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1. PURPOSE

The purpose of this engineering calculation is to document the benchmark range, over a variety of parameters, for the validation of the criticality calculations supporting the Monitored Geologic Repository (MGR). This engineering calculation accomplishes this by characterizing the Laboratory Critical Experiments (LCE) and the Pressurized Water Reactor (PWR) Commercial Reactor Criticals (CRC), and summarizing the significant parameters. This engineering calculation supports the Disposal Criticality Analysis Methodology program.

2. METHOD

The calculation method used to characterize and document the benchmark range consisted of extracting information from the reactivity calculations performed for the LCEs and CRCs documented in References 7.8 through 7.11, 7.18, 7.19, and 7.22. This information included neutron energies and weights. Other information was taken from the source documentation, as noted in Section 5.

3. ASSUMPTIONS

None Used.

4. USE OF COMPUTER SOFTWARE AND MODELS

4.1 SOFTWARE APPROVED FOR QA WORK

None used.

4.2 SOFTWARE ROUTINE

4.2.1 Excel

Title: Excel
Version/Revision Number: Microsoft® Excel 97

The Excel spreadsheet program was used for simple numeric calculations as documented in Section 5.3 of this calculation. The inputs, user-defined formulas, and results were documented in sufficient detail, in Section 5.1, Section 5.3, and Section 6, respectively, to allow an independent repetition of the various computations.

4.3 MODELS

None used.

5. CALCULATION

This calculation uses information reported in the output files from the reactivity calculations, and information retrieved from source documentation. The specific references are listed in the "Location" column of Table 5.1-1 to characterize the critical configurations. Section 6 contains these characterizations.

This calculation is based on source information taken from published reports and a handbook on benchmark experiments. Most of the LCEs are taken from Reference 7.21, which is a standard handbook, generally accepted by the scientific and engineering community. Reference 7.21 is used in a number of license applications and validation reports through out the nuclear industry. The data in this reference is therefore considered "Accepted Data".

All of the CRCs and the remainder of the LCEs are taken from various industry and national laboratory reports. Throughout the rest of this section, information regarding the CRCs and LCEs specified in Table 5-1 should be considered to be verified (TBV) in that they are not considered accepted data sources per the retroactive procedural requirement of AP-SIII.2Q initiated by the July 27, 1999 issuance of the DOE Letter, "Accepted Data Call", from R.E. Spence to J.L. Younker (Reference 7.12).

It should be noted that some of the experiments were not true critical configurations, but were subcritical approaches extrapolated to critical. The number of digits in the values cited herein may be the results of a calculation or may reflect the input from another source; consequently, the number of digits should not be interpreted as an indication of accuracy.

Table 5-1. TBV Experiments and Associated Tracking Numbers

Experiments	TBV Tracking Number
CORE2, CORE3, CORE4, CORE5, CORE6, CORE7, CORE8, CORE9, CORE10, CORE11, CORE12, CORE13, CORE14, CORE15, CORE16, CORE17, CORE18, CORE19, CORE20, CORE21	TBV-1357
UGD1, UGD2, UGD3, UGD4, UGD5, UGD6, UGD7, UGD8, UGD9, UGD10, UGD12, UGD13, UGD14, UGD15, UGD16, UGD17, UGD18, UGD19, UGD20	TBV-1358
SSR83, SSR48, SSR70, SSR57, SSR27, SSR66, SSR53, SSR74, SMR1, SMR9, SMR5, SMR11, SMR12, SMR8	TBV-1359
SUBC2P8H, SUBC3P1H, SUBC3P4H	TBV-1360
EXP12, EXP13	TBV-1361
EXP1, EXP2, EXP3, EXP4	TBV-1362
EXP5, EXP6	TBV-1363
EXP7	TBV-1364
EXP8, EXP9, EXP10, EXP11	TBV-1365
EXP34, SPHU9A, SPHU9B, SPHU9C, SPHU9D, SPHU9E, SPHU9F, SPHU9G, SPHU9H, SPHU9I, SPHU9J, SPHU9K, SPHU9L	TBV-1366
SUBC2P8H, SUBC3P1H, SUBC3P4H	TBV-1367
EXP14, EXP15, SSR83, SSR48, SSR70, SSR57, SSR27, SSR66, SSR53, SSR74, SMR1, SMR9, SMR5, SMR11, SMR12, SMR8, EXP22, EXP23, EXP24, EXP25, EXP26, EXP27	TBV-1368
TRI7, TRI18	TBV-1369
LEUJA01, LEUJA29, LEUJA33, LEUJA34, LEUJA46, LEUJA51, LEUJA54, LEUJA14, LEUJA30, LEUJA32, LEUJA36, LEUJA49	TBV-1370
FFTF001, FFTF003R, FFTF004, FFTF005, FFTF006, FFTF029	TBV-1371
All of the CRCs	TBV-1349

5.1 CALCULATION INPUTS

Table 5.1-1 contains a list of input information and the associated retrieval locations. Reference 7.21, the "International Handbook of Evaluated Criticality Safety Benchmark Experiments", contains numerable individual reports. For ease of referencing, Table 5.1-1 references the report by name only. This will imply that the reference is Reference 7.21. The following table lists the abbreviations used for these reports. The acronym is listed to the left of the "=" and the document identifier used in Reference 7.21 is listed to the right. Also listed under each acronym are the actual document identifiers that appear later in this engineering calculation, along with a list of the associated experiments taken from the references.

Table 5.1-1. Reference 7.21 Acronyms

Reference	Experiments
HMF = HEU-MET-FAST	
HMF-8	HMF8
HMF-11	HMF11
HMF-12	HMF12
HMF-13	HMF13
HMF-14	HMF14
HMF-15	HMF15
HMF-18	HMF18
HMF-19	HMF19
HMF-20	HMF20
HMF-21	HMF21
HMF-22	HMF22
HMF-24	HMF24
IMF = IEU-MET-FAST	
IMF-1	IMF1-1, IMF1-2, , IMF1-3, IMF1-4
IMF-2	IMF2-1
IMF-3	IMF3-1
IMF-4	IMF4-1
IMF-5	IMF5-1
IMF-6	IMF6-1
IMF-8	IMF8-1

Table 5.1-1. Reference 7.21 Acronyms

Reference	Experiments
PST=PU-SOL-THERM	
PST-1	PUST1T1, PUST1T2, PUST1T3, PUST1T4, PUST1T5, PUST1T6
PST-3	PU003-1, PU003-2, PU003-3, PU003-4, PU003-5, PU003-6, PU003-7, PU003-8
PST-4	PU004-1, PU004-2, PU004-3, PU004-4, PU004-5, PU004-6, PU004-7, PU004-8, PU004-9, PU004-10, PU004-11, PU004-12, PU004-13
PST-5	PU005-1, PU005-2, PU005-3, PU005-4, PU005-5, PU005-6, PU005-7, PU005-8, PU005-9
PST-7	PU007-2, PU007-3, PU007-5, PU007-6, PU007-7, PU007-8, PU007-9, PU007-10
PST-9	PUST9-1, PUST9-2, PUST9-3
PST-10	PU10091, PU10092, PU10093, PU10111, PU10112, PU10113, PU10114, PU10115, PU10116, PU10117, PU10121, PU10122, PU10123, PU10124
PST-11	PU11161, PU11162, PU11163, PU11164, PU11165, PU11181, PU11182, PU11183, PU11184, PU11185, PU11186, PU11187
PMF=PU-MET-FAST	
PMF-20	PMF20
PMF-22	PMF22
PMF-23	PMF23
PMF-24	PMF24
PMF-25	PMF25
PMF-26	PMF26
PMF-27	PMF27
PMF-28	PMF28
PMF-29	PMF29
PMF-30	PMF30
PMF-31	PMF31
PMF-32	PMF32

Table 5.1-1. Reference 7.21 Acronyms

Reference	Experiments
	MST = MIX SOLTHERM
MST-1	PNL3187, PNL3391, PNL3492, PNL3593, PNL3694, PNL3795, PNL3896, PNL3897, PNL3898, PNL3808, PNL3999, PNL5300
MST-2	PNL1158, PNL1159, PNL1161
MST-3	AWRE1, AWRE2, AWRE3, AWRE4, AWRE5, AWRE6, AWRE7, AWRE8, AWRE9, AWRE10
MST-4	PNL1577, PNL1678, PNL1783, PNL1868, PNL1969, PNL2070, PNL2565, PNL2666, PNL2767

Table 5.1-2. Calculational Input Locations

Value	Source	Location
Concentration (Solution LCEs only)	Critical Configuration Descriptions	Ref. 7.1, pp. 13-51 Ref. 7.18, Attachment 5 Ref. 7.19, pp. 9-11 Ref. 7.21: LST-1, p. 18; LST-3, p. 6 Ref. 7.22, pp. 4, 5
Density (Fast Metal LCEs only)	Critical Configuration Descriptions	Ref. 7.19, pp. 14, 18 Ref. 7.21: HMF-8, p. 14; HMF-11, p. 14; HMF-12, p. 14; HMF-13, p. 14; HMF-14, p. 12; HMF-15, p. 9; HMF-24, p. 14; IMF-1, p. 12; IMF-2, p. 3; PMF-20, p. 11 Ref. 7.22, pp. 4, 5
Mass	Critical Configuration Descriptions	Ref. 7.21: HMF-18, p. 12; HMF-19, p. 11; HMF-20, p. 12; HMF-21, p. 11; HMF-22, p. 12; IMF-3, p. 12; IMF-4, p. 11; IMF-5, p. 11; IMF-6, p. 12; IMF-8, p. 12; PMF-22, p. 11; PMF-23, p. 11; PMF-24, p. 11; PMF-25, p. 11; PMF-26, p. 11; PMF-27, p. 12; PMF-28, p. 11; PMF-29, p. 11; PMF-30, p. 11; PMF-31, p. 11; PMF-32, p. 11
Radius	Critical Configuration Descriptions	Ref. 7.21: HMF-8, p. 14; HMF-18, p. 12; HMF-19, p. 11; HMF-20, p. 12; HMF-21, p. 11; HMF-22, p. 12; IMF-3, p. 12; IMF-4, p. 11; IMF-5, p. 11; IMF-6, p. 12; IMF-8, p. 12; PMF-22, p. 11; PMF-23, p. 11; PMF-24, p. 11; PMF-25, p. 11; PMF-26, p. 11; PMF-27, p. 12; PMF-28, p. 11; PMF-29, p. 11; PMF-30, p. 11; PMF-31, p. 11; PMF-32, p. 11

Table 5.1-2. Calculational Input Locations

Value	Source	Location
Enrichment (LCEs only)	Critical Configuration Descriptions	Ref. 7.1, pp. 13-45 Ref. 7.2, pp. 13-99 Ref. 7.18, pp. 9, 11, 12, 16-19, 28, 31, 36, 41, 42, 46, 48, 53, 55 Ref. 7.19, pp. 8-16, 18 Ref. 7.21: PST-1, p. 13; PST-3, pp. 1, 11; PST-4, pp. 1, 11; PST-5, pp. 1, 11; PST-7, p. 14; PST-9, p. 6; PST-10, pp. 5, 8; PST-11, pp. 8, 10; MST-1, p. 13; MST-2, p. 7; MST-3, p. 4; MST-4, p. 10; IMF-1, p. 12; ICT-1, p. 25; PMF-20, p. 6; PMF-22, p. 6; PMF-23, p. 6; PMF-24, p. 6; PMF-25, p. 6; PMF-26, p. 6; PMF-27, p. 6; PMF-28, pp. 5; PMF-29, p. 5; PMF-30, p. 5; PMF-31, p. 5; PMF-32, p. 5; Ref. 7.22, pp. 4, 5
Fuel Pellet Diameter	Critical Configuration Descriptions	Ref. 7.2, pp. 13-102 Ref. 7.3, p. 26 Ref. 7.4, p. 22 Ref. 7.5, p. 37 Ref. 7.6, p. 22 Ref. 7.18, pp. 10, 16, 24, 25, 27, 28, 42, and Attachment V Ref. 7.19, p. 12 Ref. 7.21, HCT-7, p. 16

