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Validation of MENDF71x

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The Nuclear Data Team at Los Alamos National Laboratory has recently finished processing a new multi-group neutron data library, MENDF71x, based on ENDF/B-VII.1. MENDF71x contains room-temperature, down-scatter only cross sections for the 423 evaluations in ENDF/B-VII.1. The data has been extensively validated by using the data to calculate k_{eff} for 91 models of critical assemblies from the *International Handbook of Evaluated Criticality Safety Benchmark Experiments*. The k_{eff} values were compared to the experimental benchmarks explanations are given to explain the differences between the modeled k_{eff} and the experimentally measured k_{eff}. The results of calculating k_{eff} from critical benchmark models and comparing them to the experimental values give confidence in the validity of the data in the MENDF71x library.

The MENDF71x library was compared to the MENDF70x and LANL2006ex libraries. Differences in k_{eff} between MENDF71x and the MENDF70x and LANL2006ex were calculated. The isotopes responsible for the change in k_{eff} between MENDF71x and the other libraries were identified by reverting each isotope in the model to one of the previous libraries and again calculating the k_{eff} value to identify the change. The results of reverting each isotope is presented in this paper. The evaluations that give the biggest change in k_{eff} are also those which had the biggest change between ENDF/B-VII.0 and ENDF/B-VII.1.

1. Introduction

The Nuclear Data Team at Los Alamos National Laboratory (LANL) has recently finished processing a new multi-group neutron data library based on ENDF/B-VII.1. This library is called MENDF71x and provides room-temperature (293.6 K) data for all 423 nuclides included in ENDF/B-VII.1. MENDF71x uses the `618_lanl` energy group structure [2].

In an effort to validate MENDF71x, we performed criticality calculations using a suite of Partisn [3] benchmarks previously developed at LANL [4]. We calculated eigenvalues for these benchmarks using MENDF71x and its two predecessor libraries, MENDF70x [5] and LANL2006ex [6]. The Partisn input files used with all three libraries were identical except for a few minor changes that we made to material specifications. These changes solely involved expressing an elemental atom fraction in terms of its component isotopic atom fractions when an elemental evaluation had been replaced by isotopic evaluations between libraries.

In addition to the multi-group criticality benchmark calculations, we have also performed Monte Carlo calculations for most of the benchmark calculations that were modeled with Partisn. The Monte Carlo calculations used ENDF/B-VII.1-based continuous-energy data [7, 8]. The Monte Carlo calculations used benchmark models that were utilized in previous validation reports [9, 10]. All of the Monte Carlo calculations were performed using MCNP6-1.0 [11].

This paper serves as a validation report of the MENDF71x library. We give the results of the multi-group k_{eff} calculations using MENDF71x and compare them to calculations using older multi-group libraries (i.e., MENDF70x, and LANL2006ex) and continuous-energy (Monte Carlo) libraries (i.e., ENDF71x and ENDF70).

2. Benchmark Suite

Our suite of benchmarks is 91 Partisn models for experimental benchmarks taken from *International Handbook of Evaluated Criticality Safety Benchmark Experiments* [1] or ICSBEP. These were intended as inputs for MCNP [4], but were converted to Partisn benchmarks by researchers at Oak Ridge National Laboratory [12].

For many of the Partisn models of experimental benchmarks, we have also performed MCNP calculations using MCNP6-1.0. Even though the Partisn models originally began life as MCNP models, the MCNP models we used were created by Kahler et al. [9], but are still based on ICSBEP.

These benchmarks have been run using several different nuclear data libraries. Each of the multi-group models were run with the MENDF71x [13], MENDF70x [5], and LANL2006ex [2] libraries. The Monte Carlo models were each run with the ENDF71x [7, 8] and ENDF70 [14, 15] libraries.

The 91 benchmarks fall under eight classes of benchmarks based on the material of the critical assembly and the energy spectrum of the neutrons. In this document, the different classes will be identified and marked—in tables and figures—by the colors shown here:

HEU-MET-FAST	highly enriched uranium metal with a fast spectrum;
HEU-SOL-THERM	highly enriched uranium in solution with a thermal spectrum;
IEU-MET-FAST	intermediate enriched uranium metal with a fast spectrum;
MIX-MET-FAST	mixed uranium and plutonium metal with a fast spectrum;
PU-MET-FAST	plutonium metal with fast spectrum;
PU-SOL-THERM	plutonium in solution with thermal spectrum;
U233-MET-FAST	^{233}U metal with fast spectrum; and
U233-SOL-THERM	^{233}U in solution with thermal spectrum.

For each benchmark and data library, k_{eff} was calculated using the LANL 618 energy group structure and Partisn 7.4.2. The k_{eff} values are given in Table 1. The ratio of the multi-group (MENDF71x) to Monte Carlo (ENDF71x) k_{eff} value is also given so as to compare the multi-group to the Monte Carlo algorithm.

Those models that under-predict k_{eff} by more than 5 % from the ICSBEP experimental value are highlighted in Table 1 by purple; those that under-predict by more than 10 % are highlighted by blue; and those that under-predict by more than 15 % are highlighted by red. Those that over-predict k_{eff} by more than 3 % are highlighted by aqua. The k_{eff} values of the multi-group calculations are shown in Figure 1 with a close-up view in Figure 1b. The Monte Carlo k_{eff} estimates are shown in Figure 2. The ratio of the multi-group to Monte Carlo k_{eff} values is shown in Figure 3.

We can see that most of the benchmark models fall within just a few % of the ICSBEP experimental value, whereas all of the Monte Carlo k_{eff} estimates fall within 1 % of the ICSBEP experimental value. The k_{eff} values do not change significantly from one library to the next which suggests only modest changes in the evaluations from one library to the next. The LANL2006ex library was made from evaluations being prepared for the ENDF/B-VII.0 release; the MENDF70x library was made from the ENDF/B-VII.0 evaluations; the MENDF71x library was made from the ENDF/B-VII.1 evaluations, an update to the ENDF/B-VII.0 evaluations. The modest changes we see between libraries are expected.

There are a few benchmarks for which the multi-group model is particularly poor. Most of these are for benchmarks which do not have a fast spectrum. The weights used to calculate the multi-group cross sections are from a TD weight-function [16, 17]. The TD weight-function is appropriate for fast systems with a spectrum dominated by fission and/or fusion reactions, but is not a good approximation for a thermal spectrum. For this reason, we do not expect epithermal or thermal spectrum models to closely match the experimental k_{eff} values when using MENDF71x or its predecessors.

In addition to assuming a TD weight-function, MENDF71x (and its predecessors) has no up-scattering and all materials are assumed to be infinitely dilute, i.e., no resonance self-shielding effects are included. Again, these assumptions are appropriate for those critical assemblies made of metallic, fissile material—especially if there is little structure to the assembly—but are not valid for assemblies with appreciable up-scatter or bulk quantities of other material, or for assemblies with non-fast spectra.

This effect is seen in MIX-MET-FAST-008 Case 1, which under-predicts the experimental k_{eff} by 17 %. This critical assembly has a large amounts of iron and ^{238}U which

have significant resonances in the epithermal energy range. Without a self-shielding treatment, we can't expect the model to match the experimental k_{eff}.

We see in Table 1 that the all of the models which are solution assemblies and have a thermal spectrum (all the solution assemblies have thermal spectrums) *over*-predict k_{eff} compared to the experimental benchmark. This is a change from previous 30-group Partisn analyses [18, 12]—where only one group spanned the entire thermal range. The tests performed here used 618 groups and thus had good energy group resolution of the thermal energy range. Also note that the assemblies reflected by water or poly are under-predicted in 618 groups. They were over-predicted in previous 30-group comparisons.

Finally, the multi-group calculations do not have any $S(\alpha, \beta)$ effects included; these become important when significant quantities of water or poly are present in the critical assembly. These are typically the solution assemblies, but there are also some metal assemblies that are water reflected, such as HEU-MET-FAST-005 .

Another model that over-predicts the experimental k_{eff} is HEU-MET-FAST-003 Case 12 . In this critical assembly a large amount of nickel was used as a reflector. Resonance cross sections require that self-shielding is accounted for on a case-by-case basis which we do not do with our multi-group data. Without accounting for the flux depression that occurs around a large resonance, the multi-group cross section will be incorrect.

Table 1: Comparison of k_{eff} results for multi-group and continuous-energy benchmark models. The final column is the ratio of the multi-group (MENDF71x) k_{eff} to the Monte Carlo (ENDF71x) k_{eff}.

#	ICSBEP Name	Experimental k_{eff}	Partisn 7.14 Calculated k_{eff}			MCNP6 1.0 Calculated k_{eff}		k_{MG}/k_{MC}
			MENDF71x	MENDF70x	LANL2006ex	ENDF71x	ENDF70	
1	HEU-MET-FAST-001 Case a	1.00(1)	0.99366	0.99371	0.99311			
2	HEU-MET-FAST-001 Case b	1.00(1)	0.99366	0.99371	0.99311			
3	HEU-MET-FAST-003 Case 1	1.00(5)	0.98935	0.98941	0.98919	0.99474(9)	0.99492(9)	0.99459
4	HEU-MET-FAST-003 Case 10	1.00(5)	0.99638	1.00409	1.00258	1.00504(9)	1.01281(9)	0.99138
5	HEU-MET-FAST-003 Case 11	1.00(5)	0.99863	1.00607	1.00437	1.00913(9)	1.01683(9)	0.98959
6	HEU-MET-FAST-003 Case 12	1.00(3)	1.03260	1.03048	1.02973	1.00863(9)	1.00846(9)	1.02377
7	HEU-MET-FAST-003 Case 2	1.00(5)	0.98887	0.98892	0.98875	0.99447(9)	0.99457(9)	0.99437
8	HEU-MET-FAST-003 Case 3	1.00(5)	0.99342	0.99348	0.99331	0.99932(9)	0.99913(9)	0.99410
9	HEU-MET-FAST-003 Case 4	1.00(3)	0.99131	0.99136	0.99121	0.99731(9)	0.99729(9)	0.99398
10	HEU-MET-FAST-003 Case 5	1.00(3)	0.99483	0.99489	0.99474	1.00133(9)	1.00166(9)	0.99351
11	HEU-MET-FAST-003 Case 6	1.00(3)	0.99478	0.99484	0.99468	1.00135(9)	1.00149(9)	0.99344
12	HEU-MET-FAST-003 Case 7	1.00(3)	0.99484	0.99490	0.99474	1.00211(9)	1.00205(9)	0.99275
13	HEU-MET-FAST-003 Case 8	1.00(5)	0.99608	1.00316	1.00238	1.00204(9)	1.00846(9)	0.99405
14	HEU-MET-FAST-003 Case 9	1.00(5)	0.99576	1.00359	1.00250	1.00264(9)	1.00946(9)	0.99314
15	HEU-MET-FAST-004 Case 1	1.0020	0.86144	0.86147	0.86060	1.00314(11)	1.0032(11)	0.85875
16	HEU-MET-FAST-004 Case 2	0.9985	0.89297	0.89300	0.89211			
17	HEU-MET-FAST-008	0.9989(16)	0.98396	0.98401	0.98354	0.99577(8)	0.99581(8)	0.98814
18	HEU-MET-FAST-009 Case 1	0.9992(15)	0.98327	0.98088	0.98401	0.99739(9)	0.99526(9)	0.98584
19	HEU-MET-FAST-009 Case 2	0.9992(15)	0.98212	0.98102	0.98196	0.99654(9)	0.99545(9)	0.98553
20	HEU-MET-FAST-011	0.9989(15)	0.92721	0.92724	0.92669	0.999(11)	0.99893(11)	0.92814
21	HEU-MET-FAST-012	0.9992(18)	0.98606	0.98612	0.98475	0.99817(9)	0.99829(9)	0.98787
22	HEU-MET-FAST-013	0.9990(15)	0.99806	0.99810	0.99777	0.99748(9)	0.99731(9)	1.00058
23	HEU-MET-FAST-014	0.9989(17)	0.98657	0.98662	0.98645	0.99766(9)	0.99762(9)	0.98889
24	HEU-MET-FAST-015	0.9996(17)	0.98235	0.98240	0.98189	0.99449(8)	0.9947(9)	0.98779

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Table 1: Comparison of k_{eff} results . . . (continued from previous page)

