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1. PURPOSE

The purpose of this engineering calculation is to document the MCNP4B2LV evaluations of Laboratory Critical Experiments (LCEs) performed as part of the Disposal Criticality Analysis Methodology program. LCE evaluations documented in this report were performed for 22 different cases with varied design parameters. Some of these LCEs (10) are documented in existing references (Ref. 7.1 and 7.2), but were re-run for this calculation file using more neutron histories. The objective of this analysis is to quantify the MCNP4B2LV code system's ability to accurately calculate the effective neutron multiplication factor (k_{eff}) for various critical configurations. These LCE evaluations support the development and validation of the neutronics methodology used for criticality analyses involving Naval reactor spent nuclear fuel in a geologic repository.

2. METHOD

The calculational method used to perform the naval reactor fuel reactivity calculations consisted of using the MCNP Version 4B2LV code (Ref. 7.3) to calculate k_{eff} for the various experimentally determined critical core configurations. The calculations were performed using continuous energy cross section libraries from Evaluated Nuclear Data File (ENDF/B-VI, ENDF/B-V, and a combination of the two as selected in the *Selection of MCNP Cross Section Libraries* report (Ref. 7.4, pp. 61-68). Each of the critical core configurations was simulated, and the results reported from the MCNP calculations were the combined average values of k_{eff} from the three estimates (collision, absorption, and track length) listed in the final generation summary in the MCNP output. The LCEs documented in this report may be used to determine appropriate bias values for use in subsequent criticality evaluations performed with MCNP Version 4B2LV.

3. ASSUMPTIONS

3.1. HST121 (Ref. 7.5, HEU-SOL-THERM-012)

The following assumptions are used in Section 5.

3.1.1. The corrosion-protective liner used in the sphere may be ignored. The basis for this assumption is that the corrosion-protective liner has only a small effect on reactivity. As documented in the reference (p. 7), assessments of the effect of corrosion-protective liners in other experiments have demonstrated that the liners have only small effects on reactivity ($\Delta k_{eff} = 0.0001$). Because the sphere used in this experiment was larger than those used in the other experiments, the effect of the liner in this experiment would be smaller than the effect of the liner in the other experiments. This is consistent with the reference (p. 7).

3.1.2. The volume may be assumed to be 91.21 cm^3. The basis for this assumption is that, although the log book for the experiment documented three different volumes, the reference assumes the volume to be 91.21 cm^3 (p. 9). A sensitivity study documented in the reference (p. 6) demonstrates that the effect of the volume on k_{eff} is small ($\Delta k_{eff} = 0.0006$).

3.1.3. The zinc in the cladding may be ignored and the density of the aluminum adjusted for the omission of zinc. This is necessary, because the cross section sets available to MCNP do not

contain any zinc. The basis for this assumption is that this loss of zinc would have a negligible effect on the system reactivity because zinc appears in the aluminum only in small quantities (0.1 weight% [wt%]) and is not neutronically significant. This is consistent with the MCNP input used in the reference (p. 15).

3.2. HST321 (Ref. 7.5, HEU-SOL-THERM-032)

The following assumptions are used in Section 5.

3.2.1. The corrosion-protective liner used in the sphere may be ignored. This is consistent with the reference (p. 9). The basis for this assumption is explained in section 3.1.1.

3.2.2. The zinc in the cladding may be ignored and the density of the aluminum adjusted for the loss of zinc. The basis for this assumption is that this loss of zinc would have a negligible effect on the system reactivity because zinc appears in the aluminum only in small quantities (0.1 wt%) and is not neutronically significant. This is consistent with the isotopic composition for Type 1100 Aluminum discussed in Table 4 of the reference (p. 13) and the MCNP input used in the reference (p. 19).

3.3. LCT27-1 (Ref. 7.5, LEU-COMP-THERM-027)

The following assumptions are used in Section 5.

3.3.1. The impurities in the lead shields (Bi, Ca, Mg, and Ba) may be ignored. The basis for this assumption is that these element occur in very low concentrations. Each of these elements has a concentration less than, or equal to 100 parts per million (ppm). This is consistent with the reference (p. 11).

3.3.2. The densities for the steel and the stainless steel were not available. They were assumed to be 7.9 g/cm^3. The basis for this assumption is consistency with the value used in the reference (p. 14).

3.3.3. Duraluminum corners on the lead shields may be neglected. The basis for this assumption is that they are remote from the fuel rods, and will, therefore, have little effect on reactivity. This is consistent with the reference (p. 17).

3.3.4. The girders of the pedestal may be neglected. The basis for this assumption is that there was no girder below the fuel array, so the girders will have little effect on reactivity. This is consistent with the reference (p. 17).

3.3.5. The eight holes in the support plate may be replaced with one hole (8.4 cm diameter) of the same total cross sectional area. The basis for this assumption is that the volume of water below the core is maintained constant. This is consistent with the reference (p. 17).

3.3.6. The 121 holes in the bottom support plate of the basket may be homogenized with the material of the support plate. The basis for this assumption is that the volume of materials (water and metals) in the support plate region is maintained constant. This is consistent with the reference (p. 18).

3.3.7. The lead isotope ^{204}Pb may be distributed evenly, atom for atom, amongst the other three lead isotopes. This is necessary, because the cross section sets available to MCNP do not

contain any ^{204}Pb. The basis for this assumption is that this would have a negligible effect on the system reactivity because ^{204}Pb comprised only a small amount of the lead (~1.4 atom%).

3.3.8. The zinc in the cladding may be substituted, atom for atom, with aluminum. This is necessary, because the cross section sets available to MCNP do not contain any zinc. The basis for this assumption is that this small addition of aluminum would have a negligible effect on the system reactivity because aluminum is effectively "invisible" to neutrons.

3.4. HMF3Ni (Ref. 7.5, HEU-MET-FAST-003)

The following assumptions are used in Section 5.

3.4.1. The Oralloy density is assumed to be 18.75 g/cm^3. The basis for this assumption is consistency with the reference (p. 10).

3.5. HMF28 (Ref. 7.5, HEU-MET-FAST-028)

The following assumptions are used in Section 5.

3.5.1. The representation presented in the reference is an idealized configuration derived by experimenters. This representation is used for the purposes of this calculation also. The basis for this assumption is that the information necessary to create a more explicit representation is not available in the reference. This is consistent with the reference (p. 10).

3.6. Fast Reactor Criticals (Ref. 7.6, BNL-19302)

The Fast Reactor Criticals include VERA1B, ZPR36F, ZPR311, ZPR312, BIG10, and ZEBRA2. The following assumptions are used in Section 5.

3.6.1. The experiment descriptions presented in the reference (pp. F6-1 through F10-7 and F20-1 through F20-9) are homogenized representations of heterogeneous cores. The basis for this assumption is that the details of the experiments are not available, at this time, in sufficient detail to allow explicit representation of the heterogeneity. The homogeneous representations are used for the Fast Reactor Criticals presented in this calculation. This is consistent with the reference (pp. F6-1 through F10-7 and F20-1 through F20-9).

The MCNP input for eight of the remaining LCEs (HEST1-3, HEST1-4, HEST1-5, HEST1-6, HEST1-7, HEST1-8, HEST1-9, and HEST131) was taken from Reference 7.1 (Attachment I). Two others (HMF21 and HMF22) were taken from Reference 7.2 (Attachments). The only modification to these MCNP inputs was the number of neutron histories run.

4. USE OF COMPUTER SOFTWARE AND MODELS

4.1 Software Approved for QA Work

4.1.1 MCNP

The MCNP code was used to calculate the k_{eff} of the research reactor critical configurations. The software specifications are as follow:

- Program Name: MCNP
- Version/Revision Number: Version 4B2
- CSCI Number: 30033 V4B2LV
- Computer Type: Hewlett Packard (HP) 9000 Series Workstation
- CPU Serial Number: 2002611431

The input and output files for the various MCNP calculations are documented in the attachment to this calculation file as described in Sections 5 and 8, such that an independent repetition of the software use may be performed. The MCNP software used was: (a) appropriate for the application of research reactor k_{eff} calculations, (b) used only within the range of validation as documented throughout References 7.3 and 7.7, and (c) obtained from the Software Configuration Manager in accordance with appropriate procedures.

4.2 Software Routines

None used.

4.3 Models

None used.

5. CALCULATION

The reactivity calculations are detailed calculations of the neutron multiplication factor for actual experimental critical configurations. This report provides a comparison of the calculations performed with MCNP using cross section libraries from ENDF/B-VI, ENDF/B-V, and a combination of both. The MCNP input and output files are presented in the attachment. The k_{eff} results for each reactivity calculation are presented in Section 6. These results include the AENCF value (Average Energy of a Neutron Causing Fission), which is calculated using Equation 5.1.

Equation 5.1 AENCF (MeV) = energy per source particle/ weight per source particle

The calculation of the H/X ratio (hydrogen atoms/^{235}U atoms), listed in Section 5, was performed by two methods based upon whether the critical configuration was homogeneous or not. For homogeneous cases, the number of hydrogen atoms in the fuel region was calculated and divided by the number of ^{235}U atoms in the fuel region. In the heterogeneous (lattice) case the moderator volume was determined

by taking the volume of moderator around each fuel cell, that is the moderator that neutrons would "see" in a path to another fuel rod. This volume was used to determine the total number of hydrogen atoms present. Dividing the number of hydrogen atoms by the total number of ^{235}U atoms present in the fuel cell provides the H/X ratio.

The calculated values for AENCF are provided in Section 6 and the H/X values for each of the cases is provided in Section 5.

This engineering calculation uses information retrieved from source documentation. This calculation is based on source information taken from published reports and a handbook on benchmark experiments. Due to the nature of these sources, the source information is established fact, and should be considered accepted data.