Table 5.1-2. Calculational Input Locations

Value	Source	Location
Lattice Pitch	Critical Configuration Descriptions	Ref. 7.2, pp. 13-102 Ref. 7.3, p. 5 Ref. 7.4, p. 6 Ref. 7.5, p. 7 Ref. 7.6, p. 5 Ref. 7.18, pp. 8, 16-19, 28, 29, 37, 41, and Attachment V Ref. 7.19, p. 12 Ref. 7.21, HCT-4, p. 1; HCT-8, p. 1 Ref. 7.22, Attachments I, III, and V
Hydrogen to Fissile Isotope Ratio (H/X)	Critical Configuration Descriptions	Ref. 7.18, pp. 12, 46, 49 Ref. 7.21, p. 5
Atom Densities	Critical Configuration Descriptions	Ref. 7.18, pp. 42, 43 Ref. 7.19, Attachment I Ref. 7.21, Attachment V
Average Energy of Neutron Causing Fission (where available)	Critical Configuration Descriptions	Ref. 7.18, pp. 69, 70, 72, 74, 75, 78, 79, 82, 85, 87, 89, 91, 93, 94, 97-101, 103, 105 Ref. 7.19, pp. 28-32 Ref. 7.22, pp. 11-24
Average Energy of Neutron Causing Fission (weighted by the statistical weight of the neutrons)	MCNP Output	Summary Page Balance Sheet[1] of: Ref. 7.8, Att. III-V Ref. 7.9, Att. IV, V Ref. 7.10, Att. IV Ref. 7.11, Att. III
Average Weight of Neutron Causing Fission	MCNP Output	Summary Page Balance Sheet[1] of: Ref. 7.8, Att. III-V Ref. 7.9, Att. IV, V Ref. 7.10, Att. IV Ref. 7.11, Att. III
CRC Batch Initial Enrichments	CRC Configuration Descriptions	Ref. 7.3, pp. 30-40 Ref. 7.4, pp. 25-27 Ref. 7.5, pp. 40-46 Ref. 7.6, pp. 25-29

1. The problem summary balance sheet is discussed in Reference 7.7, p. 5-40.

Table 5.1-2. Calculational Input Locations

Value	Source	Location
Number of Assemblies per CRC Batch	CRC Configuration Descriptions	Ref. 7.3, pp. 30-40 Ref. 7.4, pp. 25-27 Ref. 7.5, pp. 40-46 Ref. 7.6, pp. 25-29
CRC Axial Node Burnup	CRC State Point Descriptions	Ref. 7.3, pp. 62-258 Ref. 7.4, pp. 37-59 Ref. 7.5, pp. 60-99 Ref. 7.6, pp. 40-60
CRC Node Height	CRC State Point Descriptions	Ref. 7.3, p. 61 Ref. 7.4, p. 36 Ref. 7.5, p. 59 Ref. 7.6, p. 39
CRC State Point Effective Full Power Days (EFPD)	CRC State Point Descriptions	Ref. 7.3, p. 27 Ref. 7.4, p. 23 Ref. 7.5, p. 38 Ref. 7.6, p. 23

5.2 DESCRIPTION

MCNP and the referenced documents do not report all of the values for the parameters discussed in Section 6. To determine these values, additional calculations are necessary. Table 5.2-1 contains a description of the parameters calculated. Section 5.3 lists the formulas used for the additional calculations.

Table 5.2-1. Description of Calculated Parameters

Parameter	Name	Description
Lattice Rod Ratio	P/D	This is the ratio of the lattice pitch for the fuel rods to the outer diameter of fuel in the rods.
Pitch (For Cylindrical Pitch Lattices Only)	P_i	This is the separation between two "rings" of fuel elements in a cylindrical pitch. It is calculated by subtracting the radius of the inner ring from the radius of the outer ring.
Average Lattice Pitch (For Cylindrical Pitch Lattices Only)	P	This is the average separation of the rings of a cylindrical lattice. This is calculated by dividing the sum of the pitches (P_i) by the number of pitches (P_i).
Density	ρ(x)	This is the average density of element "x" in the fuel regions given as grams per cubic centimeter (g/cm^3). This is calculated by dividing the sum of the masses of element "x" in the fuel regions by the sum of the volumes of the fuel regions.
Density (for HMF8)	ρ(x)	This is the average density of element "x" in the fuel regions given as grams per cubic centimeter (g/cm^3). This is calculated by dividing the sum of the product density of element "x" in the fuel regions and the volume of the fuel region by the sum of the volumes of the fuel regions.
Enrichment	e(x)	This is the average amount of isotope "x" in the fuel regions given as a weight percentage of the parent element. This is calculated by dividing the average gram density of isotope "x" by the total gram density of element "x".

Table 5.2-1. Description of Calculated Parameters

Parameter	Name	Description
Enrichment (For ugd & fftf LCEs Only)	e(x)	This is the average amount of isotope "x" in the fuel regions given as a weight percentage of the parent element. This is calculated by dividing the sum of the product of each fuel type enrichment for isotope "x" and the number of rods each the fuel type by the total number of fuel rods.
Enrichment (For SUBC2P8H, SUBC3P1H, and SUBC3P4H Only)	e(x)	This is the average amount of isotope "x" in the fuel regions given as a weight percentage of the parent element. This is calculated by dividing the sum of the product of the enrichment and the cross-sectional area for each fuel type by the sum of the cross-sectional area for each fuel type.
Enrichment (For Mixed Oxide Lattice LCEs Only, except Fast Flux Test Facility (FFTF))	e(x)	This is the average amount of isotope "x" in the fuel regions given as a weight percentage of the parent element. This is calculated by dividing the product of the atom density and the atomic mass of isotope "x" by the sum of the product of the atom density and the atomic mass of all of the isotopes of element "y".
Initial Enrichment	$e_o(x)$	This is the initial enrichment of the average assembly for a given CRC cycle. It is the amount of isotope "x" in the fuel region of the average assembly given as a weight percentage of the parent element. This is calculated by summing the product of the enrichments times the number of fuel assemblies containing that enrichment and dividing by the total number of fuel assemblies.

Table 5.2-1. Description of Calculated Parameters

Parameter	Name	Description
State Point Enrichment	$e_c(x)$	This is the average core enrichment for a given state point. It is the amount of isotope "x" in the fuel regions given as a weight percentage of the parent element. This is calculated by summing the average enrichment for all of the fuel rods in a core and diving by the total number of fuel rods.
Average Energy of a Neutron Causing Fission	AENCF	This is a measure of the neutron flux spectrum of the system. It is calculated by dividing the "weighted" average energy of a neutron causing fission (from MCNP[1] output) by the "weight" of the average neutron causing fission (from MCNP[1] output).
H/X	H/X	This is a measure of the moderation of a system. It is calculated by dividing the atom density of hydrogen in a fuel region by the sum of the atom density of the fissile isotopes (i.e., ^{235}U, ^{239}Pu, or ^{233}U) in the same fuel region.
State Point Burnup (Minimum and Maximum)	B_j	These are assembly burnup values calculated by dividing the sum of the product of the node height, the fuel pellet outside diameter squared and the node burnup by the sum of the product of the node height and the fuel pellet outside diameter squared
Core Average Burnup	B_{avg}	This is the average burnup over the entire core. It is calculated by dividing the sum of the product of the number of assemblies of a give type and the burnup of that assembly type by the total number of assemblies.

1. MCNP is a computer code used for calculating the reactivity of a system containing fissionable material.

Table 5.2-1. Description of Calculated Parameters

Parameter	Name	Description
Average Pellet Diameter (For ugd LCEs Only)	D_{avg}	This is the average diameter of the fuel rods in a lattice. This is calculated by dividing the sum of the product of the number of rods and the fuel pellet diameter of a given fuel rod type by the total number of fuel rods.

5.3 EQUATIONS FOR ADDITIONAL CALCULATIONS

The following sections discuss in more detail the calculation of the parameters listed in Table 5.2-1.

Equation 5.3-1. Lattice Rod Ratio (Ratio)

$$P/D = P / D$$

Variables: P/D = Ratio of lattice rod pitch to diameter of fuel in the rod
P = Rod pitch in the lattice in cm
D = Diameter of fuel in the rod in cm

Equation 5.3-2. Pitch (For Cylindrical Pitch Lattices Only)

$$P_l = R_2 - R_1$$

Variables: P_l = Pitch between two rings of elements in cm
R_1 = Radius of the inner ring in cm
R_2 = Radius of the outer ring in cm

Equation 5.3-3. Average Lattice Pitch (For Cylindrical Pitch Lattices Only)

$$P = \frac{\sum_i P_i}{N}$$

Variables: P = Average lattice pitch in cm
P_i = Pitch between two rings of elements in cm
N = Number of pitches

Equation 5.3-4. Density

$$\rho(x) = \frac{\sum_i m_i(x)}{\sum_i \frac{4}{3}\pi\ (OR_i^3 - IR_i^3)}$$

Variables: $\rho(x)$ = Average gram density of element "x" in g/cm^3
$m_i(x)$ = Mass of element "x" in the fuel region "i" given in g
OR_i = Outer radius of the fuel region "i" in cm
IR_i = Inner radius of the fuel region "i" in cm

Equation 5.3-5. Density (HMF8)

$$\rho(x) = \frac{\sum_i \rho_i(x)\frac{4}{3}\pi\ (OR_i^3 - IR_i^3)}{\sum_i \frac{4}{3}\pi\ (OR_i^3 - IR_i^3)}$$

Variables: $\rho(x)$ = Average gram density of element "x" in g/cm^3
$\rho_i(x)$ = Average gram density of element "x" in the fuel region "i" given in g/cm^3
OR_i = Outer radius of the fuel region "i" in cm
IR_i = Inner radius of the fuel region "i" in cm

Equation 5.3-6. Enrichment

$$e(x_i) = \frac{\rho(x_i)}{\sum_i \rho(x_i)}$$

where "x_i" are the isotopes of a single element "Y" (i.e., U or Pu)

Variables: $e(x_i)$ = Enrichment, isotopic abundance of isotope "x" in wt%
x_i ≡ Isotope (e.g., ^{233}U, ^{235}U, ^{238}U, ^{238}Pu, ^{239}Pu, etc.)
$\rho(x_i)$ = Average gram density of isotope "x" in g/cm^3

Equation 5.3-7. Enrichment (For ugd and fftf LCEs Only)

$$e(x_i) = \frac{\sum_T e_T(x_i)\, N_T}{\sum_T N_T}$$

where "x_i" are the isotopes of a single element "Y" (i.e., U or Pu)

Variables: $e(x_i)$ = Enrichment, isotopic abundance of isotope "x" in wt%
x_i ≡ Isotope (e.g., ^{233}U, ^{235}U, ^{238}U, ^{238}Pu, ^{239}Pu, etc.)
$e_T(x_i)$ = Enrichment, isotopic abundance of isotope "x" in wt%, for fuel type "T"
N_T = Number of rods of fuel type "T"

Equation 5.3-8. Enrichment (For SUBC2P8H, SUBC3P1H, and SUBC3P4H Only)

$$e(x_i) = \frac{\sum_k e_k(x_i)\ (OD_k^2 - ID_k^2)}{\sum_k (OD_k^2 - ID_k^2)}$$

where "x_i" are the isotopes of a single element "Y" (i.e., U or Pu)

Variables: $e(x_i)$ = Enrichment, isotopic abundance of isotope "x" in wt%
$e_k(x_i)$ = Enrichment of isotope "x" in fuel type "k" in wt%
x_i ≡ Isotope (e.g., ^{233}U, ^{235}U, ^{238}U, ^{238}Pu, ^{239}Pu, etc.)
OD_k = Outer diameter of fuel type "k" in cm^2
ID_k = Inner diameter of fuel type "k" in cm^2

Equation 5.3-9. Enrichment (For Mixed Oxide Lattice LCEs Only, Except for fftf)

$$e(x_i) = \frac{A(x_i)\,M(x_i)}{\sum_i A(x_i)\,M(x_i)}$$

where "x_i" are the isotopes of a single element "Y" (i.e., U or Pu)

Variables: $e(x_i)$ = Enrichment, isotopic abundance of isotope "x" in wt%
x_i ≡ Isotope (e.g., ^{233}U, ^{235}U, ^{238}U, ^{238}Pu, ^{239}Pu, etc.)
$A(x_i)$ = Atom density of isotope "x" in atoms/barn•cm
$M(x_i)$ = Atomic mass of isotope "x" in g/mole (These values are taken from Reference 7.20, pp. 975 and 976.)

