Simulated Body Shape for Dose Determination in Phototherapy

D.McG.Clarkson,
Department of Clinical Physics and Bioengineering,
UHCW NHS Trust, Coventry.
ISSUES

Complex pattern of UV irradiance over a body surface.

Bodies come in all shapes and sizes.

Choice of timed dose or automated internal dosimetry.

How effective is internal dosimetry system – if utilised?
ISSUES

If checking cabinet irradiance, how is this best done – direct or indirect?

How good is measurement technology accuracy - calibration and traceability?
Measurement Framework


Measurement Techniques


Unit Construction

Body shape constructed by L. Franks of Radiotherapy Physics Section, Walsgrave Hospital.

Styrofoam used extensively within Radiotherapy Physics Unit fabricated within three sections.
**Body Shape Advantages**

Safety aspect of not being present in cabinet when measurements made.

Reproducible positions makes comparisons more relevant.

Potential to verify internal cabinet dosimetry systems.

Potential for inter cabinet Comparisons.
<table>
<thead>
<tr>
<th></th>
<th>Male (1)</th>
<th>Female (2)</th>
<th>Mean (1)+(2)</th>
<th>Body Shape</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean height (cm)</td>
<td>175.1</td>
<td>161.9</td>
<td>168.5</td>
<td>172.5</td>
</tr>
<tr>
<td>Mean weight (Kg)</td>
<td>83.8</td>
<td>70.1</td>
<td>76.95</td>
<td>-</td>
</tr>
<tr>
<td>Est. Body surface area (m²)</td>
<td>1.994</td>
<td>1.783</td>
<td>1.889</td>
<td>1.67</td>
</tr>
<tr>
<td>Item</td>
<td>Value</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>-----------------------------</td>
<td>----------------------------</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Height</td>
<td>172.5 cm</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maximum Breadth</td>
<td>53.5 cm</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Total weight</td>
<td>4.815 Kg</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Volume</td>
<td>0.1605 m²</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Density Styrofoam</td>
<td>30 Kg/m³</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Major axis cross section area</td>
<td>0.617 m²</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Minor axis cross section</td>
<td>0.343 m²</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Material</td>
<td>Styrofoam (building insulation)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Measurement System</td>
<td>Bentham dmc150 spectroradiometer</td>
<td></td>
<td></td>
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<tr>
<td>------------------------</td>
<td>----------------------------------</td>
<td></td>
<td></td>
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<tr>
<td>Detector</td>
<td>DH-10 photomultiplier</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Calibration light source</td>
<td>CL6-H</td>
<td></td>
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<td></td>
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<tr>
<td>Detector</td>
<td>D6 diffuser f2 error 0.84% at 400 nm linked to 2 m fibre optic cable</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Slit width</td>
<td>1 nm</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Measurement interval</td>
<td>1 nm</td>
<td></td>
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</tr>
</tbody>
</table>
Single parameter value for dosimetry.
Surface Uniformity

\[ \sum_{i=0}^{H} f_i(h)A_i(h)W_i(h) \, dh \]

\[ \frac{1}{\sum A_i(h) \, dh} \]

Where \( f_i(h) \) = fraction of peak irradiance at height \( h \)

\( A_i(h) \) = body shape area at height \( h \) per cm of height

\( W_i(h) \) = arbitrary weighting (<1)
Variation of console/dmc150 reading with orientation of body shape
Coefficient of Overdosing

MAX(reference - console irradiance value)/mean

Where reference > console irradiance value

Coefficient of Underdosing

MAX(console irradiance value – reference)/mean

Based on e.g. Rotation of body shape in cabinet in units of 90 degrees
**Movement Compensation**

Describes gradient of function of reference measurements and of indicated console values. For two sites Ref$_1$ and Ref$_2$, eg front and rear of patient, a Positional Compensation term (PcxRef) can be described as:

\[\text{PcxRef}_1 = \left(\frac{\text{dRef}_1}{\text{dx}} - \frac{\text{dCon}}{\text{dx}}\right)\]

\[\text{PcxRef}_2 = \left(\frac{\text{dRef}_1}{\text{dx}} - \frac{\text{dCon}}{\text{dx}}\right)\]

Where Con is console indicated value.

These terms can be understood in the sense of x axis in direction normal to entrance door. One side of patient appears to have some form of compensation - the other does not. These are constants of the physical design of the cabinet and the physical characteristics of the body shape.
Movement Compensation Sideways

No compensation present
Considerations

• Body shapes for ‘child’ - ‘teeny’ - ‘adult’.

• Surface reflectance - application of paint an advantage - 5% reflectance target in UV

• Profile of detector.
Summary

A rigid lightweight body shape has proved of value for routine Quality Control issues.

The scope of such devices should encourage their development within the framework of a specific medical device standard for whole body treatment cabinets for ultra violet radiation.