5.1 Thermal System LCE Reactivity Calculations

The thermal system LCE reactivity calculations represent eleven critical configurations. Of these, eight are taken from Reference 7.1 (Attachment I). The other three are taken from Reference 7.5 as identified in the following subsections. The different configurations are discussed in Sections 5.1.1 through 5.1.5 with the results of the experiments listed in Section 6.

5.1.1 Uranyl Nitrate Cylinders

Reference 7.5 (HEU-SOL-THERM-001) documents ten critical experiments, each involving a tank of highly enriched uranyl nitrate; 93.172 wt% ^{235}U. These were performed at the Rocky Flats Plant which was operated at that time by Rockwell International. The experiments involved solution critical height measurements. The critical heights were determined by linear interpolation between reactor periods of slightly supercritical and slightly subcritical states. The tanks were cylindrical in shape and suspended in the approximate center of a large room. Eight of the critical configurations are used for this calculation. These eight had height to diameter ratios ranging from 0.68 to 1.2, and uranium concentrations (C) varying between 55 and 360 grams of uranium per liter. The only difference between the calculations performed here and those performed in Reference 7.1 is the number of histories, which was increased to 2 million.

All of the values listed in the Table 5.1.1-1 through Table 5.1.1-2 are taken from Reference 7.5, HEU-SOL-THERM-001 (HST-001). The specific pages are referenced in the tables titles.

Table 5.1.1-1. Uranyl Nitrate Critical Experiments (HST-001, p. 3)

Case Number	C (g U/l)	Diameter (cm)	Height (cm)	Ratio*	Case ID
3	142.92	28.01	33.55	1.2	HEST1-3
4	357.71	28.01	30.91	1.1	HEST1-4
5	54.89	33.01	39.48	1.2	HEST1-5
6	59.65	33.01	36.67	1.1	HEST1-6
7	137.4	33.01	23.96	0.73	HEST1-7
8	145.68	33.01	23.67	0.72	HEST1-8
9	357.71	33.01	22.53	0.68	HEST1-9

* Ratio = Height/Diameter

Table 5.1.1-2. Uranyl Nitrate Composition (HST-001, p. 19)

Case Number	^{235}U	^{234}U	^{236}U	^{238}U	O	N	H
3	3.4118×10^{-4}	3.7584×10^{-6}	1.5825×10^{-6}	1.9423×10^{-5}	3.5033×10^{-2}	9.0231×10^{-4}	6.3359×10^{-2}
4	8.5392×10^{-4}	9.4068×10^{-6}	3.9607×10^{-6}	4.8613×10^{-5}	3.7252×10^{-2}	2.1624×10^{-3}	5.8196×10^{-2}
5	1.3103×10^{-4}	1.4435×10^{-6}	6.0777×10^{-7}	7.4595×10^{-6}	3.4003×10^{-2}	3.4432×10^{-4}	6.5441×10^{-2}
6	1.4240×10^{-4}	1.5686×10^{-6}	6.6047×10^{-7}	8.1064×10^{-6}	3.4057×10^{-2}	3.7412×10^{-4}	6.5327×10^{-2}
7	3.2800×10^{-4}	3.6132×10^{-6}	1.5214×10^{-6}	1.8673×10^{-5}	3.4945×10^{-2}	8.7645×10^{-4}	6.3397×10^{-2}
8	3.4777×10^{-4}	3.8310×10^{-6}	1.6130×10^{-6}	1.9798×10^{-5}	3.5037×10^{-2}	9.2307×10^{-4}	6.3220×10^{-2}
9	8.5392×10^{-4}	9.4068×10^{-6}	3.9607×10^{-6}	4.8613×10^{-5}	3.7252×10^{-2}	2.1624×10^{-3}	5.8196×10^{-2}

* All atom densities are in atoms/b-cm.

Consistent with Reference 7.5, the calculations for these cases treated the aluminum tank as 97.35 wt% ^{27}Al (HST-001, p. 5) with a density of 2.737 g/cm^3 (HST-001, p. 4). Only the ^{27}Al was included in the calculations.

5.1.2 Uranyl Oxyfluoride Sphere

This water-reflected sphere is part of a series of experiments performed in the 1950's at the Oak Ridge National Laboratory with highly enriched uranium (93.2 wt% ^{235}U). This experiment involves a uranium oxyfluoride (UO_2F_2) solution in a 27.9-cm inner radius (91 liters) water-reflected sphere. The spherical shell is 0.20-cm-thick 1100 aluminum and surrounded by an effectively infinite water reflector.

All of the values listed in the Table 5.1.2-1 through Table 5.1.2-4 are taken from Reference 7.5, HEU-SOL-THERM-012 (HST-012). The specific pages are referenced in the table titles.

Table 5.1.2-1. Uranyl Oxyfluoride Critical Sphere (HST-012, p. 9)

C (g ^{235}U/l)	Diameter (cm)	H/X	Case ID
20.5	55.9	1272	HST121

Table 5.1.2-2. Uranyl Oxyfluoride Composition (HST-012, p. 9)

^{235}U	^{234}U	^{236}U	^{238}U	O	F	H
5.2444×10^{-5}	5.5393×10^{-7}	2.8022×10^{-7}	2.9675×10^{-6}	3.3473×10^{-2}	1.1249×10^{-4}	6.6722×10^{-2}

* All atom densities are in atoms/b-cm.

Table 5.1.2-3. Type 1100 Aluminum Composition (HST-012, p. 10)

Al	Si	Cu	Zn	Mn
5.9699×10^{-2}	5.5202×10^{-4}	5.1364×10^{-5}	2.4958×10^{-5}	1.4853×10^{-5}

* All atom densities are in atoms/b-cm and are based on a material density of 2.71 g/cm^3.

Table 5.1.2-4. Water Composition (HST-012, p. 10)

H	O
6.6659×10^{-2}	3.3329×10^{-2}

* All atom densities are in atoms/b-cm and are based on a material density of 0.99705 g/cm^3.

5.1.3 Uranyl Nitrate Sphere (69.2 cm Diameter)

Reference 7.5 (HEU-SOL-THERM-013) documents four measurements which are members of a series of experiments performed in the 1950's at the Oak Ridge National Laboratory with highly enriched uranium (93.2 wt% ^{235}U). This calculation considers only the first case described in the reference. The critical experiment measurement was made with 20.1 g U/l uranyl nitrate solution in an unreflected 27.24-inch-diameter sphere (174 liters). The sphere was fabricated of 0.32-cm-thick 1100 aluminum. The only difference between the calculations performed here and those performed in Reference 7.1 is that the number of histories was increased to 2 million.

All of the values listed in the Table 5.1.3-1 through Table 5.1.3-3 are taken from Reference 7.5, HEU-SOL-THERM-013 (HST-013). The specific pages are referenced in the tables.

Table 5.1.3-1. Uranyl Nitrate Critical Sphere (HST-013)

Case Number	C (g U/l) (p. 15)	Diameter (cm) (p. 14)	H/X (p. 15)	Case ID
1	20.1	69.2	1375	HEST131

Table 5.1.3-2. Uranyl Nitrate Composition (HST-013, p. 15)

^{235}U	^{234}U	^{236}U	^{238}U	O	N	H
4.8042×10^{-5}	5.3850×10^{-7}	1.3862×10^{-7}	2.8050×10^{-6}	3.3642×10^{-2}	1.8685×10^{-4}	6.6041×10^{-2}

* All atom densities are in atoms/b-cm.

Table 5.1.3-3. Type 1100 Aluminum Composition (HST-013, p. 15)

Al	Si	Cu	Zn	Mn
5.9699×10^{-2}	5.5202×10^{-4}	5.1364×10^{-5}	2.4958×10^{-5}	1.4853×10^{-5}

* All atom densities are in atoms/b-cm and are based on a material density of 2.71 g/cm^3.

5.1.4 Uranyl Nitrate Sphere (122 cm Diameter)

This experiment involves a 48.04-inch-diameter sphere (122 cm) of highly enriched uranium (93.2 wt% ^{235}U) solution with a concentration of 15.14 g U/l. The sphere was fabricated of 0.32-cm-thick 1100 aluminum. The experiment is documented in Reference 7.5, HEU-SOL-THERM-032 (HST-032).

All of the values listed in the Table 5.1.4-1 through Table 5.1.4-3 are taken from Reference 7.5, HST-032. The specific pages are referenced in the tables.

Table 5.1.4-1. Uranyl Nitrate Critical Sphere (HST-032)

C (g U/l) (p. 4)	Diameter (cm) (p. 10)	H/X (p. 1)	Case ID
15.1	122	1835	HST321

Table 5.1.4-2. Uranyl Nitrate Composition (HST-032, p. 12)

^{233}U	^{234}U	^{235}U	^{236}U	^{238}U	N	H	O
3.9124×10^{-9}	4.0905×10^{-7}	3.6157×10^{-5}	2.0858×10^{-7}	1.9878×10^{-6}	1.1212×10^{-4}	6.6409×10^{-2}	3.3601×10^{-2}

* All atom densities are in atoms/b-cm.

Table 5.1.4-3. Type 1100 Aluminum Composition (HST-032, p. 13)

Al	Si	Fe	Cu	Mn
5.9881×10^{-2}	2.1790×10^{-4}	1.10958×10^{-4}	5.1364×10^{-5}	1.4853×10^{-5}

* All atom densities are in atoms/b-cm and are based on a material density of 2.71 g/cm^3.

5.1.5 Water-Moderated, Lead-Reflected Uranium Dioxide Rod Array

Reference 7.5 (LEU-COMP-THERM-027) documents a series of four experiments involving lead-reflected, water-moderated arrays of low-enriched UO_2 fuel rods. The experiments were subcritical approaches extrapolated to critical; the multiplication factor reached was very close to 1.000 (within 0.1%). The experiments were tests of the lead reflector effect. Only the first case is considered in this calculation. This case consisted of a 14 x 14 array of 4.74 wt% enriched UO_2 fuel rods reflected on four sides by 30-cm-thick lead reflectors with no water gap between the array and the lead reflectors.

