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Experience With the SCALE Criticality Safety Cross-Section Libraries

Oak Ridge National Laboratory

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ABSTRACT

This report provides detailed information on the SCALE criticality safety cross-section libraries. Areas covered include the origins of the libraries, the data on which they are based, how they were generated, past experience and validations, and performance comparisons with measured critical experiments and numerical benchmarks.

The performance of the SCALE criticality safety cross-section libraries on various types of fissile systems are examined in detail. Most of the performance areas are demonstrated by examining the performance of the libraries vs critical experiments to show general trends and weaknesses. In areas where directly applicable critical experiments do not exist, performance is examined based on the general knowledge of the strengths and weaknesses of the cross sections. In this case, the experience in the use of the cross sections and comparisons with the results of other libraries on the same systems are relied on for establishing acceptability of application of a particular SCALE library to a particular fissile system.

This report should aid in establishing when a SCALE cross-section library would be expected to perform acceptably and where there are known or suspected deficiencies that would cause the calculations to be less reliable. To determine the acceptability of a library for a particular application, the calculational bias of the library should be established by directly applicable critical experiments.

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1 INTRODUCTION

Multi-energy group neutron cross-section libraries included in the SCALE code system[1] have seen widespread use over the years since the first release of SCALE in 1980. Numerous validation studies have been performed to satisfy ANSI/ANS-8.1-1998[2] and ANSI/ANS-8.17-1984,[3] but this information is scattered and not succinctly compiled into an easy-to-use format.

This report is intended to begin where the SCALE user manual leaves off in identifying the performance of the SCALE libraries in the analysis of various fissile systems. Some of the performance areas can be demonstrated by examining the performance of the libraries when calculating critical experiments. In areas where directly applicable critical experiments do not exist, other factors must be examined based on the general knowledge of the strengths and weaknesses of the cross sections. In this case, the experience in the use of the cross sections and comparisons to the results of other libraries on the same systems must be relied on for establishing the acceptability of the application of a particular SCALE library to a particular fissile system.

This report will aid in establishing when a SCALE cross-section library should perform acceptably and what areas of application should be more carefully scrutinized. To determine the acceptability of a library for a particular application, the calculational bias of the library should be established by directly applicable critical experiments. Preferably, the bias for a particular application should be small; however, if the bias and any trends in the bias are well defined, then the library can be used, provided the bias and trends have been properly taken into account.

Table 1.1 shows the six neutron cross-section libraries currently available in SCALE. The SCALE Hansen-Roach library is a version of the Los Alamos 16-group Hansen-Roach library[4] that has been modified at Oak Ridge National Laboratory (ORNL) and implemented into SCALE. The remaining five libraries were generated at ORNL for use as quasi system-independent criticality safety libraries. The two 27-group libraries are treated as one library in the performance comparisons presented in this report. The group-wise energy boundaries for these libraries are presented in Appendix A.

Table 1.1 SCALE cross-section libraries[5]

Library	SCALE designator
SCALE 16-group Hansen-Roach	HANSEN-ROACH
218-group ENDF/B-IV[6]	218GROUPNDF4
27-group ENDF/B-IV	27GROUPNDF4
27-group ENDF/B-IV Burnup Library	27BURNUPLIB
238-group ENDF/B-V[7]	238GROUPNDF5
44-group ENDF/B-V[8]	44GROUPNDF5

Some of the generic strengths and weaknesses of the SCALE libraries will be discussed in Section 2. Included in that section are some common characteristics of the libraries and a discussion of the SCALE codes that perform resonance processing. Also included in Section 2 is a brief description of the calculational models and methodology used to demonstrate the performance of the libraries.

In the subsequent sections a more detailed description of each cross-section library will be presented. The performance of each library will be presented against a standard set of critical experiments to show general trends and weaknesses. The discussions in these sections will aid in identifying when a library would be expected to perform acceptably and where there are known or suspected deficiencies that would cause the calculations to be less reliable.

2 GENERAL DISCUSSION

Some of the strengths and weaknesses of the SCALE libraries may be discussed in general terms. As an example, the strengths and weaknesses (assumptions and approximations) used in the codes that generate/process the SCALE cross sections become generic strengths and weaknesses of the SCALE cross-section libraries. BONAMI[9] and NITAWL,[10] the two codes used for resonance processing in SCALE, are discussed below. The manner in which a cross-section set is generated, including the processing code and assumed generating flux, also affects the performance of a library. When using any SCALE library, one of the Criticality Safety Analysis Sequences (CSAS) should be used to ensure that the resonance self-shielding is handled appropriately. An overview of common characteristics of the SCALE libraries is presented here.

In general, all of the SCALE libraries perform acceptably for unmoderated fast systems and hydrogen-moderated thermal systems. These systems represent the largest class of application of the libraries and have the largest collection of critical experiments against which to validate. The SCALE libraries should be expected to perform less reliably for systems that have intermediate spectra and/or intermediate mass moderators that dominate the system transport, because of the lack of experimental data in these areas and the lack of emphasis in these areas during the preparation of the libraries. Note that many of the weaknesses of the SCALE libraries stem from weaknesses in the adequacy of the base data used to generate the libraries. Any library can perform only as well as the data upon which it is based. In the United States, the current source for base cross-section data is the Evaluated Nuclear Data Files (ENDF) maintained at Brookhaven National Laboratory.

2.1 CROSS-SECTION GENERATION

Several factors affect the performance of multigroup cross-section libraries, regardless of the reliability of the base data. These factors include the number of energy groups, the location of the energy-group boundaries, the flux used to generate the cross-section library, and the methods used to self-shield resonance nuclides.

Two fine-group libraries have been generated and used extensively with SCALE: the 218-group ENDF/B-IV Criticality Safety Reference Library (CSRL) and the 238-group ENDF/B-V Library to Analyze Radioactive Waste (LAW). Both libraries were generated into an AMPX[11] master library format that contains all the needed information to further process the cross sections for problem-specific temperature and resonance effects (i.e., a problem-specific or working library). Thus, the AMPX master libraries are intended to be quasi-system-independent criticality safety libraries. The problem-specific resolved resonance processing for both libraries (with the exception of a few nuclides) is via the Nordheim Integral Treatment within the NITAWL code. Single-level Breit-Wigner resolved resonance data are carried on the AMPX master library for resonance nuclides.

The unresolved resonance region is processed at a fixed potential scattering cross section (σ_p) of 50,000 barns for the 218-group library. As σ_p approaches infinity, the flux spectrum approaches an infinitely dilute flux spectrum.[a] Therefore, as σ_p increases, the self-shielding decreases. Using such a large value for σ_p results in insufficient self-shielding of the cross sections in the unresolved resonance region. For typical fast and thermal systems, this lack of self-shielding is not a problem. The unresolved resonance region in the 238-group library is handled by

[a]Infinite dilution assumes that the amount of the nuclide is infinitesimally small (or infinitely dilute) so that there is no effect on the flux and thus no self-shielding of the cross-section resonances. Self-shielding reduces the magnitude of the resonance because of reduction in the flux caused by other atoms of the same nuclide. See Figure 2.1.

Bondarenko data, which are processed by BONAMI on a problem-specific basis. This method of handling the unresolved resonance region is more accurate.

The group structure for the fine-group libraries was developed for use on fast systems and thermal systems. Groups were intentionally added in the 238-group library structure to subdivide resolved resonances of important nuclides (for example ^{238}U) to minimize the effects of limitations of the Nordheim treatment within NITAWL on resonance processing. The additional energy-group structure allows the resonance structure to be described in multigroup data similar to point data. Other groups were added in going from the 218- to the 238-group library to specifically address the 0.3 eV thermal resonance in ^{239}Pu that cannot be properly modeled in NITAWL due to its low energy and lack of resonance data and the thermal Maxwellian peak. The additional energy-group structure also enables more accurate handling of thermal upscatter.

The two fine-group libraries were generated with a different flux function. Resonance nuclides were generated with a fission Maxwellian (10 MeV to 70 keV) - 1/E (70 keV to 0.125 eV) - thermal Maxwellian (0.125 to 10^{-5} eV) flux function in both libraries. Nonresonance nuclides were generated with a fission Maxwellian - $1/(E\sigma_t)$ - thermal Maxwellian flux function in the 218-group library and with a fission Maxwellian - 1/E - thermal Maxwellian flux function in the 238-group library. This difference in generating function can cause the two libraries to calculate differently for certain classes of systems.

The use of a $1/(E\sigma_t)$ weighting function results in a flux spectrum approximating the spectrum in a material composed entirely of that nuclide. Conversely, the use of a 1/E weighting function results in an infinitely dilute flux spectrum, thus providing no self-shielding effect and resulting in the loss of resonance data. In the former case, the cross-section structure is highly shielded and in the latter it is totally unshielded. The significance of this difference lies in the fact that there are many nuclides in ENDF which have significant resonance structure but which, according to ENDF, are considered to be nonresonance nuclides. These nuclides are usually intermediate-mass nuclides (e.g., Al, Si, S, Cl, K) and, if they play a significant role in the absorption and/or transport in a calculation, the two fine-group libraries can perform quite differently. The impact of the weighting on cross-section performance will be discussed more fully in the respective sections for the 218- and 238-group libraries.

The manner in which the ENDF/B-IV 27-group library and the ENDF/B-V 44-group library were collapsed from the parent fine-group libraries is also characteristically different. The 27-group library was collapsed using the generating flux of the 218-group library described above. This characteristic causes all nonresonance nuclides to have any cross-section structure fully self-shielded; both capture and scatter cross sections are minimized. This characteristic is desirable for systems where a nuclide other than hydrogen dominates the transport (intermediate spectrum), but has little impact on fast or well-thermalized systems.

The 44-group library was collapsed using a typical light-water-reactor lattice spectrum at room temperature conditions. This spectrum is very similar to an infinite dilute 1/E spectrum, except that structure due to oxygen and ^{238}U cross-section structure appears in the collapsing flux. The group structure of the library is the same as the 27-group library except that additional groups have been added below 0.4 eV to address the ^{239}Pu resonance region (0.2 – 0.4 eV) and the thermal Maxwellian (0.003 – 0.1 eV). The library performs well on fast or well-thermalized systems and for lattices of fuel pins. The use of an infinite dilute collapsing flux causes all nonresonance nuclides to have cross-section structure shielded at minimum values. Both capture and scatter cross sections are maximized, which adversely impacts some classes of homogeneous systems and systems where nuclides other than hydrogen dominate the transport.

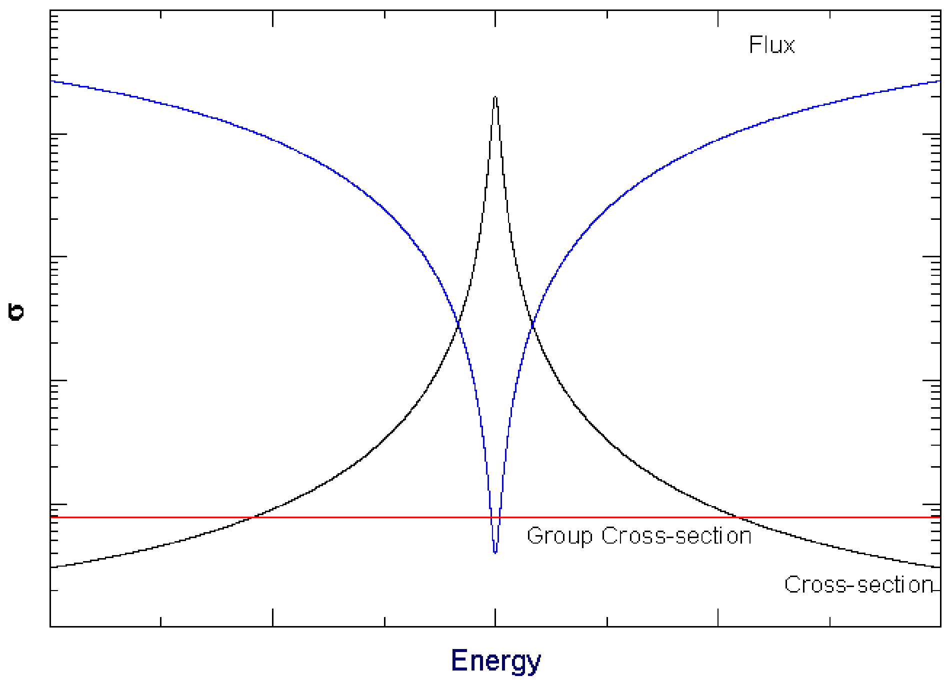

Figure 2.1 Self-shielding of cross-section resonance

2.2 RESONANCE PROCESSING

Resonance processing in the SCALE sequences is performed by BONAMI and NITAWL. Both of these codes are able to process resolved and unresolved resonance data using different methods discussed in the following sections. A common trait between both modules is that neither BONAMI nor NITAWL treat resonance overlap or resonance interference. Resonance overlap may occur because of several characteristics of a system. Typically, resonance overlap occurs when two nuclides in a mixture have resonances at the same or nearly the same energies, as discussed in Section M7.A of the SCALE manual.[1] When resonance overlap is ignored, the flux used to shield the cross section is incorrect and thus the group cross section can be in error. Another form of resonance overlap can occur when the same resonance nuclide appears in different regions (mixtures) of a geometry specification, because SCALE currently only processes one region at a time. Again, because an incorrect flux is used to shield the cross sections, the group cross sections can be in error. An example of this is in a dissolver where a fuel lump is surrounded by fissile solution containing the same resonance absorbers.

Resonance interference is similar to resonance overlap. When two resonances are close together, the higher-energy resonance affects the flux shape in the lower-energy resonance, because the flux does not reach the asymptotic flux form before the next resonance. Resonance interference can occur between resonances of different nuclides or two closely spaced resonances of the same nuclide. The limitations and approximations used in BONAMI and NITAWL will be discussed below.

NITAWL performs temperature broadening during resonance processing. If temperature data are included in the library, BONAMI performs temperature broadening at the user-specified problem temperature during resonance processing. Starting with SCALE 4.3, NITAWL also performs a temperature interpolation of thermal-scattering data on the master library.

2.2.1 BONAMI

The BONAMI module self-shields cross sections with Bondarenko data using the shielding-factor methodology. Nuclides with Bondarenko data carry an infinite dilute cross section on the master library and tables of shielding factors that are dilution-dependent. BONAMI performs an iteration for each nuclide and each energy group that has shielding factors. Convergence is achieved when the sum of the individually shielded cross sections agrees with the shielded total cross section. In this manner, the problem-dependent self-shielded cross sections for each nuclide and each group are determined and interacting effects are taken into account. When CSAS calls BONAMI, heterogenous geometry effects are accounted for in the escape cross section that is passed to BONAMI. The escape cross section is determined based on the system geometry specified in the cross-section processing portion of the SCALE input. The geometry type, materials, characteristic dimensions, and the Dancoff factor are all used to determine the escape cross section. By using the escape cross section to account for geometry effects, all nuclides can be processed by BONAMI as infinite homogeneous media in the CSAS sequences.

The performance of libraries shielded by the Bondarenko method depends on the adequacy of the approximations used to generate the Bonderenko data. The typical approach is to use the narrow resonance approximation to generate these data, which is adequate for a broad range of applications. When a resonance is not narrow relative to the slowing down in the system, the narrow resonance approximation breaks down and the resonance corrections for the cross sections can be in error. This breakdown has been observed for libraries that use the Bondarenko method to shield the low-energy resolved resonances for ^{238}U for systems with low hydrogen moderation[12] and for many nuclides when the principal moderator is an intermediate-mass nuclide. The solution to this type of breakdown is to either carry sufficient cross-section energy groups to march across the resonance and/or to use more appropriate flux-generating methods to compute the Bondarenko factors. This problem does not occur in the SCALE libraries because Bondarenko data are only used in the unresolved resonance range.

2.2.2 NITAWL

The NITAWL-II module shields cross sections with resonance data utilizing the Nordheim integral transport method. In the SCALE implementation, the infinite-dilute multi-group cross sections are adjusted by a correction value determined by NITAWL. The correction is calculated by first determining the infinite dilute contribution of each resonance to the group cross section and then by calculating what the contribution would be if the resonance was shielded for the specific problem. The geometry type, materials, characteristic dimensions, and Dancoff factor are all passed to NITAWL for determining the details of the approximations used to self-shield the cross sections. NITAWL uses two moderators when reconstructing the shielded flux. The slowing-down mass and scatter cross section for the principal material (first moderator) mixed with the fuel are used explicitly. The remaining materials (second moderator) are treated using an averaged slowing-down mass and scatter cross section.

A fundamental assumption of the Nordheim method is that resonances are widely spaced, both within a particular nuclide and between nuclides. If this assumption is not correct, the flux used to construct the resonance contribution to the group cross section is incorrect. Breakdowns have been observed when NITAWL was used to self-shield cross sections of fissile nuclides with overlapping resonances in dissolver-type systems[13] and in systems with intermediate-mass moderators and intermediate-mass resonance materials.

2.2.3 Thermal-Scattering Data Limitation

A discrepancy was discovered prior to the release of SCALE 4.3, when KENO V.a calculations using the 27-group library were compared with calculations using a commercial 2-D lattice physics code for LWR fuel assemblies in a storage configuration as a function of temperature. The two codes were in relative agreement at low temperatures (20°C) and small water gaps between assemblies. However, as the temperature of the system was increased to 120°C, the 2-D lattice code calculations gave increasingly larger values of k_{eff} relative to KENO. Larger water gaps (between assemblies) enhanced the temperature effects on calculated k_{eff}. The KENO results were as much as 3% lower at 120°C.

The cause of this discrepancy was identified as a limitation in processing the thermal-scattering data when NITAWL makes a working library in versions of SCALE prior to 4.3. The SCALE ENDF/B-IV hydrogen has scattering matrices at 293 K and 550 K (20°C and 277°C). When NITAWL processes hydrogen, the scattering matrix with a temperature closest to that specified is used. It was determined that the temperature dependence of the scattering can increase the multiplication factor by as much as 2.5%. Users of earlier versions of SCALE should be aware of this problem and ensure that the hydrogen-scattering matrices used in their analyses are either appropriate or conservative with respect to k_{eff}. The SCALE ENDF/B-V libraries contain hydrogen scattering matrices at eight temperatures and were not released until SCALE 4.3, so this problem does not exist for the ENDF/B-V libraries.

Information on the thermal-scattering data available in the SCALE criticality-safety libraries may be found in Appendices C–E.

2.3 GENERAL DESCRIPTION OF THE VALIDATION EXPERIMENTS

In addition to discussing general experience and performance for each SCALE cross-section library, the performance of each library will be demonstrated for a set of benchmark models. These models are primarily composed of critical experiment models that have been used in the past to validate one or more of the SCALE libraries.

The performance of each library for these calculations provides a measure of the adequacy of the library. It is not surprising that, in general, the libraries perform rather predictably for these benchmarks; after all, most of the systems fall into the realm of typical applications for which the libraries were intended. The calculations show the general range of application of the libraries. **It cannot be emphasized too strongly that application of cross sections outside the range of validation must be done with great care, regardless of the criticality safety code and/or cross sections used.** This caution is due to potential unidentified deficiencies in both the base cross-section data and in the manner the cross sections are processed from ENDF/B formats for use by the various codes.

The descriptions and results for several calculational benchmarks are presented in Appendix B. These calculational benchmarks are models that are hypothetical and do not model actual critical experiments, but were set up to study characteristics of the library over a range of parameters and to allow for easy comparison of two or more cross-section libraries. Because they do not model an actual experiment, the calculational benchmarks do not demonstrate the adequacy of a particular code or cross-section set, but show over the range of possible application where different cross-section libraries agree or disagree. Agreement between the libraries for the various parametric studies does not, in itself, demonstrate the adequacy of the library for the application. Disagreement between libraries, however, does indicate where one or another of the libraries may be deficient. An obvious extension of this statement is that when different cross-section libraries give different results for the same system, similar differences should show up in the equivalent validations for the libraries; otherwise, neither library has been validated for the application.

2.3.1 High-Enriched Homogeneous ^{235}U Experiments

More than 130 critical experiments from Table 5 of ORNL/TM-238 (Ref. 14) and the *International Handbook of Evaluated Criticality Safety Benchmark Experiments*[15] (IHECSBE) were selected to evaluate the performance of the cross-section libraries for high-enriched homogeneous uranium systems. In addition, eight experiments using high-enriched uranium disks and polyethylene disks,[16] commonly referred to as the Jemima plates, were selected. A list of the experiments is provided in Table 2.1. The experiments can be subdivided into three groups: (1) uranium metal systems with fast or intermediate-energy spectra; (2) Jemima high-enriched experiments with intermediate-energy spectra; and (3) uranyl nitrate and uranyl fluoride solutions with thermal-energy spectra. These experiments are similar to those that have been used for criticality safety validation of weapons facilities. Six of the experiments in Table 5 of ORNL/TM-238 were also included in the evaluated experiments of Ref. 15. The evaluated models were used when available.

Table 2.1 High-enriched homogeneous ^{235}U experiments

Case	Experimental description
CAS01[a]	Y-12 validation case A-1. 93.8% U metal sphere, unreflected (GODIVA)
CAS04	Y-12 validation case A-2. 93.2% U-Mo alloy cylinder annulus, unreflected
CAS05	Y-12 validation case A-3. 93.2% UO_2F_2 solution, 19.992 g U/L, in Al sphere, unreflected
CAS06[a]	Y-12 validation case A-4. 93.18% $UO_2(NO_3)_2$ solution, 20.12 g U/L, in Al sphere, unreflected
CAS07	Y-12 validation case A-5. 93.5% U metal hemispherical shell, H_2O-reflected
CAS08	Y-12 validation case A-6. 93.2% U metal cylinder annulus, graphite-reflected
CAS09	Y-12 validation case A-7. 94% U metal cuboid, natural U-reflected
CAS10	Y-12 validation case A-8. 93.1% U metal hemispherical shell, oil-reflected
CAS11	Y-12 validation case A-9. 93.1 % U metal hemispherical shell, steel center and oil-reflected
CAS02[a]	Y-12 validation case A-10. 97.67% U metal sphere, H_2O-reflected
CAS03[a]	Y-12 validation case A-11. 93.172% $UO_2(NO_3)_2$ solution, 346.7 g U/L, in SS cylinder, unreflected
CAS12	Y-12 validation case B-1. 93.2% U metal cylinder annulus, unreflected, smaller U cylinder in hole touching one wall
CAS22	Y-12 validation case B-2. 93.2% U metal cylinder annulus, unreflected, smaller U block in hole touching one wall
CAS23	Y-12 validation case B-3. 93.2% U metal, unreflected cylinders and cuboids in approximate circular arrangement, cylinder, cuboid, and hemisphere stack in center

Table 2.1 (continued)

Case	Experimental description
CAS24	Y-12 validation case B-4. 93.2% U metal cylinders, 4 × 4 × 4 array, unreflected
CAS25	Y-12 validation case B-5. 93.2% U metal cylinders, 2 × 2 × 2 array, each unit in the array is a smaller cylinder capped on each end by a larger cylinder, unreflected
CAS26	Y-12 validation case B-6. 93.2% U metal cylinders, 2 × 2 × 2 array, paraffin-reflected
CAS27	Y-12 validation case B-7. 93.2% U metal cylinders, 2 × 2 × 2 array, each unit in the array is a smaller cylinder capped on each end by a larger cylinder, paraffin-reflected
CAS28	Y-12 validation case B-8. 93.2% U metal cylinders each in a Plexiglas box, 2 × 2 × 2 array of these units unreflected
CAS14	Y-12 validation case B-11. 93.2% $UO_2(NO_3)_2$ solution, 505 g U/L, in SS cylinders, 4 × 4 array, standing in a solution slab, Plexiglas-reflected
CAS15	Y-12 validation case B-12. 93.2% U metal cylinders, 2 × 2 × 2 array, graphite-moderated and polyethylene-reflected
CAS19	Y-12 validation case B-16. 93.1% $UO_2(NO_3)_2$ solution, 450.8 g U/L, in SS containers, square central column with 8 perpendicular cylindrical arms unreflected
CAS20[a]	Y-12 validation case B-17. 93.17% $UO_2(NO_3)_2$ solution, 355.9 g U/L, in A1 cylinders, 4 × 4 array, Plexiglas-reflected
CAS21[a]	Y-12 validation case B-18. 93.17% $UO_2(NO_3)_2$ solution, 364.1 g U/L, in A1 cylinders, 4 × 4 array, concrete-reflected
CAS30	Problem S333SP0. 93.2% UO_2F_2 solution, 81.8 g U/L, in A1 slabs, three 7.62-cm slabs in 3 × 1 array, 0 cm separation, unreflected, cylindrical tank, floor and walls in experiment room included
CAS32	Problem S333SP1. 93.2% UO_2F_2 solution, 81.8 g U/L, in A1 slabs, three 7.62-cm slabs in 3 × 1 array, 2.54-cm separation, unreflected, cylindrical tank, floor, and walls in experiment room included

Table 2.1 (continued)

Case	Experimental description
CAS34	Problem S333SP3. 93.2% UO_2F_2 solution, 81.8 g U/L, in Al slabs, three 7.62-cm slabs in 3 × 1 array, 7.62 cm separation, unreflected, cylindrical tank, floor, and walls in experiment room included
CAS 36	Problem S333SP4. 93.2% UO_2F_2 solution, 81.8 g U/L, in Al stabs, three 7.62-cm slabs in 3 × 1 array, 11.43-cm separation, unreflected,cylindrical tank, floor, and walls in experiment room included
CAS38	Problem S333SP5. 93.2% UO_2F_2 solution, 81.8 g U/L, in Al slabs, three 7.62-cm slabs in 3 × 1 array, 13.97 cm separation, unreflected, cylindrical tank, floor, and walls in experiment room included
CAS40	Problem S333SP6. 93.2% UO_2F_2 solution, 81.8 g U/L, in Al slabs, three 7.62-cm slabs in 3 × 1 array, 15.24 cm separation, unreflected, cylindrical tank, floor, and walls in experiment room included
CAS31	Problem S333SP0R. 93.2% UO_2F_2 solution, 81.8 g U/L, in A1 slabs, three 7.62-cm slabs in 3 × 1 array, 0 cm separation, H_2O-reflected
CAS33	Problem S333SP1R. 93.2% UO_2F_2 solution, 81.8 g U/L, in Al slabs, three 7.62-cm slabs in 3 × 1 array, 2.54-cm separation, H_2O-reflected
CAS35	Problem S333SP3R. 93.2% UO_2F_2 solution, 81.8 g U/L, in A1 slabs, three 7.62-cm slabs in 3 × 1 array, 7.62-cm separation, H_2O-reflected
CAS37	Problem S333SP4R. 93.2% UO_2F_2 solution, 81.8 g U/L, in Al slabs, three 7.62-cm slabs in 3 × 1 array, 11.43-cm separation, H_2O-reflected
CAS39	Problem S333SP5R. 93.2% UO_2F_2 solution, 81.8 g U/L, in A1 slabs, three 7.62-cm slabs in 3 × 1 array, 13.97-cm separation, H_2O-reflected
CAS42	Problem S36SP2. 93.2% UO_2F_2 solution, 81.8 g U/L in A1 slabs, 7.62- and 14.834-cm slabs in 2 × 1 array, 5.08-cm separation, unreflected

Table 2.1 (continued)

Case	Experimental description
CAS41	Problem S36SP15. 93.2% UO_2F_2 solution, 81.8 g U/L in Al slabs, 7.62- and 14.834-cm slabs in 2 × 1 array, 38.1-cm separation, unreflected
CAS43	Problem S36SP30. 93.2% UO_2F_2 solution, 81.8 g U/L in A1 slabs, 7.62- and 14.834-cm slabs in 2 × 1 array, 76.2-cm separation, unreflected
CAS44	Problem S36SP48. 93.2% UO_2F_2 solution, 81.8 g U/L in A1 slabs, 7.62- and 14.834-cm slabs in 2 × 1 array, 121.92-cm separation, unreflected
CAS45	Problem S363SP0. 93.2% UO_2F_2 solution, 81.8 g U/L, in A1 slabs, 7.62-, 14.834-, and 7.62-cm slabs in 3 × 1 array, 0-cm separation, unreflected
CAS46	Problem S363SP10. 93.2% UO_2F_2 solution, 81.8 g U/L, in Al slabs, 7.62-, 14.834-, and 7.62-cm slabs in 3 × 1 array, 25.4-cm separation, unreflected
CAS47	Problem S363SP20. 93.2% UO_2F_2 solution, 81.8 g U/L, in A1 slabs, 7.62-, 14.834-, and 7.62-cm slabs in 3 × 1 array, 50.8-cm separation, unreflected
CAS48	Problem S363SP32. 93.2% UO_2F_2 solution, 81.8 g U/L, in A1 slabs, 7.62-, 14.834-, and 7.62-cm slabs in 3 × 1 array, 81.28-cm separation, unreflected
CAS52	Problem S63SP6. 93.2% UO_2F_2 solution, 81.8 g U/L, in A1 slabs. One slab is made up from two 7.62-cm slabs snugly fit together, the other is 7.62 cm, 2 × 1 array, 15.24-cm separation, unreflected
CAS49	Problem S63SP12. 93.2% UO_2F_2 solution, 81.8 g U/L, in A1 slabs. One slab is made up from two 7.62-cm slabs snugly fit together, the other is 7.62-cm, 2 × 1 array, 30.48-cm separation, unreflected
CAS50	Problem S63SP18. 93.2% UO_2F_2 solution, 81.8 g U/L, in A1 slabs. One slab is made up from two 7.62-cm slabs snugly fit together, the other is 7.62 cm, 2 × 1 array, 45.72-cm separation, unreflected

Table 2.1 (continued)

Case	Experimental description
CAS51	Problem S63SP30. 93.2% UO_2F_2 solution, 81.8 g U/L, in A1 slabs. One slab is made up from two 7.62-cm slabs snugly fit together, the other is 7.62 cm, 2 × 1 array, 76.2-cm separation, unreflected
CAS54	Problem S66SP2. 93.2% UO_2F_2 solution, 81.8 g U/L, in A1 slabs. One slab is 14.834 cm, and the other is made up from two 7.62-cm slabs snugly fit together, 2 × 1 array, 5.08-cm separation, unreflected
CAS58	Problem S66SP6. 93.2% UO_2F_2 solution, 81.8 g U/L, in Al slabs. One slab is 14.834 cm, and the other is made up from two 7.62-cm slabs snugly fit together, 2 × 1 array, 15.24-cm separation, unreflected
CAS53	Problem S66SP15. 93.2% UO_2F_2 solution, 81.8 g U/L, in Al slabs. One slab is 14.834 cm, and the other is made up from two 7.62-cm slabs snugly fit together, 2 × 1 array, 38.1-cm separation, unreflected
CAS55	Problem S66SP20. 93.2% UO_2F_2 solution, 81.8 g U/L, in A1 slabs. One slab is 14.834 cm, and the other is made up from two 7.62-cm slabs snugly fit together, 2 × 1 array, 50.8-cm separation, unreflected
CAS56	Problem S66SP30. 93.2% UO_2F_2 solution, 81.8 g U/L, in Al slabs. One slab is 14.834 cm, and the other is made up from two 7.62-cm slabs snugly fit together, 2 × 1 array, 76.2-cm separation, unreflected
CAS57	Problem S66SP48. 93.2% UO_2F_2 solution, 81.8 g U/L, in Al slabs. One slab is 14.834 cm, and the other is made up from two 7.62-cm slabs fit snugly together, 2 × 1 array, 121.92-cm separation, unreflected
CAS59	Problem S66SP66. 93.2% UO_2F_2 solution, 81.8 g U/L, in Al slabs. One slab is 14.834 cm, and the other is made up from two 7.62-cm slabs fit snugly together, 2 × 1 array, 167.64-cm separation, unreflected
CAS91	Problem U6B271F. 92.6% $UO_2(NO_3)_2$ solution, 63.3 g U/L, in Plexiglas cylinders, 3 × 3 × 3 array, unreflected, walls, floor, and tank in experiment room included

Table 2.1 (continued)

Case	Experimental description
CAS60	Problem U2B271F. 92.6% $UO_2(NO_3)_2$ solution, 279 g U/L, in Plexiglas cylinders, 3 × 3 × 3 array, unreflected, walls, floor, and tank in experiment room included
CAS61	Problem U2B81F. 92.6% $UO_2(NO_3)_2$ solution, 279 g U/L, in Plexiglas cylinders, 2 × 2 × 2 array, unreflected, walls, floor, and tank in experiment room included
CAS62	Problem U4B1251F. 92.6% $UO_2(NO_3)_2$ solution, 415 g U/L, in Plexiglas cylinders, 5 × 5 × 5 array, unreflected, walls, floor, and tank in experiment room included
CAS64	Problem U4B641F. 92.6% $UO_2(NO_3)_2$ solution, 415 g U/L, in Plexiglas cylinders, 4 × 4 × 4 array, unreflected, walls, floor, and tank in experiment room included
CAS63	Problem U4B271F. 92.6% $UO_2(NO_3)_2$ solution, 415 g U/L, in Plexiglas cylinders, 3 × 3 × 3 array, unreflected, walls, floor, and tank in experiment room included
CAS65	Problem U4B81F. 92.6% $UO_2(NO_3)_2$ solution, 415 g U/L, in Plexiglas cylinders, 2 × 2 × 2 array, unreflected, walls, floor, and tank in experiment room included
CAS90	Problem U4U2B27. 92.6% $UO_2(NO_3)_2$ solution, 415 g U/L, in Plexiglas cylinders, 3 × 3 × 3 array, unreflected, 279 g U/L in 5 central units, walls, floor, and tank in experiment room included
CAS66	Problem U4R27AlF. 92.6% $UO_2(NO_3)_2$ solution, 415 g U/L, in Plexiglas cylinders, 3 × 3 × 3 array, reflected, 15.24 cm paraffin on bottom, 1.27-cm Plexiglas on other faces
CAS67	Problem U4R27BlF. 92.6% $UO_2(NO_3)_2$ solution, 415 g U/L, in Plexiglas cylinders, 3 × 3 × 3 array, reflected, 15.24-cm paraffin on bottom, 2.54-cm Plexiglas on other faces
CAS68	Problem U4R27C1F. 92.6% $UO_2(NO_3)_2$ solution, 415 g U/L, in Plexiglas cylinders, 3 × 3 × 3 array, reflected, 15.24-cm paraffin on bottom, 1.27-cm paraffin on other faces
CAS69	Problem U4R27D1F. 92.6% $UO_2(NO_3)_2$ solution, 415 g U/L, in Plexiglas cylinders, 3 × 3 × 3 array, reflected, 15.24-cm paraffin on 5 faces, 15.24-cm Plexiglas on 1 face

Table 2.1 (continued)

Case	Experimental description
CAS70	Problem U4R27ElF. 92.6% $UO_2(NO_3)_2$ solution, 415 g U/L, in Plexiglas cylinders, 3 × 3 × 3 array, reflected, 15.24-cm paraffin on bottom, 3.81-cm paraffin on other faces
CAS71	Problem U4R27FlF. 92.6% $UO_2(NO_3)_2$ solution, 415 g U/L, in Plexiglas cylinders, 3 × 3 × 3 array, reflected, 15.24-cm paraffin on bottom, 7.62-cm paraffin on other faces
CAS72	Problem U4R27GlF. 92.6% $UO_2(NO_3)_2$ solution, 415 g U/L, in Plexiglas cylinders, 3 × 3 × 3 array, reflected, 1.27-cm Plexiglas all faces
CAS73	Problem U4R27Hl F. 92.6% $UO_2(NO_3)_2$ solution, 415 g U/L, in Plexiglas cylinders, 3 × 3 × 3 array, reflected, 1.27-cm paraffin all faces
CAS74	Problem U4R27IlF. 92.6% $UO_2(NO_3)_2$ solution, 415 g U/L, in Plexiglas cylinders, 3 × 3 × 3 array, reflected, 15.24-cm paraffin all faces
CAS75	Problem U4R27JlF. 92.6% $UO_2(NO_3)_2$ solution, 415 g U/L, in Plexiglas cylinders, 3 × 3 × 3 array, reflected, 3.81-cm paraffin all faces
CAS76	Problem U4R8AlF. 92.6% $UO_2(NO_3)_2$ solution, 415 g U/L, in Plexiglas cylinders, 2 × 2 × 2 array, reflected, 15.24-cm paraffin on bottom, 1.27-cm Plexiglas on other faces
CAS77	Problem U4R8BlF. 92.6% $UO_2(NO_3)_2$ solution, 415 g U/L, in Plexiglas cylinders, 2 × 2 × 2 array, reflected, 15.24-cm paraffin on bottom, 11.43-cm Plexiglas on other faces
CAS78	Problem U4R8C1F. 92.6% $UO_2(NO_3)_2$ solution, 415 g U/L, in Plexiglas cylinders, 2 × 2 × 2 array, reflected, 15.24-cm paraffin on bottom, 15.24-cm Plexiglas on other faces
CAS79	Problem U4R8D1F. 92.6% $UO_2(NO_3)_2$ solution, 415 g U/L, in Plexiglas cylinders, 2 × 2 × 2 array, reflected, 15.24-cm paraffin on bottom, 2.54-cm Plexiglas on other faces
CAS80	Problem U4R8ElF. 92.6% $UO_2(NO_3)_2$ solution, 415 g U/L, in Plexiglas cylinders, 2 × 2 × 2 array, reflected, 15.24-cm paraffin on bottom, 4.45-cm Plexiglas on other faces

Table 2.1 (continued)

Case	Experimental description
CAS81	Problem U4R8FlF. 92.6% $UO_2(NO_3)_2$ solution, 415 g U/L, in Plexiglas cylinders, 2 × 2 × 2 array, reflected, 15.24-cm paraffin on bottom, 6.35-cm Plexiglas on other faces
CAS82	Problem U4R8GlF. 92.6% $UO_2(NO_3)_2$ solution, 415 g U/L, in Plexiglas cylinders, 2 × 2 × 2 array, reflected, 15.24-cm paraffin on bottom, 1.27-cm Plexiglas on other faces
CAS83	Problem U4R8HlF. 92.6% $UO_2(NO_3)_2$ solution, 415 g U/L, in Plexiglas cylinders, 2 × 2 × 2 array, reflected, 15.24-cm paraffin on bottom, 3.81-cm Plexiglas on other faces
CAS84	Problem U4R8IlF. 92.6% $UO_2(NO_3)_2$ solution, 415 g U/L, in Plexiglas cylinders, 2 × 2 × 2 array, reflected, 15.24-cm paraffin on bottom, 7.62-cm Plexiglas on other faces
CAS85	Problem U4R8J1F. 92.6% $UO_2(NO_3)_2$ solution, 415 g U/L, in Plexiglas cylinders, 2 × 2 × 2 array, reflected, 1.27-cm Plexiglas all faces
CAS86	Problem U4R8KlF. 92.6% $UO_2(NO_3)_2$ solution, 415 g U/L, in Plexiglas cylinders, 2 × 2 × 2 array, reflected, 1.27-cm paraffin all faces
CAS87	Problem U4R8L1F. 92.6% $UO_2(NO_3)_2$ solution, 415 g U/L, in Plexiglas cylinders, 2 × 2 × 2 array, reflected, 15.24-cm paraffin all faces
CAS88	Problem U4R8M1F. 92.6% $UO_2(NO_3)_2$ solution, 415 g U/L, in Plexiglas cylinders, 2 × 2 × 2 array, reflected, 3.81-cm paraffin all faces
CAS89	Problem U4R8N1F. 92.6% $UO_2(NO_3)_2$ solution, 415 g U/L, in Plexiglas cylinders, 2 × 2 × 2 array, reflected, 7.62-cm paraffin all faces
HEU-MET-FAST-001	Bare, highly enriched uranium sphere (Godiva) Same as CAS01
HEU-MET-FAST-004	Water-reflected, highly enriched uranium sphere Same as CAS02
HEU-SOL-THERM-001	Minimally reflected cylinders of highly enriched solutions of uranyl nitrate (10 experiments - Exp. 2 same as CAS03)

Table 2.1 (continued)

Case	Experimental description
HEU-SOL-THERM-007	Concrete reflected arrays highly enriched solutions of uranyl nitrate (17 experiments - Exp. 4 same as CAS21)
HEU-SOL-THERM-008	Plexiglas reflected arrays highly enriched solutions of uranyl nitrate (14 experiments - Exp. 4 same as CAS20)
HEU-SOL-THERM-013	Unreflected 174-L spheres of enriched uranium nitrate solutions (4 experiments - Exp. 1 same as CAS06)
Jemima	1/8 in.-thick × 15 in.-diam U(93) plates Experiment 1 – with no polyethylene disks Experiment 2 – with 1/16 in.-thick polyethylene disks Experiment 3 – with 1/8 in.-thick polyethylene disks Experiment 4 – with 1/4 in.-thick polyethylene disks Experiment 5 – with ½ in.-thick polyethylene disks Experiment 6 – with 1 in.-thick polyethylene disks Experiment 7 – with 1-1/2 in.-thick polyethylene disks Experiment 8 – with 2 in.-thick polyethylene disks

[a] Case from IHECSBE used instead

2.3.2 Low-Enriched Homogeneous ^{235}U Experiments

Forty-nine critical experiments from Table 3 of ORNL/TM-238 (Ref. 14) were selected to evaluate the performance of the cross-section libraries for low-enriched homogeneous uranium systems. A list of the experiments is provided in Table 2.2. The experiments consist of three types: (1) UF_4/paraffin blocks; (2) damp oxide powders (U_3O_8); and (3) uranyl fluoride solutions. These experiments are typical of those used to perform criticality-safety validation for the low-enriched portion of a diffusion plant.

Table 2.2 Low-enriched homogeneous ^{235}U experiments

Case	Experimental description
CAS04	An unreflected rectangular parallelepiped of homogeneous U(1.4)F_4 and paraffin with an H/U-235 atomic ratio of 421.8; 93.1 cm × 93.0 cm × 123.8 cm
CAS05	An unreflected rectangular parallelepiped of homogeneous U(1.4)F_4 and paraffin with an H/U-235 atomic ratio of 421.8; 100.0 cm × 99.9 cm × 103.1 cm
CAS06	An unreflected rectangular parallelepiped of homogeneous U(1.4)F_4 and paraffin with an H/U-235 atomic ratio of 421.8; 130.7 cm × 130.6 cm × 74.2 cm
CASl l	A reflected rectangular parallelepiped of homogeneous U(2)F_4 and paraffin with an H/U-235 atomic ratio of 195.2; 56.22 cm × 56.22 cm × 112.88 cm, reflected with 15.2 cm of paraffin on top and sides and 15.2 cm of Plexiglas on the bottom
CAS12	An unreflected rectangular parallelepiped of homogeneous U(2)F_4 and paraffin with an H/U-235 atomic ratio of 195.2; 71.47 cm × 71.47 cm × 94.14 cm
CAS13	A reflected rectangular parallelepiped of homogeneous U(2)F_4 and paraffin with an H/U-235 atomic ratio of 293.9; 51.11 cm × 51.11 cm × 73.87 cm, reflected with 15.2 cm of paraffin on top
CAS14	An unreflected rectangular parallelepiped of homogeneous U(2)F_4 and paraffin with an H/U-235 atomic ratio of 293.9; 56.22 cm × 56.22 cm × 122.47 cm
CAS15	A reflected rectangular parallelepiped of homogeneous U(2)F_4 and paraffin with an H/U-235 atomic ratio of 406.3; 53.67 cm × 53.67 cm × 54.29 cm, reflected with 15.2 cm of paraffin on top and sides and 15.2 cm of Plexiglas on the bottom

Table 2.2 (continued)

Case	Experimental description
CAS16	A reflected rectangular parallelepiped of homogeneous $U(2)F_4$ and paraffin with an H/U-235 atomic ratio of 495.9; 46.00 cm × 46.00 cm × 96.57 cm, reflected with 15.2 cm of paraffin on top and sides and 15.2 cm of Plexiglas on the bottom
CAS17	A reflected rectangular parallelepiped of homogeneous $U(2)F_4$ and paraffin with an H/U-235 atomic ratio of 613.6; 56.32 cm × 61.29 cm × 54.08 cm, reflected with 15.2 cm of polyethylene on top and sides and 15.2 cm of Plexiglas on the bottom
CAS18	An unreflected rectangular parallelepiped of homogeneous $U(2)F_4$ and paraffin with an H/U-235 atomic ratio of 613.6; 61.3 cm × 66.54 cm × 66.52 cm
CAS19	A reflected rectangular parallelepiped of homogeneous $U(2)F_4$ and paraffin with an H/U-235 atomic ratio of 971.7; 76.51 cm × 76.44 cm × 82.42 cm, reflected with 5.2 cm of polyethylene on top and sides and 15.2 cm of Plexiglas on the bottom
CAS20	An unreflected rectangular parallelepiped of homogeneous $U(2)F_4$ and paraffin with an H/U-235 atomic ratio of 971.7; 81.45 cm × 86.70 cm × 88.22 cm
CAS21	A reflected rectangular parallelepiped of homogeneous $U(3)F_4$ and paraffin with an H/U-235 atomic ratio of 133.4; 51.14 cm × 51.14 cm × 51.27 cm, reflected with 15.2 cm of paraffin on top and sides and 15.2 cm of Plexiglas on the bottom
CAS22	A reflected rectangular parallelepiped of homogeneous $U(3)F_4$ and paraffin with an H/U-235 atomic ratio of 133.4; 43.47 cm × 43.47 cm × 86.39 cm, reflected with 15.2 cm of paraffin on top and sides and 15.2 cm of Plexiglas on the bottom
CAS23	A reflected rectangular parallelepiped of homogeneous $U(3)F_4$ and paraffin with an H/U-235 atomic ratio of 133.4; 46.02 cm × 46.02 cm × 67.57 cm, reflected with 15.2 cm of paraffin on top and sides and 15.2 cm of Plexiglas on the bottom
CAS24	A reflected rectangular parallelepiped of homogeneous $U(3)F_4$ and paraffin with an H/U-235 atomic ratio of 133.4; 56.25 cm × 56.25 cm × 43.41 cm, reflected with 15.2 cm of paraffin on top and sides and 15.2 cm

Table 2.2 (continued)

Case	Experimental description
	of Plexiglas on the bottom
CAS25	A reflected rectangular parallelepiped of homogeneous $U(3)F_4$ and paraffin with an H/U-235 atomic ratio of 133.4; 61.36 cm × 61.36 cm × 38.67 cm, reflected with 15.2 cm of paraffin on top and sides and 15.2 cm of Plexiglas on the bottom
CAS26	An unreflected rectangular parallelepiped of homogeneous $U(3)F_4$ and paraffin with an H/U-235 atomic ratio of 133.4; 56.47 cm × 56.47 cm × 86.64 cm
CAS27	An unreflected rectangular parallelepiped of homogeneous $U(3)F_4$ and paraffin with an H/U-235 atomic ratio of 133.4; 56.25 cm × 61.36 cm × 74.38 cm
CAS28	An unreflected rectangular parallelepiped of homogeneous $U(3)F_4$ and paraffin with an H/U-235 atomic ratio of 133.4; 61.4 cm × 61.4 cm × 66.0 cm
CAS29	A reflected rectangular parallelepiped of homogeneous $U(3)F_4$ and paraffin with an H/U-235 atomic ratio of 276.9; 40.81 cm × 40.80 cm × 39.49 cm, reflected with 15.2 cm of polyethylene on top and sides and 15.2 cm of Plexiglas on the bottom
CAS30	An unreflected rectangular parallelepiped of homogeneous $U(3)F_4$ and paraffin with an H/U-235 atomic ratio of 276.9; 40.90 cm × 40.93 cm × 116.80 cm
CAS31	An unreflected rectangular parallelepiped of homogeneous $U(3)F_4$ and paraffin with an H/U-235 atomic ratio of 276.9; 48.59 cm × 51.14 cm × 48.53 cm
CAS32	An unreflected rectangular parallelepiped of homogeneous $U(3)F_4$ and paraffin with an H/U-235 atomic ratio of 276.9; 81.71 cm × 81.66 cm × 31.34 cm
CAS33	A composite cadmium/steel/water side reflected stainless steel cylinder of 0.079 cm wall thickness and 19.545 cm IR filled to a height of 54.45 cm with $U(4.98)O_2F_2$ solution at an H/U-235 atomic ratio of 488
CAS34	A composite 1-in. steel/water side reflected steel cylinder of 0.079 cm wall thickness and 16.51 cm IR filled to a height of 143 cm with $U(4.98)O_2F_2$ solution at an H/U-235 atomic ratio of 488

Table 2.2 (continued)

Case	Experimental description
CAS35	An unreflected sphere of $U(4.98)O_2F_2$ with an H/U-235 atomic ratio of 490. Solution radius of 25.3873 cm and stainless steel container wall thickness of 0.0508 cm
CAS36	An unreflected stainless steel cylinder of 0.07874 cm wall thickness and a 19.55 cm IR filled to a height of 101.7 cm, with $U(4.98)O_2F_2$ solution at H/U-235 atomic ratio of 496
CAR01	Experiment 1. 4.46%-enriched U_3O_8, H/U = 0.77, 42 fuel cans with 2.44-cm interstitial moderation, plastic-reflected
CAR02	Experiment 2. 4.46%-enriched U_3O_8, H/U = 0.77, 43 fuel cans with 2.44-cm interstitial moderation, plastic-reflected
CAR03	Experiment 3. 4.46%-enriched U_3O_8, H/U = 0.77, 100 fuel cans with 0.929-cm interstitial moderation, plastic-reflected
CAR04	Experiment 13. 4.46%-enriched U_3O_8, H/U = 0.77, 40 fuel cans with 2.44-cm interstitial moderation, concrete-reflected
CAR05	Experiment 15. 4.46%-enriched U_3O_8, H/U = 0.77, 98 fuel cans with 0.929-cm interstitial moderation, concrete-reflected
CAR06	4.46%-enriched U_3O_8, H/U = 0.77, driven by 93.12%-enriched uranium metal sphere (29.870 kg), 120 + 4S fuel cans, plastic-reflected
CAR07	4.46%-enriched U_3O_8, H/U = 0.77, driven by high-concentration (14.844 kg 351.18 gU/L) 93.17%-enriched $UO_2(NO_3)_2$, 119 + 2S fuel cans, plastic-reflected
CAR08	4.46% enriched U_3O_8, H/U = 0.77, driven by low-concentration (12.871 kg 86.42 gU/L) 93.17%-enriched $UO_2(NO_3)_2$, 119 + 2S fuel cans, plastic-reflected
CAR09	4.46% enriched U_3O_8, H/U = 0.77, driven by low-concentration (13.001 kg 86.42 gU/L) 93.17%-enriched $UO_2(NO_3)_2$, 119 + 2S fuel cans, plastic-reflected

Table 2.2 (continued)

Case	Experimental description
CAR10	4.46%-enriched U_3O_8, H/U = 0.77, driven by low concentration (12.446 kg 86.42 gU/L) 93.17%-enriched $UO_2(NO_3)_2$, 119 + 2S fuel cans, concrete-reflected
CAR11	Experiment A. 4.46%-enriched U_3O_8 H/U = 1.25, 38 fuel cans with 2.44-cm interstitial moderation, plastic-reflected
CAR12	Experiment B. 4.46%-enriched U_3O_8 H/U = 1.25, 78 fuel cans with 0.929-cm interstitial moderation, plastic-reflected
CAR13	Experiment C. 4.46%-enriched U_3O_8 H/U = 1.25, 80 fuel cans with 0.929-cm interstitial moderation, plastic-reflected
CAR14	4.46%-enriched U_3O_8 H/U = 1.25, driven by high concentration (12.268 kg 351.64 gU/L), 93.17%-enriched $UO_2(NO_3)_2$, 119 + 2S fuel cans, plastic-reflected
CAR15	4.46%-enriched U_3O_8 H/U = 1.25, driven by high concentration (12.400 kg 351.65 gU/L), 93.17%-enriched $UO_2(NO_3)_2$, 119 + 2S fuel cans, plastic-reflected
CAR16	4.46%-enriched U_3O_8 H/U = 1.25, driven by low concentration (10.836 kg 86.60 gU/L), 93.17% enriched $UO_2(NO_3)_2$, 119 + 2S fuel cans, plastic-reflected
CAR17	Experiment F. 4.46%-enriched U_3O_8 H/U = 2.03, 48 fuel cans with 0.92-cm interstitial moderation, plastic-reflected
CAR18	Experiment G. 4.46%-enriched U_3O_8 H/U = 2.03, 30 fuel cans with 2.44-cm interstitial moderation, plastic-reflected
CARl9	Experiment D. 4.46%-enriched U_3O_8 H/U = 2.03, driven by 93.12% enriched-uranium metal sphere (13.73 kg), 120 + 4S fuel cans, plastic-reflected
CAR20	Experiment E. 4.46%-enriched U_3O_8 H/U = 2.03, driven by 93.12%-enriched hollow uranium metal sphere (12.786 kg), 120 + 4S fuel cans, plastic-reflected

2.3.3 LWR Lattice Experiments

Critical experiment cases 1 through 59 were selected from Table 4.1 of NUREG/CR-6102 (Ref. 8) to evaluate the performance of the SCALE codes and cross-section libraries for heterogeneous systems. A list of the experiments is given in Table 2.3. These experiments are low-enriched light-water-reactor (LWR) lattices. The series of experiments demonstrates the performance of both the cross sections and the SCALE resonance cross-section processing methodology. These experiments span a range of moderation and fuel pin arrangements that might be of interest in evaluating LWR fuel storage and transport.

Table 2.3 LWR lattice experiments

Case No.	Case designation	Enrich. (wt %)	Description	Lattice water/fuel volume ratio
1	p2438x05	2.35	No absorber plates	2.92
2	p2438x17	2.35	Boral absorber plates	2.92
3	p2438x28	2.35	Stainless steel absorber plates	2.92
4	p2615x14	4.31	Stainless steel absorber plates	3.88
5	p2615x23	4.31	Cadmium absorber plates	3.88
6	p2615x31	4.31	Boral absorber plates	3.88
7	p2827u2a	2.35	Uranium reflector	2.92
8	p2827l2a	2.35	Lead reflector	2.92
9	p2827non	2.35	No reflector	2.92
10	p2827u2b	4.31	Uranium reflector	3.88
11	p2827l2b	4.31	Lead reflector	3.88
12	p3314a	4.31	0.226-cm Boroflex absorber plates	1.6
13	p3314b	4.31	0.452-cm Boroflex absorber plates	1.6
14	p3602n2	2.35	Steel reflector, no absorber	2.92
15	p3602non	4.31	Steel reflector, no absorber	1.6
16	p3602s4	4.31	Steel reflector, borated steel absorber plates	1.6
17	p3602b4	4.31	Steel reflector, Boral absorber plates	1.6

Table 2.3 (continued)

Case No.	Case designation	Enrich. (wt %)	Description	Lattice water/fuel volume ratio
18	p3602c4	4.31	Steel reflector, cadmium absorber plates	1.6
19	p3926u2a	2.35	Uranium reflector	1.6
20	p3926l2a	2.35	Lead reflector	1.6
21	p3926n2	2.35	No reflector	1.6
22	p3926u4a	4.31	Uranium reflector	1.6
23	p3926l4a	4.31	Lead reflector	1.6
24	p3926nob	4.31	No reflector	1.6
25	p4267a	4.31	No soluble boron	1.59
26	p4267b	4.31	2550 ppm soluble boron	1.59
27	p4267c	4.31	No soluble boron	1.09
28	p4267d	4.31	2550 ppm soluble boron	1.09
29	pnl194	4.31	Hexagonal lattice, narrow pitch	0.509
30	ft214r	4.31	Flux traps, no voids	1.6
31	ft214v3	4.31	Flux traps with voids	1.6
32	baw1231a		Core I — 1152 ppm soluble borom	0.994
33	baw1231b		Core I — 3389 ppm soluble borom	0.994
34	baw1273m	2.46	Core XX — 1675 ppm soluble boron	0.999
35	baw1484a	2.46	2.46 Core IV — 84 B4C pins — 1 pitch between assemblies	1.84
36	baw1484b	2.46	Core IX - No B4C pins — 4 pitches between assemblies	1.84
37	baw1484c	2.46	Core XIII - 1.6 wt % Boral — 1 pitch between assemblies	34.55
38	baw1484d	2.46	Core XXI - 0.1 wt % Boral — 3 pitches between assemblies	35.17
39	baw1645t	2.46	Triangular pitch, pitch = pin O.D.	0.149

Table 2.3 (continued)

Case No.	Case designation	Enrich. (wt %)	Description	Lattice water/fuel volume ratio
40	baw1645s	2.46	Square pitch, pitch = pin O.D.	0.383
41	bw1645so	2.46	Square pitch, pitch = 1.17*pin O.D.	1.014
42	bnw1810a	2.46 and 4.02	Core 12 - No Gd fuel rods	1.84 and 1.53
43	bnw1810b	2.46 and 4.02	Core 14 - 12 Gd fuel rods	1.84 and 1.53
44	bnw1810c	2.46 and 4.02	Core 16 - 16 Gd fuel rods	1.84 and 1.53
45	e196u6n	2.35	0.615-in. pitch, 0 ppm soluble boron	1.196
46	epru615b	2.35	0.615-in. pitch, 464 ppm soluble boron	1.196
47	epru75	2.35	0.750-in. pitch, 0 ppm soluble boron	2.408
48	epru75b	2.35	0.750-in. pitch, 568 ppm soluble boron	2.408
49	e196u87c	2.35	0.870-in. pitch, 0 ppm soluble boron	3.687
50	epru87b	2.35	0.870-in. pitch, 286 ppm soluble boron	3.687
51	saxu56	5.74	2 lattice pitches, SS clad, 0.56-in. pitch	1.933
52	saxu792	5.74	2 lattice pitches, SS clad, 0.792-in. pitch	5.067
53	w3269a	3.7	Ag-In-Cd (0.330-in. O.D) absorber rods, 0.405-in. pitch	2.2
54	w3269b	3.7	Ag-In-Cd (0.330-in. O.D) absorber rods, 0.435-in. pitch	2.9
55	w3269c	2.72	Ag-In-Cd (0.403-in. O.D) absorber rods, 0.600-in. pitch	3.1
56	ans33bp2	4.75	Cruciform box, polyethylene powder absorbers	1.81
57	ans33bb2	4.75	Cruciform box, polyethylene balls absorbers	1.81
58	ans33bh2	4.75	Cruciform box only	1.81
59	ans33h2	4.75	No absorbers	1.81

2.3.4 ^{239}Pu Experiments

Thirty-four critical experiments from Table E.2 of ORNL/TM-12374 (Ref. 17) were utilized to evaluate the plutonium cross sections in SCALE (see Table 2.4). These experiments span a range of geometry, moderation level, and ^{240}Pu content. In addition, four models were taken from the IHECSBE Handbook. These experiments are listed in Table 2.5.

Table 2.4 ^{239}Pu experiments from ORNL/TM-12374

Koponen citation ID No.[a]	H/Pu atom ratio	% ^{240}Pu ratio	Pu density (g/cm**3)	Geometry	Reflector
2110-2	125	5	0.172	Sphere	None
2110-4	758	5	0.034	Sphere	6.6 mm steel
2110-5	15	2	1.12	Parallelpiped	None
2110-6	15	2	1.12	Parallelpiped	Plexiglas
2110-7	422	5	0.058	Slab	None
2110-8	50	18	0.37	Parallelpiped	None
2110-9, 13	50	18	0.37	Parallelpiped	Plexiglas
2210-14	210	8	0.116	Cylinder	20 cm water
2110-15, 16	0	18	5.8	Parallelpiped	None
2110-17, 21	0	18	5.8	Parallelpiped	Plexiglas
2110-23	5	11	2.3	Parallelpiped	None
2110-24, 27	5	11	2.3	Parallelpiped	Plexiglas
2110-29	623	43	0.041	Cylinder	20 cm water
2110-30	1067	4.6	0.024	Sphere	20 cm water
2110-32	1031	4.6	0.025	Sphere	2 mm steel + 20 cm water
2109-20	684	4.6	0.036	Sphere	25.4 cm concrete
2109-21	684	4.6	0.0355	Sphere	10.16 cm concrete
2109-22	496	4.6	0.0452	Sphere	10.16 cm concrete
2109-23	454	4.6	0.0509	Sphere	0.762 mm Cd + 10.16 cm concrete
2109-24	540	4.6	0.0469	Sphere	0.762 mm Cd + 32 cm concrete
2109-25	0	4.8	15.375	Sphere	19.6 cm natural U
1727-09	0	5.5	19.74	Cylinder	Water

[a] Comma denotes inclusive (i.e., 17, 22 means experiments 17 through 22).

Table 2.5 ^{239}Pu experiments from IHECSBE Handbook

Case	Experiment description
PU-MET-FAST-001	^{239} Pu Jezebel: Bare Sphere of Plutonium-239 Metal
PU-MET-FAST-002	^{240} Pu Jezebel: Bare Sphere of Plutonium-239 Metal (20.1 at. % 240 Pu, 1.01 wt % Ga)
PU-SOL-THERM-004	Water-Reflected 14-in.-diam Spheres of Plutonium Nitrate Solutions, 0.54% to 3.43%
PU-SOL-THERM-009	Unreflected 48-in.-diam Sphere of Plutonium Nitrate Solution

2.3.5 ^{233}U Experiments

Thirty-three critical experiments involving ^{233}U were taken from the IHECSBE Handbook (see Table 2.6). These experiments span a range of geometry and moderation level. Only evaluated experiments were chosen for inclusion here because of known deficiencies in some of the experimental models and descriptions previously utilized for validation.

Table 2.6 ^{233}U critical experiments

IHECSBE Case No.	Experimental description
U233-MET-FAST-001	^{233}U Jezebel: A Bare Sphere of ^{233}U Metal
U233-MET-FAST-002	Benchmark Critical Experiments of ^{233}U Spheres Surrounded by ^{235}U Experiment No. 1, 10 kg ^{233}U core Experiment No. 2, 7.6 kg ^{233}U core
U233-MET-FAST-003	Benchmark Critical Experiments of Highly Enriched ^{233}U Spheres Reflected by Normal Uranium Experiment No. 1, 10 kg ^{233}U core Experiment No. 2, 7.6 kg ^{233}U core
U233-MET-FAST-004	Benchmark Critical Experiments of Highly Enriched ^{233}U Spheres
U233-MET-FAST-005	Benchmark Critical Experiment of Highly Enriched ^{233}U Spheres
U233-MET-FAST-006	Benchmark Critical Experiment of a ^{233}U Sphere Reflected by Natural Uranium with Flattop

Table 2.6 (continued)

IHECSBE Case No.	Experimental description		
U233-SOL-THERM-002	Paraffin-reflected 8-, 8.5-, 9-, 10-, and 12-in.-diam cylinders of ^{233}U Uranyl Nitrate Solutions		
	Experiment No.	Cylinder diameter (in.)	Solution height (cm)
	4	8	16.5195
	5	8	16.8195
	8	8	18.9195
	22	8	14.8195
	24	8	14.5195
	34	8	16.8195
	35	8	19.4195
	10	8.5	19.5253
	11	8.5	21.6253
	12	9	21.4331
	36	9	23.0331
	14	10	19.4482
	15	10	
	38	10	
	17	12	
	18	12	
	19	12	
U233-SOL-THERM-004	Paraffin-reflected 5-, 6-, and 7.5-in.-diam Cylinders of ^{233}U Uranyl		
	Experiment No.	Cylinder diameter (in.)	Solution height (cm)
	3	6	38.5880
	6	6	46.8880
	20	6	30.7880
	25	6	27.9880
	30	6	29.0880
	27	7.5	16.4109
	28	7.5	16.3109
	33	7.5	18.7109

2.3.6 Mixed-Oxide (MOX) Experiments

Critical experiment cases 60 through 77 from Table 4.1 of NUREG/CR-6102 (Ref. 8) were used to evaluate the performance of the SCALE codes and cross sections for mixed-oxide systems. These experiments include both LWR and fast-reactor-type mixed-oxide fuel pin lattices. The experiments are listed in Table 2.7.

Table 2.7 Mixed-oxide (MOX) lattice experiments

Case No.	Case designation	Enrich. (wt %)	Description	Lattice water/fuel volume ratio
LWR-type mixed-oxide (UO_2-PuO_2) fuel pin lattices				
60	epri70un	^{235}U: 0.72 ^{239}Pu: 90	0.700-in. pitch, 0 ppm soluble boron, 2 wt % PuO_2	1.195
61	epri70b	^{235}U: 0.72 ^{239}Pu: 90	0.700-in. pitch, 681 ppm soluble boron, 2 wt % PuO_2	1.195
62	epri87un	^{235}U: 0.72 ^{239}Pu: 90	0.870-in. pitch, 0 ppm soluble boron, 2 wt % PuO_2	1.527
63	epri87b	^{235}U: 0.72 ^{239}Pu: 90	0.870-in. pitch, 1090 ppm soluble boron, 2 wt % PuO_2	1.527
64	epri99un	^{235}U: 0.72 ^{239}Pu: 90	0.990-in. pitch, 0 ppm soluble boron, 2 wt % PuO_2	3.641
65	epri99b	^{235}U: 0.72 ^{239}Pu: 90	0.990-in. pitch, 767 ppm soluble boron, 2 wt % PuO_2	3.641
66	saxton52	^{235}U: 0.72 ^{239}Pu: 90	UO_2/PuO_2 square lattice, 0.52-in. pitch, 6.6 wt % PuO_2	1.681
67	saxton56	^{235}U: 0.72 ^{239}Pu: 90	UO_2/PuO_2 square lattice, 0.56-in. pitch, 6.6 wt % PuO_2	2.165
68	saxtn56b	^{235}U: 0.72 ^{239}Pu: 90	UO_2/PuO_2 square lattice, 0.56-in. pitch, 337 ppm boron, 6.6 wt % PuO_2	2.165
69	saxtn735	^{235}U: 0.72 ^{239}Pu: 90	UO_2/PuO_2 square lattice, 0.735-in. pitch, 6.6 wt % PuO_2	4.699
70	saxtn792	^{235}U: 0.72 ^{239}Pu: 90	UO_2/PuO_2 square lattice, 0.792-in. pitch, 6.6 wt % PuO_2	5.673
71	saxtn104	^{235}U: 0.72 ^{239}Pu: 90	UO_2/PuO_2 square lattice, 1.04-in. pitch, 6.6 wt % PuO_2	10.754

Table 2.7 (continued)

Case No.	Case designation	Enrich. (wt %)	Description	Lattice water/fuel volume ratio
72	pnl4976	^{235}U: 0.72 ^{239}Pu: 90 and ^{235}U: 4.31	MOX & UO_2 rods in uniform pattern, 2 wt % PuO_2 in MOX	0.460 and 0.509
Fast Reactor (FFTF) mixed oxide (UO_2-PuO_2) fuel pin lattices				
73	p5803x21	^{235}U: 0.72 ^{239}Pu: 86	FFTF rods, H_2O-moderated, 0.968-cm pitch, 20 wt % PuO_2	3.49
74	p5803x32	^{235}U: 0.72 ^{239}Pu: 86	FFTF rods, H_2O-moderated, 1.935-cm pitch, 20 wt % PuO_2	18.13
75	p5803x43	^{235}U: 0.72 ^{239}Pu: 86	FFTF rods, H_2O-moderated, 1.242-cm pitch, 20 wt % PuO_2	6.65
76	p5803x67	^{235}U: 0.72 ^{239}Pu: 86	FFTF rods, H_2O-moderated, 0.761-cm pitch, 20 wt % PuO_2	1.62
77	p5803x68r	^{235}U: 0.72 ^{239}Pu: 86	FFTF rods, H_2O-moderated, 1.537-cm pitch, 20 wt % PuO_2	10.93

2.4 INTERPRETATION AND PRESENTATION OF CALCULATED RESULTS

Substantial emphasis is placed on the demonstration of performance of the cross-section libraries for a set of critical experiments. This method is an ideal means of evaluating a cross-section library for a particular application. It establishes the bias and trends of the codes and cross-section data used for specific types of applications. All of the critical systems have an experimental k_{eff} = 1. However, not all of the experiments and models utilized here have been evaluated for uncertainties in the experimental descriptions or approximations used to develop the models. Because of this, one cannot absolutely show that differences between the calculated k_{eff} value and a k_{eff} = 1 are due to the codes and cross sections used in the calculation. Several calculated k_{eff} values from the cross-section libraries may show similar trends. These trends could be due to common characteristics of the cross sections or may stem from uncertainties in the experiments or calculational models. In either case, when there are unexplained trends or large scatter in the calculational results, a larger margin of subcriticality should be applied when establishing the subcriticality of similar systems. A statistical method for establishing the upper subcritical limit is presented in Ref. 18.

When calculations are performed with multiple cross-section libraries for the same set of experiments, several items become of interest: overall shift in the average bias for a set of experiments, any changes in trends, and whether the scatter in the calculated k_{eff} values becomes larger or smaller. Comparison of the performance of multiple libraries against the same set of models can effectively show when there are significant deficiencies in one or more of the libraries.

The figures in the subsequent sections are presented as calculated k_{eff} values vs the calculated spectral parameter defined as the energy corresponding to the average lethargy of the neutron causing fission (EALF). This parameter is useful because it contains significant information about the neutronics of the system. It is an indicator of the average neutron flux spectrum for a system and the relative importance of the various energy regions of the flux on the fission multiplication. The EALF is sensitive to characteristics of the system moderator, the degree of moderation, the effect of absorbers in the system, fissile materials in the system, and the effects of leakage and reflecting materials on the system. The EALF, however, does not indicate directly what material is governing the slowing down and transport in the system.

For most of the systems utilized in this performance assessment, hydrogen is the principal moderator. Extension of the results to interpret performance for systems in which materials other than hydrogen are the principal moderator is not recommended. Benchmark calculations using critical experiments with the same moderator material are strongly recommended.

3 THE SCALE 16-GROUP HANSEN-ROACH LIBRARY

3.1 ORIGINS OF THE LIBRARY

The SCALE 16-group Hansen-Roach library is based on the original Los Alamos report[4] by Hansen and Roach. It was originally intended for fast calculations (6 fast groups), and later extended to 16 groups, covering the full energy range. It is the only library discussed in this report that was not generated at ORNL. The original Hansen-Roach library was modified for easy use in the SCALE system. Several important nuclides not available in the original library were added by collapsing the 27-group ENDF/B-IV library to the 16-group structure of the Hansen-Roach library. The 16-group Hansen-Roach energy-group structure is shown in Appendix A. A list of available nuclides in the library together with the source of the data for each nuclide are provided in Appendix C.

The original Hansen-Roach library was primarily developed for fast ^{235}U systems. There are 12 fast groups and 4 thermal groups (below 3 eV). However, thermal upscatter was not included in the original Hansen-Roach data. It has been included in the nuclides added for SCALE, although most of those are heavy nuclides where thermal upscatter is not important. The original cross sections are generally P_0 cross sections that are transport corrected to account for leakage. Two exceptions are hydrogen and deuterium, which are P_1 with P_2 transport corrections. All of the nuclides later added to the original library were generated to the P_3 scattering order. One other significant improvement to the original library was made by Knight's modifications, where multipliers for the ^{238}U capture cross section were generated as a function of background cross section based on three sets of low-enriched critical experiments (PCTR). This last modification was key to extending the use of the SCALE Hansen-Roach library to thermal low-enriched-uranium systems.

Resonance nuclides in the original Hansen-Roach library had cross sections tabulated at several σ_p values. Prior to the development of the CSAS sequences in SCALE, the selection of one of these preprocessed shielded cross-section sets at Oak Ridge[19] was made by hand calculation of σ_p for the problem of interest and the user then selecting the closest shielded cross-section set. When the Hansen-Roach library was incorporated into SCALE, the calculation of σ_p was automated. The method used to calculate σ_p and to select the shielded cross-sections will impact the performance of the Hansen-Roach library. The SCALE methodology has been used for the calculations discussed here.

In SCALE, σ_p is calculated on a group-wise basis using the total cross section. Cross-section shielding is then done on a group-wise basis with standard SCALE cross-section processing modules, in particular, the BONAMI module.

