Argonne Data Testing of New Evaluations for ENDF/B

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Overview

- Revised evaluations were downloaded about 3 weeks ago from NNDC for:
  - ^{239}Pu
  - ^{240}Pu
  - ^{55}Mn
  - ^{52,53}Cr
  - ^{58,60}Ni
  - Minor Cr and Ni isotopes were not tested
- A set of benchmarks were selected which might test ^{240}Pu and the structural materials.

Most discrepant benchmark analysis with ENDF/B-VII.0
ZPR-6/10 (A clean Pu/C/SST assembly)

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

	k_{eff}	C – E (in % Δk)
Experiment	1.0016 0.0013	
ENDF/B-V	1.0009 0.0007	-0.07 0.15
ENDF/B-VI	1.0380 0.0005	3.64 ± 0.14
ENDF/B-VII.0	1.0392 0.0003	3.76 ± 0.13

- Note that there was NO bias with ENDF/B-V data.
- Using ENDF/B-VII.0 data with ENDF/B-V data for ^{239}Pu : reduces C/E by 1.1% Δk
- Using ENDF/B-VII.0 data with ENDF/B-V data for Cr : reduces C/E by 1.7% Δk
- Using ENDF/B-VII.0 data with ENDF/B-V data for Mn : reduces C/E by 0.6% Δk
- Using ENDF/B-VII.0 data with new ORNL data for Mn : reduces C/E by 0.6% Δk

Benchmarks with High Sensitivity to Structural Materials

Benchmark	Description	BM/AB k-eff	AVGE (MeV)	EALF (MeV)	Fission Distribution, %			Capture				
					Therm	Inter	Fast	Cr	Mn	Ni	Leakage	Prod
PMI-002	ZPR-6/10: 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	1.00160	4.05E-01	1.09E-02	0.15	62.33	37.52	80.81	72.1	54.19	46.12	1019.7
HCI-005-2	KBR-9: K-infinity Experiments in Intermediate Neutron Spectra for Various Structural Materials (SST)	1.05000	1.22E-01	3.21E-03	0.03	79.33	20.64	74.39	50.41	65.43	34.61	1028.94
HCI-005-3	KBR-10: K-infinity Experiments in Intermediate Neutron Spectra for Various Structural Materials (SST / Mo)	1.03000	1.46E-01	6.37E-03	0.01	75.23	24.76	59.88	37.08	55.38	33.265	993.04
HCI-005-4	KBR-15: K-infinity Experiments in Intermediate Neutron Spectra for Various Structural Materials (Cr)	1.06400	1.09E-01	3.33E-03	0	83.3	16.7	270.94	7.08	8.16	176.46	916.19
ZPPR-LMFR-EXP-001	ZPPR-10A: A 650 MWe-Class Sodium-Cooled MOX-Fueled FBR EMC Assembly L07 JUPITER-I	1.00110	8.51E-01	1.13E-01	0	41.63	58.37					
MMF-008-3	ZEBRA 8C/2: K-infinity Experiments in Fast/Intermediate Neutron Spectra for Various Fissile Materials	0.98600	6.77E-01	7.09E-02	0	46.54	53.46	23.24	10.28	23.11	0.32	975.58

Benchmarks with High Sensitivity to Structural Materials (Cont.)