#	ICSBEP Name	Experimental k_{eff}	Partisn 7.14 Calculated k_{eff} MENDF71x	MENDF70x	LANL2006ex	MCNP6 1.0 Calculated k_{eff} ENDF71x	ENDF70	k_{MG}/k_{MC}
25	HEU-MET-FAST-018	1.000(16)	0.99328	0.99335	0.99281	1.00024(8)	1.00022(8)	0.99304
26	HEU-MET-FAST-019	1.00(3)	1.00082	1.00089	1.00030	1.0071(9)	1.00719(9)	0.99377
27	HEU-MET-FAST-020	1.00(3)	0.99140	0.99147	0.99087	1.00064(9)	1.0008(10)	0.99077
28	HEU-MET-FAST-021	1.000(26)	1.01346	1.01356	1.01321	0.99722(9)	0.99745(9)	1.01628
29	HEU-MET-FAST-022	1.000(21)	0.99198	0.99205	0.99001	0.99762(9)	0.99772(9)	0.99435
30	HEU-MET-FAST-028	1.00(3)	0.99622	0.99627	0.99612	1.00288(9)	1.0029(9)	0.99336
31	HEU-SOL-THERM-013 Case 1	1.0012(26)	1.03718	1.03709	1.03557	0.99872(8)	0.99854(8)	1.03851
32	HEU-SOL-THERM-013 Case 2	1.0007(36)	1.03259	1.03250	1.03102	0.99691(27)	0.99758(27)	1.03579
33	HEU-SOL-THERM-013 Case 3	1.0009(36)	1.02644	1.02636	1.02491	0.9939(27)	0.9936(29)	1.03274
34	HEU-SOL-THERM-013 Case 4	1.0003(36)	1.02690	1.02682	1.02537	0.99529(29)	0.99561(29)	1.03176
35	HEU-SOL-THERM-032	1.0015(26)	1.03298	1.03289	1.03157	0.99942(5)	0.99944(5)	1.03358
36	IEU-MET-FAST-001 Case 1	0.9989(9)	0.99181	0.99202	0.99206	0.99994(29)	1.00047(27)	0.99187
37	IEU-MET-FAST-001 Case 2	0.9997(9)	0.99006	0.99023	0.99031	1.00016(27)	1.00135(27)	0.98990
38	IEU-MET-FAST-001 Case 3	0.9993(3)	0.99456	0.99457	0.99517	1.00122(27)	1.00053(27)	0.99334
39	IEU-MET-FAST-001 Case 4	1.0002(3)	0.99015	0.99027	0.99050	1.00163(25)	1.00182(25)	0.98854
40	IEU-MET-FAST-002	1.00(3)	0.98311	0.98318	0.98337	0.99909(8)	0.99909(8)	0.98401
41	IEU-MET-FAST-003	1.000(17)	0.99581	0.99586	0.99618	1.00221(9)	1.00233(9)	0.99362
42	IEU-MET-FAST-004	1.00(3)	1.00040	1.00046	1.00075	1.00736(9)	1.00748(9)	0.99309
43	IEU-MET-FAST-005	1.000(21)	1.01561	1.01571	1.01603	1.00188(9)	1.00184(9)	1.01370
44	IEU-MET-FAST-006	1.000(23)	0.97352	0.97357	0.97218	0.99619(9)	0.99639(9)	0.97725
45	IEU-MET-FAST-007	0.996(3)	0.98453	0.98460	0.98467			
46	IEU-MET-FAST-007	0.996(3)	0.98212	0.98219	0.98227			
47	MIX-MET-FAST-001	1.000(16)	0.99724	0.99728	0.99717	0.99949(8)	0.99945(9)	0.99775
48	MIX-MET-FAST-003	0.9993(16)	0.99452	0.99460	0.99448	1.00085(9)	1.00072(9)	0.99367

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Table 1: Comparison of k_{eff} results ... (continued from previous page)

#	ICSBEP Name	Experimental k_{eff}	Partisn 7.14 Calculated k_{eff}			MCNP6 1.0 Calculated k_{eff}		k_{MG}/k_{MC}
			MENDF71x	MENDF70x	LANL2006ex	ENDF71x	ENDF70	
49	MIX-MET-FAST-008 Case 1	0.9920(63)	0.83026	0.83055	0.83028			
50	PU-MET-FAST-001	1.00(2)	0.99837	0.99841	0.99860	1.00005(8)	0.99986(8)	0.99832
51	PU-MET-FAST-002	1.00(2)	0.99780	0.99834	0.99847	1.00025(8)	0.99995(8)	0.99756
52	PU-MET-FAST-005	1.000(13)	0.99954	1.00837	1.00892	1.00119(9)	1.00929(9)	0.99835
53	PU-MET-FAST-006	1.00(3)	0.99925	0.99935	1.00000	1.00107(10)	1.00105(10)	0.99818
54	PU-MET-FAST-008 Case 1	1.00(6)	0.99753	0.99787	1.00785	0.99771(9)	0.99802(9)	0.99982
55	PU-MET-FAST-008 Case 2	1.00(6)	0.95841	0.95878	0.96877	0.99766(27)	0.99772(27)	0.96066
56	PU-MET-FAST-009	1.000(27)	1.00633	1.00638	1.00503	1.00524(9)	1.00517(9)	1.00109
57	PU-MET-FAST-010	1.000(18)	0.99843	0.99849	0.99908	0.99954(9)	0.99954(9)	0.99889
58	PU-MET-FAST-011	1.00(1)	0.94286	0.94284	0.94284	1.00027(11)	1.00019(11)	0.94260
59	PU-MET-FAST-018	1.00(3)	0.99782	0.99475	1.00016	0.9994(9)	0.99646(9)	0.99842
60	PU-MET-FAST-019	0.9992(15)	0.99267	0.98972	0.99534	1.00083(9)	0.99785(9)	0.99185
61	PU-MET-FAST-020	0.9993(17)	0.99361	0.99378	0.99441	0.99791(9)	0.99823(9)	0.99569
62	PU-MET-FAST-021 Case 1	1.000(26)	1.02379	1.02192	1.02573	0.99867(31)	0.99691(29)	1.02515
63	PU-MET-FAST-021 Case 2	1.000(26)	1.01302	1.01229	1.01372	0.99357(29)	0.99227(29)	1.01957
64	PU-MET-FAST-022	1.000(21)	0.99712	0.99714	0.99739	0.99849(8)	0.9986(8)	0.99863
65	PU-MET-FAST-023	1.00(2)	0.99858	0.99859	0.99902	0.99997(9)	0.99985(9)	0.99861
66	PU-MET-FAST-024	1.00(2)	0.99584	0.99584	0.99647	1.00186(9)	1.00178(9)	0.99399
67	PU-MET-FAST-025	1.00(2)	1.00058	1.00060	1.00103	0.9988(9)	0.99885(9)	1.00178
68	PU-MET-FAST-026	1.000(24)	1.01920	1.01925	1.01987	0.99858(9)	0.99871(9)	1.02065
69	PU-SOL-THERM-011 Case 16-1	1.000(52)	1.04590	1.04589	1.04641			
70	PU-SOL-THERM-011 Case 16-5	1.000(52)	1.03932	1.03933	1.03980			
71	PU-SOL-THERM-011 Case 18-1	1.000(52)	1.02526	1.02520	1.02561	0.99409(35)	0.99383(36)	1.03136
72	PU-SOL-THERM-011 Case 18-6	1.000(52)	1.02859	1.02854	1.02889			

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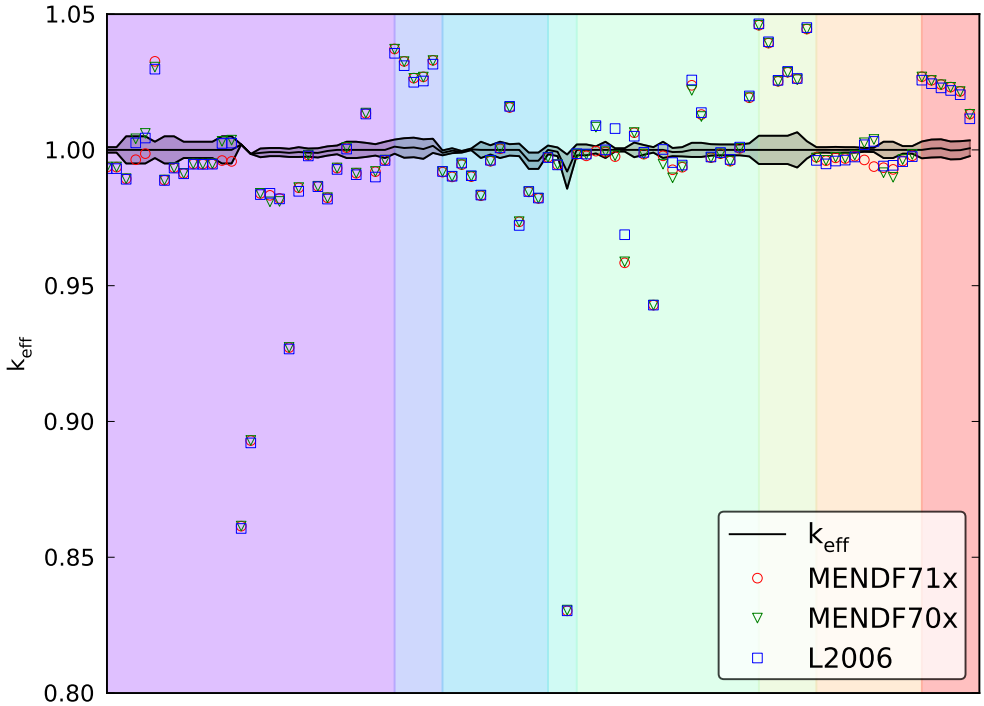
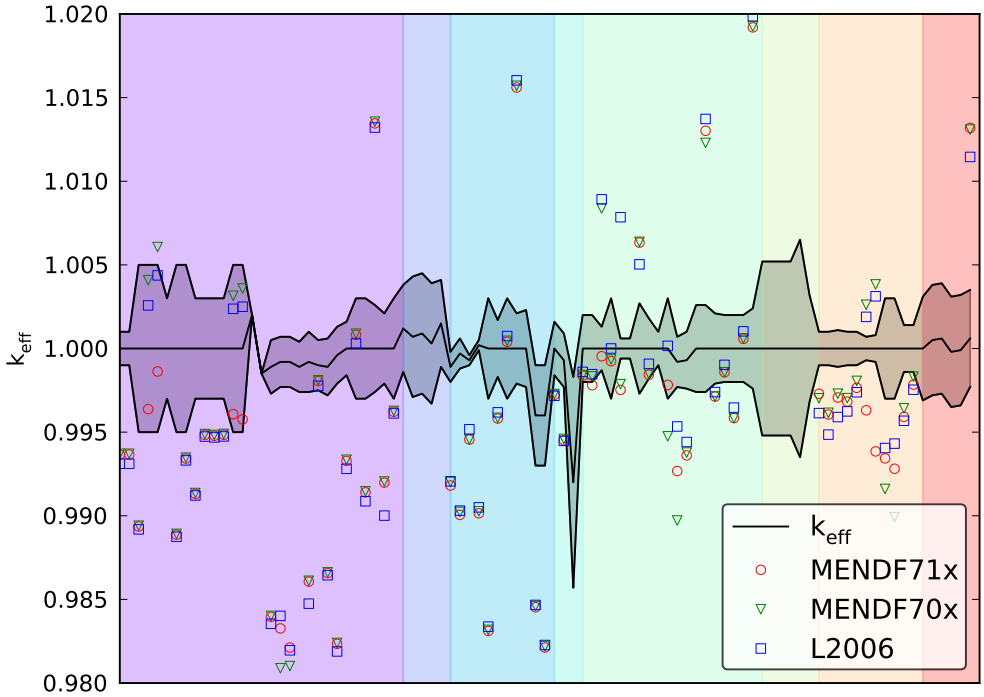
Table 1: Comparison of k_{eff} results . . . (continued from previous page)

#	ICSBEP Name	Experimental k_{eff}	Partisn 7.14 Calculated k_{eff} MENDF71x	MENDF70x	LANL2006ex	MCNP6 1.0 Calculated k_{eff} ENDF71x	ENDF70	k_{MG}/k_{MC}
73	PU-SOL-THERM-021 Case 3	1.000(65)	1.02612	1.02586	1.02629	1.00432(44)	1.00438(44)	1.02171
74	PU-SOL-THERM-021 Case 7	1.000(32)	1.04450	1.04445	1.04503			
75	U233-MET-FAST-001	1.00(1)	0.99729	0.99703	0.99614	0.99989(8)	0.99953(8)	0.99740
76	U233-MET-FAST-002 Case 1	1.00(1)	0.99605	0.99616	0.99485	0.99887(8)	0.99904(8)	0.99718
77	U233-MET-FAST-002 Case 2	1.000(11)	0.99707	0.99730	0.99590	0.99994(8)	1.00046(8)	0.99713
78	U233-MET-FAST-003 Case 1	1.00(1)	0.99683	0.99704	0.99624	0.99927(8)	0.99962(8)	0.99756
79	U233-MET-FAST-003 Case 2	1.00(1)	0.99765	0.99807	0.99739	0.99983(9)	1.00022(9)	0.99782
80	U233-MET-FAST-004 Case 1	1.00(7)	0.99630	1.00262	1.00189	0.99871(9)	1.00461(9)	0.99759
81	U233-MET-FAST-004 Case 2	1.00(8)	0.99385	1.00383	1.00312	0.99589(9)	1.00489(9)	0.99795
82	U233-MET-FAST-005 Case 1	1.00(3)	0.99343	0.99161	0.99405	0.99623(9)	0.9943(9)	0.99719
83	U233-MET-FAST-005 Case 2	1.00(3)	0.99281	0.98992	0.99432	0.99533(10)	0.99262(9)	0.99747
84	U233-MET-FAST-006	1.000(14)	0.99591	0.99643	0.99568	0.99884(10)	0.99926(10)	0.99707
85	U233-MET-FAST-006	1.000(14)	0.99784	0.99832	0.99754	0.99884(10)	0.99926(10)	0.99900
86	U233-SOL-THERM-001 Case 1	1.000(31)	1.02694	1.02686	1.02568	1.00113(8)	1.00127(8)	1.02578
87	U233-SOL-THERM-001 Case 2	1.0005(33)	1.02564	1.02556	1.02439	1.00134(8)	1.00126(8)	1.02427
88	U233-SOL-THERM-001 Case 3	1.0006(33)	1.02408	1.02400	1.02284	1.00086(8)	1.0008(8)	1.02320
89	U233-SOL-THERM-001 Case 4	0.9998(33)	1.02312	1.02304	1.02189	1.00073(8)	1.00084(8)	1.02238
90	U233-SOL-THERM-001 Case 5	0.9999(33)	1.02155	1.02147	1.02032	1.00003(8)	1.00009(9)	1.02152
91	U233-SOL-THERM-008	1.0006(29)	1.01319	1.01309	1.01145	1.00155(5)	1.00137(5)	1.01162



(a) All k_{eff} values.



