Back to Basics - Dose Algorithms

Presented by:
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Presented at the 2007 Dosimetry and Records Symposium
Overview

- Performance goals
- Response data
- Designs
- Testing
- DOELAP revision
- Issues
Goals

• Performance
  • Good dosimetry in the field
    • Accurately record dose
  • Meet the standard
    • Which one?

• Design
  • Simple design?
  • Hand calculation friendly?
  • Linear?
Response Data

- Critical investment
- Establishes algorithm “calibration”
- Only pure fields are necessary
- Panasonic (Ash & Doc) data excellent starting point
- Most algorithm designs allow good performance using a representative subset of possible fields.
- Single element
- Dose = response * correction factor
- Knowledge of field or perfect dosimeter required for best accuracy
- Example: single element extremity dosimeter
**Design – Simple (ctd.)**

- **Benefits**
  - Simplicity
  - Minimal uncertainty
  - Very useful for troubleshooting more complex algorithms
  - Hand calculations possible

- **Drawbacks**
  - Need field information or perfect dosimeter
  - Minimal redundancy
- Multiple elements.
- Use relative element responses (ratios) to determine correction factors
- Knowledge of field or perfect dosimeter not required
- Examples: SDose, DOC, branching style Panasonic, Thermo,...
**Benefits**
- Versatility, range of accommodated fields
- No need for *a priori* field knowledge
- Readings provide information about the field
- Can provide redundancy with multiple elements

**Drawbacks**
- Complexity means greater uncertainty
- Hand calculation can be difficult to impossible
Testing

- Pure fields (from test data)
  - Optimize design
- Mixed fields (synthetic testing)
  - Optimize design
- Worker data
  - Check for unreasonable doses
- Low dose data
  - Check for unreasonable doses
Testing – Synthetic testing

Results of 130 test fields
Shallow dose:
  85% within 10%
  98% within 20%

Deep dose:
  83% within 10%
  94% within 20%

- Use arithmetic to combine pure field responses and generate mixed field responses (TLD responses are additive)
- Run and rerun test file to fine tune algorithm
DOELAP Revision

- Proficiency test standard for DOE facilities being revised
- New revision will adopt much of ANSI N13.11-2001
- Algorithms must be revised to maintain performance levels
<table>
<thead>
<tr>
<th></th>
<th><strong>DOE/EH-0027 (1986)</strong></th>
<th><strong>ANSI N13.11-2001</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Photon fields</strong></td>
<td>6 fields 20-662 keV</td>
<td>• 70 fields, 20-1332 keV,</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• New ck factors,</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Angles for keV &gt; 70</td>
</tr>
<tr>
<td><strong>Beta fields</strong></td>
<td>3 fields ($^{204}$Tl, $^{90}$Sr/Y, DU)</td>
<td>3 fields ($^{85}$Kr, $^{204}$Tl, $^{90}$Sr/Y)</td>
</tr>
<tr>
<td><strong>Neutron fields</strong></td>
<td>2 fields ($^{252}$Cf bare, D$_2$O mod)</td>
<td>-- same --</td>
</tr>
<tr>
<td><strong>Mixtures</strong></td>
<td>• $^{137}$Cs + any x-ray,</td>
<td>Same, with $^{60}$Co as well as $^{137}$Cs available for gamma source</td>
</tr>
<tr>
<td></td>
<td>• Any photon plus neutron,</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• High E beta + any photon</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Any beta + $^{137}$Cs</td>
<td></td>
</tr>
<tr>
<td><strong>Other</strong></td>
<td></td>
<td>10% rule?</td>
</tr>
</tbody>
</table>
Photon dose conversion factors will change

- DOELAP (1986) was based on Yoder et al
- NVLAP (2001) based on Grosswendt data
Dose ≠ Dose
- Dose (DOELAP) is not equal to Dose (NVLAP)
- Most pronounced for energies < 50 keV

Response/dose will change, algorithm will need modification.
**Issues**

- **Background subtraction**
  - Element specific
  - Dose
- **Investigating suspect performance**
  - Algorithm problem
  - Dosimeter/reader problem
How do you subtract background?

1. Subtract background doses
   - Net dose = \( \text{alg(gross response)} - \text{alg(bkgd response)} \)

2. Subtract background responses
   - Net dose = \( \text{alg(gross responses-bkgd responses)} \)

• Subtracting doses:
  - Reduces available information on worker field
  - Added uncertainty with dose calculation on background dosimeter
Example:

30 mrem 20 KeV x-ray
+ 30 mrem Cs bgd

<table>
<thead>
<tr>
<th></th>
<th>E1</th>
<th>E2</th>
<th>E3</th>
<th>E4</th>
<th>R34</th>
<th>Energy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Net</td>
<td>37</td>
<td>30</td>
<td>499</td>
<td>22</td>
<td>22.7</td>
<td>20 keV</td>
</tr>
<tr>
<td>bkgd</td>
<td>29</td>
<td>30</td>
<td>30</td>
<td>31</td>
<td>1.0</td>
<td>662 keV</td>
</tr>
<tr>
<td>Gross</td>
<td>66</td>
<td>60</td>
<td>529</td>
<td>53</td>
<td>10.0</td>
<td>42 keV</td>
</tr>
</tbody>
</table>

Using (gross dose) – (background dose) confounds information available on worker dosimeter response.
Issues – Suspect performance

Is it the algorithm or the dosimeter/reader?

1. Calculate response/dose for pure fields
   - Observed = mR*/mrem
2. Compare to algorithm development data
3. If current response = R&D resp. then problem is with algorithm design.
4. Otherwise, check dosimeter and reader for instability or non-standard conditions
Issues – Suspect performance

Example:
- 500 mrem M30 (20 keV x-ray)
- Calculated doses low by 20%

<table>
<thead>
<tr>
<th></th>
<th>E1</th>
<th>E2</th>
<th>E3</th>
<th>E4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Observed mR*</td>
<td>300</td>
<td>240</td>
<td>5000</td>
<td>218</td>
</tr>
<tr>
<td>mR*/mrem</td>
<td>0.6</td>
<td>0.48</td>
<td>10</td>
<td>0.436</td>
</tr>
<tr>
<td>Dev. Data mR*/mrem</td>
<td>0.7332</td>
<td>0.6068</td>
<td>9.9758</td>
<td>0.4404</td>
</tr>
<tr>
<td>%diff</td>
<td>-18.2%</td>
<td>-20.9%</td>
<td>0.2%</td>
<td>-1.0%</td>
</tr>
</tbody>
</table>

- Something changed since algorithm dev data.
- This is a good time to apply “simple algorithm” approach.
Final Thoughts

- Start with good data
- Keep algorithm design as simple as practical
- Test it as much as possible
- Document it thoroughly
- Check it constantly
- Revise it when necessary
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