Argonne NATIONAL LABORATORY

Performance of the β2 Data for a Series of Diverse ZPR/ZPPR Assemblies

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List of "As-Built" Benchmark Models

ZPR-6/6A	IEU-COMP-FAST-001	UO2 LMFBR - HEU/DU/Na/Steel/Fe2O3/U3O8 core - Du reflector
ZPR-6/7	MIX-COMP-FAST-001	Mixed oxide LMFBR - Pu/DU/Na/Steel/Fe2O3/U3O8 core - DU reflector
ZPPR-21A	PU-MET-FAST-033	IFR fuel casting - 12.5 v/o Pu-U-Mo/25 v/o Pu-Al/12.5 v/o Zr/6.25 v/o DU/18.75 v/o SST/25 v/o void unit cell - graphite reflector
ZPPR-21B	MIX-MET-FAST-011	IFR fuel casting - 12.5 v/o Pu-U-Mo/18.75 v/o Pu-Al/12.5 v/o Zr/6.25 v/o DU/25 v/o void/21.875 v/o SST/3.125 v/o HEU unit cell - graphite reflector
ZPPR-21C	MIX-MET-FAST-011	IFR fuel casting - 12.5 v/o Pu-U-Mo/12.5 v/o Pu-Al/12.5 v/o Zr/6.25 v/o DU/25 v/o void/21.875 v/o SST/9.375 v/o HEU unit cell - graphite reflector
ZPPR-21D	MIX-MET-FAST-011	IFR fuel casting - 12.5 v/o Pu-U-Mo/6.25 v/o Pu-Al/12.5 v/o Zr/6.25 v/o DU/25 v/o void/25 v/o SST/12.5 v/o HEU unit cell - graphite reflector
ZPPR-21E	MIX-MET-FAST-011	IFR fuel casting - 12.5 v/o Pu-U-Mo/12.5 v/o Zr/6.25 v/o DU/25 v/o void/25 v/o SST/18.75 v/o HEU unit cell - graphite reflector
ZPPR-21F	HEU-MET-FAST-061	IFR fuel casting - 25 v/o HEU/12.5 v/o Zr/12.5 v/o DU/18.75 v/o SST/31.25 v/o void unit cell - graphite reflector

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ZPR-9/1	IEU-MET-FAST-013	HEU/DU core - Al reflector - ~11% enrichment - 12.5 v/o HEU/87.5 v/o DU unit cell
ZPR-9/2	IEU-MET-FAST-014	HEU/DU/W core - Al reflector - ~16% enrichment - 12.5 v/o HEU/62.5 v/o DU/25 v/o W unit cell
ZPR-9/3	IEU-MET-FAST-014	HEU/DU/W core - Al reflector - ~21% enrichment - 12.5 v/o HEU/43.75 v/o DU/43.75 v/o W unit cell
ZPR-9/4	HEU-MET-FAST-060	HEU/W core - Al reflector - 18.75 v/o HEU/81.25 v/o W unit cell
ZPR-9/5	HEU-MET-FAST-067	HEU/W/C core - Al reflector - 12.5 v/o HEU/43.75 v/o W/43.75 v/o C unit cell
ZPR-9/6	HEU-MET-FAST-067	HEU/W/Al (perforated) core - Al reflector - 12.5 v/o HEU/43.75 v/o W/43.75 v/o Al (45% Al,55% void) unit cell
ZPR-9/7	HEU-MET-FAST-070	HEU/W/Al (perforated) core - Al2O3 reflector - 12.5 v/o HEU/43.75 v/o W/43.75 v/o Al (45% Al,55% void) unit cell
ZPR-9/8	HEU-MET-FAST-070	HEU/W/Al2O3/Al (perforated) core - Al ax ref, BeO rad, Al outer rad ref-12.5 v/o HEU/43.75 v/o W/25 v/o Al2O3-18.75 v/o Al (45% al,55% void) unit cell
ZPR-9/9	HEU-MET-FAST-070	HEU/W/Al2O3/Al (perforated) core - Al2O3 reflector, Al outer reflector - 12.5 v/o HEU/43.75 v/o W/25 v/o Al2O3/18.75 v/o Al (45% Al,55% void) unit cell

