ACR MAP QC in the Digital Era
Douglas Pfeiffer, MS, DABR
Boulder Community Hospital

MQSA and the ACR
• Mandated essentially the ACR QC program
• All new equipment had to follow suit

But FFDM Didn’t Fit
• Tests were not applicable to digital mammography
• Tests did not evaluate salient features of digital mammography
• Manufacturer’s were required to develop a QC program...

...individually!

So Where Did That Leave Us?
CONFUSED!
Clinical Representatives

- Chris Adant-Delaney, RT - Northwestern Memorial Hospital
- Jay Baker, MD - Duke University Medical Center
- Lawrence Bassett, MD – UCLA Medical Center  
  - Chair, Joint Committee on Breast Imaging for Appropriateness Criteria and Guidelines
- Shelli Dixon, RT – The Women’s Imaging Center of Denver
- R. Edward Hendrick, PhD
- Debra Monticciolo, MD – Texas A&M Health Sciences Center  
  - Chair of ACR Accreditation Program Chairs
  - Chair of ACR Mammography Accreditation
- Douglas Pfeiffer, MS – Boulder Community Hospital
- Margarita Zuley, MD – University of Pittsburgh Medical Center

MITA Representatives

- Medical Imaging & Technology Alliance  
  - [John Sandrik, PhD (Ret.) – GE Medical Systems]
  - Robert Uzenoff – FUJIFILM Medical Systems
  - Stephen Vastagh – MITA (now in new position)
  - Moustafa Zerhouni – Computerized Imaging References Systems

ACR Representatives

- Marion Boston, RT – Manager, ACR Breast Imaging Accreditation
- Priscilla Butler, MS – Senior Director, ACR Breast Imaging Accreditation Programs

Subcommittee Charge

- Design ACR Accreditation Phantom for FFDM
- Write QC Manual for ACR FFDM Mammography Accreditation Program
- Update the 1999 ACR Screen-Film QC Manual

Subcommittee Goals

- Standardize all QC tests for all digital manufacturers
- Standardize test frequencies
- Standardize performance criteria
- ACR FFDM QC Manual to become basis of new regulations

QC Tests

- Based on a variety of sources
  - MQSA
  - SFM
  - ACRIN DMIST
  - Manufacturer’s QC programs
  - MITA
  - Subcommittee clinical experience
- Apply to all manufacturers
- Be clinically relevant
- Be user friendly
Process

- Design & build new phantom
- Write QC Manual
  - When complete, draft will be sent to manufacturers for their input
  - When final, ACR will apply for the alternative standard under current regulations

Phantom Design Goals

- More challenging targets
- More sensitive to changes
- Fewer digital processing artifacts
- Full field
- Same attenuation as current phantom
- Same Pass/Fail targets as current phantom

Current Phantom

Prototype Phantom

Everything I Say From Now On Might Be A Lie

Cousins
Prototype in Clinical Environment

Wax Insert Specifications with Virtual "Placement Grit"

Attenuation Compensator

Test Object Comparison

Pass/Fail Criteria
Clinical Unit Image

Lorad/Hologic Digital Mo/Mo

Auto-Filter
52 mm Mo/Mo
29 kVp
66 mAs
1.64 mGy

Attenuation Equalization

Compensator is 9 mil polyvinylidene (C₂H₂Cl₂)

The New Insert

Specks are lime glass spheres

Insert Design

Mass Sliver Thickness

1.00 0.75 0.50 0.38 0.25 0.20

Phantom Scoring

CR Imaging
CR Imaging

Screen-Film Imaging

AEC Technique Comparison

<table>
<thead>
<tr>
<th>Mode</th>
<th>Lorad – Mo</th>
<th>Lorad – W</th>
<th>Fuji CR 18 x 24 cm</th>
<th>Fischer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mode</td>
<td>Auto-Filter</td>
<td>Auto-Filter</td>
<td>AA</td>
<td>Auto-Technique</td>
</tr>
<tr>
<td>Phantom</td>
<td>FFDM</td>
<td>SFM</td>
<td>FFDM</td>
<td>SFM</td>
</tr>
<tr>
<td>Compression Thickness (cm)</td>
<td>5.2</td>
<td>5.2</td>
<td>5.2</td>
<td>5.2</td>
</tr>
<tr>
<td>Target/Filter</td>
<td>Mo/Mo</td>
<td>Mo/Mo</td>
<td>W/Rh</td>
<td>W/Rh</td>
</tr>
<tr>
<td>kVp</td>
<td>29</td>
<td>29</td>
<td>28</td>
<td>28</td>
</tr>
<tr>
<td>mAs</td>
<td>65</td>
<td>65</td>
<td>92.5</td>
<td>97.6</td>
</tr>
<tr>
<td>Machine Reported Dose (mGy)</td>
<td>1.64</td>
<td>1.61</td>
<td>1.95</td>
<td>1.98</td>
</tr>
</tbody>
</table>

