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CRITICALITY SAFETY EVALUATION FOR TRU WASTE IN STORAGE AT THE RWMC

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ABSTRACT

Stored containers (drums, boxes, and bins) of transuranic waste at the Radioactive Waste Management Complex (RWMC) facility located at the Idaho National Engineering Laboratory (INEL) were evaluated based on inherent neutron absorption characteristics of the waste materials. It was demonstrated that these properties are sufficient to preclude a criticality accident at the actual fissile levels present in the waste stored at the RWMC. Based on the database information available, the results reported herein confirm that the waste drums, boxes, and bins currently stored at the RWMC will remain safely subcritical if rearranged, restacked, or otherwise handled. Acceptance criteria for receiving future drum shipments were established based on fully infinite systems.

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1.0 INTRODUCTION

More than 100,000 drums, 10,000 boxes, and 500 bins of radioactive waste are stored at the Radioactive Waste Management Complex (RWMC) facility located at the Idaho National Engineering Laboratory (INEL). The amount of fissile material in each container is generally very small; however, limits on the vertical height to which the containers may be stacked and on the fissile mass per container have been imposed in order to ensure that adequate criticality safety margins are maintained. The approach taken in past evaluations has been to demonstrate that, up to a certain vertical stack height, neutron leakage is sufficiently high to prevent infinite planar arrays of containers from becoming critical. The fissile material was very conservatively represented in these past evaluations as optimally moderated (water and/or polyethylene) plutonium systems. The containers at the RWMC will always have vertical stacking requirements because of structural and seismic considerations. However, stacking limits and controls imposed because of criticality safety concerns are much more costly to administer. The approach used in this evaluation to establish a basis for criticality safety of the waste containers stored at the RWMC is to demonstrate that the inherent neutron absorption characteristics of the waste materials are sufficient to preclude the possibility of a criticality at the RWMC with any number of containers in any configuration. The purpose of this evaluation is to demonstrate that stacking limits or other imposed handling restrictions are unnecessary by:

1. Demonstrating that the drums, boxes, and bins that are currently stored at the RWMC are safe (from a criticality safety viewpoint) in any configuration (including the loss of container integrity) and

2. Establishing criteria for the receipt of containers that might be shipped to the INEL in the future.

Individual drums loaded at relatively high fissile levels do not present a criticality hazard because their occurrence is rare and when identified are isolated from other heavily loaded drums. If a criticality involving heavily loaded drums can be shown to be incredible, drums can be handled in the most efficient and cost-effective way by eliminating the need for controls on allowable container configurations (stack height, array size, intermixing drums, etc.).

This evaluation focuses on the drums, boxes, and bins that were shipped to the INEL from the Rocky Flats Plant. Data on these containers, which includes data on approximately 73,000 drums, 10,000 boxes, and 500 bins, were readily available and may be used to conservatively envelop containers that were shipped from other waste generators.

2.0 DESCRIPTION

The RWMC provides a temporary storage location for containers of transuranic waste and is designed for use until the waste can be shipped to a permanent repository. Operations at the RWMC include storage, shipping, and receiving of radioactive waste from various Department of Energy (DOE) facilities, primarily the Rocky Flats Plant (RFP) near Denver, Colorado. Historically, storage at RWMC has been in soil vaults or bulk pits, with the waste contained in metal drums or wooden bins. The majority of containment is in 55 gallon drums, some of which are overpacked in 83 gallon drums.

Waste stored at the INEL originates from several sources within the DOE facilities. Typically, the waste material is contaminated laboratory clothing, equipment, and tools; contaminated soil from spill cleanup; process residues; and filters or other debris from maintenance, renovation, or decommissioning projects. Distribution of fissile material inside the containers ranges from mostly homogeneous mixtures of process residues or soil to non-uniform configurations resulting from the use of inner containers or absorbent materials.

Waste that is currently received is stored in enclosed facilities where it is stacked on concrete or asphalt pads with layers of plywood between drums. From 1970 to 1982, drums were stacked on asphalt pads and covered with a two foot layer of soil. Drums are presently stored with various spacing requirements, sometimes in close-packed triangular-pitched arrays. Other containers, such as bins and boxes, are stored in various arrangements at the facility.

3.0 REQUIREMENTS DOCUMENTATION

This analysis is classified as Quality Level A (according to the EG&G Idaho Quality Manual) and is intended to comply with NQA-1. As required by the Nuclear Engineering Standard Practice, NE-SP-2[a], any operational procedures which result from, or are based on, information contained in this report must be reviewed by Reactor and Radiation Physics personnel to ensure that the technical information given in this Criticality Safety Evaluation has been properly incorporated into the procedures.

Based on the analysis presented in this report, the safety of waste storage at the RWMC will ultimately depend on the concentration of plutonium in the waste. According to DOE ID 5480.5A Chapter I Section 4.b(1)(c), Concentration Control, "For a system to be considered critically safe by concentration alone, the fissile isotope concentration shall be limited to 75% of the critical concentration for a geometrically infinite system..." Limits established by this document comply with this requirement. There are no other requirements that are unique to this evaluation.

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[a] *Criticality Safety Evaluations and Design Calculations*, Criticality Safety Analysis Standard Practice for Nuclear Engineering, NE-SP-2, EG&G Idaho, Idaho National Engineering Laboratory, October, 1991. (Internal document available for viewing upon request at the Idaho National Engineering Laboratory.)

4.0 METHODOLOGY

The calculations performed for this evaluation were designed with two specific objectives. The first objective was to demonstrate that all of the containers presently in storage at the RWMC are safe from criticality when stored in any configuration. Accomplishment of this objective was based on the concentrations of fissile material actually present, even if concentrations in individual containers exceed the newly established acceptance criteria. The second objective was to determine simplified criteria for the receipt of future shipments of containers. This was accomplished by determining a minimum critical fissile concentration for a fully infinite system of a given waste type. A threshold value or "acceptance criteria" was then established by calculating 75% of the critical concentration. This value is referred to as an "acceptance criteria" because any number of any size container could be safely accepted for storage and stored in any arrangement provided the contents are within the established criteria. Container acceptance criteria can be simplified in this manner since the calculations are based on fully infinite systems with no credit taken for the neutron absorption properties of the container.

The results of criticality calculations for several concentration ranges of plutonium mixed with non-fissile matrices were compared to the existing database listing information about the stored waste. It was easily demonstrated from the results, that the majority of the containers are of essentially no concern from a criticality safety viewpoint because the concentration of fissile material is so low.

4.1 Calculations

Due to the number of containers present and the variety of their contents, the modeling of each individual container is not practical. Simplifications to container contents were made and calculations performed for fully infinite systems of homogeneous ^{239}Pu and matrix material. To increase assurance that the conclusions of this evaluation can be applied confidently to the entire inventory, other models conservatively representing the most heavily loaded containers were utilized.

Several different neutronics codes and cross section data were used for this evaluation. The majority of critical concentrations were found using the results of calculations performed with the one-dimensional, discrete ordinates (S_N), transport theory code, SCAMP,[a] using 16-group Hansen-Roach

[a]C. L. Beck letter to R. S. Marsden, Beck-2-68, *Input Description of SCAMP Codes (Sn Codes for the Analysis of Multigroup Problems)*, May 17, 1968. (Internal document available for viewing upon request at the Idaho National Engineering Laboratory.)

cross sections (Ref. 1). S_2 calculations were performed for infinite homogeneous systems and S_6 calculations were performed for heterogeneous systems. Additional calculations necessary to accomplish the objectives of this evaluation were performed with the three-dimensional Monte Carlo code, KENO-V.a (Ref. 2), using both 16-group KENO cross section data comprised primarily of Hansen-Roach data and 27-group cross section data based on ENDF/B-IV data (Ref. 3). Calculations intended to verify the original SCAMP results using Hansen-Roach cross sections were performed with the three-dimensional Monte Carlo code, MCNP (Ref. 4), using continuous energy ENDF/B-V cross sections (Ref. 5) and with SCAMP using 16-group ENDF/B-V cross sections generated through the neutron spectrum and cross section generation program, COMBINE (Ref. 6).

4.2 Validation

Calculations used to evaluate the majority of drums were performed with Configuration Release A of the one-dimensional, discrete ordinates, transport theory code, SCAMP, on either an HP 9000/720 workstation with Version 8.07 operating system and Version 8.07 of the FORTRAN compiler or on an IBM Model 320 RISC 6000 workstation with the AIX Version 3.1.5 operating system and AIX Version 2.1 of the FORTRAN compiler.[a]

Other calculations were performed using two separate versions of the three-dimensional Monte Carlo code, KENO-V.a. The first version was a stand-alone version using the 16-group KENO cross section data set comprised mainly of Hansen-Roach cross section data. The second was accessed through the Criticality Safety Analytic Sequence (CSAS) Module CSAS25 (Ref. 3) where a problem-dependent 27-group cross section data set based on ENDF/B-IV data was generated and used for the KENO-V.a calculations. Both versions of KENO-V.a are available through the SCALE4 collection of codes (Ref. 7). The coding of KENO-V.a itself was identical in both versions.

The KENO code has been used extensively in the criticality safety industry for several years. KENO-V.a is an extension of earlier versions of the KENO code and includes many versatile new geometry capabilities and plot routines to facilitate geometry verification. All KENO-V.a calculations in this evaluation were performed on either an IBM Model 320 RISC 6000 workstation with AIX Version 3.1.5 operating system and Version 2.1 of the FORTRAN compiler, or an HP 9000/720 workstation with Version 8.07 operating system and Version 8.07 of the FORTRAN compiler. Configuration Release

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[a]J. L. Judd, *SCAMP Benchmark Notes*, NRRT-N-92-010, May 1992. (Internal document available for viewing upon request at the Idaho National Engineering Laboratory.)

1.10 of the KENO-V.a code and the associated Hansen-Roach cross section data set were verified for proper operation on these computational platforms by repeating the 25 sample problems that were transmitted with the code. All calculated k_{eff} values agree well (generally within 1%) with the results obtained on the Oak Ridge National Laboratory computer system (Ref. 2).

Hydrogen-moderated plutonium benchmark critical experiments were evaluated with the KENO-V.a code.[a] These results indicate that a bias in addition to the statistical uncertainties associated with the Monte Carlo calculations is not warranted for hydrogenously moderated systems with H/Pu ratios ranging from about 100 to 1200. Threshold values in this report were for hydrogenously moderated systems with much higher H/Pu ratios (near 3700) and benchmark critical data are not available for systems of this nature. Extensions to the range of applicability are justified by performing comparisons with several independent codes and cross section sets. For an infinite homogeneous system of ^{239}Pu with H_2O moderator at a concentration of 3.2 g Pu/lb H_2O, the SCAMP calculation resulted in a k_∞ of 1.004. This indicates good agreement between the code and literature where the critical concentration for Pu in water is reported at 7 g/ℓ, which is equivalent to 3.175 g Pu/lb H_2O (Ref. 8).

The same type of large extensions to the range of applicability are necessary for many of the other materials used in this evaluation where benchmark critical and subcritical data are entirely unavailable. Calculations incorporating identical geometry, atom densities, moderation, and reflection were performed with SCAMP using Hansen-Roach cross sections, KENO-V.a using 16-group cross sections based on Hansen-Roach data, KENO-V.a using 27-group cross sections based on ENDF/B-IV data, and MCNP using continuous energy ENDF/B-V cross-sections. It should be noted that different versions of the Hansen-Roach library were used for SCAMP and KENO-V.a. Additional SCAMP calculations using 16-group ENDF/B-V cross-section data processed by the COMBINE code were included for some materials. The results are reported in Table 1. The calculations were performed to provide validation for the SCAMP results by comparison.

For many of the materials, good agreement was achieved for the results of all of the codes used. Where slight differences exist, SCAMP is generally conservative and for such cases, SCAMP

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[a]L. M. Montierth, *Development and Validation Notes - CSAS4/IBM RISC 6000*, NRRT-N-91-020 Rev. 1, May 1992.

L. M. Montierth, *Development and Validation Notes - CSAS4/HP 9000 720*, NRRT-W-92-005, August 1992.

(Internal documents available for viewing upon request at the Idaho National Engineering Laboratory.)

Table 1. Code comparisons for concentrations of ^{239}Pu in various waste matrix materials.

Case	Description		k_∞		$k_\infty \pm \sigma$		
	Matrix material	239Pu concentration (g Pu/lb matrix)	SCAMP		KENO-V.a		MCNP
			Hansen-Roach	16-group COMBINE ENDF/B-V	Hansen-Roach	27-group SCALE4 ENDF/B-IV	Continuous energy ENDF/B-V
1	water	3.2	1.004	0.994[a]	1.004 ± 0.001	0.998 ± 0.001	0.991 ± 0.001
2	polyethylene	4.15	1.006	0.998[a]	1.005 ± 0.001	1.000 ± 0.001	0.996 ± 0.0005
3	cellulose	1.8	1.006		1.007 ± 0.001	0.999 ± 0.001	0.989 ± 0.0005
4	aluminum metal	1.25	1.043		1.041 ± 0.001	1.038 ± 0.002	1.007 ± 0.001
5	concrete[b]	0.75	0.998		1.010 ± 0.001	0.995 ± 0.001	0.990 ± 0.001
6	Al_2O_3	0.37[c]	0.995	1.097[a]	0.996 ± 0.001	1.082 ± 0.001	1.085 ± 0.001
7	SiO_2	0.16[c]	1.018[d]	0.913[a]	0.828 ± 0.001	0.898 ± 0.001	0.893 ± 0.001
8	MgO	0.20[c]	1.002[d]		1.178 ± 0.001	1.236 ± 0.001	1.238 ± 0.001
9	graphite	0.03	1.079		1.079 ± 0.002	1.097 ± 0.002	1.084 ± 0.001
10	graphite	0.6[e]	1.910		1.91 ± 0.001	1.847 ± 0.002	1.872 ± 0.001

a. Calculated on Silicon-Graphics-4D/35 Workstation.
b. Ordinary concrete as given in the KENO Hansen-Roach cross section library.
c. These "critical concentration" values are based on the initial SCAMP results using Hansen-Roach cross section data. Due to the findings discussed in Section 4.2, the actual critical values used for subsequent calculations differ.
d. There are errors in the SCAMP Hansen-Roach library for this material. If corrected, results similar to the KENO-V.a results are obtained. Calculations for this material were made with KENO-V.a using CSAS processed 27-energy-group cross section data.
e. This case is supercritical but is included in these results as a comparison for higher plutonium concentrations in graphite.

results were used to determine critical values. However, SiO_2, MgO, and Al_2O_3 cases resulted in pronounced discrepancies in the calculated k_{eff} values for the various codes apparently because of problems with using the Hansen-Roach cross sections for silicon, magnesium, aluminum, and oxygen in dry systems. Throughout the report, cases containing SiO_2, MgO, or Al_2O_3, which were originally evaluated using SCAMP or KENO-V.a with Hansen-Roach cross section data, were recalculated using KENO-V.a with 27-energy-group cross sections through the CSAS code sequence. For all except the aluminum metal case, results from KENO-V.a calculations using the 27-group cross section library agreed reasonably well with MCNP calculations using ENDF/B-V cross section data. The cause of the difference for aluminum metal was not determined; however, critical values for the metal matrix (aluminum) were based on SCAMP results since these were conservative.

While the results indicate reasonably good agreement among the different codes and cross section sets, they also indicate a need for benchmark data for typical waste matrices that have not traditionally been included in criticality safety calculations.

5.0 DISCUSSION OF CONTINGENCIES

A criticality in a large array of waste containers is incredible based on known drum fissile loadings. To achieve a critical configuration in such containers, unrealistically high (incredible) ^{239}Pu concentrations in a large number of containers would be required. According to the waste database information, the number of drums with fissile material concentrations at 75% of calculated critical values for fully infinite systems (with no steel or spacing from drums) is insignificant. A situation where many drums exceed the recorded values would only be reached if large errors existed in the database due to a systematic failure of all of the measurement methods and gross violations of the waste packaging and shipping procedures. If such errors exist and if all (rather than a random number) underestimate the amount of fissile material by 100%, the number of drums that exceed threshold values (75% of calculated critical concentration) is still very small, about 6% of the total number of waste drums (see Table 14, Section 6.5).

The conditions required for an inadvertent criticality are incredible, therefore, double contingency is satisfied. That is, no single, unlikely failure can be identified which could result in the critical point being reached.

6.0 EVALUATION AND RESULTS

Section 6.1 below contains a discussion of the simplifications used to limit the number of calculations by determining a small number of materials to represent the various types of waste stored at the RWMC. Actual atom densities used for the calculations are listed in Appendix A. Section 6.2 gives the details of the various models used and the results of the calculations. There are some drums listed in the database which exceed calculated threshold values; these are discussed in Section 6.3. The improbability of a criticality in a single drum is discussed in Section 6.4. Section 6.5 contains an analysis of the impact of possible errors in the database. Typical input listings are given in Appendix B.

6.1 Content Code Groupings

Waste containers at RWMC are labeled with identifying content codes which were developed over time.[a] For the present analysis, content codes were grouped into several larger categories depending on the main component of the waste form. This allowed a comparison of the reactivity for various matrices while reducing calculations to a manageable number. Code numbers 800-899 appear in the two references with conflicting descriptions. For purposes of this evaluation those code numbers are handled according to Mound Laboratory waste code descriptions[a] which correspond to the INEL database. The 800-899 numbers are also used as Rocky Flats pre-certified codes, but are preceded by an RF indicator on those containers.

Table 2 shows the major component list for the nine groups of content codes. Each component represents a commonly occurring constituent in a portion of the waste drums stored at the RWMC. Because water is important with regards to criticality concerns, a water matrix has been evaluated and presented in this report even though there are no drums having content codes currently classified as water. The large number of mixtures actually present in the drums would be arduous to model, but knowledge of the neutron moderating or absorbing behavior of some of the materials, coupled with parametric optimization, allows the actual compositions to be conservatively represented by simpler models. Appendix C contains an abbreviated summary of the content code descriptions and Appendix D contains the summary database information.

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[a]T. L. Clements, Jr., *Content Code Assessments for INEL Contact-Handled Stored Transuranic Wastes*, WM-F1-82-021, Idaho National Engineering Laboratory, October 1982.
T. L. Clements, Jr., *Program Plan for Certifications of INEL Contact-Handled Stored Transuranic Wastes*, WM-PD-88-011-4, Idaho National Engineering Laboratory, July 1991.
(Internal documents available for viewing upon request at the Idaho National Engineering Laboratory.)

Table 2. Content code grouping for calculations.

Group #	1	2	3	4	5	6	7	8	9
Major Component	Water (H_2O)	Polyethylene (CH_2)	Graphite (C)	Glass, Slag (SiO_2, MgO)	Cellulose ($C_6H_{10}O_5$)	Concrete[a]	Metals (Al)	Salt (NaCl, CaCl)	Brick (Al_2O_3)
Content Codes		3	115	7	10	1	20	5	371
		112	300	30	116	2	101	124	373
		123	301	40	119	4	117	409	377
		153	303	69	120	15	155	410	378
Description of Content Codes given in Appendix C		202	310	90	121	95	156	411	379
		332	311	100	153	111	201	412	
		337	312	102	203	113	320	413	
		339	814	105	302	122	321	414	
		423		114	328	152	333	429	
		430		118	330	154	416	454	
		431		150	331	157	480		
		432		241	334	200	481		
		460		368	335	204	482		
		463		370	336	290	488		
		700		372	338	292	803		
		802		390	360	295	824		
		804		391	361	299	825		
		812		392	375	374	950		
				393	376	701			
				420	438	702			
				421	464	811			
				422	490	812			
				425	491	836			
				440	801	960			
				441	805	976			
				442	826	978			
				470	827	980			
				483	847	995			
				810	900				
				813	970				
				834					
				955					
				990					

a. Ordinary concrete as given in the KENO Hansen-Roach cross section library.

Aluminum was chosen to represent metal waste such as ducting, cut-up glove boxes, source housings, and other equipment. Preliminary calculations showed that, for the fully infinite systems evaluated, aluminum is a more reactive matrix material than either copper or stainless steel. Lead is a more reactive matrix material than aluminum, but was not a logical choice to represent the types of material actually present since it occurs in much smaller amounts than the other metals. Only 5 of the 23 metal content code descriptions mention that lead may be present in some drums, and for only one code (321) is it the major component.

After initial calculations indicated which pure matrix materials increased reactivity, the content code groupings were reexamined. If there was more than one major constituent for a content code or if the major constituent could not be determined from the description, every effort was made to group that code with the most reactive component. This means that drums containing some amount of more than one of the pure materials are conservatively enveloped by the models used. Due to this method of categorizing code descriptions, one of the more reactive matrix groups (glass/slag modeled as SiO_2 or MgO) includes the largest number of content codes. Some error may still result from misinterpretation or lack of sufficient documentation about the actual drum contents; however, the approach used is conservative, especially in combination with other factors considered in the evaluation.

6.2 Calculations and Results

This section gives the details of the various models used and the results of the calculations. Section 6.2.1 contains the primary results of the comparison of the database to the calculations. Sections 6.2.2 through 6.2.5 contain the results of parametric studies and other variations used to verify conservatism.

6.2.1 Fully Infinite Systems and Comparison of Results to the Database

SCAMP (Hansen-Roach) or KENO-V.a (27-group) calculations were performed for fully infinite systems of ^{239}Pu, at various concentrations, mixed with several non-fissile matrix materials. Fully infinite systems were represented in the code input by applying mirror reflection to the top and bottom faces of a 100-cm-thick slab (SCAMP) or to all faces of a cube having 100-cm sides (KENO-V.a). Representative input listings for the calculations are included in Appendix B of this document. Parametric calculations were performed in which the plutonium density, in terms of grams of ^{239}Pu per pound of matrix material, was varied to obtain calculated k_∞ values in the range of 0.9 to 1.0. The results of these calculations are given in Table 3; curves generated from these results for each of the matrix materials can be seen in Figures 1 and 2. From these data, the critical concentration was determined. A calculation for a salt mixture of NaCl and $CaCl_2$ was also performed. The results are given in Table 3 but have not been included on the plots because the critical concentration (7.4 g Pu/lb matrix) was much higher than for the other materials.

Once the critical concentration for a fully infinite system was established, the number of drums with a concentration (g Pu/lb matrix) greater than 75% of critical was determined from fissile gram content and matrix weight reported in the database. (As can be seen from Figures 1 and 2, calculated k_∞ values corresponding to a concentration equal to 75% of the critical value were well below 0.95.) A summary of comparative information for all waste matrix materials evaluated is provided in Table 4. These results indicate that, except for graphite, fewer than 9% of the drums in each group contained a concentration of ^{239}Pu at or above this level for all of the selected waste matrix materials. The worst case was graphite for which over 80% of the drums exceeded the threshold concentration calculated for the fully infinite graphite systems. The second worst case was the glass group using MgO as the matrix material, in which 887 or 8.96% of the drums exceeded 0.09 g Pu/lb matrix (75% of the critical value for an infinite system of ^{239}Pu in MgO). Section 6.3 contains further discussion for the drums which exceed the threshold values and the results of calculations which demonstrate, that under optimal theoretical conditions, the currently stored drums could not approach a critical configuration.

Table 3. Results of SCAMP and KENO-V.a calculations used to determine the calculated critical concentration of ^{239}Pu in various matrix materials.

Matrix group		^{239}Pu Concentration (g Pu/lb matrix)	k_∞		Calculated critical concentration	
Number	Material		SCAMP[a]	KENO-V.a[b]	g Pu/lb matrix	g Pu/ℓ matrix
1	water	2.0 2.5 3.0 3.5 4.0	0.76790 0.87860 0.97159 1.05079 1.11899		3.17	6.99
2	polyethylene	2.5 3.0 3.5 4.0 4.5	0.75082 0.84034 0.91840 0.98700 1.04770		4.10	8.32
3	graphite	0.020 0.025 0.030 0.050	0.87119 0.98535 1.07931 1.33341		0.03	0.09
4	glass, slag (SiO2)	0.10 0.12 0.14 0.15 0.16 0.20 0.25		0.67934 0.76000 0.83545 0.86852 0.89770 1.00844 1.11525	0.20	1.01
	glass, slag (MgO)	0.05 0.07 0.10 0.12 0.13 0.15 0.20 0.25 0.30		0.58225 0.73056 0.90398 0.99442 1.03267 1.10303 1.23570 1.32796 1.39530	0.12	0.96
5	cellulose	1.0 1.5 2.0 2.5 3.0	0.71291 0.91253 1.06017 1.17690 1.26237		1.78	2.51

Table 3. Continued.

Matrix group		^{239}Pu Concentration (g Pu/lb matrix)	k_∞		Calculated critical concentration	
Number	Material		SCAMP[a]	KENO-V.a[b]	g Pu/lb matrix	g Pu/ℓ matrix
6	concrete[c]	0.50 0.60 0.75 0.80 1.00	0.80125 0.88937 0.99827 1.02957 1.13558		0.75	3.93
7	metals (Al)	0.50 0.75 1.00 1.50 2.00	0.72271 0.86322 0.96490 1.10633 1.20393		1.10	6.54
8	salts	5.0 5.5 6.1 6.5 7.0 8.0	0.77896 0.83157 0.88938 0.92561 0.96889 1.04926		7.4	35.14
9	brick (Al_2O_3)	0.20 0.23 0.25 0.28 0.30 0.33 0.37 0.40		0.80372 0.86994 0.90725 0.96033 0.99067 1.03226 1.08136 1.11474	0.31	2.68

a. SCAMP calculations performed using 16-group Hansen-Roach cross sections.
b. KENO-V.a calculations performed using 27-group cross sections based on ENDF/B-IV data.
c. Ordinary concrete as given in the KENO Hansen-Roach cross section library.

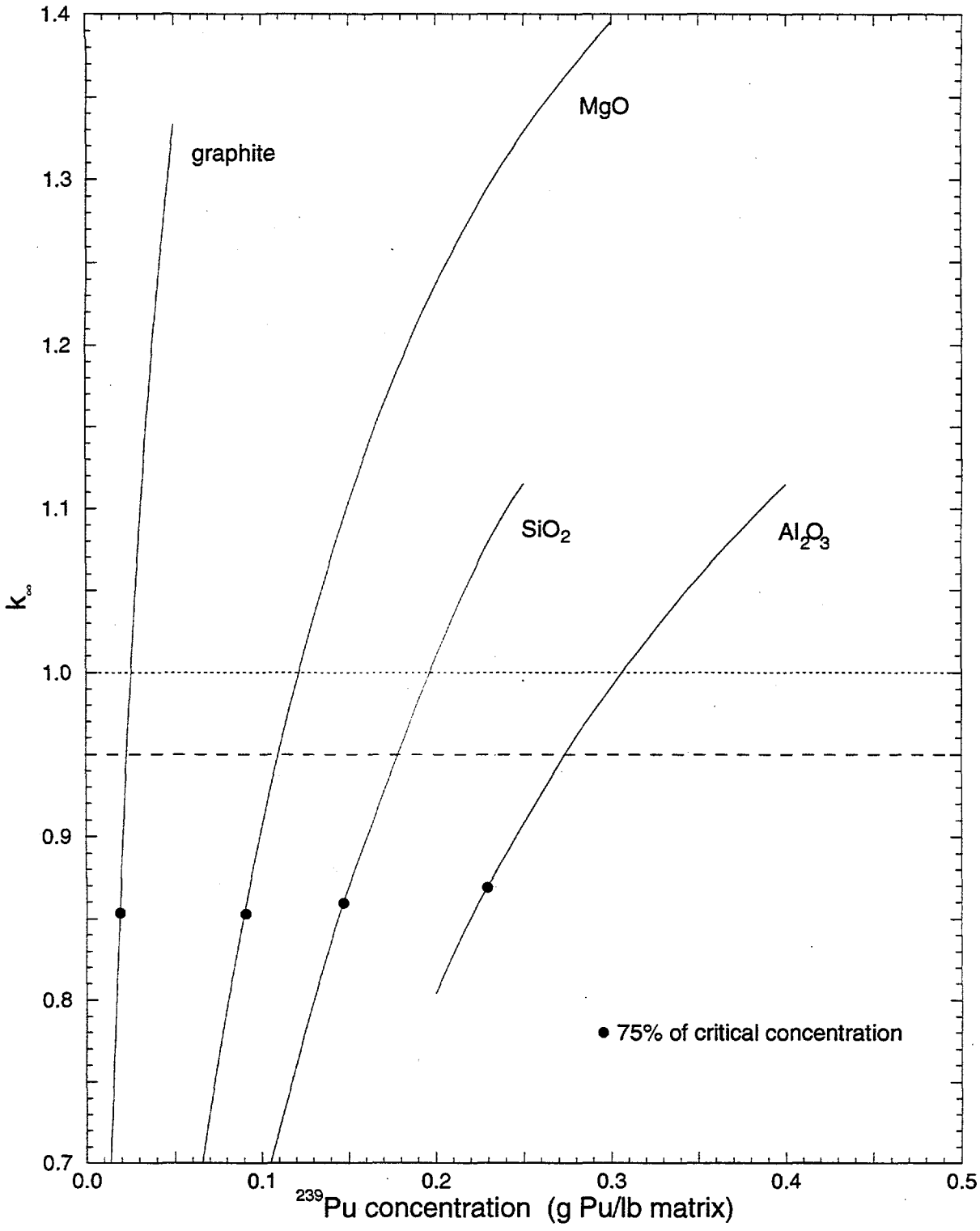


Figure 1. Calculated k_∞ vs. ^{239}Pu concentration in graphite, MgO, SiO_2, and Al_2O_3

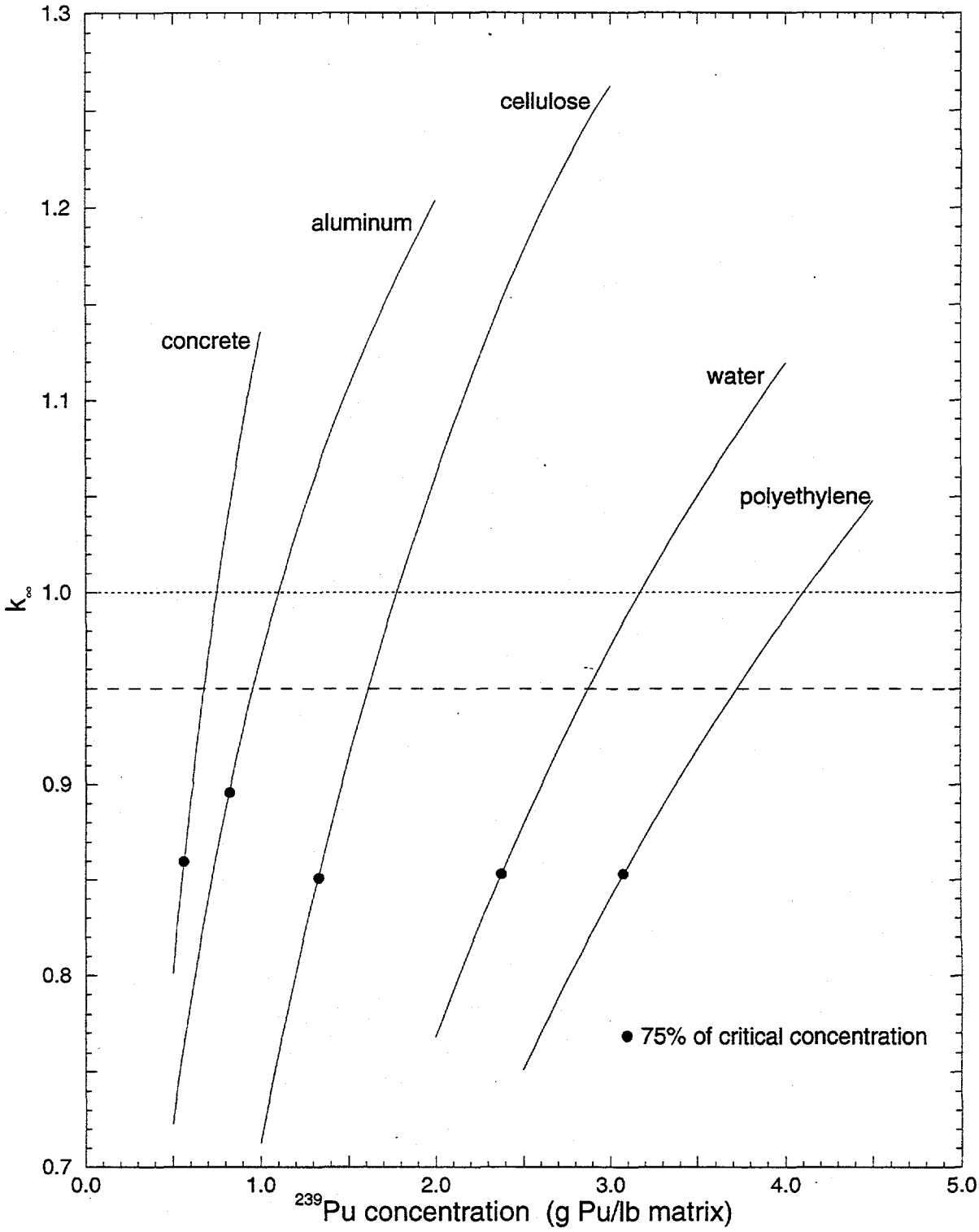


Figure 2. Calculated k_∞ vs. ^{239}Pu concentration in Al, concrete, cellulose, water, and polyethylene

Table 4. Comparison of calculated threshold concentrations with database information.

Matrix group			Threshold concentration[a] (g Pu/lb matrix)	Drums			
Number	Material	Density (g/cm^3)		^{239}Pu mass at threshold concentration[b] (g/drum)	Total in matrix group (#)	Exceeding threshold concentration	
						#	%
1	water	1.0	2.4	c	c	c	c
2	polyethylene	0.92	3.1	1362.12	11376	0	0.00
3	graphite	1.6[d]	0.02	14.86	2365	1904	80.51
4[e]	glass, slag (SiO_2) glass, slag (MgO)	2.32 3.58	0.15 0.09	166.09 156.94	9904[e] 9904[e]	489 887	4.94 8.96
5	cellulose	0.64[f]	1.3	410.49	16408	308	1.88
6	concrete[g]	2.37	0.56	643.67	27526	34	0.12
7	metal (Al)	2.7	0.82	1070.19	4030	59	1.46
8	salts	2.16	5.53	5752.28	88	1	1.14
9	brick (Al_2O_3)	3.965	0.23	438.45	1031	82	7.95

a. Threshold concentrations correspond to 75% of the critical concentrations given in Table 3.
b. For information only. These mass values should not be construed as mass limits. The 200 gram per drum transportation limit still exists and it is assumed that drums do not significantly violate this limit. Under no circumstances should the results of this analysis be applied to drums that contain more than 75% of the minimum critical mass of plutonium in water (approximately 380 grams ^{239}Pu). Special handling requirements must be used for drums that exceed 380 grams of ^{239}Pu. The handling of highly loaded drums is beyond the scope of this report.
c. There are no drums in the database classified as water.
d. The graphite density was taken from J. R. Lamarsh, *Nuclear Reactor Theory*, Addison-Wesley, 1966. This is typical of commercial grade graphite. The density of the graphite shipped to Rocky Flats ranges from 1.71 to 1.78 g/cm^3. (Private communication with the vendor, Sigri Great Lakes Carbon, North Carolina.) Bulk densities of graphite in waste is judged to be much less than the value used.
e. Both SiO_2 and MgO were used to evaluate the glass group. SiO_2 is by far the most predominate of the two. The total number of drums in the glass group is 9904. There are not 9904 drums represented as SiO_2 and 9904 drums represented as MgO.
f. Cellulose is used to represent crushed paper, filter media, etc. The density selected conservatively corresponds to that of a typical hard wood. (Theodore Baumeister, Lionel S. Marks, *Standard Handbook for Mechanical Engineers*, Seventh Edition, McGraw-Hill, p. 6-152, 1967.)
g. Ordinary concrete as given in KENO Hansen-Roach cross section library.

As mentioned in the introduction, boxes and bins of waste are also stored at the RWMC site. Only 37 of the 517 bins (7.2%) contain concentrations which are more than the smallest threshold value reported in Table 4 (0.02 g Pu/lb matrix calculated for a fully infinite system of ^{239}Pu in graphite). Of these 37 bins, only five have ^{239}Pu concentrations that exceed the threshold value of the next most reactive matrix material, MgO (0.09 g Pu/lb MgO), and only three exceed the threshold value of the third most reactive matrix material, SiO_2 (0.15 g Pu.lb SiO_2). The database included in Appendix D shows that these three bins contain between 500 and 600 g ^{239}Pu. This amount of fissile material is in excess of the INEL administrative limit of 350 grams per bin. Original manifests were checked by the originator and RWMC and containers in excess of limits were not shipped or accepted. Therefore, these are believed to be errors in the database.

All but nine of the 9943 boxes of radioactive waste (0.09%) listed in the database contain concentrations which fall below 75% of the minimum critical values calculated for fully infinite systems of the various matrix materials. These nine boxes are all categorized as glass or slag. Only one of the nine boxes has a concentration that slightly exceeds the calculated minimum critical value of 0.2 g Pu/lb glass. Five boxes, categorized as cellulose, are shown on the database to contain over the 350 gram per box limit, but only two of these boxes exceed 380 g ^{239}Pu, 75% of the minimum critical mass of plutonium in water (see Section 3.0). Again, these are believed to be errors in record transcription and not the actual reported gram content.

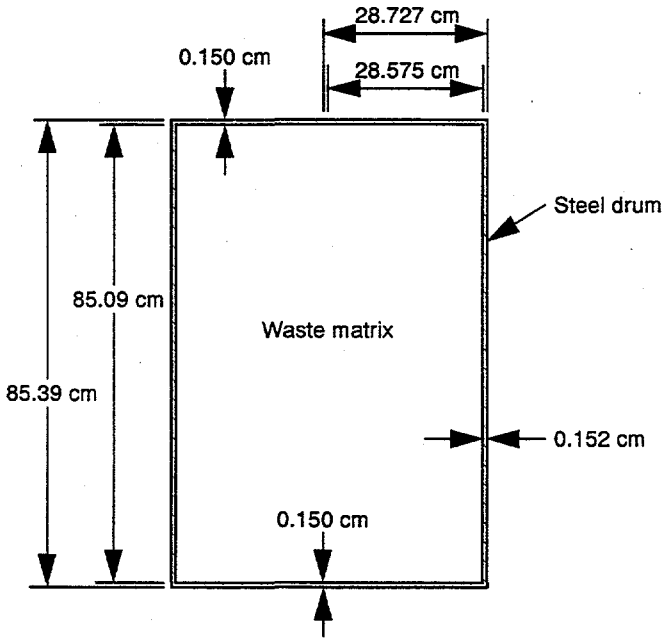
The average concentration in g Pu/lb matrix are much smaller for bins and boxes than for drums. The boxes average 0.010 g Pu/lb matrix and the bins average 0.007 g Pu/lb matrix compared to 0.018 g Pu/lb matrix in the drums. It may be concluded that the safety of the bins and boxes is adequately demonstrated by the initial calculations for fully infinite drum arrays and by the results in Section 6.3. Waste boxes and bins are not examined further in this report; however, the database information for bins and boxes is included in Appendix D.

6.2.2 Effects of Discretely Modeled Drums

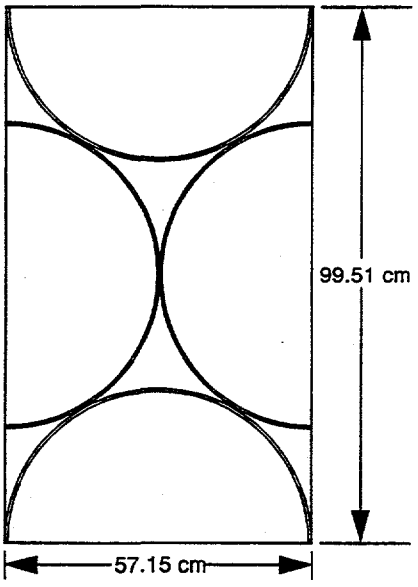
Calculations were performed using KENO-V.a to determine the effects of discretely modeled drums. Concrete and cellulose were selected because, as a group, they encompassed the largest number of drums (See Table 4). Graphite was also selected because the threshold concentration for graphite waste is relatively small (0.02 g Pu/lb matrix) and because the majority of the drums that are classified as graphite waste exceed the threshold concentration. By applying mirror reflection to all faces of a 57 x 57 x 100 cm cuboid (57.15 cm is the inner diameter of a single 55 gallon drum) in a KENO-V.a model, a comparison can be made between the results obtained from Monte Carlo and discrete ordinates methods for fully infinite homogeneous systems. The drums, in a close-packed arrangement, were then modeled using an array of unit cells (Figure 3). Results of calculations using this model, when compared to the homogeneous KENO-V.a results, demonstrate the effects of explicitly modeling the drums in an infinite system. To demonstrate that concrete and water reflectors are no more effective than waste containers, a 42 x 42 x 42 array of explicitly modeled drums, containing either concrete or cellulose matrix, was modeled with a concrete or water reflector on all sides and results are compared to an infinite array of drums (See Cases 3, 4, and 5 of Table 5). Representative input listings for KENO-V.a calculations are included in Appendix B of this document. The results of calculations are reported in Table 5.

A comparison of Cases 2 and 3, 7 and 8, 12 and 13, 15 and 16, and 18 and 19 indicate that the effect of adding steel to represent the drums explicitly depends on the matrix type. The greatest effect of explicitly representing the steel drum structure can be seen in graphite matrix having a low ^{239}Pu concentration (decrease of 30%) and the least effect can be seen in the concrete matrix (decrease of 8.5%). In all cases, k_∞ decreases when the steel drum structure is represented. A comparison of Cases 3, 4 and 5, and Cases 8, 9 and 10 indicate that infinite arrays were not substantially more reactive than large finite arrays that are reflected by concrete or water. The results of these two comparisons indicate that the SCAMP and KENO-V.a results for fully infinite, homogenous systems, which are the basis for all threshold values in Table 4, are conservative.

Additional calculations were performed for graphite waste to demonstrate the degree of conservatism in the calculations and to further demonstrate the effects of discretely modeled drums. The results of these calculations are documented in Table 6. The receipt criteria established later in this evaluation are not based in any way on the results in the table nor are these results required to demonstrate the safety of existing containers. However, part of the methodology developed in this section is used in Section 6.3 to demonstrate the safety of existing containers.



a. Dimensions of 55-gallon storage drum.



b. Unit cell for KENO model showing four close-packed 55-gallon drums.

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Figure 3. Sketch of 55 gallon waste storage drum showing dimensions and modeled unit cell

Table 5. Summary of calculations showing the effects of discretely modeled drums and large finite systems.

Case	Model			Reflector	SCAMP[a]	KENO-V.a[b]	
	Description	Matrix material	^{239}Pu concentration (g Pu/lb matrix)		k_{∞}	$k_{\infty} \pm \sigma$	$k_{eff} \pm \sigma$
1	homogeneous 100-cm-thick slab	concrete[c]	0.75	mirror	0.998		
2	57.2 x 57.2 x 100 cm homogeneous cuboid	concrete[c]	0.75	mirror		1.010 ± 0.001	
3	infinite array of drums	concrete[c]	0.75	mirror		0.924 ± 0.001	
4	42 x 42 x 42 array of steel drums	concrete[c]	0.75	concrete			0.922 ± 0.001
5	42 x 42 x 42 array of steel drums	concrete[c]	0.75	water			0.922 ± 0.001
6	homogeneous 100-cm-thick slab	cellulose	1.7	mirror	0.977		
7	57.2 x 57.2 x 100 cm homogeneous cuboid	cellulose	1.7	mirror		0.975 ± 0.001	
8	infinite array of drums	cellulose	1.7	mirror		0.850 ± 0.001	
9	42 x 42 x 42 array of steel drums	cellulose	1.7	concrete			0.847 ± 0.001
10	42 x 42 x 42 array of steel drums	cellulose	1.7	water			0.847 ± 0.001
11	homogeneous 100-cm-thick slab	graphite	0.5	mirror	1.904		
12	57.2 x 57.2 x 100 cm homogeneous cuboid	graphite	0.5	mirror		1.906 ± 0.002	
13	infinite array of drums	graphite	0.5	mirror		1.328 ± 0.002	
14	homogeneous 100-cm-thick slab	graphite	1.0	mirror	1.909		
15	57.2 x 57.2 x 100 cm homogeneous cuboid	graphite	1.0	mirror		1.908 ± 0.002	
16	Infinite array of drums	graphite	1.0	mirror		1.571 ± 0.002	
17	homogeneous 100-cm-thick slab	graphite	1.5	mirror	1.894		
18	57.2 x 57.2 x 100 cm homogeneous cuboid	graphite	1.5	mirror		1.892 ± 0.002	
19	infinite array of drums	graphite	1.5	mirror		1.662 ± 0.001	

a. SCAMP calculations performed using 16-group Hansen-Roach cross sections.
b. KENO-V.a calculations performed using 16-group KENO cross sections based on Hansen-Roach cross section data.
c. Ordinary concrete as given in KENO Hansen-Roach cross section library.

Table 6. Summary of calculations for drums containing graphite with high concentrations of ^{239}Pu used to determine the thickness of surrounding matrix material necessary to eliminate interaction effects between arrays of drums.

Case	Model of matrix material surrounding array of drums			$k_{eff} \pm \sigma^a$ *1.5 g Pu/lb of graphite*
	Matrix material	^{239}Pu concentration (g Pu/lb matrix)	Thickness (cm)	
Base Model 14 x 14 x 14 array of drums (2744 drums) 260 lbs of graphite per drum based on graphite density of 1.6 g/cm^3 array surrounded by thickness of ^{239}Pu and matrix material on all sides mirror reflection on all sides				
1	SiO_2	0.15	0.001	1.347 ± 0.001
2	SiO_2	0.15	10	1.312 ± 0.001
3	SiO_2	0.15	30	1.255 ± 0.001
4	SiO_2	0.15	60	1.216 ± 0.001
5	SiO_2	0.15	80	1.205 ± 0.001
6	SiO_2	0.15	100	1.199 ± 0.001
7	SiO_2	0.15	110	1.194 ± 0.001
8	SiO_2	0	100	1.132 ± 0.001
9	water	0	100	1.034 ± 0.001
10	MgO	0.10	100	1.193 ± 0.001
11	Al metal	0.82	2000[b]	1.180 ± 0.001
12	Al_2O_3	0.23	100	1.187 ± 0.001
13	cellulose	1.3	100	1.113 ± 0.001
14	polyethylene	3.1	100	1.103 ± 0.001
15	water	2.4	100	1.102 ± 0.001

a. KENO-V.a calculations performed using 27-group cross sections based on ENDF/B-IV data.
b. The isolation thickness is much greater for aluminum metal than for compounds containing oxygen and hydrogen.

In a "worst case" scenario, all 2365 drums containing graphite would be stored in a single location. For the calculations documented in Table 6, 2744 drums in a 14 x 14 x 14 array were represented. This size was chosen as a cubic array (cubic by number of drums, not by dimension) with more drums than are actually listed in the inventory data. The volume occupied by the ^{239}Pu/graphite mixture in each drum was based on 260 lbs of the graphite matrix using the theoretical graphite density of 1.6 g/cm^3. As demonstrated in Sections 6.2.4 and 6.2.5, this is a conservative representation for the recorded weight of graphite present in the drums. The weight of 260 lbs was chosen because the information on the database indicated that 98% of drums containing graphite waste weighed 260 lbs or less. The original intention of this evaluation was to use the maximum recorded weight of drums. Due to changes in the content code groupings, 37 drums heavier than 260 lbs were added to this group after most of the calculations were complete. However, 260 lbs remains the maximum average drum weight when drums are grouped by fissile concentration and the fissile concentration for these drums is low, 0.004 g ^{239}Pu/lb graphite. This, along with the fact that the number of drums exceeding 260 lbs is only 2% of the total number of drums containing graphite on the database supports the decision not to reevaluate all of the graphite cases. Surrounding the array of drums was a cuboid representing the fissile waste contained in the remaining drums (those without graphite). Outside the cuboid surrounding the drums, mirror reflection was applied to all faces to produce an infinite system.

The cuboid surrounding the explicitly modeled drums was parametrically increased in thickness until k_{eff} was approximately constant. At this point, the interaction between the separate arrays of drums has been eliminated. The additional arrays of drums mentioned here result from the mirror-reflective boundary condition applied to the model. SiO_2 matrix was chosen for this parametric study as the material surrounding the array because it is one of the more abundant and more reactive waste matrix materials. An unrealistically high ^{239}Pu concentration of 1.5 g Pu/lb matrix was represented in the graphite matrix in order to maximize interaction effects and isolation thicknesses. The results of this study are shown in Cases 1-7 of Table 6. It can be seen that a 100-cm-thick region surrounding the array of drums (200 cm SiO_2 between the arrays) will isolate the modeled array. The SiO_2 matrix was replaced by several other matrix materials. Except for aluminum, which has a much larger isolation thickness (2000 cm half-thickness), the 100-cm-thick region, calculated previously, was used in these models. The concentration of ^{239}Pu in each matrix material was held at 75% of critical value as determined from the previous SCAMP and KENO-V.a calculations. For all of these calculations, the entire array of drums and surrounding cuboid were mirror reflected on all six sides and 5000 neutrons were started in flat distribution. The calculated results for these models are given in Cases 10-15 in Table 6.

It can be seen from this table that k_{eff} values for all models are below that calculated for SiO_2. MgO was shown to be more reactive than the other matrix materials, except graphite, in the calculations discussed in Section 6.2.1. However, for these calculations involving drums with graphite, placing SiO_2 in the surrounding cuboid was a slightly more reactive configuration. SiO_2 has a higher threshold concentration than MgO. Other materials, however, with even higher threshold ^{239}Pu concentrations (water, polyethylene, and cellulose), resulted in significantly lower k_{eff} values. Comparing the results of Case 6 to Case 8 and Case 9 to Case 15 in Table 6, in which ^{239}Pu was removed from the surrounding matrix, indicates that the change in k_{eff} results not only from the choice of matrix, as demonstrated above, but also from the ^{239}Pu concentration in that matrix.

The threshold concentration (75% of the critical concentration) for a fully infinite homogeneous graphite system calculated by SCAMP was 0.02 g Pu/lb graphite. A large percentage of drums currently in storage exceed this value. A parametric study was performed to determine the critical concentration of ^{239}Pu in a graphite matrix when 2744 drums are explicitly modeled surrounded by an infinite medium. The results of this study are given in Table 7 and are shown graphically in Figure 4. Table 7 indicates that the calculated k_{eff} value was approximately 1.0 when the ^{239}Pu concentration was 0.75 g/lb graphite with SiO_2 as the surrounding infinite medium and 0.80 g/lb graphite with MgO as the surrounding infinite medium. This can also be seen from the results plotted in Figure 4. Using the lower critical concentration of 0.75 g Pu/lb graphite, a threshold concentration (75% of critical) of 0.56 g Pu/lb matrix can be calculated for ^{239}Pu in graphite waste when represented in the discretely modeled drums. This value exceeds the threshold concentration given in Table 4 (0.02 g Pu/lb graphite) by a factor of 28.

The calculations documented in Table 6 using a ^{239}Pu concentration in graphite of 1.5 g Pu/ lb matrix were repeated using the threshold concentration of 0.56 g Pu/lb matrix determined from Table 7. The results of these calculations are given in Table 8. The results in Table 8 demonstrate that existing drums containing graphite waste will remain in a subcritical state when stacked in any configuration.

Table 7. Summary of calculations for drums containing graphite waste used to determine the critical concentration when discretely modeling drums.

Case	^{239}Pu concentration in graphite (g Pu/lb graphite)	Matrix material surrounding array of drums		$k_{eff} \pm \sigma^a$
		Material	^{239}Pu concentration (g Pu/lb matrix)	
Base Model 14 x 14 x 14 array of drums (2744 drums) 260 lbs of graphite per drum based on graphite density of 1.6 g/cm^3 array surrounded by 100-cm-thick region of ^{239}Pu and matrix material on all sides mirror reflection on all sides				
1	0.50	SiO_2	0.15	0.892 ± 0.001
2	0.75	SiO_2	0.15	1.005 ± 0.001
3	0.80	SiO_2	0.15	1.025 ± 0.001
4	1.00	SiO_2	0.15	1.090 ± 0.001
5	0.50	MgO	0.10	0.853 ± 0.001
6	0.75	MgO	0.10	0.987 ± 0.001
7	0.80	MgO	0.10	1.007 ± 0.001
8	1.00	MgO	0.10	1.079 ± 0.001

a. KENO-V.a calculations performed using 27-group cross sections based on ENDF/B-IV data.