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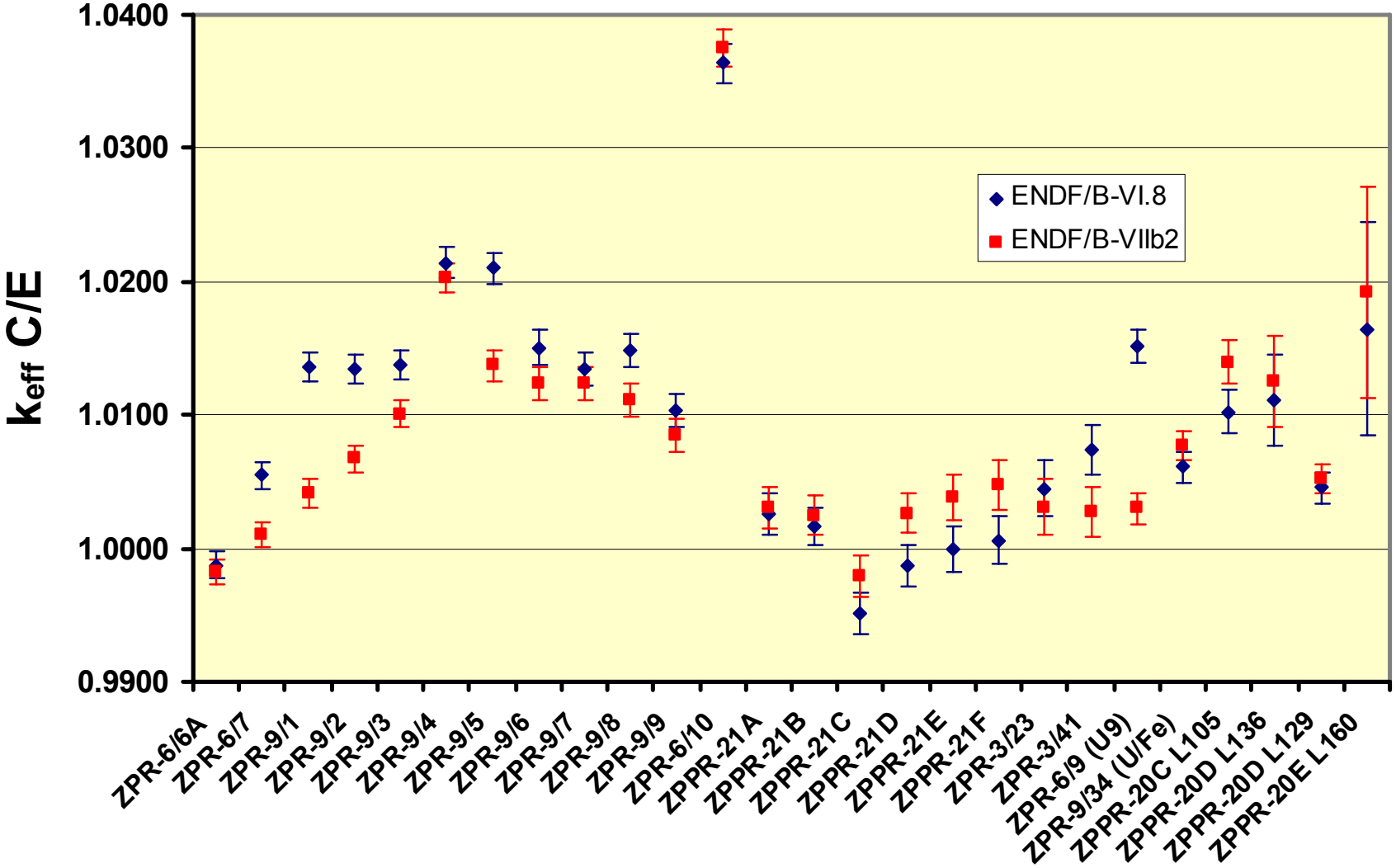
ZPR-6/10	PU-MET-INTER-002	Pu/C/Steel core - Steel reflector, Iron radial reflector - 6.25 v/o Pu/37.5 v/o C/56.25 v/o steel unit cell
ZPR-3/23	HEU-MET-FAST-055	HEU/Al (perforated) core - DU reflector -12.5 v/o HEU/87.5 v/o Al (63% Al/37% void) unit cell
ZPR-3/41	IEU-MET-FAST-012	HEU/DU/Steel/Al (perforated) core - DU reflector - ~16% enrichment - 7.8125 v/o HEU/35.9375 v/o DU/6.25 v/o SST/50 v/o Al (45% Al,55% void) unit cell
ZPR-6/9 (U9)	IEU-MET-FAST-010	HEU/DU core - DU reflector - ~9% enrichment - 9.375 v/o HEU/90.625 v/o DU unit cell
ZPR-9/34 (U/Fe)	HEU-MET-INTER-001	HEU/Fe/Stainless steel core - Stainless steel reflector - 3.125 v/o HEU/87.5 v/o Fe/9.375 v/o stainless steel unit cell
ZPPR-20C L105	HEU-MET-FAST-075	HEU/Li/Nb/Re core-BeO rad ref-Be ax ref-SP-100 mockup
ZPPR-20D L136	SUB-HEU-MET-MIXED-001	HEU/poly/Nb/Re core-BeO rad refl-Poly rad, axial refl-SP-100 mockup with flooding-subcritical
ZPPR-20D L129	HEU-MET-MIXED-012	HEU/poly/Nb/Re core-BeO rad refl-Poly rad, axial refl-SP-100 mockup with flooding-critical reference
ZPPR-20E L160	SUB-HEU-MET-FAST-001	HEU/Li/Nb/Re core-BeO rad refl-Sand rad, axial refl-SP-100 mockup with earth burial-subcritical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ZPPR-21B
ZPPR-21C
ZPPR-21D
ZPPR-21E
ZPPR-21F
ZPR-3/23
ZPR-3/41
ZPR-6/9 (U9)
ZPR-9/34 (U/Fe)
ZPPR-20C L105
ZPPR-20D L136
ZPPR-20D L129
ZPPR-20E L160