Manual Technique Signal Comparison

<table>
<thead>
<tr>
<th>Mode</th>
<th>Lorad/Hologic – Mo/Mo</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mode</td>
<td>Manual</td>
</tr>
<tr>
<td>Phantom</td>
<td>FFDM</td>
</tr>
<tr>
<td>Target/Filter</td>
<td>Mo/Mo</td>
</tr>
<tr>
<td>kVp</td>
<td>29</td>
</tr>
<tr>
<td>mAs</td>
<td>65</td>
</tr>
<tr>
<td>Signal in Wax</td>
<td>542.0</td>
</tr>
<tr>
<td>St. Dev. In Wax</td>
<td>9.7</td>
</tr>
</tbody>
</table>

Measurements Using Phantom

- ACR Phantom Image Quality
- Compression Thickness Consistency & Verification
- Phantom AGD Check
- AEC Consistency
- Phantom Scoring on Monitors
- CNR Consistency
- Artifact Evaluation
- SNR Measurement
- Exposure Duration
**Measurements Using Phantom**
- Laser Printer QC
  - Phantom Scoring
  - Artifact Evaluation
- Background OD Check
- Dmax OD Check
- Contrast OD
- ACR Phantom Printed Size Check

**Measurements Using Phantom**
- Monitors
  - ACR Phantom Scoring
  - Artifact Check
- Ghost Image Evaluation
- Spatial Resolution
- Average Glandular Dose
- CR Artifact Evaluation (if applicable)
- CR SNR Inter-Plate Consistency (if applicable)

**QC Manual**
- Focussing on FFDM
- Selective, high-yield tests
- Applicable to all units
- Will eventually unify with screen-film manual

**The Technologist’s QC Tests**

**Tech Tests**

**Tech Tests**
1. ACR Phantom Image Quality

The ACR Phantom Image must be free of clinically significant artifacts. Comment on any identified artifacts.

- The Contrast-to-Noise Ratio (CNR) must be within 2.0 or less. The Fiber score must be greater than 2.0.

- Mean Signal in Cavity - Mean Background < 5.0 mm.

- Mean Signal in Background = 2.0 mm or less.

- Mean Signal in Cavity = 5.0 mm or less.

- The AEC Cell must be within 0.20 mGy or less of operating level.

- The Monitor must be within 0.20 mGy or less of operating level.

- Compression Force: 12 lbs or 5 daN.

- The Clinical paddle (reg. or flex) must be used.

- The Clinical technique for typical screening patient is required.

- The frequency of testing is weekly.

- Monitors must be calibrated per Mfr. recommendations.

- SMPTE Test Pattern: The high-contrast line-pair patterns must be distinguishable at the center and corners. 0%-5% and 95%-100% contrast boxes must be visible.

- Foam Pad(s): 0, 1, or 2 (If App.)?
### Radiologist Workstation (RW) Monitor QC

**Frequency:** Tech Weekly

<table>
<thead>
<tr>
<th>Facility Workstation ID</th>
<th>MAP ID-Unit# (00000-00)</th>
<th>Monitor Mfr &amp; Model</th>
<th>S/N Left Monitor</th>
<th>S/N Right Monitor</th>
<th>Frequency: Weekly</th>
</tr>
</thead>
</table>

1. **Check the monitor screens to verify they are clean.**
2. **Access and view Test Pattern (SMPTE or TG18) on monitor(s) (do not adjust window/level).**

**Monitor Mfr instructions for finding & viewing TG18 test pattern:**

3. **Verify 0%-5% and 95%-100% contrast boxes are visible.**
4. **Verify the line-pair images are sharp and distinguishable (corners & center).**
5. **Score the ACR phantom & evaluate for artifacts.**
6. **If applicable, perform monitor calibration tests per Mfr. recommendations.**

(See Medical Physicist for Mfr. Recommendation, if any)

<table>
<thead>
<tr>
<th>Mfr Rec. Test</th>
<th>Frequency</th>
<th>Overall Pass/Fail (P or F)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Pass = P</td>
</tr>
</tbody>
</table>