Benchmark	Description	BM/AB k-eff	AVGE (MeV)	EALF (MeV)	Fission Distribution, %			Capture				
					Therm	Inter	Fast	Cr	Mn	Ni	Leakage	Prod
HCT-022-1	SPERT III Stainless-Steel-Clad Plate-Type Fuel in Water -- Case 1	1.00000	1.65E-02	9.40E-08	88.97	10.05	0.98	32.46	7.47	21.75	22.25	988.1
HCT-014-1	Experiments with Square-Pitched Lattices of Highly Enriched (~80% U235) Stainless-Steel Clad Fuel Rods -- Case 1	0.99860	2.55E-02	1.16E-07	87.96	10.57	1.47	36.85	9.09	26.43	97.64	998.76
HCT-014-2	Experiments with Square-Pitched Lattices of Highly Enriched (~80% U235) Stainless-Steel-Clad Fuel Rods -- Case 2	0.99860	2.23E-02	9.65E-08	89.84	8.89	1.27	34.54	8.33	24.74	81.23	998.53
HCT-011-1	Experiments with Square-Pitched Lattices of Highly Enriched (~80% U235) Stainless-Steel-Clad Fuel Rods -- Case 1	0.99880	5.16E-02	6.94E-07	68.46	28.1	3.44	33.6	9.35	25.1	67.38	998.66
HCT-011-2	Experiments with Square-Pitched Lattices of Highly Enriched (~80% U235) Stainless-Steel-Clad Fuel Rods -- Case 2	0.99880	4.91E-02	5.35E-07	71.5	25.25	3.25	34.7	9.44	25.79	80.08	998.77
HCT-011-3	Experiments with Square-Pitched Lattices of Highly Enriched (~80% U235) Stainless-Steel-Clad Fuel Rods -- Case 3	0.99880	4.59E-02	4.20E-07	74.18	22.83	2.99	33.96	9.08	25.19	72.75	998.26

Testing new ^{239}Pu Evaluation with THERM Benchmarks

ICSBEP Benchmark	Case Number	ENDF/B-VII.0 k-eff	±	σ	ENDF/A ^{239}Pu k-eff	±	σ	Benchmark or As-Built k-eff	±	σ	Δk-eff Old - New	±	σ
PST-001-1	1	1.00551	±	0.00029	1.00549	±	0.00028	1.00000	±	0.00500	-0.00002	±	0.00040
PST-001-2	2	1.00781	±	0.00029	1.00743	±	0.00030	1.00000	±	0.00500	-0.00038	±	0.00042
PST-001-3	3	1.01070	±	0.00029	1.01033	±	0.00029	1.00000	±	0.00500	-0.00037	±	0.00041
PST-001-4	4	1.00479	±	0.00029	1.00449	±	0.00028	1.00000	±	0.00500	-0.00030	±	0.00040
PST-001-5	5	1.00852	±	0.00029	1.00850	±	0.00028	1.00000	±	0.00500	-0.00002	±	0.00040
PST-001-6	6	1.00966	±	0.00030	1.00965	±	0.00029	1.00000	±	0.00500	-0.00001	±	0.00042
PST-002-1	1	1.00428	±	0.00027	1.00422	±	0.00028	1.00000	±	0.00470	-0.00006	±	0.00039
PST-002-3	3	1.00414	±	0.00027	1.00357	±	0.00027	1.00000	±	0.00470	-0.00057	±	0.00038
PST-002-5	5	1.00893	±	0.00028	1.00997	±	0.00028	1.00000	±	0.00470	0.00104	±	0.00040
PST-002-6	6	1.00525	±	0.00028	1.00557	±	0.00029	1.00000	±	0.00470	0.00032	±	0.00040
PST-002-7	7	1.00791	±	0.00028	1.00781	±	0.00028	1.00000	±	0.00470	-0.00010	±	0.00040
PST-003-1	1	1.00272	±	0.00025	1.00262	±	0.00025	1.00000	±	0.00470	-0.00010	±	0.00035
PST-003-4	4	1.00444	±	0.00025	1.00485	±	0.00026	1.00000	±	0.00470	0.00041	±	0.00036
PST-003-6	6	1.00613	±	0.00026	1.00589	±	0.00027	1.00000	±	0.00470	-0.00024	±	0.00037
PST-004-1	1	1.00392	±	0.00025	1.00410	±	0.00024	1.00000	±	0.00470	0.00018	±	0.00035
PST-004-6	6	1.00148	±	0.00025	1.00139	±	0.00026	1.00000	±	0.00470	-0.00009	±	0.00036
PST-004-9	9	1.00019	±	0.00026	1.00050	±	0.00026	1.00000	±	0.00470	0.00031	±	0.00037
PST-004-10	10	1.00157	±	0.00026	1.00194	±	0.00025	1.00000	±	0.00470	0.00037	±	0.00036
PST-004-11	11	1.00050	±	0.00026	1.00118	±	0.00026	1.00000	±	0.00470	0.00068	±	0.00037
PST-006-1	1	1.00031	±	0.00023	1.00026	±	0.00024	1.00000	±	0.00350	-0.00005	±	0.00033
PST-007-2	2	1.00933	±	0.00030	1.00926	±	0.00028	1.00000	±	0.00470	-0.00007	±	0.00041
PST-007-3	3	1.00315	±	0.00029	1.00362	±	0.00030	1.00000	±	0.00470	0.00047	±	0.00042
PST-007-7	7	1.00543	±	0.00030	1.00517	±	0.00028	1.00000	±	0.00470	-0.00026	±	0.00041
PST-007-10	10	1.00012	±	0.00029	1.00064	±	0.00028	1.00000	±	0.00470	0.00052	±	0.00040
PST-009-3	3	1.01902	±	0.00012	1.01911	±	0.00012	1.00000	±	0.00330	0.00009	±	0.00017
PST-011-16	16	1.01692	±	0.00029	1.01672	±	0.00029	1.00000	±	0.00520	-0.00020	±	0.00041
PST-011-18	18	0.99951	±	0.00026	0.99950	±	0.00026	1.00000	±	0.00520	-0.00001	±	0.00037

