71-9294

Global Nuclear Fuel

Charles M. Vaughan
Manager
Facility Licensing

A Joint Venture of GE, Toshiba & Hatachi

Global Nuclear Fuel – Americas, LLC
Mail Code K-84
3901 Castle Hayne Road, Wilmington, NC 28401
(910) 675-5656, Fax (910) 675-362-5656

June 30, 2005

Mr. E. William Brach, Director
Spent Fuel Project Office, M/S O-13D13
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555-0001

Dear Mr. Brach:

Subject: Additional Criticality Safety Demonstration for the New Powder Container (NPC)

References: (1) Docket 71-9294, USA/9294/AF-85, TAC No. L23355
(2) Recent telephone conversations between NRC and GNF

The Global Nuclear Fuel - Americas, L.L.C. (GNF) facility in Wilmington, North Carolina, hereby submits additional criticality safety demonstration for the NPC package. The information being submitted is in response to a question raised by the United Kingdom and augments similar information in Chapter 6.0, Criticality Safety Evaluation of the approved SAR. Since this information is of a demonstration and/or confirmatory nature relative to determinations already made and does not in any way change the conditions of the certificate, a reissue of the certificate may not be necessary. However, if a revision to the current certificate is necessary as a result of this review, we request that the new certificate not supersede the prior revision for at least 90 days since we currently have many revalidations necessary to support ongoing shipments involving the NPC. The following is a description of the Attachment to this letter.

Attachment 1 contains the additional criticality safety demonstration information related to the NPC package.

Please contact me on (910) 675-5656 if you have any questions or would like to discuss this matter further.

Sincerely,

Global Nuclear Fuel – Americas, LLC

Charles M. Vaughan

Charles M. Vaughan, Manager
Facility Licensing

cc: CMV-05-040

NMSS01

ATTACHMENT 1

eDRF No. 0000-0006-6390 [ADDENDUM 1]
Criticality Safety Analysis
New Powder Container
Single Damaged Unit – Heterogeneous Study

June 2005

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eDRF No. 0000-0006-6390 [ADDENDUM 1]
Criticality Safety Analysis
New Powder Container
Single Damaged Unit - Heterogeneous Study

June 2005

Analysis By: John T. Taylor Date 6/29/05 June 29, 2005

Verified By: Lon E. Paulson Date 6/29/05 June 29, 2005

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1. INTRODUCTION

This report summarizes supplemental critical safety analysis results applicable to the New Powder Container (NPC) container [ref. 1, 2]. The current safety basis for the NPC package includes both homogeneous and heterogeneous provisions as shown in Table 1.

Table 1. Authorized Contents - NPC

Type, Form, and Maxium Quantity of Material Per Package

Material Forms[1] (≤5.00 wt.% U-235)	Particle Size Restriction: Minimum OD (inches)	Maximum Loading per ICCA (kgs)		Maximum Loading per NPC (kgs)	
		Net[4]	Uranium	Net[4]	Uranium
Homogenous Uranium Oxide/Compounds[2]	N/A	60.0	52.89	540.0	476.1
Heterogenous UO_2 Pellets (BWR)	0.342	60.0	48.48	540.0	436.3
Heterogenous UO_2 Pellets(PWR)	0.300	60.0	46.71	540.0	420.4
Heterogenous Uranium Compounds[3]	Unrestricted particle size	60.0	40.54	540.0	364.8

[1]The Material Form within any NPC must be the same.
[2]Homogenous compounds limited to UO_2, U_3O_8, UO_x $_{x>2}$, dried calcium-containing sludges, $UO_2(NO3)_2 \cdot 6H_2O$, and uranium oxide bearing ash.
[3]Heterogenous compounds limited to UO_2, U_3O_8, and UO_x $_{x>2}$.
[4]Maximum content weight of any ICCA including plastic or metal receptacles (e.g., bags, bottles, cans).
Note: Uranium-bearing contents may be moderated by water or carbon to any degree and may be mixed with other non-fissile materials within the exception of deuterium, tritium, and beryllium. Materials such as uranium metal and uranium metal alloys are not covered by this certificate.

