Mathematical Modeling as a Tool in Source Replenishments

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Irradiator Designs

Source Overlap

Product Overlap
Changing product specifications

• **THE CHALLENGE**
  – The product mix in an irradiator changed, need to re-optimize the cobalt distribution to achieve best performance over a different density range

• **THE SOLUTION**
  – Model the existing distribution then iteratively adjust to optimize at the preferred product density range

• **THE RESULT**
  – Dose uniformity was significantly improved at target density range
Model validation

Max/Min Doses 0.02 g/cc

Max/Min Doses 0.12 g/cc

- OQ min
- OQ max
- model min
- model max
Distribution shift

- Predicted vs Measured DURs

<table>
<thead>
<tr>
<th>Density</th>
<th>Model</th>
<th>Density</th>
<th>Measured</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.05g/cc</td>
<td>1.29</td>
<td>0.02g/cc</td>
<td>1.26</td>
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<tr>
<td>0.10g/cc</td>
<td>1.33</td>
<td></td>
<td></td>
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<tr>
<td>0.15g/cc</td>
<td>1.37</td>
<td>0.16g/cc</td>
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</table>
New mix of product

• THE CHALLENGE
  – A facility that needs to run both high density/low dose and low density/high dose product in the same irradiator, while optimizing the performance of both

• THE SOLUTION
  – Leverage the use of multiple racks to provide a distribution with one rack for low dose product and all racks for high dose with different distributions

• THE RESULT
  – Both product types run successfully
• Running phytosanitary successfully with only Rack #3
• For new load, maintained distribution for Rack #3 but split across Racks #1 and #3 to provide more capacity and better horizontal distribution
• Rack #2 loaded to provide same overall vertical percentages for medical product
• Dosimetry confirmed required performance, we have since reloaded with same pattern successfully
• **THE CHALLENGE**
  – Modeling the real dose to a product stack in an insulated shipper with dry ice which has to meet tight DUR requirements

• **THE SOLUTION**
  – Model individual products separately within a product stack

• **THE RESULT**
  – Model assessed that DUR could be met, confirmed with dosimetry
Model Comparison
• **THE CHALLENGE**  
  – Reduce the amount of time needed to revalidate an irradiator when an equivalent load is planned

• **THE SOLUTION**  
  – Use modeled OQ dose points to verify that locations and relative magnitudes of max, min and reference positions remain unchanged

• **THE RESULT**  
  – Data remains consistent over # years of measured and modeled data
Modeling to determine equivalency

<table>
<thead>
<tr>
<th>Loading</th>
<th>$R_{\text{mon}}$</th>
<th>Model min</th>
<th>Model max</th>
<th>DUR</th>
<th>$R_{\text{mon/min}}$</th>
<th>$R_{\text{max/mon}}$</th>
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- Data normalized to $R_{\text{mon}}=20\text{kGy}$
Conclusions

- Modeling is an effective tool in source distribution planning
- Process optimization through modeling is a collaborative effort
- Modeling can determine the best way to process certain products
- Modeling can save time in validation