OPTIONS to AIRPORT

- **ALI'S TOWNCAR: 206-459-7903**
  - $28 for 1-2 Riders; $5 ea add'l up to 4 total
  - Call 2 hours ahead
  - Direct to Airport
- **SHUTTLE EXPRESS VAN 800-487-7433**
  - $23.50 for 1st; $8 for 2nd; $5 ea add'l up to 6
  - May stop elsewhere if not full
  - Call 2 hours ahead
- **SHUTTLE EXPRESS TOWNCAR (same #)**
  - $50 for up to 4 riders (Direct to Airport)
  - Call 2 days ahead

Use of the R/F Accreditation Phantom for Fluoroscopic System Evaluation

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Overview

- ACR R/F Phantom
- Fluoroscopic System Evaluation Instructions
- Sample Results
- Corrective Actions for System Optimization
- Additional Phantom Characterization
  - Backscatter
  - Equivalent water attenuation
- ACR Vascular-Interventional Accreditation Program

Introduction

- ACR R/F Accreditation Program includes evaluation of:
  - equipment performance
  - personnel qualifications
  - quality control
  - clinical image quality

Introduction

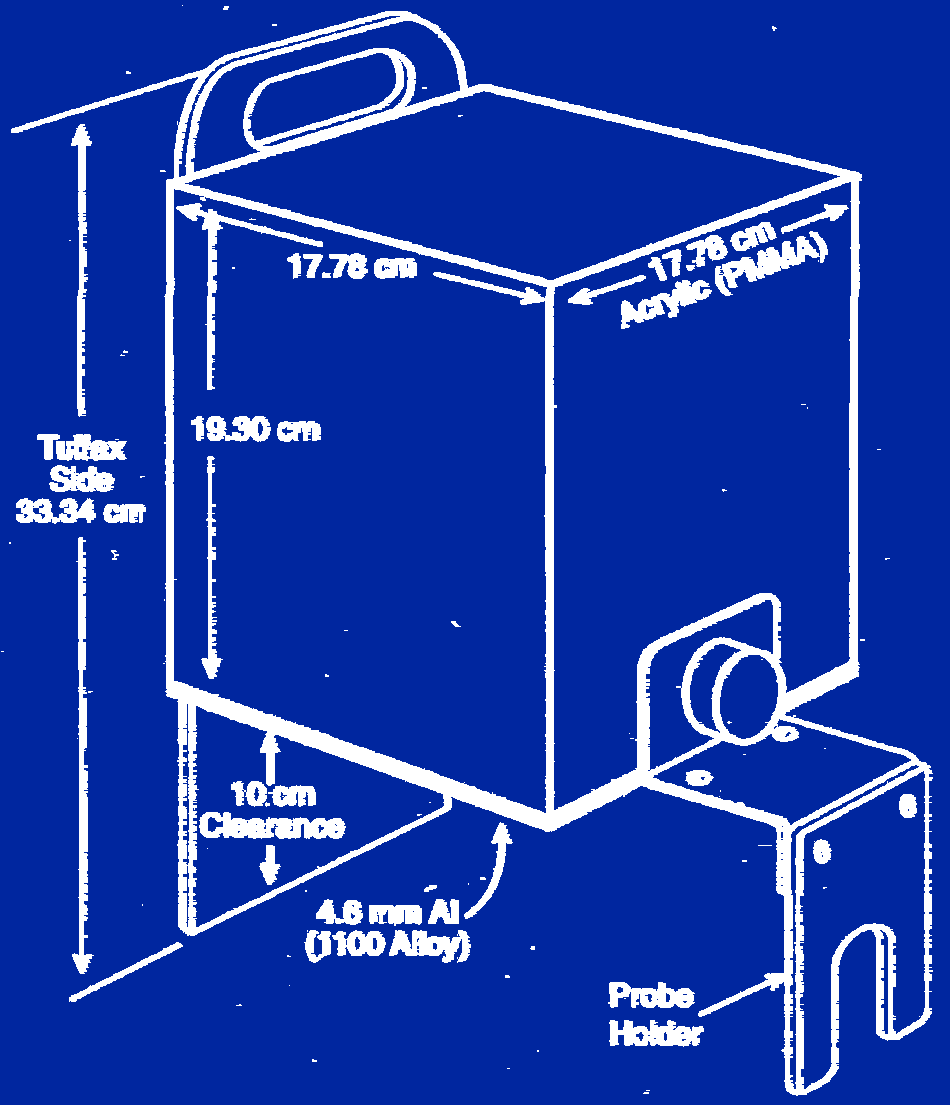
- Equipment performance is assessed with a standard phantom and image quality test tool
- Sites submit the following:
  - radiographic images from each x-ray system
    - table
    - upright bucky
  - spot films from each fluoroscopic system
  - fluoroscopic system evaluation performed by a medical physicist

ACR R/F Phantom

- Design is based on the CDRH fluoroscopic phantom
  - Patient-equivalent acrylic and aluminum phantom
  - Image quality test tool

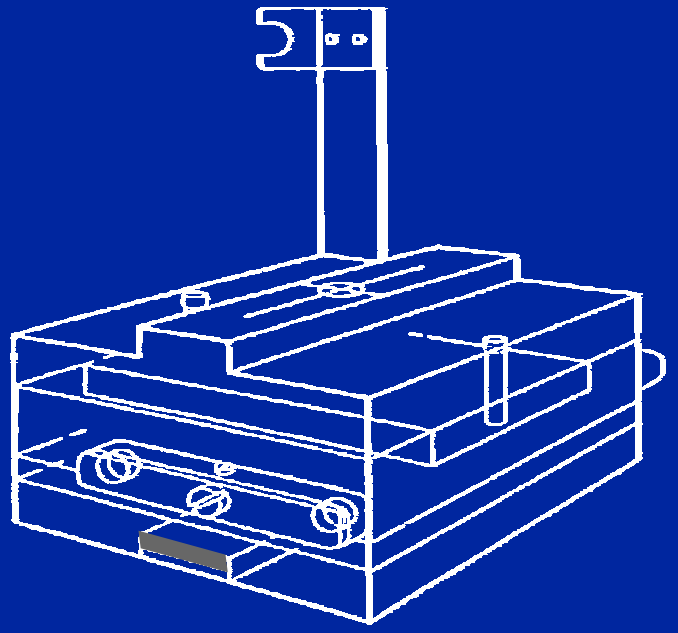
CDRH Fluoroscopic Phantom

- Dimensions:
  - 7.6” (19.3 cm) acrylic + 0.18” (4.6 mm) Al
  - Leg supports to raise phantom 3.9” (10 cm)

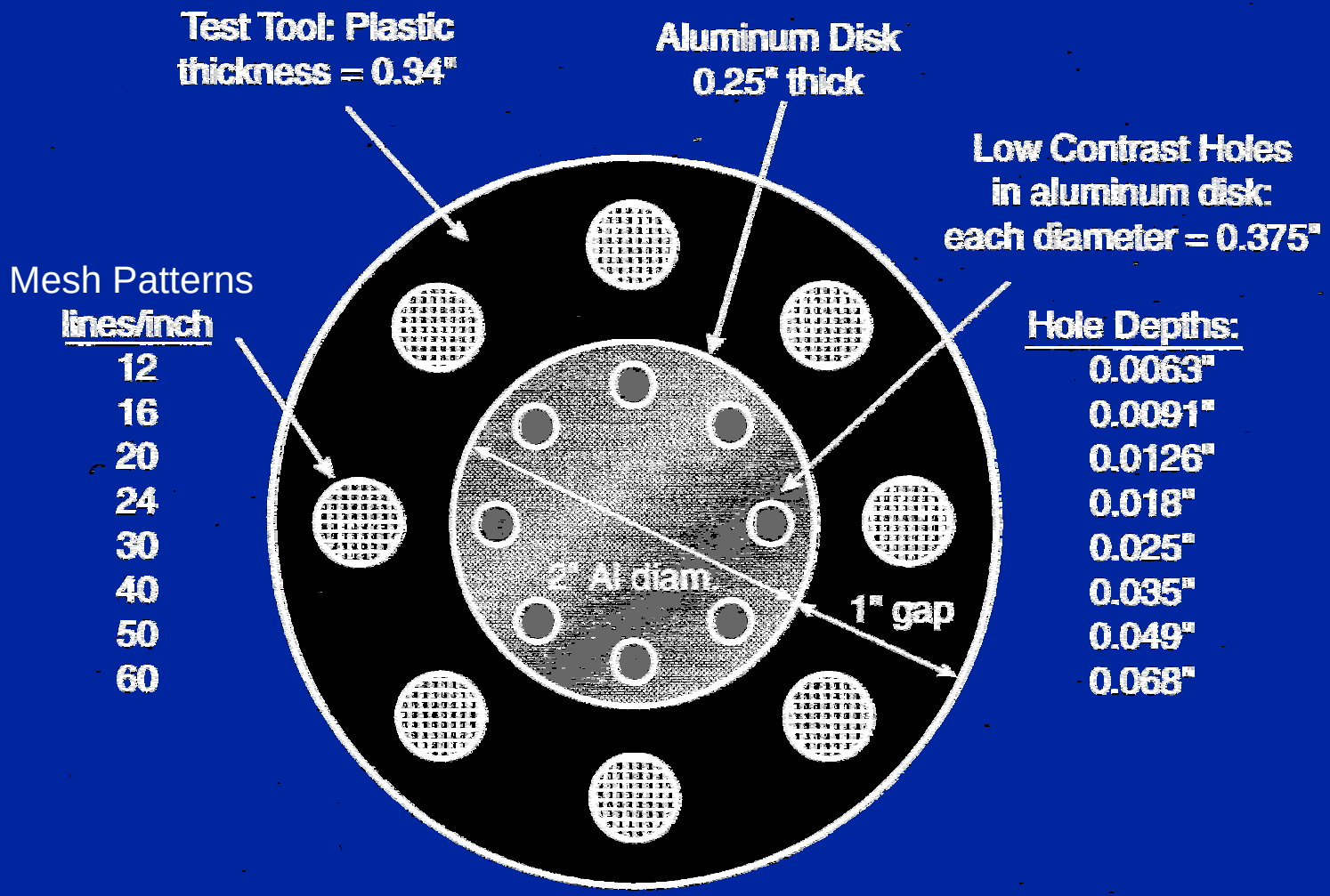


CDRH Abdomen/Spine Phantom

- Fluoroscopic phantom design is derived from the LucAl phantom
  - Simulates a 21.5 cm AP abdomen thickness in absolute and spectral transmission
  - Aluminum spine strip is included
- For the CDRH fluoroscopy phantom, the Al spine strip is extended over entire thickness

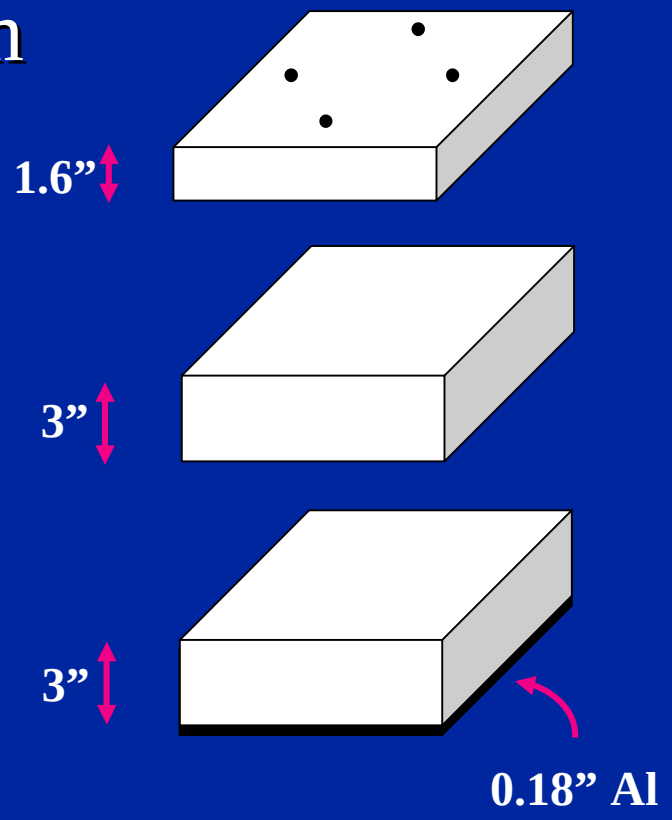


CDRH Fluoroscopic Phantom



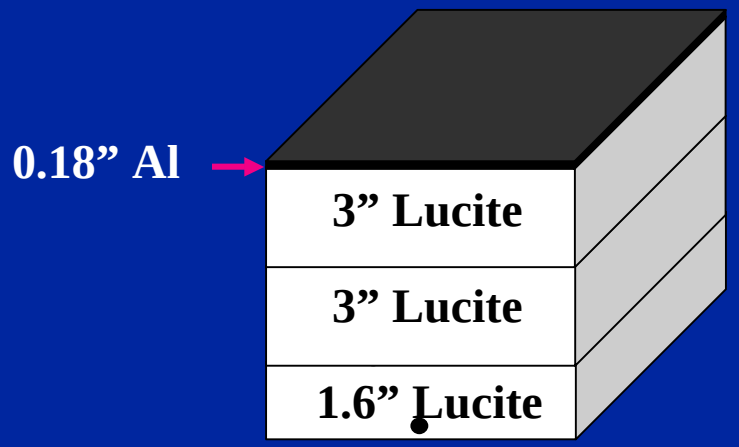
ACR R/F Phantom

- Same acrylic and aluminum thickness as the CDRH phantom
- Cut into slabs
- Increase size to 10” by 10” (25.4 by 25.4 cm)
- Lead markers included as a reference for repeatable collimation



ACR R/F Phantom

- Overtable x-ray tube configuration (radiography or fluoroscopy)
  - Al plate is placed toward the x-ray tube



ACR R/F Phantom

- Undertable x-ray tube configuration
  - Legs raise phantom 3.9” (10 cm) above the tabletop
  - Exposure measurements made at the tabletop are approximately free-in-air