This addendum is being provided to the NRC as a response to a request for additional information as a result of the United Kingdom DfT regulatory review of the latest revision of the international certificate USA/9294/AF-85 [ref. 3]. The questions center on the modeling treatment of the heterogeneous fuel region. The DfT claims the current methodology (e.g., optimally sized rods, uniformly arranged in a triangular pitch such that the W/F ratio is varied through optimum) is not sufficiently conservative, and that "spheres" or pellets should be used to model the heterogeneous fuel region.

1.1. Request for Additional Information

The primary question that has arisen during the U.K. regulatory review is as follows:

"Can you confirm that optimally moderated spheres of the appropriate diameter have been considered in the criticality assessment? Or have only optimally moderated pins been considered. "

and,

"You stated that 'the "ordered array" treatment in which the right circular cylinder elements are spaced through optimum water-to-fuel ratio ... sufficiently bounds a random distribution of pellets/particles, in which physical suspension of the fuel material is not physically possible.

Pursuant to a separate NRC request, this evaluation studies model constructs associated with the most limiting unrestricted particle size payload of 46 kgs UO2 (40.55 kgs U). Explicit model treatment comparisons between the existing ordered rod array and sphere array is made to estimate the reactivityeffectt on the single damaged NPC package.

1.2. Background - NPC Damaged Single Package

For purposes of this study, the most limiting heterogeneous payload corresponding to unrestricted particle size is assessed using an optimum sized rod OD. The subject of heterogeneous modelling used in the NPC safety demonstration is initially described in Section 6.3.1.5, which states:

- *For heterogeneous materials, the ICCA fuel region is modeled as a lattice of variably spaced UO_2 fuel in the form of right circular cylindrical elements (rods) having a fixed total (UO_2) mass with full density H_2O in the ICCA region outside of the cylindrical elements. The fixed mass, either 55 kgs, 53 kgs or 46 kgs, is based on the minimum diameter of the pellets or particles size specified in Table 6.1. Similar to the homogeneous case, the degree of moderation in the individual fuel rod lattices is varied through optimum, which is done as a function of the lattice water-to-fuel volume ratios by varying the spacing between the rods. As in the homogeneous case, the modeling of accumulations of pellets or other random oriented high-density clumps or particles as uniform lattices of UO_2 cylindrical elements (rods) is a known conservatism.*

Later, Section 6.3.3.2 describes the heterogeneous modelling used for the damaged single package.

