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Design Analysis Cover Sheet

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Table of Contents

1. Purpose

The purpose of this analysis is to document Waste Package Development Department (WPPD) MCNP evaluations of benchmark solution Laboratory Critical Experiments (LCE's). The objective of this analysis is to quantify the ability of the MCNP 4A (Reference 5.4) code system to accurately calculate the effective neutron multiplication factor (k_{eff}) for various measured critical (i.e., $k_{eff} = 1.0$) configurations. This analysis primarily quantifies the effectiveness of the MCNP criticality calculation for configurations containing either uranium or plutonium solutions or solutions that incorporate both elements as fissile species. The Los Alamos National Laboratory (LANL) ENDF/B-V cross section libraries were used in these analyses.

The results of this analysis will be used to support the development of the disposal criticality analysis methodology.

2. Quality Assurance

The Quality Assurance (QA) program applies to this analysis. The work reported in this document is part of the Waste Package Design analysis that will eventually support the License Application Design phase. This activity, when appropriately confirmed, can impact the proper functioning of the Mined Geologic Disposal System (MGDS) waste package; the waste package has been identified as an MGDS Q-List item important to safety and waste isolation (pp. 4, 15, Reference 5.1). The waste package is on the Q-List by direct inclusion by the Department of Energy (DOE), without conducting a QAP-2-3 evaluation. The Waste Package Development Department responsible manager has evaluated this activity in accordance with QAP-2-0, *Conduct of Activities*. The *Perform Criticality, Thermal, Structural, and Shielding Analyses* (Reference 5.3) evaluation has determined the preparation and review of this design analysis is subject to *Quality Assurance Requirements and Description* (Reference 5.2) requirements. As specified in NLP-3-18, this activity is subject to QA controls.

The analysis described in this document supports development of the disposal criticality analysis methodology. No designs were analyzed in this document. This document will not directly support any construction, fabrication, or procurement activity and therefore is not required to be procedurally controlled as TBV (to be verified). The calculation design inputs or information used in this document come from data accepted by the Nuclear Regulatory Commission and by the scientific and engineering community as established fact. The specific references are listed in Section 5 and identified in Section 7. The information is therefore not treated as unqualified data.

3. Method

The analytical model employed in this analysis consisted of using the MCNP computer program (Reference 5.4) to determine the effective neutron multiplication factor (k_{eff}) for LCE's. The results reported for the MCNP calculations are 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 calculation of acceptable bias values and subcritical margins are based on the results of numerous LCE evaluations performed using the MCNP code system. The LCE's documented in this analysis may be used to determine appropriate bias values for use in subsequent criticality evaluations performed with MCNP.

4. Design Inputs

No repository-related designs were analyzed and no design inputs were used in this document. The systems analyzed in this document are both LCE's used in prior licensing activities approved by the Nuclear Regulatory Commission and LCE's accepted by the scientific and engineering community. The input information is, therefore, not treated as unqualified data. Thus the results of the analysis described in this document can be used to support construction, fabrication, or procurement activities in accordance with the appropriate procedures. The dimensions listed throughout this analysis are in the metric units used directly in the codes to facilitate checking and minimize the potential for errors in input.

4.1 Design Parameters

The section is not applicable. This analysis does not evaluate designs or components for designs. Therefore, no design parameters are used. The experimental parameters used in MCNP are described for each experiment in Section 7.2. With only a few exceptions, the MNCP input representations are from the Organization for Economic Cooperation and Development (OECD) compilation (Reference 5.5).

4.2 Criteria

The design of the waste package will depend on waste package configuration criticality analyses performed using an acceptable disposal criticality analysis methodology. Criteria that relate to the development and design of repository and engineered barrier components are derived from the applicable requirements and planning documents. The Engineered Barrier Design Requirements Document (EBDRD, Reference 5.7) provides requirements for engineered barrier segment design. The Repository Design Requirements Document (RDRD, Reference 5.8) provides requirements for repository design. The Controlled Design Assumptions Document (Reference 5.9) provides

guidance for requirements listed in the EBDRD and RDRD which have unqualified or unconfirmed data associated with the requirement.

This analysis supports the disposal criticality analysis methodology by providing input, in the form of methods benchmarking. These benchmark calculations will contribute to the determination of bias values in the method of critical multiplication factor calculation that is implemented by the analytic tools to be used in the disposal criticality methodology. The requirements for utilizing the bias in the method of calculation of the critical multiplication factor for disposal configurations containing spent nuclear fuel are located in Section 3.2.2.5 of the RDRD and Section 3.2.2.6 of the EBDRD. This analysis does not satisfy these requirements, but the results from this analysis will be used as input to subsequent analyses which will satisfy these requirements.

4.3 Assumptions

This section is not used. No assumptions affecting repository design elements are made in this analysis.

4.4 Codes and Standards

This section is not applicable.

5. References

5.1 Q-List, YMP/90-55Q, REV 4, Yucca Mountain Site Characterization Project.

5.2 Quality Assurance Requirements and Description, DOE/RW-0333P REV 7, U.S. Department of Energy (DOE) Office of Civilian Radioactive Waste Management (OCRWM).

5.3 QAP-2-0 Activity Evaluation: ID #WP-20, *Perform Criticality, Thermal, Structural, and Shielding Analyses*, Civilian Radioactive Waste Management System (CRWMS) Management and Operating Contractor (M&O), August 3, 1997.

5.4 Briesmeister, J. F., Ed., *MCNP--A General Monte Carlo N-Particle Transport Code, Version 4A*, LA-12625-M, Los Alamos National Laboratory (LANL), November 1993.

5.5 NEA/NSC/DOC(95)03/J, *International Handbook of Evaluated Criticality Safety Benchmark Experiments*, Nuclear Energy Agency, Organization for Economic Cooperation and Development, Paris, 1995.

5.6 Miyoshi, Y., et al., "Critical Experiments on 10% Enriched Uranyl Nitrate Solution using a 60-cm Diameter Cylindrical Core," *Nuclear Technology*,Vol. 118, pg. 69-82, April 1997.

5.7 *Engineered Barrier Design Requirements Document*, YMP/CM-0024, REV 00, ICN 01, DOE OCRWM.

5.8 *Repository Design Requirements Document*, YMP/CM-0023, REV 00, ICN 01, DOE OCRWM.

5.9 *Controlled Design Assumptions Document*, Document Identifier: B000000000-01717-4600-00032, REV 04, ICN 02, CRWMS M&O.

5.10 *Software Qualification Report for MCNP4A, A General Monte Carlo N-Particle Transport Code*, CSCI; 30006 V4A, Document Identifier: 30006-2003 REV 02, CRWMS M&O.

5.11 Attachment for BBA000000-01717-0200-00045 REV 00 -- MCNP Evaluation of Laboratory Critical Experiments: Homogeneous Mixture Criticals. Batch Number: MOY-970904-14.

6. Use of Computer Software -

6.1 MCNP 4A HP 9000 Version, CSCI: 30006 VER. 4A (Reference 5.10), installed on a Hewlett Packard 9000 Workstation. The neutron interaction libraries used in this analysis are those documented in the Software Qualification Report. Both the ENDF/B-V and ENDF/B-VI libraries were qualified for use in Reference 5.10.

The input files used are reiterated in the output files and those output files are contained on a magnetic tape (Reference 5.11). The contents of this tape are given in Attachment I.

a) The MCNP 4A computer code (Reference 5.4) is an appropriate tool to determine the criticality potential, k_{eff}, of fresh and spent lattices of light water reactor fuel assemblies.
b) This software has been validated over the range it was used.
c) It was previously obtained from the Software Control Management (SCM) in accordance with appropriate procedures.

6.2 EXCEL, Version 7.0a, loaded on a Gateway 2000 PC.

This software was used to prepare tables and plots of the results. The only computations were to compute averages and uncertainties, which are merely averages computed in a quadratic sense.

7. Design Analysis

As previously stated, this analysis involves the use of the MCNP code system (Reference 5.4) to perform criticality analyses on various LCE configurations to determine the neutron multiplication factors (k_{eff} values). Each analyzed critical configuration represents an actual eigenvalue experiment. The k_{eff} result obtained from the MCNP computer simulation of each critical experiment is compared to unity -- since each experiment is critical -- to quantify the effectiveness of the MCNP criticality calculation.

The specific objectives of this analysis include the following:

1) Provide a general description of the MCNP code system including an identification of the utilized cross section indices; and
2) provide descriptions of the MCNP simulation k_{eff} results for each LCE documented in this analysis.

These analyses verify the applicability of the MCNP code system to the calculation of k_{eff} values for configurations relevant to development and licensing calculations.

7.1 The MCNP Code System

MCNP is a general-purpose particle transport code that can simulate neutron, photon, and electron transport or coupled systems of such particles. This capability extends to the modeling of neutron-multiplying systems. Geometrical representations of actual structures is accomplished by creating arbitrary three-dimensional configurations bounded by first-degree and second-degree surfaces and fourth-degree elliptical tori. Verification of the appropriateness of these geometrical representations is obtained through a powerful plotting package incorporated into MCNP.

These configurations are filled with material definitions representing the isotopic constituents of the volumes. The particle-transport characteristics of these materials are obtained from pointwise cross section data. For neutrons, all the reactions given in a particular cross section evaluation (e.g., ENDF/B-V) are included. The data includes very little "thinning," resulting in good reconstruction of resonance integrals. The transport of thermal neutrons may be approximated as a free gas. Alternatively, the more sophisticated $S(\alpha,\beta)$ model that accurately represents scattering from molecules and crystalline solids is used in the current evaluations.

While MCNP incorporates a wide variety of variance reduction techniques, computational efficiency and variance reduction in the present evaluations are achieved through implicit neutron capture and neutron weight variations that depend of the reaction experienced during the transport simulation. (Reference 5.4)

7.1.1 The Monte Carlo Method

The Monte Carlo method is a technique for simulating and recording the behavior of individual particles within a system. The behavior of the simulated particles is extrapolated to describe the average behavior of all of the particles within the system. In the abstract, the Monte Carlo method, as applied to neutrons in an MCNP criticality calculation, is based upon following many individual neutrons through their various transport experiences such as scattering, fission, absorption, or leakage. The fission process is regarded as the birth event that separates generations of neutrons. A generation is the lifetime of a neutron from birth by fission to death by either escape, parasitic capture, or absorption leading to fission. The average behavior of the sample set of neutrons is used to describe the average behavior of the system (i.e., neutron multiplication factor, k_{eff}).

7.1.2 MCNP Critical Multiplication Factor (k_{eff}) Results

MCNP Version 4A calculates three k_{eff} estimates for each neutron cycle in a given problem:

1. the collision estimate,
2. the absorption estimate, and
3. the track length estimate.

A detailed description of the three k_{eff} estimates may be found in Chapter 2, Section VIII, Part B, of Reference 5.4. The k_{eff} estimate used in the criticality analyses related to waste package development and in the bias value determination of this analysis is the statistical combination of all three k_{eff} estimates. For most systems involving neutron multiplication, the combined k_{eff} estimator is the best estimate of the neutron multiplication from MCNP (Reference 5.4).

7.1.3 Assessing the Validity of a Criticality Calculation

While MCNP is a powerful tool for analyzing neutron-multiplying systems, the results must be scrutinized to ensure that the simulation results are consistent with physical expectations. Two minimum requirements for assessing the validity of an MCNP criticality calculation are:

1. all cells containing fissionable material should be adequately sampled; and
2. the fundamental spatial mode should be achieved before commencing the accumulation of data for calculation of the mean k_{eff}.

MCNP also provides several features that assist in assessing the validity of a k_{eff} calculation. To satisfy the first requirement, MCNP verifies that at least one fission source point was generated in each cell containing fissionable material.

To satisfy the second requirement, MCNP provides several edits to determine if the fundamental spatial mode was achieved before the completion of the source cycles, I_c (I_c is the number of cycles skipped before fission simulation begins). One check is the comparison of the combined k_{eff} estimates and their standard deviations for the first and second half of the active k_{eff} cycles. If the difference between the average k_{eff} values for the two halves does not appear to be zero, or if the ratio of the two standard deviations is larger than expected, a "WARNING" message is provided in the output. MCNP determines the number of cycles which must be skipped to produce the minimum standard deviation for the combined three-eigenvalue estimate. If this result is larger than I_c, it may indicate that more cycles should be skipped before accumulating k_{eff} data. MCNP checks the k_{eff} estimate from each cycle to assure normality at the 95% and 99% confidence levels. If a k_{eff} estimate is not normally distributed with respect to the mean k_{eff} at the 99% confidence level, a "WARNING" message is provided in the output. If the fundamental spatial mode has been achieved and maintained, it is unlikely that all three k_{eff} estimates will not appear to be normally distributed at the 99% confidence level. Finally, MCNP tests for a monotonic trend of the combined three-eigenvalue estimate results over the last ten active cycles. If the spatial mode is well converged and maintained, there should not be a monotonic trend within the last ten active cycles. Again, a "WARNING" message is provided in the output if a monotonic trend is detected.

Compliance with the two minimum requirements addressed above should be verified for each criticality calculation using the checks provided by the MCNP code. If either of the two requirements appear to be violated, the k_{eff} results for the calculation should be evaluated further.

7.1.4 Cross Sections

Using the appropriate material cross-sections in an MCNP criticality calculation is essential to obtaining credible results.

The MCNP neutron interaction tables provide the following data:

1. all available cross section data;
2. angular distribution data for scattered neutrons;
3. energy distribution data for inelastically scattered neutrons;
4. data about secondary photon production;
5. Q-value data for each reaction; and
6. the average number of neutrons per fission data for fissionable isotopes.

For these calculations, the ENDF/B-V cross sections compiled by Los Alamos National Laboratory were used (see Appendix G of Reference 5.4). While "thinned" cross section sets are available for some nuclides to increase computational speed, the most complete cross section tables were used for the present work. These tables are sufficiently dense to permit linear interpolation and reportedly reproduce the basis data to within one percent or less.

Neutron interaction table designations are included as part of the material composition input to MCNP. Each material composition is composed of one or more elements or isotopes designated by a ZAID identifier. The ZAID identifier takes the form "ZZZAAA.nnC" where "ZZZ" represents the atomic number of the element ("ZZZ" may be one or two digits), "AAA" represents the elemental isotope ("AAA" must be three digits incorporating leading zeros), and "nn" represents the neutron interaction table designation. The ENDF/B-V neutron interaction tables generated by LANL use the ".50C" suffix.

7.1.6 S(α,β) Thermal Treatment

The S(α,β) thermal treatment accounts for binding effects in molecules and crystalline solids. The S(α,β) thermal scattering treatment is necessary in a highly moderating medium where low-energy scattering may be dominant. S(α,β) thermal treatment tables are available for a limited number of materials. In this analysis the thermal treatment is consistently applied to the materials having available data. The S(α,β) treatment is consistently applied to water in the LCE's of this analysis.

7.2 Laboratory Critical Experiment Descriptions

The LCE's presented in this section represent solutions containing fissile oxide fuel. Each of the LCE configurations described in this section have been analyzed with the MCNP code system using the cross section libraries previously described. The MCNP input decks for each of the benchmark calculations are included in the output files which are contained on the accompanying magnetic tape. An experiment identifier for each configuration is provided for subsequent reference in this document. With a few exceptions that are noted in the text, the vast majority of the assessed benchmarks come from the OCED compilation (Reference 5.5).

The following subsections briefly describe the benchmark experiments addressed in this analysis.

7.2.1 Mixed Plutonium and Natural Uranium Nitrate Solutions

The experiments involving plutonium and uranium with naturally occurring isotopic ratios are from the OECD benchmark compilation (Reference 5.5, Volume VI) and are summarized in Table 7.2.1.

Table 7.2.1. Benchmark Problem Summary for Configurations Incorporating Mixed Plutonium and Natural Uranium Nitrate Solutions

Class	Case Name	Description
MIX-SOL-THERM-001 Water Reflected Annular Cylindrical Tank with Central Bottle and Annular Inserts Experimental Uncertainty: ±0.003 in k_{eff} with additional ±0.005 in k_{eff} for cases with polyethylene		
	PNL3187	102.19 g Pu/liter, 365.20 g U/liter, 2% B_4C Concrete Annulus, No Bottle, Critical Height: 48.55 cm, H/Pu-239 (annular tank) = 234, 91.118 wt% Pu-239 in Pu
	PNL3391	103.37 g Pu/liter, 363.66 g U/liter, 0% B_4C Concrete Annulus, Bottle 2, Critical Height: 27.67 cm, H/Pu-239 (annular tank) = 231, H/Pu-239 (bottle) = 231, 91.118 wt% Pu-239 in Pu
	PNL3492	103.37 g Pu/liter, 363.66 g U/liter, 1% B_4C Concrete Annulus, Bottle 2, Critical Height: 37.19 cm, H/Pu-239 (annular tank) = 225, H/Pu-239 (bottle) = 231, 91.117 wt% Pu-239 in Pu
	PNL3593	107.91 g Pu/liter, 379.55 g U/liter, 6% B_4C Concrete Annulus, Bottle 2, Critical Height: 51.10 cm, H/Pu-239 (annular tank) = 220, H/Pu-239 (bottle) = 231, 91.117 wt% Pu-239 in Pu
	PNL3694	108.27 g Pu/liter, 380.41 g U/liter, No Concrete Annulus, Bottle 2, Critical Height: 32.86 cm, H/Pu-239 (annular tank) = 219, H/Pu-239 (bottle) = 231, 91.117 wt% Pu-239 in Pu
	PNL3795	195.61 g Pu/liter, 6.5 g U/liter, 2% B_4C Concrete Annulus, Bottle 3, Critical Height: 27.51 cm, H/Pu-239 (annular tank) = 125, H/Pu-239 (bottle) = 126, 91.572 wt% Pu-239 in Pu

Table 7.2.1. Benchmark Problem Summary for Configurations Incorporating Mixed Plutonium and Natural Uranium Nitrate Solutions

Class	Case Name	Description
	PNL3896	110.13 g Pu/liter, 3.8 g U/liter, 2% B_4C Concrete Annulus, Bottle 3, Critical Height: 25.69 cm, H/Pu-239 (annular tank) = 242, H/Pu-239 (bottle) = 126, 91.572 wt% Pu-239 in Pu
	PNL3897	58.30 g Pu/liter, 2.3 g U/liter, 2% B_4C Concrete Annulus, Bottle 3, Critical Height: 28.94 cm, H/Pu-239 (annular tank) = 477, H/Pu-239 (bottle) = 126, 91.572 wt% Pu-239 in Pu
	PNL3898	72.74 g Pu/liter, 247.33 g U/liter, 2% B_4C Concrete Annulus, Bottle 2, Critical Height: 39.58 cm, H/Pu-239 (annular tank) = 354, H/Pu-239 (bottle) = 231, 91.117 wt% Pu-239 in Pu
	PNL3808	47.08 g Pu/liter, 161.72 g U/liter, 2% B_4C Concrete Annulus, Bottle 2, Critical Height: 45.09 cm, H/Pu-239 (annular tank) = 569, H/Pu-239 (bottle) = 231, 91.117 wt% Pu-239 in Pu
	PNL3999	73.64 g Pu/liter, 250.30 g U/liter, Polyethylene with Cd Cover Annulus, Bottle 2, Critical Height: 79.18 cm, H/Pu-239 (annular tank) = 349, H/Pu-239 (bottle) = 349, 91.117 wt% Pu-239 in Pu
	PNL5300	74.25 g Pu/liter, 251.64 g U/liter, Solid Polyethylene with Cd Cover Center, Critical Height: 104.62 cm, H/Pu-239 (annular tank) = 346, 91.117 wt% Pu-239 in Pu

Table 7.2.1. Benchmark Problem Summary for Configurations Incorporating Mixed Plutonium and Natural Uranium Nitrate Solutions

Class	Case Name	Description
MIX-SOL-THERM-002 Water Reflected Cylindrical Tank With a 68.68 cm Inner Diameter (ID), 91.102 wt% Pu-239 in Pu Experimental Uncertainty: ±0.005in k_{eff}		
	PNL1158	11.83 g Pu/liter, 11.05 g U/liter, Critical Height: 76.80 cm, H/Pu-239 = 2,403
	PNL1159	11.73 g Pu/liter, 10.78 g U/liter, Critical Height: 83.14 cm, H/Pu-239 = 2,435
	PNL1161	12.19 g Pu/liter, 41.04 g U/liter, Critical Height: 81.72 cm, H/Pu-239 = 2,317
MIX-SOL-THERM-003 Water/Polyethylene Reflected Cylindrical Tank With Various Diameters, 93.95 wt% Pu-239 in Pu Experimental Uncertainty: ±0.003in k_{eff}		
	awre1	101.3 g Pu/liter, 228.5 g U/liter, ID = 25.425 cm, Critical Height: 56.31 cm, H/Pu-239 = 239
	awre2	101.3 g Pu/liter, 228.5 g U/liter, ID = 30.62 cm, Critical Height: 29.89 cm, H/Pu-239 = 239
	awre3	101.3 g Pu/liter, 228.5 g U/liter, ID = 37.99 cm, Critical Height: 21.17 cm, H/Pu-239 = 239
	awre4	101.3 g Pu/liter, 228.5 g U/liter, ID = 50.72 cm, Critical Height: 16.05 cm, H/Pu-239 = 239
	awre5	31.58 g Pu/liter, 71.3 g U/liter, ID = 30.62 cm, Critical Height: 46.18 cm, H/Pu-239 = 847

Table 7.2.1. Benchmark Problem Summary for Configurations Incorporating Mixed Plutonium and Natural Uranium Nitrate Solutions

Class	Case Name	Description
	awre6	31.58 g Pu/liter, 71.3 g U/liter, ID = 37.99 cm, Critical Height: 28.24 cm, H/Pu-239 = 847
	awre7	31.58 g Pu/liter, 71.3 g U/liter, ID = 50.72 cm, Critical Height: 20.39 cm, H/Pu-239 = 847
	awre8	18.61 g Pu/liter, 42.2 g U/liter, ID = 37.99 cm, Critical Height: 72.86 cm, H/Pu-239 = 1461
	awre9	18.61 g Pu/liter, 42.2 g U/liter, ID = 50.72 cm, Critical Height: 33.59 cm, H/Pu-239 = 1461
	awre10	17.50 g Pu/liter, 39.6 g U/liter, ID = 50.72 cm, Critical Height: 37.16 cm, H/Pu-239 = 1556
MIX-SOL-THERM-004 Cylindrical Tank With a 35.39 cm ID and either Water Reflector, Concrete Reflector, or No Reflector, 91.118 wt% Pu-239 in Pu Experimental Uncertainty: ±0.005in k_{eff} for Water Reflector and No Reflector, ±0.016 in k_{eff} for Concrete Reflector		
	PNL1577	172.56 g Pu/liter, 262.79 g U/liter, No Reflector, Critical Height: 57.97 cm, H/Pu-239 = 137
	PNL1678	172.82 g Pu/liter, 262.55 g U/liter, Water Reflector, Critical Height: 28.93 cm, H/Pu-239 = 136
	PNL1783	173.22 g Pu/liter, 262.88 g U/liter, Concrete Reflector, Critical Height: 30.60 cm, H/Pu-239 = 136
	PNL1868	118.71 g Pu/liter, 173.98 g U/liter, Concrete Reflector, Critical Height: 27.03 cm, H/Pu-239 = 214

Table 7.2.1. Benchmark Problem Summary for Configurations Incorporating Mixed Plutonium and Natural Uranium Nitrate Solutions

Class	Case Name	Description
	PNL1969	119.04 g Pu/liter, 174.67 g U/liter, Water Reflector, Critical Height: 25.26 cm, H/Pu-239 = 213
	PNL2070	118.90 g Pu/liter, 174.53 g U/liter, No Reflector, Critical Height: 41.08 cm, H/Pu-239 = 214
	PNL2565	41.69 g Pu/liter, 63.38 g U/liter, No Reflector, Critical Height: 44.46 cm, H/Pu-239 = 664
	PNL2666	41.89 g Pu/liter, 63.65 g U/liter, Water Reflector, Critical Height: 28.11 cm, H/Pu-239 = 660
	PNL2767	41.83 g Pu/liter, 63.55 g U/liter, Concrete Reflector, Critical Height: 29.36 cm, H/Pu-239 = 661

7.2.2 Plutonium Nitrate Solutions

The experiments involving plutonium are from the OECD benchmark compilation (Reference 5.5, Volume I) and are summarized in Table 7.2.2.