Equation 5.3-10. Initial Enrichment (CRCs Only)

$$e_o(x) = \frac{\sum_i e_i(x)\,N_i}{N}$$

Variables: $e_o(x)$ = Initial enrichment of the fuel in the average fuel assembly in wt%
x ≡ Isotope (e.g., ^{233}U, ^{235}U, ^{238}U, ^{238}Pu, ^{239}Pu, etc.)
$e_i(x)$ = Enrichment of fuel in assembly "i" in wt% (assumes all assemblies in a batch have the same initial enrichment)
N_i = Number of fuel assemblies containing fuel with enrichment $e_i(x)$
N = Total number of fuel assemblies in the reactor

Equation 5.3-11. Average Energy of a Neutron Causing Fission

$$AENCF = \frac{E}{w}$$

Variables: AENCF = Average energy of neutron causing fission in MeV
w = Weight of the average neutron causing fission
E = Weighted average energy of a neutron causing fission g/cm^3

Equation 5.3-12. H/X

$$H/X = \frac{A\,F_H\,V}{\sum_x A\,F_x\,V}$$

Variables: H/X = Ratio of atoms of hydrogen to atoms of fissile isotopes in a given material
A = Atom density of the material in the fuel region
F_H = Atom fraction of hydrogen
F_x = Atom fraction of fissile isotope "x"
x = Fissile isotope (e.g., ^{233}U, ^{235}U, ^{239}Pu, etc.)
V = Volume of the fuel region

Equation 5.3-13. State Point Burnup (Minimum and Maximum)

$$B_j = \frac{\sum_i H_i\,D_i^2\,B_i}{\sum_i H_i\,D_i^2}$$

Variables: B_j = Burnup value for assembly "j"
B_i = Burnup value for node "i"
H_i = Height of node "i"
D_i = Outside diameter of the fuel pellet of node "i"

Equation 5.3-14. Core Average Burnup

$$B_{avg} = \frac{\sum_j N_j\,B_j}{\sum_j N_j}$$

Variables: B_{avg} = Core average burnup
B_j = Burnup value for assembly "j"
N_j = Number of assemblies of type "j" in the core

Equation 5.3-15. Average Pellet Diameter (For ugd LCEs Only)

$$D_{avg} = \frac{\sum_i N_i\,D_i}{\sum_i N_i}$$

Variables: D_{avg} = Core average burnup
D_i = Pellet diameter of a the fuel in fuel rod type "i"
N_i = Number of fuel rods of type "i" in the lattice

6. RESULTS

This section is divided into three subsections. These are: 6.1 Homogeneous Laboratory Critical Experiments; 6.2 Lattice Laboratory Critical Experiments; and 6.3 Commercial Reactor Critical Calculations.

The first two subsections show the characterizations of the individual Laboratory Critical Experiment (LCE) calculations used as benchmarks for the repository critical analysis methodology. The third subsection contains a summary table for the Commercial Reactor Criticals (CRC).

Several of the references include experiments that are not included in this calculation file. References 7.1 and 7.18 include redundant, but different, representations of several of the same experiments. In these cases, only the most detailed representations are included in this calculation file. Reference 7.19 includes several lattice experiments that are simplified to homogeneous cylinders. These were not included in this calculation file because they do not fit into the current criticality methodology.

The AENCF values reported in the following tables are taken from the calculations using the Waste Package Operations Selected Library set documented in Reference 7.23. Results using the ENDF/B-V and ENDF/B-VI cross section libraries are also available for these experiments (Reference 7.18, pp. 69-105; Reference 7.19, pp. 34-35; and Reference 7.22, pp. 11-24).

The experiments are separated in the following table by material type and flux spectrum. The material types considered are:

- Mixed Plutonium and Natural Uranium
- Plutonium
- High Enriched Uranium
- Intermediate Enriched Uranium
- Low Enriched Uranium
- ^{233}U

The flux spectrum categories, as defined for the purposes of this calculation file are:

- Thermal (AENCF $\leq$ 0.1 Mev)
- Intermediate (0.1 Mev $\leq$ AENCF $\leq$ 1.0 Mev)
- Fast (1.0 Mev $\leq$ AENCF)

The number of digits for cited values does not necessarily indicate accuracy; it may reflect the results of a calculation, values as reported in a reference, or be an artifact of conversion.

6.1 HOMOGENEOUS LABORATORY CRITICAL EXPERIMENTS

Table 6.1-1. Mixed Plutonium and Natural Uranium Nitrate Solution Laboratory Critical Experiment Characterizations (Thermal)

	Experiment	AWRE1	AWRE2	AWRE3	AWRE4	AWRE5
Concentration	U (g/L)	228.5	228.5	228.5	228.5	71.3
	Pu (g/L)	101.3	101.3	101.3	101.3	31.6
Enrichment	U-235 (wt%)	0.72%	0.72%	0.72%	0.72%	0.72%
	Pu-239 (wt%)	93.95%	93.95%	93.95%	93.95%	93.95%
Flux Spectrum	AENCF (MeV)	0.0313	0.0321	0.0318	0.0323	0.0106
	H/X	234	234	234	234	830
	Experiment	AWRE6	AWRE7	AWRE8	AWRE9	AWRE10
Concentration	U (g/L)	71.3	71.3	42.2	42.2	39.6
	Pu (g/L)	31.6	31.6	18.6	18.6	17.5
Enrichment	U-235 (wt%)	0.72%	0.72%	0.72%	0.72%	0.72%
	Pu-239 (wt%)	93.95%	93.95%	93.95%	93.95%	93.95%
Flux Spectrum	AENCF (MeV)	0.0105	0.0109	0.0068	0.0068	0.0065
	H/X	830	830	1430	1430	1521
	Experiment	PNL1158	PNL1159	PNL1161	PNL1577	PNL1678
Concentration	U (g/L)	11.1	10. 8	41.0	262.8	262.6
	Pu (g/L)	11.8	11.7	12.2	172.6	172.8
Enrichment	U-235 (wt%)	0.71%	0.71%	0.44%	0.56%	0.56%
	Pu-239 (wt%)	91.10%	91.10%	91.10%	91.12%	91.12%
Flux Spectrum	AENCF (MeV)	0.0039	0.0038	0.0060	0.0596	0.0507
	H/X	2,374	2,405	2,268	135	134

Table 6.1-1. Mixed Plutonium and Natural Uranium Nitrate Solution Laboratory Critical Experiment Characterizations (Thermal)

	Experiment	PNL1783	PNL1868	PNL1969	PNL2070	PNL2565
Concentration	U (g/L)	262.9	174.0	174.7	174.5	63.4
	Pu (g/L)	173.2	118.7	119.0	118.9	41.7
Enrichment	U-235 (wt%)	0.56%	0.56%	0.56%	0.56%	0.56%
	Pu-239 (wt%)	91.12%	91.12%	91.12%	91.12%	91.12%
Flux Spectrum	AENCF (MeV)	0.0539	0.0342	0.0336	0.0374	0.0130
	H/X	134	211	210	211	654
	Experiment	PNL2666	PNL2767	PNL3187	PNL3391	PNL3492
Concentration	U (g/L)	63.7	63.6	365.2	363.7	363.7
	Pu (g/L)	41.9	41.8	102.2	103.4	103.4
Enrichment	U-235 (wt%)	0.56%	0.56%	0.70%	0.70%	0.70%
	Pu-239 (wt%)	91.12%	91.12%	91.12%	91.12%	91.12%
Flux Spectrum	AENCF (MeV)	0.0116	0.0120	0.0416	0.0408	0.0439
	H/X	651	652	227	223	218
	Experiment	PNL3593	PNL3694	PNL3795	PNL3808	PNL3896
Concentration	U (g/L)	379.6	380.4	6.5	161.7	3.8
	Pu (g/L)	107.9	108.3	195.6	47.1	110.1
Enrichment	U-235 (wt%)	0.70%	0.70%	2.29%	0.70%	2.29%
	Pu-239 (wt%)	91.12%	91.12%	91.57%	91.12%	91.57%
Flux Spectrum	AENCF (MeV)	0.0461	0.0448	0.0397	0.0206	0.0236
	H/X	213	212	125	551	241

Table 6.1-1. Mixed Plutonium and Natural Uranium Nitrate Solution Laboratory Critical Experiment Characterizations (Thermal)

	Experiment	PNL3897	PNL3898	PNL3999	PNL5300
Concentration	U (g/L)	2.3	247.3	250.3	251.6
	Pu (g/L)	58.3	72.7	73.6	74.3
Enrichment	U-235 (wt%)	2.29%	0.70%	0.70%	0.70%
	Pu-239 (wt%)	91.57%	91.12%	91.12%	91.12%
Flux Spectrum	AENCF (MeV)	0.0145	0.0297	0.0293	0.0292
	H/X	475	343	339	336

Table 6.1-2. Plutonium Nitrate Solution Laboratory Critical Experiment Characterizations (Thermal)

	Experiment	PU003-1	PU003-2	PU003-3	PU003-4	PU003-5
Concentration	Pu (g/L)	33.3	34.3	37.4	38.1	40.7
Enrichment	Pu-239 (wt%)	98.24%	98.24%	96.88%	96.88%	96.88%
Flux Spectrum	AENCF (MeV)	0.0062	0.0065	0.0069	0.0072	0.0079
	H/X	788	756	699	682	627
	Experiment	PU003-6	PU003-7	PU003-8	PU004-1	PU004-2
Concentration	Pu (g/L)	44.1	36.0	36.8	26.3	26.3
Enrichment	Pu-239 (wt%)	96.88%	96.88%	96.88%	99.46%	99.46%
Flux Spectrum	AENCF (MeV)	0.0085	0.0068	0.0070	0.0052	0.0054
	H/X	563	738	714	987	977
	Experiment	PU004-3	PU004-4	PU004-5	PU004-6	PU004-7
Concentration	Pu (g/L)	27.2	28.1	27.6	28.6	29.6
Enrichment	Pu-239 (wt%)	99.46%	99.46%	98.24%	96.88%	96.88%
Flux Spectrum	AENCF (MeV)	0.0054	0.0056	0.0054	0.0056	0.0056
	H/X	935	889	942	927	892
	Experiment	PU004-8	PU004-9	PU004-10	PU004-11	PU004-12
Concentration	Pu (g/L)	30.0	31.6	35.4	39.4	29.4
Enrichment	Pu-239 (wt%)	96.88%	96.88%	96.88%	96.88%	96.88%
Flux Spectrum	AENCF (MeV)	0.0062	0.0062	0.0072	0.0081	0.0059
	H/X	869	805	689	592	893

Table 6.1-2. Plutonium Nitrate Solution Laboratory Critical Experiment Characterizations (Thermal)

	Experiment	PU004-131	PU005-1	PU005-2	PU005-3	PU005-4
Concentration	Pu (g/L)	29.3	29.7	30.5	31.4	33.5
Enrichment	Pu-239 (wt%)	96.57%	95.95%	95.95%	95.95%	95.95%
Flux Spectrum	AENCF (MeV)	0.0058	0.0057	0.0059	0.0062	0.0066
	H/X	903	903	868	834	765
	Experiment	PU005-5	PU005-6	PU005-7	PU005-8	PU005-9
Concentration	Pu (g/L)	36.0	38.5	40.9	30.6	31.9
Enrichment	Pu-239 (wt%)	95.95%	95.95%	95.95%	95.60%	95.60%
Flux Spectrum	AENCF (MeV)	0.0072	0.0077	0.0084	0.0059	0.0063
	H/X	694	633	581	869	825
	Experiment	PU007-2	PU007-3	PU007-5	PU007-6	PU007-7
Concentration	Pu (g/L)	232.0	221.0	100.2	101.5	100.1
Enrichment	Pu-239 (wt%)	95.01%	95.01%	95.01%	95.01%	95.01%
Flux Spectrum	AENCF (MeV)	0.0402	0.0393	0.0176	0.0180	0.0178
	H/X	110	114	268	262	266
	Experiment	PU007-8	PU007-9	PU007-10	PU10091	PU10092
Concentration	Pu (g/L)	101.6	101.6	93.5	99.1	73.9
Enrichment	Pu-239 (wt%)	95.01%	95.01%	95.01%	97.15%	97.15%
Flux Spectrum	AENCF (MeV)	0.0181	0.0182	0.0165	0.0168	0.0130
	H/X	258	260	285	267	357
	Experiment	PU10093	PU10111	PU10112	PU10113	PU10114
Concentration	Pu (g/L)	54.5	54.5	47.2	47.2	41.7
Enrichment	Pu-239 (wt%)	97.15%	97.15%	97.15%	97.15%	97.15%
Flux Spectrum	AENCF (MeV)	0.0099	0.0100	0.0087	0.0085	0.0079
	H/X	484	485	558	558	606

Table 6.1-2. Plutonium Nitrate Solution Laboratory Critical Experiment Characterizations (Thermal)