All of the values listed in the Table 5.1.5-1 through Table 5.1.5-3 are taken from Reference 7.5, LEU-COMP-THERM-027 (LCT-027). The specific pages are referenced in the tables.

Table 5.1.5-1. Uranium Dioxide Fuel Rods (LCT-027)

Case Number	Enrichment (wt% ^{235}U) (p. 2)	Fuel Pellet Diameter (cm) (p. 2)	Pitch (cm) (p. 18)	Fuel Length (cm) (p. 2)	Clad Inner Radius (cm) (p. 2)	Clad Outer Radius (cm) (p. 2)	Rod Length (cm) (p. 2)
1	4.74	0.79	1.6	90	0.41	0.47	100

Table 5.1.5-2. Uranium Dioxide Composition (LCT-027, p. 19)

^{235}U	^{238}U	O	B_{nat}
1.1114×10^{-3}	2.2045×10^{-2}	4.6391×10^{-2}	2.8910×10^{-7}

* All atom densities are in atoms/b-cm and are based on a material density of 10.38 g/cm^3 (LCT-027, p. 11).

Table 5.1.5-3. Non-Fissile Materials Compositions (LCT-027, p. 19)

Material	Nuclide/ Element	Atom Density (atoms/b-cm)
Aluminum Alloy, AG5 (Clad, Plugs)	Al	5.9556×10^{-2}
	Mg	3.3450×10^{-4}
	Si	2.4894×10^{-4}
	Fe	6.4052×10^{-5}
Water	H	6.6709×10^{-2}
	O	3.3354×10^{-2}
Steel (Support Plates, Pedestal)	Fe	8.4488×10^{-2}
	C	2.3765×10^{-4}
	Mn	3.4639×10^{-4}
Stainless Steel (Basket, Source Support)	Fe	6.0823×10^{-2}
	Cr	1.7532×10^{-2}
	Ni	7.6509×10^{-3}
Lead	Pb	3.2523×10^{-2}

5.2 Fast System LCE Reactivity Calculations

The fast system LCE reactivity calculations represent eleven critical configurations. Of these, two are taken from Reference 7.2 (p. 53). Of the other nine, three are taken from Reference 7.5 as identified in the following subsections and six are taken from Reference 7.6. The different configurations are discussed in Sections 5.2.1 through 5.2.6 with the results of the experiments listed in Section 6.

5.2.1 Bare, Highly Enriched Uranium Sphere (Godiva)

Reference 7.5 (HEU-MET-FAST-001) documents a series of experiments performed at Los Alamos in the 1950's. This calculation considers the Godiva experiment which was performed to determine the critical mass of a bare, highly enriched uranium (94 wt% ^{235}U) sphere. The sphere consisted of two identical sets of nested Oralloy hemispheres. The upper set was supported by a 0.015 inch thick diaphragm of stainless steel, and the lower set rested on a thin-wall aluminum cylinder. By remote control, the lower stack was raised to contact the steel diaphragm for each measurement of the multiplication of neutrons from a small near-central source.

All of the values listed in the Table 5.2.1-1 through Table 5.2.1-2 are taken from Reference 7.5, HEU-MET-FAST-001 (HMF-001). The specific pages are referenced in the tables.

Table 5.2.1-1. Godiva Critical Experiments (HMF-001)

Density ($g\ U/cm^3$) (p. 10)	Diameter (cm) (p. 10)	U Mass (kg) (p. 11)	Case ID
18.74	17.48	52.42	HMF1G

Table 5.2.1-2. Oralloy Composition (HMF-001, p. 11)

^{234}U (wt%)	^{235}U (wt%)	^{238}U (wt%)
1.02	93.71	5.27

5.2.2 Nickel Reflected Oralloy Sphere

Reference 7.5 (HEU-MET-FAST-003) documents twelve experiments using a variety of reflectors. This calculation considers only the experiment involving one spherical Oralloy assembly reflected by 8 inches of nickel. The configuration involves a pseudosphere of Oralloy surrounded by blocks of nickel. It must be noted that Reference 7.5, HEU-MET-FAST-003 (p. 1) states that the acceptability of the nickel-reflected sphere as a criticality safety benchmark experiment is somewhat marginal.

All of the values listed in the Table 5.2.2-1 through Table 5.2.2-3 are taken from Reference 7.5, HEU-MET-FAST-003 (HMF-003). The uranium described in Table 5.2.2-2 is 93.5 wt% ^{235}U (HMF-003, p. 11). The specific pages are referenced in the tables.

Table 5.2.2-1. Nickel Reflected Oralloy Critical Experiments (HMF-003)

Oralloy Density ($g\ U/cm^3$) (p. 5)	Inner Diameter (cm) (p. 11)	Outer Diameter (cm) (p. 11)	Case ID
18.75	12.9254	53.5654	HMF3Ni

Table 5.2.2-2. Oralloy Composition (HMF-003, p. 12)

^{234}U (atoms/b-cm)	^{235}U (atoms/b-cm)	^{238}U (atoms/b-cm)
4.9210×10^{-4}	4.4917×10^{-2}	2.5993×10^{-3}

Table 5.2.2-3. Nickel Composition (HMF-003)

Density (g/cm^3) (p. 11)	Ni (atoms/b-cm) (p. 12)	Thickness (cm) (p. 11)
8.9	9.1322×10^{-2}	20.32

5.2.3 Steel-Reflected, Highly Enriched Sphere

Reference 7.5 (HEU-MET-FAST-021) documents criticality measurements of a steel-reflected, highly enriched uranium (90 wt% ^{235}U) sphere by VNIIEF in 1962. The spherical core consists of eight shell layers. The steel reflector consists of two steel layers.

All of the values listed in the Table 5.2.3-1 through Table 5.2.3-4 are taken from Reference 7.5, HEU-MET-FAST-021 (HMF-021). The specific pages are referenced in the tables. The only difference between the calculations performed here and those performed in Reference 7.2 is the number of histories which was increased to 2 million.

Table 5.2.3-1. Steel-Reflected Uranium Critical Experiments (HMF-021)

Uranium Density (g U/cm^3) (p. 5)	Cavity Diameter (cm) (p. 10)	Core Diameter (cm) (p. 10)	Reflector Diameter (cm) (p. 10)	Case ID
18.1 to 18.5	1.78	15.10	34.50	HMF21

Table 5.2.3-2. Experiment Layers (HMF-021, p. 11)

Layer	Material Region	Inner Radius (cm)	Outer Radius (cm)	Mass (g)
1	Uranium/Core	0.89	1.40	155.6
2	Uranium/Core	1.40	3.15	2171.1
3	Uranium/Core	3.15	4.02	2563.9
4	Uranium/Core	4.02	4.66	2787.8
5	Uranium/Core	4.66	5.35	3996.6
6	Uranium/Core	5.35	6.00	4877.0
7	Uranium/Core	6.00	6.75	7103.7
8	Uranium/Core	6.75	7.55	9506.7
9	Steel/Reflector	7.55	11.00	28265
10	Steel/Reflector	11.00	17.25	118760

Table 5.2.3-3. Core Composition (HMF-021, p. 12)

Layer	^{234}U	^{235}U	^{238}U	C	Fe	W
1	5.0626×10^{-4}	4.1761×10^{-2}	4.2630×10^{-3}	7.3073×10^{-4}	1.1787×10^{-4}	3.5804×10^{-5}
2	5.0050×10^{-4}	4.1658×10^{-2}	4.1803×10^{-3}	1.4583×10^{-3}	2.3523×10^{-4}	7.1455×10^{-5}
3	5.3263×10^{-4}	4.1312×10^{-2}	4.4603×10^{-3}	1.2746×10^{-3}	2.1538×10^{-4}	5.9477×10^{-5}
4	5.3885×10^{-4}	4.1823×10^{-2}	4.5031×10^{-3}	1.1052×10^{-3}	1.9809×10^{-4}	5.4154×10^{-5}
5	5.4361×10^{-4}	4.1769×10^{-2}	4.5313×10^{-3}	1.2895×10^{-3}	2.1791×10^{-4}	6.6193×10^{-5}
6	5.1940×10^{-4}	4.2390×10^{-2}	4.3476×10^{-3}	1.0214×10^{-3}	1.7973×10^{-4}	5.4595×10^{-5}
7	5.1956×10^{-4}	4.2360×10^{-2}	4.3676×10^{-3}	1.2074×10^{-3}	2.1973×10^{-4}	6.0679×10^{-5}
8	5.1351×10^{-4}	4.2363×10^{-2}	4.3006×10^{-3}	8.3383×10^{-4}	1.5941×10^{-4}	4.2369×10^{-5}

* All atom densities are in atoms/b-cm

Table 5.2.3-4. Reflector Composition (HMF-021, p. 12)

Layer	Fe	C	Si	Cr	Mn	Ni	Cu
9	7.9417×10^{-2}	1.1269×10^{-3}	1.6065×10^{-4}	2.6032×10^{-4}	3.2851×10^{-4}	2.3063×10^{-4}	2.1301×10^{-4}
10	7.9045×10^{-2}	1.1217×10^{-3}	1.5990×10^{-4}	2.5910×10^{-4}	3.2697×10^{-4}	2.2955×10^{-4}	2.1201×10^{-4}

* All atom densities are in atoms/b-cm

5.2.4 Duralumin-Reflected, Highly Enriched Sphere

Reference 7.5 (HEU-MET-FAST-022) documents criticality measurements of a Duralumin-reflected spherical assembly of highly enriched uranium (90 wt% ^{235}U) that were conducted by VNIIEF in 1962 The spherical core consists of nine shell layers. The steel reflector consists of three Duralumin layers, although the MCNP input treats it as one layer.