Table 7.2.2. Benchmark Problem Summary for Configurations Incorporating Plutonium Nitrate Solutions

Class	Case Name	Description
PU-SOL-THERM-001 Water Reflected 11.5-Inch Diameter Spheres, 0.049-inch thick shell of Type 304L Stainless Steel, 4.57 wt% Pu-240 in Pu Experimental Uncertainty: ±0.002 in k_{eff}		
	PUST1T1	73.0 g Pu/liter, Critical Mass: 945 gm, H/Pu-239 = 371
	PUST1T2	96.0 g Pu/liter, Critical Mass: 1243 gm, H/Pu-239 = 272
	PUST1T3	119.0 g Pu/liter, Critical Mass: 1541 gm, H/Pu-239 = 216
	PUST1T4	132.0 g Pu/liter, Critical Mass: 1709 gm, H/Pu-239 = 190
	PUST1T5	140.0 g Pu/liter, Critical Mass: 1813 gm, H/Pu-239 = 180
	PUST1T6	268.7 g Pu/liter, Critical Mass: 3480 gm, H/Pu-239 = 91
PU-SOL-THERM-003 Water Reflected 13-Inch Diameter Spheres, 0.050-inch thick shell of Type 347 Stainless Steel Unless Otherwise Indicated Experimental Uncertainty: ±0.010 in k_{eff}		
	PU003-1	33.32 g Pu/liter, Critical Mass: 631 gm, H/Pu-239 = 788, 1.76 wt% Pu-240
	PU003-2	34.32 g Pu/liter, Critical Mass: 650 gm, H/Pu-239 = 756, 1.76 wt% Pu-240

Table 7.2.2. Benchmark Problem Summary for Configurations Incorporating Plutonium Nitrate Solutions

Class	Case Name	Description
	PU003-3	37.43 g Pu/liter, Critical Mass: 709 gm, H/Pu-239 = 699, 3.12 wt% Pu-240
	PU003-4	38.12 g Pu/liter, Critical Mass: 722 gm, H/Pu-239 = 682, 3.12 wt% Pu-240
	PU003-5	40.65 g Pu/liter, Critical Mass: 770 gm, H/Pu-239 = 627, 3.12 wt% Pu-240
	PU003-6	44.09 g Pu/liter, Critical Mass: 835 gm, H/Pu-239 = 563, 3.12 wt% Pu-240
	PU003-7	35.98 g Pu/liter, Critical Mass: 649 gm, H/Pu-239 = 738, 3.12 wt% Pu-240, 20 Gauge 2S Al Shell
	PU003-8	36.81 g Pu/liter, Critical Mass: 664 gm, H/Pu-239 = 714, 3.12 wt% Pu-240, 20 Gauge 2S Al Shell
PU-SOL-THERM-004 Water Reflected 14-Inch Diameter Spheres, 0.050-inch thick shell of Type 347 Stainless Steel Experimental Uncertainty: ±0.010in k_{eff}		
	PU004-1	26.27 g Pu/liter, Critical Mass: 621 gm, H/Pu-239 = 987, 0.54 wt% Pu-240
	PU004-2	26.31 g Pu/liter, Critical Mass: 622 gm, H/Pu-239 = 977, 0.54 wt% Pu-240
	PU004-3	27.20 g Pu/liter, Critical Mass: 643 gm, H/Pu-239 = 935, 0.54 wt% Pu-240
	PU004-4	28.09 g Pu/liter, Critical Mass: 664 gm, H/Pu-239 = 889, 0.54 wt% Pu-240
	PU004-5	27.58 g Pu/liter, Critical Mass: 652 gm, H/Pu-239 = 942, 1.76 wt% Pu-240

Table 7.2.2. Benchmark Problem Summary for Configurations Incorporating Plutonium Nitrate Solutions

Class	Case Name	Description
	PU004-6	28.60 g Pu/liter, Critical Mass: 676 gm, H/Pu-239 = 927, 3.12 wt% Pu-240
	PU004-7	29.57 g Pu/liter, Critical Mass: 699 gm, H/Pu-239 = 892, 3.12 wt% Pu-240
	PU004-8	29.95 g Pu/liter, Critical Mass: 708 gm, H/Pu-239 = 869, 3.12 wt% Pu-240
	PU004-9	31.60 g Pu/liter, Critical Mass: 747 gm, H/Pu-239 = 805, 3.12 wt% Pu-240
	PU04-10	35.36 g Pu/liter, Critical Mass: 836 gm, H/Pu-239 = 689, 3.12 wt% Pu-240
	PU04-11	39.38 g Pu/liter, Critical Mass: 931 gm, H/Pu-239 = 592, 3.12 wt% Pu-240
	PU04-12	29.44 g Pu/liter, Critical Mass: 696 gm, H/Pu-239 = 893, 3.12 wt% Pu-240
	PU04-13	29.27 g Pu/liter, Critical Mass: 692 gm, H/Pu-239 = 903, 3.43 wt% Pu-240
PU-SOL-THERM-005 Water Reflected 14-Inch Diameter Spheres, 0.050-inch thick shell of Type 347 Stainless Steel Experimental Uncertainty: ±0.010in k_{eff}		
	PU005-1	29.65 g Pu/liter, Critical Mass: 701 gm, H/Pu-239 = 903, 4.05 wt% Pu-240
	PU005-2	30.54 g Pu/liter, Critical Mass: 722 gm, H/Pu-239 = 868, 4.05 wt% Pu-240
	PU005-3	31.43 g Pu/liter, Critical Mass: 743 gm, H/Pu-239 = 834, 4.05 wt% Pu-240
	PU005-4	33.54 g Pu/liter, Critical Mass: 793 gm, H/Pu-239 = 765, 4.05 wt% Pu-240

Table 7.2.2. Benchmark Problem Summary for Configurations Incorporating Plutonium Nitrate Solutions

Class	Case Name	Description
	PU005-5	36.04 g Pu/liter, Critical Mass: 852 gm, H/Pu-239 = 694, 4.05 wt% Pu-240
	PU005-6	38.49 g Pu/liter, Critical Mass: 910 gm, H/Pu-239 = 633, 4.05 wt% Pu-240
	PU005-7	40.91 g Pu/liter, Critical Mass: 967 gm, H/Pu-239 = 581, 4.05 wt% Pu-240
	PU005-8	30.58 g Pu/liter, Critical Mass: 723 gm, H/Pu-239 = 869, 4.40 wt% Pu-240
	PU005-9	31.85 g Pu/liter, Critical Mass: 753 gm, H/Pu-239 = 825, 4.40 wt% Pu-240
PU-SOL-THERM-007 Water Reflected Partly Filled 11.5-Inch Diameter Spheres, 0.049-inch thick shell of Type 304L Stainless Steel, 4.67 wt% Pu-240 Experimental Uncertainty: ±0.005 in k_{eff}		
	PU007-2	232 g Pu/liter, Critical Volume: 12.35 liters, Height Above Sphere Center: 10.8373 cm, H/Pu-239 = 110
	PU007-3	221 g Pu/liter, Critical Volume: 12.35 liters, Height Above Sphere Center: 10.8373 cm, H/Pu-239 = 114
	PU007-5	100.2 g Pu/liter, Critical Volume: 12.39 liters, Height Above Sphere Center: 10.9741 cm, H/Pu-239 = 268
	PU007-6	101.5 g Pu/liter, Critical Volume: 12.30 liters, Height Above Sphere Center: 10.6720 cm, H/Pu-239 = 262
	PU007-7	100.1 g Pu/liter, Critical Volume: 12.39 liters, Height Above Sphere Center: 10.9741 cm, H/Pu-239 = 266

Table 7.2.2. Benchmark Problem Summary for Configurations Incorporating Plutonium Nitrate Solutions

Class	Case Name	Description
	PU007-8	101.6 g Pu/liter, Critical Volume: 12.37 liters, Height Above Sphere Center: 10.9051 cm, H/Pu-239 = 258
	PU007-9	101.6 g Pu/liter, Critical Volume: 12.23 liters, Height Above Sphere Center: 10.4503 cm, H/Pu-239 = 260
	PU07-10	93.5 g Pu/liter, Critical Volume: 12.35 liters, Height Above Sphere Center: 10.8373 cm, H/Pu-239 = 285
PU-SOL-THERM-009 Unreflected 48-Inch Diameter Sphere, 0.303-inch thick shell of Type 1100 Aluminum, 97.386 wt% Pu-239 and 2.521 wt% Pu-240 in Pu Experimental Uncertainty: ±0.003 in k_{eff}		
	PUST9-1	10.02 g Pu/liter, Critical Volume: 656.6 liters, Height Above Sphere Center: 15.9558 cm, H/Pu-239 = 2648
	PUST9-2	9.539 g Pu/liter, Critical Volume: 906.5 liters, Height Above Sphere Center: 45.3705 cm, H/Pu-239 = 2779
	PUST9-3	9.457 g Pu/liter, Critical Volume: 949.1 liters, Full Sphere, H/Pu-239 = 2803
PU-SOL-THERM-0010 Water Reflected Cylinders, 0.062-inch thick shell of Type 347 stainless steel, 2.9 wt% Pu-240 in Pu Experimental Uncertainty: ±0.005 in k_{eff}		
	PU10091	99.09 g Pu/liter, Inner Radius (IR) = 11.4264 cm, Critical Height: 30.7086 cm, Critical Mass: 1249 g, H/Pu-239 = 267
	PU10092	73.92 g Pu/liter, IR = 11.4264 cm, Critical Height: 35.4076 cm, Critical Mass: 1073 g, H/Pu-239 = 357

Table 7.2.2. Benchmark Problem Summary for Configurations Incorporating Plutonium Nitrate Solutions

Class	Case Name	Description
	PU10093	54.53 g Pu/liter, IR = 11.4264 cm, Critical Height: 44.5770 cm, Critical Mass: 997 g, H/Pu-239 = 484
	PU10111	54.53 g Pu/liter, IR = 13.9684 cm, Critical Height: 25.6032 cm, Critical Mass: 856 g, H/Pu-239 = 485, Extra 0.065 inch layer of stainless steel placed around cylinder
	PU10112	47.21 g Pu/liter, IR = 13.9684 cm, Critical Height: 28.1686 cm, Critical Mass: 815 g, H/Pu-239 = 558, Extra 0.065 inch layer of stainless steel placed around cylinder
	PU10113	47.21 g Pu/liter, IR = 13.9684 cm, Critical Height: 27.0764 cm, Critical Mass: 784 g, H/Pu-239 = 558
	PU10114	41.73 g Pu/liter, IR = 13.9684 cm, Critical Height: 32.6390 cm, Critical Mass: 835 g, H/Pu-239 = 606
	PU10115	36.90 g Pu/liter, IR = 13.9684 cm, Critical Height: 43.0022 cm, Critical Mass: 973 g, H/Pu-239 = 665
	PU10116	63.99 g Pu/liter, IR = 13.9684 cm, Critical Height: 22.8092 cm, Critical Mass: 895 g, H/Pu-239 = 414
	PU10117	48.98 g Pu/liter, IR = 13.9684 cm, Critical Height: 25.9588 cm, Critical Mass: 780 g, H/Pu-239 = 535
	PU10121	48.75 g Pu/liter, IR = 15.2390 cm, Critical Height: 22.3520 cm, Critical Mass: 799 g, H/Pu-239 = 543

Table 7.2.2. Benchmark Problem Summary for Configurations Incorporating Plutonium Nitrate Solutions

Class	Case Name	Description
	PU10122	42.29 g Pu/liter, IR = 15.2390 cm, Critical Height: 25.2476 cm, Critical Mass: 779 g, H/Pu-239 = 618
	PU10123	36.52 g Pu/liter, IR = 15.2390 cm, Critical Height: 28.4734 cm, Critical Mass: 758 g, H/Pu-239 = 728
	PU10124	31.14 g Pu/liter, IR = 15.2390 cm, Critical Height: 33.4264 cm, Critical Mass: 759 g, H/Pu-239 = 850
PU-SOL-THERM-0011 Unreflected 16- & 18-Inch Diameter Spheres, 0.050 inch thick shell of Type 347 stainless steel, 0.020 inch thick Cd Cover on the 18-inch sphere, 4.2 wt% Pu-240 in Pu Experimental Uncertainty: ±0.005 in k_{eff}		
	PU11161	34.96 g Pu/liter, IR = 20.1206 cm, Critical Mass: 1194 g, H/Pu-239 = 765
	PU11162	36.22 g Pu/liter, IR = 20.1206 cm, Critical Mass: 1237 g, H/Pu-239 = 736
	PU11163	38.13 g Pu/liter, IR = 20.1206 cm, Critical Mass: 1302 g, H/Pu-239 = 691
	PU11164	38.16 g Pu/liter, IR = 20.1206 cm, Critical Mass: 1303 g, H/Pu-239 = 682
	PU11165	43.43 g Pu/liter, IR = 20.1206 cm, Critical Mass: 1483 g, H/Pu-239 = 575
	PU11181	22.35 g Pu/liter, IR = 22.6974 cm, Critical Mass: 1095 g, H/Pu-239 = 1208
	PU11182	23.27 g Pu/liter, IR = 22.6974 cm, Critical Mass: 1140 g, H/Pu-239 = 1151
	PU11183	23.10 g Pu/liter, IR = 22.6974 cm, Critical Mass: 1132 g, H/Pu-239 = 1158

Table 7.2.2. Benchmark Problem Summary for Configurations Incorporating Plutonium Nitrate Solutions		
Class	Case Name	Description
	PU11184	23.82 g Pu/liter, IR = 22.6974 cm, Critical Mass: 1167 g, H/Pu-239 = 1100
	PU11185	25.20 g Pu/liter, IR = 22.6974 cm, Critical Mass: 1235 g, H/Pu-239 = 1039
	PU11186	27.49 g Pu/liter, IR = 22.6974 cm, Critical Mass: 1347 g, H/Pu-239 = 908
	PU11187	23.94 g Pu/liter, IR = 22.6974 cm, Critical Mass: 1173 g, H/Pu-239 = 1103

7.2.3 Highly Enriched Uranium Nitrate Solutions

The experiments involving highly enriched uranium are from the OECD benchmark compilation (Reference 5.5, Volume II) and are summarized in Table 7.2.3.

Table 7.2.3. Benchmark Problem Summary for Configurations Incorporating Highly Enriched Uranium Nitrate Solutions

Class	Case Name	Description
HEU-SOL-THERM-001 Minimally Reflected Cylinder with Variable Radius, 0.32 cm thick shell of Type 304 Stainless Steel or Type 6061 Aluminum, 93.172 wt% U-235 in U Experimental Uncertainty: ±0.003 in k_{eff}		
	HEST1-1	145.68 g U/liter, ID = 27.92 cm, SS-304 shell, Critical Height: 31.20, Critical Mass: 2782.8 gm, H/U-235 = 182
	HEST1-2	346.73 g U/liter, ID = 27.92 cm, SS-304 shell, Critical Height: 28.93, Critical Mass: 6141.3 gm, H/U-235 = 71
	HEST1-3	142.92 g U/liter, ID = 28.01 cm, Al-6061 shell, Critical Height: 33.55, Critical Mass: 2954.6 gm, H/U-235 = 186
	HEST1-4	357.71 g U/liter, ID = 28.01 cm, Al-6061 shell, Critical Height: 30.91, Critical Mass: 6813.1 gm, H/U-235 = 68
	HEST1-5	54.89 g U/liter, ID = 33.01 cm, Al-6061 shell, Critical Height: 39.48, Critical Mass: 1854.6 gm, H/U-235 = 499
	HEST1-6	59.65 g U/liter, ID = 33.01 cm, Al-6061 shell, Critical Height: 36.67, Critical Mass: 1872.0 gm, H/U-235 = 459
	HEST1-7	137.40 g U/liter, ID = 33.01 cm, Al-6061 shell, Critical Height: 23.96, Critical Mass: 2817.4 gm, H/U-235 = 193

Table 7.2.3. Benchmark Problem Summary for Configurations Incorporating Highly Enriched Uranium Nitrate Solutions

Class	Case Name	Description
	HEST1-8	145.68 g U/liter, ID = 33.01 cm, Al-6061 shell, Critical Height: 23.67, Critical Mass: 2951.1 gm, H/U-235 = 182
	HEST1-9	357.71 g U/liter, ID = 33.01 cm, Al-6061 shell, Critical Height: 22.53, Critical Mass: 6897.2 gm, H/U-235 = 68
	HEST110	63.95 g U/liter, ID = 50.69 cm, Al-6061 shell, Critical Height: 20.48, Critical Mass: 2643.0 gm, H/U-235 = 427
HEU-SOL-THERM-002 Concrete Reflected Cylinder with Variable Radius, 0.32 cm thick shell of Type 304 Stainless Steel or Type 6061 Aluminum, 93.172 wt% U-235 in U, Concrete Reflector Box Inside Dimensions are 123.7 cm High X 122.2 cm (North-South) X 121.8 cm (East-West) and 25.7 cm thick side walls Experimental Uncertainty: ±0.002 in k_{eff}		
	HEST2-1	144.38 g U/liter, ID = 27.92 cm, SS-304 shell, Critical Height: 29.79 cm, Critical Mass: 2633.3 gm, H/U-235 = 184, 57.4 cm North (N) X 64.6 cm East (E) X 82.0 cm Up (Position in Concrete Box)
	HEST2-2	144.38 g U/liter, ID = 27.92 cm, SS-304 shell, Critical Height: 24.19 cm, Critical Mass: 2138.3 gm, H/U-235 = 184, 16.76 cm N X 104.49 cm E X 123.7 cm Up
	HEST2-3	334.77 g U/liter, ID = 27.92 cm, SS-304 shell, Critical Height: 27.23 cm, Critical Mass: 5581.0 gm, H/U-235 = 74, 57.4 cm N X 64.6 cm E X 82.0 cm Up
	HEST2-4	334.77 g U/liter, ID = 27.92 cm, SS-304 shell, Critical Height: 21.79 cm, Critical Mass: 4466.1 gm, H/U-235 = 74, 16.76 cm N X 104.49 cm E X 123.7 cm Up

Table 7.2.3. Benchmark Problem Summary for Configurations Incorporating Highly Enriched Uranium Nitrate Solutions

Class	Case Name	Description
	HEST2-5	144.38 g U/liter, ID = 28.01 cm, Al-6061 shell, Critical Height: 31.37 cm, Critical Mass: 2790.9 gm, H/U-235 = 184, 57.4 cm N X 64.6 cm E X 82.0 cm Up
	HEST2-6	144.38 g U/liter, ID = 28.01 cm, Al-6061 shell, Critical Height: 24.70 cm, Critical Mass: 2197.5 gm, H/U-235 = 184, 16.50 cm N X 104.0 cm E X 123.7 cm Up
	HEST2-7	334.77 g U/liter, ID = 28.01 cm, Al-6061 shell, Critical Height: 28.60 cm, Critical Mass: 5899.7 gm, H/U-235 = 74, 57.4 cm N X 64.6 cm E X 82.0 cm Up
	HEST2-8	334.77 g U/liter, ID = 28.01 cm, Al-6061 shell, Critical Height: 22.33 cm, Critical Mass: 4606.3 gm, H/U-235 = 74, 16.65 cm N X 103.75 cm E X 123.7 cm Up
	HEST2-9	59.65 g U/liter, ID = 33.01 cm, Al-6061 shell, Critical Height: 34.10 cm, Critical Mass: 1653.2 gm, H/U-235 = 460, 57.4 cm N X 64.6 cm E X 82.0 cm Up
	HEST2-10	59.65 g U/liter, ID = 33.01 cm, Al-6061 shell, Critical Height: 27.27 cm, Critical Mass: 1392.1 gm, H/U-235 = 460, 16.825 cm N X 103.88 cm E X 123.7 cm Up
	HEST2-11	144.38 g U/liter, ID = 33.01 cm, Al-6061 shell, Critical Height: 22.85 cm, Critical Mass: 2823.4 gm, H/U-235 = 184, 57.4 cm N X 64.6 cm E X 82.0 cm Up

Table 7.2.3. Benchmark Problem Summary for Configurations Incorporating Highly Enriched Uranium Nitrate Solutions

Class	Case Name	Description
	HEST2-12	144.38 g U/liter, ID = 33.01 cm, Al-6061 shell, Critical Height: 18.24 cm, Critical Mass: 2253.8 gm, H/U-235 = 184, 16.825 cm N X 103.88 cm E X 123.7 cm Up
	HEST2-13	334.77 g U/liter, ID = 33.01 cm, Al-6061 shell, Critical Height: 21.50 cm, Critical Mass: 6159.8 gm, H/U-235 = 74, 57.4 cm N X 64.6 cm E X 82.0 cm Up
	HEST2-14	334.77 g U/liter, ID = 33.01 cm, Al-6061 shell, Critical Height: 16.78 cm, Critical Mass: 4807.5 gm, H/U-235 = 74, 16.825 cm N X 104.55 cm E X 123.7 cm Up
HEU-SOL-THERM-003 Plexiglass Reflected Cylinder with Variable Radius, 0.32 cm thick shell of Type 304 Stainless Steel or Type 6061 Aluminum, 93.172 wt% U-235 in U, Plexiglass Reflector Box Inside Dimensions are 122.9 cm High X 122.9 cm (North-South) X 122.9 cm (East-West) and 20.8 cm thick side walls Experimental Uncertainty: ±0.005 in k_{eff}		
	HEUST31	60.32 g U/liter, ID = 27.93 cm, SS-304 shell, Critical Height: 50.52 cm, Critical Mass: 1867.1 gm, H/U-235 = 454, 17.71 cm N X 104.64 cm E X 122.9 cm Up
	HEUST32	60.32 g U/liter, ID = 27.93 cm, SS-304 shell, Critical Height: 67.48 cm, Critical Mass: 2493.8 gm, H/U-235 = 454, 61.1 cm N X 61.3 cm E X 122.9 cm Up
	HEUST33	147.66 g U/liter, ID = 27.92 cm, SS-304 shell, Critical Height: 29.71 cm, Critical Mass: 2685.9 gm, H/U-235 = 180, 60.4 cm N X 61.2 cm E X 81.4 cm Up

Table 7.2.3. Benchmark Problem Summary for Configurations Incorporating Highly Enriched Uranium Nitrate Solutions

Class	Case Name	Description
	HEUST34	147.66 g U/liter, ID = 27.92 cm, SS-304 shell, Critical Height: 25.03 cm, Critical Mass: 2262.8 gm, H/U-235 = 180, 17.06 cm N X 104.99 cm E X 122.9 cm Up
	HEUST35	345.33 g U/liter, ID = 27.92 cm, SS-304 shell, Critical Height: 27.60 cm, Critical Mass: 5835.3 gm, H/U-235 = 71, 60.4 cm N X 61.2 cm E X 81.4 cm Up
	HEUST36	345.33 g U/liter, ID = 27.92 cm, SS-304 shell, Critical Height: 22.75 cm, Critical Mass: 4809.9 gm, H/U-235 = 71, 16.81 cm N X 104.84 cm E X 122.9 cm Up
	HEUST37	60.32 g U/liter, ID = 27.88 cm, Al-6061 shell, Critical Height: 51.67 cm, Critical Mass: 1902.7 gm, H/U-235 = 454, 17.51 cm N X 105.15 cm E X 122.9 cm Up
	HEUST38	147.66 g U/liter, ID = 28.01 cm, Al-6061 shell, Critical Height: 31.26 cm, Critical Mass: 2844.3 gm, H/U-235 = 180, 60.4 cm N X 61.2 cm E X 81.4 cm Up
	HEUST39	147.66 g U/liter, ID = 28.01 cm, Al-6061 shell, Critical Height: 25.26 cm, Critical Mass: 2298.3 gm, H/U-235 = 180, 17.52 cm N X 104.95 cm E X 122.9 cm Up
	HEST310	345.33 g U/liter, ID = 28.01 cm, Al-6061 shell, Critical Height: 28.84 cm, Critical Mass: 6136.9 gm, H/U-235 = 71, 60.4 cm N X 61.2 cm E X 81.4 cm Up