- **Monitor must be free of dust, fingerprints, and other marks that could impede clinical interpretation.**
- **0%-5% and 95%-100% contrast boxes must be visible.**
- **The high-contrast line-pair patterns must be distinguishable at the center and corners.**
- **Fiber score must be > 2.0**
- **Speck Group score must be > 3.0**
- **Mass score must be > 2.0**
- **Test pattern and ACR phantom must be free of artifacts.**
- **Mfr's tests must pass per manufacturer recommendations if applicable.**

**Timeframe:** Immediately or before further viewing of clinical images.

### Laser Printer QC

**Frequency:** Tech Weekly

<table>
<thead>
<tr>
<th>Facility Printer ID</th>
<th>Printer ID</th>
<th>MAP ID-Unit# (00000-00)</th>
<th>Printer Mfr &amp; Model</th>
<th>Printer Serial Number</th>
<th>Frequency: Weekly</th>
</tr>
</thead>
</table>

Go to the workstation/computer used to print most clinical films:

**ID of FFDM or Workstation for Printed Phantom:** (ID TBD by MP)

**Do not adjust window and level settings prior to printing.**

**Evaluate the phantom for artifacts & score at lightbox.**

**Measure background OD at center of phantom just outside of the cavity.**

**Measure cavity OD at center of cavity (circle).**

**Calculate the Contrast OD = Cavity OD - Bkgd OD.**

**Note:** Print Phantom from same FFDM each time for this test.

**Note:** Start a new QC form if Operating Level changes.

**Note:** For each printer, Tech only needs to print a single image from a single FFDM or Workstation.

<table>
<thead>
<tr>
<th>Year</th>
<th>Date (Month &amp; Day)</th>
<th>Tech Initials</th>
<th>ACR Phantom Artifacts? (P or F)</th>
<th>Fiber Score</th>
<th>Speck Group Score</th>
<th>Mass Score</th>
<th>Scores Pass? (P or F)</th>
<th>Background OD (Max (+0.15 OD))</th>
<th>Bkgd Op Level Min (-0.15 OD)</th>
<th>Cavity OD</th>
<th>Contrast OD (Cavity - Bkgd)</th>
<th>Contrast Op Level</th>
<th>Dmax OD (P or F)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Analysis:**

- The ACR Phantom image must be free of clinically significant artifacts.
- **Fiber score must be > 2.0**
- **Speck score must be > 3.0**
- **Mass score must be > 2.0**
- **The background OD must be within + 0.15 OD of the operating level OD.**
- **The contrast (Cavity OD - Background OD) must not fall below 0.05 of the operating level OD.**
- **Dmax should be above 3.50 OD.**

**Timeframe:** Immediately or before further printing of clinical images.
The Medical Physicist’s QC Tests
### MP Tests

#### 10. Evaluation of Site's Technology QC Program

<table>
<thead>
<tr>
<th>Test Description</th>
<th>Test Date</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Site PC Power</td>
<td>4/28/11</td>
<td>Pass</td>
</tr>
<tr>
<td>Site LAN Speed</td>
<td>4/28/11</td>
<td>Pass</td>
</tr>
<tr>
<td>Site Firewall</td>
<td>4/28/11</td>
<td>Pass</td>
</tr>
</tbody>
</table>

#### 11. Radiology Workstation (RN) Monitor QC

<table>
<thead>
<tr>
<th>Test Description</th>
<th>Test Date</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monitor Resolution</td>
<td>4/28/11</td>
<td>Pass</td>
</tr>
<tr>
<td>Monitor Contrast</td>
<td>4/28/11</td>
<td>Pass</td>
</tr>
</tbody>
</table>

#### 12. Computed Tomography Tests (If Applicable)

<table>
<thead>
<tr>
<th>Test Description</th>
<th>Test Date</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scan Time</td>
<td>4/28/11</td>
<td>Pass</td>
</tr>
<tr>
<td>Scan Accuracy</td>
<td>4/28/11</td>
<td>Pass</td>
</tr>
</tbody>
</table>

#### 13. Acquisition Workstation (RN) Monitor QC

<table>
<thead>
<tr>
<th>Test Description</th>
<th>Test Date</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monitor Temperature</td>
<td>4/28/11</td>
<td>Pass</td>
</tr>
<tr>
<td>Monitor Humidity</td>
<td>4/28/11</td>
<td>Pass</td>
</tr>
</tbody>
</table>