All of the values listed in the Table 5.2.4-1 through Table 5.2.4-4 are taken from Reference 7.5, HEU-MET-FAST-022 (HMF-022). The specific pages are referenced in the tables. The only difference between the calculations performed here and those performed in Reference 7.2 is that the number of histories was increased to 2 million.

Table 5.2.4-1. Duralumin-Reflected Uranium Critical Experiments (HMF-022)

Uranium Density (g U/cm^3) (p. 6)	Cavity Diameter (cm) (p. 12)	Core Diameter (cm) (p. 12)	Reflector Diameter (cm) (p. 12)	Case ID
18.1 to 18.5	2.036	16.7	24.5	HMF22

Table 5.2.4-2. Experiment Layers (HMF-022, p. 12)

Layer	Material Region	Inner Radius (cm)	Outer Radius (cm)	Mass (g)
1	Uranium/Core	1.018	1.400	129.20
2	Uranium/Core	1.400	3.150	2171.1
3	Uranium/Core	3.150	4.020	2563.9
4	Uranium/Core	4.020	4.660	2787.8
5	Uranium/Core	4.660	5.350	3996.6
6	Uranium/Core	5.350	6.000	4877.0
7	Uranium/Core	6.000	6.750	7103.7
8	Uranium/Core	6.750	7.550	9506.7
9	Uranium/Core	7.550	8.35	11762
10	Duralumin/Reflector	8.35	12.25	13760

Table 5.2.4-3. Core Composition (HMF-022, p. 13)

Layer	^{234}U	^{235}U	^{238}U	C	Fe	W
1	5.0748×10^{-4}	4.1862×10^{-2}	4.2733×10^{-3}	7.3248×10^{-4}	1.1815×10^{-4}	3.5890×10^{-5}
2	5.0050×10^{-4}	4.1658×10^{-2}	4.1803×10^{-3}	1.4583×10^{-3}	2.3523×10^{-4}	7.1455×10^{-5}
3	5.3263×10^{-4}	4.1312×10^{-2}	4.4603×10^{-3}	1.2746×10^{-3}	2.1538×10^{-4}	5.9477×10^{-5}
4	5.3885×10^{-4}	4.1823×10^{-2}	4.5031×10^{-3}	1.1052×10^{-3}	1.9809×10^{-4}	5.4154×10^{-5}
5	5.4361×10^{-4}	4.1769×10^{-2}	4.5313×10^{-3}	1.2895×10^{-3}	2.1791×10^{-4}	6.6193×10^{-5}
6	5.1940×10^{-4}	4.2390×10^{-2}	4.3476×10^{-3}	1.0214×10^{-3}	1.7973×10^{-4}	5.4595×10^{-5}
7	5.1956×10^{-4}	4.2360×10^{-2}	4.3676×10^{-3}	1.2074×10^{-3}	2.1973×10^{-4}	6.0679×10^{-5}
8	5.1351×10^{-4}	4.2363×10^{-2}	4.3006×10^{-3}	8.3383×10^{-4}	1.5941×10^{-4}	4.2369×10^{-5}
9	5.2352×10^{-4}	4.2309×10^{-2}	4.3843×10^{-3}	9.2736×10^{-4}	1.5956×10^{-4}	4.2409×10^{-5}

* All atom densities are in atoms/b-cm

Table 5.2.4-4. Reflector Composition (HMF-022, p. 13)

Layer	Al	Fe	Cu
10	5.3934×10^{-2}	9.8702×10^{-4}	1.0161×10^{-3}

* All atom densities are in atoms/b-cm

5.2.5 Uranium-Reflected, Highly Enriched Uranium Sphere

Reference 7.5 (HEU-MET-FAST-028) documents a critical experiment that was performed at Los Alamos Scientific Laboratory in the mid-1960s. This experiment involves a spherical highly enriched uranium core reflected by normal uranium. The core is composed of two highly enriched uranium metal hemispheres. One hemisphere has a mass of 7.47 kg of uranium enriched to 93.22 wt% ^{235}U. The other hemisphere was 8.663 kg of uranium enriched to 93.27 wt% ^{235}U.

All of the values listed in the Table 5.2.5-1 through Table 5.2.5-2 are taken from Reference 7.5, HEU-MET-FAST-028 (HMF-028). The specific pages are referenced in the table titles.

Table 5.2.5-1. Uranium Critical Experiments (HMF-028, p. 10)

Region	Density (g U/cm^3)	Diameter (cm)	Enrichment (wt% ^{235}U)	Case ID
Homogenized Core	18.62	12.2312	93.24	HMF28
Reflector	19.0	48.2484	Natural	

Table 5.2.5-2. Uranium Composition (HMF-028, p. 10)

Region	Density (g U/cm^3)	^{234}U	^{235}U	^{238}U
Homogenized Core	18.62	4.8869×10^{-4}	4.4482×10^{-2}	2.7038×10^{-3}
Reflector	19.0	2.6438×10^{-6}	3.4610×10^{-4}	4.7721×10^{-2}

* All atom densities are in atoms/b-cm

5.2.6 Fast Reactor Criticals

Reference 7.6 documents a number of fast reactor critical experiments. From the list of twenty-five fast reactor criticals, this calculation uses six. Although little detail of the actual experiments is provided, the reference does document the two-dimensional descriptions that were used in previous benchmark

work. These two-dimensional representations are homogenized cylinders that represent the heterogeneous cores.

All of the values listed in the Table 5.2.6-1 through Table 5.2.6-4 are taken from Reference 7.6. The specific pages are referenced in the tables.

Table 5.2.6-1. Fast Reactor Critical Experiments Descriptions (Ref. 7.6)

Reactor	System Description	Section	Case ID
VERA-1B	Cylindrically shaped critical assembly fueled with enriched uranium and diluted with graphite. The assembly core was 27.2 cm in height and the effective core diameter was 38.214 cm. The assembly was surrounded by a blanket of natural uranium and stainless steel.	F6 (pp. F6-1 to F6-6)	VERA1B
ZPR-III 6F	Cylindrically shaped critical assembly with a core composition with a ^{238}U to ^{235}U ratio of about 1:1. The reflector was composed mostly of ^{238}U.	F7 (pp. F7-1 to F7-7)	ZPR36F
ZPR-III 11	Cylindrical critical assembly constructed with a core fueled with uranium metal such that the ratio of ^{238}U to ^{235}U was about 7:1, and a reflector composed mostly of ^{238}U.	F8 (pp. F8-1 to F8-8)	ZPR311
ZPR-III 12	This is a fast reactor benchmark source experiment on a 4:1 uranium-graphite system. The core was approximately cylindrical composed from a repetition of a one-drawer unit cell. A blanket, consisting primarily of depleted uranium, surrounded the core.	F9 (pp. F9-1 to F9-5)	ZPR312
ZEBRA-2	Cylindrical critical assembly constructed of a core surrounded by a blanket of natural uranium. The core is a uranium-plus-graphite system.	F10 (pp. F10-1 to F10-7)	ZEBRA2
BIG TEN	Cylindrical system consisting of a uranium-metal core, averaging 10 wt% ^{235}U, reflected by depleted-uranium metal. The core has a homogeneous axial region surrounded by interleaved plates of highly enriched uranium and natural uranium such that the average ^{235}U content is uniform.	F20 (pp. F20-1 to F20-9)	BIG10

Table 5.2.6-2. Fast Reactor Critical Experiments (Ref. 7.6)

Reactor	Core Diameter (cm)	Core Height (cm)	Reflector Diameter (cm)	Reflector Height (cm)
VERA1B (p. F6-3)	38.214	27.150	121.814	101.350
ZPR36F (p. F7-3)	40.586	40.884	103.966	101.984
ZPR311 (p. F8-3)	59.28	51.0	128.4	112
ZPR312 (p. F9-4)	53.92	45.92	114.92	106.92
ZEBRA2 (p. F10-3)	80.54	83.44	147.06	144.40
BIG10 (p. F20-2)	53.34	55.88	83.82	96.52

Table 5.2.6-3. Core Composition (Ref. 7.6)

Material	VERA1B (p. F6-2)	ZPR36F (p. F7-4)	ZPR311 (p. F8-4)	ZPR312 (p. F9-5)	ZEBRA2 (p. F10-4)	BIG10 (p. F20-1)
^{234}U	0.000092	0.000069	0.000046	0.000046	0.000000	0.00005
^{235}U	0.007349	0.006727	0.004567	0.004516	0.002526	0.00484
^{236}U	0.000014	0.000029	0.000019	0.000000	0.000000	0.00000
^{238}U	0.000455	0.007547	0.034373	0.016948	0.015667	0.04268
C	0.057540	0.000000	0.000000	0.026762	0.037992	0.00000
H	0.000058	0.000000	0.000000	0.000000	0.00030876	0.00000
Fe	0.006283	0.007712	0.005681	0.005704	0.0036485	0.00000
Ni	0.001635	0.000839	0.000718	0.000621	0.000483	0.00000
Cr	0.000689	0.001918	0.001486	0.001419	0.000864	0.00000
Al	0.000000	0.019019	0.000000	0.000000	0.000019	0.00000
Mn	0.000000	0.000080	0.00208	0.000059	0.000064	0.00000
Si	0.000000	0.000000	0.000000	0.000069	0.000054	0.00000
O	0.000000	0.000000	0.000000	0.000000	0.0001544	0.00000
Cu	0.000000	0.000000	0.000000	0.000000	0.000004	0.00000
Mo	0.000000	0.000000	0.000000	0.000000	0.000008	0.00000
Ti	0.000000	0.000000	0.000000	0.000000	0.000016	0.00000
V	0.000000	0.000000	0.000000	0.000000	0.000005	0.00000

* All atom densities are in atoms/b-cm

Table 5.2.6-4. Reflector Composition (Ref. 7.6)