To make the original Hansen-Roach cross sections compatible with the SCALE system, an infinite dilution set was defined for each resonance nuclide and Bondarenko data were generated for the remaining values of σ_p. This procedure required the generation of a 16-group total cross section for each nuclide to allow BONAMI to perform automatic problem-dependent cross-section processing. The original Hansen-Roach library did not carry total cross sections, per se, but contained a total cross section that included a transport correction. In order to implement the Hansen-Roach cross sections in SCALE, an infinitely dilute 16-group total cross section was generated from the SCALE 27-group library and added to the SCALE Hansen-Roach library as MT-201. The Bondarenko iteration scheme in BONAMI automatically uses MT-201 when it is present in a cross-section library; this feature permitted the original SCALE control modules to use BONAMI with the SCALE Hansen-Roach library.

Another characteristic of the SCALE Hansen-Roach library is that two sets of hydrogen cross sections are available: the dE/E set and the $\chi(E)$ set. These cross sections use different weighting schemes in the fast region. Historically, the $\chi(E)$ hydrogen was intended for fast systems and the dE/E hydrogen was intended for thermal systems. In SCALE, dE/E hydrogen is used by default in the standard compositions that contain hydrogen. Differences as large as 2% in k_{eff} can occur, depending on which hydrogen is used. All of the calculations presented here utilize the default dE/E hydrogen.

It is important to note that the original Hansen-Roach library is still used and that several techniques exist for calculating σ_p values (for example, see Ref. 20). Use of the original library and/or use of an approach to determine σ_p values other than that employed in SCALE can provide different performance than reported here for the SCALE Hansen-Roach library.

3.2 PERFORMANCE WITH HIGH-ENRICHED HOMOGENEOUS ^{235}U SYSTEMS

Figure 3.1 shows calculated k_{eff} values for highly enriched ^{235}U systems using the SCALE 16-group Hansen-Roach library. The overall trend shows an average k_{eff} of approximately 0.990 for thermal systems and 0.995 for fast systems.

3.2.1 High-Enriched Fast Systems

Fast systems in Figure 3.1 are represented by the group of calculations at an EALF of 8×10^5 eV. The original 16-group Hansen-Roach library was designed for calculation of systems similar to these. The fast systems have an average k_{eff} of about 0.995, with a variation of about ±1%.

3.2.2 High-Enriched Thermal Systems

Thermal systems in Figure 3.1 are about 0.990, with a variation of about ±2%. There is a wide spread of results in the thermal range (k_{eff} <0.96 to k_{eff} > 1.02). Similar spreads can be seen in the results for the other libraries, too. The possibility of large uncertainties in the specifications for the critical systems used to validate the thermal range cannot be ruled out as the source of the large variations in calculated k_{eff} values.

The trends and large variability of the SCALE Hansen-Roach library have been encountered in the past. Similar trends have been observed previously with uranyl nitrate solution benchmark calculations.

3.2.3 High-Enriched Intermediate-Spectrum Systems

Intermediate spectrum systems in Fig. 3.1 are those with an EALF between 3 eV and 8×10^5 eV. Few critical experiments are in the intermediate range. These systems are characterized by an ill-defined average around a k_{eff} of 1.005, with a spread of about ±1.5%. The Hansen-Roach library has few groups across the intermediate energy range. The library is a transport-corrected P_0 (isotropic-scatter) library, except for hydrogen and deuterium, which are P_2 transport-corrected P_1 cross sections. Generally, only the fissile and fissionable isotopes have resonance data. **The cross sections are not well suited for calculation of systems in the intermediate-spectrum range.**

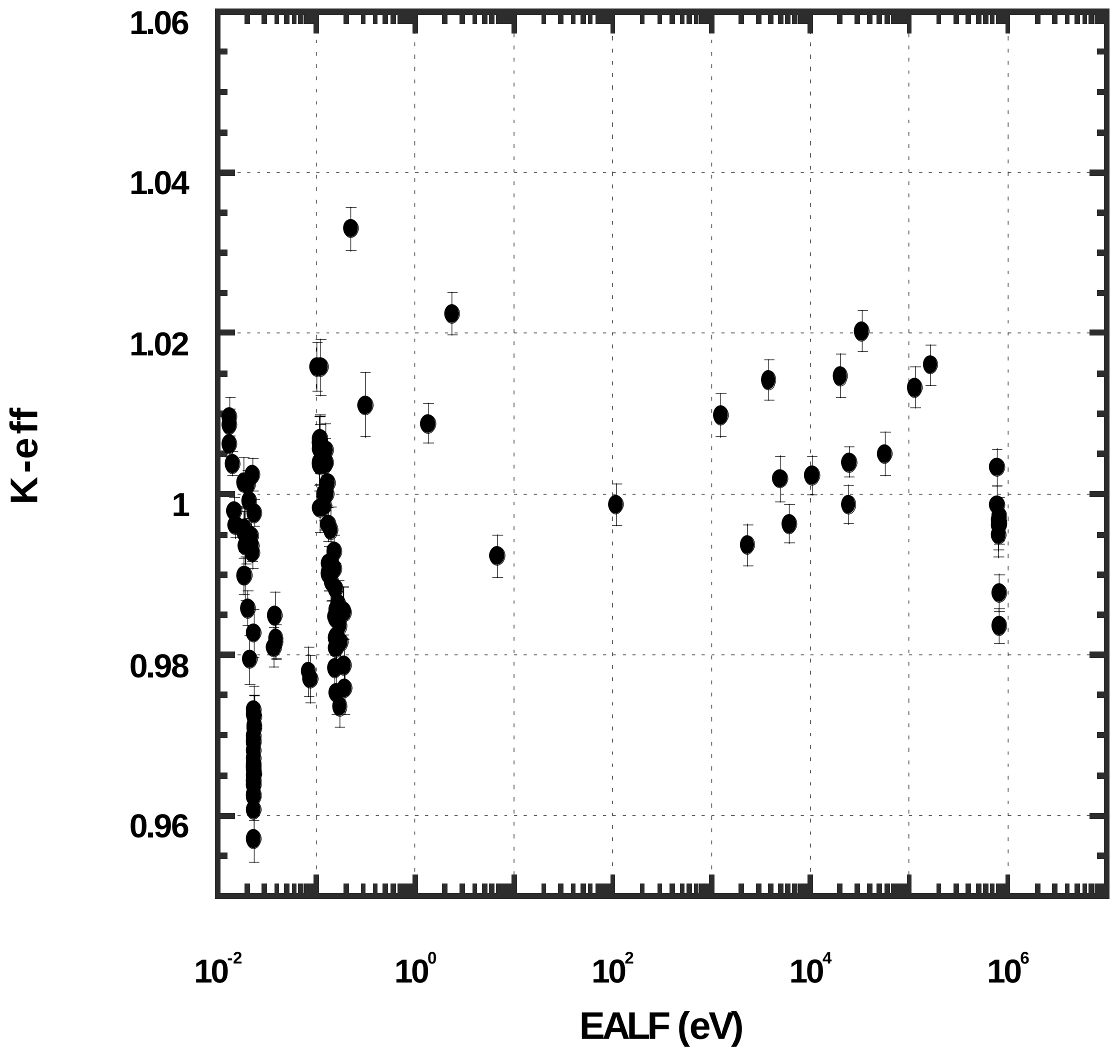

Figure 3.1 SCALE 16-group Hansen-Roach library high-enriched ^{235}U system results

3.3 PERFORMANCE WITH LOW-ENRICHED HOMOGENEOUS ^{235}U SYSTEMS

The performance of the SCALE 16-group Hansen-Roach library for homogeneous low-enriched systems is shown in Figure 3.2. The homogeneous experiments have ^{235}U enrichments below 5%. The calculations show a strong trend as a function of EALF, which is directly related to the moderation level. This trend is probably related to limitations in the narrow resonance approximation and to the ^{238}U resonance cross sections in the Hansen-Roach library.

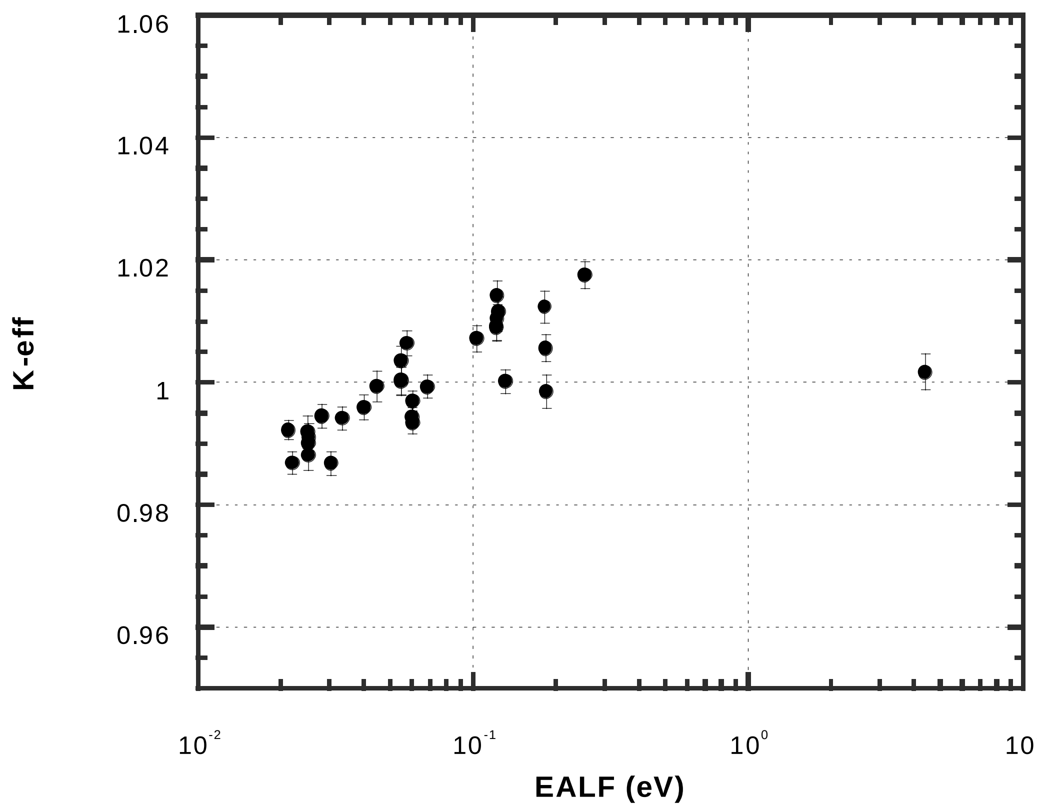

Figure 3.2 SCALE 16-group Hansen-Roach library low-enriched homogeneous ^{235}U system results

3.4 PERFORMANCE WITH LWR LATTICES

The performance of the SCALE 16-group Hansen-Roach library for heterogeneous low-enriched LWR lattice systems is shown in Figure 3.3. The maximum enrichment in the LWR lattice experiments is 5.74 wt % ^{235}U. No significant trends are apparent in the SCALE Hansen-Roach library results for heterogeneous low-enriched uranium calculations. Almost all of the cases containing boron had a calculated k_{eff} value of 1.0 or greater. The experiments have an average k_{eff} of about 1.0 with a ±1.5% variation.

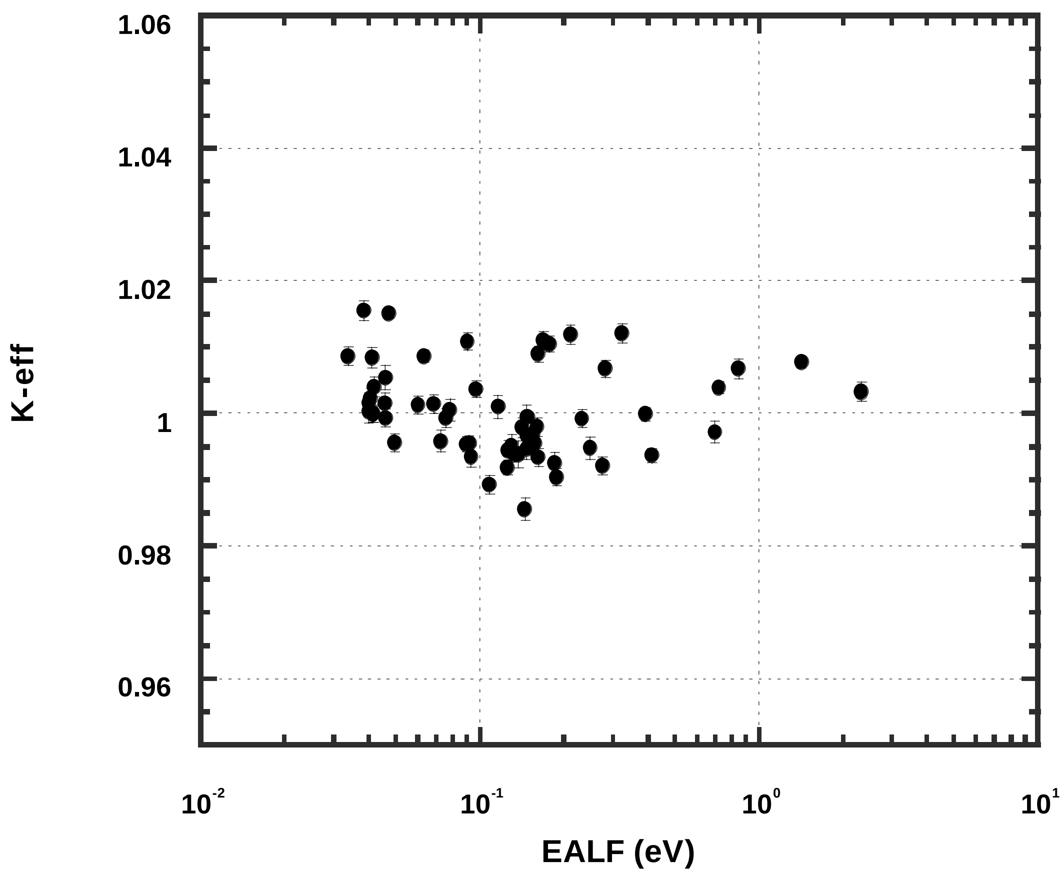

Figure 3.3 SCALE 16-group Hansen-Roach library low-enriched LWR lattice results

3.5 PERFORMANCE WITH ^{239}Pu SYSTEMS

The performance of the SCALE 16-group Hansen-Roach library for ^{239}Pu systems is shown in Figure 3.4. The performance of the library is generally poor. The library shows an overall 2% positive bias with a +1% to −3% variation. This bias is probably due to poor thermal cross sections and inadequate group structure and resonance data. There are strong localized trends in the thermal region and the intermediate-spectrum region which would be difficult to take into account for systems that are not closely related to the validation experiments.

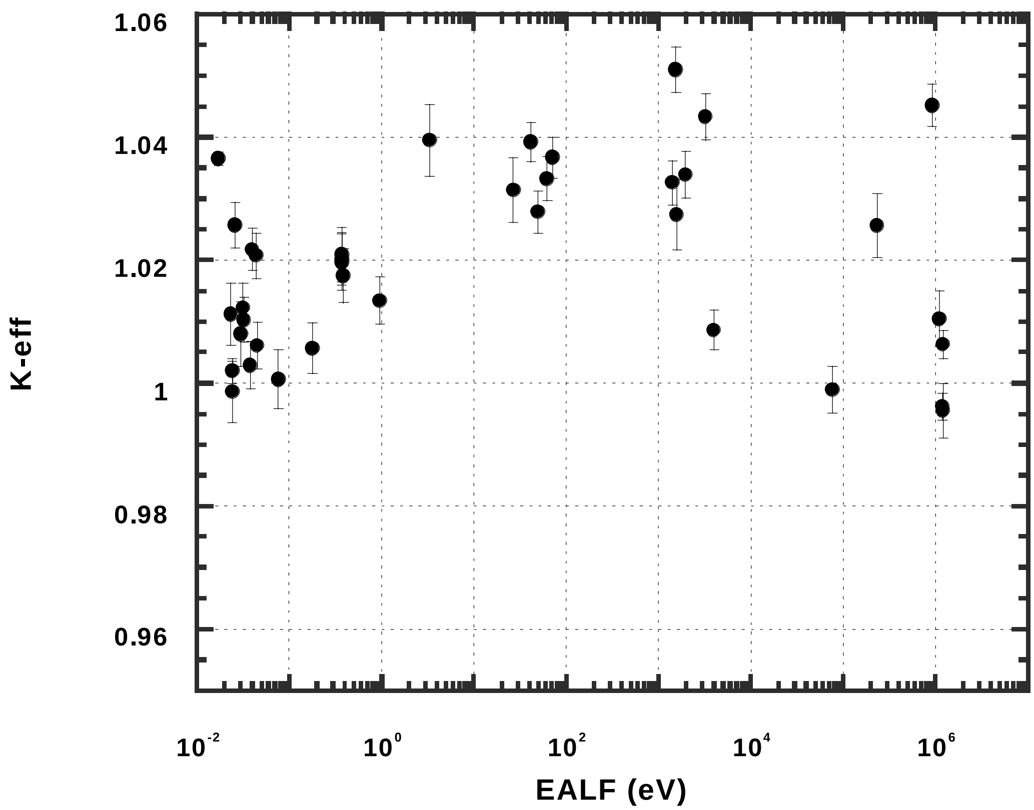

Figure 3.4 SCALE 16-group Hansen-Roach library plutonium system results

3.6 PERFORMANCE WITH ^{233}U SYSTEMS

The performance of the SCALE 16-group Hansen-Roach library for ^{233}U systems is shown in Figure 3.5. The performance of the library is generally poor, with the exception of the fast ^{233}U metal systems with an EALF around 1×10^6 eV. This performance is probably due to poor thermal cross sections and inadequate group structure and resonance data. The thermal systems have an average k_{eff} of about 0.99 with a ±2% variation. There is a strong local trend in the thermal data, similar to that seen for the highly enriched uranium systems. This trend would be difficult to take into account for systems that are not closely related to the validation experiments.

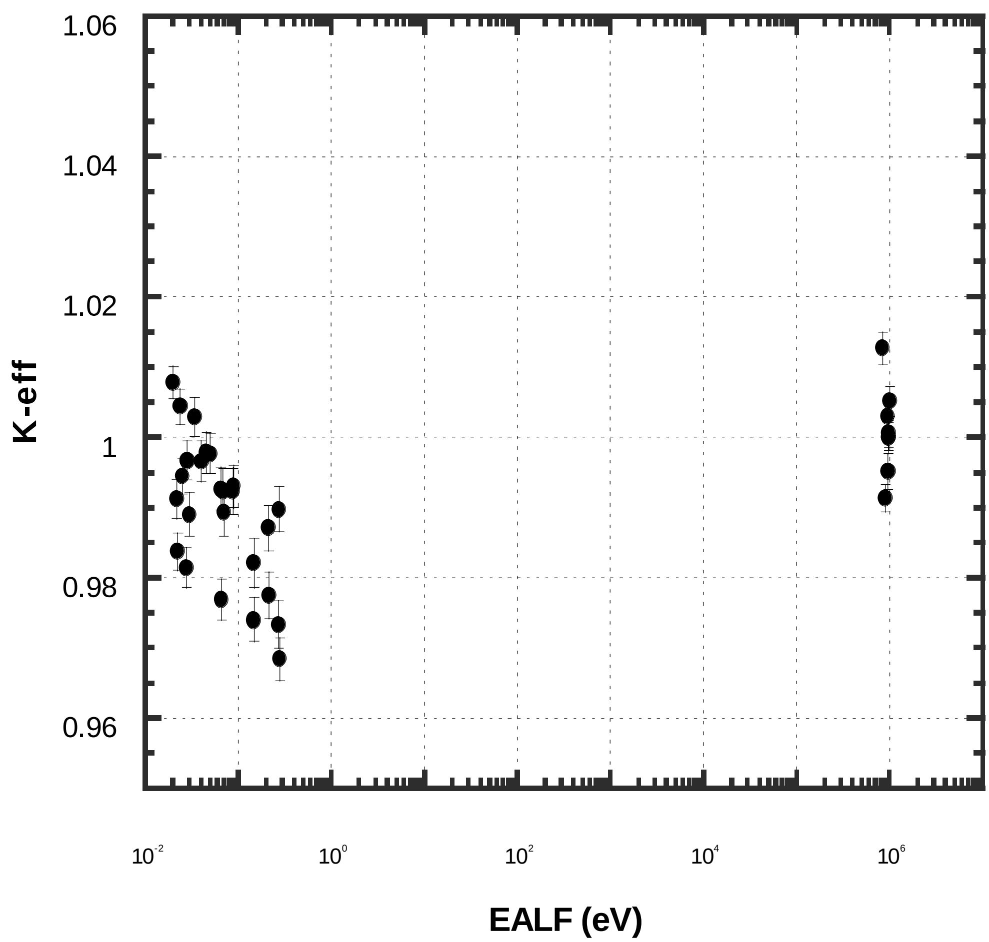

Figure 3.5 SCALE 16-group Hansen-Roach library ^{233}U system results

3.7 PERFORMANCE WITH MIXED-OXIDE LATTICES

The performance of the SCALE 16-group Hansen-Roach library for mixed-oxide (MOX) lattices is shown in Figure 3.6. All of the MOX lattice systems considered here are water-moderated thermal systems. The performance of the library is poor, probably due to inadequate group structure and resonance data. Calculated results show a sharply negatiave trend as a function of EALF, with k_{eff} values ranging from about 1.03 to 0.985. This trend would be difficult to take into account for systems that are not closely related to the validation experiments.

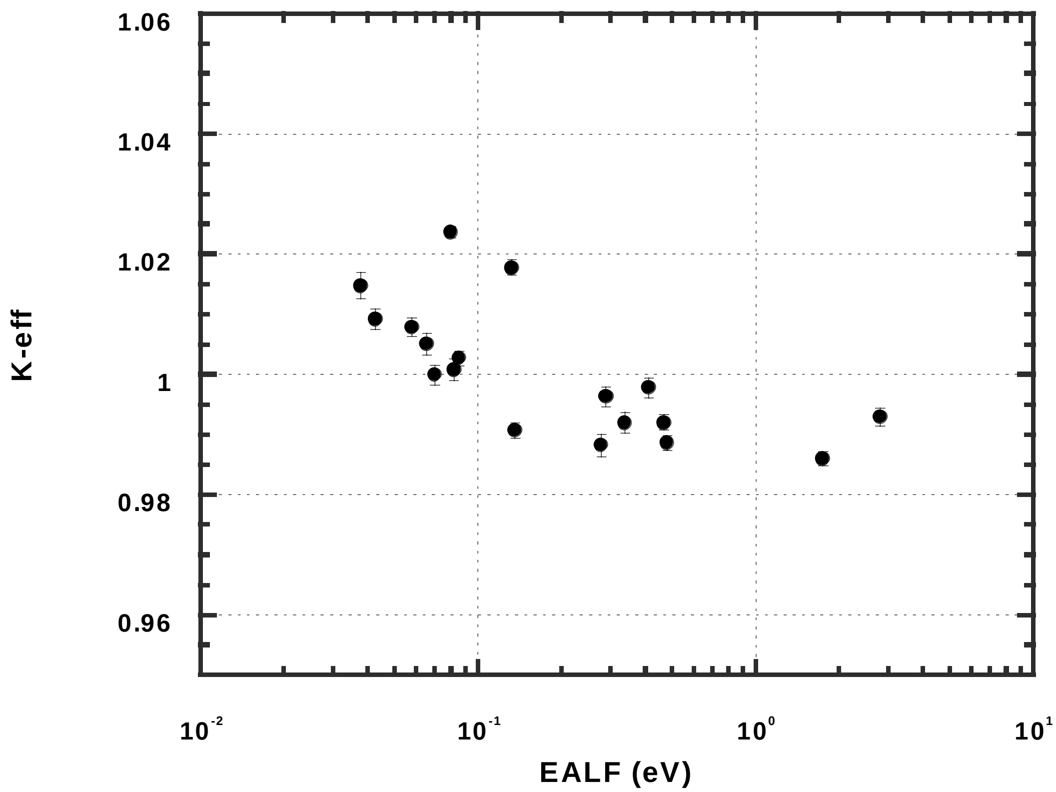

Figure 3.6 SCALE 16-group Hansen-Roach library mixed-oxide lattice results

4 THE 218-GROUP ENDF/B-IV LIBRARY

4.1 ORIGINS OF THE LIBRARY

The 218-group ENDF/B-IV library[6] was the most complete library available in SCALE prior to the release of the SCALE ENDF/B-V libraries in SCALE 4.3. The source of the data was ENDF/B-IV, and the processing of the cross sections by XLACS in the AMPX system is well documented.[6] The weighting function used in the P_3 cross-section generation was a fission-1/($E\sigma_t$)-Maxwellian weighting [except for resonance nuclides, which were weighted 1/E instead of 1/($E\sigma_t$)]. The 1/($E\sigma_t$) weighting preserved the resonance structure in nonresonance nuclides and allowed the library to be successfully collapsed to a broad-group structure that generally could reproduce the behavior of the fine-group library. One of the features of the library is that explicit resonance data carried with it can be used to generate problem-dependent, resolved resonance region multigroup cross sections using NITAWL-II. This capability allows great flexibility in the use of the library as a general-purpose criticality safety analysis library. Only the *s*-wave resonances are contained explicitly. Any *p*- and *d*-wave resonances were integrated into the background cross section. The library has 140 fast groups and 78 thermal groups (below 3.05 eV). The group structure was designed to fit the cross-section variation and reaction thresholds of the light and intermediate nuclides and to fit the major resonances of the intermediate and heavy nuclides. No unresolved resonance data are carried in the library. The unresolved resonance region was processed at σ_p = 50,000 barns.

The 218-group library has not been routinely validated because of its size and the related costs. However, the 27-group ENDF/B-IV library was derived directly from the 218-group library and has been validated against a large number of critical experiments (see Section 5). The 218-fine-group structure of the library generally will give either the same or more precise results than its companion 27-broad-group library.

An obvious advantage of a fine-group library over a broad-group library is that the library is less sensitive to the weighting spectrum used to generate the library. The cross sections more closely represent the base data, and the group structure allows a more detailed determination of the energy dependence of the flux. In past validations, it has been found useful to compare a fine-group calculation against a broad-group calculation when bias is observed. Appendix D contains a complete listing of the 218-group library nuclides, as well as those nuclides that have resonance data or thermal scattering data.

4.2 CHARACTERISTICS OF THE ENDF/B-IV LIBRARIES

The ENDF/B-IV libraries have generally displayed a negative bias of approximately 1%, and in some cases as much as 2%, for low-enriched, water-moderated UO_2 rods. The bias appears to be greatest for epithermal systems (e.g., borated water and/or closely spaced rods) and less significant for more thermalized systems. The bias has been traced in part to the lack of data in the unresolved resonance region for ^{238}U in ENDF/B-IV. The unresolved resonance region in the SCALE ENDF/B-IV libraries was processed at σ_p = 50,000 barns, which is extremely high compared to σ_p values of 3500 barns for ^{235}U and 65 barns for ^{238}U in a typical LWR lattice. For well-thermalized systems, the unresolved resonance region is not important, and the high σ_p value is inconsequential. However, as the spectrum hardens the resolved resonance region (where ENDF/B-IV had some inadequacies) and the unresolved region become more important. Thus, the SCALE ENDF/B-IV libraries trend toward a lower k_{eff} value as the spectrum hardens. Improved resonance data in ENDF/B-V eliminated this bias in the 44-group library.

A positive bias has been routinely observed in the ENDF/B-IV libraries for thermal ^{239}Pu systems and mixed-oxide (MOX) fuel rods. The MOX fuel rod bias increases with increasing thermalization. One problem identified in the 27-group library was inadequate group structure to account for flux changes across the 0.3-eV resonance of ^{239}Pu. This problem has been rectified in the 44-group ENDF/B-V library by the addition of more energy groups in this energy range.

Carbon system numerical benchmarks have shown a negative bias of as much as 2.5% with the ENDF/B-IV libraries when compared with the Hansen-Roach and ENDF/B-V libraries. Analysis of the 218-group cross-section data has revealed an incorrect scatter matrix for carbon in energy group 10 (3000 to 550 eV). In addition, the graphite thermal kernel is deficient. The impact of this deficiency is unknown.

The hafnium cross-section data available in the 218- and 27-group ENDF/B-IV libraries are not ENDF/B-IV data. The hafnium data were submitted for ENDF/B-II, but never included. Hafnium cross sections were not included in ENDF until version V. Known irregularities are present in the cross sections, and no resonance data are available with the nuclide. The cross sections are infinite dilution (1/E weighting) across the resonance range. **Use of the hafnium data in the ENDF/B-IV libraries is not recommended and should be done with caution.** Note that none of the benchmark cases in this report contain hafnium.

Systems containing gadolinium have not calculated well with the 27-group library. The problem stems from the characteristic of the gadolinium data in the thermal range. Gadolinium has low-energy resonance data down to 10^{-5} eV. The resonances are so broad that the implementation of the Nordheim treatment in NITAWL-II fails to have a mesh point in group 27 (0.01 to 0.00001 eV) of the 27-group structure. This difficulty has been addressed by setting the bottom energy of the resonance data to that of group 26 (0.03 to 0.01 eV) and carrying infinite dilution cross sections in group 27 of the master library. In addition, the ENDF resonance data for gadolinium prior to version VI are not well defined. **Use of the gadolinium data in the ENDF/B-IV libraries is not recommended and should be done with caution**. Two of the LWR lattice experiments contain gadolinium.

4.3 PERFORMANCE WITH HIGH-ENRICHED HOMOGENEOUS ^{235}U SYSTEMS

Figure 4.1 shows calculated k_{eff} values for highly enriched ^{235}U systems using the SCALE 218-group ENDF/B-IV library. The overall trend shows an average k_{eff} of approximately 1.00 for thermal and fast systems, with a large variation in results for thermal systems.

4.3.1 High-Enriched Fast Systems

Fast systems in Figure 4.1 are represented by the group of calculations at an EALF of 8×10^5 eV or greater. The fast systems have an average k_{eff} of about 1.00, with a variation of about ±1%.

4.3.2 High-Enriched Thermal Systems

Thermal systems in Figure 4.1 are represented by the calculations with an EALF below about 3 eV. The average k_{eff} in the thermal region is about 1.00, with a variation of roughly ±2%. There is a wide spread of results in the thermal range (k_{eff} <0.98 to k_{eff} > 1.03). Similar spreads can be seen in the results for the other libraries, too.

Most of the cases between 0.01 and 0.1 eV are uranyl fluoride solutions that tend to have a more negative bias. Most of the cases between 0.1 and 1 eV are uranyl nitrate solutions that show a more positive bias. The possibility of large uncertainties in the specifications for the critical systems used to validate the thermal range cannot be ruled out as the source of the large variations in calculated k_{eff} values.

4.3.3 High-Enriched Intermediate-Spectrum Systems

Intermediate-spectrum systems in Figure 4.1 are those with an EALF between 3 eV and 8×10^5 eV. Few critical experiments are in the intermediate range. These systems are characterized by an ill-defined average k_{eff} of 1.00, with a spread of about ±1.5%.

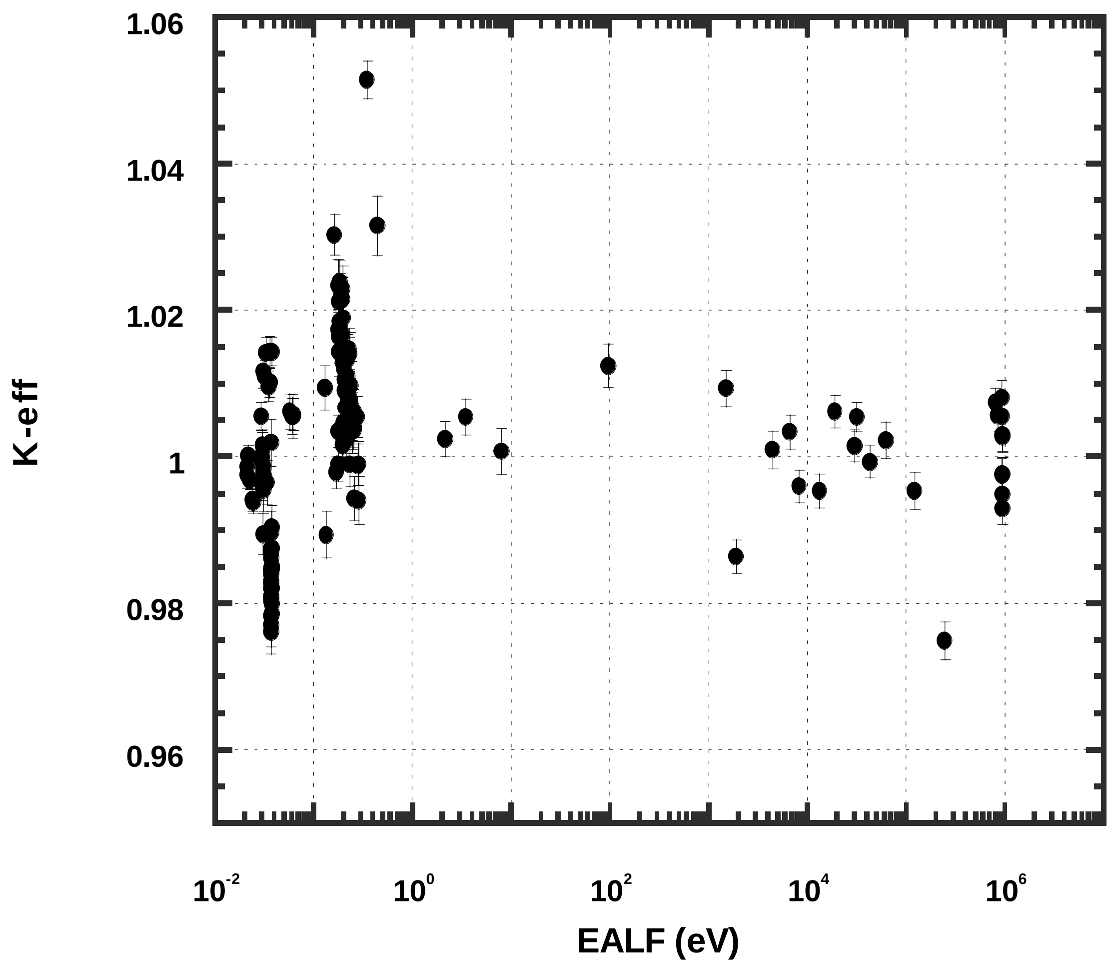

Figure 4.1 SCALE 218-group ENDF/B-IV library high-enriched ^{235}U system results

4.4 PERFORMANCE WITH LOW-ENRICHED HOMOGENEOUS ^{235}U SYSTEMS

The performance of the SCALE 218-group ENDF/B-IV library for homogeneous low-enriched systems is shown in Figure 4.2. The homogeneous experiments have ^{235}U enrichments below 5%. The calculations do not show a trend as a function of EALF, which is directly related to the moderation level. The average calculated k_{eff} value is approximately 0.995 ± 1.5%.

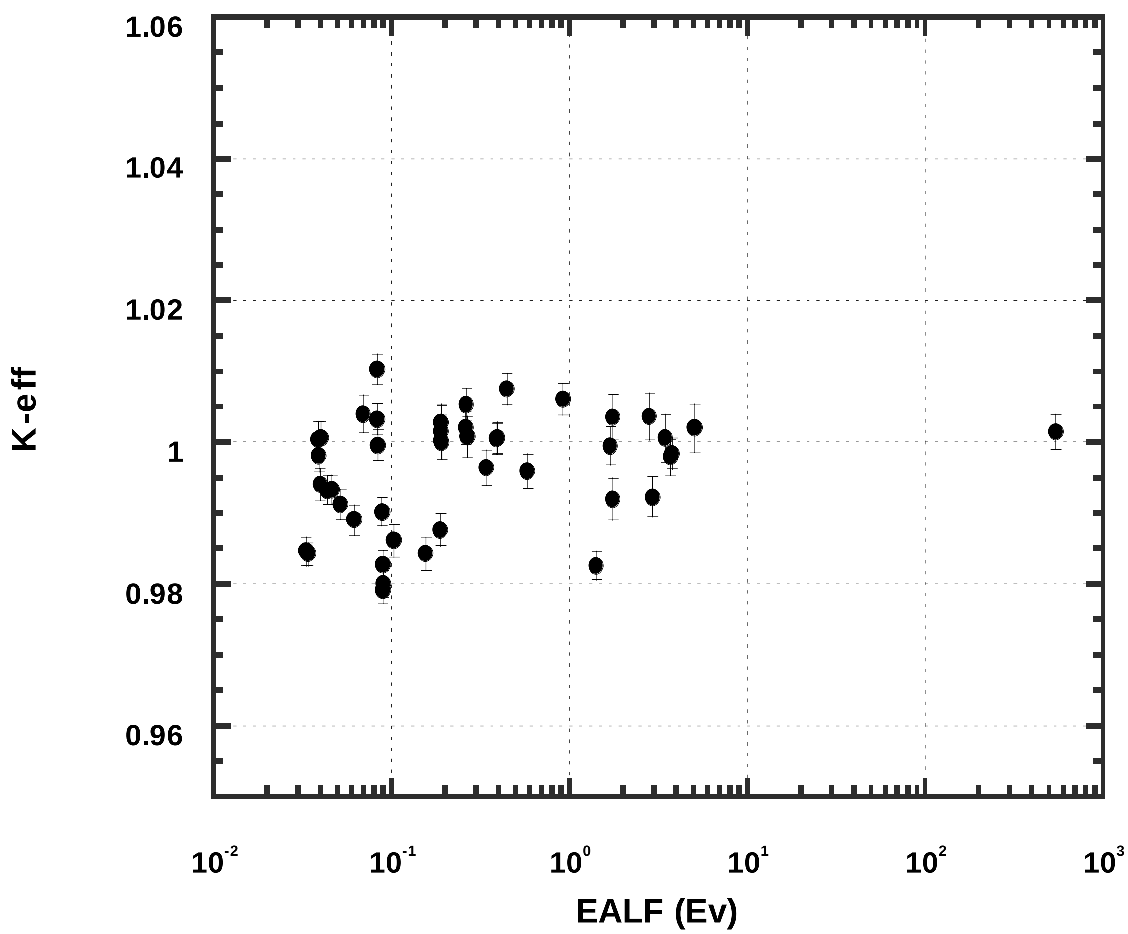

Figure 4.2 SCALE 218-group ENDF/B-IV library low-enriched homogeneous ^{235}U system results

4.5 PERFORMANCE WITH LWR LATTICES

The performance of the SCALE 218-group ENDF/B-IV library for heterogeneous low-enriched LWR lattice systems is shown in Figure 4.3. The maximum enrichment in the LWR lattice experiments is 5.74 wt % ^{235}U. The experiments have an average k_{eff} of about 0.990, with a ±1% variation. The trend of lower calculated k_{eff} values for harder thermal spectra is consistent with previous LWR fuel lattice validation experience with the 27-group ENDF/B-IV library. Because boron hardens the spectrum in LWR lattices, cases containing boron may have lower calculated k_{eff} values, although this trend was not observed for these cases.

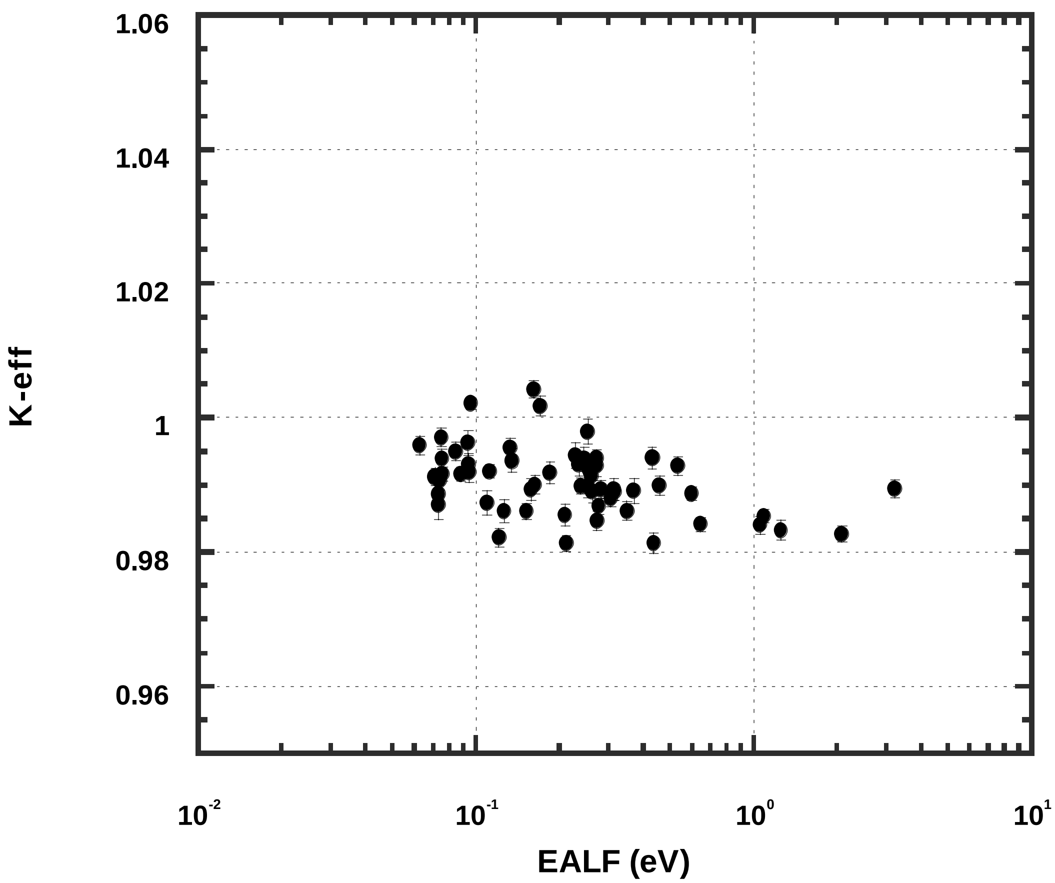

Figure 4.3 SCALE 218-group ENDF/B-IV library low-enriched LWR lattice results

4.6 PERFORMANCE WITH ^{239}Pu SYSTEMS

The performance of the SCALE 218-group ENDF/B-IV library for ^{239}Pu systems is shown in Figure 4.4. The performance of the library is generally poor. The library shows an overall 2 to 3% positive bias with a range of 1.00 to 1.05 in calculated k_{eff} values. The poor results are probably due to the base ENDF/B-IV ^{239}Pu data. The intermediate-spectrum results are worse than the thermal results. **The SCALE ENDF/B-IV libraries are not recommended for ^{239}Pu systems.**

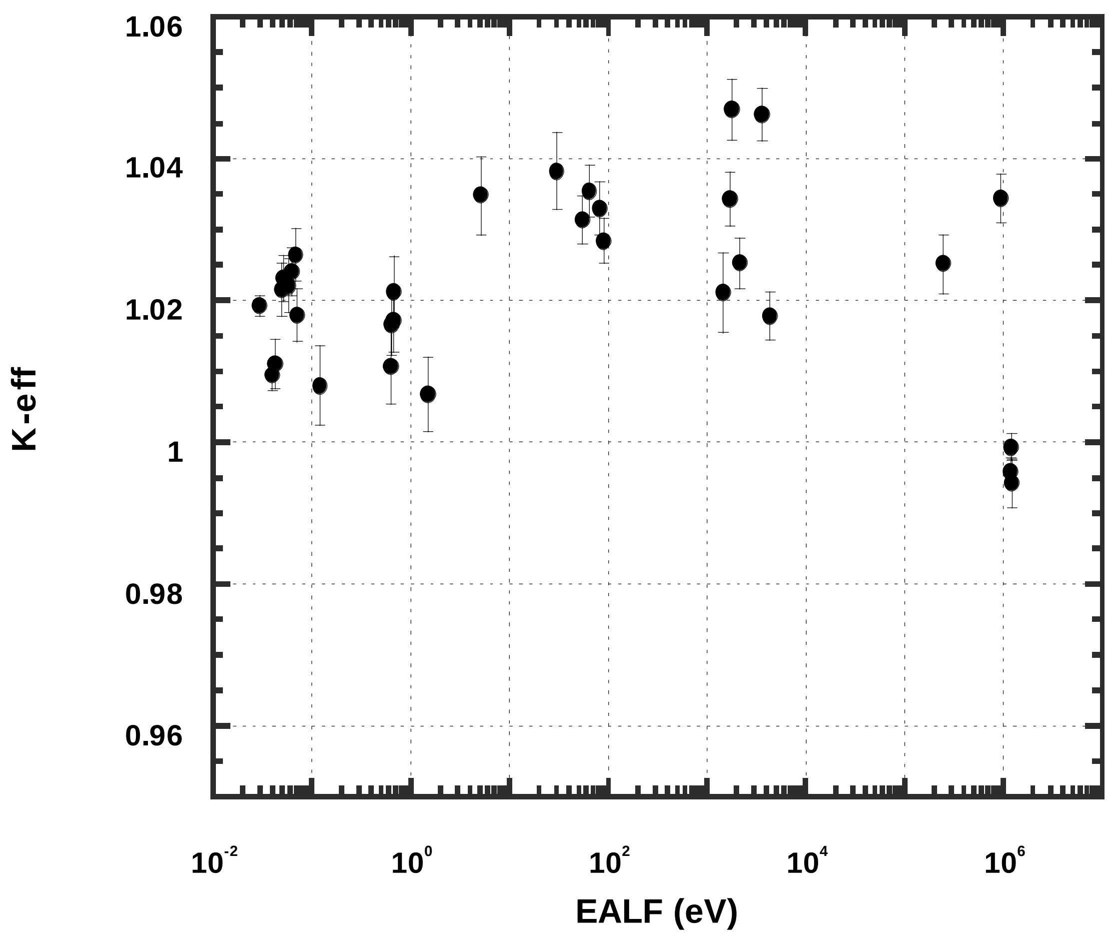

Figure 4.4 SCALE 218-group ENDF/B-IV library plutonium system results

4.7 PERFORMANCE WITH ^{233}U SYSTEMS

The performance of the SCALE 218-group ENDF/B-IV library for ^{233}U systems is shown in Figure 4.5. The performance of the library varies significantly between the thermal systems and the fast systems. The thermal systems show a strong positive bias. The thermal system results have an average calculated k_{eff} value of about 1.015 ± 1.5%. Conversely, the fast systems show a strong negative bias, with results ranging from 0.96 to 0.98. These results emphasize the importance of validation, not only for the materials in the system, but also for the appropriate energy range. Note also the lack of data in the intermediate-energy range.

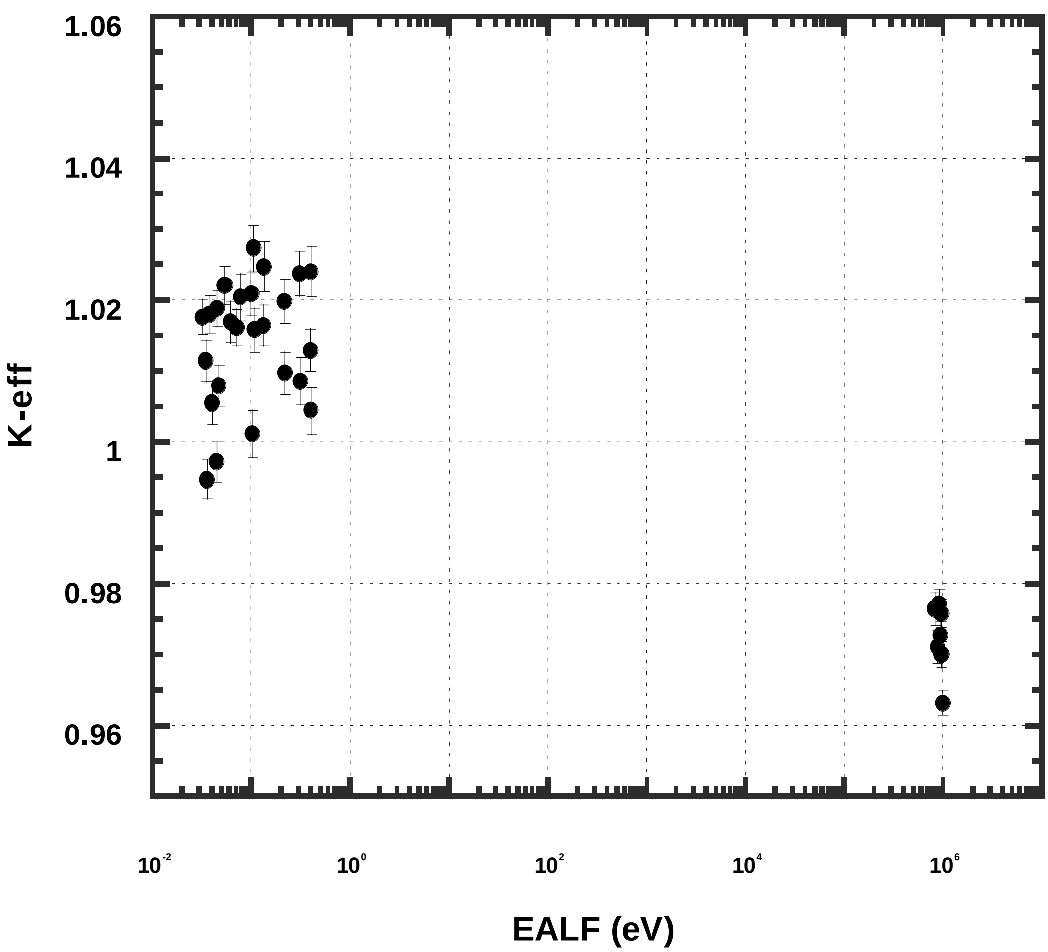

Figure 4.5 SCALE 218-group ENDF/B-IV library ^{233}U system results

4.8 PERFORMANCE WITH MIXED-OXIDE LATTICES

The performance of the SCALE 218-group ENDF/B-IV library for mixed-oxide (MOX) lattices is shown in Figure 4.6. All of the MOX lattice systems considered here are water-moderated thermal systems. The performance of the library is fair, probably due to the positive bias in the ENDF/B-IV ^{239}Pu resonance data offsetting the negative bias in the ^{238}U resonance data. The most thermalized systems (about 0.1 eV) show a small positive bias, with results ranging from 0.995 to 1.01. As the spectrum becomes harder, the calculated k_{eff} values show an increasingly negative bias, similar to that seen for the LWR lattices.

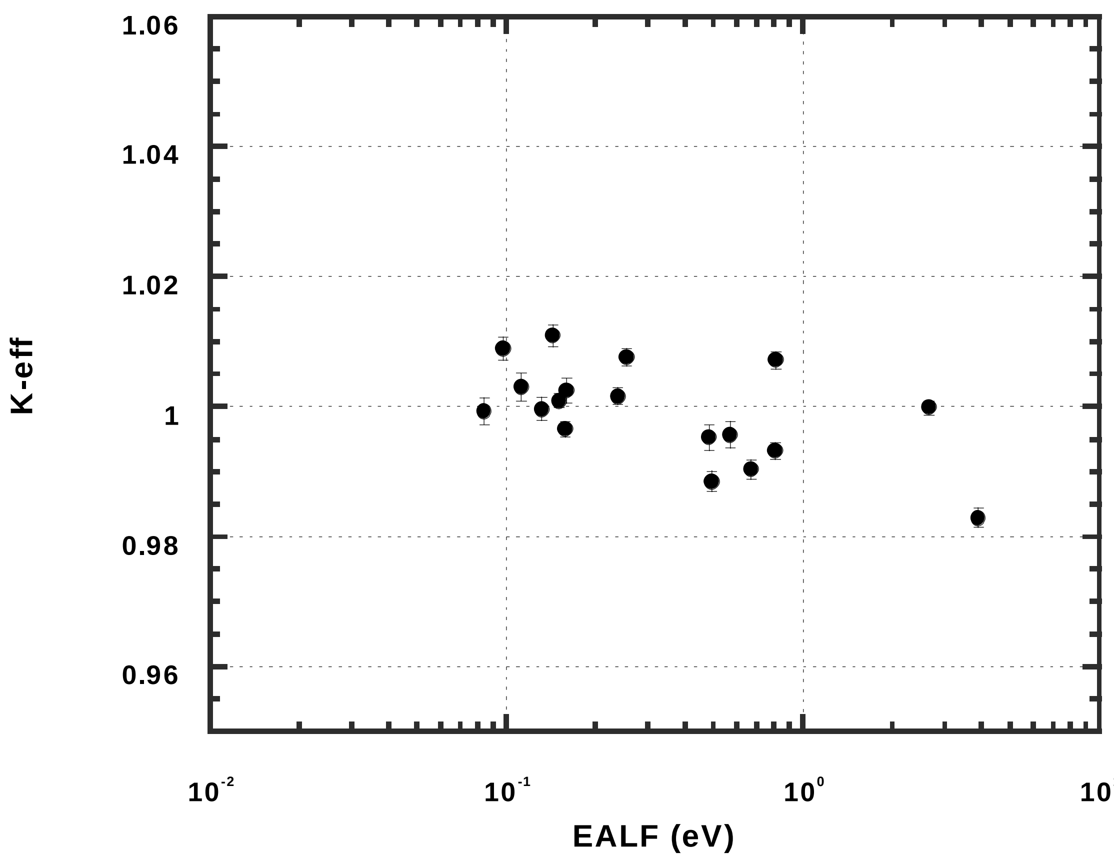

Figure 4.6 SCALE 218-group ENDF/B-IV library mixed-oxide lattice results

5 THE 27-GROUP ENDF/B-IV LIBRARIES

5.1 ORIGINS OF THE 27-GROUP ENDF/B-IV LIBRARY

The 27-group ENDF/B-IV library is the broad-group companion library to the 218-group ENDF/B-IV library. The 218-group library was flux collapsed using MALOCS and the MT 1099 flux file carried with the fine-group cross sections. (This flux file is the group representation of the original weighting spectrum used to generate the 218-group cross sections from ENDF/B-IV data.) Because of the $1/(E\sigma_t)$ weighting in the resolved resonance range, the broad-group library calculates many systems nearly as well as the fine-group library does. Trends and biases in the 218-group library are preserved in the 27-group library. The library has 14 fast groups and 13 thermal groups (below 3 eV). The group structure was chosen to match the 16-group Hansen-Roach structure with two additional fast groups and nine additional thermal groups. The additional groups were chosen such that, for the systems considered, the broad-group calculations meet an acceptance criterion of $\Delta k/k < 0.3\%$ when compared with the reference 218-group calculation using the XSDRN code. This criterion was relaxed to 1% for ^{238}U in systems where the median fission energy was greater than 1 eV and less than 100 eV. The resonance data and the thermal scattering data carried with the 27-group library and the 218-group library are the same and are processed by NITAWL-II. The library was conceived as a general-purpose criticality-analysis library, with a special interest in applicability toward shipping cask analysis and thermal neutron systems.

The 27-group library has been extensively validated against critical experiments.[14, 21-30] Areas of validation include highly enriched uranium-metal, compound and solution systems, moderated low-enriched uranium, heterogeneous and homogeneous systems, and plutonium metal and solution systems.

5.2 ORIGINS OF THE 27-GROUP BURNUP (DEPLETION) LIBRARY

The 27-group burnup library is a criticality-safety library for spent fuel, originally developed for use in the SAS2H depletion-control module (Section S2 of the SCALE manual). The library consists of the 27-group ENDF/B-IV library discussed above supplemented with data from a pre-release version of ENDF/B-V for a large number of fission products. Prior to the release of the 44-group ENDF/B-V library the large number of nuclides in this version of the 27-group library made it the preferred library for use in burnup studies when spent fuel characterization (isotopics, radiation sources, and decay heat) was the objective. **This library is no longer recommended for such studies**, because the 44-group ENDF/B-V library contains more nuclides and better base data. Because the base library was the 27-group ENDF/B-IV library, all the comments regarding the 218-group and 27-group libraries are also directly applicable to the 27-group burnup library.

5.3 CHARACTERISTICS OF THE ENDF/B-IV LIBRARIES

The ENDF/B-IV libraries have generally displayed a negative bias of approximately 1%, and in some cases as much as 2%, for low-enriched, water-moderated UO_2 rods. The bias appears to be greatest for epithermal systems (e.g., borated water and/or closely spaced rods) and less significant for more thermalized systems. The bias has been traced in part to the lack of data in the unresolved resonance region for ^{238}U in ENDF/B-IV. The unresolved resonance region in the SCALE ENDF/B-IV libraries was processed at σ_p = 50,000 barns, which is extremely high compared with σ_p values of 3500 barns for ^{235}U and 65 barns for ^{238}U in a typical LWR lattice. For well-thermalized systems, the unresolved resonance region is not important, and the high σ_p value is inconsequential. However, as the spectrum hardens the resolved resonance region (where ENDF/B-IV had some inadequacies) and the unresolved region become more important. Thus, the SCALE ENDF/B-IV libraries trend toward a lower k_{eff} value as the spectrum hardens. Improved resonance data in ENDF/B-V eliminated this bias in the 44-group library.

A positive bias has been routinely observed in the ENDF/B-IV libraries for thermal ^{239}Pu systems and mixed oxide (MOX) fuel rods. The MOX fuel rod bias increases with increasing thermalization. One problem identified in the 27-group library was inadequate group structure to account for flux changes across the 0.3-eV resonance of ^{239}Pu. This problem has been rectified in the 44-group library by the addition of more energy groups in this energy range.

Carbon system numerical benchmarks have shown a negative bias of as much as 2.5% with the ENDF/B-IV libraries when compared with the Hansen-Roach and ENDF/B-V libraries. Analysis of the 218-group cross-section data has revealed an incorrect scatter matrix for carbon in energy group 10. In addition, the graphite thermal kernel is deficient. The impact of this deficiency is unknown.

The hafnium cross-section data available in the 218- and 27-group ENDF/B-IV libraries are not ENDF/B-IV data (ENDF/B-IV did not include hafnium). Known irregularities are present in the cross section, and no resonance data are available with the nuclide. The cross sections are infinite dilution (1/E weighting) across the resonance range. **Use of the hafnium data in the ENDF/B-IV libraries is not recommended and should be done with caution.**

Systems containing gadolinium have not calculated well with the 27-group library. The problem stems from the characteristic of the gadolinium data in the thermal range. Gadolinium has low-energy resonance data down to 10^{-5} eV. The resonances are so broad that the implementation of the Nordheim treatment in NITAWL-II fails to have a mesh point in group 27 of the 27-group structure. This difficulty has been addressed by setting the bottom energy of the resonance data to that of group 26 and carrying infinite dilution cross sections in group 27 of the master library. In addition, the ENDF resonance data for gadolinium prior to version VI are not well defined. **Use of the gadolinium data in the ENDF/B-IV libraries is not recommended and should be done with caution**.

5.4 PERFORMANCE WITH HIGH-ENRICHED HOMOGENEOUS ^{235}U SYSTEMS

Figure 5.1 shows calculated k_{eff} values for highly enriched ^{235}U systems using the SCALE 27-group ENDF/B-IV library. The overall trend shows an average k_{eff} of approximately 1.00 for thermal and fast systems, with a large variation in results for thermal systems. As expected, the results are very similar to the 218-group library results.

5.4.1 High-Enriched Fast Systems

Fast systems in Figure 5.1 are represented by the group of calculations at an EALF of 8×10^5 eV or greater. The fast systems have an average k_{eff} of about 1.00, with a variation of about ±1%.

5.4.2 High-Enriched Thermal Systems

Thermal systems in Figure 5.1 are represented by the calculations with an EALF below about 3 eV. The average k_{eff} in the thermal region is about 1.00, with a variation of roughly ±2%. There is a wide spread of results in the thermal range (k_{eff} <0.98 to k_{eff} > 1.03). Similar spreads can be seen in the results for the other libraries, too. Most of the cases between 0.01 and 0.1 eV are uranyl fluoride solutions that tend to have a more negative bias. Most of the cases between 0.1 and 1 eV are uranyl nitrate solutions that show a more positive bias. The possibility of large uncertainties in the specifications for the critical systems used to validate the thermal range cannot be ruled out as the source of the large variations in calculated k_{eff} values.

5.4.3 High-Enriched Intermediate-Spectrum Systems

Intermediate-spectrum systems in Figure 5.1 are those with an EALF between 3 eV and 8×10^5 eV. Few critical experiments are in the intermediate range. These systems are characterized by an ill-defined average k_{eff} of 1.01, with a spread of about ±1%.

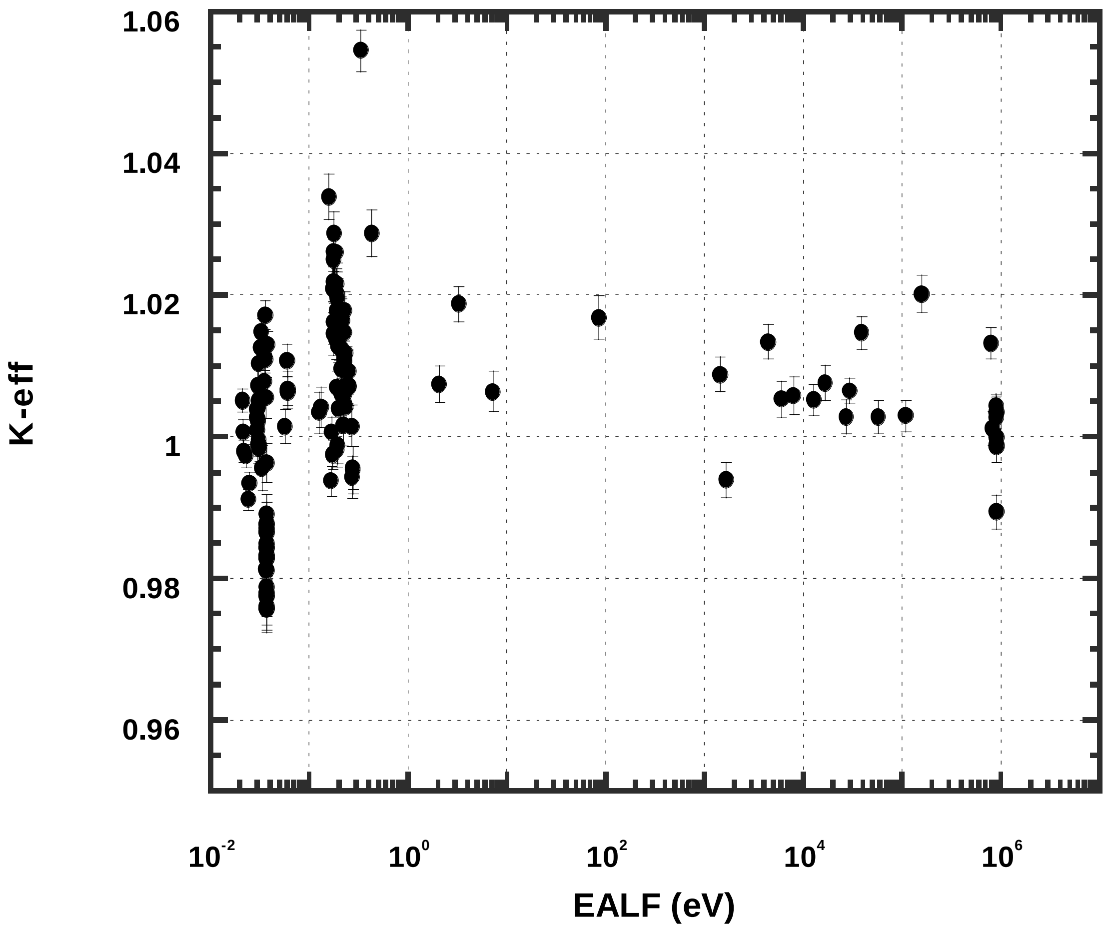

Figure 5.1 SCALE 27-group ENDF/B-IV library high-enriched ^{235}U system results

5.5 PERFORMANCE WITH LOW-ENRICHED HOMOGENEOUS ^{235}U SYSTEMS

The performance of the SCALE 27-group ENDF/B-IV library for homogeneous low enriched systems is shown in Figure 5.2. The homogeneous experiments have ^{235}U enrichments below 5%. The calculations do not show a trend as a function of energy. The average calculated k_{eff} value is approximately 1.00 ± 1.5%, about 0.5% more positive than the 218-group library results.

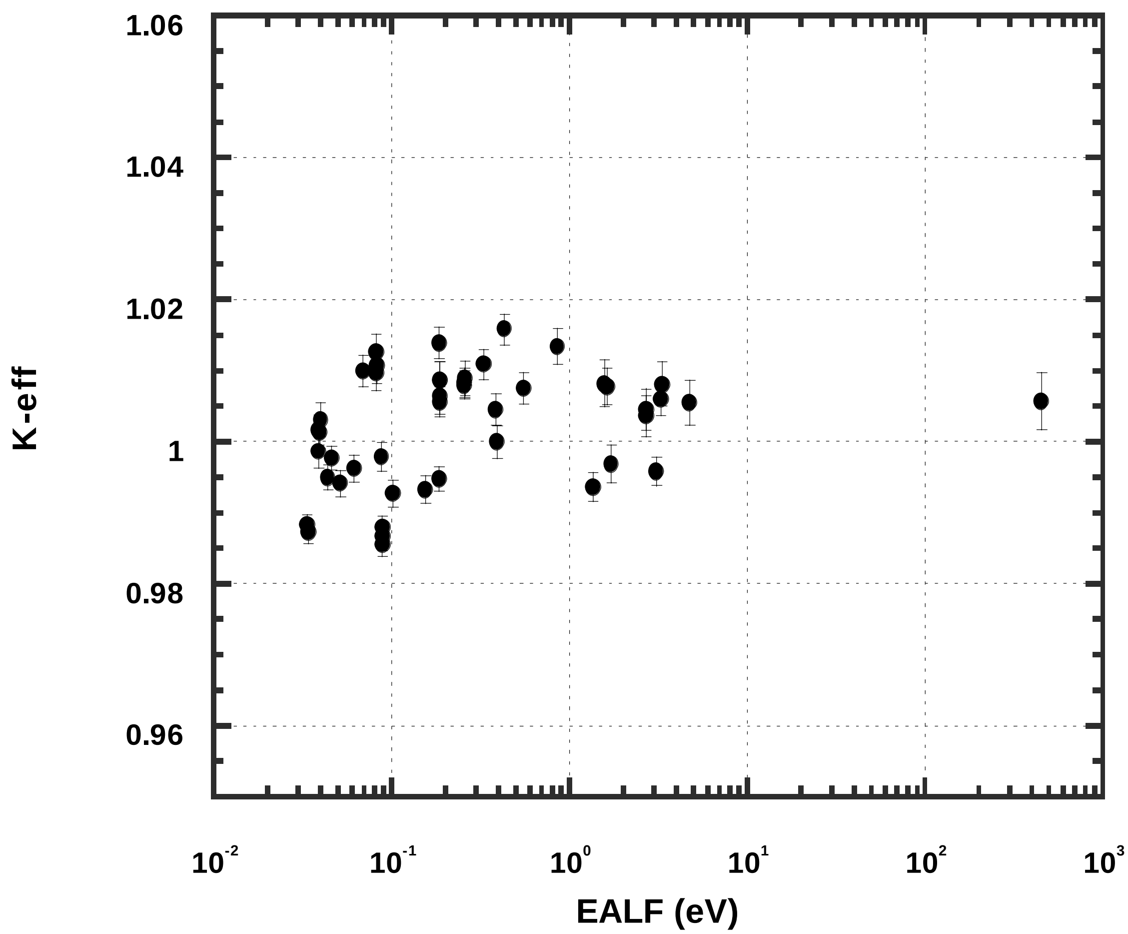

Figure 5.2 SCALE 27-group ENDF/B-IV library low-enriched homogeneous ^{235}U system results

5.6 PERFORMANCE WITH LWR LATTICES

The performance of the SCALE 27-group ENDF/B-IV library for heterogeneous low-enriched LWR lattice systems is shown in Figure 5.3. The maximum enrichment in the LWR lattice experiments is 5.74 wt % ^{235}U. The experiments have an average k_{eff} of about 0.995, with a ±1% variation, about 0.5% more positive than the 218-group library results. The trend of lower calculated k_{eff} values for harder thermal spectra is consistent with previous LWR fuel lattice validation experience with the 27-group ENDF/B-IV library. Because boron hardens the spectrum in LWR lattices, cases containing boron may have lower calculated k_{eff} values, although this trend was not observed for these cases.

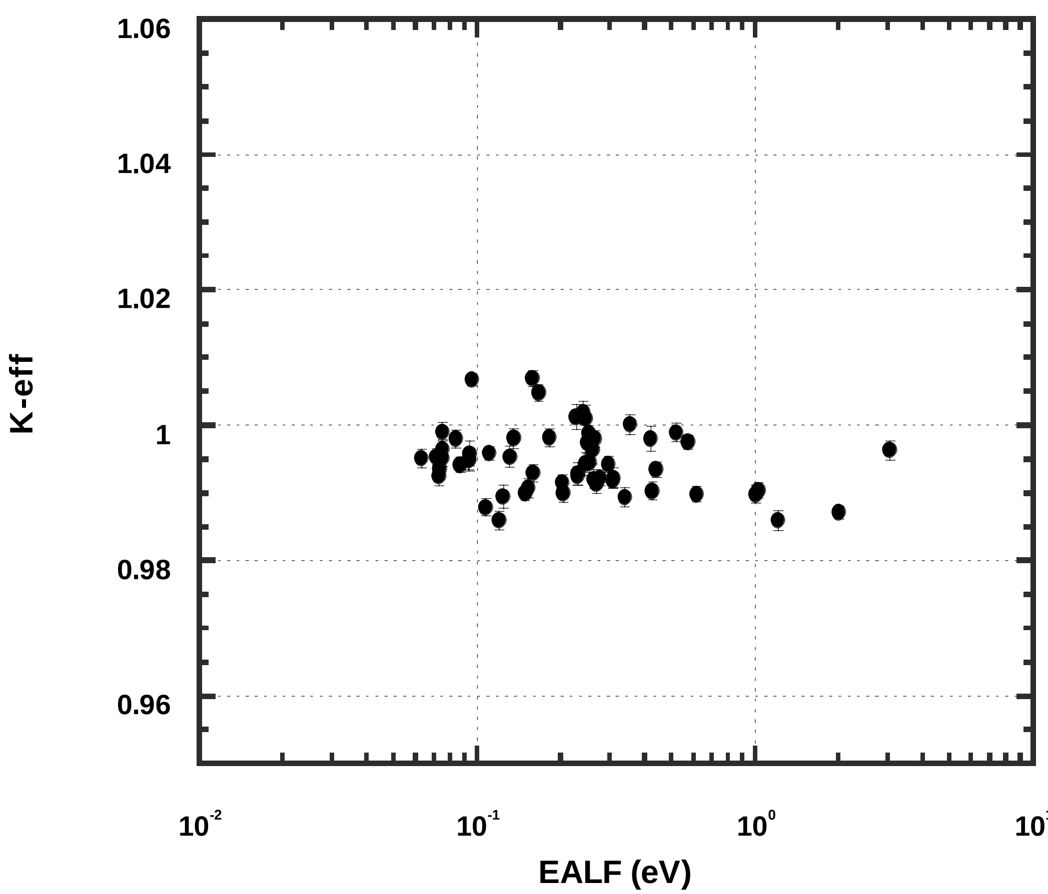

Figure 5.3 SCALE-27 group ENDF/B-IV library low-enriched LWR lattice results

5.7 PERFORMANCE WITH ^{239}Pu SYSTEMS

The performance of the SCALE 27-group ENDF/B-IV library for ^{239}Pu systems is shown in Figure 5.4. The performance of the library is generally poor. The library shows an overall 2 to 3% positive bias, with a range of 1.00 to 1.05 in calculated k_{eff} values. The results are very similar to the 218-group library results. The poor results are probably due to the base ENDF/B-IV ^{239}Pu data. The intermediate-spectrum results are worse than the thermal results. **The SCALE ENDF/B-IV libraries are not recommended for ^{239}Pu systems.**

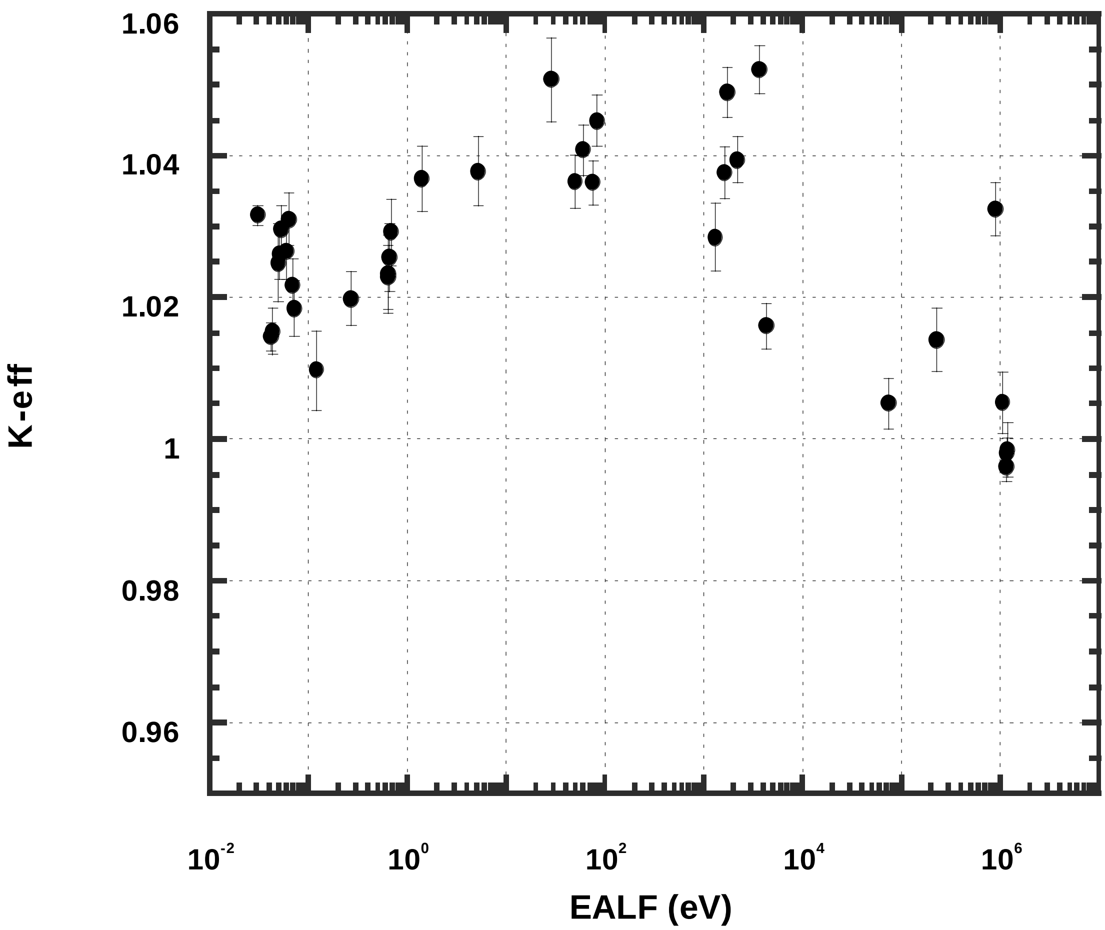

Figure 5.4 SCALE-27 group ENDF/B-IV library plutonium system results

5.8 PERFORMANCE WITH ^{233}U SYSTEMS

The performance of the SCALE 27-group ENDF/B-IV library for ^{233}U systems is shown in Figure 5.5. The performance of the library varies significantly between the thermal systems and the fast systems. The thermal systems show a strong positive bias. The thermal system results are clustered about an average k_{eff} of about 1.02 ± 1.5%, about 0.5% more positive than the 218-group library results. Conversely, the fast systems show a strong negative bias, with results ranging from 0.96 to 0.98, very similar to the 218-group library results. These results emphasize the importance of validation, not only for the materials in the system, but also for the appropriate energy range.