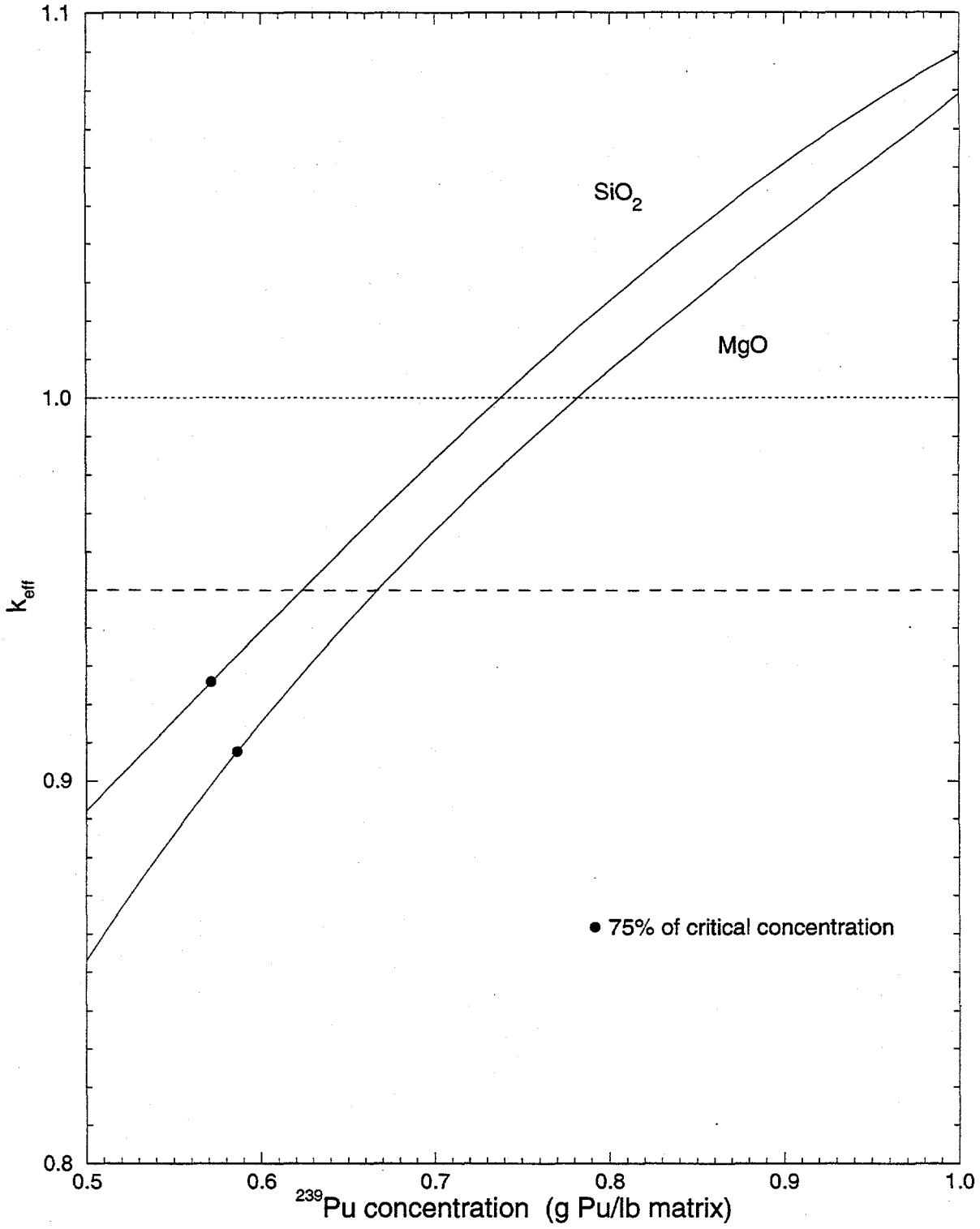


Figure 4. Calculated k_{eff} vs. ^{239}Pu concentration in graphite for discretely modeled drums

Table 8. Summary of calculations for drums containing graphite with threshold concentrations of ^{239}Pu as determined by explicitly modeling drums.

Case	Model of matrix material surrounding array of drums			$k_{eff} \pm \sigma^a$ *0.56 g Pu/lb of graphite*
	Matrix material	^{239}Pu concentration (g Pu/lb matrix)	Thickness (cm)	
Base Model 14 x 14 x 14 array of drums (2744 drums) 260 lbs of graphite per drum based on graphite density of 1.6 g/cm^3 array surrounded by thickness of ^{239}Pu and matrix material on all sides mirror reflection on all sides				
1	SiO_2	0.15	0.001	0.982 ± 0.001
2	SiO_2	0.15	10	0.964 ± 0.001
3	SiO_2	0.15	30	0.947 ± 0.001
4	SiO_2	0.15	60	0.932 ± 0.001
5	SiO_2	0.15	80	0.927 ± 0.001
6	SiO_2	0.15	100	0.921 ± 0.001
7	SiO_2	0.15	110	0.921 ± 0.001
8	SiO_2	0	100	0.800 ± 0.001
9	water	0	100	0.705 ± 0.001
10	MgO	0.10	100	0.890 ± 0.001
11	Al metal	0.82	2000[b]	0.933 ± 0.001
12	Al_2O_3	0.23	100	0.916 ± 0.001
13	cellulose	1.3	100	0.859 ± 0.001
14	polyethylene	3.1	100	0.868 ± 0.001
15	water	2.4	100	0.871 ± 0.001

a. KENO-V.a calculations performed using 27-group cross sections based on ENDF/B-IV data.
b. The isolation thickness is much greater for aluminum metal than for compounds containing oxygen and hydrogen.

6.2.3 Effects of Adding Water

The effect of possible water ingress was evaluated. Calculations were performed to demonstrate the effect of water addition to only the SiO_2 and graphite matrices since these materials have been shown to be two of the most reactive materials. Calculations were performed using infinite homogenous models for water in both SiO_2 and graphite matrices. The SiO_2 and graphite matrix materials were initially represented at theoretical density. As water was added, these matrix materials were displaced; however, the plutonium concentration conservatively remained at the initial value. Infinite systems were represented by using mirror boundary conditions. Additional calculations were performed for water in the SiO_2 matrix where mirror reflection on the top and bottom was replaced with a 30-cm-thick concrete reflector. The height of the homogeneous mixture of ^{239}Pu and SiO_2 between the concrete reflectors was equivalent to stacking the drums five high.

The results of these calculations are shown in Tables 9 and 10. In all cases, water ingress results in a decrease in k. The results in Table 10 show high k_∞ values resulting from the modeling of unrealistically high ^{239}Pu concentrations in graphite. The negative reactivity effect associated with water addition decreases as the ^{239}Pu concentration increases as would be expected due to the hardening of the spectrum with the decrease in H/x. If a positive reactivity effect, due to water ingress, were to occur, it would be at unrealistically high ^{239}Pu concentrations. Therefore, graphite waste containing realistic ^{239}Pu concentrations will show a negative reactivity effect in the event of water ingress and will remain subcritical.

Table 9. Results of KENO-V.a calculations showing the effects of adding water to SiO_2 systems.

Case	Volume %		$k_{eff} \pm \sigma$[b,c]	$k_{\infty} \pm \sigma$[b,d]
	SiO2[a]	H_2O		
1	100	0	0.819 ± 0.001	0.869 ± 0.001
2	99.5	0.5	0.799 ± 0.001	0.841 ± 0.001
3	99	1	0.783 ± 0.001	0.819 ± 0.001
4	98.5	1.5	0.770 ± 0.001	0.798 ± 0.001
5	98	2	0.754 ± 0.001	0.782 ± 0.001
6	97.5	2.5	0.741 ± 0.001	0.766 ± 0.001
7	97	3	0.727 ± 0.001	0.751 ± 0.001
8	96	4	0.706 ± 0.001	0.724 ± 0.001
9	95	5	0.682 ± 0.001	0.700 ± 0.001
10	94	6	0.663 ± 0.001	0.677 ± 0.001
11	93	7	0.645 ± 0.001	0.658 ± 0.001
12	92	8	0.629 ± 0.001	0.636 ± 0.001
13	91	9	0.611 ± 0.001	0.622 ± 0.001
14	90	10	0.596 ± 0.001	0.606 ± 0.001

a. ^{239}Pu density is held constant at the value established in Case 1 using 0.15 g Pu/lb SiO_2.
b. KENO-V.a calculations performed using 27-group cross section based on ENDF/B-IV data.
c. Homogenous cuboid equivalent to stacking 5 drums high (426.95 cm), 30-cm-thick concrete reflector on top and bottom and mirror reflection on remaining faces.
d. Infinite homogenous cuboid with mirror reflection on all faces.

Table 10. Results of SCAMP calculations showing the effects of adding water to graphite systems.

Case	Volume %		^{239}Pu concentration in graphite (g Pu/lb graphite)	k_{∞}[a]
	graphite	H2O		
1	100	0	1.0	1.909
2	90	10	1.0	1.661
3	100	0	1.5	1.894
4	90	10	1.5	1.736
5	100	0	2.0	1.878
6	90	10	2.0	1.782

a. SCAMP calculations performed using 16-group Hansen-Roach cross sections. 100-cm-thick homogeneous slab with mirror reflection on all sides.

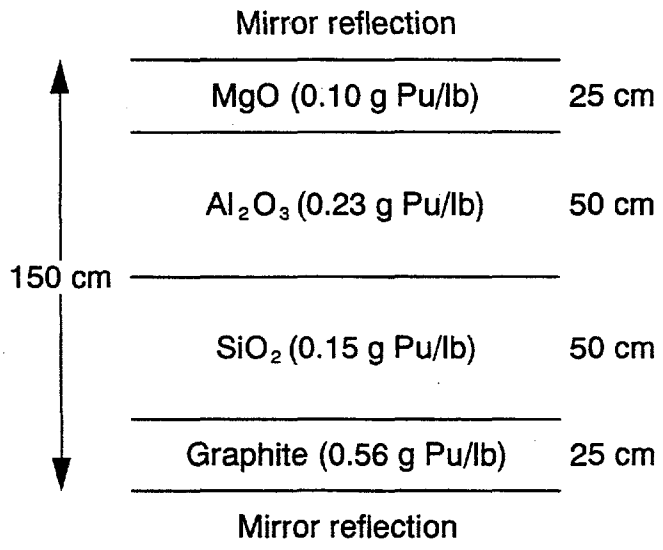
6.2.4 Effects of Heterogeneity

The effects of non-homogeneous mixtures of material were studied using SCAMP and KENO-V.a. The calculations were based on the model sketched in Figure 5(a). Layers were formed as shown in the figure and then varied as indicated in Table 11. Variable parameters include region thickness, ^{239}Pu concentration, and mesh intervals (SCAMP calculations only). A complete description of each model variation is included in the table. ^{239}Pu concentrations in each layer were 75% of critical as determined from the fully infinite homogeneous SCAMP or KENO-V.a results discussed in Section 6.2.1. The calculations were also performed with the ^{239}Pu concentration in graphite layers at 75% of the critical value as determined from KENO-V.a calculations which included the effects of steel and spacing from explicitly modeled drums as discussed in Section 6.2.2.

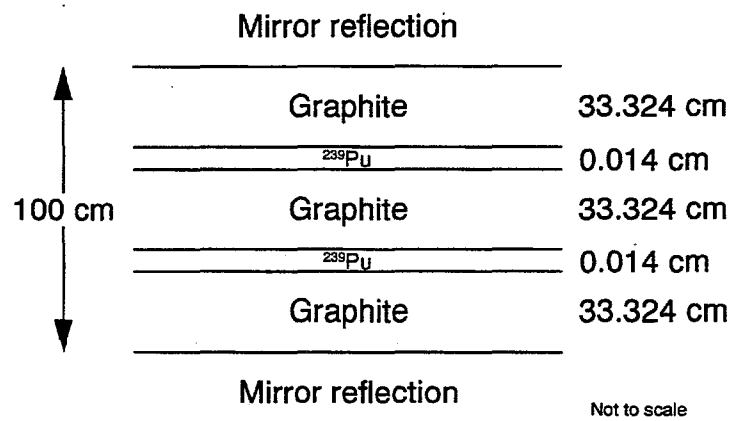
The calculated k_∞ values are listed in Table 11. The values calculated by SCAMP or KENO-V.a (using 27-group cross sections) for fully infinite homogenous systems of several different matrix materials are also listed for comparison. These results support the use of the simple yet conservative homogeneous system models . In all cases, the results for layers of different materials produced k_∞ values which were no larger than the highest value for the single matrix calculations.

As previously stated in Section 6.2.2, special, more realistic, treatment was needed to demonstrate that graphite systems were clearly subcritical. Calculated k_∞ values are unrealistically high for cases in which 0.56 g Pu/lb graphite is included in one or more layers . These values are reduced significantly when the effects of the steel in the drums and actual plutonium concentrations are considered (See Section 6.3). Acceptably low k_∞ values are obtained in all cases in which the graphite concentration is fixed at the threshold concentration value (0.02 g Pu/lb matrix) established in Section 6.2.1.

Another non-homogeneous configuration to be considered is pieces or strata of fissile material interspersed with the matrix material [See Figure 5(b)]. These calculations were performed with the SCAMP code. The details of layering are described in Table 12. Two models were calculated for each layering scheme. The total thickness of ^{239}Pu in each model was determined by the amount of ^{239}Pu present in a 100-cm-thick slab of graphite matrix containing ^{239}Pu concentrations of 1.5 g Pu/lb matrix and 0.03 g Pu/lb matrix, respectively. A density of 19.4 g/cm^3 was used for ^{239}Pu metal. The cases in Table 12 show the effects of increasing homogeneity as the ^{239}Pu mass is distributed in one to seven layers. Case 8 is the fully homogeneous calculation. It can be seen from these results that as the



a. Heterogeneous mixture of materials.
(Case 3, Table 11)



b. Heterogenous layering of Pu.
(Case 2, Table 12)

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Figure 5. Heterogeneous models used in SCAMP and KENO-V.a

Table 11. SCAMP or CSAS results showing the effects of layering materials.

Case	Order and composition of layers	Thickness of layers (cm)	^{239}Pu concentration in each layer (g Pu/lb matrix)	k_∞ [a]	$k_\infty \pm \sigma$ [b]
1	C SiO_2 Al_2O_3 MgO	50 100 100 50	0.56[c] 0.15 0.23 0.10		1.521 ± 0.001
2	C SiO_2 Al_2O_3 MgO	50 100 100 50	0.02[d] 0.15 0.23 0.10		0.871 ± 0.001
3	C SiO_2 Al_2O_3 MgO	25 50 50 25	0.56[c] 0.15 0.23 0.10		1.243 ± 0.001
4	C SiO_2 Al_2O_3 MgO	25 50 50 25	0.02[d] 0.15 0.23 0.10		0.862 ± 0.001
5	C H_2O C H_2O	50 100 100 50	0.56[c] 2.4 0.56[c] 2.4	1.307	
6	C H_2O C H_2O	50 100 100 50	0.02[d] 2.4 0.02[d] 2.4	0.858	
7	poly H_2O poly H_2O	50 100 100 50	3.1 2.4 3.1 2.4	0.857	
8	graphite	full infinite homogeneous system	0.56[c]	1.908	
9	graphite	full infinite homogeneous system	0.02[d]	0.871	
10	water	full infinite homogeneous system	2.4	0.858	
11	poly	full infinite homogeneous system	3.1	0.857	
12	SiO_2	full infinite homogeneous system	0.15		0.869 ± 0.001
13	MgO	full infinite homogeneous system	0.10		0.904 ± 0.001
14	Al_2O_3	full infinite homogeneous system	0.23		0.870 ± 0.001

a. SCAMP calculations performed using 16-group Hansen-Roach cross section data.
b. KENO-V.a calculations using 27-group cross sections based on ENDF/B-IV data.
c. 75% of critical concentration from KENO-V.a model with partially filled steel drums. (Table 7, Section 6.2.2)
d. 75% of critical concentration from infinite homogeneous SCAMP model. (Table 4, Section 6.2.1)

Table 12. Results of SCAMP calculations showing the effects of non-homogeneous distribution of ^{239}Pu in graphite.

Case	Number of layers[a]		Thickness of layers (cm)				k_∞[b]	
			1.5 g ^{239}Pu/lb graphite		0.03 g ^{239}Pu/lb graphite			
	graphite	^{239}Pu	graphite	^{239}Pu	graphite	^{239}Pu	1.5 g ^{239}Pu/lb graphite	0.03 g ^{239}Pu/lb graphite
1	2	1	49.9864	0.0272	49.999727	0.000546	1.700	0.995
2	3	2	33.3242	0.0136	33.333152	0.000273	1.848	1.042
3	4	3	24.9932	0.0091	24.999864	0.000182	1.891	1.058
4	5	4	19.9945	0.0068	19.999891	0.000136	1.901	1.064
5	6	5	16.6621	0.0055	16.666576	0.000109	1.906	1.069
6	7	6	14.2818	0.0045	14.285636	0.000091	1.907	1.072
7	8	7	12.4966	0.0039	12.499932	0.000078	1.906	1.074
8	1[c]		100[d]		100[d]		1.894	1.079
9	2[c]		f		50[e]		f	1.083

a. Graphite and ^{239}Pu alternate in model as shown in Figure 5(b).
b. SCAMP calculations performed using 16-group Hansen-Roach cross sections.
c. Homogeneous mixture of ^{239}Pu and graphite matrix.
d. Fully infinite homogeneous system.
e. ^{239}Pu concentration varies between top (0.02 g Pu/lb matrix) and bottom (0.04 g Pu/lb matrix) layers.
f. Not calculated.

number of layers increases, the heterogeneous k_{eff} increases and approaches the homogeneous system value. This is to be expected since the finite thickness layers have a measurable thermal flux depression, i.e., the thicker the fissile layer, the smaller the thermal utilization. These results are reported to demonstrate that homogeneity is an adequately conservative configuration; no significant increases in k_{eff} values or deviations from expected results are observed when the ^{239}Pu is concentrated in layers.

6.2.5 Effects of Density and Distribution of Material

Initial calculations with fixed graphite/Pu mass ratios in discretely modeled drums showed that, as expected, drums full of the graphite mixture were more reactive than partially filled drums because filled drums contained a larger mass of fissile material. The weight of a drum completely full of graphite is 770 lbs using the theoretical density of graphite (1.6 g/cm^3). The intention of this evaluation was to use the maximum recorded weight of drums in the distribution. Originally, this weight was 260 lbs. Due to changes in the content code groupings, 37 drums with weights greater than 260 lbs were added to this group after most of the calculations were complete. This number represents 2% of the drums containing graphite that are listed on the database. This, along with the fact that 260 lbs is the maximum average weight when drums are grouped by fissile concentration, support the conclusion that 260 lbs conservatively represents the total graphite and fissile content in the model.

In order to study the effects of density and distribution of the material in the drums, the volume that would be occupied by 260 lbs of graphite was calculated using the theoretical density (1.6 g/cm^3). Maintaining a total weight of 260 lbs, the height of the graphite filled region inside the drums was parametrically increased, a new graphite density calculated, and new atom densities determined based on the calculated graphite density and ^{239}Pu concentration of 1.5 g Pu/lb matrix. The results of these calculations are summarized in Table 13. Each decrease in graphite density resulted in a reduced k_{eff} value. This demonstrates that the use of theoretical densities for these calculations is conservative.

Values for k_{eff} reported in this section are much higher than would normally be considered. This is because high (relative to critical) ^{239}Pu concentrations and infinite arrays of drums were used to facilitate observing the effects of material distribution.

Table 13. Summary of KENO-V.a results showing the effects of graphite density and distribution.

Case	Graphite per drum (lbs)	Height of graphite region (cm)	Graphite density (g/cm^3)	Volume of graphite region (cm^3)	$k_\infty \pm \sigma$[a]
Base Model infinite array of discretely modeled drums modeled drums have inside dimensions of 28.575 cm radius and 85.09 cm height graphite per drum based on graphite density of 1.6 g/cm^3 ^{239}Pu concentration of 1.5 g Pu/lb graphite mirror reflection on all sides					
1	770	85.09	1.60	2.18×10^5	1.662 ± 0.001
2	260	28.81	1.60	7.39×10^4	1.402 ± 0.001
3	260	38.81	1.18	9.96×10^4	1.382 ± 0.001
4	260	48.81	0.941	1.25×10^5	1.370 ± 0.001
5	260	58.81	0.782	1.51×10^5	1.359 ± 0.001
6	260	68.81	0.668	1.76×10^5	1.348 ± 0.001
7	260	85.09	0.540	2.18×10^5	1.334 ± 0.001

a. KENO-V.a calculations performed using 16-group Hansen-Roach cross sections.

6.3 Drums with ^{239}Pu Concentrations in Excess of Threshold Values

Significant amounts of fissile material are sometimes contained in drums with relatively low overall weights. For certain waste matrix materials, the contents of a portion of those existing drums actually exceeds the calculated critical concentration (i.e., the calculated critical concentration for a fully infinite homogeneous system). Additional calculations were performed for those matrix groups to demonstrate that all existing drums, including those that exceed threshold values, will remain safely subcritical in any possible configuration including compaction due to drum damage. The following methodology was used:

1. The drums with contents that exceed 37.5% of the critical plutonium concentration were identified in the database. A value of 37.5% was selected to ensure that all drums that exceed the calculated threshold values reported in Table 4 were included in the study even if errors in the plutonium concentration values reported in the database were as large as a factor of two.

2. Of those drums identified in Item 1, the drum with the maximum average weight for each matrix material was identified. This weight and the theoretical density of the matrix material were used to establish the maximum volume that would be occupied by compacted waste. (Use of the theoretical density was shown to be conservative in Section 6.2.5.) Except in one case which will be discussed later, each of the drums with excessively high plutonium concentrations was represented in a cubical configuration using the maximum volume. The total volume of steel in a drum (~3106 cm^3) was then uniformly distributed around the cubical waste volume. By representing the drums in this manner, all external and internal void space that is characteristic of a drum array has been removed. Credit is taken for the absorption properties of steel in a conservative fashion. The steel in a drum array is always more effective when uniformly distributed throughout the waste. By representing the steel in the manner described, it is less effective than if the drums were undamaged since realistic damage to steel drums tends to disperse the steel. The thickness of the steel in the cubical drums is actually thicker than in an undamaged drum making it less effective.

3. Of those drums identified in Item 1, the drum with highest ^{239}Pu concentration was identified. This concentration was represented in all drums. In some instances, this method resulted in unacceptably high k_{eff} values. In these instances, the actual number

of drums with the higher plutonium concentration were represented and the next highest plutonium concentration was used for the remaining drums. This process was repeated until the calculated k_{eff} value was reduced to an acceptable level. By following this process, the degree of conservatism is systematically reduced, but in all cases the final representation still includes numerous conservatisms.

4. The drums were arranged within the array so the more highly concentrated waste was positioned near the center of the array. The overall array of drums was forced to be cubic by adding drums of waste material that contain the threshold concentration (75% of the critical concentration) of ^{239}Pu in the SiO_2 matrix as reported in Table 4. The actual configurations evaluated may be determined from the input listings given in Appendix B and from the information provided in Appendix E.

5. A 100-cm thickness of fissile waste (isolation thickness for SiO_2; See Table 6), represented by the threshold concentration of ^{239}Pu in the SiO_2 matrix, was represented around the array of drums. Only the fissile and matrix materials were used; the structural material of the drums was not included. Mirror reflective boundary conditions were applied to all faces of the cubic array making the entire system infinite.

The results of these calculations are given in Table 14. Calculations for polyethylene and salts were not performed because none of these drums, or an insignificant number of these drums, exceeded 37.5% of the critical plutonium concentration. When actual plutonium concentration and number of drums at that concentration is considered, the results in Table 14 indicate that all 55 gallon drums stored at the RWMC will remain safely subcritical in any configuration, even if the drums were to deteriorate significantly. Except for the case in which the waste material is represented as cellulose, all calculated k_{eff} values are well below 0.95. Due to very high concentrations (6.72 and 5.51 g Pu/lb matrix) in two drums containing cellulose waste, the calculated k_{eff} value slightly exceeds 0.95. Both of these drums contain very little waste material. When the actual waste volumes of these two drums are considered, the total contents can be conservatively combined into a single drum. The resulting k_{eff} value decreases from 0.954 to 0.864.

Case 4(c) of Table 14 is included to demonstrate, as was done previously in Section 6.2.5 with graphite, that the use of theoretical densities is conservative. Cases 4(b) and 4(c) are for drums

Table 14. Results of KENO-V.a calculations for maximum concentrations.

Case	Matrix group		^{239}Pu concentration	Drums exceeding 37.5% of the critical concentration			$k_{eff} \pm \sigma$[c]
	Number	Material	37.5% of the critical concentration[a] (g Pu/lb matrix)	Number	Maximum weight[b] (lb)	Maximum ^{239}Pu concentration (g Pu/lb matrix)	
1	1	water	1.2	0			
2	2	polyethylene	1.55	1	41.79	2.37	d
3	3	graphite	0.01	2158	203.33	1.27-0.10[e]	0.793 ± 0.0004
4	4(a) 4(b) 4(c)	glass, slag (SiO_2) glass, slag (MgO)	0.075 0.045	1015 1202	167.63 167.63	2.03-0.15[f] 2.03-0.10[g]	0.801 ± 0.0005 0.813 ± 0.0006 0.800 ± 0.0004[h]
5	5(a) 5(b)	cellulose	0.65	484	101.05	6.72-1.39[i]	0.954 ± 0.0008 0.864 ± 0.0006[j]
6	6	concrete[k]	0.28	138	202.34	1.13	0.854 ± 0.0004
7	7	metal (Al)	0.41	209	128.83	3.44	0.872 ± 0.0004
8	8	salts	2.765	10	57.32	6.09	d
9	9	brick (Al_2O_3)	0.115	136	185.33	0.95	0.832 ± 0.0004

a. Values in this column are 37.5 % of the critical concentration for a fully infinite system as reported in Table 4.
b. The equivalent volume of a single drum is based on the maximum average weight of those drums with a concentration greater than 37.5 % of the critical concentration and on the matrix density listed in Table 4.
c. KENO-V.a calculations performed using 27-group cross sections based on ENDF/B-IV data.
d. Not calculated.
e. There were 10 concentration levels modeled for graphite. See Section 6.3.
f. There were 7 concentration levels modeled for SiO_2. See Section 6.3.
g. There were 8 concentration levels modeled for MgO. See Section 6.3.
h. Base model has been changed to show that using theoretical densities for all calculations is conservative; volume of drum has been doubled and atom densities reduced by a factor of 2.
i. There were 6 concentration levels modeled for cellulose. See Section 6.3.
j. Two drums have very high concentrations with relatively low weights. The calculated k_{eff} value drops from 0.954 to 0.864 when actual weights of the two most highly concentrated drums are used.
k. Ordinary concrete as given in the KENO Hansen-Roach cross section library.

containing waste characterized as MgO. Theoretical density material was used in Case 4(b). In Case 4(c), the volume of the drums was doubled and the atom densities were reduced by a factor of 2. The total mass and ^{239}Pu concentration (g Pu/lb matrix) remained constant. Calculated k_{eff} values of 0.813 and 0.800 resulted for Cases 4(b) and 4(c), respectively. The closeness of the results of these calculations do not conclusively demonstrate the conservatism of using theoretical densities to model the matrix materials. They do, however, add evidence to the claim that it is not 'less conservative' to model in this manner.

In conclusion, the waste currently stored at RWMC will remain clearly subcritical under all normal and credible abnormal conditions. First, because only a small percentage of drums contain excess concentrations, it is incredible that a significant number could be accumulated in one location. Second, even if it were postulated to occur, it has been shown that the containers will still remain subcritical.

6.4 Single Heavily Loaded Drums

Placing a sufficiently large mass of fissile material in a single container could result in a criticality accident; however such an event is incredible for the following reasons.

1. The mass of plutonium required for a criticality to occur under ideal geometric configurations must exceed 5 kg of metal, 10 kg of unmoderated oxide, or 500 g of optimally moderated solution (Ref 9). For metal and oxides, it is incredible that mass limit violations of these magnitudes could ever occur and go undetected. Except for special processes, quantities of these magnitudes are never handled at one time. In addition, material accountability requirements are far too rigorous to allow such quantities of plutonium to be inadvertently discarded and such quantities would easily be detected by assay prior to shipment or upon receipt at the INEL.

2. Inadvertently placing 500 g of solution into a container is more likely, although still highly improbable. However, an optimal configuration is required for such small quantities of plutonium to result in a criticality. For realistic plutonium concentrations in solution, the minimum critical volume necessary to contain 500 to 1000 g quantities of fissile material exceeds 7 liters; additional hydrogenous material is also required to provide adequate reflection. Plutonium solutions of this type are processed in containers that do not exceed 1 liter. Damage to a container holding plutonium solution would result in the formation of an even less reactive geometric configuration. Material accountability requirements and assay prior to shipment decrease the possibility that a mass limit violation of this magnitude could occur. A critical configuration requires the combination of a large mass limit violation, optimum geometry, and optimal reflective conditions. This combination in a single container is clearly incredible.

6.5 Margins of Error and their Impact on the Validity of Conclusions

There are three areas of uncertainty regarding the margins of error in the Rocky Flats (RF) database: (1) The fissile gram concentration of the large stacks of drums at the RWMC versus the calculated threshold concentrations for an infinite array, (2) The number of drums and their concentrations that exceed the threshold concentrations, and (3) The fissile content for single overloaded drums. While precise margins of error have not been determined for the Rocky Flats database (and cannot be determined without opening drums), a comparison of the Rocky Flats data with the INEL assay data clearly shows that the margins of error are small compared to the margin of safety. A discussion of the two databases and each of the three areas of concern follow.

The Transuranic Waste DataBase (TWDB) contains fissile material content data for the approximately 73,000 drums, 10,000 boxes and 500 bins of Rocky Flats waste stored at the RWMC. Of this waste, approximately 17,000 drums have been assayed by INEL with the data stored in the RKIVE database. Consistency in the ^{239}Pu gram content for these 17,000 drums in these two databases shows that the margin of error is relatively small compared to the margin of safety but there is no assay data to independently confirm the accuracy of the non RF drums, the boxes or the bins. However, the non RF drums contain only 2.0 g ^{239}Pu per drum (less than one half as much as the 5.5 g ^{239}Pu per Rocky Flats drum) and the boxes and bins contain even less (0.01 g ^{239}Pu per lb and 0.007 g ^{239}Pu per lb compared to 0.018 g ^{239}Pu per lb in the RF drums). The margin of safety, as will be demonstrated, is very large for Rocky Flats drums and should be much larger for the more lightly loaded containers.

Fissile material content data derived from INEL assay of 17,152 waste drums is found in the RKIVE database. Of these drums, 17,073 can be identified in the TWDB database which gives fissile content reported by Rocky Flats. All of the drums cannot be identified because in some cases the label has become illegible. In these cases, new identification numbers were assigned for the RKIVE database. Content codes do not always match because the content code was revised in the RKIVE database but not in the TWDB if the Real Time Radiography (RTR) indicated an error in content coding. Finally, the sum of the number of drums in individual matrix groups does not match the total because some drums are coded "unknown." It is also noted that for some of the early Rocky Flats shipments, the fissile content of the individual drums are actually averages for the entire shipment; they are not individual drum determinations. Thus, a few numbers do not match but none of these factors significantly affect the analysis of the accuracy of fissile content data of more than 17,000 drums.

For the two databases, gram content distribution curves are given in Figure 6 and gram content and concentration data are given in Table 15. Both the distribution and the gram content for the same 17,000 drums in the TWDB and the RKIVE are in excellent agreement. For these 17,000 drums the average content per drum is 8.0 g ^{239}Pu for the Rocky Flats data and 7.8 g ^{239}Pu for INEL data, a difference of only 2.6%. However, the INEL average does not include the drums awaiting assay as they have been placed in a separate database. Assuming these drums each contain 200 g ^{239}Pu does not significantly affect the average but does narrow the small difference between the RF and INEL fissile content data.

The distribution curves show a small difference in the two data sets below 10 g ^{239}Pu per drum but converges to near identical averages above 10 g ^{239}Pu per drum. Furthermore, RF and INEL data show that 98.3% and 98.4% of the drums, respectively, contain less than 100 g ^{239}Pu. Both data sets show that 99.4% of the drums contain less than 150 g ^{239}Pu. The percentage of drums that might contain greater than 200 g ^{239}Pu cannot be determined from the RF curve because the limit cutoff causes a sharp deviation from the log normal distribution characteristic of the fissile loadings. However, it does appear that both data sets provide strong evidence that nearly all (greater than 99.9%) drums contain less than 200 g ^{239}Pu.

The data in Table 15 is broken into eight different content groups. Included are average ^{239}Pu gram content per drum values and ratios of INEL values to Rocky Flats values. Also included for each content group are the threshold ^{239}Pu concentrations (75% of critical; See Table 4), average concentrations (derived from the known matrix weight and the ^{239}Pu gram content taken from the Rocky Flats database), and margins of safety expressed as ratios of threshold concentration to actual concentration derived from the TWDB (Rocky Flats data).

The averages of the different content groups did not agree as well as the overall average content. The ratios of INEL to RF mass values ranged from 0.5 to 1.4, less than a factor of two. These differences are small when compared to ratios of proposed threshold concentrations (75% of critical) to actual concentrations which range from 2.1 to 170, excluding the results for graphite waste. This range is highly skewed with most of the drums having very large safety factors. [The neutron absorption cross sections for graphite are so small that very dilute concentrations have high reactivities. However, all existing graphite drums are shown to remain safely subcritical when configured in a single location within an infinite waste matrix. (See Section 6.2.2)]

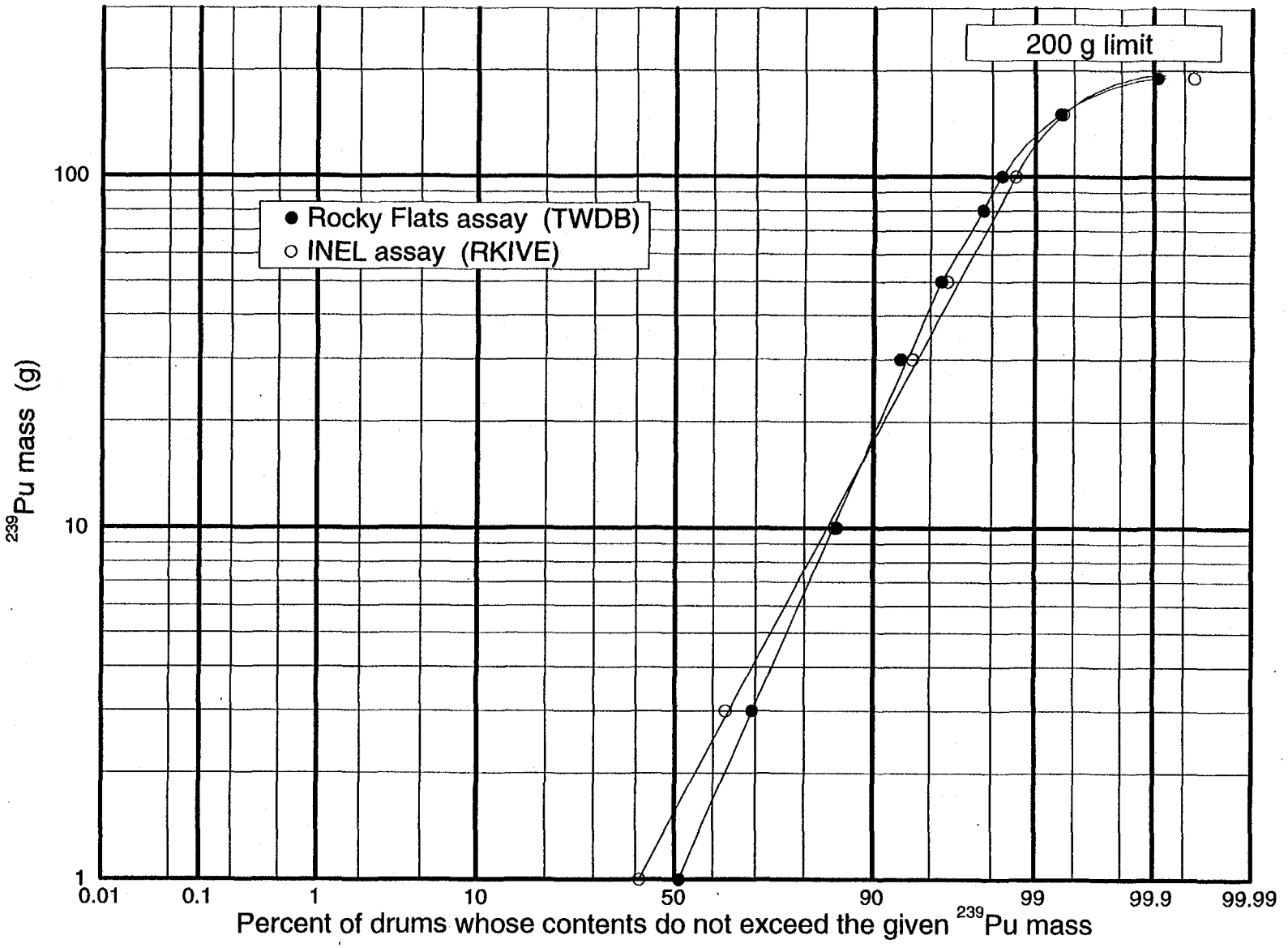

Figure 6. Distribution of ^{239}Pu in assayed drums

Table 15. Fissile content and concentrations of assayed drums.

Matrix group		^{239}Pu content of assayed drums					^{239}Pu concentration		
		INEL assay		RF assay		Ratio (INEL/RF)			
Number	Material	#	Average mass (g)	#	Average mass (g)		Threshold[a] (g Pu/lb matrix)	RF average (g Pu/lb matrix)	Ratio (Threshold/RF)
1	water	0	0.0	0	0.0		2.4	0.0	
2	polyethylene	2242	1.95	2212	3.8	0.51	3.1	0.018	170
3	graphite	834	19.9	822	20.3	0.98	0.02	0.095	0.21
4	glass, slag	5212	3.3	4406	2.3	1.4	(SiO_2) 0.15[b] (MgO) 0.09[b]	0.043	3.5 2.1
5	cellulose	2403	19.6	2403	23.1	0.85	1.3	0.07	19
6	concrete[c]	5636	5.8	6421	4.1	1.4	0.56	0.010	56
7	metals	672	10.5	657	14.1	0.74	0.82	0.078	10.5
8	salts	44	100.5	44	144.2	0.70	5.53	0.51	10.8
9	brick	109	43.0	108	38.4	1.12	0.23	0.045	5.1
all		17152	7.8	17073	8.0			0.018	

a. 75% of critical concentration as given in Table 4.
b. Threshold concentrations were calculated for glass using both SiO_2 and MgO.
c. Ordinary concrete as given in the KENO Hansen-Roach cross section library.

There is not likely to be a strong bias in one direction in either data set because the different measurement techniques performed by different personnel would not result in the same bias. More likely, in some cases the bias would be conservative and in others non-conservative. The fact that the INEL content is higher than the RF content in some groups and lower in others confirms this observation. In any case, the largest difference between the two data sets is very small compared to the safety factors. Therefore, a generous margin of safety exists for the large stacks of drums at the RWMC without taking credit for the structural integrity of the drums. It is emphasized that the average gram content and resulting concentration is the parameter of concern for this margin of safety as it has been demonstrated that the homogeneous models are conservative.

The second area of uncertainty is the margin of safety for drums that exceed threshold concentrations. The number of drums that exceed threshold concentrations was determined from the distribution data and the results from SCAMP and KENO-V.a calculations for the different content groups. An additional margin of safety is introduced by examining numbers of drums that exceed 37.5% rather than 75% of the critical concentration. A summary of data used for this comparison is given in Table 16. An inherent assumption in this approach is that all of the errors in the database are biased and the reported concentration values are lower than actual concentrations. As previously discussed, even if large errors are present, they are more likely to be random so that average values would approach real values. Thus, this conservative modeling introduces additional margins of safety. For example, there are 209 drums classified as metal with concentrations exceeding 37.5% of the critical concentration. In this example, the contents of each drum were represented with the maximum concentration *and* maximum weight resulting in 443 g ^{239}Pu per drum. A calculation of the actual content for each range in the distribution data indicates that the average for these drums is only 79 g ^{239}Pu per drum. This conservative modeling results in an additional factor of 5.6 in gram loading, equating to a large factor of conservatism. (Where multiple concentration levels were required, margins of safety are smaller.) It is also noted that at these higher gram loadings there was excellent agreement between the Rocky Flats data and the INEL assay data. In addition, it is extremely improbable that a significant portion of the drums with relatively higher ^{239}Pu concentrations would be in one location. It is clear that criticality is not a concern for the most reactive configuration of drums that exceed the threshold concentration even if large errors exist in the database for individual drums.

The margin of error for the third area of uncertainty, the fissile content of single overloaded drums, is also generous but relies more on engineering judgement rather than on an examination of the database. Single overloaded drums are discussed in Section 6.4 and are not addressed here.

Table 16. Percentage of drums exceeding 37.5% the calculated critical values.

Matrix group		37.5% of critical ^{239}Pu concentration (g Pu/lb matrix)	Drums		
Number	Material		Total in matrix group (#)	Exceeding 37.5% of critical concentration	
				#	%
1	water	1.2	0	0	0.0
2	polyethylene	1.55	11376	1	0.009
3	graphite	0.01	2365	2158	91.25[a]
4	glass, slag (SiO_2) glass slag (MgO)	0.075 0.045	9904 9904	1015 1202	10.25 12.14
5	cellulose	0.65	16408	484	2.95
6	concrete[b]	0.28	27526	138	0.50
7	metal (Al)	0.41	4030	209	5.19
8	salts	2.765	88	10	11.36
9	brick (Al_2O_3)	0.12	1031	136	13.19
all			72737[c]	4338	5.96

a. The majority of the waste drums with contents characterized as graphite have plutonium concentrations that exceed 37.5% of the minimum critical concentration. However, these drums are shown to be safely subcritical when more realistic representations are used.
b. Ordinary concrete as given in the KENO Hansen-Roach cross section library.
c. This is the total number given in the database for "all" drums. Due to unknown contents in a few drums, the sum of the number of drums in all matrix groups is 72,728.

It is of interest to note that the RF and the INEL data (shown in Table 15) indicate, when adjusted for the same number of drums, a total mass of 138 and 134 kg of ^{239}Pu, respectively. Nevertheless, this quantity of fissile material has been conclusively shown to be distributed through the waste matrix in concentrations that are far below critical. Only a very small percentage of the drums have high gram loadings so that accumulations of highly concentrated drums is extremely improbable. It is concluded that the RF database is adequate for the calculations considering the large margins of safety, the agreement with the INEL assay data, and the conservatisms in the criticality calculations and modeling. It is concluded that margins of safety are such that criticality at the RWMC is incredible.

7.0 DESIGN FEATURES (PASSIVE & ACTIVE) AND ADMINISTRATIVELY CONTROLLED LIMITS AND REQUIREMENTS

The conclusions stated in this evaluation do not rely upon design features or administrative controls. For most cases, fully infinite systems are modeled which do not incorporate container dimensions. When the containers are modeled explicitly, they are in conservative, close-packed or fully compressed, and infinite arrangements. No special design features or administratively controlled limits are required for handling drums, bins or boxes which are now in storage.

Based on the database information available, the results reported herein confirm that the waste drums, bins, and boxes currently stored at the RWMC will remain safely subcritical if rearranged, restacked, or otherwise handled. This is true for all drums presently in storage, including those suspected to be in violation of the 200 gram mass limit as long as they do not contain over 380 grams (75% of the minimum critical mass of ^{239}Pu in water) of fissile material. If encountered, such drums will require individual evaluation to determine a safe disposition. The 200 gram limit has been established for shipping purposes.

Drums may be accepted for storage only if: (1) The content code is included in those described in Table 2 and Appendix C, (2) The concentration of fissile material is no greater than that listed in Table 17, and (3) No single drum contains over 380 grams of fissile material. Since the analysis was based on fully infinite systems, any number of drums may be accepted if they meet these conditions. Other criteria may be established for specific waste streams provided criticality analyses that demonstrate an adequate margin of safety without operational or configuration controls have been reviewed and approved.

Table 17. Acceptance criteria for future receipt of waste.

Matrix group			Threshold concentration (g Pu/lb matrix)
Number	Material	Density (g/cm^3)	
1	water	1.0	2.4
2	polyethylene	0.92	3.1
3	graphite	1.6	0.02
4	glass, slag	3.58	0.09
5	cellulose	0.64	1.3
6	concrete[a]	2.37	0.56
7	metal	2.7	0.82
8	salts	2.16	5.53
9	brick	3.965	0.23

a. Ordinary concrete as given in the KENO Hansen-Roach cross section library.

8.0 SUMMARY AND CONCLUSIONS

The methodology and conclusions in this report are based primarily on the assumption that the existing database is reasonably accurate and reliable. As drums are assayed, more information becomes available which may help verify that this is indeed the case. However, until that information is available for a large number of drums, possible inaccuracy in the database remains an issue. The question of possible inaccuracies is addressed by: comparing Rocky Flats data with INEL assay values in Section 6.5; overestimating the number of drums exceeding the threshold values; and demonstrating through calculations that even if major discrepancies and large error factors exist, there are adequate conservatisms and the conclusions remain valid.

The calculational models used in this evaluation contain several conservatisms. Among them are: (1) Limits are established for fully infinite homogeneous systems, (2) Drums are categorized by the most reactive component of the waste matrix material (highly absorbing impurities are neglected), (3) Fissile concentrations and net drum weights were represented, in most cases, as if all drums had the contents equivalent to the maximum values in the database, and (4) All plutonium was modeled as 100% ^{239}Pu while in actuality, the isotopic composition includes ^{240}Pu.

The results from calculations included in this evaluation demonstrate that stored waste under current and any credible, foreseeable conditions, including total drum collapse, will remain subcritical based on the concentrations of fissile material actually present for the types of waste stored at the facility. The results and conclusions presented in this report will be valid so long as future waste shipments are of the same general type and do not exceed the acceptance criteria reported in Section 7.0 of this report.

An independent review of this evaluation verified the calculational results of this CSE and concluded that it provides an adequate basis for criticality safety of TRU waste stored at the RWMC. A copy of the independent review summary is given in Appendix F.

9.0 REFERENCES

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APPENDIX A:
MATERIALS AND COMPOSITIONS

SUMMARY OF TABLES IN APPENDIX A

Table A-1. Atom densities used to evaluate waste that is characterized as water (H_2O; ρ=1.0 g/cm^3).

Waste Component	Plutonium Concentration (g Pu/lb Matrix)	SCAMP Library ID	KENO Library ID	Atom Density (Volume Fraction)
^{239}Pu	1.5	616	94916	8.3321-6
	2.0	616	94916	1.1108-5
	2.4	616	94916	1.3331-5
	2.5	616	94916	1.3888-5
	3.0	615	94915	4.5041-6
		616	94916	1.2160-5
	3.2	615	94915	7.2170-6
		616	94916	1.0532-5
	3.5	615	94915	1.1446-5
		616	94916	7.9953-6
	4.0	615	94915	1.8392-5
		616	94916	3.8278-6
H_2O	--	708	502	(1.0)

Table A-2. Atom densities used to evaluate waste that is characterized as polyethylene (CH_2; ρ=0.92 g/cm^3).

Waste Component	Plutonium Concentration (g Pu/lb Matrix)	SCAMP Library ID	KENO Library ID	Atom Density (Volume Fraction)
^{239}Pu	2.0	616	94916	1.0221-5
	2.5	616	94916	1.2776-5
	3.0	616	94916	1.5331-5
	3.1	616	94916	1.5842-5
	3.5	616	94916	1.7886-5
	4.0	615	94915	5.9085-6
		616	94916	1.4533-5
	4.5	615	94915	1.2295-5
		616	94916	1.0701-5
CH_2	--	706	402	(1.0)

Table A-3. Atom densities used to evaluate waste that is characterized as graphite (ρ=1.6 g/cm^3).

Waste Component	Plutonium Concentration (g Pu/lb Matrix)	SCAMP Library ID	KENO Library ID	Atom Density (Volume Fraction)
^{239}Pu	0.02	616	94916	1.7770-7
	0.025	616	94916	2.2220-7
	0.03	616	94916	2.6660-7
	0.05	616	94916	4.4440-7
	0.15	616	94916	1.3328-6
	0.20	616	94916	1.7770-6
	0.50	615	94915	1.3730-6
		616	94916	3.0710-6
	0.56	615	94915	2.9533-6
		616	94916	2.0237-6
	0.60	615	94915	3.8418-6
		616	94916	1.4907-6
	0.80	614	94914	2.3499-6
		615	94915	4.7600-6
	1.00	614	94914	7.6739-6
		615	94915	1.2110-6
	1.50	613	94913	7.6759-6
		614	94914	5.6541-6
	2.00	613	94913	1.6553-5
		614	94914	1.2171-6
C	--	8	6100	8.0233-2[a]

a. Additional calculations were performed in which graphite volume fractions less than 1.0 were used. Atom densities for these cases are obtained by multiplying the carbon atom density given in this table by the volume fraction.

Table A-4. Atom densities used to evaluate waste that is characterized as silicon dioxide (SiO_2; ρ=2.32 g/cm^3).

Waste Component ID[a]	Plutonium Concentration (g Pu/lb Matrix)	Atom Density (Volume Fraction)
Pu-239	0.10	1.2887-6
	0.12	1.5464-6
	0.14	1.8042-6
	0.15	1.9330-6
	0.16	2.0619-6
	0.20	2.5774-6
	0.25	3.2218-6
Si	--	2.3256-2[b]
O	--	4.6513-2[b]

a. SCALE Standard Composition Library ID used for KENO-V.a calculations.
b. Additional calculations were performed in which silicon dioxide volume fractions less than 1.0 were used. Atom densities for these cases are obtained by multiplying the Si and O atom densities given in this table by the volume fraction.

Table A-5. Atom densities used to evaluate waste that is characterized as magnesium oxide (MgO; ρ=3.58 g/cm^3).

Waste Component ID[a]	Plutonium Concentration (g Pu/lb Matrix)	Atom Density (Volume Fraction)
Pu-239	0.05	9.9435-7
	0.07	1.3921-6
	0.10	1.9887-6
	0.12	2.3864-6
	0.13	2.5853-6
	0.15	2.9831-6
	0.20	3.9774-6
	0.25	4.9718-6
	0.30	5.9661-6
Mg	--	5.3499-2
O	--	5.3499-2

a. SCALE Standard Composition Library ID used for KENO-V.a calculations.

Table A-6. Atom densities used to evaluate waste that is characterized as cellulose ($C_6H_{10}O_5$; ρ=0.64 g/cm^3).

Waste Component	Plutonium Concentration (g Pu/lb Matrix)	SCAMP Library ID	KENO Library ID	Atom Density (Volume Fraction)
^{239}Pu	1.0	616	94916	3.5550-6
	1.3	616	94916	4.6216-6
	1.5	616	94916	5.3325-6
	1.7	615	94915	1.8392-7
		616	94916	5.8596-6
	2.0	615	94915	2.8500-6
		616	94916	4.2600-6
	2.5	615	94915	7.2930-6
		616	94916	1.5945-6
	3.0	615	94915	2.1422-6
		616	94916	8.5228-6
C	--	8	6100	1.4260-2
H	--	2	1102	2.3780-2
O	--	10	8100	1.1890-2

Table A-7. Atom densities used to evaluate waste that is characterized as concrete (ρ=2.37 g/cm^3).

Waste Component	Plutonium Concentration (g Pu/lb Matrix)	SCAMP Library ID	KENO Library ID	Atom Density (Volume Fraction)
^{239}Pu	0.5	615	94915	3.2034-6
		616	94916	3.3788-6
	0.6	615	94915	6.4941-6
		616	94916	1.4046-6
	0.75	615	94915	3.1135-6
		616	94916	6.7599-6
	0.8	615	94915	5.0852-6
		616	94916	5.4464-6
	1.0	615	94915	1.2985-5
		616	94916	1.7599-7
Ordinary Concrete	--	703	301	(1.0)

Table A-8. Atom densities used to evaluate waste that is characterized as aluminum (ρ=2.70 g/cm^3).

Waste Component	Plutonium Concentration (g Pu/lb Matrix)	SCAMP Library ID	KENO Library ID	Atom Density (Volume Fraction)
^{239}Pu	0.5	615	94915	6.8508-6
		616	94916	6.4799-7
	0.75	615	94915	7.7399-6
		616	94916	3.5078-6
	1.0	615	94915	4.2080-6
		616	94916	1.0789-5
	1.5	615	94915	4.1574-6
		616	94916	1.8339-5
	2.0	615	94915	1.9104-5
		616	94916	1.0891-5
Al	--	14	13100	6.0271-2

Table A-9. Atom densities used to evaluate waste that is characterized as salts (ρ=2.16 g/cm^3).

Waste Component	Plutonium Concentration (g Pu/lb Matrix)	SCAMP Library ID	KENO Library ID	Atom Density (Volume Fraction)
^{239}Pu	5.0	609	94909	5.2237-5
		610	94910	7.7536-6
	5.5	609	94909	6.4194-5
		610	94910	1.7948-6
	6.1	608	94908	1.0711-5
		609	94909	6.2477-5
	6.5	608	94908	2.0245-5
		609	94909	5.7743-5
	7.0	608	94908	3.2162-5
		609	94909	5.1825-5
	8.0	608	94908	5.5996-5
		609	94909	3.9988-5
Na	--	12	11100	1.1156-2
Ca	--	19	20100	5.8338-3
Cl	--	17	17100	2.2824-2

Table A-10. Atom densities used to evaluate waste that is characterized as aluminum oxide (Al_2O_3; ρ=3.965 g/cm^3).

Waste Component ID[a]	Plutonium Concentration (g Pu/lb Matrix)	Atom Density (Volume Fraction)
Pu-239	0.20	4.4049-6
	0.23	5.0656-6
	0.25	5.5061-6
	0.28	6.1668-6
	0.30	6.6072-6
	0.33	7.2679-6
	0.37	8.1489-6
	0.40	8.8097-6
Al	--	4.6844-2
O	--	7.0266-2

a. SCALE Standard Composition Library ID used for KENO-V.a calculations.

Table A-11. Atom densities used to evaluate waste that is characterized as graphite (C; 1.6 g/cm$_3$) with plutonium concentrations that exceed 37.5% of the calculated critical concentration.

Waste Component ID[a]	Plutonium Concentration (g Pu/lb Matrix)	Atom Density (Atoms/barn-cm)
Pu-239	1.27	1.1287-5
	0.99	8.7986-6
	0.85	7.5543-6
	0.65	5.7768-6
	0.54	4.7992-6
	0.44	3.9105-6
	0.34	3.0217-6
	0.24	2.1330-6
	0.14	1.2442-6
	0.10	8.8875-7
C	--	8.0233-2

a. SCALE Standard Composition Library ID used for KENO-V.a calculations.

Table A-12. Atom densities used to evaluate waste that is characterized as glass (SiO_2; 2.32 g/cm^3) with plutonium concentrations that exceed 37.5% of the calculated critical concentration.

