LECTURE 9: MEASUREMENT OF RADIATION: QUALITY

Problems

9.1 Attenuation measurements for an x-ray beam from a 120 kVp x-ray generator yield the following results:

<table>
<thead>
<tr>
<th>added filtration (mm Al)</th>
<th>percent transmission</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0</td>
<td>60.2</td>
</tr>
<tr>
<td>2.0</td>
<td>41.4</td>
</tr>
<tr>
<td>3.0</td>
<td>30.0</td>
</tr>
<tr>
<td>4.0</td>
<td>22.4</td>
</tr>
<tr>
<td>5.0</td>
<td>16.9</td>
</tr>
</tbody>
</table>

Plot the data on semilogarithmic graph paper and determine:

Attenuation of 120 kVp x-ray beam

\[ a. \text{ the first HVL} \]

50% transmission will occur at an absorber thickness of approximately

\[
1.0 \times 1.0 \times \left( \frac{60.2 - 50.0}{60.2 - 41.4} \right) = 1.0 + \frac{10.2}{18.8} = 1.54 \text{ cm}
\]
b. the second HVL

25% transmission will occur at an absorber thickness of approximately

\[ \frac{3.0 + \frac{30.0 - 25.0}{30.0 - 22.4} \times 1.0}{3.0 + \frac{5.0}{7.6}} = 3.66 \text{ cm} \]

Consequently, the second HVL is equal to \( 3.66 \text{ cm} - 1.54 \text{ cm} = 2.12 \text{ cm} \).

c. the homogeneity coefficient of the x-ray beam

The homogeneity coefficient is equal to \( \frac{1.54}{2.12} = 0.73 \).

d. the effective energy of the x-ray beam

For aluminum, which has a mass density of 2.70 g cm\(^{-3}\), the mass attenuation coefficient is given by

\[ \frac{\mu}{\rho} = \frac{0.693}{1.54 \times 2.70} \]

\[ = 0.167 \text{ cm}^2/\text{g} \]

From Table A.7 in Khan (p A-11), this mass attenuation coefficient corresponds to an effective energy of

\[ 20.0 + \frac{0.306 - 0.167}{0.306 - 0.086} \times 10.0 = 20.0 + \frac{0.139}{0.220} \times 10.0 \]

\[ = 20.0 + 6.3 \]

\[ = 26.3 \text{ keV} \]