and reviewed on regular basis
2. Facility has appropriate signage and methods of controlled access
3. Documentation of regular MRI safety training for all MR personnel

MRI Safety Program Assessment Checklist

- Written MRI safety policy addresses the following:
  - Designated MR medical device
  - Site Access Restrictions (MR Zones)
  - Patient and non MR Personnel Screening
  - Patient and non MR personnel in MR zones
  - Radiofrequency safety
  - Use of MR safe equipment
  - Use of MR safe medications
  - Use of MR safe implants
  - Use of MR safe materials

Conclusion and Comments

- The 2015 ACR MRI Quality Control Manual has relatively minor changes from the 2004 version. Specific tests are basically the same but with more options and additional testing detail. Compliance required one year from publication date: 7/1/2016.

- The 2015 QC manual includes several NEMA testing methods as options and is intended to be consistent with new Joint Commission recommendations and with AAPM Report 100.

- The 2015 manual does not identify a specific method for testing parallel imaging. However, it is recommended that images from each coil element be reconstructed and evaluated individually in order to confirm that all elements are functional.

- There is an increased emphasis on MRI safety to minimize patient risk.