(b) k_{eff} values between 0.98 and 1.02; close-up of Figure 1a.

Figure 1: Partisn calculated k_{eff} values using MENDF71x MENDF70x and LANL2006ex. The solid black line and gray shaded region indicate the experimental k_{eff} and uncertainty. The vertical lines and colors delineate the eight classes of ICSBEP benchmarks used.

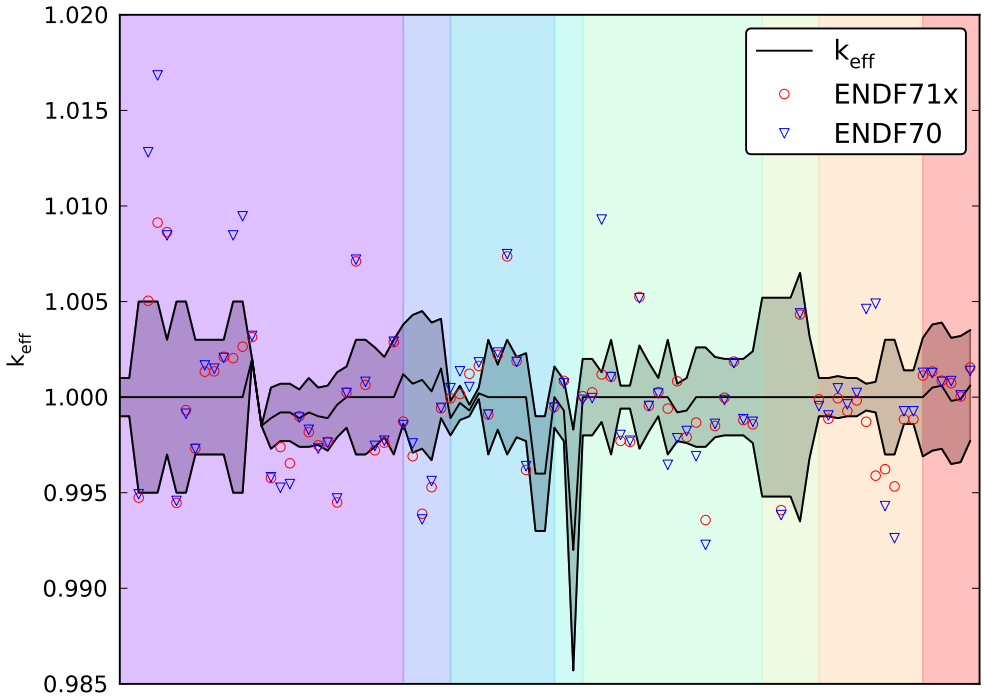


Figure 2: Monte Carlo k_{eff} estimates. The solid black line and gray shaded region indicate the experimental k_{eff} and uncertainty. The vertical lines and colors delineate the eight classes of ICSBEP benchmarks used.

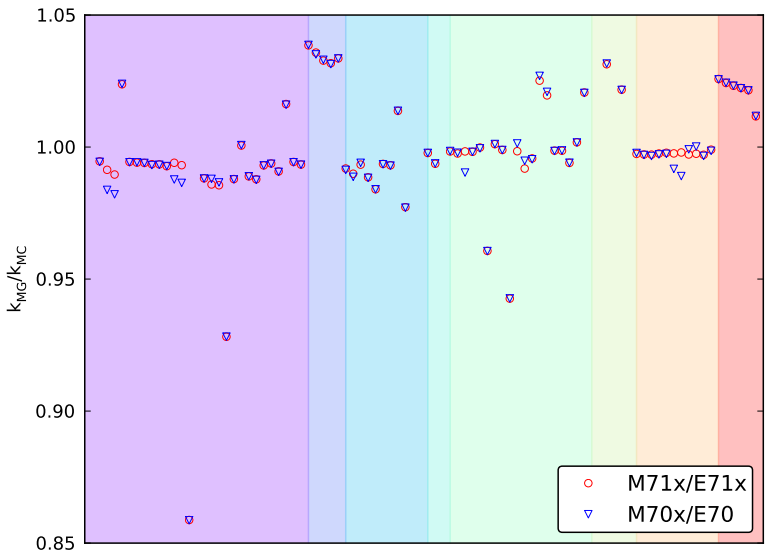


Figure 3: Ratio of multi-group to Monte Carlo k_{eff} estimates. The solid black line and gray shaded region indicate the experimental k_{eff} and uncertainty. The vertical lines and colors delineate the eight classes of ICSBEP benchmarks used.

3. Change to k_{eff} Due to Changes in Individual Evaluations

In an effort to identify the isotopes most responsible for the changes in k_{eff}, we have done additional calculations by making small modifications to our benchmark model. We have run each benchmark model using the MENDF71x library except for a single isotope which we reverted to the MENDF70x or LANL2006ex library. We have then calculated the change in k_{eff}.

Table 2 gives the ZAs that—when reverted—change k_{eff} by more than 50 pcm. The table also gives the total change in k_{eff} between MENDF71x, MENDF70x and LANL2006ex. The change in k_{eff} was calculated as

$$\Delta k_{70x} = k_{71x} - k_{70x} \tag{1a}$$

$$\Delta k_{06ex} = k_{71x} - k_{06ex}; \tag{1b}$$

where k_{71x}, k_{70x}, and k_{06ex} are the k_{eff} values using the MENDF71x, MENDF70x, and LANL2006ex multi-group libraries, respectively. The full table containing all the k_{eff} changes can be found in Appendix A.

Figure 4 shows the change in k_{eff} by reverting *all* isotopes in the benchmark model to an older library. Most of the changes in k_{eff} are smaller than 300 pcm. These are the same Δk values given in Table 2.

Figure 5 show graphically, the change in k_{eff} by reverting a single isotope to an older library; Δk_{70x} in Figure 5a and Δk_{06ex} in Figure 5b. From these figures and Table 2 we can identify the evaluations that cause the largest change in k_{eff}.

^{1}H	1001	^{183}W	74183
^{9}Be	4009	^{184}W	74184
^{16}O	8016	^{186}W	74186
^{27}Al	13027	^{232}Th	90232
^{53}Cr	24053	^{233}U	92233
^{58}Ni	28058	^{235}U	92235
^{60}Ni	28060	^{238}U	92238
^{62}Ni	28062	^{239}Pu	94239
^{183}W	74182	^{241}Pu	94241

Note that this list is not the same as a list of the biggest changes made in ENDF/B-VII.1. Our suite of 91 benchmarks does not include all the evaluations in ENDF/B-VII.1. This list is just the isotopes that effected the largest change in k_{eff} in our benchmark suite when reverting from MENDF71x to an older evaluation from either MENDF70x or LANL2006ex.

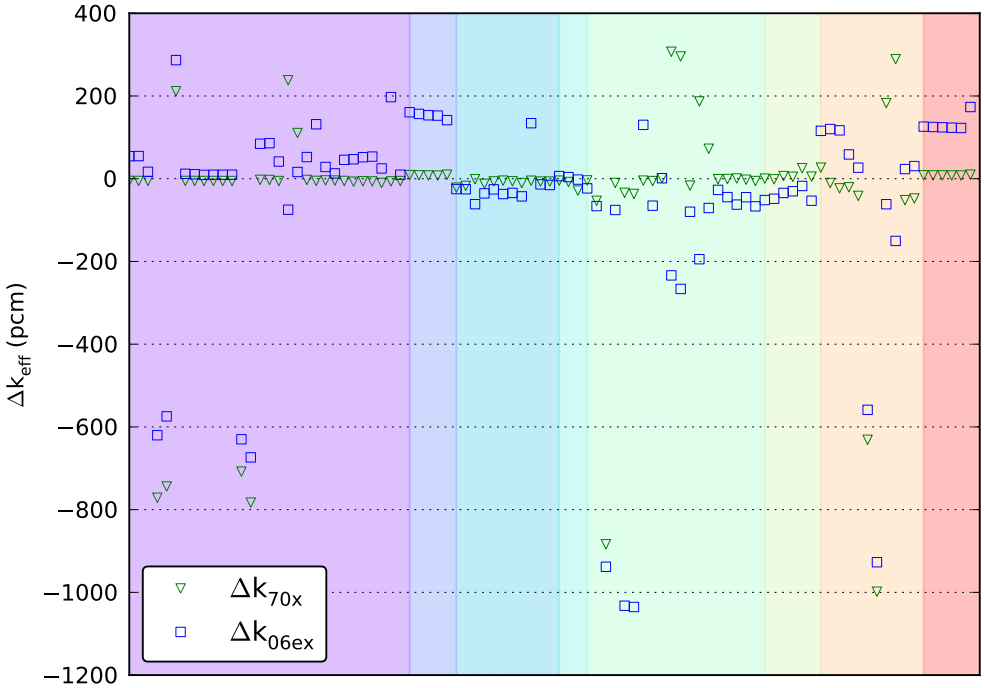
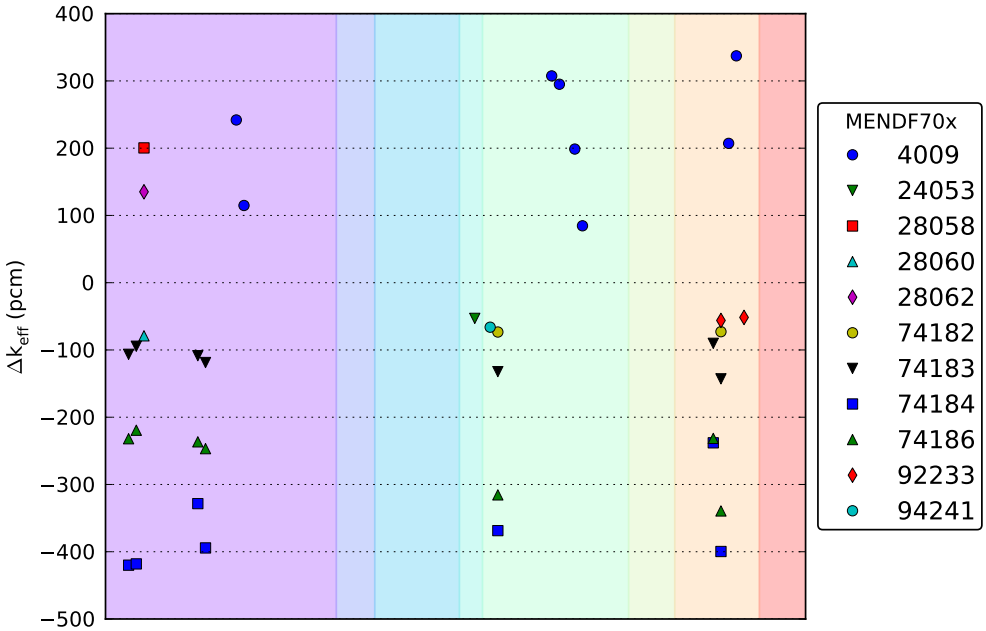
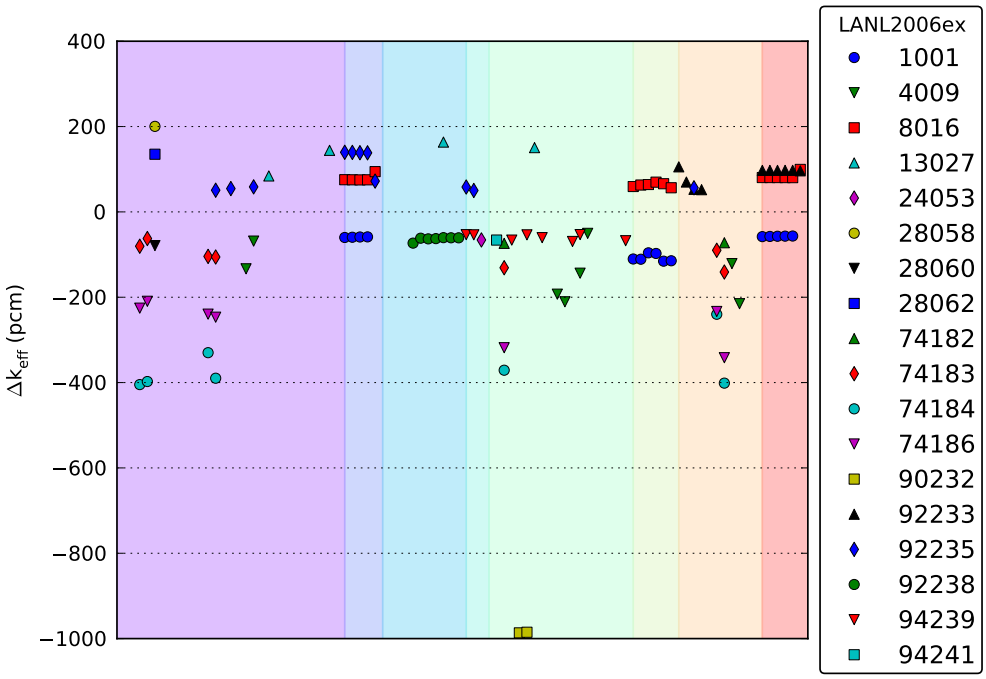


Figure 4: Change in k_{eff} values due to a different multi-group library. Change in k_{eff} calculated using Equation 1b.



(a) MENDF70x



(b) LANL2006ex

Figure 5: Changes in k_{eff} due to reverting a single isotope to an older evaluation from MENDF71x. Only includes those isotopes that cause a change >50 pcm. Compare with Table 2 to determine the specific benchmark and the precise change in k_{eff}.