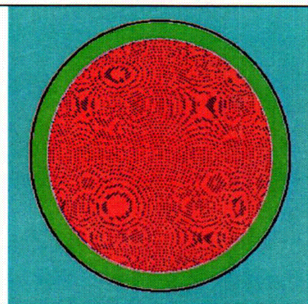
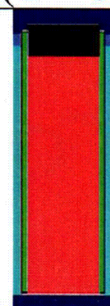
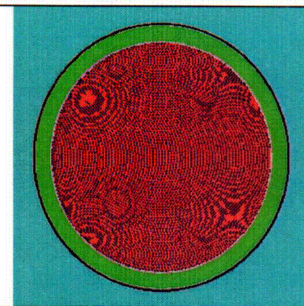
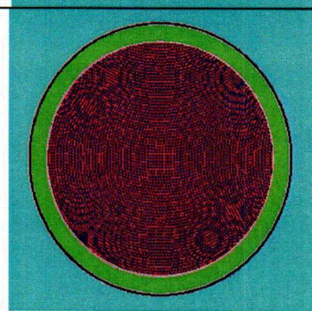
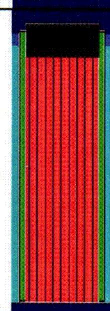
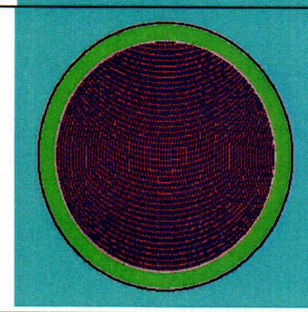
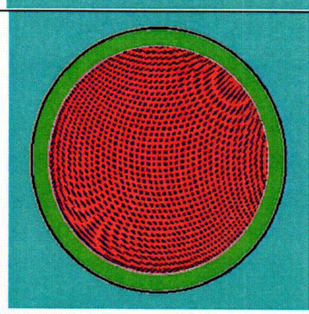
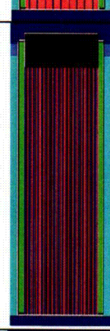
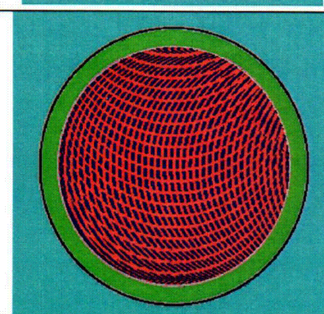
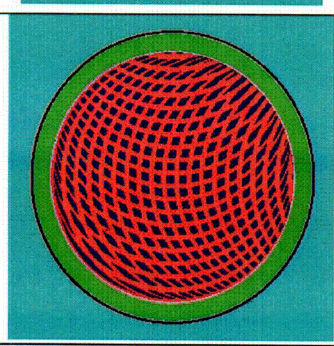
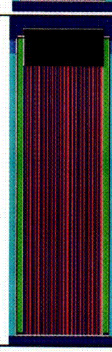
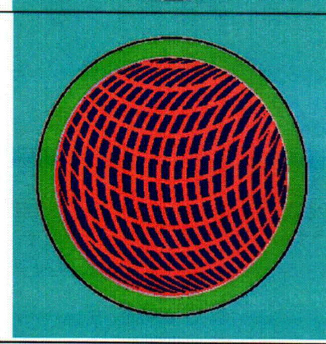
- *The package models for damaged single packages with heterogeneous UO_2 cylindrical elements (rods) in H_2O are the same as the worse case configuration as determined in the analyses for homogeneous mixtures, but with the fuel region less than or equal to the maximum ICCA inner height based upon the specified cylindrical rod lattice and UO_2 mass limit. This model is the one shown in Figure 6.5c, the "Fully reflected damaged single package ... maximum burn" construct, except for the potentially smaller fuel element lattice height. For less than maximum height lattices, the regions in the ICCAs above the lattice are modeled as voids.*

The Virtual Fill Option (or VFO, as described in Section 6.4.3.1 of the latest NPC SAR) is used in this analysis because it permits modeling of fuel lattices with a very large number of cylindrical elements (rods). Since only one geometry unit is actually used for the lattice (and the lattice is created by mirror reflection boundary conditions on the unit) the size of the array that can be modeled is essentially unlimited.

This analytic capability is required when analyzing the most reactive fuel lattice without regard to particle size outer diameter (OD) or W/F ratio since the optimum outer rod diameter for 5.00% enriched UO_2 rods is in the range of 0.05 inches to 0.15 inches. Explicit modeling of fixed arrays of these sizes of cylindrical elements in the ICCAs would require hundreds of thousands of elements in the lattice. In the present analysis, the range of cylindrical diameters analyzed for the optimum case is derived from four separate particle size diameters through optimum heterogeneity (e.g., 0.20", 0.10", 0.05", and 0.025" diameters). Example 2D plots for these cases are shown in Figure 6.6e (the XZ models are those for the square lattices; the models for the triangular lattices are similar).

The variation of rod diameter from 0.025 - 0.200 inches is considered sufficiently conservative representation of 'unrestricted' particle size ranges contained within the ICCA volume. The primary reason for this assumption is that the rod pitch is varied uniformly through optimum water equivalent moderation. The NPC SAR Chapter 6 demonstrate this optimal reactivity behaviour for the damaged single package for both square and triangular pitch lattices of unrestricted particles sizes (modelled as very small OD rods). These square and triangular pitch VFO rod lattice results are presented below in Figures 6.12g and 6.12h, respectively.

