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

1896

Current fluoroscopes are complex

The operator is an integral component of the system's many control loops
Fluoro screens were brightness limited

Initially small FOV and direct optics

Screen fluoro testing

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

Viewing means improved over time

Image Intensifiers increased brightness

Analog Interventional Systems
Image Intensifier support technology

Optical control of dose-rate

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 chains
  - Automatic dose rate control (optical sensor)

Reproducibility requirements

1950 1964

Film - Digital

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

HVL: Filters did fall out of collimator

Stray radiation measurements needed

AAPM Report 4 (1977)

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. Back 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

Some available tools c late 1970s
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

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Necessary initial testing:
A. Film Processing Testing
B. Berland Protective Circuit Test
C. Exposure Time
D. mA Repeatability
E. Peak Tube Potential - kVp
F. Image Output and Image Quality
G. Light/High Fidelity Comparison
H. Automatic Collimator Field Size
I. Interchangeable Collimator Black Slides
J. Image Uniformity
K. Radiographic Density
L. Audi Gradi Centering
M. Beam Aperture Size
N. Automatic Exposure Termination
O. Optical System Focus
P. Automatic Brightness Control
Q. Cosmetic Tomography
R. Conversion Speed, File Output

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

My timeline review ends when digital fluoro arrives.

- Digital Video
- Digital Image Storage
- Digital Subtraction Angiography