High Energy Radiography
Lecture

Betatrons & Applications
Michael Kröning

ACCELERATOR PRINCIPLE
INSTRUMENTS
RADIOGRAPHIC PARAMETERS
APPLICATIONS
EXAMPLES
Radial Stability Criterion: \( F_c = F_L \)

Centrifugal Force: \( F_c = m_e v^2/r \)

Lorentz Force: \( F_L = evB(r) \)
as reactive centrifugal force

- 2.5 MeV \( r \sim 25 \text{ mm} \)
- 300 MeV \( r \sim 1 \text{ m} \)

A: Anode
K: Cathode
M: Magnetic Field
R: Vacuum Torus

Betatron Electron Accelerator

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Betatron Torus
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Accelerator Chambers
RADIOGRAPHIC PARAMETERS
Specific Contrast Diagram for Steel High Energy Radiography

μ: absorption coefficient
K: scatter ratio
(quotient of the intensities scattered radiation divided by primary radiation).

\[ C_{sp} = \frac{\mu}{1 + k} \]
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INSTRUMENTS

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2.5 MeV Betatron Equipment
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7.5 MeV Betatron Equipment
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Power supply unit

Radiator

Control Panel

Remote Dosimeter

7.5 MeV Betatron Equipment

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## Technische Parameter

<table>
<thead>
<tr>
<th></th>
<th>Betatron 2,5 MeV</th>
<th>Betatron 7,5 MeV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy</td>
<td>1,0 and 2,5 MeV</td>
<td>2,0 and 7,5 MeV</td>
</tr>
<tr>
<td>Exposure Dose Rate</td>
<td>0,7 R/min @ 1 m</td>
<td>5 R/min @ 1 m (measured: 6 R/min)</td>
</tr>
<tr>
<td>Focal Spot size</td>
<td>0,2 x 2 mm</td>
<td>0,3 x 3 mm</td>
</tr>
<tr>
<td>Duty cycle</td>
<td>45 min. operation 15 min. break</td>
<td>40 min. operation 20 min. break</td>
</tr>
<tr>
<td>Power consumption AC (1-phase)</td>
<td>1 kW</td>
<td>2 kW</td>
</tr>
<tr>
<td>Weight of the radiator</td>
<td>31 kg</td>
<td>105 kg</td>
</tr>
<tr>
<td>Parameter</td>
<td>MIB-2.5</td>
<td>MIB-3</td>
</tr>
<tr>
<td>-----------------------------------------------</td>
<td>---------</td>
<td>-------</td>
</tr>
<tr>
<td>Peak energy of bremsstrahlung radiation, MeV</td>
<td>2.5</td>
<td>3</td>
</tr>
<tr>
<td>Peak dose rate at 1m from the target, cGy/min</td>
<td>0.1</td>
<td>2</td>
</tr>
<tr>
<td>Pulse repetition rate, Hz</td>
<td>50</td>
<td>400</td>
</tr>
<tr>
<td>Power consumption, kVA</td>
<td>0.7</td>
<td>2.5</td>
</tr>
<tr>
<td>Radiator weight, kg</td>
<td>27</td>
<td>50</td>
</tr>
<tr>
<td>Total weight of units, kg</td>
<td>45</td>
<td>120</td>
</tr>
<tr>
<td>Size of focal spot, mm</td>
<td>0.2x3</td>
<td>0.2x3</td>
</tr>
<tr>
<td>Maximal controlled thickness (of steel), mm</td>
<td>70</td>
<td>130</td>
</tr>
</tbody>
</table>
APPLICATIONS
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7.5 MeV Betatron Inspection Station in Volgogradneftemash production plant, Russia

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Inspection of Casting Process
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Engine Block (Defect Inspection)
Valve Housing (Functional Control)
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BRIDGE INSPECTION
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BRIDGE INSPECTION

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Lorry Control by Betatron Radiograph
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X-ray betatron sources for cargo inspection systems

Dual energy Betatron

Different energies are selectable by changing the acceleration cycle time.
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THANK YOU