Figure 6.6e – NPC Container Models for the VFO Analysis of Optimum Rod Diameters*

Rod Diameter (Inches)	XY Square Lattices	XZ Model (Y = 0)	XY Triangular Lattices
0.025			
0.050			
0.100			
0.200			

*46 kgs UO_2 at W/F = 5.2

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Figure 6.12g – NPC damaged single package k*eff* vs. W/F Ratio (unrestricted particle size, square pitch, 46 kgs UO_2/ICCA)

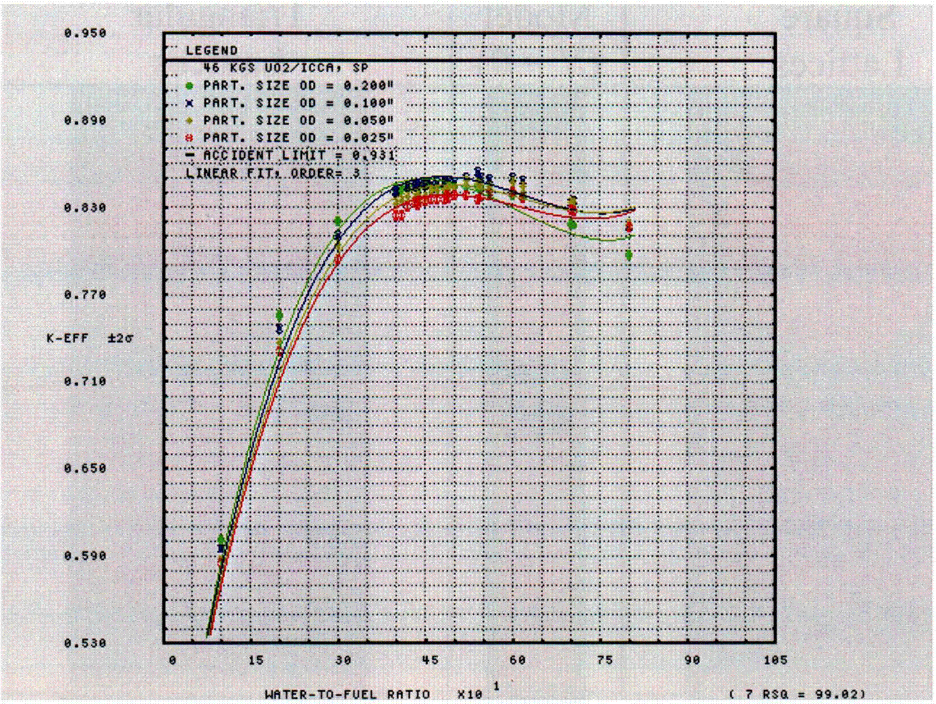
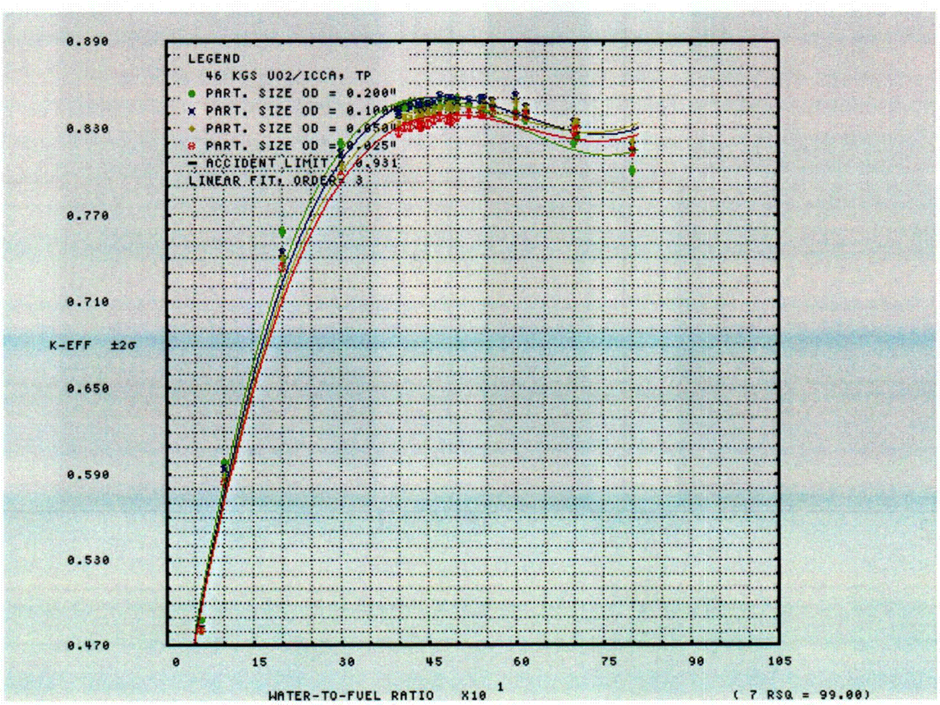


