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

Some New Additions To The Fold
- Agfa CR Mammography
- Carestream CR Mammography
- Giotto FFDM
- Lorad Dimensions
- Philips/Secta
- Fuji FDR Mammography
- Planned monitor

And the confusion continues to grow…

Clinical Representatives
- Chris Adent-Delaney, RT - Northwestern Memoria Medical Center
- Jay Baker, MD – Duke University Medical Center
- Lawrence Nassett, 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

ACR Subcommittee on Quality Assurance
- Clinical Representatives
- MITA Representatives
- ACR Representatives

+ Chaired by Eric Berns, PhD (Denver Health)
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
Everything I Say From Now On Might Be A Lie.

Prototype Phantom

Cousins

Prototype in Clinical Environment
Total Thickness = 4.10 ± 0.03 cm
31.0 ± 0.1 cm
Cover = Nominal 0.3 cm
Screws 19.0 ± 0.1 cm
CNR Cavity (0.1 ± 0.005 cm Deep)
Depth of CNR Cavity = 0.1 ± 0.005 cm

Milled out wax insert area 7.0 cm (+0.04, -0.00 cm)

Compensator = 0.023 cm
Wax = 0.70 cm ± 0.02 cm
Milled out wax insert area 13.0 cm (+0.04, -0.00 cm)

ID Tag
ACR Phantom Prototype
Air Gap = 0.027 cm Nominal
Total Insert Depth = 0.75 cm
Total Thickness Under Insert = 3.05 cm
Test object distance from base of wax = 0.35 ± 0.10 cm

Wax Insert Specifications with Virtual “Placement Grid”

• Wax insert well depth: ±0.005 cm (±2 mils).
• Wax insert well width and length: +0.04 / -0.00 cm
• CNR cavity depth: ±0.005 cm (±2 mils).
• CNR diameter: ±0.05 cm.

Notes:
1. Test objects to be centered on their respective “placement grid” locations.
2. 0.05 cm centered at each end of respective “placement grid”.
3. Wax insert well width and length: +0.04 / -0.00 cm
4. CNR cavity depth: ±0.005 cm (±2 mils).
5. CNR diameter: ±0.05 cm.

Fiber specifications
Fiber Length = 1.0 cm ± 0.1 cm
Fiber Diameter = See Table

Speck Placement & Specs
1. Specks to be placed at points on star and middle of star
2. Speck Size (spherical) = See Table
3. Center speck placement to be within +0.1 cm of center of virtual grid
4. Distance from center speck to center of speck on perimeter = 0.5 cm ± 0.1 cm

Mass Placement & Specs
1. Mass pre-cut sphere diameter = 5/8 inch
2. Mass placement to be within +0.1 cm of center of virtual grid

ID Tag Specs
Virtual Box: height = 0.5 cm, length = 1.8 cm
Location of Virtual Box

Clinical Unit Image
Lorad/Hologic Digital Mo/Mo
Auto-Filter 52 mm Mo/Mo 29 kVp 66 mAs 1.64 mGy
Attenuation Equalization

The New Insert

Specks are lime glass spheres

Expanded View of Specks

Insert Design
### Test Object Comparison

<table>
<thead>
<tr>
<th>Test Object</th>
<th>Fibers (mm)</th>
<th>Specks (mm)</th>
<th>Masses (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACR 156 FFDM</td>
<td>1.56</td>
<td>0.89</td>
<td>0.54</td>
</tr>
</tbody>
</table>

### Pass/Fail Criteria

<table>
<thead>
<tr>
<th>Test Object</th>
<th>Fibers (mm)</th>
<th>Specks (mm)</th>
<th>Masses (mm)</th>
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<tbody>
<tr>
<td>ACR 156 FFDM</td>
<td>1.56</td>
<td>0.89</td>
<td>0.54</td>
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</table>

**Pass**

<table>
<thead>
<tr>
<th>Test Object</th>
<th>Fibers (mm)</th>
<th>Specks (mm)</th>
<th>Masses (mm)</th>
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</thead>
<tbody>
<tr>
<td>ACR 156 FFDM</td>
<td>0.75</td>
<td>0.33</td>
<td>0.17</td>
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</table>

**Fail**

<table>
<thead>
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<th>Fibers (mm)</th>
<th>Specks (mm)</th>
<th>Masses (mm)</th>
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</thead>
<tbody>
<tr>
<td>ACR 156 FFDM</td>
<td>0.89</td>
<td>0.33</td>
<td>0.17</td>
</tr>
</tbody>
</table>

### Phantom Scoring

![Phantom Scoring Image](image)

### CR Imaging

![CR Imaging Image](image)
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>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>Mo/Mo</td>
<td>Mo/Mo</td>
</tr>
<tr>
<td>kVp</td>
<td>29</td>
<td>29</td>
<td>28</td>
<td>27</td>
</tr>
<tr>
<td>mAs</td>
<td>66.4</td>
<td>65.4</td>
<td>52.5</td>
<td>90</td>
</tr>
<tr>
<td>Machine Reported Dose (mGy)</td>
<td>1.64</td>
<td>1.61</td>
<td>1.03</td>
<td>1.08</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>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
- SNR/CNR Consistency
- Artifact Evaluation
- Exposure Duration

- 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

ACR Digital QC Draft Manual

- **Structure of Manual:**
  - Radiologist’s Section
  - Clinical Image Quality Section
  - Radiologic Technologist’s Section
  - Medical Physicist’s Section
  - Educational, Guidance, and Troubleshooting Section
  - Glossary
  - References
  - Index

What Will Be New?