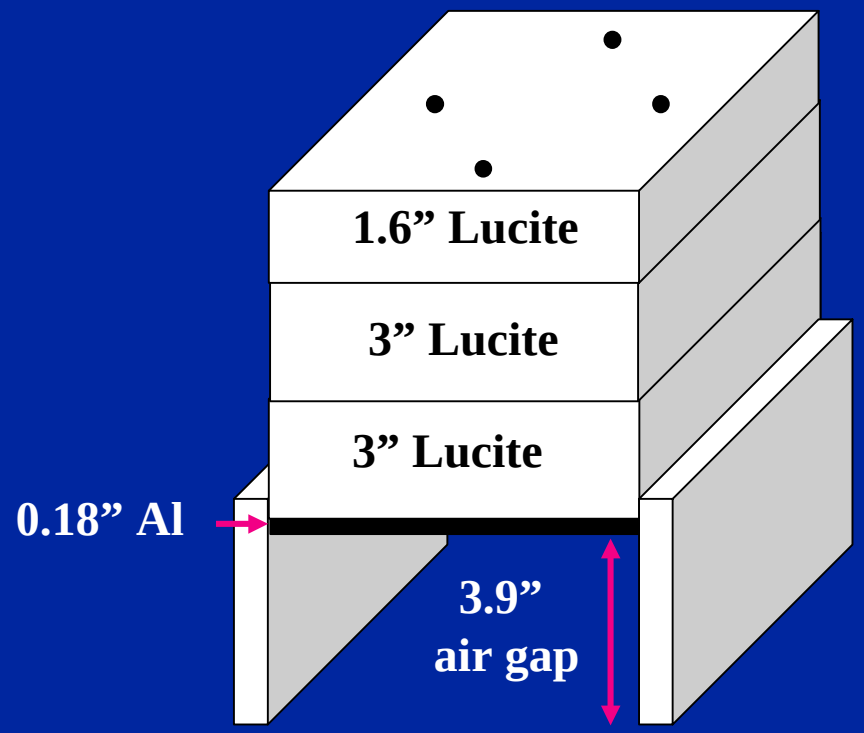
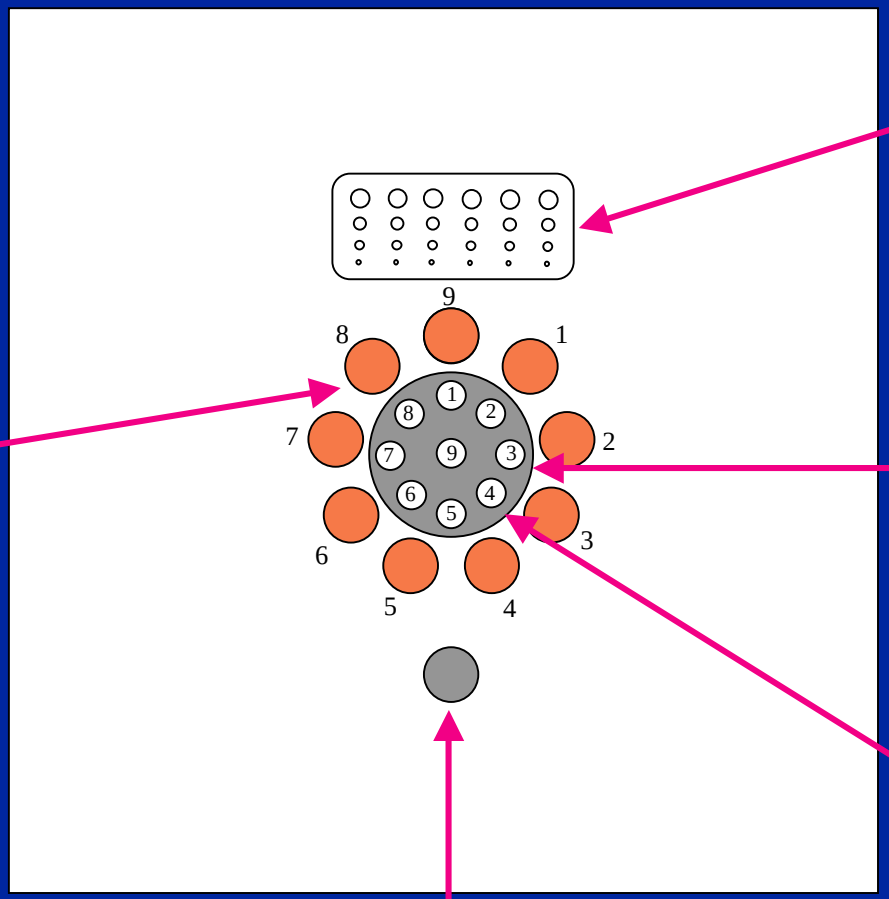


Image Quality Test Tool



Contrast Detail Holes

Mesh Patterns: 0.75” diameter

Al Disk: 2” diameter, 0.080” thickness

Low Contrast Holes in Al Disk: 0.375” diameter

Lucite Base: 10” length and width, 0.375” thickness

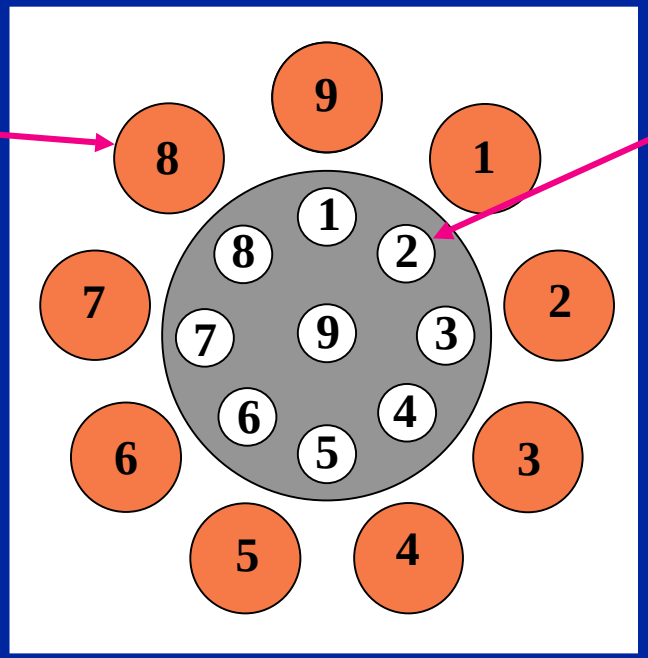
Al Plug

Image Quality Test Tool

- For fluoroscopic and spot imaging, only the central portion of the test tool is used

Mesh Patterns:

Mesh #	Lines/in
1	12
2	16
3	20
4	24
5	30
6	40
7	50
8	60
9	80

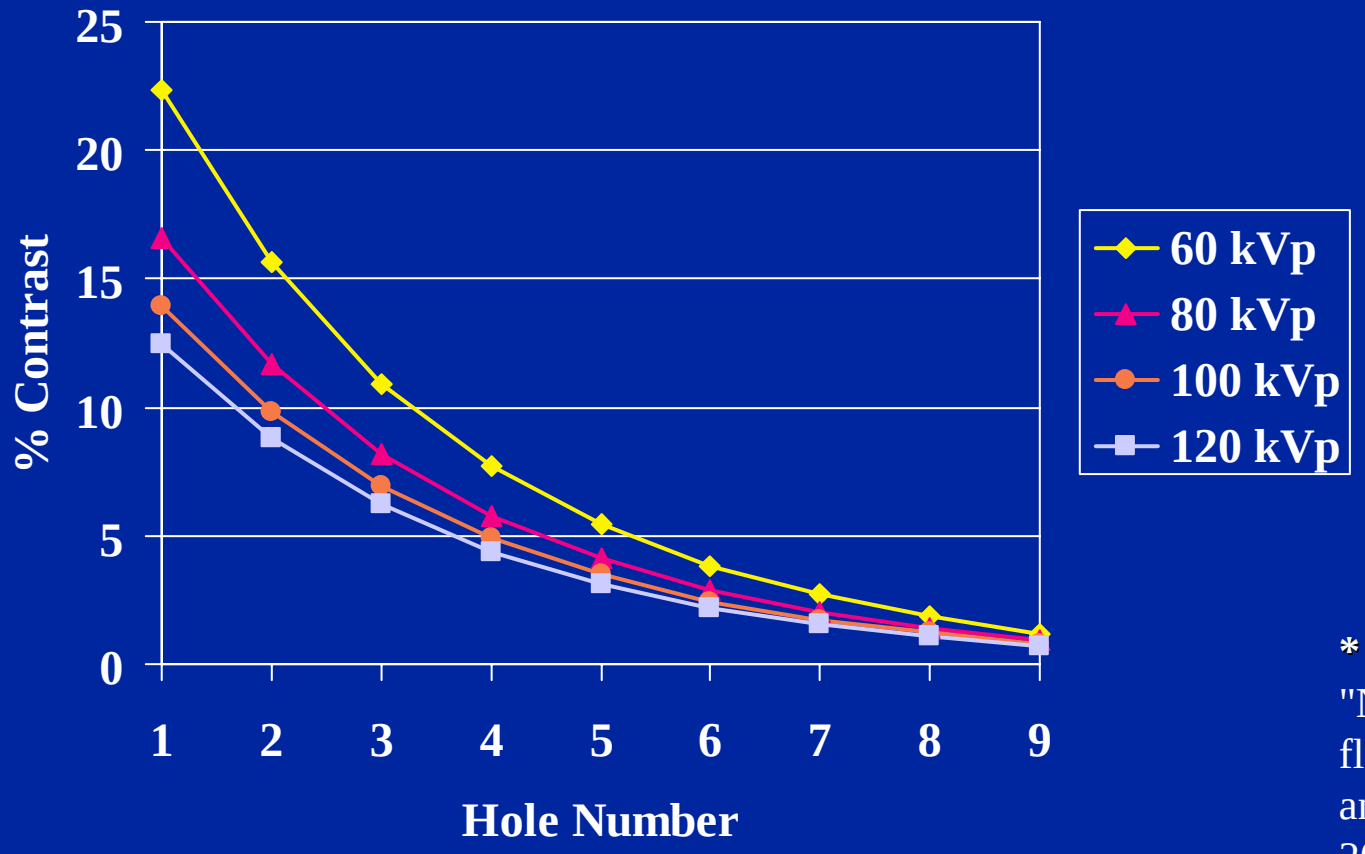


Low Contrast Holes in Al Disk:

Hole #	Depth
1	0.068”
2	0.049”
3	0.035”
4	0.025”
5	0.018”
6	0.0126”
7	0.0091”
8	0.0063”
9	0.0040”

Low Contrast Holes

- Percentage contrast of the low contrast holes has been calculated using numerically generated spectra*



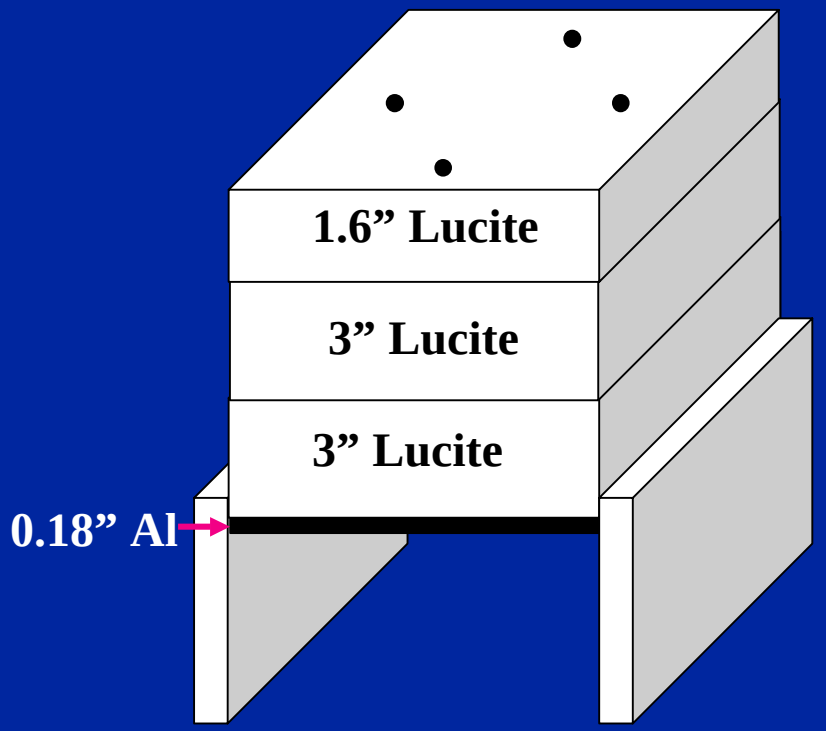
* Suleiman OH, *et al* (1997). "Nationwide survey of fluoroscopy: Radiation dose and image quality." Radiology 203:471-476.

Fluoroscopic System Evaluation

- Equipment Set-up
  - Undertable x-ray tube system
  - Overtable x-ray tube system

Equipment Set-up: Undertable Tube

1. Assemble the phantom with the leg supports so that the Al plate is toward the x-ray tube and the lead markers are toward the image receptor.



Equipment Set-up: Undertable Tube

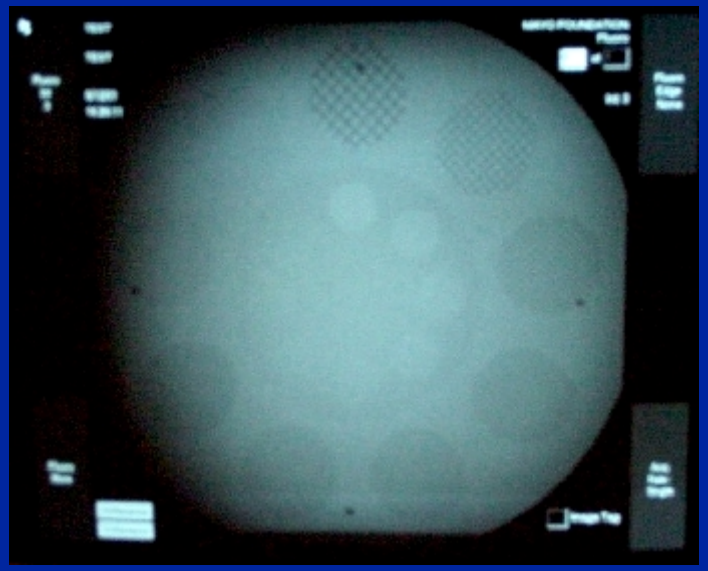
2. Center the image quality test tool on the table top underneath the phantom.

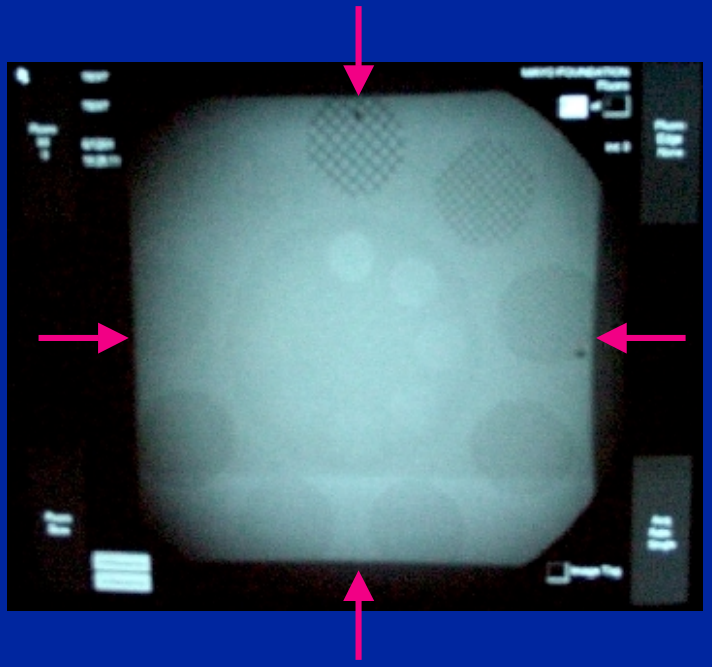
3. Center the phantom in the FOV under fluoroscopy.