Material	VERA1B (p. F6-2)	ZPR36F (p. F7-4)	ZPR311 (p. F8-4)	ZPR312 (p. F9-5)	ZEBRA2 (p. F10-4)	BIG10 (p. F20-1)
^{234}U	0.00000	0.000000	0.000000	0.000000	0.000000	0.00000
^{235}U	0.00025	0.000089	0.000089	0.000089	0.000298	0.00010
^{236}U	0.00000	0.000000	0.000000	0.000000	0.000000	0.00000
^{238}U	0.03440	0.040026	0.040025	0.040026	0.041269	0.04797
C	0.00000	0.000000	0.000000	0.000000	0.000042	0.00000
H	0.00000	0.000000	0.000000	0.000000	0.000000	0.00000
Fe	0.006464	0.004539	0.004925	0.004971	0.003323	0.00000
Ni	0.001682	0.000494	0.000536	0.000541	0.000483	0.00000
Cr	0.000708	0.001129	0.001196	0.001237	0.000864	0.00000
Al	0.000000	0.001359	0.000000	0.000000	0.000019	0.00000
Mn	0.000000	0.000047	0.000111	0.000052	0.000064	0.00000
Si	0.000000	0.000000	0.000000	0.000060	0.000054	0.00000
O	0.000000	0.000000	0.000000	0.000000	0.000000	0.00000
Cu	0.000000	0.000000	0.000000	0.000000	0.000004	0.00000
Mo	0.000000	0.000000	0.000000	0.000000	0.000008	0.00000
Ti	0.000000	0.000000	0.000000	0.000000	0.000016	0.00000
V	0.000000	0.000000	0.000000	0.000000	0.000005	0.00000

* All atom densities are in atoms/b-cm

5.3 LCE MCNP Cross Section Libraries

The MCNP cross section libraries used in the reactivity calculations are one of the primary components of the calculation that determines whether or not the neutronic behavior of the system is simulated correctly. Table 5.3-1 lists all of the MCNP cross section library identifiers (ZAID's) used in the LCE reactivity calculations documented in this calculation file. The MCNP ZAID's are used to identify the cross section libraries. The ZAID consists of a 5-integer element and isotope identifier followed by a cross section library designation suffix. The first one or two integers in the ZAID refer to the atomic number of the corresponding element. The three integers preceding the decimal always refer to the isotopic mass number. The ZAID suffixes presented in Table 5.3-1 correspond to libraries compiled

from either ENDF/B-VI, ENDF/B-V, LANL/T-2, or Lawrence Livermore National Laboratory evaluated cross section sets. The atom percent in nature of the various isotopes presented in Table 5.3-1 were obtained from Reference 7.8. The temperatures, library names, and data sources were obtained from Appendix G of Reference 7.3.

Table 5.3-1. MCNP Cross Section Libraries Used in the LCE Reactivity Calculations

Element / Isotope	MCNP ZAID	Atom % in Nature	Atomic Wt. Ratio [1]	Temp. (K)	Library Name	Data Source
H-1	1001.50c	99.985	0.9992	294.0	rmccs	ENDF/B-V.0
H-1	1001.60c	99.985	0.9992	294.0	endf60	ENDF/B-VI.1
H-2	1002.50c	0.015	1.9968	294.0	endf5p	ENDF/B-V.0
H-2	1002.60c	0.015	1.9968	294.0	endf60	ENDF/B-VI.0
Be-9	4009.50c	100.0	8.9348	294.0	rmccs	ENDF/B-V.0
Be-9	4009.60c	100.0	8.9348	294.0	endf60	ENDF/B-VI.0
B-10	5010.50c	19.400 [2]	9.9269	294.0	rmccs	ENDF/B-V.0
B-10	5010.60c	19.400 [2]	9.9269	294.0	endf60	ENDF/B-VI.1
B-11	5011.50c	80.600 [2]	10.9150	294.0	endf5p	ENDF/B-V.0
B-11	5011.56c	80.600 [2]	10.9147	294.0	newxs	LANL/T-2
B-11	5011.60c	80.600 [2]	10.9147	294.0	endf60	ENDF/B-VI.0
C-nat	6000.50c	100.0	11.8969	294.0	rmccs	ENDF/B-V.0
C-nat	6000.60c	100.0	11.8980	294.0	endf60	ENDF/B-VI.1
C-12	6012.50c	98.90	11.8969	294.0	rmccs	ENDF/B-V.0
N-14	7014.50c	99.630	13.8830	294.0	rmccs	ENDF/B-V.0
N-14	7014.60c	99.630	13.8828	294.0	endf60	LANL/T-2
N-15	7015.55c	0.37	14.8710	294.0	rmccsa	LANL/T-2
N-15	7015.60c	0.37	14.8710	294.0	endf60	ENDF/B-VI.0
O-16	8016.50c	99.760	15.8580	294.0	rmccs	ENDF/B-V.0
O-16	8016.60c	99.760	15.8532	294.0	endf60	ENDF/B-VI.0
O-17	8017.60c	0.04	16.8531	294.0	endf60	ENDF/B-VI.0
Mg-nat	12000.50c	100.0	24.0963	294.0	endf5u	ENDF/B-V.0
Mg-nat	12000.60c	100.0	24.0963	294.0	endf60	ENDF/B-VI.0
Al-27	13027.50c	100.0	26.7500	294.0	rmccs	ENDF/B-V.0
Al-27	13027.60c	100.0	26.7500	294.0	endf60	ENDF/B-VI.0
Si-nat	14000.50c	100.0	27.8440	294.0	endf5p	ENDF/B-V.0
Si-nat	14000.60c	100.0	27.8440	294.0	endf60	ENDF/B-VI.0

Table 5.3-1. MCNP Cross Section Libraries Used in the LCE Reactivity Calculations

Element / Isotope	MCNP ZAID	Atom % in Nature	Atomic Wt. Ratio [1]	Temp. (K)	Library Name	Data Source
P-31	15031.50c	100.0	30.7080	294.0	endf5u	ENDF/B-V.0
P-31	15031.60c	100.0	30.7080	294.0	endf60	ENDF/B-VI.0
S-32	16032.50c	95.02	31.6970	294.0	endf5u	ENDF/B-V.0
S-32	16032.60c	95.02	31.6970	294.0	endf60	ENDF/B-VI.0
Ca-nat	20000.50c	100.0	39.7360	294.0	endf5u	ENDF/B-V.0
Ca-nat	20000.60c	100.0	39.7360	294.0	endf60	ENDF/B-VI.0
Ti-nat	22000.50c	100.0	47.4676	294.0	endf5u	ENDF/B-V.0
Ti-nat	22000.60c	100.0	47.4676	294.0	endf60	ENDF/B-VI.0
V-nat	23000.50c	100.0	50.5040	294.0	endf5u	ENDF/B-V.0
V-nat	23000.60c	100.0	50.5040	294.0	endf60	ENDF/B-VI.0
Cr-nat	24000.50c	100.0	51.5490	294.0	rmccs	ENDF/B-V.0
Cr-50	24050.60c	4.345	49.5170	294.0	endf60	ENDF/B-VI.1
Cr-52	24052.60c	83.790	51.4940	294.0	endf60	ENDF/B-VI.1
Cr-53	24053.60c	9.500	52.4860	294.0	endf60	ENDF/B-VI.1
Cr-54	24054.60c	2.365	53.4760	294.0	endf60	ENDF/B-VI.1
Mn-55	25055.50c	100.0	54.4661	294.0	endf5u	ENDF/B-V.0
Mn-55	25055.60c	100.0	54.4661	294.0	endf60	ENDF/B-VI.0
Fe-nat	26000.55c	100.0	55.3650	294.0	rmccs	LANL/T-2
Fe-54	26054.60c	5.900	53.4760	294.0	endf60	ENDF/B-VI.1
Fe-56	26056.60c	91.720	55.4540	294.0	endf60	ENDF/B-VI.1
Fe-57	26057.60c	2.100	56.4460	294.0	endf60	ENDF/B-VI.1
Fe-58	26058.60c	0.280	57.4360	294.0	endf60	ENDF/B-VI.1
Ni-nat	28000.50c	100.0	58.1826	294.0	rmccs	ENDF/B-V.0
Ni-58	28058.60c	68.270	57.4380	294.0	endf60	ENDF/B-VI.1
Ni-60	28060.60c	26.100	59.4160	294.0	endf60	ENDF/B-VI.1
Ni-61	28061.60c	1.130	60.4080	294.0	endf60	ENDF/B-VI.1
Ni-62	28062.60c	3.590	61.3960	294.0	endf60	ENDF/B-VI.1
Ni-64	28064.60c	0.910	63.3790	294.0	endf60	ENDF/B-VI.1
Cu-nat	29000.50c	100.0	63.5460	294.0	rmccs	ENDF/B-V.0
Cu-63	29063.60c	69.170	62.3890	294.0	endf60	ENDF/B-VI.2
Cu-65	29065.60c	30.830	64.3700	294.0	endf60	ENDF/B-VI.2

Table 5.3-1. MCNP Cross Section Libraries Used in the LCE Reactivity Calculations