Table 7.2.3. Benchmark Problem Summary for Configurations Incorporating Highly Enriched Uranium Nitrate Solutions		
Class	Case Name	Description
	HEST311	345.33 g U/liter, ID = 28.01 cm, Al-6061 shell, Critical Height: 22.87 cm, Critical Mass: 4866.5 gm, H/U-235 = 71, 17.50 cm N X 105.1 cm E X 122.9 cm Up
	HEST312	60.32 g U/liter, ID = 33.01 cm, Al-6061 shell, Critical Height: 34.33 cm, Critical Mass: 1772.2 gm, H/U-235 = 454, 60.4 cm N X 61.2 cm E X 81.4 cm Up
	HEST313	60.32 g U/liter, ID = 33.01 cm, Al-6061 shell, Critical Height: 27.70 cm, Critical Mass: 1430.0 gm, H/U-235 = 454, 17.10 cm N X 105.18 cm E X 122.9 cm Up
	HEST314	60.32 g U/liter, ID = 33.01 cm, Al-6061 shell, Critical Height: 31.75 cm, Critical Mass: 1639.0 gm, H/U-235 = 454, 61.1 cm N X 61.3 cm E X 122.9 cm Up
	HEST315	66.33 g U/liter, ID = 33.01 cm, Al-6061 shell, Critical Height: 25.10 cm, Critical Mass: 1424.8 gm, H/U-235 = 412, 17.10 cm N X 105.18 cm E X 122.9 cm Up
	HEST316	147.66 g U/liter, ID = 33.01 cm, Al-6061 shell, Critical Height: 22.78 cm, Critical Mass: 2878.7 gm, H/U-235 = 180, 60.4 cm N X 61.2 cm E X 81.4 cm Up
	HEST317	147.66 g U/liter, ID = 33.01 cm, Al-6061 shell, Critical Height: 18.49 cm, Critical Mass: 2336.6 gm, H/U-235 = 180, 17.10 cm N X 105.18 cm E X 122.9 cm Up

Table 7.2.3. Benchmark Problem Summary for Configurations Incorporating Highly Enriched Uranium Nitrate Solutions

Class	Case Name	Description
	HEST318	345.33 g U/liter, ID = 33.01 cm, Al-6061 shell, Critical Height: 21.76 cm, Critical Mass: 6430.9 gm, H/U-235 = 71, 60.4 cm N X 61.2 cm E X 81.4 cm Up
	HEST319	345.33 g U/liter, ID = 33.01 cm, Al-6061 shell, Critical Height: 17.20 cm, Critical Mass: 5083.3 gm, H/U-235 = 71, 17.30 cm N X 105.2 cm E X 122.9 cm Up
HEU-SOL-THERM-007 Concrete Reflected Arrays (30.48 cm pitch) of Cylinders Containing Uranyl Nitrate, 93.172 wt% U-235 in U, Concrete Reflector Box Inside Dimensions are 123.7 cm High X 122.2 cm (North-South) X 121.8 cm (East-West) and 25.7 cm thick side walls Experimental Uncertainty: ±0.005 in k_{eff}		
	HEUST71	4 X 4 Array, 67.28 g U/liter, ID = 21.12 cm, 0.40 cm thick shell of Type 6061 Aluminum, 0.32 cm thick sleeve of Type 304 Stainless Steel, Critical Height: 28.63 cm, Critical Mass: 674.8 gm X 16, H/U-235 = 406
	HEUST72	4 X 4 Array, 369.96 g U/liter, ID = 21.12 cm, 0.40 cm thick shell of Type 6061 Aluminum, 0.32 cm thick sleeve of Type 304 Stainless Steel, Critical Height: 17.24 cm, Critical Mass: 2234.4 gm X 16, H/U-235 = 65
	HEUST73	4 X 4 Array, 67.28 g U/liter, ID = 21.12 cm, 0.40 cm thick shell of Type 6061 Aluminum, 0.0 cm thick sleeve of Type 304 Stainless Steel, Critical Height: 27.15 cm, Critical Mass: 639.9 gm X 16, H/U-235 = 406

Table 7.2.3. Benchmark Problem Summary for Configurations Incorporating Highly Enriched Uranium Nitrate Solutions

Class	Case Name	Description
	HEUST74	4 X 4 Array, 364.11 g U/liter, ID = 21.12 cm, 0.40 cm thick shell of Type 6061 Aluminum, 0.0 cm thick sleeve of Type 304 Stainless Steel, Critical Height: 17.13 cm, Critical Mass: 2234.4 gm X 16, H/U-235 = 67
	HEUST75	2 X 2 Array, 76.09 g U/liter, ID = 21.12 cm, 0.40 cm thick shell of Type 6061 Aluminum, 0.32 cm thick sleeve of Type 304 Stainless Steel, Critical Height: 60.70 cm, Critical Mass: 1618.1 gm X 4, H/U-235 = 358
	HEUST76	2 X 2 Array, 360.37 g U/liter, ID = 21.12 cm, 0.40 cm thick shell of Type 6061 Aluminum, 0.32 cm thick sleeve of Type 304 Stainless Steel, Critical Height: 29.49 cm, Critical Mass: 3723.1 gm X 4, H/U-235 = 68
	HEUST77	2 X 2 Array, 76.09 g U/liter, ID = 21.12 cm, 0.40 cm thick shell of Type 6061 Aluminum, 0.0 cm thick sleeve of Type 304 Stainless Steel, Critical Height: 62.34 cm, Critical Mass: 1661.8 gm X 4, H/U-235 = 358
	HEUST78	2 X 2 Array, 364.11 g U/liter, ID = 21.12 cm, 0.40 cm thick shell of Type 6061 Aluminum, 0.0 cm thick sleeve of Type 304 Stainless Steel, Critical Height: 31.11 cm, Critical Mass: 3968.4 gm X 4, H/U-235 = 67
	HEUST79	2 X 2 Array, 80.72 g U/liter, ID = 21.12 cm, 0.40 cm thick shell of Type 6061 Aluminum, 0.0 cm thick sleeve of Type 304 Stainless Steel, Critical Height: 57.88 cm, Critical Mass: 1636.8 gm X 4, H/U-235 = 337

Table 7.2.3. Benchmark Problem Summary for Configurations Incorporating Highly Enriched Uranium Nitrate Solutions		
Class	Case Name	Description
	HEST710	4 X 4 Array, 83.49 g U/liter, ID = 16.12 cm, 0.40 cm thick shell of Type 6061 Aluminum, 0.31 cm thick sleeve of Type 304 Stainless Steel, Critical Height: 57.34 cm, Critical Mass: 977.0 gm X 16, H/U-235 = 325
	HEST711	4 X 4 Array, 360.37 g U/liter, ID = 16.12 cm, 0.40 cm thick shell of Type 6061 Aluminum, 0.31 cm thick sleeve of Type 304 Stainless Steel, Critical Height: 32.32 cm, Critical Mass: 2377.1 gm X 16, H/U-235 = 68
	HEST712	4 X 4 Array, 83.49 g U/liter, ID = 16.12 cm, 0.40 cm thick shell of Type 6061 Aluminum, 0.0 cm thick sleeve of Type 304 Stainless Steel, Critical Height: 51.21 cm, Critical Mass: 872.6 gm X 16, H/U-235 = 325
	HEST713	4 X 4 Array, 359.55 g U/liter, ID = 16.12 cm, 0.40 cm thick shell of Type 6061 Aluminum, 0.0 cm thick sleeve of Type 304 Stainless Steel, Critical Height: 31.82 cm, Critical Mass: 2335.0 gm X 16, H/U-235 = 68
	HEST714	2 X 4 Array, 359.55 g U/liter, ID = 16.12 cm, 0.40 cm thick shell of Type 6061 Aluminum, 0.0 cm thick sleeve of Type 304 Stainless Steel, Critical Height: 51.45 cm, Critical Mass: 3775.4 gm X 8, H/U-235 = 68
	HEST715	2 X 3 Array, 359.55 g U/liter, ID = 16.12 cm, 0.40 cm thick shell of Type 6061 Aluminum, 0.0 cm thick sleeve of Type 304 Stainless Steel, Critical Height: 65.49 cm, Critical Mass: 4805.7 gm X 6, H/U-235 = 68

Table 7.2.3. Benchmark Problem Summary for Configurations Incorporating Highly Enriched Uranium Nitrate Solutions

Class	Case Name	Description
	HEST716	2 X 2 Array, 359.55 g U/liter, ID = 16.12 cm, 0.40 cm thick shell of Type 6061 Aluminum, 0.31 cm thick sleeve of Type 304 Stainless Steel, Critical Height: 101.45 cm, Critical Mass: 7444.4 gm X 4, H/U-235 = 68
	HEST717	2 X 2 Array, 359.55 g U/liter, ID = 16.12 cm, 0.40 cm thick shell of Type 6061 Aluminum, 0.0 cm thick sleeve of Type 304 Stainless Steel, Critical Height: 104.04 cm, Critical Mass: 7634.5 gm X 4, H/U-235 = 68
HEU-SOL-THERM-008 Plexiglass Reflected Arrays (30.48 cm pitch) of Cylinders Containing Uranyl Nitrate, 93.172 wt% U-235 in U, Plexiglass Reflector Box Inside Dimensions are 122.9 cm High X 122.9 cm (North-South) X 122.9 cm (East-West) and 20.8 cm thick side walls Experimental Uncertainty: ±0.003 in k_{eff}		
	HEUST81	4 X 4 Array, 60.32 g U/liter, ID = 21.12 cm, 0.40 cm thick shell of Type 6061 Aluminum, 0.32 cm thick sleeve of Type 304 Stainless Steel, Critical Height: 34.82 cm, Critical Mass: 735.8 gm X 16, H/U-235 = 454
	HEUST83	4 X 4 Array, 60.32 g U/liter, ID = 21.12 cm, 0.40 cm thick shell of Type 6061 Aluminum, 0.0 cm thick sleeve of Type 304 Stainless Steel, Critical Height: 31.76 cm, Critical Mass: 671.1 gm X 16, H/U-235 = 454
	HEUST86	2 X 2 Array, 355.94 g U/liter, ID = 21.12 cm, 0.40 cm thick shell of Type 6061 Aluminum, 0.32 cm thick sleeve of Type 304 Stainless Steel, Critical Height: 31.93 cm, Critical Mass: 3981.6 gm X 4, H/U-235 = 69

Table 7.2.3. Benchmark Problem Summary for Configurations Incorporating Highly Enriched Uranium Nitrate Solutions

Class	Case Name	Description
	HEUST89	4 X 4 Array, 60.32 g U/liter, ID = 16.12 cm, 0.40 cm thick shell of Type 6061 Aluminum, 0.31 cm thick sleeve of Type 304 Stainless Steel, Critical Height: 105.85 cm, Critical Mass: 1303.1 gm X 16, H/U-235 = 454
	HEST813	2 X 3 Array, 355.94 g U/liter, ID = 16.12 cm, 0.40 cm thick shell of Type 6061 Aluminum, 0.31 cm thick sleeve of Type 304 Stainless Steel, Critical Height: 95.20 cm, Critical Mass: 1303.1 gm X 6, H/U-235 = 69
HEU-SOL-THERM-013 Unreflected 174-Liter Sphere of HEU Nitrate Solution Poisoned with Boric Acid, 34.6 cm Radius, 0.32 cm thick shell of Type 1100 Aluminum, 93.2 wt% U-235 Experimental Uncertainty: ±0.004 in k_{eff}		
	HEST131	20.12 g U/liter, 0.0 g B/liter, Critical Mass = 3489.4 g, /U-235 = 1375
	HEST132	25.53 g U/liter, 0.0935 g B/liter, Critical Mass = 4427.6 g, H/U-235 = 1173
	HEST133	26.77 g U/liter, 0.187 g B/liter, Critical Mass = 4642.7 g, H/U-235 = 1030
	HEST134	28.45g U/liter, 0.230 g B/liter, Critical Mass = 4934.0 g, H/U-235 = 971
HEU-SOL-THERM-0014 Water Reflected Cylinders of HEU Nitrate Solution Poisoned with Gadolinium, 20 cm Inner Radius, 0.30 cm thick shell of stainless steel 1X18H10T (Russian), 89.04 wt% U-235 Experimental Uncertainty: ±0.004 to 0.009 in k_{eff}		
	HEST141	70.0 g U/liter, 0.0 g Gd/liter, Critical Height: 19.3 cm, Critical Mass= 1697.7 g, H/U-235 = 405

Table 7.2.3. Benchmark Problem Summary for Configurations Incorporating Highly Enriched Uranium Nitrate Solutions

Class	Case Name	Description
	HEST142	68.1 g U/liter, 0.100 g Gd/liter, Critical Height: 27.4 cm, Critical Mass= 2344.8 g, H/U-235 = 418, Isotopic Gd Cross Sections
	HXST142	68.1 g U/liter, 0.100 g Gd/liter, Critical Height: 27.4 cm, Critical Mass= 2344.8 g, H/U-235 = 418, Elemental Gd Cross Section (64000.35C)
	HEST143	67.7 g U/liter, 0.193 g Gd/liter, Critical Height: 44.6 cm, Critical Mass= 3794.3 g, H/U-235 = 421, Isotopic Gd Cross Sections
	HXST143	67.7 g U/liter, 0.193 g Gd/liter, Critical Height: 44.6 cm, Critical Mass= 3794.3 g, H/U-235 = 421, Elemental Gd Cross Section (64000.35C)
HEU-SOL-THERM-0015 Water Reflected Cylinders of HEU Nitrate Solution Poisoned with Gadolinium, 20 cm Inner Radius, 0.30 cm thick shell of stainless steel 1X18H10T (Russian), 89.04 wt% U-235 Experimental Uncertainty: ±0.003 to 0.009 in k_{eff}		
	HEST151	100.5 g U/liter, 0.0 g Gd/liter, Critical Height: 18.7 cm, Critical Mass= 2361.7 g, H/U-235 = 278, 15.1 cm High Reflector
	HEST152	100.5 g U/liter, 0.0 g Gd/liter, Critical Height: 16.6 cm, Critical Mass= 2096.4 g, H/U-235 = 278, 45.0 cm High Reflector
	HEST153	98.8 g U/liter, 0.197 g Gd/liter, Critical Height: 29.9 cm, Critical Mass= 3712.3 g, H/U-235 = 283, 17.0 cm High Reflector, Isotopic Gd Cross Sections

Table 7.2.3. Benchmark Problem Summary for Configurations Incorporating Highly Enriched Uranium Nitrate Solutions

Class	Case Name	Description
	HXST153	98.8 g U/liter, 0.197 g Gd/liter, Critical Height: 29.9 cm, Critical Mass= 3712.3 g, H/U-235 = 283, 17.0 cm High Reflector, Elemental Gd Cross Section (64000.35C)
	HEST154	98.8 g U/liter, 0.197 g Gd/liter, Critical Height: 25.8 cm, Critical Mass= 3203.2 g, H/U-235 = 283, 45.0 cm High Reflector, Isotopic Gd Cross Sections
	HXST154	98.8 g U/liter, 0.197 g Gd/liter, Critical Height: 25.8 cm, Critical Mass= 3203.2 g, H/U-235 = 283, 45.0 cm High Reflector, Elemental Gd Cross Section (64000.35C)
	HEST155	95.2 g U/liter, 0.400 g Gd/liter, Critical Height: 51.2 cm, Critical Mass= 6125.2 g, H/U-235 = 295, 47.0 cm High Reflector, Isotopic Gd Cross Sections
	HXST155	95.2 g U/liter, 0.400 g Gd/liter, Critical Height: 51.2 cm, Critical Mass= 6125.2 g, H/U-235 = 295, 47.0 cm High Reflector, Elemental Gd Cross Section (64000.35C)
HEU-SOL-THERM-0016 Water Reflected Cylinders of HEU Nitrate Solution Poisoned with Gadolinium, 20 cm Inner Radius, 0.30 cm thick shell of stainless steel 1X18H10T (Russian), 89.04 wt% U-235 Experimental Uncertainty: ±0.004 to 0.008 in k_{eff}		
	HEST161	156.5 g U/liter, 0.0 g Gd/liter, Critical Height: 15.1 cm, Critical Mass= 2969.6 g, H/U-235 = 175
	HEST162	143.6 g U/liter, 0.300 g Gd/liter, Critical Height: 22.1 cm, Critical Mass= 3988.0 g, H/U-235 = 192, Isotopic Gd Cross Sections

Table 7.2.3. Benchmark Problem Summary for Configurations Incorporating Highly Enriched Uranium Nitrate Solutions

Class	Case Name	Description
	HXST162	143.6 g U/liter, 0.300 g Gd/liter, Critical Height: 22.1 cm, Critical Mass= 3988.0 g, H/U-235 = 192, Elemental Gd Cross Section (64000.35C)
	HEST163	144.2 g U/liter, 0.525 g Gd/liter, Critical Height: 33.0 cm, Critical Mass= 5979.8 g, H/U-235 = 191, Isotopic Gd Cross Sections
	HXST163	144.2 g U/liter, 0.525 g Gd/liter, Critical Height: 33.0 cm, Critical Mass= 5979.8 g, H/U-235 = 191, Elemental Gd Cross Section (64000.35C)
HEU-SOL-THERM-0017 Water Reflected Cylinders of HEU Nitrate Solution Poisoned with Gadolinium, 0.30 cm thick shell of stainless steel 1X18H10T (Russian), 89.04 wt% U-235 Experimental Uncertainty: ±0.003 to 0.015 in k_{eff}		
	HEST171	202.4 g U/liter, 0.0 g Gd/liter, 12.4 cm Inner Radius, Critical Height: 22.6 cm, Critical Mass= 2776.7 g, H/U-235 = 133, 21.6 cm High Reflector
	HEST172	202.4 g U/liter, 0.0 g Gd/liter, 20.0 cm Inner Radius, Critical Height: 15.6 cm, Critical Mass= 3967.8 g, H/U-235 = 133, 0.0 cm High Reflector
	HEST173	202.4 g U/liter, 0.0 g Gd/liter, 20.0 cm Inner Radius, Critical Height: 14.3 cm, Critical Mass= 3637.1 g, H/U-235 = 133, 16.3 cm High Reflector

Table 7.2.3. Benchmark Problem Summary for Configurations Incorporating Highly Enriched Uranium Nitrate Solutions		
Class	Case Name	Description
	HEST174	196.2 g U/liter, 0.298 g Gd/liter, 12.4 cm Inner Radius, Critical Height: 34.8 cm, Critical Mass= 3298.2 g, H/U-235 = 137, 45.4 cm High Reflector, Isotopic Gd Cross Sections
	HXST174	196.2 g U/liter, 0.298 g Gd/liter, 12.4 cm Inner Radius, Critical Height: 34.8 cm, Critical Mass= 3298.2 g, H/U-235 = 137, 45.4 cm High Reflector, Elemental Gd Cross Section (64000.35C)
	HEST175	192.0 g U/liter, 0.497 g Gd/liter, 12.4 cm Inner Radius, Critical Height: 64.2 cm, Critical Mass= 5954.3 g, H/U-235 = 141, 71.5 cm High Reflector, Isotopic Gd Cross Sections
	HXST175	192.0 g U/liter, 0.497 g Gd/liter, 12.4 cm Inner Radius, Critical Height: 64.2 cm, Critical Mass= 5954.3 g, H/U-235 = 141, 71.5 cm High Reflector, Elemental Gd Cross Section (64000.35C)
	HEST176	192.0 g U/liter, 0.497 g Gd/liter, 20.0 cm Inner Radius, Critical Height: 25.7 cm, Critical Mass= 6200.7 g, H/U-235 = 141, 0.0 cm High Reflector, Isotopic Gd Cross Sections
	HEST177	192.0 g U/liter, 0.497 g Gd/liter, 20.0 cm Inner Radius, Critical Height: 22.1 cm, Critical Mass= 5332.2 g, H/U-235 = 141, 46.4 cm High Reflector, Isotopic Gd Cross Sections

Table 7.2.3. Benchmark Problem Summary for Configurations Incorporating Highly Enriched Uranium Nitrate Solutions

Class	Case Name	Description
	HEST178	186.2 g U/liter, 0.790 g Gd/liter, 20.0 cm Inner Radius, Critical Height: 37.7 cm, Critical Mass= 8821.3 g, H/U-235 = 147, 0.0 cm High Reflector, Isotopic Gd Cross Sections
	HXST178	186.2 g U/liter, 0.790 g Gd/liter, 20.0 cm Inner Radius, Critical Height: 37.7 cm, Critical Mass= 8821.3 g, H/U-235 = 147, 0.0 cm High Reflector, Elemental Gd Cross Section (64000.35C)
HEU-SOL-THERM-0018 Water Reflected Cylinders of HEU Nitrate Solution Poisoned with Gadolinium, 0.30 cm thick shell of stainless steel 1X18H10T (Russian), 89.04 wt% U-235 Experimental Uncertainty: ±0.003 to 0.007 in k_{eff}		
	HEST181	300.0 g U/liter, 0.0 g Gd/liter, 12.4 cm Inner Radius, Critical Height: 21.7 cm, Critical Mass= 3144.7 g, H/U-235 = 86, 21.6 cm High Reflector
	HEST182	300.0 g U/liter, 0.0 g Gd/liter, 20.0 cm Inner Radius, Critical Height: 15.5 cm, Critical Mass= 5843.4 g, H/U-235 = 86, 0.0 cm High Reflector
	HEST183	300.0 g U/liter, 0.0 g Gd/liter, 20.0 cm Inner Radius, Critical Height: 14.3 cm, Critical Mass= 5391.0 g, H/U-235 = 86, 14.3 cm High Reflector
	HEST184	291.3 g U/liter, 0.497 g Gd/liter, 12.4 cm Inner Radius, Critical Height: 34.8 cm, Critical Mass= 3298.2 g, H/U-235 = 89, 45.4 cm High Reflector, Isotopic Gd Cross Sections

Table 7.2.3. Benchmark Problem Summary for Configurations Incorporating Highly Enriched Uranium Nitrate Solutions

Class	Case Name	Description
	HXST184	291.3 g U/liter, 0.497 g Gd/liter, 12.4 cm Inner Radius, Critical Height: 34.8 cm, Critical Mass= 3298.2 g, H/U-235 = 89, 45.4 cm High Reflector, Elemental Gd Cross Section (64000.35C)
	HEST185	291.3 g U/liter, 0.497 g Gd/liter, 20.0 cm Inner Radius, Critical Height: 20.2 cm, Critical Mass= 7394.4 g, H/U-235 = 89, 0.0 cm High Reflector, Isotopic Gd Cross Sections
	HEST186	291.3 g U/liter, 0.497 g Gd/liter, 20.0 cm Inner Radius, Critical Height: 17.9 cm, Critical Mass= 6552.4 g, H/U-235 = 89, 21.4 cm High Reflector, Isotopic Gd Cross Sections
	HEST187	283.3 g U/liter, 0.497 g Gd/liter, 12.4 cm Inner Radius, Critical Height: 83.2 cm, Critical Mass= 11385.8 g, H/U-235 = 92, 81.1 cm High Reflector, Isotopic Gd Cross Sections
	HXST187	283.3 g U/liter, 0.497 g Gd/liter, 12.4 cm Inner Radius, Critical Height: 83.2 cm, Critical Mass= 11385.8 g, H/U-235 = 92, 81.1 cm High Reflector, Elemental Gd Cross Section (64000.35C)
	HEST188	283.3 g U/liter, 0.977 g Gd/liter, 20.0 cm Inner Radius, Critical Height: 28.1 cm, Critical Mass= 10003.7 g, H/U-235 = 92, 0.0 cm High Reflector, Isotopic Gd Cross Sections

Table 7.2.3. Benchmark Problem Summary for Configurations Incorporating Highly Enriched Uranium Nitrate Solutions		
Class	Case Name	Description
	HEST189	283.3 g U/liter, 0.977 g Gd/liter, 20.0 cm Inner Radius, Critical Height: 23.3 cm, Critical Mass= 8294.9 g, H/U-235 = 91, 31.2 cm High Reflector, Isotopic Gd Cross Sections
	HST1810	285.3 g U/liter, 1.400 g Gd/liter, 20.0 cm Inner Radius, Critical Height: 41.4 cm, Critical Mass= 14842.7 g, H/U-235 = 91, 0.0 cm High Reflector, Isotopic Gd Cross Sections
	HXT1810	285.3 g U/liter, 1.400 g Gd/liter, 20.0 cm Inner Radius, Critical Height: 41.4 cm, Critical Mass= 14842.7 g, H/U-235 = 91, 0.0 cm High Reflector, Elemental Gd Cross Section (64000.35C)
	HST1811	285.3 g U/liter, 1.400 g Gd/liter, 20.0 cm Inner Radius, Critical Height: 31.5 cm, Critical Mass= 11293.3 g, H/U-235 = 91, 55.4 cm High Reflector, Isotopic Gd Cross Sections
	HST1812	279.6 g U/liter, 1.943 g Gd/liter, 20.0 cm Inner Radius, Critical Height: 48.8 cm, Critical Mass= 17146.2 g, H/U-235 = 94, 59.4 cm High Reflector, Isotopic Gd Cross Sections
	HXT1812	279.6 g U/liter, 1.943 g Gd/liter, 20.0 cm Inner Radius, Critical Height: 48.8 cm, Critical Mass= 17146.2 g, H/U-235 = 94, 59.4 cm High Reflector, Elemental Gd Cross Section (64000.35C)

Table 7.2.3. Benchmark Problem Summary for Configurations Incorporating Highly Enriched Uranium Nitrate Solutions

Class	Case Name	Description
HEU-SOL-THERM-0019 Water Reflected Cylinders of HEU Nitrate Solution Poisoned with Gadolinium, 12.4 cm Inner Radius, 0.30 cm thick shell of stainless steel 1X18H10T (Russian), 89.04 wt% U-235 Experimental Uncertainty: ±0.004 to 0.007 in k_{eff}		
	HEST191	447.3 g U/liter, 0.0 g Gd/liter, 12.4 cm Inner Radius, Critical Height: 22.6 cm, Critical Mass= 4883.2 g, H/U-235 = 55, 21.6 cm High Reflector
	HEST192	393.6 g U/liter, 0.647 g Gd/liter, 12.4 cm Inner Radius, Critical Height: 31.5 cm, Critical Mass= 5989.1 g, H/U-235 = 63, 42.4 cm High Reflector, Isotopic Gd Cross Sections
	HXST192	393.6 g U/liter, 0.647 g Gd/liter, 12.4 cm Inner Radius, Critical Height: 31.5 cm, Critical Mass= 5989.1 g, H/U-235 = 63, 42.4 cm High Reflector, Elemental Gd Cross Section (64000.35C)
	HEST193	400.0 g U/liter, 1.160 g Gd/liter, 12.4 cm Inner Radius, Critical Height: 45.5 cm, Critical Mass= 8791.5 g, H/U-235 = 61, 59.4 cm High Reflector, Isotopic Gd Cross Sections
	HXST193	400.0 g U/liter, 1.160 g Gd/liter, 12.4 cm Inner Radius, Critical Height: 45.5 cm, Critical Mass= 8791.5 g, H/U-235 = 61, 59.4 cm High Reflector, Elemental Gd Cross Section (64000.35C)

7.2.4 Low-enrichment Uranium Solutions

The first set of experiments involving low-enrichment uranium are from the OECD benchmark compilation (Reference 5.5, Volume IV), while the second set (case prefix "JEUJ") are from work at the Japan Atomic Energy Research Institute (Reference 5.6). These problems are summarized in Table 7.2.4.