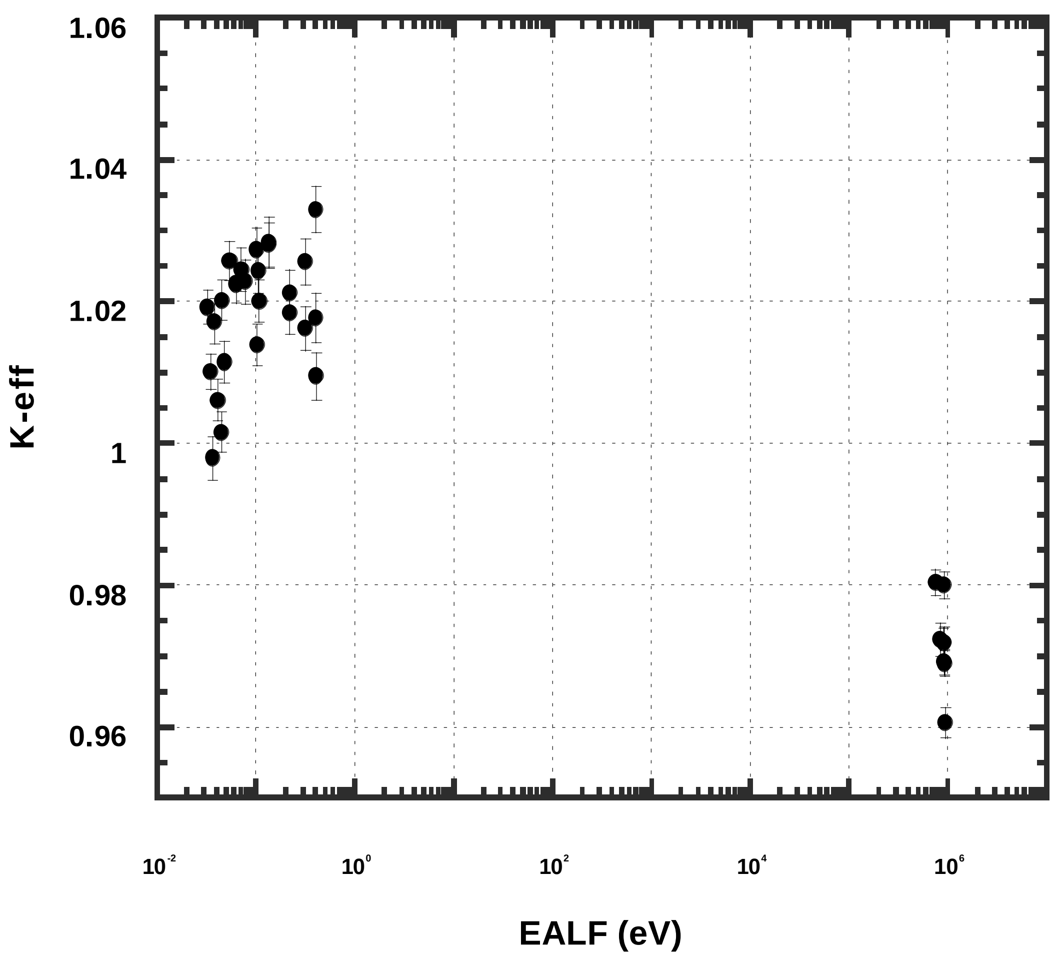

Figure 5.5 SCALE-27 group ENDF/B-IV library ^{233}U system results

5.9 PERFORMANCE WITH MIXED-OXIDE LATTICES

The performance of the SCALE 27-group ENDF/B-IV library for mixed-oxide (MOX) lattices is shown in Figure 5.6. All of the MOX lattice systems considered here are water-moderated thermal systems. The performance of the library is fair, probably due to the positive bias in the ENDF/B-IV ^{239}Pu resonance data offsetting the negative bias in the ^{238}U resonance data. The most thermalized systems (about 0.1 eV) show a small positive bias, with results ranging from 0.995 to 1.01. As the spectrum becomes harder, the calculated k_{eff} values show an increasingly negative bias, similar to that seen for the LWR lattices. As in the case of the LWR lattices, the cause may be the ^{238}U resonance data. Once again, the results are very similar to the 218-group library results.

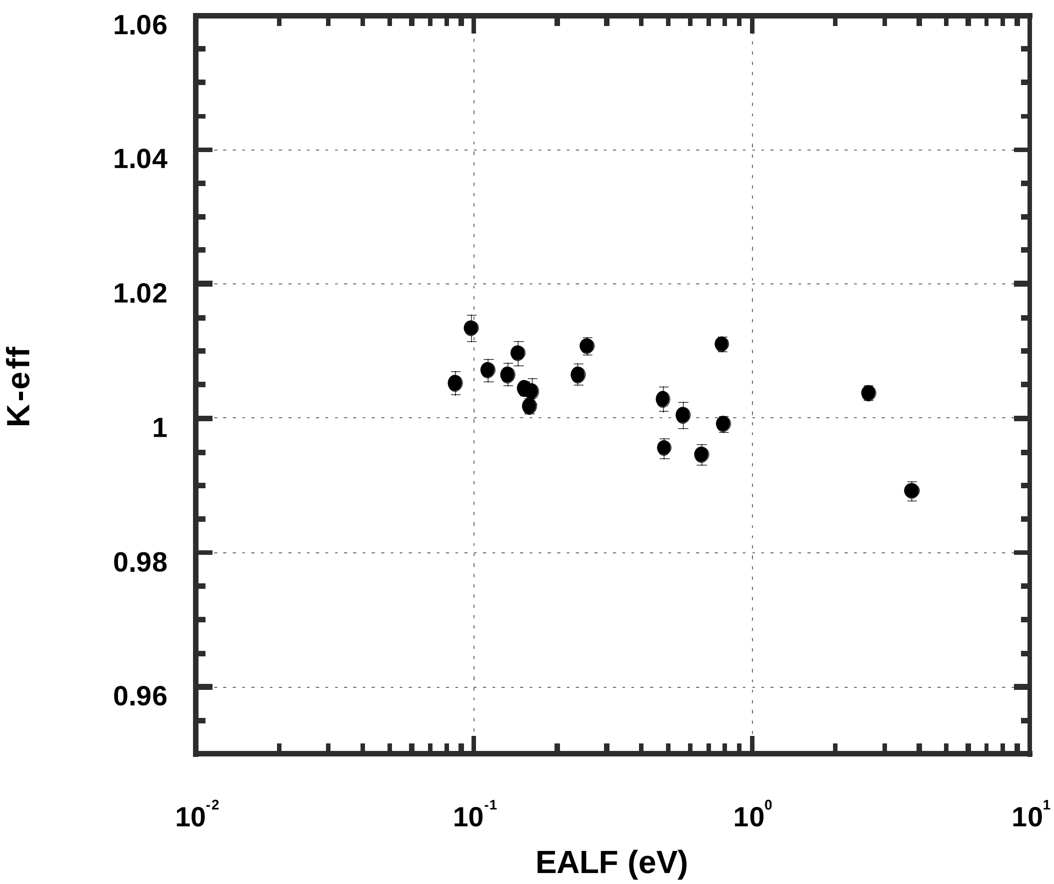

Figure 5.6 SCALE 27-group ENDF/B-IV library mixed-oxide lattice results

6 THE 238-GROUP ENDF/B-V LIBRARY

6.1 ORIGINS OF THE LIBRARY

The 238-group ENDF/B-V library[7] is a general-purpose criticality analysis library, and the most complete library available in SCALE. This library is also known as the LAW (Library to Analyze Radioactive Waste) Library. It was initially released in version 4.3 of SCALE. The library contains data for all nuclides (more than 300) available in ENDF/B-V processed by the AMPX-77 system.[11] It also contains data for ENDF/B-VI evaluations of ^{14}N, ^{15}N, ^{16}O, ^{154}Eu, and ^{155}Eu that are discussed in Section 6.2. The library has 148 fast groups and 90 thermal groups (below 3 eV). The group structure is listed in Appendix A.

Most resonance nuclides in the 238-group and 44-group ENDF/B-V libraries have resonance data (to be processed by NITAWL-II) in the resolved resonance range and Bondarenko factors (to be processed by BONAMI) for the unresolved range. Both libraries contain resolved resonance data for *s*-wave, *p*-wave, and *d*-wave resonances ($\ell = 0$, $\ell = 1$, and $\ell = 2$, respectively) as shown in Table E.1. These data can have a significant effect on results for undermoderated, intermediate-energy problems. Resonance structures in several light-to-intermediate mass nonresonance ENDF nuclides (i.e., ^{7}Li, ^{19}F, ^{27}Al, ^{28}Si) are accounted for using Bondarenko shielding factors. These structures can also be important in intermediate-energy problems. Nuclides with thermal scattering data are listed in Table E.2. The ^{235}U ENDF/B-V data have slightly too much fission, while the ^{238}U data have slightly too much capture. Although better than the ENDF/B-IV data, the thermal plutonium data still appear to have problems.

All nuclides in the 238-group LAW Library use the same weighting spectrum, consisting of

1. Maxwellian spectrum (peak at 300 K) from 10^{-5} to 0.125 eV,
2. a 1/E spectrum from 0.125 eV to 67.4 keV,
3. a fission spectrum (effective temperature at 1.273 MeV) from 67.4 keV to 10 MeV, and
4. a 1/E spectrum from 10 to 20 MeV.

A plot of this spectrum is shown in Figure 6.1. The use of this spectrum (as opposed to the $1/(E\sigma_t)$ spectrum used to generate the 218-group library) makes it difficult to collapse a general- purpose broad-group library that is valid over a wide range of problems.

All nuclides use a P_5 Legendre expansion to fit the elastic and discrete-level inelastic scattering processes in the fast range, thereby making the library suitable for both reactor and shielding applications. A P_3 fit was used for thermal-scattering. All other scattering processes use P_0 fits.

Data testing has been performed for 33 benchmarks,[8] including 28 Cross-Section Evaluation Working Group (CSEWG) benchmarks. Results obtained for these benchmarks are very close to those obtained by other data testers using different ENDF/B-V-based cross-section libraries. There is considerable improvement in the trend of k_{eff} vs leakage obtained with the use of the ENDF/B-VI oxygen evaluation.

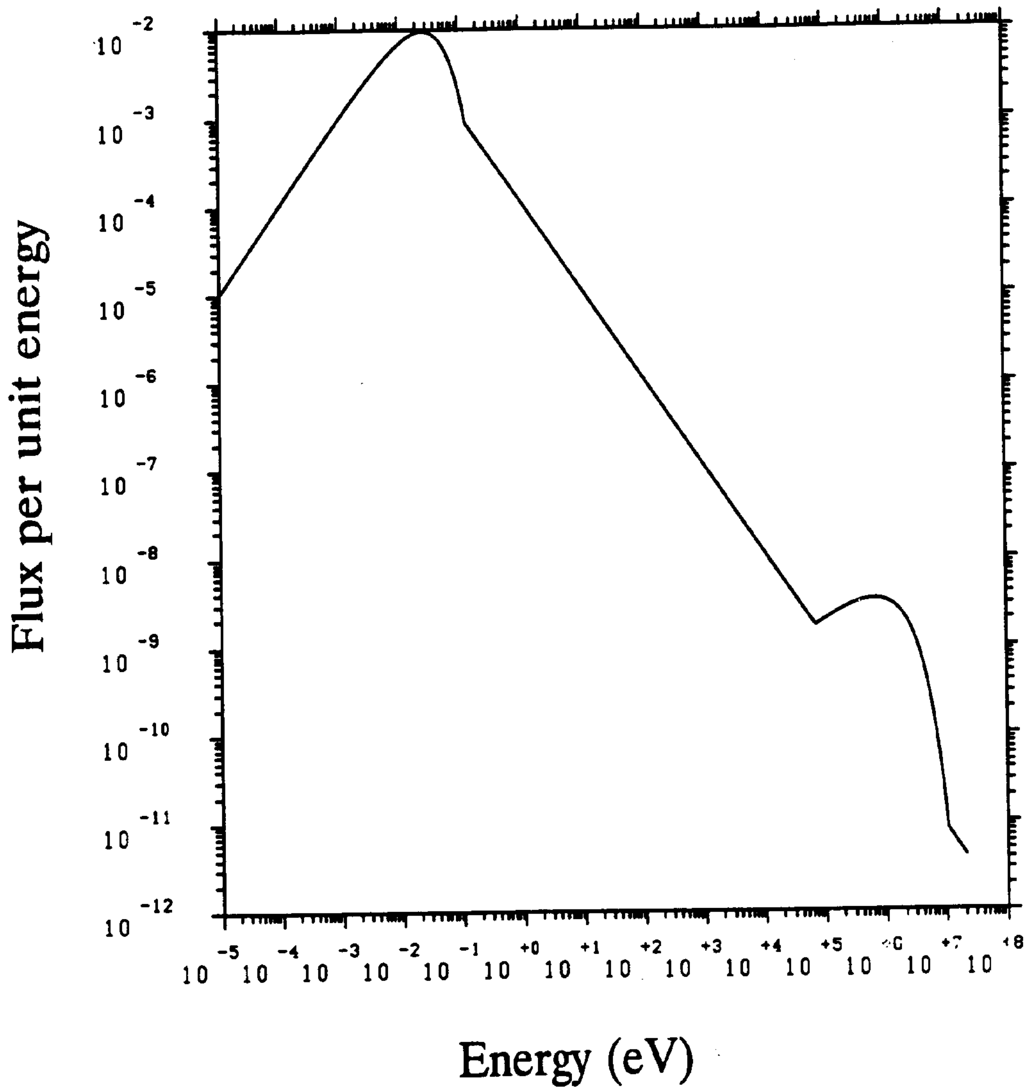

Figure 6.1 Weighting function for 238-group ENDF/B-V library

6.2 ENDF/B-VI DATA IN THE LIBRARY

Because of the significantly improved and conservative behavior of the ENDF/B-VI ^{16}O evaluation under conditions where higher-order scattering terms are important (e.g., high-leakage geometries), this cross section has been included in the 238-group and 44-group libraries as the default for ^{16}O. The ENDF/B-V evaluation is available within the library as cross-section number 801601, and may be copied into an AMPX master library using AJAX for subsequent use in calculations. Similarly, ENDF/B-VI evaluations of ^{14}N and ^{15}N are included in the library; however, ENDF/B-V versions remain the default for these isotopes. The ENDF/B-VI nitrogen data were processed using the same methods used for ^{16}O and, like oxygen, were tested to see if significant differences between ENDF/B-V and ENDF/B-VI could be identified. No significant differences have been identified; however, because they had already been processed into AMPX master library format and were readily available, ENDF/B-VI ^{14}N and ^{15}N cross sections are included in the library as cross sections 701401 and 701501, respectively. Finally, ENDF/B-VI evaluations of ^{154}Eu and ^{155}Eu are also included in the library as default cross sections 63154 and 63155, respectively. The more recent ENDF/B-VI evaluations include resonance parameters not included in previous evaluations and yield energy-dependent cross sections significantly different from those obtained using ENDF/B-V cross sections. Comparisons of depletion/decay calculations with experimental isotopic measurements have indicated that the ENDF/B-VI europium evaluations are more accurate than those available in ENDF/B-V. However, as with ^{16}O, ENDF/B-V cross sections are available within the library, as isotopes 631541 and 631551.

6.3 PERFORMANCE WITH HIGH-ENRICHED HOMOGENEOUS ^{235}U SYSTEMS

Figure 6.2 shows calculated k_{eff} values for highly enriched ^{235}U systems using the SCALE 238-group ENDF/B-V library. The overall trend shows an average k_{eff} of approximately 0.995 for thermal and fast systems, with a large variation in results for thermal systems.

6.3.1 High-Enriched Fast Systems

Fast systems in Figure 6.2 are represented by the group of calculations at an EALF of 8×10^5 eV or greater. The fast systems have an average k_{eff} of about 0.995, with a variation of about ±1%.

6.3.2 High-Enriched Thermal Systems

Thermal systems in Figure 6.2 are represented by the calculations with an EALF below about 3 eV. The average k_{eff} in the thermal region is about 1.00, with a variation of roughly ±2%. There is a wide spread of results in the thermal range (k_{eff} <0.98 to k_{eff} > 1.02). Similar spreads can be seen in the results for the other libraries, too. The possibility of large uncertainties in the specifications for the critical systems used to validate the thermal range cannot be ruled out as the source of the large variations in calculated k_{eff} values.

6.3.3 High-Enriched Intermediate-Spectrum Systems

Intermediate-spectrum systems in Figure 6.2 are those with an EALF between 3 eV and 8×10^5 eV. Few critical experiments are in the intermediate range. These systems are characterized by an ill-defined average k_{eff} of 0.99 ± 1.5%.

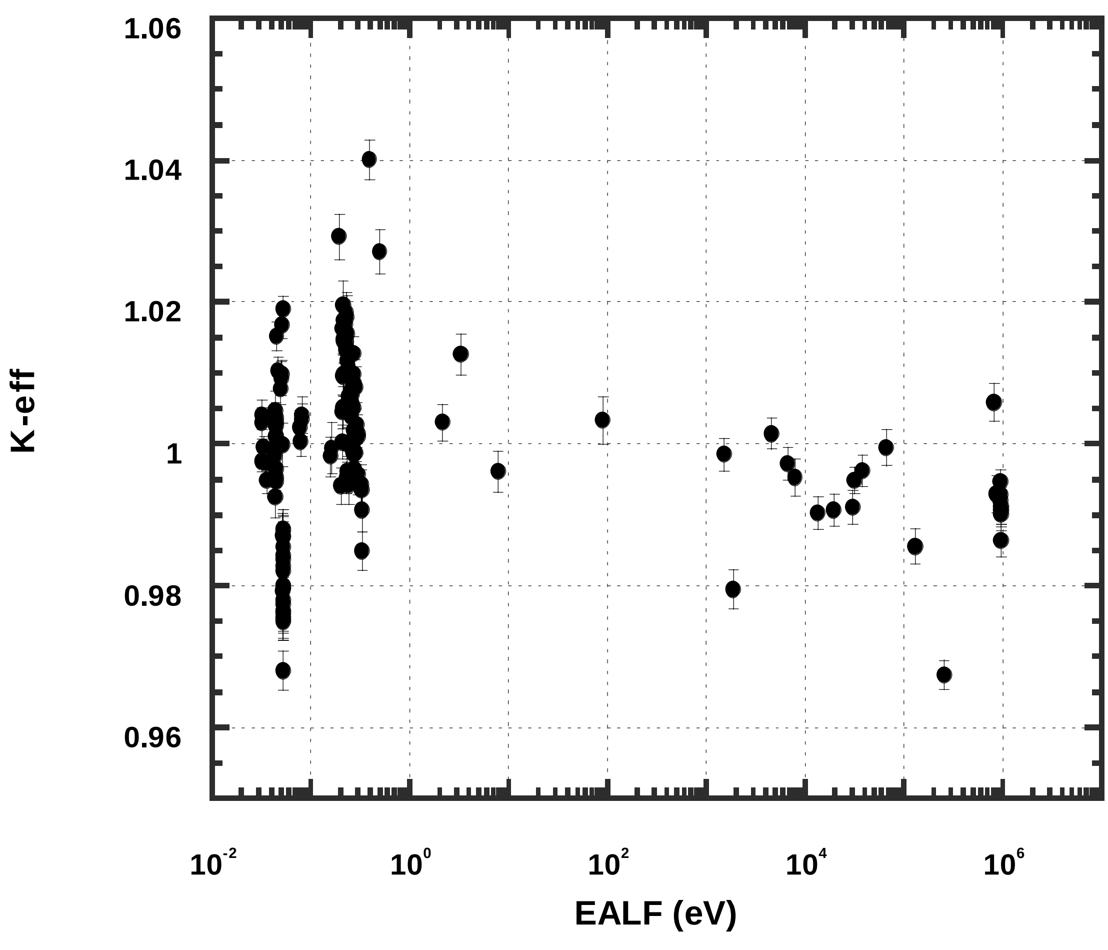

Figure 6.2 SCALE 238-group ENDF/B-V library high-enriched ^{235}U system results

6.4 PERFORMANCE WITH LOW-ENRICHED HOMOGENEOUS ^{235}U SYSTEMS

The performance of the SCALE 238-group ENDF/B-V library for homogeneous low-enriched systems is shown in Figure 6.3. The homogeneous experiments have ^{235}U enrichments below 5%. The calculations do not show a trend as a function of EALF, which is directly related to the moderation level. The average calculated k_{eff} value is approximately 1.005 ± 1.5%.

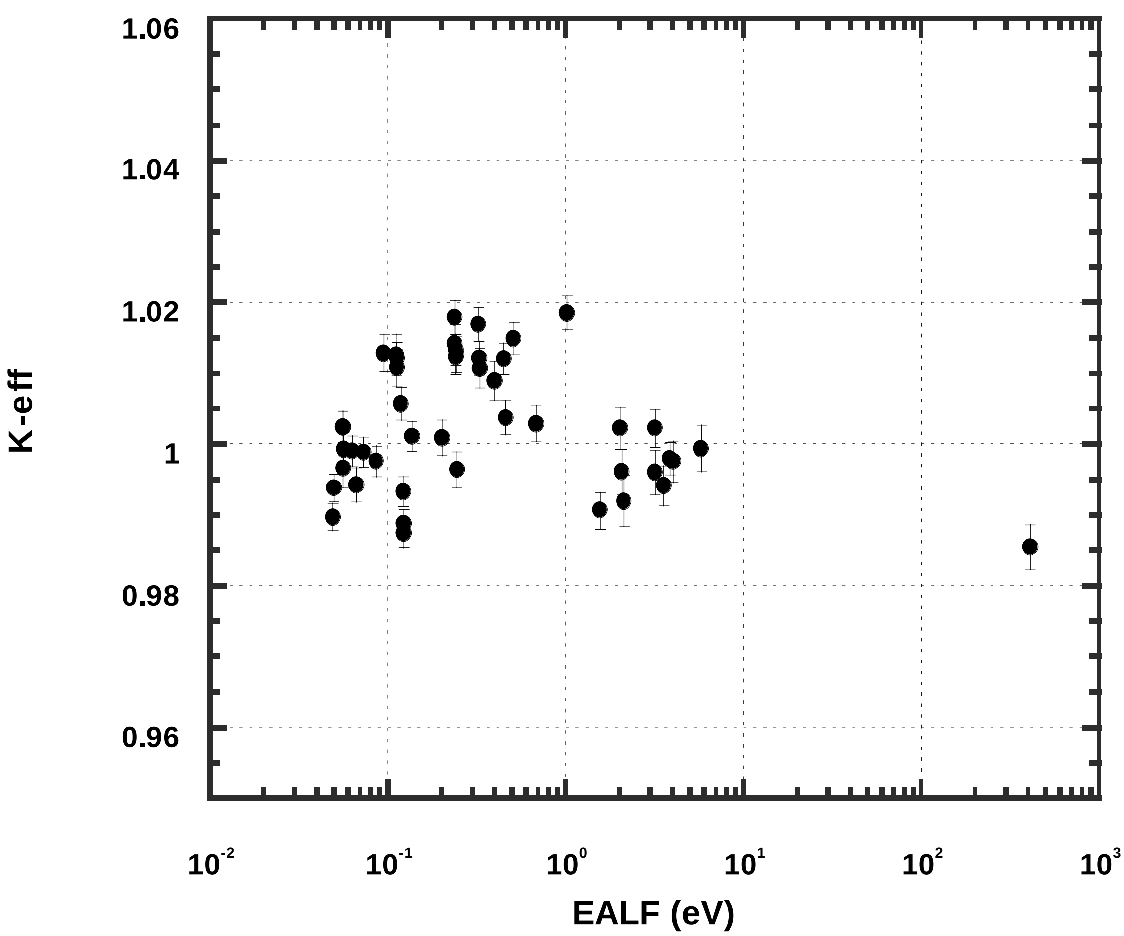

Figure 6.3 SCALE 238-group ENDF/B-V library low-enriched homogeneous ^{235}U system results

6.5 PERFORMANCE WITH LWR LATTICES

The performance of the SCALE 238-group ENDF/B-V library for heterogeneous low-enriched LWR lattice systems is shown in Figure 6.4. The maximum enrichment in the LWR lattice experiments is 5.74 wt % ^{235}U. The experiments have an average k_{eff} of about 0.995 ± 1%. The results show no bias vs energy. The cases containing boron showed no apparent bias.

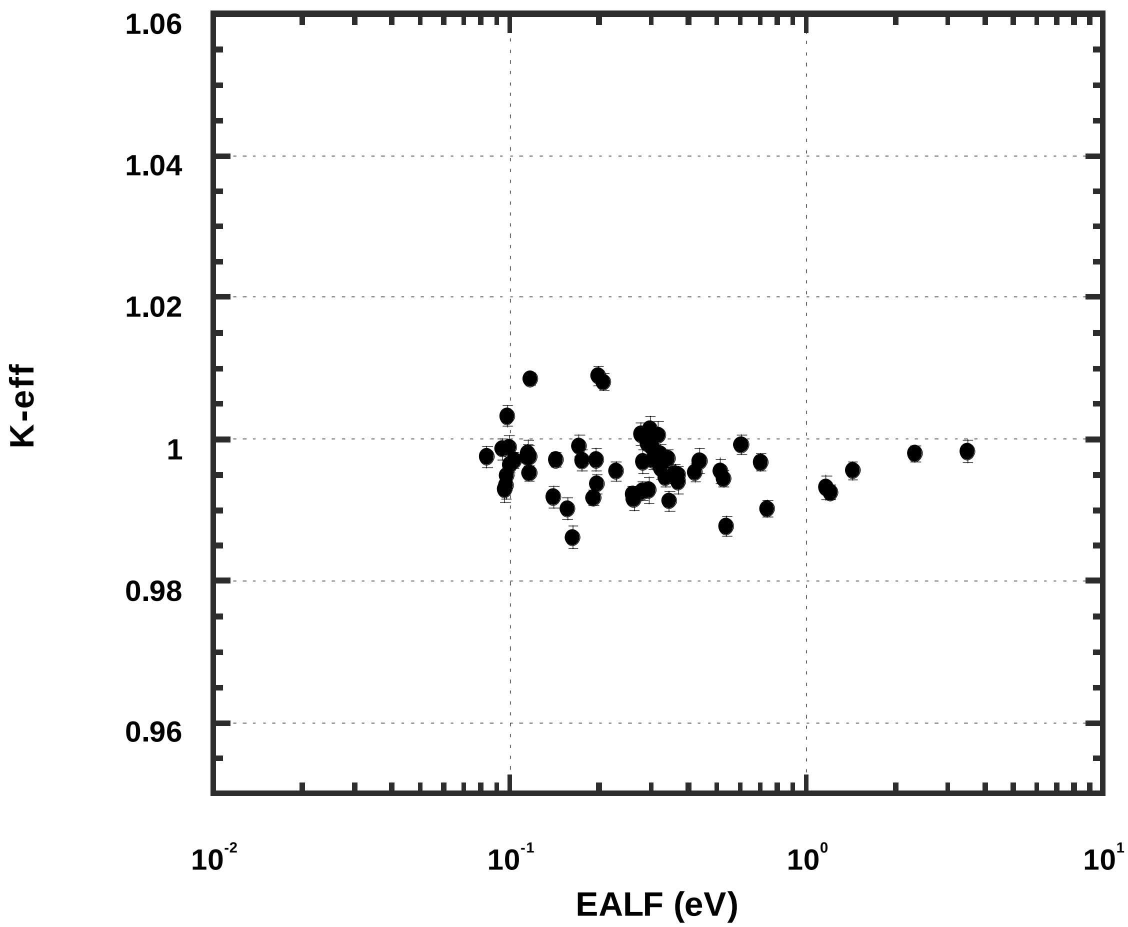

Figure 6.4 SCALE 238-group ENDF/B-V library low-enriched LWR lattice results

6.6 PERFORMANCE WITH ^{239}Pu SYSTEMS

The performance of the SCALE 238-group ENDF/B-V library for ^{239}Pu systems is shown in Figure 6.5. The performance of the library is fair, with an average k_{eff} of about 1.015 ± 2%. The results indicate possible problems in the base ENDF/B-V ^{239}Pu data. These results are better than the ENDF/B-IV libraries, particularly in the intermediate-energy range, with less variation and no apparent trends vs. energy.

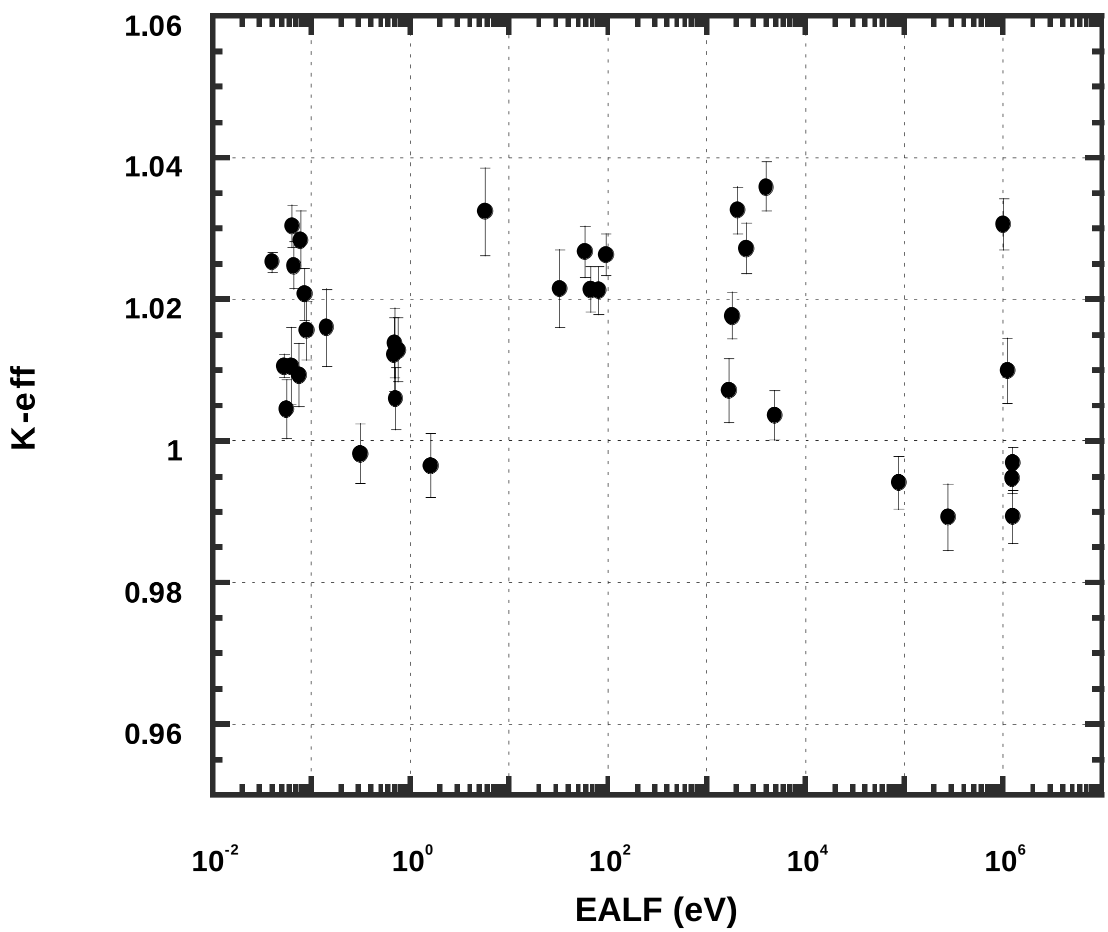

Figure 6.5 SCALE 238-group ENDF/B-V library plutonium system results

6.7 PERFORMANCE WITH ^{233}U SYSTEMS

The performance of the SCALE 238-group ENDF/B-V library for ^{233}U systems is shown in Figure 6.6. The performance of the library is good, and it is consistent between the thermal systems and the fast systems. The thermal system results have an average calculated k_{eff} value of about 0.995 ± 1.5%. The fast system results are excellent, with an average calculated k_{eff} value of about 0.999 ± 0.4%. These results are substantially better than the ENDF/B-IV libraries.

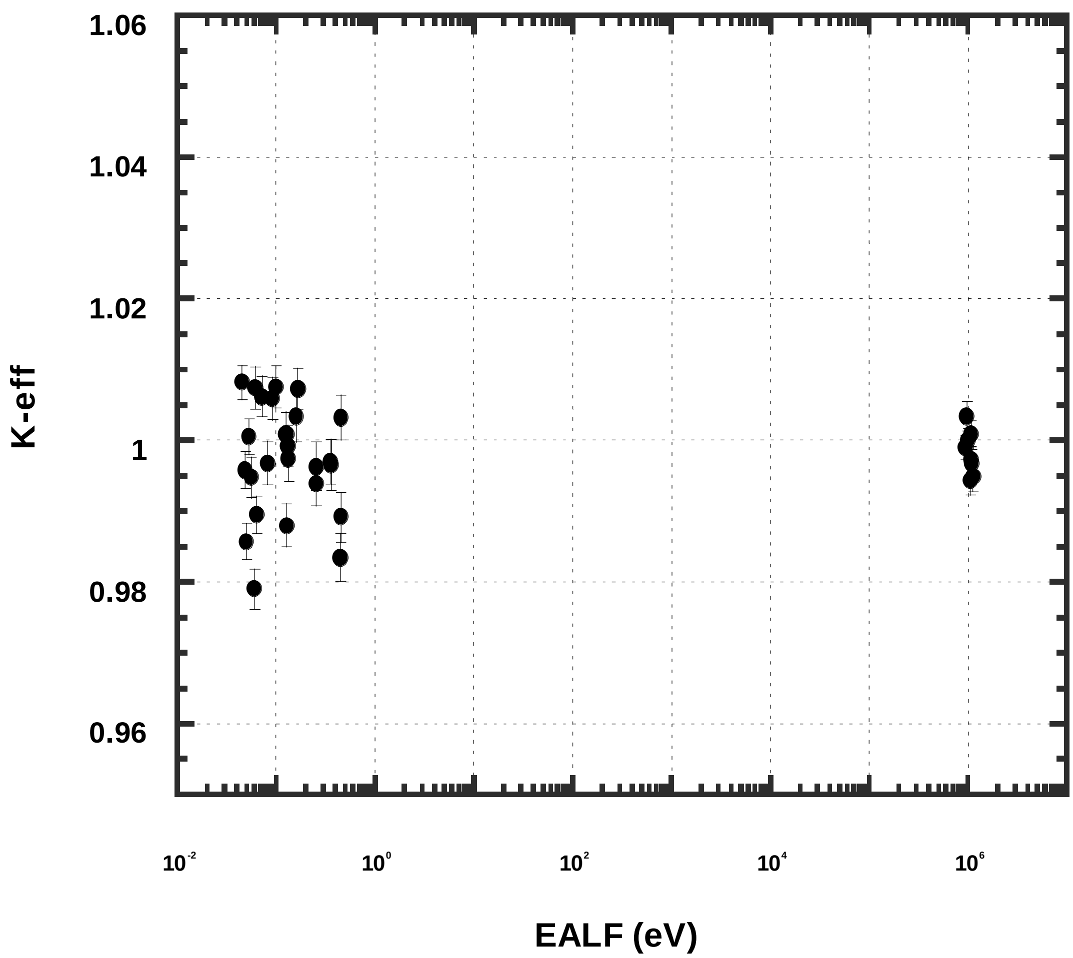

Figure 6.6 SCALE 238-group ENDF/B-V library ^{233}U system results

6.8 PERFORMANCE WITH MIXED-OXIDE LATTICES

The performance of the SCALE 238-group ENDF/B-V library for mixed-oxide (MOX) lattices is shown in Figure 6.7. All of the MOX lattice systems considered here are water-moderated thermal systems. The performance of the library is very good. The average calculated k_{eff} value is approximately 1.0 ± 1%. The results show a trend vs energy (i.e., moderation). The most thermal cases have a slightly positive bias, while those with a harder spectrum have a slightly negative bias.

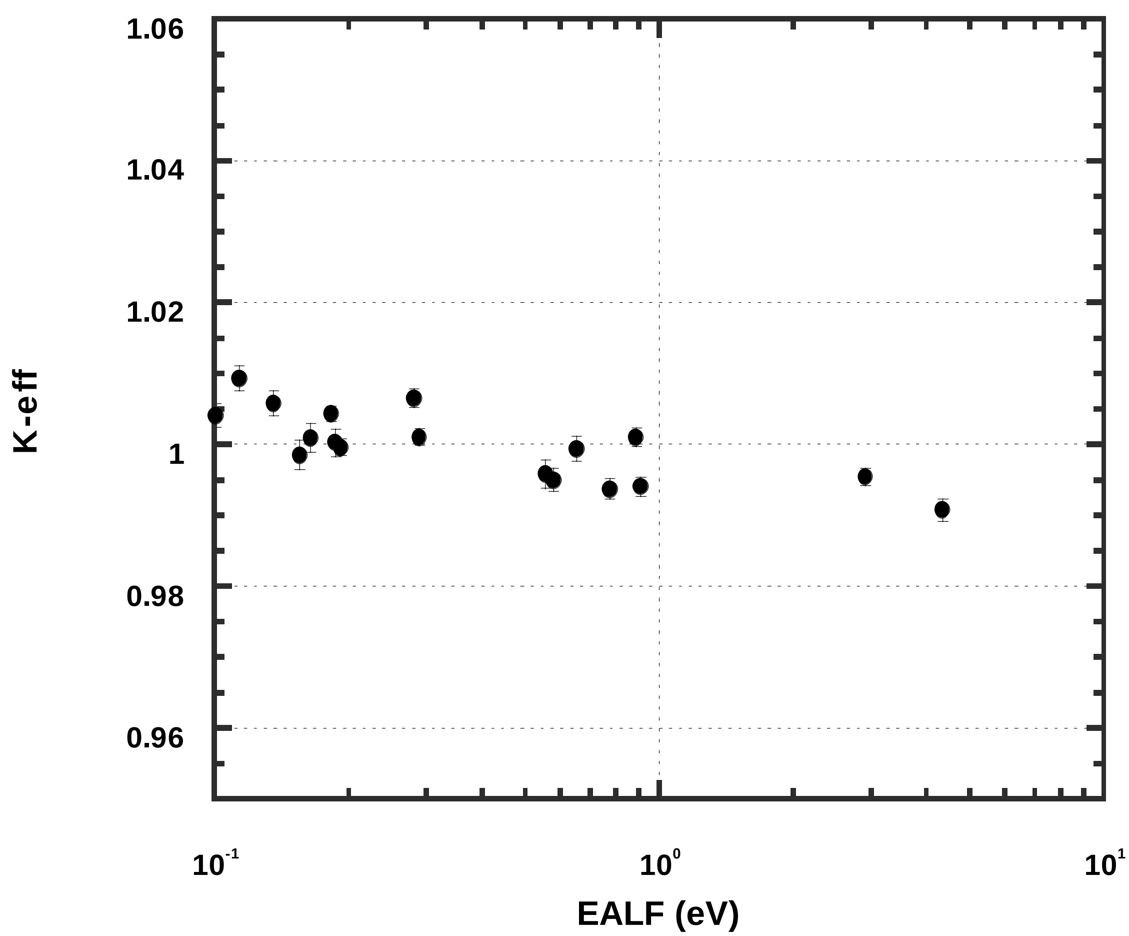

Figure 6.7 SCALE 238-group ENDF/B-V library mixed-oxide lattice results

7 THE 44-GROUP ENDF/B-V LIBRARY

7.1 ORIGINS OF THE LIBRARY

The 44-group ENDF/B-V library[8] has been developed for use in the analysis of fresh and spent fuel and radioactive waste systems. The library was initially released in version 4.3 of SCALE. Collapsed from the fine-group 238-group ENDF/B-V cross-section library, this broad-group library contains all nuclides (more than 300) from the ENDF/B-V data files. Broad-group boundaries were chosen as a subset of the parent 238-group ENDF/B-V boundaries, emphasizing the key spectral aspects of a typical LWR fuel package. Specifically, the broad-group structure was designed to accommodate the following features: two windows (where the cross section drops significantly at a particular energy, allowing neutrons at that energy to pass through the material) in the oxygen cross-section spectrum; a window in the cross section of iron; the Maxwellian peak in the thermal range; and the 0.3-eV resonance in ^{239}Pu (which, due to its low energy, cannot be properly modeled via the SCALE Nordheim Integral Treatment module NITAWL-II). The resulting boundaries represent 22 fast and 22 thermal energy groups; the full-group structure is compared with that of the 238-group library in Table A.1. The fine-group 238-group ENDF/B-V cross sections were collapsed into this broad-group structure using a fuel-cell spectrum calculated based on a 17 × 17 Westinghouse pressurized-water reactor (PWR) assembly. Thus, the 44-group library performs well for LWR lattices, but not as well for other types of systems.

The 44-group ENDF/B-V library has been tested against its parent library, using a set of 33 benchmark problems[8] in order to demonstrate that the collapsed set was an acceptable representation of 238-group ENDF/B-V, except for intermediate-energy systems. Validation of the library within the SCALE system was based on a comparison of calculated values of k_{eff} with that of 93 experiments: 92 critical and 1 subcritical experiments.[8] The experiments consisted primarily of various configurations of light-water-reactor-type fuel representative of transportation and storage conditions. Additional experiments were included to allow a comparison with results obtained in an earlier validation of the 27-group ENDF/B-IV library.

Results show that the broad 44-group structure is an acceptable representation of its parent 238-group library for thermal LWR lattice systems, as well as hard fast spectrum systems. The 44-group library is the recommended SCALE library for criticality safety analysis of arrays of light-water-reactor-type fuel assemblies, as would be encountered in fresh or spent fuel transportation or storage environments. Validation results for LWR-type UO_2 fuel show virtually no bias. A positive bias of 0.5 to 1% has been observed for very thermal mixed-oxide systems. The bias is caused by inadequate representation of plutonium cross sections, possibly in the ENDF/B-V data. The validation results for the 44-group library are consistently better relative to the same cases using the 27-group ENDF/B-IV library. Because of the weighting spectrum used to generate the 238-group library, it is difficult to collapse a general-purpose broad-group library that is valid over a wide range of problems. **For all other systems, the parent 238-group ENDF/B-V library is recommended.** A user could generate their own broad group library for a particular application by collapsing with a problem-specific flux spectrum.

7.2 ENDF/B-VI DATA IN THE LIBRARY

Because of the significantly improved and conservative behavior of the ENDF/B-VI ^{16}O evaluation under conditions where higher-order scattering terms are important (e.g., high-leakage geometries), this cross section has been included in the 238-group and 44-group libraries as the default for ^{16}O. The ENDF/B-V evaluation is available within the library as cross-section number 801601, and may be copied into an AMPX working library using AJAX for subsequent use in calculations. Similarly, ENDF/B-VI evaluations of ^{14}N and ^{15}N are included in the library; however, ENDF/B-V versions remain the default for these isotopes. The ENDF/B-VI nitrogen data were processed using the same methods used for ^{16}O, and, like oxygen, were tested to see if significant differences between ENDF/B-V and ENDF/B-VI could be identified. No significant differences have been identified; however, because they had already been processed into AMPX master library format and were readily available, ENDF/B-VI ^{14}N and ^{15}N cross sections are included in the library as cross sections 701401 and 701501, respectively. Finally, ENDF/B-VI evaluations of ^{154}Eu and ^{155}Eu are also included in the library as default cross sections 63154 and 63155, respectively. The more recent ENDF/B-VI evaluations include resonance parameters not included in previous evaluations and yield energy-dependent cross sections that are significantly different from those obtained using ENDF/B-V cross sections. Comparisons of depletion/decay calculations with experimental isotopic measurements have indicated that the ENDF/B-VI europium evaluations are more accurate than those available in ENDF/B-V. However, as with ^{16}O, ENDF/B-V cross sections are available within the library, as isotopes 631541 and 631551.

7.3 PERFORMANCE WITH HIGH-ENRICHED HOMOGENEOUS ^{235}U SYSTEMS

Figure 7.1 shows calculated k_{eff} values for highly enriched ^{235}U systems using the SCALE 44-group ENDF/B-V library. The overall trend shows an average k_{eff} of approximately 1.00 for thermal and fast systems, with a large variation in results for thermal systems.

7.3.1 High-Enriched Fast Systems

Fast systems in Figure 7.1 are represented by the group of calculations at an EALF of 8×10^5 eV or greater. The fast systems have an average k_{eff} of about 1.00, with a variation of about ±1%, very similar to the 238-group library results.

7.3.2 High-Enriched Thermal Systems

Thermal systems in Figure 7.1 are represented by the calculations with an EALF below about 3 eV. The average k_{eff} in the thermal region is about 1.00, with a variation of roughly ±2%. There is a wide spread of results in the thermal range (k_{eff} <0.98 to k_{eff} > 1.03). Similar spreads can be seen in the results for the other libraries, too. As observed with the other libraries, the uranyl fluoride results tend to be less than the uranyl nitrate results. The possibility of large uncertainties in the specifications for the critical systems used to validate the thermal range cannot be ruled out as the source of the large variations in calculated k_{eff} values.

7.3.3 High-Enriched Intermediate-Spectrum Systems

Intermediate spectrum systems in Figure 7.1 are those with an EALF between 3 eV and 8×10^5 eV. Few critical experiments are in the intermediate range. These systems are characterized by an ill-defined average k_{eff} of 1.00 ± 1.5%. Some cases are roughly 1% higher while others are nearly the same as the 238-group results.

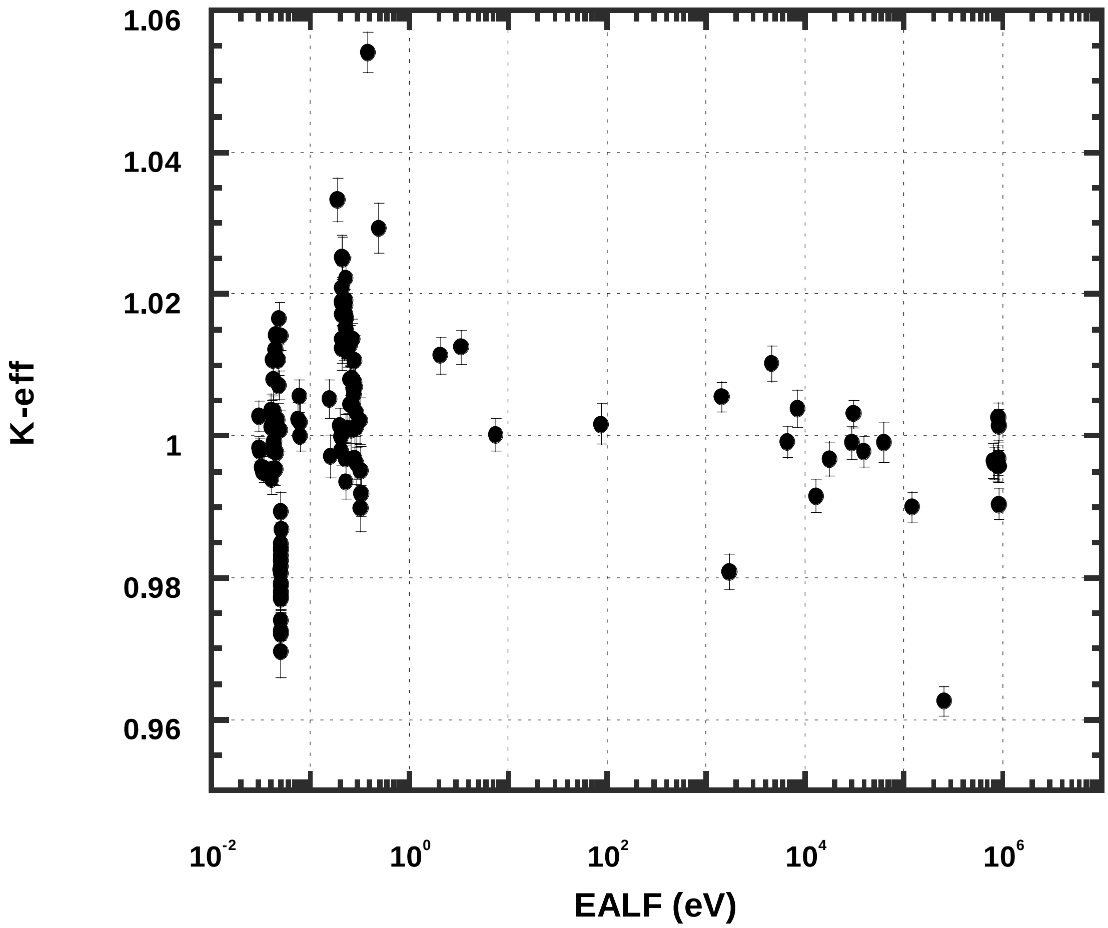

Figure 7.1 SCALE 44-group ENDF/B-V library high-enriched homogeneous ^{235}U system results

7.4 PERFORMANCE WITH LOW-ENRICHED HOMOGENEOUS ^{235}U SYSTEMS

The performance of the SCALE 44-group ENDF/B-V library for homogeneous low-enriched systems is shown in Figure 7.2. The homogeneous experiments have ^{235}U enrichments below 5%. Some of the more thermal cases show a negative bias, but all remaining cases have a positive bias. There is less scatter in these results than the 238-group library results. The harder spectra cases (> 1 eV) are about 2% higher than the 238-group results. The average calculated k_{eff} value is approximately 1.01 ± 1.5%.

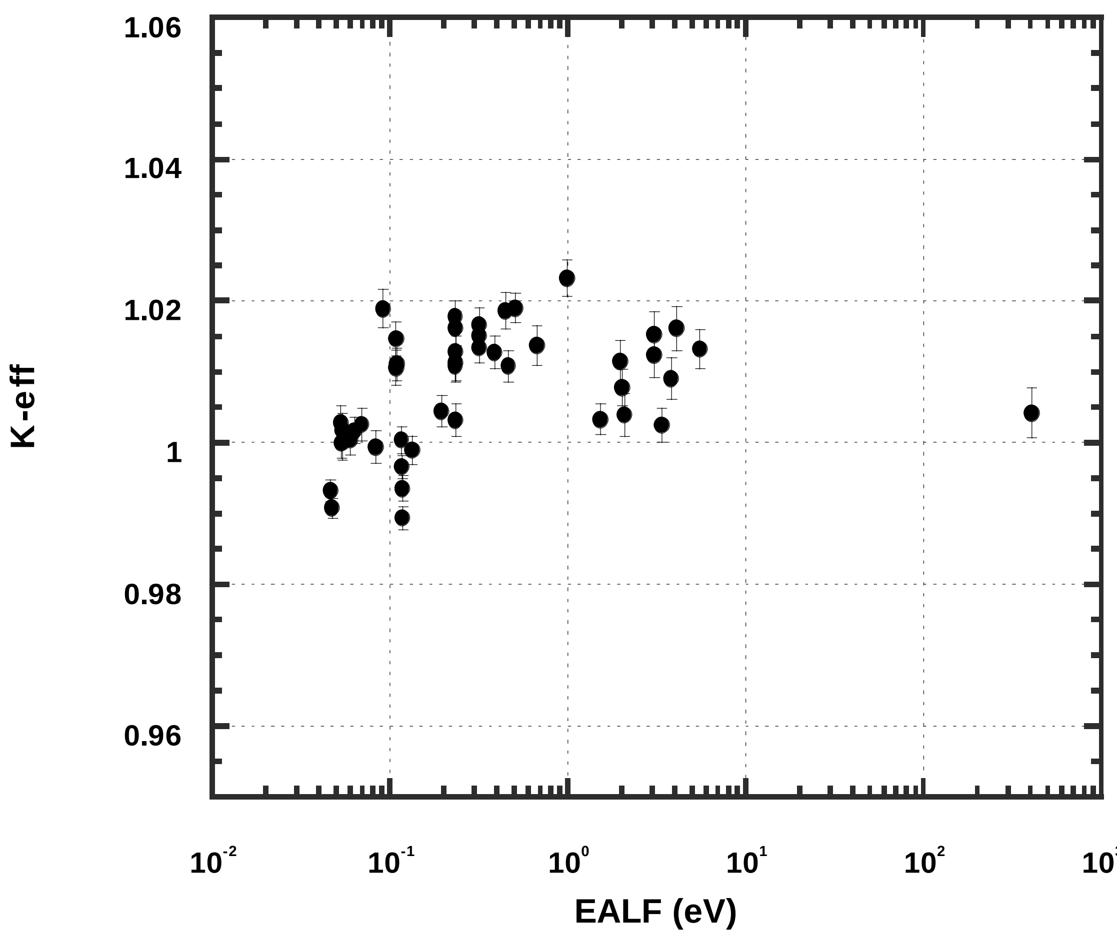

Figure 7.2 SCALE 44-group ENDF/B-V library low-enriched homogeneous ^{235}U system results

7.5 PERFORMANCE WITH LWR LATTICES

The performance of the SCALE 44-group ENDF/B-V library for heterogeneous low-enriched LWR lattice systems is shown in Figure 7.3. The maximum enrichment in the LWR lattice experiments is 5.74 wt % ^{235}U. The results for these cases are excellent, as should be expected, because the library was collapsed with an LWR lattice spectrum specifically for these types of applications. The experiments have an average k_{eff} of about 1.00 ± 1%. The results show no bias vs energy. The cases containing boron showed no apparent bias.

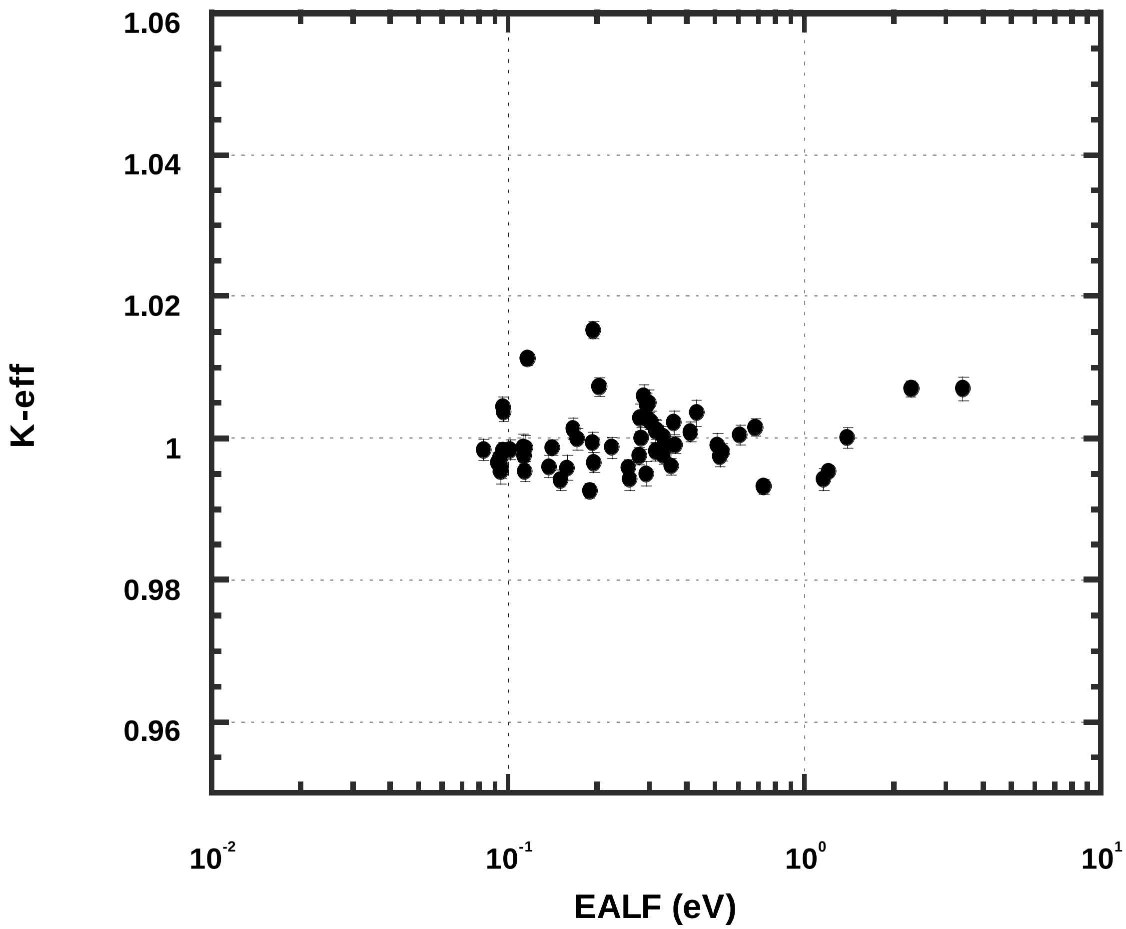

Figure 7.3 SCALE 44-group ENDF/B-V library low-enriched LWR lattice results

7.6 PERFORMANCE WITH ^{239}Pu SYSTEMS

The performance of the SCALE 44-group ENDF/B-V library for ^{239}Pu systems is shown in Figure 7.4. The performance of the library is fair, with an average k_{eff} of about 1.02 ± 2%. The results indicate possible problems in the base ENDF/B-V ^{239}Pu data. These results are 0.5 to 1.0% higher than the 238-group library for several cases.

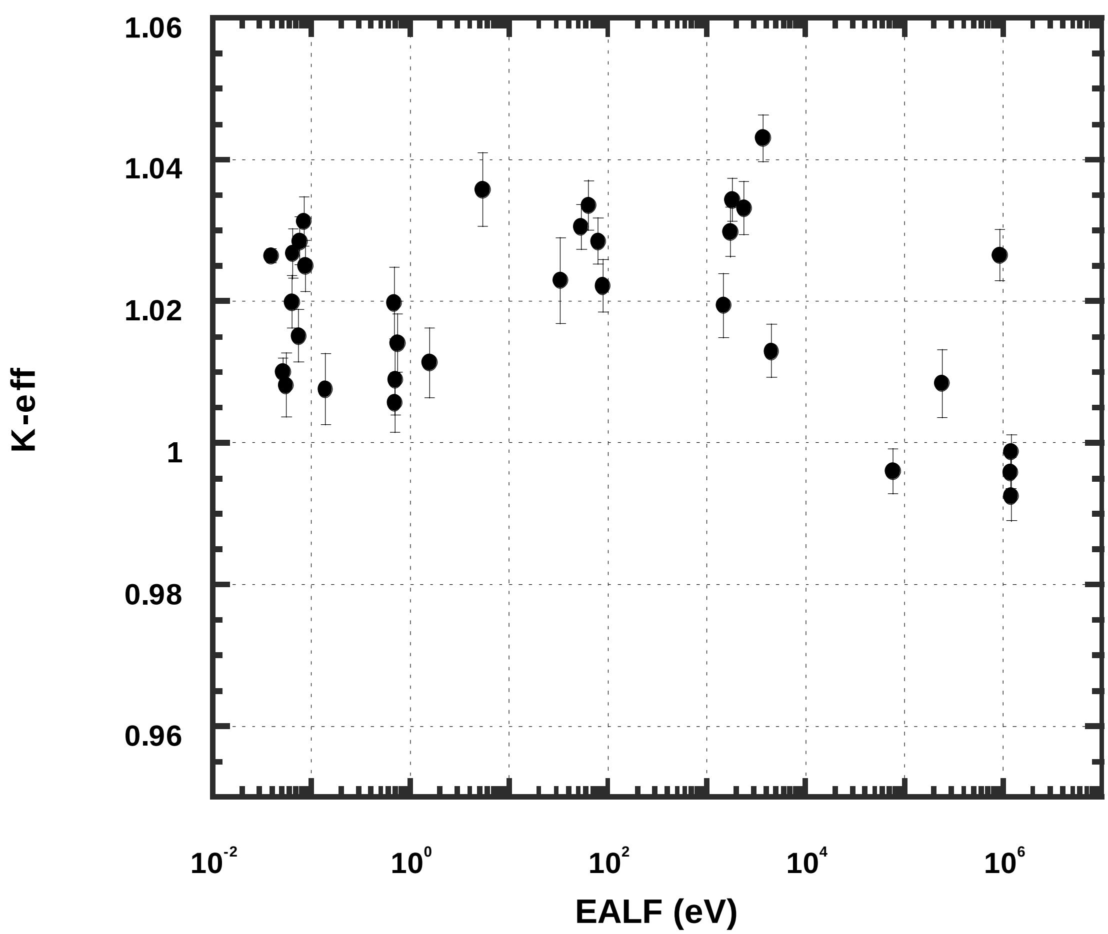

Figure 7.4 SCALE 44-group ENDF/B-V library plutonium system results

7.7 PERFORMANCE WITH ^{233}U SYSTEMS

The performance of the SCALE 44-group ENDF/B-V library for ^{233}U systems is shown in Figure 7.5. The performance of the library is good, and it is consistent between the thermal systems and the fast systems. The thermal system results have an average calculated k_{eff} value of about 1.0 ± 1.5%. The fast system results are excellent, with an average calculated k_{eff} value of about 0.997 ± 0.5%. These results are very similar to the 238-group library results.

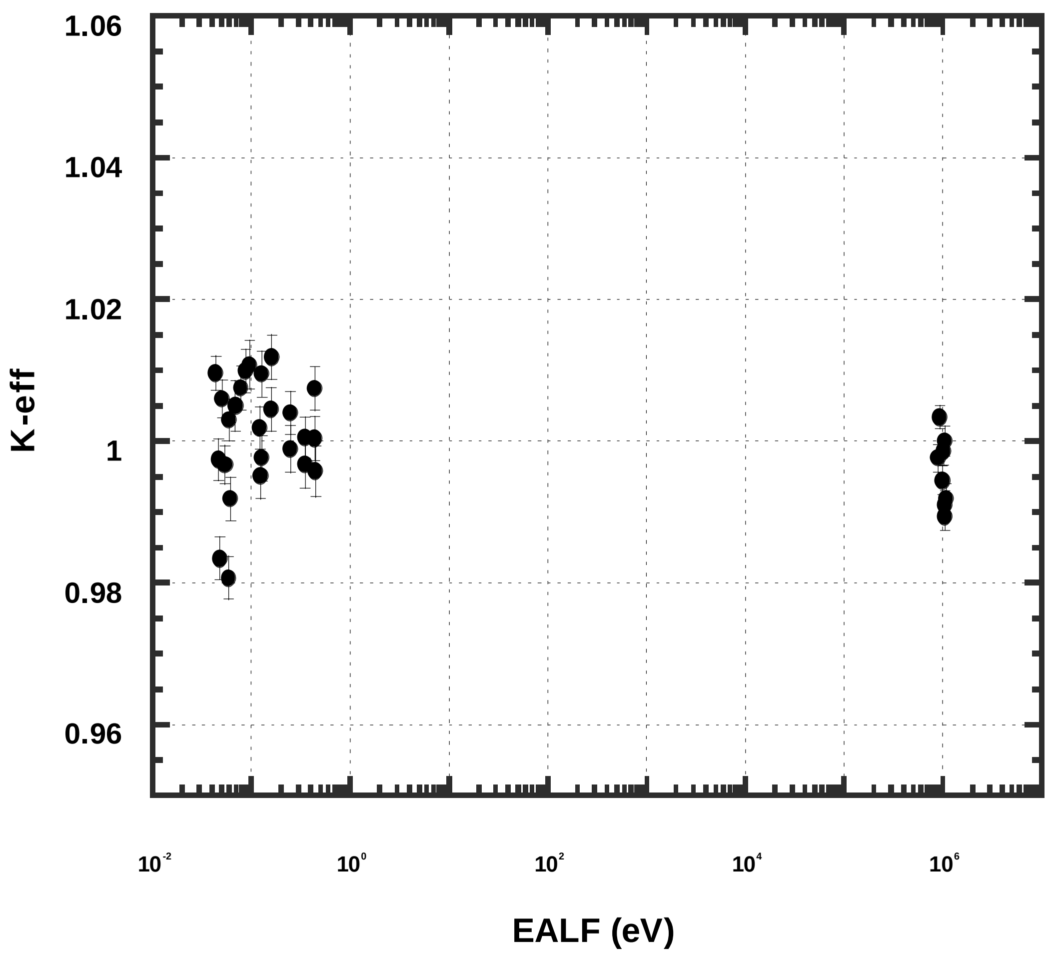

Figure 7.5 SCALE 44-group ENDF/B-V library ^{233}U system results

7.8 PERFORMANCE WITH MIXED-OXIDE LATTICES

The performance of the SCALE 44-group ENDF/B-V library for mixed-oxide (MOX) lattices is shown in Figure 7.6. All of the MOX lattice systems considered here are water-moderated thermal systems. The performance of the library is excellent. The average calculated k_{eff} value is approximately 1.003 ± 0.6%. The results may show a slight negative trend vs energy (i.e., moderation), but it is not definite.

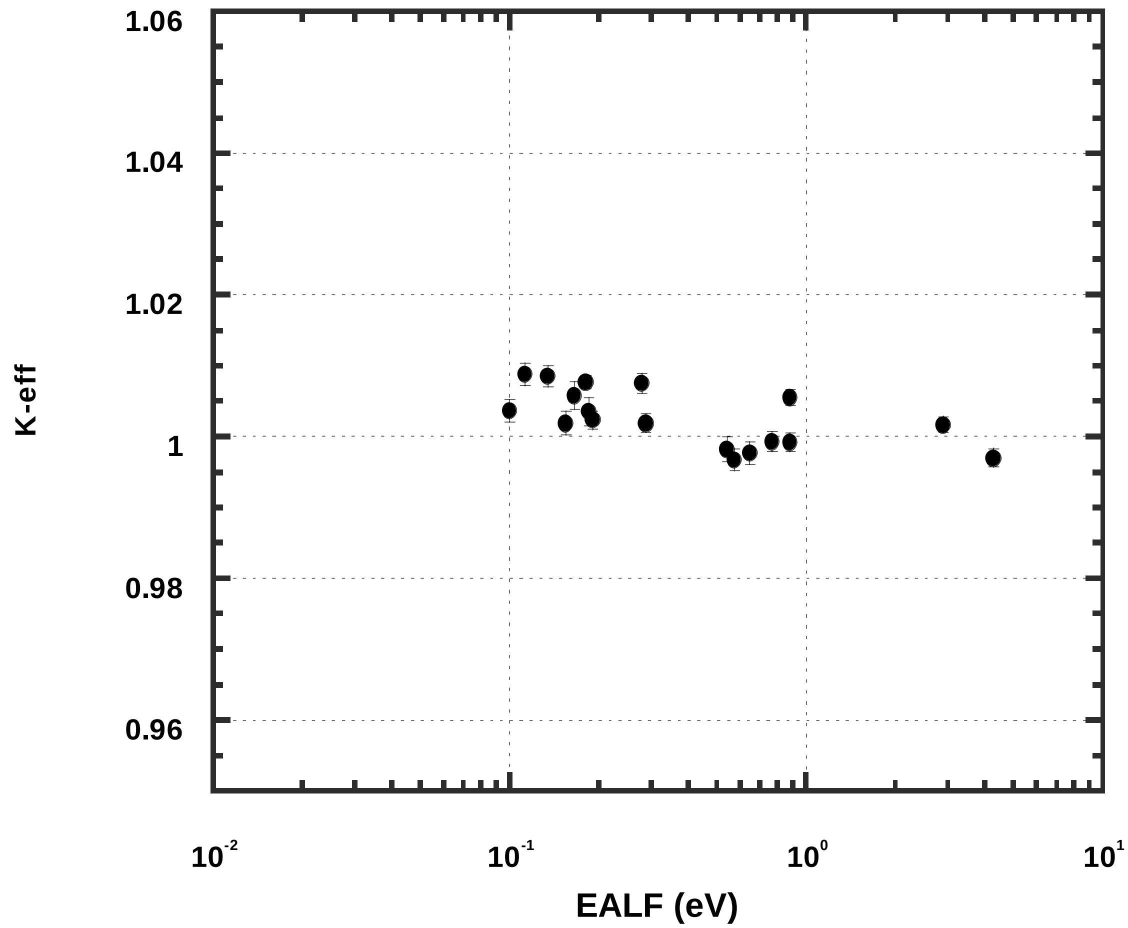

Figure 7.6 SCALE 44-group ENDF/B-V library mixed-oxide lattice results

8 SUMMARY AND CONCLUSIONS

This report provides detailed information on the SCALE criticality-safety cross-section libraries. Areas covered include the origins of the libraries, the data on which they are based, how they were generated, past experience and validations, and performance comparisons with measured critical experiments and numerical benchmarks. Performance results of each library for seven different application areas are summarized in Table 8.1.

