Troubleshooting Screen-Film Mammography Image Artifacts and Quality Control Problems "The Six-Step Solution"

Based in part on an RSNA 2002 Educational exhibit by

Joel E. Gray, Ph.D.
Director, Clinical Development
Lorad Corporation
Danbury, Connecticut
(Now with Landauer, Inc., Glenwood, Illinois)
Robert J. Pizzutiello, Jr., M.S.
President
Upstate Medical Physics, Inc.
Victor, New York
James A. Princehorn
Consultant

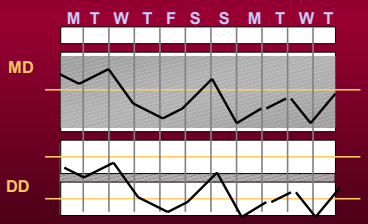
The Six Steps

1. Collect and critique all bad films (or QC data) looking for patterns
2. List changes which have occurred in department
3. List all potential sources of artifacts or QC problems
4. Look at issues with "new eyes" Identify all assumptions and challenge them
5. Review all information Source of problem determined!
6. Apply solution

For mobile mammography…

QC is even more critical…

Significant decreases in MD and DD were noted several times throughout the summer.



History

A facility changed to a new brand of mammography film and chemistry in January 2003.

- After a few months, system working consistently
- In May 2003, sensitometry changed (out of control)
- Consultation with the MP and processor service engineer
  - Change in replenishment
  - Result - consistent QC data and images
- Over the summer, sporadic occurrences of out-of-control sensitometry occurred
- The physicist was asked to return, identify the problem, and suggest corrective actions to stabilize the processing

Collect and critique all bad films looking for patterns

- During the Summer
  - 7 occurrences of drastic drop in MD and DD
- Phantom images
  - When performed near those days, showed corresponding drops in background density and DD

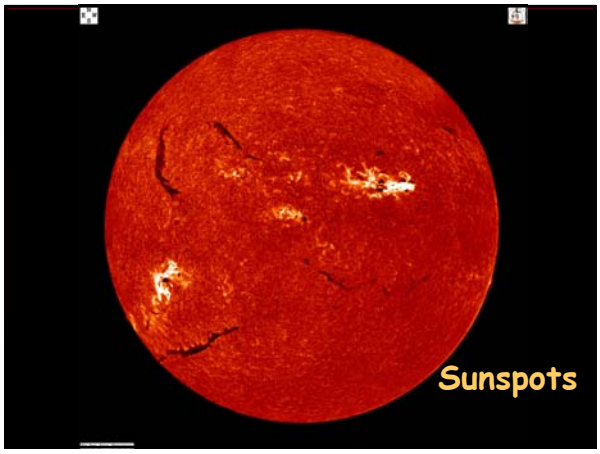
2 List all changes which have occurred in the department

- Film and chemistry changes January 2003
- Replenishment rate changes May 2003
- No changes since then

3 List all potential sources of artifacts or QC problems

- Film
- Chemistry
- Sensitometer
- Densitometer

And…..



4

Look at issues with "new eyes" Don't believe anything you are told

"I know about the door. It goes to the darkroom behind. You can't make her disappear!"

5 Review all information—Source of problem determined

On those days when the little girl visited, residual fixer on the film would contaminate the developer.

6 The solution is obvious!

- Clinical images have motion blur caused by excessive mAs (Cnt-Auto mode)
- AEC performance is identified as sub-optimal during an annual MP survey
- Immediately following re-calibration, MP re-tests AEC – results are OK
- Next morning, films again show motion and excessive mAs (ID label)

The Six Steps

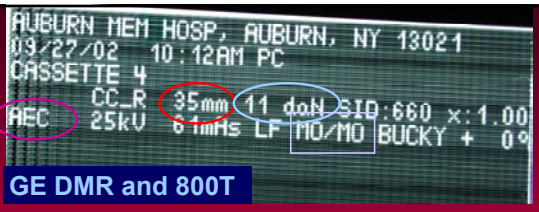
1. Collect and critique all bad films (or QC data) looking for patterns
2. List changes which have occurred in department
3. List all potential sources of artifacts or QC problems
4. Look at issues with "new eyes" Identify all assumptions and challenge them
5. Review all information Source of problem determined!
6. Apply solution

MCCORMICK, LINDA 03/18/1997
012-34-5678 12/12/1934 62 F
INSTITUTION NAME
ANYTOWN, ANYSTATE, U.S.A.
AKV 28kV 226mAs D:NO MO 3 35#
PAIN LT VOQ 6 . 0cm 123