Table 7.2.4. Benchmark Problem Summary for Configurations Incorporating Low-enrichment Uranium Solutions

Class	Case Name	Description
LEU-SOL-THERM-002 174 Liter Spherical Tank of 4.9% Enriched UO2F2 Solutions, 34.399 cm Radius, 0.1588 cm thick 1100 Aluminum Shell, Experimental Uncertainty: ±0.004 in k_{eff}.		
	LEUST21	452.2 g U/liter, 22.11 g U-235/liter, Water Reflector, Critical Volume: 170.5 Liters Critical Mass = 3769.8 g U-235, H/U-235: 1098
	LEUST22	491.7 g U/liter, 24.04 g U-235/liter, No Reflector, Critical Volume: 172 Liters, Critical Mass = 4134.9 g U-235, H/U-235: 1001
	LEUST23	491.7 g U/liter, 24.04 g U-235/liter, Water Reflector, Critical Volume = 145.6 Liters, Critical Mass = 3500.2 g U-235, H/U-235: 1001
Cylindrical Tank With a 59.0 cm ID, 0.3 cm thick stainless steel SUS 304, U-235 Enrichment of 9.97 wt% Experimental Uncertainty: ±0.009 in k_{eff}		
	LEUJA01	310.1 g U/liter, 30.9 g U-235/liter, Water Reflector, Critical Height: 41.53 cm, Critical Mass = 3508.4 g U-235, H/U-235: 719.0, H/U: 72.5

Table 7.2.4. Benchmark Problem Summary for Configurations Incorporating Low-enrichment Uranium Solutions

Class	Case Name	Description
	LEUJA29	290.4 g U/liter, 29.0 g U-235/liter, Water Reflector, Critical Height: 46.70 cm, Critical Mass = 3702.6 g U-235, H/U-235: 771.3, H/U: 77.8
	LEUJA33	270.0 g U/liter, 26.9 g U-235/liter, Water Reflector, Critical Height: 52.93 cm, Critical Mass = 3892.7 g U-235, H/U-235: 842.2, H/U: 84.9
	LEUJA34	253.6 g U/liter, 25.3 g U-235/liter, Water Reflector, Critical Height: 64.85 cm, Critical Mass = 4485.6 g U-235, H/U-235: 895.8, H/U: 90.3
	LEUJA46	241.9 g U/liter, 24.1 g U-235/liter, Water Reflector, Critical Height: 78.56 cm, Critical Mass = 5176.2 g U-235, H/U-235: 941.7, H/U: 95.0
	LEUJA51	233.2 g U/liter, 23.3 g U-235/liter, Water Reflector, Critical Height: 95.50 cm, Critical Mass = 6083.5 g U-235, H/U-235: 982.5, H/U: 99.1
	LEUJA54	225.3 g U/liter, 22.5 g U-235/liter, Water Reflector, Critical Height: 130.33 cm, Critical Mass = 8017.2 g U-235, H/U-235: 1017.5, H/U: 102.6
	LEUJA14	313.0 g U/liter, 31.2 g U-235/liter, No Reflector, Critical Height: 46.83 cm, Critical Mass = 3994.6 g U-235, H/U-235: 709.2, H/U: 71.5

Table 7.2.4. Benchmark Problem Summary for Configurations Incorporating Low-enrichment Uranium Solutions		
Class	Case Name	Description
	LEUJA30	290.7 g U/liter, 29.0 g U-235/liter, No Reflector, Critical Height: 54.20 cm, Critical Mass = 4297.3 g U-235, H/U-235: 770.0, H/U: 77.7
	LEUJA32	270.0 g U/liter, 26.9 g U-235/liter, No Reflector, Critical Height: 63.55 cm, Critical Mass = 4673.7 g U-235, H/U-235: 842.2, H/U: 84.9
	LEUJA36	253.9 g U/liter, 25.3 g U-235/liter, No Reflector, Critical Height: 83.55 cm, Critical Mass = 5779.1 g U-235, H/U-235: 896.0, H/U: 90.4
	LEUJA49	241.9 g U/liter, 24.1 g U-235/liter, No Reflector, Critical Height: 112.27 cm, Critical Mass = 7397.3 g U-235, H/U-235: 942.2, H/U: 95.0

7.2.5 Intermediate-enrichment Uranium Solutions

The experiments involving intermediate-enrichment uranium are from the OECD benchmark compilation (Reference 5.5, Volume III) and are summarized in Table 7.2.5. All involve arrays of polyehtylene-moderated $U(30)F_4$-Polytetraflouroethlyene one-inch cubes. The experimental uncertainty in the eigenvalue was reported to be ± 0.006.

Table 7.2.5. Benchmark Problem Summary for Configurations Incorporating Intermediate-enrichment Uranium Solutions

Case Name	Description
IECT101	15X14X14 Array, 2392 U Cubes, 598 Polyethylene cubes, Paraffin Reflector, Critical Mass = 36789.0 g U-235, H/U-235 = 7.94
IECT102	12X12X11 Array, 1140 U Cubes, 570 Polyethylene cubes, Paraffin Reflector, Critical Mass = 17533.2 g U-235, H/U-235 = 15.88
IECT103	10X10X9 Array, 498 U Cubes, 498 Polyethylene cubes, Paraffin Reflector, Critical Mass = 7659.2 g U-235, H/U-235 = 31.75
IECT104	10X10X8 Array, 298 U Cubes, 596 Polyethylene cubes, Paraffin Reflector, Critical Mass = 4583.2 g U-235, H/U-235 = 63.51
IECT105	16X14X14 Array, 400 U Cubes, 2800 Polyethylene cubes, Paraffin Reflector, Critical Mass = 6152.0 g U-235, H/U-235 = 222.3
IECT106	10X10X10 Array, 527 U Cubes, 527 Polyethylene cubes, Paraffin Reflector, Critical Mass = 8105.3 g U-235, H/U-235 = 31.75
IECT107	11X10X10 Array, 558 U Cubes, 558 Polyethylene cubes, Paraffin Reflector, Critical Mass = 4583.2 g U-235, H/U-235 = 31.75

Table 7.2.5. Benchmark Problem Summary for Configurations Incorporating Intermediate-enrichment Uranium Solutions	
Case Name	Description
IECT108	11X11X10 Array, 646 U Cubes, 646 Polyethylene cubes, Paraffin Reflector, Critical Mass = 9935.5 g U-235, H/U-235 = 31.75
IECT109	13X12X12 Array, 1290 U Cubes, 645 Polyethylene cubes, Paraffin Reflector, Critical Mass = 19840.2 g U-235, H/U-235 = 15.88
IECT110	11X11X14 Array, 1155 U Cubes, 578 Polyethylene cubes, Paraffin Reflector, Critical Mass = 17763.9 g U-235, H/U-235 = 15.89
IECT111	10X10X19 Array, 1295 U Cubes, 648 Polyethylene cubes, Paraffin Reflector, Critical Mass = 19917.1 g U-235, H/U-235 = 15.89
IECT112	9X9X39 Array, 2150 U Cubes, 1075 Polyethylene cubes, Paraffin Reflector, Critical Mass = 33067.0 g U-235, H/U-235 = 15.88
IECT113	9X9X11 Array, 302 U Cubes, 604 Polyethylene cubes, Paraffin Reflector, Critical Mass = 4644.8 g U-235, H/U-235 = 63.51
IECT114	8X8X16 Array, 356 U Cubes, 712Polyethylene cubes, Paraffin Reflector, Critical Mass = 5475.3 g U-235, H/U-235 = 63.51
IECT115	8X7X26 Array, 488 U Cubes, 976 Polyethylene cubes, Paraffin Reflector, Critical Mass = 7505.4 g U-235, H/U-235 = 63.51
IECT116	11X11X10 Array, 258 U Cubes, 1032 Polyethylene cubes (1/2 thickness), Paraffin Reflector, Critical Mass = 3968.0 g U-235, H/U-235 = 63.51
IECT117	16X16X16 Array, 2810 U Cubes, 1405 Polyethylene cubes (1/2 thickness), No Reflector, Critical Mass = 43217.8 g U-235, H/U-235 = 7.94

Table 7.2.5. Benchmark Problem Summary for Configurations Incorporating Intermediate-enrichment Uranium Solutions	
Case Name	Description
IECT118	13X14X13 Array, 1232 U Cubes, 1232 Polyethylene cubes (1/2 thickness), No Reflector, Critical Mass = 18948.2 g U-235, H/U-235 = 15.88
IECT119	14X13X12 Array, 464 U Cubes, 1856 Polyethylene cubes (1/2 thickness), No Reflector, Critical Mass = 7136.3 g U-235, H/U-235 = 63.51
IECT120	12X13X11 Array, 1170 U Cubes, 585 Polyethylene cubes (1/2 thickness), Paraffin Reflector, Critical Mass = 17994.6 g U-235, H/U-235 = 7.94
IECT121	15X15X13 Array, 2450 U Cubes, 612 Polyethylene cubes (1/2 thickness), Paraffin Reflector, Critical Mass = 37681.0 g U-235, H/U-235 = 3.97
IECT122	15X15X14 Array, 2235 U Cubes, 1117 Polyethylene cubes (1/2 thickness), Cd & Paraffin Reflector, Critical Mass = 34374.3 g U-235, H/U-235 = 7.93
IECT123	12X13X12 Array, 965 U Cubes, 965 Polyethylene cubes (1/2 thickness), Paraffin Reflector, Cd & Critical Mass = 14841.7 g U-235, H/U-235 = 15.88
IECT124	13X13X13 Array, 1118 U Cubes, 1118 Polyethylene cubes (1/2 thickness), B & Paraffin Reflector, Critical Mass = 17194.8 g U-235, H/U-235 = 15.88
IECT125	13X13X11 Array, 400 U Cubes, 1600 Polyethylene cubes (1/2 thickness), Cd & Paraffin Reflector, Critical Mass = 6152.0 g U-235, H/U-235 = 63.51
IECT126	12X13X12 Array, 341 U Cubes, 1364 Polyethylene cubes (1/2 thickness), Paraffin Reflector, Critical Mass = 5244.6 g U-235, H/U-235 = 63.51

Table 7.2.5. Benchmark Problem Summary for Configurations Incorporating Intermediate-enrichment Uranium Solutions	
Case Name	Description
IECT127	14X13X12 Array, 378 U Cubes, 1512 Polyethylene cubes (1/2 thickness), Paraffin Reflector, Critical Mass = 5813.6 g U-235, H/U-235 = 63.51
IECT128	14X14X13 Array, 1510 U Cubes, 755 Polyethylene cubes (1/2 thickness), Paraffin Reflector, Critical Mass = 23223.8 g U-235, H/U-235 = 7.94
IECT129	16X15X15 Array, 1807 U Cubes, 903 Polyethylene cubes (1/2 thickness), Paraffin Reflector, Critical Mass = 27791.7 g U-235, H/U-235 = 7.94

7.3 Laboratory Critical Experiment k_{eff} Results

This section tabulates the MCNP k_{eff} results for the LCE's according to experimental similarities. Tables 7.3-1 through 7.3-5 present the results for the LCE's according to the following distinct experimental classifications:

Table 7.3-1	Critical Experiments using Mixed Plutonium and Natural Uranium Nitrate Solutions
Table 7.3-2	Critical Experiments using Plutonium Nitrate Solutions
Table 7.3-3	Critical Experiments using Highly Enriched Uranium Nitrate Solutions
Table 7.3-4	Critical Experiments using Low-enrichment Uranium Solutions
Table 7.3-5	Critical Experiments using Intermediate-enrichment Uranium Solutions

Here "Highly Enriched Uranium" means in excess of 89 weight percent U-235, "Low-enrichment Uranium" mean less than 10 weight percent U-235, and "Intermediate-enrichment Uranium" has an enrichment of about 30 weight percent.

The column identified as "AENCF" contains the average energy of the neturon causing fission and is obtained from the MCNP "kcode summary" table. It is a measure of the energy spectrum of the neutrons and has units of "MeV."

The same results are exhibited graphically in Figures 7.3-1 through 7.3-5.

Table 7.3-1. Critical Experiments using Mixed Plutonium and Natural Uranium Nitrate Solutions

Case Name	Description	keff	2σ	AENCF
PNL3187	102.19 g Pu/liter 365.20 g U/liter 2% B4C Concrete Annulus No Bottle Critical Height: 48.55 cm H/Pu-239 (annular tank) = 234 91.118 wt% Pu-239 in Pu	0.9965	0.0021	4.20E-02
PNL3391	103.37 g Pu/liter 363.66 g U/liter 0% B4C Concrete Annulus Bottle 2 Critical Height: 27.67 cm H/Pu-239 (annular tank) = 231 H/Pu-239 (bottle) = 231 91.118 wt% Pu-239 in Pu	0.9922	0.0023	4.10E-02
PNL3492	103.37 g Pu/liter 363.66 g U/liter 1% B4C Concrete Annulus Bottle 2 Critical Height: 37.19 cm H/Pu-239 (annular tank) = 225 H/Pu-239 (bottle) = 231 91.117 wt% Pu-239 in Pu	0.9948	0.0023	4.40E-02
PNL3593	107.91 g Pu/liter 379.55 g U/liter 6% B4C Concrete Annulus Bottle 2 Critical Height: 51.10 cm H/Pu-239 (annular tank) = 220 H/Pu-239 (bottle) = 231 91.117 wt% Pu-239 in Pu	0.9975	0.0021	4.60E-02
PNL3694	108.27 g Pu/liter 380.41 g U/liter No Concrete Annulus Bottle 2 Critical Height: 32.86 cm H/Pu-239 (annular tank) = 219 H/Pu-239 (bottle) = 231 91.117 wt% Pu-239 in Pu	0.9989	0.0023	4.50E-02
PNL3795	195.61 g Pu/liter 6.5 g U/liter 2% B4C Concrete Annulus Bottle 3 Critical Height: 27.51 cm H/Pu-239 (annular tank) = 125 H/Pu-239 (bottle) = 126 91.572 wt% Pu-239 in Pu	1.0022	0.0023	4.00E-02
PNL3896	110.13 g Pu/liter 3.8 g U/liter 2% B4C Concrete Annulus Bottle 3 Critical Height: 25.69 cm H/Pu-239 (annular tank) = 242 H/Pu-239 (bottle) = 126 91.572 wt% Pu-239 in Pu	1.0007	0.0025	2.40E-02
PNL3897	58.30 g Pu/liter 2.3 g U/liter 2% B4C Concrete Annulus Bottle 3 Critical Height: 28.94 cm H/Pu-239 (annular tank) = 477 H/Pu-239 (bottle) = 126 91.572 wt% Pu-239 in Pu	1.0044	0.0022	1.50E-02
PNL3898	72.74 g Pu/liter 247.33 g U/liter 2% B4C Concrete Annulus Bottle 2 Critical Height: 39.58 cm H/Pu-239 (annular tank) = 354 H/Pu-239 (bottle) = 231 91.117 wt% Pu-239 in Pu	1.0036	0.0030	2.63E-02
PNL3808	47.08 g Pu/liter 161.72 g U/liter 2% B4C Concrete Annulus Bottle 2 Critical Height: 45.09 cm H/Pu-239 (annular tank) = 569 H/Pu-239 (bottle) = 231 91.117 wt% Pu-239 in Pu	1.0008	0.0021	2.10E-02
PNL3999	73.64 g Pu/liter 250.30 g U/liter Polyethylene with Cd Cover Annulus Bottle 2 Critical Height: 79.18 cm H/Pu-239 (annular tank) = 349 H/Pu-239 (bottle) = 349 91.117 wt% Pu-239 in Pu	1.0075	0.0022	2.96E-02
PNL5300	74.25 g Pu/liter 251.64 g U/liter Solid Polyethylene with Cd Cover Center Critical Height: 104.62 cm H/Pu-239 (annular tank) = 346 91.117 wt% Pu-239 in Pu	1.0099	0.0023	2.88E-02
PNL1158	11.83 g Pu/liter 11.05 g U/liter Critical Height: 76.80 cm H/Pu-239 = 2403	1.0072	0.0013	4.00E-03
PNL1159	11.73 g Pu/liter 10.78 g U/liter Critical Height: 83.14 cm H/Pu-239 = 2435	1.0083	0.0013	4.00E-03

Table 7.3-1. Critical Experiments using Mixed Plutonium and Natural Uranium Nitrate Solutions

Case Name	Description	keff	2σ	AENCF
PNL1161	12.19 g Pu/liter 41.04 g U/liter Critical Height: 81.72 cm H/Pu-239 = 2317	1.0074	0.0013	6.00E-03
awre1	101.3 g Pu/liter 228.5 g U/liter ID = 25.425 cm Critical Height: 56.31 cm H/Pu-239 = 239	1.0143	0.0021	3.20E-02
awre2	101.3 g Pu/liter 228.5 g U/liter ID = 30.62 cm Critical Height: 29.89 cm H/Pu-239 = 239	1.0136	0.0024	3.20E-02
awre3	101.3 g Pu/liter 228.5 g U/liter ID = 37.99 cm Critical Height: 21.17 cm H/Pu-239 = 239	1.0098	0.0024	3.30E-02
awre4	101.3 g Pu/liter 228.5 g U/liter ID = 50.72 cm Critical Height: 16.05 cm H/Pu-239 = 239	1.0030	0.0024	3.30E-02
awre5	31.58 g Pu/liter 71.3 g U/liter ID = 30.62 cm Critical Height: 46.18 cm H/Pu-239 = 847	1.0088	0.0020	1.05E-02
awre6	31.58 g Pu/liter 71.3 g U/liter ID = 37.99 cm Critical Height: 28.24 cm H/Pu-239 = 847	1.0111	0.0022	1.04E-02
awre7	31.58 g Pu/liter 71.3 g U/liter ID = 50.72 cm Critical Height: 20.39 cm H/Pu-239 = 847	1.0058	0.0021	1.06E-02
awre8	18.61 g Pu/liter 42.2 g U/liter ID = 37.99 cm Critical Height: 72.86 cm H/Pu-239 = 1461	1.0134	0.0016	6.90E-03
awre9	18.61 g Pu/liter 42.2 g U/liter ID = 50.72 cm Critical Height: 33.59 cm H/Pu-239 = 1461	1.0102	0.0017	7.10E-03
awre10	17.50 g Pu/liter 39.6 g U/liter ID = 50.72 cm Critical Height: 37.16 cm H/Pu-239 = 1556	1.0090	0.0018	6.60E-03
PNL1577	172.56 g Pu/liter 262.79 g U/liter No Reflector Critical Height: 57.97 cm H/Pu-239 = 137	0.9972	0.0024	5.90E-02
PNL1678	172.82 g Pu/liter 262.55 g U/liter Water Reflector Critical Height: 28.93 cm H/Pu-239 = 136	0.9967	0.0023	5.10E-02
PNL1783	173.22 g Pu/liter 262.88 g U/liter Concrete Reflector Critical Height: 30.60 cm H/Pu-239 = 136	0.9991	0.0024	5.40E-02
PNL1868	118.71 g Pu/liter 173.98 g U/liter Concrete Reflector Critical Height: 27.03 cm H/Pu-239 = 214	1.0020	0.0025	3.50E-02
PNL1969	119.04 g Pu/liter 174.67 g U/liter Water Reflector Critical Height: 25.26 cm H/Pu-239 = 213	0.9978	0.0024	3.30E-02
PNL2070	118.90 g Pu/liter 174.53 g U/liter No Reflector Critical Height: 41.08 cm H/Pu-239 = 214	1.0005	0.0025	3.80E-02
PNL2565	41.69 g Pu/liter 63.38 g U/liter No Reflector Critical Height: 44.46 cm H/Pu-239 = 664	1.0048	0.0025	1.30E-02
PNL2666	41.89 g Pu/liter 63.65 g U/liter Water Reflector Critical Height: 28.11 cm H/Pu-239 = 660	1.0028	0.0020	1.20E-02

Table 7.3-1. Critical Experiments using Mixed Plutonium and Natural Uranium Nitrate Solutions

Case Name	Description	keff	2σ	AENCF
PNL2767	41.83 g Pu/liter 63.55 g U/liter Concrete Reflector Critical Height: 29.36 cm H/Pu-239 = 661	1.0030	0.0024	1.20E-02
	Average =	1.0040	0.0022	
	Number =	34		