The remainder of this section contains a brief verbal summary of each library.

Table 8.1 Summary of SCALE library performance for various applications

	Cross-section library				
Problem Type	SCALE 16-group Hansen-Roach	27-group[a] ENDF/B-IV	218-group[a] ENDF/B-IV	44-group ENDF/B-V	238-group ENDF/B-V
Fast HEU	Very good 0.995 ± 1%	Very good 1.00 ± 1%	Very good 1.00 ± 1%	Very good 1.00 ± 1%	Very good 0.995 ± 1%
Thermal HEU	Very poor 2% high to 4% low	Poor 3% high to 2% low	Poor 1.00 ± 2%	Poor 1.00 ± 3%	Poor 1.00 ± 2%
LWR Lattices	Fair ±1.5%	Good 0.995 ± 1% small bias vs energy	Good 0.99 ± 1% small bias vs energy	Very good 1.00 ± 1%	Very good 0.995 ± 1%
Homogeneous LEU	Poor ±2% bias vs energy	Fair 1.00 ± 1.5%	Fair 0.995 ± 1.5%	Fair 1.01 ± 1.5%	Fair 1.005 ± 1.5%
^{239}Pu	Very poor up to 5% high bias vs energy	Poor up to 5% high bias vs energy	Poor up to 5% high bias vs energy	Fair 1.02 ± 2%	Fair 1.015 ± 2%
MOX lattices	Very poor 3% high to 1% low	Fair 1.00 ± 1.5% bias vs energy	Fair 1% high to 2% low bias vs energy	Excellent 1.003 ± 0.6%	Very good 1.00 ± 1% small bias vs energy
^{233}U	Poor thermal - 0.99 ± 2% fast - 1.0 ± 1%	Poor thermal - 1.02 ± 1.5% fast - 0.97 ± 1%	Poor thermal - 1.015 ± 1.5% fast - 0.97 ± 1%	Good thermal - 1.00 ± 1.5% fast - 0.997 ± 0.5%	Good thermal - 0.995 ± 1.5% fast - 0.999 ± 0.4%

[a]Use of hafnium and gadolinium data not recommended.

8.1 SCALE 16-GROUP HANSEN-ROACH LIBRARY

1. How the library was generated or collapsed:

The library was generated from available data of 1960 vintage. It was originally intended for fast calculations (6 fast groups), and later extended to 16 groups, covering the full energy range. Most of the data is P_0 transport-corrected data, but hydrogen and deuterium are P_1 data with a P_2 transport correction. The ^{238}U data in the resonance range were adjusted to give good results for the PCTR experiments.

2. Known biases/weaknesses in original data for this library:

The age and sparseness of the base data (pre-ENDF) are the major weakness. Temperature effects and thermal upscatter are not treated.

3. Application areas where the library performs well:

The library performs well for small high-enriched ^{235}U metal systems and fairly well for many LEU thermal systems.

4. Application areas where the library performs poorly:

Optimally moderated uranyl nitrate solutions underpredict by as much as 2.5 to 3% in k_{eff}. Other thermal HEU systems may vary from 2% high to 4% low. Plutonium systems may be high by 2 to 4%. Thermal ^{233}U systems can underpredict k_{eff} by 2 to 3%.

8.2 SCALE 218-GROUP LIBRARY

1. How the library was generated or collapsed:

This library was generated from ENDF/B-IV data using $\chi(E)$-$1/(E\sigma_t)$-Maxwellian weighting. The base weighting allowed the library to be successfully collapsed using the weighting spectrum to a broad-group structure that could reproduce the behavior of the fine-group library. The unresolved resonance region was processed with an extremely high-background cross section of 50,000 barns, resulting in infinite-dilution cross sections in this region. Only the *s*-wave resonances were carried on the library, and any *p*-wave and *d*-wave resonances were integrated into the background cross section. The processing of the unresolved resonances with the extremely high-background cross section and the integration of the higher angular momentum *p*- and *d*-wave resolved resonances into the background cross section resulted in too much absorption in the intermediate-energy range.

2. Known biases/weaknesses in original data for this library:

The ^{238}U base data had too much capture in the epithermal range, leading to the underprediction of k_{eff} for low-enriched systems, particularly for harder thermal systems. The graphite thermal kernel is deficient, with unknown results. There may be a problem with the thermal plutonium cross sections.

3. **Application areas where the library performs well:**

   This library performs well for most realistic criticality safety problems. Fast, small metal units, highly enriched thermal systems, and very thermal low-enriched systems are generally well predicted.

4. **Application areas where the library performs poorly:**

   Low-enriched systems with a hard thermal spectrum underpredict by approximately 1% and sometimes more. Plutonium thermal systems overpredict k_{eff} by 1.5 to 3%. The 218-group library overpredicts thermal ^{233}U systems by about 2%, while it underpredicts fast ^{233}U systems by 2 to 4%. Intermediate-energy systems, such as the Palmer problems (see Appendix B), can be wrong by large amounts.

8.3 SCALE 27-GROUP LIBRARY

1. **How the library was generated or collapsed:**

   The 27-group library was collapsed from the 218-group library, using the weighting spectra with which the nuclides were originally generated. Because of the $1/(E\sigma_t)$ weighting in the resonance range, the broad-group library calculates many systems nearly as well as the fine-group library does. Trends and biases in the fine-group library were preserved in the broad-group library.

2. **Known biases/weaknesses in original data for this library:**

   Same as the 218-group library.

3. **Application areas where the library performs well:**

   Generally the same as the 218-group library. Some trends and biases may be slightly more pronounced in the broad-group library, but most results are fairly equivalent.

4. **Application areas where the library performs poorly:**

   Same as the 218-group library.

8.4 SCALE 238-GROUP LIBRARY

1. **How the library was generated or collapsed:**

   The library was generated from ENDF/B-V data, using a $\chi(E)$-1/E-Maxwellian spectrum. The integrating function makes it more difficult to collapse a general-purpose broad-group library that is valid over a large range of problems. It contains all nuclides (over 300) in ENDF/B-V plus data for ENDF/B-VI evaluations of ^{14}N, ^{15}N, ^{16}O, ^{154}Eu, and ^{155}Eu.

2. Known biases/weaknesses in original data for this library:

The ^{235}U fission data and the ^{238}U capture data are slightly too high. There may be a problem with the thermal plutonium cross sections.

3. Application areas where the library performs well:

Generally, this library has done very well for high-enriched fast systems and low-enriched thermal homogeneous and lattice systems. Results for mixed-oxide lattices and ^{233}U systems are good, too. This library is recommended as the best library in SCALE for general-purpose criticality-safety analyses.

4. Application areas where the library performs poorly:

This library has problems with intermediate-energy problems that involve nuclides with cross-section structure without resonance parameters. Although any intermediate-energy problems are suspect because of the scarcity of critical experiments, this library performs better than any other library in SCALE.

8.5 SCALE 44-GROUP LIBRARY

1. How the library was generated or collapsed:

This library was collapsed from the 238-group library, using a LWR flux spectrum. Consequently, the library does well predicting LWR lattices, but not as well for other types of systems.

2. Known biases/weaknesses in original data for this library:

Same as the 238-group library. Because of the 1/E weighting in the 238-group library, this library is not a good general-purpose library.

3. Application areas where the library performs well:

LWR and mixed-oxide lattices are the library's strong point, and it is the recommended SCALE library for these applications. It calculates highly enriched metal systems well. It also predicts ^{233}U systems reasonably well. For other types of thermal systems, the more the spectrum differs from a LWR spectrum, the more likely it is that the calculated k_{eff} will show a bias.

4. Application areas where the library performs poorly:

The 44-group library has all the shortcomings of the 238-group library, as well as not being able to calculate homogeneous thermal, epithermal, and intermediate-energy systems as accurately as the 238-group library.

9 LESSONS LEARNED AND FUTURE DEVELOPMENTS

As this report indicates, there has been considerable experience gleaned from the processing and use of multigroup libraries for the SCALE code system. This section briefly reviews the history and lessons learned in the context of ongoing and future developments relative to SCALE cross-section libraries and problem-dependent cross-section processing.

Initially, the SCALE system criticality analysis modules utilized two well-established, existing multigroup libraries (modified Hansen-Roach and 123-group GAM-THERMOS library[31]) and the relatively new SCALE ENDF/B-IV library. A problem-dependent (fixed σ_p values) version of the Hansen-Roach library was originally distributed with early versions of SCALE to be used for running the KENO V.a sample problems only. Some users were employing it for safety analyses, running KENO V.a in stand-alone mode. This technique resulted in the misapplication of problem-dependent cross sections to other types of problems and was removed from versions after the release of SCALE 4.0. More recently, the 123-group library was removed because of problems found when using the library for high-enriched systems with low H/X ratios.[31] Because this library was removed with the release of SCALE 4.3 and is no longer considered a part of the SCALE system, this report does not discuss its characteristics or performance.

Several new development efforts are now under way to improve and update the cross-section data and resonance processing in SCALE. One of the most significant efforts is the development of an ENDF/B-VI cross-section library. The format of the ENDF data was expanded to include new parameters in version VI. These format changes resulted in incompatibilities with the cross-section processing methods used in the AMPX-77[11] and SCALE systems. A new version of AMPX is near production status, and work to produce a SCALE ENDF/B-VI library should commence in FY 2001. Experience from previous processing efforts and validation studies will be incorporated in this production effort. Like the SCALE ENDF/B-V libraries, the preparation of multigroup data for all of the nuclides present on the ENDF/B-VI files is planned. Also, application experience with the SCALE ENDF/B-IV and ENDF/B-V libraries demonstrates that the versatility of the library will be improved if a fission-($1/E\sigma_t$)-Maxwellian energy weighting is used in generating the group cross-section data from ENDF/B. Use of a $1/E\sigma_t$ weighting, rather than a 1/E weighting, provides some pseudo-self-shielding for the non-resonance nuclides and is a better approximation of the physics than the infinite dilute processing that results otherwise. Relative to the group structure, it is anticipated that the established 238-group structure will be used initially to more easily test and validate the production capabilities of the new AMPX system and the NITAWL-III resonance processing code (a new version of NITAWL that is compatible with ENDF/B-VI data formats). A refined library with additional groups (partially to facilitate analysis of problems with a dominant intermediate-energy spectrum) will likely be produced subsequent to the production of a 238-group ENDF/B-VI library for SCALE.

Another important development is CENTRM, a pointwise energy discrete-ordinates computer code that generates problem-dependent cross-sections from either ENDF/B-V or ENDF/B-VI data. CENTRM uses a fine multigroup calculation in the high- and low-energy ranges combined with a continuous-energy (i.e., pointwise) solution for energies in the resolved resonance region. A new CSAS sequence that uses CENTRM instead of NITAWL to perform resonance processing of the nuclides in the unit cell has been developed and tested. Continuous-energy cross-section libraries from ENDF/B-V and ENDF/B-VI have been developed and tested for use with CENTRM. The next version of SCALE will include a continuous-energy cross-section library, CENTRM, and the new CSAS sequence.

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APPENDIX A

SCALE CROSS-SECTION LIBRARY ENERGY-GROUP BOUNDARIES

APPENDIX A

SCALE CROSS-SECTION LIBRARY ENERGY-GROUP BOUNDARIES

Table A.1 SCALE cross-section library energy-group boundaries

ENDF/B-V 238-group	ENDF/B-IV 218-group	ENDF/B-V 44-group	ENDF/B-IV 27-group	Hansen-Roach 16-group	Upper energy (eV)
1	1	1	1		2.0000E+07
2					1.7333E+07
3					1.5683E+07
					1.5000E+07
4					1.4550E+07
5					1.3840E+07
6					1.2840E+07
7				1	1.0000E+07
8		2			8.1873E+06
9	2	3	2		6.4340E+06
10	3	4			4.8000E+06
11	4				4.3040E+06
12	5	5	3	2	3.0000E+06
13	6	6			2.4790E+06
14	7	7			2.3540E+06
15	8	8	4		1.8500E+06
16	9				1.5000E+06
17	10	9	5	3	1.4000E+06
18	11				1.3560E+06
19	12				1.3170E+06
20	13				1.2500E+06
21	14				1.2000E+06
22	15				1.1000E+06
23	16				1.0100E+06
24	17				9.2000E+05
25	18	10	6	4	9.0000E+05
26	19				8.7500E+05
27	20				8.6110E+05
28	21				8.2000E+05
29	22				7.5000E+05
30	23				6.7900E+05
31	24				6.7000E+05

Table A.1 (continued)

ENDF/B-V 238-group	ENDF/B-IV 218-group	ENDF/B-V 44-group	ENDF/B-IV 27-group	Hansen-Roach 16-group	Upper energy (eV)
32	25				6.0000E+05
33	26				5.7300E+05
34	27				5.5000E+05
35	28				4.9952E+05
36	29				4.7000E+05
37	30				4.4000E+05
38	31				4.2000E+05
39	32	11	7	5	4.0000E+05
40	33				3.3000E+05
41	34				2.7000E+05
42	35				2.0000E+05
43	36				1.5000E+05
44	37				1.2830E+05
45	38	12	8	6	1.0000E+05
46	39				8.5000E+04
47	40				8.2000E+04
48	41				7.5000E+04
49	42				7.3000E+04
50	43				6.0000E+04
51	44				5.2000E+04
52	45				5.0000E+04
53	46				4.5000E+04
54	47				3.0000E+04
55	48	13			2.5000E+04
56	49	14	9	7	1.7000E+04
57	50				1.3000E+04
58	51				9.5000E+03
59	52				8.0300E+03
60	53				6.0000E+03
61	54				3.9000E+03
62	55				3.7400E+03
63	56	15	10	8	3.0000E+03
64	57				2.5800E+03
65	58				2.2900E+03
66	59				2.2000E+03
67	60				1.8000E+03
68	61				1.5500E+03

Table A.1 (continued)

ENDF/B-V 238-group	ENDF/B-IV 218-group	ENDF/B-V 44-group	ENDF/B-IV 27-group	Hansen-Roach 16-group	Upper energy (eV)
69	62				1.5000E+03
70	63				1.1500E+03
71	64				9.5000E+02
72	65				6.8300E+02
73	66				6.7000E+02
74	67	16	11	9	5.5000E+02
75	68				3.0500E+02
76	69				2.8500E+02
77	70				2.4000E+02
78	71				2.1000E+02
79	72				2.0750E+02
80	73				1.9250E+02
81	74				1.8600E+02
82	75				1.2200E+02
83	76				1.1900E+02
84	77				1.1500E+02
85	78				1.0800E+02
86	79	17	12	10	1.0000E+02
87	80				9.0000E+01
88	81				8.2000E+01
89	82				8.0000E+01
90	83				7.6000E+01
91	84				7.2000E+01
92	85				6.7500E+01
93	86				6.5000E+01
94	87				6.1000E+01
95	88				5.9000E+01
96	89				5.3400E+01
97	90				5.2000E+01
98	91				5.0600E+01
99	92				4.9200E+01
100	93				4.8300E+01
101	94				4.7000E+01
102	95				4.5200E+01
103	96				4.4000E+01
104	97				4.2400E+01
105	98				4.1000E+01

Table A.1 (continued)

ENDF/B-V 238-group	ENDF/B-IV 218-group	ENDF/B-V 44-group	ENDF/B-IV 27-group	Hansen-Roach 16-group	Upper energy (eV)
106	99				3.9600E+01
107	100				3.9100E+01
108	101				3.8000E+01
109	102				3.7000E+01
110	103				3.5500E+01
111	104				3.4600E+01
112	105				3.3750E+01
113	106				3.3250E+01
114	107				3.1750E+01
115	108				3.1250E+01
116	109	18	13	11	3.0000E+01
117	110				2.7500E+01
118	111				2.5000E+01
119	112				2.2500E+01
120	113				2.1000E+01
121	114				2.0000E+01
122	115				1.9000E+01
123	116				1.8500E+01
124	117				1.7000E+01
125	118				1.6000E+01
126	119				1.5100E+01
127	120				1.4400E+01
128	121				1.3750E+01
129	122				1.2900E+01
130	123				1.1900E+01
131	124				1.1500E+01
132	125	19	14	12	1.0000E+01
133	126				9.1000E+00
134	127	20			8.1000E+00
135	128				7.1500E+00
136	129				7.0000E+00
137	130				6.7500E+00
138	131				6.5000E+00
139	132				6.2500E+00
140	133	21			6.0000E+00
141	134				5.4000E+00
142	135				5.0000E+00

Table A.1 (continued)

ENDF/B-V 238-group	ENDF/B-IV 218-group	ENDF/B-V 44-group	ENDF/B-IV 27-group	Hansen-Roach 16-group	Upper energy (eV)
143	136	22			4.7500E+00
144	137				4.0000E+00
145	138				3.7300E+00
146	139				3.5000E+00
147	140				3.1500E+00
148	141		15		3.0500E+00[a]
149	142	23		13	3.0000E+00[b]
150	143				2.9700E+00
151	144				2.8700E+00
152	145				2.7700E+00
153	146				2.6700E+00
154	147				2.5700E+00
155	148				2.4700E+00
156	149				2.3800E+00
157	150				2.3000E+00
158	151				2.2100E+00
159	152				2.1200E+00
160	153				2.0000E+00
161	154				1.9400E+00
162	155				1.8600E+00
163	156	24	16		1.7700E+00
164	157				1.6800E+00
165	158				1.5900E+00
166	159				1.5000E+00
167	160				1.4500E+00
168	161				1.4000E+00
169	162				1.3500E+00
170	163		17		1.3000E+00
171	164				1.2500E+00
172	165				1.2250E+00
173	166				1.2000E+00
174	167				1.1750E+00
175	168				1.1500E+00
176	169				1.1400E+00
177	170		18		1.1300E+00
178	171				1.1200E+00
179	172				1.1100E+00

Table A.1 (continued)

ENDF/B-V 238-group	ENDF/B-IV 218-group	ENDF/B-V 44-group	ENDF/B-IV 27-group	Hansen-Roach 16-group	Upper energy (eV)
180	173				1.1000E+00
181	174				1.0900E+00
182	175				1.0800E+00
183	176				1.0700E+00
184	177				1.0600E+00
185	178				1.0500E+00
186	179				1.0400E+00
187	180				1.0300E+00
188	181				1.0200E+00
189	182				1.0100E+00
190	183	25	19	14	1.0000E+00
191	184				9.7500E−01
192	185				9.5000E−01
193	186				9.2500E−01
194	187				9.0000E−01
195	188				8.5000E−01
196	189		20		8.0000E−01
197	190				7.5000E−01
198	191				7.0000E−01
199	192				6.5000E−01
200		26			6.2500E−01
201	193				6.0000E−01
202	194				5.5000E−01
203	195				5.0000E−01
204	196				4.5000E−01
205	197	27	21	15	4.0000E−01
206	198	28			3.7500E−01
207	199	29			3.5000E−01
208	200	30	22		3.2500E−01
209	201				3.0000E−01
210	202	31			2.7500E−01
211	203	32			2.5000E−01
212	204	33	23		2.2500E−01
213	205	34			2.0000E−01
214	206				1.7500E−01
215	207	35			1.5000E−01
216	208				1.2500E−01

Table A.1 (continued)

ENDF/B-V 238-group	ENDF/B-IV 218-group	ENDF/B-V 44-group	ENDF/B-IV 27-group	Hansen-Roach 16-group	Upper energy (eV)
217	209	36	24	16	1.0000E−01
218	210				9.0000E−02
219	211				8.0000E−02
220	212	37			7.0000E−02
221	213				6.0000E−02
222	214	38	25		5.0000E−02
223	215	39			4.0000E−02
224	216	40	26		3.0000E−02
225	217	41			2.5300E−02
226	218	42	27		1.0000E−02
227		43			7.5000E−03
228					5.0000E−03
229					4.0000E−03
230		44			3.0000E−03
231					2.5000E−03
232					2.0000E−03
233					1.5000E−03
234					1.2000E−03
235				*[c]	1.0000E−03
236					7.5000E−04
237					5.0000E−04
238					1.0000E−04
*[c]	*[c]	*[c]	*[c]		1.0000E−05

[a]Thermal boundary for ENDF/B-IV libraries.
[b]Thermal boundary for ENDF/B-V libraries.
[c]Lower boundary for library.

APPENDIX B

CALCULATIONAL BENCHMARKS

APPENDIX B

CALCULATIONAL BENCHMARKS

B.1 DESCRIPTION OF THE BENCHMARKS

B.1.1 Palmer Benchmarks

The Palmer benchmarks consist of three calculational benchmarks that were devised to study the performance of various cross-section sets for calculating *k-infinite* for ^{235}U/metal mixtures.[32] The following systems are considered: ^{235}U/Al at an Al/^{235}U atom ratio of 2470, ^{235}U/Fe at an Fe/^{235}U atom ratio of 320, and ^{235}U/Zr at a Zr/^{235}U atom ratio of 103. These simple systems are all dominated by scattering and fission in the intermediate energy range of 10 eV to 1 MeV and, as such, provide a severe test of the cross-section data and processing methodologies in this energy range. Studies of these systems using various codes and data libraries[32] have demonstrated a wide variation in results due to deficiencies in ENDF/B data as well as discrepancies and deficiencies in the processing of data for use by the codes. Although these systems were originally developed to have a *k-infinite* = 1.0 utilizing the ENDF/B-V cross sections in MCNP, the best estimates of *k-infinite* for the Al, Fe, and Zr systems are 1.12 ± 0.04, 1.09 ± 0.04, and 1.11 ± 0.04, respectively. There are no experiments which validate the reliability of the cross sections for these applications. The large uncertainties indicate the uncertainties expected from the known deficiencies in the cross sections.

B.1.2 Fe Benchmark

Like the Palmer benchmarks, this finite-sphere Fe benchmark is another calculational benchmark that provides a rigorous test of not only the scattering and fission but also the transport in systems with no light element thermalization (i.e., neutrons will not reach thermal energies prior to absorption). The benchmark is a simplification of the critical experiment HEU-MET-FAST-035 (Ref. 15), also known as ZPR-9/34, into a simple unreflected ^{235}U/Fe sphere, 107-cm radius, at an Fe/^{235}U atom ratio = 63.2 (N_{Fe} = 8.13913-2, $N_{U\text{-}235}$ = 1.28882-3). The best estimate of the "correct k_{eff}" for this sphere is 1.00 ± 0.02. The benchmark complements the Palmer benchmarks and shows how calculational performance for an infinite system is not necessarily indicative of performance for a finite system.

B.1.3 UO_2F_2 *K-Infinite* Calculations

The UO_2F_2 *k-infinite* calculations are a series of calculational benchmarks that span a moderation range from H/X = 0 to 700. The benchmarks were developed to study fully enriched UO_2F_2/H_2O systems. This series of benchmarks was used to identify significant deficiencies in the SCALE 123 group cross-section library[31] and ultimately led to the removal of the library from SCALE. The "expected value" was determined using MCNP and ENDF/B-V cross sections for uranium, fluorine, and hydrogen, and ENDF/B-VI oxygen. An uncertainty of 0.5% in the expected values was assigned to the series of calculations.

B.1.4 PCTR Experiments

The PCTR benchmarks are a series of *k-infinite* measurements for low-enriched UO_3 which were performed in the Physical Constant Test Reactor at Hanford.[33-35] The experiments were designed to help predict the minimum enrichment that could be made critical in a homogeneous light-water-moderated system. These experiments provide a good test of the ^{238}U cross sections and have been used to identify deficiencies in the Hansen-Roach cross-section library for LEU systems.

B.2 BENCHMARK RESULTS

A comparison of the performance of the SCALE cross-section libraries for these calculational benchmarks is presented in this section. This comparison shows how the various SCALE cross-section libraries perform for ^{235}U systems across a range of interest. This series of benchmarks includes the Palmer problems, the Fe sphere, $U(100)O_2F_2$ *k-infinite* calculations, and the PCTR LEU *k-infinite* experiments. All of these calculations, with the exception of the PCTR experiments, are numerical (i.e., calculational) benchmarks for library comparison. The results presented here may be used to supplement the information presented in Sections 3–7 of this report.

Table B.1 shows the results for all of the SCALE libraries. The "expected" k_{eff} value and an estimate of the uncertainty of the expected value are given. Excluding the PCTR experiments, the expected value is a best estimate of the correct *k* for the specified system. The uncertainty has been assigned based on previous evaluation of these systems and general uncertainties encountered in the ENDF cross sections. The PCTR values are experimentally determined *k-infinite* values and uncertainties.

Figure B.1 presents a comparison of results for the Palmer benchmarks. Note that the shift in the EALF between libraries is due to the combined effects of differences in cross sections and in averages performed over different group structures. Figure B.2 shows the results of the UO_2F_2 *k-infinite* calculations as a function of EALF. The SCALE 16-group Hansen-Roach library, which has only four thermal groups, exhibits the largest shifts in EALF. Figures B.3 – B.5 display the results for the three different enrichments of the PCTR experiments. Because no EALF data corresponding to the expected k_{eff} values are available, the expected k_{eff} values are plotted vs the 44-group library EALF values as a convenience in Figures B.1 – B.5.

B.2.1 Performance of the SCALE 16-group Hansen-Roach Library

The results in Table B.1 and Figure B.1 show that the SCALE 16-group Hansen-Roach library that calculated *k-infinite* values for the Palmer Al/U and Fe/U benchmarks are about 10% low. The Palmer Zr/U benchmark calculates about 25% high. These results are due to a combination of factors, including lack of resonance data for Al, Fe, and Zr cross sections and a broad-group structure. **The library should not be used for applications where intermediate-mass nuclides are the principal scattering materials or in intermediate-spectrum systems where absorption is dominated by intermediate-mass absorbers.**

The high-enriched U/Fe sphere calculates 20% high, but the Palmer Fe/U system calculates 10% low. This discrepancy demonstrates that flux-weighted multigroup cross sections as generated in AMPX cannot correctly model transport through thick materials with cross-section energy windows (i.e., energies where there are large "dips" in the cross-section data), such as pure iron. **Errors on the order of up to 30% in *k* can exist for similar systems.** The discrepancy does not occur unless the energy windows are seen on the macroscopic level; e.g., thick material mixtures such as iron oxide would not exhibit the characteristic.

Figure B.2 shows that there may be a large variation in performance, depending on the moderation level of the system. The calculated *k-infinite* value is 2% high when oxygen and fluorine are the principal moderators (i.e., no hydrogen present). Calculated *k-infinite* values are approximately 1% low over the intermediate-spectrum range and trend to nominally unbiased for more thermal systems. This behavior indicates that the SCALE 16-group cross-section set should be used with caution in the intermediate-spectrum, hydrogen-moderated systems.

Figures B.3 – B.5 show that there is a fairly consistent 2% positive bias for the PCTR LEU experiments. This bias is probably due to the broad-group structure and inadequate resonance processing for this system.

B.2.2 Performance of the SCALE 218-group ENDF/B-IV Library

Table B.1 and Figure B.1 show that the SCALE 218-group library calculates from 10 to 25% low for the Palmer benchmarks. Poor performance for the Al/U benchmark can be primarily attributed to poor ENDF/B-IV cross sections for Al. Poor performance for the Fe systems is probably due to a combination of effects, which include inadequate group structure, cross-section generation methods, and resonance-processing methodology (e.g., no *p*- and *d*-wave resonances and fixed σ_p value for unresolved resonance region). The Zr/U benchmark calculates low due to poor ENDF/B-IV cross sections for Zr and due to inadequate resonance processing in the SCALE 218-group library.

Similar to the Hansen-Roach library, the U/Fe sphere calculates nearly 20% high, but the Palmer Fe/U system calculates 25% low. Once again, this difference in results indicates the use of flux weighting to generate multigroup cross sections will not conserve the neutron transport for this type system unless the group structure is extremely fine across the resonance region of Fe. It is difficult to conserve both the reaction rate and the transport for systems similar to the U/Fe sphere when no low-mass moderator is present.

Figure B.2 shows that the SCALE 218-group library performs adequately across the range of the UO_2F_2 *k-infinite* benchmarks. The library shows a 0.5% positive bias across the intermediate spectrum, and a −0.5% bias for the most thermal systems.

Figures B.3 – B.5 show that the SCALE 218-group library calculates these LEU systems approximately 1% low. This is primarily due to poor ENDF/B-IV ^{238}U cross sections and inadequate unresolved- resonance-region processing in the 218-group library.

B.2.3 Performance of the SCALE 27-group ENDF/B-IV Library

Table B.1 and Figure B.1 show that the SCALE 27-group library calculates from 10 to 20% low for the Palmer benchmarks. Poor performance for the Al/U benchmark can be primarily attributed to poor ENDF/B-IV cross sections for Al. Poor performance for the Fe systems is probably due to a combination of effects which include inadequate group structure, cross-section generation methods, and resonance-processing methodology. The Zr/U benchmark calculates low due to poor ENDF/B-IV cross sections for Zr and inadequate resonance processing in the SCALE 27-group library.

Like the 218-group library, the U/Fe sphere calculates 20% high, but the Palmer Fe/U system calculates 20% low. Once again, this difference in results indicates the use of flux weighting to generate multigroup cross sections will not conserve the neutron transport for this type system unless the group structure is extremely fine across the resonance region of Fe.

Figure B.2 shows that the SCALE 27-group library performs adequately across the range of the UO_2F_2 *k-infinite* benchmarks. The results are virtually identical to the 218-group results. The library shows a 0.5% positive bias across the intermediate spectrum, and a −0.5% bias for the most thermal systems.

Figures B.3 – B.5 show that the SCALE 27-group library calculates these LEU systems nominally 0.5 to 1% low. The results are slightly higher than the 218-group results. This is primarily due to poor ENDF/B-IV ^{238}U cross sections and inadequate unresolved-resonance-region processing in the 27-group library.

B.2.4 Performance of the SCALE 238-group ENDF/B-V Library

Table B.1 and Figure B.1 show that the SCALE 238-group library calculates from 2 to 13% low for the Palmer benchmarks. Even though the Al/U results are very similar to the ENDF/B-IV libraries, the Fe/U and Zr/U are significantly better. The poor performance for the Al/U benchmark can be primarily attributed to a lack of resonance data for Al in ENDF/B-V. Aluminum has significant resonance structure but is not considered a resonance nuclide in ENDF. The Fe/U benchmark is approximately 3% low, and the Zr/U benchmark is only 2% low.

The disparity in the 238-group library results for the U/Fe sphere (10% high) and the Palmer Fe/U system (3% low) is much smaller than the other libraries. As stated previously, it is difficult to conserve both the reaction rate and the transport for systems similar to the U/Fe sphere in a multigroup structure.

Figure B.2 shows that the SCALE 238-group library performs well across the range of the UO_2F_2 *k-infinite* benchmarks. The library shows almost no bias across the entire spectrum.

Figures B.3 – B.5 show that the SCALE 238-group library calculates these LEU systems very well, within ±0.5%.

B.2.5 Performance of the SCALE 44-group ENDF/B-V Library

Table B.1 and Figure B.1 show that the SCALE 44-group library calculates from 0 to 20% low for the Palmer benchmarks. The Al/U results are 10% lower than any other library. This difference is apparently due to the broad-group collapse of the 44-group library. The resonance structure for aluminum evidently occurs over several fine groups in the 238-group library that are collapsed to a single broad group in the 44-group library, causing the loss of that resonance structure. This problem does not occur in the 27-group library collapse because of the different weighting [$1/(E\sigma_t)$] used in the 218-group library. As stated earlier in this report, the 1/E weighting of the resonance region in the 238-group library makes it difficult to collapse a general-purpose broad-group library.

Table B.1 Calculational benchmark results

Benchmarks	Expected k	Uncertainty	Calc. k (16 group)	Calc. k (27 group)	Calc. k (218 group)	Calc. k (44 group)	Calc. k (238 group)
Palmer Al/U	1.120E+00	4.000E−02	1.005E+00	1.021E+00	1.001E+00	8.808E−01	9.818E−01
Palmer Fe/U	1.090E+00	4.000E−02	1.003E+00	8.576E−01	8.193E−01	1.049E+00	1.055E+00
Palmer Zr/U	1.110E+00	4.000E−02	1.383E+00	1.027E+00	9.602E−01	1.117E+00	1.089E+00
High-enriched U/Fe sphere	1.000E+00	2.000E−02	1.203E+00	1.198E+00	1.169E+00	1.142E+00	1.105E+00
$U(100)O_2F_2$, h/x=0	2.087E+00	5.000E−03	2.133E+00	2.081E+00	2.076E+00	2.077E+00	2.085E+00
$U(100)O_2F_2$, h/x=5	1.795E+00	5.000E−03	1.797E+00	1.807E+00	1.802E+00	1.808E+00	1.804E+00
$U(100)O_2F_2$, h/x=10	1.796E+00	5.000E−03	1.785E+00	1.807E+00	1.800E+00	1.809E+00	1.803E+00
$U(100)O_2F_2$, h/x=20	1.836E+00	5.000E−03	1.819E+00	1.839E+00	1.834E+00	1.844E+00	1.840E+00
$U(100)O_2F_2$, h/x=50	1.892E+00	5.000E−03	1.876E+00	1.888E+00	1.885E+00	1.895E+00	1.894E+00
$U(100)O_2F_2$, h/x=100	1.898E+00	5.000E−03	1.884E+00	1.890E+00	1.889E+00	1.899E+00	1.898E+00
$U(100)O_2F_2$, h/x=200	1.843E+00	5.000E−03	1.835E+00	1.835E+00	1.834E+00	1.844E+00	1.844E+00
$U(100)O_2F_2$, h/x=300	1.775E+00	5.000E−03	1.771E+00	1.767E+00	1.767E+00	1.776E+00	1.776E+00
$U(100)O_2F_2$, h/x=500	1.643E+00	5.000E−03	1.645E+00	1.635E+00	1.635E+00	1.643E+00	1.643E+00
$U(100)O_2F_2$, h/x=700	1.526E+00	5.000E−03	1.532E+00	1.519E+00	1.519E+00	1.526E+00	1.526E+00
PCTR 1.006%, h/u=3.83	9.860E−01	5.000E−03	1.014E+00	9.807E−01	9.756E−01	9.894E−01	9.863E−01
PCTR 1.006%, h/u=6.23	9.860E−01	7.000E−03	9.978E−01	9.758E−01	9.727E−01	9.828E−01	9.815E−01
PCTR 1.006%, h/u=6.95	9.740E−01	5.000E−03	9.893E−01	9.683E−01	9.655E−01	9.749E−01	9.739E−01
PCTR 1.006%, h/u=7.52	9.600E−01	5.000E−03	9.812E−01	9.614E−01	9.588E−01	9.677E−01	9.669E−01
PCTR 1.071%, h/u=3.78	1.005E+00	6.000E−03	1.035E+00	1.001E+00	9.953E−01	1.010E+00	1.006E+00
PCTR 1.071%, h/u=5.84	1.005E+00	6.000E−03	1.025E+00	1.002E+00	9.987E−01	1.010E+00	1.008E+00
PCTR 1.071%, h/u=7.14	9.920E−01	7.000E−03	1.011E+00	9.902E−01	9.874E−01	9.970E−01	9.960E−01
PCTR 1.157%, h/u=3.73	1.031E+00	6.000E−03	1.059E+00	1.025E+00	1.019E+00	1.034E+00	1.030E+00
PCTR 1.157%, h/u=5.99	1.031E+00	5.000E−03	1.052E+00	1.029E+00	1.026E+00	1.037E+00	1.035E+00
PCTR 1.157%, h/u=6.90	1.030E+00	7.000E−03	1.043E+00	1.022E+00	1.019E+00	1.029E+00	1.028E+00
PCTR 1.157%, h/u=7.52	1.019E+00	5.000E−03	1.036E+00	1.016E+00	1.013E+00	1.022E+00	1.022E+00

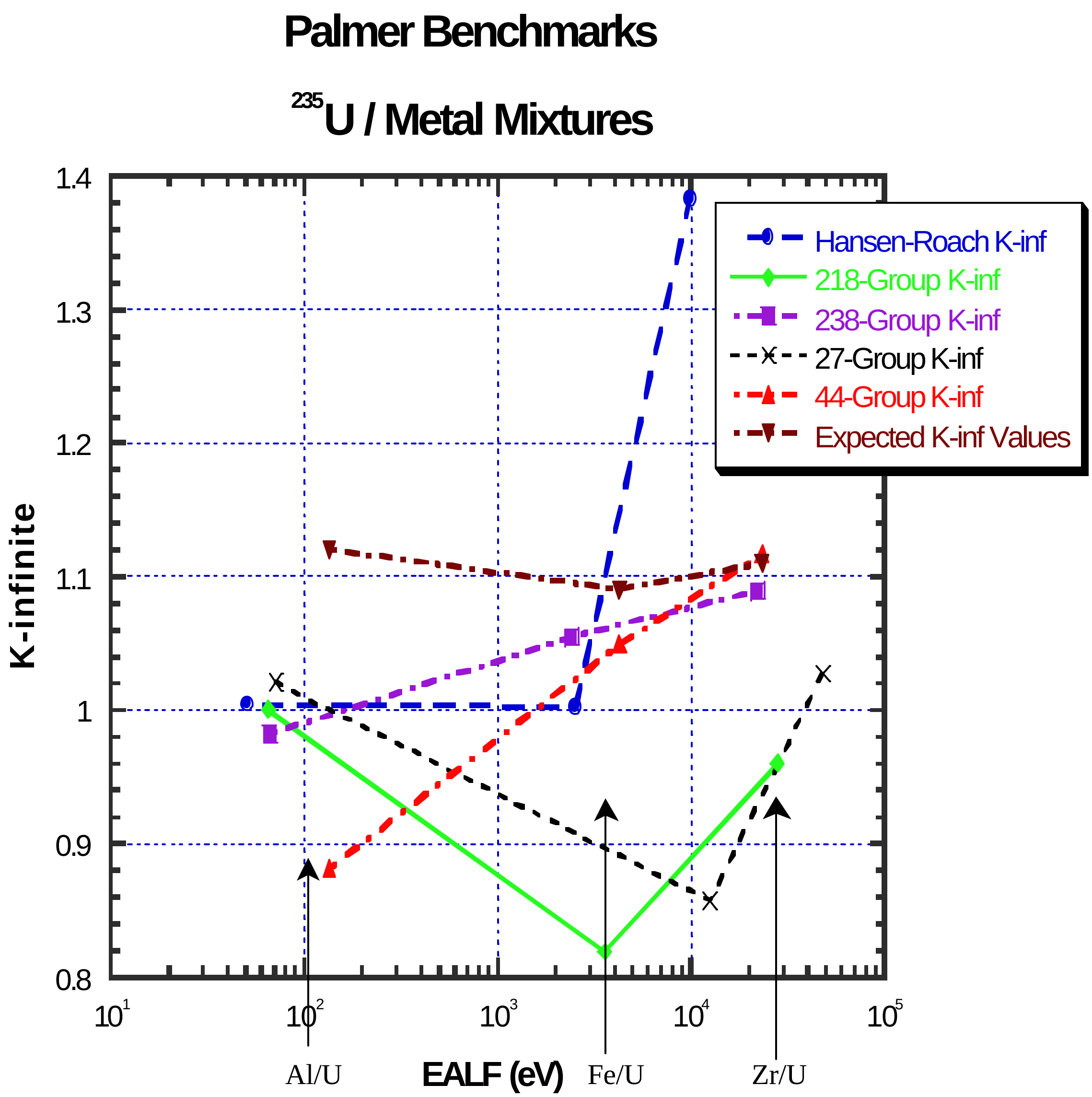

Figure B.1 Palmer ^{235}U/metal mixture benchmark results

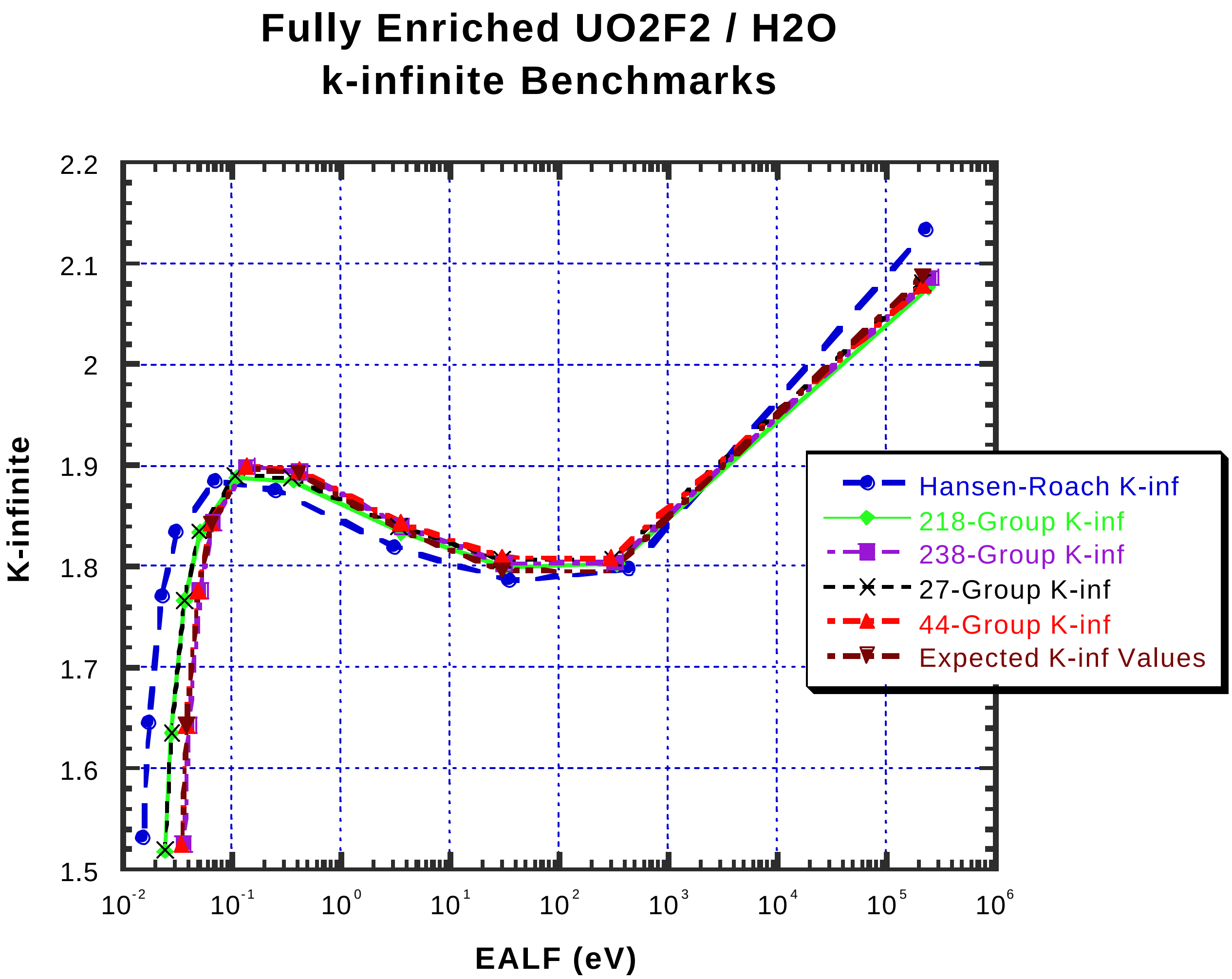

Figure B.2 Fully enriched UO_2F_2/H_2O *k-infinite* benchmark results

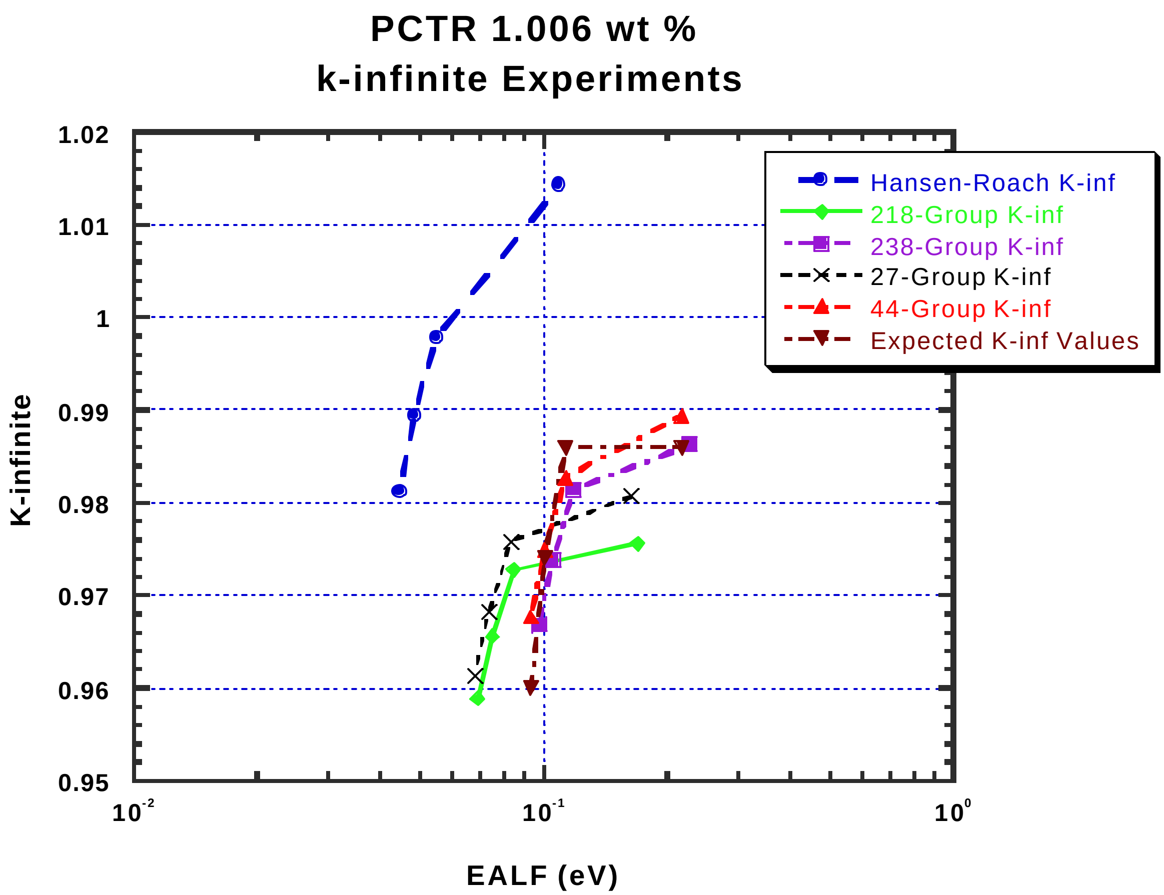

Figure B.3 PCTR 1.006 wt % *k-infinite* experiment results

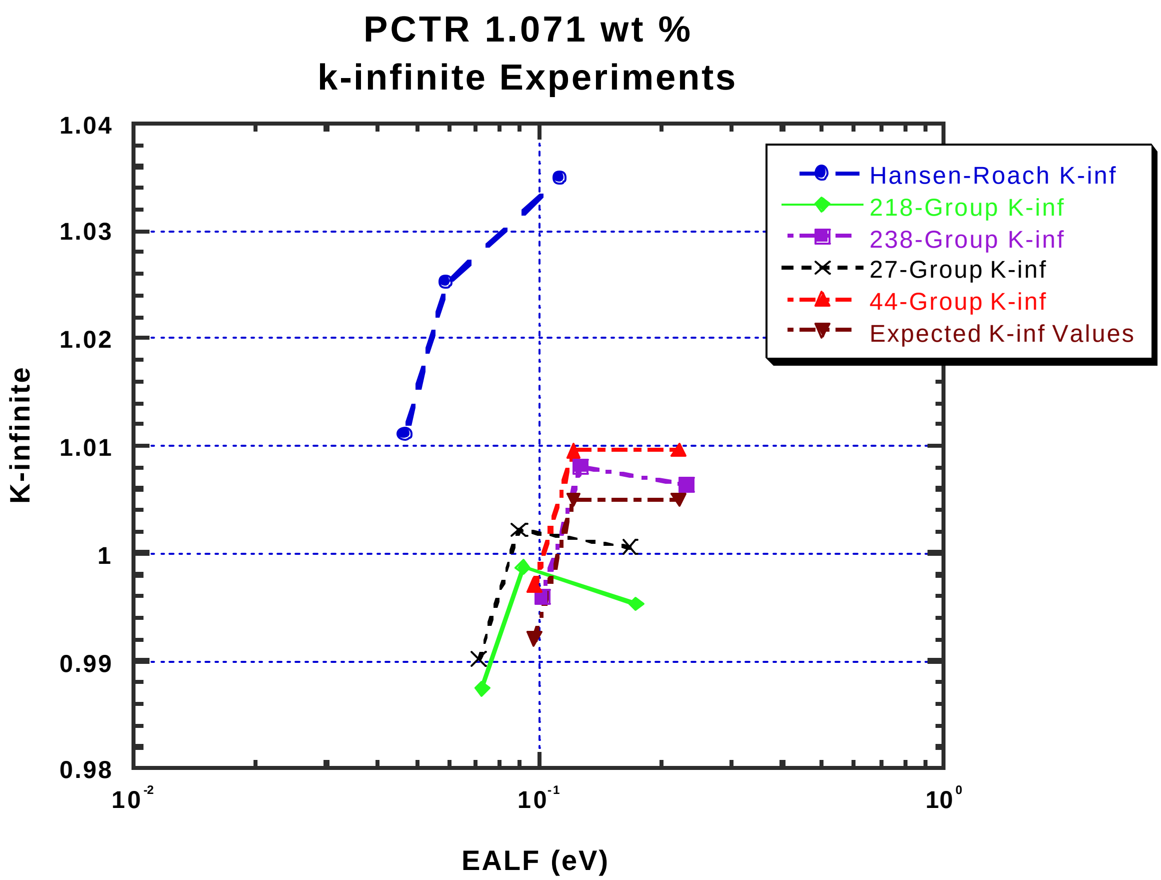

Figure B.4 PCTR 1.071 wt % *k-infinite* experiment results

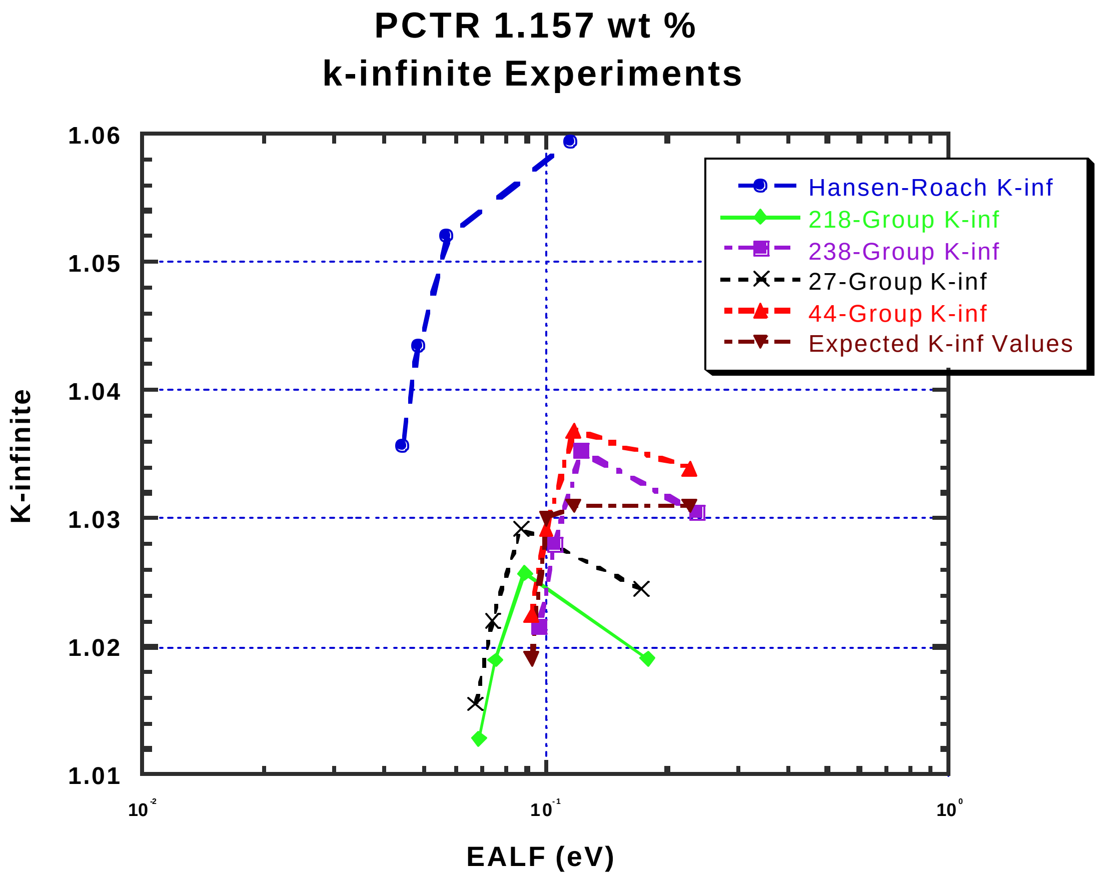

Figure B.5 PCTR 1.157 wt % *k-infinite* experiment results

The Fe/U benchmark is approximately 4% low, and the Zr/U benchmark shows agreement with the expected value. The consistent Fe/U results between the 44- and 238-group libraries is due to the careful preservation of energy windows in the Fe cross sections in the 44-group structure.

The disparity in the 44-group library results for the U/Fe sphere (14% high) and the Palmer Fe/U system (4% low) is similar to the 238-group library. As stated previously, it is difficult to conserve both the reaction rate and the transport for systems similar to the U/Fe sphere in a multigroup structure.

Figure B.2 shows that the SCALE 44-group library performs well across the range of the UO_2F_2 *k-infinite* benchmarks. The library has about a 0.5% bias for fast and intermediate-spectrum cases and no bias for thermal cases.

Figures B.3 – B.5 show that the SCALE 44-group library calculates these LEU systems very well, within ±0.5%.

APPENDIX C

DETAILS OF THE SCALE 16-GROUP HANSEN-ROACH LIBRARY

APPENDIX C

DETAILS OF THE SCALE 16-GROUP HANSEN-ROACH LIBRARY

Table C.1 Resonance nuclides found on the SCALE 16-group Hansen-Roach library

Standard composition alphanumeric name	Nuclide ID No.
Mn	25055
Ag-107	47107
Ag-109	47109
In-113	49113
In-115	49115
Dy-164	66164
Lu-175	71175
Lu-176	71176
W-182	74182
W-183	74183
W-184	74184
W-186	74186
Re-185	75185
Re-187	75187
Au	79197
Th-232	90232[a]
Pa-233	91233
U-233	92233[a]
U-234	92234
U-235	92235[a]
U-236	92236
U-238	92238[a]
Np-237	93237
Pu-238	94338[a]
Pu-239	94239[a]
Pu-240	94240[a]
Pu-241	94241
Pu-242	94242
Am-241	95241
Am-243	95243
Cm-244	96244

[a]Denotes nuclides having Bondarenko data in lieu of resonance parameters.

Table C.2 Nuclides in SCALE 16-group Hansen-Roach library with multiple sets of thermal-scattering data

Standard composition alphanumeric name	Nuclide ID No.	Temperature (K) for which different sets of thermal scattering cross-section data are available
B-10	5010	293,550
B-11	5011	293,550

Table C.3 Contents of the SCALE 16-group Hansen-Roach library

```
table of contents for /scale4.4/data/scale.rev03.xn16              on logical unit  1
tape id                       4016000
number of nuclides                 84
number of neutron groups           16
first thermal group                13
number of gamma groups              0
        scale 4 - 16 neutron group criticality safety library
          hansen-roach data with knight modifications and some endf/b 4 data
            compiled for nrc       1/27/89
              last updated                                                          08/12/94
                l.m.petrie       ornl
     999           1/v cross sections normalized to 1.0 at 0.0253 ev
    1001           hydrogen de/e                hansen-roach            updated 08/12/94
    1301           hydrogen x(e)                hansen roach            updated 08/12/94
    1002           deuterium x(e)               hansen roach            updated 08/12/94
    2004            helium-4 endf/b-iv mat 1270                         updated 08/12/94
    3006           lithium-6                    hansen roach            updated 08/12/94
    3007           lithium-7                    hansen roach            updated 08/12/94
    4009           beryllium                    hansen roach            updated 08/12/94
    5000           boron                        hansen roach            updated 08/12/94
    5010            boron-10 endf/b-iv mat 1273                         updated 08/12/94
    5011            boron-11       endf/b-iv mat 1160                   updated 08/12/94
    6012           carbon                       hansen roach            updated 08/12/94
    7014           nitrogen                     hansen roach            updated 08/12/94
    8016           oxygen                       hansen roach            updated 08/12/94
    9019           fluorine                     hansen roach            updated 08/12/94
   11023           sodium                       hansen roach            updated 08/12/94
   12000            magnesium endf/b-iv mat 1280                        updated 08/12/94
   13027           aluminum                     hansen roach            updated 08/12/94
   14000            silicon        endf/b-iv mat 1194                   updated 08/12/94
   15031            phosphorus-31 lendl mat 7019                        updated 08/12/94
   16000           sulfur  lendl mat 7020                               updated 08/12/94
   17000           chlorine                     hansen roach            updated 08/12/94
   19000           potassium                    hansen-roach            updated 08/12/94
   20000           calcium endf/b-iv mat 1195                           updated 08/12/94
   22000            titanium       endf/b-iv mat 1286                   updated 08/12/94
   23051            vanadium endf/b-iv mat 1196                         updated 08/12/94
   24000           chromium                     aerojet                 updated 08/12/94
   24304            chromium endf/b-iv mat 1191 ss-304 wt               updated 08/12/94
   24404            chromium endf/b-iv mat 1191 inconel wt              updated 08/12/94
   25055            manganese-55 endf/b-iv mat 1197                     updated 08/12/94
   26000           iron                         hansen roach            updated 08/12/94
   26304            iron endf/b-iv mat 1192 ss-304 wt                   updated 08/12/94
   26404            iron endf/b-iv mat 1192 inconel wt                  updated 08/12/94
```

27059	cobalt	hansen roach	updated 08/12/94
28000	nickel	hansen roach	updated 08/12/94
28304	nickel endf/b-iv mat 1190 ss-304 wt		updated 08/12/94
28404	nickel endf/b-iv mat 1190 inconel wt		updated 08/12/94
29000	copper endf/b-iv mat 1295		updated 08/12/94
30000	zinc	gam-2	updated 08/12/94
40000	zirconium	hansen roach	updated 08/12/94
40302	zircalloy-2 endf/b-iv mat 1284		updated 08/12/94
41093	niobium	hansen roach	updated 08/12/94
42000	molybdenum	hansen roach	updated 08/12/94
47107	silver-107 endf/b-iv mat 1138		updated 08/12/94
47109	silver-109 endf/b-iv mat 1139		updated 08/12/94
48000	cadmium endf/b-iv mat 1281		updated 08/12/94
49113	indium-113 endf/b-iv mat 445		updated 08/12/94
49115	indium-115 endf/b-iv mat 449		updated 08/12/94
50000	tin lendl mat 7039		updated 08/12/94
56138	barium-138 lendl mat 7040		updated 08/12/94
58000	cerium	hansen roach	
62000	samarium	gam-2	
63000	europium	gam-2	updated 08/12/94
64000	gadolinium endf/b-iv mat 1030		updated 08/12/94
66164	dyprosium-164 endf/b-iv mat 1031		updated 08/12/94
71175	lutetium-175 endf/b-iv mat 1032		updated 08/12/94
71176	lutetium-176 endf/b-iv mat 1033		updated 08/12/94
72000	hafnium endf/b-iv mat 1034		updated 08/12/94
73181	tantalum	hansen roach	updated 08/12/94
74182	tungsten-182 endf/b-iv mat 1128		updated 08/12/94
74183	tungsten-183 endf/b-iv mat 1129		updated 08/12/94
74184	tungsten-184 endf/b-iv mat 1130		updated 08/12/94
74186	tungsten-186 endf/b-iv mat 1131		updated 08/12/94
75185	rhenium-185 endf/b-iv mat 1083		updated 08/12/94
75187	rhenium-187 endf/b-iv mat 1084		updated 08/12/94
79197	gold-197 endf/b-iv mat 1283		updated 08/12/94
82000	lead endf/b-iv mat 1288		updated 08/12/94
90232	th-232 infinite dilution	hansen roach	updated 08/12/94
91233	protactinium-233 endf/b-iv mat 1297		updated 08/12/94
92233	u-233	hansen roach	updated 08/12/94
92234	u-234 endf/b-iv mat 1043		updated 08/12/94
92235	u-235 yr	hansen roach	updated 08/12/94
92236	u-236 endf/b-iv mat 1163		updated 08/12/94
92238	u-238 y	hansen roach	updated 08/12/94
93237	neptunium-237 endf/b-iv mat 1263		updated 08/12/94
94238	pu-238	hansen roach	updated 08/12/94
94338	pu-238 y	persimmon	
94239	pu-239	hansen roach	updated 08/12/94
94240	pu-240	hansen roach	updated 08/12/94
94241	pu-241 endf/b-iv mat 1266		updated 08/12/94
94242	plutonium-242 endf/b-iv mat 1161		updated 08/12/94
95241	am-241 endf/b-iv mat 1056		updated 08/12/94
95243	am-243 endf/b-iv mat 1057		updated 08/12/94
96244	cm-244 endf/b-iv mat 1162		updated 08/12/94

APPENDIX D

DETAILS OF THE ENDF/B-IV LIBRARIES

APPENDIX D

DETAILS OF THE ENDF/B-IV LIBRARIES

Table D.1 Resonance nuclides in the ENDF/B-IV libraries

Standard composition alphanumeric name	Nuclide ID No.
Na	11023
Mn	25055
Fe	26000
Co	27059
Co-59	27059
Cu	29000
Br-79	35079
Br-81	35081
ZIRCALLOY	40302
Nb-93	41093
Mo	42000
Ag-107	47107
Ag-109	47109
In-113	49113
In-115	49115
Cs-133	55133
Gd	64000
Dy-164	66164
Lu-175	71175
Lu-176	71176
Ta-181	73181
W-182	74182
W-183	74183
W-184	74184
W-186	74186
Re-185	75185
Re-187	75187
Au	79197
Th-232	90232
Pa-233	91233
U-233	92233
U-234	92234
U-235	92235

Table D.1 (continued)

Standard composition alphanumeric name	Nuclide ID No.
U-236	92236
U-238	92238
Np-237	93237
Pu-238	94238
Pu-239	94239
Pu-240	94240
Pu-241	94241
Pu-242	94242
Am-241	95241
Am-243	95423
Cm-244	96244

Table D.2 Nuclides in ENDF/B-IV libraries with multiple sets of thermal-scattering data

Standard composition alphanumeric name	Nuclide ID No.	Temperatures (K) for which thermal-scattering cross-section data are available
H	1001	293, 550
D	1002	293, 550
Be	4009	296, 900, 1000, 1200
B-10	5010	293, 550
B-11	5011	293, 550
C	6012	

Table D.3 Contents of the 218-group ENDF/B-IV library

```
table of contents for /scale4.4/data/scale.rev04.xn218            on logical unit  1
 tape id                         4321
 number of nuclides                79
 number of neutron groups         218
 first thermal group              141
 number of gamma groups             0
         scale 4.2 - 218 group neutron library
            based on endf-b version 4 data
               compiled for nrc     1/27/89
                  last updated                                                  08/12/94
                     l.m.petrie   -   ornl
       999          1/v cross sections normalized to 1.0 at 0.0253 ev       updated 08/12/94
      1001           hydrogen       endf/b-iv mat 1269/thrm1002             updated 08/12/94
      1002           deuterium      endf/b-iv mat 1120                      updated 08/12/94
      2004           helium-4       endf/b-iv mat 1270                      updated 08/12/94
      3006           lithium-6      endf/b-iv mat 1271                      updated 08/12/94
      3007           lithium-7      endf/b-iv mat 1272                      updated 08/12/94
      4009           beryllium-9    endf/b-iv mat 1289/thrm1064             updated 08/12/94
      5010          b-10 1273 218ngp 042375 p-3 293k                        updated 08/12/94
      5011           boron-11       endf/b-iv mat 1160                      updated 08/12/94
      6012          c-12 1274f,1065t 218 gp 030476(7)                       updated 08/12/94
      7014          n-14 1275 218 gp 030476(7)                              updated 08/12/94
      8016           oxygen-16      endf/b-iv mat 1276                      updated 08/12/94
      9019          f 1277 218gp 030476(7)                                  updated 08/12/94
     11023           sodium-23      endf/b-iv mat 1156                      updated 08/12/94
     12000          mg 1280 218 gp 1/e*sigt 040375(5)                       updated 08/12/94
     13027          al-27 1193 218 gp 040375(5)                             updated 08/12/94
     14000           silicon        endf/b-iv mat 1194                      updated 08/12/94
     15031           phosphorus-31  endf/b-iv mat 7019                      updated 08/12/94
     16000          sulfur  lendl mat 7020                                  updated 08/12/94
     19000          potassium endf/b-iv mat 1150                            updated 08/12/94
     20000          calcium endf/b-iv mat 1195                              updated 08/12/94
     22000          ti 1286 218 gp wt 1/est 042375 p3 293k                  updated 08/12/94
     23051          v 1196 218 gp 1/e*sigt 040375(5)                        updated 08/12/94
     24000          cr 1191 218ngp wt 1/e p-3 293k sigp=5+4 re(042375)      updated 08/12/94
     24304          cr 1191 wt ss-304(1/est) p-3 293k sp=5+4(42375)'        updated 08/12/94
     24404           cr (inconel)   endf/b-iv mat 1191                      updated 08/12/94
     25055           manganese-55   endf/b-iv mat 1197                      updated 08/12/94
     26000           iron           endf/b-iv mat 1192                      updated 08/12/94
     26304          fe 1192 wt ss-304(1/est) p-3 293k sp=5+4(42375)'        updated 08/12/94
     26404          fe 1192 wt inconl(1/est) p-3 293k sp=5+4(42375)'        updated 08/12/94
     27059           cobalt-59      endf/b-iv mat 1199                      updated 08/12/94
     28000          ni 1190 218ngp wt 1/e p-3 293k sigp=5+4 re(042375)      updated 08/12/94
     28304           nickel (ss304) endf/b-iv mat 1190                      updated 08/12/94
     28404          ni 1190 wt inconl(1/est) p-3 293k sp=5+4(42375)'        updated 08/12/94
     29000           copper         endf/b-iv mat 1295                      updated 08/12/94
     35079           bromine-79     endf/b-iv mat 108                       updated 08/12/94
     35081           bromine-81     endf/b-iv mat 112                       updated 08/12/94
     40000           zirconium      endf/b-iv mat 7141                      updated 08/12/94
     40302           zircalloy      endf/b-iv mat 1284                      updated 08/12/94
     41093           niobium-93     endf/b-iv mat 1189                      updated 08/12/94
     42000           molybdenum     endf/b-iv mat 1287                      updated 08/12/94
     47107           silver-107     endf/b-iv mat 1138                      updated 08/12/94
     47109           silver-109     endf/b-iv mat 1139                      updated 08/12/94
     48000           cadmium        endf/b-iv mat 1281                      updated 08/12/94
     49113           indium-113     endf/b-iv mat 445                       updated 08/12/94
     49115           indium-115     endf/b-iv mat 449                       updated 08/12/94
     50000          sn 7039 wt 1/est 218ngp p-3 293k re(042375)             updated 08/12/94
     56138           barium-138     endf/b-iv mat 7040                      updated 08/12/94
     64000          gd (1030) sig0=1.+5p3 293k f-1/e-m vb 61479             updated 08/12/94
     66164           dyprosium-164  endf/b-iv mat 1031                      updated 08/12/94
     71175           lutetium-175   endf/b-iv mat 1032                      updated 08/12/94
     71176           lutetium-176   endf/b-iv mat 1033                      updated 08/12/94
     72000          hf(nat) 1034 218ngp wt 1/e p-3 sigp=5+4 293k re(042375) updated 08/12/94
     73181           tantalum-181   endf/b-iv mat 1285                      updated 08/12/94
     74182          w-182  1128 sigp=5+4 newxlacs 218ngp p-3 293k           updated 08/12/94
```

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    74183            tungsten-183   endf/b-iv mat 1129                      updated 08/12/94
    74184            tungsten-184   endf/b-iv mat 1130                      updated 08/12/94
    74186            tungsten-186   endf/b-iv mat 1131                      updated 08/12/94
    75185            rhenium-185    endf/b-iv mat 1083                      updated 08/12/94
    75187            rhenium-187    endf/b-iv mat 1084                      updated 08/12/94
    79197            gold-197       endf/b-iv mat 1283                      updated 08/12/94
    82000           pb   1288 218ngp 042375 p-3 293k                        updated 08/12/94
    90232            thorium-232    endf/b-iv mat 1296                      updated 08/12/94
    91233            paladium-231   endf/b-iv mat 1297                      updated 08/12/94
    92233           u-233  1260 sigp=5+4 newxlacs 218ngp p-3 293k           updated 08/12/94
    92234           u-234 1043 sigo=5+4 newxlacs p-3 293k f-1/e-m(1.+5)     updated 08/12/94
    92235            uranium-235    endf/b-iv mat 1261                      updated 08/12/94
    92236            uranium-236    endf/b-iv mat 1163                      updated 08/12/94
    92238            uranium-238    endf/b-iv mat 1262                      updated 08/12/94
    93237            neptunium-237  endf/b-iv mat 1263                      updated 08/12/94
    94238            plutonium-238  endf/b-iv mat 1050                      updated 08/12/94
    94239            plutonium-239  endf/b-iv mat 1264                      updated 08/12/94
    94240            plutonium-240  endf/b-iv mat 1265                      updated 08/12/94
    94241            plutonium-241  endf/b-iv mat 1266                      updated 08/12/94
    94242            plutonium-242  endf/b-iv mat 1161                      updated 08/12/94
    95241           am-241 1056 sigp=5+4 newxlacs 218ngp p-3 293k           updated 08/12/94
    95243           am-243 1057 218 gp wt f-1/e-m 090376 p3 293k            updated 08/12/94
    96244            curium-244     endf/b-iv mat 1162                      updated 08/12/94
    17000           chlorine (mat 1149 from version iv) using 1/sigt weightiupdated 08/12/94
```

Table D.4 Contents of the 27-group ENDF/B-IV library