Waste Component ID[a]	Plutonium Concentration (g Pu/lb Matrix)	Atom Density (Atoms/barn-cm)
Pu-239	2.03	2.6160-5
	1.34	1.7268-5
	0.95	1.2243-5
	0.74	9.5362-6
	0.55	7.0877-6
	0.24	3.0928-6
	0.15	1.9330-6
	0.15[b]	1.9330-6
Si	--	2.3256-2
O	--	4.6513-2

a. SCALE Standard Composition Library ID used for KENO-V.a calculations.

b. This plutonium concentration corresponds to 75% of the minimum critical plutonium concentration in a fully infinite glass environment and was used to represent surrounding waste material in all calculations that were performed to demonstrate the safety of existing drums that exceed threshold values.

Table A-13. Atom densities used to evaluate waste that is characterized as glass (MgO; 3.58 g/cm^3) with plutonium concentrations that exceed 37.5% of the calculated critical concentration.

Waste Component ID[a]	Plutonium Concentration (g Pu/lb Matrix)	Atom Density (Atoms/barn-cm)
Pu-239	2.03	4.0468-5
	1.34	2.6647-5
	0.95	1.8891-5
	0.74	1.4715-5
	0.55	1.0937-5
	0.24	4.7726-6
	0.15	2.9829-6
	0.10	1.9886-6
	0.055	1.09370-6
Mg	--	5.3499-2
O	--	5.3499-2

a. SCALE Standard Composition Library ID used for KENO-V.a calculations.

Table A-14. Atom densities used to evaluate waste that is characterized as cellulose ($C_6H_{10}O_5$;0.64 g/cm^3) with plutonium concentrations that exceed 37.5% of the calculated critical concentration.

Waste Component ID[a]	Plutonium Concentration (g Pu/lb Matrix)	Atom Density (Atoms/barn-cm)
Pu-239	6.72	2.3890-5
	5.51	1.9588-5
	4.64	1.6495-5
	3.38	1.2016-5
	2.32	8.2476-5
	1.39	4.9414-6
	0.95	3.3772-6
C	--	1.4260-2
H	--	2.3780-2
O	--	1.1890-2

a. SCALE Standard Composition Library ID used for KENO-V.a calculations.

Table A-15. Atom densities used to evaluate waste that is characterized as concrete (2.37 g/cm^3) with plutonium concentrations that exceed 37.5% of the calculated critical concentration.

Waste Component ID[a]	Plutonium Concentration (g Pu/lb Matrix)	Atom Density (Atoms/barn-cm)
Pu-239	1.13	1.4875-5
H	--	1.4868-2
C	--	3.8140-3
O	--	4.1519-2
Ca	--	1.1588-2
Si	--	6.0370-3
Fe	--	1.9680-4
Al	--	7.3500-4
Na	--	3.0400-4
Mg	--	5.8700-4

a. SCALE Standard Composition Library ID used for KENO-V.a calculations.

Table A-16. Atom densities used to evaluate waste that is characterized as metal (Al; 2.70 g/cm^3) with plutonium concentrations that exceed 37.5% of the calculated critical concentration.

Waste Component ID[a]	Plutonium Concentration (g Pu/lb Matrix)	Atom Density (Atoms/barn-cm)
Pu-239	3.44	5.1592-5
Al	--	1.4260-2

a. SCALE Standard Composition Library ID used for KENO-V.a calculations.

Table A-17. Atom densities used to evaluate waste that is characterized as brick (Al_2O_3; 3.965 g/cm^3) with plutonium concentrations that exceed 37.5% of the calculated critical concentration.

Waste Component ID[a]	Plutonium Concentration (g Pu/lb Matrix)	Atom Density (Atoms/barn-cm)
Pu-239	0.95	2.0923-5
Al	--	4.6844-2
O	--	7.0266-2

a. SCALE Standard Composition Library ID used for KENO-V.a calculations.

APPENDIX B:

TYPICAL SCAMP, CSAS, MCNP, KENO, AND COMBINE INPUT LISTINGS

SUMMARY OF INPUT LISTINGS IN APPENDIX B

Listing 1. Table 1 Case 1, SCAMP input using Hansen-Roach cross sections.

```
LIMIT          1  16   3   1   2
H2OSLAB PU=1.5G/lb; VF H2O=1.0                                          1
       1  13   0   1  16   0   1   1   0   1   0   0   0   0   2
      19   1 999
    1  1   1   1
    2  1   1   1
11  1  1   2 616 708
       1   1  .001
       2   1  .001
    1  1   1  100.0
  1 1  1   5  1.0          1.0          1.0          1.0          1.0
  1 1  6   5  1.0          1.0          1.0          1.0          1.0
  1 1 11   5  1.0          1.0          1.0          1.0          1.0
  1 1 16   1  1.0
  1 2  1   5  1.0          1.0          1.0          1.0          1.0
  1 2  6   5  1.0          1.0          1.0          1.0          1.0
  1 2 11   5  1.0          1.0          1.0          1.0          1.0
  1 2 16   1  1.0
  5 1  1   5  .225          .347        .161         .170         .084
  5 1  6   1  .013
111 1  1   2 8.3321-6      1.0
H2OSLAB PU=2G/lb; VF H2O=1.0                                            1
      12   1   4
11  1  1   2 616 708
111 1  1   2 1.11086-5     1.0
H2OSLAB PU=2.5G/lb; VF H2O=1.0                                          1
      12   1   4
11  1  1   2 616 708
111 1  1   2 1.3888-5      1.0
H2OSLAB PU=3G/lb; VF H2O=1.0                                            1
      12   1   4
11  1  1   3 615 616 708
111 1  1   3 4.50411-6     1.21599-5    1.0
H2OSLAB PU=3.2G/lb; VF H2O=1.0                                          1
      12   1   4
11  1  1   3 615 616 708
111 1  1   3 7.21700-6     1.05323-5    1.0
H2OSLAB PU=3.5G/lb; VF H2O=1.0                                          1
      12   1   4
11  1  1   3 615 616 708
111 1  1   3 1.14457-5     7.99532-6    1.0
H2OSLAB PU=4G/lb; VF H2O=1.0                                            1
      12   1   4
11  1  1   3 615 616 708
111 1  1   3 1.83922-5     3.82776-6    1.0
```

Listing 2. Table 1 Case 1, KENO-V.a input using Hansen-Roach cross sections.

```
KWSLAB INF SLAB 3.2 G/LB PU in water
READ PARA
     TME=40.0  GEN=153   NPG=407    LIB=41
     FLX=NO     FDN=NO    AMX=NO    FAR=NO
     RUN=YES   PLT=NO    NUB=YES
END PARA
READ MIXT
     MIX=1   94915   7.2170-6  94916 1.0532-5  502 1.0
END MIXT
READ GEOM
GLOBAL
     UNIT 1
     CUBOID  1 1   4P28.575  2P50.0
END GEOM
READ START NST=0 END START
READ BOUNDS  ALL=MIRROR  END BOUNDS
READ PLOT
     PLT=YES   PIC=MIX   NCH=' *.C'
     TTL=* "X-Y CELLL" *
     XUL=-28.8  YUL=28.8  ZUL=5.0
     XLR=28.8  YLR=-28.8   ZLR=5.0
     UAX=1.0   VDN=-1.0   NAX=130   END
END PLOT
END DATA
```

Listing 3. Table 1 Case 1, KENO-V.a input using CSAS and 27-group cross sections.

```
=CSAS25
CWSLAB 3.2 g Pu /lb water
27GROUPNDF4  INFHOMMEDIUM
PU-239  1  0  1.7777-5  END
H2O     1     1.0       END
END COMP
KWSLAB INF SLAB 3.2 G/LB PU in water
READ PARA
     TME=40.0  GEN=153   NPG=407
     FLX=NO     FDN=NO    AMX=NO     FAR=NO
     RUN=YES   PLT=NO    NUB=YES
END PARA
READ GEOM
GLOBAL
     UNIT 1
     CUBOID  1 1   4P28.575  2P50.0
END GEOM
READ START NST=0 END START
READ BOUNDS  ALL=MIRROR  END BOUNDS
READ PLOT
     PLT=YES   PIC=MIX   NCH=' *.C'
     TTL=* "X-Y CELLL" *
     XUL=-28.8  YUL=28.8  ZUL=5.0
     XLR=28.8  YLR=-28.8   ZLR=5.0
     UAX=1.0   VDN=-1.0   NAX=130   END
END PLOT
END DATA
```

Listing 4. Table 1 Case 1, MCNP input.

```
MWSLAB  INF SLAB 3.2 G/LB PU IN WATER
1     1 1.00130749e-1  -1 2 -3 4 -5 6  imp:n=1  $slab

*1     px  28.575  $asterisk means reflecting surface
*2     px  -28.575
*3     py  28.575
*4     py  -28.575
*5     pz  50.0
*6     pz  -50.0

kcode  1000 1 20 145 50000  $npg=1000, nsk=20 gen=145
sdef  cel=1  $starting source in cell 1
print
m1    94239.50c 1.7749e-5  1001.50c 0.066742  8016.50c 0.033371
mt1   lwtr.01t
```

Listing 5. Table 1 Case 1, COMBINE input.

```
= blrc003  Pu in Water, PU=3.20 g/lb
1010101    0   1   1   1   4  16   2   7   0   0   0   0   0  54   1  30
1010201  166 157 154 152 149 144 136 130 123 116 111 107 101  82  44  22
1020101    3   3   3
1030101   14   0 998   0   0   0   0
1030201    1   1   0   0   1
1030202    1   2   0   0   1
1030203    1   3   0   0   1
1030204    1   4   0   0   1
1041001   1.0000E-06  1.0000E-06  2.9300E+02
1042001  505.0      1.00000  3.33710-02   0.0  0.0000E+00  0.0000E+00
1042002  509.0      1.00000  3.33710-02   0.0  0.0000E+00  0.0000E+00
1042003    1.0      1.00296  3.33710-02   0.0  0.0000E+00  0.0000E+00
1042004  645.0     94.23905  1.77490-05   0.0  0.0         0.0
```

Listing 6. Table 1 Case 1, SCAMP input with COMBINE generated cross sections.

```
LIMIT          1  16   3   1   2   2
ALCOM16 PU=.37G/lb VF AL2O3                                                  1
       1  13   0   1  16   0   1   1   3  20   0   0   0   0   2
      19   4   0 998   0   4
    1  1   1   1
    2  1   1   1
1 1 1  1   3   4   3  2  1
       1   1  .001
       2   1  .001
    1  1   1  100.0
  1 1  1   5  1.0          1.0          1.0          1.0          1.0
  1 1  6   5  1.0          1.0          1.0          1.0          1.0
  1 1 11   5  1.0          1.0          1.0          1.0          1.0
  1 1 16   1  1.0
  1 2  1   5  1.0          1.0          1.0          1.0          1.0
  1 2  6   5  1.0          1.0          1.0          1.0          1.0
  1 2 11   5  1.0          1.0          1.0          1.0          1.0
  1 2 16   1  1.0
  5 1  1   5 2.55974E-01 3.48185E-01 1.71622E-01 1.39795E-01 7.01995E-02
  5 1  6   5 1.34929E-02 6.54148E-04 7.17970E-05 5.20614E-06 3.44291E-07
  5 1 11   4 4.84487E-08 1.24487E-08 9.90516E-10 3.69914E-10
111 1  1   3 1.77490E-05 3.337100-02 3.337100-02 3.33710E-02
  0 0  3    DUMMY MATERIAL ABS O (FAST) + H2O 296K HAYWOOD(0-2 (THERMAL)
  1 3  1 1 5 3.33330E+11 3.33332E+11 3.33333E+11 3.33333E+11 3.33333E+11 0.    3
  1 3  6 1 5 3.33333E+11 3.33333E+11 3.33333E+11 3.33333E+11 3.33333E+11 0.    3
  1 3 11 1 5 3.33333E+11 3.33333E+11 3.33333E+11 3.33333E+11 8.72478E-03 0.    3
  1 3 16 1 1 4.42902E-03 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    3
  1 3  1 2 5 1.00000E-12 1.00000E-12 1.00000E-12 1.00000E-12 1.00000E-12 0.    3
  1 3  6 2 5 1.00000E-12 1.00000E-12 1.00000E-12 1.00000E-12 1.00000E-12 0.    3
  1 3 11 2 5 1.00000E-12 1.00000E-12 1.00000E-12 1.00000E-12 2.78775E-01 0.    3
  1 3 16 2 1 6.07424E-01 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    3
  4 3  1 0 5 1.00000E-12 1.00000E-12 1.00000E-12 1.00000E-12 1.00000E-12 0.    3
  4 3  6 0 5 1.00000E-12 1.00000E-12 1.00000E-12 1.00000E-12 1.00000E-12 0.    3
  4 3 11 0 5 1.00000E-12 1.00000E-12 1.00000E-12 1.00000E-12 4.27452E+01 0.    3
  4 3 16 0 1 8.17683E+01 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    3
  3 3 1511 5 0.00000E+00 0.00000E+00 0.00000E+00 8.92852E-02 3.88013E+01 0.    3
  6 3 1511 5 0.00000E+00 0.00000E+00 0.00000E+00 1.11441E-01 2.01178E+01 0.    3
  3 3 1516 1 2.62555E+01 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    3
  6 3 1516 1 2.45044E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    3
  3 3 1611 5 0.00000E+00 0.00000E+00 0.00000E+00 9.30068E-06 3.59579E+00 0.    3
  6 3 1611 5 0.00000E+00 0.00000E+00 0.00000E+00-4.19115E-07 7.65132E-01 0.    3
  3 3 1616 1 9.71905E+01 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    3
1 6 3 1616 1 1.88603E+01 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    3
  0 0  1    OXYGEN-16  VERS 5    (FAST) + DUMMY MATERIAL ABS O (THERMAL)
  1 1  1 1 5 2.70218E-01 2.34943E-01 9.30830E-02 9.44555E-02 7.58272E-02 0.    1
  1 1  6 1 5 9.09870E-02 9.27106E-02 9.27186E-02 9.27794E-02 9.29676E-02 0.    1
  1 1 11 1 5 9.26010E-02 9.28234E-02 9.28184E-02 9.27569E-02 3.33333E+06 0.    1
  1 1 16 1 1 3.33333E+06 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    1
  1 1  1 2 5 4.15622E-02 2.19921E-08 2.76998E-08 3.71206E-08 6.11484E-08 0.    1
  1 1  6 2 5 1.41066E-07 3.42413E-07 7.80394E-07 1.87374E-06 3.90670E-06 0.    1
  1 1 11 2 5 6.82652E-06 1.28674E-05 2.22528E-05 3.46154E-05 0.00000E+00 0.    1
  4 1  1 0 5 1.41571E+00 1.45799E+00 3.75056E+00 3.58401E+00 4.10658E+00 0.    1
  4 1  6 0 5 3.58611E+00 3.57567E+00 3.58742E+00 3.58987E+00 3.59042E+00 0.    1
  4 1 11 0 5 3.59052E+00 3.59052E+00 3.59053E+00 3.59057E+00 1.00000E-07 0.    1
  4 1 16 0 1 1.00000E-07 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    1
  3 1  1 1 5 1.55783E+00 3.13866E-01 4.31109E-03 3.55220E-03 1.19044E-03 0.    1
  6 1  1 1 5 6.17257E-01-1.11198E-01 8.20143E-04-2.89399E-05-2.02343E-04 0.    1
  3 1  1 6 5 3.54884E-05 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    1
  6 1  1 6 5-1.45122E-05 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    1
  3 1  2 1 5 0.00000E+00 1.22018E+00 3.54537E-01 0.00000E+00 0.00000E+00 0.    1
  6 1  2 1 5 0.00000E+00 2.18719E-01-1.01992E-01 0.00000E+00 0.00000E+00 0.    1
  3 1  3 1 5 0.00000E+00 0.00000E+00 2.81272E+00 1.04906E+00 0.00000E+00 0.    1
  6 1  3 1 5 0.00000E+00 0.00000E+00 5.07782E-01-3.96553E-01 0.00000E+00 0.    1
  3 1  4 1 5 0.00000E+00 0.00000E+00 0.00000E+00 3.57594E+00 8.35280E-01 0.    1
  6 1  4 1 5 0.00000E+00 0.00000E+00 0.00000E+00 1.13274E+00-3.05527E-01 0.    1
  3 1  5 1 5 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 3.34658E+00 0.    1
  6 1  5 1 5 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00-3.78529E-01 0.    1
  3 1  5 6 5 2.85449E-01 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    1
  6 1  5 6 5-9.60195E-02 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    1
  3 1  6 6 5 3.46328E+00 1.91393E-01 0.00000E+00 0.00000E+00 0.00000E+00 0.    1
  6 1  6 6 5 1.19348E-01-5.07849E-02 0.00000E+00 0.00000E+00 0.00000E+00 0.    1
  3 1  7 6 5 0.00000E+00 3.43893E+00 2.93641E-01 0.00000E+00 0.00000E+00 0.    1
  6 1  7 6 5 0.00000E+00 2.41985E-01-8.50785E-02 0.00000E+00 0.00000E+00 0.    1
  3 1  8 6 5 0.00000E+00 0.00000E+00 3.48804E+00 2.56804E-01 0.00000E+00 0.    1
  6 1  8 6 5 0.00000E+00 0.00000E+00 2.33661E-01-7.62301E-02 0.00000E+00 0.    1
  3 1  9 6 5 0.00000E+00 0.00000E+00 0.00000E+00 3.48941E+00 2.57998E-01 0.    1
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Listing 6. Continued.

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  6 1  9 6 5 0.00000E+00 0.00000E+00 0.00000E+00 2.35431E-01-7.78913E-02 0.    1
  3 1 10 6 5 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 3.34503E+00 0.    1
  6 1 10 6 5 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 2.74157E-01 0.    1
  3 1 1011 5 4.02942E-01 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    1
  6 1 1011 5-1.16593E-01 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    1
  3 1 1111 5 3.29749E+00 4.50584E-01 0.00000E+00 0.00000E+00 0.00000E+00 0.    1
  6 1 1111 5 2.95743E-01-1.38174E-01 0.00000E+00 0.00000E+00 0.00000E+00 0.    1
  3 1 1211 5 0.00000E+00 3.44763E+00 3.00449E-01 0.00000E+00 0.00000E+00 0.    1
  6 1 1211 5 0.00000E+00 2.48892E-01-9.13235E-02 0.00000E+00 0.00000E+00 0.    1
  3 1 1311 5 0.00000E+00 0.00000E+00 3.14444E+00 6.03634E-01 0.00000E+00 0.    1
  6 1 1311 5 0.00000E+00 0.00000E+00 3.41418E-01-1.83849E-01 0.00000E+00 0.    1
  3 1 1411 5 0.00000E+00 0.00000E+00 0.00000E+00 3.29121E+00 4.56890E-01 0.    1
  6 1 1411 5 0.00000E+00 0.00000E+00 0.00000E+00 2.93675E-01-1.36106E-01 0.    1
1 6 1 1616 1 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    1
  0 0  2    H2  MOLECULE VERS 5  (FAST) + DUMMY MATERIAL ABS O (THERMAL)
  1 2  1 1 5 1.24447E-01 9.88194E-02 1.16788E-01 9.43891E-02 7.17987E-02 0.    2
  1 2  6 1 5 4.26487E-02 3.08968E-02 2.70505E-02 2.54387E-02 2.49079E-02 0.    2
  1 2 11 1 5 2.47505E-02 2.45940E-02 2.44842E-02 2.45591E-02-7.15505E-01 0.    2
  1 2 16 1 1-1.72909E+01 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    2
  1 2  1 2 5 7.17058E-05 6.90993E-05 6.90486E-05 7.42906E-05 1.23794E-04 0.    2
  1 2  6 2 5 4.12788E-04 1.23471E-03 2.91047E-03 6.97159E-03 1.45644E-02 0.    2
  1 2 11 2 5 2.54520E-02 4.79799E-02 8.29830E-02 1.29094E-01 0.00000E+00 0.    2
  4 2  1 0 5 1.31019E+00 2.00276E+00 2.80474E+00 3.80651E+00 6.25482E+00 0.    2
  4 2  6 0 5 1.07080E+01 1.29825E+01 1.34840E+01 1.36010E+01 1.36246E+01 0.    2
  4 2 11 0 5 1.36355E+01 1.36579E+01 1.36929E+01 1.37391E+01 1.00000E-07 0.    2
  4 2 16 0 1 1.00000E-07 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    2
  3 2  1 1 5 9.68949E-01 1.43353E+00 5.08513E-01 4.14959E-01 2.65715E-01 0.    2
  6 2  1 1 5 9.11626E-01 9.93432E-01 2.53992E-01 1.54259E-01 6.31976E-02 0.    2
  3 2  1 6 5 9.23779E-02 1.12368E-02 2.66670E-03 4.63407E-04 6.95409E-05 0.    2
  6 2  1 6 5 1.11319E-02 6.03812E-04 1.05844E-04 2.50283E-05 7.24633E-06 0.    2
  3 2  111 5 1.76515E-05 7.98059E-06 1.20373E-06 4.41833E-07 0.00000E+00 0.    2
  6 2  111 5 3.20090E-06 2.58264E-06 7.12684E-07 3.36318E-07 0.00000E+00 0.    2
  3 2  2 1 5 0.00000E+00 1.66048E+00 1.66642E+00 1.35810E+00 8.68778E-01 0.    2
  6 2  2 1 5 0.00000E+00 1.53913E+00 1.24277E+00 7.53328E-01 3.07660E-01 0.    2
  3 2  2 6 5 3.01888E-01 3.62610E-02 8.56225E-03 1.48791E-03 2.23281E-04 0.    2
  6 2  2 6 5 5.35607E-02 2.67123E-03 3.82522E-04 6.79706E-05 1.74610E-05 0.    2
  3 2  211 5 5.66753E-05 2.56240E-05 3.88320E-06 2.18342E-06 2.12144E-07 0.    2
  6 2  211 5 7.51538E-06 6.01297E-06 1.67415E-06 1.43032E-06 1.67894E-07 0.    2
  3 2  3 1 5 0.00000E+00 0.00000E+00 1.67386E+00 3.51423E+00 2.24475E+00 0.    2
  6 2  3 1 5 0.00000E+00 0.00000E+00 1.61026E+00 2.64305E+00 1.07689E+00 0.    2
  3 2  3 6 5 7.79322E-01 9.33033E-02 2.16122E-02 3.75563E-03 5.63585E-04 0.    2
  6 2  3 6 5 1.86414E-01 8.98541E-03 1.12755E-03 1.57070E-04 3.46667E-05 0.    2
  3 2  311 5 1.43054E-04 6.46777E-05 9.80159E-06 5.54681E-06 1.92242E-06 0.    2
  6 2  311 5 1.43502E-05 1.13309E-05 3.14063E-06 2.70981E-06 1.47596E-06 0.    2
  3 2  4 1 5 0.00000E+00 0.00000E+00 0.00000E+00 3.51135E+00 5.59776E+00 0.    2
  6 2  4 1 5 0.00000E+00 0.00000E+00 0.00000E+00 3.19157E+00 3.68482E+00 0.    2
  3 2  4 6 5 1.94357E+00 2.35581E-01 5.39107E-02 9.36827E-03 1.40584E-03 0.    2
  6 2  4 6 5 6.36204E-01 3.04327E-02 3.51650E-03 3.93821E-04 7.08352E-05 0.    2
  3 2  411 5 3.56843E-04 1.61336E-04 2.44497E-05 1.38363E-05 6.41613E-06 0.    2
  6 2  411 5 2.74424E-05 2.11528E-05 5.81384E-06 5.00664E-06 4.08893E-06 0.    2
  3 2  416 1 3.01382E-09 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    2
  6 2  416 1 2.41826E-09 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    2
  3 2  5 1 5 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 8.03691E+00 0.    2
  6 2  5 1 5 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 6.90970E+00 0.    2
  3 2  5 6 5 9.12591E+00 1.10965E+00 2.59966E-01 4.39893E-02 6.60121E-03 0.    2
  6 2  5 6 5 5.14815E+00 2.43168E-01 2.72066E-02 2.28952E-03 2.73762E-04 0.    2
  3 2  511 5 1.67558E-03 7.57562E-04 1.14805E-04 6.49692E-05 3.11059E-05 0.    2
  6 2  511 5 8.62624E-05 6.06892E-05 1.61138E-05 1.37640E-05 1.21716E-05 0.    2
  3 2  516 1 5.02173E-06 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    2
  6 2  516 1 3.31150E-06 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    2
  3 2  6 6 5 1.79088E+01 1.05805E+01 2.51055E+00 4.30786E-01 6.29420E-02 0.    2
  6 2  6 6 5 1.46354E+01 5.51971E+00 6.06656E-01 4.50233E-02 3.35348E-03 0.    2
  3 2  611 5 1.59765E-02 7.22329E-03 1.09466E-03 6.19475E-04 2.86404E-04 0.    2
  6 2  611 5 6.55205E-04 3.16282E-04 6.84986E-05 5.53256E-05 4.42407E-05 0.    2
  3 2  616 1 8.31915E-05 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    2
  6 2  616 1 2.96623E-05 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    2
  3 2  7 6 5 0.00000E+00 1.87846E+01 1.66711E+01 2.89700E+00 4.29951E-01 0.    2
  6 2  7 6 5 0.00000E+00 1.58573E+01 9.37251E+00 6.83470E-01 4.62436E-02 0.    2
  3 2  711 5 1.06079E-01 4.79606E-02 7.26820E-03 4.11314E-03 1.89116E-03 0.    2
  6 2  711 5 6.84526E-03 2.20126E-03 3.04741E-04 2.02762E-04 1.31832E-04 0.    2
  3 2  716 1 5.92220E-04 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    2
  6 2  716 1 1.19092E-04 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    2
  3 2  8 6 5 0.00000E+00 0.00000E+00 2.13917E+01 1.57991E+01 2.37087E+00 0.    2
  6 2  8 6 5 0.00000E+00 0.00000E+00 1.75952E+01 8.73622E+00 5.81100E-01 0.    2
  3 2  811 5 5.99837E-01 2.65069E-01 3.96378E-02 2.24314E-02 1.03008E-02 0.    2
  6 2  811 5 8.29448E-02 2.19248E-02 2.02070E-03 9.65541E-04 2.87474E-04 0.    2
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Listing 6. Continued.

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  3 2  816 1 3.26412E-03 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    2
  6 2  816 1 4.64616E-04 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    2
  3 2  9 6 5 0.00000E+00 0.00000E+00 0.00000E+00 2.15778E+01 1.37566E+01 0.    2
  6 2  9 6 5 0.00000E+00 0.00000E+00 0.00000E+00 1.76733E+01 8.10452E+00 0.    2
  3 2  911 5 3.49181E+00 1.57765E+00 2.36008E-01 1.30644E-01 5.97691E-02 0.    2
  6 2  911 5 1.14371E+00 2.96416E-01 2.41021E-02 9.29117E-03 3.19250E-03 0.    2
  3 2  916 1 1.89396E-02 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    2
  6 2  916 1 6.98574E-04 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    2
  3 2 10 6 5 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 1.75454E+01 0.    2
  6 2 10 6 5 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 1.49479E+01 0.    2
  3 2 1011 5 1.47638E+01 6.67436E+00 1.01100E+00 5.70617E-01 2.52667E-01 0.    2
  6 2 1011 5 9.57736E+00 2.46620E+00 1.97745E-01 7.48229E-02 2.28535E-02 0.    2
  3 2 1016 1 8.00649E-02 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    2
  6 2 1016 1 1.03591E-03 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    2
  3 2 1111 5 1.49895E+01 2.01282E+01 3.05046E+00 1.72633E+00 7.62037E-01 0.    2
  6 2 1111 5 1.31061E+01 1.26774E+01 1.01157E+00 3.79729E-01 1.02181E-01 0.    2
  3 2 1116 1 2.41474E-01 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    2
  6 2 1116 1 1.09838E-02 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    2
  3 2 1211 5 0.00000E+00 1.98180E+01 1.11246E+01 6.29539E+00 2.77916E+00 0.    2
  6 2 1211 5 0.00000E+00 1.65046E+01 7.27408E+00 2.72017E+00 6.99623E-01 0.    2
  3 2 1216 1 8.80658E-01 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    2
  6 2 1216 1 8.93846E-02 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    2
  3 2 1311 5 0.00000E+00 0.00000E+00 1.21353E+01 1.81887E+01 8.02943E+00 0.    2
  6 2 1311 5 0.00000E+00 0.00000E+00 1.09061E+01 1.27161E+01 3.23787E+00 0.    2
  3 2 1316 1 2.54436E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    2
  6 2 1316 1 4.27689E-01 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    2
  3 2 1411 5 0.00000E+00 0.00000E+00 0.00000E+00 1.50696E+01 1.96134E+01 0.    2
  6 2 1411 5 0.00000E+00 0.00000E+00 0.00000E+00 1.31657E+01 1.24580E+01 0.    2
  3 2 1416 1 6.21507E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    2
  6 2 1416 1 1.66426E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    2
1 6 2 1616 1 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    2
  0 0  4    PLUTONIUM-239  VERS  (FAST) + PLUTONIUM-239  VERS  (THERMAL)
  1 4  1 1 5 8.43880E-02 6.98059E-02 6.70189E-02 5.74955E-02 3.81951E-02 0.    4
  1 4  6 1 5 2.68357E-02 2.14420E-02 1.50720E-02 7.34216E-03 3.74910E-03 0.    4
  1 4 11 1 5 2.08359E-03 6.80786E-03 8.94497E-03 1.72119E-03 2.36149E-04 0.    4
  1 4 16 1 1 3.75804E-04 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    4
  1 4  1 2 5 1.79071E+00 1.93879E+00 1.78961E+00 1.70879E+00 1.72597E+00 0.    4
  1 4  6 2 5 2.09498E+00 3.72753E+00 9.03868E+00 2.96685E+01 7.41050E+01 0.    4
  1 4 11 2 5 1.48932E+02 4.02879E+01 2.74447E+01 1.82512E+02 1.20154E+03 0.    4
  1 4 16 2 1 9.65201E+02 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    4
  1 4  1 3 5 6.35191E+00 6.08752E+00 5.33621E+00 4.80538E+00 4.46522E+00 0.    4
  1 4  6 3 5 4.72170E+00 6.48116E+00 1.37960E+01 4.44853E+01 1.10295E+02 0.    4
  1 4 11 3 5 2.55653E+02 7.28810E+01 6.13872E+01 3.55707E+02 2.15866E+03 0.    4
  1 4 16 3 1 2.02429E+03 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    4
  1 4  1 4 5 1.80634E+00 1.93025E+00 1.76436E+00 1.62250E+00 1.53452E+00 0.    4
  1 4  6 4 5 1.63696E+00 2.25007E+00 4.79050E+00 1.54475E+01 3.83003E+01 0.    4
  1 4 11 4 5 8.87760E+01 2.53081E+01 2.13170E+01 1.23520E+02 7.46582E+02 0.    4
  1 4 16 4 1 7.00109E+02 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    4
  4 4  1 0 5 4.01287E+00 4.75819E+00 4.98201E+00 5.82337E+00 8.76123E+00 0.    4
  4 4  6 0 5 1.24684E+01 1.55826E+01 2.21729E+01 4.54481E+01 8.88504E+01 0.    4
  4 4 11 0 5 1.59972E+02 4.88307E+01 3.72701E+01 1.93920E+02 1.20933E+03 0.    4
  4 4 16 0 1 9.73058E+02 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    4
  3 4  1 1 5 4.78343E+00 2.53963E-01 2.85347E-01 3.63082E-01 2.06905E-01 0.    4
  6 4  1 1 5 3.67741E+00 4.62685E-03 0.00000E+00 0.00000E+00 0.00000E+00 0.    4
  3 4  1 6 5 1.14737E-02 2.72164E-07 0.00000E+00 0.00000E+00 0.00000E+00 0.    4
  6 4  1 6 5 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    4
  3 4  2 1 5 0.00000E+00 4.31791E+00 3.93116E-01 4.01496E-01 2.56352E-01 0.    4
  6 4  2 1 5 0.00000E+00 2.56381E+00 2.59628E-03-1.60070E-04 0.00000E+00 0.    4
  3 4  2 6 5 1.67850E-02 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    4
  6 4  2 6 5 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    4
  3 4  3 1 5 0.00000E+00 0.00000E+00 4.37488E+00 6.93632E-01 2.42901E-01 0.    4
  6 4  3 1 5 0.00000E+00 0.00000E+00 2.11808E+00 8.52325E-03-1.03201E-03 0.    4
  3 4  3 6 5 6.55569E-03 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    4
  6 4  3 6 5 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    4
  3 4  4 1 5 0.00000E+00 0.00000E+00 0.00000E+00 5.94348E+00 4.50153E-01 0.    4
  6 4  4 1 5 0.00000E+00 0.00000E+00 0.00000E+00 2.32724E+00-5.45163E-04 0.    4
  3 4  4 6 5 4.74257E-02 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    4
  6 4  4 6 5-2.10561E-04 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    4
  3 4  5 1 5 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 8.72409E+00 0.    4
  6 4  5 1 5 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 1.84646E+00 0.    4
  3 4  5 6 5 1.48300E-01 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    4
  6 4  5 6 5-9.33595E-03 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    4
  3 4  6 6 5 1.08507E+01 1.09075E-01 0.00000E+00 0.00000E+00 0.00000E+00 0.    4
  6 4  6 6 5 5.97812E-01-1.14176E-02 0.00000E+00 0.00000E+00 0.00000E+00 0.    4
  3 4  7 6 5 0.00000E+00 1.17761E+01 1.09779E-01 2.88866E-03 5.83747E-05 0.    4
  6 4  7 6 5 0.00000E+00 5.39618E-02-2.01904E-02-2.07030E-06-3.32253E-06 0.    4
```

Listing 6. Continued.

```
  3 4   8 6 5 0.00000E+00 0.00000E+00 1.30704E+01 1.00907E-01 0.00000E+00 0.    4
  6 4   8 6 5 0.00000E+00 0.00000E+00 6.96125E-02-3.25608E-02 0.00000E+00 0.    4
  3 4   9 6 5 0.00000E+00 0.00000E+00 0.00000E+00 1.57787E+01 4.54604E-02 0.    4
  6 4   9 6 5 0.00000E+00 0.00000E+00 0.00000E+00 5.87709E-02-1.42654E-02 0.    4
  3 4  10 6 5 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 1.47297E+01 0.    4
  6 4  10 6 5 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 6.04824E-02 0.    4
  3 4 1011 5 5.73258E-02 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    4
  6 4 1011 5-1.88668E-02 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    4
  3 4 1111 5 1.10413E+01 2.96066E-02 0.00000E+00 0.00000E+00 0.00000E+00 0.    4
  6 4 1111 5 4.09977E-02-9.85630E-03 0.00000E+00 0.00000E+00 0.00000E+00 0.    4
  3 4 1211 5 0.00000E+00 8.51398E+00 5.29047E-02 0.00000E+00 0.00000E+00 0.    4
  6 4 1211 5 0.00000E+00 4.15864E-02-1.74887E-02 0.00000E+00 0.00000E+00 0.    4
  3 4 1311 5 0.00000E+00 0.00000E+00 9.73857E+00 1.14577E-01 0.00000E+00 0.    4
  6 4 1311 5 0.00000E+00 0.00000E+00 6.56665E-02-3.79503E-02 0.00000E+00 0.    4
  3 4 1411 5 0.00000E+00 0.00000E+00 0.00000E+00 1.13162E+01 1.23985E-01 0.    4
  6 4 1411 5 0.00000E+00 0.00000E+00 0.00000E+00 7.29995E-02-4.08232E-02 0.    4
  3 4 1511 5 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 7.81324E+00 0.    4
  6 4 1511 5 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 2.32600E-02 0.    4
  3 4 1616 1 7.87883E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    4
1 6 4 1616 1 2.20335E-02 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    4
```

Listing 7. Table 1 Case 2, SCAMP input using Hansen-Roach cross sections.

```
LIMIT          1  16   3   1   2   2
POLYSLAB PU=2G/lb; VF POLY=1.0                                          1
       1  13   0   1  16   0   1   1   0  01   0   0   0   0   2
      19   1 999
    1  1   1   1
    2  1   1   1
11  1  1   2 616 706
       1   1  .001
       2   1  .001
    1  1   1  100.0
  1 1  1   5  1.0          1.0          1.0          1.0          1.0
  1 1  6   5  1.0          1.0          1.0          1.0          1.0
  1 1 11   5  1.0          1.0          1.0          1.0          1.0
  1 1 16   1  1.0
  1 2  1   5  1.0          1.0          1.0          1.0          1.0
  1 2  6   5  1.0          1.0          1.0          1.0          1.0
  1 2 11   5  1.0          1.0          1.0          1.0          1.0
  1 2 16   1  1.0
  5 1  1   5 .225         .347         .161         .170         .084
  5 1  6   1 .013
111 1  1   2 1.02206E-5   1.0
POLYSLAB PU=2.5G/lb; VF POLY=1.0                                        1
      12   1   4
11  1  1   2 616 706
111 1  1   2 1.27757-5   1.0
POLYSLAB PU=3G/lb; VF POLY=1.0                                          1
      12   1   4
11  1  1   2 616 706
111 1  1   2 1.53308-5   1.0
POLYSLAB PU=3.5G/lb; VF POLY=1.0                                        1
      12   1   4
11  1  1   2 616 706
111 1  1   2 1.78860-5   1.0
POLYSLAB PU=4G/lb; VF POLY=1.0                                          1
      12   1   4
11  1  1   3 615 616 706
111 1  1   3 5.90847-6    1.45326-5   1.0
POLYSLAB PU=4.5G/lb; VF POLY=1.0                                        1
      12   1   4
11  1  1   3 615 616 706
111 1  1   3 1.22954-5    1.07008-5   1.0
POLYSLAB PU=4.15G/lb; VF POLY=1.0                                       1
      12   1   4
11  1  1   3 615 616 706
111 1  1   3 7.82446-6    1.33831-5   1.0
```

Listing 8. Table 1 Case 2, KENO-V.a input using Hansen-Roach cross sections.

```
KPOSLAB INF SLAB 4.15G/LB PU in polyethylene
READ PARA
     TME=40.0  GEN=153   NPG=407    LIB=41
     FLX=NO     FDN=NO    AMX=NO    FAR=NO
     RUN=YES   PLT=NO    NUB=YES
END PARA
READ MIXT
     MIX=1   94915   7.8245-6  94916 1.3383-5  402 1.0
END MIXT
READ GEOM
GLOBAL
     UNIT 1
     CUBOID  1 1   4P28.575  2P50.0
END GEOM
READ START NST=0 END START
READ BOUNDS  ALL=MIRROR  END BOUNDS
READ PLOT
     PLT=YES   PIC=MIX   NCH=' *.C'
     TTL=* "X-Y CELLL" *
     XUL=-28.8  YUL=28.8  ZUL=5.0
     XLR=28.8  YLR=-28.8   ZLR=5.0
     UAX=1.0   VDN=-1.0   NAX=130   END
END PLOT
END DATA
```

Listing 9. Table 1 Case 2, KENO-V.a input using CSAS and 27-group cross sections.

```
=CSAS25
CPOSLAB 4.15g Pu /lb poly
27GROUPNDF4  INFHOMMEDIUM
PU-239  1  0  2.1208-5  END
POLYETHYLENE  1  1.0    END
END COMP
KPOSLAB INF SLAB 4.15G/LB PU in poly
READ PARA
     TME=40.0  GEN=153   NPG=407
     FLX=NO     FDN=NO    AMX=NO    FAR=NO
     RUN=YES   PLT=NO    NUB=YES
END PARA
READ GEOM
GLOBAL
     UNIT 1
     CUBOID  1 1   4P28.575  2P50.0
END GEOM
READ START NST=0 END START
READ BOUNDS  ALL=MIRROR  END BOUNDS
READ PLOT
     PLT=YES   PIC=MIX   NCH=' *.C'
     TTL=* "X-Y CELLL" *
     XUL=-28.8  YUL=28.8  ZUL=5.0
     XLR=28.8  YLR=-28.8   ZLR=5.0
     UAX=1.0   VDN=-1.0   NAX=130   END
END PLOT
END DATA
```

Listing 10. Table 1 Case 2, MCNP input.

```
MPLSLAB  INF SLAB 4.15 G/LB PU IN POLYETHYLENE
1     1 1.191702075e-1  -1 2 -3 4 -5 6  imp:n=1  $slab
*1     px  28.575  $asterisk means reflecting surface
*2     px  -28.575
*3     py  28.575
*4     py  -28.575
*5     pz  50.0
*6     pz  -50.0

kcode  1000 1 20 145 50000  $npg=1000, nsk=20 gen=145
sdef  cel=1  $starting source in cell 1
print
m1    94239.50c 2.1208e-5  1001.50c 0.079433  6012.50c 0.039716
mt1   poly.01t
```

Listing 11. Table 1 Case 2, COMBINE input.

```
= blrc004  Pu in Poly, PU=4.15 g/lb 2-26-93 comb5
1010101    0   1   1   1   3  16   2   7   0   0   0   0   0  54   1  30
1010201  166 157 154 152 149 144 136 130 123 116 111 107 101  82  44  22
1020101    3   3   3
1030101   14   0 998   0   0   0   0
1030201    1   1   0   0   1
1030202    1   2   0   0   1
1030203    1   3   0   0   1
1041001   1.0000E-06  1.0000E-06  2.9300E+02
1042001  506.0     6.00302  3.9501E-02   0.0  0.0          0.0
1042002  508.0     1.00303  7.9001E-02   0.0  0.0          0.0
1042003  645.0    94.23905  2.12070-05   0.0  0.0000E+00   0.0000E+00
```

Listing 12. Table 1 Case 2, SCAMP input with COMBINE generated cross sections.

```
LIMIT          1  16   3   1   2   2
puCH2.c16  PU=4.15G/lb in poly CH2                                          1
       1  13   0   1  16   0   1   1   3  20   0   0   0   0   2
      19   4   0 998   0   3
    1  1   1   1
    2  1   1   1
1 1 1  1   3   3  2  1
       1   1  .001
       2   1  .001
    1  1   1  100.0
  1 1  1   5  1.0          1.0          1.0          1.0          1.0
  1 1  6   5  1.0          1.0          1.0          1.0          1.0
  1 1 11   5  1.0          1.0          1.0          1.0          1.0
  1 1 16   1  1.0
  1 2  1   5  1.0          1.0          1.0          1.0          1.0
  1 2  6   5  1.0          1.0          1.0          1.0          1.0
  1 2 11   5  1.0          1.0          1.0          1.0          1.0
  1 2 16   1  1.0
  5 1  1   5 2.55974E-01 3.48185E-01 1.71622E-01 1.39795E-01 7.01995E-02
  5 1  6   5 1.34929E-02 6.54148E-04 7.17970E-05 5.20614E-06 3.44291E-07
  5 1 11   4 4.84487E-08 1.24487E-08 9.90516E-10 3.69914E-10
111 1  1   3 2.12070E-05 7.900100-02 3.950100-02
  0 0  1    CARBON  VERS 5       (FAST) + CARBON 300K P0+P1 SU (THERMAL)
  1 1  1 1 5 2.70443E-01 1.83760E-01 1.48693E-01 1.14686E-01 8.89333E-02 0.    1
  1 1  6 1 5 7.66185E-02 7.45192E-02 7.44052E-02 7.44543E-02 7.44091E-02 0.    1
  1 1 11 1 5 7.45725E-02 7.44886E-02 7.44860E-02 7.44040E-02 7.22290E-02 0.    1
  1 1 16 1 1 6.45930E-02 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    1
  1 1  1 2 5 6.74008E-03 6.31203E-06 1.59958E-06 1.05698E-06 9.33671E-07 0.    1
  1 1  6 2 5 9.54515E-07 6.01811E-06 1.66994E-05 3.57934E-05 7.45418E-05 0.    1
  1 1 11 2 5 1.30182E-04 2.46287E-04 4.25073E-04 6.61223E-04 1.41329E-03 0.    1
  1 1 16 2 1 3.03740E-03 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    1
  4 1  1 0 5 1.52969E+00 1.69074E+00 2.21020E+00 2.89092E+00 3.70040E+00 0.    1
  4 1  6 0 5 4.27586E+00 4.43993E+00 4.46655E+00 4.47207E+00 4.47336E+00 0.    1
  4 1 11 0 5 4.47363E+00 4.47380E+00 4.47401E+00 4.47429E+00 4.59336E+00 0.    1
  4 1 16 0 1 4.95326E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    1
  3 1  1 1 5 1.22186E+00 5.63644E-01 1.31373E-02 8.36824E-03 3.14744E-03 0.    1
  6 1  1 1 5 5.15292E-01-2.29484E-01 1.20824E-03 6.42717E-04-1.49305E-04 0.    1
  3 1  1 6 5 2.65575E-04 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    1
  6 1  1 6 5-3.67825E-05 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    1
  3 1  2 1 5 0.00000E+00 1.42909E+00 4.00783E-01 0.00000E+00 0.00000E+00 0.    1
  6 1  2 1 5 0.00000E+00 2.41616E-01-1.02481E-01 0.00000E+00 0.00000E+00 0.    1
  3 1  3 1 5 0.00000E+00 0.00000E+00 1.68912E+00 8.19632E-01 0.00000E+00 0.    1
  6 1  3 1 5 0.00000E+00 0.00000E+00 4.67252E-01-1.68692E-01 0.00000E+00 0.    1
  3 1  4 1 5 0.00000E+00 0.00000E+00 0.00000E+00 2.61927E+00 6.16752E-01 0.    1
  6 1  4 1 5 0.00000E+00 0.00000E+00 0.00000E+00 4.86603E-01-1.41496E-01 0.    1
  3 1  5 1 5 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 3.60775E+00 0.    1
  6 1  5 1 5 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 4.41277E-01 0.    1
  3 1  5 6 5 4.24608E-01 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    1
  6 1  5 6 5-1.09317E-01 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    1
  3 1  6 6 5 4.24652E+00 3.16583E-01 0.00000E+00 0.00000E+00 0.00000E+00 0.    1
  6 1  6 6 5 3.66750E-01-7.95002E-02 0.00000E+00 0.00000E+00 0.00000E+00 0.    1
  3 1  7 6 5 0.00000E+00 4.21855E+00 4.87822E-01 0.00000E+00 0.00000E+00 0.    1
  6 1  7 6 5 0.00000E+00 4.03013E-01-1.36561E-01 0.00000E+00 0.00000E+00 0.    1
  3 1  8 6 5 0.00000E+00 0.00000E+00 4.30456E+00 4.27119E-01 0.00000E+00 0.    1
  6 1  8 6 5 0.00000E+00 0.00000E+00 3.87787E-01-1.22643E-01 0.00000E+00 0.    1
  3 1  9 6 5 0.00000E+00 0.00000E+00 0.00000E+00 4.30834E+00 4.29175E-01 0.    1
  6 1  9 6 5 0.00000E+00 0.00000E+00 0.00000E+00 3.90920E-01-1.25444E-01 0.    1
  3 1 10 6 5 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 4.14531E+00 0.    1
  6 1 10 6 5 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 4.39062E-01 0.    1
  3 1 1011 5 5.93526E-01 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    1
  6 1 1011 5-1.73512E-01 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    1
  3 1 1111 5 3.99198E+00 7.47079E-01 0.00000E+00 0.00000E+00 0.00000E+00 0.    1
  6 1 1111 5 4.88528E-01-2.22965E-01 0.00000E+00 0.00000E+00 0.00000E+00 0.    1
  3 1 1211 5 0.00000E+00 4.23921E+00 4.99905E-01 0.00000E+00 0.00000E+00 0.    1
  6 1 1211 5 0.00000E+00 4.12732E-01-1.47166E-01 0.00000E+00 0.00000E+00 0.    1
  3 1 1311 5 0.00000E+00 0.00000E+00 3.73538E+00 1.00378E+00 0.00000E+00 0.    1
  6 1 1311 5 0.00000E+00 0.00000E+00 5.61697E-01-2.96129E-01 0.00000E+00 0.    1
  3 1 1411 5 0.00000E+00 0.00000E+00 0.00000E+00 3.98371E+00 7.55483E-01 0.    1
  6 1 1411 5 0.00000E+00 0.00000E+00 0.00000E+00 4.83957E-01-2.18387E-01 0.    1
  3 1 1511 5 0.00000E+00 0.00000E+00 0.00000E+00 1.18098E-02 4.14170E+00 0.    1
  6 1 1511 5 0.00000E+00 0.00000E+00 0.00000E+00 6.58154E-04 2.47982E-01 0.    1
  3 1 1516 1 5.91693E-01 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    1
  6 1 1516 1-9.53772E-02 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    1
  3 1 1611 5 0.00000E+00 0.00000E+00 0.00000E+00 2.50910E-08 9.76632E-02 0.    1
  6 1 1611 5 0.00000E+00 0.00000E+00 0.00000E+00-1.20752E-08-1.74429E-02 0.    1
  3 1 1616 1 4.71637E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    1
```

Listing 12. Continued.

```
1 6 1 1616 1-1.18748E-01 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    1
  0 0  2    HYDROGEN  VERS 5     (FAST) +  HYDROGEN IN POLYETH (THERMAL)
  1 2  1 1 5 2.53327E-01 1.92194E-01 1.84981E-01 1.79448E-01 1.49469E-01 0.    2
  1 2  6 1 5 9.34230E-02 6.38813E-02 5.46883E-02 5.10160E-02 4.98216E-02 0.    2
  1 2 11 1 5 4.95292E-02 4.91947E-02 4.89648E-02 4.91166E-02 2.91199E-02 0.    2
  1 2 16 1 1 2.11467E-02 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    2
  1 2  1 2 5 3.58545E-05 3.45298E-05 3.45235E-05 3.72961E-05 6.20817E-05 0.    2
  1 2  6 2 5 2.06437E-04 6.17355E-04 1.45524E-03 3.48580E-03 7.28529E-03 0.    2
  1 2 11 2 5 1.27271E-02 2.39977E-02 4.14915E-02 6.45472E-02 1.39646E-01 0.    2
  1 2 16 2 1 3.00124E-01 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    2
  4 2  1 0 5 6.55099E-01 9.94591E-01 1.39117E+00 1.92510E+00 3.18041E+00 0.    2
  4 2  6 0 5 5.37546E+00 6.49236E+00 6.74212E+00 6.80048E+00 6.81228E+00 0.    2
  4 2 11 0 5 6.81773E+00 6.82897E+00 6.84646E+00 6.86955E+00 1.28167E+01 0.    2
  4 2 16 0 1 2.03668E+01 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    2
  3 2  1 1 5 4.92094E-01 7.07536E-01 2.50980E-01 2.04806E-01 1.31145E-01 0.    2
  6 2  1 1 5 4.64324E-01 4.84286E-01 1.23817E-01 7.51996E-02 3.08096E-02 0.    2
  3 2  1 6 5 4.55937E-02 5.54599E-03 1.31616E-03 2.28717E-04 3.43224E-05 0.    2
  6 2  1 6 5 5.42825E-03 2.94878E-04 5.18749E-05 1.23169E-05 3.57101E-06 0.    2
  3 2  111 5 8.71201E-06 3.93887E-06 5.93975E-07 2.15745E-07 0.00000E+00 0.    2
  6 2  111 5 1.57786E-06 1.27320E-06 3.51065E-07 1.62428E-07 0.00000E+00 0.    2
  3 2  2 1 5 0.00000E+00 8.16505E-01 8.45207E-01 6.88810E-01 4.40623E-01 0.    2
  6 2  2 1 5 0.00000E+00 7.43894E-01 6.47351E-01 3.92353E-01 1.60217E-01 0.    2
  3 2  2 6 5 1.53109E-01 1.83860E-02 4.34104E-03 7.54364E-04 1.13203E-04 0.    2
  6 2  2 6 5 2.78855E-02 1.38756E-03 1.97778E-04 3.48719E-05 8.92261E-06 0.    2
  3 2  211 5 2.87342E-05 1.29913E-05 1.96877E-06 1.10770E-06 1.09658E-07 0.    2
  6 2  211 5 3.83680E-06 3.06884E-06 8.54345E-07 7.31110E-07 9.41546E-08 0.    2
  3 2  3 1 5 0.00000E+00 0.00000E+00 8.40229E-01 1.75403E+00 1.12041E+00 0.    2
  6 2  3 1 5 0.00000E+00 0.00000E+00 7.90151E-01 1.33748E+00 5.44943E-01 0.    2
  3 2  3 6 5 3.88977E-01 4.65684E-02 1.07871E-02 1.87452E-03 2.81298E-04 0.    2
  6 2  3 6 5 9.43290E-02 4.54642E-03 5.69935E-04 7.92122E-05 1.74525E-05 0.    2
  3 2  311 5 7.14015E-05 3.22821E-05 4.89219E-06 2.76854E-06 9.58702E-07 0.    2
  6 2  311 5 7.22089E-06 5.70063E-06 1.57997E-06 1.36322E-06 7.46765E-07 0.    2
  3 2  4 1 5 0.00000E+00 0.00000E+00 0.00000E+00 1.70178E+00 2.87294E+00 0.    2
  6 2  4 1 5 0.00000E+00 0.00000E+00 0.00000E+00 1.55367E+00 1.90179E+00 0.    2
  3 2  4 6 5 9.97496E-01 1.20936E-01 2.76684E-02 4.80806E-03 7.21517E-04 0.    2
  6 2  4 6 5 3.28336E-01 1.57027E-02 1.81149E-03 2.01824E-04 3.60828E-05 0.    2
  3 2  411 5 1.83142E-04 8.28020E-05 1.25483E-05 7.10117E-06 3.31008E-06 0.    2
  6 2  411 5 1.39476E-05 1.07417E-05 2.95146E-06 2.54150E-06 2.09054E-06 0.    2
  3 2  416 1 1.72106E-09 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    2
  6 2  416 1 1.41174E-09 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    2
  3 2  5 1 5 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 4.00551E+00 0.    2
  6 2  5 1 5 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 3.47942E+00 0.    2
  3 2  5 6 5 4.59011E+00 5.58127E-01 1.30768E-01 2.21255E-02 3.32025E-03 0.    2
  6 2  5 6 5 2.51793E+00 1.18942E-01 1.33093E-02 1.12215E-03 1.34684E-04 0.    2
  3 2  511 5 8.42773E-04 3.81035E-04 5.77440E-05 3.26779E-05 1.56427E-05 0.    2
  6 2  511 5 4.25481E-05 2.99738E-05 7.96265E-06 6.80234E-06 6.02059E-06 0.    2
  3 2  516 1 2.53499E-06 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    2
  6 2  516 1 1.61323E-06 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    2
  3 2  6 6 5 8.95298E+00 5.29212E+00 1.25572E+00 2.15471E-01 3.14821E-02 0.    2
  6 2  6 6 5 7.33977E+00 2.72180E+00 2.99157E-01 2.22045E-02 1.65576E-03 0.    2
  3 2  611 5 7.99107E-03 3.61292E-03 5.47521E-04 3.09847E-04 1.43252E-04 0.    2
  6 2  611 5 3.24058E-04 1.56753E-04 3.39990E-05 2.74734E-05 2.19805E-05 0.    2
  3 2  616 1 4.16116E-05 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    2
  6 2  616 1 1.47051E-05 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    2
  3 2  7 6 5 0.00000E+00 9.39221E+00 8.33561E+00 1.44851E+00 2.14977E-01 0.    2
  6 2  7 6 5 0.00000E+00 7.94046E+00 4.67425E+00 3.40863E-01 2.30630E-02 0.    2
  3 2  711 5 5.30400E-02 2.39805E-02 3.63412E-03 2.05658E-03 9.45584E-04 0.    2
  6 2  711 5 3.41448E-03 1.09832E-03 1.52123E-04 1.01245E-04 6.58505E-05 0.    2
  3 2  716 1 2.96112E-04 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    2
  6 2  716 1 5.94711E-05 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    2
  3 2  8 6 5 0.00000E+00 0.00000E+00 1.06959E+01 7.89956E+00 1.18544E+00 0.    2
  6 2  8 6 5 0.00000E+00 0.00000E+00 8.80273E+00 4.36324E+00 2.90228E-01 0.    2
  3 2  811 5 2.99919E-01 1.32535E-01 1.98189E-02 1.12157E-02 5.15042E-03 0.    2
  6 2  811 5 4.14266E-02 1.09506E-02 1.00937E-03 4.82360E-04 1.43697E-04 0.    2
  3 2  816 1 1.63206E-03 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    2
  6 2  816 1 2.32127E-04 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    2
  3 2  9 6 5 0.00000E+00 0.00000E+00 0.00000E+00 1.07889E+01 6.87828E+00 0.    2
  6 2  9 6 5 0.00000E+00 0.00000E+00 0.00000E+00 8.83783E+00 4.05125E+00 0.    2
  3 2  911 5 1.74590E+00 7.88825E-01 1.18004E-01 6.53222E-02 2.98845E-02 0.    2
  6 2  911 5 5.71713E-01 1.48171E-01 1.20481E-02 4.64449E-03 1.59547E-03 0.    2
  3 2  916 1 9.46978E-03 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    2
  6 2  916 1 3.49686E-04 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    2
  3 2 10 6 5 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 8.76252E+00 0.    2
  6 2 10 6 5 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 7.47197E+00 0.    2
  3 2 1011 5 7.38835E+00 3.34009E+00 5.05943E-01 2.85559E-01 1.26444E-01 0.    2
  6 2 1011 5 4.79023E+00 1.23350E+00 9.89043E-02 3.74234E-02 1.14299E-02 0.    2
```