Testing new ^{239}Pu Evaluation with INTER & FAST Benchmarks

ICSBEP Benchmark	Case Number	ENDF/B-VII.0 k-eff	±	σ	ENDF/A ^{239}Pu k-eff	±	σ	Benchmark or As-Built k-eff	±	σ	Δk-eff Old - New	±	σ
PCI-001		1.01153	±	0.00017	1.01189	±	0.00017	1.00000	±	0.01100	0.00036	±	0.00024
PMI-002		1.02693	±	0.00024	1.02711	±	0.00024	0.98690	±	0.00260	0.00018	±	0.00034
MMF-001		0.99965	±	0.00018	0.99934	±	0.00019	1.00000	±	0.00160	-0.00031	±	0.00026
MMF-002-1	1	1.00544	±	0.00022	1.00484	±	0.00021	1.00000	±	0.00420	-0.00060	±	0.00030
MMF-002-2	2	1.00547	±	0.00021	1.00542	±	0.00022	1.00000	±	0.00440	-0.00005	±	0.00030
MMF-002-3	3	1.00586	±	0.00022	1.00555	±	0.00021	1.00000	±	0.00480	-0.00031	±	0.00030
PMF-001		0.99981	±	0.00018	1.00015	±	0.00019	1.00000	±	0.00200	0.00034	±	0.00026
PMF-005		1.00954	±	0.00020	1.00948	±	0.00020	1.00000	±	0.00130	-0.00006	±	0.00028
PMF-006		1.00076	±	0.00022	1.00099	±	0.00022	1.00000	±	0.00300	0.00023	±	0.00031
PMF-009		1.00469	±	0.00020	1.00464	±	0.00020	1.00000	±	0.00270	-0.00005	±	0.00028
PMF-010		0.99948	±	0.00020	0.99957	±	0.00020	1.00000	±	0.00180	0.00009	±	0.00028
PMF-011		1.00008	±	0.00023	1.00039	±	0.00024	1.00000	±	0.00100	0.00031	±	0.00033
PMF-018		0.99620	±	0.00021	0.99645	±	0.00020	1.00000	±	0.00300	0.00025	±	0.00029
PMF-022		0.99839	±	0.00019	0.99837	±	0.00019	1.00000	±	0.00140	-0.00002	±	0.00027
PMF-023		0.99976	±	0.00019	0.99978	±	0.00019	1.00000	±	0.00200	0.00002	±	0.00027
PMF-024		1.00159	±	0.00021	1.00155	±	0.00020	1.00000	±	0.00200	-0.00004	±	0.00029
PMF-025		0.99904	±	0.00020	0.99910	±	0.00019	1.00000	±	0.00200	0.00006	±	0.00028
PMF026		0.99841	±	0.00020	0.99857	±	0.00020	1.00000	±	0.00240	0.00016	±	0.00028
PMF-027		1.00307	±	0.00025	1.00282	±	0.00024	1.00000	±	0.00220	-0.00025	±	0.00035
PMF-028		0.99919	±	0.00021	0.99924	±	0.00020	1.00000	±	0.00220	0.00005	±	0.00029
PMF-029		0.99528	±	0.00018	0.99502	±	0.00019	1.00000	±	0.00200	-0.00026	±	0.00026
PMF-030		1.00265	±	0.00020	1.00312	±	0.00019	1.00000	±	0.00210	0.00047	±	0.00028
PMF-031		1.00434	±	0.00023	1.00446	±	0.00024	1.00000	±	0.00210	0.00012	±	0.00033
PMF-032		0.99850	±	0.00019	0.99891	±	0.00019	1.00000	±	0.00200	0.00041	±	0.00027