```
table of contents for /scale4.4/data/scale.rev04.xn27             on logical unit  1
tape id                         4321
number of nuclides                83
number of neutron groups          27
first thermal group               15
number of gamma groups             0
        scale 4.2 - 27 group neutron group library
           based on endf-b version 4 data
              compiled for nrc      1/27/89
                 last updated                                                   08/12/94
                    l.m.petrie   -   ornl
      900           dose factors from ansi/ans-6.1.1-1977          updated 9/07/89
      999           1/v cross sections normalized to 1.0 at 0.0253 ev       updated 08/12/94
     1001            hydrogen       endf/b-iv mat 1269/thrm1002             updated 08/12/94
     1002            deuterium      endf/b-iv mat 1120                      updated 08/12/94
     2004            helium-4       endf/b-iv mat 1270                      updated 08/12/94
     3006           li-6 1271 218 gp 1/e*sigt 040375(5)                     updated 08/12/94
     3007           li-7 1272 218 gp 1/e*sigt 040375(5)                     updated 08/12/94
     4009            beryllium-9    endf/b-iv mat 1289/thrm1064             updated 08/12/94
     5010           b-10 1273 218ngp 042375 p-3 293k                        updated 08/12/94
     5011            boron-11       endf/b-iv mat 1160                      updated 08/12/94
     6012            carbon-12      endf/b-iv mat 1274/thrm1065             updated 08/12/94
     7014            nitrogen-14    endf/b-iv mat 1275                      updated 08/12/94
     8016            oxygen-16      endf/b-iv mat 1276                      updated 08/12/94
     9019            fluorine       endf/b-iv mat 1277                      updated 08/12/94
    11023            sodium-23      endf/b-iv mat 1156                      updated 08/12/94
    12000           mg 1280 218 gp 1/e*sigt 040375(5)                       updated 08/12/94
    13027           al-27 1193 218 gp 040375(5)                             updated 08/12/94
    14000            silicon        endf/b-iv mat 1194                      updated 08/12/94
    15031           p-31 7019 218ngp wt 1/est 042375 p3 293k                updated 08/12/94
    16000           sulfur  lendl mat 7020                                  updated 08/12/94
    19000            potassium      endf/b-iv mat 1150                      updated 08/12/94
    20000           calcium endf/b-iv mat 1195                              updated 08/12/94
    22000            titanium       endf/b-iv mat 1286                      updated 08/12/94
    23051           v 1196 218 gp 1/e*sigt 040375(5)                        updated 08/12/94
    24000           cr 1191 218ngp wt 1/e p-3 293k sigp=5+4 re(042375)      updated 08/12/94
```

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  24304          cr 1191 wt ss-304(1/est) p-3 293k sp=5+4(42375)'        updated 08/12/94
  24404          cr 1191 wt inconl(1/est) p-3 293k sp=5+4(42375)'        updated 08/12/94
  25055           manganese-55   endf/b-iv mat 1197                      updated 08/12/94
  26000           iron           endf/b-iv mat 1192                      updated 08/12/94
  26304          fe 1192 wt ss-304(1/est) p-3 293k sp=5+4(42375)'        updated 08/12/94
  26404          fe 1192 wt inconl(1/est) p-3 293k sp=5+4(42375)'        updated 08/12/94
  27059           cobalt-59      endf/b-iv mat 1199                      updated 08/12/94
  28000          ni 1190 218ngp wt 1/e p-3 293k sigp=5+4 re(042375)      updated 08/12/94
  28304          ni 1190 wt ss-304(1/est) p-3 293k sp=5+4(42375)'        updated 08/12/94
  28404          ni 1190 wt inconl(1/est) p-3 293k sp=5+4(42375)'        updated 08/12/94
  29000           copper         endf/b-iv mat 1295                      updated 08/12/94
  35079           bromine-79     endf/b-iv mat 108                       updated 08/12/94
  35081           bromine-81     endf/b-iv mat 112                       updated 08/12/94
  40000           zirconium      endf/b-iv mat 7141                      updated 08/12/94
  40302           zircalloy      endf/b-iv mat 1284                      updated 08/12/94
  41093           niobium-93     endf/b-iv mat 1189                      updated 08/12/94
  42000          mo (1287) sigp=5+4 newxlacs 218ngp f-1/e-m p-3 293k     updated 08/12/94
  47107           silver-107     endf/b-iv mat 1138                      updated 08/12/94
  47109           silver-109     endf/b-iv mat 1139                      updated 08/12/94
  48000          cd 1281 wt 1/est 218ngp p-3 293k re(042375)             updated 08/12/94
  49113           indium-113     endf/b-iv mat 445                       updated 08/12/94
  49115           indium-115     endf/b-iv mat 449                       updated 08/12/94
  50000          sn 7039 wt 1/est 218ngp p-3 293k re(042375)             updated 08/12/94
  54135           xenon-135      endf/b-iv mat 1294                      updated 08/12/94
  55133           cesium-133     endf/b-iv mat 1141                      updated 08/12/94
  56138          ba-138 7040 218ngp wt 1/est 042375 p3 293k              updated 08/12/94
  64000          gd (1030) sig0=1.+5p3 293k f-1/e-m vb 61479             updated 08/12/94
  66164           dyprosium-164  endf/b-iv mat 1031                      updated 08/12/94
  71175           lutetium-175   endf/b-iv mat 1032                      updated 08/12/94
  71176           lutetium-176   endf/b-iv mat 1033                      updated 08/12/94
  72000          hf(nat) 1034 218ngp wt 1/e p-3 sigp=5+4 293k re(042375) updated 08/12/94
  73181           tantalum-181   endf/b-iv mat 1285                      updated 08/12/94
  74182           tungsten-182   endf/b-iv mat 1128                      updated 08/12/94
  74183           tungsten-183   endf/b-iv mat 1129                      updated 08/12/94
  74184           tungsten-184   endf/b-iv mat 1130                      updated 08/12/94
  74186           tungsten-186   endf/b-iv mat 1131                      updated 08/12/94
  75185           rhenium-185    endf/b-iv mat 1083                      updated 08/12/94
  75187           rhenium-187    endf/b-iv mat 1084                      updated 08/12/94
  79197           gold-197       endf/b-iv mat 1283                      updated 08/12/94
  82000          pb   1288 218ngp 042375 p-3 293k                        updated 08/12/94
  90232           thorium-232    endf/b-iv mat 1296                      updated 08/12/94
  91233          pa-233 1297 218 gp wt f-1/e-m 090376 p3 293k            updated 08/12/94
  92233          u-233  1260 sigp=5+4 newxlacs 218ngp p-3 293k           updated 08/12/94
  92234           uranium-234    endf/b-iv mat 1043                      updated 08/12/94
  92235           uranium-235    endf/b-iv mat 1261                      updated 08/12/94
  92236          u-236 1163 sigo=5+4 newxlacs p-3 293k f-1/e-m(1.+5)     updated 08/12/94
  92238           uranium-238    endf/b-iv mat 1262                      updated 08/12/94
  93237           neptunium-237  endf/b-iv mat 1263                      updated 08/12/94
  94238          pu-238 1050 sigo=5+4 newxlacs p-3 293k f-1/e-m(1.+5)    updated 08/12/94
  94239           plutonium-239  endf/b-iv mat 1264                      updated 08/12/94
  94240           plutonium-240  endf/b-iv mat 1265                      updated 08/12/94
  94241           plutonium-241  endf/b-iv mat 1266                      updated 08/12/94
  94242           plutonium-242  endf/b-iv mat 1161                      updated 08/12/94
  95241          am-241 1056 sigp=5+4 newxlacs 218ngp p-3 293k           updated 08/12/94
  95243          am-243 1057 218 gp wt f-1/e-m 090376 p3 293k            updated 08/12/94
  96244           curium-244     endf/b-iv mat 1162                      updated 08/12/94
 500000          jrk's neutron(9029) dose factors from ansi/ans-6.1.1-1977.
  17000          chlorine (mat 1149 from version iv) using 1/sigt weightiupdated 08/12/94
```

Table D.5 Contents of the 27-group burnup library

```
table of contents for /scale4.4/data/scale.rev05.xn27burn         on logical unit  1
tape id                          27
number of nuclides              252
number of neutron groups         27
first thermal group              15
number of gamma groups            0
         scale - 27 group neutron burnup library
            based on endf-b version 4 data with endf-b version 5 fission products
               compiled for nrc     1/27/89
                  last updated      1/14/98
                     l.m.petrie   -   ornl
      900          dose factors from ansi/ans-6.1.1-1977          updated 9/15/89
      999          1/v cross sections normalized to 1.0 at 0.0253 ev       updated 08/12/94
     1001           hydrogen       endf/b-iv mat 1269/thrm1002             updated 08/12/94
     1002           deuterium      endf/b-iv mat 1120                      updated 08/12/94
     2004          he-4 1270 218 gp wt f-1/est-m 042375 p3 293k            updated 08/12/94
     3006          li-6 1271 218 gp 1/e*sigt 040375(5)                     updated 08/12/94
     3007          li-7 1272 218 gp 1/e*sigt 040375(5)                     updated 08/12/94
     4009           beryllium-9    endf/b-iv mat 1289/thrm1064             updated 08/12/94
     5010          b-10 1273 218ngp 042375 p-3 293k                        updated 08/12/94
     5011           boron-11       endf/b-iv mat 1160                      updated 08/12/94
     6012           carbon-12      endf/b-iv mat 1274/thrm1065             updated 08/12/94
     7014           nitrogen-14    endf/b-iv mat 1275                      updated 08/12/94
     8016           oxygen-16      endf/b-iv mat 1276                      updated 08/12/94
     9019           fluorine       endf/b-iv mat 1277                      updated 08/12/94
    11023           sodium-23      endf/b-iv mat 1156                      updated 08/12/94
    12000          mg 1280 218 gp 1/e*sigt 040375(5)                       updated 08/12/94
    13027          al-27 1193 218 gp 040375(5)                             updated 08/12/94
    14000           silicon        endf/b-iv mat 1194                      updated 08/12/94
    15031          p-31 7019 218ngp wt 1/est 042375 p3 293k                updated 08/12/94
    16000          sulfur    lendl     mat 7020                            updated 08/12/94
    19000           potassium      endf/b-iv mat 1150                      updated 08/12/94
    20000          calcium   endf/b-iv mat 1195                            updated 08/12/94
    22000           titanium       endf/b-iv mat 1286                      updated 08/12/94
    23051          v 1196 218 gp 1/e*sigt 040375(5)                        updated 08/12/94
    24000          cr 1191 218ngp wt 1/e p-3 293k sigp=5+4 re(042375)      updated 08/12/94
    24304          cr 1191 wt ss-304(1/est) p-3 293k sp=5+4(42375)'        updated 08/12/94
    24404          cr 1191 wt inconl(1/est) p-3 293k sp=5+4(42375)'        updated 08/12/94
    25055           manganese-55   endf/b-iv mat 1197                      updated 08/12/94
    26000           iron           endf/b-iv mat 1192                      updated 08/12/94
    26304          fe 1192 wt ss-304(1/est) p-3 293k sp=5+4(42375)'        updated 08/12/94
    26404          fe 1192 wt inconl(1/est) p-3 293k sp=5+4(42375)'        updated 08/12/94
    27059           cobalt-59      endf/b-iv mat 1199                      updated 08/12/94
    28000          ni 1190 218ngp wt 1/e p-3 293k sigp=5+4 re(042375)      updated 08/12/94
    28304          ni 1190 wt ss-304(1/est) p-3 293k sp=5+4(42375)'        updated 08/12/94
    28404          ni 1190 wt inconl(1/est) p-3 293k sp=5+4(42375)'        updated 08/12/94
    29000           copper         endf/b-iv mat 1295                      updated 08/12/94
    32072           ge-72          mt=102                                  updated 08/12/94
    32073           ge-73          mt=102                                  updated 08/12/94
    32074           ge-74          mt=102                                  updated 08/12/94
    32076           ge-76          mt=102                                  updated 08/12/94
    33075           as-75          mt=102                                  updated 08/12/94
    34076           se-76          mt=102                                  updated 08/12/94
    34077           se-77          mt=102                                  updated 08/12/94
    34078           se-78          mt=102                                  updated 08/12/94
    34080           se-80             mt=  102                             updated 08/12/94
    34082           se-82          mt=102                                  updated 08/12/94
    35079           bromine-79     endf/b-iv mat 108                       updated 08/12/94
    35081           bromine-81     endf/b-iv mat 112                       updated 08/12/94
    36080           kr-80             mt=  102, 103, 104, 105, 106, 107    updated 08/12/94
    36082           kr-82             mt=  102, 103, 104, 105, 106, 107    updated 08/12/94
    36083           kr-83          mt=102,103,103,105,106,107              updated 08/12/94
    36084           kr-84             mt=  102, 103, 104, 105, 106, 107    updated 08/12/94
    36085           kr-85             mt=  102                             updated 08/12/94
    36086           kr-86             mt=  102, 103, 104, 105, 107         updated 08/12/94
    37085           rb-85          mt=102                                  updated 08/12/94
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37086	rb-86	mt=102	updated 08/12/94
37087	rb-87	mt=102	updated 08/12/94
38086	sr-86	mt= 102	updated 08/12/94
38087	sr-87	mt=102	updated 08/12/94
38088	sr-88	mt= 102	updated 08/12/94
38089	sr-89	mt=102	updated 08/12/94
38090	sr-90	mt=102	updated 08/12/94
39089	y-89	mt=102	updated 08/12/94
39090	y-90	mt= 102	updated 08/12/94
39091	y-91	mt=102	updated 08/12/94
40000	zirconium	endf/b-iv mat 7141	updated 08/12/94
40090	zr-90	mt= 102	updated 08/12/94
40091	zr-91	mt= 102	updated 08/12/94
40092	zr-92	mt=102	updated 08/12/94
40093	zr-93	mt= 102	updated 08/12/94
40094	zr-94	mt=102	updated 08/12/94
40095	zr-95	mt=102	updated 08/12/94
40096	zr-96	mt= 102	updated 08/12/94
40302	zircalloy	endf/b-iv mat 1284	updated 08/12/94
41093	niobium-93	endf/b-iv mat 1189	updated 08/12/94
41094	nb-94	mt=102	updated 08/12/94
41095	nb-95	mt=102	updated 08/12/94
42000	mo (1287) sigp=5+4 newxlacs 218ngp f-1/e-m p-3 293k		updated 08/12/94
42094	mo-94	mt= 102	updated 08/12/94
42095	mo-95	mt=102	updated 08/12/94
42096	mo-96	mt=102	updated 08/12/94
42097	mo-97	mt=102	updated 08/12/94
42098	mo-98	mt=102	updated 08/12/94
42099	mo-99	mt=102	updated 08/12/94
42100	mo-100	mt=102	updated 08/12/94
43099	tc-99	mt=102	updated 08/12/94
44099	ru-99	mt=102	updated 08/12/94
44100	ru-100	mt=102	updated 08/12/94
44101	ru-101	mt=102	updated 08/12/94
44102	ru-102	mt=102	updated 08/12/94
44103	ru-103	mt=102	updated 08/12/94
44104	ru-104	mt=102	updated 08/12/94
44105	ru-105	mt=102	updated 08/12/94
44106	ru-106	mt=102	updated 08/12/94
45105	rh-105	mt= 102	updated 08/12/94
46104	pd-104	mt=102	updated 08/12/94
46105	pd-105	mt=102	updated 08/12/94
46106	pd-106	mt=102	updated 08/12/94
46107	pd-107	mt=102	updated 08/12/94
46108	pd-108	mt=102	updated 08/12/94
46110	pd-110	mt=102	updated 08/12/94
47107	silver-107	endf/b-iv mat 1138	updated 08/12/94
47109	silver-109	endf/b-iv mat 1139	updated 08/12/94
47111	ag-111	mt=102	updated 08/12/94
48000	cadmium	endf/b-iv mat 1281	updated 08/12/94
48108	cd-108	mt=102	updated 08/12/94
48110	cd-110	mt=102	updated 08/12/94
48111	cd-111	mt=102	updated 08/12/94
48112	cd-112	mt=102	updated 08/12/94
48113	cd-113	mt= 102, 103, 107	updated 08/12/94
48114	cd-114	mt=102	updated 08/12/94
48601	cd-115m	mt= 102	updated 08/12/94
48116	cd-116	mt= 102	updated 08/12/94
49113	indium-113	endf/b-iv mat 445	updated 08/12/94
49115	indium-115	endf/b-iv mat 449	updated 08/12/94
50000	sn 7039 wt 1/est 218ngp p-3 293k re(042375)		updated 08/12/94
50115	sn-115	mt=102	updated 08/12/94
50116	sn-116	mt= 102	updated 08/12/94
50117	sn-117	mt= 102	updated 08/12/94
50118	sn-118	mt=102	updated 08/12/94
50119	sn-119	mt=102	updated 08/12/94
50120	sn-120	mt=102	updated 08/12/94
50122	sn-122	mt=102	updated 08/12/94
50123	sn-123	mt=102	updated 08/12/94
50124	sn-124	mt=102	updated 08/12/94
50125	sn-125	mt=102	updated 08/12/94

50126	sn-126	mt=102	updated 08/12/94
51121	sb-121	mt=102	updated 08/12/94
51123	sb-123	mt=102	updated 08/12/94
51124	sb-124	mt=102	updated 08/12/94
51125	sb-125	mt=102	updated 08/12/94
51126	sb-126	mt=102	updated 08/12/94
52122	te-122	mt=102	updated 08/12/94
52123	te-123	mt=102	updated 08/12/94
52124	te-124	mt=102	updated 08/12/94
52125	te-125	mt=102	updated 08/12/94
52126	te-126	mt=102	updated 08/12/94
52601	te-127m	mt= 102	updated 08/12/94
52128	te-128	mt=102	updated 08/12/94
52611	te-129m	mt= 102	updated 08/12/94
52130	te-130	mt=102	updated 08/12/94
52132	te-132	mt=102	updated 08/12/94
53127	i-127	mt=102	updated 08/12/94
53129	i-129	mt=102	updated 08/12/94
53130	i-130	mt= 102	updated 08/12/94
53131	i-131	mt= 102	updated 08/12/94
53135	i-135	mt= 102	updated 08/12/94
54128	xe-128	mt=102,103,104,105,106,107	updated 08/12/94
54129	xe-129	mt=102,103,104,105,106	updated 08/12/94
54130	xe-130	mt=102,103,104,105,106	updated 08/12/94
54131	xe-131	mt=102,103,104,105,106	updated 08/12/94
54132	xe-132	mt=102,103,104,105,106	updated 08/12/94
54133	xe-133	mt= 102	updated 08/12/94
54134	xe-134	mt=102,103,104,105,106	updated 08/12/94
54135	xenon-135	endf/b-iv mat 1294	updated 08/12/94
54136	xe-136	mt= 102, 103, 104, 105, 107	updated 08/12/94
55133	cesium-133	endf/b-iv mat 1141	updated 08/12/94
55134	cs-134	mt=102	updated 08/12/94
55135	cs-135	mt= 102	updated 08/12/94
55136	cs-136	mt= 102	updated 08/12/94
55137	cs-137	mt=102	updated 08/12/94
56134	ba-134	mt=102	updated 08/12/94
56135	ba-135	mt= 102	updated 08/12/94
56136	ba-136	mt=102	updated 08/12/94
56137	ba-137	mt= 102	updated 08/12/94
56138	ba-138 7040 218ngp wt 1/est 042375 p3 293k		updated 08/12/94
56140	ba-140	mt= 102	updated 08/12/94
57139	la-139	mt=102	updated 08/12/94
57140	la-140	mt=102	updated 08/12/94
58140	ce-140	mt=102	updated 08/12/94
58141	ce-141	mt=102	updated 08/12/94
58142	ce-142	mt=102	updated 08/12/94
58143	ce-143	mt= 102	updated 08/12/94
58144	ce-144	mt= 102	updated 08/12/94
59141	pr-141	mt=102,103,104,105,106,107	updated 08/12/94
59142	pr-142	mt= 102	updated 08/12/94
59143	pr-143	mt=102	updated 08/12/94
60142	nd-142	mt=102	updated 08/12/94
60143	nd-143	mt=102	updated 08/12/94
60144	nd-144	mt=102	updated 08/12/94
60145	nd-145	mt=102	updated 08/12/94
60146	nd-146	mt= 102, 103, 104, 105, 106, 107	updated 08/12/94
60147	nd-147	mt=102	updated 08/12/94
60148	nd-148	mt=102	updated 08/12/94
60150	nd-150	mt=102	updated 08/12/94
61147	pm-147	mt=102	updated 08/12/94
61148	pm-148	mt= 102	updated 08/12/94
61149	pm-149	mt=102	updated 08/12/94
61151	pm-151	mt=102	updated 08/12/94
62147	sm-147	endf/b-v fission product	updated 08/12/94
62148	sm-148	mt= 102	updated 08/12/94
62149	sm-149	mt=102,103,107	updated 08/12/94
62150	sm-150	mt=102	updated 08/12/94
62151	sm-151	mt=102,103,104,105,106,107	updated 08/12/94
62152	sm-152	mt=102,103,104,105,106,107	updated 08/12/94
62153	sm-153	mt=102	updated 08/12/94
62154	sm-154	mt=102	updated 08/12/94

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   63151          eu-151        mt=102,103,104,105,106,107              updated 08/12/94
   63152          eu-152        mt=102,103,104,105,106,107              updated 08/12/94
   63153          eu-153        mt=102,103,104,105,106,107              updated 08/12/94
   63154          eu-154        mt=102,103,104,105,106,107              updated 08/12/94
   63155          eu-155        mt=102,103,104,105,106,107              updated 08/12/94
   63156          eu-156        mt=102                                  updated 08/12/94
   63157          eu-157           mt=  102                             updated 08/12/94
   64000         gd (1030) sig0=1.+5p3 293k f-1/e-m vb 61479            updated 08/12/94
   64154          gd-154        mt=102                                  updated 08/12/94
   64155          gd-155        mt=102                                  updated 08/12/94
   64156          gd-156        mt=102                                  updated 08/12/94
   64157          gd-157        mt=102                                  updated 08/12/94
   64158          gd-158        mt=102                                  updated 08/12/94
   64160          gd-160        mt=102                                  updated 08/12/94
   65159          tb-159        mt=102                                  updated 08/12/94
   65160          tb-160           mt=  102                             updated 08/12/94
   66160          dy-160        mt=102                                  updated 08/12/94
   66161          dy-161        mt=102                                  updated 08/12/94
   66162          dy-162        mt=102                                  updated 08/12/94
   66163          dy-163        mt=102                                  updated 08/12/94
   66164          dyprosium-164  endf/b-iv mat 1031                     updated 08/12/94
   67165          ho-165        mt=102                                  updated 08/12/94
   68166          er-166        mt=102                                  updated 08/12/94
   68167          er-167        mt=102                                  updated 08/12/94
   71175          lutetium-175   endf/b-iv mat 1032                     updated 08/12/94
   71176          lutetium-176   endf/b-iv mat 1033                     updated 08/12/94
   72000         hf(nat) 1034 218ngp wt 1/e p-3 sigp=5+4 293k re(042375) updated 08/12/94
   73181          tantalum-181   endf/b-iv mat 1285                     updated 08/12/94
   74182          tungsten-182   endf/b-iv mat 1128                     updated 08/12/94
   74183          tungsten-183   endf/b-iv mat 1129                     updated 08/12/94
   74184          tungsten-184   endf/b-iv mat 1130                     updated 08/12/94
   74186          tungsten-186   endf/b-iv mat 1131                     updated 08/12/94
   75185         re-185 1083 sigp=5+4 newxlacs 218ngp p-3 293k          updated 08/12/94
   75187          rhenium-187    endf/b-iv mat 1084                     updated 08/12/94
   79197          gold-197       endf/b-iv mat 1283                     updated 08/12/94
   82000         pb   1288 218ngp 042375 p-3 293k                       updated 08/12/94
   90232         th-232 1296 sigp=5+4 newxlacs 218ngp p-3 293k          updated 08/12/94
   91233         pa-233 1297 218 gp wt f-1/e-m 090376 p3 293k           updated 08/12/94
   92233         u-233  1260 sigp=5+4 newxlacs 218ngp p-3 293k          updated 08/12/94
   92234         u-234 1043 sigo=5+4 newxlacs p-3 293k f-1/e-m(1.+5)    updated 08/12/94
   92235          uranium-235    endf/b-iv mat 1261                     updated 08/12/94
   92236         u-236 1163 sigo=5+4 newxlacs p-3 293k f-1/e-m(1.+5)    updated 08/12/94
   92238          uranium-238    endf/b-iv mat 1262                     updated 08/12/94
   93237          neptunium-237  endf/b-iv mat 1263                     updated 08/12/94
   94238         pu-238 1050 sigo=5+4 newxlacs p-3 293k f-1/e-m(1.+5)   updated 08/12/94
   94239          plutonium-239  endf/b-iv mat 1264                     updated 08/12/94
   94240          plutonium-240  endf/b-iv mat 1265                     updated 08/12/94
   94241          plutonium-241  endf/b-iv mat 1266                     updated 08/12/94
   94242          plutonium-242  endf/b-iv mat 1161                     updated 08/12/94
   95241         am-241 1056 sigp=5+4 newxlacs 218ngp p-3 293k          updated 08/12/94
   95243         am-243 1057 218 gp wt f-1/e-m 090376 p3 293k           updated 08/12/94
   96244          curium-244     endf/b-iv mat 1162                     updated 08/12/94
  500000         jrk’s neutron(9029) dose factors from ansi/ans-6.1.1-1977.
   17000         chlorine (mat 1149 from version iv) using 1/sigt weightiupdated 08/12/94
   45103          45rh103 hedl baw evalnov78 schenter livols       mod1 01/09/98
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APPENDIX E

DETAILS OF THE ENDF/B-V LIBRARIES

APPENDIX E

DETAILS OF THE ENDF/B-V LIBRARIES

Table E.1 Resonance nuclides in the ENDF/B-V libraries

Standard composition alphanumeric name	Nuclide ID No.	Highest order resonance (ℓ value)
NA	11023	2
S	16000	2
CR	24000	1
MN	25055	1
FE	26000	2
CO-59	27059	1
NI	28000	1
CU	29000	0
GE-72	32072	0
GE-73	32073	0
GE-74	32074	1
GE-76	32076	0
AS-75	33075	0
SE-74	34074	0
SE-76	34076	1
SE-77	34077	0
SE-78	34078	1
SE-80	34080	0
SE-82	34082	0
BR-79	35079	0
BR-81	35081	0
KR-78	36078	0
KR-80	36080	0
KR-82	36082	0

Table E.1 (continued)

Standard composition alphanumeric name	Nuclide ID No.	Highest order resonance (ℓ value)
KR-83	36083	0
KR-84	36084	0
KR-86	36086	0
RB-85	37085	1
RB-87	37087	1
SR-84	38084	0
SR-86	38086	0
SR-87	38087	0
SR-88	38088	0
Y-89	39089	0
ZR	40000	2
ZR-90	40090	2
ZR-91	40091	1
ZR-92	40092	1
ZR-94	40094	1
ZR-96	40096	1
NB-93	41093	1
NB-94	41094	0
MO	42000	1
MO-92	42092	0
MO-94	42094	0
MO-95	42095	0
MO-96	42096	1
MO-97	42097	0
MO-98	42098	0
MO-100	42100	0

Table E.1 (continued)

Standard composition alphanumeric name	Nuclide ID No.	Highest order resonance (ℓ value)
TC-99	43099	1
RU-99	44099	0
RU-100	44100	0
RU-101	44101	0
RU-102	44102	0
RU-104	44104	0
RH-103	45103	1
PD-104	46104	0
PD-105	46105	0
PD-106	46106	0
PD-108	46108	0
AG-107	47107	0
AG-109	47109	0
CD-110	48110	1
CD-111	48111	0
CD-112	48112	0
CD-113	48113	0
CD-114	48114	1
CD-116	48116	0
IN-113	49113	0
IN-115	49115	0
SN-112	50112	0
SN-114	50114	0
SN-115	50115	0
SN-116	50116	0
SN-117	50117	0

Table E.1 (continued)

Standard composition alphanumeric name	Nuclide ID No.	Highest order resonance (ℓ value)
SN-118	50118	0
SN-119	50119	0
SN-120	50120	0
SN-122	50122	0
SN-124	50124	0
SB-121	51121	0
SB-123	51123	0
TE-122	52122	0
TE-123	52123	0
TE-124	52124	0
TE-125	52125	0
TE-126	52126	0
TE-128	52128	0
TE-130	52130	0
I-127	53127	0
I-129	53129	0
XE-124	54124	0
XE-126	54126	0
XE-128	54128	0
XE-129	54129	0
XE-130	54130	0
XE-131	54131	0
XE-132	54132	0
XE-134	54134	0
CS-133	55133	0
CS-136	55136	0

Table E.1 (continued)

Standard composition alphanumeric name	Nuclide ID No.	Highest order resonance (ℓ value)
BA-134	56134	0
BA-135	56135	0
BA-136	56136	0
BA-137	56137	0
LA-139	57139	0
PR-141	59141	0
ND-142	60142	0
ND-143	60143	0
ND-144	60144	0
ND-145	60145	0
ND-146	60146	0
ND-148M	60148	0
ND-150	60150	0
PM-147	61147	0
PM-148M	61601	0
SM-147	62147	0
SM-149	62149	0
SM-150	62150	0
SM-151	62151	0
SM-152	62152	0
SM-154	62154	0
EU	63000	0
EU-151	63151	0
EU-152	63152	0
EU-153	63153	0
EU-154 a	63154	0

Table E.1 (continued)

Standard composition alphanumeric name	Nuclide ID No.	Highest order resonance (ℓ value)
EU-155 a	63155	0
GD-152	64152	0
GD-154	64154	0
GD-155	64155	0
GD-156	64156	0
GD-157	64157	0
GD-158	64158	0
GD-160	64160	0
TB-159	65159	0
DY-160	66160	0
DY-161	66161	0
DY-162	66162	0
DY-163	66163	0
DY-164	66164	0
HO-165	67165	0
ER-166	68166	1
ER-167	68167	0
LU-175	71175	0
LU-176	71176	0
HF	72000	0
HF-174	72174	0
HF-176	72176	0
HF-177	72177	0
HF-178	72178	0
HF-179	72179	0
HF-180	72180	0

Table E.1 (continued)

Standard composition alphanumeric name	Nuclide ID No.	Highest order resonance (ℓ value)
TA-181	73181	0
TA-182	73182	0
W	74000	0
W-182	74182	0
W-183	74183	0
W-184	74184	0
W-186	74186	0
RE-185	75185	0
RE-187	75187	0
AU	79197	0
TH-230	90230	0
TH-232	90232	1
PA-231	91231	0
PA-233	91233	0
U-232	92232	0
U-234	92234	0
U-235	92235	0
U-236	92236	0
U-237	92237	0
U-238	92238	1
NP-237	93237	0
PU-236	94236	0
PU-238	94238	0
PU-239	94239	0
PU-240	94240	0
PU-242	94242	0

Table E.1 (continued)

Standard composition alphanumeric name	Nuclide ID No.	Highest order resonance (ℓ value)
PU-243	94243	0
PU-244	94244	0
AM-241	95241	0
AM-243	95243	0
AM-242M	95601	0
CM-242	96242	0
CM-243	96243	0
CM-244	96244	0
CM-245	96245	0
CM-246	96246	0
CM-247	96247	0
CM-248	96248	0
BK-249	97249	0
CF-249	98249	0
CF-250	98250	0
CF-251	98251	0
CF-252	98252	0
ES-253	99253	0
EU-154 (ENDF/B-V)	631541	0

Table E.2 Nuclides in ENDF/B-V libraries with multiple sets of thermal-scattering data

Std. comp. alphanumeric name	Nuclide ID No.	Temperatures (K) for which thermal-scattering cross-section data are available
H	1001	296, 350, 400, 450, 500, 600, 800, 1000
D	1002	296, 350, 400, 450, 500, 600, 800, 1000
H-3	1003	296, 500, 900
H-ZRH2	1701	296, 400, 500, 600, 700, 800, 1000, 1200
HFREEGAS	1801	296, 500, 900
DFREEGAS	1802	296, 500, 900
H-POLY	1901	296, 350
HE-3	2003	296, 500, 900
HE	2004	296, 500, 900
LI-6	3006	296, 500, 900
LI-7	3007	296, 500, 900
BE	4009	296, 400, 500, 600, 700, 800, 1000, 1200
BEBOUND	4309	296, 400, 500, 600, 700, 800, 1000, 1200
B-10	5010	296, 500, 900
B-11	5011	296, 500, 900
C-12	6012	296, 500, 900
C-GRAPHITE	6312	296, 400, 500, 600, 700, 800, 1000, 1200, 1600, 2000
N-14	7014	296, 500, 900
N-15	7015	296, 500, 900
O-16a	8016	296, 500, 900
O-17	8017	296, 500, 900
F	9019	296, 500, 900
NA	11023	296, 500, 900
MG	12000	296, 500, 900
AL	13027	296, 500, 900
SI	14000	296, 500, 900

Table E.2 (continued)

Std. comp. alphanumeric name	Nuclide ID No.	Temperatures (K) for which thermal-scattering cross-section data are available
P	15031	296, 500, 900
S	16000	296, 500, 900
S-32	16032	296, 500, 900
CL	17000	296, 500, 900
K	19000	296, 500, 900
CA	20000	296, 500, 900
TI	22000	296, 500, 900
V	23000	296, 500, 900
CR	24000	296, 500, 900
CR (1/EsigT)	24301	296, 500, 900
CRSS	24304	296, 500, 900
MN	25055	296, 500, 900
FE	26000	296, 500, 900
FE (1/EsigT)	26301	296, 500, 900
FESS	26304	296, 500, 900
CO-59	27059	296, 500, 900
NI	28000	296, 500, 900
NI (1/EsigT)	28301	296, 500, 900
NISS	28304	296, 500, 900
CU	29000	296, 500, 900
GA	31000	296, 500, 900
GE-72	32072	296, 500, 900
GE-73	32073	296, 500, 900
GE-74	32074	296, 500, 900
GE-76	32076	296, 500, 900
AS-75	33075	296, 500, 900

Table E.2 (continued)

Std. comp. alphanumeric name	Nuclide ID No.	Temperatures (K) for which thermal-scattering cross-section data are available
SE-74	34074	296, 500, 900
SE-76	34076	296, 500, 900
SE-77	34077	296, 500, 900
SE-78	34078	296, 500, 900
SE-80	34080	296, 500, 900
SE-82	34082	296, 500, 900
BR-79	35079	296, 500, 900
BR-81	35081	296, 500, 900
KR-78	36078	296, 500, 900
KR-80	36080	296, 500, 900
KR-82	36082	296, 500, 900
KR-83	36083	296, 500, 900
KR-84	36084	296, 500, 900
KR-85	36085	296, 500, 900
KR-86	36086	296, 500, 900
RB-85	37085	296, 500, 900
RB-86	37086	296, 500, 900
RB-87	37087	296, 500, 900
SR-84	38084	296, 500, 900
SR-86	38086	296, 500, 900
SR-87	38087	296, 500, 900
SR-88	38088	296, 500, 900
SR-89	38089	296, 500, 900
SR-90	38090	296, 500, 900
Y-89	39089	296, 500, 900
Y-90	39090	296, 500, 900

Table E.2 (continued)

Std. comp. alphanumeric name	Nuclide ID No.	Temperatures (K) for which thermal-scattering cross-section data are available
Y-91	39091	296, 500, 900
ZR	40000	296, 500, 900
ZR-90	40090	296, 500, 900
ZR-91	40091	296, 500, 900
ZR-92	40092	296, 500, 900
ZR-93	40093	296, 500, 900
ZR-94	40094	296, 500, 900
ZR-95	40095	296, 500, 900
ZR-96	40096	296, 500, 900
ZR-ZRH2	40701	296, 400, 500, 600, 700, 800, 1000, 1200
NB-93	41093	296, 500, 900
NB-94	41094	296, 500, 900
NB-95	41095	296, 500, 900
MO	42000	296, 500, 900
MO-92	42092	296, 500, 900
MO-94	42094	296, 500, 900
MO-95	42095	296, 500, 900
MO-96	42096	296, 500, 900
MO-97	42097	296, 500, 900
MO-98	42098	296, 500, 900
MO-99	42099	296, 500, 900
MO-100	42100	296, 500, 900
TC-99	43099	296, 500, 900
RU-96	44096	296, 500, 900
RU-98	44098	296, 500, 900
RU-99	44099	296, 500, 900

Table E.2 (continued)

Std. comp. alphanumeric name	Nuclide ID No.	Temperatures (K) for which thermal-scattering cross-section data are available
RU-100	44100	296, 500, 900
RU-101	44101	296, 500, 900
RU-102	44102	296, 500, 900
RU-103	44103	296, 500, 900
RU-104	44104	296, 500, 900
RU-105	44105	296, 500, 900
RU-106	44106	296, 500, 900
RH-103	45103	296, 500, 900
RH-105	45105	296, 500, 900
PD-102	46102	296, 500, 900
PD-104	46104	296, 500, 900
PD-105	46105	296, 500, 900
PD-106	46106	296, 500, 900
PD-107	46107	296, 500, 900
PD-108	46108	296, 500, 900
PD-110	46110	296, 500, 900
AG-107	47107	296, 500, 900
AG-109	47109	296, 500, 900
AG-111	47111	296, 500, 900
CD	48000	296, 500, 900
CD-106	48106	296, 500, 900
CD-108	48108	296, 500, 900
CD-110	48110	296, 500, 900
CD-111	48111	296, 500, 900
CD-112	48112	296, 500, 900
CD-113	48113	296, 500, 900

Table E.2 (continued)

Std. comp. alphanumeric name	Nuclide ID No.	Temperatures (K) for which thermal-scattering cross-section data are available
CD-114	48114	296, 500, 900
CD-116	48116	296, 500, 900
CD-115M	48601	296, 500, 900
IN-113	49113	296, 500, 900
IN-115	49115	296, 500, 900
SN-112	50112	296, 500, 900
SN-114	50114	296, 500, 900
SN-115	50115	296, 500, 900
SN-116	50116	296, 500, 900
SN-117	50117	296, 500, 900
SN-118	50118	296, 500, 900
SN-119	50119	296, 500, 900
SN-120	50120	296, 500, 900
SN-122	50122	296, 500, 900
SN-123	50123	296, 500, 900
SN-124	50124	296, 500, 900
SN-125	50125	296, 500, 900
SN-126	50126	296, 500, 900
SB-121	51121	296, 500, 900
SB-123	51123	296, 500, 900
SB-124	51124	296, 500, 900
SB-125	51125	296, 500, 900
SB-126	51126	296, 500, 900
TE-120	52120	296, 500, 900
TE-122	52122	296, 500, 900
TE-123	52123	296, 500, 900

Table E.2 (continued)

Std. comp. alphanumeric name	Nuclide ID No.	Temperatures (K) for which thermal-scattering cross-section data are available
TE-124	52124	296, 500, 900
TE-125	52125	296, 500, 900
SB-126	52126	296, 500, 900
TE-126	52128	296, 500, 900
TE-130	52130	296, 500, 900
TE-132	52132	296, 500, 900
TE-127M	52601	296, 500, 900
TE-129M	52611	296, 500, 900
I-127	53127	296, 500, 900
I-129	53129	296, 500, 900
I-130	53130	296, 500, 900
I-131	53131	296, 500, 900
I-135	53135	296, 500, 900
XE-124	54124	296, 500, 900
XE-126	54126	296, 500, 900
XE-128	54128	296, 500, 900
XE-129	54129	296, 500, 900
XE-130	54130	296, 500, 900
XE-131	54131	296, 500, 900
XE-132	54132	296, 500, 900
XE-133	54133	296, 500, 900
XE-134	54134	296, 500, 900
XE-135	54135	296, 500, 900
XE-136	54136	296, 500, 900
CS-133	55133	296, 500, 900
CS-134	55134	296, 500, 900

Table E.2 (continued)

Std. comp. alphanumeric name	Nuclide ID No.	Temperatures (K) for which thermal-scattering cross-section data are available
CS-135	55135	296, 500, 900
CS-136	55136	296, 500, 900
CS-137	55137	296, 500, 900
BA-134	56134	296, 500, 900
BA-135	56135	296, 500, 900
BA-136	56136	296, 500, 900
BA-137	56137	296, 500, 900
BA-138	56138	296, 500, 900
BA-140	56140	296, 500, 900
LA-139	57139	296, 500, 900
LA-140	57140	296, 500, 900
CE-140	58140	296, 500, 900
CE-141	58141	296, 500, 900
CE-142	58142	296, 500, 900
CE-143	58143	296, 500, 900
CE-144	58144	296, 500, 900
PR-141	59141	296, 500, 900
PR-142	59142	296, 500, 900
PR-143	59143	296, 500, 900
ND-142	60142	296, 500, 900
ND-143	60143	296, 500, 900
ND-144	60144	296, 500, 900
ND-145	60145	296, 500, 900
ND-146	60146	296, 500, 900
ND-147	60147	296, 500, 900
ND-148	60148	296, 500, 900

Table E.2 (continued)

Std. comp. alphanumeric name	Nuclide ID No.	Temperatures (K) for which thermal-scattering cross-section data are available
ND-150	60150	296, 500, 900
PM-147	61147	296, 500, 900
PM-148	61148	296, 500, 900
PM-149	61149	296, 500, 900
PM-151	61151	296, 500, 900
PM-148M	61601	296, 500, 900
SM-144	62144	296, 500, 900
SM-147	62147	296, 500, 900
SM-148	62148	296, 500, 900
SM-149	62149	296, 500, 900
SM-150	62150	296, 500, 900
SM-151	62151	296, 500, 900
SM-152	62152	296, 500, 900
SM-153	62153	296, 500, 900
SM-154	62154	296, 500, 900
EU	63000	296, 500, 900
EU-151	63151	296, 500, 900
EU-152	63152	296, 500, 900
EU-153	63153	296, 500, 900
EU-154a	63154	296, 500, 900
EU-155a	63155	296, 500, 900
EU-156	63156	296, 500, 900
EU-157	63157	296, 500, 900
GD-152	64152	296, 500, 900
GD-154	64154	296, 500, 900
GD-155	64155	296, 500, 900

Table E.2 (continued)

Std. comp. alphanumeric name	Nuclide ID No.	Temperatures (K) for which thermal-scattering cross-section data are available
GD-156	64156	296, 500, 900
GD-157	64157	296, 500, 900
GD-158	64158	296, 500, 900
GD-160	64160	296, 500, 900
TB-159	65159	296, 500, 900
TB-160	65160	296, 500, 900
DY-160	66160	296, 500, 900
DY-161	66161	296, 500, 900
DY-162	66162	296, 500, 900
DY-163	66163	296, 500, 900
DY-164	66164	296, 500, 900
HO-165	67165	296, 500, 900
ER-166	68166	296, 500, 900
ER-167	68167	296, 500, 900
LU-175	71175	296, 500, 900
LU-176	71176	296, 500, 900
HF	72000	296, 500, 900
HF-174	72174	296, 500, 900
HF-176	72176	296, 500, 900
HF-177	72177	296, 500, 900
HF-178	72178	296, 500, 900
HF-179	72179	296, 500, 900
HF-180	72180	296, 500, 900
TA-181	73181	296, 500, 900
TA-182	73182	296, 500, 900
W	74000	296, 500, 900

Table E.2 (continued)

Std. comp. alphanumeric name	Nuclide ID No.	Temperatures (K) for which thermal-scattering cross-section data are available
W-182	74182	296, 500, 900
W-183	74183	296, 500, 900
W-184	74184	296, 500, 900
W-186	74186	296, 500, 900
RE-185	75185	296, 500, 900
RE-187	75187	296, 500, 900
AU	79197	296, 500, 900
PB	82000	296, 500, 900
BI-209	83209	296, 500, 900
TH-230	90230	296, 500, 900
TH-232	90232	296, 500, 900
PA-231	91231	296, 500, 900
PA-233	91233	296, 500, 900
U-232	92232	296, 500, 900
U-233	92233	300, 500, 900, 2100
U-234	92234	296, 500, 900
U-235	92235	296, 500, 900
U-236	92236	296, 500, 900
U-237	92237	296, 500, 900
U-238	92238	300, 500, 900
NP-237	93237	296, 500, 900
PU-236	94236	296, 500, 900
PU-237	94237	296, 500, 900
PU-238	94238	296, 500, 900
PU-239	94239	296, 500, 900
PU-240	94240	296, 500, 900

Table E.2 (continued)

Std. comp. alphanumeric name	Nuclide ID No.	Temperatures (K) for which thermal-scattering cross-section data are available
PU-241	94241	300, 500, 900, 2100
PU-242	94242	296, 500, 900
PU-243	94243	296, 500, 900
PU-244	94244	296, 500, 900
AM-241	95241	296, 500, 900
AM-242M	95243	296, 500, 900
AM-243	95601	296, 500, 900
CM-241	96241	296, 500, 900
CM-242	96242	296, 500, 900
CM-243	96243	296, 500, 900
CM-244	96244	296, 500, 900
CM-245	96245	296, 500, 900
CM-246	96246	296, 500, 900
CM-247	96247	296, 500, 900
CM-248	96248	296, 500, 900
BK-249	97249	296, 500, 900
CF-249	98249	296, 500, 900
CF-250	98250	296, 500, 900
CF-251	98251	296, 500, 900
CF-252	98252	296, 500, 900
ES-253	99253	296, 500, 900
EU-154 (ENDF/B-V)	631541	296, 500, 900
EU-155 (ENDF/B-V)	631551	296, 500, 900
N-14 (ENDF/B-VI)	701401	296, 500, 900
N-15 (ENDF/B-VI)	701501	296, 500, 900
O-16 (ENDF/B-V)	801601	296, 500, 900

Table E.3 Contents of the 238-group ENDF/B-V library

```
table of contents for  scale.rev08.xn238                         on logical unit  1
tape id                          238
number of nuclides               315
number of neutron groups         238
first thermal group              149
number of gamma groups             0
        scale - 238 neutron group library           based on endf-b version 5 data
          generated with a chi-1/e-maxwellian weight spectrum
            compiled for doe        8/18/94
              last updated          7/29/99
                n.m.greene & l.m.petrie    nuclear eng. appl. - cped - ornl
    24301            24CR BNL EVALDEC77 A.PRINCE AND T.    (1/esigt)  MOD2 11/18/91
    24304            24CR BNL EVALDEC77 A.PRINCE AND T.    (1/esigtSS304)  MOD2 11/18/91
    26301            26FE 0 ORNL EVALOCT77 C.Y.FU F.G.PE  (1/esigt)   MOD3 11/18/91
    26304            26FE 0 ORNL EVALOCT77 C.Y.FU F.G.PE  (1/esigtSS304)   MOD3 11/18/91
    28301            28NI 0 BNL NNDC EVALMAR77 M.DIVADEENAM (1/esigt) MOD2 11/18/91
    28304            28NI 0 BNL NNDC EVALMAR77 M.DIVADEENAM (1/esigtSS304) MOD2 11/18/91
     1701              smiler for h-1 (hzrh)  tape 132, mat 7   5-14-98
    40701              smiler for zr (in zrh)  tape 133, mat 58   5-15-98
    19000            19k gga evalfeb67 m.k.drake                   mod1 1updated 01/18/95
    92232            92u232 hedl evalnov77 mann                    mod1 11/14/97
    33075            33as 75 hedl evalapr74 r.e.schenter an        mod1 04/02/97
    56135            56ba135 hedl evalapr74 r.e.schenter an        mod1 04/02/97
    48110            48cd110 hedl evalapr74 r.e.schenter an        mod1 04/02/97
    48114            48cd114 hedl evalapr74 r.e.schenter an        mod1 04/02/97
    96244            96cm244 hedlsrllll evalapr78 mann benjamin h  mod2 11/14/97
    96248            96cm248 hedlsrllll evalapr78 mann benjamin h  mod1 11/14/97
    66160            66dy160 hedl evalapr74 r.e.schenter an        mod1 04/08/97
    66163            66dy163 hedl evalapr74 r.e.schenter an        mod1 04/09/97
    68166            68er166 hedl evalapr74 r.e.schenter an        mod1 04/23/97
    32074            32ge 74 hedl evalapr74 r.e.schenter an        mod1 04/23/97
    42096            42mo 96 hedl rcn evalfeb80 r.e.schenter an    mod1 04/23/97
    60145            60nd145 hedl bnl+ evalfeb80 schenter schmit   mod1 04/23/97
    60146            60nd146 hedl bnl+ evalfeb80 schenter schmit   mod1 04/24/97
    60150            60nd150 hedl bnl+ evalfeb80 schenter schmit   mod1 04/24/97
    46108            46pd108 hedl rcn evalfeb80 r.e.schenter an    mod1 04/24/97
    34076            34se 76 hedl evalapr74 r.e.schenter an        mod1 04/24/97
    34078            34se 78 hedl evalapr74 r.e.schenter an        mod1 04/24/97
    62152            62sm152 hedl bnl+ evalfeb80 schenter schmit   mod1 04/29/97
    62154            62sm154 hedl evalapr74 r.e.schenter an        mod1 04/29/97
    52122            52te122 hedl evalapr74 r.e.schenter an        mod1 04/29/97
     4309            be metal 13041064                             mod2 04/29/97
    60143            60nd143 hedl bnl+ evalfeb80 schenter schmit   mod1 04/23/97
    62147            62sm147 hedl bnl+ evalfeb80 schenter + man    mod2 04/24/97
       99           collected weight functions for use in collapsing    updated 5/12/95
      900           neutron dose factors from ansl/ans 6.1.1-1977       updated 5/12/95
     1802           1d 20lasl eval nov67 l.stewart lasl mod2 12/11/92 free gas
     2003           2he 30lasl evaljun68 leona stewart mod1 12/23/92 free gas
     2004           2he 40lasl evaloct73 nisley hale young mod0 12/23/92 free gas
     3006           3li0060lasl eval sep77 g.hale l.stewart mod1 12/11/92 free gas
     3007           3li 7 lanl evaldec81 p.g.young mod1 12/11/92 free gas
     4009           4be 9 free gas. lll evaloct76 howerton/perkins   mod 08/17/94
     5010           5b 100lasl evaldec76 g.hale l.stewart mod1 12/11/92 free gas
     5011           5b11 gebnl evalsep71 c.cowan mod1 12/11/92 free gas
     6012           6c ornl evaldec73 c.y.fu and f.g. perey mod2 12/11/92 free gas
     7015            7n 15 lasl evalmar77 e.arthur p.youn              mod1 12/16/88
    40096            40zr 96 sai evalapr76 m.drake d.sa                mod2 01/04/89
    74183            74w183 las anl brcevaldec80 arthur young sm       mod2 01/04/89
    74184            74w184 las anl brcevaldec80 arthur young sm       mod2 01/05/89
    92238            92U 238 ANL+ EVALJUN77 E.PENNINGTON A.            MOD3 02/13/92
   701501            7n 15 from version 6 evaluation
    14000            14si 0 ornl evalfeb74 larson perey dr             mod3 12/20/88
    63154           EU-154 FROM VERSION 6 OF ENDFB (2/9/93)
    63155           EU-155 FROM VERSION 6 OF ENDFB (6/30/93)
   631541            63eu154 bnl evaldec73 h.takahashi                 mod1 12/28/88
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631551           63eu155 bnl hedl + evaldec79 princeschenter      mod1 01/16/89
 94241          AMPX MASTER FILE FOR ENDF MAT 1381  ***  PU-241 ***
 92233          AMPX MASTER FILE FOR ENDF MAT 1393  ***  U-233  ***
 43099           43TC 99 HEDL BAW EVALNOV78 SCHENTER LIVOLS       MOD2 01/18/91
 40091           40ZR 91 SAI EVALAPR76 M.DRAKE D.SA               MOD2 01/18/91
 13027           13al 270lasl evaldec73 p.g. young d.g            mod1 11/29/88
 27059           27co 59 bnl evaljun77 s.mughabghab               mod3 12/20/88
 24000           24cr bnl evaldec77 a.prince and t.               mod2 11/29/88
  9019           9f 19 ornl evaljul74 c.y.fu d.c.lars             mod3 12/16/88
 26000           26fe 0 ornl evaloct77 c.y.fu f.g.pe              mod3 11/29/88
 25055           25mn 55 bnl evalmar77 s.f. mughabghab            mod2 12/20/88
 42000           42mo lll hedl evalfeb79 howerton schmit          mod1 02/17/89
 11023           11na 23 ornl evaldec77 d. c. larson              mod3 11/29/88
 41093           41nb 93 anl lll evalmay74 r.howerton lll         mod1 12/28/88
 28000           28ni 0 bnl nndc evalmar77 m.divadeenam           mod2 11/29/88
 37085           37rb 85 bnlbrc evaloct79 a. prince               mod1 01/03/89
 37087           37rb 87 bnlbrc evaloct79 a. prince               mod1 12/29/88
 45103           45rh103 hedl baw evalnov78 schenter livols       mod1 12/28/88
 16000           16 s 0 bnl evalapr79 divadeenam                  mod1 12/20/88
 90232           90th232 bnl evaldec77 bhat smith leon            mod2 01/05/89
 40000           40zr sai evalapr76 m.drake d.sa                  mod2 01/03/89
 40090           40zr 90 sai evalapr76 m.drake d.sa               mod2 01/04/89
 40092           40zr 92 sai evalapr76 m.drake d.sa               mod2 01/04/89
 40094           40zr 94 sai evalapr76 m.drake d.sa               mod2 01/04/89
  6312           graphite 1306/1065 96 angles 10/21/92 jpr eval.
 61601           61PM148MHEDL INEL EVALDEC79 SCHENTER SCHMIT      MOD1 01/22/91
  8016           8O 16 from version 6 evaluation
  1901           hydrogen in ch2   1301/1114           11/25/92
  1002           deuterium in d2o  1302/1004   96 angles    11/13/92
  1001           hydrogen in water 1301/1002    mod1   11/23/92
   999          1/v function (normalized to 1.0 at 2200m/s<==>0.0253ev)
 96242           96CM242 HEDLSRLLLL EVALAPR78 MANN BENJAMIN H     MOD1 01/18/91
 66164           66DY164 BNW EVALJUN67 B.R.LEONARD JR.            MOD1 01/18/91
 63151           63EU151 BNL EVALDEC77 S.F. MUGHABGHAB            MOD1 01/21/91
 64155           64GD155 BNL EVALJAN77 B.A.MAGURNO                MOD1 01/21/91
 64157           64GD157 BNL EVALJAN77 B.A.MAGURNO                MOD1 01/18/91
 72176           72HF176 SAI EVALAPR76 M.DRAKE D.SA               MOD1 01/18/91
 72179           72HF179 SAI EVALAPR76 M.DRAKE D.SA               MOD1 01/18/91
 60144           60ND144 HEDL EVALFEB80 SCHENTER SCHMIT           MOD1 01/22/91
 93237           93NP237 HEDL SRL + EVALAPR78 MANN BENJAMIN S     MOD2 01/23/91
 91231           91PA231 HEDL EVALNOV77 MANN                      MOD1 01/18/91
 94236           94PU236 HEDL SRL EVALAPR78 MANN SCHENTER B       MOD1 01/18/91
 94237           94PU237 HEDL EVALAPR78 MANN AND SCHENT           MOD1 01/18/91
 94238           94PU238 HEDL AI + EVALAPR78 MANN SCHENTER A      MOD3 01/18/91
 94242           94PU242 HEDL SRL + EVALOCT78 MANN BENJAMIN M     MOD2 01/21/91
 94243           94PU243 BNL SRL LLLEVALJUL76 KINSEYASSEMBLE      MOD1 01/18/91
 94244           94PU244 HEDL SRL EVALAPR78 MANN SCHENTER B       MOD1 01/18/91
 73181           73TA181 LLL EVALJAN72 HOWERTON PERKI             MOD2 01/22/91
 90230           90TH230 HEDL EVALNOV77 MANN                      MOD1 01/18/91
 92234           92U 234 BNL HEDL + EVALJUL78 DIVADEENAM MANN     MOD3 01/10/91
 92236           92U 236 BNL HEDL + EVALJUL78 DIVADEENAM MANN     MOD3 01/23/91
 47107           47ag107 bnl hedl evaljun83 a.prince r.e.sc       mod2 01/04/89
 47109           47ag109 bnl hedl evaljun83 a.prince r.e.sc       mod2 01/04/89
 47111           47ag111 hedl inel evaldec79 schenter schmit      mod1 01/12/89
 95241           95am241 hedl ornl evalapr78 mann schenter        mod2 01/10/90
 95601           95am242mhedlsrllll evalapr78 mann benjamin h     mod1 01/16/90
 95243           95am243 hedlsrllll evalapr78 mann benjamin h     mod2 01/10/90
 79197           79au197 bnl evalfeb77 s.f.mughabghab             mod3 01/04/89
 56134           56ba134 hedl evalapr74 r.e.schenter an           mod1 01/13/89
 56136           56ba136 hedl evalapr74 r.e.schenter an           mod1 01/13/89
 56137           56ba137 hedl evalapr74 r.e.schenter an           mod1 01/13/89
 56138           56ba138 lll evalaug78 howerton                   mod1 01/03/89
 56140           56ba140 hedl inel evaldec79 schenter schmit      mod1 01/13/89
 83209           83bi209 anl lll evalapr80 d.smith a.smith        mod1 01/04/89
 35079           35br 79 hedl evalapr74 r.e.schenter an           mod1 01/11/89
 35081           35br 81 hedl evalapr74 r.e.schenter an           mod1 01/11/89
 20000           20ca ornl evalaug71 c.y.fu and d.m.              mod3 12/20/88
 48000           48cd bnl evalmay74 s.pearlstein tr               mod1 01/03/89
 48106           48cd106 hedl evalfeb80 f.m.mann                  mod2 01/12/89
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48108	48cd108 hedl evalapr74 r.e.schenter an	mod1 01/12/89
48111	48cd111 hedl evalapr74 r.e.schenter an	mod1 01/12/89
48112	48cd112 hedl evalapr74 r.e.schenter an	mod1 01/12/89
48113	48cd113 bnl hedl evalnov78 pearlstein mann	mod1 01/03/89
48601	48cd115mhedl inel evaldec79 schenter schmit	mod1 01/12/89
48116	48cd116 hedl evalapr74 r.e.schenter an	mod1 01/12/89
58140	58ce140 hedl evalapr74 r.e.schenter an	mod1 01/13/89
58141	58ce141 hedl inel evaldec79 schenter schmit	mod1 01/13/89
58142	58ce142 hedl evalapr74 r.e.schenter an	mod1 01/13/89
58143	58ce143 hedl inel evaldec79 schenter schmit	mod1 01/13/89
58144	58ce144 hedl inel evaldec79 schenter schmit	mod1 01/16/89
98249	cf249 bnl srl lllevaljul76 kinseyassemble	mod1 01/12/89
98251	98cf251 bnl srl lllevaljul76 kinseyassemble	mod1 01/10/89
98252	98cf252 bnl srl lllevaljul76 kinseyassemble	mod1 01/10/89
17000	17cl gga evalfeb67 m.s.allen and m	mod1 03/14/89
96241	96cm241 hedl evalapr78 mann and schent	mod1 01/10/90
96243	96cm243 hedlsrllll evalapr78 mann benjamin h	mod1 01/10/90
96245	96cm245 srl lll evaljan79 benjamin and ho	mod2 01/05/89
96246	96cm246 bnl srl lllevaljul76 kinseyassemble	mod1 01/10/90
96247	96cm247 bnl srl lllevaljul76 kinseyassemble	mod1 01/10/89
55133	55cs133 hedl bnl evalnov78 schenter bhat p	mod1 01/03/89
55134	55cs134 hedl inel evaldec79 schenter schmit	mod1 01/13/89
55135	55cs135 hedl inel evaldec79 schenter schmit	mod1 01/13/89
55136	55cs136 hedl inel evaldec79 schenter schmit	mod1 01/13/89
55137	55cs137 hedl inel evaldec79 schenter schmit	mod1 01/13/89
29000	29cu ornl sai evaldec73 fu drake fricke	mod1 12/20/88
66161	66dy161 hedl evalapr74 r.e.schenter an	mod1 01/16/89
66162	66dy162 hedl evalapr74 r.e.schenter an	mod1 04/03/89
68167	68er167 hedl evalapr74 r.e.schenter an	mod1 04/03/89
99253	99es253 bnl srl evaljul76 kinsey benjamin	mod1 01/10/89
63000	63eu nndc evalaug81 autocombined	mod1 01/04/89
63152	63eu152 bnl evaldec73 h.takahashi	mod2 02/28/89
63153	63eu153 bnl evalfeb78 s.mughabghab	mod1 01/03/89
63156	63eu156 hedl inel evaldec79 schenter schmit	mod1 01/16/89
63157	63eu157 hedl evalfeb80 r.e.schenter an	mod1 01/17/89
31000	31ga lll lasl evalmay80 howerton young	mod1 12/21/88
64152	64gd152 bnl evaljan77 b.a.magurno	mod2 01/03/89
64154	64gd154 bnl evaljan77 b.a.magurno	mod1 01/03/89
64156	64gd156 bnl evaljan77 b.a.magurno	mod2 01/04/89
64158	64gd158 bnl evaljan77 b.a.magurno	mod1 01/04/89
64160	64gd160 bnl evaljan77 b.a.magurno	mod1 01/04/89
32072	32ge 72 hedl evalapr74 r.e.schenter an	mod1 01/11/89
32073	32ge 73 hedl evalapr74 r.e.schenter an	mod1 01/11/89
32076	32ge 76 hedl evalapr74 r.e.schenter an	mod1 01/11/89
1801	1h 10lasl evalaug70 l.stewart r.j.	mod1 12/16/88
72000	72hf sai evalapr76 m.drake d.sa	mod1 01/04/89
72174	72hf174 sai evalapr76 m.drake d.sa	mod1 03/21/89
72177	72hf177 sai evalapr76 m.drake d.sa	mod1 03/21/89
72178	72hf178 sai evalapr76 m.drake d.sa	mod1 03/21/89
72180	72hf180 sai evalapr76 m.drake d.sa	mod1 01/04/89
67165	67ho165 hedl evalapr74 r.e.schenter an	mod1 01/16/89
53127	53i 127 hedl rcn evalfeb80 r.e.schenter an	mod1 01/13/89
53129	53i 129 hedl inel+ evalfeb80 schenter schmit	mod1 01/13/89
53130	53i 130 hedl inel evaldec79 schenter schmit	mod1 01/13/89
53131	53i 131 hedl inel evaldec79 schenter schmit	mod1 01/13/89
53135	53i 135 hedl inel evaldec79 schenter schmit	mod1 01/13/89
49113	49in113 hedl evalapr74 r.e.schenter an	mod1 01/12/89
49115	49in115 hedl inel evaldec79 schenter schmit	mod1 01/12/89
36078	36kr 78 bnl evalapr78 a.prince	mod1 12/29/88
36080	36kr 80 bnl evalapr78 a.prince	mod1 12/29/88
36082	36kr 82 bnl evalapr78 a.prince	mod1 12/29/88
36083	36kr 83 bnl evalapr78 a.prince	mod1 12/29/88
36084	36kr 84 bnl evalapr78 a.prince	mod1 12/29/88
36085	36kr 85 hedl inel evaldec79 schenter schmit	mod1 01/11/89
36086	36kr 86 bnl evaljul72 a.prince	mod1 12/30/88
57139	57la139 hedl rcn evalfeb80 r.e.schenter an	mod1 01/13/89
57140	57la140 hedl inel evaldec79 schenter schmit	mod1 01/13/89
71175	71lu175 bnw evaljun67 b.r.leonard jr.	mod1 12/22/88
71176	71lu176 bnw evaljun67 b.r.leonard jr.	mod1 12/22/88

12000	12mg ornl evalfeb78 d.c.larson	mod1 12/16/88
42092	42mo 92 hedl evalfeb80 f.m.mann	mod1 01/12/89
42094	42mo 94 hedl rcn evalfeb80 r.e.schenter an	mod1 01/11/89
42095	42mo 95 hedl rcn evalfeb80 r.e.schenter an	mod1 01/11/89
42097	42mo 97 hedl rcn evalfeb80 r.e.schenter an	mod1 01/12/89
42098	42mo 98 hedl rcn evalfeb80 r.e.schenter an	mod1 01/12/89
42099	42mo 99 hedl inel evaldec79 schenter schmit	mod1 01/12/89
42100	42mo100 hedl rcn evalfeb80 r.e.schenter an	mod1 01/12/89
7014	7n 14 lasl evaljul73 p.young d.fost	mod2 11/28/88
41094	41nb 94 hedl inel evaldec79 schenter schmit	mod1 01/11/89
41095	41nb 95 hedl inel evaldec79 schenter schmit	mod1 01/11/89
60142	60nd142 hedl evalapr74 r.e.schenter an	mod1 01/16/89
60147	60nd147 hedl inel evaldec79 schenter schmit	mod1 01/16/89
60148	60nd148 hedl bnl+ evalfeb80 schenter schmit	mod1 03/21/89
8017	8o 17 bnl evaljan78 b.a.magurno	mod1 12/20/88
15031	15p 31 lll evaloct77 howerton	mod1 12/20/88
82000	82pb ornl evaljul71 c.y.fu and f.g.	mod2 01/04/89
46102	46pd102 hedl evalfeb80 f.m.mann	mod2 01/12/89
46104	46pd104 hedl rcn evalfeb80 r.e.schenter an	mod1 01/12/89
46105	46pd105 hedl rcn evalfeb80 r.e.schenter an	mod1 01/12/89
46106	46pd106 hedl rcn evalfeb80 r.e.schenter an	mod1 01/12/89
46107	46pd107 hedl inel+ evalfeb80 schenter schmit	mod1 01/12/89
46110	46pd110 hedl rcn evalfeb80 r.e.schenter an	mod1 01/12/89
61147	61pm147 hedl inel +evalfeb80 schenter + rei	mod1 01/16/89
61148	61pm148 hedl inel evaldec79 schenter schmit	mod1 01/16/89
61149	61pm149 hedl inel evaldec79 schenter schmit	mod1 01/16/89
61151	61pm151 hedl inel evaldec79 schenter schmit	mod1 01/16/89
59141	59pr141 hedl bnl+ evalfeb80 schenter schmit	mod1 03/21/89
59142	59pr142 hedl inel evaldec79 schenter schmit	mod1 01/16/89
59143	59pr143 hedl inel evaldec79 schenter schmit	mod1 01/16/89
94239	94pu239 lanl jun83 e.arthur p.you	mod2 02/28/89
94240	94pu240 ornl evalapr77 l.w. weston	mod3 12/12/88
37086	37rb 86 hedl inel evaldec79 schenter schmit	mod1 01/11/89
75185	75re185 ge nmpo evaljan68 w.b.henderson a	mod1 12/22/88
75187	75re187 ge nmpo evaljan68 w.b.henderson a	mod1 12/22/88
45105	45rh105 hedl inel evaldec79 schenter schmit	mod2 01/12/89
44096	44ru 96 hedl evalfeb80 f.m.mann	mod2 01/12/89
44098	44ru 98 hedl evalfeb80 f.m.mann	mod2 01/12/89
44099	44ru 99 hedl evalapr74 r.e.schenter an	mod1 01/12/89
44100	44ru100 hedl rcn evalfeb80 r.e.schenter an	mod1 01/12/89
44101	44ru101 hedl rcn evalfeb80 r.e.schenter an	mod1 01/12/89
44102	44ru102 hedl rcn evalfeb80 r.e.schenter an	mod1 01/12/89
44103	44ru103 hedl inel evaldec79 schenter schmit	mod1 01/12/89
44104	44ru104 hedl rcn evalfeb80 r.e.schenter an	mod1 01/12/89
44105	44ru105 hedl inel evaldec79 schenter schmit	mod1 01/12/89
44106	44ru106 hedl inel evaldec79 schenter schmit	mod1 01/12/89
16032	16s 32 lll evaloct77 howerton	mod1 12/20/88
51121	51sb121 hedl rcn evalfeb80 r.e.schenter an	mod1 01/13/89
51123	51sb123 hedl rcn evalfeb80 r.e.schenter an	mod1 01/13/89
51124	51sb124 hedl inel evaldec79 schenter schmit	mod1 01/13/89
51125	51sb125 hedl inel evaldec79 schenter schmit	mod1 01/13/89
51126	51sb126 hedl inel evaldec79 schenter schmit	mod1 01/13/89
34074	34se 74 hedl evalfeb80 f.m.mann	mod2 03/21/89
34077	34se 77 hedl evalapr74 r.e.schenter an	mod1 01/11/89
34080	34se 80 hedl evalapr74 r.e.schenter an	mod1 03/21/89
34082	34se 82 hedl evalapr74 r.e.schenter an	mod1 01/11/89
62144	62sm144 hedl evalfeb80 f.m.mann	mod2 01/16/89
62148	62sm148 hedl evalfeb80 schenter schmit	mod1 01/16/89
62149	62sm149 hedl bnw evalnov78 schenter leonar	mod1 01/03/89
62150	62sm150 hedl evalapr74 r.e.schenter an	mod1 03/21/89
62151	62sm151 hedl inel +evalfeb80 schenter + rei	mod1 01/16/89
62153	62sm153 hedl inel evaldec79 schenter schmit	mod1 01/16/89
50112	50sn112 hedl evalfeb80 f.m.mann	mod2 01/12/89
50114	50sn114 hedl evalfeb80 f.m.mann	mod2 01/12/89
50115	50sn115 hedl evalapr74 r.e.schenter an	mod1 01/12/89
50116	50sn116 hedl evalapr74 r.e.schenter an	mod1 01/12/89
50117	50sn117 hedl evalapr74 r.e.schenter an	mod1 01/12/89
50118	50sn118 hedl evalapr74 r.e.schenter an	mod1 01/12/89
50119	50sn119 hedl evalapr74 r.e.schenter an	mod1 01/12/89

50120	50sn120 hedl evalapr74 r.e.schenter an	mod1 01/12/89
50122	50sn122 hedl evalapr74 r.e.schenter an	mod1 01/12/89
50123	50sn123 hedl inel evaldec79 schenter schmit	mod1 01/12/89
50124	50sn124 hedl evalapr74 r.e.schenter an	mod1 01/12/89
50125	50sn125 hedl inel evaldec79 schenter schmit	mod1 01/13/89
50126	50sn126 hedl inel evaldec79 schenter schmit	mod1 01/12/89
38084	38sr 84 hedl evalfeb80 f.m.mann	mod2 01/11/89
38086	38sr 86 hedl evalapr74 r.e.schenter an	mod1 01/11/89
38087	38sr 87 hedl evalapr74 r.e.schenter an	mod1 01/11/89
38088	38sr 88 hedl evalapr74 r.e.schenter an	mod1 01/11/89
38089	38sr 89 hedl inel evaldec79 schenter schmit	mod1 01/11/89
38090	38sr 90 hedl inel evaldec79 schenter schmit	mod1 01/11/89
1003	1t 30lasl evalfeb65 leona stewart	mod2 12/16/88
73182	73ta182 ai evalapr71 j.otter c.dunfo	mod1 12/22/88
65159	65tb159 hedl rcn evalfeb80 r.e.schenter an	mod1 01/16/89
65160	65tb160 hedl inel evaldec79 schenter schmit	mod1 01/16/89
52120	52te120 hedl evalfeb80 f.m.mann	mod2 01/13/89
52123	52te123 hedl evalapr74 r.e.schenter an	mod1 03/21/89
52124	52te124 hedl evalapr74 r.e.schenter an	mod1 01/13/89
52125	52te125 hedl evalapr74 r.e.schenter an	mod1 01/13/89
52126	52te126 hedl evalapr74 r.e.schenter an	mod1 01/13/89
52601	52te127mhedl inel evaldec79 schenter schmit	mod1 01/13/89
52128	52te128 hedl evalapr74 r.e.schenter an	mod1 01/13/89
52611	52te129mhedl inel evaldec79 schenter schmit	mod1 01/13/89
52130	52te130 hedl evalapr74 r.e.schenter an	mod1 01/13/89
52132	52te132 hedl inel evaldec79 schenter schmit	mod1 01/13/89
22000	22ti buranllll evalaug77 c.philis a.smit	mod1 12/20/88
92235	92u 235 bnl evalapr77 m.r.bhat	mod3 02/28/89
92237	92u237 bnl srl lllevaljul76 kinseyassemble	mod1 01/10/89
23000	23v anllllhedl evaljan77 a.smith+ h.howe	mod1 12/20/88
74000	74w lanl evalmar82 e.d.arthur	mod1 01/04/89
74182	74w182 las anl brcevaldec80 arthur young sm	mod2 01/04/89
74186	74w186 las anl brcevaldec80 arthur young sm	mod2 01/05/89
54124	54xe124 bnl evalmar78 m.r.bhat and s.	mod1 12/29/88
54126	54xe126 bnl evalmar78 m.r.bhat and s.	mod1 12/29/88
54128	54xe128 bnl evalmar78 m.r.bhat and s.	mod1 12/30/88
54129	54xe129 bnl evalmar78 m.r.bhat and s.	mod1 01/03/89
54130	54xe130 bnl evalmar78 m.r.bhat and s.	mod1 12/30/88
54131	54xe131 bnl evalmar78 m.r.bhat and s.	mod1 01/03/89
54132	54xe132 bnl evalmar78 m.r.bhat and s.	mod2 01/03/89
54133	54xe133 hedl inel evaldec79 schenter schmit	mod1 01/13/89
54134	54xe134 bnl evalmar78 m.r.bhat and s.	mod1 01/03/89
54135	54xe135 bnw evaljun67 b.r.leonard jr.	mod1 12/28/88
54136	54xe136 bnl evalmar78 m.r.bhat and s.	mod1 01/03/89
39089	39y 89 hedl evalapr74 r.e.schenter an	mod1 01/11/89
39090	39y 90 hedl inel evaldec79 schenter schmit	mod1 01/11/89
39091	39y 91 hedl inel evaldec79 schenter schmit	mod1 01/11/89
40093	40zr 93 hedl inel evaldec79 schenter schmit	mod1 01/11/89
40095	40zr 95 hedl inel evaldec79 schenter schmit	mod1 01/11/89
801601	8o 16 lasl evalaug73 p.young d.fost	mod2 12/16/88
701401	7n 14 from version 6 evaluation	
98250	98cf250 bnl srl lllevaljul76 kinseyassemble	mod1 11/14/97
91233	91PA233 HEDL INEL EVALMAY78 MANN SCHENTER R	MOD2 01/18/91
97249	97bk249 bnl srl lllevaljul76 kinseyassemble	mod1 01/11/89