Figure 6.12h – NPC damaged single package k*eff* vs. W/F Ratio (unrestricted particle size, triangular pitch, 46 kgs UO_2/ICCA)



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1.3. Analytical technique - GEMER Monte Carlo

In this study, the effective neutron multiplication, keff, of modeled system is calculated using the GEMER Monte Carlo Code. GEMER is a GNF-A proprietary Monte Carlo program, which solves the neutron transport equation as a fixed source or an eigenvalue problem in three-space dimension. Calculations documented in this report are performed using GEMER version 1.0 on verified microcomputer workstations at GNF-A Wilmington, NC fuel fabrication facility (ref. 1).

GEMER is a Monte Carlo neutron transport code developed by combining geometry and Monte Carlo features from the KENO IV and MERIT Monte Carlo codes and be adding enhance geometry, picture geometry checking and editing features. Hence, GEMER is the evolution of Geometry Enhanced MERIT. The MERIT code is premised on the Battelle Northwest Laboratory's BMC code and is characterized by its explicit treatment of resolved resonance in material cross section set. Functionally, the GEMER Monte Carlo code is similar in analytic capability to industry-recognized codes such as KENO Va. or MCNP.

Cross sections in GEMER are processed from the ENDF/B-IV library in multigroup and resonance parameter formats. Cross-sections are prepared in the 190 energy group format and those in the resonance energy range have the form of resonance parameters. This treatment of cross-sections with explicit resonance parameters is especially suited to the analysis of uranium compounds in the form of heterogeneous accumulations or lattices.

Thermal scattering of hydrogen is represented by the Hayward Kernel $S(\alpha,\beta)$ data in the ENDF/B-IV library. The types of reactions considered in the Monte Carlo calculation are fission, elastic, inelastic, and (n,2n) reactions; absorption is implicitly treated by applying the non-absorption probability to neutron weights on each collision. As part of the solutions, GEMER produces eigenvalue, micro- and macro-group fluxes, reaction rates, cross sections, and neutron balance by isotopes.

GEMER calculations were run with 200 batches, using 2000 neutrons per batch, skipping 10 batches prior to starting the statistical output processing - for a total of 100,000 active neutron histories. Unless otherwise specified, start type = 1 (cosine) distribution over the fuel region is used. The following (representative) verified hardware workstation and validated GEMER code executable/cross-section libraries were used under a Microsoft Windows 2000 operating system:

```
organization:        gnfa, crit.safety, wilmington, nc
system:              taylor, pentium-iii, 1-ghz
hardware:            dell, optiplex, gx150, serial no. (bj2h011)
program name:        C:\PROGRAMS\GEMER.EXE
program version:     1.0
program date:        03/24/04
library name:        C:\XSEC.LIB\GEMLIB
library date:        1AB3
library time:        762F
```