Table 2: Changes in k_{eff} due to reverting a single isotope to an older evaluation. This table only includes those isotopes that cause a change >50 pcm. Table 3 in the appendix contains all of the changes. The ZA in the table indicates the single evaluation that was reverted to an older multi-group data library. The column header denotes the older library to which the single evaluation was reverted. The column values are the change in the k_{eff} value from the MENDF71x value.

		$k_{71\text{x}} - k_x$ (pcm)	
ICSBEP	ZA	MENDF70x	LANL2006ex
HEU-MET-FAST-003 Case 10	74183	−106.468	−80.411
$\Delta k_{70\text{x}} = -771.224$	74184	−419.984	−404.734
$\Delta k_{06\text{ex}} = -620.144$	74186	−231.991	−225.599
	sum	−758.443	−710.744
HEU-MET-FAST-003 Case 11	74183	−94.451	−62.430
$\Delta k_{70\text{x}} = -743.990$	74184	−418.100	−397.550
$\Delta k_{06\text{ex}} = -574.530$	74186	−219.330	−209.490
	sum	−731.881	−669.470
HEU-MET-FAST-003 Case 12	28058	200.400	200.410
$\Delta k_{70\text{x}} = 211.690$	28060	−78.980	−78.950
$\Delta k_{06\text{ex}} = 286.730$	28062	135.160	135.150
	sum	256.580	256.610
HEU-MET-FAST-003 Case 8	74183	−108.549	−104.293
$\Delta k_{70\text{x}} = -708.074$	74184	−328.439	−329.937
$\Delta k_{06\text{ex}} = -629.934$	74186	−236.607	−239.615
	sum	−673.595	−673.845
HEU-MET-FAST-003 Case 9	74183	−118.690	−105.712
$\Delta k_{70\text{x}} = -782.929$	74184	−394.354	−389.808
$\Delta k_{06\text{ex}} = -673.699$	74186	−246.741	−246.780
	92235	−4.399	50.817
	sum	−764.184	−691.483
HEU-MET-FAST-004 Case 2	92235	−3.554	54.636
$\Delta k_{70\text{x}} = -3.019$			
$\Delta k_{06\text{ex}} = 85.974$			

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Table 2: Changes in k_{eff} due to a single evaluation... (continued from previous page)

ICSBEP	ZA	$k_{71x} - k_x$ (pcm) MENDF70x	LANL2006ex
	sum	−3.554	54.636
HEU-MET-FAST-009 Case 1	4009	241.940	−133.368
$\Delta k_{70x} = 238.236$			
$\Delta k_{06ex} = -74.899$	**sum**	241.940	−133.368
HEU-MET-FAST-009 Case 2	4009	114.802	−68.429
$\Delta k_{70x} = 110.456$	92235	−4.682	58.654
$\Delta k_{06ex} = 16.267$			
	sum	110.120	−9.775
HEU-MET-FAST-012	13027	0.000	84.251
$\Delta k_{70x} = -5.159$			
$\Delta k_{06ex} = 131.727$	**sum**	0.000	84.251
HEU-MET-FAST-022	13027	0.000	144.305
$\Delta k_{70x} = -6.457$			
$\Delta k_{06ex} = 197.287$	**sum**	0.000	144.305
HEU-SOL-THERM-013 Case 1	1001	−0.190	−59.990
$\Delta k_{70x} = 8.780$	8016	−4.150	75.440
$\Delta k_{06ex} = 160.700$	92235	13.150	139.690
	sum	8.810	155.140
HEU-SOL-THERM-013 Case 2	1001	−0.160	−59.430
$\Delta k_{70x} = 8.310$	8016	−4.150	75.220
$\Delta k_{06ex} = 156.710$	92235	12.640	139.400
	sum	8.330	155.190
HEU-SOL-THERM-013 Case 3	1001	−0.130	−58.820
$\Delta k_{70x} = 7.900$	8016	−4.130	74.940
$\Delta k_{06ex} = 153.380$	92235	12.190	138.690
	sum	7.930	154.810
HEU-SOL-THERM-013 Case 4	1001	−0.130	−58.550
$\Delta k_{70x} = 7.680$	8016	−4.140	75.180
$\Delta k_{06ex} = 152.570$			

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Table 2: Changes in k_{eff} due to a single evaluation... (continued from previous page)

ICSBEP	ZA	$k_{71\text{x}} - k_x$ (pcm) MENDF70x	LANL2006ex
	92235	11.970	138.410
	sum	7.700	155.040
HEU-SOL-THERM-032	8016	−4.480	94.310
$\Delta k_{70\text{x}} = 9.750$	92235	14.470	72.180
$\Delta k_{06\text{ex}} = 141.640$			
	sum	9.990	166.490
IEU-MET-FAST-002	92238	−0.018	−73.190
$\Delta k_{70\text{x}} = -6.511$			
$\Delta k_{06\text{ex}} = -25.767$	**sum**	−0.018	−73.190
IEU-MET-FAST-003	92238	−0.005	−61.673
$\Delta k_{70\text{x}} = -4.618$			
$\Delta k_{06\text{ex}} = -37.090$	**sum**	−0.005	−61.673
IEU-MET-FAST-004	92238	0.000	−63.220
$\Delta k_{70\text{x}} = -6.170$			
$\Delta k_{06\text{ex}} = -34.330$	**sum**	0.000	−63.220
IEU-MET-FAST-005	92238	0.000	−62.630
$\Delta k_{70\text{x}} = -10.390$			
$\Delta k_{06\text{ex}} = -42.670$	**sum**	0.000	−62.630
IEU-MET-FAST-006	13027	0.000	163.602
$\Delta k_{70\text{x}} = -4.712$	92238	−0.004	−60.377
$\Delta k_{06\text{ex}} = 134.215$			
	sum	−0.004	103.225
IEU-MET-FAST-007	92238	−0.027	−60.699
$\Delta k_{70\text{x}} = -6.874$	92238	−0.027	−60.751
$\Delta k_{06\text{ex}} = -13.644$			
	sum	−0.054	−121.450
MIX-MET-FAST-001	92235	−0.844	58.318
$\Delta k_{70\text{x}} = -4.590$	94239	−4.541	−53.348
$\Delta k_{06\text{ex}} = 6.401$			
	sum	−5.385	4.970

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Table 2: Changes in k_{eff} due to a single evaluation... (continued from previous page)

ICSBEP	ZA	$k_{71x} - k_x$ (pcm) MENDF70x	LANL2006ex
MIX-MET-FAST-003	92235	−0.772	50.225
$\Delta k_{70x} = -7.983$	94239	−4.456	−53.723
$\Delta k_{06ex} = 4.000$			
	sum	−5.228	−3.498
MIX-MET-FAST-008 Case 1	24053	−53.049	−65.701
$\Delta k_{70x} = -28.726$			
$\Delta k_{06ex} = -2.110$	**sum**	−53.049	−65.701
PU-MET-FAST-002	94241	−66.164	−66.001
$\Delta k_{70x} = -53.351$			
$\Delta k_{06ex} = -66.201$	**sum**	−66.164	−66.001
PU-MET-FAST-005	74182	−73.345	−73.705
$\Delta k_{70x} = -883.685$	74183	−132.185	−130.895
$\Delta k_{06ex} = -938.105$	74184	−368.605	−371.035
	74186	−315.465	−318.305
	sum	−889.600	−893.940
PU-MET-FAST-006	94239	−6.146	−66.073
$\Delta k_{70x} = -10.228$			
$\Delta k_{06ex} = -75.608$	**sum**	−6.146	−66.073
PU-MET-FAST-008 Case 1	90232	−28.978	−986.600
$\Delta k_{70x} = -34.128$			
$\Delta k_{06ex} = -1032.320$	**sum**	−28.978	−986.600
PU-MET-FAST-008 Case 2	90232	−28.001	−985.109
$\Delta k_{70x} = -36.765$	94239	−7.370	−53.788
$\Delta k_{06ex} = -1035.333$			
	sum	−35.371	−1038.897
PU-MET-FAST-009	13027	0.000	150.620
$\Delta k_{70x} = -4.580$			
$\Delta k_{06ex} = 130.210$	**sum**	0.000	150.620
PU-MET-FAST-010	94239	−5.614	−60.315
$\Delta k_{70x} = -5.691$			
$\Delta k_{06ex} = -65.215$			

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Table 2: Changes in k_{eff} due to a single evaluation... (continued from previous page)

ICSBEP	ZA	$k_{71x} - k_x$ (pcm) MENDF70x	LANL2006ex
	sum	−5.614	−60.315
PU-MET-FAST-018	4009	307.457	−192.798
$\Delta k_{70x} = 307.008$			
$\Delta k_{06ex} = -233.740$	**sum**	307.457	−192.798
PU-MET-FAST-019	4009	295.054	−210.671
$\Delta k_{70x} = 295.520$			
$\Delta k_{06ex} = -266.482$	**sum**	295.054	−210.671
PU-MET-FAST-020	94239	−5.997	−69.298
$\Delta k_{70x} = -16.620$			
$\Delta k_{06ex} = -79.829$	**sum**	−5.997	−69.298
PU-MET-FAST-021 Case 1	4009	198.700	−143.620
$\Delta k_{70x} = 186.780$	94239	−5.050	−53.160
$\Delta k_{06ex} = -194.590$			
	sum	193.650	−196.780
PU-MET-FAST-021 Case 2	4009	84.610	−50.290
$\Delta k_{70x} = 72.510$			
$\Delta k_{06ex} = -70.820$	**sum**	84.610	−50.290
PU-MET-FAST-026	94239	−4.360	−67.540
$\Delta k_{70x} = -5.580$			
$\Delta k_{06ex} = -66.780$	**sum**	−4.360	−67.540
PU-SOL-THERM-011 Case 16-1	1001	−0.100	−110.390
$\Delta k_{70x} = 0.220$	8016	−3.850	59.500
$\Delta k_{06ex} = -51.610$			
	sum	−3.950	−50.890
PU-SOL-THERM-011 Case 16-5	1001	−0.070	−110.940
$\Delta k_{70x} = -1.440$	8016	−4.260	62.960
$\Delta k_{06ex} = -48.480$			
	sum	−4.330	−47.980
PU-SOL-THERM-011 Case 18-1	1001	−0.130	−95.950
$\Delta k_{70x} = 6.500$	8016	−3.870	64.190
$\Delta k_{06ex} = -34.400$			

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Table 2: Changes in k_{eff} due to a single evaluation... (continued from previous page)

ICSBEP	ZA	$k_{71x} - k_x$ (pcm) MENDF70x	LANL2006ex
	sum	−4.000	−31.760
PU-SOL-THERM-011 Case 18-6	1001	−0.100	−97.420
$\Delta k_{70x} = 4.790$	8016	−4.400	69.700
$\Delta k_{06ex} = -30.270$			
	sum	−4.500	−27.720
PU-SOL-THERM-021 Case 3	1001	−0.020	−115.500
$\Delta k_{70x} = 25.550$	8016	−4.690	66.010
$\Delta k_{06ex} = -17.500$			
	sum	−4.710	−49.490
PU-SOL-THERM-021 Case 7	1001	−0.090	−114.530
$\Delta k_{70x} = 5.090$	8016	−3.700	56.560
$\Delta k_{06ex} = -53.180$			
	sum	−3.790	−57.970
U233-MET-FAST-001	92233	26.939	105.577
$\Delta k_{70x} = 26.772$			
$\Delta k_{06ex} = 115.736$	**sum**	26.939	105.577
U233-MET-FAST-002 Case 1	92233	−9.758	70.000
$\Delta k_{70x} = -10.354$			
$\Delta k_{06ex} = 120.138$	**sum**	−9.758	70.000
U233-MET-FAST-002 Case 2	92233	−22.208	52.832
$\Delta k_{70x} = -23.213$	92235	−0.885	56.391
$\Delta k_{06ex} = 116.916$			
	sum	−23.093	109.223
U233-MET-FAST-003 Case 1	92233	−20.591	52.040
$\Delta k_{70x} = -20.733$			
$\Delta k_{06ex} = 58.660$	**sum**	−20.591	52.040
U233-MET-FAST-004 Case 1	74183	−90.129	−89.908
$\Delta k_{70x} = -631.153$	74184	−238.068	−239.923
$\Delta k_{06ex} = -558.753$	74186	−231.493	−233.344

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Table 2: Changes in k_{eff} due to a single evaluation... (continued from previous page)

ICSBEP	ZA	$k_{71\text{x}} - k_x$ (pcm) MENDF70x	LANL2006ex
	sum	−559.690	−563.175
U233-MET-FAST-004 Case 2	74182	−72.842	−72.288
$\Delta k_{70\text{x}} = -998.349$	74183	−142.938	−140.915
$\Delta k_{06\text{ex}} = -927.129$	74184	−399.656	−401.320
	74186	−339.350	−341.724
	92233	−56.145	2.209
	sum	−1010.931	−954.038
U233-MET-FAST-005 Case 1	4009	207.156	−121.189
$\Delta k_{70\text{x}} = 182.761$			
$\Delta k_{06\text{ex}} = -61.651$	**sum**	207.156	−121.189
U233-MET-FAST-005 Case 2	4009	337.288	−215.121
$\Delta k_{70\text{x}} = 289.040$			
$\Delta k_{06\text{ex}} = -150.355$	**sum**	337.288	−215.121
U233-MET-FAST-006	92233	−51.626	25.868
$\Delta k_{70\text{x}} = -51.811$			
$\Delta k_{06\text{ex}} = 23.352$	**sum**	−51.626	25.868
U233-SOL-THERM-001 Case 1	1001	−0.230	−57.980
$\Delta k_{70\text{x}} = 8.270$	8016	−4.120	80.490
$\Delta k_{06\text{ex}} = 125.930$	92233	12.660	97.220
	sum	8.310	119.730
U233-SOL-THERM-001 Case 2	1001	−0.220	−57.540
$\Delta k_{70\text{x}} = 8.150$	8016	−4.120	80.470
$\Delta k_{06\text{ex}} = 125.040$	92233	12.530	97.280
	sum	8.190	120.210
U233-SOL-THERM-001 Case 3	1001	−0.210	−57.110
$\Delta k_{70\text{x}} = 8.040$	8016	−4.120	80.450
$\Delta k_{06\text{ex}} = 124.240$	92233	12.400	97.310
	sum	8.070	120.650