- **Radiologist Section**
  - Image ID regulations
  - Hanging protocols (left vs. right)
  - Monitor and viewing conditions guidance
  - Section on diagnostic tools for analyzing poor images
  - How to score the ACR FFDM Phantom
  - Guides for understanding their role and responsibility for overseeing the QC program

What Will Be New?

- **Tech Section**
  - Enhanced positioning and image quality section
  - New Test: Monitor QC for the Radiologist
  - New Test: Facility QC Review
  - New Format: Corrective Action Log
  - New Documentation: Facility Equipment Inventory
  - Improved QC Forms
  - Instructions for Mobile Units
  - Eliminate calculations (TBD)
Medical Physicist Section

- Theme: provide better documentation and communication
  - Single MP Summary Form
  - For Facility, ACR, State and MQSA Inspectors
  - Include an Action Item Summary
  - MP form for Tech for Operating Levels (if app.) and QC instructions
  - Procedures for evaluating and documenting Tech QC
  - MP letter to the Radiologist
  - MP to use same Corrective Action Log form as Techs

What Will Be New?

Facility

- Guidance on how to handle multiple units at multiple locations
- Guidance on who/what/when tests need to be performed when “major” and “minor” repairs are performed on unit
- Facility QC Review (Tech Test) – Quarterly

What Will Be New?

Technologist QC Tests

- Medical Physicist Section
  - Provide QC forms in both PDF and Excel Worksheets
  - Will include guidance on how to test
    - Multiple units (FFDMs, AWs, RWs, Printers, etc)
    - Multiple facilities
ACR Digital QC Draft Manual

Technologist QC Tests

<table>
<thead>
<tr>
<th>Test Number</th>
<th>Name (# of Test Elements)</th>
<th>Minimum Frequency</th>
<th>Required Corrective Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>ACR Phantom Image Quality (5)</td>
<td>Weekly</td>
<td>Before Clinical Use</td>
</tr>
<tr>
<td>2</td>
<td>Aquacal Workstation (AW) Monitor QC (5)</td>
<td>Weekly</td>
<td>Before Clinical Use</td>
</tr>
<tr>
<td>3</td>
<td>Radiologist Workstation (RW) Monitor QC (5)</td>
<td>Weekly</td>
<td>Before Clinical Use</td>
</tr>
<tr>
<td>4</td>
<td>Laser Printer QC (5)</td>
<td>Weekly</td>
<td>Before Clinical Use</td>
</tr>
<tr>
<td>5</td>
<td>Visual Checklist (1)</td>
<td>Monthly</td>
<td>Before Clinical Use</td>
</tr>
<tr>
<td>6</td>
<td>Repeat Analysis (1)</td>
<td>Quarterly</td>
<td>Within 30 Days</td>
</tr>
<tr>
<td>7</td>
<td>Facility QC Review (1)</td>
<td>Quarterly</td>
<td>Before Clinical Use</td>
</tr>
<tr>
<td>8</td>
<td>Monitor QC for the Radiologist (1)</td>
<td>Quarterly</td>
<td>Before Clinical Use</td>
</tr>
<tr>
<td>9</td>
<td>Facility QC Review (1)</td>
<td>Quarterly</td>
<td>Not Applicable</td>
</tr>
<tr>
<td>10</td>
<td>Compression Force (1)</td>
<td>Quarterly</td>
<td>Before Clinical Use</td>
</tr>
<tr>
<td>11</td>
<td>Manufacturer Detector Calibraton (If Applicable)</td>
<td>Per WP Recommendation</td>
<td>Before Clinical Use</td>
</tr>
</tbody>
</table>

Supplemental Forms

- Corrective Action Log
- Facility Equipment Inventory Form

Tech Tests

8. Monitor QC For The Radiologist

Step 1: This test is to be performed or supervised by the Lead Interpreting Radiologist.

Step 2: The Technologist should deliver this form to the Radiologist, ensure correct completion, follow-up on any failures, and place the form into QC notebook.

Step 3: This test should be performed for ACR Accreditation issues discussed (if app.).

Step 4: Recent past and future State and/or MQSA inspections reviewed and discussed (if app).

Step 5: Offsite RW(s) & Laser Printer(s) QC Reviewed.

9. Facility QC Review - Cont’d

Items for quality improvement from QC Meeting: [List items]

Follow-up [If App.]