1.4. Validation of Calculation Method

The uranium oxide bias from critical benchmarks involving cadmium and bias adjustment due to extrapolating the validation benchmarks for low-worth cadmium absorber to a high-worth application such as the NPC package (Δk_u - β) is demonstrated using a boron substitution methodology to be no greater than -0.01888 at a 95% confidence level. The area of applicability for the uranium oxide with cadmium benchmark calculations is enrichment ranges from 2.35 to 4.98 weight percent U-235 and H/U-235 ratio 260-488 [refer Section 6.8.2 and 6.8.3 from reference 1].

The cadmium bias resulting from these benchmark experiments can therefore be successfully applied to criticality calculations involving uranium compounds for the NPC shipping package. For this evaluation, the NPC package and it contents are considered subcritical if the following condition is satisfied:

$$k_{eff} + 2\sigma \le USL$$
$$k_{eff} + 2\sigma \le 0.95 - 0.01888$$

or

$$k_{eff} + 2\sigma \le 0.93112$$

Conservatively rounding this result down, the acceptance criteria becomes:

$$k_{eff} + 2\sigma \le 0.931$$

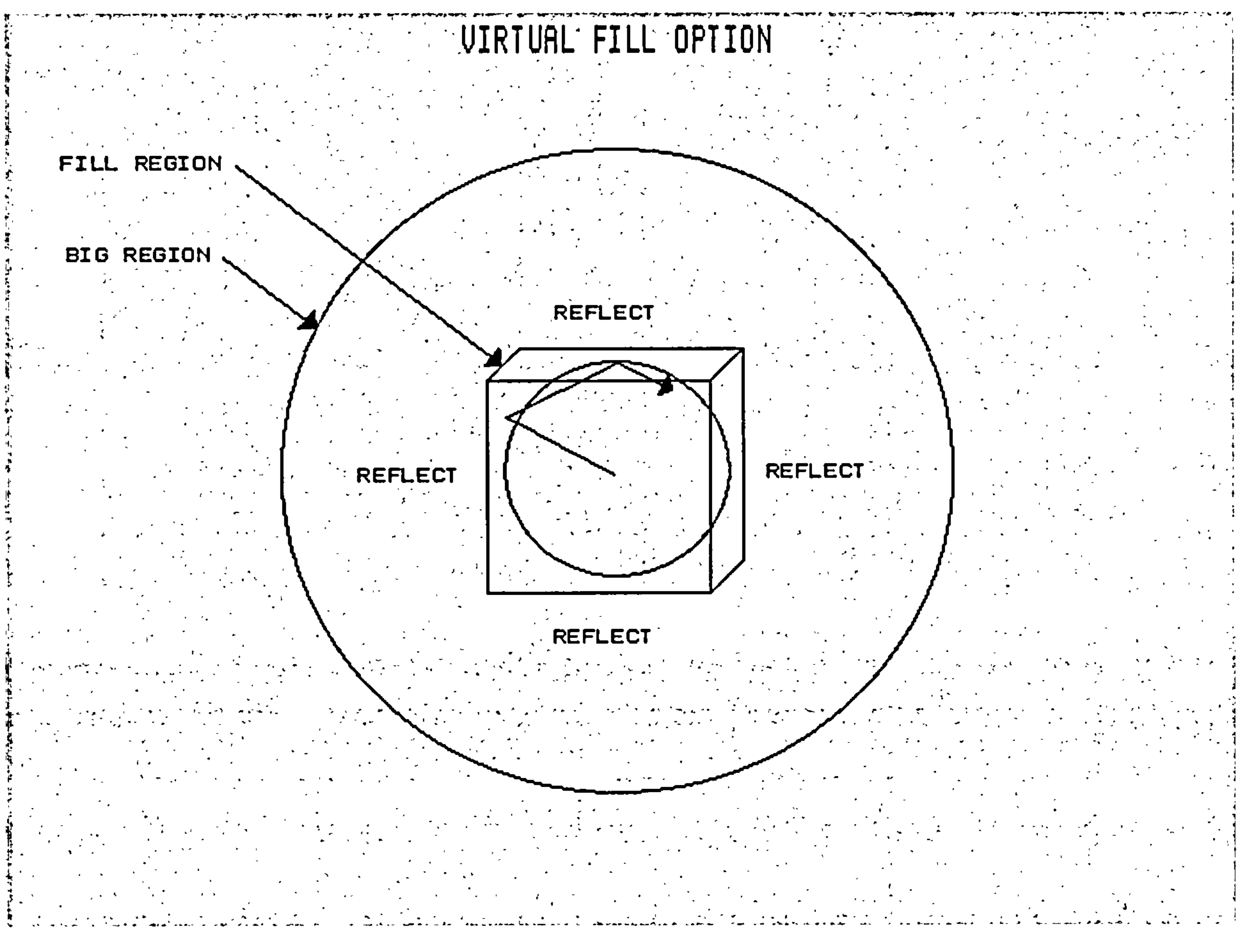
1.5. Analytical Procedure - Heterogeneous Modeling Using Spheres