4. Position the II tower so that it rests on top of the phantom.

Equipment Set-up: Undertable Tube

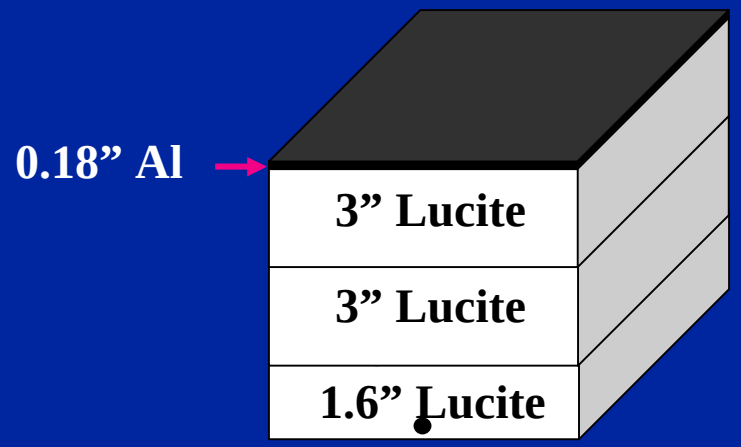
5. Set the II FOV to mode closest to 9” (23 cm).
6. Collimate to the lead markers.





Equipment Set-up: Overtable Tube

1. Assemble the phantom so that the lead markers are toward the image receptor on the table top and the Al plate is toward the x-ray tube.



Equipment Set-up: Overtable Tube

2. Center the image quality test tool on top of the phantom.

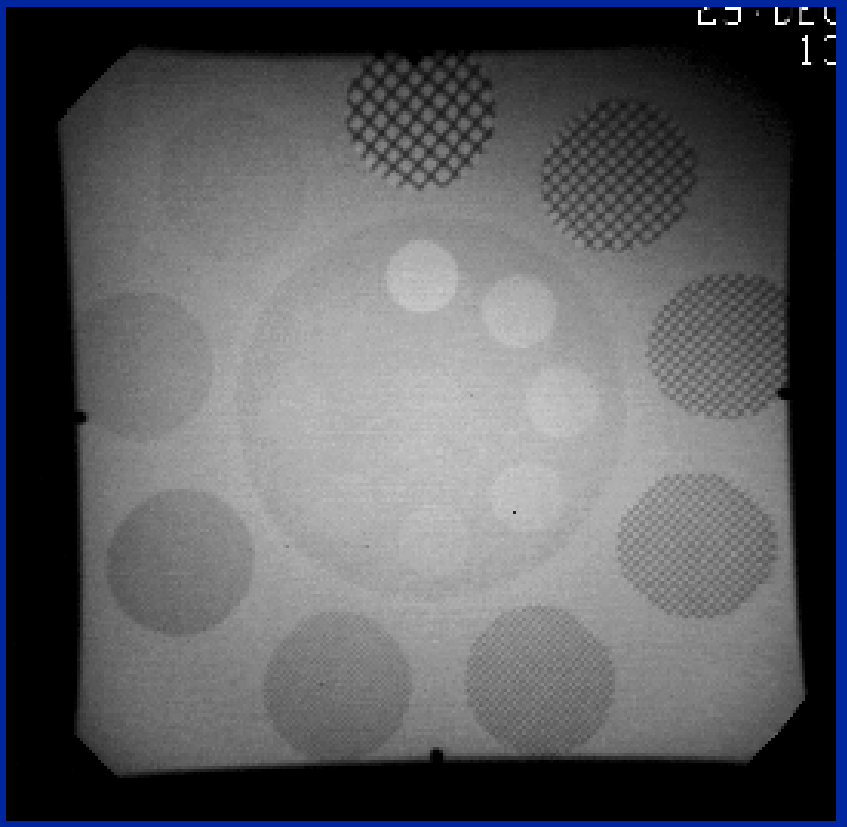
3. Center the phantom in the FOV under fluoroscopy.

Image Quality Evaluation

1. Adjust the fluoroscopic imaging settings to those routinely used for a barium enema exam.
   - Dose mode, continuous or pulsed exposure, selectable filtration, grid position, selectable kVp setting, …
   - For digital systems, window/level or other image processing settings.
2. Dim the room lights.
3. View the live fluoroscopic image.

Image Quality Evaluation

4. Count mesh patterns visible.
5. Count low contrast holes visible. Adjust monitor brightness and contrast to optimize image.
6. Note actual kVp and calculate % contrast.



Entrance Exposure Rate

1. Remove the image quality test tool.
2. For undertable tube systems, position an ion chamber under the phantom on the table top.

Entrance Exposure Rate

3. For overtable tube systems, position an ion chamber 30 cm above the table top.
4. Center the ion chamber in the FOV.
5. Using same fluoroscopic imaging settings as used to evaluate image quality, measure exposure rate.

Entrance Exposure Rate

6. Place a lead attenuator (at least 0.25” thick) on phantom and measure the maximum exposure rate.

Spot-film Device Image Acquisition

- For fluoroscopic systems capable of multiple types of spot imaging, the site selects the most commonly used mode for image submission
  - film-screen cassette
  - photospot camera
  - digital photospot
- Entrance exposure is measured with a Luxel dosimeter
- Same equipment set-up as for fluoroscopy

Film-screen Spot Image Acquisition

1. Load a 10x12” (24x30 cm) or 9.5x9.5” (24x24 cm) cassette into the spot-film device.

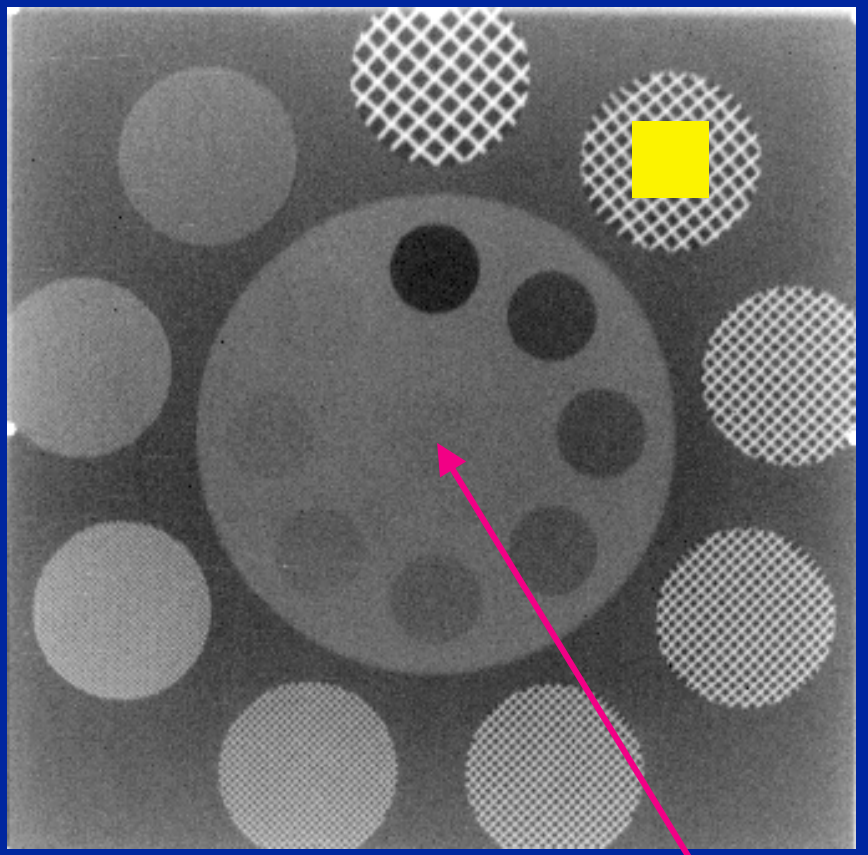
2. Select the 1 on 1 format.

Film-screen Spot Image Acquisition

3. Expose and process the film.

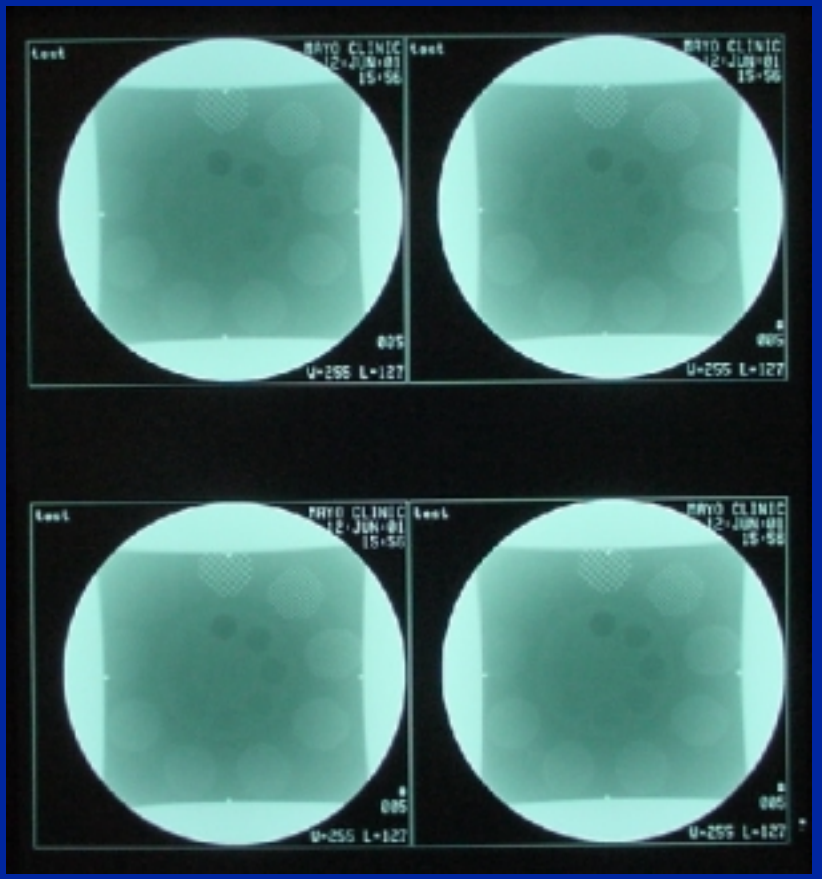
4. Measure the OD in the center of the test tool image. OD should be between 1.0 and 1.8.

5. Repeat the exposure with the dosimeter covering a mesh pattern.



Digital Photospot Image Acquisition

1. Select the image processing options routinely used for clinical imaging and expose.
2. Print a hardcopy in the most commonly used film format and size. (No OD criteria.)
3. Repeat the exposure with the dosimeter covering a mesh pattern.

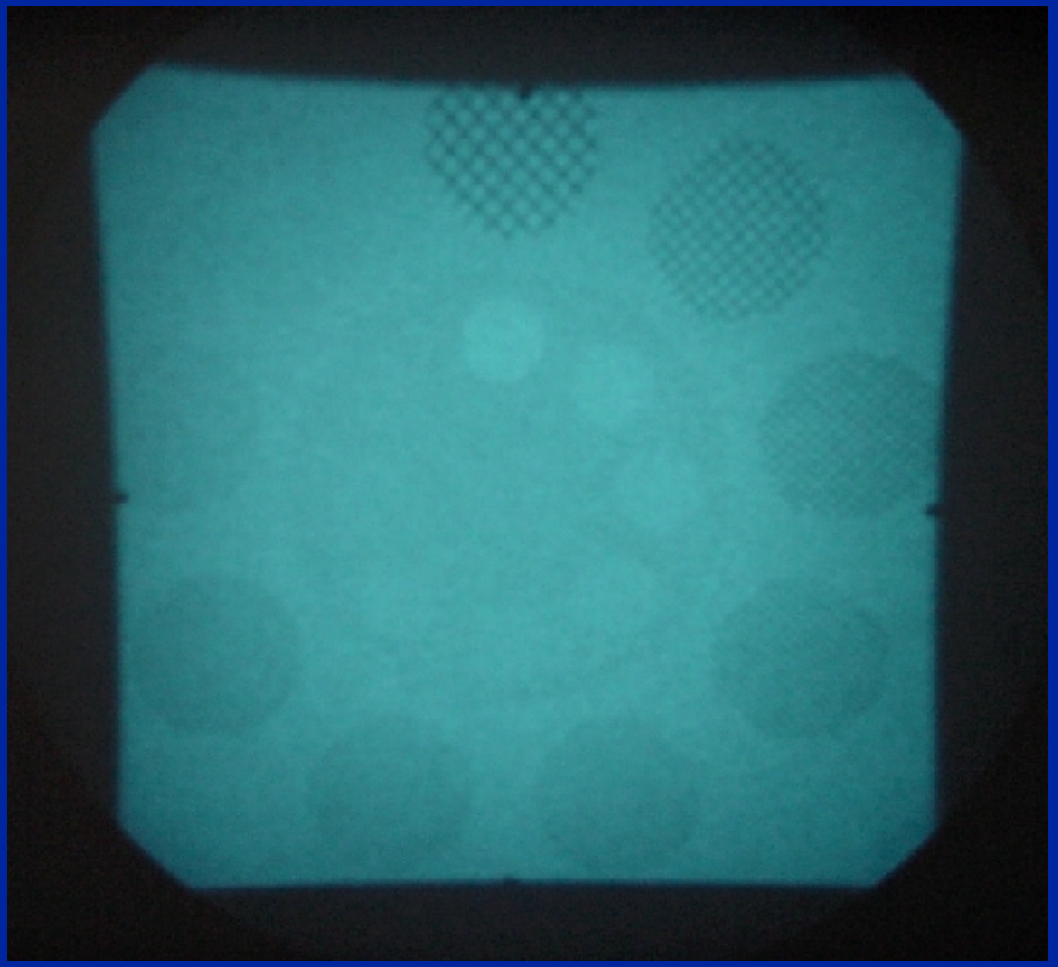


Sample Results

- Fluoroscopy
  - Example ACR R/F Phantom images
  - 1991 Upper GI Fluoroscopy NEXT (Nationwide Evaluation of X-ray Trends) survey results obtained with the CDRH fluoroscopic phantom*
- Spot images
  - Example ACR R/F Phantom images

***** Suleiman OH, *et al* (1997). "Nationwide survey of fluoroscopy: Radiation dose and image quality." Radiology 203:471-476.