	Experiment>	PU10115	PU10116	PU10117	PU10121	PU10122
Concentration	Pu (g/L)	36.9	64.0	49.0	48.8	42.3
Enrichment	Pu-239 (wt%)	97.15%	97.10%	97.10%	97.10%	97.10%
Flux Spectrum	AENCF (MeV)	0.0076	0.0111	0.0088	0.0090	0.0078
	H/X	665	414	535	543	618
	Experiment>	PU10123	PU10124	PU11161	PU11162	PU11163
Concentration	Pu (g/L)	36.5	31.1	35.0	36.2	38.1
Enrichment	Pu-239 (wt%)	97.10%	97.10%	95.83%	95.83%	95.83%
Flux Spectrum	AENCF (MeV)	0.0069	0.0061	0.0074	0.0078	0.0083
	H/X	728	850	765	736	691
	Experiment>	PU11164	PU11165	PU11181	PU11182	PU11183
Concentration	Pu (g/L)	38.2	43.4	22.4	23.3	23.1
Enrichment	Pu-239 (wt%)	95.83%	95.83%	95.80%	95.80%	95.80%
Flux Spectrum	AENCF (MeV)	0.0085	0.0097	0.0051	0.0055	0.0051
	H/X	682	575	1,208	1,151	1,158
	Experiment>	PU11184	PU11185	PU11186	PU11187	PUST111
Concentration	Pu (g/L)	23.8	25.2	27.5	23.9	73.0
Enrichment	Pu-239 (wt%)	95.80%	95.80%	95.80%	95.80%	95.01%
Flux Spectrum	AENCF (MeV)	0.0055	0.0059	0.0063	0.0055	0.0125
	H/X	1,100	1,039	908	1,103	371
	Experiment>	PUST112	PUST113	PUST114	PUST115	PUST116
Concentration	Pu (g/L)	96.0	119.0	132.0	140.0	268.7
Enrichment	Pu-239 (wt%)	95.01%	95.01%	95.01%	95.01%	95.01%
Flux Spectrum	AENCF (MeV)	0.0170	0.0216	0.0240	0.0248	0.0481
	H/X	272	216	190	180	91

Table 6.1-2. Plutonium Nitrate Solution Laboratory Critical Experiment Characterizations (Thermal)

	Experiment	PUST9-1	PUST9-2	PUST9-3
Concentration	Pu (g/L)	10.0	9.5	9.5
Enrichment	Pu-239 (wt%)	97.39%	97.39%	97.39%
Flux Spectrum	AENCF (MeV)	0.0026	0.0027	0.0025
	H/X	2,648	2,779	2,803

Table 6.1-3. Plutonium Metal Laboratory Critical Experiment Characterizations (Fast)

	Experiment	PMF20	PMF22	PMF23	PMF24	PMF25
Density	ρ (g/cm³)	15.5	15.3	15.3	15.3	15.3
Enrichment	Pu-239 (wt%)	~90%	98.2%	98.2%	98.2%	98.2%
Flux Spectrum	AENCF (MeV)	1.8886	1.8932	1.8011	1.7421	1.8316
	Experiment	PMF26	PMF27	PMF28	PMF29	PMF30
Density	ρ (g/cm³)	15.3	15.5	15.5	18.9	19.0
Enrichment	Pu-239 (wt%)	98.2%	89.7%	89.7%	88.6%	88.9%
Flux Spectrum	AENCF (MeV)	1.7318	1.4768	1.7166	1.9188	1.8152
	Experiment	PMF31	PMF32			
Density	ρ (g/cm³)	18.9	18.9			
Enrichment	Pu-239 (wt%)	88.9%	88.9%			
Flux Spectrum	AENCF (MeV)	1.6059	1.8192			

Table 6.1-4. High Enriched Uranium Nitrate Solution Laboratory Critical Experiment Characterizations (Thermal)

	Experiment	HEST1-1	HEST1-2	HEST1-3	HEST1-4	HEST1-5
Concentration	U (g/L)	145.7	346.7	142.9	357.7	54.9
Enrichment	U-235 (wt%)	93.17%	93.17%	93.17%	93.17%	93.17%
Flux Spectrum	AENCF (MeV)	0.0158	0.0386	0.0155	0.0405	0.0065
	H/X	182	71	186	68	499
	Experiment	HEST1-6	HEST1-7	HEST1-8	HEST1-9	HEST1-10
Concentration	U (g/L)	59.7	137.4	145.7	357.7	64.0
Enrichment	U-235 (wt%)	93.17%	93.17%	93.17%	93.17%	93.17%
Flux Spectrum	AENCF (MeV)	0.0068	0.0150	0.0161	0.0410	0.0076
	H/X	459	193	182	68	427
	Experiment	HEST131	HEST132	HEST133	HEST134	HEST141
Concentration	U (g/L)	20.1	25.5	26.8	28.5	70.0
Enrichment	U-235 (wt%)	93.2%	93.2%	93.2%	93.2%	89.04%
Flux Spectrum	AENCF (MeV)	0.0027	0.0031	0.0036	0.0038	0.0073
	H/X	1375	1173	1030	971	405
	Experiment	HEST142	HEST143	HEST151	HEST152	HEST153
Concentration	U (g/L)	68.1	67.7	100.5	100.5	98.8
Enrichment	U-235 (wt%)	89.04%	89.04%	89.04%	89.04%	89.04%
Flux Spectrum	AENCF (MeV)	0.0074	0.0079	0.0105	0.0101	0.0113
	H/X	418	421	278	278	283

Table 6.1-4. High Enriched Uranium Nitrate Solution Laboratory Critical Experiment Characterizations (Thermal)

	Experiment	HEST154	HEST155	HEST161	HEST162	HEST163
Concentration	U (g/L)	98.8	95.2	156.5	143.6	144.2
Enrichment	U-235 (wt%)	89.04%	89.04%	89.04%	89.04%	89.04%
Flux Spectrum	AENCF (MeV)	0.0108	0.0111	0.0152	0.0150	0.0160
	H/X	283	295	175	192	191
	Experiment	HEST171	HEST172	HEST173	HEST174	HEST175
Concentration	U (g/L)	202.4	202.4	202.4	196.2	192
Enrichment	U-235 (wt%)	89.04%	89.04%	89.04%	89.04%	89.04%
Flux Spectrum	AENCF (MeV)	0.0189	0.0210	0.0200	0.0194	0.0199
	H/X	133	133	133	137	141
	Experiment	HEST176	HEST177	HEST178	HEST181	HEST182
Concentration	U (g/L)	192	192	186.2	300	300
Enrichment	U-235 (wt%)	89.04%	89.04%	89.04%	89.04%	89.04%
Flux Spectrum	AENCF (MeV)	0.0221	0.0205	0.0222	0.0284	0.0315
	H/X	141	141	147	86	86
	Experiment	HEST183	HEST184	HEST185	HEST186	HEST187
Concentration	U (g/L)	300.0	291.3	291.3	291.3	283.3
Enrichment	U-235 (wt%)	89.04%	89.04%	89.04%	89.04%	89.04%
Flux Spectrum	AENCF (MeV)	0.0299	0.0290	0.0327	0.0307	0.0297
	H/X	86	89	89	89	92
	Experiment	HEST188	HEST189	HEST191	HEST192	HEST193
Concentration	U (g/L)	283.3	283.3	447.3	393.6	400.0
Enrichment	U-235 (wt%)	89.04%	89.04%	89.04%	89.04%	89.04%
Flux Spectrum	AENCF (MeV)	0.0334	0.0309	0.0426	0.0392	0.0415
	H/X	92	91	55	63	61

Table 6.1-4. High Enriched Uranium Nitrate Solution Laboratory Critical Experiment Characterizations (Thermal)

	Experiment	HEST2-1	HEST2-2	HEST2-3	HEST2-4	HEST2-5
Concentration	U (g/L)	144.4	144.4	334.8	334.8	144.4
Enrichment	U-235 (wt%)	93.17%	93.17%	93.17%	93.17%	93.17%
Flux Spectrum	AENCF (MeV)	0.0155	0.0151	0.0359	0.0346	0.0158
	H/X	184	184	74	74	184
	Experiment	HEST2-6	HEST2-7	HEST2-8	HEST2-9	HEST2-10
Concentration	U (g/L)	144.4	334.8	334.8	59.7	59.7
Enrichment	U-235 (wt%)	93.17%	93.17%	93.17%	93.17%	93.17%
Flux Spectrum	AENCF (MeV)	0.0147	0.0366	0.0342	0.0071	0.0066
	H/X	184	74	74	460	460
	Experiment	HEST2-11	HEST2-12	HEST2-13	HEST2-14	HEST3-10
Concentration	U (g/L)	144.4	144.4	334.8	334.8	345.3
Enrichment	U-235 (wt%)	93.17%	93.17%	93.17%	93.17%	93.17%
Flux Spectrum	AENCF (MeV)	0.0155	0.0144	0.0370	0.0336	0.0382
	H/X	184	184	74	74	71
	Experiment	HEST3-11	HEST3-12	HEST3-13	HEST3-14	HEST3-15
Concentration	U (g/L)	345.3	60.3	60.3	60.3	66.3
Enrichment	U-235 (wt%)	93.17%	93.17%	93.17%	93.17%	93.17%
Flux Spectrum	AENCF (MeV)	0.0357	0.0065	0.0065	0.0070	0.0072
	H/X	71	454	454	454	412
	Experiment	HEST3-16	HEST3-17	HEST3-18	HEST3-19	HEST3-10
Concentration	U (g/L)	147.7	147.7	345.3	345.3	83.5
Enrichment	U-235 (wt%)	93.17%	93.17%	93.17%	93.17%	93.17%
Flux Spectrum	AENCF (MeV)	0.0159	0.0150	0.0384	0.0341	0.0086
	H/X	180	180	71	71	325

Table 6.1-4. High Enriched Uranium Nitrate Solution Laboratory Critical Experiment Characterizations (Thermal)

	Experiment>	HEST141	HEST142	HEST143	HEST144	HEST145
Concentration	U (g/L)	360.4	83.5	359.6	359.6	359.6
Enrichment	U-235 (wt%)	93.17%	93.17%	93.17%	93.17%	93.17%
Flux Spectrum	AENCF (MeV)	0.0351	0.0086	0.0352	0.0362	0.0357
	H/X	68	325	68	68	68
	Experiment>	HEST146	HEST147	HEST315	HEUST31	HEUST32
Concentration	U (g/L)	359.6	359.6	355.9	60.3	60.3
Enrichment	U-235 (wt%)	93.17%	93.17%	93.17%	93.17%	93.17%
Flux Spectrum	AENCF (MeV)	0.0363	0.0358	0.0356	0.0066	0.0068
	H/X	68	68	69	454	454
	Experiment>	HEUST33	HEUST34	HEUST35	HEUST36	HEUST37
Concentration	U (g/L)	147.7	147.7	345.3	345.3	60.3
Enrichment	U-235 (wt%)	93.17%	93.17%	93.17%	93.17%	93.17%
Flux Spectrum	AENCF (MeV)	0.0163	0.0154	0.0380	0.0354	0.0069
	H/X	180	180	71	71	454
	Experiment>	HEUST38	HEUST39	HEUST71	HEUST72	HEUST73
Concentration	U (g/L)	147.7	147.7	67.3	370.0	67.3
Enrichment	U-235 (wt%)	93.17%	93.17%	93.17%	93.17%	93.17%
Flux Spectrum	AENCF (MeV)	0.0164	0.0151	0.0070	0.0361	0.0071
	H/X	180	180	406	65	406
	Experiment>	HEUST74	HEUST75	HEUST76	HEUST77	HEUST78
Concentration	U (g/L)	364.1	76.1	360.4	76.1	364.1
Enrichment	U-235 (wt%)	93.17%	93.17%	93.17%	93.17%	93.17%
Flux Spectrum	AENCF (MeV)	0.0351	0.0084	0.0377	0.0084	0.0383
	H/X	67	358	68	358	67

Table 6.1-4. High Enriched Uranium Nitrate Solution Laboratory Critical Experiment Characterizations (Thermal)

	Experiment	HEUST79	HEUST81	HEUST83	HEUST86	HEUST89
Concentration	U (g/L)	80.7	60.3	60.3	355.9	60.3
Enrichment	U-235 (wt%)	93.17%	93.17%	93.17%	93.17%	93.17%
Flux Spectrum	AENCF (MeV)	0.0090	0.0067	0.0064	0.0379	0.0064
	H/X	337	454	454	69	454
	Experiment	HST180	HST181	HST182	HST321	HST321
Concentration	U (g/L)	285.3	285.3	279.6	20.5	15.1
Enrichment	U-235 (wt%)	89.04%	89.04%	89.04%	93.2%	93.2%
Flux Spectrum	AENCF (MeV)	0.0344	0.0318	0.0328	0.0027	0.0022
	H/X	91	91	94	1,272	1,835

Table 6.1-5. High Enriched Uranium Metal Laboratory Critical Experiment Characterizations (Fast)

