Radiographic Density Control

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Factors influencing the X-ray spectrum

- kV (accelerating anode voltage)
- Filtration material
- Target material
- mA (tube anode current) or mAs
- kV Rectification (type of generator)

Energy in a single exposure:

\[ X \sim Z \cdot kV^2 \cdot mAs \]

Content from Johns and Cunningham “The Physics of Radiology”

Exposure Kilovolts (kVp)

Energy in a single exposure leads to change of X-ray energy, Anode effectiveness, Dose and spectrum

The X-ray anode efficiency:

\[ \eta \sim Z \cdot U_a \]

Photographic analogue: none
Effective increase of kV, but with decrease of Dose.

Soft energy quanta increase the contrast (mammography use), but also increase the patient absorbed dose.

\[ \text{Al} \uparrow = \text{C} \downarrow \]

**Added Filtration (Al) influence**
X-ray spectrum – quality and quantity change

![Graph showing the effect of added filtration on X-ray spectrum](image)

**Type of Anode material influence**
X-ray spectrum – quality and quantity change

![Graph showing the efficiency of anode material](image)

Change of mA leads to change of X-ray intensity (with no spectrum change)

Energy in a single exposure

\[ X \sim Z \cdot kV^2 \cdot \text{mA} \]

Photographic analogue:
-speed

Change of mAs (msec) leads to change of X-ray intensity (with no spectrum change)

Energy in a single exposure

\[ X \sim Z \cdot kV^2 \cdot \text{mAs} \]

Photographic analogue:
 exposure time
### Type of Generator influence

X-ray spectrum – quality and quantity change

<table>
<thead>
<tr>
<th>Energy (keV)</th>
<th>Quality Changes</th>
<th>High Frequency</th>
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</table>

### Scatter radiation influence

With anti-scatter grid

Without anti-scatter grid

### Influence of the characteristic curve

- **RX breast screen film reading processing**
- **Un-processed image**

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**mAs influence**

- 70 kVp, 25 mAs
- 70 kVp, 50 mAs
- 70 kVp, 80 mAs

**kVp influence**

- 60 kVp, 50 mAs
- 70 kVp, 50 mAs
- 81 kVp, 50 mAs

Approx. Linear function

Approx. Square function

* Loss of Contrast
X-ray film processing influence – temperature of the developer

27 °C  33 °C  36 °C

Influence of:
- Material of the screen
- Thickness of the screen
- Energy Sensitivity of the screen
- Patient (tissue composition and thickness \((\mu.d)\))

\[ I_x = I_o \cdot e^{-\mu.d} \]

Digital Imaging Density control:
- Optical Density is less influenced due to very large dynamic, but still depends on:
  - All X-ray spectrum parameters
  - Window technique
  - Image processing

Radiographic Table ~1960

Screen/Film Images

Digital Images

Pixel Value

Exposure (mR)

under exposed

under exposed

under exposed