Listing 12. Continued.

```
  3 2 1016 1 4.00674E-02 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    2
  6 2 1016 1 5.18337E-04 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    2
  3 2 1111 5 7.49276E+00 1.00656E+01 1.52546E+00 8.63299E-01 3.81077E-01 0.    2
  6 2 1111 5 6.55419E+00 6.33768E+00 5.05704E-01 1.89834E-01 5.10829E-02 0.    2
  3 2 1116 1 1.20755E-01 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    2
  6 2 1116 1 5.49092E-03 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    2
  3 2 1211 5 0.00000E+00 9.90305E+00 5.56543E+00 3.14947E+00 1.39036E+00 0.    2
  6 2 1211 5 0.00000E+00 8.24940E+00 3.63899E+00 1.36081E+00 3.49997E-01 0.    2
  3 2 1216 1 4.40577E-01 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    2
  6 2 1216 1 4.47166E-02 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    2
  3 2 1311 5 0.00000E+00 0.00000E+00 6.06762E+00 9.09436E+00 4.01472E+00 0.    2
  6 2 1311 5 0.00000E+00 0.00000E+00 5.45304E+00 6.35808E+00 1.61894E+00 0.    2
  3 2 1316 1 1.27218E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    2
  6 2 1316 1 2.13845E-01 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    2
  3 2 1411 5 0.00000E+00 0.00000E+00 0.00000E+00 7.53460E+00 9.80683E+00 0.    2
  6 2 1411 5 0.00000E+00 0.00000E+00 0.00000E+00 6.58294E+00 6.22893E+00 0.    2
  3 2 1416 1 3.10758E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    2
  6 2 1416 1 8.32120E-01 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    2
  3 2 1511 5 0.00000E+00 0.00000E+00 0.00000E+00 2.39296E-02 1.61604E+01 0.    2
  6 2 1511 5 0.00000E+00 0.00000E+00 0.00000E+00 2.30583E-02 1.10480E+01 0.    2
  3 2 1516 1 8.54314E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    2
  6 2 1516 1 9.79431E-01 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    2
  3 2 1611 5 0.00000E+00 0.00000E+00 0.00000E+00 6.32213E-06 1.18831E+00 0.    2
  6 2 1611 5 0.00000E+00 0.00000E+00 0.00000E+00 5.51435E-07 2.28547E-01 0.    2
  3 2 1616 1 4.54245E+01 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    2
1 6 2 1616 1 2.63176E+01 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    2
  0 0  3    PLUTONIUM-239  VERS  (FAST) + PLUTONIUM-239  VERS  (THERMAL)
  1 3  1 1 5 8.46874E-02 6.96306E-02 6.69624E-02 5.71760E-02 3.83585E-02 0.    3
  1 3  6 1 5 2.68659E-02 2.14478E-02 1.50743E-02 7.34266E-03 3.75016E-03 0.    3
  1 3 11 1 5 2.08397E-03 6.83842E-03 8.94495E-03 1.72123E-03 2.62799E-04 0.    3
  1 3 16 1 1 3.99705E-04 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    3
  1 3  1 2 5 1.78932E+00 1.94036E+00 1.78997E+00 1.70827E+00 1.72613E+00 0.    3
  1 3  6 2 5 2.09511E+00 3.72755E+00 9.03869E+00 2.96685E+01 7.40186E+01 0.    3
  1 3 11 2 5 1.48989E+02 3.99224E+01 2.74447E+01 1.82520E+02 1.19673E+03 0.    3
  1 3 16 2 1 9.54277E+02 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    3
  1 3  1 3 5 6.35933E+00 6.08649E+00 5.33778E+00 4.79561E+00 4.46463E+00 0.    3
  1 3  6 3 5 4.72182E+00 6.48117E+00 1.37961E+01 4.44853E+01 1.10163E+02 0.    3
  1 3 11 3 5 2.55754E+02 7.23323E+01 6.13873E+01 3.55722E+02 2.14995E+03 0.    3
  1 3 16 3 1 1.99900E+03 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    3
  1 3  1 4 5 1.80541E+00 1.93166E+00 1.76479E+00 1.61989E+00 1.53439E+00 0.    3
  1 3  6 4 5 1.63700E+00 2.25008E+00 4.79050E+00 1.54475E+01 3.82544E+01 0.    3
  1 3 11 4 5 8.88113E+01 2.51176E+01 2.13170E+01 1.23525E+02 7.43568E+02 0.    3
  1 3 16 4 1 6.91363E+02 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    3
  4 3  1 0 5 4.00458E+00 4.78336E+00 4.97913E+00 5.86391E+00 8.76095E+00 0.    3
  4 3  6 0 5 1.24632E+01 1.55826E+01 2.21729E+01 4.54481E+01 8.87533E+01 0.    3
  4 3 11 0 5 1.60031E+02 4.84627E+01 3.72701E+01 1.93929E+02 1.20449E+03 0.    3
  4 3 16 0 1 9.62127E+02 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    3
  3 3  1 1 5 4.78398E+00 2.51872E-01 2.84829E-01 3.61921E-01 2.06069E-01 0.    3
  6 3  1 1 5 3.68059E+00 4.26559E-03 0.00000E+00 0.00000E+00 0.00000E+00 0.    3
  3 3  1 6 5 1.14430E-02 2.98313E-07 0.00000E+00 0.00000E+00 0.00000E+00 0.    3
  6 3  1 6 5 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    3
  3 3  2 1 5 0.00000E+00 4.30020E+00 3.96271E-01 4.00502E-01 2.56277E-01 0.    3
  6 3  2 1 5 0.00000E+00 2.52439E+00 2.93320E-03-1.79535E-04 0.00000E+00 0.    3
  3 3  2 6 5 1.68921E-02 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    3
  6 3  2 6 5 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    3
  3 3  3 1 5 0.00000E+00 0.00000E+00 4.37488E+00 6.92555E-01 2.42598E-01 0.    3
  6 3  3 1 5 0.00000E+00 0.00000E+00 2.11954E+00 9.03607E-03-1.08627E-03 0.    3
  3 3  3 6 5 6.61040E-03 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    3
  6 3  3 6 5 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    3
  3 3  4 1 5 0.00000E+00 0.00000E+00 0.00000E+00 5.97614E+00 4.59211E-01 0.    3
  6 3  4 1 5 0.00000E+00 0.00000E+00 0.00000E+00 2.32857E+00-9.87491E-04 0.    3
  3 3  4 6 5 4.76583E-02 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    3
  6 3  4 6 5-2.24539E-04 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    3
  3 3  5 1 5 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 8.73227E+00 0.    3
  6 3  5 1 5 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 1.85626E+00 0.    3
  3 3  5 6 5 1.49904E-01 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    3
  6 3  5 6 5-8.89649E-03 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    3
  3 3  6 6 5 1.08508E+01 1.09157E-01 0.00000E+00 0.00000E+00 0.00000E+00 0.    3
  6 3  6 6 5 6.03042E-01-1.11443E-02 0.00000E+00 0.00000E+00 0.00000E+00 0.    3
  3 3  7 6 5 0.00000E+00 1.17761E+01 1.09780E-01 2.88850E-03 5.83714E-05 0.    3
  6 3  7 6 5 0.00000E+00 5.38414E-02-2.00726E-02-2.07126E-06-3.32407E-06 0.    3
  3 3  8 6 5 0.00000E+00 0.00000E+00 1.30704E+01 1.00908E-01 0.00000E+00 0.    3
  6 3  8 6 5 0.00000E+00 0.00000E+00 6.95402E-02-3.24882E-02 0.00000E+00 0.    3
  3 3  9 6 5 0.00000E+00 0.00000E+00 0.00000E+00 1.57787E+01 4.54604E-02 0.    3
  6 3  9 6 5 0.00000E+00 0.00000E+00 0.00000E+00 5.87636E-02-1.42585E-02 0.    3
  3 3 10 6 5 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 1.47187E+01 0.    3
```

Listing 12. Continued.

```
  6 3 10 6 5 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 6.05063E-02 0.    3
  3 3 1011 5 5.76656E-02 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    3
  6 3 1011 5-1.88986E-02 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    3
  3 3 1111 5 1.10432E+01 2.96321E-02 0.00000E+00 0.00000E+00 0.00000E+00 0.    3
  6 3 1111 5 4.09983E-02-9.85503E-03 0.00000E+00 0.00000E+00 0.00000E+00 0.    3
  3 3 1211 5 0.00000E+00 8.51153E+00 5.29369E-02 0.00000E+00 0.00000E+00 0.    3
  6 3 1211 5 0.00000E+00 4.15925E-02-1.74989E-02 0.00000E+00 0.00000E+00 0.    3
  3 3 1311 5 0.00000E+00 0.00000E+00 9.73858E+00 1.14577E-01 0.00000E+00 0.    3
  6 3 1311 5 0.00000E+00 0.00000E+00 6.56671E-02-3.79508E-02 0.00000E+00 0.    3
  3 3 1411 5 0.00000E+00 0.00000E+00 0.00000E+00 1.13162E+01 1.23996E-01 0.    3
  6 3 1411 5 0.00000E+00 0.00000E+00 0.00000E+00 7.29971E-02-4.08209E-02 0.    3
  3 3 1511 5 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 7.78186E+00 0.    3
  6 3 1511 5 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 2.23598E-02 0.    3
  3 3 1616 1 7.87268E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    3
1 6 3 1616 1 2.20415E-02 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    3
```

Listing 13. Table 1 Case 3, SCAMP input using Hansen-Roach cross sections.

```
LIMIT          1  16   5   1   2   2
CELLUSLAB PU=5G/lb; VF PAPER=1.0                                          1
       1  13   0   1  16   0   1   1   0   2   0   0   0   0   2
      19   1 999
    1  1   1   1
    2  1   1   1
11  1  1   5 613 614 8   2   10
       1   1  .001
       2   1  .001
    1  1   1  100.0
  1 1  1   5  1.0          1.0          1.0          1.0          1.0
  1 1  6   5  1.0          1.0          1.0          1.0          1.0
  1 1 11   5  1.0          1.0          1.0          1.0          1.0
  1 1 16   1  1.0
  1 2  1   5  1.0          1.0          1.0          1.0          1.0
  1 2  6   5  1.0          1.0          1.0          1.0          1.0
  1 2 11   5  1.0          1.0          1.0          1.0          1.0
  1 2 16   1  1.0
  5 1  1   5  .225          .347         .161         .170         .084
  5 1  6   1  .013
111 1  1   5  5.692-6     1.208-5      1.426-2      2.378-2      1.189-2
CELLUSLAB PU=4G/lb; VF PAPER=1.0                                          1
      12   1   4
11  1  1   5 614 615 8   2   10
111 1  1   5  1.2805-5    1.4152-6     1.426-2      2.378-2      1.189-2
CELLUSLAB PU=3G/lb; VF PAPER=1.0                                          1
      12   1   4
11  1  1   5 614 615 8   2   10
111 1  1   5  2.1422-6    8.5228-6     1.426-2      2.378-2      1.189-2
CELLUSLAB PU=2G/lb; VF PAPER=1.0                                          1
      12   1   4
11  1  1   5 615 616 8   2   10
111 1  1   5  2.8500-6    4.2602-6     1.426-2      2.378-2      1.189-2
CELLUSLAB PU=1G/lb; VF PAPER=1.0                                          1
      12   1   4
11  1  1   4 616   8 2  10
111 1  1   4  3.555-6     1.426-2      2.378-2      1.189-2
CELLUSLAB PU=1.5G/lb; VF PAPER=1.0                                        1
      12   1   4
11  1  1   4 616   8 2   10
111 1  1   4  5.3326-6    1.426-2      2.378-2      1.189-2
CELLUSLAB PU=2.5G/lb; VF PAPER=1.0                                        1
      12   1   4
11  1  1   5 615 616 8   2   10
111 1  1   5  7.29298-6   1.59453-6    1.426-2      2.378-2      1.189-2
CELLUSLAB PU=1.7G/lb; VF PAPER=1.0                                        1
      12   1   4
11  1  1   5 615 616 8   2   10
111 1  1   5  1.83924-7   5.85958-6    1.426-2      2.378-2      1.189-2
CELLUSLAB PU=1.8G/lb; VF PAPER=1.0                                        1
      12   1   4
11  1  1   5 615 616 8   2   10
111 1  1   5  1.94743-7   6.20426-6    1.426-2      2.378-2      1.189-2
```

Listing 14. Table 1 Case 3, KENO-V.a input using Hansen-Roach cross sections.

```
KCELSLAB INF SLAB 1.7 G/LB PU in cellulose
READ PARA
     TME=40.0  GEN=153   NPG=407    LIB=41
     FLX=NO     FDN=NO    AMX=NO    FAR=NO
     RUN=YES   PLT=NO    NUB=YES
END PARA
READ MIXT
     MIX=1   94915 1.83924-7  94916 5.85985-6  6100 1.426-2
             1102 2.378-2  8100 1.189-2
END MIXT
READ GEOM
GLOBAL
     UNIT 1
     CUBOID  1 1   4P28.575  2P50.0
END GEOM
READ START NST=0 END START
READ BOUNDS  ALL=MIRROR  END BOUNDS
READ PLOT
     PLT=YES   PIC=MIX   NCH=' *.C'
     TTL=* "X-Y CELLL" *
     XUL=-28.8  YUL=28.8  ZUL=5.0
     XLR=28.8  YLR=-28.8   ZLR=5.0
     UAX=1.0   VDN=-1.0   NAX=130   END
END PLOT
END DATA
```

Listing 15. Table 1 Case 3, KENO-V.a input using CSAS and 27-group cross sections.

```
=CSAS25
CCELSLAB 1.7 g Pu /lb cellulose
27GROUPNDF4  INFHOMMEDIUM
PU-239  1  0  6.3990-6  END
C       1  0  1.4260-2  END
O       1  0  1.1890-2  END
H       1  0  2.3780-2  END
END COMP
KCELSLAB INF SLAB 1.7 G/LB PU in cellulose
READ PARA
     TME=40.0  GEN=153   NPG=407
     FLX=NO     FDN=NO    AMX=NO    FAR=NO
     RUN=YES   PLT=NO    NUB=YES
END PARA
READ GEOM
GLOBAL
     UNIT 1
     CUBOID  1 1   4P28.575  2P50.0
END GEOM
READ START NST=0 END START
READ BOUNDS  ALL=MIRROR  END BOUNDS
READ PLOT
     PLT=YES   PIC=MIX   NCH=' *.C'
     TTL=* "X-Y CELLL" *
     XUL=-28.8  YUL=28.8  ZUL=5.0
     XLR=28.8  YLR=-28.8   ZLR=5.0
     UAX=1.0   VDN=-1.0   NAX=130   END
END PLOT
END DATA
```

Listing 16. Table 1 Case 3, MCNP input.

```
MCLSLAB  INF SLAB 1.8 G/LB PU IN CELLULOSE
1     1 4.993639904e-2  -1 2 -3 4 -5 6  imp:n=1  $slab

*1     px  28.575  $asterisk means reflecting surface
*2     px  -28.575
*3     py  28.575
*4     py  -28.575
*5     pz  50.0
*6     pz  -50.0

kcode  1000 1 20 145 50000  $npg=1000, nsk=20 gen=145
sdef  cel=1  $starting source in cell 1
print
m1    94239.50c 6.39904e-6  6012.50c 1.426e-2
     1001.50c 2.378e-2  8016.50c 1.189e-2
```

Listing 17. Table 1 Case 4, SCAMP input using Hansen-Roach cross sections.

```
LIMIT          1  16   3   1   2   2
ALSLAB PU=.5G/lb; VF  AL=1.0                                              1
       1  13   0   1  16   0   1   1   0   1   0   0   0   0   2
      19   1 999
    1  1   1   1
    2  1   1   1
1 1 1  1   3 612 613 14
       1   1  .001
       2   1  .001
    1  1   1  100.0
  1 1  1   5  1.0          1.0          1.0          1.0          1.0
  1 1  6   5  1.0          1.0          1.0          1.0          1.0
  1 1 11   5  1.0          1.0          1.0          1.0          1.0
  1 1 16   1  1.0
  1 2  1   5  1.0          1.0          1.0          1.0          1.0
  1 2  6   5  1.0          1.0          1.0          1.0          1.0
  1 2 11   5  1.0          1.0          1.0          1.0          1.0
  1 2 16   1  1.0
  5 1  1   5 .225          .347         .161         .170         .084
  5 1  6   1 .013
111 1  1   3 6.8508-6    6.4799-7   6.0271-2
ALSLAB PU=.75G/lb; VF  AL=1.0                                             1
      12   1   4
1 1 1  1   3 611 612 14
111 1  1   3 7.7399-6    3.5078-6   6.0271-2
ALSLAB PU=1G/lb; VF  AL=1.0                                               1
      12   1   4
1 1 1  1   3 610 611 14
111 1  1   3 4.2080-6    1.0789-5   6.0271-2
ALSLAB PU=1.5G/lb; VF  AL=1.0                                             1
      12   1   4
1 1 1  1   3 609 610 14
111 1  1   3 4.1574-6    1.8339-5   6.0271-2
ALSLAB PU=2G/lb; VF  AL=1.0                                               1
      12   1   4
1 1 1  1   3 609 610 14
111 1  1   3 1.9104-5    1.0891-5   6.0271-2
```

Listing 18. Table 1 Case 4, KENO-V.a input using Hansen-Roach cross sections.

```
KAMSLAB INF SLAB 1.25 G/LB PU in aluminum
READ PARA
     TME=40.0  GEN=153   NPG=407    LIB=41
     FLX=NO     FDN=NO    AMX=NO    FAR=NO
     RUN=YES   PLT=NO    NUB=YES
END PARA
READ MIXT
     MIX=1   94910 1.5432-5  94911 3.3154-6  13100 6.0271-2
END MIXT
READ GEOM
GLOBAL
     UNIT 1
     CUBOID  1 1   4P28.575  2P50.0
END GEOM
READ START NST=0 END START
READ BOUNDS  ALL=MIRROR  END BOUNDS
READ PLOT
     PLT=YES   PIC=MIX   NCH=' *.C'
     TTL=* "X-Y CELLL" *
     XUL=-28.8  YUL=28.8  ZUL=5.0
     XLR=28.8  YLR=-28.8   ZLR=5.0
     UAX=1.0   VDN=-1.0   NAX=130   END
END PLOT
END DATA
```

Listing 19. Table 1 Case 4, KENO-V.a input using CSAS and 27-group cross sections.

```
=CSAS25
CAMSLAB 1.25g Pu /lb aluminum
27GROUPNDF4  INFHOMMEDIUM
PU-239  1  0   1.8747-5  END
Al      1  0   6.0271-2  END
END COMP
KAMSLAB INF SLAB 1.25 G/LB PU in aluminum
READ PARA
     TME=40.0  GEN=153   NPG=407
     FLX=NO     FDN=NO    AMX=NO    FAR=NO
     RUN=YES   PLT=NO    NUB=YES
END PARA
READ GEOM
GLOBAL
     UNIT 1
     CUBOID  1 1   4P28.575  2P50.0
END GEOM
READ START NST=0 END START
READ BOUNDS  ALL=MIRROR  END BOUNDS
READ PLOT
     PLT=YES   PIC=MIX   NCH=' *.C'
     TTL=* "X-Y CELLL" *
     XUL=-28.8  YUL=28.8  ZUL=5.0
     XLR=28.8  YLR=-28.8   ZLR=5.0
     UAX=1.0   VDN=-1.0   NAX=130   END
END PLOT
END DATA
```

Listing 20. Table 1 Case 4, MCNP input.

```
MAMSLAB  INF SLAB 1.25 G/LB PU IN ALUMINUM
1     1 6.02897474e-2  -1 2 -3 4 -5 6  imp:n=1  $slab

*1     px  28.575  $asterisk means reflecting surface
*2     px  -28.575
*3     py  28.575
*4     py  -28.575
*5     pz  50.0
*6     pz  -50.0

kcode  1000 1 20 145 50000  $npg=1000, nsk=20 gen=145
sdef  cel=1  $starting source in cell 1
print
m1    94239.50c 1.87474e-5  13027.50c 6.0271e-2
```

Listing 21. Table 1 Case 5, SCAMP input using Hansen-Roach cross sections.

```
LIMIT          1  16   3   1   2   2
CONCSLAB PU=1G/lb; VF CONC=0.5                                          1
       1  13   0   1  16   0   1   1   0   1   0   0   0   0   2
      19   1 999
    1  1   1   1
    2  1   1   1
1 1 1  1   3 615 616 703
       1   1  .001
       2   1  .001
    1  1   1  100.0
  1 1  1   5  1.0          1.0          1.0          1.0          1.0
  1 1  6   5  1.0          1.0          1.0          1.0          1.0
  1 1 11   5  1.0          1.0          1.0          1.0          1.0
  1 1 16   1  1.0
  1 2  1   5  1.0          1.0          1.0          1.0          1.0
  1 2  6   5  1.0          1.0          1.0          1.0          1.0
  1 2 11   5  1.0          1.0          1.0          1.0          1.0
  1 2 16   1  1.0
  5 1  1   5  .225         .347         .161         .170         .084
  5 1  6   1  .013
111 1  1   3  3.2034-6   3.3788-6    1.0
CONCSLAB PU=.6G/lb; VF CONC=1.0                                         1
      12   1   4
1 1 1  1   3 615 616 703
111 1  1   3  6.4941-6   1.4046-6    1.0
CONCSLAB PU=.75G/lb; VF CONC=1.0                                        1
      12   1   4
1 1 1  1   3 614 615 703
111 1  1   3  3.1135-6    6.7599-6   1.0
CONCSLAB PU=.8G/lb; VF CONC=1.0                                         1
      12   1   4
1 1 1  1   3 614 615 703
111 1  1   3  5.0852-6   5.4464-6    1.0
CONCSLAB PU=1.0/lb; VF CONC=1.0                                         1
      12   1   4
1 1 1  1   3 614 615 703
111 1  1   3  1.2985-5    1.7599-7   1.0
```

Listing 22. Table 1 Case 5, KENO-V.a input using Hansen-Roach cross sections.

```
KCONSLAB INF SLAB 0.75G/LB PU in concrete
READ PARA
     TME=40.0  GEN=153   NPG=407    LIB=41
     FLX=NO     FDN=NO    AMX=NO    FAR=NO
     RUN=YES   PLT=NO    NUB=YES
END PARA
READ MIXT
     MIX=1   94914  3.1135-6  94915 6.7599-6  301 1.0
END MIXT
READ GEOM
GLOBAL
     UNIT 1
     CUBOID  1 1   4P28.575  2P50.0
END GEOM
READ START NST=0 END START
READ BOUNDS  ALL=MIRROR  END BOUNDS
READ PLOT
     PLT=YES   PIC=MIX   NCH=' *.C'
     TTL=* "X-Y CELLL" *
     XUL=-28.8  YUL=28.8  ZUL=5.0
     XLR=28.8  YLR=-28.8   ZLR=5.0
     UAX=1.0   VDN=-1.0   NAX=130   END
END PLOT
END DATA
```

Listing 23. Table 1 Case 5, KENO-V.a input using CSAS and 27-group cross sections.

```
=CSAS25
CCONSLAB INF SLAB 0.75G/LB PU in concrete
27GROUPNDF4  INFHOMMEDIUM
PU-239  1  0  9.8734-6  END
H    1   0  0.014868    END
C    1   0  0.003814    END
O    1   0  0.041519    END
CA   1   0  0.011588    END
SI   1   0  0.006037    END
FE   1   0  0.0001968   END
AL   1   0  0.000735    END
NA   1   0  0.000304    END
MG   1   0  0.000587    END
END COMP
KCONSLAB INF SLAB 0.75G/LB PU in concrete
READ PARA
     TME=40.0  GEN=153   NPG=407
     FLX=NO     FDN=NO    AMX=NO    FAR=NO
     RUN=YES   PLT=NO    NUB=YES
END PARA
READ GEOM
GLOBAL
     UNIT 1
     CUBOID  1 1   4P28.575  2P50.0
END GEOM
READ START NST=0 END START
READ BOUNDS  ALL=MIRROR  END BOUNDS
READ PLOT
     PLT=YES   PIC=MIX   NCH=' *.C'
     TTL=* "X-Y CELLL" *
     XUL=-28.8  YUL=28.8  ZUL=5.0
     XLR=28.8  YLR=-28.8   ZLR=5.0
     UAX=1.0   VDN=-1.0   NAX=130   END
END PLOT
END DATA
```

Listing 24. Table 1 Case 5, MCNP input.

```
MHCSLAB  INF SLAB 0.75 G/LB PU IN CONCRETE (KENO/H-R)
1     1 7.96586734e-2  -1 2 -3 4 -5 6  imp:n=1  $slab

*1     px  28.575  $asterisk means reflecting surface
*2     px  -28.575
*3     py  28.575
*4     py  -28.575
*5     pz  50.0
*6     pz  -50.0

kcode  1000 1 20 145 50000  $npg=1000, nsk=20 gen=145
sdef  cel=1  $starting source in cell 1
print
m1    94239.50c 9.8734e-6  13027.50c 0.000735
      8016.50c 0.041519  1001.50c .014868  20000.50c .011588
      14000.50c 0.006037  26000.50c 0.0001968  11023.50c 0.000304
      6000.50c .003814  12000.50c .000587
```

Listing 25. Table 1 Case 6, SCAMP input using Hansen-Roach cross sections.

```
LIMIT          1  16   4   1   2   2
ALOXSLAB PU=.2G/lb; VF  AL2O3=1.0                                          1
       1  13   0   1  16   0   1   1   0   1   0   0   0   0   2
      19   1 999
    1  1   1   1
    2  1   1   1
1 1 1  1   4 615 616 14 10
       1   1  .001
       2   1  .001
    1  1   1  100.0
  1 1  1   5  1.0          1.0          1.0          1.0          1.0
  1 1  6   5  1.0          1.0          1.0          1.0          1.0
  1 1 11   5  1.0          1.0          1.0          1.0          1.0
  1 1 16   1  1.0
  1 2  1   5  1.0          1.0          1.0          1.0          1.0
  1 2  6   5  1.0          1.0          1.0          1.0          1.0
  1 2 11   5  1.0          1.0          1.0          1.0          1.0
  1 2 16   1  1.0
  5 1  1   5 .225          .347         .161         .170         .084
  5 1  6   1 .013
111 1  1   4 2.8423-6      1.5626-6     4.6844-2   7.0266-2
ALOXSLAB PU=.25G/lb; VF  AL2O3=1.0                                         1
      12   1   4
1 1 1  1   4 614 615 14 10
111 1  1   4 1.7756-7      5.3284-6     4.6844-2   7.0266-2
ALOXSLAB PU=.28G/lb; VF  AL2O3=1.0                                         1
      12   1   4
1 1 1  1   4 614 615 14 10
111 1  1   4 2.1593-6      4.0075-6     4.6844-2   7.0266-2
ALOXSLAB PU=.3G/lb; VF  AL2O3=1.0                                          1
      12   1   4
1 1 1  1   4 614 615 14 10
111 1  1   4 3.4804-6      3.1268-6     4.6844-2   7.0266-2
ALOXSLAB PU=.37G/lb; VF  AL2O3=1.0                                         1
      12   1   4
1 1 1  1   4 614 615 14 10
111 1  1   4 8.1044-6      4.4467-8     4.6844-2   7.0266-2
ALOXSLAB PU=.4G/lb; VF  AL2O3=1.0                                          1
      12   1   4
1 1 1  1   4 613 614 14 10
111 1  1   4 1.2765-6      7.5331-6     4.6844-2   7.0266-2
ALOXSLAB PU=.5G/lb; VF  AL2O3=1.0                                          1
      12   1   4
1 1 1  1   4 613 614 14 10
111 1  1   4 5.6798-6      5.3322-6     4.6844-2   7.0266-2
```

Listing 26. Table 1 Case 6, KENO-V.a input using Hansen-Roach cross sections.

```
KAOXSLAB INF SLAB 0.37 G/LB PU in aluminum oxide
READ PARA
     TME=40.0  GEN=153   NPG=407    LIB=41
     FLX=NO     FDN=NO    AMX=NO    FAR=NO
     RUN=YES   PLT=NO    NUB=YES
END PARA
READ MIXT
     MIX=1   94914 8.1044-6 94915 4.4467-8 13100 4.6844-2 8100 7.0266-2
END MIXT
READ GEOM
GLOBAL
     UNIT 1
     CUBOID  1 1   4P28.575  2P50.0
END GEOM
READ START NST=0 END START
READ BOUNDS  ALL=MIRROR  END BOUNDS
READ PLOT
     PLT=YES   PIC=MIX   NCH=' *.C'
     TTL=* "X-Y CELLL" *
     XUL=-28.8  YUL=28.8  ZUL=5.0
     XLR=28.8  YLR=-28.8   ZLR=5.0
     UAX=1.0   VDN=-1.0   NAX=130   END
END PLOT
END DATA
```

Listing 27. Table 1 Case 6, KENO-V.a input using CSAS and 27-group cross sections.

```
=CSAS25
CAOXSLAB 0.37 Pu /lb aluminum oxide
27GROUPNDF4  INFHOMMEDIUM
PU-239  1  0   8.1489-6  END
Al      1  0   4.6844-2  END
O       1  0   7.0266-2  END
END COMP
KAOXSLAB INF SLAB 0.37G/LB PU in aluminum oxide
READ PARA
     TME=40.0  GEN=153   NPG=407
     FLX=NO     FDN=NO    AMX=NO    FAR=NO
     RUN=YES   PLT=NO    NUB=YES
END PARA
READ GEOM
GLOBAL
     UNIT 1
     CUBOID  1 1   4P28.575  2P50.0
END GEOM
READ START NST=0 END START
READ BOUNDS  ALL=MIRROR  END BOUNDS
READ PLOT
     PLT=YES   PIC=MIX   NCH=' *.C'
     TTL=* "X-Y CELLL" *
     XUL=-28.8  YUL=28.8  ZUL=5.0
     XLR=28.8  YLR=-28.8   ZLR=5.0
     UAX=1.0   VDN=-1.0   NAX=130   END
END PLOT
END DATA
```

Listing 28. Table 1 Case 6, MCNP input.

```
MAOSLAB  INF SLAB 0.37 G/LB PU IN ALUMINUM OXIDE
1     1 1.17118148867e-1  -1 2 -3 4 -5 6  imp:n=1  $slab

*1     px  28.575  $asterisk means reflecting surface
*2     px  -28.575
*3     py  28.575
*4     py  -28.575
*5     pz  50.0
*6     pz  -50.0

kcode  1000 1 20 145 50000  $npg=1000, nsk=20 gen=145
sdef  cel=1  $starting source in cell 1
print
m1    94239.50c 8.148867e-6  13027.50c 4.6844e-2
      8016.50c  7.0266e-2
```

Listing 29. Table 1 Case 6, COMBINE input.

```
= blrc001  Pu in AL2O3, PU= .37 g/lb
1010101    0   1   1   1   3  16   2   7   0   0   0   0   0  54   1  30
1010201  166 157 154 152 149 144 136 130 123 116 111 107 101  82  44  22
1020101    3   3   3
1030101   14   0 998   0   0   0   0
1030201    1   1   0   0   1
1030202    1   2   0   0   1
1030203    1   3   0   0   1
1041001   1.0000E-06  1.0000E-06  2.9300E+02
1042001  505.0     8.00293  7.0266E-02   0.0  0.0000E+00  0.0000E+00
1042002  510.0    13.00004  4.6844E-02   0.0  0.0000E+00  0.0000E+00
1042003  645.0    94.23905  8.14887-06   0.0  0.0000E+00  0.0000E+00
```

Listing 30. Table 1 Case 6, SCAMP input with COMBINE generated cross sections.

```
LIMIT          1  16   3   1   2   2
ALCOM16 PU=.37G/lb VF AL2O3                                                  1
       1  13    0   1  16    0   1   1   3  20   0   0   0   0   2
      19   4    0 998   0   3
    1  1   1    1
    2  1   1    1
1 1 1  1   3    3  2  1
       1   1  .001
       2   1  .001
    1  1   1  100.0
  1 1  1   5  1.0          1.0          1.0          1.0          1.0
  1 1  6   5  1.0          1.0          1.0          1.0          1.0
  1 1 11   5  1.0          1.0          1.0          1.0          1.0
  1 1 16   1  1.0
  1 2  1   5  1.0          1.0          1.0          1.0          1.0
  1 2  6   5  1.0          1.0          1.0          1.0          1.0
  1 2 11   5  1.0          1.0          1.0          1.0          1.0
  1 2 16   1  1.0
  5 1  1   5 2.55974E-01 3.48185E-01 1.71622E-01 1.39795E-01 7.01995E-02
  5 1  6   5 1.34929E-02 6.54148E-04 7.17970E-05 5.20614E-06 3.44291E-07
  5 1 11   4 4.84487E-08 1.24487E-08 9.90516E-10 3.69914E-10
111 1  1   3 8.148870-06 4.684400-02 7.026600-02
  0 0  1    OXYGEN-16  VERS 5    (FAST) + OXYGEN 293K FREE GAS (THERMAL)
  1 1  1 1 5 2.63334E-01 2.64069E-01 9.13996E-02 1.12207E-01 8.36516E-02 0.    1
  1 1  6 1 5 9.43623E-02 9.29318E-02 9.28946E-02 9.28137E-02 9.26112E-02 0.    1
  1 1 11 1 5 9.28413E-02 9.27295E-02 9.26654E-02 9.23394E-02 8.96236E-02 0.    1
  1 1 16 1 1 8.85972E-02 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    1
  1 1  1 2 5 3.40840E-02 2.20520E-08 2.76976E-08 3.70282E-08 6.32470E-08 0.    1
  1 1  6 2 5 1.52465E-07 3.42509E-07 7.80789E-07 1.87179E-06 3.88178E-06 0.    1
  1 1 11 2 5 6.82728E-06 1.27306E-05 2.22330E-05 3.44602E-05 6.35669E-05 0.    1
  1 1 16 2 1 1.42812E-04 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    1
  4 1  1 0 5 1.47432E+00 1.45927E+00 3.74808E+00 3.43973E+00 4.01535E+00 0.    1
  4 1  6 0 5 3.55890E+00 3.57563E+00 3.58742E+00 3.58987E+00 3.59041E+00 0.    1
  4 1 11 0 5 3.59052E+00 3.59052E+00 3.59053E+00 3.59057E+00 3.62300E+00 0.    1
  4 1 16 0 1 3.69651E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    1
  3 1  1 1 5 1.58216E+00 3.84998E-01 2.69085E-03 2.35068E-03 7.97236E-04 0.    1
  6 1  1 1 5 6.76516E-01-1.44253E-01 6.87530E-04-2.48563E-05-1.31321E-04 0.    1
  3 1  1 6 5 2.43051E-05 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    1
  6 1  1 6 5-1.01821E-05 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    1
  3 1  2 1 5 0.00000E+00 1.20257E+00 3.70891E-01 0.00000E+00 0.00000E+00 0.    1
  6 1  2 1 5 0.00000E+00 2.00672E-01-8.64833E-02 0.00000E+00 0.00000E+00 0.    1
  3 1  3 1 5 0.00000E+00 0.00000E+00 2.81357E+00 1.04774E+00 0.00000E+00 0.    1
  6 1  3 1 5 0.00000E+00 0.00000E+00 4.72860E-01-3.59629E-01 0.00000E+00 0.    1
  3 1  4 1 5 0.00000E+00 0.00000E+00 0.00000E+00 3.50060E+00 6.72785E-01 0.    1
  6 1  4 1 5 0.00000E+00 0.00000E+00 0.00000E+00 8.93923E-01-1.60268E-01 0.    1
  3 1  5 1 5 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 3.17792E+00 0.    1
  6 1  5 1 5 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00-2.56367E-01 0.    1
  3 1  5 6 5 4.14442E-01 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    1
  6 1  5 6 5-1.66624E-01 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    1
  3 1  6 6 5 3.38938E+00 2.78034E-01 0.00000E+00 0.00000E+00 0.00000E+00 0.    1
  6 1  6 6 5 2.11713E-01-1.03199E-01 0.00000E+00 0.00000E+00 0.00000E+00 0.    1
  3 1  7 6 5 0.00000E+00 3.42722E+00 3.05314E-01 0.00000E+00 0.00000E+00 0.    1
  6 1  7 6 5 0.00000E+00 2.51449E-01-9.45390E-02 0.00000E+00 0.00000E+00 0.    1
  3 1  8 6 5 0.00000E+00 0.00000E+00 3.48754E+00 2.57314E-01 0.00000E+00 0.    1
  6 1  8 6 5 0.00000E+00 0.00000E+00 2.35938E-01-7.85051E-02 0.00000E+00 0.    1
  3 1  9 6 5 0.00000E+00 0.00000E+00 0.00000E+00 3.49125E+00 2.56153E-01 0.    1
  6 1  9 6 5 0.00000E+00 0.00000E+00 0.00000E+00 2.35691E-01-7.81508E-02 0.    1
  3 1 10 6 5 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 3.38173E+00 0.    1
  6 1 10 6 5 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 2.62473E-01 0.    1
  3 1 1011 5 3.66243E-01 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    1
  6 1 1011 5-1.04909E-01 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    1
  3 1 1111 5 3.29601E+00 4.52065E-01 0.00000E+00 0.00000E+00 0.00000E+00 0.    1
  6 1 1111 5 2.94731E-01-1.37163E-01 0.00000E+00 0.00000E+00 0.00000E+00 0.    1
  3 1 1211 5 0.00000E+00 3.46294E+00 2.85134E-01 0.00000E+00 0.00000E+00 0.    1
  6 1 1211 5 0.00000E+00 2.44479E-01-8.69107E-02 0.00000E+00 0.00000E+00 0.    1
  3 1 1311 5 0.00000E+00 0.00000E+00 3.15103E+00 5.97046E-01 0.00000E+00 0.    1
  6 1 1311 5 0.00000E+00 0.00000E+00 3.39302E-01-1.81733E-01 0.00000E+00 0.    1
  3 1 1411 5 0.00000E+00 0.00000E+00 0.00000E+00 3.31459E+00 4.33514E-01 0.    1
  6 1 1411 5 0.00000E+00 0.00000E+00 0.00000E+00 2.85299E-01-1.27730E-01 0.    1
  3 1 1511 5 0.00000E+00 0.00000E+00 0.00000E+00 5.43846E-02 3.40059E+00 0.    1
  6 1 1511 5 0.00000E+00 0.00000E+00 0.00000E+00 9.51863E-03 2.11565E-01 0.    1
  3 1 1516 1 3.27247E-01 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    1
  6 1 1516 1-6.18007E-02 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    1
  3 1 1611 5 0.00000E+00 0.00000E+00 0.00000E+00 3.08771E-14 2.46751E-01 0.    1
  6 1 1611 5 0.00000E+00 0.00000E+00 0.00000E+00-2.80049E-14-1.77337E-02 0.    1
  3 1 1616 1 3.61522E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    1
1 6 1 1616 1 1.83338E-01 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    1
  0 0  2    ALUMINUM-27  VERS 5  (FAST) + ALUMINUM VERS 4 MATE (THERMAL)
  1 2  1 1 5 2.25083E-01 1.84379E-01 1.43689E-01 1.10590E-01 8.49440E-02 0.    2
  1 2  6 1 5 1.41919E-01 2.35827E-01 2.53533E-01 2.53129E-01 2.52051E-01 0.    2
```

Listing 30. Continued.

```
  1 2 11 1 5 2.52380E-01 2.50462E-01 2.48011E-01 2.44719E-01 2.38859E-01 0.    2
  1 2 16 1 1 2.23006E-01 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    2
  1 2  1 2 5 1.80449E-02 1.74297E-04 1.62598E-04 4.16257E-04 1.41786E-03 0.    2
  1 2  6 2 5 3.45517E-03 8.82689E-03 2.47629E-03 2.82994E-03 5.05645E-03 0.    2
  1 2 11 2 5 8.90149E-03 1.66599E-02 2.89931E-02 4.49353E-02 8.16649E-02 0.    2
  1 2 16 2 1 1.83868E-01 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    2
  4 2  1 0 5 1.49392E+00 1.84542E+00 2.30728E+00 3.03547E+00 4.17063E+00 0.    2
  4 2  6 0 5 3.48630E+00 1.45134E+00 1.31475E+00 1.31650E+00 1.31878E+00 0.    2
  4 2 11 0 5 1.32262E+00 1.33028E+00 1.34253E+00 1.35843E+00 1.39509E+00 0.    2
  4 2 16 0 1 1.49788E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    2
  3 2  1 1 5 1.60687E+00 4.84628E-01 1.15407E-01 1.00981E-01 2.87198E-02 0.    2
  6 2  1 1 5 8.47700E-01 7.42507E-03 9.41498E-03-1.59475E-03-4.83591E-04 0.    2
  3 2  1 6 5 1.64988E-03 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    2
  6 2  1 6 5-7.30169E-05 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    2
  3 2  2 1 5 0.00000E+00 2.57759E+00 2.90984E-01 1.05055E-01 2.82620E-02 0.    2
  6 2  2 1 5 0.00000E+00 1.17700E+00-1.82424E-02 1.44200E-03-7.54219E-04 0.    2
  3 2  2 6 5 2.79726E-03 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    2
  6 2  2 6 5-7.27289E-06 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    2
  3 2  3 1 5 0.00000E+00 0.00000E+00 2.85514E+00 4.96239E-01 6.01466E-02 0.    2
  6 2  3 1 5 0.00000E+00 0.00000E+00 1.14728E+00-3.61674E-02 3.38988E-03 0.    2
  3 2  3 6 5 9.50889E-03 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    2
  6 2  3 6 5-5.85105E-04 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    2
  3 2  4 1 5 0.00000E+00 0.00000E+00 0.00000E+00 3.72493E+00 2.11088E-01 0.    2
  6 2  4 1 5 0.00000E+00 0.00000E+00 0.00000E+00 9.28508E-01-2.75444E-02 0.    2
  3 2  5 1 5 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 4.19662E+00 0.    2
  6 2  5 1 5 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 3.73364E-01 0.    2
  3 2  5 6 5 2.45740E-01 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    2
  6 2  5 6 5-1.00213E-01 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    2
  3 2  6 6 5 3.49812E+00 4.41375E-02 0.00000E+00 0.00000E+00 0.00000E+00 0.    2
  6 2  6 6 5 7.60891E-02-1.66757E-02 0.00000E+00 0.00000E+00 0.00000E+00 0.    2
  3 2  7 6 5 0.00000E+00 1.41310E+00 6.54396E-02 0.00000E+00 0.00000E+00 0.    2
  6 2  7 6 5 0.00000E+00 5.70282E-02-2.10069E-02 0.00000E+00 0.00000E+00 0.    2
  3 2  8 6 5 0.00000E+00 0.00000E+00 1.29014E+00 5.56819E-02 0.00000E+00 0.    2
  6 2  8 6 5 0.00000E+00 0.00000E+00 5.11788E-02-1.76382E-02 0.00000E+00 0.    2
  3 2  9 6 5 0.00000E+00 0.00000E+00 0.00000E+00 1.29182E+00 5.54189E-02 0.    2
  6 2  9 6 5 0.00000E+00 0.00000E+00 0.00000E+00 5.11308E-02-1.75547E-02 0.    2
  3 2 10 6 5 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 1.27731E+00 0.    2
  6 2 10 6 5 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 5.54238E-02 0.    2
  3 2 1011 5 6.99903E-02 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    2
  6 2 1011 5-2.18463E-02 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    2
  3 2 1111 5 1.25109E+00 9.61998E-02 0.00000E+00 0.00000E+00 0.00000E+00 0.    2
  6 2 1111 5 6.39604E-02-3.03830E-02 0.00000E+00 0.00000E+00 0.00000E+00 0.    2
  3 2 1211 5 0.00000E+00 1.28543E+00 6.17640E-02 0.00000E+00 0.00000E+00 0.    2
  6 2 1211 5 0.00000E+00 5.31382E-02-1.95633E-02 0.00000E+00 0.00000E+00 0.    2
  3 2 1311 5 0.00000E+00 0.00000E+00 1.21779E+00 1.29323E-01 0.00000E+00 0.    2
  6 2 1311 5 0.00000E+00 0.00000E+00 7.44779E-02-4.09051E-02 0.00000E+00 0.    2
  3 2 1411 5 0.00000E+00 0.00000E+00 0.00000E+00 1.25181E+00 9.52593E-02 0.    2
  6 2 1411 5 0.00000E+00 0.00000E+00 0.00000E+00 6.29455E-02-2.93737E-02 0.    2
  3 2 1511 5 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 1.34700E+00 0.    2
  6 2 1511 5 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 3.35703E-02 0.    2
  3 2 1616 1 1.34760E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    2
1 6 2 1616 1 3.35848E-02 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    2
  0 0  3     PLUTONIUM-239  VERS  (FAST) + PLUTONIUM-239  VERS  (THERMAL)
  1 3  1 1 5 8.28686E-02 7.01084E-02 6.71238E-02 5.81989E-02 3.72416E-02 0.    3
  1 3  6 1 5 2.58110E-02 2.14085E-02 1.50412E-02 7.33773E-03 3.67665E-03 0.    3
  1 3 11 1 5 2.08546E-03 5.92669E-03 8.96149E-03 1.77517E-03 1.70648E-04 0.    3
  1 3 16 1 1 3.86994E-04 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    3
  1 3  1 2 5 1.78883E+00 1.93799E+00 1.78966E+00 1.70751E+00 1.73155E+00 0.    3
  1 3  6 2 5 2.16192E+00 3.72921E+00 9.04315E+00 2.96344E+01 7.55658E+01 0.    3
  1 3 11 2 5 1.48942E+02 4.59209E+01 2.73799E+01 1.77600E+02 2.00923E+03 0.    3
  1 3 16 2 1 8.65119E+02 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    3
  1 3  1 3 5 6.23087E+00 6.08438E+00 5.33642E+00 4.80274E+00 4.46356E+00 0.    3
  1 3  6 3 5 4.78246E+00 6.49101E+00 1.38026E+01 4.44464E+01 1.12588E+02 0.    3
  1 3 11 3 5 2.55753E+02 8.12811E+01 6.12685E+01 3.46520E+02 3.50592E+03 0.    3
  1 3 16 3 1 1.79053E+03 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    3
  1 3  1 4 5 1.79746E+00 1.92942E+00 1.76442E+00 1.62160E+00 1.53514E+00 0.    3
  1 3  6 4 5 1.65845E+00 2.25349E+00 4.79279E+00 1.54340E+01 3.90963E+01 0.    3
  1 3 11 4 5 8.88109E+01 2.82251E+01 2.12758E+01 1.20330E+02 1.21254E+03 0.    3
  1 3 16 4 1 6.19264E+02 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    3
  4 3  1 0 5 4.06115E+00 4.68554E+00 4.98528E+00 5.80944E+00 8.97957E+00 0.    3
  4 3  6 0 5 1.28207E+01 1.55813E+01 2.21771E+01 4.54128E+01 9.04735E+01 0.    3
  4 3 11 0 5 1.59970E+02 5.44882E+01 3.72036E+01 1.88976E+02 2.01905E+03 0.    3
  4 3 16 0 1 8.72907E+02 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    3
  3 3  1 1 5 4.82413E+00 2.66927E-01 2.92358E-01 3.73782E-01 2.13079E-01 0.    3
  6 3  1 1 5 3.70356E+00 5.96342E-03 0.00000E+00 0.00000E+00 0.00000E+00 0.    3
  3 3  1 6 5 1.15699E-02 1.12137E-07 0.00000E+00 0.00000E+00 0.00000E+00 0.    3
  6 3  1 6 5 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    3
  3 3  2 1 5 0.00000E+00 4.31429E+00 3.97226E-01 4.00968E-01 2.56089E-01 0.    3
  6 3  2 1 5 0.00000E+00 2.63585E+00 2.21696E-03-1.35733E-04 0.00000E+00 0.    3
  3 3  2 6 5 1.69048E-02 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    3
```

Listing 30. Continued.

```
  6 3  2 6 5 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    3
  3 3  3 1 5 0.00000E+00 0.00000E+00 4.37488E+00 6.93487E-01 2.42860E-01 0.    3
  6 3  3 1 5 0.00000E+00 0.00000E+00 2.11549E+00 7.61330E-03-9.35741E-04 0.    3
  3 3  3 6 5 6.56306E-03 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    3
  6 3  3 6 5 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    3
  3 3  4 1 5 0.00000E+00 0.00000E+00 0.00000E+00 5.95005E+00 4.25297E-01 0.    3
  6 3  4 1 5 0.00000E+00 0.00000E+00 0.00000E+00 2.32760E+00 8.50389E-04 0.    3
  3 3  4 6 5 5.48634E-02 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    3
  6 3  4 6 5-1.65946E-04 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    3
  3 3  5 1 5 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 8.83341E+00 0.    3
  6 3  5 1 5 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 1.78655E+00 0.    3
  3 3  5 6 5 1.84357E-01 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    3
  6 3  5 6 5-1.68016E-02 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    3
  3 3  6 6 5 1.08868E+01 1.57804E-01 0.00000E+00 0.00000E+00 0.00000E+00 0.    3
  6 3  6 6 5 4.09032E-01-2.32190E-02 0.00000E+00 0.00000E+00 0.00000E+00 0.    3
  3 3  7 6 5 0.00000E+00 1.17694E+01 1.13478E-01 2.97074E-03 6.00333E-05 0.    3
  6 3  7 6 5 0.00000E+00 5.62228E-02-2.24351E-02-2.15824E-06-3.46366E-06 0.    3
  3 3  8 6 5 0.00000E+00 0.00000E+00 1.30699E+01 1.01108E-01 0.00000E+00 0.    3
  6 3  8 6 5 0.00000E+00 0.00000E+00 7.05821E-02-3.35326E-02 0.00000E+00 0.    3
  3 3  9 6 5 0.00000E+00 0.00000E+00 0.00000E+00 1.57778E+01 4.51351E-02 0.    3
  6 3  9 6 5 0.00000E+00 0.00000E+00 0.00000E+00 5.88202E-02-1.43129E-02 0.    3
  3 3 10 6 5 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 1.48977E+01 0.    3
  6 3 10 6 5 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 5.90817E-02 0.    3
  3 3 1011 5 5.21045E-02 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    3
  6 3 1011 5-1.69758E-02 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    3
  3 3 1111 5 1.10293E+01 2.97038E-02 0.00000E+00 0.00000E+00 0.00000E+00 0.    3
  6 3 1111 5 4.08724E-02-9.78399E-03 0.00000E+00 0.00000E+00 0.00000E+00 0.    3
  3 3 1211 5 0.00000E+00 8.54123E+00 5.02078E-02 0.00000E+00 0.00000E+00 0.    3
  6 3 1211 5 0.00000E+00 4.08388E-02-1.66436E-02 0.00000E+00 0.00000E+00 0.    3
  3 3 1311 5 0.00000E+00 0.00000E+00 9.73811E+00 1.13326E-01 0.00000E+00 0.    3
  6 3 1311 5 0.00000E+00 0.00000E+00 6.52245E-02-3.75134E-02 0.00000E+00 0.    3
  3 3 1411 5 0.00000E+00 0.00000E+00 0.00000E+00 1.12910E+01 1.17641E-01 0.    3
  6 3 1411 5 0.00000E+00 0.00000E+00 0.00000E+00 7.03811E-02-3.83102E-02 0.    3
  3 3 1511 5 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 9.84031E+00 0.    3
  6 3 1511 5 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 2.74454E-02 0.    3
  3 3 1616 1 7.80976E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    3
1 6 3 1616 1 2.19546E-02 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    3
```