Table E.4 Contents of the 44-group ENDF/B-V library

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table of contents for  scale.rev10.xn44                            on logical unit  1
tape id                          44
number of nuclides              315
number of neutron groups         44
first thermal group              23
number of gamma groups            0
        scale - 44 neutron group library            based on endf-b version 5 data
          collapsed with a light water reactor cell flux spectrum from 238 groups
            compiled for nrc        9/01/94
              last updated          7/29/99
                m.d.dehart & l.m.petrie    nuclear eng. appl. - cped - ornl
    24301           24CR BNL EVALDEC77 A.PRINCE AND T.    (1/esigt)  MOD2 11/18/91
    24304           24CR BNL EVALDEC77 A.PRINCE AND T.    (1/esigtSS304)  MOD2 11/18/91
    26301           26FE 0 ORNL EVALOCT77 C.Y.FU F.G.PE  (1/esigt)   MOD3 11/18/91
    26304           26FE 0 ORNL EVALOCT77 C.Y.FU F.G.PE  (1/esigtSS304)   MOD3 11/18/91
    28301           28NI 0 BNL NNDC EVALMAR77 M.DIVADEENAM (1/esigt) MOD2 11/18/91
    28304           28NI 0 BNL NNDC EVALMAR77 M.DIVADEENAM (1/esigtSS304) MOD2 11/18/91
     1701             smiler for h-1 (hzrh)  tape 132, mat 7   5-14-98
    40701             smiler for zr (in zrh)  tape 133, mat 58   5-15-98
    19000           19k gga evalfeb67 m.k.drake                  mod1 1updated 01/18/95
    92232           92u232 hedl evalnov77 mann                   mod1 11/14/97
    33075           33as 75 hedl evalapr74 r.e.schenter an       mod1 04/02/97
    56135           56ba135 hedl evalapr74 r.e.schenter an       mod1 04/02/97
    48110           48cd110 hedl evalapr74 r.e.schenter an       mod1 04/02/97
    48114           48cd114 hedl evalapr74 r.e.schenter an       mod1 04/02/97
    96244           96cm244 hedlsrllll evalapr78 mann benjamin h     mod2 11/14/97
    96248           96cm248 hedlsrllll evalapr78 mann benjamin h     mod1 11/14/97
    66160           66dy160 hedl evalapr74 r.e.schenter an       mod1 04/08/97
    66163           66dy163 hedl evalapr74 r.e.schenter an       mod1 04/09/97
    68166           68er166 hedl evalapr74 r.e.schenter an       mod1 04/23/97
    32074           32ge 74 hedl evalapr74 r.e.schenter an       mod1 04/23/97
    42096           42mo 96 hedl rcn evalfeb80 r.e.schenter an       mod1 04/23/97
    60145           60nd145 hedl bnl+ evalfeb80 schenter schmit      mod1 04/23/97
    60146           60nd146 hedl bnl+ evalfeb80 schenter schmit      mod1 04/24/97
    60150           60nd150 hedl bnl+ evalfeb80 schenter schmit      mod1 04/24/97
    46108           46pd108 hedl rcn evalfeb80 r.e.schenter an       mod1 04/24/97
    34076           34se 76 hedl evalapr74 r.e.schenter an       mod1 04/24/97
    34078           34se 78 hedl evalapr74 r.e.schenter an       mod1 04/24/97
    62152           62sm152 hedl bnl+ evalfeb80 schenter schmit      mod1 04/29/97
    62154           62sm154 hedl evalapr74 r.e.schenter an       mod1 04/29/97
    52122           52te122 hedl evalapr74 r.e.schenter an       mod1 04/29/97
     4309           be metal 13041064                            mod2 04/29/97
    60143           60nd143 hedl bnl+ evalfeb80 schenter schmit      mod1 04/23/97
    62147           62sm147 hedl bnl+ evalfeb80 schenter + man       mod2 04/24/97
       99          collected weight functions for use in collapsing    updated 5/12/95
      900          neutron dose factors from ansl/ans 6.1.1-1977       updated 5/12/95
     1802          1d 20lasl eval nov67 l.stewart lasl mod2 12/11/92 free gas
     2003          2he 30lasl evaljun68 leona stewart mod1 12/23/92 free gas
     2004          2he 40lasl evaloct73 nisley hale young mod0 12/23/92 free gas
     3006          3li0060lasl eval sep77 g.hale l.stewart mod1 12/11/92 free gas
     3007          3li 7 lanl evaldec81 p.g.young mod1 12/11/92 free gas
     4009          4be 9 free gas. lll evaloct76 howerton/perkins   mod 08/17/94
     5010          5b 100lasl evaldec76 g.hale l.stewart mod1 12/11/92 free gas
     5011          5b11 gebnl evalsep71 c.cowan mod1 12/11/92 free gas
     6012          6c ornl evaldec73 c.y.fu and f.g. perey mod2 12/11/92 free gas
     7015           7n 15 lasl evalmar77 e.arthur p.youn             mod1 12/16/88
    40096           40zr 96 sai evalapr76 m.drake d.sa               mod2 01/04/89
    74183           74w183 las anl brcevaldec80 arthur young sm      mod2 01/04/89
    74184           74w184 las anl brcevaldec80 arthur young sm      mod2 01/05/89
    92238           92U 238 ANL+ EVALJUN77 E.PENNINGTON A.           MOD3 02/13/92
   701501           7n 15 from version 6 evaluation
    14000           14si 0 ornl evalfeb74 larson perey dr            mod3 12/20/88
    63154          EU-154 FROM VERSION 6 OF ENDFB (2/9/93)
    63155          EU-155 FROM VERSION 6 OF ENDFB (6/30/93)
   631541           63eu154 bnl evaldec73 h.takahashi                mod1 12/28/88
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631551	63eu155 bnl hedl + evaldec79 princeschenter	mod1 01/16/89
94241	AMPX MASTER FILE FOR ENDF MAT 1381 *** PU-241 ***	
92233	AMPX MASTER FILE FOR ENDF MAT 1393 *** U-233 ***	
43099	43TC 99 HEDL BAW EVALNOV78 SCHENTER LIVOLS	MOD2 01/18/91
40091	40ZR 91 SAI EVALAPR76 M.DRAKE D.SA	MOD2 01/18/91
13027	13al 270lasl evaldec73 p.g. young d.g	mod1 11/29/88
27059	27co 59 bnl evaljun77 s.mughabghab	mod3 12/20/88
24000	24cr bnl evaldec77 a.prince and t.	mod2 11/29/88
9019	9f 19 ornl evaljul74 c.y.fu d.c.lars	mod3 12/16/88
26000	26fe 0 ornl evaloct77 c.y.fu f.g.pe	mod3 11/29/88
25055	25mn 55 bnl evalmar77 s.f. mughabghab	mod2 12/20/88
42000	42mo lll hedl evalfeb79 howerton schmit	mod1 02/17/89
11023	11na 23 ornl evaldec77 d. c. larson	mod3 11/29/88
41093	41nb 93 anl lll evalmay74 r.howerton lll	mod1 12/28/88
28000	28ni 0 bnl nndc evalmar77 m.divadeenam	mod2 11/29/88
37085	37rb 85 bnlbrc evaloct79 a. prince	mod1 01/03/89
37087	37rb 87 bnlbrc evaloct79 a. prince	mod1 12/29/88
45103	45rh103 hedl baw evalnov78 schenter livols	mod1 12/28/88
16000	16 s 0 bnl evalapr79 divadeenam	mod1 12/20/88
90232	90th232 bnl evaldec77 bhat smith leon	mod2 01/05/89
40000	40zr sai evalapr76 m.drake d.sa	mod2 01/03/89
40090	40zr 90 sai evalapr76 m.drake d.sa	mod2 01/04/89
40092	40zr 92 sai evalapr76 m.drake d.sa	mod2 01/04/89
40094	40zr 94 sai evalapr76 m.drake d.sa	mod2 01/04/89
6312	graphite 1306/1065 96 angles 10/21/92 jpr eval.	
61601	61PM148MHEDL INEL EVALDEC79 SCHENTER SCHMIT	MOD1 01/22/91
8016	8O 16 from version 6 evaluation	
1901	hydrogen in ch2 1301/1114 11/25/92	
1002	deuterium in d2o 1302/1004 96 angles 11/13/92	
1001	hydrogen in water 1301/1002 mod1 11/23/92	
999	1/v function (normalized to 1.0 at 2200m/s<==>0.0253ev)	
96242	96CM242 HEDLSRLLLL EVALAPR78 MANN BENJAMIN H	MOD1 01/18/91
66164	66DY164 BNW EVALJUN67 B.R.LEONARD JR.	MOD1 01/18/91
63151	63EU151 BNL EVALDEC77 S.F. MUGHABGHAB	MOD1 01/21/91
64155	64GD155 BNL EVALJAN77 B.A.MAGURNO	MOD1 01/21/91
64157	64GD157 BNL EVALJAN77 B.A.MAGURNO	MOD1 01/18/91
72176	72HF176 SAI EVALAPR76 M.DRAKE D.SA	MOD1 01/18/91
72179	72HF179 SAI EVALAPR76 M.DRAKE D.SA	MOD1 01/18/91
60144	60ND144 HEDL EVALFEB80 SCHENTER SCHMIT	MOD1 01/22/91
93237	93NP237 HEDL SRL + EVALAPR78 MANN BENJAMIN S	MOD2 01/23/91
91231	91PA231 HEDL EVALNOV77 MANN	MOD1 01/18/91
94236	94PU236 HEDL SRL EVALAPR78 MANN SCHENTER B	MOD1 01/18/91
94237	94PU237 HEDL EVALAPR78 MANN AND SCHENT	MOD1 01/18/91
94238	94PU238 HEDL AI + EVALAPR78 MANN SCHENTER A	MOD3 01/18/91
94242	94PU242 HEDL SRL + EVALOCT78 MANN BENJAMIN M	MOD2 01/21/91
94243	94PU243 BNL SRL LLLEVALJUL76 KINSEYASSEMBLE	MOD1 01/18/91
94244	94PU244 HEDL SRL EVALAPR78 MANN SCHENTER B	MOD1 01/18/91
73181	73TA181 LLL EVALJAN72 HOWERTON PERKI	MOD2 01/22/91
90230	90TH230 HEDL EVALNOV77 MANN	MOD1 01/18/91
92234	92U 234 BNL HEDL + EVALJUL78 DIVADEENAM MANN	MOD3 01/10/91
92236	92U 236 BNL HEDL + EVALJUL78 DIVADEENAM MANN	MOD3 01/23/91
47107	47ag107 bnl hedl evaljun83 a.prince r.e.sc	mod2 01/04/89
47109	47ag109 bnl hedl evaljun83 a.prince r.e.sc	mod2 01/04/89
47111	47ag111 hedl inel evaldec79 schenter schmit	mod1 01/12/89
95241	95am241 hedl ornl evalapr78 mann schenter	mod2 01/10/90
95601	95am242mhedlsrllll evalapr78 mann benjamin h	mod1 01/16/90
95243	95am243 hedlsrllll evalapr78 mann benjamin h	mod2 01/10/90
79197	79au197 bnl evalfeb77 s.f.mughabghab	mod3 01/04/89
56134	56ba134 hedl evalapr74 r.e.schenter an	mod1 01/13/89
56136	56ba136 hedl evalapr74 r.e.schenter an	mod1 01/13/89
56137	56ba137 hedl evalapr74 r.e.schenter an	mod1 01/13/89
56138	56ba138 lll evalaug78 howerton	mod1 01/03/89
56140	56ba140 hedl inel evaldec79 schenter schmit	mod1 01/13/89
83209	83bi209 anl lll evalapr80 d.smith a.smith	mod1 01/04/89
35079	35br 79 hedl evalapr74 r.e.schenter an	mod1 01/11/89
35081	35br 81 hedl evalapr74 r.e.schenter an	mod1 01/11/89
20000	20ca ornl evalaug71 c.y.fu and d.m.	mod3 12/20/88
48000	48cd bnl evalmay74 s.pearlstein tr	mod1 01/03/89
48106	48cd106 hedl evalfeb80 f.m.mann	mod2 01/12/89

48108	48cd108 hedl evalapr74 r.e.schenter an	mod1 01/12/89
48111	48cd111 hedl evalapr74 r.e.schenter an	mod1 01/12/89
48112	48cd112 hedl evalapr74 r.e.schenter an	mod1 01/12/89
48113	48cd113 bnl hedl evalnov78 pearlstein mann	mod1 01/03/89
48601	48cd115mhedl inel evaldec79 schenter schmit	mod1 01/12/89
48116	48cd116 hedl evalapr74 r.e.schenter an	mod1 01/12/89
58140	58ce140 hedl evalapr74 r.e.schenter an	mod1 01/13/89
58141	58ce141 hedl inel evaldec79 schenter schmit	mod1 01/13/89
58142	58ce142 hedl evalapr74 r.e.schenter an	mod1 01/13/89
58143	58ce143 hedl inel evaldec79 schenter schmit	mod1 01/13/89
58144	58ce144 hedl inel evaldec79 schenter schmit	mod1 01/16/89
98249	cf249 bnl srl lllevaljul76 kinseyassemble	mod1 01/12/89
98251	98cf251 bnl srl lllevaljul76 kinseyassemble	mod1 01/10/89
98252	98cf252 bnl srl lllevaljul76 kinseyassemble	mod1 01/10/89
17000	17cl gga evalfeb67 m.s.allen and m	mod1 03/14/89
96241	96cm241 hedl evalapr78 mann and schent	mod1 01/10/90
96243	96cm243 hedlsrllll evalapr78 mann benjamin h	mod1 01/10/90
96245	96cm245 srl lll evaljan79 benjamin and ho	mod2 01/05/89
96246	96cm246 bnl srl lllevaljul76 kinseyassemble	mod1 01/10/90
96247	96cm247 bnl srl lllevaljul76 kinseyassemble	mod1 01/10/89
55133	55cs133 hedl bnl evalnov78 schenter bhat p	mod1 01/03/89
55134	55cs134 hedl inel evaldec79 schenter schmit	mod1 01/13/89
55135	55cs135 hedl inel evaldec79 schenter schmit	mod1 01/13/89
55136	55cs136 hedl inel evaldec79 schenter schmit	mod1 01/13/89
55137	55cs137 hedl inel evaldec79 schenter schmit	mod1 01/13/89
29000	29cu ornl sai evaldec73 fu drake fricke	mod1 12/20/88
66161	66dy161 hedl evalapr74 r.e.schenter an	mod1 01/16/89
66162	66dy162 hedl evalapr74 r.e.schenter an	mod1 04/03/89
68167	68er167 hedl evalapr74 r.e.schenter an	mod1 04/03/89
99253	99es253 bnl srl evaljul76 kinsey benjamin	mod1 01/10/89
63000	63eu nndc evalaug81 autocombined	mod1 01/04/89
63152	63eu152 bnl evaldec73 h.takahashi	mod2 02/28/89
63153	63eu153 bnl evalfeb78 s.mughabghab	mod1 01/03/89
63156	63eu156 hedl inel evaldec79 schenter schmit	mod1 01/16/89
63157	63eu157 hedl evalfeb80 r.e.schenter an	mod1 01/17/89
31000	31ga lll lasl evalmay80 howerton young	mod1 12/21/88
64152	64gd152 bnl evaljan77 b.a.magurno	mod2 01/03/89
64154	64gd154 bnl evaljan77 b.a.magurno	mod1 01/03/89
64156	64gd156 bnl evaljan77 b.a.magurno	mod2 01/04/89
64158	64gd158 bnl evaljan77 b.a.magurno	mod1 01/04/89
64160	64gd160 bnl evaljan77 b.a.magurno	mod1 01/04/89
32072	32ge 72 hedl evalapr74 r.e.schenter an	mod1 01/11/89
32073	32ge 73 hedl evalapr74 r.e.schenter an	mod1 01/11/89
32076	32ge 76 hedl evalapr74 r.e.schenter an	mod1 01/11/89
1801	1h 10lasl evalaug70 l.stewart r.j.	mod1 12/16/88
72000	72hf sai evalapr76 m.drake d.sa	mod1 01/04/89
72174	72hf174 sai evalapr76 m.drake d.sa	mod1 03/21/89
72177	72hf177 sai evalapr76 m.drake d.sa	mod1 03/21/89
72178	72hf178 sai evalapr76 m.drake d.sa	mod1 03/21/89
72180	72hf180 sai evalapr76 m.drake d.sa	mod1 01/04/89
67165	67ho165 hedl evalapr74 r.e.schenter an	mod1 01/16/89
53127	53i 127 hedl rcn evalfeb80 r.e.schenter an	mod1 01/13/89
53129	53i 129 hedl inel+ evalfeb80 schenter schmit	mod1 01/13/89
53130	53i 130 hedl inel evaldec79 schenter schmit	mod1 01/13/89
53131	53i 131 hedl inel evaldec79 schenter schmit	mod1 01/13/89
53135	53i 135 hedl inel evaldec79 schenter schmit	mod1 01/13/89
49113	49in113 hedl evalapr74 r.e.schenter an	mod1 01/12/89
49115	49in115 hedl inel evaldec79 schenter schmit	mod1 01/12/89
36078	36kr 78 bnl evalapr78 a.prince	mod1 12/29/88
36080	36kr 80 bnl evalapr78 a.prince	mod1 12/29/88
36082	36kr 82 bnl evalapr78 a.prince	mod1 12/29/88
36083	36kr 83 bnl evalapr78 a.prince	mod1 12/29/88
36084	36kr 84 bnl evalapr78 a.prince	mod1 12/29/88
36085	36kr 85 hedl inel evaldec79 schenter schmit	mod1 01/11/89
36086	36kr 86 bnl evaljul72 a.prince	mod1 12/30/88
57139	57la139 hedl rcn evalfeb80 r.e.schenter an	mod1 01/13/89
57140	57la140 hedl inel evaldec79 schenter schmit	mod1 01/13/89
71175	71lu175 bnw evaljun67 b.r.leonard jr.	mod1 12/22/88
71176	71lu176 bnw evaljun67 b.r.leonard jr.	mod1 12/22/88

12000	12mg ornl evalfeb78 d.c.larson	mod1 12/16/88
42092	42mo 92 hedl evalfeb80 f.m.mann	mod1 01/12/89
42094	42mo 94 hedl rcn evalfeb80 r.e.schenter an	mod1 01/11/89
42095	42mo 95 hedl rcn evalfeb80 r.e.schenter an	mod1 01/11/89
42097	42mo 97 hedl rcn evalfeb80 r.e.schenter an	mod1 01/12/89
42098	42mo 98 hedl rcn evalfeb80 r.e.schenter an	mod1 01/12/89
42099	42mo 99 hedl inel evaldec79 schenter schmit	mod1 01/12/89
42100	42mo100 hedl rcn evalfeb80 r.e.schenter an	mod1 01/12/89
7014	7n 14 lasl evaljul73 p.young d.fost	mod2 11/28/88
41094	41nb 94 hedl inel evaldec79 schenter schmit	mod1 01/11/89
41095	41nb 95 hedl inel evaldec79 schenter schmit	mod1 01/11/89
60142	60nd142 hedl evalapr74 r.e.schenter an	mod1 01/16/89
60147	60nd147 hedl inel evaldec79 schenter schmit	mod1 01/16/89
60148	60nd148 hedl bnl+ evalfeb80 schenter schmit	mod1 03/21/89
8017	8o 17 bnl evaljan78 b.a.magurno	mod1 12/20/88
15031	15p 31 lll evaloct77 howerton	mod1 12/20/88
82000	82pb ornl evaljul71 c.y.fu and f.g.	mod2 01/04/89
46102	46pd102 hedl evalfeb80 f.m.mann	mod2 01/12/89
46104	46pd104 hedl rcn evalfeb80 r.e.schenter an	mod1 01/12/89
46105	46pd105 hedl rcn evalfeb80 r.e.schenter an	mod1 01/12/89
46106	46pd106 hedl rcn evalfeb80 r.e.schenter an	mod1 01/12/89
46107	46pd107 hedl inel+ evalfeb80 schenter schmit	mod1 01/12/89
46110	46pd110 hedl rcn evalfeb80 r.e.schenter an	mod1 01/12/89
61147	61pm147 hedl inel +evalfeb80 schenter + rei	mod1 01/16/89
61148	61pm148 hedl inel evaldec79 schenter schmit	mod1 01/16/89
61149	61pm149 hedl inel evaldec79 schenter schmit	mod1 01/16/89
61151	61pm151 hedl inel evaldec79 schenter schmit	mod1 01/16/89
59141	59pr141 hedl bnl+ evalfeb80 schenter schmit	mod1 03/21/89
59142	59pr142 hedl inel evaldec79 schenter schmit	mod1 01/16/89
59143	59pr143 hedl inel evaldec79 schenter schmit	mod1 01/16/89
94239	94pu239 lanl jun83 e.arthur p.you	mod2 02/28/89
94240	94pu240 ornl evalapr77 l.w. weston	mod3 12/12/88
37086	37rb 86 hedl inel evaldec79 schenter schmit	mod1 01/11/89
75185	75re185 ge nmpo evaljan68 w.b.henderson a	mod1 12/22/88
75187	75re187 ge nmpo evaljan68 w.b.henderson a	mod1 12/22/88
45105	45rh105 hedl inel evaldec79 schenter schmit	mod2 01/12/89
44096	44ru 96 hedl evalfeb80 f.m.mann	mod2 01/12/89
44098	44ru 98 hedl evalfeb80 f.m.mann	mod2 01/12/89
44099	44ru 99 hedl evalapr74 r.e.schenter an	mod1 01/12/89
44100	44ru100 hedl rcn evalfeb80 r.e.schenter an	mod1 01/12/89
44101	44ru101 hedl rcn evalfeb80 r.e.schenter an	mod1 01/12/89
44102	44ru102 hedl rcn evalfeb80 r.e.schenter an	mod1 01/12/89
44103	44ru103 hedl inel evaldec79 schenter schmit	mod1 01/12/89
44104	44ru104 hedl rcn evalfeb80 r.e.schenter an	mod1 01/12/89
44105	44ru105 hedl inel evaldec79 schenter schmit	mod1 01/12/89
44106	44ru106 hedl inel evaldec79 schenter schmit	mod1 01/12/89
16032	16s 32 lll evaloct77 howerton	mod1 12/20/88
51121	51sb121 hedl rcn evalfeb80 r.e.schenter an	mod1 01/13/89
51123	51sb123 hedl rcn evalfeb80 r.e.schenter an	mod1 01/13/89
51124	51sb124 hedl inel evaldec79 schenter schmit	mod1 01/13/89
51125	51sb125 hedl inel evaldec79 schenter schmit	mod1 01/13/89
51126	51sb126 hedl inel evaldec79 schenter schmit	mod1 01/13/89
34074	34se 74 hedl evalfeb80 f.m.mann	mod2 03/21/89
34077	34se 77 hedl evalapr74 r.e.schenter an	mod1 01/11/89
34080	34se 80 hedl evalapr74 r.e.schenter an	mod1 03/21/89
34082	34se 82 hedl evalapr74 r.e.schenter an	mod1 01/11/89
62144	62sm144 hedl evalfeb80 f.m.mann	mod2 01/16/89
62148	62sm148 hedl evalfeb80 schenter schmit	mod1 01/16/89
62149	62sm149 hedl bnw evalnov78 schenter leonar	mod1 01/03/89
62150	62sm150 hedl evalapr74 r.e.schenter an	mod1 03/21/89
62151	62sm151 hedl inel +evalfeb80 schenter + rei	mod1 01/16/89
62153	62sm153 hedl inel evaldec79 schenter schmit	mod1 01/16/89
50112	50sn112 hedl evalfeb80 f.m.mann	mod2 01/12/89
50114	50sn114 hedl evalfeb80 f.m.mann	mod2 01/12/89
50115	50sn115 hedl evalapr74 r.e.schenter an	mod1 01/12/89
50116	50sn116 hedl evalapr74 r.e.schenter an	mod1 01/12/89
50117	50sn117 hedl evalapr74 r.e.schenter an	mod1 01/12/89
50118	50sn118 hedl evalapr74 r.e.schenter an	mod1 01/12/89
50119	50sn119 hedl evalapr74 r.e.schenter an	mod1 01/12/89

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  50120          50sn120 hedl evalapr74 r.e.schenter an         mod1 01/12/89
  50122          50sn122 hedl evalapr74 r.e.schenter an         mod1 01/12/89
  50123          50sn123 hedl inel evaldec79 schenter schmit    mod1 01/12/89
  50124          50sn124 hedl evalapr74 r.e.schenter an         mod1 01/12/89
  50125          50sn125 hedl inel evaldec79 schenter schmit    mod1 01/13/89
  50126          50sn126 hedl inel evaldec79 schenter schmit    mod1 01/12/89
  38084          38sr 84 hedl evalfeb80 f.m.mann                mod2 01/11/89
  38086          38sr 86 hedl evalapr74 r.e.schenter an         mod1 01/11/89
  38087          38sr 87 hedl evalapr74 r.e.schenter an         mod1 01/11/89
  38088          38sr 88 hedl evalapr74 r.e.schenter an         mod1 01/11/89
  38089          38sr 89 hedl inel evaldec79 schenter schmit    mod1 01/11/89
  38090          38sr 90 hedl inel evaldec79 schenter schmit    mod1 01/11/89
   1003          1t 30lasl evalfeb65 leona stewart              mod2 12/16/88
  73182          73ta182 ai evalapr71 j.otter c.dunfo           mod1 12/22/88
  65159          65tb159 hedl rcn evalfeb80 r.e.schenter an     mod1 01/16/89
  65160          65tb160 hedl inel evaldec79 schenter schmit    mod1 01/16/89
  52120          52te120 hedl evalfeb80 f.m.mann                mod2 01/13/89
  52123          52te123 hedl evalapr74 r.e.schenter an         mod1 03/21/89
  52124          52te124 hedl evalapr74 r.e.schenter an         mod1 01/13/89
  52125          52te125 hedl evalapr74 r.e.schenter an         mod1 01/13/89
  52126          52te126 hedl evalapr74 r.e.schenter an         mod1 01/13/89
  52601          52te127mhedl inel evaldec79 schenter schmit    mod1 01/13/89
  52128          52te128 hedl evalapr74 r.e.schenter an         mod1 01/13/89
  52611          52te129mhedl inel evaldec79 schenter schmit    mod1 01/13/89
  52130          52te130 hedl evalapr74 r.e.schenter an         mod1 01/13/89
  52132          52te132 hedl inel evaldec79 schenter schmit    mod1 01/13/89
  22000          22ti buranllll evalaug77 c.philis a.smit       mod1 12/20/88
  92235          92u 235 bnl evalapr77 m.r.bhat                 mod3 02/28/89
  92237          92u237 bnl srl lllevaljul76 kinseyassemble     mod1 01/10/89
  23000          23v anllllhedl evaljan77 a.smith+ h.howe       mod1 12/20/88
  74000          74w lanl evalmar82 e.d.arthur                  mod1 01/04/89
  74182          74w182 las anl brcevaldec80 arthur young sm    mod2 01/04/89
  74186          74w186 las anl brcevaldec80 arthur young sm    mod2 01/05/89
  54124          54xe124 bnl evalmar78 m.r.bhat and s.          mod1 12/29/88
  54126          54xe126 bnl evalmar78 m.r.bhat and s.          mod1 12/29/88
  54128          54xe128 bnl evalmar78 m.r.bhat and s.          mod1 12/30/88
  54129          54xe129 bnl evalmar78 m.r.bhat and s.          mod1 01/03/89
  54130          54xe130 bnl evalmar78 m.r.bhat and s.          mod1 12/30/88
  54131          54xe131 bnl evalmar78 m.r.bhat and s.          mod1 01/03/89
  54132          54xe132 bnl evalmar78 m.r.bhat and s.          mod2 01/03/89
  54133          54xe133 hedl inel evaldec79 schenter schmit    mod1 01/13/89
  54134          54xe134 bnl evalmar78 m.r.bhat and s.          mod1 01/03/89
  54135          54xe135 bnw evaljun67 b.r.leonard jr.          mod1 12/28/88
  54136          54xe136 bnl evalmar78 m.r.bhat and s.          mod1 01/03/89
  39089          39y 89 hedl evalapr74 r.e.schenter an          mod1 01/11/89
  39090          39y 90 hedl inel evaldec79 schenter schmit     mod1 01/11/89
  39091          39y 91 hedl inel evaldec79 schenter schmit     mod1 01/11/89
  40093          40zr 93 hedl inel evaldec79 schenter schmit    mod1 01/11/89
  40095          40zr 95 hedl inel evaldec79 schenter schmit    mod1 01/11/89
 801601          8o 16 lasl evalaug73 p.young d.fost            mod2 12/16/88
 701401          7n 14 from version 6 evaluation
  98250          98cf250 bnl srl lllevaljul76 kinseyassemble    mod1 11/14/97
  91233          91PA233 HEDL INEL EVALMAY78 MANN SCHENTER R    MOD2 01/18/91
  97249          97bk249 bnl srl lllevaljul76 kinseyassemble    mod1 01/11/89
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APPENDIX F

CALCULATIONAL RESULTS

APPENDIX F

CALCULATIONAL RESULTS

Hansen-Roach_High-Enriched_Uranium

Case	Title	k-eff	sigma	EALF
cas04	keno-5 validation case a-2	1.0033	0.0023	7.77607E+05
cas05	keno-5 validation case a-3	1.0087	0.0019	1.33937E-02
cas07	keno-5 validation case a-5	1.0098	0.0027	1.24027E+03
cas08	keno-5 validation case a-6	1.0160	0.0025	1.66572E+05
cas09	keno-5 validation case a-7	0.9986	0.0024	7.73553E+05
cas10	keno-5 validation case a-8	1.0142	0.0025	3.80165E+03
cas11	keno-5 validation case a-9	1.0023	0.0024	1.04495E+04
cas12	keno-5 validation case b-1	0.9961	0.0030	8.14558E+05
cas14	keno-5 validation case b-11	1.0330	0.0027	2.24871E-01
cas15	keno-5 validation case b-12	1.0203	0.0025	3.35858E+04
cas19	keno-5 validation case b-16	1.0111	0.0040	3.11702E-01
cas22	keno-5 validation case b-2	0.9973	0.0023	8.21774E+05
cas23	keno-5 validation case b-3	0.9877	0.0023	8.17676E+05
cas24	keno-5 validation case b-4	0.9836	0.0022	8.23963E+05
cas25	keno-5 validation case b-5	0.9965	0.0023	8.20854E+05
cas26	keno-5 validation case b-6	0.9963	0.0024	6.16140E+03
cas27	keno-5 validation case b-7	1.0019	0.0028	4.98093E+03
cas28	keno-5 validation case b-8	1.0050	0.0027	5.69274E+04
cas30	93.2% uo2f2 3 in al slab 3x1x1 array 0 in sep room	0.9827	0.0030	2.32358E-02
cas31	93.2% uo2f2 3 in al slab 3x1x1 array 0 in sep h2o refl	0.9794	0.0030	2.10961E-02
cas32	93.2% uo2f2 3 in al slab 3x1x1 array 1 in sep room	0.9726	0.0024	2.34384E-02
cas33	93.2% uo2f2 3 in al slab 3x1x1 array 1 in sep h2o refl	0.9898	0.0030	1.91490E-02
cas34	93.2% uo2f2 3 in al slab 3x1x1 array 3 in sep room	0.9652	0.0029	2.37152E-02
cas35	93.2% uo2f2 3 in al slab 3x1x1 array 3 in sep h2o refl	0.9953	0.0025	1.85122E-02
cas36	93.2% uo2f2 3 in al slab 3x1x1 array 4.5 in sep room	0.9708	0.0027	2.36975E-02
cas37	93.2% uo2f2 3 in al slab 3x1x1 array 4.5 in sep h2o refl	1.0015	0.0030	1.87347E-02
cas38	93.2% uo2f2 3 in al slab 3x1x1 array 5.5 in sep room	0.9712	0.0027	2.37213E-02
cas39	93.2% uo2f2 3 in al slab 3x1x1 array 5.5 in sep h2o refl	0.9957	0.0026	1.88407E-02
cas40	93.2% uo2f2 3 in al slab 3x1x1 array 6 in sep room	0.9722	0.0027	2.36949E-02
cas41	93.2% uo2f2 3, 6 in al slabs 2x1x1 array 15 in sep	0.9623	0.0029	2.34795E-02
cas42	93.2% uo2f2 3, 6 in al slabs 2x1x1 array 2 in sep	0.9698	0.0032	2.34051E-02
cas43	93.2% uo2f2 3, 6 in al slabs 2x1x1 array 30 in sep	0.9626	0.0027	2.34482E-02
cas44	93.2% uo2f2 3, 6 in al slabs 2x1x1 array 48 in sep	0.9571	0.0029	2.33963E-02
cas45	93.2% uo2f2 3, 6, 3 in al slabs 3x1x1 array 0 in sep	0.9658	0.0029	2.32727E-02
cas46	93.2% uo2f2 3, 6, 3 in al slabs 3x1x1 array 10 in sep	0.9650	0.0027	2.35586E-02
cas47	93.2% uo2f2 3, 6, 3 in al slabs 3x1x1 array 20 in sep	0.9637	0.0031	2.35362E-02
cas48	93.2% uo2f2 3, 6, 3 in al slabs 3x1x1 array 32 in sep	0.9643	0.0029	2.35072E-02
cas49	93.2% uo2f2 6 & 3 in al slabs 2x1x1 array 12 in sep	0.9691	0.0030	2.34210E-02
cas50	93.2% uo2f2 6 & 3 in al slabs 2x1x1 array 18 in sep	0.9660	0.0034	2.35640E-02
cas51	93.2% uo2f2 6 & 3 in al slabs 2x1x1 array 30 in sep	0.9607	0.0030	2.34900E-02
cas52	93.2% uo2f2 6 & 3 in al slabs 2x1x1 array 6 in sep	0.9671	0.0027	2.35545E-02
cas53	93.2% uo2f2 6 in al slab 2x1x1 array 15 in sep	0.9694	0.0028	2.34739E-02
cas54	93.2% uo2f2 6 in al slab 2x1x1 array 2 in sep	0.9638	0.0030	2.34929E-02
cas55	93.2% uo2f2 6 in al slab 2x1x1 array 20 in sep	0.9681	0.0034	2.34771E-02
cas56	93.2% uo2f2 6 in al slab 2x1x1 array 30 in sep	0.9661	0.0026	2.34327E-02
cas57	93.2% uo2f2 6 in al slab 2x1x1 array 48 in sep	0.9731	0.0030	2.33448E-02
cas58	93.2% uo2f2 6 in al slab 2x1x1 array 6 in sep	0.9664	0.0029	2.34476E-02
cas59	93.2% uo2f2 6 in al slab 2x1x1 array 66 in sep	0.9644	0.0032	2.34246E-02
cas60	uo2(no3)2 279 g U/L 3x3x3 array unrefl. walls, tank, & floor	0.9770	0.0029	8.69611E-02
cas61	uo2(no3)2 279 g U/L 2x2x2 array unrefl. walls, tank, & floor	0.9779	0.0031	8.47812E-02
cas62	uo2(no3)2 415 g U/L 5x5x5 array unrefl. walls, tank, & floor	0.9852	0.0032	1.89848E-01
cas63	uo2(no3)2 415 g U/L 3x3x3 array unrefl. walls, tank, & floor	0.9758	0.0032	1.94881E-01
cas64	uo2(no3)2 415 g U/L 4x4x4 array unrefl. walls, floor, & tank	0.9787	0.0032	1.92820E-01
cas65	uo2(no3)2 415 g U/L 2x2x2 array unrefl. walls, floor, & tank	0.9855	0.0030	1.86427E-01
cas66	uo2(no3)2 415 g U/L 3x3x3 array 15.24 cm par. bot., 1.27 cm p	0.9823	0.0032	1.62225E-01
cas67	uo2(no3)2 415 g U/L 3x3x3 array 15.24 cm par. bot., 2.54 cm p	0.9955	0.0029	1.42671E-01
cas68	uo2(no3)2 415 g U/L 3x3x3 array 15.24 cm par. bot., 1.27 cm p	0.9882	0.0032	1.56155E-01
cas69	uo2(no3)2 415 g U/L 3x3x3 array 15.24 cm par 5 fc, plex 1 fc	1.0040	0.0029	1.08541E-01
cas70	uo2(no3)2 415 g U/L 3x3x3 array 15.24 cm par. bot., 3.81 cm p	0.9985	0.0030	1.21692E-01
cas71	uo2(no3)2 415 g U/L 3x3x3 array 15.24 cm par. bot., 7.62 cm p	1.0158	0.0035	1.11321E-01
cas72	uo2(no3)2 415 g U/L 3x3x3 array 1.27 cm plexiglass refl.	0.9836	0.0027	1.72521E-01
cas73	uo2(no3)2 415 g U/L 3x3x3 array 1.27 cm paraffin refl.	0.9847	0.0032	1.65077E-01
cas74	uo2(no3)2 415 g U/L 3x3x3 array 15.24 cm paraffin refl.	1.0056	0.0031	1.09818E-01
cas75	uo2(no3)2 415 g U/L 3x3x3 array 3.81 cm paraffin refl.	1.0054	0.0034	1.24189E-01
cas76	uo2(no3)2 415 g U/L 2x2x2 array 15.24 cm par. bot., 1.27 cm p	0.9846	0.0031	1.57781E-01
cas77	uo2(no3)2 415 g U/L 2x2x2 array 15.24 cm par. bot., 11.43 cm	1.0068	0.0031	1.08926E-01
cas78	uo2(no3)2 415 g U/L 2x2x2 array 15.24 cm par. bot., 15.24 cm	1.0064	0.0032	1.07953E-01
cas79	uo2(no3)2 415 g U/L 2x2x2 array 15.24 cm par. bot., 2.54 cm p	0.9900	0.0033	1.42225E-01
cas80	uo2(no3)2 415 g U/L 2x2x2 array 15.24 cm par. bot., 4.45 cm p	1.0040	0.0029	1.23314E-01
cas81	uo2(no3)2 415 g U/L 2x2x2 array 15.24 cm par. bot., 6.35 cm p	1.0040	0.0032	1.14418E-01
cas82	uo2(no3)2 415 g U/L 2x2x2 array 15.24 cm par. bot., 1.27 cm p	0.9908	0.0029	1.52040E-01
cas83	uo2(no3)2 415 g U/L 2x2x2 array 15.24 cm par. bot., 3.81 cm p	1.0000	0.0032	1.20155E-01
cas84	uo2(no3)2 415 g U/L 2x2x2 array 15.24 cm par. bot., 7.62 cm p	0.9982	0.0030	1.09533E-01
cas85	uo2(no3)2 415 g U/L 2x2x2 array 1.27 cm plexiglass refl.	0.9863	0.0029	1.69409E-01
cas86	uo2(no3)2 415 g U/L 2x2x2 array 1.27 cm paraffin refl.	0.9857	0.0029	1.61786E-01
cas87	uo2(no3)2 415 g U/L 2x2x2 array 15.24 cm paraffin refl.	1.0037	0.0033	1.07370E-01
cas88	uo2(no3)2 415 g U/L 2x2x2 array 3.81 cm paraffin refl.	1.0038	0.0027	1.22459E-01

cas89	uo2(no3)2 415 g U/L 2x2x2 array 7.62 cm paraffin refl.	1.0065	0.0032	1.09826E-01
cas90	uo2(no3)2 415 g U/L 3x3x3 array unrefl. 279 g U/L 5 cent. uni	0.9784	0.0032	1.53642E-01
cas91	uo2(no3)2 63.3 g U/L 3x3x3 array unrefl. walls, floor, & tank	0.9952	0.0030	1.90523E-02
jemima	disks - 15" diam plates 93.15 w% enriched stacked to 3.0258"	0.9962	0.0024	8.21013E+05
jemima	jemima - ~1/8" x 15" diam u(93.29) plates with 1/16" thk poly	1.0133	0.0025	1.15950E+05
jemima	jemima - ~1/8" thk 15" diam u(93.24) plates with 1/8" thk pol	1.0147	0.0027	2.03747E+04
jemima	jemima - ~1/8" thk 15" diam u(93.24) plates with 1/4" thk pol	0.9936	0.0026	2.35579E+03
jemima	jemima - ~1/8" thk 15" diam u(93.24) plates with 1/2" thk pol	0.9987	0.0026	1.09210E+02
jemima	jemima - ~1/8" thk 15" diam u(93.24) plates with 1" thk poly,	0.9923	0.0026	6.83616E+00
jemima	jemima - ~1/8" x 15" dia u(93) with symetric 1-1/2" thk poly,	1.0224	0.0026	2.39521E+00
jemima	jemima - ~1/8" x 15" dia u(93) with symetric 2" thk poly, pg-	1.0088	0.0024	1.35447E+00
heumf001	godiva	0.9968	0.0022	8.11167E+05
heumf004	water-reflected heu sphere on hollow plexiglas cylinder	1.0040	0.0019	2.49125E+04
heust001	case 1 heust001	0.9820	0.0026	3.91734E-02
heust001	case 2 heust001	0.9753	0.0027	1.60525E-01
heust001	case 3 heust001	0.9849	0.0029	3.84310E-02
heust001	case 4 heust001	0.9816	0.0027	1.74350E-01
heust001	case 5 heust001	0.9898	0.0023	1.86292E-02
heust001	case 6 heust001	0.9935	0.0022	1.93724E-02
heust001	case 7 heust001	0.9810	0.0025	3.68972E-02
heust001	case 8 heust001	0.9816	0.0021	3.92983E-02
heust001	case 9 heust001	0.9736	0.0026	1.73976E-01
heust001	case 10 heust001	0.9858	0.0022	2.01686E-02
heust007	case 1 , heust007	0.9992	0.0022	2.08291E-02
heust007	case 2 , heust007	0.9928	0.0021	1.52516E-01
heust007	case 3 , heust007	1.0012	0.0017	2.02094E-02
heust007	case 4 , heust007	0.9962	0.0021	1.31990E-01
heust007	case 5 , heust007	0.9935	0.0019	2.23399E-02
heust007	case 6 , heust007	0.9821	0.0022	1.57065E-01
heust007	case 7 , heust007	0.9948	0.0022	2.19533E-02
heust007	case 8 , heust007	0.9848	0.0027	1.53818E-01
heust007	case 9 , heust007	0.9927	0.0019	2.28056E-02
heust007	case 10 , heust007	0.9977	0.0017	2.36936E-02
heust007	case 11 , heust007	0.9916	0.0019	1.44416E-01
heust007	case 12 , heust007	1.0024	0.0020	2.26783E-02
heust007	case 13 , heust007	1.0000	0.0021	1.27157E-01
heust007	case 14 , heust007	0.9902	0.0022	1.33280E-01
heust007	case 15 , heust007	0.9913	0.0021	1.33863E-01
heust007	case 16 , heust007	0.9890	0.0022	1.44398E-01
heust007	case 17 , heust007	0.9900	0.0020	1.33672E-01
heust013	uranium aqueous 23 cm sphere #1	1.0063	0.0017	1.34537E-02
heust013	uranium aqueous 32 cm sphere #2	1.0038	0.0015	1.41402E-02
heust013	uranium aqueous 32 cm sphere #3	0.9979	0.0017	1.48319E-02
heust013	uranium aqueous 32 cm sphere #4	0.9961	0.0015	1.51659E-02

Hansen-Roach_Low-Enriched_Uranium

Case	Title	k-eff	sigma	EALF
car04	rocky flats criticals nureg/cr-1071 experiment number 13 (27	1.0176	0.0022	2.54486E-01
car10	rocky flats criticals nureg/cr-0674 concrete reflected (27 gr	1.0017	0.0029	4.41936E+00
cas04	british handbook of criticality safety u(1.42)f4 & paraffin (	0.9943	0.0016	5.98346E-02
cas05	british handbook of criticality safety u(1.42)f4 & paraffin (	0.9934	0.0018	6.02642E-02
cas06	british handbook of criticality safety u(1.42)f4 & paraffin (	0.9970	0.0016	6.01956E-02
cas11	raffety and malhalczo u(2)f4-1 reflected (case 11)	1.0071	0.0022	1.02945E-01
cas12	raffety and malhalczo u(2)f4-1 unreflected (case12)	1.0001	0.0019	1.31206E-01
cas13	raffety and malhalczo u(2)f4-2 reflected (case 13) no biasing	1.0064	0.0021	5.75211E-02
cas14	raffety and malhalczo u(2)f4-2 unreflected (case 14)	0.9993	0.0019	6.83002E-02
cas15	raffety and malhalczo u(2)f4-3 reflected (case 15)	0.9959	0.0020	4.01377E-02
cas16	raffety and malhalczo u(2)f4-4 reflected (case 16)	0.9941	0.0019	3.34136E-02
cas17	raffety and malhalczo u(2)f4-5 reflected (case 17)	0.9945	0.0019	2.81481E-02
cas18	raffety and malhalczo u(2)f4-5 unreflected (case18)	0.9867	0.0019	3.04016E-02
cas19	raffety and malhalczo u(2)f4-6 reflected (case 19)	0.9922	0.0016	2.13396E-02
cas20	raffety and malhalczo u(2)f4-6 unreflected (case20)	0.9868	0.0018	2.19281E-02
cas21	raffety and milhalczo u(3)f4-1 reflected (case 21) no bias	1.0089	0.0022	1.21645E-01
cas22	raffety and malhalczo u(3)f4-1 reflected (case 22)	1.0142	0.0024	1.22539E-01
cas23	raffety and malhalczo u(3)f4-1 reflected (case 23)	1.0115	0.0025	1.23546E-01
cas24	raffety and malhalczo u(3)f4-1 reflected (case 24) no biasing	1.0105	0.0022	1.22432E-01
cas25	raffety and malhalczo u(3)f4-1 reflected (case 25)	1.0092	0.0024	1.21949E-01
cas26	raffety and malhalczo u(3)f4-1 unreflected (case 26)	1.0123	0.0026	1.82095E-01
cas27	raffety and malhalczo u(3)f4-1 unreflected (case 27)	0.9985	0.0027	1.84934E-01
cas28	raffety and malhalczo u(3)f4-1 unreflected (case 28)	1.0056	0.0022	1.84011E-01
cas29	raffety and malhalczo u(3)f4-2 reflected (cas29)	0.9994	0.0025	4.46403E-02
cas30	raffety and malhalczo u(3)f4-2 unreflected (case 30)	1.0003	0.0024	5.47192E-02
cas31	raffety and malhalczo u(3)f4-2 unreflected (case 31)	1.0035	0.0024	5.46609E-02
cas32	raffety and malhalczo u(3)f4-2 unreflected (case 32)	1.0001	0.0023	5.47027E-02
cas33	critical reflected cylinder of aqueous u(4.98)o2f2 (case 33)	0.9910	0.0022	2.52174E-02
cas34	critical reflected cylinder of aqueous u(4.98)o2f2 (case 34)	0.9901	0.0023	2.50841E-02
cas35	critical sphere of aqueous u(4.98)o2f2 (case 35)	0.9919	0.0027	2.49452E-02
cas36	critical cylinder of aqueous u(4.98)o2f2 (case 36)	0.9881	0.0025	2.51360E-02

Hansen-Roach_LWR_Lattices

Case	Title	k-eff	sigma	EALF
cas01	exp#5, 8.39 cm h2o separating 3 20x16 arrays	1.0016	0.0015	4.01212E-02
cas02	exp#017, 5.05 cm h2o/boral separating 2 22x16 arrays and 1 20	0.9999	0.0012	4.16543E-02
cas03	exp#28, 6.88 cm h2o/ss separating 3 20x16 arrays	1.0022	0.0016	4.06589E-02
cas04	exp no. 14 8.58 cm h2o/ss separating 3 15x8 arrays	0.9993	0.0014	4.59885E-02
cas05	exp no. 23 7.28 cm h2o/cadmium separating 3 15x8 arrays	1.0015	0.0016	4.58746E-02
cas06	exp no. 31 6.72 cm h2o/boral separating 3 15x8 arrays	1.0054	0.0018	4.60670E-02
cas07	u refl. 1.956 cm from array, 14.11 cm h2o separating 3 19x1	0.9993	0.0015	7.58374E-02
cas08	pb refl. .660 cm from array, 13.72 cm h2o separating 3 19x16	1.0084	0.0015	4.11320E-02
cas09	no refl. 8.31cm h2o separating 19x16 arrays	1.0003	0.0017	4.00471E-02
cas10	uranium refl. 15.32cm h2o separating 12x8 arrays	1.0010	0.0017	1.15835E-01
cas11	lead refl. 20.78cm h2o separating 13x8 arrays	1.0151	0.0008	4.73598E-02
cas12	2.83cm and 3.60cm separating 4 11x14 arrays	0.9969	0.0017	1.55706E-01
cas13	2.83cm and 4.94cm separating 2 11x14 + 2 11x16 arrays	0.9955	0.0012	1.57698E-01
cas14	ss refl. 0.66 cm from array, 11.20 cm h2o separating 3 19x16	1.0040	0.0015	4.19563E-02
cas15	steel refl. 15.84cm h2o separating 3 12x16 arrays	0.9938	0.0020	1.37992E-01
cas16	steel refl. 9.83cm h2o separating 3 12x16 arrays w/borated	0.9947	0.0017	1.47802E-01
cas17	steel refl. 8.30cm h2o separating 3 12x16 arrays w/boral pl	0.9995	0.0018	1.47371E-01
cas18	steel refl. 8.94cm h2o separating 3 12x16 arrays w/cd plate	0.9966	0.0011	1.48039E-01
cas19	u refl 1.321 cm from array, 9.50 cm h2o sep. 23x18/2-20x18 ar	0.9934	0.0014	1.62719E-01
cas20	pb refl 0.660 cm from array, 10.11 cm h2o sep. 23x18/2-20x18	1.0005	0.0016	7.83753E-02
cas21	no refl infinite from array, 6.59 cm h2o sep. 23x18/2-20x18 a	0.9958	0.0016	7.26904E-02
cas22	uranium refl. 19.24cm h2o separating 12x16 arrays	0.9948	0.0017	2.48751E-01
cas23	lead refl. 18.18cm h2o separating 12x16 arrays	0.9979	0.0015	1.42233E-01
cas24	no refl. 12.91cm h2o separating 3 12x16 arrays	0.9951	0.0018	1.29982E-01
cas25	pnl-4267 exp. 173 40 x 8.92 array (357 total rods) boron = 0	0.9938	0.0011	1.33170E-01
cas26	pnl-4267 exp.177 40 x 30.92 array 1237 total rods) boron = 2.	1.0121	0.0014	3.24686E-01
cas27	pnl-4267 exp. 178 44 x 11.57array (509 total rods) boron = 0	0.9921	0.0013	2.75387E-01
cas28	pnl-4267 exp. 181 44 x 27.09 array (1192 total rods) boron =	0.9972	0.0017	6.94395E-01
cas29	pnl-4976 4.3-000-194 4.3%uo2 1.598cm-pitch	1.0033	0.0014	2.33139E+00
cas30	flux trap assembly no. 214r	0.9925	0.0016	1.86083E-01
cas31	flux trap assembly no. 214v3	0.9904	0.0013	1.88319E-01
cas32	baw-1231 core i 936 rods boron=1.152 g/l	0.9937	0.0011	4.13858E-01
cas33	baw-1231 core i 4904 rods boron=3.389 g/l	1.0039	0.0009	7.19295E-01
cas34	baw-1273 core xx 2.46 wt%u235 5137 rods	1.0067	0.0013	2.81765E-01
cas35	baw-1484-7 core iv exp 2282 2.46 wt%u235 9 assys 14x14 w/ 8	0.9954	0.0012	8.97058E-02
cas36	baw-1484-7 core ix exp 2321 2.46 wt%u235 9 assys 14x14	1.0012	0.0014	6.01269E-02
cas37	baw-1484-7 core xiii exp 2378 2.46 wt%u235 9 assys 14x14	0.9935	0.0016	9.30151E-02
cas38	baw-1484-7 core xxi exp 2420 2.46 wt%u235 9 assys 14x14	1.0014	0.0014	6.85769E-02
cas39	baw-1645-4 exp,mt=2452 triangular pitch=o.d. boron=435ppm	1.0078	0.0009	1.42185E+00
cas40	baw-1645-4 exp,mt=2485 pitch=o.d. boron=886ppm	1.0067	0.0015	8.44659E-01
cas41	baw-1645-4 exp,mt=2500 pitch=1.17*o.d. boron=1156ppm	1.0119	0.0015	2.11017E-01
cas42	baw-1810 core 12 - 4.02 & 2.46 w/o uo2 1899.3 ppm; no uo2-gd2	1.0105	0.0012	1.78132E-01
cas43	baw-1810 core 14 - 4.02 & 2.46 w/o uo2 1654 ppm; 28 uo2-gd2o3	1.0110	0.0013	1.69295E-01
cas44	baw-1810 core 16 - 4.02 & 2.46 w/o uo2 1579 ppm; 36 uo2-gd2o3	1.0089	0.0012	1.62736E-01
cas45	epri np-196 .615 inch pitch unborated uo2	0.9944	0.0015	1.26813E-01
cas46	epri np-196 .615 inch pitch borated uo2	0.9980	0.0014	1.61003E-01
cas47	epri np-196 .75 inch pitch unborated uo2	0.9956	0.0014	4.96818E-02
cas48	epri np-196 .75 inch pitch borated uo2	1.0086	0.0009	6.33596E-02
cas49	epri np-196 .87 inch pitch unborated uo2	1.0086	0.0014	3.38758E-02
cas50	epri np-196 .87 inch pitch borated uo2	1.0155	0.0015	3.84836E-02
cas51	saxton uo2 5.742 wt% u-235 critical exp. 0.56 inch pitch (wca	0.9856	0.0017	1.45548E-01
cas52	saxton uo2 5.742 wt% u-235 critical exp. 0.792inch pitch (wca	1.0000	0.0013	4.16089E-02
cas53	wcap-3269-39, 2692 fuel rods, 16 ag-in-cd rods,h2o ht=115.55	0.9999	0.0010	3.92248E-01
cas54	wcap-3269-39, 2209 fuel rods, 24 ag-in-cd rods,h2o ht=64.56 c	0.9992	0.0014	2.32561E-01
cas55	wcap-3269-39, 945 fuel rods, 16 ag-in-cd rods,h2o ht=89.75	0.9918	0.0010	1.25826E-01
cas56	4-18x18 array 5.0cm int.,polyethylene powder in box,30.16cm h	0.9892	0.0014	1.08875E-01
cas57	4-18x18 array 5.0cm int.,polyethylene balls in box,30.73cm h2	1.0036	0.0013	9.73983E-02
cas58	4-18x18 array 5.0cm int.,water in box,32.78cm h2o height	1.0108	0.0013	9.06123E-02
cas59	4-18x18 array 5.0cm int.,water without box,31.47cm h2o height	0.9955	0.0012	9.17513E-02

Hansen-Roach_Mixed_Oxide

Case	Title	k-eff	sigma	EALF
cas60	epri .70inch pitch unborated plutonium	0.9963	0.0016	2.88863E-01
cas61	epri .70inch pitch borated plutonium	0.9978	0.0017	4.11172E-01
cas62	epri .87inch pitch unborated plutonium	1.0027	0.0012	8.54599E-02
cas63	epri .87inch pitch borated plutonium	1.0178	0.0013	1.32185E-01
cas64	epri .99inch pitch unborated plutonium	1.0079	0.0015	5.77115E-02
cas65	epri .99inch pitch borated plutonium	1.0237	0.0010	7.98822E-02
cas66	saxton puo2-uo2 critical exp. 0.52 inch pitch (wcap-3385-54)	0.9920	0.0013	4.66612E-01
cas67	saxton puo2-uo2 critical exp. 0.56 inch pitch (wcap-3385-54)	0.9882	0.0019	2.77775E-01
cas68	saxton puo2-uo2 critical exp. 0.56 inch pitch with boron (wca	0.9920	0.0017	3.37919E-01
cas69	saxton puo2-uo2 critical exp. 0.735 inch pitch (wcap-3385-54)	1.0008	0.0018	8.16982E-02
cas70	saxton puo2-uo2 critical exp. 0.792 inch pitch (wcap-3385-54)	1.0050	0.0018	6.52434E-02
cas71	saxton puo2-uo2 critical exp. 01.04 inch pitch (wcap-3385-54)	1.0148	0.0022	3.77593E-02
cas72	pnl4976 exp196 1174 uo2 & 583 mo2 rods to approx. 20,000 mwd/	0.9929	0.0015	2.80791E+00
cas73	exp.no 021(063) pitch=968 (fuel region = pin array + mix 500	0.9886	0.0012	4.79901E-01
cas74	exp.no 032(060) pitch=1.935(fuel region=pin array+mix 500 wit	1.0092	0.0017	4.26464E-02
cas75	exp.no 043(062) pitch=1.242(fuel region=pin array+mix 500 wit	0.9907	0.0013	1.35829E-01
cas76	exp.no 067 pitch=0.761 (fuel region = pin array + mix 500 wit	0.9860	0.0012	1.74172E+00
cas77	exp. no 68r pitch=1.537 (fuel region = pin array + mix 500 wi	0.9999	0.0017	6.98325E-02

Hansen-Roach_Plutonium

Case	Title	k-eff	sigma	EALF
1727_09	la-3067-msr table iiia1, entry 13, water ref., metal, pu sphe	0.9989	0.0038	7.58773E+04
2109_20	benchmark 20, pu sphere with 25.4 cm concrete ref. h/pu=684.3	1.0103	0.0037	3.27775E-02
2109_21	benchmark 21, pu sphere with 10.16 cm concrete ref. h/pu=684.	1.0122	0.0040	3.15817E-02
2109_22	benchmark 22, pu sphere with 10.16 cm concrete ref. h/pu=496	1.0217	0.0034	3.96408E-02
2109_23	benchmark 23, pu sphere with cd shell & 10.16 cm concrete ref	1.0207	0.0037	4.42417E-02
2109_24	benchmark 24, pu sphere with cd shell & 32.00 cm water, h/pu=	1.0029	0.0038	3.82479E-02
2109_25	pu benchmark 25 from 2109, pu metal sphere reflected with nat	1.0105	0.0045	1.10321E+06
2110_02	benchmark#2 critical pu(no3)4solution, unreflected in a ss(ty	1.0057	0.0041	1.76977E-01
2110_04	sphere described by keno geometry	1.0080	0.0053	2.97914E-02
2110_05	rectangular parallelpipeds of homogeneous pu(2.2)o2	1.0314	0.0052	2.66686E+01
2110_06	rectangular parallelipiped of pu(2.2)o2 reflected with 15cm p	1.0395	0.0059	3.28196E+00
2110_07	benchmark#7 semi-inf homogeneous critical solution of pu-239	1.0061	0.0038	4.57238E-02
2110_08	rectangular parallelipiped of puo2	1.0134	0.0039	9.58870E-01
2110_09	rectangular parallelipipeds of pu02	1.0175	0.0044	3.87028E-01
2110_10	rectangular parallelipipeds of pu02	1.0197	0.0046	3.71340E-01
2110_11	rectangular parallelipipeds of pu02	1.0209	0.0044	3.73535E-01
2110_12	rectangular parallelipipeds of pu02	1.0202	0.0043	3.70099E-01
2110_13	sphere described by keno geometry	0.9955	0.0044	1.21372E+06
2110_14	cylinder described by keno geometry	1.0006	0.0048	7.59820E-02
2110_15	rectangular parallelipipeds of puo2-h20	1.0256	0.0052	2.34687E+05
2110_16	rectangular parallelipipeds of puo2-h20	1.0452	0.0034	9.22063E+05
2110_17	rectangular parallelipipeds of puo2-h20	1.0326	0.0036	1.42087E+03
2110_18	rectangular parallelipipeds of puo2-h20	1.0433	0.0038	3.24817E+03
2110_19	rectangular parallelipipeds of puo2-h20	1.0086	0.0032	3.99149E+03
2110_20	rectangular parallelipipeds of puo2-h20	1.0339	0.0038	1.95737E+03
2110_21	rectangular parallelipipeds of puo2-h20	1.0510	0.0037	1.53926E+03
2110_23	rectangular parallelipipeds of puo2-polystyrene	1.0274	0.0057	1.59507E+03
2110_24	rectangular parallelipipeds of puo2-polystyrene	1.0367	0.0033	7.07344E+01
2110_25	rectangular parallelipipeds of puo2-polystyrene	1.0333	0.0036	6.23229E+01
2110_26	rectangular parallelipipeds of puo2-polystyrene	1.0278	0.0034	4.93146E+01
2110_27	rectangular parallelipipeds of puo2-polystyrene	1.0392	0.0032	4.15995E+01
2110_29	cylinder described by keno geometry	1.0257	0.0037	2.59491E-02
2110_30	sphere described by keno geometry	1.0112	0.0050	2.32226E-02
2110_32	sphere described by keno geometry	0.9986	0.0050	2.42950E-02
pumf001	read parameters	0.9962	0.0022	1.20071E+06
pumf002	pu-met-fast-002	1.0063	0.0023	1.20410E+06
pust004	case 1,kvpusolnsphexp,27gp,26.27gpU/L, 0.54w/o240,h2orefl,14i	1.0020	0.0020	2.43301E-02
pust009	case 3a,kvpusolnsphexp,27,9.457gpU/L, 2.5w/o240,bare,48in dia	1.0365	0.0011	1.71242E-02

Hansen-Roach_U-233

Case	Title	k-eff	sigma	EALF
u233mf001	unreflected u233 sphere	1.0051	0.0021	9.96734E+05
u233mf002	case 1, 10 kg u233/heu sphere, ref u233-met-fast-002	1.0030	0.0021	9.42421E+05
u233mf002	case 2, 7.6 kg u233/heu sphere, ref u233-met-fast-002	1.0006	0.0020	9.73504E+05
u233mf003	case 1, 10 kg u233 sphere natural uranium reflector, ref u233	1.0000	0.0024	9.71277E+05
u233mf003	case 2, 7.6 kg u233 sphere natural uranium reflector, ref u23	1.0001	0.0020	9.70456E+05
u233mf004	case 1, 10 kg u233 sphere reflected by tungsten	0.9913	0.0019	8.87722E+05
u233mf005	case 1, 10 kg u233 sphere be reflector, ref u233-met-fast-xxx	1.0127	0.0023	8.42475E+05
u233mf006	u-233/nu sphere	0.9951	0.0025	9.62912E+05
u233st002	exp 4 simplified model	0.9930	0.0030	8.88939E-02
u233st002	exp 5 simplified model	0.9769	0.0029	6.63200E-02
u233st002	exp 8 simplified model	0.9977	0.0028	5.06006E-02
u233st002	exp 10 simplified model	0.9966	0.0029	3.99158E-02
u233st002	exp 11 simplified model	1.0029	0.0028	3.39182E-02
u233st002	exp 12 simplified model	0.9890	0.0031	2.98367E-02
u233st002	exp 14 simplified model	0.9814	0.0028	2.80096E-02
u233st002	exp 15 simplified model	0.9945	0.0026	2.53109E-02
u233st002	exp 17 simplified model	0.9837	0.0026	2.25552E-02
u233st002	exp 18 simplified model	0.9912	0.0028	2.17131E-02
u233st002	exp 19 simplified model	1.0078	0.0023	1.99151E-02
u233st002	exp 22 simplified model	0.9740	0.0031	1.47011E-01
u233st002	exp 24 simplified model	0.9733	0.0034	2.72694E-01
u233st002	exp 34 simplified model	0.9893	0.0034	6.96272E-02
u233st002	exp 35 simplified model	0.9978	0.0029	4.52550E-02
u233st002	exp 36 simplified model	0.9967	0.0028	2.84089E-02
u233st002	exp 38 simplified model	1.0044	0.0025	2.37650E-02
u233st004	exp 3 simplified model	0.9923	0.0033	8.79058E-02
u233st004	exp 6 simplified model	0.9927	0.0030	6.54092E-02
u233st004	exp 20 simplified model	0.9821	0.0035	1.46772E-01
u233st004	exp 25 simplified model	0.9684	0.0030	2.76581E-01
u233st004	exp 30 simplified model	0.9775	0.0033	2.13731E-01
u233st004	exp 27 simplified model	0.9897	0.0032	2.74376E-01
u233st004	exp 28 simplified model	0.9871	0.0032	2.11394E-01
u233st004	exp 33 simplified model	0.9923	0.0032	6.90990E-02