	Experiment	HMF16	HMF3N	HMF8	HMF11	HMF12
Density	ρ (g/cm^3)	18.7	18.8	18.2	18.0	18.0
Enrichment	U-235 (wt%)	94%	93.5%	90%	90%	90%
Flux Spectrum	AENCF (MeV)	1.5681	1.3649	1.5503	1.1620	1.5222
	Experiment	HMF13	HMF14	HMF15	HMF18	HMF19
Density	ρ (g/cm^3)	18.0	18.0	18.6	18.4	18.5
Enrichment	U-235 (wt%)	90%	90%	96%	90%	90%
Flux Spectrum	AENCF (MeV)	1.4860	1.5443	1.5808	1.5522	1.4765
	Experiment	HMF20	HMF21	HMF22	HMF24	HMF28
Density	ρ (g/cm^3)	18.5	18.4	18.4	18.0	18.6
Enrichment	U-235 (wt%)	90%	90%	90%	90%	93.24%
Flux Spectrum	AENCF (MeV)	1.4333	1.4481	1.5039	1.2504	1.5979

Table 6.1-6. Intermediate Enriched Uranium Laboratory Critical Experiment Characterizations (Thermal)

	Experiment	IECT104	IECT105	IECT113	IECT114	IECT115
Enrichment	U-235 (wt%)	29.83%	29.83%	29.83%	29.83%	29.83%
Flux Spectrum	AENCF (MeV)	0.0741	0.0455	0.0743	0.0738	0.0740
	H/X	64	222	64	64	64
	Experiment	IECT116	IECT119	IECT125	IECT126	IECT127
Enrichment	U-235 (wt%)	29.83%	29.83%	29.83%	29.83%	29.83%
Flux Spectrum	AENCF (MeV)	0.0555	0.0603	0.0599	0.0570	0.0562
	H/X	64	64	64	64	64

Table 6.1-7. Intermediate Enriched Uranium Laboratory Critical Experiment Characterizations (Intermediate)

	Experiment	IECT101	IECT102	IECT103	IECT106	IECT107
Enrichment	U-235 (wt%)	29.83%	29.83%	29.83%	29.83%	29.83%
Flux Spectrum	AENCF (MeV)	0.2168	0.1582	0.1041	0.1079	0.1106
	H/X	8	16	32	32	32
	Experiment	IECT108	IECT109	IECT110	IECT111	IECT112
Enrichment	U-235 (wt%)	29.83%	29.83%	29.83%	29.83%	29.83%
Flux Spectrum	AENCF (MeV)	0.1187	0.1679	0.1576	0.1573	0.1557
	H/X	32	16	16	16	16
	Experiment	IECT117	IECT118	IECT120	IECT121	IECT122
Enrichment	U-235 (wt%)	29.83%	29.83%	29.83%	29.83%	29.83%
Flux Spectrum	AENCF (MeV)	0.2084	0.1338	0.1554	0.2133	0.1977
	H/X	8	16	8	4	8

Table 6.1-7. Intermediate Enriched Uranium Laboratory Critical Experiment Characterizations (Intermediate)

	Experiment>	IECT123	IECT124	IECT128	IECT129
Enrichment	U-235 (wt%)	29.83%	29.83%	29.83%	29.83%
Flux Spectrum	AENCF (MeV)	0.1283	0.1331	0.1583	0.1510
	H/X	16	16	8	8

Table 6.1-8. Intermediate Enriched Uranium Metal Laboratory Critical Experiment Characterizations (Fast)

	Experiment>	IMF1-1	IMF1-2	IMF1-3	IMF1-4	IMF2-1
Density	ρ (g/cm³)	18.8	18.8	18.9	18.9	18.8
Enrichment	U-235 (wt%)	55.38%	53.53%	36.33%	37.76%	16%
Flux Spectrum	AENCF (MeV)	1.4395	1.4403	1.3862	1.3848	1.2784
	Experiment>	IMF3-1	IMF4-1	IMF5-1	IMF6-1	IMF8-1
Density	ρ (g/cm³)	18.4	18.6	18.4	18.4	18.4
Enrichment	U-235 (wt%)	36%	36%	36%	36%	36%
Flux Spectrum	AENCF (MeV)	1.3526	1.3076	1.2872	1.2915	1.3639

Table 6.1-9. Low Enriched Uranium Laboratory Critical Experiment Characterizations (Thermal)

	Experiment	LEUJA01	LEUJA13	LEUJA29	LEUJA30	LEUJA32
Concentration	U (g/L)	310.1	313.0	290.4	290.7	270.0
Enrichment	U-235 (wt%)	9.97%	9.97%	9.97%	9.97%	9.97%
Flux Spectrum	AENCF (MeV)	0.0190	0.0200	0.0181	0.0188	0.0176
	H/X	719	709	771	770	842
	Experiment	LEUJA33	LEUJA34	LEUJA36	LEUJA46	LEUJA49
Concentration	U (g/L)	270.0	253.6	253.9	241.9	241.9
Enrichment	U-235 (wt%)	9.97%	9.97%	9.97%	9.97%	9.97%
Flux Spectrum	AENCF (MeV)	0.0166	0.0159	0.0167	0.0154	0.0159
	H/X	842	896	896	942	942
	Experiment	LEUJA54	LEUJA54	LEUS121	LEUS122	LEUS123
Concentration	U (g/L)	233.2	225.3	452.2	491.7	491.7
Enrichment	U-235 (wt%)	9.97%	9.97%	4.9%	4.9%	4.9%
Flux Spectrum	AENCF (MeV)	0.0148	0.0144	0.0249	0.0283	0.0267
	H/X	983	1,018	1,098	1,001	1,001
	Experiment	lst3-1	lst3-1	lst3-2	lst3-3	lst3-4
Concentration	U (g/L)	978.3	296.0	264.0	260.0	255.0
Enrichment	U-235 (wt%)	5%	10%	10%	10%	10%
Flux Spectrum	AENCF (MeV)	0.0523	0.0185	0.0165	0.0164	0.0160
	H/X	454	770	878	897	913

Table 6.1-9. Low Enriched Uranium Laboratory Critical Experiment Characterizations (Thermal)

	Experiment>	lst3-5	lst3-6	lst3-7	lst3-8	lst3-9
Concentration	U (g/L)	203.0	197.0	193.0	171.0	168.0
Enrichment	U-235 (wt%)	10%	10%	10%	10%	10%
Flux Spectrum	AENCF (MeV)	0.0131	0.0130	0.0126	0.0115	0.0114
	H/X	1,173	1,213	1,240	1,412	1,438

Table 6.1-10. Low Enriched Uranium Laboratory Critical Experiment Characterizations (Intermediate)

	Experiment>	SPHU9A	SPHU9B	SPHU9C	SPHU9D	SPHU9E
Concentration	Solution (g/L)	1,998.0	2,293.0	2,232.0	1,720.0	1,726.0
Enrichment	U-235 (wt%)	1.01%	1.01%	1.01%	1.01%	1.01%
Flux Spectrum	AENCF (MeV)	0.2541	0.2163	0.1883	0.1737	0.1591
	H/X	370	491	605	676	731
	Experiment>	SPHU9F	SPHU9G	SPHU9H	SPHU9I	SPHU9J
Concentration	Solution (g/L)	1,778.0	1,790.0	1,842.0	1,796.0	1,828.0
Enrichment	U-235 (wt%)	1.07%	1.07%	1.07%	1.16%	1.16%
Flux Spectrum	AENCF (MeV)	0.2511	0.1839	0.1651	0.2495	0.1783
	H/X	344	533	653	318	476
	Experiment>	SPHU9K	SPHU9L			
Concentration	Solution (g/L)	1,913.0	1,640.0			
Enrichment	U-235 (wt%)	1.16%	1.16%			
Flux Spectrum	AENCF (MeV)	0.1661	0.1549			
	H/X	583	635			

Table 6.1-11. ^{233}U Laboratory Critical Experiment Characterizations (Thermal)

Experiment		u233c1	u233c2	u233c3	u233c4	u233c5
Concentration	U (g/L)	17.1	17.9	18.5	19.2	19.8
Enrichment	U-235 (wt%)	0.04%	0.04%	0.04%	0.04%	0.04%
	U-233 (wt%)	99.70%	97.70%	97.70%	97.70%	97.70%
Flux Spectrum	AENCF (MeV)	0.0374	0.0039	0.0040	0.0043	0.0044
	H/X	1,531	1,471	1,419	1,369	1,325

Experiment		u233c6
Concentration	U (g/L)	13.3
Enrichment	U-235 (wt%)	0.03%
	U-233 (wt%)	97.67%
Flux Spectrum	AENCF (MeV)	0.0030
	H/X	1,984

Table 6.1-12. ^{233}U Laboratory Critical Experiment Characterizations (Fast)

Experiment		u2331a	u2332a	u2332b	u2333a	u2333b
Density	ρ (g/cm³)	18.4	18.6	18.6	18.6	18.6
Enrichment	U-235 (wt%)	0.03%	0.00%	0.00%	0.00%	0.00%
	U-233 (wt%)	98.13%	98.20%	98.20%	98.20%	98.20%
Flux Spectrum	AENCF (MeV)	1.7739	1.7370	1.7079	1.7483	1.7623

Experiment		u2334a	u2334b	u2335a	u2335b	u2336a
Density	ρ (g/cm³)	18.6	18.6	18.6	18.6	18.4
Enrichment	U-235 (wt%)	0.00%	0.00%	0.00%	0.00%	0.03%
	U-233 (wt%)	98.20%	98.20%	98.20%	98.20%	98.13%
Flux Spectrum	AENCF (MeV)	1.6119	1.5178	1.6195	1.5187	1.7740

6.2 LATTICE LABORATORY CRITICAL EXPERIMENTS

Table 6.2-1. Mixed Oxide Fuel Pin Lattice Laboratory Critical Experiment Characterizations (Thermal)

	Experiment	rtd004	rtd006	3r74
Geometry	Pitch Type	Square	Square	Square
	Rod Pitch (cm)	1.53	1.91	2.64
	Fuel Diameter (cm)	0.49	0.49	0.86
	P/D Ratio	3.11	3.89	3.08
Enrichment	U-235 (wt%)	0.71%	0.71%	0.71%
	Pu-239 (wt%)	86.15%	86.15%	90.61%
Flux Spectrum	AENCF (MeV)	0.0819	0.0609	0.0790

Table 6.2-2. Mixed Oxide Fuel Pin Lattice Laboratory Critical Experiment Characterizations (Intermediate)

	Experiment	exp22	exp23	exp24	exp25	exp26
Geometry	Pitch Type	Square	Square	Square	Square	Square
	Rod Pitch (cm)	1.78	1.78	2.21	2.21	2.52
	Fuel Diameter (cm)	1.28	1.28	1.28	1.28	1.28
	P/D Ratio	1.39	1.39	1.72	1.72	1.96
Enrichment	U-235 (wt%)	0.71%	0.71%	0.71%	0.71%	0.71%
	Pu-239 (wt%)	91.84%	91.84%	91.84%	91.84%	91.84%
Flux Spectrum	AENCF (MeV)	0.2556	0.2740	0.1613	0.1894	0.1319
	Experiment	exp27	exp34	ffff001	ffff003	ffff005
Geometry	Pitch Type	Square	Triangular	Square	Square	Squarer
	Rod Pitch (cm)	2.52	1.60	1.26	0.77	0.95
	Fuel Diameter (cm)	1.28	1.27	0.49	0.49	0.49
	P/D Ratio	1.96	1.26	2.55	1.55	1.93
Enrichment	U-235 (wt%)	0.71%	0.71%	0.71%	0.71%	0.71%
	Pu-239 (wt%)	91.84%	91.84%	86.15%	86.14%	86.15%
Flux Spectrum	AENCF (MeV)	0.1537	0.3776	0.1015	0.2453	0.1728
	Experiment	ffff0029	ssr27	ssr53	ssr57	ssr66
Geometry	Pitch Type	Square	Square	Square	Square	Square
	Rod Pitch (cm)	0.97	1.42	2.01	1.42	1.87
	Fuel Diameter (cm)	0.49	0.86	0.86	0.86	0.86
	P/D Ratio	1.96	1.66	2.35	1.66	2.18
Enrichment	U-235 (wt%)	0.71%	0.71%	0.71%	0.71%	0.71%
	Pu-239 (wt%)	86.15%	90.61%	90.61%	90.61%	90.61%
Flux Spectrum	AENCF (MeV)	0.1647	0.2015	0.1065	0.1938	0.1183

1. The values listed for exp34 are for the MOX rods only. The LCE also involved UO_2 (4.31 wt% ^{235}U) rods (See Reference 7.2, p. 102)..