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Table 2: Changes in k_{eff} due to a single evaluation... (continued from previous page)

ICSBEP	ZA	$k_{71\text{x}} - k_x$ (pcm) MENDF70x	LANL2006ex
U233-SOL-THERM-001 Case 4	1001	−0.200	−56.880
$\Delta k_{70\text{x}} = 7.920$	8016	−4.120	80.370
$\Delta k_{06\text{ex}} = 123.380$	92233	12.270	97.390
	sum	7.950	120.880
U233-SOL-THERM-001 Case 5	1001	−0.190	−56.560
$\Delta k_{70\text{x}} = 7.810$	8016	−4.110	80.280
$\Delta k_{06\text{ex}} = 122.620$	92233	12.150	97.410
	sum	7.850	121.130
U233-SOL-THERM-008	8016	−4.420	99.550
$\Delta k_{70\text{x}} = 9.960$	92233	14.670	96.230
$\Delta k_{06\text{ex}} = 173.320$			
	sum	10.250	195.780

4. Conclusion

We have performed a number of validation calculations using MENDF71x and Partisn. The calculations consist of 91 models of experimental benchmarks from the *International Handbook of Evaluated Criticality Safety Benchmark Experiments*. The models fall into eight classes or categories of critical benchmarks:

HEU-MET-FAST	highly enriched uranium metal with a fast spectrum;
HEU-SOL-THERM	highly enriched uranium in solution with a thermal spectrum;
IEU-MET-FAST	intermediate enriched uranium metal with a fast spectrum;
MIX-MET-FAST	mixed uranium and plutonium metal with a fast spectrum;
PU-MET-FAST	plutonium metal with fast spectrum;
PU-SOL-THERM	plutonium in solution with thermal spectrum;
U233-MET-FAST	^{233}U metal with fast spectrum; and
U233-SOL-THERM	^{233}U in solution with thermal spectrum.

We have run each of the 91 benchmark models with Partisn 7.14 using the ENDF/B-VII.1-based, multi-group, MENDF71x library and have calculated k_{eff}. We have also run the same models using older multi-group libraries: MENDF70x and LANL2006ex and have calculated k_{eff}. We have compared the k_{eff} values from the MENDF71x library to

the MENDF70x and LANL2006ex library.

The biggest differences in k_{eff} are between MENDF71x and LANL2006ex, which is expected as there have been more changes between those libraries than between the MENDF71x and MENDF70x libraries. For most of the benchmarks, the overall change in k_{eff} is a few hundred pcm with a dozen or so benchmarks with a greater change in k_{eff}. Overall, MENDF71x is a modest improvement over the MENDF70x and LANL2006ex libraries.

Most of the k_{eff} values calculated using Partisn and MENDF71x are within one or two sigmas of experimentally measured k_{eff} values and uncertainty. Those benchmarks that are far from the experimental values are generally expected to be that way because of the assumptions of the multi-group and deterministic neutron transport algorithm utilized in Partisn. We have compared our multi-group k_{eff} models to Monte Carlo/continuous-energy models of the same benchmarks. Most models have similar k_{eff} values as the Monte Carlo counterparts. Those that are not similar are due to the same multi-group limitations that make the multi-group k_{eff} calculations differ from the experimental values. In general, the Monte Carlo calculations more closely match the experimental values, but take a lot longer to calculate.

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A. All Isotope Reversion Results

Here I give all the results from reverting a single isotope to an older evaluation. Table 3 is the full version of Table 2.

Table 3: Changes in k_{eff} due to reverting a single isotope to an older evaluation. The ZA in the table indicates the single evaluation that was reverted to an older multi-group data library. The column header denotes the older library to which the single evaluation was reverted. The column values are the change in the k_{eff} value from the MENDF71x value.

		$k_{71\text{x}} - k_x$ (pcm)	
ICSBEP	ZA	MENDF70x	LANL2006ex
HEU-MET-FAST-001 Case a	92234	−0.106	16.042
$\Delta k_{70\text{x}} = -5.327$	92235	−5.221	42.035
$\Delta k_{06\text{ex}} = 54.436$	92238	0.000	−3.724
	sum	−5.327	54.353
HEU-MET-FAST-001 Case b	92234	−0.106	16.016
$\Delta k_{70\text{x}} = -5.325$	92235	−5.219	42.258
$\Delta k_{06\text{ex}} = 54.770$	92238	0.000	−3.587
	sum	−5.325	54.687
HEU-MET-FAST-003 Case 1	92234	−0.089	17.543
$\Delta k_{70\text{x}} = -5.267$	92235	−5.176	9.514
$\Delta k_{06\text{ex}} = 16.689$	92238	−0.001	−10.400
	sum	−5.266	16.657
HEU-MET-FAST-003 Case 10	6000	−0.442	−0.428
$\Delta k_{70\text{x}} = -771.224$	74182	−19.929	2.142
$\Delta k_{06\text{ex}} = -620.144$	74183	−106.468	−80.411
	74184	−419.984	−404.734
	74186	−231.991	−225.599
	92234	−0.103	25.558
	92235	−4.387	49.705
	92238	0.000	−3.532
	sum	−783.304	−637.299
HEU-MET-FAST-003 Case 11	6000	−0.487	−0.471
$\Delta k_{70\text{x}} = -743.990$	74182	−17.740	9.920
$\Delta k_{06\text{ex}} = -574.530$	74183	−94.451	−62.430
	74184	−418.100	−397.550
	74186	−219.330	−209.490

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Table 3: Changes in k_{eff} due to a single evaluation... (continued from previous page)

ICSBEP	ZA	$k_{71x} - k_x$ (pcm) MENDF70x	LANL2006ex
	92234	−0.101	25.832
	92235	−4.408	48.530
	92238	0.000	−3.531
	sum	−754.617	−589.190
HEU-MET-FAST-003 Case 12	28058	200.400	200.410
$\Delta k_{70x} = 211.690$	28060	−78.980	−78.950
$\Delta k_{06ex} = 286.730$	28061	−9.360	−9.360
	28062	135.160	135.150
	28064	−31.730	−31.740
	92234	−0.120	27.420
	92235	−3.740	48.600
	92238	0.000	−4.040
	sum	211.630	287.490
HEU-MET-FAST-003 Case 2	92234	−0.080	17.592
$\Delta k_{70x} = -5.318$	92235	−5.236	7.555
$\Delta k_{06ex} = 11.851$	92238	−0.003	−13.302
	sum	−5.319	11.845
HEU-MET-FAST-003 Case 3	92234	−0.072	17.801
$\Delta k_{70x} = -5.386$	92235	−5.310	7.436
$\Delta k_{06ex} = 10.891$	92238	−0.003	−14.325
	sum	−5.385	10.912
HEU-MET-FAST-003 Case 4	92234	−0.068	17.630
$\Delta k_{70x} = -5.422$	92235	−5.350	6.378
$\Delta k_{06ex} = 9.297$	92238	−0.005	−14.675
	sum	−5.423	9.333
HEU-MET-FAST-003 Case 5	92234	−0.061	17.704
$\Delta k_{70x} = -5.490$	92235	−5.423	5.619
$\Delta k_{06ex} = 9.660$	92238	−0.005	−13.605

Continued on next page

Table 3: Changes in k_{eff} due to a single evaluation... (continued from previous page)

ICSBEP	ZA	$k_{71x} - k_x$ (pcm) MENDF70x	LANL2006ex
	sum	−5.489	9.718
HEU-MET-FAST-003 Case 6	92234	−0.061	17.663
$\Delta k_{70x} = -5.506$	92235	−5.439	5.120
$\Delta k_{06ex} = 9.612$	92238	−0.005	−13.105
	sum	−5.505	9.678
HEU-MET-FAST-003 Case 7	92234	−0.059	17.608
$\Delta k_{70x} = -5.527$	92235	−5.461	4.391
$\Delta k_{06ex} = 9.743$	92238	−0.006	−12.186
	sum	−5.526	9.813
	6000	−0.193	−0.187
	74182	−37.806	−35.796
	74183	−108.549	−104.293
HEU-MET-FAST-003 Case 8	74184	−328.439	−329.937
$\Delta k_{70x} = -708.074$	74186	−236.607	−239.615
$\Delta k_{06ex} = -629.934$	92234	−0.115	23.293
	92235	−4.478	48.132
	92238	0.000	−3.647
	sum	−716.187	−642.050
	6000	−0.322	−0.312
	74182	−29.888	−19.903
	74183	−118.690	−105.712
HEU-MET-FAST-003 Case 9	74184	−394.354	−389.808
$\Delta k_{70x} = -782.929$	74186	−246.741	−246.780
$\Delta k_{06ex} = -673.699$	92234	−0.111	24.718
	92235	−4.399	50.817
	92238	0.000	−3.573
	sum	−794.505	−690.553
	1001	0.014	0.822
	6000	−0.065	−0.065
HEU-MET-FAST-004 Case 1	8016	−0.536	8.099
$\Delta k_{70x} = -2.774$			
$\Delta k_{06ex} = 84.512$			

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Table 3: Changes in k_{eff} due to a single evaluation... (continued from previous page)

ICSBEP	ZA	$k_{71x} - k_x$ (pcm) MENDF70x	LANL2006ex
	92234	−0.175	24.193
	92235	−3.377	49.981
	92236	2.519	2.442
	92238	0.000	−0.274
	sum	−1.620	85.198
HEU-MET-FAST-004 Case 2 $\Delta k_{70x} = -3.019$ $\Delta k_{06ex} = 85.974$	1001	0.014	0.394
	8016	−0.368	7.326
	92234	−0.164	23.108
	92235	−3.554	54.636
	92236	1.052	1.026
	92238	0.000	−0.389
	sum	−3.020	86.101
HEU-MET-FAST-008 $\Delta k_{70x} = -5.553$ $\Delta k_{06ex} = 41.545$	6000	−0.004	−0.003
	13027	0.000	1.330
	26054	0.000	0.047
	26056	0.000	−0.605
	28058	0.377	0.376
	28060	−0.143	−0.143
	28061	−0.001	−0.001
	28062	0.138	0.138
	28064	−0.056	−0.056
	29063	0.048	0.728
	29065	0.000	−0.001
	74182	−0.296	−0.295
	74183	−0.049	−0.048
	74184	−0.742	−0.742
	74186	−0.118	−0.118
	92234	−0.244	17.828
	92235	−4.913	28.931
	92236	−0.087	0.130
	92238	0.000	−6.138
	sum	−6.090	41.358

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Table 3: Changes in k_{eff} due to a single evaluation... (continued from previous page)

ICSBEP	ZA	$k_{71\text{x}} - k_x$ (pcm) MENDF70x	LANL2006ex
HEU-MET-FAST-009 Case 1 $\Delta k_{70\text{x}} = 238.236$ $\Delta k_{06\text{ex}} = -74.899$	4009	241.940	−133.368
	6000	−0.004	−0.004
	8016	0.000	0.008
	26054	0.000	−0.003
	26056	−1.134	−0.027
	28058	0.594	0.593
	28060	−0.193	−0.193
	28061	−0.003	−0.003
	28062	−0.070	0.215
	28064	−0.054	−0.054
	29063	0.000	−0.004
	29065	0.000	−0.003
	74182	−0.458	−0.457
	74183	−0.053	−0.052
	74184	−0.152	−0.151
	74186	−0.147	−0.096
	92234	−0.133	23.383
	92235	−4.672	39.313
	92236	0.597	0.562
	92238	0.000	−6.734
	sum	236.058	−77.075
HEU-MET-FAST-009 Case 2 $\Delta k_{70\text{x}} = 110.456$ $\Delta k_{06\text{ex}} = 16.267$	4009	114.802	−68.429
	6000	−0.458	−0.458
	8016	−0.812	6.347
	26054	0.000	−0.059
	26056	0.000	−0.023
	28058	0.436	0.435
	28060	−0.112	−0.112
	28061	−0.002	−0.002
	28062	−0.154	−0.154
	28064	−0.199	−0.199
	29063	0.000	−0.457
	29065	0.000	−0.002
	74182	−0.617	−0.616
	74183	−0.030	−0.029
	74184	−0.125	−0.124

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Table 3: Changes in k_{eff} due to a single evaluation... (continued from previous page)