218-Group_High-Enriched_Uranium

Case	Title	k-eff	sigma	EALF
cas04	keno-5 validation case a-2	1.0056	0.0021	8.57235E+05
cas05	keno-5 validation case a-3	0.9975	0.0019	2.11803E-02
cas07	keno-5 validation case a-5	1.0093	0.0025	1.49343E+03
cas08	keno-5 validation case a-6	0.9748	0.0026	2.46935E+05
cas09	keno-5 validation case a-7	1.0074	0.0019	8.04930E+05
cas10	keno-5 validation case a-8	1.0009	0.0026	4.48635E+03
cas11	keno-5 validation case a-9	0.9954	0.0023	1.34541E+04
cas12	keno-5 validation case b-1	0.9948	0.0025	9.43110E+05
cas14	keno-5 validation case b-11	1.0515	0.0026	3.51906E-01
cas15	keno-5 validation case b-12	0.9993	0.0022	4.27514E+04
cas19	keno-5 validation case b-16	1.0315	0.0041	4.43410E-01
cas22	keno-5 validation case b-2	1.0080	0.0024	9.35405E+05
cas23	keno-5 validation case b-3	0.9977	0.0022	9.39647E+05
cas24	keno-5 validation case b-4	0.9929	0.0021	9.49648E+05
cas25	keno-5 validation case b-5	1.0029	0.0023	9.39287E+05
cas26	keno-5 validation case b-6	0.9959	0.0022	8.36677E+03
cas27	keno-5 validation case b-7	1.0034	0.0023	6.66272E+03
cas28	keno-5 validation case b-8	1.0022	0.0025	6.19139E+04
cas30	93.2% uo2f2 3 in al slab 3x1x1 array 0 in sep room	1.0019	0.0032	3.68823E-02
cas31	93.2% uo2f2 3 in al slab 3x1x1 array 0 in sep h2o refl	0.9965	0.0030	3.39431E-02
cas32	93.2% uo2f2 3 in al slab 3x1x1 array 1 in sep room	0.9829	0.0028	3.71593E-02
cas33	93.2% uo2f2 3 in al slab 3x1x1 array 1 in sep h2o refl	0.9955	0.0030	3.13895E-02
cas34	93.2% uo2f2 3 in al slab 3x1x1 array 3 in sep room	0.9786	0.0034	3.75107E-02
cas35	93.2% uo2f2 3 in al slab 3x1x1 array 3 in sep h2o refl	0.9894	0.0028	3.07313E-02
cas36	93.2% uo2f2 3 in al slab 3x1x1 array 4.5 in sep room	0.9847	0.0029	3.76951E-02
cas37	93.2% uo2f2 3 in al slab 3x1x1 array 4.5 in sep h2o refl	0.9978	0.0028	3.07684E-02
cas38	93.2% uo2f2 3 in al slab 3x1x1 array 5.5 in sep room	0.9904	0.0029	3.75307E-02
cas39	93.2% uo2f2 3 in al slab 3x1x1 array 5.5 in sep h2o refl	0.9983	0.0027	3.10940E-02
cas40	93.2% uo2f2 3 in al slab 3x1x1 array 6 in sep room	0.9875	0.0030	3.77210E-02
cas41	93.2% uo2f2 3, 6 in al slabs 2x1x1 array 15 in sep	0.9862	0.0029	3.72357E-02
cas42	93.2% uo2f2 3, 6 in al slabs 2x1x1 array 2 in sep	0.9761	0.0031	3.70742E-02
cas43	93.2% uo2f2 3, 6 in al slabs 2x1x1 array 30 in sep	0.9808	0.0032	3.72255E-02
cas44	93.2% uo2f2 3, 6 in al slabs 2x1x1 array 48 in sep	0.9769	0.0028	3.70845E-02
cas45	93.2% uo2f2 3, 6, 3 in al slabs 3x1x1 array 0 in sep	0.9782	0.0031	3.70304E-02
cas46	93.2% uo2f2 3, 6, 3 in al slabs 3x1x1 array 10 in sep	0.9799	0.0034	3.75152E-02
cas47	93.2% uo2f2 3, 6, 3 in al slabs 3x1x1 array 20 in sep	0.9839	0.0032	3.73240E-02
cas48	93.2% uo2f2 3, 6, 3 in al slabs 3x1x1 array 32 in sep	0.9809	0.0034	3.73044E-02
cas49	93.2% uo2f2 6 & 3 in al slabs 2x1x1 array 12 in sep	0.9897	0.0029	3.73073E-02
cas50	93.2% uo2f2 6 & 3 in al slabs 2x1x1 array 18 in sep	0.9850	0.0029	3.74113E-02
cas51	93.2% uo2f2 6 & 3 in al slabs 2x1x1 array 30 in sep	0.9826	0.0030	3.73340E-02
cas52	93.2% uo2f2 6 & 3 in al slabs 2x1x1 array 6 in sep	0.9874	0.0027	3.73524E-02
cas53	93.2% uo2f2 6 in al slab 2x1x1 array 15 in sep	0.9847	0.0030	3.72580E-02
cas54	93.2% uo2f2 6 in al slab 2x1x1 array 2 in sep	0.9803	0.0036	3.71434E-02
cas55	93.2% uo2f2 6 in al slab 2x1x1 array 20 in sep	0.9870	0.0028	3.71939E-02
cas56	93.2% uo2f2 6 in al slab 2x1x1 array 30 in sep	0.9842	0.0029	3.70609E-02
cas57	93.2% uo2f2 6 in al slab 2x1x1 array 48 in sep	0.9820	0.0031	3.71613E-02
cas58	93.2% uo2f2 6 in al slab 2x1x1 array 6 in sep	0.9820	0.0025	3.74674E-02
cas59	93.2% uo2f2 6 in al slab 2x1x1 array 66 in sep	0.9845	0.0034	3.70261E-02
cas60	uo2(no3)2 279 g U/L 3x3x3 array unrefl. walls, tank, & floor	0.9893	0.0032	1.35560E-01
cas61	uo2(no3)2 279 g U/L 2x2x2 array unrefl. walls, tank, & floor	1.0094	0.0030	1.30203E-01
cas62	uo2(no3)2 415 g U/L 5x5x5 array unrefl. walls, tank, & floor	0.9989	0.0029	2.84541E-01
cas63	uo2(no3)2 415 g U/L 3x3x3 array unrefl. walls, tank, & floor	0.9990	0.0030	2.87533E-01
cas64	uo2(no3)2 415 g U/L 4x4x4 array unrefl. walls, floor, & tank	0.9940	0.0033	2.89598E-01
cas65	uo2(no3)2 415 g U/L 2x2x2 array unrefl. walls, floor, & tank	1.0054	0.0028	2.76754E-01
cas66	uo2(no3)2 415 g U/L 3x3x3 array 15.24 cm par. bot., 1.27 cm p	1.0036	0.0032	2.47625E-01
cas67	uo2(no3)2 415 g U/L 3x3x3 array 15.24 cm par. bot., 2.54 cm p	1.0111	0.0030	2.21864E-01
cas68	uo2(no3)2 415 g U/L 3x3x3 array 15.24 cm par. bot., 1.27 cm p	1.0076	0.0031	2.37434E-01
cas69	uo2(no3)2 415 g U/L 3x3x3 array 15.24 cm par 5 fc, plex 1 fc	1.0163	0.0035	1.80759E-01
cas70	uo2(no3)2 415 g U/L 3x3x3 array 15.24 cm par. bot., 3.81 cm p	1.0218	0.0029	1.94018E-01
cas71	uo2(no3)2 415 g U/L 3x3x3 array 15.24 cm par. bot., 7.62 cm p	1.0239	0.0029	1.83646E-01
cas72	uo2(no3)2 415 g U/L 3x3x3 array 1.27 cm plexiglass refl.	0.9943	0.0030	2.59663E-01
cas73	uo2(no3)2 415 g U/L 3x3x3 array 1.27 cm paraffin refl.	1.0048	0.0027	2.49685E-01
cas74	uo2(no3)2 415 g U/L 3x3x3 array 15.24 cm paraffin refl.	1.0184	0.0035	1.83359E-01
cas75	uo2(no3)2 415 g U/L 3x3x3 array 3.81 cm paraffin refl.	1.0215	0.0030	1.98010E-01
cas76	uo2(no3)2 415 g U/L 2x2x2 array 15.24 cm par. bot., 1.27 cm p	1.0097	0.0034	2.41320E-01
cas77	uo2(no3)2 415 g U/L 2x2x2 array 15.24 cm par. bot., 11.43 cm	1.0211	0.0031	1.81104E-01
cas78	uo2(no3)2 415 g U/L 2x2x2 array 15.24 cm par. bot., 15.24 cm	1.0233	0.0036	1.78291E-01
cas79	uo2(no3)2 415 g U/L 2x2x2 array 15.24 cm par. bot., 2.54 cm p	1.0134	0.0033	2.19405E-01
cas80	uo2(no3)2 415 g U/L 2x2x2 array 15.24 cm par. bot., 4.45 cm p	1.0167	0.0030	1.98364E-01
cas81	uo2(no3)2 415 g U/L 2x2x2 array 15.24 cm par. bot., 6.35 cm p	1.0219	0.0031	1.87721E-01
cas82	uo2(no3)2 415 g U/L 2x2x2 array 15.24 cm par. bot., 1.27 cm p	1.0147	0.0028	2.31556E-01
cas83	uo2(no3)2 415 g U/L 2x2x2 array 15.24 cm par. bot., 3.81 cm p	1.0145	0.0029	1.95659E-01
cas84	uo2(no3)2 415 g U/L 2x2x2 array 15.24 cm par. bot., 7.62 cm p	1.0143	0.0033	1.82143E-01
cas85	uo2(no3)2 415 g U/L 2x2x2 array 1.27 cm plexiglass refl.	1.0041	0.0031	2.56820E-01
cas86	uo2(no3)2 415 g U/L 2x2x2 array 1.27 cm paraffin refl.	1.0055	0.0033	2.46967E-01
cas87	uo2(no3)2 415 g U/L 2x2x2 array 15.24 cm paraffin refl.	1.0173	0.0029	1.78054E-01
cas88	uo2(no3)2 415 g U/L 2x2x2 array 3.81 cm paraffin refl.	1.0128	0.0029	1.97267E-01
cas89	uo2(no3)2 415 g U/L 2x2x2 array 7.62 cm paraffin refl.	1.0179	0.0029	1.83059E-01
cas90	uo2(no3)2 415 g U/L 3x3x3 array unrefl. 279 g U/L 5 cent. uni	0.9990	0.0031	2.34043E-01
cas91	uo2(no3)2 63.3 g U/L 3x3x3 array unrefl. walls, floor, & tank	1.0003	0.0030	3.02549E-02
jemima	disks - 15" diam plates 93.15 w% enriched stacked to 3.0258"	1.0028	0.0021	9.48314E+05
jemima	jemima - ~1/8" x 15" diam u(93.29) plates with 1/16" thk poly	0.9953	0.0025	1.23178E+05
jemima	jemima - ~1/8" thk 15" diam u(93.24) plates with 1/8" thk pol	1.0062	0.0022	1.91947E+04
jemima	jemima - ~1/8" thk 15" diam u(93.24) plates with 1/4" thk pol	0.9863	0.0023	1.90790E+03

jemima	jemima - ~1/8" thk 15" diam u(93.24) plates with 1/2" thk pol	1.0124	0.0030	9.54148E+01
jemima	jemima - ~1/8" thk 15" diam u(93.24) plates with 1" thk poly,	1.0007	0.0032	7.97240E+00
jemima	jemima - ~1/8" x 15" dia u(93) with symetric 1-1/2" thk poly,	1.0054	0.0025	3.47882E+00
jemima	jemima - ~1/8" x 15" dia u(93) with symetric 2" thk poly, pg-	1.0024	0.0024	2.16156E+00
heumf001	read parameters	1.0055	0.0021	9.24612E+05
heumf004	water-reflected heu sphere on hollow plexiglas cylinder	1.0054	0.0020	3.14659E+04
heust001	case 1 heust001	1.0058	0.0022	6.18678E-02
heust001	case 2 heust001	1.0053	0.0029	2.38542E-01
heust001	case 3 heust001	1.0055	0.0025	6.07781E-02
heust001	case 4 heust001	1.0062	0.0029	2.55761E-01
heust001	case 5 heust001	1.0055	0.0019	2.94557E-02
heust001	case 6 heust001	1.0116	0.0023	3.07806E-02
heust001	case 7 heust001	1.0062	0.0024	5.83064E-02
heust001	case 8 heust001	1.0055	0.0030	6.17842E-02
heust001	case 9 heust001	1.0037	0.0025	2.55768E-01
heust001	case 10 heust001	0.9973	0.0023	3.20292E-02
heust007	case 1 , heust007	1.0141	0.0021	3.30667E-02
heust007	case 2 , heust007	1.0139	0.0023	2.31938E-01
heust007	case 3 , heust007	1.0111	0.0021	3.22024E-02
heust007	case 4 , heust007	1.0189	0.0022	2.02858E-01
heust007	case 5 , heust007	1.0102	0.0021	3.54239E-02
heust007	case 6 , heust007	1.0062	0.0025	2.36377E-01
heust007	case 7 , heust007	1.0096	0.0021	3.49131E-02
heust007	case 8 , heust007	1.0080	0.0019	2.32824E-01
heust007	case 9 , heust007	1.0101	0.0020	3.64053E-02
heust007	case 10 , heust007	1.0143	0.0019	3.77483E-02
heust007	case 11 , heust007	1.0077	0.0021	2.21192E-01
heust007	case 12 , heust007	1.0143	0.0021	3.62600E-02
heust007	case 13 , heust007	1.0138	0.0021	1.98880E-01
heust007	case 14 , heust007	1.0120	0.0026	2.04744E-01
heust007	case 15 , heust007	1.0105	0.0023	2.05797E-01
heust007	case 16 , heust007	1.0078	0.0021	2.21208E-01
heust007	case 17 , heust007	1.0089	0.0023	2.05418E-01
heust008	case 1 , heust008	0.9989	0.0019	3.06830E-02
heust008	case 2 , heust008	1.0046	0.0022	2.01218E-01
heust008	case 3 , heust008	0.9962	0.0021	2.98479E-02
heust008	case 4 , heust008	0.9990	0.0023	1.78648E-01
heust008	case 5 , heust008	0.9995	0.0019	3.06064E-02
heust008	case 6 , heust008	1.0024	0.0025	2.19197E-01
heust008	case 7 , heust008	1.0000	0.0020	3.00992E-02
heust008	case 8 , heust008	1.0066	0.0027	2.08335E-01
heust008	case 9 , heust008	1.0016	0.0021	3.05784E-02
heust008	case 10 , heust008	1.0016	0.0024	1.99162E-01
heust008	case 11 , heust008	0.9995	0.0019	2.92645E-02
heust008	case 12 , heust008	0.9979	0.0022	1.71894E-01
heust008	case 13 , heust008	1.0017	0.0024	1.96629E-01
heust008	case 14 , heust008	1.0035	0.0022	1.77598E-01
heust013	uranium aqueous 23 cm sphere #1	1.0001	0.0015	2.17462E-02
heust013	uranium aqueous 32 cm sphere #2	0.9969	0.0014	2.28882E-02
heust013	uranium aqueous 32 cm sphere #3	0.9941	0.0015	2.39695E-02
heust013	uranium aqueous 32 cm sphere #4	0.9937	0.0014	2.45661E-02

218-Group_Low-Enriched_Uranium

Case	Title	k-eff	sigma	EALF
car01	rocky flats criticals nureg/cr-1071 experiment number 1 (27 g	1.0006	0.0022	3.94999E-01
car02	rocky flats criticals nureg/cr-1071 experiment number 2 (27 g	1.0005	0.0022	3.93085E-01
car03	rocky flats criticals nureg/cr-1071 experiment number 3 (27 g	0.9826	0.0020	1.42251E+00
car04	rocky flats criticals nureg/cr-1071 experiment number 13 (27	1.0075	0.0022	4.47478E-01
car06	rocky flats criticals nureg/cr-0674 experiment number ? (27 g	1.0015	0.0025	5.43776E+02
car07	rocky flats criticals nureg/cr-0674 experiment number ? (27 g	1.0006	0.0034	3.48957E+00
car08	rocky flats criticals nureg/cr-0674 experiment number ? (27 g	0.9920	0.0030	1.75924E+00
car09	rocky flats criticals nureg/cr-0674 experiment number 2 (27 g	1.0035	0.0032	1.76475E+00
car10	rocky flats criticals nureg/cr-0674 concrete reflected (27 gr	1.0020	0.0034	5.05230E+00
car11	rocky flats criticals nureg/cr-1653 experiment a (27 group)	0.9964	0.0025	3.42585E-01
car12	rocky flats criticals nureg/cr-1653 experiment b (27 group)	1.0061	0.0022	9.22813E-01
car14	rocky flats criticals nureg/cr-1653 experiment number ? (27 g	1.0036	0.0033	2.83742E+00
car15	rocky flats criticals nureg/cr-1653 experiment number ? (27 g	0.9923	0.0028	2.95204E+00
car16	rocky flats criticals nureg/cr-1653 experiment number ? (27 g	0.9995	0.0027	1.70924E+00
car17	rocky flats criticals nureg/cr-2500 experiment f (27 group)	0.9959	0.0024	5.88001E-01
car19	rocky flats criticals nureg/cr-2500 experiment number ? (27 g	0.9984	0.0022	3.79885E+00
car20	rocky flats criticals nureg/cr-2500 experiment number ? (27 g	0.9979	0.0025	3.71471E+00
cas04	british handbook of criticality safety u(1.42)f4 & paraffin (	0.9791	0.0018	8.96750E-02
cas05	british handbook of criticality safety u(1.42)f4 & paraffin (	0.9828	0.0019	8.96465E-02
cas06	british handbook of criticality safety u(1.42)f4 & paraffin (	0.9800	0.0019	9.03933E-02
cas11	raffety and malhalczo u(2)f4-1 reflected (case 11)	0.9842	0.0023	1.57178E-01
cas12	raffety and malhalczo u(2)f4-1 unreflected (case12)	0.9877	0.0023	1.89916E-01
cas13	raffety and malhalczo u(2)f4-2 reflected (case 13) no biasing	0.9902	0.0020	8.90524E-02
cas14	raffety and malhalczo u(2)f4-2 unreflected (case 14)	0.9862	0.0023	1.02992E-01
cas15	raffety and malhalczo u(2)f4-3 reflected (case 15)	0.9890	0.0021	6.21983E-02
cas16	raffety and malhalczo u(2)f4-4 reflected (case 16)	0.9912	0.0021	5.18809E-02
cas17	raffety and malhalczo u(2)f4-5 reflected (case 17)	0.9932	0.0020	4.38522E-02
cas18	raffety and malhalczo u(2)f4-5 unreflected (case18)	0.9933	0.0021	4.66593E-02
cas19	raffety and malhalczo u(2)f4-6 reflected (case 19)	0.9846	0.0020	3.32038E-02
cas20	raffety and malhalczo u(2)f4-6 unreflected (case20)	0.9842	0.0016	3.41368E-02
cas21	raffety and milhalczo u(3)f4-1 reflected (case 21) no bias	1.0028	0.0024	1.91295E-01

cas22	raffety and malhalczo u(3)f4-1 reflected (case 22)	1.0001	0.0025	1.91734E-01
cas23	raffety and malhalczo u(3)f4-1 reflected (case 23)	1.0028	0.0026	1.92158E-01
cas24	raffety and malhalczo u(3)f4-1 reflected (case 24) no biasing	0.9998	0.0021	1.93289E-01
cas25	raffety and malhalczo u(3)f4-1 reflected (case 25)	1.0016	0.0023	1.91741E-01
cas26	raffety and malhalczo u(3)f4-1 unreflected (case 26)	1.0008	0.0029	2.66530E-01
cas27	raffety and malhalczo u(3)f4-1 unreflected (case 27)	1.0020	0.0023	2.64539E-01
cas28	raffety and malhalczo u(3)f4-1 unreflected (case 28)	1.0053	0.0022	2.65378E-01
cas29	raffety and malhalczo u(3)f4-2 reflected (cas29)	1.0040	0.0026	6.97213E-02
cas30	raffety and malhalczo u(3)f4-2 unreflected (case 30)	0.9996	0.0022	8.38485E-02
cas31	raffety and malhalczo u(3)f4-2 unreflected (case 31)	1.0103	0.0021	8.31691E-02
cas32	raffety and malhalczo u(3)f4-2 unreflected (case 32)	1.0033	0.0022	8.35523E-02
cas33	critical reflected cylinder of aqueous u(4.98)o2f2 (case 33)	1.0006	0.0023	4.02568E-02
cas34	critical reflected cylinder of aqueous u(4.98)o2f2 (case 34)	0.9981	0.0023	3.93348E-02
cas35	critical sphere of aqueous u(4.98)o2f2 (case 35)	1.0003	0.0026	3.90638E-02
cas36	critical cylinder of aqueous u(4.98)o2f2 (case 36)	0.9940	0.0022	3.98501E-02

218-Group_LWR_Lattices

Case	Title	k-eff	sigma	EALF
cas01	exp#5, 8.39 cm h2o separating 3 20x16 arrays	0.9870	0.0021	7.31826E-02
cas02	exp#017, 5.05 cm h2o/boral separating 2 22x16 arrays and 1 20	0.9916	0.0011	7.57345E-02
cas03	exp#28, 6.88 cm h2o/ss separating 3 20x16 arrays	0.9906	0.0014	7.39831E-02
cas04	exp no. 14 8.58 cm h2o/ss separating 3 15x8 arrays	0.9930	0.0017	9.39196E-02
cas05	exp no. 23 7.28 cm h2o/cadmium separating 3 15x8 arrays	0.9962	0.0018	9.37279E-02
cas06	exp no. 31 6.72 cm h2o/boral separating 3 15x8 arrays	0.9919	0.0015	9.46590E-02
cas07	u refl. 1.956 cm from array, 14.11 cm h2o separating 3 19x1	0.9936	0.0017	1.34920E-01
cas08	pb refl. .660 cm from array, 13.72 cm h2o separating 3 19x16	0.9971	0.0014	7.52285E-02
cas09	no refl. 8.31cm h2o separating 19x16 arrays	0.9886	0.0014	7.31741E-02
cas10	uranium refl. 15.32cm h2o separating 12x8 arrays	0.9944	0.0019	2.28104E-01
cas11	lead refl. 20.78cm h2o separating 13x8 arrays	1.0021	0.0008	9.57944E-02
cas12	2.83cm and 3.60cm separating 4 11x14 arrays	0.9928	0.0016	2.71025E-01
cas13	2.83cm and 4.94cm separating 2 11x14 + 2 11x16 arrays	0.9939	0.0012	2.71469E-01
cas14	ss refl. 0.66 cm from array, 11.20 cm h2o separating 3 19x16	0.9938	0.0014	7.55889E-02
cas15	steel refl. 15.84cm h2o separating 3 12x16 arrays	0.9938	0.0018	2.45558E-01
cas16	steel refl. 9.83cm h2o separating 3 12x16 arrays w/borated	0.9924	0.0017	2.54566E-01
cas17	steel refl. 8.30cm h2o separating 3 12x16 arrays w/boral pl	0.9913	0.0018	2.61571E-01
cas18	steel refl. 8.94cm h2o separating 3 12x16 arrays w/cd plate	0.9920	0.0012	2.57808E-01
cas19	u refl 1.321 cm from array, 9.50 cm h2o sep. 23x18/2-20x18 ar	0.9846	0.0014	2.72838E-01
cas20	pb refl 0.660 cm from array, 10.11 cm h2o sep. 23x18/2-20x18	0.9955	0.0015	1.32471E-01
cas21	no refl infinite from array, 6.59 cm h2o sep. 23x18/2-20x18 a	0.9861	0.0017	1.26938E-01
cas22	uranium refl. 19.24cm h2o separating 12x16 arrays	0.9940	0.0016	4.29985E-01
cas23	lead refl. 18.18cm h2o separating 12x16 arrays	0.9979	0.0018	2.52231E-01
cas24	no refl. 12.91cm h2o separating 3 12x16 arrays	0.9931	0.0018	2.35292E-01
cas25	pnl-4267 exp. 173 40 x 8.92 array (357 total rods) boron = 0	0.9898	0.0012	2.38528E-01
cas26	pnl-4267 exp.177 40 x 30.92 array 1237 total rods) boron = 2.	0.9928	0.0014	5.33489E-01
cas27	pnl-4267 exp. 178 44 x 11.57array (509 total rods) boron = 0	0.9899	0.0014	4.57461E-01
cas28	pnl-4267 exp. 181 44 x 27.09 array (1192 total rods) boron =	0.9840	0.0013	1.05426E+00
cas29	pnl-4976 4.3-000-194 4.3%uo2 1.598cm-pitch	0.9894	0.0013	3.22852E+00
cas30	flux trap assembly no. 214r	0.9893	0.0016	3.13594E-01
cas31	flux trap assembly no. 214v3	0.9889	0.0012	3.14387E-01
cas32	baw-1231 core i 936 rods boron=1.152 g/l	0.9841	0.0011	6.42345E-01
cas33	baw-1231 core i 4904 rods boron=3.389 g/l	0.9853	0.0010	1.09035E+00
cas34	baw-1273 core xx 2.46 wt%u235 5137 rods	0.9813	0.0015	4.35169E-01
cas35	baw-1484-7 core iv exp 2282 2.46 wt%u235 9 assys 14x14 w/ 8	0.9861	0.0012	1.51773E-01
cas36	baw-1484-7 core ix exp 2321 2.46 wt%u235 9 assys 14x14	0.9873	0.0018	1.09533E-01
cas37	baw-1484-7 core xiii exp 2378 2.46 wt%u235 9 assys 14x14	0.9893	0.0016	1.57662E-01
cas38	baw-1484-7 core xxi exp 2420 2.46 wt%u235 9 assys 14x14	0.9821	0.0014	1.21402E-01
cas39	baw-1645-4 exp,mt=2452 triangular pitch=o.d. boron=435ppm	0.9826	0.0012	2.07517E+00
cas40	baw-1645-4 exp,mt=2485 pitch=o.d. boron=886ppm	0.9833	0.0015	1.25336E+00
cas41	baw-1645-4 exp,mt=2500 pitch=1.17*o.d. boron=1156ppm	0.9862	0.0014	3.49389E-01
cas42	baw-1810 core 12 - 4.02 & 2.46 w/o uo2 1899.3 ppm; no uo2-gd2	0.9880	0.0013	3.05712E-01
cas43	baw-1810 core 14 - 4.02 & 2.46 w/o uo2 1654 ppm; 28 uo2-gd2o3	0.9893	0.0013	2.82602E-01
cas44	baw-1810 core 16 - 4.02 & 2.46 w/o uo2 1579 ppm; 36 uo2-gd2o3	0.9868	0.0012	2.77284E-01
cas45	epri np-196 .615 inch pitch unborated uo2	0.9855	0.0017	2.09623E-01
cas46	epri np-196 .615 inch pitch borated uo2	0.9890	0.0016	2.62418E-01
cas47	epri np-196 .75 inch pitch unborated uo2	0.9916	0.0011	8.84393E-02
cas48	epri np-196 .75 inch pitch borated uo2	0.9920	0.0010	1.12055E-01
cas49	epri np-196 .87 inch pitch unborated uo2	0.9959	0.0014	6.29723E-02
cas50	epri np-196 .87 inch pitch borated uo2	0.9912	0.0013	7.14114E-02
cas51	saxton uo2 5.742 wt% u-235 critical exp. 0.56 inch pitch (wca	0.9898	0.0017	2.52263E-01
cas52	saxton uo2 5.742 wt% u-235 critical exp. 0.792inch pitch (wca	0.9950	0.0014	8.44485E-02
cas53	wcap-3269-39, 2692 fuel rods, 16 ag-in-cd rods,h2o ht=115.55	0.9887	0.0010	5.98311E-01
cas54	wcap-3269-39, 2209 fuel rods, 24 ag-in-cd rods,h2o ht=64.56 c	0.9891	0.0018	3.70456E-01
cas55	wcap-3269-39, 945 fuel rods, 16 ag-in-cd rods,h2o ht=89.75	0.9813	0.0012	2.11051E-01
cas56	4-18x18 array 5.0cm int.,polyethylene powder in box,30.16cm h	0.9918	0.0016	1.84824E-01
cas57	4-18x18 array 5.0cm int.,polyethylene balls in box,30.73cm h2	1.0017	0.0015	1.69951E-01
cas58	4-18x18 array 5.0cm int.,water in box,32.78cm h2o height	1.0042	0.0013	1.61607E-01
cas59	4-18x18 array 5.0cm int.,water without box,31.47cm h2o height	0.9900	0.0014	1.63096E-01

218-Group_Mixed_Oxide

Case	Title	k-eff	sigma	EALF
cas60	epri .70inch pitch unborated plutonium	0.9885	0.0016	4.93211E-01
cas61	epri .70inch pitch borated plutonium	0.9903	0.0015	6.69112E-01
cas62	epri .87inch pitch unborated plutonium	0.9965	0.0012	1.57390E-01

cas63	epri .87inch pitch borated plutonium	1.0016	0.0013	2.37628E-01
cas64	epri .99inch pitch unborated plutonium	1.0030	0.0021	1.12362E-01
cas65	epri .99inch pitch borated plutonium	1.0009	0.0011	1.50800E-01
cas66	saxton puo2-uo2 critical exp. 0.52 inch pitch (wcap-3385-54)	0.9932	0.0013	8.06082E-01
cas67	saxton puo2-uo2 critical exp. 0.56 inch pitch (wcap-3385-54)	0.9952	0.0020	4.83024E-01
cas68	saxton puo2-uo2 critical exp. 0.56 inch pitch with boron (wca	0.9956	0.0020	5.69167E-01
cas69	saxton puo2-uo2 critical exp. 0.735 inch pitch (wcap-3385-54)	1.0024	0.0019	1.59498E-01
cas70	saxton puo2-uo2 critical exp. 0.792 inch pitch (wcap-3385-54)	0.9996	0.0018	1.31846E-01
cas71	saxton puo2-uo2 critical exp. 01.04 inch pitch (wcap-3385-54)	0.9993	0.0020	8.44048E-02
cas72	pnl4976 exp196 1174 uo2 & 583 mo2 rods to approx. 20,000 mwd/	0.9829	0.0015	3.90997E+00
cas73	exp.no 021(063) pitch=968 (fuel region = pin array + mix 500	1.0071	0.0013	8.09349E-01
cas74	exp.no 032(060) pitch=1.935(fuel region=pin array+mix 500 wit	1.0089	0.0018	9.73447E-02
cas75	exp.no 043(062) pitch=1.242(fuel region=pin array+mix 500 wit	1.0076	0.0013	2.53936E-01
cas76	exp.no 067 pitch=0.761 (fuel region = pin array + mix 500 wit	0.9998	0.0011	2.66626E+00
cas77	exp. no 68r pitch=1.537 (fuel region = pin array + mix 500 wi	1.0109	0.0017	1.43396E-01

218-Group_Plutonium

Case	Title	k-eff	sigma	EALF
2109_20	benchmark 20, pu sphere with 25.4 cm concrete ref. h/pu=684.3	1.0231	0.0032	5.16629E-02
2109_21	benchmark 21, pu sphere with 10.16 cm concrete ref. h/pu=684.	1.0215	0.0037	4.98331E-02
2109_22	benchmark 22, pu sphere with 10.16 cm concrete ref. h/pu=496	1.0240	0.0034	6.17991E-02
2109_23	benchmark 23, pu sphere with cd shell & 10.16 cm concrete ref	1.0264	0.0037	6.86368E-02
2109_24	benchmark 24, pu sphere with cd shell & 32.00 cm water, h/pu=	1.0221	0.0038	5.87382E-02
2110_05	rectangular parallelpipeds of homogeneous pu(2.2)o2	1.0382	0.0054	3.02218E+01
2110_06	rectangular parallelipiped of pu(2.2)o2 reflected with 15cm p	1.0348	0.0055	5.18024E+00
2110_07	benchmark#7 semi-inf homogeneous critical solution of pu-239	1.0179	0.0037	7.12103E-02
2110_08	rectangular parallelipiped of puo2	1.0067	0.0052	1.48979E+00
2110_09	rectangular parallelipipeds of pu02	1.0212	0.0050	6.76814E-01
2110_10	rectangular parallelipipeds of pu02	1.0172	0.0045	6.65798E-01
2110_11	rectangular parallelipipeds of pu02	1.0166	0.0044	6.42817E-01
2110_12	rectangular parallelipipeds of pu02	1.0107	0.0053	6.36030E-01
2110_13	sphere described by keno geometry	0.9942	0.0035	1.22581E+06
2110_14	cylinder described by keno geometry	1.0080	0.0056	1.20783E-01
2110_15	rectangular parallelipipeds of puo2-h20	1.0251	0.0042	2.46347E+05
2110_16	rectangular parallelipipeds of puo2-h20	1.0344	0.0034	9.52307E+05
2110_17	rectangular parallelipipeds of puo2-h20	1.0343	0.0038	1.70871E+03
2110_18	rectangular parallelipipeds of puo2-h20	1.0462	0.0037	3.63834E+03
2110_19	rectangular parallelipipeds of puo2-h20	1.0178	0.0034	4.32956E+03
2110_20	rectangular parallelipipeds of puo2-h20	1.0252	0.0036	2.16310E+03
2110_21	rectangular parallelipipeds of puo2-h20	1.0469	0.0043	1.77724E+03
2110_23	rectangular parallelipipeds of puo2-polystyrene	1.0211	0.0056	1.45852E+03
2110_24	rectangular parallelipipeds of puo2-polystyrene	1.0284	0.0032	9.12097E+01
2110_25	rectangular parallelipipeds of puo2-polystyrene	1.0330	0.0037	8.17618E+01
2110_26	rectangular parallelipipeds of puo2-polystyrene	1.0354	0.0036	6.53850E+01
2110_27	rectangular parallelipipeds of puo2-polystyrene	1.0313	0.0034	5.48046E+01
2110_29	cylinder described by keno geometry	1.0110	0.0035	4.22712E-02
pumf001	read parameters	0.9958	0.0020	1.18798E+06
pumf002	pu-met-fast-002	0.9993	0.0019	1.21724E+06
pust004	case 1,kvpusolnsphexp,27gp,26.27gpU/L, 0.54w/o240,h2orefl,14i	1.0094	0.0021	4.01972E-02
pust009	case 3a,kvpusolnsphexp,27,9.457gpU/L, 2.5w/o240,bare,48in dia	1.0192	0.0014	2.92598E-02

218-Group_U-233

Case	Title	k-eff	sigma	EALF
u233mf001	unreflected u233 sphere	0.9632	0.0017	9.96415E+05
u233mf002	case 1, 10 kg u233/heu sphere, ref u233-met-fast-002	0.9758	0.0020	9.67456E+05
u233mf002	case 2, 7.6 kg u233/heu sphere, ref u233-met-fast-002	0.9700	0.0019	9.74693E+05
u233mf003	case 1, 10 kg u233 sphere natural uranium reflector, ref u233	0.9700	0.0019	9.60313E+05
u233mf003	case 2, 7.6 kg u233 sphere natural uranium reflector, ref u23	0.9727	0.0019	9.53695E+05
u233mf004	case 1, 10 kg u233 sphere reflected by tungsten	0.9711	0.0023	8.81734E+05
u233mf005	case 1, 10 kg u233 sphere be reflector, ref u233-met-fast-xxx	0.9765	0.0023	8.30195E+05
u233mf006	u-233/nu sphere	0.9771	0.0020	9.16551E+05
u233st002	exp 4 simplified model	1.0247	0.0035	1.36063E-01
u233st002	exp 5 simplified model	1.0011	0.0033	1.03111E-01
u233st002	exp 8 simplified model	1.0204	0.0033	7.89818E-02
u233st002	exp 10 simplified model	1.0169	0.0030	6.24587E-02
u233st002	exp 11 simplified model	1.0221	0.0027	5.37025E-02
u233st002	exp 12 simplified model	1.0079	0.0029	4.75664E-02
u233st002	exp 14 simplified model	0.9972	0.0028	4.45793E-02
u233st002	exp 15 simplified model	1.0055	0.0031	4.07691E-02
u233st002	exp 17 simplified model	0.9947	0.0027	3.61638E-02
u233st002	exp 18 simplified model	1.0114	0.0029	3.48580E-02
u233st002	exp 19 simplified model	1.0176	0.0024	3.21938E-02
u233st002	exp 22 simplified model	1.0097	0.0030	2.19634E-01
u233st002	exp 24 simplified model	1.0129	0.0030	4.00789E-01
u233st002	exp 34 simplified model	1.0158	0.0031	1.07339E-01
u233st002	exp 35 simplified model	1.0161	0.0026	7.11225E-02
u233st002	exp 36 simplified model	1.0188	0.0026	4.54736E-02
u233st002	exp 38 simplified model	1.0180	0.0026	3.81578E-02
u233st004	exp 3 simplified model	1.0164	0.0029	1.34418E-01
u233st004	exp 6 simplified model	1.0208	0.0030	1.00574E-01
u233st004	exp 20 simplified model	1.0198	0.0031	2.17961E-01
u233st004	exp 25 simplified model	1.0044	0.0033	4.06822E-01
u233st004	exp 30 simplified model	1.0086	0.0033	3.15473E-01
u233st004	exp 27 simplified model	1.0240	0.0035	4.03712E-01

u233st004	exp 28 simplified model	1.0237	0.0031	3.10239E-01
u233st004	exp 33 simplified model	1.0273	0.0032	1.06955E-01

27-Group_High-Enriched_Uranium

Case	Title	k-eff	sigma	EALF
cas04	keno-5 validation case a-2	1.0012	0.0024	8.25177E+05
cas05	keno-5 validation case a-3	1.0051	0.0016	2.12729E-02
cas07	keno-5 validation case a-5	1.0088	0.0024	1.43238E+03
cas08	keno-5 validation case a-6	1.0202	0.0026	1.59606E+05
cas09	keno-5 validation case a-7	1.0132	0.0022	7.99182E+05
cas10	keno-5 validation case a-8	1.0134	0.0024	4.39491E+03
cas11	keno-5 validation case a-9	1.0052	0.0022	1.28208E+04
cas12	keno-5 validation case b-1	0.9988	0.0024	9.06663E+05
cas14	keno-5 validation case b-11	1.0545	0.0029	3.35277E-01
cas15	keno-5 validation case b-12	1.0147	0.0023	3.90048E+04
cas19	keno-5 validation case b-16	1.0287	0.0033	4.28583E-01
cas22	keno-5 validation case b-2	1.0034	0.0024	9.07820E+05
cas23	keno-5 validation case b-3	0.9999	0.0021	9.04580E+05
cas24	keno-5 validation case b-4	0.9894	0.0024	9.11988E+05
cas25	keno-5 validation case b-5	1.0033	0.0022	8.97214E+05
cas26	keno-5 validation case b-6	1.0058	0.0027	8.11693E+03
cas27	keno-5 validation case b-7	1.0053	0.0025	6.04371E+03
cas28	keno-5 validation case b-8	1.0028	0.0023	5.80892E+04
cas30	93.2% uo2f2 3 in al slab 3x1x1 array 0 in sep room	1.0055	0.0029	3.66423E-02
cas31	93.2% uo2f2 3 in al slab 3x1x1 array 0 in sep h2o refl	0.9956	0.0032	3.37742E-02
cas32	93.2% uo2f2 3 in al slab 3x1x1 array 1 in sep room	0.9875	0.0032	3.70072E-02
cas33	93.2% uo2f2 3 in al slab 3x1x1 array 1 in sep h2o refl	0.9982	0.0033	3.12980E-02
cas34	93.2% uo2f2 3 in al slab 3x1x1 array 3 in sep room	0.9842	0.0028	3.72751E-02
cas35	93.2% uo2f2 3 in al slab 3x1x1 array 3 in sep h2o refl	0.9989	0.0026	3.04115E-02
cas36	93.2% uo2f2 3 in al slab 3x1x1 array 4.5 in sep room	0.9866	0.0028	3.72423E-02
cas37	93.2% uo2f2 3 in al slab 3x1x1 array 4.5 in sep h2o refl	1.0051	0.0026	3.07787E-02
cas38	93.2% uo2f2 3 in al slab 3x1x1 array 5.5 in sep room	0.9890	0.0029	3.73485E-02
cas39	93.2% uo2f2 3 in al slab 3x1x1 array 5.5 in sep h2o refl	1.0044	0.0027	3.08833E-02
cas40	93.2% uo2f2 3 in al slab 3x1x1 array 6 in sep room	0.9963	0.0028	3.73356E-02
cas41	93.2% uo2f2 3, 6 in al slabs 2x1x1 array 15 in sep	0.9776	0.0029	3.68925E-02
cas42	93.2% uo2f2 3, 6 in al slabs 2x1x1 array 2 in sep	0.9779	0.0031	3.70629E-02
cas43	93.2% uo2f2 3, 6 in al slabs 2x1x1 array 30 in sep	0.9779	0.0026	3.69950E-02
cas44	93.2% uo2f2 3, 6 in al slabs 2x1x1 array 48 in sep	0.9774	0.0029	3.69031E-02
cas45	93.2% uo2f2 3, 6, 3 in al slabs 3x1x1 array 0 in sep	0.9813	0.0029	3.67765E-02
cas46	93.2% uo2f2 3, 6, 3 in al slabs 3x1x1 array 10 in sep	0.9761	0.0027	3.72860E-02
cas47	93.2% uo2f2 3, 6, 3 in al slabs 3x1x1 array 20 in sep	0.9757	0.0030	3.71699E-02
cas48	93.2% uo2f2 3, 6, 3 in al slabs 3x1x1 array 32 in sep	0.9756	0.0033	3.72024E-02
cas49	93.2% uo2f2 6 & 3 in al slabs 2x1x1 array 12 in sep	0.9812	0.0028	3.70269E-02
cas50	93.2% uo2f2 6 & 3 in al slabs 2x1x1 array 18 in sep	0.9827	0.0029	3.70684E-02
cas51	93.2% uo2f2 6 & 3 in al slabs 2x1x1 array 30 in sep	0.9863	0.0026	3.70451E-02
cas52	93.2% uo2f2 6 & 3 in al slabs 2x1x1 array 6 in sep	0.9849	0.0029	3.70524E-02
cas53	93.2% uo2f2 6 in al slab 2x1x1 array 15 in sep	0.9877	0.0030	3.69003E-02
cas54	93.2% uo2f2 6 in al slab 2x1x1 array 2 in sep	0.9788	0.0029	3.69552E-02
cas55	93.2% uo2f2 6 in al slab 2x1x1 array 20 in sep	0.9833	0.0028	3.69450E-02
cas56	93.2% uo2f2 6 in al slab 2x1x1 array 30 in sep	0.9871	0.0026	3.68452E-02
cas57	93.2% uo2f2 6 in al slab 2x1x1 array 48 in sep	0.9827	0.0032	3.69738E-02
cas58	93.2% uo2f2 6 in al slab 2x1x1 array 6 in sep	0.9831	0.0034	3.69268E-02
cas59	93.2% uo2f2 6 in al slab 2x1x1 array 66 in sep	0.9844	0.0027	3.68209E-02
cas60	uo2(no3)2 279 g U/L 3x3x3 array unrefl. walls, tank, & floor	1.0042	0.0028	1.31018E-01
cas61	uo2(no3)2 279 g U/L 2x2x2 array unrefl. walls, tank, & floor	1.0034	0.0029	1.26948E-01
cas62	uo2(no3)2 415 g U/L 5x5x5 array unrefl. walls, tank, & floor	0.9943	0.0030	2.73618E-01
cas63	uo2(no3)2 415 g U/L 3x3x3 array unrefl. walls, tank, & floor	0.9956	0.0030	2.76888E-01
cas64	uo2(no3)2 415 g U/L 4x4x4 array unrefl. walls, floor, & tank	0.9953	0.0033	2.78316E-01
cas65	uo2(no3)2 415 g U/L 2x2x2 array unrefl. walls, floor, & tank	1.0015	0.0029	2.71382E-01
cas66	uo2(no3)2 415 g U/L 3x3x3 array 15.24 cm par. bot., 1.27 cm p	1.0042	0.0029	2.39237E-01
cas67	uo2(no3)2 415 g U/L 3x3x3 array 15.24 cm par. bot., 2.54 cm p	1.0163	0.0032	2.14582E-01
cas68	uo2(no3)2 415 g U/L 3x3x3 array 15.24 cm par. bot., 1.27 cm p	1.0107	0.0028	2.29550E-01
cas69	uo2(no3)2 415 g U/L 3x3x3 array 15.24 cm par 5 fc, plex 1 fc	1.0145	0.0030	1.76230E-01
cas70	uo2(no3)2 415 g U/L 3x3x3 array 15.24 cm par. bot., 3.81 cm p	1.0260	0.0028	1.87077E-01
cas71	uo2(no3)2 415 g U/L 3x3x3 array 15.24 cm par. bot., 7.62 cm p	1.0287	0.0031	1.77129E-01
cas72	uo2(no3)2 415 g U/L 3x3x3 array 1.27 cm plexiglass refl.	1.0071	0.0028	2.49885E-01
cas73	uo2(no3)2 415 g U/L 3x3x3 array 1.27 cm paraffin refl.	1.0094	0.0033	2.41178E-01
cas74	uo2(no3)2 415 g U/L 3x3x3 array 15.24 cm paraffin refl.	1.0261	0.0028	1.75409E-01
cas75	uo2(no3)2 415 g U/L 3x3x3 array 3.81 cm paraffin refl.	1.0203	0.0029	1.92302E-01
cas76	uo2(no3)2 415 g U/L 2x2x2 array 15.24 cm par. bot., 1.27 cm p	1.0178	0.0026	2.31912E-01
cas77	uo2(no3)2 415 g U/L 2x2x2 array 15.24 cm par. bot., 11.43 cm	1.0219	0.0029	1.76687E-01
cas78	uo2(no3)2 415 g U/L 2x2x2 array 15.24 cm par. bot., 15.24 cm	1.0208	0.0032	1.73787E-01
cas79	uo2(no3)2 415 g U/L 2x2x2 array 15.24 cm par. bot., 2.54 cm p	1.0164	0.0034	2.12739E-01
cas80	uo2(no3)2 415 g U/L 2x2x2 array 15.24 cm par. bot., 4.45 cm p	1.0216	0.0029	1.91607E-01
cas81	uo2(no3)2 415 g U/L 2x2x2 array 15.24 cm par. bot., 6.35 cm p	1.0214	0.0031	1.80898E-01
cas82	uo2(no3)2 415 g U/L 2x2x2 array 15.24 cm par. bot., 1.27 cm p	1.0106	0.0033	2.27365E-01
cas83	uo2(no3)2 415 g U/L 2x2x2 array 15.24 cm par. bot., 3.81 cm p	1.0136	0.0027	1.88998E-01
cas84	uo2(no3)2 415 g U/L 2x2x2 array 15.24 cm par. bot., 7.62 cm p	1.0250	0.0029	1.76417E-01
cas85	uo2(no3)2 415 g U/L 2x2x2 array 1.27 cm plexiglass refl.	1.0092	0.0031	2.46337E-01
cas86	uo2(no3)2 415 g U/L 2x2x2 array 1.27 cm paraffin refl.	1.0117	0.0030	2.36859E-01
cas87	uo2(no3)2 415 g U/L 2x2x2 array 15.24 cm paraffin refl.	1.0161	0.0030	1.75556E-01
cas88	uo2(no3)2 415 g U/L 2x2x2 array 3.81 cm paraffin refl.	1.0203	0.0034	1.89939E-01
cas89	uo2(no3)2 415 g U/L 2x2x2 array 7.62 cm paraffin refl.	1.0219	0.0031	1.77361E-01
cas90	uo2(no3)2 415 g U/L 3x3x3 array unrefl. 279 g U/L 5 cent. uni	1.0017	0.0030	2.22231E-01
cas91	uo2(no3)2 63.3 g U/L 3x3x3 array unrefl. walls, floor, & tank	1.0072	0.0033	3.03766E-02
jemima	disks - 15" diam plates 93.15 w% enriched stacked to 3.0258"	0.9985	0.0021	9.11779E+05

jemima	jemima - ~1/8" x 15" diam u(93.29) plates with 1/16" thk poly	1.0029	0.0022	1.09798E+05
jemima	jemima - ~1/8" thk 15" diam u(93.24) plates with 1/8" thk pol	1.0076	0.0025	1.69595E+04
jemima	jemima - ~1/8" thk 15" diam u(93.24) plates with 1/4" thk pol	0.9939	0.0025	1.65789E+03
jemima	jemima - ~1/8" thk 15" diam u(93.24) plates with 1/2" thk pol	1.0168	0.0031	8.58453E+01
jemima	jemima - ~1/8" thk 15" diam u(93.24) plates with 1" thk poly,	1.0064	0.0028	7.27811E+00
jemima	jemima - ~1/8" x 15" dia u(93) with symetric 1-1/2" thk poly,	1.0187	0.0025	3.27479E+00
jemima	jemima - ~1/8" x 15" dia u(93) with symetric 2" thk poly, pg-	1.0074	0.0026	2.10161E+00
heumf001	read parameters	1.0043	0.0018	9.00065E+05
heumf004	water-reflected heu sphere on hollow plexiglas cylinder	1.0065	0.0018	2.94412E+04
heust001	case 1 heust001	1.0064	0.0021	6.08439E-02
heust001	case 2 heust001	1.0047	0.0026	2.31856E-01
heust001	case 3 heust001	1.0108	0.0023	5.97192E-02
heust001	case 4 heust001	1.0069	0.0029	2.49416E-01
heust001	case 5 heust001	1.0039	0.0019	2.95264E-02
heust001	case 6 heust001	1.0103	0.0021	3.06560E-02
heust001	case 7 heust001	1.0015	0.0024	5.74311E-02
heust001	case 8 heust001	1.0066	0.0026	6.10304E-02
heust001	case 9 heust001	1.0072	0.0025	2.48467E-01
heust001	case 10 heust001	0.9988	0.0022	3.18901E-02
heust007	case 1 , heust007	1.0148	0.0019	3.29526E-02
heust007	case 2 , heust007	1.0147	0.0024	2.23061E-01
heust007	case 3 , heust007	1.0125	0.0021	3.21306E-02
heust007	case 4 , heust007	1.0140	0.0025	1.96752E-01
heust007	case 5 , heust007	1.0113	0.0020	3.52662E-02
heust007	case 6 , heust007	1.0111	0.0024	2.27402E-01
heust007	case 7 , heust007	1.0077	0.0025	3.47670E-02
heust007	case 8 , heust007	1.0060	0.0025	2.25179E-01
heust007	case 9 , heust007	1.0110	0.0021	3.59785E-02
heust007	case 10 , heust007	1.0130	0.0019	3.74407E-02
heust007	case 11 , heust007	1.0124	0.0020	2.12040E-01
heust007	case 12 , heust007	1.0172	0.0020	3.59965E-02
heust007	case 13 , heust007	1.0178	0.0018	1.91280E-01
heust007	case 14 , heust007	1.0127	0.0022	1.97240E-01
heust007	case 15 , heust007	1.0131	0.0023	1.98894E-01
heust007	case 16 , heust007	1.0096	0.0021	2.13028E-01
heust007	case 17 , heust007	1.0147	0.0023	1.97778E-01
heust008	case 1 , heust008	0.9996	0.0023	3.07031E-02
heust008	case 2 , heust008	0.9988	0.0026	1.94851E-01
heust008	case 3 , heust008	1.0027	0.0018	2.96884E-02
heust008	case 4 , heust008	1.0006	0.0022	1.71674E-01
heust008	case 5 , heust008	1.0020	0.0018	3.04500E-02
heust008	case 6 , heust008	1.0061	0.0021	2.11288E-01
heust008	case 7 , heust008	1.0024	0.0021	2.99475E-02
heust008	case 8 , heust008	1.0040	0.0027	2.01170E-01
heust008	case 9 , heust008	1.0041	0.0019	3.04749E-02
heust008	case 10 , heust008	0.9981	0.0024	1.92482E-01
heust008	case 11 , heust008	1.0009	0.0019	2.93566E-02
heust008	case 12 , heust008	0.9937	0.0021	1.67395E-01
heust008	case 13 , heust008	1.0069	0.0023	1.90642E-01
heust008	case 14 , heust008	0.9974	0.0021	1.73162E-01
heust013	uranium aqueous 23 cm sphere #1	0.9979	0.0015	2.18895E-02
heust013	uranium aqueous 32 cm sphere #2	0.9973	0.0016	2.30049E-02
heust013	uranium aqueous 32 cm sphere #3	0.9911	0.0015	2.41103E-02
heust013	uranium aqueous 32 cm sphere #4	0.9934	0.0015	2.46565E-02

27-Group_Low-Enriched_Uranium

Case	Title	k-eff	sigma	EALF
car01	rocky flats criticals nureg/cr-1071 experiment number 1 (27 g	1.0045	0.0022	3.87554E-01
car02	rocky flats criticals nureg/cr-1071 experiment number 2 (27 g	0.9999	0.0023	3.91219E-01
car03	rocky flats criticals nureg/cr-1071 experiment number 3 (27 g	0.9936	0.0020	1.35941E+00
car04	rocky flats criticals nureg/cr-1071 experiment number 13 (27	1.0158	0.0022	4.32465E-01
car06	rocky flats criticals nureg/cr-0674 experiment number ? (27 g	1.0057	0.0040	4.55156E+02
car07	rocky flats criticals nureg/cr-0674 experiment number ? (27 g	1.0081	0.0031	3.33012E+00
car08	rocky flats criticals nureg/cr-0674 experiment number ? (27 g	1.0082	0.0033	1.58310E+00
car09	rocky flats criticals nureg/cr-0674 experiment number 2 (27 g	0.9969	0.0027	1.71940E+00
car10	rocky flats criticals nureg/cr-0674 concrete reflected (27 gr	1.0055	0.0032	4.74156E+00
car11	rocky flats criticals nureg/cr-1653 experiment a (27 group)	1.0109	0.0021	3.28500E-01
car12	rocky flats criticals nureg/cr-1653 experiment b (27 group)	1.0134	0.0025	8.64307E-01
car14	rocky flats criticals nureg/cr-1653 experiment number ? (27 g	1.0036	0.0029	2.69715E+00
car15	rocky flats criticals nureg/cr-1653 experiment number ? (27 g	1.0045	0.0029	2.69777E+00
car16	rocky flats criticals nureg/cr-1653 experiment number ? (27 g	1.0078	0.0026	1.63458E+00
car17	rocky flats criticals nureg/cr-2500 experiment f (27 group)	1.0075	0.0022	5.55228E-01
car19	rocky flats criticals nureg/cr-2500 experiment number ? (27 g	1.0060	0.0023	3.27849E+00
car20	rocky flats criticals nureg/cr-2500 experiment number ? (27 g	0.9958	0.0020	3.08323E+00
cas04	british handbook of criticality safety u(1.42)f4 & paraffin (	0.9855	0.0017	8.92388E-02
cas05	british handbook of criticality safety u(1.42)f4 & paraffin (	0.9866	0.0020	8.90776E-02
cas06	british handbook of criticality safety u(1.42)f4 & paraffin (	0.9879	0.0016	8.88506E-02
cas11	raffety and malhalczo u(2)f4-1 reflected (case 11)	0.9932	0.0019	1.55228E-01
cas12	raffety and malhalczo u(2)f4-1 unreflected (case12)	0.9948	0.0017	1.86181E-01
cas13	raffety and malhalczo u(2)f4-2 reflected (case 13) no biasing	0.9978	0.0020	8.79297E-02
cas14	raffety and malhalczo u(2)f4-2 unreflected (case 14)	0.9927	0.0019	1.01576E-01
cas15	raffety and malhalczo u(2)f4-3 reflected (case 15)	0.9962	0.0019	6.15050E-02
cas16	raffety and malhalczo u(2)f4-4 reflected (case 16)	0.9941	0.0018	5.17969E-02
cas17	raffety and malhalczo u(2)f4-5 reflected (case 17)	0.9950	0.0018	4.38689E-02
cas18	raffety and malhalczo u(2)f4-5 unreflected (case18)	0.9977	0.0017	4.62707E-02
cas19	raffety and malhalczo u(2)f4-6 reflected (case 19)	0.9882	0.0015	3.33592E-02

cas20	raffety and malhalczo u(2)f4-6 unreflected (case20)	0.9873	0.0016	3.40929E-02
cas21	raffety and milhalczo u(3)f4-1 reflected (case 21) no bias	1.0139	0.0022	1.85045E-01
cas22	raffety and malhalczo u(3)f4-1 reflected (case 22)	1.0086	0.0026	1.86574E-01
cas23	raffety and malhalczo u(3)f4-1 reflected (case 23)	1.0087	0.0025	1.87329E-01
cas24	raffety and malhalczo u(3)f4-1 reflected (case 24) no biasing	1.0056	0.0021	1.86411E-01
cas25	raffety and malhalczo u(3)f4-1 reflected (case 25)	1.0064	0.0025	1.86497E-01
cas26	raffety and malhalczo u(3)f4-1 unreflected (case 26)	1.0089	0.0024	2.58533E-01
cas27	raffety and malhalczo u(3)f4-1 unreflected (case 27)	1.0080	0.0020	2.57356E-01
cas28	raffety and malhalczo u(3)f4-1 unreflected (case 28)	1.0083	0.0021	2.57319E-01
cas29	raffety and malhalczo u(3)f4-2 reflected (cas29)	1.0099	0.0022	6.94461E-02
cas30	raffety and malhalczo u(3)f4-2 unreflected (case 30)	1.0096	0.0024	8.17992E-02
cas31	raffety and malhalczo u(3)f4-2 unreflected (case 31)	1.0127	0.0025	8.18491E-02
cas32	raffety and malhalczo u(3)f4-2 unreflected (case 32)	1.0107	0.0025	8.23629E-02
cas33	critical reflected cylinder of aqueous u(4.98)o2f2 (case 33)	1.0031	0.0024	3.99815E-02
cas34	critical reflected cylinder of aqueous u(4.98)o2f2 (case 34)	0.9986	0.0023	3.90375E-02
cas35	critical sphere of aqueous u(4.98)o2f2 (case 35)	1.0017	0.0021	3.90282E-02
cas36	critical cylinder of aqueous u(4.98)o2f2 (case 36)	1.0013	0.0023	3.96570E-02

27-Group_LWR_Lattices

Case	Title	k-eff	sigma	EALF
cas01	exp#5, 8.39 cm h2o separating 3 20x16 arrays	0.9936	0.0015	7.32948E-02
cas02	exp#017, 5.05 cm h2o/boral separating 2 22x16 arrays and 1 20	0.9951	0.0012	7.49622E-02
cas03	exp#28, 6.88 cm h2o/ss separating 3 20x16 arrays	0.9954	0.0015	7.40122E-02
cas04	exp no. 14 8.58 cm h2o/ss separating 3 15x8 arrays	0.9950	0.0016	9.33947E-02
cas05	exp no. 23 7.28 cm h2o/cadmium separating 3 15x8 arrays	0.9949	0.0017	9.37307E-02
cas06	exp no. 31 6.72 cm h2o/boral separating 3 15x8 arrays	0.9958	0.0018	9.40061E-02
cas07	u refl. 1.956 cm from array, 14.11 cm h2o separating 3 19x1	0.9981	0.0015	1.35373E-01
cas08	pb refl. .660 cm from array, 13.72 cm h2o separating 3 19x16	0.9990	0.0014	7.48681E-02
cas09	no refl. 8.31cm h2o separating 19x16 arrays	0.9925	0.0015	7.30107E-02
cas10	uranium refl. 15.32cm h2o separating 12x8 arrays	1.0012	0.0018	2.26990E-01
cas11	lead refl. 20.78cm h2o separating 13x8 arrays	1.0067	0.0009	9.57487E-02
cas12	2.83cm and 3.60cm separating 4 11x14 arrays	0.9963	0.0020	2.61667E-01
cas13	2.83cm and 4.94cm separating 2 11x14 + 2 11x16 arrays	0.9980	0.0012	2.66483E-01
cas14	ss refl. 0.66 cm from array, 11.20 cm h2o separating 3 19x16	0.9964	0.0014	7.49206E-02
cas15	steel refl. 15.84cm h2o separating 3 12x16 arrays	1.0019	0.0017	2.40167E-01
cas16	steel refl. 9.83cm h2o separating 3 12x16 arrays w/borated	0.9974	0.0016	2.49256E-01
cas17	steel refl. 8.30cm h2o separating 3 12x16 arrays w/boral pl	0.9973	0.0016	2.54696E-01
cas18	steel refl. 8.94cm h2o separating 3 12x16 arrays w/cd plate	0.9988	0.0011	2.53015E-01
cas19	u refl 1.321 cm from array, 9.50 cm h2o sep. 23x18/2-20x18 ar	0.9920	0.0014	2.63682E-01
cas20	pb refl 0.660 cm from array, 10.11 cm h2o sep. 23x18/2-20x18	0.9954	0.0016	1.31238E-01
cas21	no refl infinite from array, 6.59 cm h2o sep. 23x18/2-20x18 a	0.9894	0.0017	1.24163E-01
cas22	uranium refl. 19.24cm h2o separating 12x16 arrays	0.9980	0.0018	4.21807E-01
cas23	lead refl. 18.18cm h2o separating 12x16 arrays	1.0010	0.0019	2.44825E-01
cas24	no refl. 12.91cm h2o separating 3 12x16 arrays	0.9928	0.0017	2.30886E-01
cas25	pnl-4267 exp. 173 40 x 8.92 array (357 total rods) boron = 0	0.9925	0.0014	2.30683E-01
cas26	pnl-4267 exp.177 40 x 30.92 array 1237 total rods) boron = 2.	0.9989	0.0014	5.20775E-01
cas27	pnl-4267 exp. 178 44 x 11.57array (509 total rods) boron = 0	0.9935	0.0011	4.41446E-01
cas28	pnl-4267 exp. 181 44 x 27.09 array (1192 total rods) boron =	0.9898	0.0013	1.00604E+00
cas29	pnl-4976 4.3-000-194 4.3%uo2 1.598cm-pitch	0.9963	0.0014	3.06248E+00
cas30	flux trap assembly no. 214r	0.9922	0.0015	3.08803E-01
cas31	flux trap assembly no. 214v3	0.9918	0.0012	3.07797E-01
cas32	baw-1231 core i 936 rods boron=1.152 g/l	0.9898	0.0011	6.15731E-01
cas33	baw-1231 core i 4904 rods boron=3.389 g/l	0.9904	0.0011	1.03030E+00
cas34	baw-1273 core xx 2.46 wt%u235 5137 rods	0.9903	0.0013	4.26890E-01
cas35	baw-1484-7 core iv exp 2282 2.46 wt%u235 9 assys 14x14 w/ 8	0.9900	0.0011	1.48972E-01
cas36	baw-1484-7 core ix exp 2321 2.46 wt%u235 9 assys 14x14	0.9879	0.0013	1.07245E-01
cas37	baw-1484-7 core xiii exp 2378 2.46 wt%u235 9 assys 14x14	0.9907	0.0014	1.52380E-01
cas38	baw-1484-7 core xxi exp 2420 2.46 wt%u235 9 assys 14x14	0.9859	0.0014	1.19936E-01
cas39	baw-1645-4 exp,mt=2452 triangular pitch=o.d. boron=435ppm	0.9871	0.0009	2.01240E+00
cas40	baw-1645-4 exp,mt=2485 pitch=o.d. boron=886ppm	0.9859	0.0015	1.21020E+00
cas41	baw-1645-4 exp,mt=2500 pitch=1.17*o.d. boron=1156ppm	0.9893	0.0014	3.39788E-01
cas42	baw-1810 core 12 - 4.02 & 2.46 w/o uo2 1899.3 ppm; no uo2-gd2	0.9942	0.0012	2.97288E-01
cas43	baw-1810 core 14 - 4.02 & 2.46 w/o uo2 1654 ppm; 28 uo2-gd2o3	0.9922	0.0012	2.76263E-01
cas44	baw-1810 core 16 - 4.02 & 2.46 w/o uo2 1579 ppm; 36 uo2-gd2o3	0.9913	0.0013	2.69143E-01
cas45	epri np-196 .615 inch pitch unborated uo2	0.9900	0.0014	2.05086E-01
cas46	epri np-196 .615 inch pitch borated uo2	0.9945	0.0015	2.53968E-01
cas47	epri np-196 .75 inch pitch unborated uo2	0.9941	0.0011	8.72283E-02
cas48	epri np-196 .75 inch pitch borated uo2	0.9959	0.0010	1.10618E-01
cas49	epri np-196 .87 inch pitch unborated uo2	0.9951	0.0014	6.30229E-02
cas50	epri np-196 .87 inch pitch borated uo2	0.9954	0.0012	7.14725E-02
cas51	saxton uo2 5.742 wt% u-235 critical exp. 0.56 inch pitch (wca	0.9943	0.0017	2.45481E-01
cas52	saxton uo2 5.742 wt% u-235 critical exp. 0.792inch pitch (wca	0.9980	0.0013	8.36359E-02
cas53	wcap-3269-39, 2692 fuel rods, 16 ag-in-cd rods,h2o ht=115.55	0.9975	0.0010	5.74663E-01
cas54	wcap-3269-39, 2209 fuel rods, 24 ag-in-cd rods,h2o ht=64.56 c	1.0001	0.0015	3.55053E-01
cas55	wcap-3269-39, 945 fuel rods, 16 ag-in-cd rods,h2o ht=89.75	0.9915	0.0012	2.02680E-01
cas56	4-18x18 array 5.0cm int.,polyethylene powder in box,30.16cm h	0.9982	0.0013	1.82579E-01
cas57	4-18x18 array 5.0cm int.,polyethylene balls in box,30.73cm h2	1.0048	0.0012	1.66669E-01
cas58	4-18x18 array 5.0cm int.,water in box,32.78cm h2o height	1.0069	0.0012	1.58953E-01
cas59	4-18x18 array 5.0cm int.,water without box,31.47cm h2o height	0.9929	0.0013	1.59847E-01

27-Group_Mixed_Oxide

Case	Title	k-eff	sigma	EALF
cas60	epri .70inch pitch unborated plutonium	0.9955	0.0015	4.85418E-01
cas61	epri .70inch pitch borated plutonium	0.9946	0.0015	6.59195E-01

cas62	epri .87inch pitch unborated plutonium	1.0018	0.0011	1.58773E-01
cas63	epri .87inch pitch borated plutonium	1.0065	0.0016	2.37206E-01
cas64	epri .99inch pitch unborated plutonium	1.0071	0.0017	1.12977E-01
cas65	epri .99inch pitch borated plutonium	1.0044	0.0010	1.52939E-01
cas66	saxton puo2-uo2 critical exp. 0.52 inch pitch (wcap-3385-54)	0.9991	0.0012	7.89713E-01
cas67	saxton puo2-uo2 critical exp. 0.56 inch pitch (wcap-3385-54)	1.0028	0.0018	4.79583E-01
cas68	saxton puo2-uo2 critical exp. 0.56 inch pitch with boron (wca	1.0004	0.0019	5.65981E-01
cas69	saxton puo2-uo2 critical exp. 0.735 inch pitch (wcap-3385-54)	1.0040	0.0019	1.62447E-01
cas70	saxton puo2-uo2 critical exp. 0.792 inch pitch (wcap-3385-54)	1.0065	0.0017	1.32753E-01
cas71	saxton puo2-uo2 critical exp. 01.04 inch pitch (wcap-3385-54)	1.0052	0.0017	8.57241E-02
cas72	pnl4976 exp196 1174 uo2 & 583 mo2 rods to approx. 20,000 mwd/	0.9891	0.0014	3.75185E+00
cas73	exp.no 021(063) pitch=968 (fuel region = pin array + mix 500	1.0110	0.0011	7.83215E-01
cas74	exp.no 032(060) pitch=1.935(fuel region=pin array+mix 500 wit	1.0134	0.0020	9.81348E-02
cas75	exp.no 043(062) pitch=1.242(fuel region=pin array+mix 500 wit	1.0107	0.0013	2.56284E-01
cas76	exp.no 067 pitch=0.761 (fuel region = pin array + mix 500 wit	1.0037	0.0011	2.61938E+00
cas77	exp. no 68r pitch=1.537 (fuel region = pin array + mix 500 wi	1.0096	0.0018	1.44861E-01

27-Group_Plutonium

Case	Title	k-eff	sigma	EALF
1727_09	la-3067-msr table iiia1, entry 13, water ref., metal, pu sphe	1.0050	0.0036	7.37764E+04
2109_20	benchmark 20, pu sphere with 25.4 cm concrete ref. h/pu=684.3	1.0296	0.0033	5.29605E-02
2109_21	benchmark 21, pu sphere with 10.16 cm concrete ref. h/pu=684.	1.0261	0.0035	5.08546E-02
2109_22	benchmark 22, pu sphere with 10.16 cm concrete ref. h/pu=496	1.0310	0.0037	6.29458E-02
2109_23	benchmark 23, pu sphere with cd shell & 10.16 cm concrete ref	1.0217	0.0037	6.95508E-02
2109_24	benchmark 24, pu sphere with cd shell & 32.00 cm water, h/pu=	1.0265	0.0039	5.98424E-02
2109_25	pu benchmark 25 from 2109, pu metal sphere reflected with nat	1.0051	0.0043	1.06688E+06
2110_02	benchmark#2 critical pu(no3)4solution, unreflected in a ss(ty	1.0198	0.0038	2.72852E-01
2110_04	sphere described by keno geometry	1.0249	0.0055	4.92471E-02
2110_05	rectangular parallelpipeds of homogeneous pu(2.2)o2	1.0507	0.0059	2.88407E+01
2110_06	rectangular parallelipiped of pu(2.2)o2 reflected with 15cm p	1.0378	0.0049	5.27143E+00
2110_07	benchmark#7 semi-inf homogeneous critical solution of pu-239	1.0184	0.0039	7.17644E-02
2110_08	rectangular parallelipiped of puo2	1.0367	0.0046	1.40745E+00
2110_09	rectangular parallelipipeds of pu02	1.0292	0.0047	6.92776E-01
2110_10	rectangular parallelipipeds of pu02	1.0228	0.0045	6.42973E-01
2110_11	rectangular parallelipipeds of pu02	1.0256	0.0048	6.58349E-01
2110_12	rectangular parallelipipeds of pu02	1.0233	0.0055	6.43369E-01
2110_13	sphere described by keno geometry	0.9985	0.0038	1.18711E+06
2110_14	cylinder described by keno geometry	1.0097	0.0056	1.20561E-01
2110_15	rectangular parallelipipeds of puo2-h20	1.0140	0.0045	2.27778E+05
2110_16	rectangular parallelipipeds of puo2-h20	1.0324	0.0037	8.93599E+05
2110_17	rectangular parallelipipeds of puo2-h20	1.0376	0.0036	1.64120E+03
2110_18	rectangular parallelipipeds of puo2-h20	1.0521	0.0034	3.65901E+03
2110_19	rectangular parallelipipeds of puo2-h20	1.0159	0.0032	4.26807E+03
2110_20	rectangular parallelipipeds of puo2-h20	1.0394	0.0033	2.20254E+03
2110_21	rectangular parallelipipeds of puo2-h20	1.0490	0.0035	1.72756E+03
2110_23	rectangular parallelipipeds of puo2-polystyrene	1.0285	0.0048	1.30875E+03
2110_24	rectangular parallelipipeds of puo2-polystyrene	1.0449	0.0036	8.36567E+01
2110_25	rectangular parallelipipeds of puo2-polystyrene	1.0361	0.0031	7.60241E+01
2110_26	rectangular parallelipipeds of puo2-polystyrene	1.0407	0.0036	6.03526E+01
2110_27	rectangular parallelipipeds of puo2-polystyrene	1.0363	0.0038	5.03329E+01
2110_29	cylinder described by keno geometry	1.0152	0.0033	4.35008E-02
pumf001	read parameters	0.9961	0.0021	1.15483E+06
pumf002	pu-met-fast-002	0.9980	0.0021	1.17833E+06
pust004	case 1,kvpusolnsphexp,27gp,26.27gpU/L, 0.54w/o240,h2orefl,14i	1.0144	0.0020	4.16522E-02
pust009	case 3a,kvpusolnsphexp,27,9.457gpU/L, 2.5w/o240,bare,48in dia	1.0315	0.0014	3.08556E-02

27-Group_U-233

Case	Title	k-eff	sigma	EALF
u233mf001	unreflected u233 sphere	0.9606	0.0022	9.53093E+05
u233mf002	case 1, 10 kg u233/heu sphere, ref u233-met-fast-002	0.9800	0.0019	9.20987E+05
u233mf002	case 2, 7.6 kg u233/heu sphere, ref u233-met-fast-002	0.9690	0.0018	9.34208E+05
u233mf003	case 1, 10 kg u233 sphere natural uranium reflector, ref u233	0.9720	0.0022	9.22547E+05
u233mf003	case 2, 7.6 kg u233 sphere natural uranium reflector, ref u23	0.9692	0.0018	9.15874E+05
u233mf004	case 1, 10 kg u233 sphere reflected by tungsten	0.9723	0.0023	8.38232E+05
u233mf005	case 1, 10 kg u233 sphere be reflector, ref u233-met-fast-xxx	0.9804	0.0018	7.55819E+05
u233mf006	u-233/nu sphere	0.9720	0.0020	9.05503E+05
u233st002	exp 4 simplified model	1.0280	0.0032	1.35803E-01
u233st002	exp 5 simplified model	1.0139	0.0029	1.03454E-01
u233st002	exp 8 simplified model	1.0228	0.0031	7.89827E-02
u233st002	exp 10 simplified model	1.0226	0.0028	6.30183E-02
u233st002	exp 11 simplified model	1.0257	0.0028	5.42097E-02
u233st002	exp 12 simplified model	1.0115	0.0029	4.79043E-02
u233st002	exp 14 simplified model	1.0016	0.0028	4.49952E-02
u233st002	exp 15 simplified model	1.0061	0.0029	4.11486E-02
u233st002	exp 17 simplified model	0.9979	0.0030	3.65743E-02
u233st002	exp 18 simplified model	1.0101	0.0025	3.51384E-02
u233st002	exp 19 simplified model	1.0192	0.0024	3.24831E-02
u233st002	exp 22 simplified model	1.0212	0.0033	2.21292E-01
u233st002	exp 24 simplified model	1.0177	0.0035	4.08451E-01
u233st002	exp 34 simplified model	1.0201	0.0030	1.07854E-01
u233st002	exp 35 simplified model	1.0245	0.0030	7.11163E-02
u233st002	exp 36 simplified model	1.0202	0.0028	4.58427E-02
u233st002	exp 38 simplified model	1.0172	0.0032	3.84771E-02
u233st004	exp 3 simplified model	1.0284	0.0035	1.35825E-01
u233st004	exp 6 simplified model	1.0273	0.0031	1.02251E-01

u233st004	exp 20 simplified model	1.0184	0.0030	2.19344E-01
u233st004	exp 25 simplified model	1.0095	0.0033	4.09481E-01
u233st004	exp 30 simplified model	1.0162	0.0031	3.16501E-01
u233st004	exp 27 simplified model	1.0330	0.0033	4.02504E-01
u233st004	exp 28 simplified model	1.0256	0.0033	3.16807E-01
u233st004	exp 33 simplified model	1.0244	0.0033	1.06962E-01