Table 6.2-2. Mixed Oxide Fuel Pin Lattice Laboratory Critical Experiment Characterizations (Intermediate)

	Experiment	smr10	smr1	smr5	smr8	smr9
Geometry	Pitch Type	Square	Square	Square	Square	Square
	Rod Pitch (cm)	1.32	1.42	1.42	1.42	1.42
	Fuel Diameter (cm)	0.86	0.86	0.86	0.86	0.86
	P/D Ratio	1.54	1.63	1.61	1.61	1.63
Enrichment	U-235 (wt%)	0.71%	0.71%	0.71%	0.71%	0.71%
	Pu-239 (wt%)	90.61%	90.61%	90.61%	90.61%	90.61%
Flux Spectrum	AENCF (MeV)	0.2295	0.1715	0.1919	0.2051	0.1673

	Experiment	smr11	smr12
Geometry	Pitch Type	Square	Square
	Rod Pitch (cm)	1.42	1.42
	Fuel Diameter (cm)	0.86	0.86
	P/D Ratio	1.61	1.61
Enrichment	U-235 (wt%)	0.71%	0.71%
	Pu-239 (wt%)	90.61%	90.61%
Flux Spectrum	AENCF (MeV)	0.2048	0.2049

1. The values listed for smr1, smr5, smr8, smr9, smr11, and smr12 are for the MOX rods only. The LCE also involved UO_2 (5.74 wt% ^{235}U) rods (See Reference 7.18, p. 41 and 42).

Table 6.2-3. High Enriched Uranium Oxide Fuel Pin Lattice Laboratory Critical Experiment Characterizations (Thermal)

	Experiment	hct101	hct102	hct103	hct104	hct105
Geometry	Pitch Type	Square	Square	Square	Square	Square
	Rod Pitch (cm)	1.22	1.22	1.47	1.72	1.98
	Average Pellet Diameter (cm)	0.83	0.83	0.83	0.83	0.83
	P/D Ratio	1.47	1.47	1.77	2.07	2.38
Enrichment	U-235 (Avg. wt%)	62.40%	62.40%	62.40%	62.40%	62.40%
Flux Spectrum	AENCF (MeV)	0.0793	0.0799	0.0555	0.0439	0.0357
	Experiment	hct106	hct107	hct108	hct109	hct110
Geometry	Pitch Type	Square	Square	Square	Square	Square
	Rod Pitch (cm)	1.98	2.26	2.26	2.23	2.49
	Average Pellet Diameter (cm)	0.83	0.83	0.83	0.83	0.83
	P/D Ratio	2.38	2.72	2.72	2.69	2.99
Enrichment	U-235 (Avg. wt%)	62.40%	62.40%	62.40%	62.40%	62.40%
Flux Spectrum	AENCF (MeV)	0.0359	0.0357	0.0320	0.0316	0.0288
	Experiment	hct111	hct112	hct113	hct114	hct115
Geometry	Pitch Type	Square	Square	Square	Square	Hexagonal
	Rod Pitch (cm)	2.49	2.76	2.97	2.50[1]	2.58
	Average Pellet Diameter (cm)	0.83	0.83	0.83	0.83	0.83
	P/D Ratio	2.99	3.32	3.58	3.01[1]	3.11
Enrichment	U-235 (Avg. wt%)	62.40%	62.40%	62.40%	62.40%	62.40%
Flux Spectrum	AENCF (MeV)	0.0285	0.0262	0.0252	0.0284	0.0288

1. LCE hct114 has a different horizontal pitch (1.544 cm) and vertical pitch (1.585 cm). The values reported for Rod Pitch and P/D Ratio are averages.

Table 6.2-3. High Enriched Uranium Oxide Fuel Pin Lattice Laboratory Critical Experiment Characterizations (Thermal)

Experiment		hct116	hct117	hct118	hct119	hct120
Geometry	Pitch Type	Square	Square	Square	Square	Square
	Rod Pitch (cm)	2.48	2.48	2.48	2.48	2.48
	Average Pellet Diameter (cm)	0.83	0.83	0.83	0.83	0.83
	P/D Ratio	2.99	2.99	2.99	2.99	2.99
Enrichment	U-235 (Avg. wt%)	62.40%	62.40%	62.40%	62.40%	62.40%
Flux Spectrum	AENCF (MeV)	0.0282	0.0286	0.0288	0.0296	0.0229

Experiment		hct121
Geometry	Pitch Type	Square
	Rod Pitch (cm)	2.48
	Average Pellet Diameter (cm)	0.83
	P/D Ratio	2.99
Enrichment	U-235 (Avg. wt%)	62.40%
Flux Spectrum	AENCF (MeV)	0.0277

Table 6.2-4. High Enriched Uranium Oxide Fuel Pin Lattice Laboratory Critical Experiment Characterizations (Intermediate)

	Experiment	hcl2-1	hcl2-2	hcl2-3	hcl2-4	hcl2-5
Geometry	Pitch Type	Cylindrical	Cylindrical	Cylindrical	Cylindrical	Cylindrical
	Rod Pitch (cm)[1]	3.51	3.51	3.51	3.51	3.51
	Average Pellet Diameter (cm)	1.70	1.70	1.70	1.70	1.70
	P/D Ratio	2.07	2.07	2.07	2.07	2.07
Enrichment	U-235 (Avg. wt%)	96%	96%	96%	96%	96%
Flux Spectrum	AENCF (MeV)	0.2422	0.2413	0.2381	0.2376	0.2376

1. These LCEs have a different inner zone and outer zone pitches. The values reported for Rod Pitch are averages.

Table 6.2-5. High Enriched Uranium Oxide Fuel Plate Lattice Laboratory Critical Experiment Characterizations (Thermal)

	Experiment	pert1	pert2	pert3	pert4	pert5
Geometry	Pitch Type	Rectangular	Rectangular	Rectangular	Rectangular	Rectangular
	Plate Pitch (cm)	0.32	0.32	0.32	0.32	0.32
	Average Fuel Thickness, W (cm)	0.05	0.05	0.05	0.05	0.05
	P/W Ratio	6.23	6.23	6.23	6.23	6.23
Enrichment	U-235 (Avg. wt%)	93.17%	93.17%	93.17%	93.17%	93.17%
Flux Spectrum	AENCF (MeV)	0.0147	0.0126	0.0117	0.0110	0.0105

Table 6.2-5. High Enriched Uranium Oxide Fuel Plate Lattice Laboratory Critical Experiment Characterizations (Thermal)

	Experiment	sperd6	sperd7	sperd8	sperd9	sperd10
Geometry	Pitch Type	Rectangular	Rectangular	Rectangular	Rectangular	Rectangular
	Rod Pitch (cm)	0.32	0.32	0.32	0.32	0.32
	Average Fuel Thickness, W (cm)	0.05	0.05	0.05	0.05	0.05
	P/W Ratio	6.23	6.23	6.23	6.23	6.23
Enrichment	U-235 (Avg. wt%)	93.17%	93.17%	93.17%	93.17%	93.17%
Flux Spectrum	AENCF (MeV)	0.0102	0.0097	0.0098	0.0099	0.0147
	Experiment	sperd11	sperd12	sperd13	sperd14	sperd15
Geometry	Pitch Type	Rectangular	Rectangular	Rectangular	Rectangular	Rectangular
	Rod Pitch (cm)	0.32	0.32	0.32	0.32	0.32
	Average Fuel Thickness, W (cm)	0.05	0.05	0.05	0.05	0.05
	P/W Ratio	6.23	6.23	6.23	6.23	6.23
Enrichment	U-235 (Avg. wt%)	93.17%	93.17%	93.17%	93.17%	93.17%
Flux Spectrum	AENCF (MeV)	0.0115	0.0101	0.0143	0.0106	0.0106
	Experiment	sperd16	sperd17	sperd18	sperd19	sperd20
Geometry	Pitch Type	Rectangular	Rectangular	Rectangular	Rectangular	Rectangular
	Rod Pitch (cm)	0.32	0.32	0.32	0.32	0.32
	Average Fuel Thickness, W (cm)	0.05	0.05	0.05	0.05	0.05
	P/W Ratio	6.23	6.23	6.23	6.23	6.23
Enrichment	U-235 (Avg. wt%)	93.17%	93.17%	93.17%	93.17%	93.17%
Flux Spectrum	AENCF (MeV)	0.0120	0.0131	0.0140	0.0097	0.0114

Table 6.2-5. High Enriched Uranium Oxide Fuel Plate Lattice Laboratory Critical Experiment Characterizations (Thermal)

	Experiment	spert21	spert22	spert23	
Geometry	Pitch Type	Rectangular	Rectangular	Rectangular	
	Rod Pitch (cm)	0.32	0.32	0.32	
	Average Fuel Thickness, W (cm)	0.05	0.05	0.05	
	P/W Ratio	6.23	6.23	6.23	
Enrichment	U-235 (Avg. wt%)	93.17%	93.17%	93.17%	
Flux Spectrum	AENCF (MeV)	0.0126	0.0133	0.0132	

Table 6.2-6. High Enriched Uranium Oxide One-Zone Cruciform Rod Lattice Laboratory Critical Experiment Characterizations (Thermal)

	Experiment	hct4-1	hct4-2	hct4-3	hct4-4	hct4-5
Geometry	Pitch Type	Hexagonal	Hexagonal	Hexagonal	Hexagonal	Hexagonal
	Rod Pitch (cm)	0.53	0.53	0.53	0.53	0.52
	Equivalent Fuel Diameter (cm)	0.30	0.30	0.30	0.30	0.33
	P/D Ratio	1.75	1.75	1.75	1.75	1.57
Enrichment	U-235 (wt%)	90%	90%	90%	90%	80%
Flux Spectrum	AENCF (MeV)	0.0740	0.0732	0.0765	0.0748	0.0776

	Experiment	hct6-1	hct6-2	hct6-3	hct7-4	hct7-5
Geometry	Pitch Type	Hexagonal	Hexagonal	Hexagonal	Hexagonal	Hexagonal
	Rod Pitch (cm)	0.56	1	2.11	1.06	2.11
	Equivalent Fuel Diameter (cm)	0.33	0.33	0.33	0.33	0.33
	P/D Ratio	1.70	3.03	6.40	3.21	6.42
Enrichment	U-235 (wt%)	80%	80%	80%	80%	80%
Flux Spectrum	AENCF (MeV)	0.0715	0.0231	0.0106	0.0340	0.0448

	Experiment	hct8-6	hct8-7	hct8-9	[illegible]
Geometry	Pitch Type	Hexagonal	Hexagonal	Hexagonal	[illegible]
	Rod Pitch (cm)	4.23	0.53	0.53	[illegible]
	Equivalent Fuel Diameter (cm)	0.33	0.33	0.33	[illegible]
	P/D Ratio	12.83	1.60	1.60	[illegible]
Enrichment	U-235 (wt%)	80%	80%	80%	[illegible]
Flux Spectrum	AENCF (MeV)	0.0486	0.0882	0.0919	[illegible]

Table 6.2-7. High Enriched Uranium Oxide Two-Zone Cruciform Rod Lattice Laboratory Critical Experiment Characterizations (Thermal)

	Experiment	hct3-1	hct3-2	hct3-3	hct3-4	hct3-5
Geometry	Pitch Type	Hexagonal	Hexagonal	Hexagonal	Hexagonal	Hexagonal
	Inner Zone Rod Pitch (cm)	1.22	1.22	1.22	1.22	1.22
	Inner Zone Equivalent Fuel Diameter (cm)	0.33	0.33	0.33	0.33	0.33
	Inner Zone P/D Ratio	3.70	3.70	3.70	3.70	3.70
	Outer Zone Rod Pitch (cm)	0.61	0.61	0.61	0.61	0.61
	Outer Zone Equivalent Fuel Diameter (cm)	0.33	0.33	0.33	0.33	0.33
	Outer Zone P/D Ratio	1.85	1.85	1.85	5.56	5.56
Enrichment	U-235 (wt%)	80%	80%	80%	80%	80%
Flux Spectrum	AENCF (MeV)	0.0466	0.0417	0.0330	0.0262	0.0207

1. Reference 7.18 (p. 24) indicates that the "hct3" LCEs use the same fuel rod design as the "hct7" LCEs.

(Table Continued on Next Page)

Table 6.2-7. High Enriched Uranium Oxide Two-Zone Cruciform Rod Lattice Laboratory Critical Experiment Characterizations (Thermal)