Listing 31. Table 1 Case 7, SCAMP input using Hansen-Roach cross sections.

```
LIMIT          1  16   4   1   2   2
SILSLAB PU=.2G/lb VF SiO2=1.0                                              1
       1  13   0   1  16   0   1   1   0   1   0   0   0   0   2
      19   1 999
    1  1   1   1
    2  1   1   1
1 1 1  1   4 615 616  15  10
       1   1  .001
       2   1  .001
    1  1   1  100.0
  1 1  1   5  1.0          1.0          1.0          1.0          1.0
  1 1  6   5  1.0          1.0          1.0          1.0          1.0
  1 1 11   5  1.0          1.0          1.0          1.0          1.0
  1 1 16   1  1.0
  1 2  1   5  1.0          1.0          1.0          1.0          1.0
  1 2  6   5  1.0          1.0          1.0          1.0          1.0
  1 2 11   5  1.0          1.0          1.0          1.0          1.0
  1 2 16   1  1.0
  5 1  1   5  .225         .347         .161         .170         .084
  5 1  6   1  .013
111 1  1   4 8.31902-7    1.74545-6   2.3256-2    4.6513-2
SILSLAB PU=.16G/lb; VF SiO2=1.0                                            1
      12   1   4
1 1 1  1   3 616 15  10
111 1  1   3 2.06189-6   2.3256-2    4.6513-2
SILSLAB PU=.15G/lb; VF SiO2=1.0                                            1
      12   1   4
1 1 1  1   3 616 15  10
111 1  1   3 1.93302-6   2.3256-2    4.6513-2
SILSLAB PU=.14G/lb; VF SiO2=1.0                                            1
      12   1   4
1 1 1  1   3 616 15  10
111 1  1   3 1.80415-6   2.3256-2    4.6513-2
SILSLAB PU=.12G/lb; VF SiO2=1.0                                            1
      12   1   4
1 1 1  1   3 616 15  10
111 1  1   3 1.54642-6   2.3256-2    4.6513-2
SILSLAB PU=.1G/lb; VF SiO2=1.0                                             1
      12   1   4
1 1 1  1   3 616 15  10
111 1  1   3 1.28868-6   2.3256-2    4.6513-2
SILSLAB PU=.07G/lb VF SiO2=1.0                                             1
      12   1   4
1 1 1  1   3 616 15  10
111 1  1   3 9.02075-7    2.3256-2    4.6513-2
SILSLAB PU=.05 G/lb; VF SiO2=1.0                                           1
      12   1   4
1 1 1  1   3 616 15  10
111 1  1   3 6.44339-7   2.3256-2    4.6513-2
SILSLAB PU=.04 G/lb; VF SiO2=1.0                                           1
      12   1   4
1 1 1  1   3 616 15  10
111 1  1   3 5.15471-7   2.3256-2    4.6513-2
```

Listing 32. Table 1 Case 7, KENO-V.a input using Hansen-Roach cross sections.

```
KSILSLAB INF SLAB 0.16G/LB PU in SiO2
READ PARA
     TME=40.0  GEN=153   NPG=407    LIB=41
     FLX=YES     FDN=YES    AMX=YES    FAR=YES
     RUN=YES   PLT=NO    NUB=YES
END PARA
READ MIXT
     MIX=1   94916 2.0619-6  14100 2.3256-2  8100 4.6513-2
END MIXT
READ GEOM
GLOBAL
     UNIT 1
     CUBOID  1 1   4P28.575  2P50.0
END GEOM
READ START NST=0 END START
READ BOUNDS  ALL=MIRROR  END BOUNDS
READ PLOT
     PLT=YES   PIC=MIX   NCH=' *.C'
     TTL=* "X-Y CELLL" *
     XUL=-28.8  YUL=28.8  ZUL=5.0
     XLR=28.8  YLR=-28.8   ZLR=5.0
     UAX=1.0   VDN=-1.0   NAX=130   END
END PLOT
END DATA
```

Listing 33. Table 1 Case 7, KENO-V.a input using CSAS and 27-group cross sections.

```
=CSAS25
CSILSLAB 0.16g Pu /lb SiO2
27GROUPNDF4  INFHOMMEDIUM
PU-239  1  0  2.0619-6  END
SI      1  0  2.3256-2  END
O       1  0  4.6513-2  END
END COMP
KSILSLAB INF SLAB 0.16G/LB PU in SiO2
READ PARA
     TME=60.0  GEN=153   NPG=407
     FLX=YES    FDN=YES   AMX=YES   FAR=YES
     RUN=YES   PLT=NO    NUB=YES
END PARA
READ GEOM
GLOBAL
     UNIT 1
     CUBOID  1 1   4P28.575  2P50.0
END GEOM
READ START NST=0 END START
READ BOUNDS  ALL=MIRROR  END BOUNDS
READ PLOT
     PLT=YES   PIC=MIX   NCH=' *.C'
     TTL=* "X-Y CELLL" *
     XUL=-28.8  YUL=28.8  ZUL=5.0
     XLR=28.8  YLR=-28.8   ZLR=5.0
     UAX=1.0   VDN=-1.0   NAX=130   END
END PLOT
END DATA
```

Listing 34. Table 1 Case 7, MCNP input.

```
MSILSLAB  INF SLAB .16 G/LB PU IN SILICON DIOXIDE
1     1 6.97710619e-2  -1 2 -3 4 -5 6  imp:n=1  $slab

*1     px  28.575  $asterisk means reflecting surface
*2     px  -28.575
*3     py  28.575
*4     py  -28.575
*5     pz  50.0
*6     pz  -50.0

kcode  1000 1 20 145 50000  $npg=1000, nsk=20 gen=145
sdef  cel=1  $starting source in cell 1
print
m1    94239.50c 2.0619e-6  14000.50c 2.3256e-2  8016.50c 4.6513e-2
```

Listing 35. Table 1 Case 7, COMBINE input.

```
= blrc006  PU=0.16 G/LB; VF SIO2=1.0
1010101    0   1   1   1   3  16   2   7   0   0   0   0   0  54   1  30
1010201  166 157 154 152 149 144 136 130 123 116 111 107 101  82  44  22
1020101    3   3   3
1030101   14   0 998   0   0   0   0
1030201    1   1   0   0   1
1030202    1   2   0   0   1
1030203    1   3   0   0   1
1041001   1.0000E-06  1.0000E-06  2.9300E+02
1042001  505.0      8.00293  4.6513E-02    0.0  0.0000E+00  0.0000E+00
1042002  516.0     14.00004  2.3256E-02    0.0  0.0000E+00  0.0000E+00
1042003  645.0     94.23905  2.0619E-06    0.0  0.0000E+00  0.0000E+00
```

Listing 36. Table 1 Case 7, SCAMP input with COMBINE generated cross sections.

```
LIMIT          1  16   3   1   2   2
SICOM16 PU=.16G/lb VF SiO2=1.0                                          1
       1  13   0   1  16   0   1   1   3  20   0   0   0   0   2
      19   4   0 998   0   3
    1  1   1   1
    2  1   1   1
1 1 1  1   3   3  2  1
       1   1  .001
       2   1  .001
    1  1   1  100.0
  1 1  1   5  1.0          1.0          1.0          1.0          1.0
  1 1  6   5  1.0          1.0          1.0          1.0          1.0
  1 1 11   5  1.0          1.0          1.0          1.0          1.0
  1 1 16   1  1.0
  1 2  1   5  1.0          1.0          1.0          1.0          1.0
  1 2  6   5  1.0          1.0          1.0          1.0          1.0
  1 2 11   5  1.0          1.0          1.0          1.0          1.0
  1 2 16   1  1.0
  5 1  1   5 2.55974E-01 3.48185E-01 1.71622E-01 1.39795E-01 7.01995E-02
  5 1  6   5 1.34929E-02 6.54148E-04 7.17970E-05 5.20614E-06 3.44291E-07
  5 1 11   4 4.84487E-08 1.24487E-08 9.90516E-10 3.69914E-10
111 1  1   3 2.061900-06 2.325600-02 4.651300-02
  0 0  1    OXYGEN-16  VERS 5    (FAST) + OXYGEN 293K FREE GAS (THERMAL)
  1 1  1 1 5 2.60897E-01 2.72274E-01 9.14483E-02 1.14400E-01 8.77847E-02 0.    1
  1 1  6 1 5 9.24801E-02 9.31671E-02 9.28930E-02 9.28351E-02 9.26699E-02 0.    1
  1 1 11 1 5 9.29584E-02 9.27863E-02 9.27501E-02 9.25623E-02 9.10577E-02 0.    1
  1 1 16 1 1 8.90998E-02 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    1
  1 1  1 2 5 3.27739E-02 2.20760E-08 2.76403E-08 3.68787E-08 6.52450E-08 0.    1
  1 1  6 2 5 1.46794E-07 3.43514E-07 7.81001E-07 1.87326E-06 3.88581E-06 0.    1
  1 1 11 2 5 6.83591E-06 1.27525E-05 2.22439E-05 3.45389E-05 6.70957E-05 0.    1
  1 1 16 2 1 1.53332E-04 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    1
  4 1  1 0 5 1.48601E+00 1.43680E+00 3.73289E+00 3.42573E+00 3.93702E+00 0.    1
  4 1  6 0 5 3.56836E+00 3.57575E+00 3.58742E+00 3.58987E+00 3.59041E+00 0.    1
  4 1 11 0 5 3.59052E+00 3.59052E+00 3.59053E+00 3.59057E+00 3.62471E+00 0.    1
  4 1 16 0 1 3.71242E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    1
  3 1  1 1 5 1.59044E+00 3.98766E-01 2.47518E-03 2.17020E-03 7.36352E-04 0.    1
  6 1  1 1 5 6.94314E-01-1.53430E-01 6.47608E-04-2.43361E-05-1.20197E-04 0.    1
  3 1  1 6 5 2.24819E-05 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    1
  6 1  1 6 5-9.40849E-06 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    1
  3 1  2 1 5 0.00000E+00 1.19069E+00 3.59744E-01 0.00000E+00 0.00000E+00 0.    1
  6 1  2 1 5 0.00000E+00 1.89972E-01-7.63356E-02 0.00000E+00 0.00000E+00 0.    1
  3 1  3 1 5 0.00000E+00 0.00000E+00 2.83616E+00 1.01233E+00 0.00000E+00 0.    1
  6 1  3 1 5 0.00000E+00 0.00000E+00 4.31518E-01-3.15919E-01 0.00000E+00 0.    1
  3 1  4 1 5 0.00000E+00 0.00000E+00 0.00000E+00 3.46908E+00 6.45881E-01 0.    1
  6 1  4 1 5 0.00000E+00 0.00000E+00 0.00000E+00 8.32034E-01-1.42800E-01 0.    1
  3 1  5 1 5 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 3.11487E+00 0.    1
  6 1  5 1 5 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00-1.03860E-01 0.    1
  3 1  5 6 5 4.76273E-01 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    1
  6 1  5 6 5-2.42010E-01 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    1
  3 1  6 6 5 3.43320E+00 2.27925E-01 0.00000E+00 0.00000E+00 0.00000E+00 0.    1
  6 1  6 6 5 1.62060E-01-6.93013E-02 0.00000E+00 0.00000E+00 0.00000E+00 0.    1
  3 1  7 6 5 0.00000E+00 3.43300E+00 2.99669E-01 0.00000E+00 0.00000E+00 0.    1
  6 1  7 6 5 0.00000E+00 2.48248E-01-9.13284E-02 0.00000E+00 0.00000E+00 0.    1
  3 1  8 6 5 0.00000E+00 0.00000E+00 3.48707E+00 2.57782E-01 0.00000E+00 0.    1
  6 1  8 6 5 0.00000E+00 0.00000E+00 2.36015E-01-7.85824E-02 0.00000E+00 0.    1
  3 1  9 6 5 0.00000E+00 0.00000E+00 0.00000E+00 3.48992E+00 2.57480E-01 0.    1
  6 1  9 6 5 0.00000E+00 0.00000E+00 0.00000E+00 2.36112E-01-7.85717E-02 0.    1
  3 1 10 6 5 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 3.37888E+00 0.    1
  6 1 10 6 5 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 2.63251E-01 0.    1
  3 1 1011 5 3.69091E-01 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    1
  6 1 1011 5-1.05687E-01 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    1
  3 1 1111 5 3.28998E+00 4.58096E-01 0.00000E+00 0.00000E+00 0.00000E+00 0.    1
  6 1 1111 5 2.97044E-01-1.39475E-01 0.00000E+00 0.00000E+00 0.00000E+00 0.    1
```

Listing 36. Continued.

```
  3 1 1211 5 0.00000E+00 3.45978E+00 2.88298E-01 0.00000E+00 0.00000E+00 0.    1
  6 1 1211 5 0.00000E+00 2.45498E-01-8.79296E-02 0.00000E+00 0.00000E+00 0.    1
  3 1 1311 5 0.00000E+00 0.00000E+00 3.14742E+00 6.00662E-01 0.00000E+00 0.    1
  6 1 1311 5 0.00000E+00 0.00000E+00 3.40502E-01-1.82933E-01 0.00000E+00 0.    1
  3 1 1411 5 0.00000E+00 0.00000E+00 0.00000E+00 3.30317E+00 4.44932E-01 0.    1
  6 1 1411 5 0.00000E+00 0.00000E+00 0.00000E+00 2.89608E-01-1.32039E-01 0.    1
  3 1 1511 5 0.00000E+00 0.00000E+00 0.00000E+00 3.57381E-02 3.28910E+00 0.    1
  6 1 1511 5 0.00000E+00 0.00000E+00 0.00000E+00 5.81033E-03 2.29541E-01 0.    1
  3 1 1516 1 4.59159E-01 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    1
  6 1 1516 1-7.59939E-02 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    1
  3 1 1611 5 0.00000E+00 0.00000E+00 0.00000E+00 2.19050E-14 1.93090E-01 0.    1
  6 1 1611 5 0.00000E+00 0.00000E+00 0.00000E+00-1.98218E-14-1.67221E-02 0.    1
  3 1 1616 1 3.68573E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    1
1 6 1 1616 1 1.83277E-01 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    1
  0 0  2    SILICON  VERS 5      (FAST) + SILICON         VERS (THERMAL)
  1 2  1 1 5 2.32300E-01 1.80622E-01 1.52291E-01 1.15015E-01 1.07570E-01 0.    2
  1 2  6 1 5 1.85717E-01 1.67335E-01 1.64283E-01 1.63017E-01 1.63006E-01 0.    2
  1 2 11 1 5 1.64758E-01 1.65684E-01 1.65439E-01 1.64423E-01 1.54437E-01 0.    2
  1 2 16 1 1 1.49294E-01 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    2
  1 2  1 2 5 3.25181E-02 6.51562E-04 1.29747E-03 1.52473E-03 2.59643E-03 0.    2
  1 2  6 2 5 3.35070E-03 2.73198E-03 1.24228E-03 1.68969E-03 3.50586E-03 0.    2
  1 2 11 2 5 6.18118E-03 1.15244E-02 2.00683E-02 3.12131E-02 5.97300E-02 0.    2
  1 2 16 2 1 1.36424E-01 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    2
  4 2  1 0 5 1.43965E+00 1.92069E+00 2.26236E+00 2.93025E+00 3.84018E+00 0.    2
  4 2  6 0 5 1.91131E+00 1.99299E+00 2.02911E+00 2.04459E+00 2.03984E+00 0.    2
  4 2 11 0 5 2.02700E+00 2.01138E+00 2.01375E+00 2.02480E+00 2.15825E+00 0.    2
  4 2 16 0 1 2.23495E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    2
  3 2  1 1 5 1.55749E+00 4.64253E-01 1.51698E-01 1.73816E-02 4.66450E-03 0.    2
  6 2  1 1 5 7.88229E-01 6.69916E-03-6.21536E-03-1.07272E-04-1.73266E-04 0.    2
  3 2  1 6 5 7.00775E-05 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    2
  6 2  1 6 5-3.29789E-06 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    2
  3 2  2 1 5 0.00000E+00 2.54364E+00 2.12830E-01 1.22330E-01 4.53389E-02 0.    2
  6 2  2 1 5 0.00000E+00 1.03006E+00-1.90688E-02 1.35044E-02-5.22259E-03 0.    2
  3 2  2 6 5 1.40676E-02 2.48691E-03 9.17683E-05 0.00000E+00 0.00000E+00 0.    2
  6 2  2 6 5 1.41167E-03 8.43784E-05-2.11901E-05 0.00000E+00 0.00000E+00 0.    2
  3 2  3 1 5 0.00000E+00 0.00000E+00 2.91919E+00 4.95674E-01 0.00000E+00 0.    2
  6 2  3 1 5 0.00000E+00 0.00000E+00 1.13777E+00 1.60615E-02 0.00000E+00 0.    2
  3 2  3 6 5 4.14963E-05 1.09069E-05 4.44006E-07 0.00000E+00 0.00000E+00 0.    2
  6 2  3 6 5 1.45552E-05-1.91452E-06-1.53116E-07 0.00000E+00 0.00000E+00 0.    2
  3 2  4 1 5 0.00000E+00 0.00000E+00 0.00000E+00 3.33299E+00 1.92614E-01 0.    2
  6 2  4 1 5 0.00000E+00 0.00000E+00 0.00000E+00 6.18105E-01-2.12277E-02 0.    2
  3 2  5 1 5 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 3.91669E+00 0.    2
  6 2  5 1 5 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 1.47894E-01 0.    2
  3 2  5 6 5 5.31465E-02 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    2
  6 2  5 6 5-1.56362E-02 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    2
  3 2  6 6 5 1.92266E+00 6.91458E-02 0.00000E+00 0.00000E+00 0.00000E+00 0.    2
  6 2  6 6 5 1.05790E-01-2.19455E-02 0.00000E+00 0.00000E+00 0.00000E+00 0.    2
  3 2  7 6 5 0.00000E+00 1.94382E+00 9.52467E-02 0.00000E+00 0.00000E+00 0.    2
  6 2  7 6 5 0.00000E+00 7.90049E-02-3.01909E-02 0.00000E+00 0.00000E+00 0.    2
  3 2  8 6 5 0.00000E+00 0.00000E+00 1.99442E+00 8.31848E-02 0.00000E+00 0.    2
  6 2  8 6 5 0.00000E+00 0.00000E+00 7.61237E-02-2.63799E-02 0.00000E+00 0.    2
  3 2  9 6 5 0.00000E+00 0.00000E+00 0.00000E+00 2.00974E+00 8.32712E-02 0.    2
  6 2  9 6 5 0.00000E+00 0.00000E+00 0.00000E+00 7.65490E-02-2.64362E-02 0.    2
  3 2 10 6 5 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 1.98166E+00 0.    2
  6 2 10 6 5 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 8.26698E-02 0.    2
  3 2 1011 5 1.04622E-01 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    2
  6 2 1011 5-3.27177E-02 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    2
  3 2 1111 5 1.92695E+00 1.43433E-01 0.00000E+00 0.00000E+00 0.00000E+00 0.    2
  6 2 1111 5 9.51181E-02-4.55472E-02 0.00000E+00 0.00000E+00 0.00000E+00 0.    2
  3 2 1211 5 0.00000E+00 1.95787E+00 9.10410E-02 0.00000E+00 0.00000E+00 0.    2
  6 2 1211 5 0.00000E+00 7.79729E-02-2.89147E-02 0.00000E+00 0.00000E+00 0.    2
  3 2 1311 5 0.00000E+00 0.00000E+00 1.85285E+00 1.89743E-01 0.00000E+00 0.    2
  6 2 1311 5 0.00000E+00 0.00000E+00 1.09079E-01-6.01733E-02 0.00000E+00 0.    2
  3 2 1411 5 0.00000E+00 0.00000E+00 0.00000E+00 1.89984E+00 1.42650E-01 0.    2
  6 2 1411 5 0.00000E+00 0.00000E+00 0.00000E+00 9.33243E-02-4.44212E-02 0.    2
  3 2 1511 5 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 2.15000E+00 0.    2
  6 2 1511 5 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 5.14770E-02 0.    2
  3 2 1616 1 2.15000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    2
1 6 2 1616 1 5.14770E-02 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    2
  0 0  3    PLUTONIUM-239  VERS  (FAST) + PLUTONIUM-239  VERS  (THERMAL)
  1 3  1 1 5 8.24866E-02 7.02444E-02 6.72189E-02 5.85071E-02 3.55568E-02 0.    3
  1 3  6 1 5 2.63987E-02 2.13778E-02 1.50405E-02 7.33308E-03 3.68033E-03 0.    3
  1 3 11 1 5 2.07334E-03 5.95276E-03 8.95205E-03 1.74660E-03 1.85698E-04 0.    3
  1 3 16 1 1 3.67441E-04 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    3
  1 3  1 2 5 1.78959E+00 1.93710E+00 1.79098E+00 1.70810E+00 1.73604E+00 0.    3
  1 3  6 2 5 2.11989E+00 3.73907E+00 9.04557E+00 2.96602E+01 7.54746E+01 0.    3
  1 3 11 2 5 1.49678E+02 4.56657E+01 2.74155E+01 1.80037E+02 1.80814E+03 0.    3
  1 3 16 2 1 9.11435E+02 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    3
  1 3  1 3 5 6.21502E+00 6.08568E+00 5.34206E+00 4.80873E+00 4.46415E+00 0.    3
  1 3  6 3 5 4.73922E+00 6.49426E+00 1.38058E+01 4.44756E+01 1.12307E+02 0.    3
```

Listing 36. Continued.

```
  1 3 11 3 5 2.57174E+02 8.08960E+01 6.13337E+01 3.51082E+02 3.16934E+03 0.    3
  1 3 16 3 1 1.89897E+03 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    3
  1 3  1 4 5 1.79734E+00 1.92864E+00 1.76594E+00 1.62325E+00 1.53628E+00 0.    3
  1 3  6 4 5 1.64324E+00 2.25463E+00 4.79387E+00 1.54441E+01 3.89989E+01 0.    3
  1 3 11 4 5 8.93044E+01 2.80914E+01 2.12984E+01 1.21914E+02 1.09613E+03 0.    3
  1 3 16 4 1 6.56766E+02 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    3
  4 3  1 0 5 4.07339E+00 4.66452E+00 4.98584E+00 5.79385E+00 9.24494E+00 0.    3
  4 3  6 0 5 1.26261E+01 1.55990E+01 2.21796E+01 4.54396E+01 9.03666E+01 0.    3
  4 3 11 0 5 1.60710E+02 5.42386E+01 3.72401E+01 1.91430E+02 1.81718E+03 0.    3
  4 3 16 0 1 9.19256E+02 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    3
  3 3  1 1 5 4.83075E+00 2.68976E-01 2.93334E-01 3.75528E-01 2.14155E-01 0.    3
  6 3  1 1 5 3.70419E+00 6.33809E-03 0.00000E+00 0.00000E+00 0.00000E+00 0.    3
  3 3  1 6 5 1.15799E-02 1.07359E-07 0.00000E+00 0.00000E+00 0.00000E+00 0.    3
  6 3  1 6 5 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    3
  3 3  2 1 5 0.00000E+00 4.32677E+00 3.94329E-01 4.01732E-01 2.56189E-01 0.    3
  6 3  2 1 5 0.00000E+00 2.66660E+00 1.93841E-03-1.19803E-04 0.00000E+00 0.    3
  3 3  2 6 5 1.68103E-02 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    3
  6 3  2 6 5 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    3
  3 3  3 1 5 0.00000E+00 0.00000E+00 4.37486E+00 6.89612E-01 2.41767E-01 0.    3
  6 3  3 1 5 0.00000E+00 0.00000E+00 2.11243E+00 6.53609E-03-8.21773E-04 0.    3
  3 3  3 6 5 6.76000E-03 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    3
  6 3  3 6 5 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    3
  3 3  4 1 5 0.00000E+00 0.00000E+00 0.00000E+00 5.93056E+00 4.26181E-01 0.    3
  6 3  4 1 5 0.00000E+00 0.00000E+00 0.00000E+00 2.32327E+00 8.70615E-04 0.    3
  3 3  4 6 5 5.29820E-02 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    3
  6 3  4 6 5-1.65786E-04 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    3
  3 3  5 1 5 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 8.91891E+00 0.    3
  6 3  5 1 5 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 1.66035E+00 0.    3
  3 3  5 6 5 2.26331E-01 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    3
  6 3  5 6 5-2.40159E-02 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    3
  3 3  6 6 5 1.08844E+01 1.28893E-01 0.00000E+00 0.00000E+00 0.00000E+00 0.    3
  6 3  6 6 5 5.22741E-01-1.55745E-02 0.00000E+00 0.00000E+00 0.00000E+00 0.    3
  3 3  7 6 5 0.00000E+00 1.17802E+01 1.10633E-01 2.88327E-03 5.82658E-05 0.    3
  6 3  7 6 5 0.00000E+00 5.54718E-02-2.16732E-02-2.05291E-06-3.29462E-06 0.    3
  3 3  8 6 5 0.00000E+00 0.00000E+00 1.30698E+01 1.01291E-01 0.00000E+00 0.    3
  6 3  8 6 5 0.00000E+00 0.00000E+00 7.06154E-02-3.35657E-02 0.00000E+00 0.    3
  3 3  9 6 5 0.00000E+00 0.00000E+00 0.00000E+00 1.57786E+01 4.53690E-02 0.    3
  6 3  9 6 5 0.00000E+00 0.00000E+00 0.00000E+00 5.89013E-02-1.43900E-02 0.    3
  3 3 10 6 5 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 1.48815E+01 0.    3
  6 3 10 6 5 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 5.91650E-02 0.    3
  3 3 1011 5 5.25096E-02 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    3
  6 3 1011 5-1.71018E-02 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    3
  3 3 1111 5 1.10322E+01 3.01002E-02 0.00000E+00 0.00000E+00 0.00000E+00 0.    3
  6 3 1111 5 4.10503E-02-9.94901E-03 0.00000E+00 0.00000E+00 0.00000E+00 0.    3
  3 3 1211 5 0.00000E+00 8.54632E+00 5.07651E-02 0.00000E+00 0.00000E+00 0.    3
  6 3 1211 5 0.00000E+00 4.10533E-02-1.68388E-02 0.00000E+00 0.00000E+00 0.    3
  3 3 1311 5 0.00000E+00 0.00000E+00 9.73836E+00 1.14013E-01 0.00000E+00 0.    3
  6 3 1311 5 0.00000E+00 0.00000E+00 6.54752E-02-3.77611E-02 0.00000E+00 0.    3
  3 3 1411 5 0.00000E+00 0.00000E+00 0.00000E+00 1.13037E+01 1.20739E-01 0.    3
  6 3 1411 5 0.00000E+00 0.00000E+00 0.00000E+00 7.17292E-02-3.96028E-02 0.    3
  3 3 1511 5 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 9.06363E+00 0.    3
  6 3 1511 5 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 2.54138E-02 0.    3
  3 3 1616 1 7.84331E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    3
1 6 3 1616 1 2.20517E-02 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.    3
```

Listing 37. Table 1 Case 9, SCAMP input using Hansen-Roach cross sections.

```
LIMIT           1  16   3   1   2   2
LOWGRAPH PU=0.05G/lb; VF GRA=1.0                                        1
       1  13   0   1  16   0   1   1   0  01  0   0   0   0   2
      19   1 999
    1  1   1   1
    2  1   1   1
1 1 1  1   2 616 8
       1   1  .001
       2   1  .001
    1  1   1  100.0
  1 1  1   5  1.0          1.0          1.0          1.0          1.0
  1 1  6   5  1.0          1.0          1.0          1.0          1.0
  1 1 11   5  1.0          1.0          1.0          1.0          1.0
  1 1 16   1  1.0
  1 2  1   5  1.0          1.0          1.0          1.0          1.0
  1 2  6   5  1.0          1.0          1.0          1.0          1.0
  1 2 11   5  1.0          1.0          1.0          1.0          1.0
  1 2 16   1  1.0
  5 1  1   5  .225         .347         .161         .170         .084
  5 1  6   1 .013
111 1  1   2 4.444-7       0.080233
LOWGRAPH PU=0.04G/lb; VF GRA=1.0 WVF=0                                  1
      12   1   4
1 1 1  1   2 616 8
111 1  1   2 3.555-7       0.080233
LOWGRAPH PU=0.03G/lb; VF GRA=1.0 WVF=0                                  1
      12   1   4
1 1 1  1   2 616 8
111 1  1   2 2.666-7       0.080233
LOWGRAPH PU=0.02G/lb; VF GRA=1.0 WVF=0                                  1
      12   1   4
1 1 1  1   2 616 8
111 1  1   2 1.777-7       0.080233
LOWGRAPH PU=0.01G/lb; VF GRA=1.0 WVF=0                                  1
      12   1   4
1 1 1  1   2 616 8
111 1  1   2 8.887-8       0.080233
```

Listing 38. Table 1 Case 9, KENO-V.a input using Hansen-Roach cross sections.

```
KGSLAB INF SLAB .03 G/LB PU in graphite
READ PARA
     TME=40.0  GEN=153   NPG=407     LIB=41
     FLX=NO     FDN=NO    AMX=NO     FAR=NO
     RUN=YES   PLT=NO    NUB=YES
END PARA
READ MIXT
     MIX=1   94916 2.666-7  6100 .080233
END MIXT
READ GEOM
GLOBAL
     UNIT 1
     CUBOID  1 1   4P28.575  2P50.0
END GEOM
READ START NST=0 END START
READ BOUNDS  ALL=MIRROR  END BOUNDS
READ PLOT
     PLT=YES   PIC=MIX   NCH=' *.C'
     TTL=* "X-Y CELLL" *
     XUL=-28.8  YUL=28.8  ZUL=5.0
     XLR=28.8  YLR=-28.8   ZLR=5.0
     UAX=1.0   VDN=-1.0   NAX=130   END
END PLOT
END DATA
```

Listing 39. Table 1 Case 9, KENO-V.a input using CSAS and 27-group cross sections.

```
=CSAS25
CGSLAB 0.03g Pu /lb graphite
27GROUPNDF4  INFHOMMEDIUM
PU-239  1  0   2.6660-7  END
C       1  0   8.0233-2  END
END COMP
KGSLAB INF SLAB .03 G/LB PU in graphite
READ PARA
     TME=80.0  GEN=153   NPG=407
     FLX=NO     FDN=NO    AMX=NO     FAR=NO
     RUN=YES   PLT=NO    NUB=YES
END PARA
READ GEOM
GLOBAL
     UNIT 1
     CUBOID  1 1   4P28.575  2P50.0
END GEOM
READ START NST=0 END START
READ BOUNDS  ALL=MIRROR  END BOUNDS
READ PLOT
     PLT=YES   PIC=MIX   NCH=' *.C'
     TTL=* "X-Y CELLL" *
     XUL=-28.8  YUL=28.8  ZUL=5.0
     XLR=28.8  YLR=-28.8   ZLR=5.0
     UAX=1.0   VDN=-1.0   NAX=130   END
END PLOT
END DATA
```

Listing 40. Table 1 Case 9, MCNP input.

```
MGSLAB  INF SLAB .03 G/LB PU IN GRAPHITE
1     1 8.02332666e-2  -1 2 -3 4 -5 6  imp:n=1  $slab

*1     px  28.575  $asterisk means reflecting surface
*2     px  -28.575
*3     py  28.575
*4     py  -28.575
*5     pz  50.0
*6     pz  -50.0

kcode  4000 1 20 80 50000  $npg=4000, nsk=20 gen=80
sdef  cel=1  $starting source in cell 1
print
m1    94239.50c 2.666e-7  6000.50c 0.080233
mt1   grph.01t
```

Listing 41. Table 5 Case 5, KENO-V.a input.

```
CODRUMLW ARRAY OF DRUMS WITH CONCRETE and Pu-239(0.75 G/LB)
READ PARA
     TME=120.0  GEN=153   NPG=5003    LIB=41
     FLX=NO     FDN=NO    AMX=NO     FAR=NO
     RUN=YES    PLT=YES   NUB=YES    LNG=184000
END PARA
READ MIXT
     MIX=1   94915  3.1135-6  94916 6.7599-6  301  1.0
     MIX=2   100   1.0
     MIX=3   502 1.0
END MIXT
READ GEOM
     UNIT 1
     COM=*RIGHT SIDE OF UNIT CELL *
     ZHEMICYL+X   1 1   28.5750  2P42.5450
     ZHEMICYL+X   2 1   28.7270  2P42.6950
     UNIT 2
     COM=*LEFT SIDE OF UNIT CELL *
     ZHEMICYL-X   1 1   28.5750  2P42.5450
     ZHEMICYL-X   2 1   28.7270  2P42.6950
     UNIT 3
     COM=*UPPER PART OF UNIT CELL *
     ZHEMICYL-Y   1 1   28.5750  2P42.5450
     ZHEMICYL-Y   2 1   28.7270  2P42.6950
     UNIT 4
     COM=* UNIT CELL TRI PITCH*
     ZHEMICYL+Y   1 1   28.5750  2P42.5450
     ZHEMICYL+Y   2 1   28.7270  2P42.6950
     CUBOID       0 1   2P28.7271  99.513248  0.0  2P42.6951
     HOLE         3    0.0  99.513248  0.0
     HOLE         1     -28.727  49.756624  0.0
     HOLE         2      28.727  49.756624  0.0
GLOBAL
COM=*ARRAY OF 74088 DRUMS WITH CONC SURROUNDING- 30 CM*
 UNIT 5
     ARRAY        1     0.0   0.0   0.0
     REPLICATE    3  2   6*3.0 10
END GEOM
READ START NST=0 END START
READ BIAS ID=501  2  11  END BIAS
READ ARRAY  ARA=1  NUX=42  NUY=21 NUZ=42
     LOOP  4   1 42 1   1 21 1     1 42 1
END LOOP
END ARRAY
READ PLOT
     PLT=YES PIC=MIX   NCH=' *SW'
     TTL=* "X-Y VIEW" *
     XUL=-30.0  YUL=30.0   ZUL=0.0
     XLR=30.0  YLR=-30.0   ZLR=0.0
     UAX=1.0   VDN=-1.0   NAX=130   END
END PLOT
END DATA
```

Listing 42. Table 5 Case 8, KENO-V.a input.

```
CLDRUMS INF ARRAY OF DRUMS WITH CELL.and Pu-239(1.7 G/LB)
READ PARA
     TME=120.0  GEN=153   NPG=5003    LIB=41
     FLX=NO     FDN=NO    AMX=NO     FAR=NO
     RUN=YES   PLT=NO    NUB=YES    LNG=148000
END PARA
READ MIXT
     MIX=1   94915 1.8392-7  94916 5.8596-6  6100 1.426-2
             1102 2.378-2  8100 1.189-2
     MIX=2   100   1.0
END MIXT
READ GEOM
     UNIT 1
     COM=*RIGHT SIDE OF UNIT CELL *
     ZHEMICYL+X   1 1   28.5750  2P42.5450
     ZHEMICYL+X   2 1   28.7270  2P42.6950
     UNIT 2
     COM=*LEFT SIDE OF UNIT CELL *
     ZHEMICYL-X   1 1   28.5750  2P42.5450
     ZHEMICYL-X   2 1   28.7270  2P42.6950
     UNIT 3
     COM=*UPPER PART OF UNIT CELL *
     ZHEMICYL-Y   1 1   28.5750  2P42.5450
     ZHEMICYL-Y   2 1   28.7270  2P42.6950
GLOBAL
     UNIT 4
     COM=* UNIT CELL TRI PITCH*
     ZHEMICYL+Y   1 1   28.5750  2P42.5450
     ZHEMICYL+Y   2 1   28.7270  2P42.6950
     CUBOID       0 1   2P28.7271  99.513248  0.0  2P42.6951
     HOLE         3    0.0  99.513248  0.0
     HOLE         1     -28.727  49.756624  0.0
     HOLE         2      28.727  49.756624  0.0
END GEOM
READ START NST=0 END START
READ BOUNDS  ALL=MIRROR  END BOUNDS
READ PLOT
     PLT=YES PIC=MIX   NCH=' *SW'
     TTL=* "X-Y ARRAY" *
     XUL=-60.0  YUL=757.0   ZUL=20.0
     XLR=807.0 YLR=-60.0  ZLR=20.0
     UAX=1.0 VDN=-1.0  NAX=130   END
     PLT=YES PIC=MIX   NCH=' *SW'
     TTL=* "X-Y CELL" *
     XUL=0.0  YUL=100.0   ZUL=20.0
     XLR=58.0 YLR=0.0   ZLR=20.0
     UAX=1.0   VDN=-1.0   NAX=130   END
     PLT=YES PIC=MIX   NCH=' *SW'
     TTL=* "X-Z VIEW" *
     XUL=-60.0  YUL=0.0   ZUL=1085.0
     XLR=807.0 YLR=0.0   ZLR=-60.0
     UAX=1.0   WDN=-1.0   NAX=130   END
END PLOT
```

Listing 43. Table 5 Case 12, KENO-V.a input.

```
SLABG2 INF SLAB 0.5 G/LB PU in graphite
READ PARA
     TME=40.0  GEN=153   NPG=407    LIB=41
     FLX=NO     FDN=NO    AMX=NO    FAR=NO
     RUN=YES   PLT=NO    NUB=YES
END PARA
READ MIXT
     MIX=1   94915   1.37298-6 94916  3.07102-6  6100 .080233
END MIXT
READ GEOM
GLOBAL
     UNIT 1
     CUBOID  1 1   4P28.575  2P50.0
END GEOM
READ START NST=0 END START
READ BOUNDS  ALL=MIRROR  END BOUNDS
READ PLOT
     PLT=YES   PIC=MIX   NCH=' *.C'
     TTL=* "X-Y CELLL" *
     XUL=-28.8  YUL=28.8  ZUL=5.0
     XLR=28.8  YLR=-28.8   ZLR=5.0
     UAX=1.0   VDN=-1.0   NAX=130   END
END PLOT
END DATA
```

Listing 44. Table 5 Case 16, KENO-V.a input.

```
DRUMSG1 INF ARRAY OF DRUMS WITH 1 G/LB PU
READ PARA
     TME=40.0  GEN=153   NPG=407    LIB=41
     FLX=NO     FDN=NO    AMX=NO    FAR=NO
     RUN=YES   PLT=NO    NUB=YES
END PARA
READ MIXT
     MIX=1   94914   7.6739-6  94915  1.2111-6 6100 .080233
     MIX=2   100   1.0
     MIX=3   402   1.0
END MIXT
READ GEOM
     UNIT 1
     COM=*RIGHT SIDE OF UNIT CELL *
     ZHEMICYL+X   1 1   28.5750  2P42.5450
     ZHEMICYL+X   2 1   28.7270  2P42.6950
     UNIT 2
     COM=*LEFT SIDE OF UNIT CELL *
     ZHEMICYL-X   1 1   28.5750  2P42.5450
     ZHEMICYL-X   2 1   28.7270  2P42.6950
     UNIT 3
     COM=*UPPER PART OF UNIT CELL *
     ZHEMICYL-Y   1 1   28.5750  2P42.5450
     ZHEMICYL-Y   2 1   28.7270  2P42.6950
GLOBAL
     UNIT 4
     COM=* UNIT CELL TRI PITCH*
     ZHEMICYL+Y   1 1   28.5750  2P42.5450
     ZHEMICYL+Y   2 1   28.7270  2P42.6950
     CUBOID       0 1   2P28.727001  99.513248  -0.0  2P42.6950
     HOLE         3    0.0  99.513248  0.0
     HOLE         1     -28.727001  49.756624  0.0
     HOLE         2      28.727001  49.756624  0.0
END GEOM
READ START NST=0 END START
READ BOUNDS  ALL=MIRROR  END BOUNDS
READ PLOT
     PLT=YES   PIC=MIX   NCH=' *.C'
     TTL=* "X-Y CELLL" *
     XUL=-28.8  YUL=49.8  ZUL=25.0
     XLR=28.8  YLR=-49.8   ZLR=25.0
     UAX=1.0   VDN=-1.0   NAX=130   END
END PLOT
END DATA
```

Listing 45. Table 5 Case 19, KENO-V.a input.

```
DRUMSG INF ARRAY OF DRUMS WITH 1.5 G/LB PU
READ PARA
     TME=120.0  GEN=153   NPG=5000    LIB=41
     FLX=NO     FDN=NO    AMX=NO     FAR=NO
     RUN=YES   PLT=NO    NUB=YES    LNG=148000
END PARA
READ MIXT
     MIX=1   94913   7.6759-6  94914  5.6541-6 6100 .080233
     MIX=2   100   1.0
END MIXT
READ GEOM
     UNIT 1
     COM=*RIGHT SIDE OF UNIT CELL *
     ZHEMICYL+X    1 1   28.5750  2P42.5450
     ZHEMICYL+X    2 1   28.7270  2P42.6950
     UNIT 2
     COM=*LEFT SIDE OF UNIT CELL *
     ZHEMICYL-X    1 1   28.5750  2P42.5450
     ZHEMICYL-X    2 1   28.7270  2P42.6950
     UNIT 3
     COM=*UPPER PART OF UNIT CELL *
     ZHEMICYL-Y    1 1   28.5750  2P42.5450
     ZHEMICYL-Y    2 1   28.7270  2P42.6950
     UNIT 4
     COM=* UNIT CELL TRI PITCH*
     ZHEMICYL+Y    1 1   28.5750  2P42.5450
     ZHEMICYL+Y    2 1   28.7270  2P42.6950
     CUBOID        0 1   2P28.7271  99.513248  0.0  2P42.6951
     HOLE          3    0.0  99.513248  0.0
     HOLE          1     -28.727  49.756624  0.0
     HOLE          2      28.727  49.756624  0.0
END GEOM
READ START NST=0 END START
READ BOUNDS  ALL=MIRROR  END BOUNDS
END DATA
```

Listing 46. Table 6 Case 6, KENO-V.a input.

```
=CSAS25     PARM=SIZE=148000
XCMA5 0.15g Pu /lb SiO2 in cuboid, 0.56 g/lb in graphite
27GROUPNDF4  INFHOMMEDIUM
PU-239  1  0  4.9770-6   END
C       1  0  .080233    END
SS316   2  1.0           END
PU-239  3  0  1.9330-6   END
SI      3  0  2.3256-2   END
O       3  0  4.6513-2   END
END COMP
XCMA5 0.15g Pu /lb SiO2 in cuboid, 0.56 g/lb in graphite
READ PARA
     TME=120.0  GEN=153   NPG=5003
     FLX=NO     FDN=NO    AMX=NO    FAR=NO
     RUN=YES   PLT=YES   NUB=YES  LNG=400000
END PARA
READ GEOM
     UNIT 1
     COM=*RIGHT SIDE OF UNIT CELL *
     ZHEMICYL+X   0 1   28.5750  42.5450  -13.735
     ZHEMICYL+X   1 1   28.5760  2P42.5450
     ZHEMICYL+X   2 1   28.7270  2P42.6950
     UNIT 2
     COM=*LEFT SIDE OF UNIT CELL *
     ZHEMICYL-X   0 1   28.5750  42.5450  -13.735
     ZHEMICYL-X   1 1   28.5760  2P42.5450
     ZHEMICYL-X   2 1   28.7270  2P42.6950
     UNIT 3
     COM=*UPPER PART OF UNIT CELL *
     ZHEMICYL-Y   0 1   28.5750  42.5450  -13.735
     ZHEMICYL-Y   1 1   28.5760  2P42.5450
     ZHEMICYL-Y   2 1   28.7270  2P42.6950
     UNIT 4
     COM=* UNIT CELL TRI PITCH*
     ZHEMICYL+Y   0 1   28.5750  42.5450  -13.735
     ZHEMICYL+Y   1 1   28.5760  2P42.5450
     ZHEMICYL+Y   2 1   28.7270  2P42.6950
     CUBOID       0 1   2P28.7271  99.513248  0.0  2P42.6951
     HOLE         3    0.0  99.513248  0.0
     HOLE         1     -28.727  49.756624  0.0
     HOLE         2      28.727  49.756624  0.0
GLOBAL
COM=*ARRAY OF 2744 DRUMS WITH SIL WASTE SURROUNDING- 100 CM*
 UNIT 5
     ARRAY        1     0.0   0.0   0.0
     CUBOID       0 1   804.359 0.0  696.593 0.0  1195.464  0.0
     CUBOID       3 1   904.359 -100.00  796.593 -100.000  1295.464  -100.00
END GEOM
READ START NST=0 END START
READ ARRAY  ARA=1  NUX=14  NUY=7  NUZ=14
     LOOP  4   1 14 1   1 7 1     1 14 1
END LOOP
END ARRAY
READ BOUNDS  ALL=MIRROR  END BOUNDS
READ PLOT
     PLT=YES PIC=MIX   NCH=' *SW'
     TTL=* "X-Y ARRAY" *
     XUL=-60.0  YUL=757.0   ZUL=20.0
     XLR=807.0 YLR=-60.0  ZLR=20.0
     UAX=1.0 VDN=-1.0  NAX=130   END
     PLT=YES PIC=MIX   NCH=' *SW'
     TTL=* "X-Y CELL" *
     XUL=0.0  YUL=100.0   ZUL=20.0
     XLR=58.0 YLR=0.0   ZLR=20.0
     UAX=1.0   VDN=-1.0   NAX=130   END
     PLT=YES PIC=MIX   NCH=' *SW'
     TTL=* "X-Z VIEW" *
     XUL=-60.0  YUL=0.0   ZUL=1085.0
     XLR=807.0 YLR=0.0   ZLR=-60.0
     UAX=1.0   WDN=-1.0   NAX=130   END
END PLOT
END DATA
```

Listing 47. Table 9 Case 9, 5 drums high KENO-V.a input.

```
=CSAS25
CS95W5 INF SLAB .15 G/LB PU in SiO2/H2O, 5hi
27GROUPNDF4  INFHOMMEDIUM
PU-239  1  0  1.9330-6  END
SI      1  0  2.2094-2  END
O       1  0  4.4187-2  END
H2O     1  0.05         END
H    2   0  0.014868    END
C    2   0  0.003814    END
O    2   0  0.041519    END
CA   2   0  0.011588    END
SI   2   0  0.006037    END
FE   2   0  0.0001968   END
AL   2   0  0.000735    END
NA   2   0  0.000304    END
MG   2   0  0.000587    END
END COMP
CS95W5 INF SLAB .15 G/LB PU in SiO2/H2O, 5hi
READ PARA
     TME=40.0  GEN=153   NPG=1000
     FLX=NO     FDN=NO    AMX=NO    FAR=NO
     RUN=YES   PLT=NO    NUB=YES
END PARA
READ GEOM
GLOBAL
     UNIT 1
     CUBOID     1 1   4P28.575  2P213.475
     REPLICATE  2 2   4*0.0  2*5.0  6
END GEOM
READ START NST=0 END START
READ BOUNDS  XYF=MIRROR  END BOUNDS
READ BIAS  ID=301  2 7  END BIAS
READ PLOT
     PLT=YES   PIC=MIX   NCH=' *.C'
     TTL=* "X-Y VIEW" *
     XUL=-28.8  YUL=28.8  ZUL=5.0
     XLR=28.8  YLR=-28.8   ZLR=5.0
     UAX=1.0   VDN=-1.0   NAX=130   END
END PLOT
END DATA
```

Listing 48. Table 9 Case 9, fully infinite, KENO-V.a input.

```
=CSAS25
CS95W5 (i50g)INF SLAB .15 G/LB PU in SiO2/H2O
27GROUPNDF4  INFHOMMEDIUM
PU-239  1  0  1.9330-6  END
SI      1  0  2.2094-2  END
O       1  0  4.4187-2  END
H2O     1  0.05         END
END COMP
CS95W5 (i50g)INF SLAB .15 G/LB PU in SiO2/H2O
READ PARA
     TME=40.0  GEN=153   NPG=1000
     FLX=NO     FDN=NO    AMX=NO    FAR=NO
     RUN=YES   PLT=NO    NUB=YES
END PARA
READ GEOM
GLOBAL
     UNIT 1
     CUBOID     1 1   4P28.575  2P50.0
END GEOM
READ START NST=0 END START
READ BOUNDS  ALL=MIRROR  END BOUNDS
READ PLOT
     PLT=YES   PIC=MIX   NCH=' *.C'
     TTL=* "X-Y VIEW" *
     XUL=-28.8  YUL=28.8  ZUL=5.0
     XLR=28.8  YLR=-28.8   ZLR=5.0
     UAX=1.0   VDN=-1.0   NAX=130   END
END PLOT
END DATA
```

Listing 49. Table 9 Case 12, 5 drums high, KENO-V.a input.

```
=CSAS25
CS92W8 INF SLAB .15 G/LB PU in SiO2/H20, 5hi
27GROUPNDF4  INFHOMMEDIUM
PU-239  1  0  1.9330-6  END
SI      1  0  2.1396-2  END
O       1  0  4.2792-2  END
H2O     1  0.08         END
H    2   0  0.014868    END
C    2   0  0.003814    END
O    2   0  0.041519    END
CA   2   0  0.011588    END
SI   2   0  0.006037    END
FE   2   0  0.0001968   END
AL   2   0  0.000735    END
NA   2   0  0.000304    END
MG   2   0  0.000587    END
END COMP
CS92W8 INF SLAB .15 G/LB PU in SiO2/H20, 5hi
READ PARA
     TME=40.0  GEN=153   NPG=1000
     FLX=NO     FDN=NO    AMX=NO    FAR=NO
     RUN=YES   PLT=NO    NUB=YES
END PARA
READ GEOM
GLOBAL
     UNIT 1
     CUBOID     1 1   4P28.575  2P213.475
     REPLICATE  2 2   4*0.0  2*5.0  6
END GEOM
READ START NST=0 END START
READ BOUNDS  XYF=MIRROR  END BOUNDS
READ BIAS  ID=301  2 7  END BIAS
READ PLOT
     PLT=YES   PIC=MIX   NCH=' *.C'
     TTL=* "X-Y VIEW" *
     XUL=-28.8  YUL=28.8  ZUL=5.0
     XLR=28.8  YLR=-28.8   ZLR=5.0
     UAX=1.0   VDN=-1.0   NAX=130   END
END PLOT
END DATA
```

Listing 50. Table 10 All Cases, SCAMP input.

```
LIMIT          1  16   4   1   2   2
GRAPHSLAB PU=1.5G/lb; VF GRA=1.0; WVF=.1                                    1
       1  13   0   1  16   0   1   1   0  01   0   0   0   0   2
      19   1 999
    1  1    1   1
    2  1    1   1
1 1 1  1    4 613 614 708 8
       1    1  .001
       2    1  .001
    1  1    1  100.0
  1 1  1    5  1.0          1.0          1.0          1.0          1.0
  1 1  6    5  1.0          1.0          1.0          1.0          1.0
  1 1 11    5  1.0          1.0          1.0          1.0          1.0
  1 1 16    1  1.0
  1 2  1    5  1.0          1.0          1.0          1.0          1.0
  1 2  6    5  1.0          1.0          1.0          1.0          1.0
  1 2 11    5  1.0          1.0          1.0          1.0          1.0
  1 2 16    1  1.0
  5 1  1    5 .225         .347         .161         .170         .084
  5 1  6    1 .013
111 1  1    4 2.45851-7     1.30841-5    0.1          0.080233
GRAPHSLAB PU=1.5G/lb; VF GRA=1.0 WVF=0                                      1
      12    1   0
1 1 1  1    3 613 614 8
111 1  1    3 7.6759-6      5.6541-6     0.080233
GRAPHSLAB PU=2.0G/lb; VF GRA=1.0 WVF=.1                                     1
      12    1   4
1 1 1  1    4 613 614 708 8
111 1  1    4 9.12286-6     8.64714-6    0.1          0.080233
GRAPHSLAB PU=2.0G/lb; VF GRA=1.0 WVF=0                                      1
      12    1   4
1 1 1  1    3 613 614 8
111 1  1    3 1.65529-5     1.21709-6    0.080233
GRAPHSLAB PU=2.0G/lb; VF GRA=1.0 WVF=0   C density=2.2                     1
      12    1   4
1 1 1  1    3 613 614 8
111 1  1    3 2.27029-5     1.70214-6    0.11032
GRAPHSLAB PU=1.0G/lb; VF GRA=1.0 WVF=0                                      1
      12    1   4
1 1 1  1    3 614 615 8
111 1  1    3 7.67390-6     1.21110-6    0.080233
GRAPHSLAB PU=1.0G/lb; VF GRA=1.0 WVF=.1                                     1
      12    1   4
1 1 1  1    4 614 615 708 8
111 1  1    3 2.4385-6      8.6412-6      .1          0.080233
```

