Walk down memory lane Fluoroscopes & QA: 1895-1980



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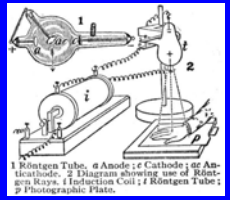
Learning Objectives

- Review of analog fluoroscopic technology
  - Fluoroscopic screen
  - ZnCdS Image Intensifier
    - Optical viewing
    - Analog Video
    - Film Acquisition (direct & indirect)
- Review of medical physics QA
  - In context of c 1970 equipment
  - Different needs in 2020?

Early Fluoroscopes

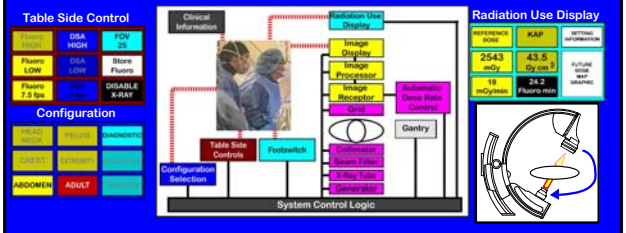

1 Röntgen Tube, a Anode; c Cathode; ac Anticathode. 2 Diagram showing use of Röntgen Rays. i Induction Coil; t Röntgen Tube; p Photographic Plate.


Gas X-Ray tubes needed continuous QA



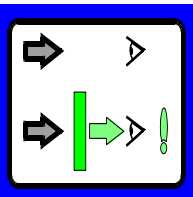
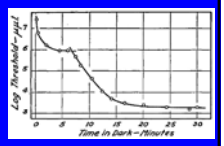
Screen fluoroscopes are simple !

Current fluoroscopes are complex

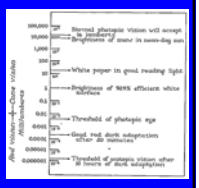


The operator is an integral component of the system's many control loops

Fluoro screens were brightness limited





Screen fluoro testing

- Beam Confinement
  - Regulations required visible field edges
- Radiation Measurements
  - Dose rate limits
  - HVL
- Minimum SSD
- 5 minute fluoro timer

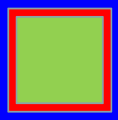
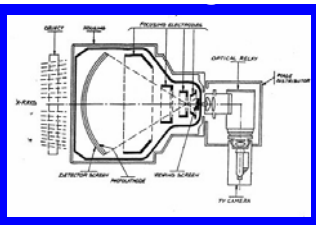
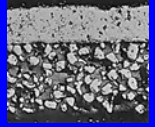
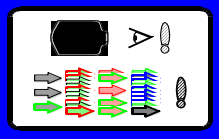
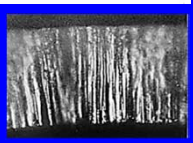