AutoFilm ID Label

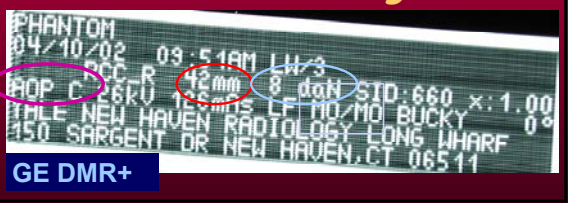
The ID Camera as a Tool

- Troubleshooting sub-optimal techniques
- Check to see what information is printed
  - Patient name, date, facility, address, etc…..
  - kVp, mAs, target, filter
  - Tube angulation
  - Density control
  - AEC mode
  - AEC sensor position
- Look carefully, verify that everything you need is there

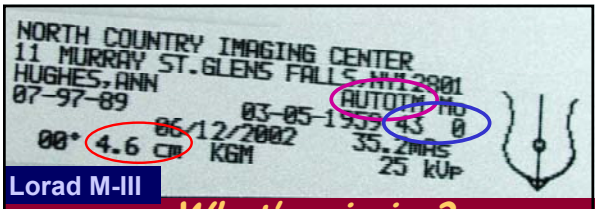


GE DMR and 800T

What's missing?



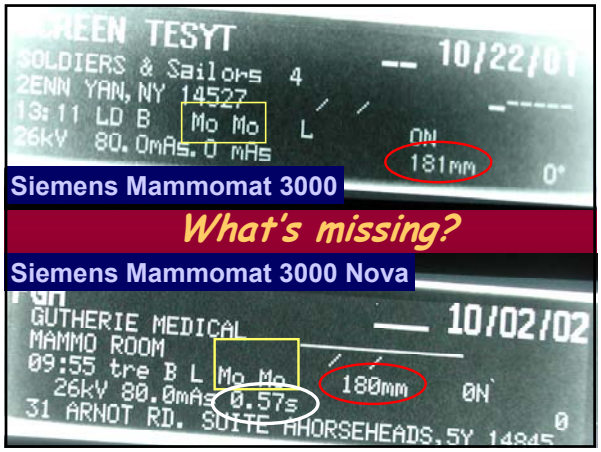
GE DMR+



Lorad M-III

What's missing?

Lorad M-IV, Elite

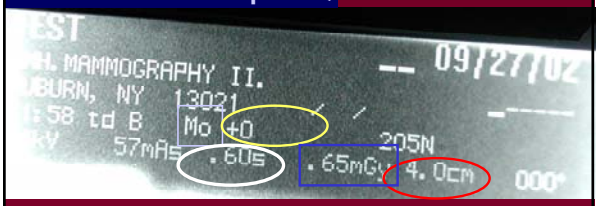


Siemens Mammomat 3000

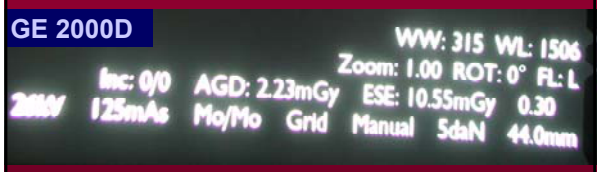
What's missing?

Siemens Mammomat 3000 Nova

Instrumentarium Alpha IQ



GE 2000D



ID Label Comparison

	DMR & 800T	DMR +	M3	M4-Elite	S 3000	S 3000 Nova	Inst.
Facility name, address	✓	✓	✓	✓	✓	✓	✓
Patient name	✓	✓	✓	✓	✓	✓	✓
Date	✓	✓	✓	✓	✓	✓	✓
View	✓	✓					
kVp, mAs	✓	✓	✓	✓	✓	✓	✓
Target/Filter	✓	✓		✓	✓	✓	✓
Time						✓	✓
AEC mode	✓	✓	✓	✓			
AEC position				✓			
Density			✓	✓			✓
Thickness	✓	✓	✓	✓	✓	✓	✓
Force	✓	✓					
Dose							✓
Tube Angle	✓	✓	✓	✓	✓	✓	✓

QC Overview
Control Charts tell the story

- Philosophy: Everything changes - nothing stays the same
- Tracks changes in multiple parameters
  - X-ray machine output
  - Film
  - Cassette
  - Processing
  - Phantom

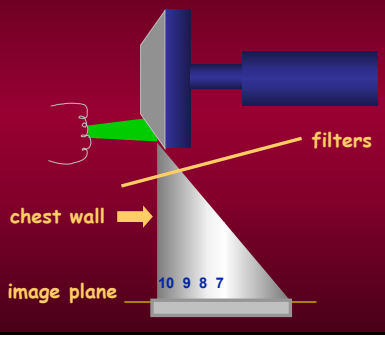
Film Variability

- 1995 ACR-CDC document pg 31
  "Recommend Specifications for New Mammography Equipment"
- Emulsion mixed in batches (temp, humidity, barometric pressure)
- Aging effects
- Variability between emulsion batches: Density should be within ± 0.30 @ 1.25 OD (split phantom test)
- (AEC variability ± 0.30…± 0.15 10/22/2002)
- Film variability can overwhelm other factors