Listing 51. Table 11 Case 2, KENO-V.a input.

```
=CSAS25     PARM=SIZE=153000
CCSAM3  PU at 75% of crit C(.02)/SiO2(.15)/AlO2(.23)/MgO(.10)
27GROUPNDF4  INFHOMMEDIUM
PU-239  1  0  1.7775-7  END
C       1  0  8.0233-2  END
PU-239  2  0  1.9330-6  END
SI      2  0  2.3256-2  END
O       2  0  4.6513-2  END
PU-239  3  0  5.0656-6  END
AL      3  0  4.6844-2  END
O       3  0  7.0266-2  END
PU-239  4  0  1.9887-6  END
MG      4  0  5.3499-2  END
O       4  0  5.3499-2  END
END COMP
CCSAM3  PU at 75% of crit C(.02)/SiO2(.15)/AlO2(.23)/MgO(.10)
READ PARA
     TME=200.0  GEN=153   NPG=3003
     FLX=NO     FDN=NO    AMX=NO    FAR=NO
     RUN=YES   PLT=YES   NUB=YES
END PARA
READ GEOM
     UNIT 1
     CUBOID  1 1   4P28.575  2P25.0
     UNIT 2
     CUBOID  2 1   4P28.575  2P50.0
     UNIT 3
     CUBOID  3 1   4P28.575  2P50.0
     UNIT 4
     CUBOID  4 1   4P28.575  2P25.0
  GLOBAL   COM='Array of 4 layers(50cm) of Pu in different waste mixtures'
     UNIT 5
     ARRAY     1   0.0    0.0   0.0
END GEOM
READ START NST=0 END START
READ ARRAY
  ARA=1  NUX=1   NUY=1   NUZ=4
    FILL  1 2 3 4 END FILL
END ARRAY
READ START  NST=1  END START
READ BOUNDS  ALL=MIRROR  END BOUNDS
READ PLOT
     PLT=YES   PIC=MIX   NCH=' *.C'
     TTL=* "X-Y VIEW" *
     XUL=-28.8  YUL=28.8  ZUL=5.0
     XLR=28.8  YLR=-28.8   ZLR=5.0
     UAX=1.0   VDN=-1.0   NAX=130   END
END PLOT
END DATA
```

Listing 52. Table 11 Case 9, SCAMP input.

```
LIMIT           1  16   3   1   2   2
LOWGRAPH PU=0.05G/lb; VF GRA=1.0                                        1
       1  13   0   1  16   0   1   1   0  01   0   0   0   0   2
      19   1 999
    1  1   1   1
    2  1   1   1
1 1 1  1   2 616 8
       1   1  .001
       2   1  .001
    1  1   1  100.0
  1 1  1   5  1.0          1.0          1.0          1.0          1.0
  1 1  6   5  1.0          1.0          1.0          1.0          1.0
  1 1 11   5  1.0          1.0          1.0          1.0          1.0
  1 1 16   1  1.0
  1 2  1   5  1.0          1.0          1.0          1.0          1.0
  1 2  6   5  1.0          1.0          1.0          1.0          1.0
  1 2 11   5  1.0          1.0          1.0          1.0          1.0
  1 2 16   1  1.0
  5 1  1   5  .225          .347         .161         .170         .084
  5 1  6   1 .013
111 1  1   2 4.444-7       0.080233
LOWGRAPH PU=0.04G/lb; VF GRA=1.0 WVF=0                                  1
      12   1   4
1 1 1  1   2 616 8
111 1  1   2 3.555-7       0.080233
LOWGRAPH PU=0.03G/lb; VF GRA=1.0 WVF=0                                  1
      12   1   4
1 1 1  1   2 616 8
111 1  1   2 2.666-7       0.080233
LOWGRAPH PU=0.02G/lb; VF GRA=1.0 WVF=0                                  1
      12   1   4
1 1 1  1   2 616 8
111 1  1   2 1.777-7       0.080233
LOWGRAPH PU=0.01G/lb; VF GRA=1.0 WVF=0                                  1
      12   1   4
1 1 1  1   2 616 8
111 1  1   2 8.887-8       0.080233
```

Listing 53. Table 12 Case 1, SCAMP input.

```
LIMIT           2  16   1   3 203   6
HETER      PU 0.1 cm   VF GRA=1.0                                       1
       1  13   0   3  16   0   1   1   0  20   0   0   0   0   6
      19   1 999
    1  1   3   2   1   2
    2  1   3 100   2 100
  1 1  1   1 616
1 1 2  1   1   8
       1   1  .001
       2   1  .001
    1  1   3 49.95        0.1         49.95
  1 1  1   5  1.0          1.0          1.0          1.0          1.0
  1 1  6   5  1.0          1.0          1.0          1.0          1.0
  1 1 11   5  1.0          1.0          1.0          1.0          1.0
  1 1 16   1  1.0
  1 2  1   5  1.0          1.0          1.0          1.0          1.0
  1 2  6   5  1.0          1.0          1.0          1.0          1.0
  1 2 11   5  1.0          1.0          1.0          1.0          1.0
  1 2 16   1  1.0
  5 1  1   5  .225          .347         .161         .170         .084
  5 1  6   1  .013
 11 1  1   1  4.888-2
111 2  1   1  8.0233-2
HETER      PU 0.05cm   VF GRA=1.0                                       1
1      12   1   0
1   1  1   3 49.975       0.05        49.975
HETER      PU 0.0273cm VF GRA=1.0                                       1
1      12   1   0
1   1  1   3 49.9864      0.0272      49.9864
```

Listing 54. Table 12 Case 6, SCAMP input.

```
LIMIT          2  16   1  13 252   6
HETER6   6  PU 0.0046 cm   VF GRA=1.0                                          1
       1  13   0  13  16   0   1   1   0  20   0   0   0   0   6
      19   1 999
    1  1  13   2   1   2   1   2   1   2   1   2   1   2   1   2
    2  1  13  35   1  35   1  35   1  35   1  35   1  35   1  35
  1 1  1   1 616
1 1 2  1   1   8
       1   1  .001
       2   1  .001
    1  1   5 14.2818      0.0045     14.2818      0.0045     14.2818
    1  6   5  0.0045     14.2818      0.0045     14.2818      0.0045
    1 11   3 14.2818      0.0045     14.2818
  1 1  1   5  1.0         1.0         1.0         1.0         1.0
  1 1  6   5  1.0         1.0         1.0         1.0         1.0
  1 1 11   5  1.0         1.0         1.0         1.0         1.0
  1 1 16   1  1.0
  1 2  1   5  1.0         1.0         1.0         1.0         1.0
  1 2  6   5  1.0         1.0         1.0         1.0         1.0
  1 2 11   5  1.0         1.0         1.0         1.0         1.0
  1 2 16   1  1.0
  5 1  1   5  .225         .347        .161        .170        .084
  5 1  6   1  .013
 11 1  1   1 4.888-2
111 2  1   1 8.0233-2
```

Listing 55. Table 13 Case 2, KENO-V.a input.

```
DMGMXV INF ARRAY OF DRUMS WITH 1.5 G/LB PU, C vol based on 260 lb, 1.6 g/cc
READ PARA
     TME=120.0  GEN=153   NPG=5000    LIB=41
     FLX=NO     FDN=NO    AMX=NO     FAR=NO
     RUN=YES   PLT=NO    NUB=YES    LNG=148000
END PARA
READ MIXT
     MIX=1   94913   7.6759-6  94914  5.6541-6 6100 .080233
     MIX=2   100   1.0
END MIXT
READ GEOM
     UNIT 1
     COM=*RIGHT SIDE OF UNIT CELL *
     ZHEMICYL+X    0 1   28.5750  42.5450  -13.735
     ZHEMICYL+X    1 1   28.5750  2P42.5450
     ZHEMICYL+X    2 1   28.7270  2P42.6950
     UNIT 2
     COM=*LEFT SIDE OF UNIT CELL *
     ZHEMICYL-X    0 1   28.5750  42.5450  -13.735
     ZHEMICYL-X    1 1   28.5750  2P42.5450
     ZHEMICYL-X    2 1   28.7270  2P42.6950
     UNIT 3
     COM=*UPPER PART OF UNIT CELL *
     ZHEMICYL-Y    0 1   28.5750  42.5450  -13.735
     ZHEMICYL-Y    1 1   28.5750  2P42.5450
     ZHEMICYL-Y    2 1   28.7270  2P42.6950
     UNIT 4
     COM=* UNIT CELL TRI PITCH*
     ZHEMICYL+Y    0 1   28.5750  42.5450  -13.735
     ZHEMICYL+Y    1 1   28.5750  2P42.5450
     ZHEMICYL+Y    2 1   28.7270  2P42.6950
     CUBOID        0 1   2P28.7271  99.513248  0.0  2P42.6951
     HOLE          3    0.0  99.513248  0.0
     HOLE          1     -28.727  49.756624  0.0
     HOLE          2      28.727  49.756624  0.0
GLOBAL
     UNIT 5
     ARRAY         1     0.0   0.0   0.0
     CUBOID        0 1   746.905 0.0  696.593 0.0  1024.683  0.0
     CUBOID        0 1   746.906 -0.001  696.594 -0.001  1024.684  -0.001
END GEOM
READ START NST=0 END START
READ ARRAY  ARA=1  NUX=13  NUY=7  NUZ=12
     LOOP  4   1 13 1   1 7 1     1 12 1
END LOOP
END ARRAY
READ BOUNDS  ALL=MIRROR  END BOUNDS
READ PLOT
     PLT=YES PIC=MIX   NCH=' *SW'
     TTL=* "X-Y ARRAY" *
     XUL=-60.0  YUL=757.0   ZUL=20.0
     XLR=807.0 YLR=-60.0  ZLR=20.0
     UAX=1.0 VDN=-1.0  NAX=130   END
     PLT=YES PIC=MIX   NCH=' *SW'
     TTL=* "X-Y CELL" *
     XUL=0.0  YUL=100.0   ZUL=20.0
     XLR=58.0 YLR=0.0   ZLR=20.0
     UAX=1.0   VDN=-1.0   NAX=130   END
     PLT=YES PIC=MIX   NCH=' *SW'
     TTL=* "X-Z VIEW" *
     XUL=-60.0  YUL=0.0   ZUL=1085.0
     XLR=807.0 YLR=0.0   ZLR=-60.0
     UAX=1.0   WDN=-1.0   NAX=130   END
END PLOT
END DATA
```

Listing 56. Table 13 Case 4, KENO-V.a input.

```
DMD2 INF ARRAY OF DRUMS WITH 1.5 G/LB PU, C vol based on 260 lb, .942 g/cc
READ PARA
     TME=120.0  GEN=153   NPG=5000    LIB=41
     FLX=NO     FDN=NO    AMX=NO    FAR=NO
     RUN=YES   PLT=NO    NUB=YES LNG=148000
END PARA
READ MIXT
     MIX=1   94913   4.52052-6  94914  3.32820-6 6100 .0472373
     MIX=2   100   1.0
END MIXT
READ GEOM
     UNIT 1
     COM=*RIGHT SIDE OF UNIT CELL *
     ZHEMICYL+X   0 1   28.5750  42.5450  6.265
     ZHEMICYL+X   1 1   28.5750  2P42.5450
     ZHEMICYL+X   2 1   28.7270  2P42.6950
     UNIT 2
     COM=*LEFT SIDE OF UNIT CELL *
     ZHEMICYL-X   0 1   28.5750  42.5450  6.265
     ZHEMICYL-X   1 1   28.5750  2P42.5450
     ZHEMICYL-X   2 1   28.7270  2P42.6950
     UNIT 3
     COM=*UPPER PART OF UNIT CELL *
     ZHEMICYL-Y   0 1   28.5750  42.5450  6.265
     ZHEMICYL-Y   1 1   28.5750  2P42.5450
     ZHEMICYL-Y   2 1   28.7270  2P42.6950
     UNIT 4
     COM=* UNIT CELL TRI PITCH*
     ZHEMICYL+Y   0 1   28.5750  42.5450  6.265
     ZHEMICYL+Y   1 1   28.5750  2P42.5450
     ZHEMICYL+Y   2 1   28.7270  2P42.6950
     CUBOID       0 1   2P28.7271  99.513248  0.0  2P42.6951
     HOLE         3    0.0  99.513248  0.0
     HOLE         1     -28.727  49.756624  0.0
     HOLE         2      28.727  49.756624  0.0
GLOBAL
     UNIT 5
     ARRAY        1     0.0   0.0   0.0
     CUBOID       0 1   746.905 0.0  696.593 0.0  1024.683  0.0
     CUBOID       0 1   746.906 -0.001  696.594 -0.001  1024.684  -0.001
END GEOM
READ START NST=0 END START
READ ARRAY  ARA=1  NUX=13  NUY=7  NUZ=12
     LOOP  4   1 13 1   1 7 1     1 12 1
END LOOP
END ARRAY
READ BOUNDS  ALL=MIRROR  END BOUNDS
READ PLOT
     PLT=YES PIC=MIX   NCH=' *SW'
     TTL=* "X-Y ARRAY" *
     XUL=-60.0  YUL=757.0   ZUL=5.0
     XLR=807.0 YLR=-60.0  ZLR=5.0
     UAX=1.0 VDN=-1.0  NAX=130   END
     PLT=YES PIC=MIX   NCH=' *SW'
     TTL=* "X-Y CELL" *
     XUL=0.0  YUL=100.0   ZUL=5.0
     XLR=58.0 YLR=0.0   ZLR=5.0
     UAX=1.0   VDN=-1.0   NAX=130   END
     PLT=YES PIC=MIX   NCH=' *SW'
     TTL=* "X-Z VIEW" *
     XUL=-60.0  YUL=0.0   ZUL=1085.0
     XLR=807.0 YLR=0.0   ZLR=-60.0
     UAX=1.0   WDN=-1.0   NAX=130   END
END PLOT
END DATA
```

Listing 57. Table 14 Case 4b, Heavily loaded drums with MgO waste.

```
=CSAS25     PARM=SIZE=153000
RWMC035  MgO - Compressed Cube Model of Individual Heavily Loaded Drums
27GROUPNDF4  INFHOMMEDIUM
PU-239  1  0  4.0368-5  END
MG      1  0  5.3499-2  END
O       1  0  5.3499-2  END
PU-239  2  0  2.6647-5  END
MG      2  0  5.3499-2  END
O       2  0  5.3499-2  END
PU-239  3  0  1.8891-5  END
MG      3  0  5.3499-2  END
O       3  0  5.3499-2  END
PU-239  4  0  1.4715-5  END
MG      4  0  5.3499-2  END
O       4  0  5.3499-2  END
PU-239  5  0  1.0937-5  END
MG      5  0  5.3499-2  END
O       5  0  5.3499-2  END
PU-239  6  0  4.7726-6  END
MG      6  0  5.3499-2  END
O       6  0  5.3499-2  END
PU-239  7  0  2.9829-6  END
MG      7  0  5.3499-2  END
O       7  0  5.3499-2  END
PU-239  8  0  1.9886-6  END
MG      8  0  5.3499-2  END
O       8  0  5.3499-2  END
PU-239  9  0  1.9330-6  END
SI      9  0  2.3256-2  END
O       9  0  4.6513-2  END
SS304  10  1.0          END
END COMP
RWMC035  MgO - Compressed Cube Model of Individual Heavily Loaded Drums
READ PARA
     TME=350   GEN=253   NPG=2500
     FLX=NO     FDN=NO    AMX=NO    FAR=NO
     RUN=YES  PLT=NO    NUB=YES
 END PARA
 READ GEOM
     UNIT 1
     COM=* MGO - CONCENTRATION=2.03 G PU/LB *
     CUBOID       1 1   6P13.84660
     CUBOID      10 1   6P14.49113
     UNIT 2
     COM=* MGO - CONCENTRATION=1.34 G PU/LB *
     CUBOID       2 1   6P13.84660
     CUBOID      10 1   6P14.49113
     UNIT 3
     COM=* MGO - CONCENTRATION=0.95 G PU/LB *
     CUBOID       3 1   6P13.84660
     CUBOID      10 1   6P14.49113
     UNIT 4
     COM=* MGO - CONCENTRATION=0.74 G PU/LB *
     CUBOID       4 1   6P13.84660
     CUBOID      10 1   6P14.49113
     UNIT 5
     COM=* MGO - CONCENTRATION=0.55 G PU/LB *
     CUBOID       5 1   6P13.84660
     CUBOID      10 1   6P14.49113
     UNIT 6
     COM=* MGO - CONCENTRATION=0.24 G PU/LB *
     CUBOID       6 1   6P13.84660
     CUBOID      10 1   6P14.49113
     UNIT 7
     COM=* MGO - CONCENTRATION=0.15 G PU/LB *
     CUBOID       7 1   6P13.84660
     CUBOID      10 1   6P14.49113
     UNIT 8
     COM=* MGO - CONCENTRATION=0.10 G PU/LB *
     CUBOID       8 1   6P13.84660
     CUBOID      10 1   6P14.49113
     UNIT 9
     COM=* SIO2 - CONCENTRATION=0.15 G PU/LB *
     CUBOID       9 1   6P13.84660
     CUBOID      10 1   6P14.49113
     GLOBAL
```

Listing 57. Continued.

```
      UNIT 10
      COM=* ARRAY OF OVERLOADED COMPRESSED DRUMS *
      ARRAY 1   -159.40243  -159.40243  -159.40243
      CUBOID       9 1   6P259.40243
 END GEOM
 READ START NST=1 END START
 READ BOUNDS  ALL=MIRROR  END BOUNDS
 READ ARRAY
     ARA=1  NUX=11  NUY=11  NUZ=11
     LOOP   7   1 11 1   1 11 1    1 11 1
            8   1 11 1   1 11 1    1 11 10
            8   1 11 1   1 11 10   2 10 8
            8   1 11 10  1 11 1    2 10 8
            8   1 11 1   1 11 10   3  9 6
            8   1 11 10  1 11 1    3  9 6
            8   1 11 1   1 11 10   4  8 4
            8   1 11 10  1 11 1    4  8 4
            8   2 10 8   2 10 8    2 10 8
            8   2 10 8   2 10 8    3  9 6
            7   2 10 8   2  2 1    9  9 1
            9   1 11 1   1 11 10   1 11 10
            9   1 11 10  1 11 1    1 11 10
            9   2 10 1   2 10 8    1 11 10
            9   2 10 8   2 10 2    1 11 10
            9   6  6 1   6  6 1    1  1 1
            6   2 10 1   2 10 1    4  8 4
            6   2 10 2   1 11 10   5  7 2
            6   1 11 1   2 10 2    5  7 2
            6   1 11 10  7  7 1    5  7 2
            5   5  7 1   9  9 1    4  8 4
            5   3  9 6   6  6 1    4  8 4
            5   6  6 1   3  3 1    4  8 4
            5   5  7 2   3  3 1    8  8 4
            5   2 10 1   2 10 1    5  7 2
            5   1 11 1   1 11 1    6  6 1
            4   6  6 1   3  3 1    8  8 1
            4   3  9 6   5  7 1    5  7 2
            4   5  7 1   3  9 6    5  7 2
            4   3  9 6   3  9 6    6  6 1
            4   6  6 1   2 10 8    6  6 1
            3   4  8 1   3  9 6    6  6 1
            3   3  9 6   4  8 1    6  6 1
            4   4  8 4   9  9 1    6  6 1
            2   4  8 1   4  8 1    4  8 1
            1   6  7 1   6  6 1    6  6 1
            3   4  8 4   4  8 4    4  8 4
            2   4  4 1   4  4 1    8  8 1
     END LOOP
 END ARRAY
 READ PLOT
      PLT=NO  PIC=MIX   NCH=' 12345678*.'
      TTL=* "X-Y SLICE" *
      XUL=-170.0  YUL=170.0   ZUL=0.0
      XLR=170.0 YLR=-170.0  ZLR=0.0
      UAX=1.0 VDN=-1.0  NAX=130   END
      TTL=* "X-Z SLICE" *
      XUL=-170.0  YUL=0.0   ZUL=170.0
      XLR=170.0 YLR=0.0  ZLR=-170.0
      UAX=1.0 WDN=-1.0  NAX=130   END
 END PLOT
 END DATA
 END KENO
```

Listing 58. Table 14 Case 4c, Heavily loaded drums with MgO waste. Double volume - half density.

```
=CSAS25     PARM=SIZE=153000
RWMC040  RWMC033 with double volume and reduced atom densities
27GROUPNDF4  INFHOMMEDIUM
PU-239  1  0  2.0184-5  END
MG      1  0  2.6750-2  END
O       1  0  2.6750-2  END
PU-239  2  0  1.3323-5  END
MG      2  0  2.6750-2  END
O       2  0  2.6750-2  END
PU-239  3  0  9.4455-6  END
MG      3  0  2.6750-2  END
O       3  0  2.6750-2  END
PU-239  4  0  7.3575-6  END
MG      4  0  2.6750-2  END
O       4  0  2.6750-2  END
PU-239  5  0  5.4685-6  END
MG      5  0  2.6750-2  END
O       5  0  2.6750-2  END
PU-239  6  0  2.3863-6  END
MG      6  0  2.6750-2  END
O       6  0  2.6750-2  END
PU-239  7  0  1.4914-6  END
MG      7  0  2.6750-2  END
O       7  0  2.6750-2  END
PU-239  8  0  9.9430-7  END
MG      8  0  2.6750-2  END
O       8  0  2.6750-2  END
PU-239  9  0  1.9330-6  END
SI      9  0  2.3256-2  END
O       9  0  4.6513-2  END
SS304  10  1.0          END
END COMP
RWMC040  RWMC033 with double volume and reduced atom densities
READ PARA
     TME=350  GEN=257   NPG=2500
     FLX=NO    FDN=NO    AMX=NO    FAR=NO
     RUN=YES   PLT=NO    NUB=YES
 END PARA
 READ GEOM
     UNIT 1
     COM=* MGO - CONCENTRATION=2.03 G PU/LB *
     CUBOID       1 1   6P17.44562
     CUBOID      10 1   6P17.86088
     UNIT 2
     COM=* MGO - CONCENTRATION=1.34 G PU/LB *
     CUBOID       2 1   6P17.44562
     CUBOID      10 1   6P17.86088
     UNIT 3
     COM=* MGO - CONCENTRATION=0.95 G PU/LB *
     CUBOID       3 1   6P17.44562
     CUBOID      10 1   6P17.86088
     UNIT 4
     COM=* MGO - CONCENTRATION=0.74 G PU/LB *
     CUBOID       4 1   6P17.44562
     CUBOID      10 1   6P17.86088
     UNIT 5
     COM=* MGO - CONCENTRATION=0.55 G PU/LB *
     CUBOID       5 1   6P17.44562
     CUBOID      10 1   6P17.86088
     UNIT 6
     COM=* MGO - CONCENTRATION=0.24 G PU/LB *
     CUBOID       6 1   6P17.44562
     CUBOID      10 1   6P17.86088
     UNIT 7
     COM=* MGO - CONCENTRATION=0.15 G PU/LB *
     CUBOID       7 1   6P17.44562
     CUBOID      10 1   6P17.86088
     UNIT 8
     COM=* MGO - CONCENTRATION=0.10 G PU/LB *
     CUBOID       8 1   6P17.44562
     CUBOID      10 1   6P17.86088
     UNIT 9
     COM=* SIO2 - CONCENTRATION=0.15 G PU/LB *
     CUBOID       9 1   6P17.44562
     CUBOID      10 1   6P17.86088
```

Listing 58. Continued.

```
      GLOBAL
      UNIT 10
      COM=* ARRAY OF OVERLOADED COMPRESSED DRUMS *
      ARRAY 1    -196.46968  -196.46968  -196.46968
      CUBOID       9 1   6P296.46968
 END GEOM
 READ START NST=0 END START
 READ BOUNDS  ALL=MIRROR  END BOUNDS
 READ ARRAY
     ARA=1  NUX=11  NUY=11  NUZ=11
     LOOP   7   1 11 1   1 11 1    1 11 1
            8   1 11 1   1 11 1    1 11 10
            8   1 11 1   1 11 10   2 10 8
            8   1 11 10  1 11 1    2 10 8
            8   1 11 1   1 11 10   3  9 6
            8   1 11 10  1 11 1    3  9 6
            8   1 11 1   1 11 10   4  8 4
            8   1 11 10  1 11 1    4  8 4
            8   2 10 8   2 10 8    2 10 8
            8   2 10 8   2 10 8    3  9 6
            7   2 10 8   2  2 1    9  9 1
            9   1 11 1   1 11 10   1 11 10
            9   1 11 10  1 11 1    1 11 10
            9   2 10 1   2 10 8    1 11 10
            9   2 10 8   2 10 2    1 11 10
            9   6  6 1   6  6 1    1  1 1
            6   2 10 1   2 10 1    4  8 4
            6   2 10 2   1 11 10   5  7 2
            6   1 11 1   2 10 2    5  7 2
            6   1 11 10  7  7 1    5  7 2
            5   5  7 1   9  9 1    4  8 4
            5   3  9 6   6  6 1    4  8 4
            5   6  6 1   3  3 1    4  8 4
            5   5  7 2   3  3 1    8  8 4
            5   2 10 1   2 10 1    5  7 2
            5   1 11 1   1 11 1    6  6 1
            4   6  6 1   3  3 1    8  8 1
            4   3  9 6   5  7 1    5  7 2
            4   5  7 1   3  9 6    5  7 2
            4   3  9 6   3  9 6    6  6 1
            4   6  6 1   2 10 8    6  6 1
            3   4  8 1   3  9 6    6  6 1
            3   3  9 6   4  8 1    6  6 1
            4   4  8 4   9  9 1    6  6 1
            2   4  8 1   4  8 1    4  8 1
            1   6  7 1   6  6 1    6  6 1
            3   4  8 4   4  8 4    4  8 4
            2   4  4 1   4  4 1    8  8 1
     END LOOP
 END ARRAY
 READ PLOT
      PLT=NO  PIC=MIX   NCH=' 123456789*.'
      TTL=* "X-Y SLICE" *
      XUL=-170.0  YUL=170.0   ZUL=0.0
      XLR=170.0 YLR=-170.0  ZLR=0.0
      UAX=1.0 VDN=-1.0  NAX=130   END
      TTL=* "X-Z SLICE" *
      XUL=-170.0  YUL=0.0   ZUL=170.0
      XLR=170.0 YLR=0.0  ZLR=-170.0
      UAX=1.0 WDN=-1.0  NAX=130   END
 END PLOT
 END DATA
 END KENO
```

Listing 59. Table 14 Case 5a, KENO-V.a input.

```
=CSAS25     PARM=SIZE=153000
RWMC036  Cellulose - Compressed Cube Model of Individual Heavily Loaded Drums
27GROUPNDF4  INFHOMMEDIUM
PU-239  1  0  2.3890-5  END
C       1  0  1.4260-2  END
H       1  0  2.3780-2  END
O       1  0  1.1890-2  END
PU-239  2  0  1.9588-5  END
C       2  0  1.4260-2  END
H       2  0  2.3780-2  END
O       2  0  1.1890-2  END
PU-239  3  0  1.6495-5  END
C       3  0  1.4260-2  END
H       3  0  2.3780-2  END
O       3  0  1.1890-2  END
PU-239  4  0  1.2016-5  END
C       4  0  1.4260-2  END
H       4  0  2.3780-2  END
O       4  0  1.1890-2  END
PU-239  5  0  8.2476-6  END
C       5  0  1.4260-2  END
H       5  0  2.3780-2  END
O       5  0  1.1890-2  END
PU-239  6  0  4.9414-6  END
C       6  0  1.4260-2  END
H       6  0  2.3780-2  END
O       6  0  1.1890-2  END
PU-239  7  0  1.9330-6  END
SI      7  0  2.3256-2  END
O       7  0  4.6513-2  END
SS304   8  1.0          END
END COMP
RWMC036  Cellulose - Compressed Cube Model of Individual Heavily Loaded Drums
READ PARA
      TME=350    GEN=253    NPG=2500
      FLX=NO     FDN=NO     AMX=NO     FAR=NO
      RUN=YES    PLT=NO     NUB=YES
 END PARA
 READ GEOM
      UNIT 1
      COM=* CELLULOSE - CONCENTRATION=6.72 G PU/LB *
      CUBOID        1 1   6P20.76409
      CUBOID        8 1   6P21.06002
      UNIT 2
      COM=* CELLULOSE - CONCENTRATION=5.51 G PU/LB *
      CUBOID        2 1   6P20.76409
      CUBOID        8 1   6P21.06002
      UNIT 3
      COM=* CELLULOSE - CONCENTRATION=4.64 G PU/LB *
      CUBOID        3 1   6P20.76409
      CUBOID        8 1   6P21.06002
      UNIT 4
      COM=* CELLULOSE - CONCENTRATION=3.38 G PU/LB *
      CUBOID        4 1   6P20.76409
      CUBOID        8 1   6P21.06002
      UNIT 5
      COM=* CELLULOSE - CONCENTRATION=2.32 G PU/LB *
      CUBOID        5 1   6P20.76409
      CUBOID        8 1   6P21.06002
      UNIT 6
      COM=* CELLULOSE - CONCENTRATION=1.39 G PU/LB *
      CUBOID        6 1   6P20.76409
      CUBOID        8 1   6P21.06002
      UNIT 7
      COM=* SIO2 - CONCENTRATION=0.15 G PU/LB *
      CUBOID        7 1   6P20.76409
      CUBOID        8 1   6P21.06002
      GLOBAL
      UNIT 8
      COM=* ARRAY OF OVERLOADED COMPRESSED DRUMS *
      ARRAY 1   -189.54018  -189.54018  -189.54018
      CUBOID        7 1   6P289.54018
 END GEOM
 READ START NST=1 END START
 READ BOUNDS  ALL=MIRROR  END BOUNDS
 READ ARRAY
```

Listing 59. Continued.

```
    ARA=1  NUX=9   NUY=9   NUZ=9
    LOOP   7   1   9 1   1   9 1     1   9 1
           6   4   6 1   3   7 1     1   9 8
           6   3   3 1   4   6 1     1   9 8
           6   7   7 1   5   5 1     9   9 1
           6   2   8 1   2   8 1     2   8 1
           6   1   9 8   4   6 1     2   8 1
           6   4   6 1   1   9 8     2   8 1
           6   1   9 1   1   9 1     5   5 1
           5   3   7 1   4   6 1     4   6 2
           5   4   6 1   7   7 1     4   6 2
           4   4   6 1   5   5 1     4   6 2
           4   5   5 1   6   6 1     4   6 2
           5   3   7 4   4   6 1     5   5 1
           5   4   6 1   3   7 4     5   5 1
           5   4   6 2   4   6 2     5   5 1
           4   5   5 1   4   4 1     5   5 1
           3   4   6 2   5   5 1     5   5 1
           2   5   5 1   6   6 1     5   5 1
           1   5   5 1   5   5 1     5   5 1
    END LOOP
END ARRAY
READ PLOT
     PLT=NO  PIC=MIX   NCH=' 123456789*.'
     TTL=* "X-Y SLICE" *
     XUL=-200.0  YUL=200.0   ZUL=0.0
     XLR=200.0 YLR=-200.0  ZLR=0.0
     UAX=1.0 VDN=-1.0  NAX=130   END
     TTL=* "X-Z SLICE" *
     XUL=-200.0  YUL=0.0   ZUL=200.0
     XLR=200.0 YLR=0.0  ZLR=-200.0
     UAX=1.0 WDN=-1.0  NAX=130   END
END PLOT
END DATA
END KENO
```

Listing 60. Table 14 Case 5b, KENO-V.a input.

```
=CSAS25     PARM=SIZE=153000
RWMC037  Cellulose - Compressed Cube Model of Individual Heavily Loaded Drums
27GROUPNDF4  INFHOMMEDIUM
PU-239  1  0  2.3890-5  END
C       1  0  1.4260-2  END
H       1  0  2.3780-2  END
O       1  0  1.1890-2  END
PU-239  2  0  1.9588-5  END
C       2  0  1.4260-2  END
H       2  0  2.3780-2  END
O       2  0  1.1890-2  END
PU-239  3  0  1.6495-5  END
C       3  0  1.4260-2  END
H       3  0  2.3780-2  END
O       3  0  1.1890-2  END
PU-239  4  0  1.2016-5  END
C       4  0  1.4260-2  END
H       4  0  2.3780-2  END
O       4  0  1.1890-2  END
PU-239  5  0  8.2476-6  END
C       5  0  1.4260-2  END
H       5  0  2.3780-2  END
O       5  0  1.1890-2  END
PU-239  6  0  4.9418-6  END
C       6  0  1.4260-2  END
H       6  0  2.3780-2  END
O       6  0  1.1890-2  END
PU-239  7  0  1.9330-6  END
SI      7  0  2.3256-2  END
O       7  0  4.6513-2  END
SS304   8  1.0          END
END COMP
RWMC037  Cellulose - Compressed Cube Model of Individual Heavily Loaded Drums
READ PARA
      TME=350   GEN=253   NPG=2500
      FLX=NO     FDN=NO    AMX=NO    FAR=NO
      RUN=YES  PLT=NO    NUB=YES
 END PARA
 READ GEOM
      UNIT 1
      COM=* CELLULOSE - CONCENTRATION=6.72 G PU/LB *
      CUBOID       1 1   6P20.76409
      CUBOID       8 1   6P21.06002
      UNIT 2
      COM=* CELLULOSE - CONCENTRATION=5.51 G PU/LB *
      CUBOID       2 1   6P20.76409
      CUBOID       8 1   6P21.06002
      UNIT 3
      COM=* CELLULOSE - CONCENTRATION=4.64 G PU/LB *
      CUBOID       3 1   6P20.76409
      CUBOID       8 1   6P21.06002
      UNIT 4
      COM=* CELLULOSE - CONCENTRATION=3.38 G PU/LB *
      CUBOID       4 1   6P20.76409
      CUBOID       8 1   6P21.06002
      UNIT 5
      COM=* CELLULOSE - CONCENTRATION=2.32 G PU/LB *
      CUBOID       5 1   6P20.76409
      CUBOID       8 1   6P21.06002
      UNIT 6
      COM=* CELLULOSE - CONCENTRATION=1.39 G PU/LB *
      CUBOID       6 1   6P20.76409
      CUBOID       8 1   6P21.06002
      UNIT 7
      COM=* SIO2 - CONCENTRATION=0.15 G PU/LB *
      CUBOID       7 1   6P20.76409
      CUBOID       8 1   6P21.06002
      UNIT 8
      COM=* CELLULOSE - CONCENTRATION=6.72, 5.51 & 4.64 G PU/LB *
      CUBOID       1 1   6P13.69611
      CUBOID       8 1   6P14.35392
      CUBOID       2 1   6P18.28286
      CUBOID       8 1   6P18.66211
      CUBOID       3 1   6P20.76409
      CUBOID       8 1   6P21.06002
      GLOBAL
```

Listing 60. Continued.

```
      UNIT 9
      COM=* ARRAY OF OVERLOADED COMPRESSED DRUMS *
      ARRAY 1   -189.54018  -189.54018  -189.54018
      CUBOID       7 1   6P289.54018
 END GEOM
 READ START NST=1 END START
 READ BOUNDS  ALL=MIRROR  END BOUNDS
 READ ARRAY
     ARA=1  NUX=9   NUY=9   NUZ=9
     LOOP   7   1  9 1   1  9 1    1  9 1
            6   4  6 1   3  7 1    1  9 8
            6   3  3 1   4  6 1    1  9 8
            6   7  7 1   5  5 1    9  9 1
            6   2  8 1   2  8 1    2  8 1
            6   1  9 8   4  6 1    2  8 1
            6   4  6 1   1  9 8    2  8 1
            6   1  9 1   1  9 1    5  5 1
            5   3  7 1   4  6 1    4  6 2
            5   4  6 1   7  7 1    4  6 2
            4   4  6 1   5  5 1    4  6 2
            4   5  5 1   6  6 1    4  6 2
            5   3  7 4   4  6 1    5  5 1
            5   4  6 1   3  7 4    5  5 1
            5   4  6 2   4  6 2    5  5 1
            4   5  5 1   4  4 1    5  5 1
            3   4  6 2   5  5 1    5  5 1
            2   5  5 1   6  6 1    5  5 1
            8   5  5 1   5  5 1    5  5 1
            5   5  5 1   6  6 1    5  5 1
     END LOOP
 END ARRAY
 READ PLOT
      PLT=NO  PIC=MIX   NCH=' 123456789*.'
      TTL=* "X-Y SLICE" *
      XUL=-200.0  YUL=200.0   ZUL=0.0
      XLR=200.0 YLR=-200.0  ZLR=0.0
      UAX=1.0 VDN=-1.0  NAX=130   END
      TTL=* "X-Z SLICE" *
      XUL=-200.0  YUL=0.0   ZUL=200.0
      XLR=200.0 YLR=0.0  ZLR=-200.0
      UAX=1.0 WDN=-1.0  NAX=130   END
 END PLOT
 END DATA
 END KENO
```

Listing 61. Table 14 Case 7, KENO-V.a input.

```
=CSAS25     PARM=SIZE=153000
RWMC018  Aluminium - Compressed Cube Model of Individual Heavily Loaded Drums
27GROUPNDF4  INFHOMMEDIUM
PU-239  1  0  5.1592-5  END
AL      1  0  6.0271-2  END
PU-239  2  0  1.9330-6  END
SI      2  0  2.3256-2  END
O       2  0  4.6513-2  END
SS304   3  1.0          END
END COMP
RWMC018  Aluminium - Compressed Cube Model of Individual Heavily Loaded Drums
READ PARA
      TME=300    GEN=253    NPG=2500
      FLX=NO     FDN=NO     AMX=NO     FAR=NO
      RUN=YES    PLT=NO     NUB=YES
 END PARA
 READ GEOM
      UNIT 1
      COM=* ALUMINIUM - CONCENTRATION=3.44 G PU/LB *
      CUBOID        1 1   6P13.93396
      CUBOID        3 1   6P14.57096
      UNIT 2
      COM=* SIO2 - CONCENTRATION=0.15 G PU/LB *
      CUBOID        2 1   6P13.93396
      CUBOID        3 1   6P14.57096
      GLOBAL
      UNIT 3
      COM=* ARRAY OF OVERLOADED COMPRESSED DRUMS *
      ARRAY 1     -87.42576  -87.42576  -87.42576
      CUBOID        2 1   6P187.42576
 END GEOM
 READ START NST=1 END START
 READ BOUNDS  ALL=MIRROR  END BOUNDS
 READ ARRAY
     ARA=1  NUX=6   NUY=6   NUZ=6
     LOOP   1   1  6 1   1  6 1    1  6 1
            2   1  6 5   1  6 5    1  6 5
            1   6  6 1   1  1 1    6  6 1
     END LOOP
 END ARRAY
 READ PLOT
      PLT=NO  PIC=MIX   NCH=' 1*.'
      TTL=* "X-Y SLICE" *
      XUL=-200.0  YUL=200.0   ZUL=0.0
      XLR=200.0 YLR=-200.0  ZLR=0.0
      UAX=1.0 VDN=-1.0  NAX=130   END
      TTL=* "X-Z SLICE" *
      XUL=-200.0  YUL=0.0   ZUL=200.0
      XLR=200.0 YLR=0.0  ZLR=-200.0
      UAX=1.0 WDN=-1.0  NAX=130   END
 END PLOT
 END DATA
 END KENO
```

APPENDIX C:

TRANSURANIC WASTE CONTENT CODES DESCRIPTIONS

Transuranic Waste content Code Description

CONTENT CODE	CONTENT DESCRIPTION
0	NOT RECORDED - UNKNOWN
1	FIRST STAGE SLUDGE
2	SECOND STAGE SLUDGE
3	ORGANIC SETUPS, OIL SOLIDS
4	SPECIAL SET UPS (CEMENT)
5	EVAPORATED SALTS
7	BLDG 374 DRY SLUDGE
10	COMBUSTIBLE (RAGS, GLOVES, POLY)
15	NEUTRON SOURCES
20	NONCOMPRESSIBLE, NONCOMBUSTIBLE
30	GRINDING SLUDGE, FILTERS, ETC. (BETTIS)
40	BINARY SCRAP (BETTIS)
69	ROASTER OXIDE
90	DIRT
95	SLUDGE
100	GENERAL PLANT WASTE
101	CUT-UP GLOVEBOXES
102	ABSORBED LIQUIDS
105	EMPLTY GLASS BOTTLES
111	CERT SOLID. WET SLUDGE (UNCERT. IDC. 001, 007)
112	CERT SOLID. ORGANICS (UNCERT. IDC. 003)
113	CERT SOLID. LAB WASTE (UNCERT. IDC. 004)
114	CERT. SOLID. PROCESS SOL. (UNCERT. IDC. 292, 311, 372, 373, 393, 421, 423, 432)
115	CERT. TRU GRAPHITE WASTE (UNCERT. IDC. 300)
116	CERT. TRU COMBUSTIBLE WASTE (UNCERT. ID. 330, 336, 337, 831, 832, 833)
117	CERT. TRU METAL WASTE (UNCERT. IDC. 320, 480, 481)
118	CERT. TRU GLASS WASTE (UNCERT. IDC. 370, 440, 441, 442)
119	CERT. TRU HEPA FILTER WASTE (UNCERT. IDC. 335, 490)
120	CERT. TRU INSULATION & FILTER MEDIA (UNCERT. IDC. 328, 338, 376)
121	CERT. TRU ORGANIC SOLID WASTE (UNCERT. IDC. 302)
122	CERT. TRU INORGANIC SOLID WASTE (UNCERT. IDC. 371, 375)
123	CERT. TRU LEADED RUBBER (UNCERT. IDC. 339)
124	CERT. TRU PYROCHEMICAL SALT WASTE (UNCERT. IDC. 410, 411, 414)
150	LABORATORY WASTE
152	PU NEUTRON SOURCES
153	PU-BE NEUTRON SOURCE
154	ACTINIDE NEUTRON SOURCES
155	TRU SCRAP
156	CHEMICAL CELL RIP-OUT
157	MISC. SOURCES
200	AMERICIUM SOURCES
201	NON-COMBUSTIBLE SOLIDS
202	COMBUSTIBLE SOLIDS
203	MIXED PAPER, METAL, GLASS
204	SOLIDIFIED WASH SOLUTIONS
241	AMERICIUM PROCESS RESIDUE
290	SLUDGE, FILTER
292	CEMENTED SLUDGE

295	SEWAGE SLUDGE
299	MISCELLANEOUS SLUDGES
300	GRAPHITE MOLDS
301	GRAPHITE CORES
302	BENELEX AND PLEXIGLASS
303	SCARFED GRAPHITE CHUNKS
310	GRAPHITE SCAFFINGS
311	GRAPHITE HEELS
312	GRAPHITE, COARSE
320	TANTALUM
321	LEAD
328	FILTERS, FULFLO INCINERATOR
330	PAPER AND RAGS - DRY
331	FILTERS, FULFLO
332	SLUDGE, OILY
333	METAL, CALCIUM
334	BLANKETS, FIRE
335	FILTERS, ABSOLUTE 8X8
336	PAPER AND RAGS - MOIST
337	PLASTICS, TEFLON, WASH, PVC
338	INSULATION AND CWS FILTER MEDIA
339	LEADED RUBBER GLOVES AND APRONS
360	INSULATION
361	INSULATION HEEL
368	MG OXIDE CERAMIC CRUCIBLES - NOT LECO
370	CRUCIBLE, LECO
371	BRICK, FIRE
372	GRIT
373	FIRE BRICK, LECO HEELS
374	BLACKTOP CONCRETE DIRT AND SAND
375	OIL DRI RESIDUES FROM INCIN'TR
376	CEMENT INSULATION AND FILTER MEDIA
377	FIRE BRICK, COARSE
378	FIRE BRICK, PULVERIZED OR FINES
379	FIREBRICK, SCARFED (SCARFED FIREBRICK)
390	SLAG
391	CRUCIBLE AND SAND
392	SAND, SLAG AND CRUCIBLES
393	SAND, SLAG AND CRUCIBLE HEELS
409	MOLTEN SALTS-30% UNPULVERIZED
410	MOLTEN SALTS-30% PULVERIZED
411	ELECTROREFINING SALT
412	GIBSON SALTS
413	IMPURE SALT - CELL CLEANOUT
414	DIRECT OXIDE REDUCTION SALT
416	ZINC MANGANESE ALLOY METAL
420	ASH, INCINERATOR (VIRGIN)
421	HEELS, ASH (> 2% G/G)
422	SOOT
423	RESIN, AND SOOT CALCINATED
425	FLUID BED ASH
429	SPENT SALT (SCRUB ALLOY SPENT SALT)
430	RESIN, ION COLUMN UNLEACHED
431	RESIN, LEACHED
432	RESIN, LEACHED AND CEMENTED
438	INSULATION (INSULATION, INCLUDING FIRE BLANKET)
440	GLASS
441	RASCHIG RINGS, UNLEACHED
442	RASCHIG RINGS, LEACHED
454	DOR SALTS (DIRECT OXIDE SALT - OXIDIZED CA)
460	WASHABLES, RUBBER, PLASTICS
463	GLOVES, DRYBOX

CONTENT CODE	CONTENT DESCRIPTION
464	PLEXIGLASS AND BENELEX
470	HEEL, ASH (< 2% G/G)
480	METAL SCRAP (NON SS)
481	METAL LEACHED (NON SS)
482	METAL, SCRAP (CONT WITH PB)
483	SAND AND GRAVEL
488	GLOVEBOX PARTS WITH LEAD
490	FILTERS, CWS
491	PREFILTERS (PLENUM PREFILTERS)
700	OASIS WASTE
701	SLUDGE - DCP
702	SLUDGE WITH WASH WATER - DCP
801	RAGS, PAPER, WOOD (MOUND LABORATORY)
802	DRY BOX GLOVES AND O-RINGS (MOUND LABORATORY)
803	EQUIPMENT, PIPES (MOUND LABORATORY)
804	PLASTIC, TYGON, MANIPULATOR BOOTS (MOUND LABORATORY)
805	ASBESTOS FILTERS (MOUND LABORATORY)
810	GLASS, FLASKS, SMAPLE VIALS (MOUND LABORATORY)
811	EVAPORATOR AND DISSOLVER SLUDGE (MOUND LABORATORY)
812	SPENT RESIN (MOUND LABORATORY)
813	GLASS FILTERS (MOUND LABORATORY)
814	GRAPHITE (MOUND LABORATORY)
824	NONCOMBUSTIBLES (MOUND LABORATORY)
825	NONCOMBUSTIBLES (MOUND LABORATORY)
826	COMBUSTIBLE BOXES (MOUND LABORATORY)
827	COMBUSTIBLE DRUMS (MOUND LABORATORY)
834	ABSORBED ACID LIQUIDS (MOUND LABORATORY)
836	CEMENTED SLUDGE
847	COMBUSTIBLES (PLATIC SHEETING, GLOVES, WOOD, PAPER)
900	LSA PAPER, PLASTICS, ETC.
950	LSA METAL, GLASS, ETC.
955	ROASTER OXIDE
960	CONCRETE, ASPHALT, ETC.
970	WOOD
976	BLDG 776 PROCESS SLUDGE
978	LAUNDRY SLUDGE
980	EQUIPMENT
990	DIRT
995	SLUDGE

APPENDIX D:

SUMMARY OF DATABASE INFORMATION BY MATRIX GROUPS

CONCENTRATION DISTRIBUTION
(GRAMS PER POUNDS)

CONTENT: ALL
CONTENT CODES: ALL

CONCENTRATION RANGE	AVERAGE WEIGHT (LBS)	AVERAGE WEIGHT (GRAMS)	AVERAGE CONCENTRATION	NUMBER OF DRUMS	RUNNING TOTAL
0.0 TO 0.0	231.847	0.000	0.000	25,896	25,896
0.0 TO 0.0001	362.982	0.027	0.000	1,844	27,740
0.0001 TO 0.0002	502.655	0.086	0.000	808	28,548
0.0002 TO 0.0003	432.203	0.101	0.000	1,440	29,988
0.0003 TO 0.0004	432.181	0.151	0.000	365	30,353
0.0004 TO 0.0005	440.496	0.200	0.000	580	30,933
0.0005 TO 0.0006	478.335	0.269	0.001	1,126	32,059
0.0006 TO 0.0007	458.999	0.298	0.001	3,551	35,610
0.0007 TO 0.0008	414.542	0.307	0.001	1,995	37,605
0.0008 TO 0.0009	433.257	0.370	0.001	1,111	38,716
0.0009 TO 0.001	424.470	0.402	0.001	867	39,583
0.001 TO 0.002	398.184	0.581	0.001	3,049	42,632
0.002 TO 0.003	434.452	1.071	0.002	1,894	44,526
0.003 TO 0.004	433.227	1.511	0.003	2,017	46,543
0.004 TO 0.005	409.939	1.843	0.004	1,818	48,361
0.005 TO 0.006	401.064	2.197	0.005	1,709	50,070
0.006 TO 0.007	404.338	2.617	0.006	1,466	51,536
0.007 TO 0.008	371.788	2.783	0.007	1,314	52,850
0.008 TO 0.009	351.819	2.986	0.008	1,121	53,971
0.009 TO 0.01	328.997	3.125	0.009	1,022	54,993
0.01 TO 0.02	308.216	4.309	0.014	5,513	60,506
0.02 TO 0.03	262.060	6.309	0.024	2,323	62,829
0.03 TO 0.04	200.284	6.911	0.035	1,189	64,018
0.04 TO 0.05	187.555	8.434	0.045	847	64,865
0.05 TO 0.06	186.387	10.243	0.055	567	65,432
0.06 TO 0.07	184.103	11.909	0.065	551	65,983
0.07 TO 0.08	185.327	13.870	0.075	454	66,437
0.08 TO 0.09	185.454	15.751	0.085	426	66,863
0.09 TO 0.1	184.918	17.592	0.095	374	67,237
0.1 TO 0.2	181.684	25.939	0.143	2,358	69,595
0.2 TO 0.3	159.877	38.699	0.242	981	70,576
0.3 TO 0.4	144.025	49.668	0.345	562	71,138
0.4 TO 0.5	132.621	59.543	0.449	380	71,518
0.5 TO 0.6	119.976	65.662	0.547	241	71,759
0.6 TO 0.7	117.750	76.274	0.648	149	71,908
0.7 TO 0.8	116.294	86.770	0.746	141	72,049
0.8 TO 0.9	117.495	99.875	0.850	104	72,153
0.9 TO 1	125.402	118.833	0.948	78	72,231
1 TO 2	104.505	138.373	1.324	427	72,658
2 TO 3	66.155	153.673	2.323	55	72,713
3 TO 4	49.394	165.632	3.353	19	72,732
4 TO 5	41.100	190.500	4.635	2	72,734
5 TO 6	35.600	196.000	5.506	1	72,735
6 TO 7	24.600	159.000	6.463	2	72,737
WEIGHTED AVERAGE	303.950	5.461	0.018	72,737	

CONCENTRATION DISTRIBUTION
(GRAMS PER POUNDS)

CONTENT: POLYETHYLENE
CONTENT CODES: 3, 112, 123, 153, 202, 332, 337, 339, 423, 430, 431, 432, 460, 463, 700, 802, 804, 812

CONCENTRATION RANGE	AVERAGE WEIGHT (LBS)	AVERAGE WEIGHT (GRAMS)	AVERAGE CONCENTRATION	NUMBER OF DRUMS	RUNNING TOTAL
0.0 TO 0.0	334.119	0.000	0.000	4,970	4,970
0.0 TO 0.0001	336.893	0.029	0.000	124	5,094
0.0001 TO 0.0002	535.605	0.100	0.000	161	5,255
0.0002 TO 0.0003	428.618	0.100	0.000	571	5,826
0.0003 TO 0.0004	459.543	0.161	0.000	61	5,887
0.0004 TO 0.0005	447.949	0.202	0.000	117	6,004
0.0005 TO 0.0006	485.132	0.271	0.001	160	6,164
0.0006 TO 0.0007	456.464	0.294	0.001	193	6,357
0.0007 TO 0.0008	432.768	0.326	0.001	169	6,526
0.0008 TO 0.0009	450.702	0.383	0.001	144	6,670
0.0009 TO 0.001	447.622	0.425	0.001	105	6,775
0.001 TO 0.002	346.439	0.520	0.002	919	7,694
0.002 TO 0.003	464.365	1.136	0.002	475	8,169
0.003 TO 0.004	483.707	1.673	0.003	324	8,493
0.004 TO 0.005	445.059	1.991	0.004	215	8,708
0.005 TO 0.006	422.918	2.315	0.005	186	8,894
0.006 TO 0.007	385.012	2.485	0.006	156	9,050
0.007 TO 0.008	381.049	2.853	0.007	140	9,190
0.008 TO 0.009	353.777	2.993	0.008	97	9,287
0.009 TO 0.01	296.681	2.819	0.010	87	9,374
0.01 TO 0.02	237.964	3.356	0.014	462	9,836
0.02 TO 0.03	171.132	4.241	0.025	228	10,064
0.03 TO 0.04	194.443	6.841	0.035	166	10,230
0.04 TO 0.05	223.381	10.060	0.045	132	10,362
0.05 TO 0.06	229.989	12.801	0.056	94	10,456
0.06 TO 0.07	243.705	15.753	0.065	89	10,545
0.07 TO 0.08	264.593	19.747	0.075	60	10,605
0.08 TO 0.09	253.954	21.537	0.085	72	10,677
0.09 TO 0.1	266.544	25.379	0.095	62	10,739
0.1 TO 0.2	242.359	34.036	0.141	421	11,160
0.2 TO 0.3	210.686	50.645	0.241	108	11,268
0.3 TO 0.4	193.490	66.043	0.341	46	11,314
0.4 TO 0.5	175.102	80.074	0.458	27	11,341
0.5 TO 0.6	160.736	88.900	0.545	10	11,351
0.6 TO 0.7	141.516	91.500	0.649	8	11,359
0.7 TO 0.8	94.676	70.667	0.745	3	11,362
0.8 TO 0.9	160.293	138.500	0.865	2	11,364
0.9 TO 1	147.694	140.500	0.953	4	11,368
1 TO 2	114.700	134.429	1.221	7	11,375
2 TO 3	41.788	99.000	2.369	1	11,376
WEIGHTED AVERAGE	347.749	3.930	0.018	11,376	