ICSBEP	ZA	$k_{71\text{x}} - k_x$ (pcm) MENDF70x	LANL2006ex
	74186	−0.071	−0.543
	92234	−0.140	23.872
	92235	−4.682	58.654
	92236	0.258	0.236
	92238	−0.001	−5.961
	sum	108.093	12.376
HEU-MET-FAST-011 $\Delta k_{70\text{x}} = -2.953$ $\Delta k_{06\text{ex}} = 52.346$	1001	−0.001	4.034
	6000	−0.470	−0.438
	26054	0.000	−0.222
	26056	−0.004	0.003
	26057	0.000	−0.004
	26058	0.000	−0.004
	28058	0.842	0.881
	28060	−0.284	−0.186
	28061	0.091	0.091
	28062	0.258	0.258
	28064	−0.072	−0.072
	29063	0.000	−0.001
	74182	−0.056	−0.013
	74183	−0.119	−0.098
	74184	−0.210	−0.257
	74186	−0.303	−0.141
	92234	−0.102	23.487
	92235	−3.793	30.779
	92236	0.336	0.476
	92238	−0.001	−5.611
	sum	−3.888	52.962
HEU-MET-FAST-012 $\Delta k_{70\text{x}} = -5.159$ $\Delta k_{06\text{ex}} = 131.727$	6000	−0.004	−0.004
	13027	0.000	84.251
	26054	0.000	−0.002
	26056	0.000	−0.045
	28058	0.057	0.285
	28060	−0.310	−0.310
	28061	−0.001	−0.001

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Table 3: Changes in k_{eff} due to a single evaluation... (continued from previous page)

ICSBEP	ZA	$k_{71\text{x}} - k_x$ (pcm) MENDF70x	LANL2006ex
	28062	0.738	0.738
	28064	−0.085	−0.085
	29063	0.000	−0.003
	29065	0.000	−0.001
	74182	−0.190	−0.190
	74183	−0.192	−0.192
	74184	−0.182	−0.182
	74186	−0.800	−0.800
	92234	0.033	19.346
	92235	−4.802	36.068
	92236	0.628	0.808
	92238	0.000	−6.713
	sum	−5.110	132.968
HEU-MET-FAST-013 $\Delta k_{70\text{x}} = -4.058$ $\Delta k_{06\text{ex}} = 28.386$	6000	−0.006	−0.001
	14028	0.000	−0.003
	24050	−0.017	−0.017
	24052	−1.000	−1.001
	24053	−0.113	−0.113
	24054	−0.086	−0.086
	25055	0.981	0.980
	26054	0.000	−1.597
	26056	0.004	−2.402
	26058	0.000	−0.209
	28058	−0.087	−0.089
	28060	−0.287	−0.287
	28061	−0.001	−0.001
	28062	0.048	0.048
	28064	−0.221	−0.221
	29063	0.000	−0.211
	29065	0.000	−0.209
	74182	−0.210	−0.209
	74183	−0.211	−0.210
	74184	−0.314	−0.314
	74186	−0.060	−0.060
	92234	−0.112	21.495
	92235	−4.478	14.468

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Table 3: Changes in k_{eff} due to a single evaluation... (continued from previous page)

ICSBEP	ZA	$k_{71x} - k_x$ (pcm) MENDF70x	LANL2006ex
	92236	−0.073	0.213
	92238	0.000	−7.797
	sum	−6.243	22.167
HEU-MET-FAST-014 $\Delta k_{70x} = -4.347$ $\Delta k_{06ex} = 12.865$	6000	0.029	−0.004
	13027	0.000	2.697
	25055	−0.119	−0.119
	26054	0.000	0.715
	26056	0.000	0.260
	26057	0.000	0.819
	28058	1.430	1.242
	28060	1.149	0.073
	28061	0.738	0.738
	28062	0.688	0.688
	28064	−0.300	−0.300
	29063	0.000	−0.001
	29065	0.000	0.253
	74182	0.788	0.790
	74183	1.179	1.180
	74184	0.121	0.122
	74186	1.140	1.170
	92234	−0.768	20.556
	92235	−5.259	1.980
	92236	0.338	0.317
	92238	−0.005	−13.850
	sum	1.149	19.326
HEU-MET-FAST-015 $\Delta k_{70x} = -5.361$ $\Delta k_{06ex} = 45.692$	6000	−0.001	−0.001
	26054	0.000	−0.002
	26056	0.000	−0.047
	74182	−0.005	−0.005
	74183	−0.005	−0.005
	74184	−0.016	−0.016
	74186	−0.011	−0.011
	92234	−0.118	17.190
	92235	−5.204	30.561

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Table 3: Changes in k_{eff} due to a single evaluation... (continued from previous page)

ICSBEP	ZA	$k_{71\text{x}} - k_x$ (pcm) MENDF70x	LANL2006ex
	92238	0.000	−2.183
	sum	−5.360	45.481
HEU-MET-FAST-018 $\Delta k_{70\text{x}} = -7.164$ $\Delta k_{06\text{ex}} = 47.032$	6000	−0.010	−0.010
	26056	0.000	−0.003
	74182	−0.248	−0.248
	74183	−0.259	−0.257
	74184	−0.780	−0.782
	74186	−0.536	−0.539
	92234	−0.111	18.231
	92235	−5.217	37.335
	92238	0.000	−6.809
	sum	−7.161	46.918
HEU-MET-FAST-019 $\Delta k_{70\text{x}} = -6.190$ $\Delta k_{06\text{ex}} = 51.990$	6000	−0.110	−0.110
	74182	−0.180	−0.180
	74183	−0.200	−0.200
	74184	−0.630	−0.620
	74186	−0.380	−0.380
	92234	−0.120	22.650
	92235	−4.540	38.080
	92238	0.000	−7.270
	sum	−6.160	51.970
HEU-MET-FAST-020 $\Delta k_{70\text{x}} = -6.453$ $\Delta k_{06\text{ex}} = 53.499$	1001	0.006	−1.075
	6000	−0.037	−0.038
	26054	0.000	−0.001
	26056	0.000	−0.003
	74182	−0.267	−0.260
	74183	−0.194	−0.183
	74184	−0.656	−0.651
	74186	−0.416	−0.413
	92234	−0.136	23.571
	92235	−4.756	39.489
	92238	−0.001	−6.945

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Table 3: Changes in k_{eff} due to a single evaluation... (continued from previous page)

ICSBEP	ZA	$k_{71x} - k_x$ (pcm) MENDF70x	LANL2006ex
	sum	−6.457	53.491
HEU-MET-FAST-021 $\Delta k_{70x} = -10.200$ $\Delta k_{06ex} = 24.840$	6000	−0.010	−0.010
	24050	−0.160	−0.160
	24052	−5.740	−5.750
	24053	0.390	0.390
	24054	−0.260	−0.260
	25055	1.470	1.470
	26054	0.000	−0.100
	26056	0.010	−1.570
	28058	0.210	0.210
	28060	−0.170	−0.170
	28062	0.260	0.260
	28064	−0.080	−0.080
	74182	−0.210	−0.210
	74183	−0.220	−0.210
	74184	−0.630	−0.630
	74186	−0.360	−0.360
	92234	−0.100	23.030
	92235	−4.520	16.520
	92238	0.000	−7.440
	sum	−10.120	24.930
HEU-MET-FAST-022 $\Delta k_{70x} = -6.457$ $\Delta k_{06ex} = 197.287$	6000	−0.011	−0.011
	13027	0.000	144.305
	26054	0.000	−0.001
	26056	0.000	−0.017
	29063	0.000	−0.001
	74182	−0.189	−0.188
	74183	−0.214	−0.212
	74184	−0.660	−0.661
	74186	−0.426	−0.428
	92234	−0.129	20.830
	92235	−4.827	42.791
	92238	0.000	−6.902

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Table 3: Changes in k_{eff} due to a single evaluation... (continued from previous page)

ICSBEP	ZA	$k_{71x} - k_x$ (pcm) MENDF70x	LANL2006ex
	sum	−6.456	199.505
HEU-MET-FAST-028	92234	−0.062	17.821
$\Delta k_{70x} = -5.501$	92235	−5.434	5.614
$\Delta k_{06ex} = 9.729$	92238	−0.006	−13.645
	sum	−5.502	9.790
	1001	−0.190	−59.990
	8016	−4.150	75.440
HEU-SOL-THERM-013 Case 1	13027	0.000	1.900
$\Delta k_{70x} = 8.780$	92234	−0.020	2.960
$\Delta k_{06ex} = 160.700$	92235	13.150	139.690
	92236	0.000	0.010
	92238	0.000	0.670
	sum	8.790	160.680
	1001	−0.160	−59.430
	5010	0.000	−4.310
HEU-SOL-THERM-013 Case 2	8016	−4.150	75.220
$\Delta k_{70x} = 8.310$	13027	0.000	1.890
$\Delta k_{06ex} = 156.710$	92234	−0.030	3.150
	92235	12.640	139.400
	92238	0.000	0.750
	sum	8.300	156.670
	1001	−0.130	−58.820
	5010	0.000	−7.480
	8016	−4.130	74.940
HEU-SOL-THERM-013 Case 3	13027	0.000	1.890
$\Delta k_{70x} = 7.900$	92234	−0.020	3.310
$\Delta k_{06ex} = 153.380$	92235	12.190	138.690
	92236	0.010	0.010
	92238	0.000	0.830
	sum	7.920	153.370

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Table 3: Changes in k_{eff} due to a single evaluation... (continued from previous page)

ICSBEP	ZA	$k_{71\text{x}} - k_x$ (pcm) MENDF70x	LANL2006ex
HEU-SOL-THERM-013 Case 4	1001	−0.130	−58.550
	5010	0.000	−8.660
$\Delta k_{70\text{x}} = 7.680$	8016	−4.140	75.180
$\Delta k_{06\text{ex}} = 152.570$	13027	0.000	1.870
	92234	−0.020	3.410
	92235	11.970	138.410
	92238	0.000	0.860
	sum	7.680	152.520
HEU-SOL-THERM-032	1001	−0.230	−28.920
	8016	−4.480	94.310
$\Delta k_{70\text{x}} = 9.750$	13027	0.000	0.860
$\Delta k_{06\text{ex}} = 141.640$	92233	0.000	0.010
	92234	−0.030	2.390
	92235	14.470	72.180
	92238	−0.010	0.490
	sum	9.720	141.320
IEU-MET-FAST-001 Case 1	13027	0.125	9.029
	24050	−2.474	−2.474
$\Delta k_{70\text{x}} = -21.558$	24052	−15.038	−13.295
$\Delta k_{06\text{ex}} = -25.052$	24053	0.858	2.101
	24054	−1.266	−1.267
	25055	−0.641	−0.641
	26054	0.000	−1.092
	26056	0.000	−2.003
	26057	0.000	0.205
	26058	0.000	0.205
	28058	−1.456	−0.753
	28060	−2.483	−0.646
	28061	−1.047	−1.047
	28062	−1.293	−0.203
	28064	−1.080	−1.080
	29063	0.000	−0.784
	92234	−0.188	14.807
	92235	−5.724	−0.446

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Table 3: Changes in k_{eff} due to a single evaluation... (continued from previous page)

ICSBEP	ZA	$k_{71\text{x}} - k_x$ (pcm) MENDF70x	LANL2006ex
	92238	−0.002	−39.313
	sum	−31.709	−38.697
IEU-MET-FAST-001 Case 2 $\Delta k_{70\text{x}} = -17.328$ $\Delta k_{06\text{ex}} = -25.405$	13027	0.000	15.899
	24050	1.554	3.765
	24052	−12.683	−12.633
	24053	2.766	3.815
	24054	4.344	4.344
	25055	2.981	2.981
	26054	0.000	3.318
	26056	0.000	3.187
	28058	3.803	2.550
	28060	1.592	1.591
	28061	2.419	2.419
	28062	4.716	4.716
	28064	1.689	1.689
	29063	0.000	0.001
	92234	1.024	19.383
	92235	−3.174	3.390
	92238	−0.001	−35.057
	sum	11.030	25.358
IEU-MET-FAST-002 $\Delta k_{70\text{x}} = -6.511$ $\Delta k_{06\text{ex}} = -25.767$	92234	0.021	14.814
	92235	−6.514	33.137
	92238	−0.018	−73.190
	sum	−6.511	−25.239
IEU-MET-FAST-003 $\Delta k_{70\text{x}} = -4.618$ $\Delta k_{06\text{ex}} = -37.090$	6000	−0.018	−0.017
	26056	0.000	−0.003
	28058	1.693	1.692
	28060	−0.345	−0.345
	28061	−0.004	−0.004
	28062	0.632	0.632
	28064	−0.167	−0.167
	74182	−0.081	−0.079

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Table 3: Changes in k_{eff} due to a single evaluation... (continued from previous page)

ICSBEP	ZA	$k_{71\text{x}} - k_x$ (pcm) MENDF70x	LANL2006ex
	74183	−0.073	−0.071
	74184	−0.219	−0.219
	74186	−0.103	−0.103
	92234	−0.005	12.840
	92235	−5.923	10.358
	92238	−0.005	−61.673
	sum	−4.618	−37.159
IEU-MET-FAST-004 $\Delta k_{70\text{x}} = -6.170$ $\Delta k_{06\text{ex}} = -34.330$	6000	−0.090	−0.090
	74182	−0.070	−0.070
	74183	−0.060	−0.060
	74184	−0.190	−0.190
	74186	−0.080	−0.080
	92234	−0.010	14.240
	92235	−5.660	15.200
	92238	0.000	−63.220
	sum	−6.160	−34.270
IEU-MET-FAST-005 $\Delta k_{70\text{x}} = -10.390$ $\Delta k_{06\text{ex}} = -42.670$	6000	−0.020	−0.020
	24050	−0.190	−0.190
	24052	−5.730	−5.730
	24053	0.440	0.440
	24054	−0.270	−0.270
	25055	−0.170	−0.170
	26054	0.000	−0.100
	26056	0.000	−1.440
	28058	1.400	1.400
	28060	−0.290	−0.300
	28062	0.600	0.600
	28064	−0.150	−0.150
	74182	−0.070	−0.070
	74183	−0.060	−0.060
	74184	−0.190	−0.190
	74186	−0.060	−0.060
	92234	0.000	15.190
	92235	−5.570	11.240

