Delivering science and technology to protect our nation and promote world stability
2023 NCSP Technical Program Review – Lessons Learned in Experiment Design and Execution

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NEN-2
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Overview

• Operational NCERC lessons learned from experiments and activities in 2022
  – Focus on experiment design and execution

• Experiments:
  – TEX-Hf (IER 532)
  – PFUNS (IER 153)
  – Flat-Top Benchmark Physical Measurements (IER 423)

• Lessons learned often apply generically

• Lessons often already known, but demonstrate importance for future work
TEX-Hf (IER 532)

- Measurement difficulties when using height gauge
- Source placement for 1/M
TEX-Hf: Height Gauge Measurement Difficulties

• Not much room to securely place the base of the height gauge for the height measurements on the bottom stack
  − Holding down height gauge by hand or with clamps?
  − Avoid restacking on a cart/table due to reproducibility

• Solutions:
  − Collar around the base of the bottom to allow for additional space for the height gauge
    ▪ Flatness issues
    ▪ Can’t forget to remove the collar, as it will interfere with operations
  − Do not use height gauge, use a Coordinate Measurement Machine (CMM) instead
TEX-Hf: 1/M Source Placement

• TEX-U/TEX-Hf bottom HDPE reflector includes location for neutron source
  – Source removed for final benchmark measurement
  – Removal entails unstacking the bottom, removing the source, then restacking the bottom
  – ~30-60 minute operation

• Can the source be placed outside of the HDPE and still get good 1/M data?

• Outside source locations were attempted early in the TEX-Hf experimental cycle
TEX-Hf: 1/M Source Placement

- Outside source placed on the outside of the system, opposite to the start-up neutron detectors
- 1/M results were very non-conservative
- Experimental team did not feel comfortable continuing with the non-conservative 1/M and moved source back to inside of the bottom HDPE reflector
TEX-Hf: 1/M Source Placement

1/M Source Outside

<table>
<thead>
<tr>
<th>Mass (kg)</th>
<th>Predicted Critical (kg)</th>
<th>1/2 Rule (kg)</th>
<th>3/4 Rule (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>12.9</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>19.4</td>
<td>163.6</td>
<td>91.5</td>
<td>122.7</td>
</tr>
<tr>
<td>25.9</td>
<td>140.5</td>
<td>83.2</td>
<td>105.4</td>
</tr>
<tr>
<td>32.3</td>
<td>126.7</td>
<td>79.5</td>
<td>95.0</td>
</tr>
</tbody>
</table>

1/M Source Inside

<table>
<thead>
<tr>
<th>Mass (kg)</th>
<th>Predicted Critical (kg)</th>
<th>1/2 Rule (kg)</th>
<th>3/4 Rule (kg)</th>
</tr>
</thead>
<tbody>
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<td>32.3</td>
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<td>-</td>
<td>-</td>
</tr>
<tr>
<td>38.6</td>
<td>67.6</td>
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<td>50.7</td>
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<tr>
<td>44.8</td>
<td>61.6</td>
<td>53.2</td>
<td>46.2</td>
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<tr>
<td>51.1</td>
<td>60.8</td>
<td>56.0</td>
<td>45.6</td>
</tr>
<tr>
<td>57.4</td>
<td>63.2</td>
<td>60.3</td>
<td>47.4</td>
</tr>
</tbody>
</table>

Critical Mass: ~64 kg

1/M Plot

Source Outside
Source Inside
Critical
TEX-Hf: 1/M Source Placement

- After TEX-Hf complete, discussed a redesign of the bottom HDPE moderator (and surrounding Al structure) to include a removable source
PFUNS (IER 153)

- Planned PFUNS irradiation involved highest dose rates from a Planet experiment
- Locations of some equipment necessary to Planet operations inadequate for this high powered irradiation
  - Power supplies and motor controller located in JB next to Planet
- Irradiation could not be performed without moving this equipment
  - Relocated to JBs outside of experimental area, behind shielding wall
  - Similar to Comet/Godiva IV building
- Modifications improve Planet and machine capability, more robust capability
PFUNS (IER 153)

• Irradiation dosimetry studies useful for future high radiation area work
• Continuity between CED stages
  – ~ 5 year gap between CED-2 to CED-3
    ▪ Primarily due to safety basis delays (unattended counting)
    – Lost knowledge due to personnel turnover (retirements, job transfers, lost knowledge)
• Good reminders on planning and organization:
  – Engage engineering design personnel early, who will engage cognizant systems engineers
  – Engage HPs 2+ months in advance if new RWPs are required
  – Incorporate 1/M approach early in design
Flat-Top Benchmark Measurements (IER 423)

• During the Time of COVID:
  - Ensure that at least two people on the team are very familiar with the planned work and instruments

• Measurement Specific Lessons Learned:
  - Coordinate Measuring Machine (CMM)
  - Pycnometer
Flat-Top Benchmark Measurements

• Coordinate Measuring Machine (CMM):
  - Points needed to construct shapes
    ▪ Additional points give better results
    ▪ Three points for sphere minimum
    ▪ Some shapes split into multiple
      - Cylinder: two planes and a circle
  - Proper positioning for CMM base when taking measurement
    ▪ Just because the arm can move to a location does not mean that
      the arm can collect data in that location.
  - CMM placement: On a stable surface
    ▪ Flat-Top table is very stable
    ▪ Cart/table is not
    ▪ Machining table ideal
Flat-Top Benchmark Measurements

• Pycnometer
  − DAF and steady-state temperature
    ▪ Need temperature equilibrium between sample holder and sample
    ▪ Few degrees difference results in large uncertainty for volume/density
  − Sample preparation: Dry cleaning methods only
    ▪ Wet methods can introduce additional liquids and disrupt volume measurement
    ▪ Wet methods are the “go-to” cleaning method for radcon

NCERC Personnel performing pycnometer measurements on Flat-Top parts
Acknowledgements

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