Testing new ^{240}Pu Evaluation with INTER & FAST Benchmarks

ICSBEP Benchmark	Case Number	ENDF/B-VII.0 k-eff	±	σ	ENDF/A ^{240}Pu k-eff	±	σ	Benchmark or As-Built k-eff	±	σ	Δk-eff Old - New	±	σ
PST-018-1	1	1.00925	±	0.00009	1.01561	±	0.00028	1.00000	±	0.00340	0.00636	±	0.00029
PST-018-2	2	1.01260	±	0.00009	1.01828	±	0.00029	1.00000	±	0.00340	0.00568	±	0.00030
PST-018-3	3	1.01058	±	0.00008	1.01596	±	0.00027	1.00000	±	0.00320	0.00538	±	0.00028
PST-018-4	4	1.00875	±	0.00008	1.01422	±	0.00028	1.00000	±	0.00300	0.00547	±	0.00029
PST-018-5	5	1.00767	±	0.00008	1.01293	±	0.00025	1.00000	±	0.00300	0.00526	±	0.00026
PST-018-6	6	1.00571	±	0.00008	1.01075	±	0.00026	1.00000	±	0.00310	0.00504	±	0.00027
PST-018-7	7	1.00501	±	0.00008	1.01024	±	0.00024	1.00000	±	0.00320	0.00523	±	0.00025
PST-018-8	8	1.00463	±	0.00008	1.00901	±	0.00023	1.00000	±	0.00330	0.00438	±	0.00024
PST-018-9	9	1.00291	±	0.00007	1.00739	±	0.00022	1.00000	±	0.00340	0.00448	±	0.00023
PST-012-6	6	1.00833	±	0.00009	1.01085	±	0.00029	1.00000	±	0.00070	0.00252	±	0.00030
PST-012-17	17	1.00669	±	0.00007	1.00765	±	0.00021	1.00000	±	0.00430	0.00096	±	0.00022
PMF-001		0.99989	±	0.00002	0.99995	±	0.00003	1.00000	±	0.00200	0.00006	±	0.00004
PMF-002		0.99990	±	0.00002	0.99996	±	0.00003	1.00000	±	0.00200	0.00006	±	0.00004
MCF-001		1.00150	±	0.00005	1.00134	±	0.00017	1.00051	±	0.00087	-0.00016	±	0.00018
MCF-002		1.00028	±	0.00005	1.00016	±	0.00015	1.00080	±	0.00090	-0.00012	±	0.00016
MCF-003-2	2	1.00184	±	0.00006	1.00198	±	0.00018	1.00170	±	0.00070	0.00014	±	0.00019
BFS-97-4		1.00229	±	0.00010	1.00341	±	0.00015	1.00110	±	0.00270	0.00112	±	0.00018