Fluoroscopy Example 1



Continuous fluoro

Grid in

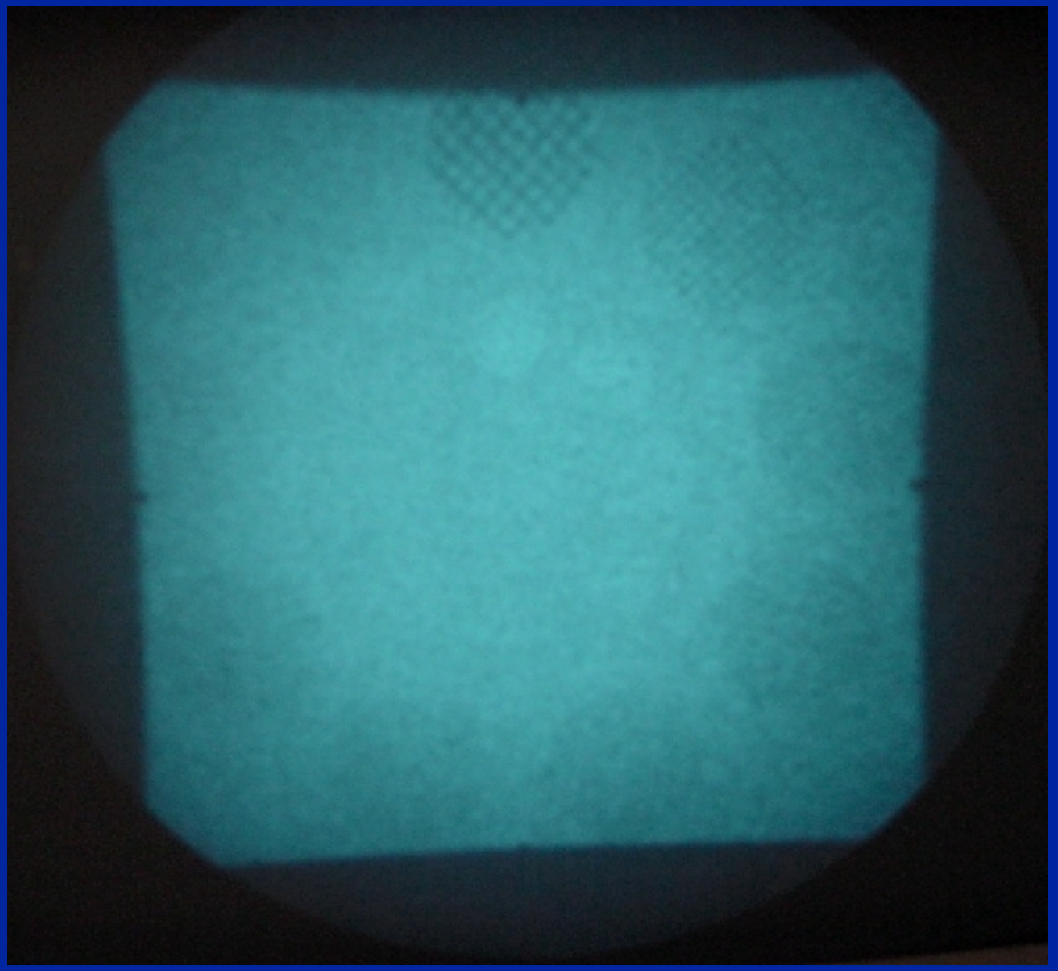
110 kVp / 2.4 mA

5 mesh patterns (30 lines/in)

7 holes (1.6% contrast)

8 R/min

Fluoroscopy Example 2



Pulsed fluoro (15 pps)

Grid out

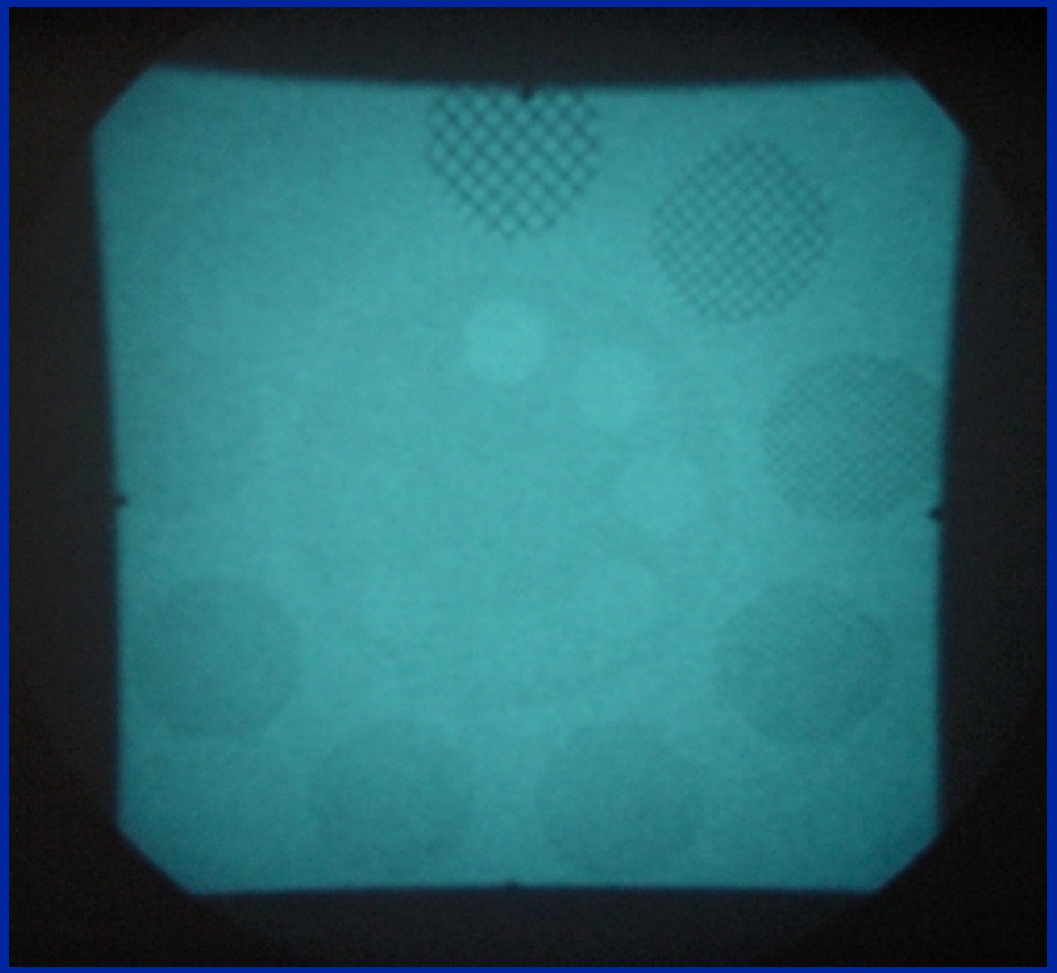
90 kVp / 4 mA

5 mesh patterns (30 lines/in)

6 holes (2.6% contrast)

1 R/min

Fluoroscopy Example 3



Continuous fluoro

Grid out

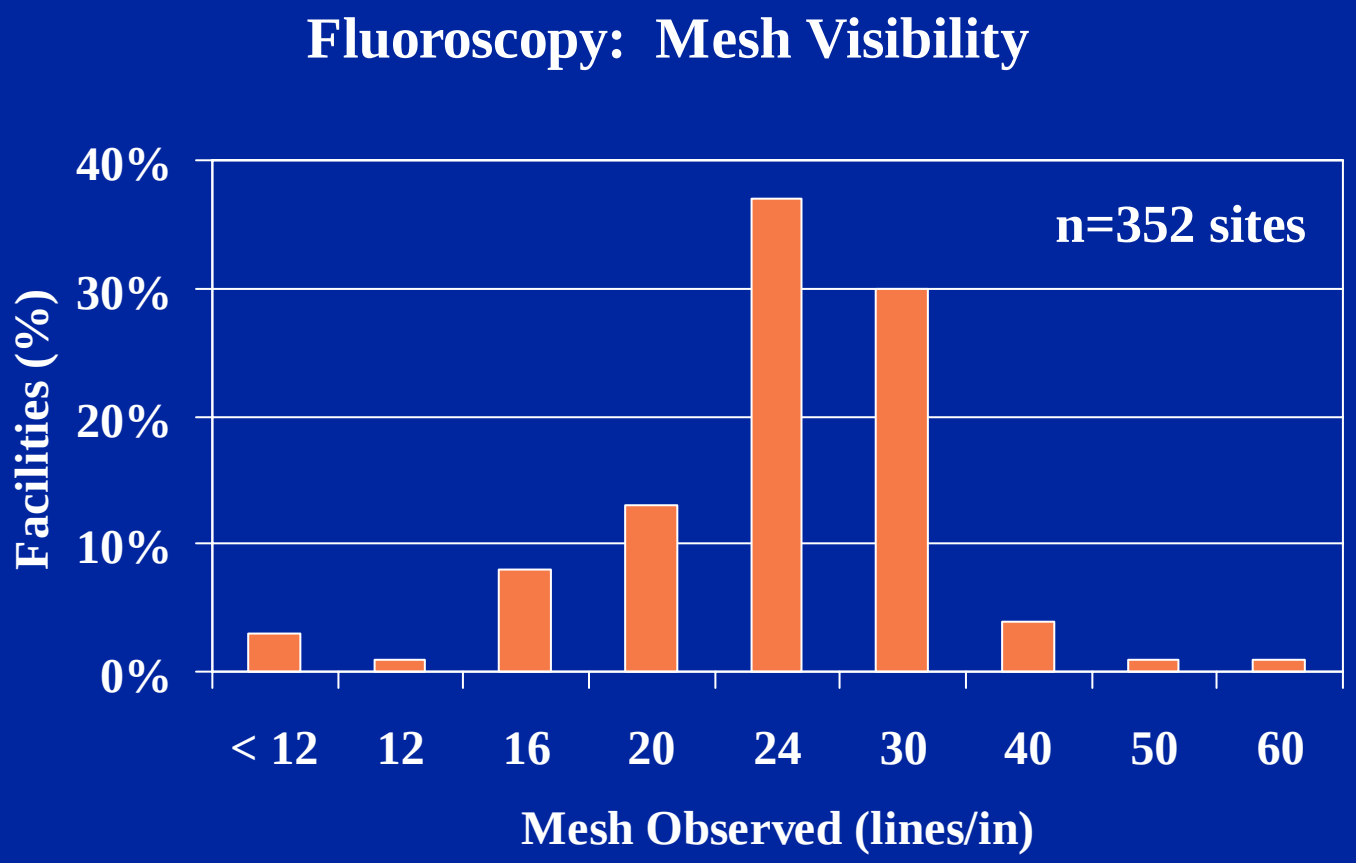
80 kVp / 2.6 mA

5 mesh patterns (30 lines/in)

7 holes (2.1% contrast)