Element / Isotope	MCNP ZAID	Atom % in Nature	Atomic Wt. Ratio [1]	Temp. (K)	Library Name	Data Source
Ga-nat	31000.50c	100.0	69.1211	294.0	rmccs	ENDF/B-V.0
Ga-nat	31000.60c	100.0	69.1211	294.0	endf60	ENDF/B-VI.0
Zr-nat	40000.56c	100.0	90.4360	300	misc5xs	ENDF/B-V: XTM
Zr-nat	40000.60c	100.0	90.4360	294.0	endf60	ENDF/B-VI.1
Nb-93	41093.50c	100.0	92.1051	294.0	endf5p	ENDF/B-V.0
Nb-93	41093.60c	100.0	92.1051	294.0	endf60	ENDF/B-VI.1
Mo-nat	42000.50c	100.0	95.1160	294.0	endf5u	ENDF/B-V.0
Mo-nat	42000.60c	100.0	95.1160	294.0	endf60	ENDF/B-VI.0
Cd-nat	48000.50c	100.0	111.4600	294.0	endf5u	ENDF/B-V.0
Gd-152	64152.50c	0.2	150.6150	294.0	endf5u	ENDF/B-V.0
Gd-152	64152.60c	0.2	150.6150	294.0	endf60	ENDF/B-VI.0
Gd-154	64154.50c	2.18	152.5990	294.0	endf5u	ENDF/B-V.0
Gd-154	64154.60c	2.18	152.5990	294.0	endf60	ENDF/B-VI.0
Gd-155	64155.50c	14.80	153.5920	294.0	endf5u	ENDF/B-V.0
Gd-155	64155.60c	14.80	153.5920	294.0	endf60	ENDF/B-VI.0
Gd-156	64156.50c	20.47	154.5830	294.0	endf5u	ENDF/B-V.0
Gd-156	64156.60c	20.47	154.5830	294.0	endf60	ENDF/B-VI.0
Gd-157	64157.50c	15.65	155.5760	294.0	endf5u	ENDF/B-V.0
Gd-157	64157.60c	15.65	155.5760	294.0	endf60	ENDF/B-VI.0
Gd-158	64158.50c	24.84	156.5670	294.0	endf5u	ENDF/B-V.0
Gd-158	64158.60c	24.84	156.5670	294.0	endf60	ENDF/B-VI.0
Gd-160	64160.50c	21.86	158.5530	294.0	endf5u	ENDF/B-V.0
Gd-160	64160.60c	21.86	158.5530	294.0	endf60	ENDF/B-VI.0
W-nat	74000.55c	100.0	182.2770	294.0	rmccs	ENDF/B-V.2
W-182	74182.60c	26.3	180.3900	294.0	endf60	ENDF/B-VI.0
W-183	74183.60c	14.28	181.3800	294.0	endf60	ENDF/B-VI.0
W-184	74184.60c	30.7	182.3700	294.0	endf60	ENDF/B-VI.0
W-186	74186.60c	28.6	184.3600	294.0	endf60	ENDF/B-VI.0
U-234	92234.50c	0.0055	232.0300	294.0	endf5p	ENDF/B-V.0
U-234	92234.60c	0.0055	232.0300	294.0	endf60	ENDF/B-VI.0

Table 5.3-1. MCNP Cross Section Libraries Used in the LCE Reactivity Calculations

Element / Isotope	MCNP ZAID	Atom % in Nature	Atomic Wt. Ratio [1]	Temp. (K)	Library Name	Data Source
U-235	92235.50c	0.7200	233.0250	294.0	rmccs	ENDF/B-V.0
U-235	92235.60c	0.7200	233.0250	294.0	endf60	ENDF/B-VI.2
U-236	92236.50c	0.0	234.0180	294.0	endf5p	ENDF/B-V.0
U-236	92236.60c	0.0	234.0180	294.0	endf60	ENDF/B-VI.0
U-238	92238.50c	99.2745	236.0060	294.0	rmccs	ENDF/B-V.0
U-238	92238.60c	99.2745	236.0060	294.0	endf60	ENDF/B-VI.2
Pu-238	94238.50c	0.0	236.1670	294.0	endf5p	ENDF/B-V.0
Pu-238	94238.60c	0.0	236.0045	294.0	endf60	ENDF/B-VI.0
Pu-239	94239.55c	0.0	236.9990	294.0	rmccs	ENDF/B-V.2
Pu-239	94239.60c	0.0	236.9986	294.0	endf60	ENDF/B-VI.2
Pu-240	94240.50c	0.0	237.9920	294.0	rmccs	ENDF/B-V.0
Pu-240	94240.60c	0.0	237.9920	294.0	endf60	ENDF/B-VI.2
Pu-241	94241.50c	0.0	238.9780	294.0	endf5p	ENDF/B-V.0
Pu-241	94241.60c	0.0	238.9780	294.0	endf60	ENDF/B-VI.1
Pu-242	94242.50c	0.0	239.9790	294.0	endf5p	ENDF/B-V.0
Pu-242	94242.60c	0.0	239.9790	294.0	endf60	ENDF/B-VI.0
Am-241	95241.50c	0.0	238.9860	294.0	endf5u	ENDF/B-V.0
Am-241	95241.60c	0.0	238.9860	300	endf60	LANL/T-2

1. The atomic weight ratio presented for each isotope/element is the ratio of the isotope/element mass to the mass of a neutron. The mass of a neutron is 1.008664904 amu (Ref. 7.8, p. 57). The atomic weight ratio values are obtained from the "xsdir" file for MCNP as identified on page III-2 of Reference 7.7.

2. The atom percent in nature of B-10 and B-11 varies significantly between different geographical regions of the world. The atom percents in nature that are listed in Table 5.3-1 for B-10 and B-11 were obtained from page 232 of Reference 7.9.

6. RESULTS

This calculation file documents the LCE reactivity evaluations that were performed for benchmark calculations. Sections 6.1 through 6.2 present the k_{eff} results for each of the LCE evaluations. Section 6.3 contains summary tables which are organized on the basis of cross section library used. The k_{eff} results represent the average combined collision, absorption, and track-length estimator from the MCNP calculations. The standard deviation (σ) represents the standard deviation of k_{eff} about the average combined collision, absorption, and track-length estimate due to the Monte Carlo calculation statistics.

6.1 Thermal System Results

6.1.1 HST-001 Results

Table 6.1.1-1 presents the MCNP calculation results for ENDF/B-V, WPO Selected, and ENDF/B-VI cross section libraries for the HST-001 set of critical experiments. Table 6.1.1-2 shows the calculated AENCF values for the same experiments. For these LCEs, the ENDF/B-V and the WPO Selected cases have identical inputs. The input and output for these cases are included in the attachment in the ENDF/B-V directories (attIII and attIV, respectively) only.

Table 6.1.1-1. LCE Reactivity Calculation Results for HST-001 Experiments

MCNP Case Name	ENDF/B-V $k_{eff} \pm \sigma$	WPO Selected $k_{eff} \pm \sigma$	ENDF/B-VI $k_{eff} \pm \sigma$
HEST1-3	1.0064 ± 0.0008	1.0064 ± 0.0008	1.0017 ± 0.0008
HEST1-4	1.0030 ± 0.0008	1.0030 ± 0.0008	1.0011 ± 0.0008
HEST1-5	1.0040 ± 0.0007	1.0040 ± 0.0007	0.9987 ± 0.0006
HEST1-6	1.0072 ± 0.0006	1.0072 ± 0.0006	1.0015 ± 0.0006
HEST1-7	1.0033 ± 0.0008	1.0033 ± 0.0008	0.9982 ± 0.0008
HEST1-8	1.0025 ± 0.0007	1.0025 ± 0.0007	0.9960 ± 0.0008
HEST1-9	0.9988 ± 0.0008	0.9988 ± 0.0008	0.9967 ± 0.0008

Table 6.1.1-2. AENCF for HST-001 Experiments (MeV)

MCNP Case Name	ENDF/B-V	WPO Selected	ENDF/B-VI
HEST1-3	0.0158	0.0158	0.0155
HEST1-4	0.0405	0.0405	0.0397
HEST1-5	0.0065	0.0065	0.0062
HEST1-6	0.0069	0.0069	0.0069
HEST1-7	0.0153	0.0153	0.0149
HEST1-8	0.0162	0.0162	0.0159
HEST1-9	0.0408	0.0408	0.0401

6.1.2 HST-012 Results

Table 6.1.2-1 presents the MCNP calculation results for ENDF/B-V, WPO Selected, and ENDF/B-VI cross section libraries for the HST-012 critical experiment. Table 6.1.2-2 shows the calculated AENCF values for the same experiment. For this LCE, the ENDF/B-V and the WPO Selected cases have identical input. The input and output for this case are included in the attachment in the ENDF/B-V directories (attIII and attIV, respectively) only.

Table 6.1.2-1. LCE Reactivity Calculation Results for HST-012 Experiments

MCNP Case Name	ENDF/B-V $k_{eff} \pm \sigma$	WPO Selected $k_{eff} \pm \sigma$	ENDF/B-VI $k_{eff} \pm \sigma$
HST121	1.0035 ± 0.0004	1.0035 ± 0.0004	0.9993 ± 0.0004

Table 6.1.2-2. AENCF for HST-012 Experiments (MeV)

MCNP Case Name	ENDF/B-V	WPO Selected	ENDF/B-VI
HST121	0.0027	0.0027	0.0027

6.1.3 HST-013 Results (Case 1)

Table 6.1.3-1 presents the MCNP calculation results for ENDF/B-V, WPO Selected, and ENDF/B-VI cross section libraries for the HST-013 (case 1) critical experiment. Table 6.1.3-2 shows the calculated AENCF values for the same experiment.

Table 6.1.3-1. LCE Reactivity Calculation Results for HST-013 Experiments

MCNP Case Name	ENDF/B-V $k_{eff} \pm \sigma$	WPO Selected $k_{eff} \pm \sigma$	ENDF/B-VI $k_{eff} \pm \sigma$
HEST131	1.0007 ± 0.0004	1.0004 ± 0.0004	0.9966 ± 0.0004

Table 6.1.3-2. AENCF for HST-013 Experiments (MeV)

MCNP Case Name	ENDF/B-V	WPO Selected	ENDF/B-VI
HEST131	0.0027	0.0027	0.0026

6.1.4 HST-032 Results (ORNL10)

Table 6.1.4-1 presents the MCNP calculation results for ENDF/B-V, WPO Selected, and ENDF/B-VI cross section libraries for the HST-032 ORNL10 critical experiment. Table 6.1.4-2 shows the calculated AENCF values for the same experiment.

