Title: Sharing of Good Industry Practices and/or Lessons Learned in Nuclear Criticality Safety: Using Sensitivity-Uncertainty Methods to Improve Traditional Validation

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Sharing of Good Industry Practices and/or Lessons Learned in Nuclear Criticality Safety

Using Sensitivity-Uncertainty Methods to Improve Traditional Validation

Jennifer Alwin
Using Sensitivity-Uncertainty Methods to Improve Traditional Validation

- Selection of Benchmarks
- Rejection of Outliers
- Basis for Margin of Subcriticality
- Quantification of Missing Uncertainties

Which benchmarks are similar to the application?
Selection of Benchmarks

- **ANSI/ANS-8.24-2007:**
  - “Appropriate system or process parameters that correlate the experiments to the system(s) or process(es) under consideration shall be identified. Automated selection systems that consider isotopes, their abundances, energy ranges, cross-section uncertainties, or other parameters may be used.”

- Neutronic similarity based upon specific energy, isotope & reaction
  - Correlation of application to benchmarks
    - Example: Pu oxide-water mixture
      - 3 cylinders
      - Water, steel reflection
      - H/D variation

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<table>
<thead>
<tr>
<th>Case 1: Dry Oxide</th>
<th>EALF= 0.606</th>
<th>ANECF= 1.70</th>
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<tr>
<td>Bias</td>
<td>0.00852</td>
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<td>Bias Uncertainty</td>
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<tr>
<td>Benchmark</td>
<td>Ck</td>
<td>weight</td>
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<td>PMF044-005</td>
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<table>
<thead>
<tr>
<th>Case 67: 60% Water</th>
<th>EALF= 0.009</th>
<th>ANECF= 0.969</th>
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Rejection of Statistical Outliers

- ANSI/ANS-8.24-2017:
  - "Identification of data outliers may be based on established statistical rejection methods; rejection of outliers shall be based on the inconsistency of the data with known physical behavior in the experimental data."
  - Iterative diagonal chi-squared method until $\chi^{2}_{\text{min}} < 1.2$
  - 10% of Whisper-1.1 library identified as outliers
  - Include or exclude identified outliers to determine impact on USL

Basis for Margin of Subcriticality

- ANSI/ANS-8.24-2017:
  - "The margin of subcriticality and its basis shall be documented."
- ANSI/ANS-8.24-2017:
  - "Margin of subcriticality: an allowance beyond the calculational margin to ensure subcriticality."
  - S/U tools help support MOS basis: neutronic similarity, nuclear data uncertainties, validation weaknesses

Quantification of Missing Experimental Uncertainties

- Based upon neutronically similar benchmarks