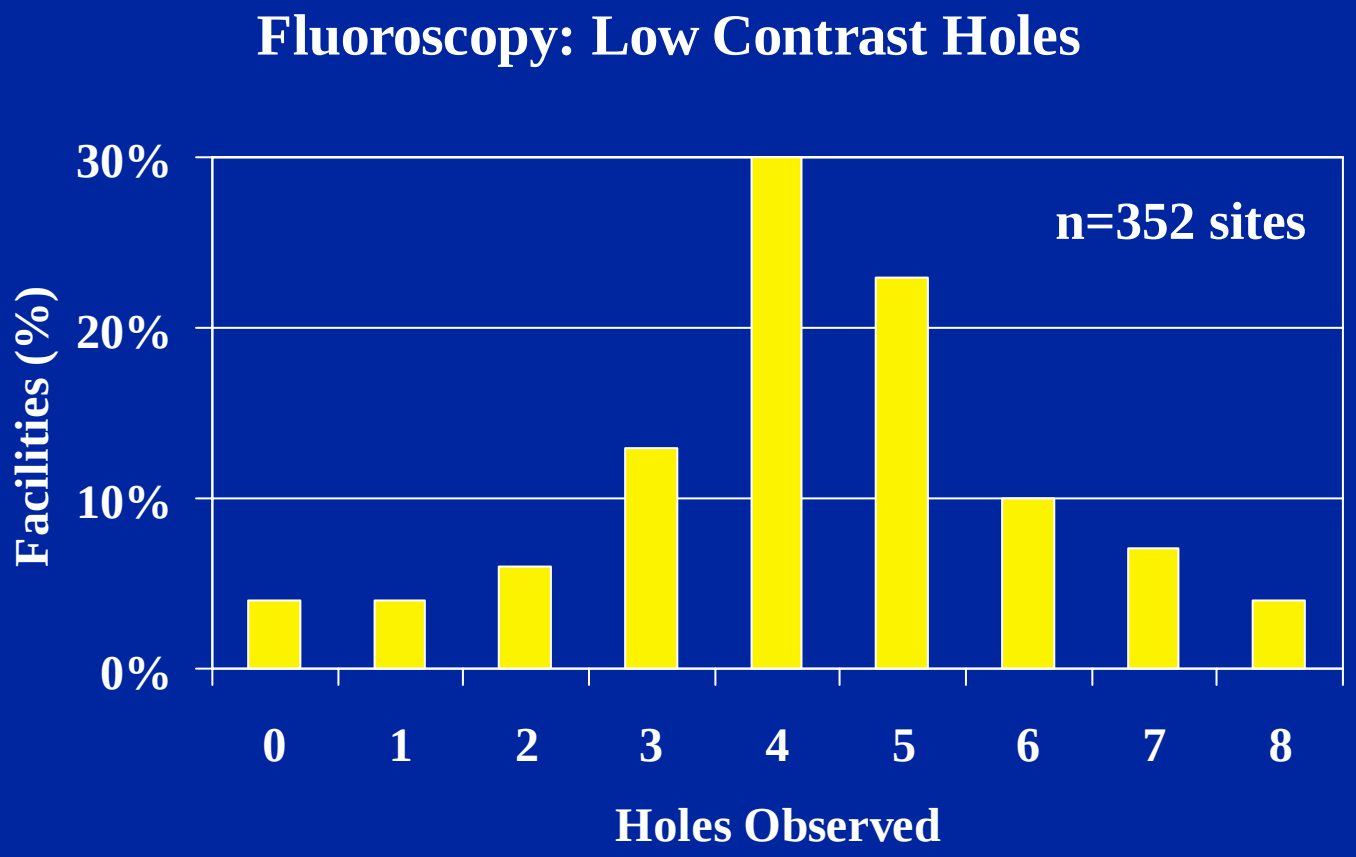
3 R/min

NEXT Survey Results

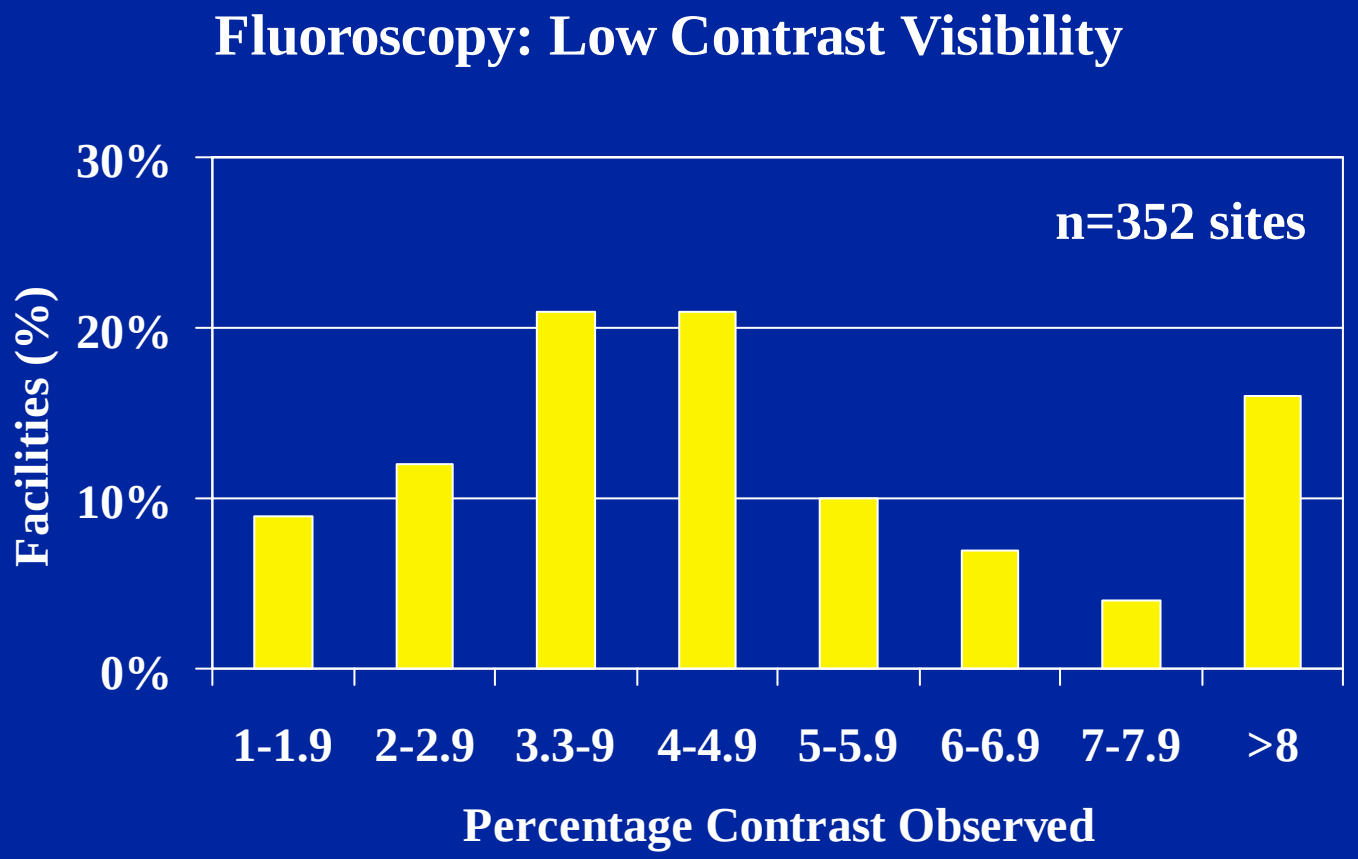


Mean: 24 lines/in (4 mesh patterns)

NEXT Survey Results

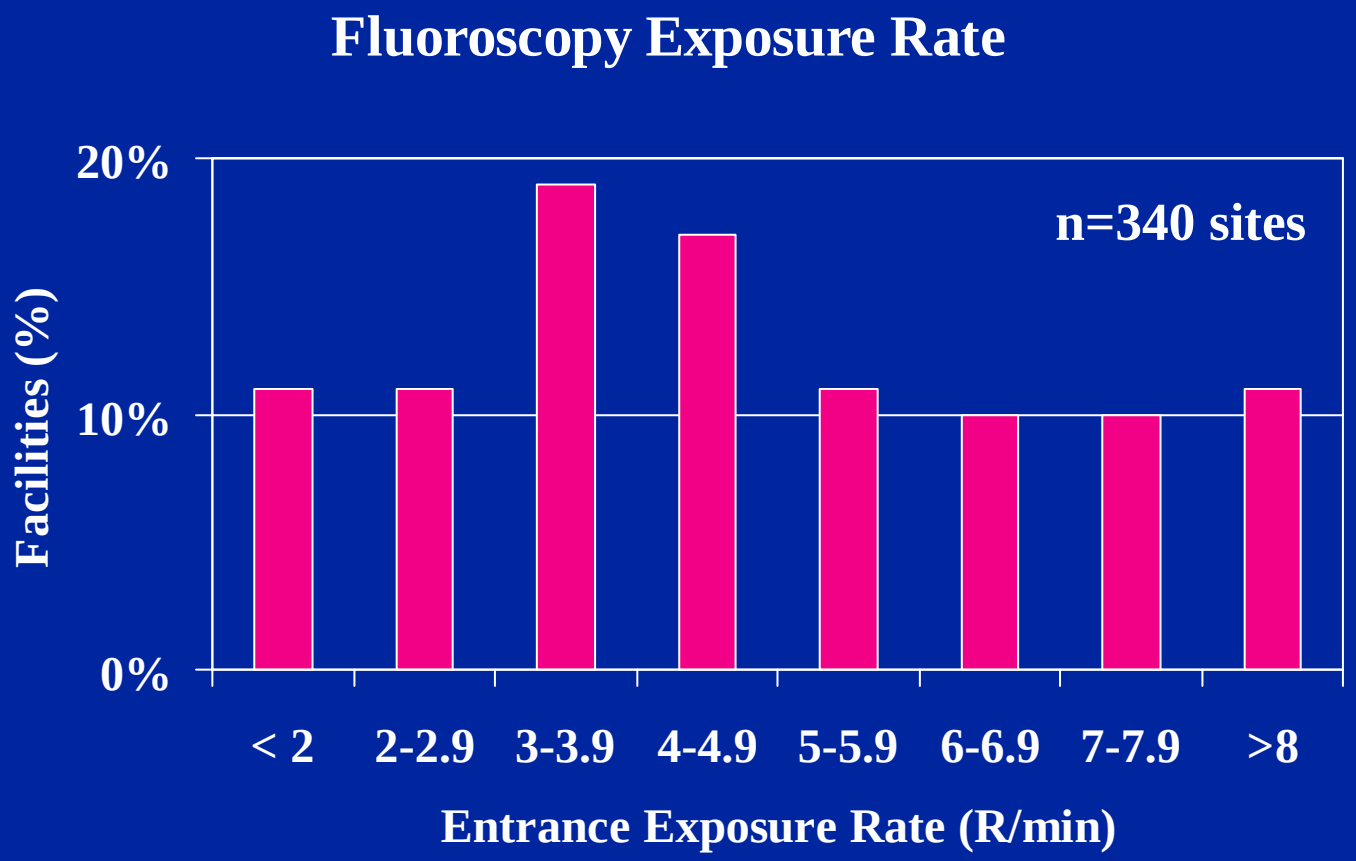


NEXT Survey Results



Mean: 4.9%

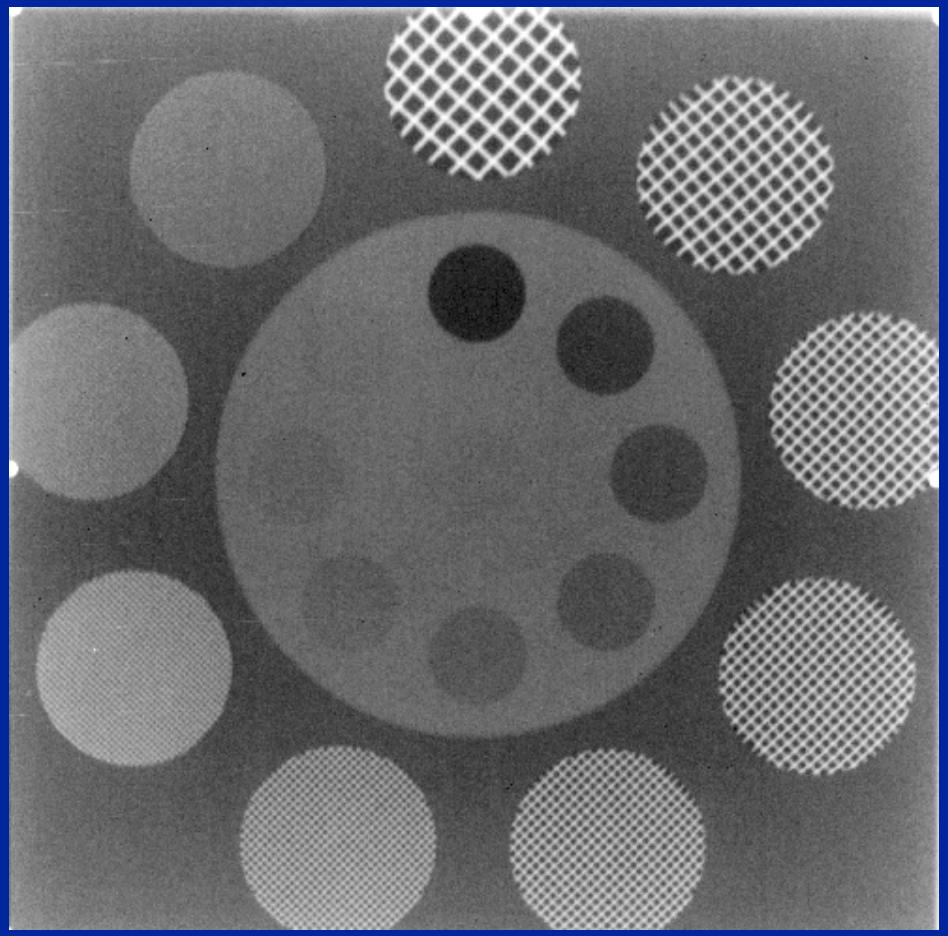
NEXT Survey Results



Mean:
5.0 R/min

Mean kVp:
102

Spot Image Example 1



Film-screen

85 kVp / 17 mAs

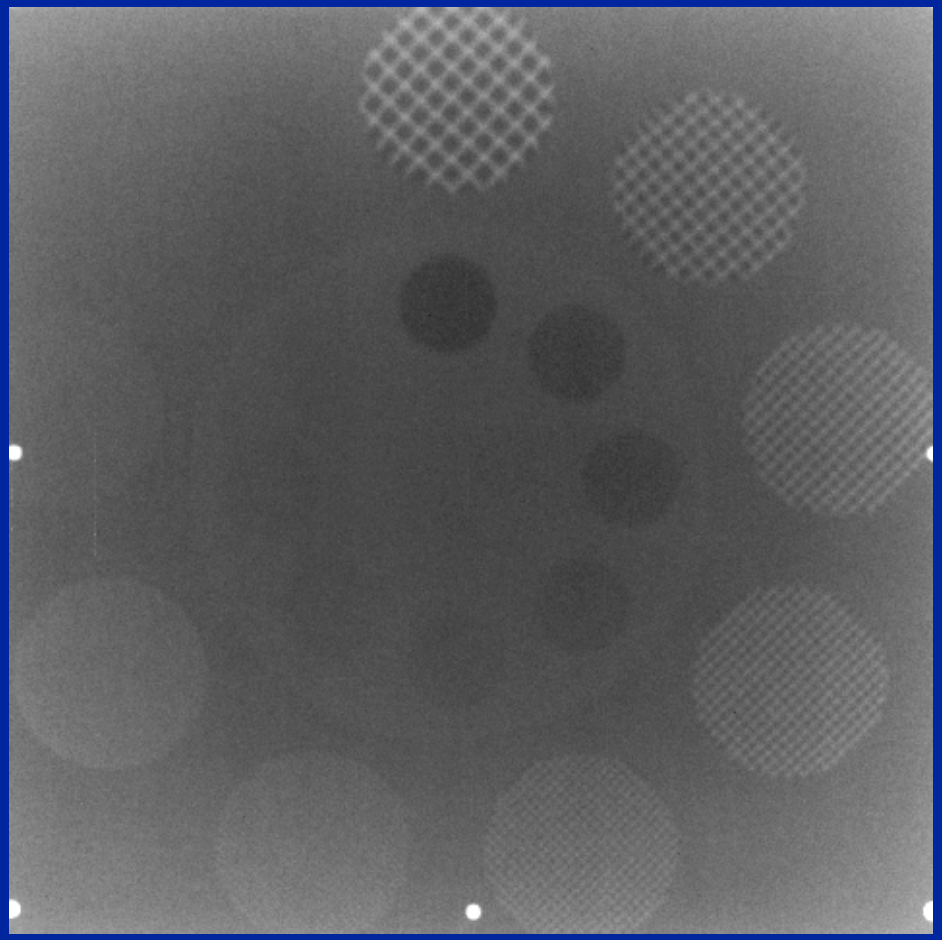
Small focal spot

8 mesh patterns (60 lines/in)