#### 14. BM Monitor QC - User Test

<table>
<thead>
<tr>
<th>Test Description</th>
<th>Test Date</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>BM Functionality</td>
<td>4/28/11</td>
<td>Pass</td>
</tr>
<tr>
<td>BM Calibration</td>
<td>4/28/11</td>
<td>Pass</td>
</tr>
</tbody>
</table>

#### 15. Laser Printer QC

<table>
<thead>
<tr>
<th>Test Description</th>
<th>Test Date</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Print Quality</td>
<td>4/28/11</td>
<td>Pass</td>
</tr>
<tr>
<td>Print Speed</td>
<td>4/28/11</td>
<td>Pass</td>
</tr>
</tbody>
</table>

#### 16. Overall Pass/Fail (P or F)

<table>
<thead>
<tr>
<th>Metric</th>
<th>Test Date</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall</td>
<td>4/28/11</td>
<td>Pass</td>
</tr>
</tbody>
</table>

**Note:**

- All tests are completed as per the site's technology QC program.
MP Tests

Medical Physicist's FFDM QC Test Summary

Phantom Radiation Dose Values

<table>
<thead>
<tr>
<th>Test Description</th>
<th>Phantom Radiation Dose</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 cm breast dose (mGy)</td>
<td>1.46</td>
</tr>
<tr>
<td>2 cm breast dose (mGy)</td>
<td>1.52</td>
</tr>
<tr>
<td>6 cm breast dose (mGy)</td>
<td>NA</td>
</tr>
</tbody>
</table>

**ACR Phantom Scores**

- **Phantom Resolution**: Pass
- **ACR image has artifacts galore and detector should be replaced.**
- **Masses**: Baseline value does not change.
- **Specks**: 1.76
- **Fibers**: NA

**Recommended Action Items**

1. Artifacts seen on detector, perform recalibration.
2. CNR outside limits, give copy of Corrective Action Log Form to a qualified service engineer.
3. Post and follow the new Technique Chart on the notice board.
4. Post and follow the new Technique Chart on the notice board.
5. QC Tech doing outstanding job with performing and documenting QC. Keep up the good work.

**Description of Actions Taken:**

- **Relevant Personnel Notified:**
- **QC Test Name and # (if app.):**
- **Phantom Radiation Dose Values:**
- **Confirmation of Resolution:**

**Other Relevant Information:**

- **Documentation from Service Engineer Obtained?**: Yes
- **Event resolved?**: Yes
- **Relevant Personnel Notified**: Tech, Manager, MP, Rad
- **Date/Time of Call/Notification**: 4/28/11
- **Patient ID**: NA
- **Phone**: 303-111-2222
- **Email**: NA
- **File Room Wkstn**: OL for "Contrast OD" for Laser Printer QC.
- **OL for indicated AGD (mGy) for Phantom**: 6.4
- **Imaging mode to be used for ACR Phantom QC**: Anywhere Breast Center Suite 900 Room 1
- **Film size to be printed for Laser Printer QC (should match paddle size)**: 10 x 12
- **Operating Level (OL) for indicated AGD (mGy) for Phantom**: 3.38
- **Recommended clinical imaging mode (See Technique Chart)**: NA
- **Artifact Scores**
- **Radiation Dose**

**Note:** This is only a summary page, the Corrective Action Log Form may contain further details.

**Correction Log Form**

- **Initials**: M
- **Signature**: H
- **Date/Time of Call/Notification**: 4/28/11
- **Documenting QC. Keep up the good work.**
- **Significant Doses**:
- **Required Action**: Immediately
- **Immediate Action**: Immediately
- **Utilize Corrective Action Log Form**
### What’s Not Included?

<table>
<thead>
<tr>
<th>Test</th>
<th>Description Summary</th>
<th>ACR Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tech – Viewing Conditions Check</td>
<td>Measure (and not) angle of “optimal” viewing conditions of reading room and adjust room accordingly.</td>
<td>ACR recommends ≥ 90°. We found no ACR reporting this value. Radiation levels to viewing area.</td>
</tr>
</tbody>
</table>
Future Efforts

- Finish manual
- Submit to MITA for comments
- Submit to FDA for approval as an alternative standard under current regulations

Summary

- The only way for this to be effective is to make QC phantom and manual a requirement
- Having a single phantom with a unified QC manual and program solves many problems
- Tests designed to be:
  - User friendly
  - Organized to maximize efficiency
  - Provide data to reflect performance of systems
- Remember, the above tests still have to undergo two more reviews

Many Thanks...

- Eric Berns, PhD
- Penny Butler, MS

Questions?