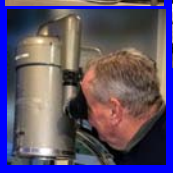
Image Intensifiers increased brightness

Initially small FOV and direct optics




Viewing means improved over time



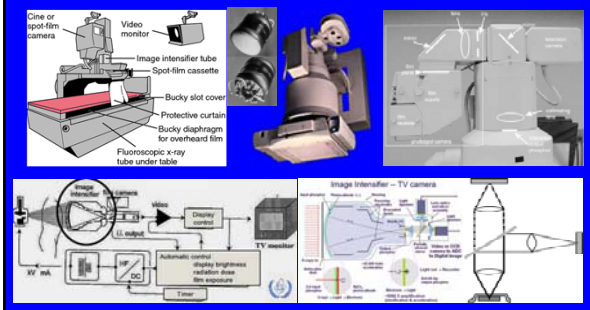



Analog Interventional Systems





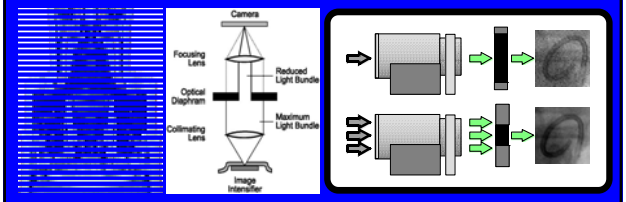

Image Intensifier support technology



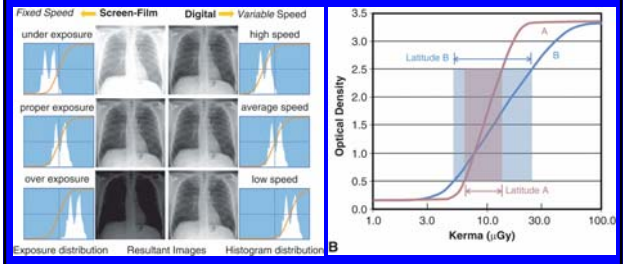
Reproducibility requirements

1950 1964

Optical control of dose-rate



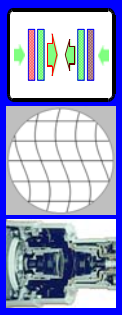
Film - Digital



QA needs c 1975

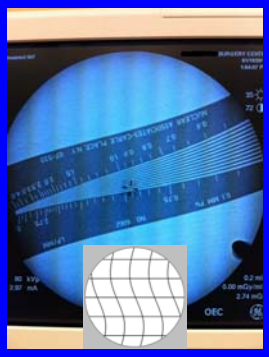
- Generators had open loop controls
  - Images stored on direct or indirect photographic film
  - Dose rate limits / 5 minute timer
- Minimum HVL
  - Filters could and did fall out of collimator
- Beam confinement
  - Spot film field size > Image intensifier input size
- Image intensifier
  - Known deterioration over time
  - Spatial resolution
    - Defocusing and gas had strong influences on MTF
    - Influence of stray magnetic fields.
  - Contrast resolution
    - Gas buildup in image intensifier
    - Dust, etc. along optical chain
  - Automatic dose rate control (optical sensor)

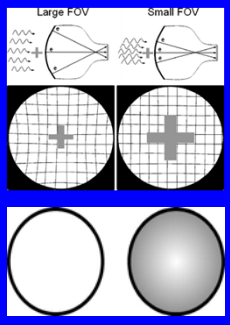
Image intensifiers were unstable



- Photocathode efficiency declines over time
- Optical diaphragms used to set dose rates.
  - If full aperture for fluoro, then change II
- Spatial resolution and distortion limits
  - Distortion due to changes in environment
  - Electronic focus in II
  - Optical lenses in output path
- Contrast sensitivity decreases over time
  - Internal: gas, defocused electrons.
  - External: dirt build up in optical path
  - Vingetting in electro/optical path elements

Image intensifier distortions





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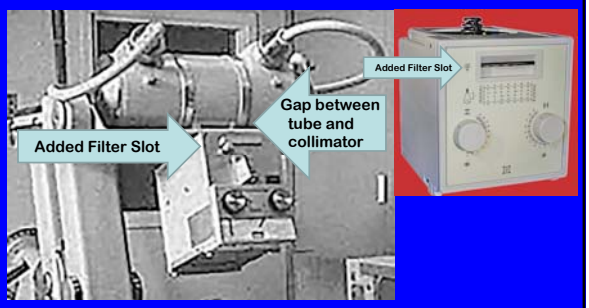
HVL: Filters did fall out of collimator



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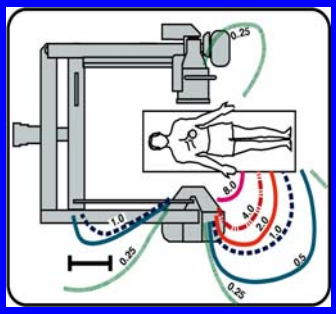
Stray radiation measurements needed



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AAPM Report 4 (1977)

BASIC QUALITY CONTROL IN DIAGNOSTIC RADIOLOGY

AAPM REPORT No. 4

Diagnostic Radiology Committee
Task Force on Quality Assurance Protocol
November 1977

This document is designed to offer assistance and guidance to a radiologic technologist implementing and operating a quality assurance program in diagnostic radiology. It is designed for implementation at any level of service from a single unit that is infrequently operated to a large number of units operating at maximum capacity in a large institution. The equipment and test tools described in the protocol are simple, relatively inexpensive and easy to procure from several suppliers.