X-ray Machine Variability

- Generator (rare on newer units)
- AEC (reproducibility)
- AEC detector position
- Bucky vs. Cassette Holder (DMR, 800T)

Focal Spot Geometry - Heel Effect



AEC's are not clever (auto-time)

- They do only one thing (when working)
- Allow exposure to continue until sensor has received a pre-calibrated amount of radiation exposure
- Sensor positioned towards chest wall will **reduce** overall exposure (density), since sensor receives max exposure rate
- Sensor towards nipple increases background density

Cassette Variability

- Different screen manufacturers (Fuji, Kyokko)
- Newer replacement screens vs. older ones
- Thickness of plastic cassette material affects AEC (detector behind the cassette)
- Different cassettes can vary mAs and OD
- Medical Physicist tests annually
- Check with your MP before using new cassettes or screens
- Test with acrylic or phantom imaging (AEC)

The Phantom Itself

- We assume that they are all the same
- Mass-production (> 10,000 units)
- Acrylic tolerance
- mAs differences of 10 - 15% are common
- Fibers, specks, masses, artifacts
- Check or make a contact test film
- Remember that they are all NOT the same!

Phantom Image Quality Fails

- Artifacts? (processor, cassette, film, equipment, metal filings, etc.)
- Check technique factors
- Check daily processor QC
- Check correct film, cassette
- Work with your medical physicist
- Expect your MP to help troubleshoot problems

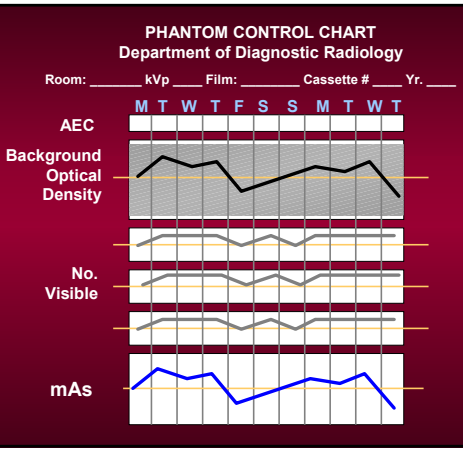
Phantom Control Chart

- X-ray unit
  - mAs and kVp (target/filter)
  - AEC position
  - If kVp, target/filter, mAs are constant, x-ray machine is OK
- Film and processing affect background density, DD
  - Check film emulsion number (clinical film)
  - Processing sensitometry (QC film)
- Remember: QC film is not Clinical Film

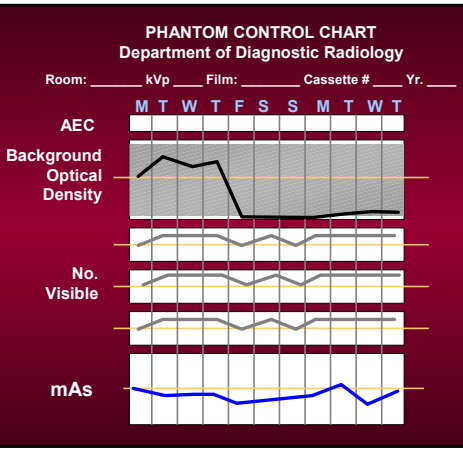
Setting Operating Levels

- Check with medical physicist
- Select values when system is optimized
- mAs tolerance is 10 - 15%, per ACR QC Manual
- 1999 ACR Manual recommends 3 OD measurements
  - Background (center of wax insert)
  - Inside contrast disc
  - To the side of contrast disc
- Darker mammograms have better contrast
- ACR Manual recommends background density > 1.20
- We recommend background density 1.60 - 1.90, depending on viewboxes and viewing conditions, masking...