The procedure has been to select limiting cases from prior work [ref. 1] to show the reactivity effect by modeling a spatial distribution of spheres corresponding to the unrestricted particle size payload of 46.0 kgs UO2. Two separate spatial spherical distributions are quantified and compared to the uniform ordered rod array treatment. These distributions include a simple cubic lattice of spheres and a triangular lattice of spheres (TRITERS).

1.5.1 Heterogeneous Modeling Using a Simple Cubic Array

The SPHERE geometry construct is used for specifying a simple cubic lattice of spherical particles in a given matrix such as water to be represented using the Virtual Fill Option (VFO). In the simple cubic geometry, each sphere has six (6) nearest neighbors. The simple cubic geometry consists of a sphere centered within a cube. When mirror reflected in the ±X, ±Y and ±Z axes, the overall geometry becomes the original unbounded simple cubic lattice (Figure 1).

Figure 1. SPHERE Geometry Construct in VFO



1.5.2 Heterogeneous Modeling Using TRITERS

The **TRITERS geometry construct** is used for specifying a triangular pitch lattices of spherical particles in a given matrix such as water to be represented using the Virtual Fill Option (VFO). The TRITERS construct represents a true triangular lattice of spherical particles rather than a body-centered cubic lattice. In the TRITERS geometry, each sphere has ten (10) nearest neighbors. As shown in **Figure 2a**, the TRITERS geometry consists of a regular parallelepiped box in which two sets of opposite corners are cut out by 1/8[th] of a sphere at each of the corners. Dimensions of the sides are scaled such that when mirror reflected in the ±X, ±Y and ±Z axes, the overall geometry becomes the original unbounded triangular lattice (**Figure 2b**).