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Table 3: Changes in k_{eff} due to a single evaluation... (continued from previous page)

ICSBEP	ZA	$k_{71\text{x}} - k_x$ (pcm) MENDF70x	LANL2006ex
	92238	0.000	−62.630
	sum	−10.330	−42.510
IEU-MET-FAST-006 $\Delta k_{70\text{x}} = -4.712$ $\Delta k_{06\text{ex}} = 134.215$	6000	−0.014	−0.014
	13027	0.000	163.602
	26054	0.000	−0.001
	26056	0.000	−0.023
	28058	1.115	1.116
	28060	−0.160	−0.160
	28061	−0.003	−0.003
	28062	0.338	0.338
	28064	−0.077	−0.077
	29063	0.000	−0.002
	29065	0.000	−0.001
	74182	−0.069	−0.066
	74183	−0.064	−0.062
	74184	−0.193	−0.193
	74186	−0.077	−0.077
	92234	−0.011	13.324
	92235	−5.489	19.426
	92238	−0.004	−60.377
	sum	−4.708	136.750
IEU-MET-FAST-007 $\Delta k_{70\text{x}} = -6.874$ $\Delta k_{06\text{ex}} = -13.644$	92234	0.024	13.212
	92234	0.023	13.069
	92235	−6.871	34.747
	92235	−6.866	33.312
	92238	−0.027	−60.699
	92238	−0.027	−60.751
	sum	−13.744	−27.110
MIX-MET-FAST-001 $\Delta k_{70\text{x}} = -4.590$ $\Delta k_{06\text{ex}} = 6.401$	31069	−0.040	0.000
	31071	−0.059	0.000
	92235	−0.844	58.318
	92238	0.000	−0.334

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Table 3: Changes in k_{eff} due to a single evaluation... (continued from previous page)

ICSBEP	ZA	$k_{71\text{x}} - k_x$ (pcm) MENDF70x	LANL2006ex
	94239	−4.541	−53.348
	94240	1.812	2.377
	94241	−0.943	−0.935
	sum	−4.615	6.078
MIX-MET-FAST-003 $\Delta k_{70\text{x}} = -7.983$ $\Delta k_{06\text{ex}} = 4.000$	6000	−0.002	−0.002
	13027	0.000	4.435
	25055	−0.277	−0.277
	26056	0.000	−0.013
	28058	1.836	1.826
	28060	−0.417	−0.419
	28061	−0.002	−0.002
	28062	0.535	0.535
	28064	−0.141	−0.141
	29063	0.000	−0.001
	31069	−0.480	0.000
	31071	−0.081	0.000
	74182	−0.420	−0.419
	74183	−0.179	−0.178
	74184	−0.575	−0.576
	74186	−0.284	−0.285
	92234	−0.196	1.739
	92235	−0.772	50.225
	92236	−0.436	−0.473
	92238	0.000	−0.571
	94239	−4.456	−53.723
	94240	1.454	2.548
	94241	−4.591	−4.476
	sum	−9.484	−0.248
MIX-MET-FAST-008 Case 1 $\Delta k_{70\text{x}} = -28.726$ $\Delta k_{06\text{ex}} = -2.110$	24053	−53.049	−65.701
	24054	13.815	4.077
	sum	−39.234	−61.624
PU-MET-FAST-001 $\Delta k_{70\text{x}} = -4.041$ $\Delta k_{06\text{ex}} = -23.349$	31069	−0.008	0.000

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Table 3: Changes in k_{eff} due to a single evaluation... (continued from previous page)

ICSBEP	ZA	$k_{71\text{x}} - k_x$ (pcm) MENDF70x	LANL2006ex
	31071	−0.089	0.000
	94239	−5.456	−23.740
	94240	5.069	5.787
	94241	−3.593	−3.581
	sum	−4.077	−21.534
PU-MET-FAST-002 $\Delta k_{70\text{x}} = -53.351$ $\Delta k_{06\text{ex}} = -66.201$	31069	0.048	0.000
	31071	0.107	0.000
	94239	−5.008	−30.960
	94240	6.786	10.570
	94241	−66.164	−66.001
	94242	10.205	10.244
	sum	−54.026	−76.147
PU-MET-FAST-005 $\Delta k_{70\text{x}} = -883.685$ $\Delta k_{06\text{ex}} = -938.105$	28058	5.681	5.605
	28060	−4.906	−4.924
	28061	−0.029	−0.029
	28062	6.365	6.364
	28064	−2.008	−2.008
	29063	0.000	−0.004
	29065	0.000	−0.002
	31069	−0.029	0.000
	31071	−0.044	0.000
	40090	−6.324	−6.716
	40091	0.257	−2.403
	40092	−1.676	−5.292
	40094	2.549	−1.426
	40096	−0.188	−0.494
	74182	−73.345	−73.705
	74183	−132.185	−130.895
	74184	−368.605	−371.035
	74186	−315.465	−318.305
	94239	−5.022	−41.176
	94240	1.727	2.276
	94241	−0.526	−0.527

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Table 3: Changes in k_{eff} due to a single evaluation... (continued from previous page)

ICSBEP	ZA	$k_{71x} - k_x$ (pcm) MENDF70x	LANL2006ex
	sum	−893.773	−944.696
PU-MET-FAST-006 $\Delta k_{70x} = -10.228$ $\Delta k_{06ex} = -75.608$	31069	−0.055	0.000
	31071	−0.080	0.000
	92234	0.000	0.119
	92235	−0.086	1.209
	92238	−0.005	−12.201
	94239	−6.146	−66.073
	94240	−0.782	−0.164
	94241	−3.101	−3.102
	sum	−10.255	−80.212
PU-MET-FAST-008 Case 1 $\Delta k_{70x} = -34.128$ $\Delta k_{06ex} = -1032.320$	31069	−0.045	0.000
	31071	−0.070	0.000
	90232	−28.978	−986.600
	94239	−5.626	−47.191
	94240	2.563	3.217
	94241	−1.805	−1.801
	sum	−33.961	−1032.375
PU-MET-FAST-008 Case 2 $\Delta k_{70x} = -36.765$ $\Delta k_{06ex} = -1035.333$	31069	0.488	0.000
	31071	−0.436	0.000
	90232	−28.001	−985.109
	94239	−7.370	−53.788
	94240	0.117	0.572
	94241	−1.058	−1.173
	sum	−36.260	−1039.498
PU-MET-FAST-009 $\Delta k_{70x} = -4.580$ $\Delta k_{06ex} = 130.210$	13027	0.000	150.620
	25055	−0.720	−0.720
	31069	−0.010	0.000
	31071	−0.090	0.000
	94239	−4.710	−33.310
	94240	3.220	3.810
	94241	−2.300	−2.290

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Table 3: Changes in k_{eff} due to a single evaluation... (continued from previous page)

ICSBEP	ZA	$k_{71\text{x}} - k_x$ (pcm) MENDF70x	LANL2006ex
	sum	−4.610	118.110
PU-MET-FAST-010 $\Delta k_{70\text{x}} = -5.691$ $\Delta k_{06\text{ex}} = -65.215$	31069	−0.052	0.000
	31071	−0.070	0.000
	92235	−0.016	0.601
	92238	−0.001	−7.129
	94239	−5.614	−60.315
	94240	2.236	2.888
	94241	−2.204	−2.197
	sum	−5.721	−66.152
PU-MET-FAST-011 $\Delta k_{70\text{x}} = 1.269$ $\Delta k_{06\text{ex}} = 1.169$	1001	0.013	−0.532
	8016	−0.190	6.150
	94239	−4.382	−10.673
	94240	5.708	6.260
	94241	−1.213	−1.289
	94242	1.302	1.303
	sum	1.238	1.219
PU-MET-FAST-018 $\Delta k_{70\text{x}} = 307.008$ $\Delta k_{06\text{ex}} = -233.740$	4009	307.457	−192.798
	8016	−0.020	0.289
	31069	−0.031	0.000
	31071	−0.034	0.000
	94239	−4.430	−28.510
	94240	3.974	4.466
	94241	0.469	0.433
	sum	307.385	−216.120
PU-MET-FAST-019 $\Delta k_{70\text{x}} = 295.520$ $\Delta k_{06\text{ex}} = -266.482$	4009	295.054	−210.671
	6000	−0.003	−0.003
	8016	−0.021	5.015
	26054	0.000	1.212
	26056	0.000	0.707
	26057	0.000	−4.214
	26058	0.000	2.042

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Table 3: Changes in k_{eff} due to a single evaluation... (continued from previous page)

ICSBEP	ZA	$k_{71\text{x}} - k_x$ (pcm) MENDF70x	LANL2006ex
	28058	5.950	0.145
	28060	−1.262	−20.771
	28061	−0.076	−0.076
	28062	0.995	−7.524
	28064	1.756	1.756
	29063	0.000	−7.402
	29065	0.000	4.846
	31069	7.494	0.000
	31071	4.217	0.000
	74182	5.316	−3.481
	74183	−7.116	−8.677
	74184	−8.147	−4.012
	74186	−0.020	−0.020
	94239	−6.660	−38.019
	94240	11.304	7.233
	94241	−18.758	−6.672
	sum	290.023	−288.586
PU-MET-FAST-020 $\Delta k_{70\text{x}} = -16.620$ $\Delta k_{06\text{ex}} = -79.829$	6000	−0.001	−0.001
	13027	0.000	1.391
	25055	0.178	0.484
	26054	0.000	0.257
	26056	0.000	−0.030
	26057	0.000	−0.209
	28058	1.890	1.642
	28060	−0.006	−0.005
	28061	−0.002	−0.002
	28062	0.878	0.863
	28064	0.003	0.033
	31069	0.723	0.000
	31071	−1.652	0.000
	74182	−1.757	−1.753
	74183	−0.416	−0.413
	74184	−0.415	−0.413
	74186	−0.063	−0.062
	92235	−0.680	0.455
	92238	−0.001	−11.957

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Table 3: Changes in k_{eff} due to a single evaluation... (continued from previous page)

ICSBEP	ZA	$k_{71\text{x}} - k_x$ (pcm) MENDF70x	LANL2006ex
	94239	−5.997	−69.298
	94240	−0.448	0.607
	94241	−10.590	−11.077
	sum	−18.356	−89.488
PU-MET-FAST-021 Case 1 $\Delta k_{70\text{x}} = 186.780$ $\Delta k_{06\text{ex}} = -194.590$	4009	198.700	−143.620
	8016	−0.200	0.340
	13027	0.000	3.750
	22046	−0.660	0.000
	22047	−0.280	0.000
	22048	−0.620	0.000
	22049	−0.500	0.000
	22050	−0.390	0.000
	24050	−0.260	−0.260
	24052	−7.800	−7.800
	24053	0.700	0.550
	24054	−0.200	−0.200
	25055	−0.430	−0.430
	26054	0.000	0.170
	26056	0.000	−0.020
	28058	0.540	0.860
	28061	0.160	0.160
	28062	0.230	0.150
	28064	−0.330	0.010
	94239	−5.050	−53.160
	94240	1.390	1.980
	94241	−0.970	−0.980
	sum	184.030	−198.500
PU-MET-FAST-021 Case 2 $\Delta k_{70\text{x}} = 72.510$ $\Delta k_{06\text{ex}} = -70.820$	4009	84.610	−50.290
	8016	−1.290	21.790
	13027	0.000	4.490
	22046	−0.620	0.000
	22048	−0.310	0.000
	22049	−0.210	0.000
	22050	0.180	0.000

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Table 3: Changes in k_{eff} due to a single evaluation... (continued from previous page)

ICSBEP	ZA	$k_{71\text{x}} - k_x$ (pcm) MENDF70x	LANL2006ex
	24050	−0.150	−0.150
	24052	−7.470	−7.470
	24053	0.520	0.520
	24054	−0.360	−0.360
	25055	−0.420	−0.420
	26056	0.000	−0.100
	28058	0.610	0.630
	28060	0.110	0.110
	28062	0.410	0.410
	28064	0.020	0.020
	94239	−4.370	−35.750
	94240	−1.100	−0.620
	94241	−0.650	−1.080
	sum	69.510	−68.270
PU-MET-FAST-022 $\Delta k_{70\text{x}} = -1.057$ $\Delta k_{06\text{ex}} = -26.986$	6000	−0.002	−0.002
	26056	0.000	−0.002
	28058	2.577	2.565
	28060	−0.812	−0.814
	28061	−0.003	−0.003
	28062	1.099	1.099
	28064	−0.298	−0.298
	31069	−0.030	0.000
	31071	−0.308	0.000
	94239	−5.374	−25.257
	94240	2.084	2.353
	sum	−1.067	−20.359
PU-MET-FAST-023 $\Delta k_{70\text{x}} = -0.700$ $\Delta k_{06\text{ex}} = -44.467$	6000	−0.070	−0.075
	26056	0.000	−0.001
	28058	2.540	2.533
	28060	−0.586	−0.588
	28061	−0.003	−0.003
	28062	0.859	0.859
	28064	−0.209	−0.209
	31069	−0.055	0.000

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Table 3: Changes in k_{eff} due to a single evaluation... (continued from previous page)