- Generally increases the over-prediction of the THERM systems
- No effect in the FAST systems

Testing new ^{55}Mn Evaluation with INTER & THERM Benchmarks

ICSBEP Benchmark	Case Number	ENDF/B-VII.0 k-eff ± σ	ENDF/A ^{55}Mn k-eff ± σ	Benchmark or As-Built k-eff ± σ	Δk-eff Old - New ± σ
PMI-002	ZPR-6/10 - AB	1.03955 ± 0.00024	1.03332 ± 0.00023	1.00160 ± 0.00130	0.00623 ± 0.00033
HCI-005-2	KBR-9 - SS	1.09779 ± 0.00012	1.08698 ± 0.00012	1.05000 ± 0.00800	0.01081 ± 0.00017
HCI-005-3	KBR-10 - SS/MO	1.04860 ± 0.00012	1.04139 ± 0.00012	1.03000 ± 0.00600	0.00721 ± 0.00017
HCT-022-1	Case 1	0.99494 ± 0.00025	0.99509 ± 0.00025	1.00000 ± 0.00810	-0.00015 ± 0.00035

- Very nice reduction in the over-prediction of the FAST systems while retaining good agreement in the THERM system

Testing new ^{52,53}Cr Evaluation with THERM, INTER & FAST Benchmarks

		ENDF/B-VII.0			ENDF/A ^{52,53}Cr			Benchmark or As-Built					
ICSBEP Benchmark	Case Number	k-eff	±	σ	k-eff	±	σ	k-eff	±	σ	Δk-eff Old - New	±	σ
PMI-002	ZPR-6/10 - AB	1.03955	±	0.00024	1.03386	±	0.00024	1.00160	±	0.00130	0.00569	±	0.00034
HCI-005-2	KBR-9 - SS	1.09779	±	0.00012	1.10493	±	0.00012	1.05000	±	0.00800	-0.00714	±	0.00017
HCI-005-3	KBR-10 - SS/MO	1.04860	±	0.00012	1.05544	±	0.00012	1.03000	±	0.00600	-0.00684	±	0.00017
HCI-005-4	KBR-15 - CR	1.14605	±	0.00012	1.17054	±	0.00012	1.06400	±	0.01800	-0.02449	±	0.00017
ZPPR-10A	L07 - AB	1.00117	±	0.00015				1.00110	±	0.00150			
MMF-008-3	ZEBRA 8C/2 - C. 3	0.99075	±	0.00014	0.99300	±	0.00014	0.98600	±	0.00440	-0.00225	±	0.00020
HCT-022-1	Case 1	0.99494	±	0.00025	0.99345	±	0.00023	1.00000	±	0.00810	0.00149	±	0.00034
HCT-014-1	Case 1	0.99863	±	0.00024	0.99670	±	0.00024	0.99860	±	0.00480	0.00193	±	0.00034
HCT-014-2	Case 2	0.99854	±	0.00024	0.99734	±	0.00022	0.99860	±	0.00490	0.00120	±	0.00033
HCT-011-1	Case 1	0.98970	±	0.00027	0.98689	±	0.00023	0.99880	±	0.00420	0.00281	±	0.00035
HCT-011-2	Case 2	0.99179	±	0.00025	0.98924	±	0.00024	0.99880	±	0.00420	0.00255	±	0.00035
HCT-011-3	Case 3	0.99327	±	0.00024	0.99051	±	0.00025	0.99880	±	0.00420	0.00276	±	0.00035

- Increased the under-prediction of the THERM systems and mixed performance in the INTER and FAST systems