Table 7.3-2. Critical Experiments using Plutonium Nitrate Solutions				
Case Name	Description	keff	2σ	AENCF
PUST1T1	73.0 g Pu/liter Critical Mass: 945 gm H/Pu-239 = 371	1.0099	0.002	1.29E-02
PUST1T2	96.0 g Pu/liter Critical Mass: 1243 gm H/Pu-239 = 272	1.0108	0.0022	1.68E-02
PUST1T3	119.0 g Pu/liter Critical Mass: 1541 gm H/Pu-239 = 216	1.0125	0.0021	2.08E-02
PUST1T4	132.0 g Pu/liter Critical Mass: 1709 gm H/Pu-239 = 190	1.0088	0.0020	2.40E-02
PUST1T5	140.0 g Pu/liter Critical Mass: 1813 gm H/Pu-239 = 180	1.0131	0.0020	2.58E-02
PUST1T6	268.7 g Pu/liter Critical Mass: 3480 gm H/Pu-239 = 91	1.0105	0.0021	4.81E-02
PU003-1	33.32 g Pu/liter Critical Mass: 631 gm H/Pu-239 = 788	1.0105	0.0019	6.30E-03
PU003-2	34.32 g Pu/liter Critical Mass: 650 gm H/Pu-239 = 756	1.0090	0.0019	6.60E-03
PU003-3	37.43 g Pu/liter Critical Mass: 709 gm H/Pu-239 = 699	1.0102	0.0019	7.30E-03
PU003-4	38.12 g Pu/liter Critical Mass: 722 gm H/Pu-239 = 682	1.0106	0.0018	7.30E-03
PU003-5	40.65 g Pu/liter Critical Mass: 770 gm H/Pu-239 = 627	1.0100	0.0018	7.60E-03
PU003-6	44.09 g Pu/liter Critical Mass: 835 gm H/Pu-239 = 563	1.0123	0.0018	8.60E-03
PU003-7	35.98 g Pu/liter Critical Mass: 649 gm H/Pu-239 = 738	1.0120	0.0019	6.90E-03
PU003-8	36.81 g Pu/liter Critical Mass: 664 gm H/Pu-239 = 714	1.0127	0.0018	6.70E-02
PU004-1	26.27 g Pu/liter Critical Mass: 621 gm H/Pu-239 = 987	1.0116	0.0018	5.10E-03
PU004-2	26.31 g Pu/liter Critical Mass: 622 gm H/Pu-239 = 977	1.0045	0.0017	5.40E-03
PU004-3	27.20 g Pu/liter Critical Mass: 643 gm H/Pu-239 = 935	1.0071	0.0018	5.60E-03
PU004-4	28.09 g Pu/liter Critical Mass: 664 gm H/Pu-239 = 889	1.0060	0.0018	5.70E-03
PU004-5	27.58 g Pu/liter Critical Mass: 652 gm H/Pu-239 = 942	1.0059	0.0018	5.40E-03
PU004-6	28.60 g Pu/liter Critical Mass: 676 gm H/Pu-239 = 927	1.0080	0.0018	5.60E-03
PU004-7	29.57 g Pu/liter Critical Mass: 699 gm H/Pu-239 = 892	1.0135	0.0018	5.80E-03
PU004-8	29.95 g Pu/liter Critical Mass: 708 gm H/Pu-239 = 869	1.0062	0.0017	5.90E-03
PU004-9	31.60 g Pu/liter Critical Mass: 747 gm H/Pu-239 = 805	1.0078	0.0019	6.20E-03
PU04-10	35.36 g Pu/liter Critical Mass: 836 gm H/Pu-239 = 689	1.0071	0.0018	7.20E-03
PU04-11	39.38 g Pu/liter Critical Mass: 931 gm H/Pu-239 = 592	1.0093	0.0018	8.30E-03
PU04-12	29.44 g Pu/liter Critical Mass: 696 gm H/Pu-239 = 893	1.0100	0.0018	5.80E-03
PU04-13	29.27 g Pu/liter Critical Mass: 692 gm H/Pu-239 = 903	1.0070	0.0017	5.50E-03
PU005-1	29.65 g Pu/liter Critical Mass: 701 gm H/Pu-239 = 903	1.0075	0.0018	5.80E-03
PU005-2	30.54 g Pu/liter Critical Mass: 722 gm H/Pu-239 = 868	1.0085	0.0018	6.00E-03
PU005-3	31.43 g Pu/liter Critical Mass: 743 gm H/Pu-239 = 834	1.0088	0.0018	6.20E-03
PU005-4	33.54 g Pu/liter Critical Mass: 793 gm H/Pu-239 = 765	1.0119	0.0017	6.70E-03
PU005-5	36.04 g Pu/liter Critical Mass: 852 gm H/Pu-239 = 694	1.0126	0.0019	7.20E-03
PU005-6	38.49 g Pu/liter Critical Mass: 910 gm H/Pu-239 = 633	1.0117	0.0019	7.90E-03
PU005-7	40.91 g Pu/liter Critical Mass: 967 gm H/Pu-239 = 581	1.0111	0.0018	8.30E-03
PU005-8	30.58 g Pu/liter Critical Mass: 723 gm H/Pu-239 = 869	1.0073	0.0018	6.00E-03
PU005-9	31.85 g Pu/liter Critical Mass: 753 gm H/Pu-239 = 825	1.0086	0.0018	6.30E-03

Table 7.3-2. Critical Experiments using Plutonium Nitrate Solutions				
Case Name	Description	keff	2σ	AENCF
PU007-2	232 g Pu/liter Critical Volume: 12.35 liters Height Above Sphere Center: 10.8373 cm	1.0118	0.0020	4.10E-02
PU007-3	221 g Pu/liter Critical Volume: 12.35 liters Height Above Sphere Center: 10.8373 cm	1.0056	0.0021	3.89E-02
PU007-5	100.2 g Pu/liter Critical Volume: 12.39 liters Height Above Sphere Center: 10.9741 cm	1.0138	0.0021	1.75E-02
PU007-6	101.5 g Pu/liter Critical Volume: 12.30 liters Height Above Sphere Center: 10.6720 cm	1.0075	0.0020	1.79E-02
PU007-7	100.1 g Pu/liter Critical Volume: 12.39 liters Height Above Sphere Center: 10.9741 cm	1.0106	0.0020	1.72E-02
PU007-8	101.6 g Pu/liter Critical Volume: 12.37 liters Height Above Sphere Center: 10.9051 cm	1.0047	0.0021	1.82E-02
PU007-9	101.6 g Pu/liter Critical Volume: 12.23 liters Height Above Sphere Center: 10.4503 cm	1.0003	0.0020	1.78E-02
PU07-10	93.5 g Pu/liter Critical Volume: 12.35 liters Height Above Sphere Center: 10.8373 cm	1.0065	0.0022	1.65E-02
PUST9-1	10.02 g Pu/liter Critical Volume: 656.6 liters Height Above Sphere Center: 15.9558 cm	1.0198	0.0017	2.88E-03
PUST9-2	9.539 g Pu/liter Critical Volume: 906.5 liters Height Above Sphere Center: 45.3705 cm	1.0238	0.0016	2.58E-03
PUST9-3	9.457 g Pu/liter Critical Volume: 949.1 liters Full Sphere	1.0225	0.0017	2.63E-03
PU10091	99.09 g Pu/liter IR = 11.4264 cm Critical Height: 30.7086 cm	1.0228	0.0021	1.70E-02
PU10092	73.92 g Pu/liter IR = 11.4264 cm Critical Height: 35.4076 cm	1.0200	0.0020	1.31E-02
PU10093	54.53 g Pu/liter IR = 11.4264 cm Critical Height: 44.5770 cm	1.0138	0.0020	9.60E-03
PU10111	54.53 g Pu/liter IR = 13.9684 cm Critical Height: 25.6032 cm	1.0203	0.0021	1.70E-02
PU10112	47.21 g Pu/liter IR = 13.9684 cm Critical Height: 28.1686 cm	1.0157	0.0020	8.70E-03
PU10113	47.21 g Pu/liter IR = 13.9684 cm Critical Height: 27.0764 cm	1.0163	0.0019	8.40E-03
PU10114	41.73 g Pu/liter IR = 13.9684 cm Critical Height: 32.6390 cm	1.0076	0.0020	8.10E-03
PU10115	36.90 g Pu/liter IR = 13.9684 cm Critical Height: 43.0022 cm	1.0093	0.0018	7.40E-03
PU10116	63.99 g Pu/liter IR = 13.9684 cm Critical Height: 22.8092 cm	1.0199	0.0021	1.12E-02
PU10117	48.98 g Pu/liter IR = 13.9684 cm Critical Height: 25.9588 cm	1.0079	0.0020	9.10E-03
PU10121	48.75 g Pu/liter IR = 15.2390 cm Critical Height: 22.3520 cm	1.0174	0.0019	8.60E-03
PU10122	42.29 g Pu/liter IR = 15.2390 cm Critical Height: 25.2476 cm	1.0158	0.0019	7.90E-03
PU10123	36.52 g Pu/liter IR = 15.2390 cm Critical Height: 28.4734 cm	1.0213	0.0019	7.00E-03
PU10124	31.14 g Pu/liter IR = 15.2390 cm Critical Height: 33.4264 cm	1.0170	0.0017	6.00E-03
PU11161	34.96 g Pu/liter IR = 20.1206 cm Critical Mass: 1194 g	1.0172	0.0020	7.50E-03
PU11162	36.22 g Pu/liter IR = 20.1206 cm Critical Mass: 1237 g	1.0233	0.0020	7.50E-03
PU11163	38.13 g Pu/liter IR = 20.1206 cm Critical Mass: 1302 g	1.0253	0.0020	8.50E-03

Table 7.3-2. Critical Experiments using Plutonium Nitrate Solutions

Case Name	Description	keff	2σ	AENCF
PU11164	38.16 g Pu/liter IR = 20.1206 cm Critical Mass: 1303 g	1.0174	0.0021	8.30E-03
PU11165	43.43 g Pu/liter IR = 20.1206 cm Critical Mass: 1483 g	1.0156	0.0020	9.70E-03
PU11181	22.35 g Pu/liter IR = 22.6974 cm Critical Mass: 1095 g	1.0022	0.0018	5.00E-03
PU11182	23.27 g Pu/liter IR = 22.6974 cm Critical Mass: 1140 g	1.0078	0.0018	5.20E-03
PU11183	23.10 g Pu/liter IR = 22.6974 cm Critical Mass: 1132 g	1.0040	0.0018	5.20E-03
PU11184	23.82 g Pu/liter IR = 22.6974 cm Critical Mass: 1167 g	1.0031	0.0018	5.50E-03
PU11185	25.20 g Pu/liter IR = 22.6974 cm Critical Mass: 1235 g	1.0124	0.0018	5.80E-03
PU11186	27.49 g Pu/liter IR = 22.6974 cm Critical Mass: 1347 g	1.0103	0.0019	6.60E-03
PU11187	23.94 g Pu/liter IR = 22.6974 cm Critical Mass: 1173 g	1.0094	0.0019	5.60E-03
	Average =	1.0116	0.0019	
	Number =	73		

Table 7.3-3. Critical Experiments using Highly Enriched Uranium Nitrate Solutions				
Case Name	Description	keff	2σ	AENCF
HEST1-1	145.68 g U/liter ID = 27.92 cm SS-304 shell Critical Height: 31.20 Critical Mass: 2782.8 gm H/U-235 = 182	1.0043	0.0041	1.59E-02
HEST1-2	346.73 g U/liter ID = 27.92 cm SS-304 shell Critical Height: 28.93 Critical Mass: 6141.3 gm H/U-235 = 71	0.9995	0.0041	3.91E-02
HEST1-3	142.92 g U/liter ID = 28.01 cm Al-6061 shell Critical Height: 33.55 Critical Mass: 2954.6 gm H/U-235 = 186	1.0064	0.0040	1.61E-02
HEST1-4	357.71 g U/liter ID = 28.01 cm Al-6061 shell Critical Height: 30.91 Critical Mass: 6813.1 gm H/U-235 = 68	1.0016	0.0042	4.13E-02
HEST1-5	54.89 g U/liter ID = 33.01 cm Al-6061 shell Critical Height: 39.48 Critical Mass: 1854.6 gm H/U-235 = 499	1.0027	0.0033	6.60E-03
HEST1-6	59.65 g U/liter ID = 33.01 cm Al-6061 shell Critical Height: 36.67 Critical Mass: 1872.0 gm H/U-235 = 459	1.0074	0.0032	6.70E-02
HEST1-7	137.40 g U/liter ID = 33.01 cm Al-6061 shell Critical Height: 23.96 Critical Mass: 2817.4 gm H/U-235 = 193	1.0019	0.0042	1.55E-02
HEST1-8	145.68 g U/liter ID = 33.01 cm Al-6061 shell Critical Height: 23.67 Critical Mass: 2951.1 gm H/U-235 = 182	1.0039	0.0041	1.63E-02
HEST1-9	357.71 g U/liter ID = 33.01 cm Al-6061 shell Critical Height: 22.53 Critical Mass: 6897.2 gm H/U-235 = 68	0.9981	0.0044	4.02E-02
HEST110	63.95 g U/liter ID = 50.69 cm Al-6061 shell Critical Height: 20.48 Critical Mass: 2643.0 gm H/U-235 = 427	0.9976	0.0035	7.30E-03
HEST2-1	144.38 g U/liter ID = 27.92 cm SS-304 shell Critical Height: 29.79 cm Critical Mass: 2633.3 gm H/U-235 = 184 57.4 cm North X 64.6 cm East X 82.0 cm Up (Position in Concrete Box)	1.0047	0.0042	1.61E-02
HEST2-2	144.38 g U/liter ID = 27.92 cm SS-304 shell Critical Height: 24.19 cm Critical Mass: 2138.3 gm H/U-235 = 184 16.76 cm N X 104.49 cm E X 123.7 cm Up	1.0097	0.0044	1.47E-02
HEST2-3	334.77 g U/liter ID = 27.92 cm SS-304 shell Critical Height: 27.23 cm Critical Mass: 5581.0 gm H/U-235 = 74 57.4 cm N X 64.6 cm E X 82.0 cm Up	1.0066	0.0048	3.68E-02
HEST2-4	334.77 g U/liter ID = 27.92 cm SS-304 shell Critical Height: 21.79 cm Critical Mass: 4466.1 gm H/U-235 = 74 16.76 cm N X 104.49 cm E X 123.7 cm Up	1.0075	0.0045	3.46E-02
HEST2-5	144.38 g U/liter ID = 28.01 cm Al-6061 shell Critical Height: 31.37 cm Critical Mass: 2790.9 gm H/U-235 = 184 57.4 cm N X 64.6 cm E X 82.0 cm Up	1.0058	0.0045	1.60E-02
HEST2-6	144.38 g U/liter ID = 28.01 cm Al-6061 shell Critical Height: 24.70 cm Critical Mass: 2197.5 gm H/U-235 = 184 16.50 cm N X 104.0 cm E X 123.7 cm Up	1.0137	0.0045	1.52E-02
HEST2-7	334.77 g U/liter ID = 28.01 cm Al-6061 shell Critical Height: 28.60 cm Critical Mass: 5899.7 gm H/U-235 = 74 57.4 cm N X 64.6 cm E X 82.0 cm Up	1.0048	0.0046	3.64E-02

Table 7.3-3. Critical Experiments using Highly Enriched Uranium Nitrate Solutions				
Case Name	Description	keff	2σ	AENCF
HEST2-8	334.77 g U/liter ID = 28.01 cm Al-6061 shell Critical Height: 22.33 cm Critical Mass: 4606.3 gm H/U-235 = 74 16.65 cm N X 103.75 cm E X 123.7 cm Up	1.0066	0.0046	3.55E-02
HEST2-9	59.65 g U/liter ID = 33.01 cm Al-6061 shell Critical Height: 34.10 cm Critical Mass: 1653.2 gm H/U-235 = 460 57.4 cm N X 64.6 cm E X 82.0 cm Up	1.0066	0.0045	6.80E-03
HEST2-10	59.65 g U/liter ID = 33.01 cm Al-6061 shell Critical Height: 27.27 cm Critical Mass: 1392.1 gm H/U-235 = 460 16.825 cm N X 103.88 cm E X 123.7 cm Up	1.0065	0.004	6.60E-03
HEST2-11	144.38 g U/liter ID = 33.01 cm Al-6061 shell Critical Height: 22.85 cm Critical Mass: 2823.4 gm H/U-235 = 184 57.4 cm N X 64.6 cm E X 82.0 cm Up	1.0065	0.0047	1.57E-02
HEST2-12	144.38 g U/liter ID = 33.01 cm Al-6061 shell Critical Height: 18.24 cm Critical Mass: 2253.8 gm H/U-235 = 184 16.825 cm N X 103.88 cm E X 123.7 cm Up	1.0097	0.0047	1.44E-02
HEST2-13	334.77 g U/liter ID = 33.01 cm Al-6061 shell Critical Height: 21.50 cm Critical Mass: 6159.8 gm H/U-235 = 74 57.4 cm N X 64.6 cm E X 82.0 cm Up	1.0063	0.0046	3.72E-02
HEST2-14	334.77 g U/liter ID = 33.01 cm Al-6061 shell Critical Height: 16.78 cm Critical Mass: 4807.5 gm H/U-235 = 74 16.825 cm N X 104.55 cm E X 123.7 cm Up	1.0092	0.0039	3.45E-02
HEUST31	60.32 g U/liter ID = 27.93 cm SS-304 shell Critical Height: 50.52 cm Critical Mass: 1867.1 gm H/U-235 = 454 17.71 cm N X 104.64 cm E X 122.9 cm Up	1.0071	0.0039	6.90E-03
HEUST32	60.32 g U/liter ID = 27.93 cm SS-304 shell Critical Height: 67.48 cm Critical Mass: 2493.8 gm H/U-235 = 454 61.1 cm N X 61.3 cm E X 122.9 cm Up	1.0069	0.0041	6.90E-03
HEUST33	147.66 g U/liter ID = 27.92 cm SS-304 shell Critical Height: 29.71 cm Critical Mass: 2685.9 gm H/U-235 = 180 60.4 cm N X 61.2 cm E X 81.4 cm Up	1.0073	0.0049	1.63E-02
HEUST34	147.66 g U/liter ID = 27.92 cm SS-304 shell Critical Height: 25.03 cm Critical Mass: 2262.8 gm H/U-235 = 180 17.06 cm N X 104.99 cm E X 122.9 cm Up	1.0061	0.0042	1.49E-02
HEUST35	345.33 g U/liter ID = 27.92 cm SS-304 shell Critical Height: 27.60 cm Critical Mass: 5835.3 gm H/U-235 = 71 60.4 cm N X 61.2 cm E X 81.4 cm Up	1.0009	0.0042	3.86E-02
HEUST36	345.33 g U/liter ID = 27.92 cm SS-304 shell Critical Height: 22.75 cm Critical Mass: 4809.9 gm H/U-235 = 71 16.81 cm N X 104.84 cm E X 122.9 cm Up	1.0005	0.005	3.58E-02
HEUST37	60.32 g U/liter ID = 27.88 cm Al-6061 shell Critical Height: 51.67 cm Critical Mass: 1902.7 gm H/U-235 = 454 17.51 cm N X 105.15 cm E X 122.9 cm Up	1.0066	0.0039	6.50E-03

Table 7.3-3. Critical Experiments using Highly Enriched Uranium Nitrate Solutions

Case Name	Description	keff	2σ	AENCF
HEUST38	147.66 g U/liter ID = 28.01 cm Al-6061 shell Critical Height: 31.26 cm Critical Mass: 2844.3 gm H/U-235 = 180 60.4 cm N X 61.2 cm E X 81.4 cm Up	1.0065	0.0045	1.58E-02
HEUST39	147.66 g U/liter ID = 28.01 cm Al-6061 shell Critical Height: 25.26 cm Critical Mass: 2298.3 gm H/U-235 = 180 17.52 cm N X 104.95 cm E X 122.9 cm Up	1.0091	0.0043	1.53E-02
HEST310	345.33 g U/liter ID = 28.01 cm Al-6061 shell Critical Height: 28.84 cm Critical Mass: 6136.9 gm H/U-235 = 71 60.4 cm N X 61.2 cm E X 81.4 cm Up	1.0000	0.0046	3.87E-02
HEST311	345.33 g U/liter ID = 28.01 cm Al-6061 shell Critical Height: 22.87 cm Critical Mass: 4866.5 gm H/U-235 = 71 17.50 cm N X 105.1 cm E X 122.9 cm Up	1.0099	0.0042	3.47E-02
HEST312	60.32 g U/liter ID = 33.01 cm Al-6061 shell Critical Height: 34.33 cm Critical Mass: 1772.2 gm H/U-235 = 454 60.4 cm N X 61.2 cm E X 81.4 cm Up	1.0040	0.0044	6.80E-03
HEST313	60.32 g U/liter ID = 33.01 cm Al-6061 shell Critical Height: 27.70 cm Critical Mass: 1430.0 gm H/U-235 = 454 17.10 cm N X 105.18 cm E X 122.9 cm Up	1.0082	0.0042	6.20E-03
HEST314	60.32 g U/liter ID = 33.01 cm Al-6061 shell Critical Height: 31.75 cm Critical Mass: 1639.0 gm H/U-235 = 454 61.1 cm N X 61.3 cm E X 122.9 cm Up	1.0031	0.0039	6.60E-03
HEST315	66.33 g U/liter ID = 33.01 cm Al-6061 shell Critical Height: 25.10 cm Critical Mass: 1424.8 gm H/U-235 = 412 17.10 cm N X 105.18 cm E X 122.9 cm Up	0.9978	0.0041	7.10E-03
HEST316	147.66 g U/liter ID = 33.01 cm Al-6061 shell Critical Height: 22.78 cm Critical Mass: 2878.7 gm H/U-235 = 180 60.4 cm N X 61.2 cm E X 81.4 cm Up	1.0027	0.0045	1.68E-02
HEST317	147.66 g U/liter ID = 33.01 cm Al-6061 shell Critical Height: 18.49 cm Critical Mass: 2336.6 gm H/U-235 = 180 17.10 cm N X 105.18 cm E X 122.9 cm Up	1.0086	0.0042	1.51E-02
HEST318	345.33 g U/liter ID = 33.01 cm Al-6061 shell Critical Height: 21.76 cm Critical Mass: 6430.9 gm H/U-235 = 71 60.4 cm N X 61.2 cm E X 81.4 cm Up	0.9952	0.0045	3.90E-02
HEST319	345.33 g U/liter ID = 33.01 cm Al-6061 shell Critical Height: 17.20 cm Critical Mass: 5083.3 gm H/U-235 = 71 17.30 cm N X 105.2 cm E X 122.9 cm Up	1.0113	0.0045	3.42E-02
HEUST71	4 X 4 Array 67.28 g U/liter ID = 21.12 cm 0.40 cm thick shell of Type 6061 Aluminum 0.32 cm thick sleeve of Type 304 Stainless Steel Critical Height: 28.63 cm Critical Mass: 674.8 gm X 16 Critical Height: 28.63 cm	1.0148	0.0024	7.10E-03

Table 7.3-3. Critical Experiments using Highly Enriched Uranium Nitrate Solutions

Case Name	Description	keff	2σ	AENCF
HEUST72	4 X 4 Array 369.96 g U/liter ID = 21.12 cm 0.40 cm thick shell of Type 6061 Aluminum 0.32 cm thick sleeve of Type 304 Stainless Steel Critical Height: 17.24 cm Critical Mass: 2234.4 gm X 16 Critical Height: 17.24 cm	1.0131	0.0025	3.55E-02
HEUST73	4 X 4 Array 67.28 g U/liter ID = 21.12 cm 0.40 cm thick shell of Type 6061 Aluminum 0.0 cm thick sleeve of Type 304 Stainless Steel Critical Height: 27.15 cm Critical Mass: 639.9 gm X 16 Critical Height: 27.15 cm	1.0080	0.0021	7.00E-03
HEUST74	4 X 4 Array 364.11 g U/liter ID = 21.12 cm 0.40 cm thick shell of Type 6061 Aluminum 0.0 cm thick sleeve of Type 304 Stainless Steel Critical Height: 17.13 cm Critical Mass: 2234.4 gm X 16 Critical Height: 17.13 cm	1.0109	0.0028	3.49E-02
HEUST75	2 X 2 Array 76.09 g U/liter ID = 21.12 cm 0.40 cm thick shell of Type 6061 Aluminum 0.32 cm thick sleeve of Type 304 Stainless Steel Critical Height: 60.70 cm Critical Mass: 1618.1 gm X 4 Critical Height: 60.70 cm	1.0088	0.0025	8.20E-03
HEUST76	2 X 2 Array 360.37 g U/liter ID = 21.12 cm 0.40 cm thick shell of Type 6061 Aluminum 0.32 cm thick sleeve of Type 304 Stainless Steel Critical Height: 29.49 cm Critical Mass: 3723.1 gm X 4 Critical Height: 29.49 cm	1.0028	0.0026	3.76E-02
HEUST77	2 X 2 Array 76.09 g U/liter ID = 21.12 cm 0.40 cm thick shell of Type 6061 Aluminum 0.0 cm thick sleeve of Type 304 Stainless Steel Critical Height: 62.34 cm Critical Mass: 1661.8 gm X 4 Critical Height: 62.34 cm	1.0043	0.0024	8.10E-03
HEUST78	2 X 2 Array 364.11 g U/liter ID = 21.12 cm 0.40 cm thick shell of Type 6061 Aluminum 0.0 cm thick sleeve of Type 304 Stainless Steel Critical Height: 31.11 cm Critical Mass: 3968.4 gm X 4 Critical Height: 31.11 cm	1.0044	0.0027	3.84E-02
HEUST79	2 X 2 Array 80.72 g U/liter ID = 21.12 cm 0.40 cm thick shell of Type 6061 Aluminum 0.0 cm thick sleeve of Type 304 Stainless Steel Critical Height: 57.88 cm Critical Mass: 1636.8 gm X 4 Critical Height: 57.88 cm	1.0057	0.0024	8.80E-03
HEST710	4 X 4 Array 83.49 g U/liter ID = 16.12 cm 0.40 cm thick shell of Type 6061 Aluminum 0.31 cm thick sleeve of Type 304 Stainless Steel Critical Height: 57.34 cm Critical Mass: 977.0 gm X 16 Critical Height: 57.34 cm	1.0150	0.0023	8.60E-03
HEST711	4 X 4 Array 360.37 g U/liter ID = 16.12 cm 0.40 cm thick shell of Type 6061 Aluminum 0.31 cm thick sleeve of Type 304 Stainless Steel Critical Height: 32.32 cm Critical Mass: 2377.1 gm X 16 Critical Height: 32.32 cm	1.0085	0.0027	3.51E-02
HEST712	4 X 4 Array 83.49 g U/liter ID = 16.12 cm 0.40 cm thick shell of Type 6061 Aluminum 0.0 cm thick sleeve of Type 304 Stainless Steel Critical Height: 51.21 cm Critical Mass: 872.6 gm X 16 Critical Height: 51.21 cm	1.0059	0.0022	8.80E-03