9 holes

300 mR

Spot Image Example 2



Film-screen

120 kVp / 4 mAs

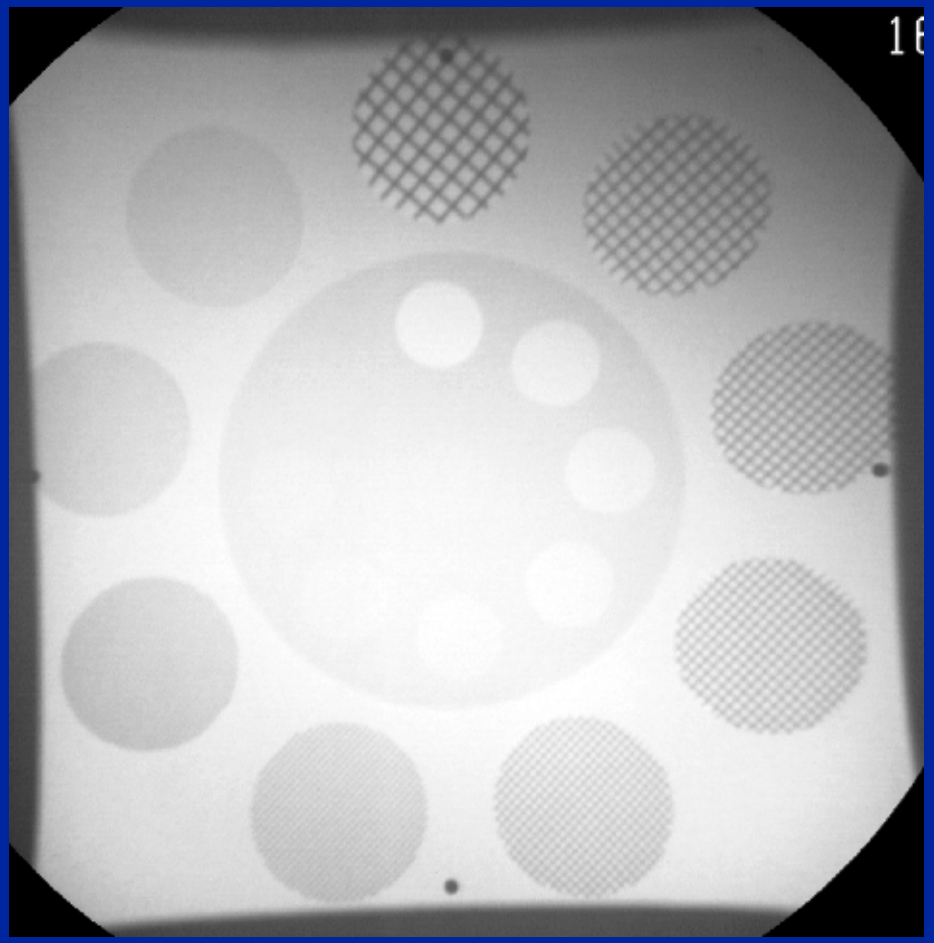
Large focal spot

6 mesh patterns (40 lines/in)

7 holes

200 mR

Spot Image Example 3



Digital Photospot

60 kVp / 50 mAs

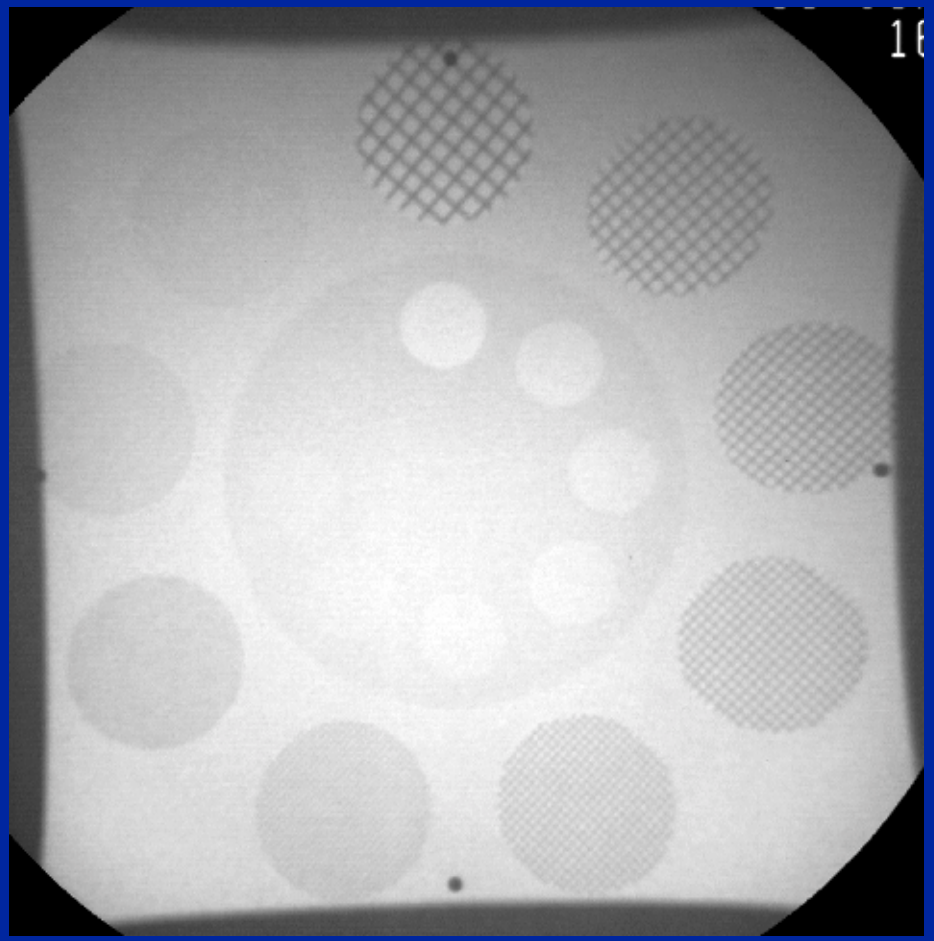
Small focal spot

6 mesh patterns (40 lines/in)

9 holes

400 mR

Spot Image Example 4



Digital Photospot

80 kVp / 3 mAs

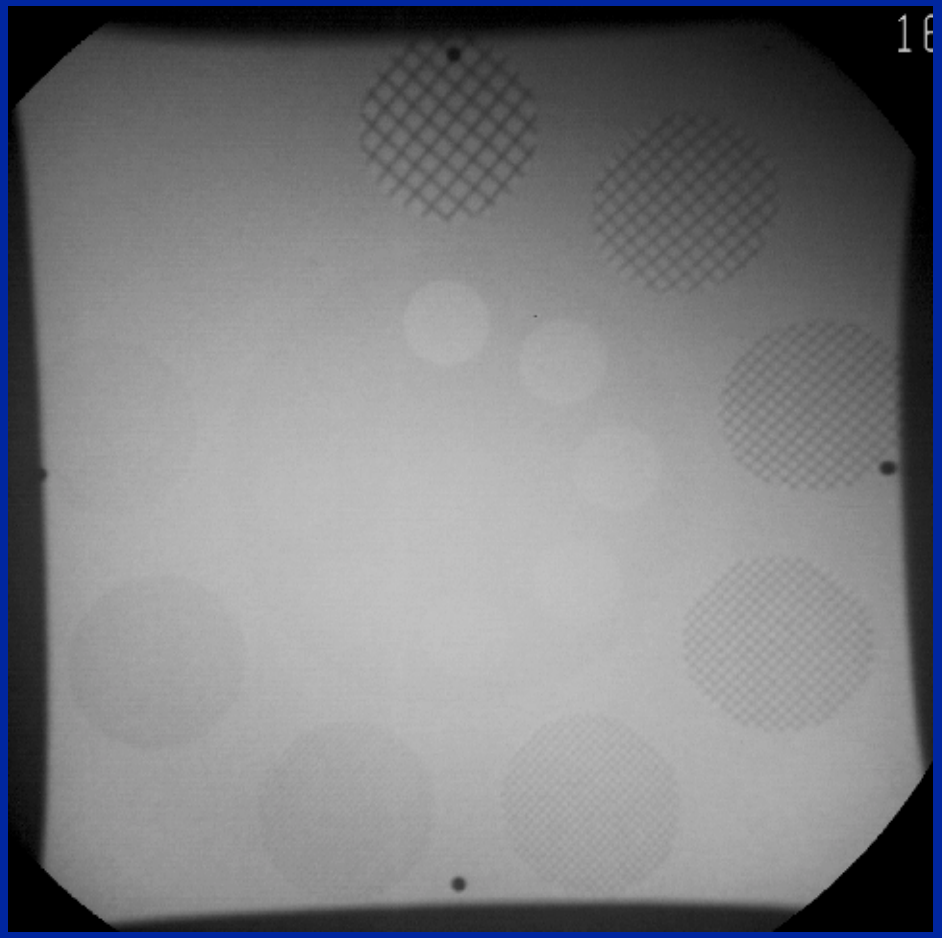
Small focal spot

6 mesh patterns (40 lines/in)

8 holes

55 mR

Spot Image Example 5



Digital Photospot

120 kVp / 1 mAs

Small focal spot

6 mesh patterns (40 lines/in)

7 holes

60 mR

Suggested Corrective Actions

- If phantom image quality or dose does not meet minimum pass/fail criteria, the medical physicist may be called on to suggest corrective action

Corrective Actions

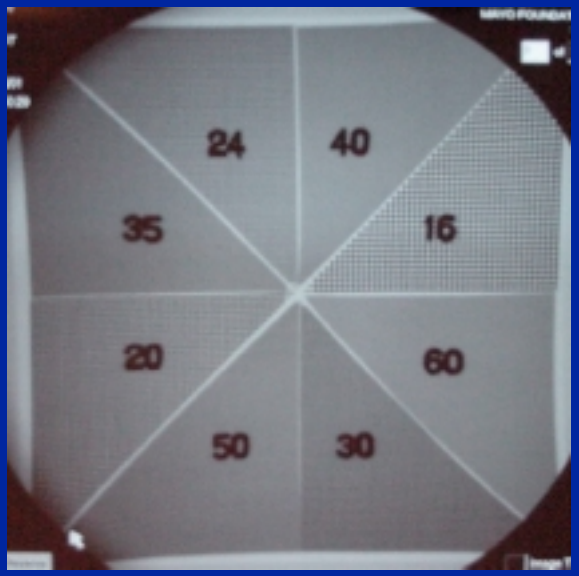
- Phantom entrance exposure rate too high
  - Image intensifier exposure rate is set too high
    - 1-3 μR/frame in the 9” (23 cm) FOV recommended
  - Increase filtration
    - 3-3.5 mm Al at 80 kVp recommended
  - Remove grid during fluoroscopy

Corrective Actions

- Number of mesh patterns observed is too low
  - Image intensifier focus is poor

Corrective Actions

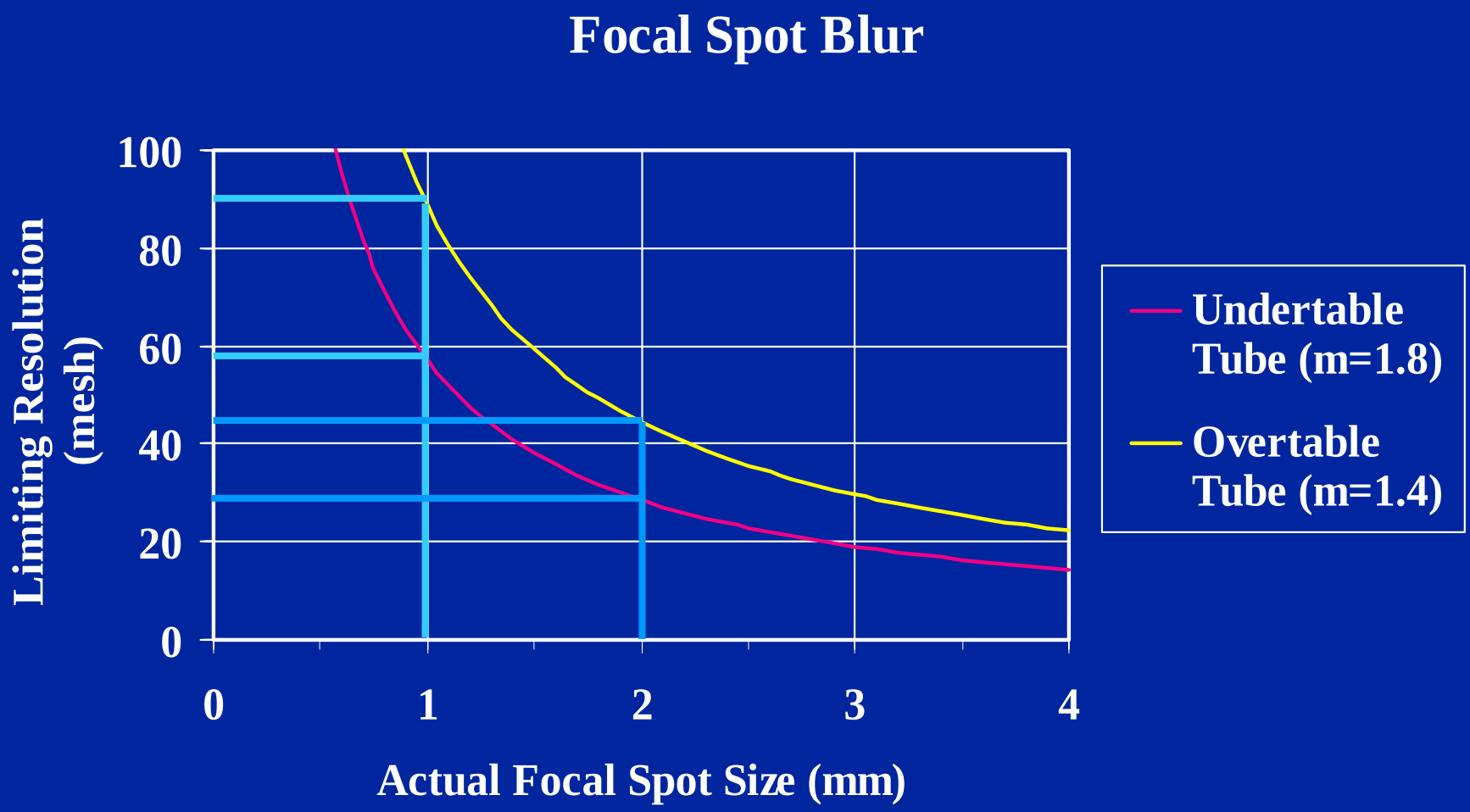
- High contrast spatial resolution measurement
  - Measure at center and edge of image
  - 1.25 lp/mm (line bar pattern) or 30 wires/in (mesh pattern) in the 9” FOV recommended