ICSBEP	ZA	$k_{71\text{x}} - k_x$ (pcm) MENDF70x	LANL2006ex
	31071	−0.297	0.000
	94239	−4.422	−38.833
	94240	1.535	1.743
	sum	−0.708	−34.574
PU-MET-FAST-024 $\Delta k_{70\text{x}} = 0.536$ $\Delta k_{06\text{ex}} = -62.584$	1001	0.008	−2.750
	6000	−0.033	−0.035
	26056	0.000	−0.002
	28058	2.599	2.591
	28060	−0.693	−0.694
	28061	−0.037	−0.037
	28062	0.944	0.945
	28064	−0.265	−0.265
	31069	−0.082	0.000
	31071	−0.273	0.000
	94239	−4.767	−19.347
	94240	3.122	3.330
	sum	0.523	−16.264
PU-MET-FAST-025 $\Delta k_{70\text{x}} = -2.350$ $\Delta k_{06\text{ex}} = -44.710$	6000	−0.010	−0.010
	14028	0.000	−0.010
	24050	−0.040	−0.040
	24052	−1.500	−1.500
	24053	0.070	0.070
	24054	−0.070	−0.070
	25055	0.060	0.060
	26054	0.000	−0.030
	26056	0.000	−0.570
	28058	2.680	2.670
	28060	−0.740	−0.740
	28061	−0.010	−0.010
	28062	1.050	1.050
	28064	−0.270	−0.270
	31069	−0.040	0.000
	31071	−0.340	0.000
	94239	−4.940	−43.230

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Table 3: Changes in k_{eff} due to a single evaluation... (continued from previous page)

ICSBEP	ZA	$k_{71\text{x}} - k_x$ (pcm) MENDF70x	LANL2006ex
	94240	1.680	1.920
	sum	−2.420	−40.710
PU-MET-FAST-026 $\Delta k_{70\text{x}} = -5.580$ $\Delta k_{06\text{ex}} = -66.780$	24050	−0.140	−0.140
	24052	−5.480	−5.490
	24053	0.320	0.320
	24054	−0.240	−0.240
	25055	1.040	1.040
	26054	0.000	−0.100
	26056	0.010	−1.540
	28058	2.800	2.800
	28060	−0.600	−0.600
	28062	1.010	1.010
	28064	−0.230	−0.230
	31071	−0.350	0.000
	94239	−4.360	−67.540
	94240	0.710	0.920
	sum	−5.510	−69.790
PU-SOL-THERM-011 Case 16-1 $\Delta k_{70\text{x}} = 0.220$ $\Delta k_{06\text{ex}} = -51.610$	1001	−0.100	−110.390
	7014	−0.010	0.000
	8016	−3.850	59.500
	24050	−0.450	−0.450
	24052	−2.720	−2.720
	24053	−1.970	−1.970
	24054	−0.240	−0.240
	26054	0.000	−0.010
	26056	0.000	−0.020
	28058	0.180	0.180
	28060	0.040	0.040
	28061	0.020	0.020
	28062	−0.020	−0.020
	28064	−0.010	−0.010
	94239	9.250	4.130
	94240	0.020	0.200

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Table 3: Changes in k_{eff} due to a single evaluation... (continued from previous page)

ICSBEP	ZA	$k_{71x} - k_x$ (pcm) MENDF70x	LANL2006ex
	sum	0.140	−51.760
PU-SOL-THERM-011 Case 16-5 $\Delta k_{70x} = -1.440$ $\Delta k_{06ex} = -48.480$	1001	−0.070	−110.940
	8016	−4.260	62.960
	24050	−0.470	−0.470
	24052	−2.860	−2.870
	24053	−2.080	−2.080
	24054	−0.260	−0.260
	26056	0.000	−0.020
	28058	0.190	0.190
	28060	0.040	0.040
	28061	0.020	0.020
	28062	−0.010	−0.020
	28064	−0.010	−0.010
	94239	8.190	4.590
	94240	0.110	0.260
	sum	−1.470	−48.610
PU-SOL-THERM-011 Case 18-1 $\Delta k_{70x} = 6.500$ $\Delta k_{06ex} = -34.400$	1001	−0.130	−95.950
	8016	−3.870	64.190
	24050	−0.320	−0.320
	24052	−2.000	−2.000
	24053	−1.410	−1.410
	24054	−0.170	−0.170
	26056	0.000	−0.010
	28058	0.150	0.140
	28060	0.040	0.040
	28061	0.020	0.020
	28062	−0.010	−0.010
	48106	0.000	−0.070
	48108	0.030	−0.040
	48110	0.600	−2.470
	48111	−0.020	−0.430
	48112	0.540	−0.040
	48113	0.270	−0.280
	48114	1.600	1.600
	48116	−0.160	−0.180

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Table 3: Changes in k_{eff} due to a single evaluation... (continued from previous page)

ICSBEP	ZA	$k_{71\text{x}} - k_x$ (pcm) MENDF70x	LANL2006ex
	94239	11.410	2.800
	94240	−0.060	0.130
	sum	6.510	−34.460
PU-SOL-THERM-011 Case 18-6 $\Delta k_{70\text{x}} = 4.790$ $\Delta k_{06\text{ex}} = -30.270$	1001	−0.100	−97.420
	7014	0.000	0.010
	8016	−4.400	69.700
	24050	−0.340	−0.340
	24052	−2.130	−2.140
	24053	−1.510	−1.510
	24054	−0.180	−0.180
	26056	0.000	−0.010
	28058	0.150	0.150
	28060	0.040	0.040
	28061	0.020	0.020
	28062	−0.010	−0.010
	48106	0.010	−0.070
	48108	0.040	−0.040
	48110	0.640	−2.630
	48111	−0.020	−0.460
	48112	0.580	−0.030
	48113	0.300	−0.290
	48114	1.710	1.710
	48116	−0.170	−0.190
	94239	10.230	3.220
	94240	0.000	0.170
	sum	4.860	−30.300
PU-SOL-THERM-021 Case 3 $\Delta k_{70\text{x}} = 25.550$ $\Delta k_{06\text{ex}} = -17.500$	1001	−0.020	−115.500
	8016	−4.690	66.010
	94239	5.140	8.980
	94240	1.090	1.120
	94241	23.770	21.570
	94242	0.280	0.280
	sum	25.570	−17.540

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Table 3: Changes in k_{eff} due to a single evaluation... (continued from previous page)

ICSBEP	ZA	$k_{71x} - k_x$ (pcm) MENDF70x	LANL2006ex
PU-SOL-THERM-021 Case 7	1001	−0.090	−114.530
$\Delta k_{70x} = 5.090$	8016	−3.700	56.560
$\Delta k_{06ex} = -53.180$	94239	8.820	4.460
	94240	0.060	0.250
	sum	5.090	−53.260
U233-MET-FAST-001	92233	26.939	105.577
$\Delta k_{70x} = 26.772$	92234	−0.165	10.510
$\Delta k_{06ex} = 115.736$	92235	−0.001	0.017
	92238	0.000	−0.352
	sum	26.773	115.752
U233-MET-FAST-002 Case 1	92233	−9.758	70.000
$\Delta k_{70x} = -10.354$	92234	−0.133	9.037
$\Delta k_{06ex} = 120.138$	92235	−0.461	41.626
	92238	0.000	−0.541
	sum	−10.352	120.122
U233-MET-FAST-002 Case 2	92233	−22.208	52.832
$\Delta k_{70x} = -23.213$	92234	−0.119	8.440
$\Delta k_{06ex} = 116.916$	92235	−0.885	56.391
	92238	0.000	−0.881
	sum	−23.212	116.782
U233-MET-FAST-003 Case 1	92233	−20.591	52.040
$\Delta k_{70x} = -20.733$	92234	−0.134	10.111
$\Delta k_{06ex} = 58.660$	92235	−0.007	0.387
	92238	−0.001	−3.986
	sum	−20.733	58.552
U233-MET-FAST-003 Case 2	92233	−41.290	26.742
$\Delta k_{70x} = -41.427$	92234	−0.118	10.395
$\Delta k_{06ex} = 26.688$	92235	−0.018	0.534

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Table 3: Changes in k_{eff} due to a single evaluation... (continued from previous page)

ICSBEP	ZA	$k_{71x} - k_x$ (pcm) MENDF70x	LANL2006ex
	92238	−0.001	−11.144
	sum	−41.427	26.527
U233-MET-FAST-004 Case 1 $\Delta k_{70x} = -631.153$ $\Delta k_{06ex} = -558.753$	28058	2.820	2.765
	28060	−3.082	−3.094
	28061	−0.012	−0.012
	28062	3.862	3.862
	28064	−1.186	−1.186
	29063	0.000	−0.004
	29065	0.000	−0.002
	40090	−4.124	−4.191
	40091	0.111	−1.589
	40092	−0.932	−3.141
	40094	1.679	−0.942
	40096	−0.126	−0.304
	74182	−44.755	−45.618
	74183	−90.129	−89.908
	74184	−238.068	−239.923
	74186	−231.493	−233.344
	92233	−30.273	36.018
	92234	−0.153	12.068
	92238	0.000	−0.390
	sum	−635.861	−568.935
U233-MET-FAST-004 Case 2 $\Delta k_{70x} = -998.349$ $\Delta k_{06ex} = -927.129$	28058	6.829	6.753
	28060	−4.999	−5.017
	28061	−0.035	−0.035
	28062	6.645	6.645
	28064	−2.049	−2.050
	29063	0.000	−0.004
	29065	0.000	−0.002
	40090	−6.628	−6.532
	40091	0.189	−2.290
	40092	−1.626	−4.995
	40094	2.683	−1.071
	40096	−0.199	−0.448

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Table 3: Changes in k_{eff} due to a single evaluation... (continued from previous page)

ICSBEP	ZA	$k_{71x} - k_x$ (pcm) MENDF70x	LANL2006ex
	74182	−72.842	−72.288
	74183	−142.938	−140.915
	74184	−399.656	−401.320
	74186	−339.350	−341.724
	92233	−56.145	2.209
	92234	−0.148	13.506
	92238	0.000	−0.368
	sum	−1010.269	−949.946
U233-MET-FAST-005 Case 1 $\Delta k_{70x} = 182.761$ $\Delta k_{06ex} = -61.651$	4009	207.156	−121.189
	8016	−0.008	0.155
	92233	−23.277	46.990
	92234	−0.172	13.124
	92238	0.000	−0.389
	sum	183.699	−61.309
U233-MET-FAST-005 Case 2 $\Delta k_{70x} = 289.040$ $\Delta k_{06ex} = -150.355$	4009	337.288	−215.121
	8016	−0.023	0.275
	92233	−45.723	47.319
	92234	−0.178	16.036
	92238	0.000	−0.375
	sum	291.364	−151.866
U233-MET-FAST-006 $\Delta k_{70x} = -51.811$ $\Delta k_{06ex} = 23.352$	92233	−51.626	25.868
	92233	−47.537	32.613
	92234	−0.102	11.563
	92234	−0.103	11.561
	92235	−0.078	1.091
	92235	−0.075	1.042
	92238	−0.005	−15.530
	92238	−0.004	−15.009
	sum	−99.530	53.199
U233-SOL-THERM-001 Case 1 $\Delta k_{70x} = 8.270$ $\Delta k_{06ex} = 125.930$	1001	−0.230	−57.980

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Table 3: Changes in k_{eff} due to a single evaluation... (continued from previous page)

ICSBEP	ZA	$k_{71\text{x}} - k_x$ (pcm) MENDF70x	LANL2006ex
	8016	−4.120	80.490
	13027	0.000	1.880
	90232	0.000	0.050
	92233	12.660	97.220
	92234	−0.040	4.240
	92235	0.000	0.060
	92238	0.000	0.070
	sum	8.270	126.030
U233-SOL-THERM-001 Case 2	1001	−0.220	−57.540
$\Delta k_{70\text{x}} = 8.150$	5010	0.000	−1.440
$\Delta k_{06\text{ex}} = 125.040$	8016	−4.120	80.470
	13027	0.000	1.870
	90232	0.000	0.050
	92233	12.530	97.280
	92234	−0.040	4.280
	92235	0.000	0.060
	92238	0.000	0.070
	sum	8.150	125.100
U233-SOL-THERM-001 Case 3	1001	−0.210	−57.110
$\Delta k_{70\text{x}} = 8.040$	5010	0.000	−2.690
$\Delta k_{06\text{ex}} = 124.240$	8016	−4.120	80.450
	13027	0.000	1.860
	90232	0.000	0.050
	92233	12.400	97.310
	92234	−0.040	4.320
	92235	0.000	0.060
	92238	0.000	0.070
	sum	8.030	124.320
U233-SOL-THERM-001 Case 4	1001	−0.200	−56.880
$\Delta k_{70\text{x}} = 7.920$	5010	0.000	−3.820
$\Delta k_{06\text{ex}} = 123.380$	8016	−4.120	80.370
	13027	0.000	1.860

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Table 3: Changes in k_{eff} due to a single evaluation... (continued from previous page)

ICSBEP	ZA	$k_{71\text{x}} - k_x$ (pcm) MENDF70x	LANL2006ex
	90232	0.000	0.050
	92233	12.270	97.390
	92234	−0.040	4.370
	92235	0.000	0.060
	92238	0.000	0.070
	sum	7.910	123.470
U233-SOL-THERM-001 Case 5 $\Delta k_{70\text{x}} = 7.810$ $\Delta k_{06\text{ex}} = 122.620$	1001	−0.190	−56.560
	5010	0.000	−4.880
	8016	−4.110	80.280
	13027	0.000	1.860
	90232	0.000	0.050
	92233	12.150	97.410
	92234	−0.040	4.410
	92235	0.000	0.060
	92238	0.000	0.070
	sum	7.810	122.700
U233-SOL-THERM-008 $\Delta k_{70\text{x}} = 9.960$ $\Delta k_{06\text{ex}} = 173.320$	1001	−0.260	−26.360
	8016	−4.420	99.550
	13027	0.000	0.860
	90232	0.000	0.040
	92233	14.670	96.230
	92234	−0.040	3.220
	92235	0.000	0.020
	92238	0.000	0.060
	sum	9.950	173.620