Table 7.3-3. Critical Experiments using Highly Enriched Uranium Nitrate Solutions

Case Name	Description	keff	2σ	AENCF
HEST713	4 X 4 Array 359.55 g U/liter ID = 16.12 cm 0.40 cm thick shell of Type 6061 Aluminum 0.0 cm thick sleeve of Type 304 Stainless Steel Critical Height: 31.82 cm Critical Mass: 2335.0 gm X 16 Critical Height: 31.82 cm	1.0113	0.0023	3.54E-02
HEST714	2 X 4 Array 359.55 g U/liter ID = 16.12 cm 0.40 cm thick shell of Type 6061 Aluminum 0.0 cm thick sleeve of Type 304 Stainless Steel Critical Height: 51.45 cm Critical Mass: 3775.4 gm X 8 Critical Height: 51.45 cm	1.0066	0.0023	3.57E-02
HEST715	2 X 3 Array 359.55 g U/liter ID = 16.12 cm 0.40 cm thick shell of Type 6061 Aluminum 0.0 cm thick sleeve of Type 304 Stainless Steel Critical Height: 65.49 cm Critical Mass: 4805.7 gm X 6 Critical Height: 65.49 cm	1.0039	0.0026	3.64E-02
HEST716	2 X 2 Array 359.55 g U/liter ID = 16.12 cm 0.40 cm thick shell of Type 6061 Aluminum 0.31 cm thick sleeve of Type 304 Stainless Steel Critical Height: 101.45 cm Critical Mass: 7444.4 gm X 4 Critical Height: 101.45 cm	1.0066	0.0023	3.60E-02
HEST717	2 X 2 Array 359.55 g U/liter ID = 16.12 cm 0.40 cm thick shell of Type 6061 Aluminum 0.0 cm thick sleeve of Type 304 Stainless Steel Critical Height: 104.04 cm Critical Mass: 7634.5 gm X 4 Critical Height: 104.04 cm	1.0065	0.0029	3.66E-02
HEUST81	4 X 4 Array 60.32 g U/liter ID = 21.12 cm 0.40 cm thick shell of Type 6061 Aluminum 0.32 cm thick sleeve of Type 304 Stainless Steel Critical Height: 34.82 cm Critical Mass: 735.8 gm X 16 Critical Height: 34.82 cm	1.0044	0.0028	6.70E-03
HEUST83	4 X 4 Array 60.32 g U/liter ID = 21.12 cm 0.40 cm thick shell of Type 6061 Aluminum 0.0 cm thick sleeve of Type 304 Stainless Steel Critical Height: 31.76 cm Critical Mass: 671.1 gm X 16 Critical Height: 31.76 cm	0.9978	0.0036	6.50E-03
HEUST86	2 X 2 Array 355.94 g U/liter ID = 21.12 cm 0.40 cm thick shell of Type 6061 Aluminum 0.32 cm thick sleeve of Type 304 Stainless Steel Critical Height: 31.93 cm Critical Mass: 3981.6 gm X 4 Critical Height: 31.93 cm	1.0075	0.0043	3.70E-02
HEUST89	4 X 4 Array 60.32 g U/liter ID = 16.12 cm 0.40 cm thick shell of Type 6061 Aluminum 0.31 cm thick sleeve of Type 304 Stainless Steel Critical Height: 105.85 cm Critical Mass: 1303.1 gm X 16 Critical Height: 105.85 cm	1.0011	0.0028	6.80E-03
HEST813	2 X 3 Array 355.94 g U/liter ID = 16.12 cm 0.40 cm thick shell of Type 6061 Aluminum 0.31 cm thick sleeve of Type 304 Stainless Steel Critical Height: 95.20 cm Critical Mass: 1303.1 gm X 6 Critical Height: 95.20 cm	1.0032	0.0042	3.63E-02
HEST131	20.12 g U/liter 0.0 g B/liter Critical Mass = 3489.4 g /U-235 = 1375	1.0008	0.0011	2.70E-03
HEST132	25.53 g U/liter 0.0935 g B/liter Critical Mass = 4427.6 g H/U-235 = 1173	0.9998	0.0012	3.10E-03

Table 7.3-3. Critical Experiments using Highly Enriched Uranium Nitrate Solutions

Case Name	Description	keff	2σ	AENCF
HEST133	26.77 g U/liter 0.187 g B/liter Critical Mass = 4642.7 g H/U-235 = 1030	0.9961	0.0012	3.50E-03
HEST134	28.45g U/liter 0.230 g B/liter Critical Mass = 4934.0 g H/U-235 = 971	0.9979	0.0013	3.70E-03
HEST141	70.0 g U/liter 0.0 g Gd/liter Critical Height: 19.3 cm Critical Mass= 1697.7 g H/U-235 = 405	0.9963	0.0024	7.20E-03
HEST142	68.1 g U/liter 0.100 g Gd/liter Critical Height: 27.4 cm Critical Mass= 2344.8 g H/U-235 = 418 Isotopic Gd Cross Sections	1.0131	0.0022	7.40E-03
HXST142	68.1 g U/liter 0.100 g Gd/liter Critical Height: 27.4 cm Critical Mass= 2344.8 g H/U-235 = 418 Elemental Gd Cross Section (64000.35C)	1.0099	0.0021	7.30E-03
HEST143	67.7 g U/liter 0.193 g Gd/liter Critical Height: 44.6 cm Critical Mass= 3794.3 g H/U-235 = 421 Isotopic Gd Cross Sections	1.0023	0.0022	7.60E-03
HXST143	67.7 g U/liter 0.193 g Gd/liter Critical Height: 44.6 cm Critical Mass= 3794.3 g H/U-235 = 421 Elemental Gd Cross Section (64000.35C)	1.0128	0.0022	7.60E-03
HEST151	100.5 g U/liter 0.0 g Gd/liter Critical Height: 18.7 cm Critical Mass= 2361.7 g H/U-235 = 278 15.1 cm High Reflector	1.0030	0.0024	1.05E-02
HEST152	100.5 g U/liter 0.0 g Gd/liter Critical Height: 16.6 cm Critical Mass= 2096.4 g H/U-235 = 278 45.0 cm High Reflector	0.9951	0.0024	9.80E-03
HEST153	98.8 g U/liter 0.197 g Gd/liter Critical Height: 29.9 cm Critical Mass= 3712.3 g H/U-235 = 283 17.0 cm High Reflector Isotopic Gd Cross Sections	1.0105	0.0025	1.11E-02
HXST153	98.8 g U/liter 0.197 g Gd/liter Critical Height: 29.9 cm Critical Mass= 3712.3 g H/U-235 = 283 17.0 cm High Reflector Elemental Gd Cross Section (64000.35C)	1.0045	0.0025	1.13E-02
HEST154	98.8 g U/liter 0.197 g Gd/liter Critical Height: 25.8 cm Critical Mass= 3203.2 g H/U-235 = 283 45.0 cm High Reflector Isotopic Gd Cross Sections	1.0156	0.0025	1.05E-02
HXST154	98.8 g U/liter 0.197 g Gd/liter Critical Height: 25.8 cm Critical Mass= 3203.2 g H/U-235 = 283 45.0 cm High Reflector Elemental Gd Cross Section (64000.35C)	1.0090	0.0024	1.08E-02
HEST155	95.2 g U/liter 0.400 g Gd/liter Critical Height: 51.2 cm Critical Mass= 6125.2 g H/U-235 = 295 47.0 cm High Reflector Isotopic Gd Cross Sections	1.0120	0.0020	1.11E-02
HXST155	95.2 g U/liter 0.400 g Gd/liter Critical Height: 51.2 cm Critical Mass= 6125.2 g H/U-235 = 295 47.0 cm High Reflector Elemental Gd Cross Section (64000.35C)	0.9961	0.0021	1.13E-02

Table 7.3-3. Critical Experiments using Highly Enriched Uranium Nitrate Solutions				
Case Name	Description	keff	2σ	AENCF
HEST161	156.5 g U/liter 0.0 g Gd/liter Critical Height: 15.1 cm Critical Mass= 2969.6 g H/U-235 = 175	0.9948	0.0029	1.52E-02
HEST162	143.6 g U/liter 0.300 g Gd/liter Critical Height: 22.1 cm Critical Mass= 3988.0 g H/U-235 = 192 Isotopic Gd Cross Sections	1.0091	0.0026	1.49E-02
HXST162	143.6 g U/liter 0.300 g Gd/liter Critical Height: 22.1 cm Critical Mass= 3988.0 g H/U-235 = 192 Elemental Gd Cross Section (64000.35C)	1.0039	0.0023	1.50E-02
HEST163	144.2 g U/liter 0.525 g Gd/liter Critical Height: 33.0 cm Critical Mass= 5979.8 g H/U-235 = 191 Isotopic Gd Cross Sections	1.0248	0.0024	1.60E-02
HXST163	144.2 g U/liter 0.525 g Gd/liter Critical Height: 33.0 cm Critical Mass= 5979.8 g H/U-235 = 191 Elemental Gd Cross Section (64000.35C)	1.0088	0.0023	1.66E-02
HEST171	202.4 g U/liter 0.0 g Gd/liter 12.4 cm Inner Radius Critical Height: 22.6 cm Critical Mass= 2776.7 g H/U-235 = 133 21.6 cm High Reflector	0.9968	0.0025	1.90E-02
HEST172	202.4 g U/liter 0.0 g Gd/liter 20.0 cm Inner Radius Critical Height: 15.6 cm Critical Mass= 3967.8 g H/U-235 = 133 0.0 cm High Reflector	0.9880	0.0026	2.08E-02
HEST173	202.4 g U/liter 0.0 g Gd/liter 20.0 cm Inner Radius Critical Height: 14.3 cm Critical Mass= 3637.1 g H/U-235 = 133 16.3 cm High Reflector	0.9834	0.0028	1.98E-02
HEST174	196.2 g U/liter 0.298 g Gd/liter 12.4 cm Inner Radius Critical Height: 34.8 cm Critical Mass= 3298.2 g H/U-235 = 137 45.4 cm High Reflector Isotopic Gd Cross Sections	1.0037	0.0026	1.94E-02
HXST174	196.2 g U/liter 0.298 g Gd/liter 12.4 cm Inner Radius Critical Height: 34.8 cm Critical Mass= 3298.2 g H/U-235 = 137 45.4 cm High Reflector Elemental Gd Cross Section (64000.35C)	0.9963	0.0025	1.94E-02
HEST175	192.0 g U/liter 0.497 g Gd/liter 12.4 cm Inner Radius Critical Height: 64.2 cm Critical Mass= 5954.3 g H/U-235 = 141 71.5 cm High Reflector Isotopic Gd Cross Sections	1.0091	0.0023	1.96E-02
HXST175	192.0 g U/liter 0.497 g Gd/liter 12.4 cm Inner Radius Critical Height: 64.2 cm Critical Mass= 5954.3 g H/U-235 = 141 71.5 cm High Reflector Elemental Gd Cross Section (64000.35C)	1.0000	0.0025	2.01E-02
HEST176	192.0 g U/liter 0.497 g Gd/liter 20.0 cm Inner Radius Critical Height: 25.7 cm Critical Mass= 6200.7 g H/U-235 = 141 0.0 cm High Reflector Isotopic Gd Cross Sections	1.0056	0.0025	2.20E-02
HEST177	192.0 g U/liter 0.497 g Gd/liter 20.0 cm Inner Radius Critical Height: 22.1 cm Critical Mass= 5332.2 g H/U-235 = 141 46.4 cm High Reflector Isotopic Gd Cross Sections	1.0082	0.0024	2.05E-02

Table 7.3-3. Critical Experiments using Highly Enriched Uranium Nitrate Solutions				
Case Name	Description	keff	2σ	AENCF
HEST178	186.2 g U/liter 0.790 g Gd/liter 20.0 cm Inner Radius Critical Height: 37.7 cm Critical Mass= 8821.3 g H/U-235 = 147 0.0 cm High Reflector Isotopic Gd Cross Sections	1.0056	0.0022	2.20E-02
HXST178	186.2 g U/liter 0.790 g Gd/liter 20.0 cm Inner Radius Critical Height: 37.7 cm Critical Mass= 8821.3 g H/U-235 = 147 0.0 cm High Reflector Elemental Gd Cross Section (64000.35C)	0.9919	0.0025	2.24E-02
HEST181	300.0 g U/liter 0.0 g Gd/liter 12.4 cm Inner Radius Critical Height: 21.7 cm Critical Mass= 3144.7 g H/U-235 = 86 21.6 cm High Reflector	0.9949	0.0028	2.83E-02
HEST182	300.0 g U/liter 0.0 g Gd/liter 20.0 cm Inner Radius Critical Height: 15.5 cm Critical Mass= 5843.4 g H/U-235 = 86 0.0 cm High Reflector	0.9922	0.0029	3.09E-02
HEST183	300.0 g U/liter 0.0 g Gd/liter 20.0 cm Inner Radius Critical Height: 14.3 cm Critical Mass= 5391.0 g H/U-235 = 86 14.3 cm High Reflector	0.9929	0.0027	2.93E-02
HEST184	291.3 g U/liter 0.497 g Gd/liter 12.4 cm Inner Radius Critical Height: 34.8 cm Critical Mass= 3298.2 g H/U-235 = 89 45.4 cm High Reflector Isotopic Gd Cross Sections	1.0019	0.0026	1.94E-02
HXST184	291.3 g U/liter 0.497 g Gd/liter 12.4 cm Inner Radius Critical Height: 34.8 cm Critical Mass= 3298.2 g H/U-235 = 89 45.4 cm High Reflector Elemental Gd Cross Section (64000.35C)	0.9966	0.0023	2.91E-02
HEST185	291.3 g U/liter 0.497 g Gd/liter 20.0 cm Inner Radius Critical Height: 20.2 cm Critical Mass= 7394.4 g H/U-235 = 89 0.0 cm High Reflector Isotopic Gd Cross Sections	0.9977	0.0026	3.26E-02
HEST186	291.3 g U/liter 0.497 g Gd/liter 20.0 cm Inner Radius Critical Height: 17.9 cm Critical Mass= 6552.4 g H/U-235 = 89 21.4 cm High Reflector Isotopic Gd Cross Sections	0.9948	0.0026	3.11E-02
HEST187	283.3 g U/liter 0.497 g Gd/liter 12.4 cm Inner Radius Critical Height: 83.2 cm Critical Mass= 11385.8 g H/U-235 = 92 81.1 cm High Reflector Isotopic Gd Cross Sections	1.0129	0.0026	2.91E-02
HXST187	283.3 g U/liter 0.497 g Gd/liter 12.4 cm Inner Radius Critical Height: 83.2 cm Critical Mass= 11385.8 g H/U-235 = 92 81.1 cm High Reflector Elemental Gd Cross Section (64000.35C)	0.9990	0.0025	3.05E-02
HEST188	283.3 g U/liter 0.977 g Gd/liter 20.0 cm Inner Radius Critical Height: 28.1 cm Critical Mass= 10003.7 g H/U-235 = 92 0.0 cm High Reflector Isotopic Gd Cross Sections	1.0134	0.0025	3.31E-02
HEST189	283.3 g U/liter 0.977 g Gd/liter 20.0 cm Inner Radius Critical Height: 23.3 cm Critical Mass= 8294.9 g H/U-235 = 91 31.2 cm High Reflector Isotopic Gd Cross Sections	1.0101	0.0025	3.10E-02
HST1810	285.3 g U/liter 1.400 g Gd/liter 20.0 cm Inner Radius Critical Height: 41.4 cm Critical Mass= 14842.7 g H/U-235 = 91 0.0 cm High Reflector Isotopic Gd Cross Sections	1.0282	0.0024	3.45E-02

Table 7.3-3. Critical Experiments using Highly Enriched Uranium Nitrate Solutions

Case Name	Description	keff	2σ	AENCF
HXT1810	285.3 g U/liter 1.400 g Gd/liter 20.0 cm Inner Radius Critical Height: 41.4 cm Critical Mass= 14842.7 g H/U-235 = 91 0.0 cm High Reflector Elemental Gd Cross Section (64000.35C)	1.0104	0.0024	3.48E-02
HST1811	285.3 g U/liter 1.400 g Gd/liter 20.0 cm Inner Radius Critical Height: 31.5 cm Critical Mass= 11293.3 g H/U-235 = 91 55.4 cm High Reflector Isotopic Gd Cross Sections	1.0237	0.0023	3.25E-02
HST1812	279.6 g U/liter 1.943 g Gd/liter 20.0 cm Inner Radius Critical Height: 48.8 cm Critical Mass= 17146.2 g H/U-235 = 94 59.4 cm High Reflector Isotopic Gd Cross Sections	1.0211	0.0022	3.33E-02
HXT1812	279.6 g U/liter 1.943 g Gd/liter 20.0 cm Inner Radius Critical Height: 48.8 cm Critical Mass= 17146.2 g H/U-235 = 94 59.4 cm High Reflector Elemental Gd Cross Section (64000.35C)	1.0002	0.0020	3.34E-02
HEST191	447.3 g U/liter 0.0 g Gd/liter 12.4 cm Inner Radius Critical Height: 22.6 cm Critical Mass= 4883.2 g H/U-235 = 55 21.6 cm High Reflector	1.0024	0.0025	4.22E-02
HEST192	393.6 g U/liter 0.647 g Gd/liter 12.4 cm Inner Radius Critical Height: 31.5 cm Critical Mass= 5989.1 g H/U-235 = 63 42.4 cm High Reflector Isotopic Gd Cross Sections	1.0020	0.0025	3.92E-02
HXST192	393.6 g U/liter 0.647 g Gd/liter 12.4 cm Inner Radius Critical Height: 31.5 cm Critical Mass= 5989.1 g H/U-235 = 63 42.4 cm High Reflector Elemental Gd Cross Section (64000.35C)	0.9970	0.0025	3.87E-02
HEST193	400.0 g U/liter 1.160 g Gd/liter 12.4 cm Inner Radius Critical Height: 45.5 cm Critical Mass= 8791.5 g H/U-235 = 61 59.4 cm High Reflector Isotopic Gd Cross Sections	0.9998	0.0024	4.20E-02
HXST193	400.0 g U/liter 1.160 g Gd/liter 12.4 cm Inner Radius Critical Height: 45.5 cm Critical Mass= 8791.5 g H/U-235 = 61 59.4 cm High Reflector Elemental Gd Cross Section (64000.35C)	0.9914	0.0024	4.27E-02
	Average =	1.0047	0.0033	
	Number =	119		

Table 7.3-4. Critical Experiments using Low-enrichment Uranium Solutions				
Case Name	Description	keff	2σ	AENCF
LEUST21	452.2 g U/liter 22.11 g U-235/liter Water Reflector Critical Volume: 170.5 Liters Critical Mass = 3769.8 g U-235 H/U-235: 1098	0.9986	0.0012	2.46E-02
LEUST22	491.7 g U/liter 24.04 g U-235/liter No Reflector Critical Volume: 172 Liters Critical Mass = 4134.9 g U-235 H/U-235: 1001	0.9956	0.0013	2.82E-02
LEUST23	491.7 g U/liter 24.04 g U-235/liter Water Reflector Critical Volume = 145.6 Liters Critical Mass = 3500.2 g U-235 H/U-235: 1001	1.0008	0.0012	2.65E-02
LEUJA01	310.1 g U/liter 30.9 g U-235/liter Water Reflector Critical Height: 41.53 cm Critical Mass = 3508.4 g U-235 H/U-235: 719.0 H/U: 72.5	1.0030	0.0018	1.93E-02
LEUJA29	290.4 g U/liter 29.0 g U-235/liter Water Reflector Critical Height: 46.70 cm Critical Mass = 3702.6 g U-235 H/U-235: 771.3 H/U: 77.8	1.0028	0.0017	1.81E-02
LEUJA33	270.0 g U/liter 26.9 g U-235/liter Water Reflector Critical Height: 52.93 cm Critical Mass = 3892.7 g U-235 H/U-235: 842.2 H/U: 84.9	1.0017	0.0018	1.66E-02
LEUJA34	253.6 g U/liter 25.3 g U-235/liter Water Reflector Critical Height: 64.85 cm Critical Mass = 4485.6 g U-235 H/U-235: 895.8 H/U: 90.3	1.0037	0.0016	1.57E-02
LEUJA46	241.9 g U/liter 24.1 g U-235/liter Water Reflector Critical Height: 78.56 cm Critical Mass = 5176.2 g U-235 H/U-235: 941.7 H/U: 95.0	1.0043	0.0015	1.55E-02
LEUJA51	233.2 g U/liter 23.3 g U-235/liter Water Reflector Critical Height: 95.50 cm Critical Mass = 6083.5 g U-235 H/U-235: 982.5 H/U: 99.1	1.0031	0.0015	1.46E-02
LEUJA54	225.3 g U/liter 22.5 g U-235/liter Water Reflector Critical Height: 130.33 cm Critical Mass = 8017.2 g U-235 H/U-235: 1017.5 H/U: 102.6	1.0037	0.0014	1.44E-02
LEUJA14	313.0 g U/liter 31.2 g U-235/liter No Reflector Critical Height: 46.83 cm Critical Mass = 3994.6 g U-235 H/U-235: 709.2 H/U: 71.5	0.9989	0.0021	1.98E-02
LEUJA30	290.7 g U/liter 29.0 g U-235/liter No Reflector Critical Height: 54.20 cm Critical Mass = 4297.3 g U-235 H/U-235: 770.0 H/U: 77.7	0.9987	0.0018	1.88E-02
LEUJA32	270.0 g U/liter 26.9 g U-235/liter No Reflector Critical Height: 63.55 cm Critical Mass = 4673.7 g U-235 H/U-235: 842.2 H/U: 84.9	0.9988	0.0017	1.72E-02
LEUJA36	253.9 g U/liter 25.3 g U-235/liter No Reflector Critical Height: 83.55 cm Critical Mass = 5779.1 g U-235 H/U-235: 896.0 H/U: 90.4	1.0016	0.0017	1.69E-02

Table 7.3-4. Critical Experiments using Low-enrichment Uranium Solutions

Case Name	Description	keff	2σ	AENCF
LEUJA49	241.9 g U/liter 24.1 g U-235/liter No Reflector Critical Height: 112.27 cm Critical Mass = 7397.3 g U-235 H/U-235: 942.2 H/U: 95.0	1.0003	0.0017	1.69E-02
	Average =	1.0010	0.0016	
	Number =	15		