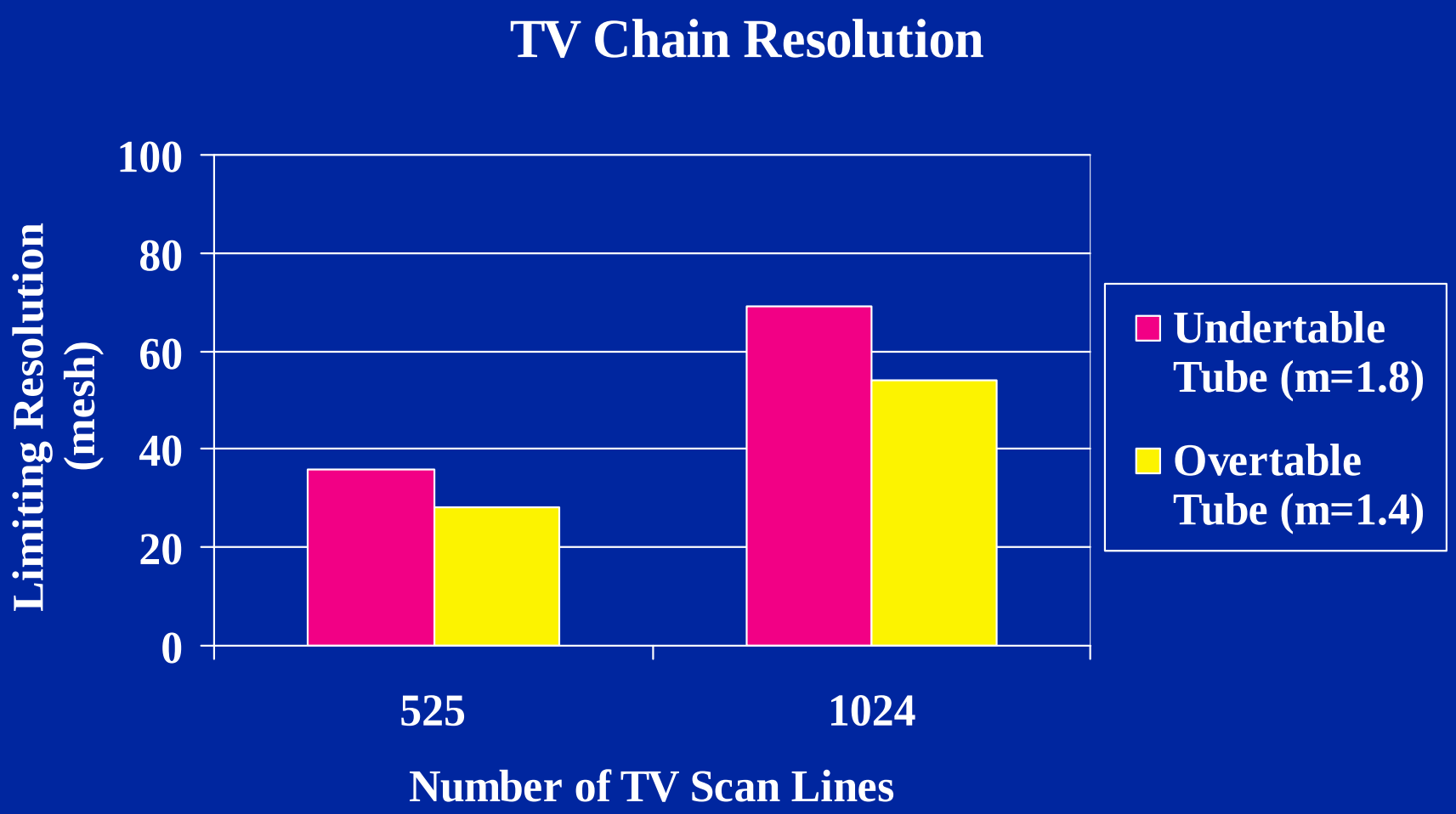
Corrective Actions

- Number of mesh patterns observed is too low
  - Image intensifier focus is poor
  - Focal spot size is too large

Corrective Actions



Corrective Actions



Corrective Actions

- Number of mesh patterns observed is too low
  - Image intensifier focus is poor
  - Focal spot size is too large
  - Poor monitor performance
  - Excessive image noise
  - Poor contrast

Corrective Actions

- Percentage contrast detectability is too high
  - Image intensifier exposure rate is set too low
    - 1-3 μR/frame in the 9” (23 cm) FOV recommended
  - Consider a replacement II or replacement monitor

Additional Phantom Characterization

1. Backscatter:

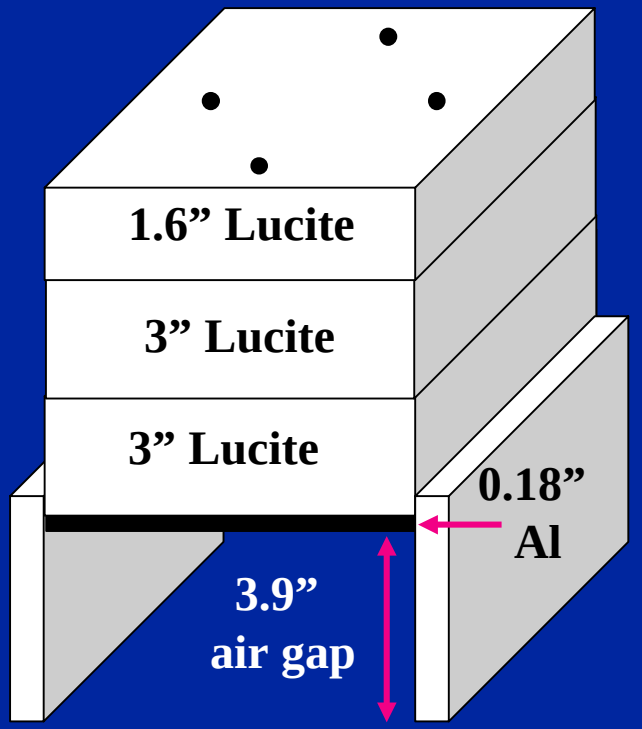
   Measurement of the amount of backscatter produced by the ACR R/F phantom at the exposure measurement location

2. Equivalent Water Attenuation:

   Comparison of the ACR R/F phantom transmission with other common phantoms

ACR R/F Phantom: Backscatter

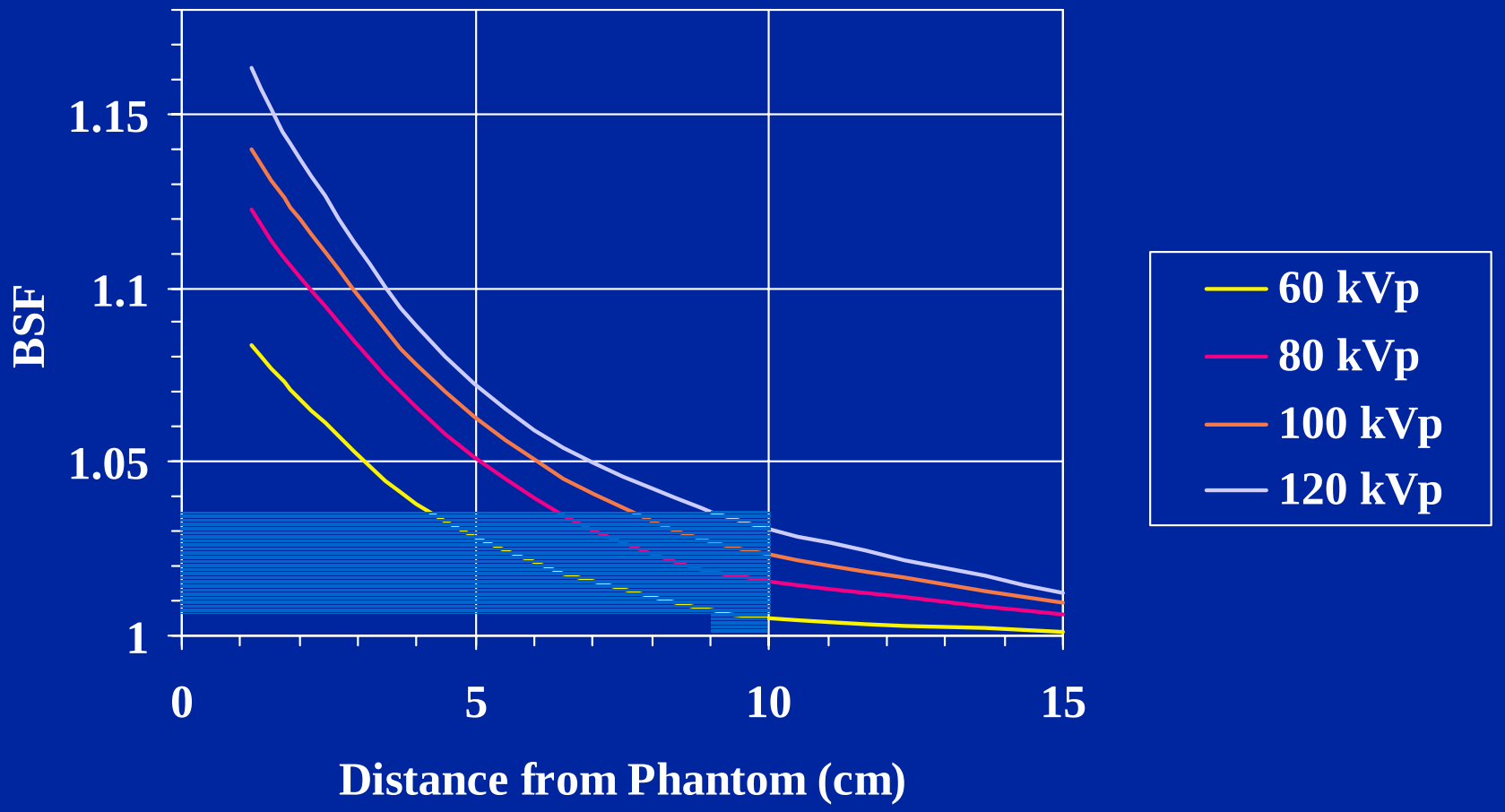
- The CDRH fluoroscopy phantom design allows for measurement of the entrance exposure with minimal contribution from backscatter
  - Leg supports raise the phantom 3.9” (10 cm) from the tabletop
  - The Al plate is positioned on the entrance side of the phantom



Backscatter: Methods

- For validation, the backscatter factor (BSF) was measured as a function of distance from the phantom
  - BSF = Exposure with phantom in place ÷ Exposure without phantom
  - FOV was collimated to the lead markers
  - Measurements made at 60, 80, 100 and 120 kVp

Backscatter: Results

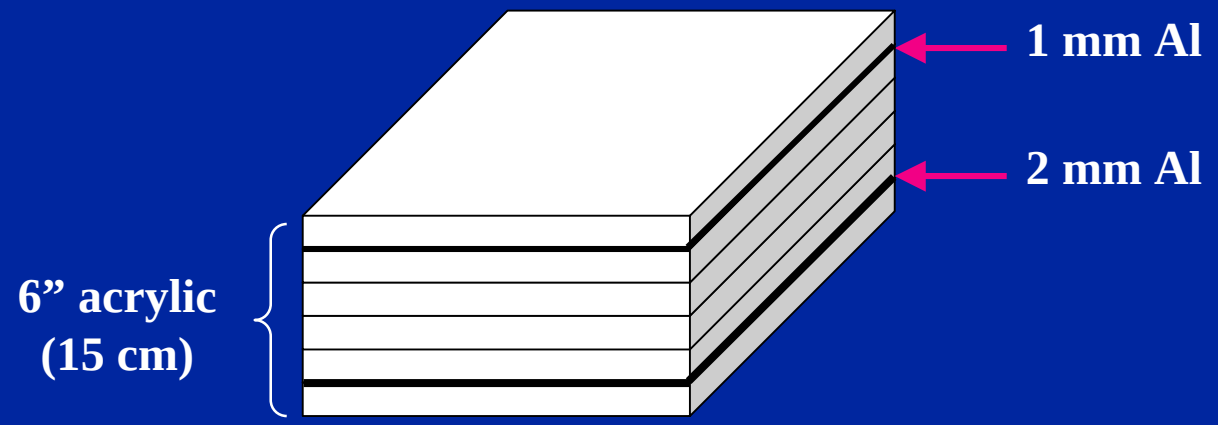


Attenuation: Methods

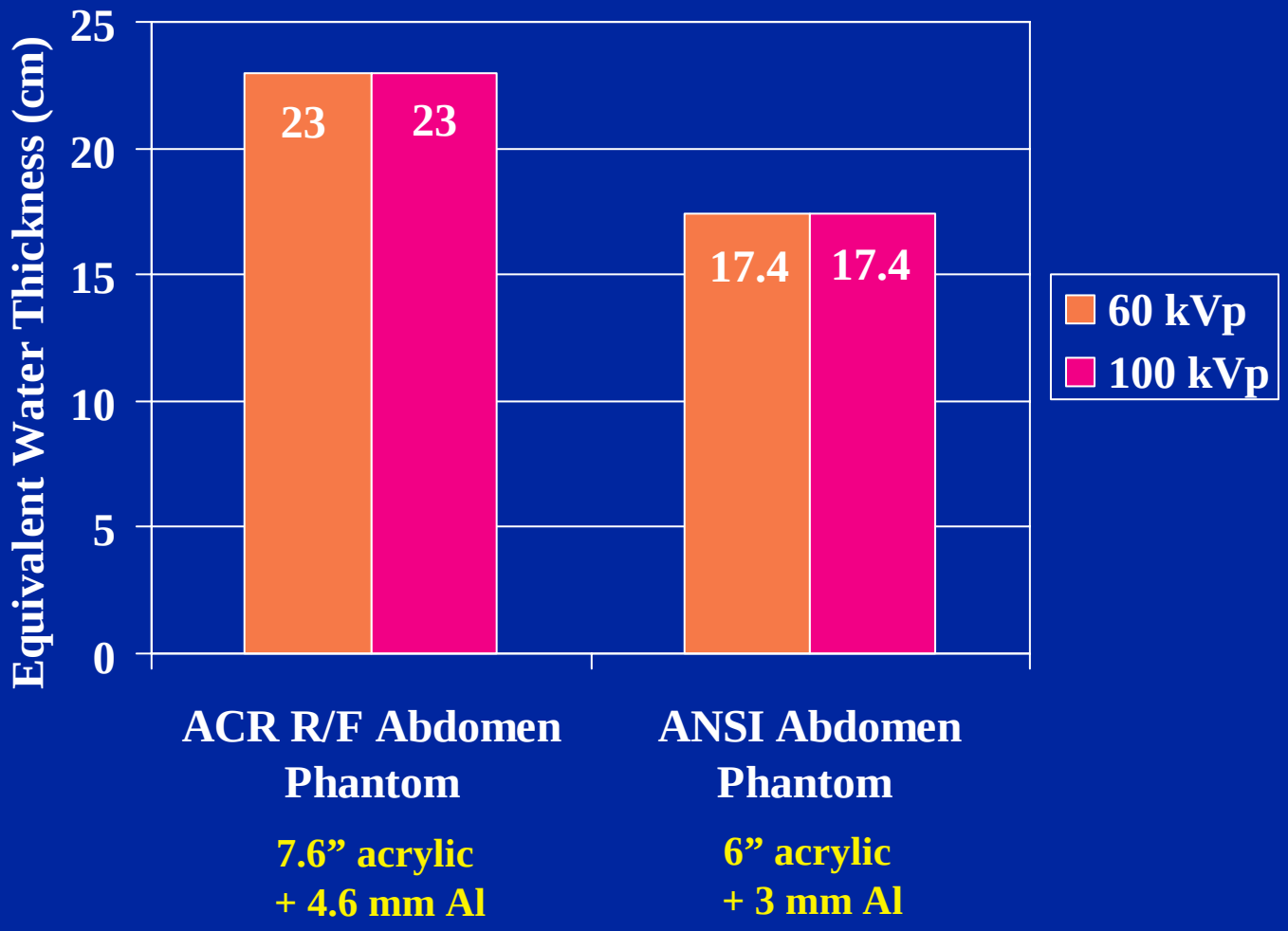
- Measure the equivalent water thickness of the ACR R/F Phantom
  - Matching exposures determined by matching radiographic screen-film optical densities (to within 0.02 OD)
  - FOV was collimated to the lead markers
  - Measurements made at 60 and 100 kVp
  - Repeat for an ANSI abdomen phantom