Table 6.1.4-1. LCE Reactivity Calculation Results for HST-032 Experiments

MCNP Case Name	ENDF/B-V $k_{eff} \pm \sigma$	WPO Selected $k_{eff} \pm \sigma$	ENDF/B-VI $k_{eff} \pm \sigma$
HST321	0.9996 ± 0.0003	0.9991 ± 0.0003	0.9972 ± 0.0003

Table 6.1.4-2. AENCF for HST-032 Experiments (MeV)

MCNP Case Name	ENDF/B-V	WPO Selected	ENDF/B-VI
HST321	0.0021	0.0022	0.0021

6.1.5 LCT-027 Results (Case 1)

Table 6.1.5-1 presents the MCNP calculation results for ENDF/B-V, WPO Selected, and ENDF/B-VI cross section libraries for the LCT-001 (case 1) critical experiment. Table 6.1.5-2 shows the calculated AENCF values for the same experiment.

Table 6.1.5-1. LCE Reactivity Calculation Results for LCT-001 Experiments

MCNP Case Name	ENDF/B-V $k_{eff} \pm \sigma$	WPO Selected $k_{eff} \pm \sigma$	ENDF/B-VI $k_{eff} \pm \sigma$
LCT27-1	1.0139 ± 0.0005	1.0157 ± 0.0005	1.0102 ± 0.0006

Table 6.1.5-2. AENCF for LCT-001 Experiments (MeV)

MCNP Case Name	ENDF/B-V	WPO Selected	ENDF/B-VI
LCT27-1	0.1024	0.1025	0.1023

6.2 Fast System Results

6.2.1 HMF-001 Results (Godiva)

Table 6.2.1-1 presents the MCNP calculation results for ENDF/B-V, WPO Selected, and ENDF/B-VI cross section libraries for the HMF-001 Godiva critical experiment. Table 6.2.1-2 shows the calculated AENCF values for the same experiment. For this LCE, the ENDF/B-V and the WPO Selected cases have identical input. The input and output for this case are included in the attachment in the ENDF/B-V directories (attIII and attIV, respectively) only.

Table 6.2.1-1. LCE Reactivity Calculation Results for HMF-001 Experiments

MCNP Case Name	ENDF/B-V $k_{eff} \pm \sigma$	WPO Selected $k_{eff} \pm \sigma$	ENDF/B-VI $k_{eff} \pm \sigma$
HMF1g	0.9986 ± 0.0004	0.9986 ± 0.0004	0.9970 ± 0.0004

Table 6.2.1-2. AENCF for HMF-001 Experiments (MeV)

MCNP Case Name	ENDF/B-V	WPO Selected	ENDF/B-VI
HMF1g	1.5681	1.5681	1.4893

6.2.2 HMF-003 Results (Nickel-Reflected)

Table 6.2.2-1 presents the MCNP calculation results for ENDF/B-V, WPO Selected, and ENDF/B-VI cross section libraries for the HMF-003 nickel-reflected critical experiment. Table 6.2.2-2 shows the calculated AENCF values for the same experiment.

Table 6.2.2-1. LCE Reactivity Calculation Results for HMF-003 Experiments

MCNP Case Name	ENDF/B-V $k_{eff} \pm \sigma$	WPO Selected $k_{eff} \pm \sigma$	ENDF/B-VI $k_{eff} \pm \sigma$
HMF3Ni	1.0145 ± 0.0005	1.0036 ± 0.0005	1.0045 ± 0.0005

Table 6.2.2-2. AENCF for HMF-003 Experiments (MeV)

MCNP Case Name	ENDF/B-V	WPO Selected	ENDF/B-VI
HMF3Ni	1.3555	1.3649	1.2964

6.2.3 HMF-021 Results

Table 6.2.3-1 presents the MCNP calculation results for ENDF/B-V, WPO Selected, and ENDF/B-VI cross section libraries for the HMF-021 critical experiment. Table 6.2.3-2 shows the calculated AENCF values for the same experiment.

Table 6.2.3-1. LCE Reactivity Calculation Results for HMF-021 Experiments

MCNP Case Name	ENDF/B-V $k_{eff} \pm \sigma$	WPO Selected $k_{eff} \pm \sigma$	ENDF/B-VI $k_{eff} \pm \sigma$
HMF21	1.0017 ± 0.0004	0.9965 ± 0.0004	0.9946 ± 0.0005

Table 6.2.3-2. AENCF for HMF-021 Experiments (MeV)

MCNP Case Name	ENDF/B-V	WPO Selected	ENDF/B-VI
HMF21	1.4405	1.4478	1.3796

6.2.4 HMF-022 Results

Table 6.2.4-1 presents the MCNP calculation results for ENDF/B-V, WPO Selected, and ENDF/B-VI cross section libraries for the HMF-022 critical experiment. Table 6.2.4-2 shows the calculated AENCF values for the same experiment.

Table 6.2.4-1. LCE Reactivity Calculation Results for HMF-022 Experiments

MCNP Case Name	ENDF/B-V $k_{eff} \pm \sigma$	WPO Selected $k_{eff} \pm \sigma$	ENDF/B-VI $k_{eff} \pm \sigma$
HMF22	0.9918 ± 0.0004	0.9917 ± 0.0004	0.9917 ± 0.0004

Table 6.2.4-2. AENCF for HMF-022 Experiments (MeV)

MCNP Case Name	ENDF/B-V	WPO Selected	ENDF/B-VI
HMF22	1.5038	1.5035	1.4289

6.2.5 HMF-028 Results (Flattop-25)

Table 6.2.5-1 presents the MCNP calculation results for ENDF/B-V, WPO Selected, and ENDF/B-VI cross section libraries for the HMF-028 (Flattop-25) critical experiment. Table 6.2.5-2 shows the calculated AENCF values for the same experiment. For this LCE, the ENDF/B-V and the WPO Selected cases have identical input. The input and output for this case are included in the attachment in the ENDF/B-V directories (attIII and attIV, respectively) only.

Table 6.2.5-1. LCE Reactivity Calculation Results for HMF-028 Experiments

MCNP Case Name	ENDF/B-V $k_{eff} \pm \sigma$	WPO Selected $k_{eff} \pm \sigma$	ENDF/B-VI $k_{eff} \pm \sigma$
HMF28	1.0040 ± 0.0005	1.0040 ± 0.0005	1.0026 ± 0.0005

Table 6.2.5-2. AENCF for HMF-028 Experiments (MeV)

MCNP Case Name	ENDF/B-V	WPO Selected	ENDF/B-VI
HMF28	1.5979	1.5979	1.5498

6.2.6 BNL 19302 Results

Table 6.2.6-1 presents the MCNP calculation results for ENDF/B-V, WPO Selected, and ENDF/B-VI cross section libraries for the BNL 19302 fast reactor critical experiments. Table 6.2.6-2 shows the calculated AENCF values for the same experiments. For BIG10, the ENDF/B-V and the WPO Selected cases have identical input. The input and output for this case are included in the attachment in the ENDF/B-V directories (attIII and attIV, respectively) only.

Table 6.2.6-1. LCE Reactivity Calculation Results for BNL 19302 Experiments

MCNP Case Name	ENDF/B-V $k_{eff} \pm \sigma$	WPO Selected $k_{eff} \pm \sigma$	ENDF/B-VI $k_{eff} \pm \sigma$
VERA1B	0.9929 ± 0.0005	0.9906 ± 0.0005	0.9981 ± 0.0005
ZPR36F	1.0012 ± 0.0004	0.9951 ± 0.0004	0.9960 ± 0.0004
ZPR311	1.0066 ± 0.0004	1.0046 ± 0.0004	1.0052 ± 0.0004
ZPR312	0.9964 ± 0.0004	0.9947 ± 0.0004	1.0002 ± 0.0004
BIG10	1.0032 ± 0.0003	1.0032 ± 0.0003	1.0041 ± 0.0004
ZEBRA2	0.9805 ± 0.0004	0.9805 ± 0.0004	0.9970 ± 0.0004

Table 6.2.6-2. AENCF for BNL 19302 Experiments (MeV)

MCNP Case Name	ENDF/B-V	WPO Selected	ENDF/B-VI
VERA1B	1.0390	1.0371	1.0084
ZPR36F	1.1901	1.1871	1.1628
ZPR311	1.1763	1.1739	1.1618
ZPR312	1.0798	1.0779	1.0558
BIG10	1.2415	1.2415	1.2271
ZEBRA2	0.9305	0.9288	0.9031

6.3 Results Summary

Tables 6.3-1 through 6.3-3 summarize the results of the LCE reactivity calculations. Table 6.3-1 contains the results of the calculations using the ENDF/B-VI cross section library. Table 6.3-2 lists the results of the calculations using the ENDF/B-V cross section library. Table 6.3-3 presents the results of the calculations using the WPO Selected cross section library.