Table 7.3-5. Critical Experiments using Intermediate-enrichment Uranium Solutions				
Case Name	Description	keff	2σ	AENCF
IECT101	15X14X14 Array 2392 U Cubes 598 Polyethylene cubes Paraffin Reflector Critical Mass = 36789.0 g U-235 H/U-235 = 7.94	0.9958	0.0019	2.19E-01
IECT102	12X12X11 Array 1140 U Cubes 570 Polyethylene cubes Paraffin Reflector Critical Mass = 17533.2 g U-235 H/U-235 = 15.88	0.9996	0.0018	1.58E-01
IECT103	10X10X9 Array 498 U Cubes 498 Polyethylene cubes Paraffin Reflector Critical Mass = 7659.2 g U-235 H/U-235 = 31.75	0.9939	0.0019	1.05E-01
IECT104	10X10X8 Array 298 U Cubes 596 Polyethylene cubes Paraffin Reflector Critical Mass = 4583.2 g U-235 H/U-235 = 63.51	0.9975	0.0020	7.44E-02
IECT105	16X14X14 Array 400 U Cubes 2800 Polyethylene cubes Paraffin Reflector Critical Mass = 6152.0 g U-235 H/U-235 = 222.3	1.0078	0.0015	4.55E-02
IECT106	10X10X10 Array 527 U Cubes 527 Polyethylene cubes Paraffin Reflector Critical Mass = 8105.3 g U-235 H/U-235 = 31.75	1.0007	0.0021	1.08E-01
IECT107	11X10X10 Array 558 U Cubes 558 Polyethylene cubes Paraffin Reflector Critical Mass = 4583.2 g U-235 H/U-235 = 31.75	0.9978	0.0019	1.11E-01
IECT108	11X11X10 Array 646 U Cubes 646 Polyethylene cubes Paraffin Reflector Critical Mass = 9935.5 g U-235 H/U-235 = 31.75	0.9968	0.0020	1.19E-01
IECT109	13X12X12 Array 1290 U Cubes 645 Polyethylene cubes Paraffin Reflector Critical Mass = 19840.2 g U-235 H/U-235 = 15.88	1.0017	0.0018	1.68E-01
IECT110	11X11X14 Array 1155 U Cubes 578 Polyethylene cubes Paraffin Reflector Critical Mass = 17763.9 g U-235 H/U-235 = 15.89	0.9949	0.0020	1.57E-01
IECT111	10X10X19 Array 1295 U Cubes 648 Polyethylene cubes Paraffin Reflector Critical Mass = 19917.1 g U-235 H/U-235 = 15.89	0.9944	0.0019	1.58E-01
IECT112	9X9X39 Array 2150 U Cubes 1075 Polyethylene cubes Paraffin Reflector Critical Mass = 33067.0 g U-235 H/U-235 = 15.88	0.9960	0.0021	1.57E-01
IECT113	9X9X11 Array 302 U Cubes 604 Polyethylene cubes Paraffin Reflector Critical Mass = 4644.8 g U-235 H/U-235 = 63.51	0.9996	0.0021	7.39E-02
IECT114	8X8X16 Array 356 U Cubes 712Polyethylene cubes Paraffin Reflector Critical Mass = 5475.3 g U-235 H/U-235 = 63.51	0.9990	0.0019	7.43E-02
IECT115	8X7X26 Array 488 U Cubes 976 Polyethylene cubes Paraffin Reflector Critical Mass = 7505.4 g U-235 H/U-235 = 63.51	0.9999	0.0019	7.32E-02

Table 7.3-5. Critical Experiments using Intermediate-enrichment Uranium Solutions				
Case Name	Description	keff	2σ	AENCF
IECT116	11X11X10 Array 258 U Cubes 1032 Polyethylene cubes (½ thickness) Paraffin Reflector Critical Mass = 3968.0 g U-235 H/U-235 = 63.51	1.0021	0.0019	5.50E-02
IECT117	16X16X16 Array 2810 U Cubes 1405 Polyethylene cubes (½ thickness) No Reflector Critical Mass = 43217.8 g U-235 H/U-235 = 7.94	0.9958	0.0019	2.07E-01
IECT118	13X14X13 Array 1232 U Cubes 1232 Polyethylene cubes (½ thickness) No Reflector Critical Mass = 18948.2 g U-235 H/U-235 = 15.88	0.9970	0.0021	1.33E-01
IECT119	14X13X12 Array 464 U Cubes 1856 Polyethylene cubes (½ thickness) No Reflector Critical Mass = 7136.3 g U-235 H/U-235 = 63.51	1.0029	0.0018	6.55E-02
IECT120	12X13X11 Array 1170 U Cubes 585 Polyethylene cubes (½ thickness) Paraffin Reflector Critical Mass = 17994.6 g U-235 H/U-235 = 7.94	1.0027	0.0019	1.55E-01
IECT121	15X15X13 Array 2450 U Cubes 612 Polyethylene cubes (½ thickness) Paraffin Reflector Critical Mass = 37681.0 g U-235 H/U-235 = 3.97	0.9968	0.0019	2.13E-01
IECT122	15X15X14 Array 2235 U Cubes 1117 Polyethylene cubes (½ thickness) Cd & Paraffin Reflector Critical Mass = 34374.3 g U-235 H/U-235 = 7.93	0.9954	0.0020	1.97E-01
IECT123	12X13X12 Array 965 U Cubes 965 Polyethylene cubes (½ thickness) Paraffin Reflector Cd & Critical Mass = 14841.7 g U-235 H/U-235 = 15.88	0.9930	0.0027	1.28E-01
IECT124	13X13X13 Array 1118 U Cubes 1118 Polyethylene cubes (½ thickness) B & Paraffin Reflector Critical Mass = 17194.8 g U-235 H/U-235 = 15.88	1.0017	0.0023	1.32E-01
IECT125	13X13X11 Array 400 U Cubes 1600 Polyethylene cubes (½ thickness) Cd & Paraffin Reflector Critical Mass = 6152.0 g U-235 H/U-235 = 63.51	1.0016	0.0019	6.01E-02
IECT126	12X13X12 Array 341 U Cubes 1364 Polyethylene cubes (½ thickness) Paraffin Reflector Critical Mass = 5244.6 g U-235 H/U-235 = 63.51	1.0061	0.0018	5.62E-02
IECT127	14X13X12 Array 378 U Cubes 1512 Polyethylene cubes (½ thickness) Paraffin Reflector Critical Mass = 5813.6 g U-235 H/U-235 = 63.51	1.0034	0.0018	5.59E-02
IECT128	14X14X13 Array 1510 U Cubes 755 Polyethylene cubes (½ thickness) Paraffin Reflector Critical Mass = 23223.8 g U-235 H/U-235 = 7.94	1.0034	0.0018	1.59E-01

IECT129	16X15X15 Array 1807 U Cubes 903 Polyethylene cubes (½ thickness) Paraffin Reflector Critical Mass = 27791.7 g U-235 H/U-235 = 7.94	1.0018	0.0019	1.52E-01
		Average =	0.9993	0.0020
		Number =	29	

Figure 7.3-1. Critical Experiments using Mixed Plutonium and Uranium Nitrate Solutions

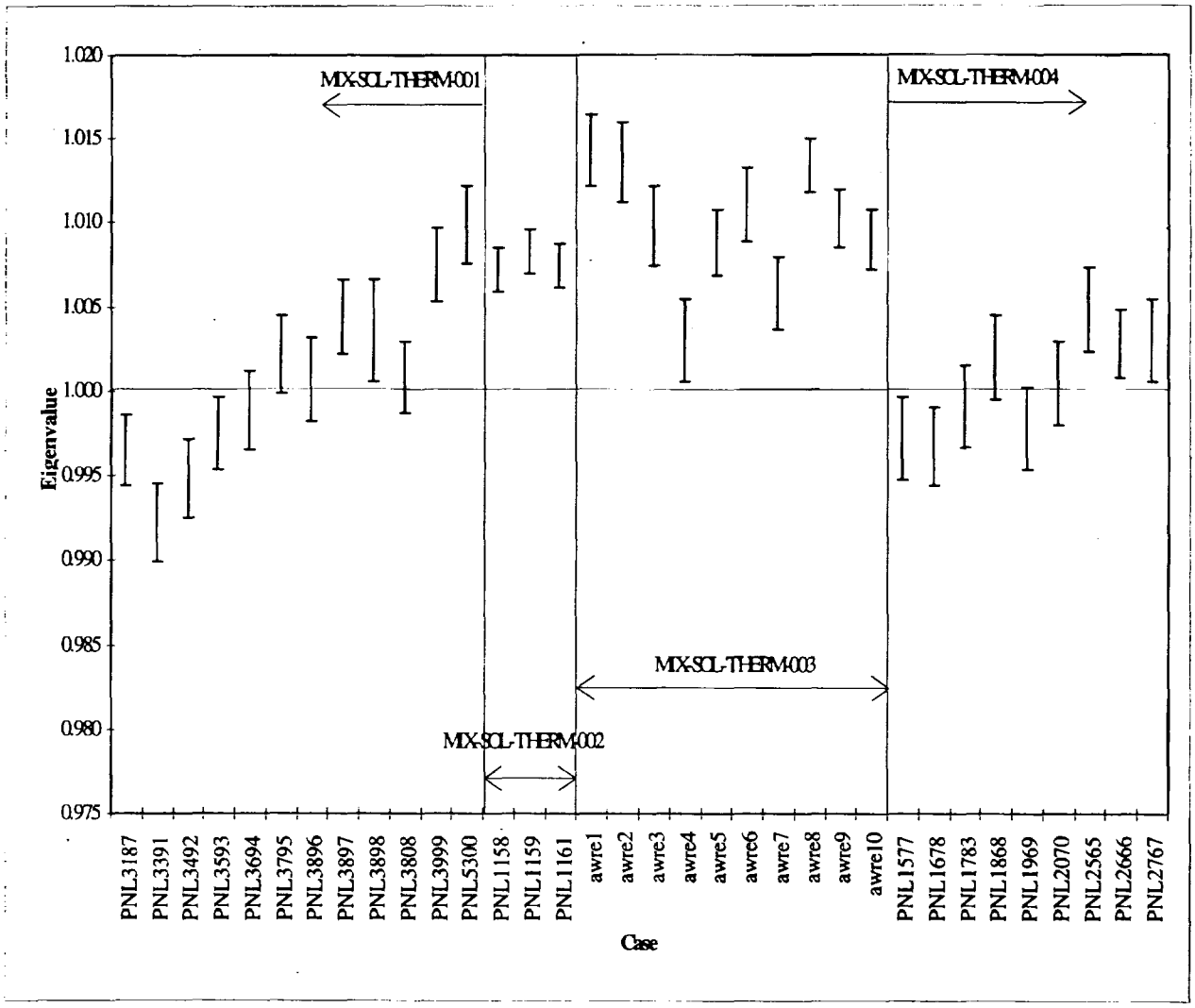


Figure 7.3-2. Critical Experiments using Plutonium Nitrate Solutions

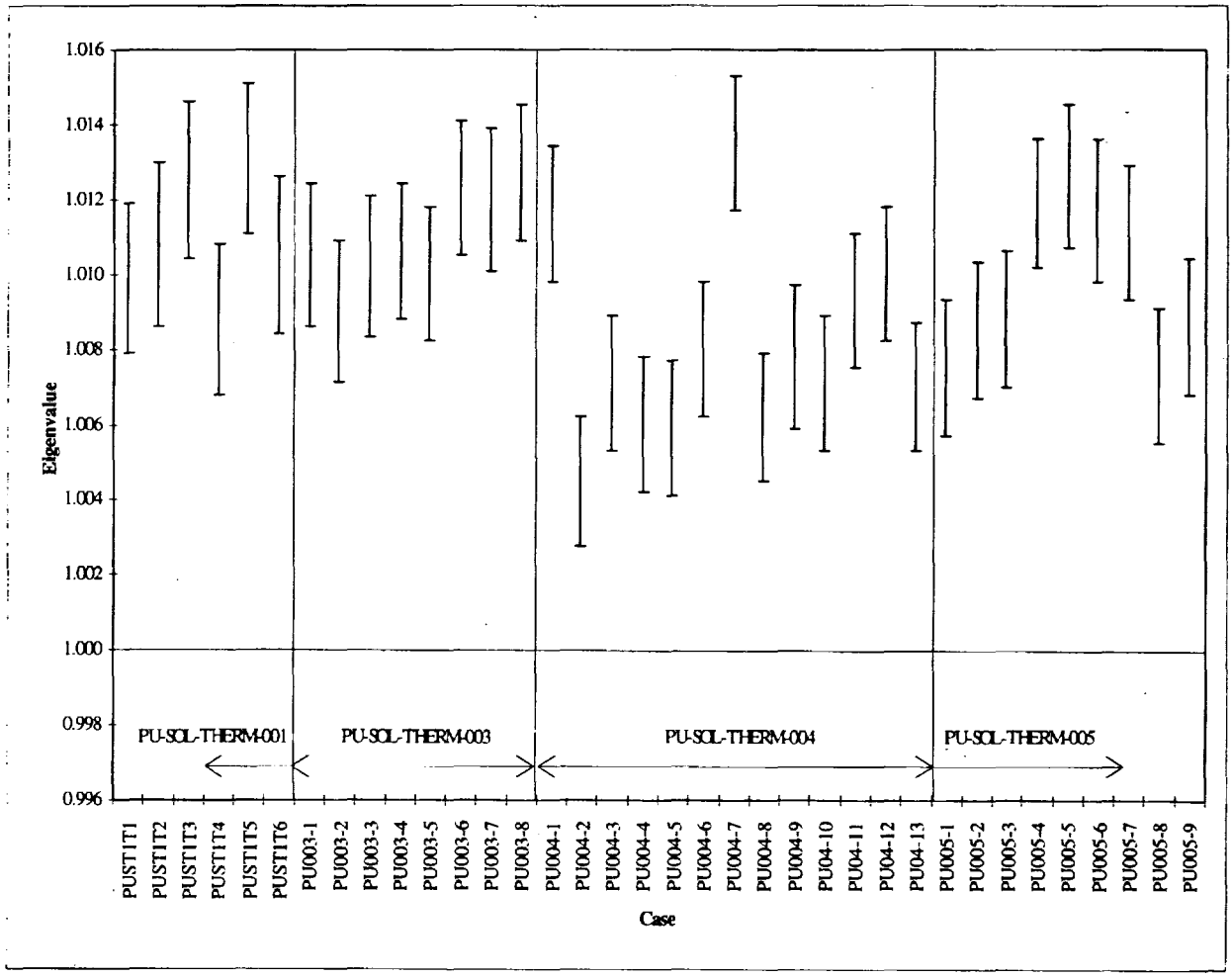


Figure 7.3-2. (cont'd)

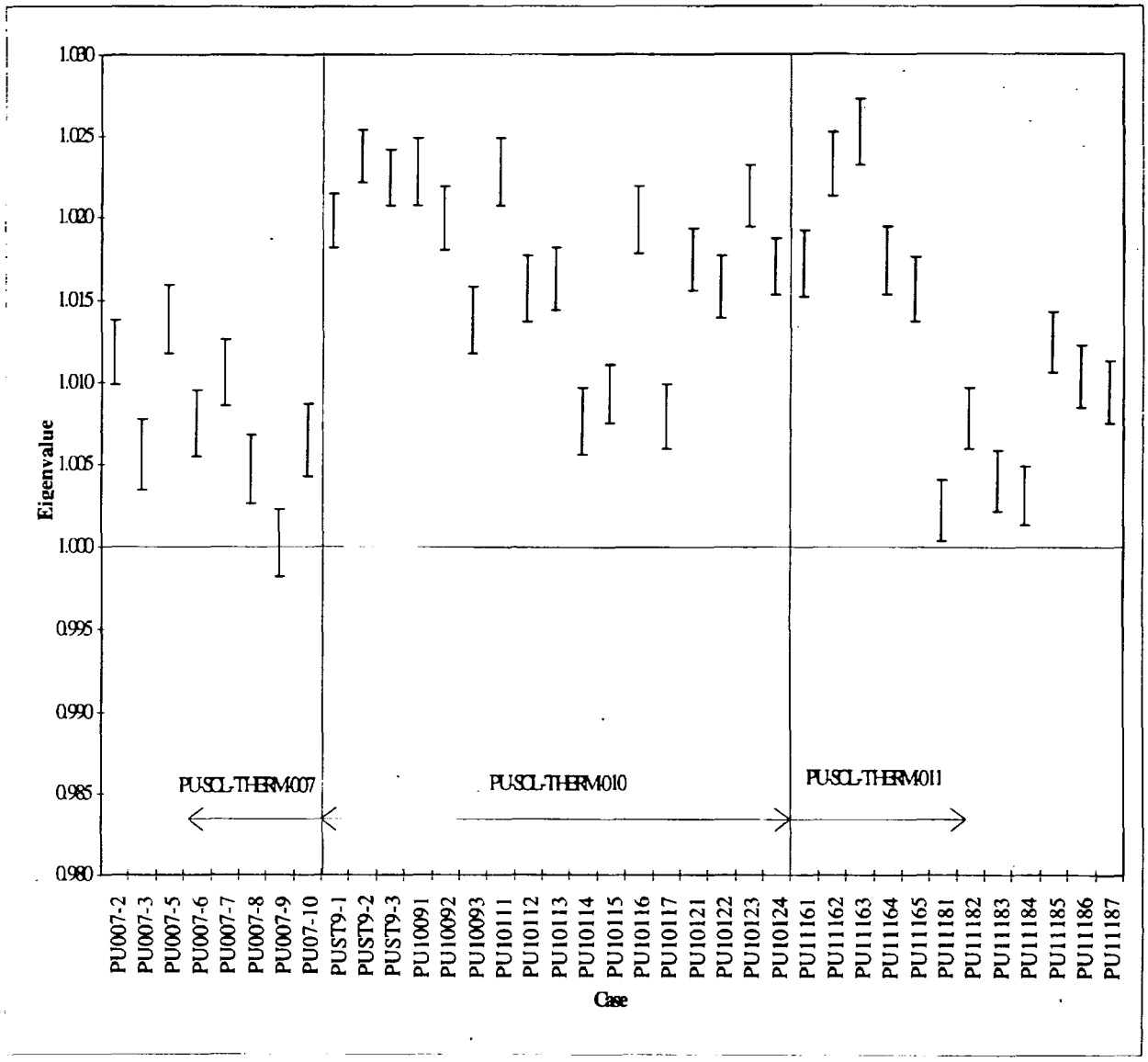


Figure 7.3-3. Critical Experiments using Highly Enriched Uranium Nitrate Solutions

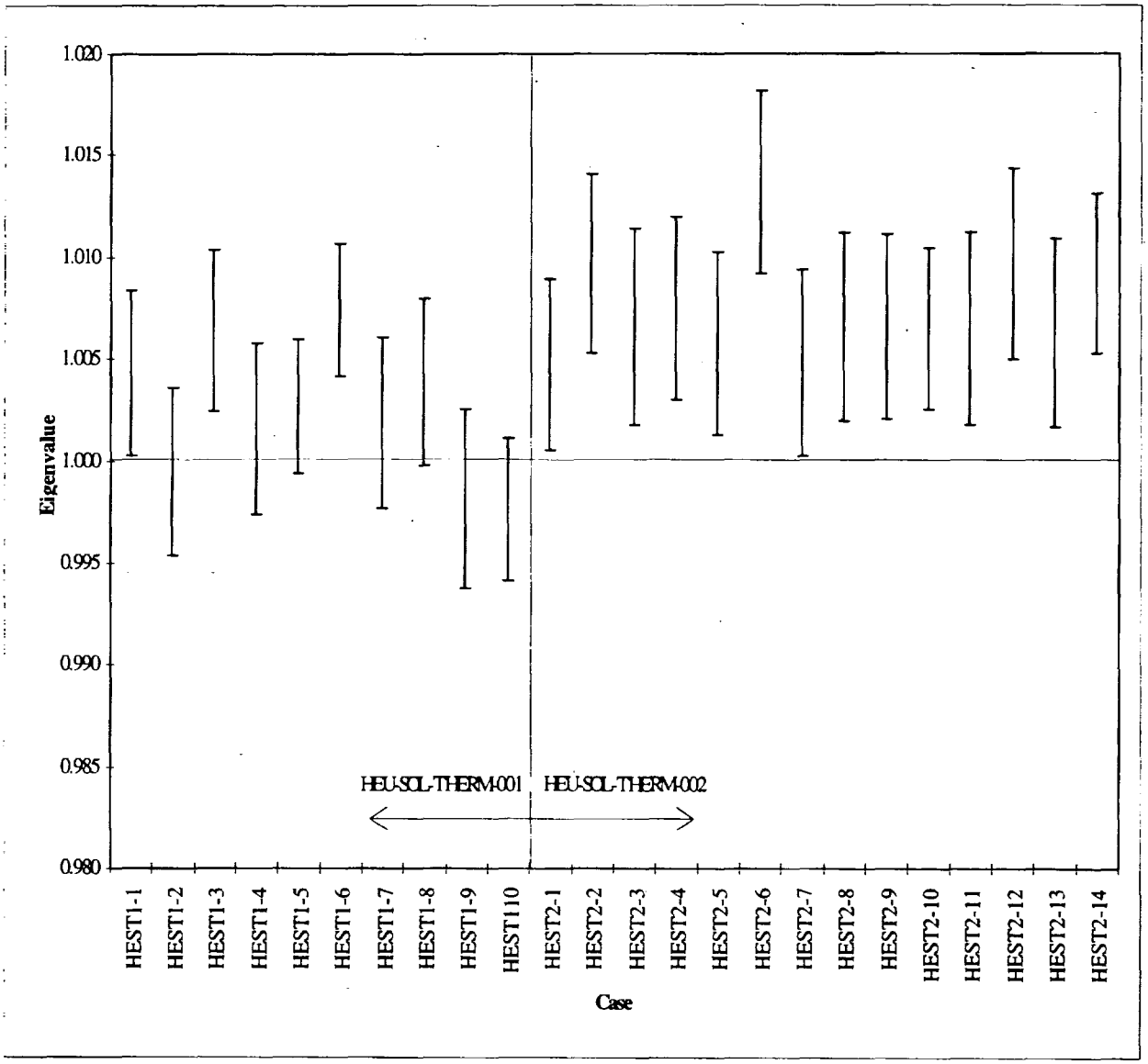


Figure 7.3-3. (cont'd)

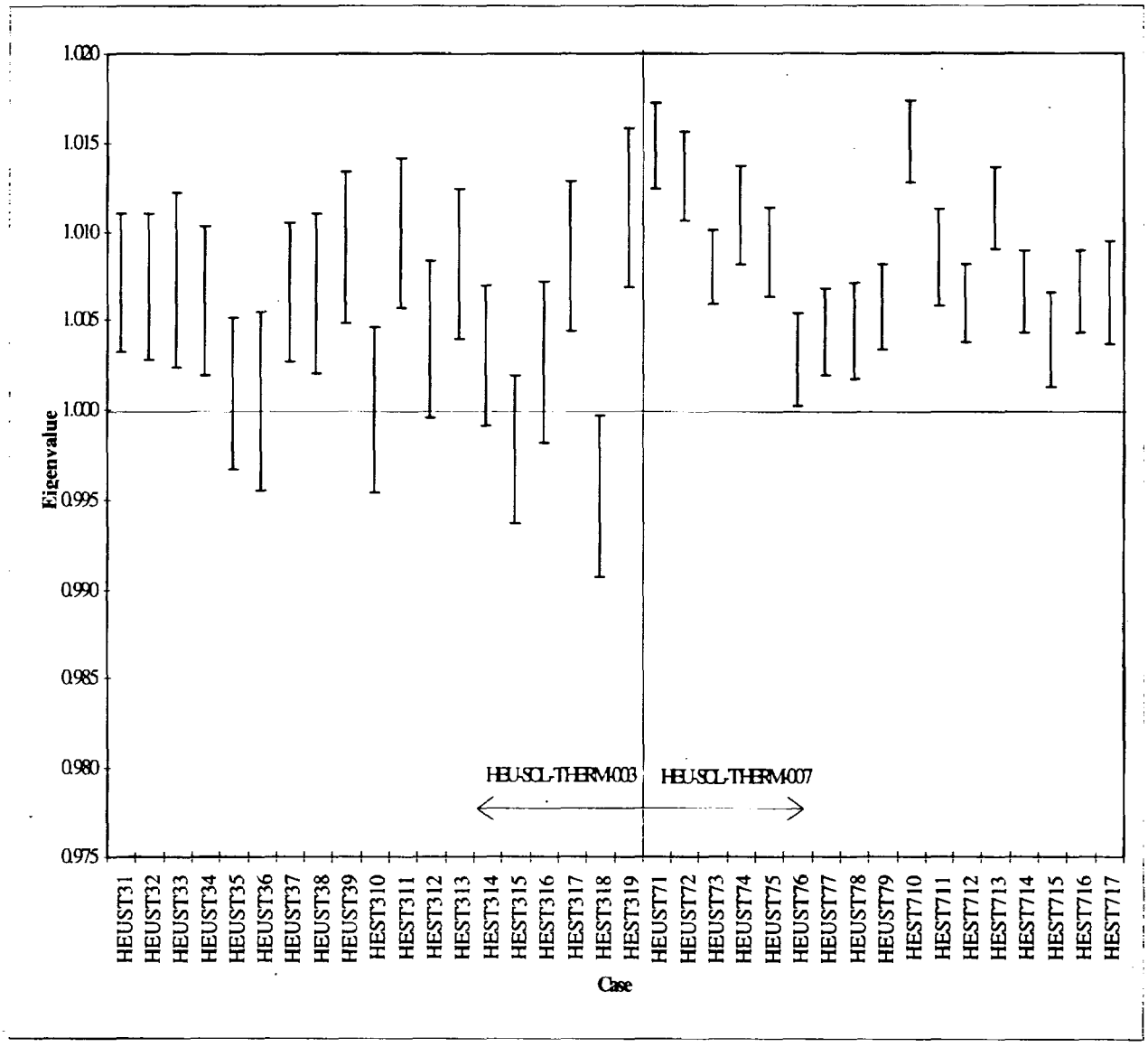


Figure 7.3-3. (cont'd)