	Experiment	hct3-6	hct3-7	hct3-8	hct3-9	hct3-10
Geometry	Pitch Type	Hexagonal	Hexagonal	Hexagonal	Hexagonal	Hexagonal
	Inner Zone Rod Pitch (cm)	0.61	0.61	0.61	0.61	0.61
	Inner Zone Equivalent Fuel Diameter (cm)	0.33	0.33	0.33	0.33	0.33
	Inner Zone P/D Ratio	1.85	1.85	1.85	1.85	1.85
	Outer Zone Rod Pitch (cm)	1.22	1.22	1.22	1.22	1.22
	Outer Zone Equivalent Fuel Diameter (cm)	0.33	0.33	0.33	0.33	0.33
	Outer Zone P/D Ratio	3.70	3.70	3.70	3.70	3.70
Enrichment	U-235 (wt%)	80%	80%	80%	80%	80%
Flux Spectrum	AENCF (MeV)	0.0419	0.0345	0.0342	0.0265	0.0202

(Table Continued on Next Page)

Table 6.2-7. High Enriched Uranium Oxide Two-Zone Cruciform Rod Lattice Laboratory Critical Experiment Characterizations (Thermal)

Experiment		hct311	hct312	hct313	hct314	hct315
Geometry	Pitch Type	Hexagonal	Hexagonal	Hexagonal	Hexagonal	Hexagonal
	Inner Zone Rod Pitch (cm)	0.61	1.83	1.83	0.61	0.61
	Inner Zone Equivalent Fuel Diameter (cm)	0.33	0.33	0.33	0.33	0.33
	Inner Zone P/D Ratio	1.85	5.56	5.56	1.85	1.85
	Outer Zone Rod Pitch (cm)	1.22	0.61	0.61	1.83	1.83
	Outer Zone Equivalent Fuel Diameter (cm)	0.33	0.33	0.33	0.33	0.33
	Outer Zone P/D Ratio	3.70	1.85	1.85	5.56	5.56
Enrichment	U-235 (wt%)	80%	80%	80%	80%	80%
Flux Spectrum	AENCF (MeV)	0.0177	0.0263	0.0140	0.0305	0.0185

Table 6.2-8. Intermediate Enriched Uranium Oxide Fuel Pin Lattice Laboratory Critical Experiment Characterizations (Thermal)

Experiment		tri17	tri18
Geometry	Pitch Type	Cylindrical	Cylindrical
	Rod Pitch (cm)	4	4
	Fuel Diameter (cm)	3.64[1]	3.64[1]
	P/D Ratio	1.10	1.10
Enrichment	U-235 (wt%)	20%	20%
Flux Spectrum	AENCF (MeV)	0.0236	0.0240

1. The TRIGA rods used in tri17 and tri18 include a 0.635 cm diameter zirconium rod in the center of the fuel.

Table 6.2-9. Low Enriched Uranium Oxide Fuel Pin Lattice Laboratory Critical Experiment Characterizations (Thermal)

Experiment		exp18
Geometry	Pitch Type	Square
	Rod Pitch (cm)	2.012
	Fuel Diameter (cm)	0.907
	P/D Ratio	2.22
Enrichment	U-235 (wt%)	5.74%
Flux Spectrum	AENCF (MeV)	0.0886

Table 6.2-10. Low Enriched Uranium Oxide Fuel Pin Lattice Laboratory Critical Experiment Characterizations (Intermediate)

Experiment		core2	core3	core4	core5	core6
Geometry	Pitch Type	Square	Square	Square	Square	Square
	Rod Pitch (cm)	1.64	1.64	1.64	1.64	1.64
	Fuel Diameter (cm)	1.03	1.03	1.03	1.03	1.03
	P/D Ratio	1.59	1.59	1.59	1.59	1.59
Enrichment	U-235 (wt%)	2.46%	2.46%	2.46%	2.46%	2.46%
Flux Spectrum	AENCF (MeV)	0.1999	0.1808	0.1791	0.1692	0.1722
Experiment		core7	core8	core9	core10	core11
Geometry	Pitch Type	Square	Square	Square	Square	Square
	Rod Pitch (cm)	1.64	1.64	1.64	1.64	1.64
	Fuel Diameter (cm)	1.03	1.03	1.03	1.03	1.03
	P/D Ratio	1.59	1.59	1.59	1.59	1.59
Enrichment	U-235 (wt%)	2.46%	2.46%	2.46%	2.46%	2.46%
Flux Spectrum	AENCF (MeV)	0.1596	0.1650	0.1553	0.1604	0.1789

Table 6.2-10. Low Enriched Uranium Oxide Fuel Pin Lattice Laboratory Critical Experiment Characterizations (Intermediate)

	Experiment	core12	core13	core15	core16	core17
Geometry	Pitch Type	Square	Square	Square	Square	Square
	Rod Pitch (cm)	1.64	1.64	1.64	1.64	1.64
	Fuel Diameter (cm)	1.03	1.03	1.03	1.03	1.03
	P/D Ratio	1.59	1.59	1.59	1.59	1.59
Enrichment	U-235 (wt%)	2.46%	2.46%	2.46%	2.46%	2.46%
Flux Spectrum	AENCF (MeV)	0.1667	0.1808	0.1835	0.1695	0.1819
	Experiment	core18	core19	core20	core21	exp1
Geometry	Pitch Type	Square	Square	Square	Square	Square
	Rod Pitch (cm)	1.64	1.64	1.64	1.64	2.03
	Fuel Diameter (cm)	1.03	1.03	1.03	1.03	1.12
	P/D Ratio	1.59	1.59	1.59	1.59	1.82
Enrichment	U-235 (wt%)	2.46%	2.46%	2.46%	2.46%	2.35%
Flux Spectrum	AENCF (MeV)	0.1686	0.1835	0.1693	0.1623	0.1210
	Experiment	exp2	exp3	exp4	exp5	exp6
Geometry	Pitch Type	Square	Square	Square	Square	Square
	Rod Pitch (cm)	2.03	2.03	2.03	1.89	1.89
	Fuel Diameter (cm)	1.12	1.12	1.12	1.26	1.26
	P/D Ratio	1.82	1.82	1.82	1.50	1.50
Enrichment	U-235 (wt%)	2.35%	2.35%	2.35%	4.31%	4.31%
Flux Spectrum	AENCF (MeV)	0.1247	0.1217	0.1200	0.2797	0.1766

Table 6.2-10. Low Enriched Uranium Oxide Fuel Pin Lattice Laboratory Critical Experiment Characterizations (Intermediate)

	Experiment	exp7	exp8	exp9	exp10	exp11
Geometry	Pitch Type	Square	Square	Square	Square	Square
	Rod Pitch (cm)	1.89	1.89	1.89	1.72	1.72
	Fuel Diameter (cm)	1.26	1.26	1.26	1.26	1.26
	P/D Ratio	1.50	1.49	1.49	1.36	1.36
Enrichment	U-235 (wt%)	4.31%	4.31%	4.31%	4.31%	4.31%
Flux Spectrum	AENCF (MeV)	0.1784	0.1774	0.2217	0.2239	0.2664
	Experiment	exp12	exp13	exp14	exp15	exp16
Geometry	Pitch Type	Square	Square	Square	Square	Square
	Rod Pitch (cm)	1.89	1.89	1.53	2.21	1.42
	Fuel Diameter (cm)	1.27	1.27	1.12	1.12	0.91
	P/D Ratio	1.49	1.49	1.37	1.98	1.57
Enrichment	U-235 (wt%)	4.31%	4.31%	2.35%	2.35%	5.74%
Flux Spectrum	AENCF (MeV)	0.1946	0.1942	0.2095	0.1098	0.1564
	Experiment	ugd1	ugd2	ugd3	ugd4	ugd5
Geometry	Pitch Type	Square	Square	Square	Square	Square
	Rod Pitch (cm)	1.64	1.64	1.64	1.64	1.64
	Average Pellet Diameter (cm)	1.03	1.03	1.03	1.03	1.03
	P/D Ratio	1.59	1.59	1.59	1.59	1.59
Enrichment	U-235 (Avg. wt%)	2.46%	2.46%	2.46%	2.46%	2.46%
Flux Spectrum	AENCF (MeV)	0.2013	0.1983	0.1995	0.1999	0.1975

Table 6.2-10. Low Enriched Uranium Oxide Fuel Pin Lattice Laboratory Critical Experiment Characterizations (Intermediate)

	Experiment	ugd6	ugd7	ugd8	ugd9	ugd10
Geometry	Pitch Type	Square	Square	Square	Square	Square
	Rod Pitch (cm)	1.64	1.64	1.64	1.64	1.64
	Average Pellet Diameter (cm)	1.03	1.03	1.03	1.03	1.03
	P/D Ratio	1.59	1.59	1.59	1.59	1.59
Enrichment	U-235 (Avg. wt%)	2.46%	2.46%	2.46%	2.46%	2.46%
Flux Spectrum	AENCF (MeV)	0.1978	0.1968	0.1976	0.1987	0.2011
	Experiment	ugd12	ugd13	ugd14	ugd15	ugd16
Geometry	Pitch Type	Square	Square	Square	Square	Square
	Rod Pitch (cm)	1.64	1.64	1.64	1.64	1.64
	Average Pellet Diameter (cm)	1.05	1.05	1.05	1.05	1.05
	P/D Ratio	1.56	1.56	1.56	1.56	1.56
Enrichment	U-235 (Avg. wt%)	2.75%	2.75%	2.74%	2.74%	2.73%
Flux Spectrum	AENCF (MeV)	0.2097	0.2084	0.2042	0.2056	0.2065
	Experiment	ugd1	ugd18	ugd19	ugd20	Case1
Geometry	Pitch Type	Square	Square	Square	Square	Square
	Rod Pitch (cm)	1.64	1.64	1.64	1.64	2.03
	Average Pellet Diameter (cm)	1.05	1.05	1.05	1.05	1.12
	P/D Ratio	1.56	1.56	1.56	1.56	1.82
Enrichment	U-235 (Avg. wt%)	2.73%	2.78%	2.77%	2.76%	2.35%
Flux Spectrum	AENCF (MeV)	0.2034	0.2085	0.2101	0.2070	0.1229

Table 6.2-10. Low Enriched Uranium Oxide Fuel Pin Lattice Laboratory Critical Experiment Characterizations (Intermediate)

	Experiment	Case2	Case3	Case4	Case5	Case6
Geometry	Pitch Type	Square	Square	Square	Square	Square
	Rod Pitch (cm)	2.03	2.03	2.03	2.03	2.03
	Average Pellet Diameter (cm)	1.12	1.12	1.12	1.12	1.12
	P/D Ratio	1.82	1.82	1.82	1.82	1.82
Enrichment	U-235 (Avg. wt%)	2.35%	2.35%	2.35%	2.35%	2.35%
Flux Spectrum	AENCF (MeV)	0.1223	0.1200	0.1222	0.1204	0.1221
	Experiment	Case7	Case8	SUBC2P8H	SUBC3P1H	SUBC3P4H
Geometry	Pitch Type	Square	Square	Hexagonal	Hexagonal	Hexagonal
	Rod Pitch (cm)	2.03	2.03	7.11	7.87	8.64
	Average Pellet Diameter (cm)	1.12	1.12	5.98	5.98	5.98
	P/D Ratio	1.82	1.82	1.19	1.32	1.44
Enrichment	U-235 (Avg. wt%)	2.35%	2.35%	1.15%	1.15%	1.15%
Flux Spectrum	AENCF (MeV)	0.1211	0.1209	0.4085	0.3417	0.3153
	Experiment	ssr83	ssr48	ct27-1		
Geometry	Pitch Type	Square	Square	Square		
	Rod Pitch (cm)	1.32	1.42	1.6		
	Average Pellet Diameter (cm)	0.91	0.91	0.79		
	P/D Ratio	1.46	1.57	2.03		
Enrichment	U-235 (Avg. wt%)	5.74%	5.74%	4.74%		
Flux Spectrum	AENCF (MeV)	0.1820	0.1557	0.1025		

Note: The fuel rods used in SUBC2P8H, SUBC3P1H, and SUBC3P4H were annular rods.