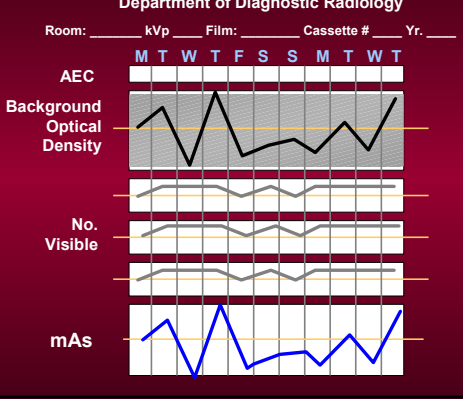
#1



#2



#3



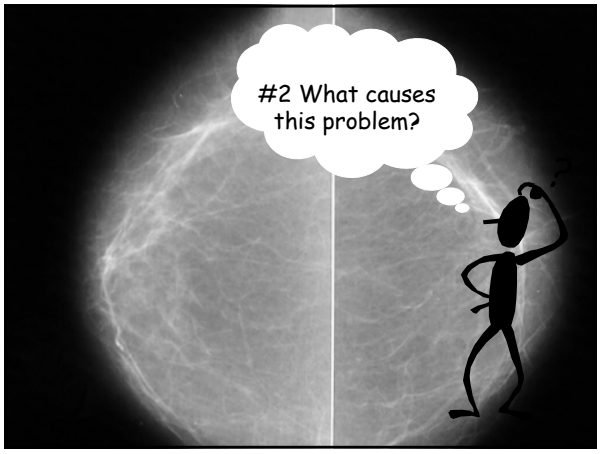
How to Solve Real QC Mysteries

- What do the Final Regulations mandate?
- How would you go about problem solving?
- What do you think was happening?
- How can problem be corrected?
- When can you continue mammography?
- Documentation

#1 Today's phantom is what??

- AEC mode
- Background Density acceptable
- mAs unchanged from operating level
- DD varies
- Image Quality score acceptable
- Do I stop doing mammograms?

- QC film vs. clinical film
- mAs constant - AEC OK
- Check emulsion numbers on film
- Check processor QC
- Look for pattern of OD or DD changes
- Very common
- Document your analysis



- Objects closest to film are sharpest
- Objects farther away are magnified, blurred
- Could it be the collimator?
- Could it be the compression device?
- Could it be screen misalignment in the cassette?
- How much misalignment is acceptable?

#3 GE DMR/800T

- Contrast Auto vs. AEC mode
- Phantom screw heads deflect compression device
- Background density acceptable
- mAs increased, DD decreased
- Image Quality score decreased
- Do I stop doing mammograms?

- Check phantom image control chart
- Check image ID label for techniques
- Processor QC is OK
- mAs changed
- Filter changed
- Be sure Mo/Mo is used
- Use Contrast - Auto, per technique chart

#4 Bennett phantom story

- BACE vs. AEC mode
- Position of AEC detector
- mAs inconsistent
- Background Density acceptable
- DD acceptable
- Image Quality score acceptable
- Do I stop doing mammograms?

- Different technologist taking the image
- QC cassette?
- Position of AEC sensor
- BACE mode selects kVp based on compressed breast thickness
- Different degree of compression casued kVp to change
- Battery failure (older unit) caused compression thickness to be inaccurate

#5 Instrumentarium phantom story

- AA vs. A mode
- Position of AEC detector
- mAs inconsistent
- Background Density acceptable
- DD acceptable
- Image Quality score acceptable
- Do I stop doing mammograms?
- What mode do I use for phantoms?

- Check control chart
- Check ID data on films
- kVp not constant
- 1 kVp never clinically significant, but causes mAs change
- AA mode starting kVp chosen by thickness
- QSE to recalibrate AA mode to minimize mAs change
- Use AA mode, per technique chart

#6 Mobile problem

- Mobile unit returns to base at end of day
- Phantom image processed first
- Image quality poor
- MD is low, DD is low
- What to do?

- Check processor QC book (QC is OK)
- Repeat QC strip
- Processor out of control
- Difference between AM and PM performance of the processor
- Check temperature
- New chemistry
- Do not process mammograms until problem is resolved

Film-screen Contact Test

- Remember to do for any new/replacement cassettes
- What is the correct delay time after loading?
- If any cassettes fail, remove from service immediately (Final Regs)
- Document your actions

#7 Darkroom Fog Test

- Test fails
- OD increases by 0.70
- What to do?
- Can I still process mammograms?

- Possible causes of fog
  - ✓Door seals, passbox
  - ✓Safe light case and filter
  - ✓Hall light outside of the room (ceiling tiles)
  - ✓Phone or other lights, LED's, pagers, watches
- Try w/o safelight, turn outside lights off
- If test can pass, document temporary action
- Implement a long-term solution

#8 Processing artifacts

- Multiple Dramatic artifacts observed
- Parallel and perpendicular to processing direction
- Some were unfamiliar
- Observed on phantoms from both machine – hence processing related

General Questions to Consider

- When do I do the test
  - ✓Weekly: on Monday or Friday, AM or PM?
  - ✓Quarterly means 3 month interval
- What if you do a test early and it fails?
- Document the date of testing,
- Document corrective action
- Remember that QC tests provide important information about image quality
- A cancelled mammogram is better than a poor quality one

The Six Steps

1. Collect and critique all bad films (or QC data) looking for patterns
2. List changes which have occurred in department
3. List all potential sources of artifacts or QC problems
4. Look at issues with "new eyes" Identify all assumptions and challenge them
5. Review all information Source of problem determined!
6. Apply solution