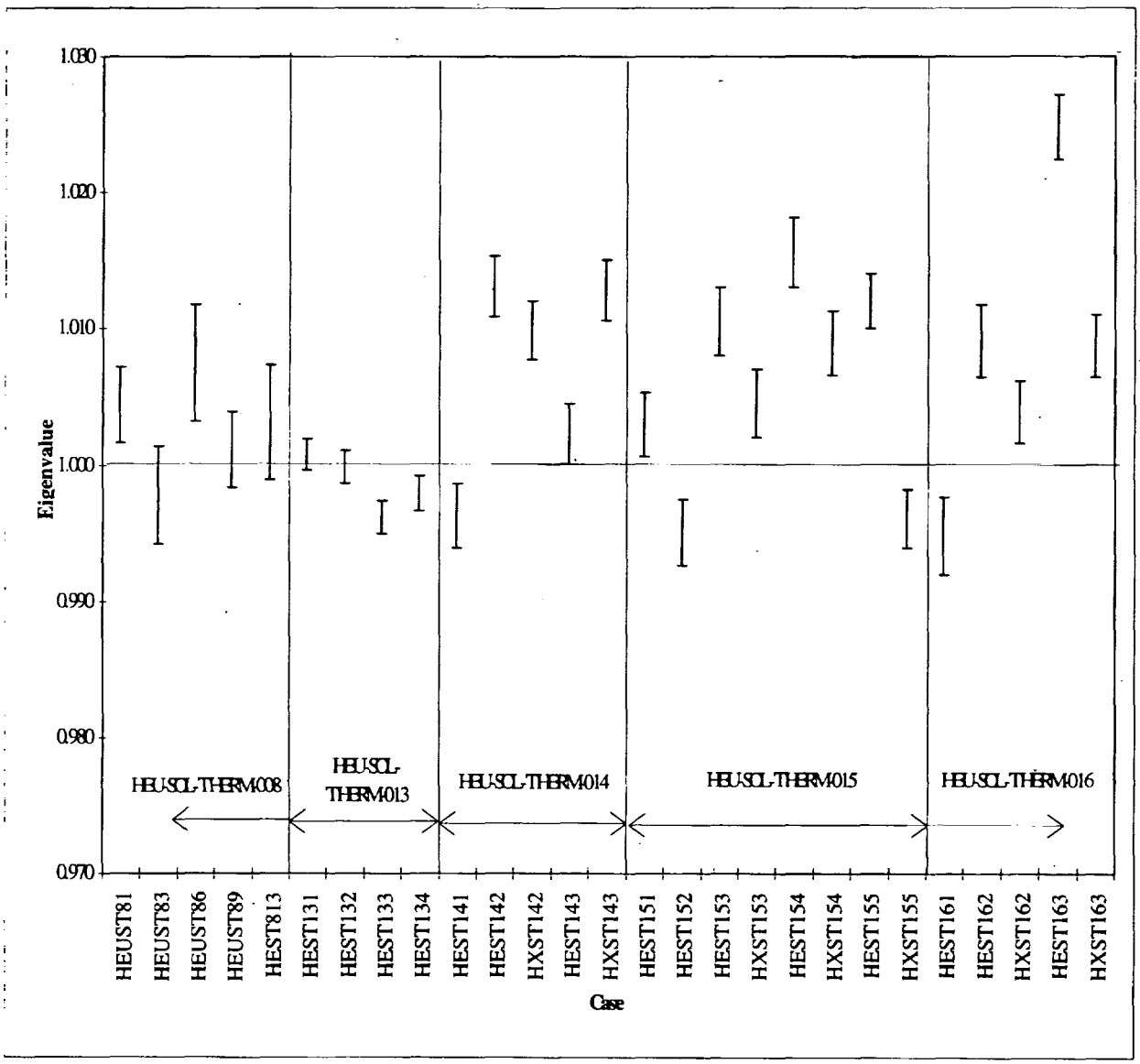


Figure 7.3-3. (cont'd)

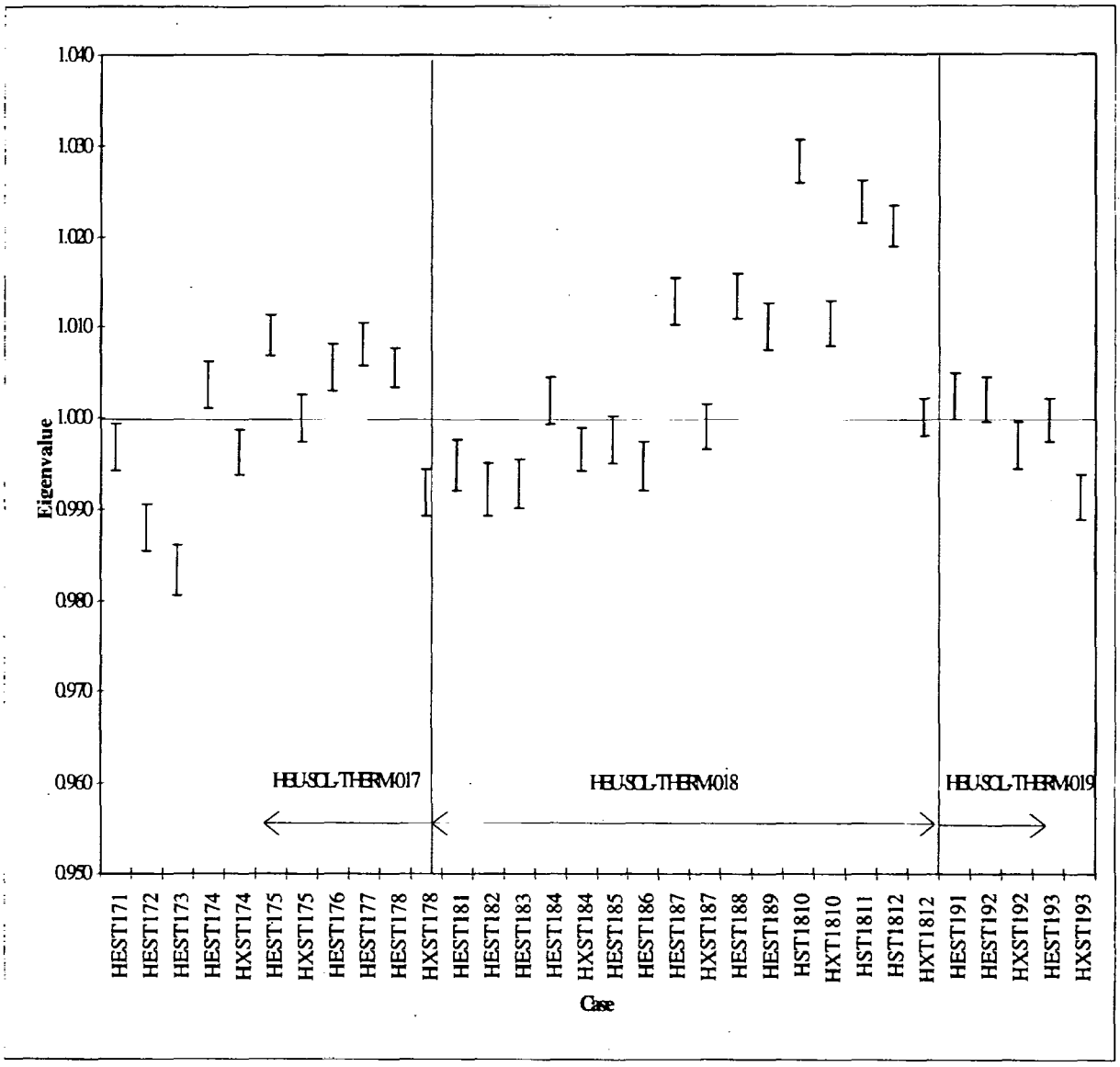


Figure 7.3-4. Critical Experiments using Low-enrichment Uranium Solutions

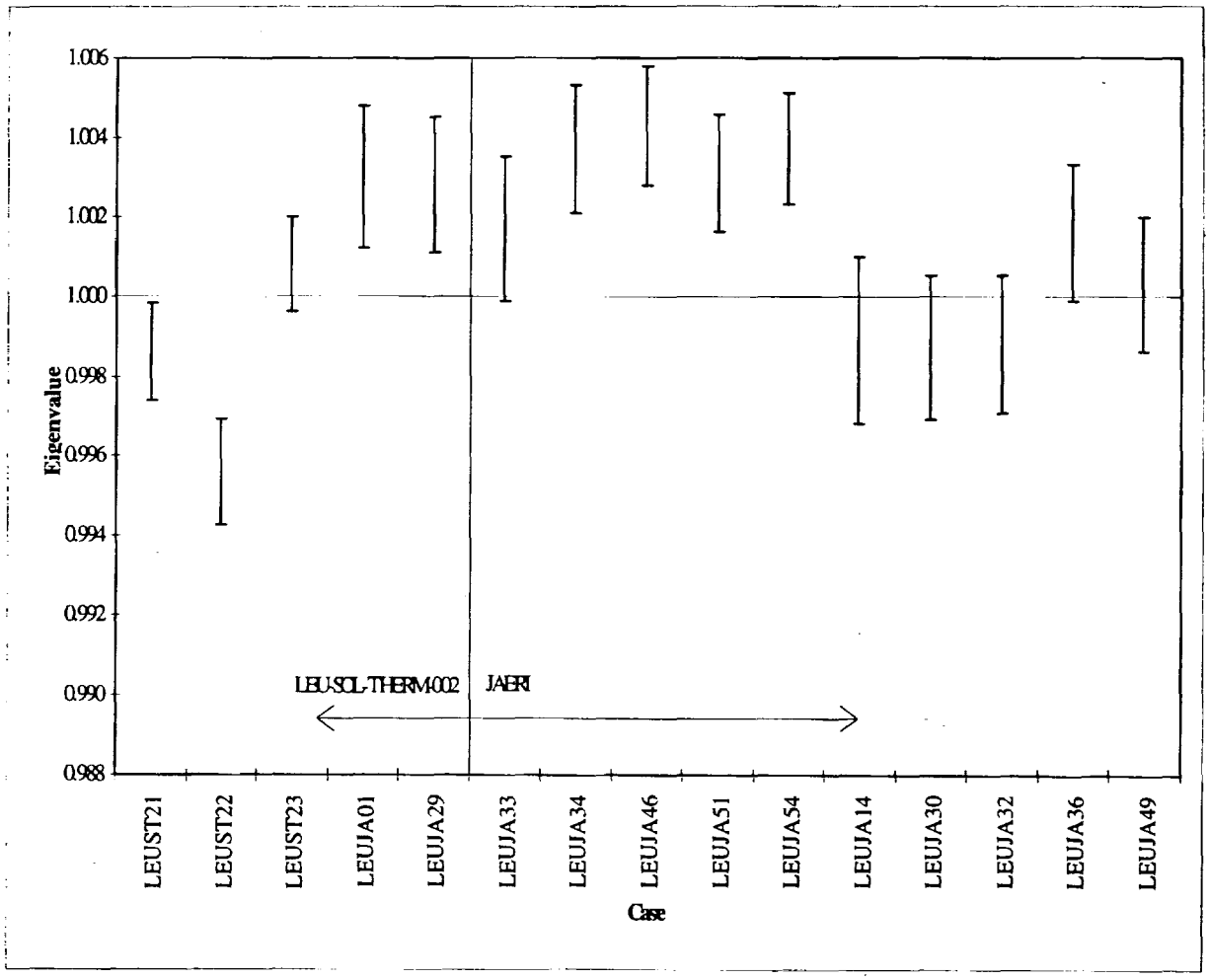
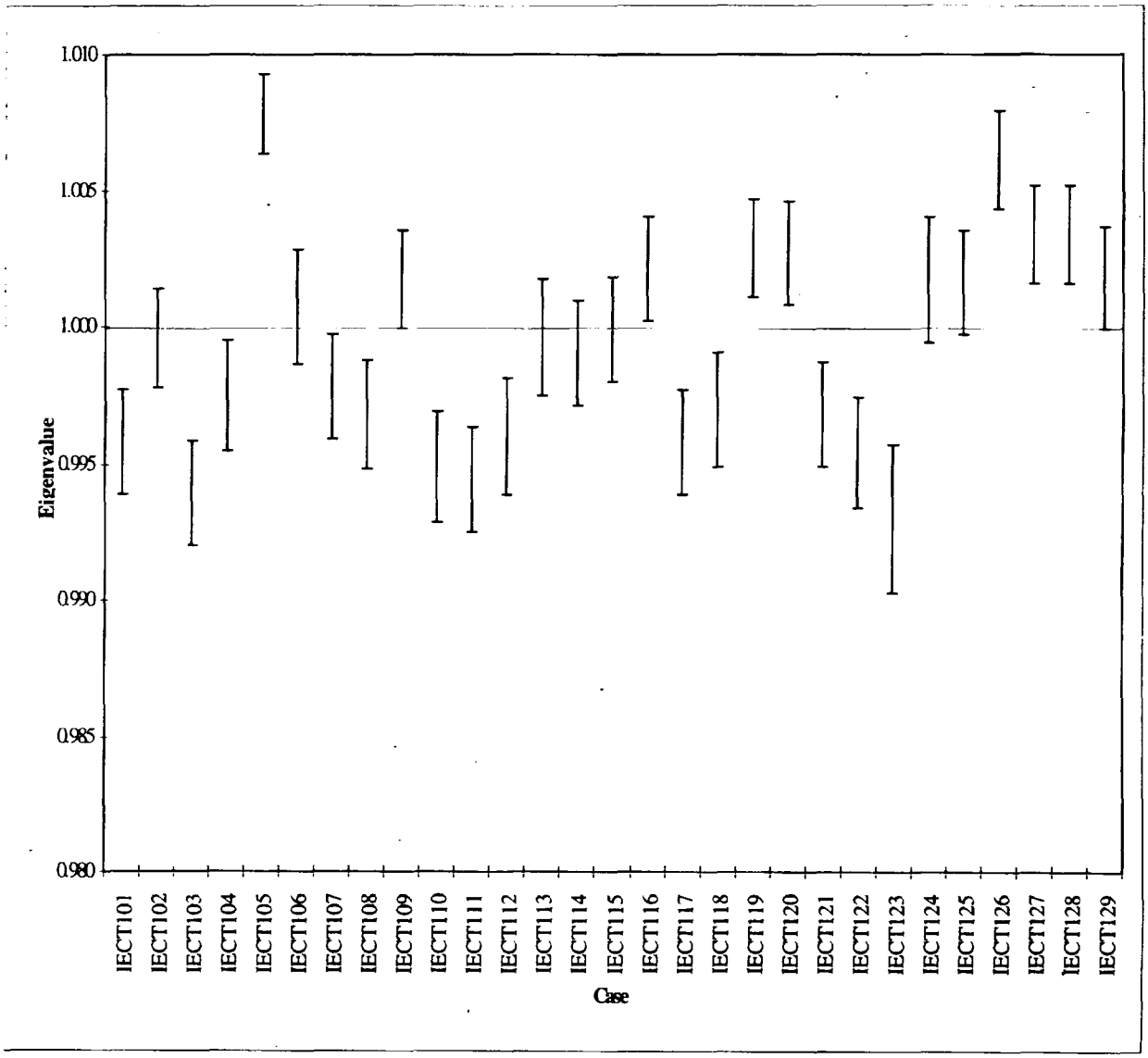


Figure 7.3-5. Critical Experiments using Intermediate-enrichement Uranium Solutions



7.4 MCNP Results

The average eigenvalues and uncertainty values for each of the classes of cases are summarized in Table 7.4-1. The pertinent features of the results may be summarized as:

1. Agreement between MCNP and the experiments appears to degrade for systems that incorporate plutonium; and
2. Agreement is progressively better with low and intermediate enrichments for systems that only incorporated uranium as the fissile material.

It is important to note that the average eigenvalue and uncertainty values shown in Table 7.4-1 are not those intended for use in repository calculations, but are only factors in determining the bias function to use in such applications.

Table 7.4-1. MCNP Average Neutron Multiplication and Uncertainties

Description	k_{eff}	Uncertainty	Number
Mixed Plutonium and Natural Uranium Nitrate Solutions	1.0040	0.0022	34
Plutonium Nitrate Solutions	1.0116	0.0019	73
Highly Enriched Uranium Nitrate Solutions	1.0047	0.0033	119
Low-enrichment Uranium Solutions	1.0010	0.0016	15
Intermediate-enrichment Uranium Solutions	0.9993	0.0020	29
	Average	Average	Total
	1.00411	0.00261	270

8. Conclusions

The ability of the M&O controlled version of MCNP 4A to predict eigenvalues for uranium and plutonium homogeneous mixtures was determined for a large constellation of Laboratory Critical Experiments using ENDF/B-V cross section libraries. The agreement was well within one percent except for systems exclusively incorporating plutonium as the fissile species. These results will subsequently be used to determine an appropriate bias for waste package criticality calculations.

In order to better understand the sensitivity of the results to the libraries used and to clearly quantify the range of parameters important to criticality embodied in each experiment, additional studies should be performed. Sensitivity studies might include use of ENDF/B-VI cross section libraries and investigations of the specific cross section treatments for the fissionable nuclides to improve agreement with libraries tuned to the specific problem set. Range-of-applicability studies would be used to study the variation in the bias and might include the following parameters:

- H/U ratio,
- leakage from the critical configuration,
- ratio of fissile plutonium to fissile uranium, and
- average energy of neutron causing fission (AENCF).

Further, these results should be compared with those obtained in the OECD compilation (Reference 5.5), which was the source of the MCNP input representations for the vast majority of the configurations studied.

The purpose of this analysis was to assess the ability of MCNP to predict the neutron multiplication of criticality safety benchmark experiments involving solutions of uranium and plutonium.

9. Attachments

List of Attachments

Attachment	Description	Number of Pages
I	List of MCNP Output Files on Enclosed Magnetic Tape [a]	2

[a]. The magnetic tape has been logged to the Document Records as Reference 5.11.

Contents of Tape Containing Output Files

File Name	Size (KB)	File Name	Size (KB)	File Name	Size (KB)	File Name	Size (KB)
AWRE10O	313	HEST1-6O	382	HEST310O	234	HST1811O	280
AWRE1O	311	HEST171O	278	HEST311O	234	HST1812O	279
AWRE2O	311	HEST172O	275	HEST312O	234	HXST142O	278
AWRE3O	311	HEST173O	276	HEST313O	234	HXST143O	277
AWRE4O	311	HEST174O	283	HEST314O	233	HXST153O	275
AWRE5O	313	HEST175O	283	HEST315O	234	HXST154O	278
AWRE6O	312	HEST176O	279	HEST316O	234	HXST155O	276
AWRE7O	311	HEST178O	278	HEST317O	233	HXST162O	277
AWRE8O	314	HEST1-7O	382	HEST318O	234	HXST163O	276
AWRE9O	314	HEST181O	277	HEST319O	233	HXST174O	278
HEUST77P	331	HEST182O	275	HEST710O	347	HXST175O	278
HEST711P	346	HEST183O	276	HEST712O	342	HXST178O	275
HEST714P	329	HEST184O	283	HEST713O	340	HXST184O	278
HEUST71P	347	HEST185O	278	HEST715O	340	HXST187O	278
HEUST73P	332	HEST186O	279	HEST716O	346	HXST192O	278
HEST177P	280	HEST187O	282	HEST717O	340	HXST193O	278
HEST110O	382	HEST188O	278	HEST813O	287	HXT1810O	275
HEST1-1O	386	HEST189O	280	HEUST31O	237	HXT1812O	275
HEST1-2O	386	HEST1-8O	382	HEUST32O	237	IECT101O	340
HEST131O	395	HEST191O	277	HEUST33O	237	IECT102O	335
HEST132O	396	HEST192O	281	HEUST34O	237	IECT103O	330
HEST133O	392	HEST193O	281	HEUST35O	237	IECT104O	330
HEST134O	391	HEST1-9O	382	HEUST36O	237	IECT105O	343
HEST1-3O	382	HEST210O	231	HEUST37O	234	IECT106O	330
HEST141O	277	HEST211O	230	HEUST38O	234	IECT107O	331
HEST142O	283	HEST212O	231	HEUST39O	233	IECT108O	332
HEST143O	281	HEST213O	230	HEUST72O	346	IECT109O	384
HEST1-4O	382	HEST214O	230	HEUST74O	329	IECT110O	336
HEST151O	275	HEST2-1O	233	HEUST75O	347	IECT111O	344
HEST152O	277	HEST2-2O	235	HEUST76O	346	IECT112O	357
HEST153O	279	HEST2-3O	233	HEUST78O	329	IECT113O	331
HEST154O	280	HEST2-4O	235	HEUST79O	331	IECT114O	335
HEST155O	281	HEST2-5O	230	HEUST81O	412	IECT115O	341
HEST1-5O	383	HEST2-6O	231	HEUST83O	279	IECT116O	345
HEST161O	276	HEST2-7O	230	HEUST86O	286	IECT117O	344
HEST162O	280	HEST2-8O	231	HEUST89O	326	IECT118O	336
HEST163O	280	HEST2-9O	230	HST1810O	278	IECT119O	385

Contents of Tape Containing Output Files (cont'd)

File Name	Size (KB)	File Name	Size (KB)	File Name	Size (KB)	File Name	Size (KB)
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IECT121O	356	PNL3391O	344	PU007-2O	848	PU11187O	840
IECT122O	343	PNL3492O	343	PU007-3O	849	PUST1T1O	480
IECT123O	337	PNL3593O	343	PU007-5O	848	PUST1T2O	481
IECT124O	339	PNL3694O	332	PU007-6O	848	PUST1T3O	480
IECT125O	51	PNL3795O	344	PU007-7O	849	PUST1T4O	480
IECT126O	57	PNL3808O	344	PU007-8O	848	PUST1T5O	480
IECT127O	60	PNL3896O	344	PU007-9O	848	PUST1T6O	479
IECT128O	53	PNL3897O	344	PU04-10O	846	PUST9-1O	155
IECT129O	345	PNL3898O	344	PU04-11O	845	PUST9-2O	155
LEUJA01O	277	PNL3999O	270	PU04-12O	846	PUST9-3O	155
LEUJA14O	274	PNL5300O	267	PU04-13O	847		
LEUJA29O	276	PU003-1O	847	PU07-10O	848		
LEUJA30O	273	PU003-2O	847	PU10091O	856		
LEUJA32O	274	PU003-3O	847	PU10092O	856		
LEUJA33O	276	PU003-4O	847	PU10093O	855		
LEUJA34O	277	PU003-5O	847	PU10111O	855		
LEUJA36O	275	PU003-6O	847	PU10112O	856		
LEUJA46O	277	PU003-7O	848	PU10113O	856		
LEUJA49O	275	PU003-8O	849	PU10114O	855		
LEUJA51O	277	PU004-1O	846	PU10115O	855		
LEUJA54O	276	PU004-2O	847	PU10116O	855		
LEUST21O	397	PU004-3O	847	PU10117O	855		
LEUST22O	392	PU004-4O	847	PU10121O	855		
LEUST23O	397	PU004-5O	847	PU10122O	857		
PNL1158O	321	PU004-6O	847	PU10123O	856		
PNL1159O	323	PU004-7O	847	PU10124O	857		
PNL1161O	317	PU004-8O	847	PU11161O	838		
PNL1577O	281	PU004-9O	847	PU11162O	838		
PNL1678O	269	PU005-1O	847	PU11163O	838		
PNL1783O	285	PU005-2O	847	PU11164O	838		
PNL1868O	285	PU005-3O	847	PU11165O	837		
PNL1969O	269	PU005-4O	846	PU11181O	841		
PNL2070O	281	PU005-5O	845	PU11182O	841		
PNL2565O	281	PU005-6O	845	PU11183O	841		
PNL2666O	269	PU005-7O	846	PU11184O	841		
PNL2767O	285	PU005-8O	847	PU11185O	840		