Observations – as initially noted at June CSEWG meeting

- Comparison of 6/6A and 6/7 shows small bias (^{239}Pu more reactive than ^{235}U) – not observed for Godiva and Jezebel
- ZPR-9 Assemblies 1-4 shows degradation of performance as Tungsten replaces ^{238}U
- ZPR-6/10 (Pu/C/SST) very bad (+3.8% delta-k)
- ZPR-6/9 (U9) shows same dramatic improvements with β2 as Big Ten
- Large biases for Space Nuclear criticals (ZPPR-20 Phases C, D, and E)

Considering most discrepant assembly – ZPR-6/10 (A clean Pu/C/SST assembly)

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	k_{eff}	C – E (in % Δk)
Experiment	1.0016 ± 0.0013	
ENDF/B-VII β2	1.0392 ± 0.0003	3.76 ± 0.13
ENDF/B-VI	1.0380 ± 0.0005	3.64 ± 0.14
ENDF/B-V	1.0009 ± 0.0007	0.07 ± 0.15

- Note that there was NO bias with ENDF/B-V data.
- Using ENDF/B-VII β2 data with ENDF/B-V data for ^{239}Pu : reduces C/E by 1.1% Δk
- Using ENDF/B-VII β2 data with ENDF/B-V data for Cr : reduces C/E by 1.7% Δk
- Using ENDF/B-VII β2 data with ENDF/B-V data for Mn : reduces C/E by 0.6% Δk

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2. RESONANCE PARAMETERS

From 1 keV to about 900 keV, the parameters are derived from recent ORNL (AG84) and Geel (BR86, RO89) transmission data. Unfortunately, the reported resonance parameters were obtained by analyzing individual energy regions of the experimental data independently, with the same nuclear radius and set of dummy resonances not necessarily used for each region. Thus, simply adopting the resonance parameters and generating pointwise cross sections from them yield results which are often in poor agreement with the original experimental data. ……Further work needs to be done to provide a consistent, accurate set of resonance parameters commensurate with the quality of those in the iron and nickel evaluations.

Observations – more recently

- **Results for ZPR-6/10 using ENDF/B-VII β2 data indicate:**
  - **Bias from low energy data for modern ^{239}Pu evaluations is long-standing and consistent with general overpredict for Pu solution criticals – new evaluation should be high priority for ENDF/B-VII**
  - **Bias from low energy data for modern isotopic Cr evaluations is now evident – new evaluation should also be high priority for ENDF/B-VII**
  - **Re-evaluation of Mn data is already requested**
- **Intercomparison of "as-built" models with "simplified" benchmark models is confirming both Δk-transformation values and their uncertainty estimates. This will be studied further and documented.**