CONCENTRATION DISTRIBUTION
(GRAMS PER POUNDS)

CONTENT: GRAPHITE
CONTENT CODES: 115, 300, 301, 303, 310, 311, 312, 814

CONCENTRATION RANGE			AVERAGE WEIGHT (LBS)	AVERAGE WEIGHT (GRAMS)	AVERAGE CONCENTRATION	NUMBER OF DRUMS	RUNNING TOTAL
0.0	TO	0.0	183.277	0.000	0.000	90	90
0.0	TO	0.0001	126.900	0.011	0.000	10	100
0.0001	TO	0.003	0.000	0.000	0.000	0	100
0.003	TO	0.004	260.674	1.000	0.004	2	102
0.004	TO	0.005	217.703	1.000	0.005	30	132
0.005	TO	0.006	179.872	1.000	0.006	28	160
0.006	TO	0.007	158.375	1.000	0.006	12	172
0.007	TO	0.008	223.973	1.667	0.007	9	181
0.008	TO	0.009	236.268	2.000	0.008	10	191
0.009	TO	0.01	210.807	2.000	0.009	16	207
0.01	TO	0.02	203.329	3.000	0.015	254	461
0.02	TO	0.03	189.648	4.762	0.025	206	667
0.03	TO	0.04	177.756	6.175	0.035	171	838
0.04	TO	0.05	179.314	8.137	0.045	160	998
0.05	TO	0.06	183.814	10.052	0.055	97	1,095
0.06	TO	0.07	177.241	11.424	0.065	151	1,246
0.07	TO	0.08	183.137	13.691	0.075	129	1,375
0.08	TO	0.09	181.339	15.383	0.085	126	1,501
0.09	TO	0.1	178.170	16.957	0.095	94	1,595
0.1	TO	0.2	178.684	25.210	0.141	506	2,101
0.2	TO	0.3	173.920	41.577	0.239	156	2,257
0.3	TO	0.4	173.596	58.783	0.339	60	2,317
0.4	TO	0.5	172.326	75.586	0.440	29	2,346
0.5	TO	0.6	157.254	84.167	0.538	6	2,352
0.6	TO	0.7	82.978	53.750	0.643	4	2,356
0.8	TO	0.9	101.450	86.000	0.848	2	2,358
0.9	TO	1	184.487	182.000	0.987	1	2,359
1	TO	2	124.213	157.500	1.294	6	2,365
WEIGHTED AVERAGE			182.869	16.583	0.095	2,365	

CONCENTRATION DISTRIBUTION
(GRAMS PER POUNDS)

CONTENT: GLASS, SLAG
CONTENT CODES: 7, 30, 40, 69, 90, 100, 102, 105, 114, 118, 150, 241, 368, 370, 372, 390, 391, 392, 393, 420, 421, 422, 425, 440, 441, 442, 470, 483, 810, 813, 834, 955, 990

CONCENTRATION RANGE	AVERAGE WEIGHT (LBS)	AVERAGE WEIGHT (GRAMS)	AVERAGE CONCENTRATION	NUMBER OF DRUMS	RUNNING TOTAL
0.0 TO 0.0	259.476	0.000	0.000	3,061	3,061
0.0 TO 0.0001	413.676	0.022	0.000	545	3,606
0.0001 TO 0.0002	439.185	0.067	0.000	231	3,837
0.0002 TO 0.0003	427.267	0.102	0.000	462	4,299
0.0003 TO 0.0004	427.995	0.148	0.000	150	4,449
0.0004 TO 0.0005	427.655	0.194	0.000	210	4,659
0.0005 TO 0.0006	410.879	0.228	0.001	187	4,846
0.0006 TO 0.0007	422.288	0.277	0.001	154	5,000
0.0007 TO 0.0008	429.254	0.321	0.001	168	5,168
0.0008 TO 0.0009	445.620	0.382	0.001	273	5,441
0.0009 TO 0.001	425.463	0.406	0.001	203	5,644
0.001 TO 0.002	420.960	0.592	0.001	823	6,467
0.002 TO 0.003	394.999	0.956	0.002	180	6,647
0.003 TO 0.004	414.046	1.422	0.003	342	6,989
0.004 TO 0.005	359.424	1.629	0.005	108	7,097
0.005 TO 0.006	319.335	1.738	0.005	79	7,176
0.006 TO 0.007	265.538	1.738	0.007	69	7,245
0.007 TO 0.008	187.521	1.406	0.008	114	7,359
0.008 TO 0.009	138.545	1.169	0.008	117	7,476
0.009 TO 0.01	134.718	1.272	0.009	107	7,583
0.01 TO 0.02	168.203	2.519	0.015	449	8,032
0.02 TO 0.03	166.416	4.133	0.025	299	8,331
0.03 TO 0.04	155.462	5.371	0.035	216	8,547
0.04 TO 0.05	149.800	6.723	0.045	155	8,702
0.05 TO 0.06	158.737	8.730	0.055	105	8,807
0.06 TO 0.07	147.030	9.495	0.065	82	8,889
0.07 TO 0.08	146.317	10.941	0.075	76	8,965
0.08 TO 0.09	149.841	12.754	0.085	52	9,017
0.09 TO 0.1	135.726	12.844	0.095	52	9,069
0.1 TO 0.2	160.457	23.130	0.144	346	9,415
0.2 TO 0.3	153.068	37.199	0.244	142	9,557
0.3 TO 0.4	154.185	53.179	0.344	84	9,641
0.4 TO 0.5	154.790	68.843	0.444	51	9,692
0.5 TO 0.6	130.079	71.839	0.553	36	9,728
0.6 TO 0.7	165.901	108.313	0.656	16	9,744
0.7 TO 0.8	156.676	116.059	0.742	17	9,761
0.8 TO 0.9	158.805	134.400	0.847	10	9,771
0.9 TO 1	166.081	157.200	0.946	15	9,786
1 TO 2	140.165	183.103	1.335	116	9,902
2 TO 3	86.549	175.500	2.028	2	9,904
WEIGHTED AVERAGE	298.211	6.437	0.043	9,904	

CONCENTRATION DISTRIBUTION
(GRAMS PER POUNDS)

CONTENT: CELLULOSE
CONTENT CODES: 10, 116, 119, 120, 121, 153, 203, 302, 328, 330, 331, 334, 335, 336, 338, 360, 361, 375, 376, 438, 464, 490, 491, 801, 805, 826, 827, 847, 900, 970

CONCENTRATION RANGE	AVERAGE WEIGHT (LBS)	AVERAGE WEIGHT (GRAMS)	AVERAGE CONCENTRATION	NUMBER OF DRUMS	RUNNING TOTAL
0.0 TO 0.0	128.471	0.000	0.000	11,704	11,704
0.0 TO 0.0001	87.712	0.007	0.000	242	11,946
0.0001 TO 0.0004	0.000	0.000	0.000	0	11,946
0.0004 TO 0.0005	202.449	0.100	0.000	2	11,948
0.0005 TO 0.0006	170.517	0.100	0.001	1	11,949
0.0006 TO 0.0007	160.538	0.100	0.001	1	11,950
0.0007 TO 0.0008	137.253	0.100	0.001	3	11,953
0.0008 TO 0.0009	119.624	0.100	0.001	1	11,954
0.0009 TO 0.001	105.986	0.100	0.001	3	11,957
0.001 TO 0.002	167.814	0.262	0.001	13	11,970
0.002 TO 0.003	205.965	0.529	0.003	7	11,977
0.003 TO 0.004	280.632	1.000	0.004	20	11,997
0.004 TO 0.005	218.420	0.983	0.005	105	12,102
0.005 TO 0.006	179.688	0.985	0.005	98	12,200
0.006 TO 0.007	164.307	1.077	0.007	39	12,239
0.007 TO 0.008	145.390	1.094	0.008	80	12,319
0.008 TO 0.009	138.329	1.174	0.009	100	12,419
0.009 TO 0.01	127.690	1.214	0.010	154	12,573
0.01 TO 0.02	121.232	1.758	0.014	840	13,413
0.02 TO 0.03	131.072	3.226	0.025	359	13,772
0.03 TO 0.04	133.219	4.618	0.035	226	13,998
0.04 TO 0.05	132.691	5.972	0.045	145	14,143
0.05 TO 0.06	134.601	7.435	0.055	93	14,236
0.06 TO 0.07	128.445	8.341	0.065	87	14,323
0.07 TO 0.08	135.407	10.180	0.075	84	14,407
0.08 TO 0.09	131.644	11.177	0.085	81	14,488
0.09 TO 0.1	117.754	11.241	0.095	63	14,551
0.1 TO 0.2	127.577	18.759	0.147	478	15,029
0.2 TO 0.3	119.392	29.389	0.248	297	15,326
0.3 TO 0.4	109.782	38.091	0.346	232	15,558
0.4 TO 0.5	101.206	45.643	0.451	174	15,732
0.5 TO 0.6	103.287	56.625	0.547	119	15,851
0.6 TO 0.7	97.979	63.553	0.648	73	15,924
0.7 TO 0.8	100.364	74.639	0.746	79	16,003
0.8 TO 0.9	101.052	86.033	0.851	60	16,063
0.9 TO 1	95.538	90.108	0.943	37	16,100
1 TO 2	85.108	117.427	1.392	251	16,351
2 TO 3	65.900	152.795	2.349	44	16,395
3 TO 4	44.465	150.222	3.381	9	16,404
4 TO 5	41.100	190.500	4.634	2	16,406
5 TO 6	35.600	196.000	5.506	1	16,407
6 TO 7	29.000	195.000	6.724	1	16,408
WEIGHTED AVERAGE	126.794	6.561	0.069	16,408	

CONCENTRATION DISTRIBUTION
(GRAMS PER POUNDS)

CONTENT: CONCRETE
CONTENT CODES: 1, 2, 4, 15, 95, 111, 113, 122, 152, 154, 157, 200, 204, 290, 292, 295, 299, 374, 701, 702, 811, 812, 836, 960, 976, 978, 980, 995

CONCENTRATION RANGE	AVERAGE WEIGHT (LBS)	AVERAGE WEIGHT (GRAMS)	AVERAGE CONCENTRATION	NUMBER OF DRUMS	RUNNING TOTAL
0.0 TO 0.0	417.311	0.000	0.000	3,439	3,439
0.0 TO 0.0001	432.456	0.037	0.000	845	4,284
0.0001 TO 0.0002	525.149	0.092	0.000	416	4,700
0.0002 TO 0.0003	442.838	0.102	0.000	407	5,107
0.0003 TO 0.0004	425.422	0.149	0.000	154	5,261
0.0004 TO 0.0005	449.668	0.204	0.000	251	5,512
0.0005 TO 0.0006	493.549	0.279	0.001	778	6,290
0.0006 TO 0.0007	461.033	0.299	0.001	3,203	9,493
0.0007 TO 0.0008	411.691	0.304	0.001	1,655	11,148
0.0008 TO 0.0009	425.219	0.363	0.001	693	11,841
0.0009 TO 0.001	421.457	0.398	0.001	556	12,397
0.001 TO 0.002	422.701	0.621	0.001	1,291	13,688
0.002 TO 0.003	430.762	1.069	0.002	1,181	14,869
0.003 TO 0.004	433.673	1.522	0.004	1,281	16,150
0.004 TO 0.005	434.121	1.952	0.005	1,310	17,460
0.005 TO 0.006	431.571	2.365	0.005	1,274	18,734
0.006 TO 0.007	433.792	2.806	0.006	1,147	19,881
0.007 TO 0.008	422.391	3.162	0.007	927	20,808
0.008 TO 0.009	420.539	3.572	0.008	764	21,572
0.009 TO 0.01	422.623	4.015	0.010	637	22,209
0.01 TO 0.02	404.589	5.591	0.014	3,253	25,462
0.02 TO 0.03	379.565	8.990	0.024	1,062	26,524
0.03 TO 0.04	321.552	10.968	0.034	270	26,794
0.04 TO 0.05	270.283	12.050	0.045	134	26,928
0.05 TO 0.06	216.825	11.815	0.055	73	27,001
0.06 TO 0.07	218.999	14.324	0.065	54	27,055
0.07 TO 0.08	237.709	17.772	0.075	29	27,084
0.08 TO 0.09	208.911	17.786	0.085	35	27,119
0.09 TO 0.1	197.267	18.785	0.095	24	27,143
0.1 TO 0.2	190.558	27.613	0.146	172	27,315
0.2 TO 0.3	186.159	45.105	0.243	73	27,388
0.3 TO 0.4	181.750	63.055	0.348	56	27,444
0.4 TO 0.5	202.340	90.912	0.449	32	27,476
0.5 TO 0.6	200.969	107.813	0.535	16	27,492
0.6 TO 0.7	163.079	103.909	0.639	11	27,503
0.7 TO 0.8	144.056	105.833	0.735	6	27,509
0.8 TO 0.9	165.457	141.400	0.854	5	27,514
0.9 TO 1	152.269	145.750	0.957	4	27,518
1 TO 2	124.792	140.250	1.133	8	27,526
WEIGHTED AVERAGE	422.036	2.881	0.010	27,526	

CONCENTRATION DISTRIBUTION
(GRAMS PER POUNDS)

CONTENT: METALS
CONTENT CODES: 20, 101, 117, 155, 156, 201, 320, 321, 333, 416, 480, 481, 482, 488, 803, 824, 825, 950

CONCENTRATION RANGE			AVERAGE WEIGHT (LBS)	AVERAGE WEIGHT (GRAMS)	AVERAGE CONCENTRATION	NUMBER OF DRUMS	RUNNING TOTAL
0.0	TO	0.0	189.293	0.000	0.000	1,931	1,931
0.0	TO	0.0001	181.629	0.016	0.000	69	2,000
0.0001	TO	0.001	0.000	0.000	0.000	0	2,000
0.001	TO	0.002	290.264	0.300	0.001	1	2,001
0.002	TO	0.003	404.113	1.000	0.003	11	2,012
0.003	TO	0.004	284.081	1.000	0.004	28	2,040
0.004	TO	0.005	237.408	1.051	0.004	39	2,079
0.005	TO	0.006	193.976	1.088	0.006	34	2,113
0.006	TO	0.007	201.935	1.324	0.007	34	2,147
0.007	TO	0.008	192.591	1.432	0.007	37	2,184
0.008	TO	0.009	175.437	1.500	0.009	26	2,210
0.009	TO	0.01	179.818	1.722	0.010	18	2,228
0.01	TO	0.02	167.309	2.489	0.015	231	2,459
0.02	TO	0.03	180.465	4.483	0.025	151	2,610
0.03	TO	0.04	177.298	6.129	0.035	126	2,736
0.04	TO	0.05	177.481	7.971	0.045	103	2,839
0.05	TO	0.06	204.652	11.191	0.055	98	2,937
0.06	TO	0.07	208.940	13.474	0.065	78	3,015
0.07	TO	0.08	204.911	15.366	0.075	71	3,086
0.08	TO	0.09	203.113	17.269	0.085	52	3,138
0.09	TO	0.1	214.661	20.386	0.095	70	3,208
0.1	TO	0.2	201.945	28.646	0.142	377	3,585
0.2	TO	0.3	178.650	42.942	0.241	171	3,756
0.3	TO	0.4	149.544	52.092	0.349	65	3,821
0.4	TO	0.5	128.829	57.340	0.447	50	3,871
0.5	TO	0.6	106.396	58.068	0.547	44	3,915
0.6	TO	0.7	107.823	70.107	0.652	27	3,942
0.7	TO	0.8	113.905	85.690	0.755	29	3,971
0.8	TO	0.9	105.353	90.176	0.856	17	3,988
0.9	TO	1	119.717	113.818	0.952	11	3,999
1	TO	2	109.579	130.700	1.201	30	4,029
2	TO	3	0.000	0.000	0.000	0	4,029
3	TO	4	22.400	77.000	3.438	1	4,030
WEIGHTED AVERAGE			186.491	11.615	0.078	4,030	

CONCENTRATION DISTRIBUTION
(GRAMS PER POUNDS)

CONTENT: SALTS
CONTENT CODES: 5, 124, 409, 410, 411, 412, 413, 414, 429, 454

CONCENTRATION RANGE	AVERAGE WEIGHT (LBS)	AVERAGE WEIGHT (GRAMS)	AVERAGE CONCENTRATION	NUMBER OF DRUMS	RUNNING TOTAL
0.0 TO 0.0	348.641	0.000	0.000	4	4
0.004 TO 0.005	375.335	1.600	0.004	4	8
0.005 TO 0.006	189.975	1.000	0.005	2	10
0.008 TO 0.009	242.365	2.000	0.008	1	11
0.01 TO 0.02	257.391	3.715	0.014	8	19
0.02 TO 0.03	191.472	5.333	0.028	3	22
0.03 TO 0.04	239.372	9.000	0.038	1	23
0.04 TO 0.05	309.224	14.000	0.045	2	25
0.05 TO 0.06	313.216	16.000	0.051	1	26
0.08 TO 0.09	251.346	21.500	0.086	2	28
0.1 TO 0.2	143.324	17.250	0.120	4	32
0.2 TO 0.3	245.398	60.250	0.246	4	36
0.3 TO 0.4	175.850	61.500	0.350	4	40
0.4 TO 0.5	205.000	100.000	0.488	1	41
0.5 TO 0.6	155.918	84.333	0.541	3	44
0.6 TO 0.7	293.000	191.000	0.652	1	45
0.7 TO 0.8	209.400	158.400	0.756	5	50
0.8 TO 0.9	190.333	158.833	0.835	6	56
0.9 TO 1	178.600	169.000	0.946	5	61
1 TO 2	129.848	160.222	1.234	9	70
2 TO 3	65.507	159.875	2.441	8	78
3 TO 4	57.322	190.889	3.330	9	87
6 TO 7	20.200	123.000	6.089	1	88
WEIGHTED AVERAGE	185.913	95.501	0.514	88	

CONCENTRATION DISTRIBUTION
(GRAMS PER POUNDS)

CONTENT: BRICK
CONTENT CODES: 371, 373, 377, 378, 379

CONCENTRATION RANGE	AVERAGE WEIGHT (LBS)	AVERAGE WEIGHT (GRAMS)	AVERAGE CONCENTRATION	NUMBER OF DRUMS	RUNNING TOTAL
0.0 TO 0.0	326.978	0.000	0.000	691	691
0.0 TO 0.0001	184.222	0.017	0.000	9	700
0.0001 TO 0.001	0.000	0.000	0.000	0	700
0.001 TO 0.002	530.259	1.000	0.002	2	702
0.002 TO 0.003	412.974	1.000	0.002	39	741
0.003 TO 0.004	293.594	1.000	0.003	20	761
0.004 TO 0.005	262.893	1.143	0.004	7	768
0.005 TO 0.006	260.811	1.375	0.005	8	776
0.006 TO 0.007	154.433	1.000	0.006	8	784
0.007 TO 0.008	210.850	1.571	0.007	7	791
0.008 TO 0.009	261.932	2.167	0.008	6	797
0.009 TO 0.01	174.692	1.667	0.009	3	800
0.01 TO 0.02	224.396	2.867	0.014	15	815
0.02 TO 0.03	197.373	4.867	0.025	15	830
0.03 TO 0.04	183.874	6.077	0.033	13	843
0.04 TO 0.05	194.637	8.875	0.045	16	859
0.05 TO 0.06	142.026	7.667	0.053	6	865
0.06 TO 0.07	163.531	10.600	0.064	10	875
0.07 TO 0.08	140.422	10.600	0.075	5	880
0.08 TO 0.09	173.127	14.833	0.085	6	886
0.09 TO 0.1	183.218	17.556	0.095	9	895
0.1 TO 0.2	185.333	27.593	0.148	54	949
0.2 TO 0.3	154.856	37.367	0.241	30	979
0.3 TO 0.4	173.539	58.733	0.340	15	994
0.4 TO 0.5	127.838	58.956	0.461	16	1,010
0.5 TO 0.6	146.391	81.857	0.560	7	1,017
0.6 TO 0.7	141.747	90.944	0.640	9	1,026
0.7 TO 0.8	153.300	120.500	0.786	2	1,028
0.8 TO 0.9	142.300	119.500	0.840	2	1,030
0.9 TO 1	161.000	153.000	0.950	1	1,031
WEIGHTED AVERAGE	290.432	7.145	0.045	1,031	

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MATRIX WEIGHT DISTRIBUTION
(POUNDS)

CONTENT: ALL
CONTENT CODES: ALL

MATRIX WEIGHT RANGE	AVERAGE WEIGHT (LBS)	NUMBER OF DRUMS	RUNNING TOTAL
10 TO 25 LBS.	22.74	8	8
25 TO 50 LBS.	42.79	425	433
50 TO 75 LBS.	64.56	2,777	3,210
75 TO 100 LBS.	88.02	5,442	8,652
100 TO 125 LBS.	112.11	6,436	15,088
125 TO 150 LBS.	136.68	4,702	19,790
150 TO 175 LBS.	161.45	3,691	23,481
175 TO 200 LBS.	185.82	3,148	26,629
200 TO 225 LBS.	210.05	2,417	29,046
225 TO 250 LBS.	236.34	1,685	30,731
250 TO 275 LBS.	262.65	1,206	31,937
275 TO 300 LBS.	287.72	1,054	32,991
300 TO 325 LBS.	312.79	1,294	34,285
325 TO 350 LBS.	337.45	1,749	36,034
350 TO 375 LBS.	361.34	2,885	38,919
375 TO 400 LBS.	385.37	4,500	43,419
400 TO 425 LBS.	413.27	8,174	51,593
425 TO 450 LBS.	440.44	6,303	57,896
450 TO 475 LBS.	464.32	5,240	63,136
475 TO 500 LBS.	488.04	3,915	67,051
500 TO 525 LBS.	512.30	2,364	69,415
525 TO 550 LBS.	536.66	1,519	70,934
550 TO 575 LBS.	560.63	775	71,709
575 TO 600 LBS.	584.51	424	72,133
600 TO 625 LBS.	610.62	311	72,444
625 TO 650 LBS.	638.94	145	72,589
650 TO 675 LBS.	663.52	76	72,665
675 TO 700 LBS.	687.83	32	72,697
700 TO 725 LBS.	710.26	19	72,716
725 TO 750 LBS.	733.38	13	72,729
750 TO 775 LBS.	753.29	1	72,730
775 TO 800 LBS.	784.22	3	72,733
800 TO 825 LBS.	814.09	2	72,735
900 TO 925 LBS.	922.20	1	72,736
WEIGHTED AVERAGE	302.53	72,736	

RWMCSR3H
RUN DATE: 10/14/93

MATRIX WEIGHT DISTRIBUTION
(POUNDS)

CONTENT: POLYETHYLENE
CONTENT CODES: 3, 112, 123, 153, 202, 332, 337, 339, 423, 430, 431, 432, 460, 463, 700, 802, 804, 812,

MATRIX WEIGHT RANGE	AVERAGE WEIGHT (LBS)	NUMBER OF DRUMS	RUNNING TOTAL
10 TO 25 LBS.	23.16	3	3
25 TO 50 LBS.	42.27	26	29
50 TO 75 LBS.	64.71	670	699
75 TO 100 LBS.	86.28	647	1,346
100 TO 125 LBS.	110.66	405	1,751
125 TO 150 LBS.	137.60	314	2,065
150 TO 175 LBS.	161.43	254	2,319
175 TO 200 LBS.	184.92	186	2,505
200 TO 225 LBS.	209.66	192	2,697
225 TO 250 LBS.	237.55	247	2,944
250 TO 275 LBS.	264.03	241	3,185
275 TO 300 LBS.	288.17	237	3,422
300 TO 325 LBS.	312.79	303	3,725
325 TO 350 LBS.	337.80	429	4,154
350 TO 375 LBS.	362.34	762	4,916
375 TO 400 LBS.	386.55	997	5,913
400 TO 425 LBS.	412.74	1,258	7,171
425 TO 450 LBS.	438.98	1,021	8,192
450 TO 475 LBS.	464.36	988	9,180
475 TO 500 LBS.	488.39	848	10,028
500 TO 525 LBS.	512.74	620	10,648
525 TO 550 LBS.	536.63	427	11,075
550 TO 575 LBS.	559.38	186	11,261
575 TO 600 LBS.	582.04	66	11,327
600 TO 625 LBS.	609.27	35	11,362
625 TO 650 LBS.	638.67	10	11,372
650 TO 675 LBS.	662.25	2	11,374
675 TO 700 LBS.	684.22	2	11,376
WEIGHTED AVERAGE	347.47	11,376	

RWMCSR3H
RUN DATE: 10/14/93

MATRIX WEIGHT DISTRIBUTION
(POUNDS)

CONTENT: GRAPHITE
CONTENT CODES: 115, 300, 301, 303, 310, 311, 312, 814

MATRIX WEIGHT RANGE	AVERAGE WEIGHT (LBS)	NUMBER OF DRUMS	RUNNING TOTAL
25 TO 50 LBS.	45.50	6	6
50 TO 75 LBS.	62.58	10	16
75 TO 100 LBS.	89.61	18	34
100 TO 125 LBS.	113.57	50	84
125 TO 150 LBS.	141.24	177	261
150 TO 175 LBS.	162.35	636	897
175 TO 200 LBS.	185.34	802	1,699
200 TO 225 LBS.	208.40	484	2,183
225 TO 250 LBS.	232.96	114	2,297
250 TO 275 LBS.	260.32	31	2,328
275 TO 300 LBS.	284.77	17	2,345
300 TO 325 LBS.	306.66	7	2,352
325 TO 350 LBS.	336.83	4	2,356
375 TO 400 LBS.	381.00	4	2,360
400 TO 425 LBS.	406.60	5	2,365
WEIGHTED AVERAGE	182.85	2,365	

RWMCSR3H
RUN DATE: 10/14/93

MATRIX WEIGHT DISTRIBUTION
(POUNDS)

CONTENT: GLASS, SLAG
CONTENT CODES: 7, 30, 40, 69, 90, 100, 102, 105, 114, 118, 150, 241, 368, 370, 372, 390, 391, 392, 393, 420, 421, 422, 425, 440, 441, 442, 470, 483, 810, 813, 834, 955, 990

MATRIX WEIGHT RANGE	AVERAGE WEIGHT (LBS)	NUMBER OF DRUMS	RUNNING TOTAL
10 TO 25 LBS.	24.60	1	1
25 TO 50 LBS.	43.26	19	20
50 TO 75 LBS.	64.76	75	95
75 TO 100 LBS.	91.22	395	490
100 TO 125 LBS.	113.52	1,607	2,097
125 TO 150 LBS.	135.48	1,188	3,285
150 TO 175 LBS.	160.08	406	3,691
175 TO 200 LBS.	185.77	235	3,926
200 TO 225 LBS.	210.71	224	4,150
225 TO 250 LBS.	236.94	180	4,330
250 TO 275 LBS.	264.49	141	4,471
275 TO 300 LBS.	287.72	104	4,575
300 TO 325 LBS.	313.86	145	4,720
325 TO 350 LBS.	337.54	237	4,957
350 TO 375 LBS.	360.73	345	5,302
375 TO 400 LBS.	383.96	658	5,960
400 TO 425 LBS.	414.00	1,476	7,436
425 TO 450 LBS.	443.52	880	8,316
450 TO 475 LBS.	466.46	669	8,985
475 TO 500 LBS.	489.59	384	9,369
500 TO 525 LBS.	513.00	212	9,581
525 TO 550 LBS.	536.57	95	9,676
550 TO 575 LBS.	560.21	59	9,735
575 TO 600 LBS.	585.91	48	9,783
600 TO 625 LBS.	610.50	45	9,828
625 TO 650 LBS.	635.86	39	9,867
650 TO 675 LBS.	663.22	23	9,890
675 TO 700 LBS.	684.75	5	9,895
700 TO 725 LBS.	708.88	6	9,901
725 TO 750 LBS.	739.32	1	9,902
800 TO 825 LBS.	821.00	1	9,903
900 TO 925 LBS.	922.20	1	9,904
WEIGHTED AVERAGE	298.09	9,904	

RWMCSR3H
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MATRIX WEIGHT DISTRIBUTION
(POUNDS)

CONTENT: CELLULOSE
CONTENT CODES: 10, 116, 119, 120, 121, 153, 203, 302, 309, 328, 330, 331, 334, 335, 336, 338, 360, 361, 375, 376, 438, 464, 490, 491, 801, 805, 826, 827, 847, 900, 970

MATRIX WEIGHT RANGE	AVERAGE WEIGHT (LBS)	NUMBER OF DRUMS	RUNNING TOTAL
10 TO 25 LBS.	22.61	2	2
25 TO 50 LBS.	42.51	283	285
50 TO 75 LBS.	64.87	1,650	1,935
75 TO 100 LBS.	88.01	3,868	5,803
100 TO 125 LBS.	111.41	3,738	9,541
125 TO 150 LBS.	136.56	2,317	11,858
150 TO 175 LBS.	161.35	1,679	13,537
175 TO 200 LBS.	185.80	1,195	14,732
200 TO 225 LBS.	210.09	808	15,540
225 TO 250 LBS.	235.70	462	16,002
250 TO 275 LBS.	259.65	217	16,219
275 TO 300 LBS.	284.83	85	16,304
300 TO 325 LBS.	308.83	45	16,349
325 TO 350 LBS.	335.95	19	16,368
350 TO 375 LBS.	361.94	17	16,385
375 TO 400 LBS.	382.21	7	16,392
400 TO 425 LBS.	401.03	2	16,394
425 TO 450 LBS.	443.11	6	16,400
450 TO 475 LBS.	459.16	4	16,404
500 TO 525 LBS.	500.82	1	16,405
525 TO 550 LBS.	535.75	1	16,406
650 TO 675 LBS.	661.48	1	16,407
WEIGHTED AVERAGE	126.65	16,407	

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RUN DATE: 10/14/93 PAGE NO.: 1

MATRIX WEIGHT DISTRIBUTION
(POUNDS)

CONTENT: CONCRETE
CONTENT CODES: 1, 2, 4, 15, 95, 111, 113, 122, 152, 154, 157, 200, 204, 290, 292, 295, 299, 374, 701, 702, 811, 812, 836, 863, 960, 976, 978, 980, 995

MATRIX WEIGHT RANGE	AVERAGE WEIGHT (LBS)	NUMBER OF DRUMS	RUNNING TOTAL
25 TO 50 LBS.	39.45	4	4
50 TO 75 LBS.	66.70	36	40
75 TO 100 LBS.	87.76	107	147
100 TO 125 LBS.	114.36	175	322
125 TO 150 LBS.	137.63	185	507
150 TO 175 LBS.	162.13	210	717
175 TO 200 LBS.	186.92	294	1,011
200 TO 225 LBS.	211.11	289	1,300
225 TO 250 LBS.	236.44	282	1,582
250 TO 275 LBS.	263.72	253	1,835
275 TO 300 LBS.	289.17	324	2,159
300 TO 325 LBS.	313.71	522	2,681
325 TO 350 LBS.	337.62	895	3,576
350 TO 375 LBS.	361.05	1,627	5,203
375 TO 400 LBS.	385.23	2,751	7,954
400 TO 425 LBS.	413.22	5,356	13,310
425 TO 450 LBS.	440.18	4,333	17,643
450 TO 475 LBS.	463.91	3,531	21,174
475 TO 500 LBS.	487.72	2,637	23,811
500 TO 525 LBS.	511.99	1,510	25,321
525 TO 550 LBS.	536.67	980	26,301
550 TO 575 LBS.	561.01	514	26,815
575 TO 600 LBS.	584.64	292	27,107
600 TO 625 LBS.	610.75	222	27,329
625 TO 650 LBS.	640.17	95	27,424
650 TO 675 LBS.	663.75	50	27,474
675 TO 700 LBS.	688.33	24	27,498
700 TO 725 LBS.	711.02	12	27,510
725 TO 750 LBS.	732.76	11	27,521
750 TO 775 LBS.	753.29	1	27,522
775 TO 800 LBS.	784.22	3	27,525
800 TO 825 LBS.	807.18	1	27,526
WEIGHTED AVERAGE	421.63	27,526	

RWMCSR3H
RUN DATE: 10/14/93

MATRIX WEIGHT DISTRIBUTION
(POUNDS)

CONTENT: METALS
CONTENT CODES: 20, 101, 117, 155, 156, 201, 320, 321, 333, 416, 480, 481, 482, 488, 803, 824, 825, 950

MATRIX WEIGHT RANGE	AVERAGE WEIGHT (LBS)	NUMBER OF DRUMS	RUNNING TOTAL
10 TO 25 LBS.	22.40	1	1
25 TO 50 LBS.	44.24	78	79
50 TO 75 LBS.	62.47	314	393
75 TO 100 LBS.	87.83	380	773
100 TO 125 LBS.	112.92	412	1,185
125 TO 150 LBS.	136.89	404	1,589
150 TO 175 LBS.	161.72	428	2,017
175 TO 200 LBS.	186.54	375	2,392
200 TO 225 LBS.	210.94	374	2,766
225 TO 250 LBS.	236.58	330	3,096
250 TO 275 LBS.	261.77	253	3,349
275 TO 300 LBS.	286.27	198	3,547
300 TO 325 LBS.	310.94	167	3,714
325 TO 350 LBS.	335.75	106	3,820
350 TO 375 LBS.	361.26	83	3,903
375 TO 400 LBS.	384.63	35	3,938
400 TO 425 LBS.	412.14	29	3,967
425 TO 450 LBS.	438.64	16	3,983
450 TO 475 LBS.	464.57	12	3,995
475 TO 500 LBS.	486.56	17	4,012
500 TO 525 LBS.	518.03	4	4,016
525 TO 550 LBS.	542.98	4	4,020
550 TO 575 LBS.	568.01	3	4,023
575 TO 600 LBS.	587.64	2	4,025
600 TO 625 LBS.	620.29	2	4,027
625 TO 650 LBS.	645.00	1	4,028
675 TO 700 LBS.	698.40	1	4,029
725 TO 750 LBS.	734.33	1	4,030
WEIGHTED AVERAGE	186.47	4,030	

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MATRIX WEIGHT DISTRIBUTION
(POUNDS)

CONTENT: SALTS
CONTENT CODES: 5, 124, 409, 410, 411, 412, 413, 414, 429, 454

MATRIX WEIGHT RANGE	AVERAGE WEIGHT (LBS)	NUMBER OF DRUMS	RUNNING TOTAL
10 TO 25 LBS.	20.20	1	1
25 TO 50 LBS.	34.87	3	4
50 TO 75 LBS.	61.01	13	17
75 TO 100 LBS.	83.80	6	23
100 TO 125 LBS.	114.55	3	26
125 TO 150 LBS.	134.93	3	29
150 TO 175 LBS.	162.17	5	34
175 TO 200 LBS.	184.13	19	53
200 TO 225 LBS.	207.90	7	60
225 TO 250 LBS.	232.69	8	68
250 TO 275 LBS.	270.65	2	70
275 TO 300 LBS.	292.69	4	74
300 TO 325 LBS.	312.59	8	82
325 TO 350 LBS.	348.14	1	83
350 TO 375 LBS.	361.12	2	85
400 TO 425 LBS.	405.02	1	86
425 TO 450 LBS.	438.45	2	88
WEIGHTED AVERAGE	185.91	88	

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MATRIX WEIGHT DISTRIBUTION
(POUNDS)

CONTENT: BRICK
CONTENT CODES: 371, 373, 377, 378, 379

MATRIX WEIGHT RANGE	AVERAGE WEIGHT (LBS)	NUMBER OF DRUMS	RUNNING TOTAL
25 TO 50 LBS.	41.20	6	6
50 TO 75 LBS.	65.86	9	15
75 TO 100 LBS.	89.07	20	35
100 TO 125 LBS.	115.50	46	81
125 TO 150 LBS.	139.86	114	195
150 TO 175 LBS.	160.26	73	268
175 TO 200 LBS.	186.46	41	309
200 TO 225 LBS.	212.21	38	347
225 TO 250 LBS.	239.90	60	407
250 TO 275 LBS.	263.80	68	475
275 TO 300 LBS.	287.42	84	559
300 TO 325 LBS.	311.78	97	656
325 TO 350 LBS.	335.43	58	714
350 TO 375 LBS.	359.76	48	762
375 TO 400 LBS.	389.55	48	810
400 TO 425 LBS.	411.25	46	856
425 TO 450 LBS.	439.48	45	901
450 TO 475 LBS.	464.61	35	936
475 TO 500 LBS.	487.92	29	965
500 TO 525 LBS.	515.20	17	982
525 TO 550 LBS.	535.58	12	994
550 TO 575 LBS.	563.84	13	1,007
575 TO 600 LBS.	587.51	16	1,023
600 TO 625 LBS.	611.44	7	1,030
700 TO 725 LBS.	709.38	1	1,031
WEIGHTED AVERAGE	290.42	1,031	

CONCENTRATION DISTRIBUTION
(GRAMS PER POUNDS)

CONTENT: ALL
CONTENT CODES: ALL

CONCENTRATION RANGE	AVERAGE WEIGHT (LBS)	AVERAGE WEIGHT (GRAMS)	AVERAGE CONCENTRATION	NUMBER OF BOXES	RUNNING TOTAL
0.0 TO 0.0	2,570.754	0.000	0.000	1,182	1,182
0.0 TO 0.0001	2,434.270	0.167	0.000	2,334	3,516
0.0001 TO 0.0002	2,211.846	0.277	0.000	290	3,806
0.0002 TO 0.0003	2,631.235	0.656	0.000	57	3,863
0.0003 TO 0.0004	2,589.960	0.911	0.000	63	3,926
0.0004 TO 0.0005	2,507.764	1.126	0.000	39	3,965
0.0005 TO 0.0006	1,989.785	1.100	0.001	84	4,049
0.0006 TO 0.0007	2,054.403	1.324	0.001	84	4,133
0.0007 TO 0.0008	2,342.338	1.729	0.001	42	4,175
0.0008 TO 0.0009	2,029.640	1.718	0.001	50	4,225
0.0009 TO 0.001	2,255.317	2.140	0.001	43	4,268
0.001 TO 0.002	2,828.830	4.347	0.002	460	4,728
0.002 TO 0.003	2,590.044	6.467	0.002	411	5,139
0.003 TO 0.004	2,508.740	8.742	0.003	457	5,596
0.004 TO 0.005	2,468.500	11.087	0.004	440	6,036
0.005 TO 0.006	2,200.970	12.002	0.005	333	6,369
0.006 TO 0.007	1,927.524	12.520	0.006	307	6,676
0.007 TO 0.008	1,892.677	14.111	0.007	222	6,898
0.008 TO 0.009	1,992.644	16.818	0.008	151	7,049
0.009 TO 0.01	2,051.391	19.506	0.010	144	7,193
0.01 TO 0.02	1,878.125	27.295	0.015	973	8,166
0.02 TO 0.03	1,889.342	46.401	0.025	588	8,754
0.03 TO 0.04	1,864.724	64.535	0.035	378	9,132
0.04 TO 0.05	2,034.444	91.638	0.045	213	9,345
0.05 TO 0.06	1,923.804	105.591	0.055	154	9,499
0.06 TO 0.07	2,048.376	132.540	0.065	115	9,614
0.07 TO 0.08	2,282.483	169.459	0.074	70	9,684
0.08 TO 0.09	2,045.548	173.823	0.085	62	9,746
0.09 TO 0.1	2,221.266	212.111	0.095	54	9,800
0.1 TO 0.2	1,889.217	241.295	0.128	136	9,936
0.2 TO 0.3	1,455.586	332.200	0.228	5	9,941
0.3 TO 0.4	1,679.000	635.500	0.378	2	9,943
WEIGHTED AVERAGE	2,276.093	23.133	0.010	9,943	

CONCENTRATION DISTRIBUTION
(GRAMS PER POUNDS)

CONTENT: POLYETHYLENE
CONTENT CODES: 3, 112, 123, 153, 202, 332, 337, 339, 423, 430, 431, 432, 460, 463, 700, 802, 804, 812,

CONCENTRATION RANGE	AVERAGE WEIGHT (LBS)	AVERAGE WEIGHT (GRAMS)	AVERAGE CONCENTRATION	NUMBER OF BOXES	RUNNING TOTAL
0.0 TO 0.0001	2,781.016	0.180	0.000	10	10
0.0003 TO 0.0004	2,874.820	1.000	0.000	1	11
0.0006 TO 0.0007	1,569.000	1.000	0.001	1	12
0.0008 TO 0.0009	2,395.829	2.000	0.001	1	13
0.001 TO 0.002	2,648.629	3.667	0.001	3	16
0.002 TO 0.003	2,974.610	8.000	0.003	1	17
0.005 TO 0.006	2,854.862	16.000	0.006	1	18
0.008 TO 0.009	2,415.787	21.000	0.009	2	20
0.009 TO 0.01	1,318.099	13.000	0.010	1	21
0.02 TO 0.03	1,657.000	39.000	0.024	1	22
0.03 TO 0.04	1,701.000	53.000	0.031	1	23
0.1 TO 0.2	1,838.500	296.250	0.161	4	27
WEIGHTED AVERAGE	2,418.031	50.844	0.021	27	

CONCENTRATION DISTRIBUTION
(GRAMS PER POUNDS)

CONTENT: GRAPHITE
CONTENT CODES: 115, 300, 301, 303, 310, 311, 312, 814

CONCENTRATION RANGE	AVERAGE WEIGHT (LBS)	AVERAGE WEIGHT (GRAMS)	AVERAGE CONCENTRATION	NUMBER OF BOXES	RUNNING TOTAL
0.006 TO 0.007	1,876.922	13.000	0.007	1	1
WEIGHTED AVERAGE	1,876.920	13.000	0.007	1	

CONCENTRATION DISTRIBUTION
(GRAMS PER POUNDS)

CONTENT: GLASS, SLAG
CONTENT CODES: 7, 30, 40, 69, 90, 100, 102, 105, 114, 118, 150, 241, 368, 370, 372, 390, 391, 392, 393, 420, 421, 422, 425, 440, 441, 442, 470, 483, 810, 813, 834, 955, 990

CONCENTRATION RANGE	AVERAGE WEIGHT (LBS)	AVERAGE WEIGHT (GRAMS)	AVERAGE CONCENTRATION	NUMBER OF BOXES	RUNNING TOTAL
0.0 TO 0.0001	3,901.000	0.350	0.000	1	1
0.0003 TO 0.0004	2,801.000	1.000	0.000	1	2
0.0007 TO 0.0008	2,801.000	2.000	0.001	1	3
0.001 TO 0.002	3,241.000	5.000	0.002	2	5
0.002 TO 0.003	3,725.000	9.800	0.003	5	10
0.003 TO 0.004	3,461.000	12.000	0.003	1	11
0.004 TO 0.005	2,654.333	11.900	0.004	3	14
0.005 TO 0.006	2,623.592	15.000	0.006	2	16
0.006 TO 0.007	2,801.000	18.000	0.006	2	18
0.007 TO 0.008	3,314.333	24.333	0.007	3	21
0.008 TO 0.009	3,241.000	27.000	0.008	1	22
0.01 TO 0.02	2,485.235	36.235	0.015	17	39
0.02 TO 0.03	2,268.111	55.000	0.024	9	48
0.03 TO 0.04	2,410.500	86.376	0.036	12	60
0.04 TO 0.05	2,801.000	131.667	0.047	3	63
0.05 TO 0.06	2,354.400	129.100	0.055	10	73
0.06 TO 0.07	2,940.333	197.667	0.067	3	76
0.07 TO 0.08	3,076.000	222.250	0.072	4	80
0.08 TO 0.09	2,639.667	233.000	0.088	3	83
0.09 TO 0.1	2,691.000	249.000	0.093	2	85
0.1 TO 0.2	2,172.131	251.500	0.116	6	91
0.2 TO 0.3	1,481.000	309.001	0.209	1	92
WEIGHTED AVERAGE	2,636.326	93.550	0.035	92	

CONCENTRATION DISTRIBUTION
(GRAMS PER POUNDS)

CONTENT: CELLULOSE
CONTENT CODES: 10, 116, 119, 120, 121, 153, 203, 302, 328, 330, 331, 334, 335, 336, 338, 360, 361, 375, 376, 438, 464, 490, 491, 801, 805, 826, 827, 847, 900, 970

CONCENTRATION RANGE	AVERAGE WEIGHT (LBS)	AVERAGE WEIGHT (GRAMS)	AVERAGE CONCENTRATION	NUMBER OF BOXES	RUNNING TOTAL
0.0 TO 0.0	1,520.628	0.000	0.000	191	191
0.0 TO 0.0001	1,875.560	0.119	0.000	904	1,095
0.0001 TO 0.0002	1,938.670	0.247	0.000	126	1,221
0.0002 TO 0.0003	1,841.611	0.423	0.000	13	1,234
0.0003 TO 0.0004	1,980.037	0.700	0.000	12	1,246
0.0004 TO 0.0005	2,110.196	0.953	0.000	15	1,261
0.0005 TO 0.0006	1,830.283	1.014	0.001	63	1,324
0.0006 TO 0.0007	1,625.188	1.041	0.001	58	1,382
0.0007 TO 0.0008	1,627.880	1.195	0.001	22	1,404
0.0008 TO 0.0009	1,732.425	1.468	0.001	34	1,438
0.0009 TO 0.001	1,672.268	1.594	0.001	18	1,456
0.001 TO 0.002	1,799.813	2.666	0.001	253	1,709
0.002 TO 0.003	1,723.007	4.304	0.002	226	1,935
0.003 TO 0.004	1,725.481	6.000	0.003	240	2,175
0.004 TO 0.005	1,737.281	7.821	0.005	153	2,328
0.005 TO 0.006	1,788.362	9.878	0.006	167	2,495
0.006 TO 0.007	1,725.181	11.233	0.007	191	2,686
0.007 TO 0.008	1,708.108	12.747	0.007	159	2,845
0.008 TO 0.009	1,632.069	13.788	0.008	108	2,953
0.009 TO 0.01	1,669.316	15.839	0.009	97	3,050
0.01 TO 0.02	1,625.972	23.441	0.014	747	3,797
0.02 TO 0.03	1,613.235	39.491	0.024	459	4,256
0.03 TO 0.04	1,602.322	55.803	0.035	286	4,542
0.04 TO 0.05	1,628.071	73.199	0.045	145	4,687
0.05 TO 0.06	1,517.622	83.121	0.055	99	4,786
0.06 TO 0.07	1,532.418	99.092	0.065	66	4,852
0.07 TO 0.08	1,538.529	115.094	0.075	32	4,884
0.08 TO 0.09	1,545.575	130.343	0.084	35	4,919
0.09 TO 0.1	1,662.027	157.450	0.095	20	4,939
0.1 TO 0.2	1,499.695	201.789	0.135	66	5,005
0.2 TO 0.3	1,511.977	355.333	0.235	3	5,008
0.3 TO 0.4	1,679.000	635.500	0.378	2	5,010
WEIGHTED AVERAGE	1,706.748	23.464	0.014	5,010	

CONCENTRATION DISTRIBUTION
(GRAMS PER POUNDS)

CONTENT: CONCRETE
CONTENT CODES: 1, 2, 4, 15, 95, 111, 113, 122, 152, 154, 157, 200, 204, 290, 292, 295, 299, 374, 701, 702, 811, 812, 836, 960, 976, 978, 980, 995

CONCENTRATION RANGE	AVERAGE WEIGHT (LBS)	AVERAGE WEIGHT (GRAMS)	AVERAGE CONCENTRATION	NUMBER OF BOXES	RUNNING TOTAL
0.0 TO 0.0	4,086.876	0.000	0.000	164	164
0.0 TO 0.0001	3,799.079	0.264	0.000	74	238
0.0001 TO 0.0002	2,894.778	0.300	0.000	1	239
0.0002 TO 0.0003	4,195.744	1.000	0.000	2	241
0.0006 TO 0.0007	4,651.078	3.000	0.001	1	242
0.001 TO 0.002	3,597.006	6.000	0.002	2	244
0.003 TO 0.004	3,784.241	13.200	0.003	5	249
0.004 TO 0.005	3,149.068	13.256	0.004	4	253
0.005 TO 0.006	2,361.000	13.000	0.006	1	254
0.006 TO 0.007	1,876.922	13.000	0.007	1	255
0.01 TO 0.02	3,625.004	50.900	0.014	3	258
0.03 TO 0.04	1,525.000	59.098	0.039	1	259
WEIGHTED AVERAGE	3,948.518	1.520	0.000	259	

CONCENTRATION DISTRIBUTION
(GRAMS PER POUNDS)

CONTENT: METALS
CONTENT CODES: 20, 101, 117, 155, 156, 201, 320, 321, 333, 416, 480, 481, 482, 488, 803, 824, 825, 950

CONCENTRATION RANGE	AVERAGE WEIGHT (LBS)	AVERAGE WEIGHT (GRAMS)	AVERAGE CONCENTRATION	NUMBER OF BOXES	RUNNING TOTAL
0.0 TO 0.0	2,510.883	0.000	0.000	826	826
0.0 TO 0.0001	2,734.939	0.194	0.000	1,335	2,161
0.0001 TO 0.0002	2,426.922	0.301	0.000	161	2,322
0.0002 TO 0.0003	2,801.153	0.712	0.000	42	2,364
0.0003 TO 0.0004	2,729.216	0.959	0.000	49	2,413
0.0004 TO 0.0005	2,756.255	1.233	0.000	24	2,437
0.0005 TO 0.0006	2,468.319	1.357	0.001	21	2,458
0.0006 TO 0.0007	3,003.724	1.950	0.001	24	2,482
0.0007 TO 0.0008	3,145.483	2.332	0.001	19	2,501
0.0008 TO 0.0009	2,678.931	2.267	0.001	15	2,516
0.0009 TO 0.001	2,675.120	2.532	0.001	25	2,541
0.001 TO 0.002	4,121.563	6.461	0.002	200	2,741
0.002 TO 0.003	3,650.895	9.095	0.002	179	2,920
0.003 TO 0.004	3,362.289	11.733	0.003	210	3,130
0.004 TO 0.005	2,855.943	12.831	0.004	279	3,409
0.005 TO 0.006	2,618.284	14.144	0.005	159	3,568
0.006 TO 0.007	2,268.708	14.683	0.006	107	3,675
0.007 TO 0.008	2,319.078	17.288	0.007	59	3,734
0.008 TO 0.009	2,913.836	24.535	0.008	40	3,774
0.009 TO 0.01	2,873.026	27.380	0.010	46	3,820
0.01 TO 0.02	2,724.762	40.320	0.015	205	4,025
0.02 TO 0.03	2,927.705	72.468	0.025	119	4,144
0.03 TO 0.04	2,749.352	93.406	0.034	78	4,222
0.04 TO 0.05	2,905.588	130.923	0.045	65	4,287
0.05 TO 0.06	2,721.718	149.800	0.055	45	4,332
0.06 TO 0.07	2,730.496	176.283	0.065	46	4,378
0.07 TO 0.08	2,889.325	214.415	0.074	34	4,412
0.08 TO 0.09	2,700.421	229.833	0.085	24	4,436
0.09 TO 0.1	2,541.438	243.969	0.096	32	4,468
0.1 TO 0.2	2,292.784	280.067	0.122	60	4,528
0.2 TO 0.3	1,261.000	286.000	0.227	1	4,529
WEIGHTED AVERAGE	2,802.169	22.502	0.008	4,529	

CONCENTRATION DISTRIBUTION
(GRAMS PER POUNDS)

CONTENT: SALTS
CONTENT CODES: 5, 124, 409, 410, 411, 412, 413, 414, 429, 454

CONCENTRATION RANGE	AVERAGE WEIGHT (LBS)	AVERAGE WEIGHT (GRAMS)	AVERAGE CONCENTRATION	NUMBER OF BOXES	RUNNING TOTAL
0.0 TO 0.0	3,992.466	0.000	0.000	1	1
WEIGHTED AVERAGE	3,992.470	0.000	0.000	1	

CONCENTRATION DISTRIBUTION
(GRAMS PER POUNDS)

CONTENT: BRICK
CONTENT CODES: 371, 373, 377, 378, 379

CONCENTRATION RANGE	AVERAGE WEIGHT (LBS)	AVERAGE WEIGHT (GRAMS)	AVERAGE CONCENTRATION	NUMBER OF BOXES	RUNNING TOTAL
0.0 TO 0.0001	2,214.211	0.150	0.000	10	10
0.0001 TO 0.0002	1,767.153	0.250	0.000	2	12
0.003 TO 0.004	3,932.592	13.000	0.003	1	13
0.004 TO 0.005	2,974.610	13.000	0.004	1	14
0.005 TO 0.006	2,498.944	13.000	0.005	3	17
0.006 TO 0.007	2,026.605	13.000	0.006	5	22
0.007 TO 0.008	1,817.048	13.000	0.007	1	23
0.01 TO 0.02	1,198.352	13.000	0.011	1	24
WEIGHTED AVERAGE	2,217.870	6.583	0.003	24	

CONCENTRATION DISTRIBUTION
(GRAMS PER POUNDS)