ANSI Abdomen Phantom

- Acrylic and aluminum (type 1100 alloy) phantom
  - Patient-equivalent in absolute and spectral transmission



Attenuation: Results



ACR V-I Accreditation Program

- Vascular, interventional, neurovascular procedures
- Accreditation Program includes evaluation of
  - equipment performance
  - personnel qualifications (physician, RT, MP, nurse)
  - quality control
  - clinical image quality

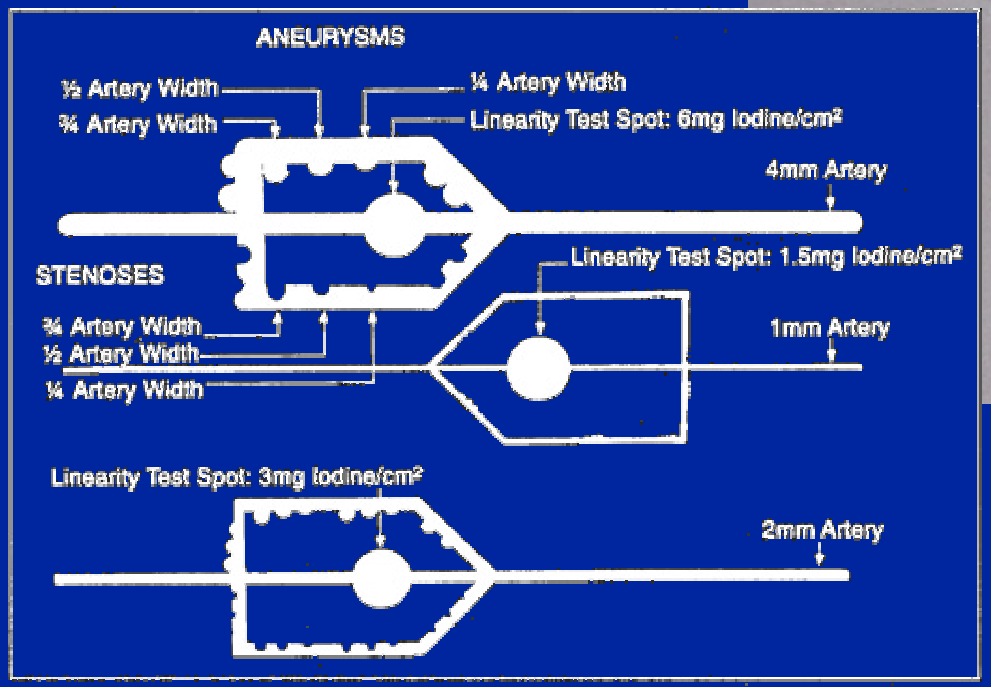
ACR V-I Accreditation Program

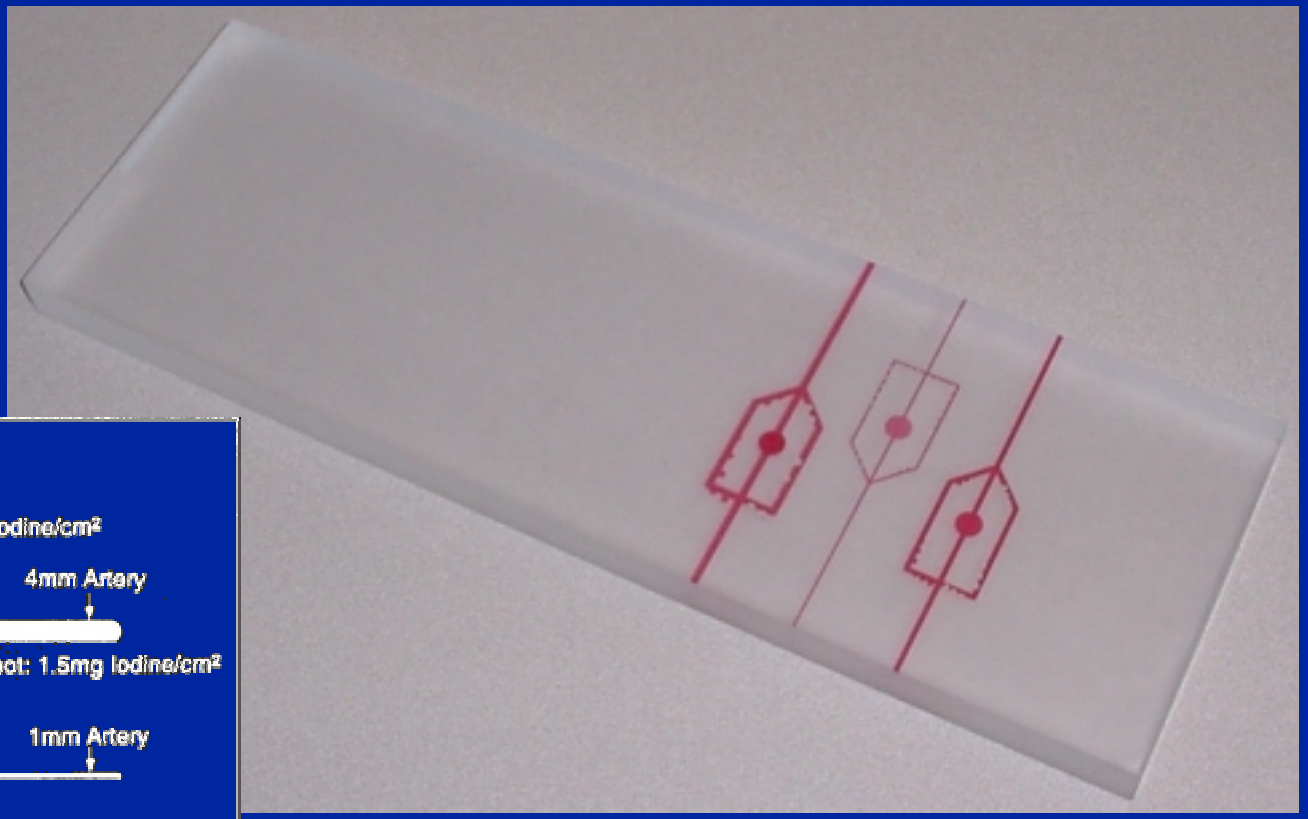
- Quality control
  - Initial and annual medical physics tests
  - More frequent technologist tests
- Patient dose monitoring recommended
  - dose-area product meter
  - skin dose monitor
  - entrance skin dose calculation
  - estimation from fluoroscopy time and number of images

ACR V-I Phantom

- Same as the R/F phantom, with the addition of an artery block
- Artery block includes iodine-filled simulated arteries of various diameters with stenoses and aneurysms

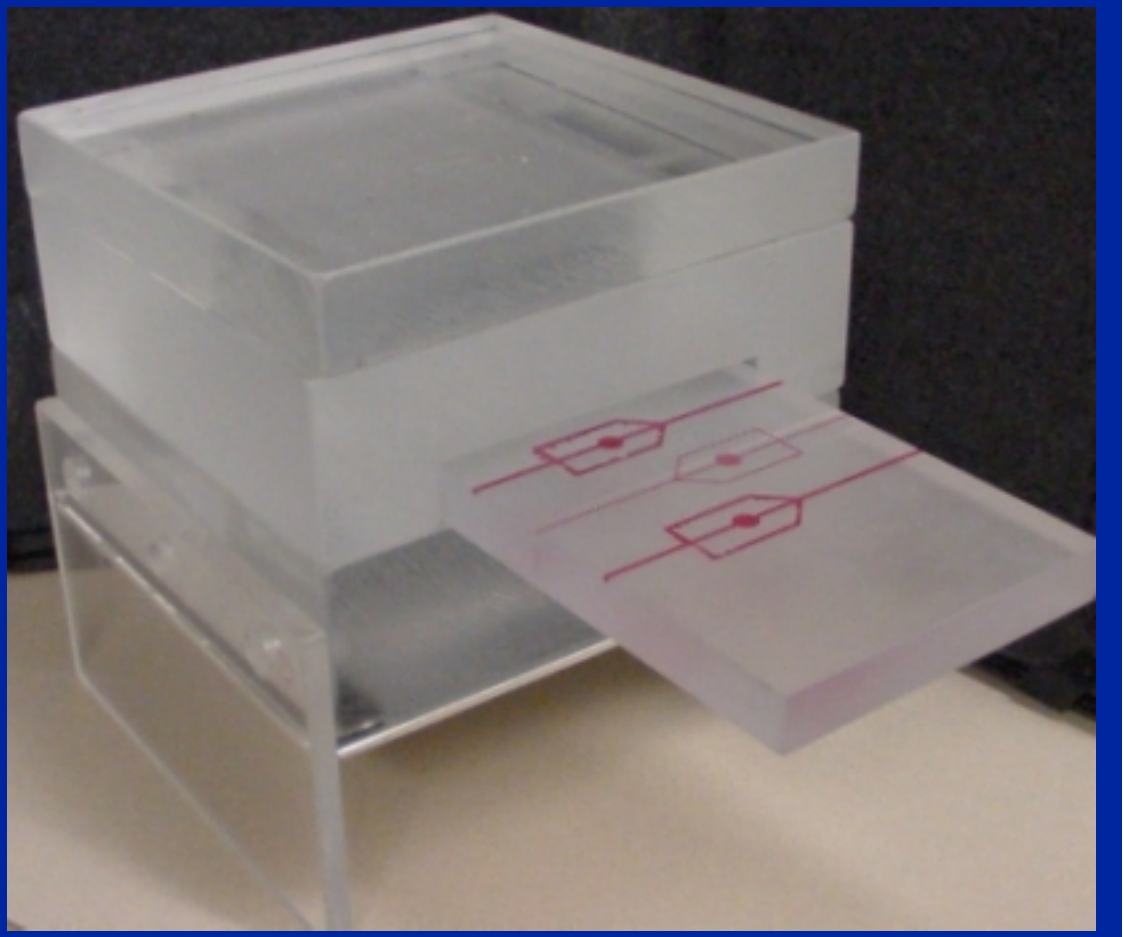
Artery Block





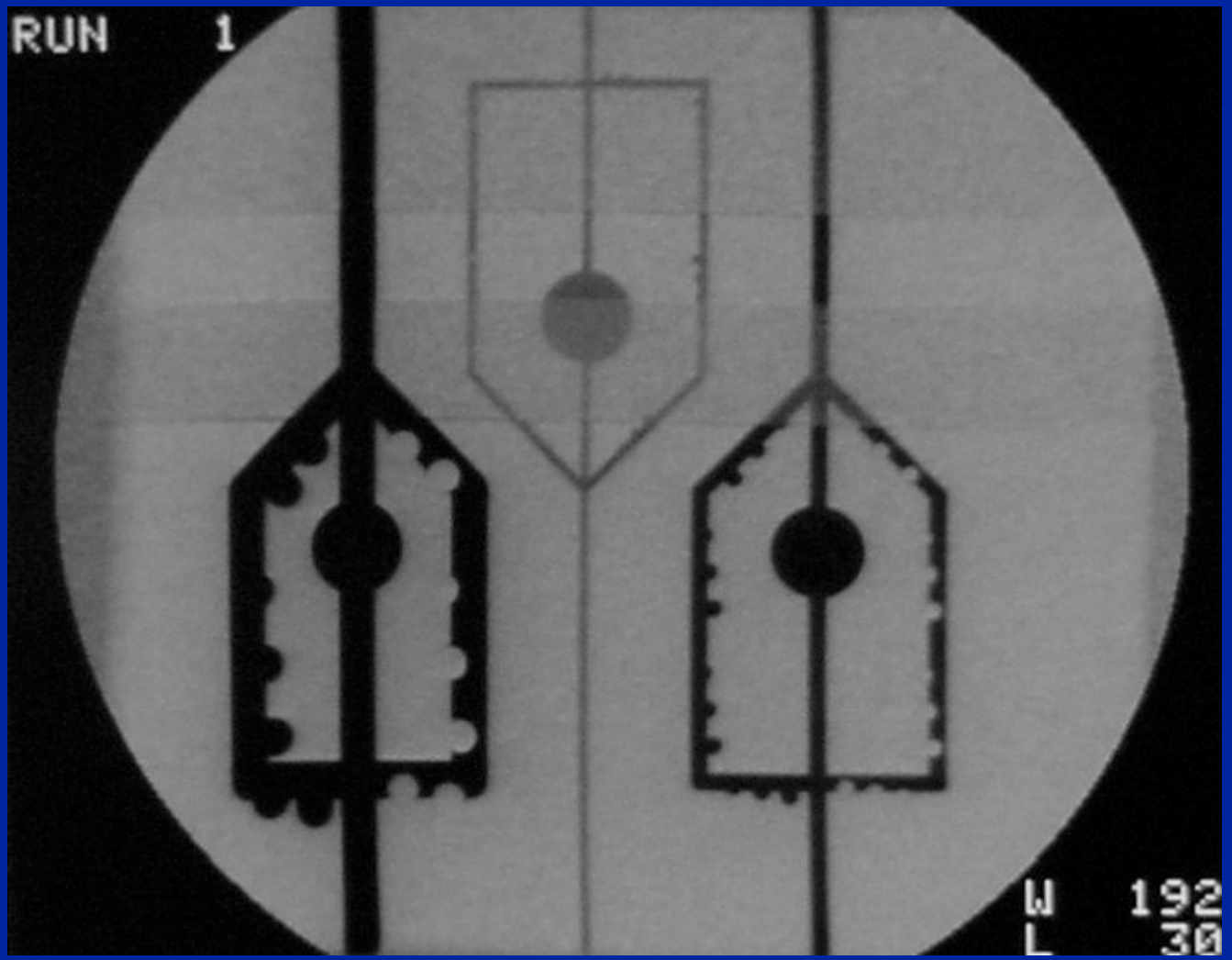
ACR V-I Phantom

- Subtraction imaging of the artery block
  - One 3” section of the phantom is replaced with a slot block
  - Artery block is passed through the slot: blank side for mask, artery side for live image



ACR V-I Phantom

- DSA image of the artery block



Use of the R/F Accreditation Phantom for Fluoroscopic System Evaluation

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