6.3 COMMERCIAL REACTOR CRITICALS

Table 6.3-1. Commercial Reactor Criticals State Points

State Point	Reactor	Cycle	Time of Measurement EFPD*
1	Crystal River, Unit #3	1a	0.0
2	Crystal River, Unit #3	1b	268.8
3	Crystal River, Unit #3	1b	411.0
4	Crystal River, Unit #3	2	0.0
5	Crystal River, Unit #3	3	0.0
6	Crystal River, Unit #3	3	168.5
7	Crystal River, Unit #3	3	250.0
8	Crystal River, Unit #3	4	0.0
9	Crystal River, Unit #3	4	228.1
10	Crystal River, Unit #3	4	253.0
11	Crystal River, Unit #3	5	0.0
12	Crystal River, Unit #3	5	388.5
13	Crystal River, Unit #3	6	0.0
14	Crystal River, Unit #3	6	96.0
15	Crystal River, Unit #3	6	400.0
16	Crystal River, Unit #3	7	0.0
17	Crystal River, Unit #3	7	260.3
18	Crystal River, Unit #3	7	291.0
19	Crystal River, Unit #3	7	319.0
20	Crystal River, Unit #3	7	462.3
21	Crystal River, Unit #3	7	479.0
22	Crystal River, Unit #3	8	0.0
23	Crystal River, Unit #3	8	97.6

Table 6.3-1. Commercial Reactor Criticals State Points

State Point	Reactor	Cycle	Time of Measurement EFPD*
24	Crystal River, Unit #3	8	139.8
25	Crystal River, Unit #3	8	404.0
26	Crystal River, Unit #3	8	409.6
27	Crystal River, Unit #3	8	515.5
28	Crystal River, Unit #3	9	0.0
29	Crystal River, Unit #3	9	158.8
30	Crystal River, Unit #3	9	219.0
31	Crystal River, Unit #3	9	363.1
32	Crystal River, Unit #3	10	0.0
33	Crystal River, Unit #3	10	573.7
36	Sequoyah, Unit #2	1	0.0
37	Sequoyah, Unit #2	3	0.0
38	Sequoyah, Unit #2	3	210.9
46	McGuire, Unit #1	1	0.0
47	McGuire, Unit #1	6	0.0
48	McGuire, Unit #1	6	62.4
49	McGuire, Unit #1	7	0.0
50	McGuire, Unit #1	7	129.0
51	McGuire, Unit #1	7	282.3
59	Three Mile Island, Unit #1	1	0.0
60	Three Mile Island, Unit #1	5	0.0
61	Three Mile Island, Unit #1	5	114.4

* Note: EFPD = Effective Full Power Days

Table 6.3-2. Commercial Reactor Criticals Fuel Characterizations

State Point	Initial Enrichment (wt% ^{235}U)	Burnup (GWd/MTU)		
		Minimum	Maximum	Core Average
1	2.445	0	0	0
2	2.446	4	11	8
3	2.446	7	16	12
4	2.670	0	17	9
5	2.693	0	20	8
6	2.693	3	25	13
7	2.693	4	28	15
8	2.648	0	18	7
9	2.648	6	25	14
10	2.648	7	26	15
11	2.915	0	17	7
12	2.915	9	28	19
13	3.210	0	22	12
14	3.210	3	25	15
15	3.210	13	35	24
16	3.554	0	25	10
17	3.554	6	33	18
18	3.554	7	34	19
19	3.554	8	35	20
20	3.554	11	39	24
21	3.554	12	40	25
22	3.755	0	31	12
23	3.755	3	32	15
24	3.755	4	33	17
25	3.755	11	36	25

Table 6.3-2. Commercial Reactor Criticals Fuel Characterizations

State Point	Initial Enrichment (wt% ^{235}U)	Burnup (GWd/MTU)		
		Minimum	Maximum	Core Average
26	3.755	11	36	25
27	3.755	14	39	28
28	3.892	0	35	14
29	3.892	5	37	19
30	3.892	7	37	21
31	3.892	11	40	25
32	4.015	0	35	15
33	4.015	18	49	33
36	2.535	0	0	0
37	3.427	0	27	11
38	3.427	7	34	19
46	2.602	0	0	0
47	3.472	0	28	12
48	3.472	2	31	14
49	3.618	0	27	11
50	3.618	4	32	16
51	3.618	9	38	23
59	2.633	0	0	0
60	2.820	0	25	10
61	2.820	2	28	14

The AENCF values reported in the following table are for the "best-estimate" isotope set, and are calculated from References 7.8, 7.9, 7.10 and 7.11 as noted in Table 5.1-1.

Table 6.3-3. Commercial Reactor Criticals Summary Table

	State Point	1	2	3	4	5
Geometry	Pitch Type	Square	Square	Square	Square	Square
	Rod Pitch in Assembly (cm)	1.44	1.44	1.44	1.44	1.44
	Average Pellet Diameter (cm)	0.94	0.94	0.94	0.94	0.94
	P/D Ratio	1.53	1.53	1.53	1.53	1.53
Flux Spectrum	AENCF (MeV)	0.2344	0.2504	0.2518	0.2498	0.2489
	State Point	6	7	8	9	10
Geometry	Pitch Type	Square	Square	Square	Square	Square
	Rod Pitch in Assembly (cm)	1.44	1.44	1.44	1.44	1.44
	Average Pellet Diameter (cm)	0.94	0.94	0.94	0.94	0.94
	P/D Ratio	1.53	1.53	1.53	1.53	1.53
Flux Spectrum	AENCF (MeV)	0.2536	0.2547	0.2499	0.2576	0.2568
	State Point	11	12	13	14	15
Geometry	Pitch Type	Square	Square	Square	Square	Square
	Rod Pitch in Assembly (cm)	1.44	1.44	1.44	1.44	1.44
	Average Pellet Diameter (cm)	0.94	0.94	0.94	0.94	0.94
	P/D Ratio	1.53	1.53	1.53	1.53	1.53
Flux Spectrum	AENCF (MeV)	0.2475	0.2605	0.2513	0.2557	0.2612

Table 6.3-3. Commercial Reactor Criticals Summary Table

	State Point	16	17	18	19	20
Geometry	Pitch Type	Square	Square	Square	Square	Square
	Rod Pitch in Assembly (cm)	1.44	1.44	1.44	1.44	1.44
	Average Pellet Diameter (cm)	0.94	0.94	0.94	0.94	0.94
	P/D Ratio	1.53	1.53	1.53	1.53	1.53
Flux Spectrum	AENCF (MeV)	0.2504	0.2583	0.2598	0.2587	0.2582
	State Point	21	22	23	24	25
Geometry	Pitch Type	Square	Square	Square	Square	Square
	Rod Pitch in Assembly (cm)	1.44	1.44	1.44	1.44	1.44
	Average Pellet Diameter (cm)	0.94	0.94	0.94	0.94	0.94
	P/D Ratio	1.53	1.53	1.53	1.53	1.53
Flux Spectrum	AENCF (MeV)	0.2616	0.2532	0.2572	0.2582	0.2615
	State Point	26	27	28	29	30
Geometry	Pitch Type	Square	Square	Square	Square	Square
	Rod Pitch in Assembly (cm)	1.44	1.44	1.44	1.44	1.44
	Average Pellet Diameter (cm)	0.94	0.94	0.94	0.94	0.94
	P/D Ratio	1.53	1.53	1.53	1.53	1.53
Flux Spectrum	AENCF (MeV)	0.2610	0.2643	0.2546	0.2584	0.2597

Table 6.3-3. Commercial Reactor Criticals Summary Table

	State Point	31	32	33	36	37
Geometry	Pitch Type	Square	Square	Square	Square	Square
	Rod Pitch in Assembly (cm)	1.44	1.44	1.44	1.26	1.26
	Average Pellet Diameter (cm)	0.94	0.94	0.94	0.82	0.82
	P/D Ratio	1.53	1.53	1.53	1.54	1.54
Flux Spectrum	AENCF (MeV)	0.2635	0.2558	0.2660	0.2374	0.2518
	State Point	38	46	47	48	49
Geometry	Pitch Type	Square	Square	Square	Square	Square
	Rod Pitch in Assembly (cm)	1.26	1.26	1.26	1.26	1.26
	Average Pellet Diameter (cm)	0.82	0.82	0.78	0.78	0.78
	P/D Ratio	1.54	1.54	1.62	1.62	1.62
Flux Spectrum	AENCF (MeV)	0.2555	0.2390	0.2351	0.2375	0.2362
	State Point	50	51	59	60	61
Geometry	Pitch Type	Square	Square	Square	Square	Square
	Rod Pitch in Assembly (cm)	1.26	1.26	1.44	1.44	1.44
	Average Pellet Diameter (cm)	0.78	0.78	0.94	0.94	0.94
	P/D Ratio	1.62	1.62	1.53	1.53	1.53
Flux Spectrum	AENCF (MeV)	0.2388	0.2426	0.2353	0.2476	0.2498

7. REFERENCES

7.1 Civilian Radioactive Waste Management System (CRWMS) Management and Operating Contractor (M&O) 1997. *MCNP Evaluation of Laboratory Critical Experiments: Homogeneous Mixture Criticals*. BBA000000-01717-0200-00045 REV 00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19971230.0134.

7.2 CRWMS M&O 1997. *MCNP Evaluation of Laboratory Critical Experiments: Lattice Criticals*. BBA000000-01717-0200-00009 REV 00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19971229.0283.

7.3 CRWMS M&O 1998. *Summary Report of Commercial Reactor Criticality Data for Crystal River Unit 3*. B00000000-01717-5705-00060 REV 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19980728.0189.

7.4 CRWMS M&O 1998. *Summary Report of Commercial Reactor Criticality Data for Sequoyah Unit 2*. B00000000-01717-5705-000064 REV 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19980716.0015.

7.5 CRWMS M&O 1998. *Summary Report of Commercial Reactor Criticality Data for McGuire Unit 1*. B00000000-01717-5705-00063 REV 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19980622.0079.

7.6 CRWMS M&O 1998. *Summary Report of Commercial Reactor Criticality Data for Three Mile Island Unit 1*. B00000000-01717-5705-000069 REV 00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19980619.0134.

7.7 Briesmeister, Judith F., ed. 1997. *MCNP—A General Monte Carlo N-Particle Transport Code*. User manual, Report Number: LA-12625-M, Version 4B. Los Alamos, New Mexico: Los Alamos National Laboratory. TIC: 241044

7.8 CRWMS M&O 1998. *CRC Reactivity Calculations for Crystal River Unit 3*. B00000000-01717-0210-00002 REV 00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19980728.0004.

7.9 CRWMS M&O 1998. *CRC Reactivity Calculations for Sequoyah Unit 2*. B00000000-01717-0210-00006 REV 00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19980728.0005.

7.10 CRWMS M&O 1998. *CRC Reactivity Calculations for McGuire Unit 1*. B00000000-01717-0210-00004 REV 00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19980728.0006.

7.11 CRWMS M&O 1998. *CRC Reactivity Calculations for Three Mile Island Unit 1*. B00000000-01717-0210-00008 REV 00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19980728.0003.

7.12 DOE 1999. DOE Letter "Accepted Data Call", from R. E. Spence to J. L. Younker, July 27, 1999. North Las Vegas, Nevada: DOE OCRWM Yucca Mountain Site Characterization Office. ACC: MOL.19990811.0170.

7.13 [Reserved]

7.14 CRWMS M&O 1997. *Criticality Evaluation of Degraded Internal Configurations for the PWR AUCF WP Designs.* BBA000000-01717-0200-00056 REV 00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19971231.0251.

7.15 CRWMS M&O 1997. *Criticality Safety and Shielding Evaluations of the Codisposal Canister in the Five-Pack DHLW Waste Package.* BBA000000-01717-0200-00052 REV 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19971210.0010.

7.16 CRWMS M&O 1998. *Disposal Criticality Analysis for Aluminum-based Fuel in a Codisposal Waste Package – ORR and MIT SNF – Phase II.* BBA000000-01717-0200-00060 REV 00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19980224.0670.

7.17 CRWMS M&O 1998. *Evaluation of Codisposal Viability for Aluminum-Clad DOE-Owned Spent Fuel: Phase II Degraded Codisposal Waste Package Internal Criticality.* BBA000000-01717-5705-00017 REV 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19980701.0782.

7.18 CRWMS M&O 1999. *LCE for Research Reactor Benchmark Calculations.* B00000000-01717-0210-00034 REV 00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19990329.0394.

7.19 CRWMS M&O 1999. *LCEs for Naval Reactor Benchmark Calculations.* B00000000-01717-0210-00087 REV 00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19990819.0239.

7.20 Benedict, Manson; Pigford, T.H.; Levi, H.W. 1981. *Nuclear Chemical Engineering, Second Edition.* New York, New York: McGraw-Hill Book Company. TIC#: 245089.

7.21 Organization for Economic Cooperation and Development - Nuclear Energy Agency (OECD-NEA) 1998. *International Handbook of Evaluated Criticality Safety Benchmark Experiments.* NEA/NSC/DOC(95)03, September 1998 Edition. Paris, France: OECD. TIC: 243013.

7.22 CRWMS M&O 1999. *Laboratory Critical Experiment Reactivity Calculations.* B00000000-01717-0210-00018 REV 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19990526.0294.

7.23 CRWMS M&O 1998. *Selection of MCNP Cross Section Libraries.* B00000000-01717-5705-00099 REV 00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19980722.0042.

8. ATTACHMENTS

None Used.