CONTENT: ALL
CONTENT CODES: ALL

CONCENTRATION	AVERAGE WEIGHT (LBS)	AVERAGE WEIGHT (GRAMS)	AVERAGE CONCENTRATION	NUMBER OF BINS	RUNNING TOTAL
0.000E+00	2,056.887	0.000	0.000	29	29
3.413E-05	2,929.704	0.100	0.000	1	30
4.472E-05	2,236.164	0.100	0.000	2	32
4.910E-05	2,036.586	0.100	0.000	2	34
6.202E-05	1,612.479	0.100	0.000	1	35
1.221E-04	1,637.427	0.200	0.000	1	36
1.375E-04	2,909.746	0.400	0.000	1	37
1.399E-04	2,859.852	0.400	0.000	1	38
1.411E-04	2,834.902	0.400	0.000	2	40
1.416E-04	2,824.925	0.400	0.000	1	41
1.462E-04	2,735.115	0.400	0.000	1	42
1.490E-04	2,685.220	0.400	0.000	1	43
1.518E-04	2,635.325	0.400	0.000	1	44
1.578E-04	2,535.535	0.400	0.000	1	45
1.633E-04	1,837.006	0.300	0.000	1	46
1.712E-04	2,335.955	0.400	0.000	1	47
2.065E-04	1,936.796	0.400	0.000	3	50
2.120E-04	1,886.901	0.400	0.000	1	51
2.148E-04	1,861.953	0.400	0.000	1	52
2.177E-04	1,837.006	0.400	0.000	1	53
2.303E-04	1,737.216	0.400	0.000	2	55
2.371E-04	1,687.322	0.400	0.000	1	56
2.458E-04	1,627.448	0.400	0.000	1	57
2.618E-04	1,527.658	0.400	0.000	1	58
2.689E-04	1,487.742	0.400	0.000	1	59
2.989E-04	1,338.057	0.400	0.000	1	60
3.291E-04	2,735.115	0.900	0.000	1	61
3.408E-04	2,934.694	1.000	0.000	1	62
3.513E-04	1,138.478	0.400	0.000	1	63
3.527E-04	2,834.904	1.000	0.000	1	64
3.656E-04	2,735.115	1.000	0.000	1	65
4.064E-04	2,460.692	1.000	0.000	1	66
4.344E-04	2,141.000	0.930	0.000	1	67
4.387E-04	2,735.115	1.200	0.000	1	68
4.709E-04	2,335.955	1.100	0.000	1	69
4.753E-04	2,735.115	1.300	0.000	1	70
4.845E-04	1,238.267	0.600	0.000	1	71
4.868E-04	1,437.846	0.700	0.000	3	74
4.886E-04	1,637.426	0.800	0.000	4	78
4.899E-04	1,837.005	0.900	0.000	11	89
4.910E-04	2,036.586	1.000	0.000	4	93
4.919E-04	2,236.164	1.100	0.000	8	101
4.927E-04	2,435.743	1.200	0.000	5	106
4.933E-04	2,635.324	1.300	0.000	3	109
4.938E-04	2,834.904	1.400	0.000	1	110
5.111E-04	2,934.692	1.500	0.001	12	122
5.119E-04	2,735.113	1.400	0.001	10	132
5.127E-04	2,535.532	1.300	0.001	10	142
5.137E-04	2,335.954	1.200	0.001	10	152
5.149E-04	2,136.375	1.100	0.001	13	165
5.163E-04	1,936.792	1.000	0.001	36	201
5.181E-04	1,737.215	0.900	0.001	19	220
5.203E-04	1,537.633	0.800	0.001	13	233
5.231E-04	1,338.056	0.700	0.001	5	238
5.270E-04	1,138.478	0.600	0.001	4	242
5.291E-04	2,834.902	1.500	0.001	3	245
5.312E-04	2,635.325	1.400	0.001	1	246
5.325E-04	938.898	0.500	0.001	1	247
5.337E-04	2,435.743	1.300	0.001	7	254
5.366E-04	2,236.164	1.200	0.001	4	258
5.401E-04	2,036.586	1.100	0.001	5	263
5.444E-04	1,837.006	1.000	0.001	2	265
5.496E-04	1,637.426	0.900	0.001	3	268

CONCENTRATION DISTRIBUTION
(GRAMS PER POUNDS)

CONTENT: ALL
CONTENT CODES: ALL

CONCENTRATION	AVERAGE WEIGHT (LBS)	AVERAGE WEIGHT (GRAMS)	AVERAGE CONCENTRATION	NUMBER OF BINS	RUNNING TOTAL
5.564E-04	1,437.845	0.800	0.001	10	278
5.653E-04	1,238.267	0.700	0.001	2	280
6.532E-04	1,837.006	1.200	0.001	1	281
6.702E-04	2,834.904	1.900	0.001	1	282
6.955E-04	1,437.847	1.000	0.001	1	283
7.021E-04	2,136.375	1.500	0.001	1	284
7.621E-04	1,837.006	1.400	0.001	1	285
7.745E-04	1,936.796	1.500	0.001	2	287
8.261E-04	1,936.796	1.600	0.001	1	288
8.519E-04	2,934.694	2.500	0.001	1	289
8.819E-04	2,834.904	2.500	0.001	1	290
9.362E-04	2,136.375	2.000	0.001	1	291
9.838E-04	2,236.166	2.200	0.001	1	292
9.877E-04	2,834.904	2.800	0.001	1	293
9.882E-04	2,934.694	2.900	0.001	1	294
1.022E-03	2,934.694	3.000	0.001	1	295
1.058E-03	2,834.904	3.000	0.001	1	296
1.097E-03	2,735.115	3.000	0.001	1	297
1.129E-03	2,036.586	2.300	0.001	2	299
1.183E-03	2,535.535	3.000	0.001	1	300
1.188E-03	1,936.796	2.300	0.001	1	301
1.228E-03	2,036.586	2.500	0.001	1	302
1.232E-03	2,435.745	3.000	0.001	1	303
1.284E-03	2,335.955	3.000	0.001	1	304
1.291E-03	1,936.796	2.500	0.001	1	305
1.295E-03	2,934.694	3.800	0.001	1	306
1.404E-03	2,136.375	3.000	0.001	1	307
1.438E-03	2,086.481	3.000	0.001	1	308
1.518E-03	2,635.325	4.000	0.002	1	309
1.533E-03	2,934.694	4.500	0.002	1	310
1.609E-03	2,485.640	4.000	0.002	1	311
1.712E-03	2,335.955	4.000	0.002	1	312
1.972E-03	2,535.535	5.000	0.002	1	313
2.450E-03	2,735.115	6.700	0.002	1	314
2.450E-03	1,837.005	4.500	0.002	3	317
2.814E-03	1,777.133	5.000	0.003	1	318
3.392E-03	589.634	2.000	0.003	1	319
3.550E-03	2,535.535	9.000	0.004	1	320
3.576E-03	1,118.519	4.000	0.004	1	321
3.610E-03	2,216.202	8.000	0.004	44	365
3.642E-03	1,647.406	6.000	0.004	1	366
3.919E-03	2,934.692	11.500	0.004	5	371
3.944E-03	2,535.535	10.000	0.004	1	372
4.021E-03	2,834.904	11.400	0.004	1	373
4.022E-03	2,735.115	11.000	0.004	1	374
4.061E-03	2,216.207	9.000	0.004	2	376
4.089E-03	2,934.694	12.000	0.004	1	377
4.168E-03	2,735.113	11.400	0.004	4	381
4.191E-03	2,934.694	12.300	0.004	1	382
4.229E-03	2,435.745	10.300	0.004	1	383
4.288E-03	2,635.324	11.300	0.004	3	386
4.419E-03	2,036.586	9.000	0.004	1	387
4.457E-03	2,535.533	11.300	0.004	2	389
4.515E-03	2,834.904	12.800	0.005	1	390
4.598E-03	2,435.744	11.200	0.005	2	392
4.681E-03	2,136.375	10.000	0.005	1	393
4.709E-03	2,335.955	11.000	0.005	1	394
4.795E-03	2,335.955	11.200	0.005	1	395
4.907E-03	2,934.693	14.400	0.005	2	397
4.941E-03	2,934.694	14.500	0.005	1	398
4.964E-03	2,236.164	11.100	0.005	6	404
5.044E-03	2,834.904	14.300	0.005	1	405
5.181E-03	1,737.216	9.000	0.005	1	406

CONCENTRATION DISTRIBUTION
(GRAMS PER POUNDS)

CONTENT: ALL
CONTENT CODES: ALL

CONCENTRATION	AVERAGE WEIGHT (LBS)	AVERAGE WEIGHT (GRAMS)	AVERAGE CONCENTRATION	NUMBER OF BINS	RUNNING TOTAL
5.196E-03	2,136.375	11.100	0.005	1	407
5.232E-03	2,236.166	11.700	0.005	1	408
5.401E-03	2,036.586	11.000	0.005	3	411
5.452E-03	2,934.694	16.000	0.005	1	412
5.520E-03	2,934.694	16.200	0.006	1	413
5.661E-03	1,837.006	10.400	0.006	1	414
5.679E-03	1,936.794	11.000	0.006	6	420
5.908E-03	2,335.955	13.800	0.006	1	421
5.934E-03	1,837.005	10.900	0.006	4	425
5.934E-03	3,134.274	18.600	0.006	1	426
5.992E-03	2,236.166	13.400	0.006	1	427
6.274E-03	1,737.215	10.900	0.006	6	433
6.596E-03	1,637.426	10.800	0.007	4	437
6.611E-03	2,934.694	19.400	0.007	1	438
6.679E-03	2,934.694	19.600	0.007	1	439
7.024E-03	1,537.634	10.800	0.007	7	446
7.442E-03	1,437.846	10.700	0.007	3	449
7.769E-03	2,934.694	22.800	0.008	1	450
7.951E-03	1,936.796	15.400	0.008	1	451
8.076E-03	1,238.267	10.000	0.008	1	452
8.246E-03	2,934.694	24.200	0.008	1	453
8.485E-03	2,934.694	24.900	0.008	1	454
9.579E-03	2,735.115	26.200	0.010	1	455
9.927E-03	2,216.208	22.000	0.010	1	456
1.022E-02	3,034.484	31.000	0.010	1	457
1.038E-02	2,216.208	23.000	0.010	1	458
1.094E-02	2,834.904	31.000	0.011	1	459
1.094E-02	1,737.216	19.000	0.011	1	460
1.190E-02	2,361.000	28.100	0.012	1	461
1.398E-02	1,931.807	27.000	0.014	1	462
1.424E-02	2,934.694	41.800	0.014	1	463
1.439E-02	1,737.216	25.000	0.014	1	464
1.444E-02	2,216.208	32.000	0.014	1	465
1.479E-02	2,934.694	43.400	0.015	1	466
1.482E-02	2,934.694	43.500	0.015	1	467
1.522E-02	2,036.586	31.000	0.015	1	468
1.585E-02	2,801.000	44.400	0.016	1	469
1.625E-02	3,021.000	49.100	0.016	1	470
1.642E-02	2,435.745	40.000	0.016	1	471
1.664E-02	2,535.535	42.200	0.017	1	472
1.670E-02	2,635.325	44.000	0.017	1	473
1.697E-02	2,934.694	49.800	0.017	1	474
1.714E-02	2,934.694	50.300	0.017	1	475
1.754E-02	3,021.000	53.000	0.018	1	476
1.760E-02	2,216.208	39.000	0.018	1	477
1.840E-02	2,500.608	46.000	0.018	1	478
1.850E-02	2,216.208	41.000	0.019	1	479
1.923E-02	2,735.115	52.600	0.019	1	480
2.099E-02	2,934.694	61.600	0.021	1	481
2.517E-02	2,435.745	61.300	0.025	1	482
2.632E-02	2,735.115	72.000	0.026	1	483
2.640E-02	1,943.000	51.300	0.026	1	484
2.719E-02	2,361.000	64.200	0.027	1	485
2.926E-02	2,119.000	62.000	0.029	1	486
2.933E-02	2,216.208	65.000	0.029	1	487
3.010E-02	1,936.796	58.300	0.030	1	488
3.076E-02	2,535.535	78.000	0.031	1	489
3.201E-02	1,936.796	62.000	0.032	1	490
3.294E-02	2,216.208	73.000	0.033	1	491
3.438E-02	2,934.694	100.900	0.034	1	492
3.473E-02	2,735.115	95.000	0.035	1	493
3.513E-02	2,934.694	103.100	0.035	1	494
3.651E-02	2,136.375	78.000	0.037	1	495

CONCENTRATION DISTRIBUTION
(GRAMS PER POUNDS)

CONTENT: ALL
CONTENT CODES: ALL

CONCENTRATION	AVERAGE WEIGHT (LBS)	AVERAGE WEIGHT (GRAMS)	AVERAGE CONCENTRATION	NUMBER OF BINS	RUNNING TOTAL
4.353E-02	2,136.375	93.000	0.044	1	496
4.519E-02	1,737.216	78.500	0.045	1	497
4.783E-02	2,216.208	106.000	0.048	1	498
4.959E-02	2,036.586	101.000	0.050	2	500
4.968E-02	2,236.166	111.100	0.050	1	501
4.976E-02	2,435.745	121.200	0.050	1	502
4.982E-02	2,635.324	131.300	0.050	3	505
5.162E-02	2,934.693	151.500	0.052	3	508
5.215E-02	1,936.796	101.000	0.052	1	509
5.233E-02	1,737.216	90.900	0.052	1	510
5.576E-02	3,461.000	193.000	0.056	1	511
7.972E-02	2,859.852	228.000	0.080	1	512
1.164E-01	2,560.482	298.000	0.116	1	513
1.364E-01	2,119.000	289.000	0.136	1	514
1.809E-01	2,884.799	522.000	0.181	1	515
2.062E-01	2,934.693	605.000	0.206	2	517
WEIGHTED AVERAGE	2,174.655	16.132	0.007	517	

APPENDIX E:

CALCULATIONAL CONFIGURATION OF EXISTING MORE HEAVILY LOADED DRUMS

WASTE CHARACTERIZED BY *GRAPHITE* WITH PLUTONIUM CONCENTRATIONS THAT EXCEED 37.5% OF THE MINIMUM CRITICAL VALUE

Drum No.	^{239}Pu Concentration (g Pu/lb matrix)	Number of drums
1	1.27	6
2	0.99	1
3	0.85	2
4	0.65	4
5	0.54	6
6	0.44	29
7	0.34	60
8	0.24	156
9	0.14	506
10	0.10	1388
11[a]	0.15	39

a. Drum Type 11 contains SiO_2 at 75% of the critical concentration. This drum type was used to complete the cubic configuration of the array.

```
z layer   1
11 11 11 10 10 10 10 10 10 10 11 11 11
11 10 10 10 10 10 10 10 10 10 10 10 11
11 10 10 10 10 10 10 10 10 10 10 10 11
10 10 10 10 10 10 10 10 10 10 10 10 10
10 10 10 10 10 10 10 10 10 10 10 10 10
10 10 10 10 10 10 10 10 10 10 10 10 10
10 10 10 10 10 10 10 10 10 10 10 10 10
10 10 10 10 10 10 10 10 10 10 10 10 10
10 10 10 10 10 10 10 10 10 10 10 10 10
10 10 10 10 10 10 10 10 10 10 10 10 10
10 10 10 10 10 10 10 10 10 10 10 10 11
11 10 10 10 10 10 10 10 10 10 10 10 11
11 11 11 10 10 10 10 10 10 10 11 11 11
```

```
z layer   2
10 10 10 10 10 10 10 10 10 10 10 10 10
10 10 10 10 10 10 10 10 10 10 10 10 10
10 10 10 10 10 10 10 10 10 10 10 10 10
10 10 10 10 10 10 10 10 10 10 10 10 10
10 10 10 10 10 10 10 10 10 10 10 10 10
10 10 10 10 10 10 10 10 10 10 10 10 10
10 10 10 10 10 10 10 10 10 10 10 10 10
10 10 10 10 10 10 10 10 10 10 10 10 10
10 10 10 10 10 10 10 10 10 10 10 10 10
10 10 10 10 10 10 10 10 10 10 10 10 10
10 10 10 10 10 10 10 10 10 10 10 10 10
10 10 10 10 10 10 10 10 10 10 10 10 10
10 10 10 10 10 10 10 10 10 10 10 10 10
```

```
z layer   3
10 10 10 10 10 10 10 10 10 10 10 10 10
10 10 10 10 10 10 10 10 10 10 10 10 10
10 10  9  9  9  9  9  9  9  9  9 10 10
10 10  9  9  9  9  9  9  9  9  9 10 10
10 10  9  9  9  9  9  9  9  9  9 10 10
10 10  9  9  9  9  9  9  9  9  9 10 10
10 10  9  9  9  9  9  9  9  9  9 10 10
10 10  9  9  9  9  9  9  9  9  9 10 10
10 10  9  9  9  9  9  9  9  9  9 10 10
10 10  9  9  9  9  9  9  9  9  9 10 10
10 10  9  9  9  9  9  9  9  9  9 10 10
10 10 10 10 10 10 10 10 10 10 10 10 10
10 10 10 10 10 10 10 10 10 10 10 10 10
```

```
z layer   4
10 10 10 10 10 10 10 10 10 10 10 10 10
10  9 10 10 10 10 10 10 10 10 10  9 10
10  9  9  9  9  9  9  9  9  9  9  9 10
10  9  9  9  8  8  8  8  8  9  9  9 10
10  9  9  9  8  8  8  8  8  9  9  9 10
10  9  9  9  8  8  8  8  8  9  9  9 10
10  9  9  9  8  8  8  8  8  9  9  9 10
10  9  9  9  8  8  8  8  8  9  9  9 10
10  9  9  9  8  8  8  8  8  9  9  9 10
10  9  9  9  9  9  9  9  9  9  9  9 10
10  9  9  9  9  9  9  9  9  9  9  9 10
10 10 10 10 10 10 10 10 10 10 10 10 10
10 10 10 10 10 10 10 10 10 10 10 10 10
```

```
z layer   5
10 10 10 10 10 10 10 10 10 10 10 10 10
10 10 10 10 10 10 10 10 10 10 10 10 10
10 10  9  9  9  9  9  9  9  9  9 10 10
10 10  9  8  8  8  8  8  8  9  9 10 10
10 10  9  8  7  7  7  7  8  9  9 10 10
10 10  9  8  7  7  7  7  8  9  9 10 10
10 10  9  8  7  7  7  7  8  9  9 10 10
10 10  9  8  7  7  7  7  8  8  9 10 10
10 10  9  8  8  8  8  8  8  8  9 10 10
10 10  9  9  9  9  9  9  9  8  9 10 10
10 10  9  9  9  9  9  9  9  9  9 10 10
10 10 10 10 10 10 10 10 10 10 10 10 10
10 10 10 10 10 10 10 10 10 10 10 10 10
```

```
z layer   6
10 10 10 10 10 10 10 10 10 10 10 10 10
10 10 10 10 10 10 10 10 10 10 10 10 10
10 10  9  9  9  9  9  9  9  9  9 10 10
10 10  9  8  8  8  8  8  8  8  9 10 10
10 10  9  8  7  6  6  6  7  8  9 10 10
10 10  9  8  7  5  5  6  7  8  9 10 10
10 10  9  8  7  4  1  4  7  8  9 10 10
10 10  9  8  7  6  5  6  7  8  9 10 10
10 10  9  8  7  6  6  6  7  8  9 10 10
10 10  9  9  9  9  9  9  9  8  9 10 10
10 10  9  9  9  9  9  9  9  9  9 10 10
10 10 10 10 10 10 10 10 10 10 10 10 10
10 10 10 10 10 10 10 10 10 10 10 10 10
```

z layer 7

10	10	10	10	10	10	9	10	10	10	10	10	10
10	10	10	10	10	10	10	10	10	10	10	10	10
10	10	9	9	9	9	9	9	9	9	9	10	10
10	10	9	8	8	8	8	8	8	8	9	10	10
10	10	9	8	6	6	6	6	6	8	9	10	10
10	10	9	8	7	5	1	6	7	8	9	10	10
10	10	9	7	7	1	1	1	7	8	9	10	10
10	10	9	8	7	5	1	6	7	8	9	10	10
10	10	9	8	6	6	6	6	6	8	9	10	10
10	10	9	9	9	9	9	9	9	8	9	10	10
10	10	9	9	9	9	9	9	9	9	9	10	10
10	10	10	10	10	10	10	10	10	10	10	10	10
10	10	10	10	10	10	10	10	10	10	10	10	10

z layer 8

10	10	10	10	10	10	10	10	10	10	10	10	10
10	10	10	10	10	10	10	10	10	10	10	10	10
10	10	9	9	9	9	9	9	9	9	9	10	10
10	10	9	8	8	8	8	8	8	8	9	10	10
10	10	9	8	7	6	6	6	7	8	9	10	10
10	10	9	8	7	5	4	6	7	8	9	10	10
10	10	9	8	7	3	2	3	7	8	9	10	10
10	10	9	8	7	6	4	6	7	8	9	10	10
10	10	9	8	7	6	6	7	7	8	9	10	10
10	10	9	9	9	9	9	9	9	8	9	10	10
10	10	9	9	9	9	9	9	9	9	9	10	10
10	10	10	10	10	10	10	10	10	10	10	10	10
10	10	10	10	10	10	10	10	10	10	10	10	10

z layer 9

10	10	10	10	10	10	10	10	10	10	10	10	10
10	10	10	10	10	10	10	10	10	10	10	10	10
10	10	9	9	9	9	9	9	9	9	9	10	10
10	10	9	8	8	8	8	8	8	9	9	10	10
10	10	9	8	7	7	7	7	8	9	9	10	10
10	10	9	8	7	7	7	7	8	9	9	10	10
10	10	9	8	7	7	7	7	8	9	9	10	10
10	10	9	8	7	7	7	7	8	9	9	10	10
10	10	9	8	8	8	8	8	8	9	9	10	10
10	10	9	9	9	9	9	9	9	9	9	10	10
10	10	9	9	9	9	9	9	9	9	9	10	10
10	10	10	10	10	10	10	10	10	10	10	10	10
10	10	10	10	10	10	10	10	10	10	10	10	10

z layer 10

10	10	10	10	10	10	10	10	10	10	10	10	10
10	9	10	10	10	10	10	10	10	10	10	9	10
10	9	9	9	9	9	9	9	9	9	9	9	10
10	9	9	9	8	8	8	8	8	9	9	9	10
10	9	9	9	8	8	8	8	8	9	9	9	10
10	9	9	9	8	8	8	8	8	9	9	9	10
10	9	9	9	8	8	8	8	8	9	9	9	10
10	9	9	9	8	8	8	8	8	9	9	9	10
10	9	9	9	8	8	8	8	8	9	9	9	10
10	9	9	9	9	9	9	9	9	9	9	9	10
10	9	9	9	9	9	9	9	9	9	9	9	10
10	10	10	10	10	10	10	10	10	10	10	10	10
10	10	10	10	10	10	10	10	10	10	10	10	10

z layer 11

10	10	10	10	10	10	10	10	10	10	10	10	10
10	10	10	10	10	10	10	10	10	10	10	10	10
10	10	9	9	9	9	9	9	9	9	9	10	10
10	10	9	9	9	9	9	9	9	9	9	10	10
10	10	9	9	9	9	9	9	9	9	9	10	10
10	10	9	9	9	9	9	9	9	9	9	10	10
10	10	9	9	9	9	9	9	9	9	9	10	10
10	10	9	9	9	9	9	9	9	9	9	10	10
10	10	9	9	9	9	9	9	9	9	9	10	10
10	10	9	9	9	9	9	9	9	9	9	10	10
10	10	9	9	9	9	9	9	9	9	9	10	10
10	10	10	10	10	10	10	10	10	10	10	10	10
10	10	10	10	10	10	10	10	10	10	10	10	10

z layer 12

10	10	10	10	10	10	10	10	10	10	10	10	10
10	10	10	10	10	10	10	10	10	10	10	10	10
10	10	10	10	10	10	10	10	10	10	10	10	10
10	10	10	10	10	10	10	10	10	10	10	10	10
10	10	10	10	10	10	10	10	10	10	10	10	10
10	10	10	10	10	10	10	10	10	10	10	10	10
10	10	10	10	10	10	10	10	10	10	10	10	10
10	10	10	10	10	10	10	10	10	10	10	10	10
10	10	10	10	10	10	10	10	10	10	10	10	10
10	10	10	10	10	10	10	10	10	10	10	10	10
10	10	10	10	10	10	10	10	10	10	10	10	10
10	10	10	10	10	10	10	10	10	10	10	10	10
10	10	10	10	10	10	10	10	10	10	10	10	10

z layer 13

11	11	11	10	10	10	10	10	10	10	11	11	11
11	10	10	10	10	10	10	10	10	10	10	10	11
11	10	10	10	10	10	10	10	10	10	10	10	11
10	10	10	10	10	10	10	10	10	10	10	10	10
10	10	10	10	10	10	10	10	10	10	10	10	10
10	10	10	10	10	10	10	10	10	10	10	10	10
10	10	10	10	10	10	10	10	10	10	10	10	10
10	10	10	10	10	10	10	10	10	10	10	10	10
10	10	10	10	10	10	10	10	10	10	10	10	10
10	10	10	10	10	10	10	10	10	10	10	10	10
11	10	10	10	10	10	10	10	10	10	10	10	11
11	10	10	10	10	10	10	10	10	10	10	10	11
11	11	11	10	10	10	10	10	10	10	11	11	11

WASTE CHARACTERIZED BY SIO_2 WITH PLUTONIUM CONCENTRATIONS THAT EXCEED 37.5% OF THE MINIMUM CRITICAL VALUE

Drum No.	^{239}Pu Concentration (g Pu/lb matrix)	Number of drums
1	2.03	2
2	1.31	116
3	0.95	25[a]
4	0.74	33[b]
5	0.55	171[c]
6	0.24	142
7	0.15	526
8[d]	0.15	316

a. Number of drums includes those having ^{239}Pu concentrations of 0.95 and 0.85.
b. Number of drums includes those having ^{239}Pu concentrations of 0.74 and 0.65.
c. Number of drums includes those having ^{239}Pu concentrations of 0.55, 0.44 and 0.34.
d. Drum Type 8 contains SiO_2 at 75% of the critical concentration. This drum type was used to complete the cubic configuration of the array.

z layer 1

8 8 8 8 8 8 8 8 8 8 8
8 8 8 8 8 8 8 8 8 8 8
8 8 8 8 8 8 8 8 8 8 8
8 8 8 8 8 8 8 8 8 8 8
8 8 8 8 8 8 8 8 8 8 8
8 8 8 8 8 8 8 8 8 8 8
8 8 8 8 8 8 8 8 8 8 8
8 8 8 8 8 8 8 8 8 8 8
8 8 8 8 8 8 8 8 8 8 8
8 8 8 8 8 8 8 8 8 8 8
8 8 8 8 8 8 8 8 8 8 8

z layer 2

7 8 8 8 8 8 8 8 8 8 7
8 7 7 7 7 7 7 7 7 7 8
8 7 7 7 7 7 7 7 7 7 8
8 7 7 7 7 7 7 7 7 7 8
8 7 7 7 7 7 7 7 7 7 8
8 7 7 7 7 7 7 7 7 7 8
8 7 7 7 7 7 7 7 7 7 8
8 7 7 7 7 7 7 7 7 7 8
8 7 7 7 7 7 7 7 7 7 8
8 7 7 7 7 7 7 7 7 7 8
8 8 8 8 8 8 8 8 8 8 8

z layer 3

7 7 7 7 7 7 7 7 7 7 7
7 7 7 7 7 7 7 7 7 7 7
7 7 7 7 7 7 7 7 7 7 7
7 7 7 7 7 7 7 7 7 7 7
7 7 7 7 7 7 7 7 7 7 7
7 7 7 7 7 7 7 7 7 7 7
7 7 7 7 7 7 7 7 7 7 7
7 7 7 7 7 7 7 7 7 7 7
7 7 7 7 7 7 7 7 7 7 7
7 7 7 7 7 7 7 7 7 7 7
7 7 7 7 7 7 7 7 7 7 7

z layer 4

7 7 7 7 7 7 7 7 7 7 7
7 6 6 6 6 6 6 6 6 6 7
7 6 6 6 5 5 5 6 6 6 7
7 6 6 3 2 2 2 3 6 6 7
7 6 6 2 2 2 2 2 6 6 7
7 6 5 2 2 2 2 2 5 6 7
7 6 6 2 2 2 2 2 6 6 7
7 6 6 3 2 2 2 3 6 6 7
7 6 6 6 6 5 6 6 6 6 7
7 6 6 6 6 6 6 6 6 6 7
7 7 7 7 7 7 7 7 7 7 7

z layer 5

7 6 7 6 7 6 7 6 7 6 7
6 5 5 5 5 5 5 5 5 5 6
7 5 5 5 4 4 4 5 5 5 7
6 5 5 2 2 2 2 2 5 5 6
6 5 4 2 2 2 2 2 4 5 6
6 5 4 2 2 2 2 2 4 5 6
7 5 4 2 2 2 2 2 4 5 7
6 5 5 2 2 2 2 2 5 5 6
7 5 5 5 4 4 4 5 5 5 7
6 5 5 5 5 5 5 5 5 5 6
7 6 7 6 7 6 7 6 7 6 7

z layer 6

5 5 5 5 5 5 5 5 5 5 5
5 5 5 5 5 4 5 5 5 5 5
5 5 4 4 3 3 3 4 4 5 5
5 5 3 2 2 2 2 2 3 5 5
5 5 3 2 2 2 2 2 3 5 5
5 5 3 2 2 1 1 2 3 5 5
5 5 3 2 2 2 2 2 3 5 5
5 5 3 2 2 2 2 2 3 5 5
5 5 4 3 3 3 3 3 4 5 5
5 5 5 5 5 4 5 5 5 5 5
5 5 5 5 5 5 5 5 5 5 5

z layer 7

7 6 7 6 7 6 7 6 7 6 7
6 5 5 5 5 5 5 5 5 5 6
7 5 5 5 4 4 4 5 5 5 7
6 5 5 2 2 2 2 2 5 5 6
6 5 4 2 2 2 2 2 4 5 6
6 5 4 2 2 2 2 2 4 5 6
7 5 4 2 2 2 2 2 4 5 7
6 5 5 2 2 2 2 2 5 5 6
7 5 5 5 4 4 4 5 5 5 7
6 5 5 5 5 5 5 5 5 5 6
7 6 7 6 7 6 7 6 7 6 7

z layer 8

7 7 7 7 7 7 7 7 7 7 7
7 6 6 6 6 6 6 6 6 6 7
7 6 6 6 5 5 5 6 6 6 7
7 6 6 3 2 2 2 3 6 6 7
7 6 6 2 2 2 2 2 6 6 7
7 6 5 2 2 2 2 2 5 6 7
7 6 6 2 2 2 2 2 6 6 7
7 6 6 2 2 2 2 3 6 6 7
7 6 6 6 5 4 5 6 6 6 7
7 6 6 6 6 6 6 6 6 6 7
7 7 7 7 7 7 7 7 7 7 7

z layer 9

7 7 7 7 7 7 7 7 7 7 7
7 7 7 7 7 7 7 7 7 7 7
7 7 7 7 7 7 7 7 7 7 7
7 7 7 7 7 7 7 7 7 7 7
7 7 7 7 7 7 7 7 7 7 7
7 7 7 7 7 7 7 7 7 7 7
7 7 7 7 7 7 7 7 7 7 7
7 7 7 7 7 7 7 7 7 7 7
7 7 7 7 7 7 7 7 7 7 7
7 7 7 7 7 7 7 7 7 7 7
7 7 7 7 7 7 7 7 7 7 7

z layer 10

7 8 8 8 8 8 8 8 8 8 7
8 7 7 7 7 7 7 7 7 7 8
8 7 7 7 7 7 7 7 7 7 8
8 7 7 7 7 7 7 7 7 7 8
8 7 7 7 7 7 7 7 7 7 8
8 7 7 7 7 7 7 7 7 7 8
8 7 7 7 7 7 7 7 7 7 8
8 7 7 7 7 7 7 7 7 7 8
8 7 7 7 7 7 7 7 7 7 8
8 7 7 7 7 7 7 7 7 7 8
7 8 8 8 8 8 8 8 8 8 7

z layer 11

8 8 8 8 8 8 8 8 8 8 8
8 8 8 8 8 8 8 8 8 8 8
8 8 8 8 8 8 8 8 8 8 8
8 8 8 8 8 8 8 8 8 8 8
8 8 8 8 8 8 8 8 8 8 8
8 8 8 8 8 8 8 8 8 8 8
8 8 8 8 8 8 8 8 8 8 8
8 8 8 8 8 8 8 8 8 8 8
8 8 8 8 8 8 8 8 8 8 8
8 8 8 8 8 8 8 8 8 8 8
8 8 8 8 8 8 8 8 8 8 8

WASTE CHARACTERIZED BY *MGO* WITH PLUTONIUM CONCENTRATIONS THAT EXCEED 37.5% OF THE MINIMUM CRITICAL VALUE

Drum No.	^{239}Pu Concentration (g Pu/lb matrix)	Number of drums
1	2.03	2
2	1.34	116
3	0.95	25[a]
4	0.74	33[b]
5	0.55	171[c]
6	0.24	142
7	0.15	346
8	0.10	367
9[d]	0.15	129

a. Number of drums includes those having ^{239}Pu concentrations of 0.95 and 0.85.
b. Number of drums includes those having ^{239}Pu concentrations of 0.74 and 0.65.
c. Number of drums includes those having ^{239}Pu concnetrations of 0.55, 0.44 and 0.34.
d. Drum Type 9 contains SiO_2 at 75% of the critical concentration. This drum type was used to complete the cubic configuration of the array.

z layer 1

9 9 9 9 9 9 9 9 9 9 9
9 9 9 9 9 9 9 9 9 9 9
9 8 8 8 8 8 8 8 8 8 9
9 9 8 8 8 8 8 8 8 9 9
9 8 8 8 8 8 8 8 8 8 9
9 9 8 8 8 9 8 8 8 9 9
9 8 8 8 8 8 8 8 8 8 9
9 9 8 8 8 8 8 8 8 9 9
9 8 8 8 8 8 8 8 8 8 9
9 9 9 9 9 9 9 9 9 9 9
9 9 9 9 9 9 9 9 9 9 9

z layer 2

8 8 8 8 8 8 8 8 8 8 8
8 8 7 7 7 7 7 7 7 8 8
8 7 7 7 7 7 7 7 7 7 8
8 7 7 7 7 7 7 7 7 7 8
8 7 7 7 7 7 7 7 7 7 8
8 7 7 7 7 7 7 7 7 7 8
8 7 7 7 7 7 7 7 7 7 8
8 7 7 7 7 7 7 7 7 7 8
8 7 7 7 7 7 7 7 7 7 8
8 8 7 7 7 7 7 7 7 8 8
8 8 8 8 8 8 8 8 8 8 8

z layer 3

8 8 8 8 8 8 8 8 8 8 8
8 8 7 7 7 7 7 7 7 8 8
8 7 7 7 7 7 7 7 7 7 8
8 7 7 7 7 7 7 7 7 7 8
8 7 7 7 7 7 7 7 7 7 8
8 7 7 7 7 7 7 7 7 7 8
8 7 7 7 7 7 7 7 7 7 8
8 7 7 7 7 7 7 7 7 7 8
8 7 7 7 7 7 7 7 7 7 8
8 8 7 7 7 7 7 7 7 8 8
8 8 8 8 8 8 8 8 8 8 8

z layer 4

8 8 8 8 8 8 8 8 8 8 8
8 6 6 6 6 6 6 6 6 6 8
8 6 6 6 5 5 5 6 6 6 8
8 6 6 3 2 2 2 3 6 6 8
8 6 6 2 2 2 2 2 6 6 8
8 6 5 2 2 2 2 2 5 6 8
8 6 6 2 2 2 2 2 6 6 8
8 6 6 3 2 2 2 3 6 6 8
8 6 6 6 6 5 6 6 6 6 8
8 6 6 6 6 6 6 6 6 6 8
8 8 8 8 8 8 8 8 8 8 8

z layer 5

7 6 7 6 7 6 7 6 7 6 7
6 5 5 5 5 5 5 5 5 5 6
7 5 5 5 4 4 4 5 5 5 7
6 5 5 2 2 2 2 2 5 5 6
6 5 4 2 2 2 2 2 4 5 6
6 5 4 2 2 2 2 2 4 5 6
7 5 4 2 2 2 2 2 4 5 7
6 5 5 2 2 2 2 2 5 5 6
7 5 5 5 4 4 4 5 5 5 7
6 5 5 5 5 5 5 5 5 5 6
7 6 7 6 7 6 7 6 7 6 7

z layer 6

5 5 5 5 5 5 5 5 5 5 5
5 5 5 5 5 4 5 5 5 5 5
5 5 4 4 3 3 3 4 4 5 5
5 5 3 2 2 2 2 2 3 5 5
5 5 3 2 2 2 2 2 3 5 5
5 5 3 2 2 1 1 2 3 5 5
5 5 3 2 2 2 2 2 3 5 5
5 5 3 2 2 2 2 2 3 5 5
5 5 4 3 3 3 3 3 4 5 5
5 5 5 5 5 4 5 5 5 5 5
5 5 5 5 5 5 5 5 5 5 5

z layer 7

7 6 7 6 7 6 7 6 7 6 7
6 5 5 5 5 5 5 5 5 5 6
7 5 5 5 4 4 4 5 5 5 7
6 5 5 2 2 2 2 2 5 5 6
6 5 4 2 2 2 2 2 4 5 6
6 5 4 2 2 2 2 2 4 5 6
7 5 4 2 2 2 2 2 4 5 7
6 5 5 2 2 2 2 2 5 5 6
7 5 5 5 4 4 4 5 5 5 7
6 5 5 5 5 5 5 5 5 5 6
7 6 7 6 7 6 7 6 7 6 7

z layer 8

8 8 8 8 8 8 8 8 8 8 8
8 6 6 6 6 6 6 6 6 6 8
8 6 6 6 5 5 5 6 6 6 8
8 6 6 3 2 2 2 3 6 6 8
8 6 6 2 2 2 2 2 6 6 8
8 6 5 2 2 2 2 2 5 6 8
8 6 6 2 2 2 2 2 6 6 8
8 6 6 2 2 2 2 3 6 6 8
8 6 6 6 5 4 5 6 6 6 8
8 6 6 6 6 6 6 6 6 6 8
8 8 8 8 8 8 8 8 8 8 8

z layer 9

8 8 8 8 8 8 8 8 8 8 8
8 8 7 7 7 7 7 7 7 8 8
8 7 7 7 7 7 7 7 7 7 8
8 7 7 7 7 7 7 7 7 7 8
8 7 7 7 7 7 7 7 7 7 8
8 7 7 7 7 7 7 7 7 7 8
8 7 7 7 7 7 7 7 7 7 8
8 7 7 7 7 7 7 7 7 7 8
8 7 7 7 7 7 7 7 7 7 8
8 7 7 7 7 7 7 7 7 7 8
8 8 8 8 8 8 8 8 8 8 8

z layer 10

```
8 8 8 8 8 8 8 8 8 8 8
8 8 7 7 7 7 7 7 7 8 8
8 7 7 7 7 7 7 7 7 7 8
8 7 7 7 7 7 7 7 7 7 8
8 7 7 7 7 7 7 7 7 7 8
8 7 7 7 7 7 7 7 7 7 8
8 7 7 7 7 7 7 7 7 7 8
8 7 7 7 7 7 7 7 7 7 8
8 7 7 7 7 7 7 7 7 7 8
8 8 7 7 7 7 7 7 7 8 8
8 8 8 8 8 8 8 8 8 8 8
```

z layer 11

```
9 9 9 9 9 9 9 9 9 9 9
9 9 9 9 9 9 9 9 9 9 9
9 9 8 8 8 8 8 8 8 9 9
9 9 8 8 8 8 8 8 8 9 9
9 8 8 8 8 8 8 8 8 8 9
9 9 8 8 8 8 8 8 8 9 9
9 8 8 8 8 8 8 8 8 8 9
9 9 8 8 8 8 8 8 8 9 9
9 8 8 8 8 8 8 8 8 8 9
9 9 9 9 9 9 9 9 9 9 9
9 9 9 9 9 9 9 9 9 9 9
```

WASTE CHARACTERIZED BY *CELLULOSE* WITH PLUTONIUM CONCENTRATIONS THAT EXCEED 37.5% OF THE MINIMUM CRITICAL VALUE

Drum No.	^{239}Pu Concentration (g Pu/lb matrix)	Number of drums
1	6.72	1
2	5.51	1
3	4.64	2
4	3.38	9
5	2.32	44
6	1.39	427
7[a]	0.15	245

a. Drum Type 7 contains SiO_2 at 75% of the critical concentration. This drum type was used to complete the cubic configuration of the array.

z layer 1

```
7 7 7 7 7 7 7 7 7
7 7 7 7 7 7 7 7 7
7 7 7 6 6 6 7 7 7
7 7 6 6 6 6 6 7 7
7 7 6 6 6 6 6 7 7
7 7 6 6 6 6 6 7 7
7 7 7 6 6 6 7 7 7
7 7 7 7 7 7 7 7 7
7 7 7 7 7 7 7 7 7
```

z layer 2

```
7 7 7 6 6 6 7 7 7
7 6 6 6 6 6 6 6 7
7 6 6 6 6 6 6 6 7
6 6 6 6 6 6 6 6 6
6 6 6 6 6 6 6 6 6
6 6 6 6 6 6 6 6 6
7 6 6 6 6 6 6 6 7
7 6 6 6 6 6 6 6 7
7 7 7 6 6 6 7 7 7
```

z layer 3

```
7 7 7 6 6 6 7 7 7
7 6 6 6 6 6 6 6 7
7 6 6 6 6 6 6 6 7
6 6 6 6 6 6 6 6 6
6 6 6 6 6 6 6 6 6
6 6 6 6 6 6 6 6 6
7 6 6 6 6 6 6 6 7
7 6 6 6 6 6 6 6 7
7 7 7 6 6 6 7 7 7
```

z layer 4

```
7 7 7 6 6 6 7 7 7
7 6 6 6 6 6 6 6 7
7 6 6 5 5 5 6 6 7
6 6 5 5 4 5 5 6 6
6 6 5 4 4 4 5 6 6
6 6 5 5 5 5 5 6 6
7 6 6 6 6 6 6 6 7
7 6 6 6 6 6 6 6 7
7 7 7 6 6 6 7 7 7
```

z layer 5

```
6 6 6 6 6 6 6 6 6
6 6 6 6 6 6 6 6 6
6 6 6 5 5 5 6 6 6
6 6 5 5 2 5 5 6 6
6 6 5 3 1 3 5 6 6
6 6 5 5 4 5 5 6 6
6 6 6 5 5 5 6 6 6
6 6 6 6 6 6 6 6 6
6 6 6 6 6 6 6 6 6
```

z layer 6

```
7 7 7 6 6 6 7 7 7
7 6 6 6 6 6 6 6 7
7 6 6 5 5 5 6 6 7
6 6 5 5 4 5 5 6 6
6 6 5 4 4 4 5 6 6
6 6 5 5 5 5 5 6 6
7 6 6 6 6 6 6 6 7
7 6 6 6 6 6 6 6 7
7 7 7 6 6 6 7 7 7
```

z layer 7

```
7 7 7 6 6 6 7 7 7
7 6 6 6 6 6 6 6 7
7 6 6 6 6 6 6 6 7
6 6 6 6 6 6 6 6 6
6 6 6 6 6 6 6 6 6
6 6 6 6 6 6 6 6 6
7 6 6 6 6 6 6 6 7
7 6 6 6 6 6 6 6 7
7 7 7 6 6 6 7 7 7
```

z layer 8

```
7 7 7 6 6 6 7 7 7
7 6 6 6 6 6 6 6 7
7 6 6 6 6 6 6 6 7
6 6 6 6 6 6 6 6 6
6 6 6 6 6 6 6 6 6
6 6 6 6 6 6 6 6 6
7 6 6 6 6 6 6 6 7
7 6 6 6 6 6 6 6 7
7 7 7 6 6 6 7 7 7
```

z layer 9

```
7 7 7 7 7 7 7 7 7
7 7 7 7 7 7 7 7 7
7 7 7 6 6 6 7 7 7
7 7 6 6 6 6 6 7 7
7 7 6 6 6 6 6 7 7
7 7 6 6 6 6 6 7 7
7 7 7 6 6 6 7 7 7
7 7 7 7 7 7 7 7 7
7 7 7 7 7 7 7 7 7
```

WASTE CHARACTERIZED BY *CONCRETE* WITH PLUTONIUM CONCENTRATIONS THAT EXCEED 37.5% OF THE MINIMUM CRITICAL VALUE

Drum No.	^{239}Pu Concentration (g Pu/lb matrix)	Number of drums
1	1.13	138
2[a]	0.15	78

a. Drum Type 2 contains SiO_2 at 75% of the critical concentration. This drum type was used to complete the cubic configuration of the array.

```
z layer   1
2 2 1 1 2 2
2 1 1 1 1 2
2 1 1 1 1 2
2 1 1 1 1 2
2 1 1 1 1 2
2 2 1 1 2 2

z layer   2
2 2 1 1 2 2
2 1 1 1 1 2
1 1 1 1 1 1
1 1 1 1 1 1
2 1 1 1 1 2
2 2 1 1 2 2

z layer   3
2 2 1 1 2 2
2 1 1 1 1 2
1 1 1 1 1 1
1 1 1 1 1 1
2 1 1 1 1 2
2 2 1 1 2 2

z layer   4
2 2 1 1 2 2
2 1 1 1 1 2
1 1 1 1 1 1
1 1 1 1 1 1
2 1 1 1 1 2
2 2 1 1 2 2

z layer   5
2 2 1 1 2 2
2 1 1 1 1 2
1 1 1 1 1 1
1 1 1 1 1 1
2 1 1 1 1 2
2 2 1 1 2 2

z layer   6
2 2 1 1 2 2
2 1 1 1 1 2
2 1 1 1 1 2
1 1 1 1 1 1
2 1 1 1 1 2
2 2 1 1 2 2
```

WASTE CHARACTERIZED BY *ALUMINUM* WITH PLUTONIUM CONCENTRATIONS THAT EXCEED 37.5% OF THE MINIMUM CRITICAL VALUE

Drum No.	^{239}Pu Concentration (g Pu/lb matrix)	Number of drums
1	3.44	209
2[a]	0.15	7

a. Drum Type 2 contains SiO_2 at 75% of the critical concentration. This drum type was used to complete the cubic configuration of the array.

```
z layer 1
2 1 1 1 1 2
1 1 1 1 1 1
1 1 1 1 1 1
1 1 1 1 1 1
1 1 1 1 1 1
2 1 1 1 1 2

z layer 2
1 1 1 1 1 1
1 1 1 1 1 1
1 1 1 1 1 1
1 1 1 1 1 1
1 1 1 1 1 1
1 1 1 1 1 1

z layer 3
1 1 1 1 1 1
1 1 1 1 1 1
1 1 1 1 1 1
1 1 1 1 1 1
1 1 1 1 1 1
1 1 1 1 1 1

z layer 4
1 1 1 1 1 1
1 1 1 1 1 1
1 1 1 1 1 1
1 1 1 1 1 1
1 1 1 1 1 1
1 1 1 1 1 1

z layer 5
1 1 1 1 1 1
1 1 1 1 1 1
1 1 1 1 1 1
1 1 1 1 1 1
1 1 1 1 1 1
1 1 1 1 1 1

z layer 6
2 1 1 1 1 2
1 1 1 1 1 1
1 1 1 1 1 1
1 1 1 1 1 1
1 1 1 1 1 1
2 1 1 1 1 1
```

WASTE CHARACTERIZED BY AL_2O_3 WITH PLUTONIUM CONCENTRATIONS THAT EXCEED 37.5% OF THE MINIMUM CRITICAL VALUE

Drum No.	^{239}Pu Concentration (g Pu/lb matrix)	Number of drums
1	0.95	136
2[a]	0.15	80

a. Drum Type 2 contains SiO_2 at 75% of the critical concentration. This drum type was used to complete the cubic configuration of the array.

```
z layer 1
2 2 2 2 2 2
2 2 2 2 2 2
2 2 2 2 2 2
2 2 2 2 2 2
2 2 2 2 2 2
2 2 2 2 2 2

z layer 2
2 1 1 1 1 2
1 1 1 1 1 1
1 1 1 1 1 1
1 1 1 1 1 1
1 1 1 1 1 1
2 1 1 1 1 2

z layer 3
1 1 1 1 1 1
1 1 1 1 1 1
1 1 1 1 1 1
1 1 1 1 1 1
1 1 1 1 1 1
1 1 1 1 1 1

z layer 4
1 1 1 1 1 1
1 1 1 1 1 1
1 1 1 1 1 1
1 1 1 1 1 1
1 1 1 1 1 1
1 1 1 1 1 1

z layer 5
2 1 1 1 1 2
1 1 1 1 1 1
1 1 1 1 1 1
1 1 1 1 1 1
1 1 1 1 1 1
2 1 1 1 1 2

z layer 6
2 2 2 2 2 2
2 2 2 2 2 2
2 2 2 2 2 2
2 2 2 2 2 2
2 2 2 2 2 2
2 2 2 2 2 2
```

APPENDIX F:
INDEPENDENT REVIEW

EG&G Idaho

"Providing research and development services to the government"

INTEROFFICE CORRESPONDENCE

Date: October 26, 1993

To: J. B. Briggs, MS 3890

From: H. A. Worle, MS 3960

Subject: INDEPENDENT REVIEW OF THE CRITICALITY SAFETY EVALUATION FOR TRU WASTE IN STORAGE AT THE RWMC - WORLE-07-93

Attached is the summary of my review of the Criticality Safety Evaluation (CSE) for transuranic waste in storage at the Radioactive Waste Management Complex. The independent calculations in this review verify those contained in the CSE. The review verifies that modelling in the CSE is adequately conservative. Editorial and other verbal comments have been forwarded to you earlier and are appropriately addressed in the latest revision of the draft CSE. The subject CSE is a fine piece of work, and this reviewer concurs with its findings.

Attachment:
As Stated

cc: R. L. Nitschke, MS 3960
G. J. Briscoe,
H. A. Worle File, MS 3960
Central Files, MS 1651

INDEPENDENT REVIEW OF THE CRITICALITY SAFETY EVALUATION FOR TRU WASTE IN STORAGE AT THE RWMC

Criticality safety calculations for the storage of transuranic-contaminated (TRU) waste have been performed and reported.[1] Reference 1 constitutes the primary Criticality Safety Evaluation (CSE) for this waste storage. EG&G Idaho, Inc. Company Procedure 7.2 requires the performance of an Independent Criticality Analysis (ICA) "to verify calculations and assumptions made by the author of the CSE." The CSE includes a multi-code comparison as part of the code validation and verification. Calculations with different criticality computer codes and nuclear cross-section libraries were performed by different individuals within the performing organization. It has been concluded that many of the essential requirements for an ICA have already been fulfilled and are incorporated into the CSE. Therefore, a full ICA is not required. A thorough review, including a few key independent computer calculations, has been performed and is reported here. The author of this review has been in contact with the authors of the primary CSE throughout the review process. Significant findings during the review have been passed on to the primary CSE authors, and have led to modifications of that document in a few cases. This review methodology has been judged to be the most appropriate and efficient way to comply with the independent review requirement cited above.

The basis for the criticality safety approach used in the primary CSE is to determine critical concentrations of Pu-239 in infinite systems of various waste matrices. These calculations have been independently repeated for this review. The calculations were performed with a personal computer version of the SCALE4[2] system of computer codes. The KENO-V.a computer code within that system was used, either as a stand-alone code with the 16-energy group cross-section library that is included with this code, or as part of the Criticality Safety Analytical Sequence (CSAS25), which allows the use of a 27-energy group cross-section library based on ENDF/B-IV (Evaluated Nuclear Data File/B-IV) cross-sections. Nine waste matrices were investigated: Water, polyethylene, cellulose, concrete, aluminum metal, aluminum oxide, silicon oxide, magnesium oxide, and graphite (water was later eliminated as a matrix). In most cases, the critical Pu-239 concentration is very close for the two calculational tools used. However, the metal oxides show a significant difference, with the calculations using the 27-group cross-sections yielding lower critical concentrations than the calculations using the Hansen-Roach library. Table 1 shows the results of these calculations and the comparative values from the primary CSE. The independently calculated Pu-239 concentrations show good agreement with the infinite system critical concentrations found in the primary CSE.

Computer input listings for many of the calculations reported in the various tables of the CSE have been reviewed. In one case, an error was found, leading to a recalculation of that case. Dimensions of realistic waste drum models used in certain calculations in the CSE were reviewed and found to be correct. A few independent calculations, other than those for infinite system critical concentrations discussed above, were performed for this review. The

results, in all cases showed good agreement with those reported in the CSE. Constituent atom densities for many calculations reported in the CSE are listed in that document's Appendix A. Check calculations of those atom densities were performed, and close agreement was found in all cases.

Other reviews performed include an editorial review. Comments forwarded to the authors of the primary CSE have been incorporated into that document to improve its clarity.

It is the conclusion of this review that the results reported in Reference 1 are correct and that the primary CSE provides an adequate basis for a determination of criticality safety of the TRU waste stored at the Radioactive Waste Management Complex.

Table 1. Results of Independent Calculations of Critical Concentrations of Pu-239 in Various Matrices.

Matrix	Density (g/cm^3)	Critical Pu-239 Concentrations (g per lb matrix) H-R 16-group	27-group	From Reference 1
Water	1.0	3.18		3.2
Polyethylene	0.92	4.12		4.12
Cellulose	0.64	1.79	1.79	1.78
Aluminum	2.70	1.10	1.09	1.10
Concrete	2.37	0.73	0.75	0.75
Al_2O_3	3.695	0.37	0.308	0.31
SiO_2	2.32	0.228	0.197	0.20
MgO	3.58	0.14	0.12	0.12
Graphite	1.6	0.0258	0.0246	0.0260

REFERENCES

1. Maria E. Shaw, et al., Criticality Safety Evaluation for TRU Waste in Storage at the RWMC, EGG-NRE-10754, EG&G Idaho, Inc., October 1993.

2. SCALE: A Modular Code System for Performing Standardized Computer Analyses for Licensing Evaluation, RSIC Computer Code Collection, CCC-545, NUREG/CR-0200, Rev. 4, ORNL/NUREG/CSD-2/R4, Oak Ridge National Laboratory.