Table 6.3-1. LCE Reactivity Calculation Results Using ENDF/B-VI

MCNP Case Name	k_{eff}	σ	AENCF
HEST1-3	1.0017	0.0008	0.0155
HEST1-4	1.0011	0.0008	0.0397
HEST1-5	0.9987	0.0006	0.0062
HEST1-6	1.0015	0.0006	0.0069
HEST1-7	0.9982	0.0008	0.0149
HEST1-8	0.9960	0.0008	0.0159
HEST1-9	0.9967	0.0008	0.0401
HST121	0.9993	0.0004	0.0027
HEST131	0.9966	0.0004	0.0026
HST321	0.9972	0.0003	0.0021
LCT27-1	1.0102	0.0006	0.1023
HMF1g	0.9970	0.0004	1.4893
HMF3NI	1.0045	0.0005	1.2964
HMF21	0.9946	0.0005	1.3796
HMF22	0.9917	0.0004	1.4289
HMF28	1.0026	0.0005	1.5498
VERA1B	0.9981	0.0005	1.0084
ZPR36F	0.9960	0.0004	1.1628
ZPR311	1.0052	0.0004	1.1618
ZPR312	1.0002	0.0004	1.0558
BIG10	1.0041	0.0004	1.2271
ZEBRA2	0.9970	0.0004	0.9031

Table 6.3-2. LCE Reactivity Calculation Results Using ENDF/B-V

MCNP Case Name	k_{eff}	σ	AENCF
HEST1-3	1.0064	0.0008	0.0158
HEST1-4	1.0030	0.0008	0.0405
HEST1-5	1.0040	0.0007	0.0065
HEST1-6	1.0072	0.0006	0.0069
HEST1-7	1.0033	0.0008	0.0153
HEST1-8	1.0025	0.0007	0.0162
HEST1-9	0.9988	0.0008	0.0408
HST121	1.0035	0.0004	0.0027
HEST131	1.0007	0.0004	0.0027
HST321	0.9996	0.0003	0.0021
LCT27-1	1.0139	0.0005	0.1024
HMF1g	0.9986	0.0004	1.5681
HMF3NI	1.0145	0.0004	1.3555
HMF21	1.0017	0.0004	1.4405
HMF22	0.9918	0.0004	1.5038
HMF28	1.0040	0.0005	1.5979
VERA1B	0.9929	0.0005	1.0390
ZPR36F	1.0012	0.0004	1.1901
ZPR311	1.0066	0.0004	1.1763
ZPR312	0.9964	0.0004	1.0797
BIG10	1.0032	0.0003	1.2415
ZEBRA2	0.9805	0.0004	0.9304

Table 6.3-3. LCE Reactivity Calculation Results Using WPO Selected

MCNP Case Name	k_{eff}	σ	AENCF
HEST1-3	1.0064	0.0008	0.0158
HEST1-4	1.0030	0.0008	0.0405
HEST1-5	1.0040	0.0007	0.0065
HEST1-6	1.0072	0.0006	0.0069
HEST1-7	1.0033	0.0008	0.0153
HEST1-8	1.0025	0.0007	0.0162
HEST1-9	0.9988	0.0008	0.0408
HST121	1.0035	0.0004	0.0027
HEST131	1.0004	0.0004	0.0027
HST321	0.9991	0.0003	0.0022
LCT27-1	1.0157	0.0005	0.1025
HMF1g	0.9986	0.0004	1.5681
HMF3NI	1.0036	0.0005	1.3649
HMF21	0.9965	0.0004	1.4478
HMF22	0.9917	0.0004	1.5035
HMF28	1.0040	0.0005	1.5979
VERA1B	0.9906	0.0005	1.0371
ZPR36F	0.9951	0.0004	1.1871
ZPR311	1.0046	0.0004	1.1739
ZPR312	0.9947	0.0004	1.0779
BIG10	1.0032	0.0003	1.2415
ZEBRA2	0.9805	0.0004	0.9288

Attachment I contains the MCNP input and output files for the ENDF/B-VI, ENDF/B-V, and WPO Selected cross section libraries.

7. REFERENCES

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7.9 U.S. Public Health Service 1970. *Radiological Health Handbook.* Report Number: PB230846. Washington, D.C.: Public Health Service. TIC: 214902

8. ATTACHMENTS

Table 8-1 contains a description of the folders included in the attachment. Table 8-2 through Table 8-6 presents the folder contents for each of the six folders.

Table 8-1. Attachment Listing

Folder	Contents
attI	MCNP inputs using ENDF/B-VI cross section library for the LCE benchmark calculations
attII	MCNP outputs using ENDF/B-VI cross section library for the LCE benchmark calculations
attIII	MCNP inputs using ENDF/B-V cross section library for the LCE benchmark calculations
attIV	MCNP outputs using ENDF/B-V cross section library for the LCE benchmark calculations
attV	MCNP inputs using WPO Selected cross section library for the LCE benchmark calculations
attVI	MCNP outputs using WPO Selected cross section library for the LCE benchmark calculations

Table 8-2. attI, ENDF/B-VI Input

Name	Date	Time	Size (bytes)
big10	3/24/99	10:00	506
hest1-3	3/24/99	10:00	776
hest1-4	3/24/99	10:00	780
hest1-5	3/24/99	10:00	782
hest1-6	3/24/99	10:00	782
hest1-7	3/24/99	10:00	782
hest1-8	3/24/99	10:00	781
hest1-9	3/24/99	10:00	779
hest131	3/24/99	10:00	727
hmf1g	3/24/99	10:00	284
hmf21	3/24/99	10:00	4587
hmf22	3/24/99	10:00	4051
hmf28	3/24/99	10:00	397
hmf3ni	3/24/99	10:00	455
hst121	3/24/99	10:00	694
hst321	3/24/99	10:00	753
lct27-1	3/24/99	10:00	11559
vera1b	3/24/99	10:00	1251
zebra2	3/24/99	10:00	1634
zpr311	3/24/99	10:00	1235
zpr312	3/24/99	10:00	1300
zpr36f	3/24/99	10:00	1299

Table 8-3. attII, ENDF/B-VI Output

Name	Date	Time	Size (bytes)
big10.out	3/24/99	10:25	824262
hest1-3.out	3/24/99	10:25	827852
hest1-4.out	3/24/99	10:25	827852
hest1-5.out	3/24/99	10:25	828599
hest1-6.out	3/24/99	10:25	828592
hest1-7.out	3/24/99	10:25	827975
hest1-8.out	3/24/99	10:25	827975
hest1-9.out	3/24/99	10:25	827975
hest131.out	3/24/99	10:25	831471
hmf1g.out	3/24/99	10:25	821541
hmf21.out	3/24/99	10:25	869939
hmf22.out	3/24/99	10:25	863079
hmf28.out	3/24/99	10:25	822975
hmf3ni.out	3/24/99	10:25	826360
hst121.out	3/24/99	10:25	833850
hst321.out	3/24/99	10:25	829087
lct27-1.out	3/24/99	10:25	1017889
vera1b.out	3/24/99	10:25	840948
zebra2.out	3/24/99	10:25	848435
zpr311.out	3/24/99	10:25	839554
zpr312.out	3/24/99	10:25	840316
zpr36f.out	3/24/99	10:25	841788

Table 8-4. attIII, ENDF/B-V Input

Name	Date	Time	Size (bytes)
big10	3/24/99	10:28	506
hest1-3	3/24/99	10:28	790
hest1-4	3/24/99	10:29	788
hest1-5	3/24/99	10:29	725
hest1-6	3/24/99	10:29	786
hest1-7	3/24/99	10:30	793
hest1-8	3/24/99	10:30	795
hest1-9	3/24/99	10:37	794
hest131	3/24/99	10:38	663
hmf1g	3/24/99	10:41	284
hmf21	3/24/99	10:42	2944
hmf22	3/24/99	10:43	2897
hmf28	3/24/99	10:41	398
hmf3ni	3/24/99	10:41	351
hst121	3/24/99	10:38	669
hst321	3/24/99	10:38	649
lct27-1	3/24/99	10:45	10810
vera1b	3/24/99	10:45	733
zebra2	3/24/99	10:47	1062
zpr311	3/24/99	10:46	715
zpr312	3/24/99	10:46	780
zpr36f	3/24/99	10:46	779

Table 8-5. attIV, ENDF/B-V Output

Name	Date	Time	Size (bytes)
big10.out	3/24/99	16:03	824469
hest1-3.out	3/24/99	12:27	828401
hest1-4.out	3/24/99	18:55	828278
hest1-5.out	3/24/99	21:40	829025
hest1-6.out	3/24/99	22:05	829025
hest1-7.out	3/24/99	20:17	828162
hest1-8.out	3/24/99	20:14	828162
hest1-9.out	3/24/99	19:11	828278
hest131.out	3/25/99	3:14	831624
hmf1g.out	3/25/99	8:06	822228
hmf21.out	3/25/99	9:05	855958
hmf22.out	3/25/99	8:42	855877
hmf28.out	3/25/99	9:43	824474
hmf3ni.out	3/25/99	9:36	824470
hst121.out	3/25/99	4:39	832646
hst321.out	3/25/99	5:14	829941
lct27-1.out	3/26/99	3:20	982106
vera1b.out	3/25/99	20:29	830660
zebra2.out	3/26/99	0:44	836330
zpr311.out	3/26/99	8:03	830604
zpr312.out	3/26/99	7:52	830171
zpr36f.out	3/26/99	8:24	830003

Table 8-6. attV, WPO Selected Input

Name	Date	Time	Size (bytes)
hest131	3/25/99	7:51	640
hst321	3/25/99	7:52	755
lct27-1	3/25/99	7:53	11507
hmf3ni	3/25/99	8:27	457
hmf21	3/25/99	8:19	4548
hmf22	3/25/99	8:21	4008
vera1b	3/25/99	8:23	1253
zpr36f	3/25/99	8:23	1300
zpr311	3/25/99	8:24	1236
zpr312	3/25/99	8:24	1301
zebra2	3/25/99	8:25	1636

Table 8-7. attVI, WPO Selected Output

Name	Date	Time	Size (bytes)
hest131.out	3/26/99	10:03	831801
hst321.out	3/26/99	13:23	830643
lct27-1.out	3/26/99	10:41	1015082
hmf3ni.out	3/26/99	0:10	825125
hmf21.out	3/25/99	23:06	871487
hmf22.out	3/25/99	19:06	864835
vera1b.out	3/27/99	6:10	840424
zpr36f.out	3/27/99	8:40	841996
zpr311.out	3/27/99	8:35	840926
zpr312.out	3/27/99	8:34	839942
zebra2.out	3/27/99	9:56	848142