Facility QC Review - Cont’d

- Corrective Action Log
- Facility Equipment Inventory Form

Tech Tests

9. Facility QC Review - Cont’d

QC Meeting Notes

- Items for quality improvement from QC Meeting:

- Other QC Notes:

- Reviewed: [Date]

- Action Log: [Date]
### Medical Physicists QC Tests

<table>
<thead>
<tr>
<th>Test Number</th>
<th>Name (# of Test Elements)</th>
<th>Minimum Frequency</th>
<th>Required Corrective Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>ACR Phantom Image Quality (6)</td>
<td>Annual</td>
<td>Before Clinical Use</td>
</tr>
<tr>
<td>2</td>
<td>Ghost Image Evaluation (1)</td>
<td>Annual</td>
<td>Before Clinical Use</td>
</tr>
<tr>
<td>3</td>
<td>Spatial Resolution (1)</td>
<td>Annual</td>
<td>Before Clinical Use</td>
</tr>
<tr>
<td>4</td>
<td>Automatic Exposure Control System Performance (2)</td>
<td>Annual</td>
<td>Before Clinical Use</td>
</tr>
<tr>
<td>5</td>
<td>Calibration Assessment (1)</td>
<td>Annual</td>
<td>Before Clinical Use</td>
</tr>
<tr>
<td>6</td>
<td>kVp Accuracy and Reproducibility (1)</td>
<td>MEE Only</td>
<td>Before Clinical Use</td>
</tr>
<tr>
<td>7</td>
<td>Beam Quality (Half-Value Layer) Assessment (1)</td>
<td>Annual</td>
<td>Within 30 Days</td>
</tr>
<tr>
<td>8</td>
<td>Average Glucuronic Acid (2)</td>
<td>Annual</td>
<td>Before Clinical Use</td>
</tr>
<tr>
<td>9</td>
<td>Unit Checklist (5)</td>
<td>Annual</td>
<td>Before Clinical Use</td>
</tr>
<tr>
<td>10</td>
<td>Evaluation of Site’s Technologist QC Program (1)</td>
<td>Annual</td>
<td>Within 30 Days</td>
</tr>
<tr>
<td>11</td>
<td>MQSA Equipment Requirements (1)</td>
<td>MEE Only</td>
<td>Before Clinical Use</td>
</tr>
<tr>
<td>12</td>
<td>Computed Radiography (if applicable) (3)</td>
<td>Annual</td>
<td>Before Clinical Use</td>
</tr>
<tr>
<td>13</td>
<td>Acquisition Workstation (AR) Monitor QC (5)</td>
<td>Annual</td>
<td>Before Clinical Use</td>
</tr>
<tr>
<td>14</td>
<td>Radiologist Workstation (RW) Monitor QC (11)</td>
<td>Annual</td>
<td>Before Clinical Use</td>
</tr>
<tr>
<td>15</td>
<td>Laser Printer QC (7)</td>
<td>Annual</td>
<td>Before Clinical Use</td>
</tr>
<tr>
<td>16</td>
<td>Viewbox Luminance and Room Illuminance (2)</td>
<td>Annual</td>
<td>Before Clinical Use</td>
</tr>
<tr>
<td>17</td>
<td>Evaluation of Off-Site Technologist QC Program (if applicable)</td>
<td>Annual</td>
<td>Before Clinical Use</td>
</tr>
</tbody>
</table>

### Supplemental Forms

#### Medical Physicists QC Tests

<table>
<thead>
<tr>
<th>Supplemental Forms</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Medical Physicist Summary Report</td>
</tr>
<tr>
<td>2. Technologist Operating Level Information and QC Instruction Form</td>
</tr>
<tr>
<td>3. Medical Physicist Summary Letter for the Radiologist</td>
</tr>
<tr>
<td>4. Mammography Corrective Action Log</td>
</tr>
<tr>
<td>5. Technologist Pre-Emission Interview Form</td>
</tr>
<tr>
<td>6. Technique Chart</td>
</tr>
</tbody>
</table>

### Challenges

- Accounting for, and incorporating, all the different FFDM technologies
- Handling offsite equipment
- Predicting and accounting for future FFDM systems
- Ensuring all necessary tests are included, meaningful, and relevant
What’s Next

3 Steps

✦ When ready, draft will be sent to manufacturers, FDA, and select reviewers for preliminary feedback
✦ Subcommittee to review comments and edit manual
✦ Final draft to be sent to FDA from ACR to apply for alternative standard under current regulations
  • Alternative standard will allow facilities to use this instead of the manufacturer’s manuals
  • Potential for ACR QC Manual to be basis for new MQSA Regulations

Future Efforts

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

Preemptive Questions

✦ Cost of phantom?
  • Don’t know. Reason to believe it will be affordable.
✦ Implementation and roll-out?
  • ACR to develop a plan to include some sort of training.
✦ When?
  • Goes to FDA Summer 2012 for review as alternative standard

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