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AAPM Report 4 (1977) Contents

IV. Quality Assurance Tests
- A. Film Processor Monitoring
- B. Overload Protective Circuit Test
- C. Exposure Time
- D. mAs Reciprocity
- E. Peak Tube Potential – kVp
- F. X-Ray Output and Beam Quality
- G. Light/X-Ray Field Congruence
- H. Automatic Collimator Field Size
- I. Fluoroscopic Collimator Field Size
- J. Grid Alignment
- K. Bucky Grid Centering
- L. Focal Spot Size
- M. Automatic Exposure Termination
- N. Optical System Focus
- O. Automatic Brightness Control
- P. Geometric Tomography
- Q. Cassettes: Speed, Film Contact

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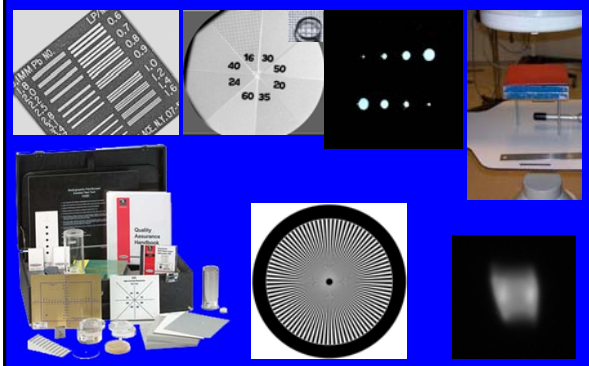
Some available tools c late 1970s



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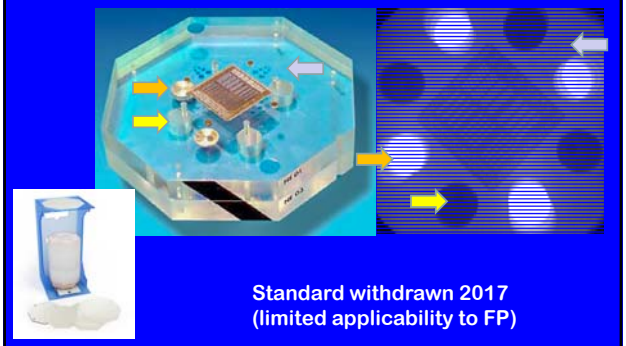
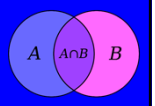
NEMA XR-21 Phantom (2000)



Standard withdrawn 2017
(limited applicability to FP)

Regulations do not assure Best Practices !

- Necessary initial testing
  - Comprehensive acceptance testing
  - Post commissioning testing
- Unnecessary periodic tests
  - Half-Value-Layer
  - Quantitative scatter measurements
- Missing from most current regulations
  - Detector uniformity
  - Accuracy of integrated radiation indicators
  - Output matrix for the most common procedure
  - Protocol review for all (common) procedures for each system



Little has changed

NYS Guide 2004

- Standard output data
- Exposure rates
- Collimator
- Fluoro 5 min timer
- Half-value-layer
- KV and mA accuracy
- Spatial resolution
- Low contrast

AAPM Report 4 (1977)

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Current and future IEC Standards

Required by current IEC standards in IFU

- Scatter radiation fields
- Outputs under standard test conditions
- Accuracy tolerances (may have regulatory impact)

Expected in future IEC standards

- AAPM TG 190 basis for verifying radiation displays
- NEMA XR-27 implementation – including protocol auditing
- Real time skin dose maps – including calibration protocol
- Tools for reject and repeat analysis
- Physicist level test procedures for use in a hospital
  - Associated test tools (may come with system)
  - Nominal results of testing

Little may change

NYS Guide 2004

- Standard output data
- Fluoro exposure rates
  acquisition not mentioned
- Collimator
- Fluoro 5 min timer
- Half-value-layer
- KV and mA accuracy
- Spatial resolution
- Low contrast

NYC *Proposal* 2017

- Standard output data
- Fluoro exposure rates
  acquisition not mentioned
- Collimator
- Fluoro 5 min timer
- Half-value-layer
- KV and mA accuracy
- Spatial resolution
- Low contrast
- *Monitor performance*
- *Radiation protocols*

My timeline review ends when digital fluoro arrives.

- Digital Video
- Digital Image Storage
- Digital Subtraction Angiography


from a Philips slide c 1985