238-Group_High-Enriched_Uranium

Case	Title	k-eff	sigma	EALF
cas04	keno-5 validation case a-2	0.9929	0.0026	8.72602E+05
cas05	keno-5 validation case a-3	1.0029	0.0022	3.19847E-02
cas07	keno-5 validation case a-5	0.9985	0.0023	1.51839E+03
cas08	keno-5 validation case a-6	0.9674	0.0021	2.55059E+05
cas09	keno-5 validation case a-7	1.0059	0.0027	8.19004E+05
cas10	keno-5 validation case a-8	1.0015	0.0022	4.60081E+03
cas11	keno-5 validation case a-9	0.9903	0.0023	1.35781E+04
cas12	keno-5 validation case b-1	0.9863	0.0023	9.57343E+05
cas14	keno-5 validation case b-11	1.0401	0.0028	3.95126E-01
cas15	keno-5 validation case b-12	0.9962	0.0022	3.83563E+04
cas19	keno-5 validation case b-16	1.0271	0.0031	4.99861E-01
cas22	keno-5 validation case b-2	0.9911	0.0028	9.56962E+05
cas23	keno-5 validation case b-3	0.9908	0.0022	9.62937E+05
cas25	keno-5 validation case b-5	0.9921	0.0023	9.52954E+05
cas26	keno-5 validation case b-6	0.9953	0.0026	7.99033E+03
cas27	keno-5 validation case b-7	0.9972	0.0023	6.70276E+03
cas28	keno-5 validation case b-8	0.9995	0.0025	6.75293E+04
cas30	93.2% uo2f2 3 in al slab 3x1x1 array 0 in sep room	0.9999	0.0030	5.16381E-02
cas32	93.2% uo2f2 3 in al slab 3x1x1 array 1 in sep room	0.9797	0.0034	5.21406E-02
cas33	93.2% uo2f2 3 in al slab 3x1x1 array 1 in sep h2o refl	1.0010	0.0026	4.45316E-02
cas34	93.2% uo2f2 3 in al slab 3x1x1 array 3 in sep room	0.9800	0.0033	5.25296E-02
cas35	93.2% uo2f2 3 in al slab 3x1x1 array 3 in sep h2o refl	0.9925	0.0029	4.35018E-02
cas36	93.2% uo2f2 3 in al slab 3x1x1 array 4.5 in sep room	0.9870	0.0028	5.27040E-02
cas37	93.2% uo2f2 3 in al slab 3x1x1 array 4.5 in sep h2o refl	0.9965	0.0026	4.38570E-02
cas38	93.2% uo2f2 3 in al slab 3x1x1 array 5.5 in sep room	0.9869	0.0031	5.25612E-02
cas39	93.2% uo2f2 3 in al slab 3x1x1 array 5.5 in sep h2o refl	1.0011	0.0029	4.39968E-02
cas40	93.2% uo2f2 3 in al slab 3x1x1 array 6 in sep room	0.9880	0.0028	5.25405E-02
cas41	93.2% uo2f2 3, 6 in al slabs 2x1x1 array 15 in sep	0.9680	0.0028	5.22359E-02
cas42	93.2% uo2f2 3, 6 in al slabs 2x1x1 array 2 in sep	0.9797	0.0027	5.20680E-02
cas43	93.2% uo2f2 3, 6 in al slabs 2x1x1 array 30 in sep	0.9799	0.0027	5.21397E-02
cas44	93.2% uo2f2 3, 6 in al slabs 2x1x1 array 48 in sep	0.9774	0.0029	5.20884E-02
cas45	93.2% uo2f2 3, 6, 3 in al slabs 3x1x1 array 0 in sep	0.9871	0.0031	5.18392E-02
cas46	93.2% uo2f2 3, 6, 3 in al slabs 3x1x1 array 10 in sep	0.9755	0.0031	5.24709E-02
cas47	93.2% uo2f2 3, 6, 3 in al slabs 3x1x1 array 20 in sep	0.9764	0.0031	5.22873E-02
cas48	93.2% uo2f2 3, 6, 3 in al slabs 3x1x1 array 32 in sep	0.9753	0.0029	5.23936E-02
cas49	93.2% uo2f2 6 & 3 in al slabs 2x1x1 array 12 in sep	0.9821	0.0031	5.23102E-02
cas50	93.2% uo2f2 6 & 3 in al slabs 2x1x1 array 18 in sep	0.9779	0.0029	5.22187E-02
cas51	93.2% uo2f2 6 & 3 in al slabs 2x1x1 array 30 in sep	0.9837	0.0033	5.21954E-02
cas52	93.2% uo2f2 6 & 3 in al slabs 2x1x1 array 6 in sep	0.9843	0.0031	5.22766E-02
cas53	93.2% uo2f2 6 in al slab 2x1x1 array 15 in sep	0.9878	0.0030	5.20851E-02
cas54	93.2% uo2f2 6 in al slab 2x1x1 array 2 in sep	0.9762	0.0036	5.21981E-02
cas55	93.2% uo2f2 6 in al slab 2x1x1 array 20 in sep	0.9855	0.0035	5.20153E-02
cas56	93.2% uo2f2 6 in al slab 2x1x1 array 30 in sep	0.9827	0.0032	5.20723E-02
cas57	93.2% uo2f2 6 in al slab 2x1x1 array 48 in sep	0.9792	0.0028	5.19591E-02
cas58	93.2% uo2f2 6 in al slab 2x1x1 array 6 in sep	0.9750	0.0026	5.21925E-02
cas59	93.2% uo2f2 6 in al slab 2x1x1 array 66 in sep	0.9765	0.0029	5.22049E-02
cas60	uo2(no3)2 279 g U/L 3x3x3 array unrefl. walls, tank, & floor	0.9994	0.0036	1.63707E-01
cas61	uo2(no3)2 279 g U/L 2x2x2 array unrefl. walls, tank, & floor	0.9982	0.0028	1.59976E-01
cas62	uo2(no3)2 415 g U/L 5x5x5 array unrefl. walls, tank, & floor	0.9935	0.0029	3.27299E-01
cas63	uo2(no3)2 415 g U/L 3x3x3 array unrefl. walls, tank, & floor	0.9907	0.0031	3.32000E-01
cas64	uo2(no3)2 415 g U/L 4x4x4 array unrefl. walls, floor, & tank	0.9849	0.0027	3.32017E-01
cas65	uo2(no3)2 415 g U/L 2x2x2 array unrefl. walls, floor, & tank	0.9943	0.0028	3.21700E-01
cas66	uo2(no3)2 415 g U/L 3x3x3 array 15.24 cm par. bot., 1.27 cm p	0.9987	0.0031	2.85922E-01
cas67	uo2(no3)2 415 g U/L 3x3x3 array 15.24 cm par. bot., 2.54 cm p	1.0057	0.0028	2.60094E-01
cas68	uo2(no3)2 415 g U/L 3x3x3 array 15.24 cm par. bot., 1.27 cm p	1.0098	0.0030	2.74454E-01
cas69	uo2(no3)2 415 g U/L 3x3x3 array 15.24 cm par 5 fc, plex 1 fc	1.0098	0.0031	2.13964E-01
cas70	uo2(no3)2 415 g U/L 3x3x3 array 15.24 cm par. bot., 3.81 cm p	1.0136	0.0025	2.29726E-01
cas71	uo2(no3)2 415 g U/L 3x3x3 array 15.24 cm par. bot., 7.62 cm p	1.0174	0.0028	2.16388E-01
cas72	uo2(no3)2 415 g U/L 3x3x3 array 1.27 cm plexiglass refl.	0.9957	0.0029	3.01624E-01
cas73	uo2(no3)2 415 g U/L 3x3x3 array 1.27 cm paraffin refl.	1.0079	0.0030	2.87622E-01
cas74	uo2(no3)2 415 g U/L 3x3x3 array 15.24 cm paraffin refl.	1.0148	0.0033	2.14444E-01
cas75	uo2(no3)2 415 g U/L 3x3x3 array 3.81 cm paraffin refl.	1.0185	0.0029	2.31371E-01
cas76	uo2(no3)2 415 g U/L 2x2x2 array 15.24 cm par. bot., 1.27 cm p	1.0085	0.0034	2.79851E-01
cas77	uo2(no3)2 415 g U/L 2x2x2 array 15.24 cm par. bot., 11.43 cm	1.0162	0.0035	2.09829E-01
cas78	uo2(no3)2 415 g U/L 2x2x2 array 15.24 cm par. bot., 15.24 cm	1.0196	0.0034	2.10811E-01
cas79	uo2(no3)2 415 g U/L 2x2x2 array 15.24 cm par. bot., 2.54 cm p	1.0061	0.0030	2.57502E-01
cas80	uo2(no3)2 415 g U/L 2x2x2 array 15.24 cm par. bot., 4.45 cm p	1.0117	0.0030	2.32547E-01
cas81	uo2(no3)2 415 g U/L 2x2x2 array 15.24 cm par. bot., 6.35 cm p	1.0169	0.0034	2.20610E-01
cas82	uo2(no3)2 415 g U/L 2x2x2 array 15.24 cm par. bot., 1.27 cm p	1.0019	0.0035	2.71412E-01
cas83	uo2(no3)2 415 g U/L 2x2x2 array 15.24 cm par. bot., 3.81 cm p	1.0133	0.0029	2.26284E-01
cas84	uo2(no3)2 415 g U/L 2x2x2 array 15.24 cm par. bot., 7.62 cm p	1.0096	0.0029	2.13056E-01
cas85	uo2(no3)2 415 g U/L 2x2x2 array 1.27 cm plexiglass refl.	1.0027	0.0032	2.93017E-01
cas86	uo2(no3)2 415 g U/L 2x2x2 array 1.27 cm paraffin refl.	1.0006	0.0031	2.85736E-01
cas87	uo2(no3)2 415 g U/L 2x2x2 array 15.24 cm paraffin refl.	1.0051	0.0030	2.10814E-01
cas88	uo2(no3)2 415 g U/L 2x2x2 array 3.81 cm paraffin refl.	1.0143	0.0030	2.30669E-01
cas89	uo2(no3)2 415 g U/L 2x2x2 array 7.62 cm paraffin refl.	1.0145	0.0032	2.14353E-01

cas90	uo2(no3)2 415 g U/L 3x3x3 array unrefl. 279 g U/L 5 cent. uni	0.9988	0.0033	2.68293E-01
cas91	uo2(no3)2 63.3 g U/L 3x3x3 array unrefl. walls, floor, & tank	1.0047	0.0028	4.35694E-02
jemima	disks - 15" diam plates 93.15 w% enriched stacked to 3.0258"	0.9901	0.0023	9.54288E+05
jemima	jemima - ~1/8" x 15" diam u(93.29) plates with 1/16" thk poly	0.9856	0.0025	1.29348E+05
jemima	jemima - ~1/8" thk 15" diam u(93.24) plates with 1/8" thk pol	0.9907	0.0022	1.96389E+04
jemima	jemima - ~1/8" thk 15" diam u(93.24) plates with 1/4" thk pol	0.9795	0.0028	1.87563E+03
jemima	jemima - ~1/8" thk 15" diam u(93.24) plates with 1/2" thk pol	1.0033	0.0033	9.10357E+01
jemima	jemima - ~1/8" thk 15" diam u(93.24) plates with 1" thk poly,	0.9961	0.0029	7.84216E+00
jemima	jemima - ~1/8" x 15" dia u(93) with symetric 1-1/2" thk poly,	1.0126	0.0029	3.32451E+00
jemima	jemima - ~1/8" x 15" dia u(93) with symetric 2" thk poly, pg-	1.0030	0.0026	2.15208E+00
heumf001	godiva	0.9947	0.0017	9.46515E+05
heumf004	water-reflected heu sphere on hollow plexiglas cylinder	0.9949	0.0019	3.17230E+04
heust001	case 1 heust001	1.0034	0.0023	8.15659E-02
heust001	case 2 heust001	0.9965	0.0025	2.78903E-01
heust001	case 3 heust001	1.0004	0.0022	8.02241E-02
heust001	case 4 heust001	1.0015	0.0026	2.97525E-01
heust001	case 5 heust001	0.9991	0.0020	4.26179E-02
heust001	case 6 heust001	1.0037	0.0022	4.41837E-02
heust001	case 7 heust001	1.0023	0.0024	7.72749E-02
heust001	case 8 heust001	1.0041	0.0025	8.16412E-02
heust001	case 9 heust001	1.0010	0.0024	2.97578E-01
heust001	case 10 heust001	0.9947	0.0024	4.57878E-02
heust007	case 1 , heust007	1.0103	0.0020	4.70221E-02
heust007	case 2 , heust007	1.0127	0.0025	2.69161E-01
heust007	case 3 , heust007	1.0152	0.0020	4.57855E-02
heust007	case 4 , heust007	1.0156	0.0021	2.38054E-01
heust007	case 5 , heust007	1.0092	0.0024	4.98972E-02
heust007	case 6 , heust007	0.9990	0.0025	2.76414E-01
heust007	case 7 , heust007	1.0077	0.0021	4.93724E-02
heust007	case 8 , heust007	0.9985	0.0023	2.69885E-01
heust007	case 9 , heust007	1.0098	0.0020	5.09965E-02
heust007	case 10 , heust007	1.0190	0.0018	5.25449E-02
heust007	case 11 , heust007	1.0068	0.0025	2.58842E-01
heust007	case 12 , heust007	1.0168	0.0019	5.08038E-02
heust007	case 13 , heust007	1.0133	0.0024	2.32334E-01
heust007	case 14 , heust007	1.0109	0.0023	2.39805E-01
heust007	case 15 , heust007	1.0066	0.0024	2.42767E-01
heust007	case 16 , heust007	1.0075	0.0020	2.57196E-01
heust007	case 17 , heust007	1.0122	0.0022	2.40834E-01
heust008	case 1 , heust008	1.0030	0.0021	4.41151E-02
heust008	case 2 , heust008	1.0001	0.0022	2.35278E-01
heust008	case 3 , heust008	0.9982	0.0022	4.28655E-02
heust008	case 4 , heust008	1.0045	0.0024	2.08457E-01
heust008	case 5 , heust008	0.9954	0.0020	4.39679E-02
heust008	case 6 , heust008	1.0040	0.0023	2.56841E-01
heust008	case 7 , heust008	0.9994	0.0021	4.31425E-02
heust008	case 8 , heust008	0.9942	0.0027	2.43907E-01
heust008	case 9 , heust008	1.0026	0.0019	4.38698E-02
heust008	case 10 , heust008	0.9961	0.0021	2.34092E-01
heust008	case 11 , heust008	0.9993	0.0019	4.22503E-02
heust008	case 12 , heust008	0.9941	0.0026	2.03867E-01
heust008	case 13 , heust008	0.9952	0.0022	2.31398E-01
heust008	case 14 , heust008	1.0003	0.0024	2.09187E-01
heust013	uranium aqueous 23 cm sphere #1	0.9975	0.0014	3.23536E-02
heust013	uranium aqueous 32 cm sphere #2	0.9996	0.0015	3.38035E-02
heust013	uranium aqueous 32 cm sphere #3	0.9973	0.0016	3.51838E-02
heust013	uranium aqueous 32 cm sphere #4	0.9949	0.0018	3.59196E-02

238-Group_Low-Enriched_Uranium

Case	Title	k-eff	sigma	EALF
car01	rocky flats criticals nureg/cr-1071 experiment number 1 (27 g	1.0120	0.0022	4.49065E-01
car02	rocky flats criticals nureg/cr-1071 experiment number 2 (27 g	1.0037	0.0024	4.62296E-01
car03	rocky flats criticals nureg/cr-1071 experiment number 3 (27 g	0.9906	0.0026	1.57168E+00
car04	rocky flats criticals nureg/cr-1071 experiment number 13 (27	1.0149	0.0022	5.12451E-01
car06	rocky flats criticals nureg/cr-0674 experiment number ? (27 g	0.9855	0.0031	4.07508E+02
car07	rocky flats criticals nureg/cr-0674 experiment number ? (27 g	0.9975	0.0029	4.02812E+00
car08	rocky flats criticals nureg/cr-0674 experiment number ? (27 g	0.9920	0.0035	2.13766E+00
car09	rocky flats criticals nureg/cr-0674 experiment number 2 (27 g	0.9961	0.0032	2.07664E+00
car10	rocky flats criticals nureg/cr-0674 concrete reflected (27 gr	0.9994	0.0033	5.80807E+00
car11	rocky flats criticals nureg/cr-1653 experiment a (27 group)	1.0089	0.0027	3.98382E-01
car12	rocky flats criticals nureg/cr-1653 experiment b (27 group)	1.0185	0.0024	1.01915E+00
car14	rocky flats criticals nureg/cr-1653 experiment number ? (27 g	0.9960	0.0031	3.19301E+00
car15	rocky flats criticals nureg/cr-1653 experiment number ? (27 g	1.0022	0.0026	3.19702E+00
car16	rocky flats criticals nureg/cr-1653 experiment number ? (27 g	1.0022	0.0029	2.02756E+00
car17	rocky flats criticals nureg/cr-2500 experiment f (27 group)	1.0029	0.0025	6.84178E-01
car19	rocky flats criticals nureg/cr-2500 experiment number ? (27 g	0.9979	0.0023	3.88138E+00
car20	rocky flats criticals nureg/cr-2500 experiment number ? (27 g	0.9941	0.0028	3.55597E+00
cas04	british handbook of criticality safety u(1.42)f4 & paraffin (	0.9888	0.0020	1.23327E-01
cas05	british handbook of criticality safety u(1.42)f4 & paraffin (	0.9933	0.0021	1.22794E-01
cas06	british handbook of criticality safety u(1.42)f4 & paraffin (	0.9875	0.0021	1.23536E-01
cas11	raffety and malhalczo u(2)f4-1 reflected (case 11)	1.0009	0.0025	2.03221E-01
cas12	raffety and malhalczo u(2)f4-1 unreflected (case12)	0.9964	0.0025	2.45621E-01
cas13	raffety and malhalczo u(2)f4-2 reflected (case 13) no biasing	1.0057	0.0023	1.19077E-01
cas14	raffety and malhalczo u(2)f4-2 unreflected (case 14)	1.0011	0.0021	1.37058E-01
cas15	raffety and malhalczo u(2)f4-3 reflected (case 15)	0.9975	0.0022	8.68601E-02
cas16	raffety and malhalczo u(2)f4-4 reflected (case 16)	0.9988	0.0021	7.31192E-02

cas17	raffety and malhalczo u(2)f4-5 reflected (case 17)	0.9990	0.0021	6.32955E-02
cas18	raffety and malhalczo u(2)f4-5 unreflected (case18)	0.9942	0.0024	6.68026E-02
cas19	raffety and malhalczo u(2)f4-6 reflected (case 19)	0.9897	0.0019	4.89725E-02
cas20	raffety and malhalczo u(2)f4-6 unreflected (case20)	0.9938	0.0019	4.99469E-02
cas21	raffety and milhalczo u(3)f4-1 reflected (case 21) no bias	1.0179	0.0024	2.40291E-01
cas22	raffety and malhalczo u(3)f4-1 reflected (case 22)	1.0127	0.0026	2.42018E-01
cas23	raffety and malhalczo u(3)f4-1 reflected (case 23)	1.0123	0.0025	2.40792E-01
cas24	raffety and malhalczo u(3)f4-1 reflected (case 24) no biasing	1.0133	0.0022	2.41798E-01
cas25	raffety and malhalczo u(3)f4-1 reflected (case 25)	1.0142	0.0026	2.38868E-01
cas26	raffety and malhalczo u(3)f4-1 unreflected (case 26)	1.0169	0.0024	3.24076E-01
cas27	raffety and malhalczo u(3)f4-1 unreflected (case 27)	1.0107	0.0028	3.28492E-01
cas28	raffety and malhalczo u(3)f4-1 unreflected (case 28)	1.0121	0.0024	3.27693E-01
cas29	raffety and malhalczo u(3)f4-2 reflected (cas29)	1.0129	0.0026	9.54956E-02
cas30	raffety and malhalczo u(3)f4-2 unreflected (case 30)	1.0121	0.0022	1.12435E-01
cas31	raffety and malhalczo u(3)f4-2 unreflected (case 31)	1.0126	0.0029	1.12253E-01
cas32	raffety and malhalczo u(3)f4-2 unreflected (case 32)	1.0108	0.0026	1.12948E-01
cas33	critical reflected cylinder of aqueous u(4.98)o2f2 (case 33)	0.9993	0.0024	5.65883E-02
cas34	critical reflected cylinder of aqueous u(4.98)o2f2 (case 34)	1.0024	0.0022	5.58962E-02
cas35	critical sphere of aqueous u(4.98)o2f2 (case 35)	1.0023	0.0023	5.59508E-02
cas36	critical cylinder of aqueous u(4.98)o2f2 (case 36)	0.9966	0.0027	5.64167E-02

238-Group_LWR_Lattices

Case	Title	k-eff	sigma	EALF
cas01	exp#5, 8.39 cm h2o separating 3 20x16 arrays	0.9935	0.0019	9.72779E-02
cas02	exp#017, 5.05 cm h2o/boral separating 2 22x16 arrays and 1 20	0.9963	0.0011	9.99550E-02
cas03	exp#28, 6.88 cm h2o/ss separating 3 20x16 arrays	0.9949	0.0017	9.74634E-02
cas04	exp no. 14 8.58 cm h2o/ss separating 3 15x8 arrays	0.9980	0.0018	1.15539E-01
cas05	exp no. 23 7.28 cm h2o/cadmium separating 3 15x8 arrays	0.9975	0.0018	1.15129E-01
cas06	exp no. 31 6.72 cm h2o/boral separating 3 15x8 arrays	0.9975	0.0017	1.16097E-01
cas07	u refl. 1.956 cm from array, 14.11 cm h2o separating 3 19x1	0.9970	0.0015	1.75684E-01
cas08	pb refl. .660 cm from array, 13.72 cm h2o separating 3 19x16	1.0033	0.0014	9.81849E-02
cas09	no refl. 8.31cm h2o separating 19x16 arrays	0.9929	0.0018	9.63093E-02
cas10	uranium refl. 15.32cm h2o separating 12x8 arrays	1.0007	0.0015	2.76143E-01
cas11	lead refl. 20.78cm h2o separating 13x8 arrays	1.0085	0.0009	1.17492E-01
cas12	2.83cm and 3.60cm separating 4 11x14 arrays	1.0006	0.0018	3.15834E-01
cas13	2.83cm and 4.94cm separating 2 11x14 + 2 11x16 arrays	0.9979	0.0014	3.22608E-01
cas14	ss refl. 0.66 cm from array, 11.20 cm h2o separating 3 19x16	0.9988	0.0017	9.94491E-02
cas15	steel refl. 15.84cm h2o separating 3 12x16 arrays	0.9994	0.0018	2.91242E-01
cas16	steel refl. 9.83cm h2o separating 3 12x16 arrays w/borated	0.9988	0.0019	3.01840E-01
cas17	steel refl. 8.30cm h2o separating 3 12x16 arrays w/boral pl	0.9983	0.0017	3.08394E-01
cas18	steel refl. 8.94cm h2o separating 3 12x16 arrays w/cd plate	0.9971	0.0014	3.05121E-01
cas19	u refl 1.321 cm from array, 9.50 cm h2o sep. 23x18/2-20x18 ar	0.9913	0.0014	3.45496E-01
cas20	pb refl 0.660 cm from array, 10.11 cm h2o sep. 23x18/2-20x18	0.9990	0.0016	1.70965E-01
cas21	no refl infinite from array, 6.59 cm h2o sep. 23x18/2-20x18 a	0.9862	0.0016	1.63154E-01
cas22	uranium refl. 19.24cm h2o separating 12x16 arrays	0.9955	0.0018	5.13386E-01
cas23	lead refl. 18.18cm h2o separating 12x16 arrays	1.0014	0.0018	2.96916E-01
cas24	no refl. 12.91cm h2o separating 3 12x16 arrays	0.9968	0.0017	2.81792E-01
cas25	pnl-4267 exp. 173 40 x 8.92 array (357 total rods) boron = 0	0.9927	0.0013	2.81114E-01
cas26	pnl-4267 exp.177 40 x 30.92 array 1237 total rods) boron = 2.	0.9992	0.0014	6.05176E-01
cas27	pnl-4267 exp. 178 44 x 11.57array (509 total rods) boron = 0	0.9944	0.0012	5.26820E-01
cas28	pnl-4267 exp. 181 44 x 27.09 array (1192 total rods) boron =	0.9932	0.0017	1.16687E+00
cas29	pnl-4976 4.3-000-194 4.3%uo2 1.598cm-pitch	0.9983	0.0015	3.50327E+00
cas30	flux trap assembly no. 214r	0.9940	0.0016	3.70966E-01
cas31	flux trap assembly no. 214v3	0.9950	0.0012	3.71058E-01
cas32	baw-1231 core i 936 rods boron=1.152 g/l	0.9902	0.0012	7.41684E-01
cas33	baw-1231 core i 4904 rods boron=3.389 g/l	0.9925	0.0010	1.20418E+00
cas34	baw-1273 core xx 2.46 wt%u235 5137 rods	0.9877	0.0014	5.39135E-01
cas35	baw-1484-7 core iv exp 2282 2.46 wt%u235 9 assys 14x14 w/ 8	0.9917	0.0011	1.91459E-01
cas36	baw-1484-7 core ix exp 2321 2.46 wt%u235 9 assys 14x14	0.9918	0.0015	1.40568E-01
cas37	baw-1484-7 core xiii exp 2378 2.46 wt%u235 9 assys 14x14	0.9971	0.0016	1.96163E-01
cas38	baw-1484-7 core xxi exp 2420 2.46 wt%u235 9 assys 14x14	0.9902	0.0016	1.56510E-01
cas39	baw-1645-4 exp,mt=2452 triangular pitch=o.d. boron=435ppm	0.9980	0.0011	2.32818E+00
cas40	baw-1645-4 exp,mt=2485 pitch=o.d. boron=886ppm	0.9956	0.0013	1.43103E+00
cas41	baw-1645-4 exp,mt=2500 pitch=1.17*o.d. boron=1156ppm	0.9953	0.0013	4.21402E-01
cas42	baw-1810 core 12 - 4.02 & 2.46 w/o uo2 1899.3 ppm; no uo2-gd2	0.9951	0.0014	3.59815E-01
cas43	baw-1810 core 14 - 4.02 & 2.46 w/o uo2 1654 ppm; 28 uo2-gd2o3	0.9973	0.0012	3.40863E-01
cas44	baw-1810 core 16 - 4.02 & 2.46 w/o uo2 1579 ppm; 36 uo2-gd2o3	0.9946	0.0014	3.35341E-01
cas45	epri np-196 .615 inch pitch unborated uo2	0.9915	0.0015	2.62708E-01
cas46	epri np-196 .615 inch pitch borated uo2	0.9959	0.0015	3.24378E-01
cas47	epri np-196 .75 inch pitch unborated uo2	0.9952	0.0011	1.15987E-01
cas48	epri np-196 .75 inch pitch borated uo2	0.9971	0.0010	1.43469E-01
cas49	epri np-196 .87 inch pitch unborated uo2	0.9975	0.0015	8.38792E-02
cas50	epri np-196 .87 inch pitch borated uo2	0.9986	0.0014	9.43365E-02
cas51	saxton uo2 5.742 wt% u-235 critical exp. 0.56 inch pitch (wca	0.9928	0.0019	2.94992E-01
cas52	saxton uo2 5.742 wt% u-235 critical exp. 0.792inch pitch (wca	0.9970	0.0011	1.03491E-01
cas53	wcap-3269-39, 2692 fuel rods, 16 ag-in-cd rods,h2o ht=115.55	0.9967	0.0012	7.02891E-01
cas54	wcap-3269-39, 2209 fuel rods, 24 ag-in-cd rods,h2o ht=64.56 c	0.9969	0.0018	4.35257E-01
cas55	wcap-3269-39, 945 fuel rods, 16 ag-in-cd rods,h2o ht=89.75	0.9922	0.0011	2.59930E-01
cas56	4-18x18 array 5.0cm int.,polyethylene powder in box,30.16cm h	0.9955	0.0014	2.28675E-01
cas57	4-18x18 array 5.0cm int.,polyethylene balls in box,30.73cm h2	1.0081	0.0012	2.07415E-01
cas58	4-18x18 array 5.0cm int.,water in box,32.78cm h2o height	1.0089	0.0014	1.98793E-01
cas59	4-18x18 array 5.0cm int.,water without box,31.47cm h2o height	0.9937	0.0013	1.97221E-01

238-Group_Mixed_Oxide

Case	Title	k-eff	sigma	EALF
cas60	epri .70inch pitch unborated plutonium	0.9950	0.0016	5.79362E-01
cas61	epri .70inch pitch borated plutonium	0.9937	0.0014	7.73542E-01
cas62	epri .87inch pitch unborated plutonium	0.9996	0.0012	1.92595E-01
cas63	epri .87inch pitch borated plutonium	1.0065	0.0013	2.80882E-01
cas64	epri .99inch pitch unborated plutonium	1.0058	0.0017	1.36046E-01
cas65	epri .99inch pitch borated plutonium	1.0043	0.0011	1.83063E-01
cas66	saxton puo2-uo2 critical exp. 0.52 inch pitch (wcap-3385-54)	0.9940	0.0013	9.08366E-01
cas67	saxton puo2-uo2 critical exp. 0.56 inch pitch (wcap-3385-54)	0.9958	0.0020	5.56103E-01
cas68	saxton puo2-uo2 critical exp. 0.56 inch pitch with boron (wca	0.9994	0.0017	6.52494E-01
cas69	saxton puo2-uo2 critical exp. 0.735 inch pitch (wcap-3385-54)	1.0002	0.0019	1.87434E-01
cas70	saxton puo2-uo2 critical exp. 0.792 inch pitch (wcap-3385-54)	0.9985	0.0021	1.55424E-01
cas71	saxton puo2-uo2 critical exp. 01.04 inch pitch (wcap-3385-54)	1.0041	0.0017	1.00630E-01
cas72	pnl4976 exp196 1174 uo2 & 583 mo2 rods to approx. 20,000 mwd/	0.9907	0.0016	4.33548E+00
cas73	exp.no 021(063) pitch=968 (fuel region = pin array + mix 500	1.0010	0.0013	8.87803E-01
cas74	exp.no 032(060) pitch=1.935(fuel region=pin array+mix 500 wit	1.0093	0.0018	1.13573E-01
cas75	exp.no 043(062) pitch=1.242(fuel region=pin array+mix 500 wit	1.0010	0.0012	2.89041E-01
cas76	exp.no 067 pitch=0.761 (fuel region = pin array + mix 500 wit	0.9954	0.0012	2.90946E+00
cas77	exp. no 68r pitch=1.537 (fuel region = pin array + mix 500 wi	1.0009	0.0020	1.64627E-01

238-Group_Plutonium

Case	Title	k-eff	sigma	EALF
1727_09	la-3067-msr table iiia1, entry 13, water ref., metal, pu sphe	0.9941	0.0037	8.74593E+04
2109_20	benchmark 20, pu sphere with 25.4 cm concrete ref. h/pu=684.3	1.0248	0.0033	6.68450E-02
2109_21	benchmark 21, pu sphere with 10.16 cm concrete ref. h/pu=684.	1.0303	0.0030	6.47639E-02
2109_22	benchmark 22, pu sphere with 10.16 cm concrete ref. h/pu=496	1.0284	0.0040	7.80916E-02
2109_23	benchmark 23, pu sphere with cd shell & 10.16 cm concrete ref	1.0207	0.0037	8.61406E-02
2109_24	benchmark 24, pu sphere with cd shell & 32.00 cm water, h/pu=	1.0093	0.0045	7.55822E-02
2109_25	pu benchmark 25 from 2109, pu metal sphere reflected with nat	1.0099	0.0046	1.09881E+06
2110_02	benchmark#2 critical pu(no3)4solution, unreflected in a ss(ty	0.9982	0.0042	3.14377E-01
2110_04	sphere described by keno geometry	1.0106	0.0054	6.25452E-02
2110_05	rectangular parallelpipeds of homogeneous pu(2.2)o2	1.0215	0.0055	3.25438E+01
2110_06	rectangular parallelipiped of pu(2.2)o2 reflected with 15cm p	1.0324	0.0062	5.75456E+00
2110_07	benchmark#7 semi-inf homogeneous critical solution of pu-239	1.0156	0.0042	8.90235E-02
2110_08	rectangular parallelipiped of puo2	0.9965	0.0045	1.61025E+00
2110_09	rectangular parallelipipeds of pu02	1.0129	0.0045	7.49517E-01
2110_10	rectangular parallelipipeds of pu02	1.0060	0.0044	7.15587E-01
2110_11	rectangular parallelipipeds of pu02	1.0122	0.0052	6.92043E-01
2110_12	rectangular parallelipipeds of pu02	1.0138	0.0049	7.04008E-01
2110_13	sphere described by keno geometry	0.9893	0.0038	1.26282E+06
2110_14	cylinder described by keno geometry	1.0160	0.0054	1.42869E-01
2110_15	rectangular parallelipipeds of puo2-h20	0.9892	0.0047	2.76979E+05
2110_16	rectangular parallelipipeds of puo2-h20	1.0306	0.0036	1.01504E+06
2110_17	rectangular parallelipipeds of puo2-h20	1.0177	0.0033	1.81528E+03
2110_18	rectangular parallelipipeds of puo2-h20	1.0359	0.0035	4.02615E+03
2110_19	rectangular parallelipipeds of puo2-h20	1.0036	0.0035	4.90390E+03
2110_20	rectangular parallelipipeds of puo2-h20	1.0272	0.0036	2.52214E+03
2110_21	rectangular parallelipipeds of puo2-h20	1.0326	0.0033	2.06263E+03
2110_23	rectangular parallelipipeds of puo2-polystyrene	1.0071	0.0045	1.67868E+03
2110_24	rectangular parallelipipeds of puo2-polystyrene	1.0263	0.0030	9.63733E+01
2110_25	rectangular parallelipipeds of puo2-polystyrene	1.0213	0.0034	8.13644E+01
2110_26	rectangular parallelipipeds of puo2-polystyrene	1.0214	0.0032	6.68965E+01
2110_27	rectangular parallelipipeds of puo2-polystyrene	1.0267	0.0036	5.85304E+01
2110_29	cylinder described by keno geometry	1.0045	0.0042	5.66907E-02
pumf001	read parameters	0.9948	0.0022	1.24211E+06
pumf002	pu-met-fast-002	0.9970	0.0021	1.26133E+06
pust004	case 1,kvpusolnsphexp,27gp,26.27gpU/L, 0.54w/o240,h2orefl,14i	1.0106	0.0016	5.33603E-02
pust009	case 3a,kvpusolnsphexp,27,9.457gpU/L, 2.5w/o240,bare,48in dia	1.0252	0.0014	4.06586E-02

238-Group_U-233

Case	Title	k-eff	sigma	EALF
u233mf001	unreflected u233 sphere	0.9949	0.0021	1.12624E+06
u233mf002	case 1, 10 kg u233/heu sphere, ref u233-met-fast-002	1.0009	0.0018	1.07140E+06
u233mf002	case 2, 7.6 kg u233/heu sphere, ref u233-met-fast-002	0.9968	0.0019	1.09184E+06
u233mf003	case 1, 10 kg u233 sphere natural uranium reflector, ref u233	0.9973	0.0019	1.08439E+06
u233mf003	case 2, 7.6 kg u233 sphere natural uranium reflector, ref u23	0.9944	0.0021	1.06831E+06
u233mf004	case 1, 10 kg u233 sphere reflected by tungsten	1.0034	0.0021	9.72986E+05
u233mf005	case 1, 10 kg u233 sphere be reflector, ref u233-met-fast-xxx	0.9990	0.0017	9.45442E+05
u233mf006	u-233/nu sphere	0.9999	0.0018	1.00260E+06
u233st002	exp 4 simplified model	1.0073	0.0029	1.65051E-01
u233st002	exp 5 simplified model	0.9880	0.0030	1.27540E-01
u233st002	exp 8 simplified model	1.0075	0.0030	9.98798E-02
u233st002	exp 10 simplified model	0.9968	0.0030	8.20234E-02
u233st002	exp 11 simplified model	1.0062	0.0028	7.17533E-02
u233st002	exp 12 simplified model	0.9895	0.0026	6.41775E-02
u233st002	exp 14 simplified model	0.9790	0.0028	6.07490E-02
u233st002	exp 15 simplified model	0.9948	0.0029	5.59668E-02
u233st002	exp 17 simplified model	0.9857	0.0025	5.05877E-02
u233st002	exp 18 simplified model	0.9958	0.0026	4.89457E-02
u233st002	exp 19 simplified model	1.0082	0.0024	4.56554E-02
u233st002	exp 22 simplified model	0.9939	0.0031	2.54080E-01

u233st002	exp 24 simplified model	0.9892	0.0035	4.53345E-01
u233st002	exp 34 simplified model	0.9974	0.0032	1.34044E-01
u233st002	exp 35 simplified model	1.0059	0.0030	9.20007E-02
u233st002	exp 36 simplified model	1.0074	0.0030	6.16613E-02
u233st002	exp 38 simplified model	1.0005	0.0025	5.32661E-02
u233st004	exp 3 simplified model	1.0034	0.0037	1.61695E-01
u233st004	exp 6 simplified model	1.0009	0.0031	1.26983E-01
u233st004	exp 20 simplified model	0.9963	0.0034	2.56595E-01
u233st004	exp 25 simplified model	0.9835	0.0034	4.49624E-01
u233st004	exp 30 simplified model	0.9965	0.0036	3.59591E-01
u233st004	exp 27 simplified model	1.0032	0.0032	4.52504E-01
u233st004	exp 28 simplified model	0.9970	0.0031	3.55180E-01
u233st004	exp 33 simplified model	0.9992	0.0029	1.31412E-01

44-Group_High-Enriched_Uranium

Case	Title	k-eff	sigma	EALF
cas04	keno-5 validation case a-2	0.9961	0.0022	8.27402E+05
cas05	keno-5 validation case a-3	1.0028	0.0021	3.03857E-02
cas07	keno-5 validation case a-5	1.0055	0.0021	1.43512E+03
cas08	keno-5 validation case a-6	0.9626	0.0021	2.56420E+05
cas09	keno-5 validation case a-7	0.9965	0.0025	8.02787E+05
cas10	keno-5 validation case a-8	1.0102	0.0025	4.68810E+03
cas11	keno-5 validation case a-9	0.9915	0.0023	1.29666E+04
cas12	keno-5 validation case b-1	0.9969	0.0024	9.11484E+05
cas14	keno-5 validation case b-11	1.0541	0.0028	3.83565E-01
cas15	keno-5 validation case b-12	0.9978	0.0022	3.97055E+04
cas19	keno-5 validation case b-16	1.0293	0.0035	4.91972E-01
cas22	keno-5 validation case b-2	0.9957	0.0023	9.12139E+05
cas23	keno-5 validation case b-3	0.9904	0.0022	9.20083E+05
cas25	keno-5 validation case b-5	1.0015	0.0023	9.16032E+05
cas26	keno-5 validation case b-6	1.0039	0.0026	8.46295E+03
cas27	keno-5 validation case b-7	0.9992	0.0022	6.65054E+03
cas28	keno-5 validation case b-8	0.9991	0.0028	6.33665E+04
cas30	93.2% uo2f2 3 in al slab 3x1x1 array 0 in sep room	1.0008	0.0029	4.95825E-02
cas31	93.2% uo2f2 3 in al slab 3x1x1 array 0 in sep h2o refl	0.9976	0.0027	4.59142E-02
cas32	93.2% uo2f2 3 in al slab 3x1x1 array 1 in sep room	0.9778	0.0029	5.02354E-02
cas33	93.2% uo2f2 3 in al slab 3x1x1 array 1 in sep h2o refl	0.9993	0.0028	4.26149E-02
cas34	93.2% uo2f2 3 in al slab 3x1x1 array 3 in sep room	0.9792	0.0030	5.06065E-02
cas35	93.2% uo2f2 3 in al slab 3x1x1 array 3 in sep h2o refl	0.9980	0.0025	4.16554E-02
cas36	93.2% uo2f2 3 in al slab 3x1x1 array 4.5 in sep room	0.9848	0.0030	5.03493E-02
cas37	93.2% uo2f2 3 in al slab 3x1x1 array 4.5 in sep h2o refl	0.9986	0.0023	4.20791E-02
cas38	93.2% uo2f2 3 in al slab 3x1x1 array 5.5 in sep room	0.9893	0.0028	5.04825E-02
cas39	93.2% uo2f2 3 in al slab 3x1x1 array 5.5 in sep h2o refl	1.0079	0.0028	4.22311E-02
cas40	93.2% uo2f2 3 in al slab 3x1x1 array 6 in sep room	0.9868	0.0027	5.06559E-02
cas41	93.2% uo2f2 3, 6 in al slabs 2x1x1 array 15 in sep	0.9769	0.0030	5.00974E-02
cas42	93.2% uo2f2 3, 6 in al slabs 2x1x1 array 2 in sep	0.9774	0.0028	5.01126E-02
cas43	93.2% uo2f2 3, 6 in al slabs 2x1x1 array 30 in sep	0.9725	0.0029	5.01940E-02
cas44	93.2% uo2f2 3, 6 in al slabs 2x1x1 array 48 in sep	0.9789	0.0033	4.99943E-02
cas45	93.2% uo2f2 3, 6, 3 in al slabs 3x1x1 array 0 in sep	0.9812	0.0029	4.97176E-02
cas46	93.2% uo2f2 3, 6, 3 in al slabs 3x1x1 array 10 in sep	0.9722	0.0034	5.05098E-02
cas47	93.2% uo2f2 3, 6, 3 in al slabs 3x1x1 array 20 in sep	0.9740	0.0028	5.02911E-02
cas48	93.2% uo2f2 3, 6, 3 in al slabs 3x1x1 array 32 in sep	0.9720	0.0031	5.03027E-02
cas49	93.2% uo2f2 6 & 3 in al slabs 2x1x1 array 12 in sep	0.9780	0.0034	5.03063E-02
cas50	93.2% uo2f2 6 & 3 in al slabs 2x1x1 array 18 in sep	0.9806	0.0034	5.03061E-02
cas51	93.2% uo2f2 6 & 3 in al slabs 2x1x1 array 30 in sep	0.9825	0.0028	5.01101E-02
cas52	93.2% uo2f2 6 & 3 in al slabs 2x1x1 array 6 in sep	0.9824	0.0030	5.00571E-02
cas53	93.2% uo2f2 6 in al slab 2x1x1 array 15 in sep	0.9842	0.0030	5.01835E-02
cas54	93.2% uo2f2 6 in al slab 2x1x1 array 2 in sep	0.9772	0.0026	5.02553E-02
cas55	93.2% uo2f2 6 in al slab 2x1x1 array 20 in sep	0.9791	0.0027	4.99922E-02
cas56	93.2% uo2f2 6 in al slab 2x1x1 array 30 in sep	0.9831	0.0027	4.99471E-02
cas57	93.2% uo2f2 6 in al slab 2x1x1 array 48 in sep	0.9815	0.0026	5.00679E-02
cas58	93.2% uo2f2 6 in al slab 2x1x1 array 6 in sep	0.9696	0.0037	5.04142E-02
cas59	93.2% uo2f2 6 in al slab 2x1x1 array 66 in sep	0.9839	0.0032	4.98814E-02
cas60	uo2(no3)2 279 g U/L 3x3x3 array unrefl. walls, tank, & floor	0.9971	0.0030	1.61543E-01
cas61	uo2(no3)2 279 g U/L 2x2x2 array unrefl. walls, tank, & floor	1.0052	0.0027	1.56140E-01
cas62	uo2(no3)2 415 g U/L 5x5x5 array unrefl. walls, tank, & floor	0.9898	0.0033	3.23599E-01
cas63	uo2(no3)2 415 g U/L 3x3x3 array unrefl. walls, tank, & floor	0.9951	0.0034	3.23451E-01
cas64	uo2(no3)2 415 g U/L 4x4x4 array unrefl. walls, floor, & tank	0.9919	0.0033	3.24631E-01
cas65	uo2(no3)2 415 g U/L 2x2x2 array unrefl. walls, floor, & tank	1.0021	0.0033	3.15319E-01
cas66	uo2(no3)2 415 g U/L 3x3x3 array 15.24 cm par. bot., 1.27 cm p	0.9969	0.0030	2.81903E-01
cas67	uo2(no3)2 415 g U/L 3x3x3 array 15.24 cm par. bot., 2.54 cm p	1.0079	0.0032	2.54614E-01
cas68	uo2(no3)2 415 g U/L 3x3x3 array 15.24 cm par. bot., 1.27 cm p	1.0066	0.0030	2.72320E-01
cas69	uo2(no3)2 415 g U/L 3x3x3 array 15.24 cm par 5 fc, plex 1 fc	1.0187	0.0031	2.07907E-01
cas70	uo2(no3)2 415 g U/L 3x3x3 array 15.24 cm par. bot., 3.81 cm p	1.0172	0.0029	2.25525E-01
cas71	uo2(no3)2 415 g U/L 3x3x3 array 15.24 cm par. bot., 7.62 cm p	1.0250	0.0030	2.10462E-01
cas72	uo2(no3)2 415 g U/L 3x3x3 array 1.27 cm plexiglass refl.	1.0013	0.0029	2.95021E-01
cas73	uo2(no3)2 415 g U/L 3x3x3 array 1.27 cm paraffin refl.	1.0107	0.0034	2.84036E-01
cas74	uo2(no3)2 415 g U/L 3x3x3 array 15.24 cm paraffin refl.	1.0189	0.0034	2.10003E-01
cas75	uo2(no3)2 415 g U/L 3x3x3 array 3.81 cm paraffin refl.	1.0140	0.0030	2.28122E-01
cas76	uo2(no3)2 415 g U/L 2x2x2 array 15.24 cm par. bot., 1.27 cm p	1.0058	0.0028	2.76132E-01
cas77	uo2(no3)2 415 g U/L 2x2x2 array 15.24 cm par. bot., 11.43 cm	1.0252	0.0031	2.08300E-01
cas78	uo2(no3)2 415 g U/L 2x2x2 array 15.24 cm par. bot., 15.24 cm	1.0208	0.0033	2.07481E-01
cas79	uo2(no3)2 415 g U/L 2x2x2 array 15.24 cm par. bot., 2.54 cm p	1.0127	0.0029	2.50266E-01
cas80	uo2(no3)2 415 g U/L 2x2x2 array 15.24 cm par. bot., 4.45 cm p	1.0191	0.0029	2.28760E-01
cas81	uo2(no3)2 415 g U/L 2x2x2 array 15.24 cm par. bot., 6.35 cm p	1.0137	0.0030	2.17799E-01
cas82	uo2(no3)2 415 g U/L 2x2x2 array 15.24 cm par. bot., 1.27 cm p	1.0136	0.0029	2.67261E-01

cas83	uo2(no3)2 415 g U/L 2x2x2 array 15.24 cm par. bot., 3.81 cm p	1.0169	0.0030	2.24381E-01
cas84	uo2(no3)2 415 g U/L 2x2x2 array 15.24 cm par. bot., 7.62 cm p	1.0136	0.0033	2.09469E-01
cas85	uo2(no3)2 415 g U/L 2x2x2 array 1.27 cm plexiglass refl.	1.0068	0.0031	2.89104E-01
cas86	uo2(no3)2 415 g U/L 2x2x2 array 1.27 cm paraffin refl.	1.0076	0.0030	2.81125E-01
cas87	uo2(no3)2 415 g U/L 2x2x2 array 15.24 cm paraffin refl.	1.0124	0.0032	2.09238E-01
cas88	uo2(no3)2 415 g U/L 2x2x2 array 3.81 cm paraffin refl.	1.0153	0.0029	2.26437E-01
cas89	uo2(no3)2 415 g U/L 2x2x2 array 7.62 cm paraffin refl.	1.0172	0.0032	2.10012E-01
cas90	uo2(no3)2 415 g U/L 3x3x3 array unrefl. 279 g U/L 5 cent. uni	1.0008	0.0035	2.60302E-01
cas91	uo2(no3)2 63.3 g U/L 3x3x3 array unrefl. walls, floor, & tank	1.0108	0.0031	4.17099E-02
jemima	disks - 15" diam plates 93.15 w% enriched stacked to 3.0258"	0.9957	0.0023	9.20645E+05
jemima	jemima - ~1/8" x 15" diam u(93.29) plates with 1/16" thk poly	0.9900	0.0021	1.22180E+05
jemima	jemima - ~1/8" thk 15" diam u(93.24) plates with 1/8" thk pol	0.9968	0.0024	1.77282E+04
jemima	jemima - ~1/8" thk 15" diam u(93.24) plates with 1/4" thk pol	0.9809	0.0025	1.73254E+03
jemima	jemima - ~1/8" thk 15" diam u(93.24) plates with 1/2" thk pol	1.0017	0.0028	8.79715E+01
jemima	jemima - ~1/8" thk 15" diam u(93.24) plates with 1" thk poly,	1.0002	0.0023	7.49203E+00
jemima	jemima - ~1/8" x 15" dia u(93) with symetric 1-1/2" thk poly,	1.0125	0.0024	3.34259E+00
jemima	jemima - ~1/8" x 15" dia u(93) with symetric 2" thk poly, pg-	1.0113	0.0025	2.09217E+00
heumf001	read parameters	1.0026	0.0020	9.05790E+05
heumf004	water-reflected heu sphere on hollow plexiglas cylinder	1.0031	0.0019	3.10106E+04
heust001	case 1 heust001	1.0019	0.0027	7.91224E-02
heust001	case 2 heust001	1.0042	0.0023	2.72577E-01
heust001	case 3 heust001	1.0056	0.0023	7.74878E-02
heust001	case 4 heust001	1.0032	0.0029	2.92934E-01
heust001	case 5 heust001	1.0036	0.0024	4.07241E-02
heust001	case 6 heust001	1.0035	0.0022	4.23172E-02
heust001	case 7 heust001	1.0023	0.0024	7.47451E-02
heust001	case 8 heust001	1.0000	0.0021	7.92721E-02
heust001	case 9 heust001	0.9961	0.0029	2.93771E-01
heust001	case 10 heust001	0.9953	0.0023	4.38689E-02
heust007	case 1 , heust007	1.0142	0.0020	4.50008E-02
heust007	case 2 , heust007	1.0136	0.0022	2.65339E-01
heust007	case 3 , heust007	1.0122	0.0020	4.39946E-02
heust007	case 4 , heust007	1.0148	0.0022	2.34590E-01
heust007	case 5 , heust007	1.0108	0.0022	4.79721E-02
heust007	case 6 , heust007	1.0074	0.0024	2.70926E-01
heust007	case 7 , heust007	1.0022	0.0023	4.73873E-02
heust007	case 8 , heust007	1.0081	0.0023	2.64386E-01
heust007	case 9 , heust007	1.0071	0.0020	4.89854E-02
heust007	case 10 , heust007	1.0141	0.0020	5.05970E-02
heust007	case 11 , heust007	1.0133	0.0023	2.52299E-01
heust007	case 12 , heust007	1.0165	0.0023	4.89307E-02
heust007	case 13 , heust007	1.0184	0.0022	2.27846E-01
heust007	case 14 , heust007	1.0165	0.0024	2.34844E-01
heust007	case 15 , heust007	1.0119	0.0022	2.37071E-01
heust007	case 16 , heust007	1.0079	0.0021	2.52257E-01
heust007	case 17 , heust007	1.0141	0.0021	2.35576E-01
heust008	case 1 , heust008	0.9953	0.0021	4.22118E-02
heust008	case 2 , heust008	0.9935	0.0024	2.31104E-01
heust008	case 3 , heust008	0.9938	0.0020	4.09847E-02
heust008	case 4 , heust008	0.9999	0.0022	2.05444E-01
heust008	case 5 , heust008	0.9988	0.0018	4.21128E-02
heust008	case 6 , heust008	1.0044	0.0024	2.52500E-01
heust008	case 7 , heust008	1.0030	0.0020	4.12450E-02
heust008	case 8 , heust008	1.0011	0.0021	2.39927E-01
heust008	case 9 , heust008	1.0024	0.0018	4.19634E-02
heust008	case 10 , heust008	0.9969	0.0022	2.28981E-01
heust008	case 11 , heust008	1.0013	0.0019	4.03665E-02
heust008	case 12 , heust008	1.0015	0.0024	2.00040E-01
heust008	case 13 , heust008	1.0008	0.0022	2.28131E-01
heust008	case 14 , heust008	0.9979	0.0020	2.06134E-01
heust013	uranium aqueous 23 cm sphere #1	0.9979	0.0017	3.07174E-02
heust013	uranium aqueous 32 cm sphere #2	0.9956	0.0015	3.21388E-02
heust013	uranium aqueous 32 cm sphere #3	0.9949	0.0015	3.34913E-02
heust013	uranium aqueous 32 cm sphere #4	0.9955	0.0017	3.41915E-02

44-Group_Low-Enriched_Uranium

Case	Title	k-eff	sigma	EALF
car01	rocky flats criticals nureg/cr-1071 experiment number 1 (27 g	1.0186	0.0026	4.44623E-01
car02	rocky flats criticals nureg/cr-1071 experiment number 2 (27 g	1.0108	0.0022	4.64385E-01
car03	rocky flats criticals nureg/cr-1071 experiment number 3 (27 g	1.0033	0.0022	1.53118E+00
car04	rocky flats criticals nureg/cr-1071 experiment number 13 (27	1.0190	0.0021	5.07803E-01
car06	rocky flats criticals nureg/cr-0674 experiment number ? (27 g	1.0042	0.0035	4.03798E+02
car07	rocky flats criticals nureg/cr-0674 experiment number ? (27 g	1.0090	0.0029	3.85165E+00
car08	rocky flats criticals nureg/cr-0674 experiment number ? (27 g	1.0039	0.0030	2.08837E+00
car09	rocky flats criticals nureg/cr-0674 experiment number 2 (27 g	1.0078	0.0026	2.02702E+00
car10	rocky flats criticals nureg/cr-0674 concrete reflected (27 gr	1.0132	0.0027	5.54167E+00
car11	rocky flats criticals nureg/cr-1653 experiment a (27 group)	1.0128	0.0023	3.90935E-01
car12	rocky flats criticals nureg/cr-1653 experiment b (27 group)	1.0232	0.0026	9.96943E-01
car14	rocky flats criticals nureg/cr-1653 experiment number ? (27 g	1.0124	0.0032	3.06365E+00
car15	rocky flats criticals nureg/cr-1653 experiment number ? (27 g	1.0153	0.0032	3.07174E+00
car16	rocky flats criticals nureg/cr-1653 experiment number ? (27 g	1.0114	0.0030	1.97964E+00
car17	rocky flats criticals nureg/cr-2500 experiment f (27 group)	1.0137	0.0028	6.71267E-01
car19	rocky flats criticals nureg/cr-2500 experiment number ? (27 g	1.0161	0.0031	4.07956E+00
car20	rocky flats criticals nureg/cr-2500 experiment number ? (27 g	1.0024	0.0024	3.38199E+00
cas04	british handbook of criticality safety u(1.42)f4 & paraffin (	0.9893	0.0016	1.18906E-01
cas05	british handbook of criticality safety u(1.42)f4 & paraffin (	0.9966	0.0016	1.17981E-01

cas06	british handbook of criticality safety u(1.42)f4 & paraffin (	0.9935	0.0018	1.18155E-01
cas11	raffety and malhalczo u(2)f4-1 reflected (case 11)	1.0044	0.0022	1.95339E-01
cas12	raffety and malhalczo u(2)f4-1 unreflected (case12)	1.0032	0.0023	2.36120E-01
cas13	raffety and malhalczo u(2)f4-2 reflected (case 13) no biasing	1.0003	0.0019	1.16287E-01
cas14	raffety and malhalczo u(2)f4-2 unreflected (case 14)	0.9989	0.0020	1.33748E-01
cas15	raffety and malhalczo u(2)f4-3 reflected (case 15)	0.9994	0.0023	8.33167E-02
cas16	raffety and malhalczo u(2)f4-4 reflected (case 16)	1.0025	0.0023	7.00365E-02
cas17	raffety and malhalczo u(2)f4-5 reflected (case 17)	1.0003	0.0020	6.02006E-02
cas18	raffety and malhalczo u(2)f4-5 unreflected (case18)	1.0017	0.0019	6.36542E-02
cas19	raffety and malhalczo u(2)f4-6 reflected (case 19)	0.9932	0.0016	4.66342E-02
cas20	raffety and malhalczo u(2)f4-6 unreflected (case20)	0.9907	0.0014	4.76361E-02
cas21	raffety and milhalczo u(3)f4-1 reflected (case 21) no bias	1.0112	0.0024	2.35639E-01
cas22	raffety and malhalczo u(3)f4-1 reflected (case 22)	1.0178	0.0023	2.33853E-01
cas23	raffety and malhalczo u(3)f4-1 reflected (case 23)	1.0129	0.0022	2.36111E-01
cas24	raffety and malhalczo u(3)f4-1 reflected (case 24) no biasing	1.0161	0.0024	2.35595E-01
cas25	raffety and malhalczo u(3)f4-1 reflected (case 25)	1.0108	0.0022	2.33917E-01
cas26	raffety and malhalczo u(3)f4-1 unreflected (case 26)	1.0166	0.0024	3.18432E-01
cas27	raffety and malhalczo u(3)f4-1 unreflected (case 27)	1.0134	0.0022	3.19981E-01
cas28	raffety and malhalczo u(3)f4-1 unreflected (case 28)	1.0151	0.0023	3.19474E-01
cas29	raffety and malhalczo u(3)f4-2 reflected (cas29)	1.0189	0.0027	9.13878E-02
cas30	raffety and malhalczo u(3)f4-2 unreflected (case 30)	1.0106	0.0025	1.08752E-01
cas31	raffety and malhalczo u(3)f4-2 unreflected (case 31)	1.0146	0.0024	1.08544E-01
cas32	raffety and malhalczo u(3)f4-2 unreflected (case 32)	1.0111	0.0023	1.09087E-01
cas33	critical reflected cylinder of aqueous u(4.98)o2f2 (case 33)	1.0018	0.0024	5.41788E-02
cas34	critical reflected cylinder of aqueous u(4.98)o2f2 (case 34)	0.9998	0.0020	5.37375E-02
cas35	critical sphere of aqueous u(4.98)o2f2 (case 35)	1.0028	0.0024	5.33620E-02
cas36	critical cylinder of aqueous u(4.98)o2f2 (case 36)	0.9999	0.0024	5.40102E-02

44-Group_LWR_Lattices

Case	Title	k-eff	sigma	EALF
cas01	exp#5, 8.39 cm h2o separating 3 20x16 arrays	0.9972	0.0015	9.38091E-02
cas02	exp#017, 5.05 cm h2o/boral separating 2 22x16 arrays and 1 20	0.9983	0.0012	9.64360E-02
cas03	exp#28, 6.88 cm h2o/ss separating 3 20x16 arrays	0.9960	0.0016	9.51528E-02
cas04	exp no. 14 8.58 cm h2o/ss separating 3 15x8 arrays	0.9987	0.0019	1.13131E-01
cas05	exp no. 23 7.28 cm h2o/cadmium separating 3 15x8 arrays	0.9954	0.0015	1.13879E-01
cas06	exp no. 31 6.72 cm h2o/boral separating 3 15x8 arrays	0.9986	0.0018	1.14574E-01
cas07	u refl. 1.956 cm from array, 14.11 cm h2o separating 3 19x1	0.9999	0.0016	1.70932E-01
cas08	pb refl. .660 cm from array, 13.72 cm h2o separating 3 19x16	1.0044	0.0015	9.61639E-02
cas09	no refl. 8.31cm h2o separating 19x16 arrays	0.9954	0.0019	9.43868E-02
cas10	uranium refl. 15.32cm h2o separating 12x8 arrays	1.0000	0.0016	2.82370E-01
cas11	lead refl. 20.78cm h2o separating 13x8 arrays	1.0112	0.0009	1.15957E-01
cas12	2.83cm and 3.60cm separating 4 11x14 arrays	1.0010	0.0016	3.14724E-01
cas13	2.83cm and 4.94cm separating 2 11x14 + 2 11x16 arrays	1.0011	0.0013	3.17311E-01
cas14	ss refl. 0.66 cm from array, 11.20 cm h2o separating 3 19x16	1.0037	0.0014	9.67520E-02
cas15	steel refl. 15.84cm h2o separating 3 12x16 arrays	1.0059	0.0016	2.87059E-01
cas16	steel refl. 9.83cm h2o separating 3 12x16 arrays w/borated	1.0050	0.0018	2.98164E-01
cas17	steel refl. 8.30cm h2o separating 3 12x16 arrays w/boral pl	1.0022	0.0017	3.04131E-01
cas18	steel refl. 8.94cm h2o separating 3 12x16 arrays w/cd plate	1.0025	0.0012	3.01025E-01
cas19	u refl 1.321 cm from array, 9.50 cm h2o sep. 23x18/2-20x18 ar	0.9993	0.0014	3.38900E-01
cas20	pb refl 0.660 cm from array, 10.11 cm h2o sep. 23x18/2-20x18	1.0013	0.0015	1.65840E-01
cas21	no refl infinite from array, 6.59 cm h2o sep. 23x18/2-20x18 a	0.9958	0.0017	1.58234E-01
cas22	uranium refl. 19.24cm h2o separating 12x16 arrays	0.9990	0.0017	5.08130E-01
cas23	lead refl. 18.18cm h2o separating 12x16 arrays	1.0046	0.0018	2.94494E-01
cas24	no refl. 12.91cm h2o separating 3 12x16 arrays	1.0029	0.0019	2.79098E-01
cas25	pnl-4267 exp. 173 40 x 8.92 array (357 total rods) boron = 0	0.9975	0.0012	2.77046E-01
cas26	pnl-4267 exp.177 40 x 30.92 array 1237 total rods) boron = 2.	1.0005	0.0014	6.07987E-01
cas27	pnl-4267 exp. 178 44 x 11.57array (509 total rods) boron = 0	0.9981	0.0012	5.28004E-01
cas28	pnl-4267 exp. 181 44 x 27.09 array (1192 total rods) boron =	0.9942	0.0015	1.16275E+00
cas29	pnl-4976 4.3-000-194 4.3%uo2 1.598cm-pitch	1.0070	0.0017	3.44375E+00
cas30	flux trap assembly no. 214r	1.0022	0.0017	3.63882E-01
cas31	flux trap assembly no. 214v3	0.9990	0.0012	3.66500E-01
cas32	baw-1231 core i 936 rods boron=1.152 g/l	0.9932	0.0010	7.30419E-01
cas33	baw-1231 core i 4904 rods boron=3.389 g/l	0.9954	0.0008	1.20468E+00
cas34	baw-1273 core xx 2.46 wt%u235 5137 rods	0.9974	0.0014	5.19322E-01
cas35	baw-1484-7 core iv exp 2282 2.46 wt%u235 9 assys 14x14 w/ 8	0.9926	0.0010	1.88811E-01
cas36	baw-1484-7 core ix exp 2321 2.46 wt%u235 9 assys 14x14	0.9960	0.0015	1.37543E-01
cas37	baw-1484-7 core xiii exp 2378 2.46 wt%u235 9 assys 14x14	0.9994	0.0015	1.92775E-01
cas38	baw-1484-7 core xxi exp 2420 2.46 wt%u235 9 assys 14x14	0.9941	0.0014	1.50631E-01
cas39	baw-1645-4 exp,mt=2452 triangular pitch=o.d. boron=435ppm	1.0070	0.0011	2.28086E+00
cas40	baw-1645-4 exp,mt=2485 pitch=o.d. boron=886ppm	1.0001	0.0015	1.40038E+00
cas41	baw-1645-4 exp,mt=2500 pitch=1.17*o.d. boron=1156ppm	1.0009	0.0013	4.14787E-01
cas42	baw-1810 core 12 - 4.02 & 2.46 w/o uo2 1899.3 ppm; no uo2-gd2	0.9961	0.0012	3.54751E-01
cas43	baw-1810 core 14 - 4.02 & 2.46 w/o uo2 1654 ppm; 28 uo2-gd2o3	0.9977	0.0013	3.35276E-01
cas44	baw-1810 core 16 - 4.02 & 2.46 w/o uo2 1579 ppm; 36 uo2-gd2o3	1.0003	0.0015	3.32830E-01
cas45	epri np-196 .615 inch pitch unborated uo2	0.9942	0.0015	2.57054E-01
cas46	epri np-196 .615 inch pitch borated uo2	0.9982	0.0013	3.15214E-01
cas47	epri np-196 .75 inch pitch unborated uo2	0.9975	0.0011	1.13283E-01
cas48	epri np-196 .75 inch pitch borated uo2	0.9986	0.0011	1.41065E-01
cas49	epri np-196 .87 inch pitch unborated uo2	0.9984	0.0014	8.24161E-02
cas50	epri np-196 .87 inch pitch borated uo2	0.9965	0.0014	9.24040E-02
cas51	saxton uo2 5.742 wt% u-235 critical exp. 0.56 inch pitch (wca	0.9950	0.0018	2.92580E-01
cas52	saxton uo2 5.742 wt% u-235 critical exp. 0.792inch pitch (wca	0.9984	0.0013	1.02102E-01
cas53	wcap-3269-39, 2692 fuel rods, 16 ag-in-cd rods,h2o ht=115.55	1.0015	0.0012	6.84832E-01
cas54	wcap-3269-39, 2209 fuel rods, 24 ag-in-cd rods,h2o ht=64.56 c	1.0036	0.0018	4.32027E-01
cas55	wcap-3269-39, 945 fuel rods, 16 ag-in-cd rods,h2o ht=89.75	0.9959	0.0012	2.55357E-01
cas56	4-18x18 array 5.0cm int.,polyethylene powder in box,30.16cm h	0.9987	0.0014	2.23525E-01

cas57	4-18x18 array 5.0cm int.,polyethylene balls in box,30.73cm h2	1.0073	0.0013	2.03561E-01
cas58	4-18x18 array 5.0cm int.,water in box,32.78cm h2o height	1.0153	0.0012	1.93742E-01
cas59	4-18x18 array 5.0cm int.,water without box,31.47cm h2o height	0.9965	0.0014	1.95025E-01

44-Group_Mixed_Oxide

Case	Title	k-eff	sigma	EALF
cas60	epri .70inch pitch unborated plutonium	0.9967	0.0016	5.74410E-01
cas61	epri .70inch pitch borated plutonium	0.9993	0.0014	7.68866E-01
cas62	epri .87inch pitch unborated plutonium	1.0023	0.0013	1.90262E-01
cas63	epri .87inch pitch borated plutonium	1.0075	0.0014	2.79793E-01
cas64	epri .99inch pitch unborated plutonium	1.0085	0.0015	1.34765E-01
cas65	epri .99inch pitch borated plutonium	1.0077	0.0010	1.80510E-01
cas66	saxton puo2-uo2 critical exp. 0.52 inch pitch (wcap-3385-54)	0.9992	0.0013	8.83101E-01
cas67	saxton puo2-uo2 critical exp. 0.56 inch pitch (wcap-3385-54)	0.9982	0.0018	5.40776E-01
cas68	saxton puo2-uo2 critical exp. 0.56 inch pitch with boron (wca	0.9977	0.0016	6.47043E-01
cas69	saxton puo2-uo2 critical exp. 0.735 inch pitch (wcap-3385-54)	1.0035	0.0020	1.85393E-01
cas70	saxton puo2-uo2 critical exp. 0.792 inch pitch (wcap-3385-54)	1.0019	0.0017	1.54707E-01
cas71	saxton puo2-uo2 critical exp. 01.04 inch pitch (wcap-3385-54)	1.0036	0.0016	9.99436E-02
cas72	pnl4976 exp196 1174 uo2 & 583 mo2 rods to approx. 20,000 mwd/	0.9970	0.0013	4.27282E+00
cas73	exp.no 021(063) pitch=968 (fuel region = pin array + mix 500	1.0055	0.0011	8.84044E-01
cas74	exp.no 032(060) pitch=1.935(fuel region=pin array+mix 500 wit	1.0088	0.0016	1.12694E-01
cas75	exp.no 043(062) pitch=1.242(fuel region=pin array+mix 500 wit	1.0019	0.0013	2.87530E-01
cas76	exp.no 067 pitch=0.761 (fuel region = pin array + mix 500 wit	1.0017	0.0011	2.90665E+00
cas77	exp. no 68r pitch=1.537 (fuel region = pin array + mix 500 wi	1.0058	0.0019	1.65538E-01

44-Group_Plutonium

Case	Title	k-eff	sigma	EALF
1727_09	la-3067-msr table iiia1, entry 13, water ref., metal, pu sphe	0.9960	0.0032	7.62626E+04
2109_20	benchmark 20, pu sphere with 25.4 cm concrete ref. h/pu=684.3	1.0267	0.0035	6.50197E-02
2109_21	benchmark 21, pu sphere with 10.16 cm concrete ref. h/pu=684.	1.0199	0.0037	6.28530E-02
2109_22	benchmark 22, pu sphere with 10.16 cm concrete ref. h/pu=496	1.0285	0.0034	7.64713E-02
2109_23	benchmark 23, pu sphere with cd shell & 10.16 cm concrete ref	1.0312	0.0035	8.43735E-02
2109_24	benchmark 24, pu sphere with cd shell & 32.00 cm water, h/pu=	1.0151	0.0037	7.39281E-02
2110_05	rectangular parallelpipeds of homogeneous pu(2.2)o2	1.0229	0.0061	3.28214E+01
2110_06	rectangular parallelipiped of pu(2.2)o2 reflected with 15cm p	1.0358	0.0052	5.39858E+00
2110_07	benchmark#7 semi-inf homogeneous critical solution of pu-239	1.0250	0.0036	8.66114E-02
2110_08	rectangular parallelipiped of puo2	1.0113	0.0049	1.57573E+00
2110_09	rectangular parallelipipeds of pu02	1.0141	0.0041	7.42683E-01
2110_10	rectangular parallelipipeds of pu02	1.0089	0.0049	7.09447E-01
2110_11	rectangular parallelipipeds of pu02	1.0198	0.0051	6.91517E-01
2110_12	rectangular parallelipipeds of pu02	1.0057	0.0042	6.97871E-01
2110_13	sphere described by keno geometry	0.9926	0.0036	1.21787E+06
2110_14	cylinder described by keno geometry	1.0076	0.0050	1.40397E-01
2110_15	rectangular parallelipipeds of puo2-h20	1.0084	0.0048	2.41605E+05
2110_16	rectangular parallelipipeds of puo2-h20	1.0265	0.0036	9.23852E+05
2110_17	rectangular parallelipipeds of puo2-h20	1.0298	0.0035	1.73370E+03
2110_18	rectangular parallelipipeds of puo2-h20	1.0430	0.0033	3.72166E+03
2110_19	rectangular parallelipipeds of puo2-h20	1.0130	0.0037	4.52183E+03
2110_20	rectangular parallelipipeds of puo2-h20	1.0332	0.0037	2.37424E+03
2110_21	rectangular parallelipipeds of puo2-h20	1.0343	0.0030	1.80538E+03
2110_23	rectangular parallelipipeds of puo2-polystyrene	1.0194	0.0045	1.47668E+03
2110_24	rectangular parallelipipeds of puo2-polystyrene	1.0222	0.0037	8.91457E+01
2110_25	rectangular parallelipipeds of puo2-polystyrene	1.0285	0.0033	8.02661E+01
2110_26	rectangular parallelipipeds of puo2-polystyrene	1.0335	0.0035	6.47283E+01
2110_27	rectangular parallelipipeds of puo2-polystyrene	1.0305	0.0032	5.41442E+01
2110_29	cylinder described by keno geometry	1.0082	0.0045	5.52232E-02
pumf001	read parameters	0.9958	0.0022	1.19898E+06
pumf002	pu-met-fast-002	0.9987	0.0024	1.21514E+06
pust004	case 1,kvpusolnsphexp,27gp,26.27gpU/L, 0.54w/o240,h2orefl,14i	1.0100	0.0019	5.17840E-02
pust009	case 3a,kvpusolnsphexp,27,9.457gpU/L, 2.5w/o240,bare,48in dia	1.0264	0.0010	3.92387E-02

44-Group_U-233

Case	Title	k-eff	sigma	EALF
u233mf001	unreflected u233 sphere	0.9919	0.0021	1.08355E+06
u233mf002	case 1, 10 kg u233/heu sphere, ref u233-met-fast-002	0.9986	0.0019	1.02037E+06
u233mf002	case 2, 7.6 kg u233/heu sphere, ref u233-met-fast-002	1.0000	0.0021	1.04793E+06
u233mf003	case 1, 10 kg u233 sphere natural uranium reflector, ref u233	0.9910	0.0020	1.05216E+06
u233mf003	case 2, 7.6 kg u233 sphere natural uranium reflector, ref u23	0.9894	0.0019	1.04668E+06
u233mf004	case 1, 10 kg u233 sphere reflected by tungsten	1.0034	0.0016	9.34088E+05
u233mf005	case 1, 10 kg u233 sphere be reflector, ref u233-met-fast-xxx	0.9976	0.0020	9.00310E+05
u233mf006	u-233/nu sphere	0.9945	0.0020	9.85652E+05
u233st002	exp 4 simplified model	1.0119	0.0031	1.60789E-01
u233st002	exp 5 simplified model	0.9951	0.0032	1.24082E-01
u233st002	exp 8 simplified model	1.0108	0.0034	9.65217E-02
u233st002	exp 10 simplified model	1.0075	0.0032	7.87800E-02
u233st002	exp 11 simplified model	1.0050	0.0036	6.92738E-02
u233st002	exp 12 simplified model	0.9919	0.0031	6.14775E-02
u233st002	exp 14 simplified model	0.9807	0.0030	5.85012E-02
u233st002	exp 15 simplified model	0.9967	0.0027	5.37426E-02
u233st002	exp 17 simplified model	0.9835	0.0030	4.84792E-02
u233st002	exp 18 simplified model	0.9974	0.0029	4.67960E-02
u233st002	exp 19 simplified model	1.0096	0.0024	4.35886E-02

u233st002	exp 22 simplified model	0.9989	0.0033	2.49136E-01
u233st002	exp 24 simplified model	1.0004	0.0031	4.43794E-01
u233st002	exp 34 simplified model	0.9976	0.0032	1.29027E-01
u233st002	exp 35 simplified model	1.0099	0.0031	8.84865E-02
u233st002	exp 36 simplified model	1.0030	0.0030	5.95246E-02
u233st002	exp 38 simplified model	1.0060	0.0027	5.06776E-02
u233st004	exp 3 simplified model	1.0045	0.0031	1.58522E-01
u233st004	exp 6 simplified model	1.0019	0.0030	1.22567E-01
u233st004	exp 20 simplified model	1.0040	0.0030	2.48265E-01
u233st004	exp 25 simplified model	0.9958	0.0036	4.45099E-01
u233st004	exp 30 simplified model	0.9968	0.0034	3.51216E-01
u233st004	exp 27 simplified model	1.0074	0.0031	4.40937E-01
u233st004	exp 28 simplified model	1.0005	0.0029	3.52269E-01
u233st004	exp 33 simplified model	1.0095	0.0032	1.27729E-01

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This report provides detailed information on the SCALE criticality safety cross-section libraries. Areas covered include the origins of the libraries, the data on which they are based, how they were generated, past experience and validations, and performance comparisons to measured critical experiments and numerical benchmarks.

The performance of the SCALE criticality safety cross-section libraries on various types of fissile systems are examined in detail. Most of the performance areas are demonstrated by examining the performance of the libraries vs critical experiments to show general trends and weaknesses. In areas where directly applicable critical experiments do not exist, performance is examined based on the general knowledge of the strengths and weaknesses of the cross sections. In this case, the experience in the use of the cross sections and comparisons to the results of other libraries on the same systems are relied on for establishing acceptability of application of a particular SCALE library to a particular fissile system.

This report should aid in establishing when a SCALE cross-section library would be expected to perform acceptably and where there are known or suspected deficiencies that would cause the calculations to be less reliable. To determine the acceptability of a library for a particular application, the calculational bias of the library should be established by directly applicable critical experiments.

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