Testing new ^{58,60}Ni Evaluation with THERM, INTER & FAST Benchmarks

		ENDF/B-VII.0			ENDF/A ^{58,60}Ni			Benchmark or As-Built				
ICSBEP Benchmark	Case Number	k-eff	±	σ	k-eff	±	σ	k-eff	±	σ	Δk-eff Old - New	± σ
PMI-002	ZPR-6/10 - AB	1.03955	±	0.00024	1.03990	±	0.00025	1.00160	±	0.00130	-0.00035	± 0.00035
HCI-005-1	KBR-7 - NI	1.02547	±	0.00011	1.03097	±	0.00013	1.03200	±	0.00400	-0.00550	± 0.00017
HCI-005-2	KBR-9 - SS	1.09779	±	0.00012	1.09835	±	0.00012	1.05000	±	0.00800	-0.00056	± 0.00017
HCI-005-3	KBR-10 - SS/MO	1.04860	±	0.00012	1.04900	±	0.00011	1.03000	±	0.00600	-0.00040	± 0.00016
ZPPR-10A	L07 - AB	1.00117	±	0.00015				1.00110	±	0.00150		
MMF-008-3	ZEBRA 8C/2 - C. 3	0.99075	±	0.00014	0.99114	±	0.00013	0.98600	±	0.00440	-0.00039	± 0.00019
HMF-003	HEU sph, Ni refl	1.00845	±	0.00020	1.00624	±	0.00020	1.00000	±	0.00300	0.00221	± 0.00028
MCF-004	ZPR-3/56 - AB	1.00293	±	0.00018	1.00278	±	0.00018	0.99950	±	0.00110	0.00015	± 0.00025
PMF-045-1	Pu core-Ni refl	1.01070	±	0.00021	1.00993	±	0.00021	1.00000	±	0.00470	0.00077	± 0.00030
PMF-045-2	Pu core-Ni/Fe refl	1.00853	±	0.00021	1.00800	±	0.00021	1.00000	±	0.00460	0.00053	± 0.00030
PMF-045-3	Pu core-Ni/Fe refl	1.01334	±	0.00020	1.01257	±	0.00022	1.00000	±	0.00440	0.00077	± 0.00030
PMF-045-4	Pu core-Ni refl	1.01210	±	0.00021	1.01155	±	0.00020	1.00000	±	0.00460	0.00055	± 0.00029
PMF-045-5	Pu core-Ni refl	1.01816	±	0.00021	1.01739	±	0.00022	1.00000	±	0.00450	0.00077	± 0.00030
HCT-022-1	Case 1	0.99494	±	0.00025	0.99560	±	0.00023	1.00000	±	0.00810	-0.00066	± 0.00034
HCT-014-1	Case 1	0.99863	±	0.00024	0.99865	±	0.00025	0.99860	±	0.00480	-0.00002	± 0.00035
HCT-014-2	Case 2	0.99854	±	0.00024	0.99909	±	0.00023	0.99860	±	0.00490	-0.00055	± 0.00033
HCT-011-1	Case 1	0.98970	±	0.00027	0.98986	±	0.00026	0.99880	±	0.00420	-0.00016	± 0.00037
HCT-011-2	Case 2	0.99179	±	0.00025	0.99167	±	0.00026	0.99880	±	0.00420	0.00012	± 0.00036
HCT-011-3	Case 3	0.99327	±	0.00024	0.99340	±	0.00025	0.99880	±	0.00420	-0.00013	± 0.00035

- Most of these systems are insensitive to Ni; the only two systems with significant changes are improved.

Summary

- ^{239}**Pu** – generally small changes on THERM, INTER and FAST systems.
- ^{240}**Pu** – Generally increases the over-prediction of the THERM systems; no effect in the FAST systems.
- ^{55}**Mn** – Nice improvement in FAST systems; little effect in THERMAL systems.
- ^{52,53}**Cr** – Increased the under-prediction of the THERM systems and mixed performance in the INTER and FAST systems.
- ^{58,60}**Ni** – Most of these systems are insensitive to Ni; the only two systems with significant changes are improved.