Figure 2a. TRITERS Geometry Construct

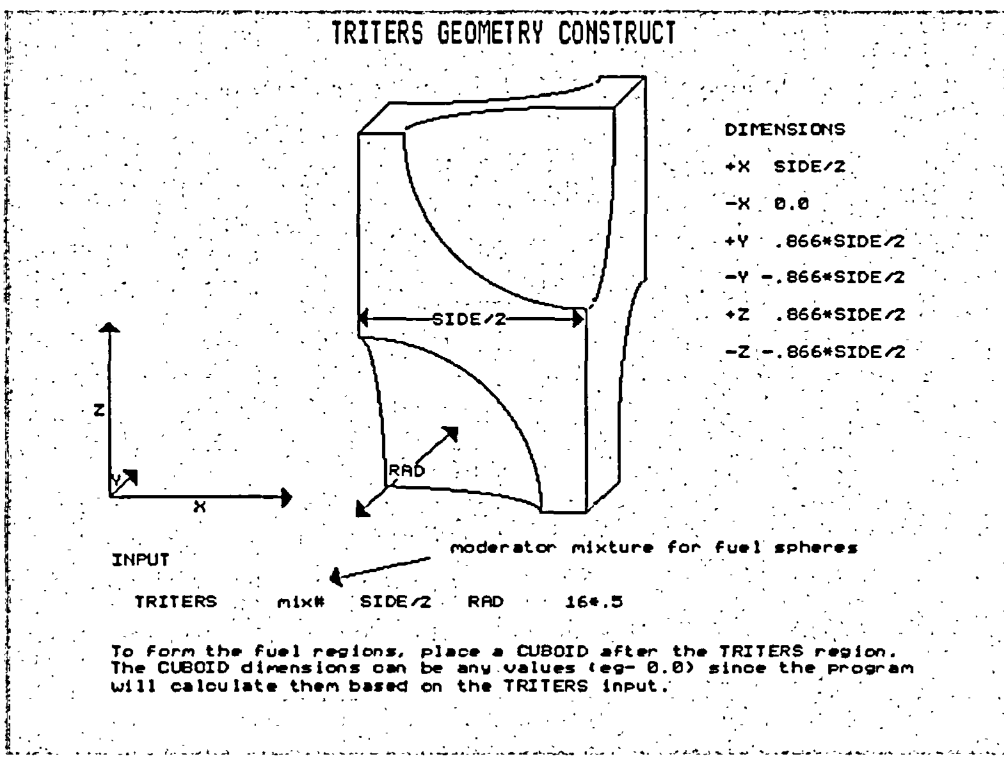
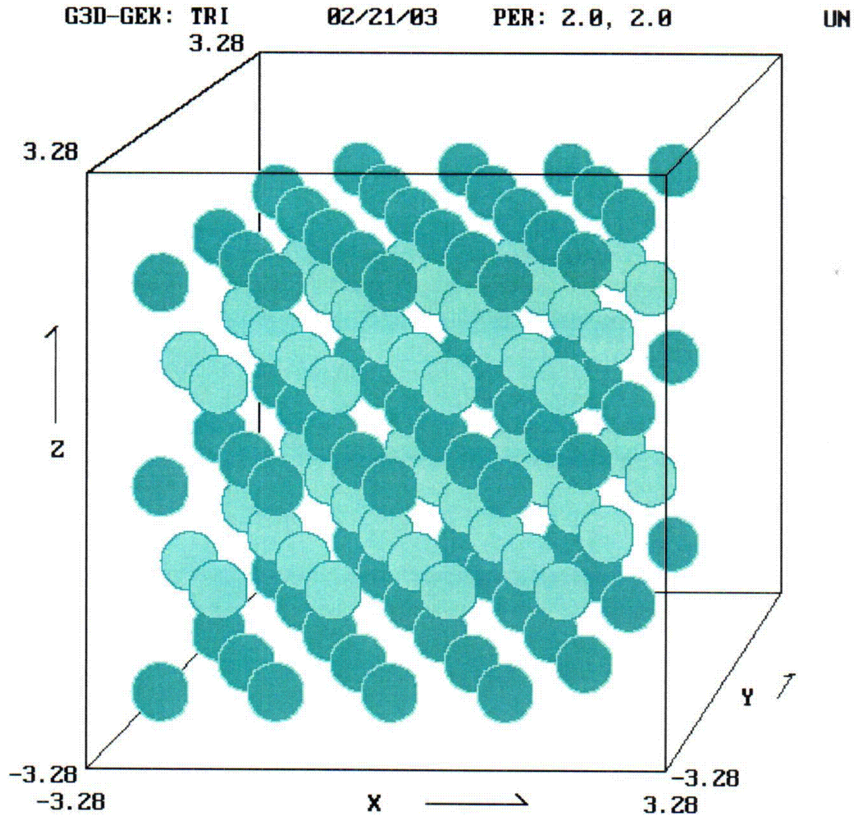


Figure 2b. TRITERS Triangular Sphere Lattice Illustration



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2. RESULTS OF CALCULATIONS

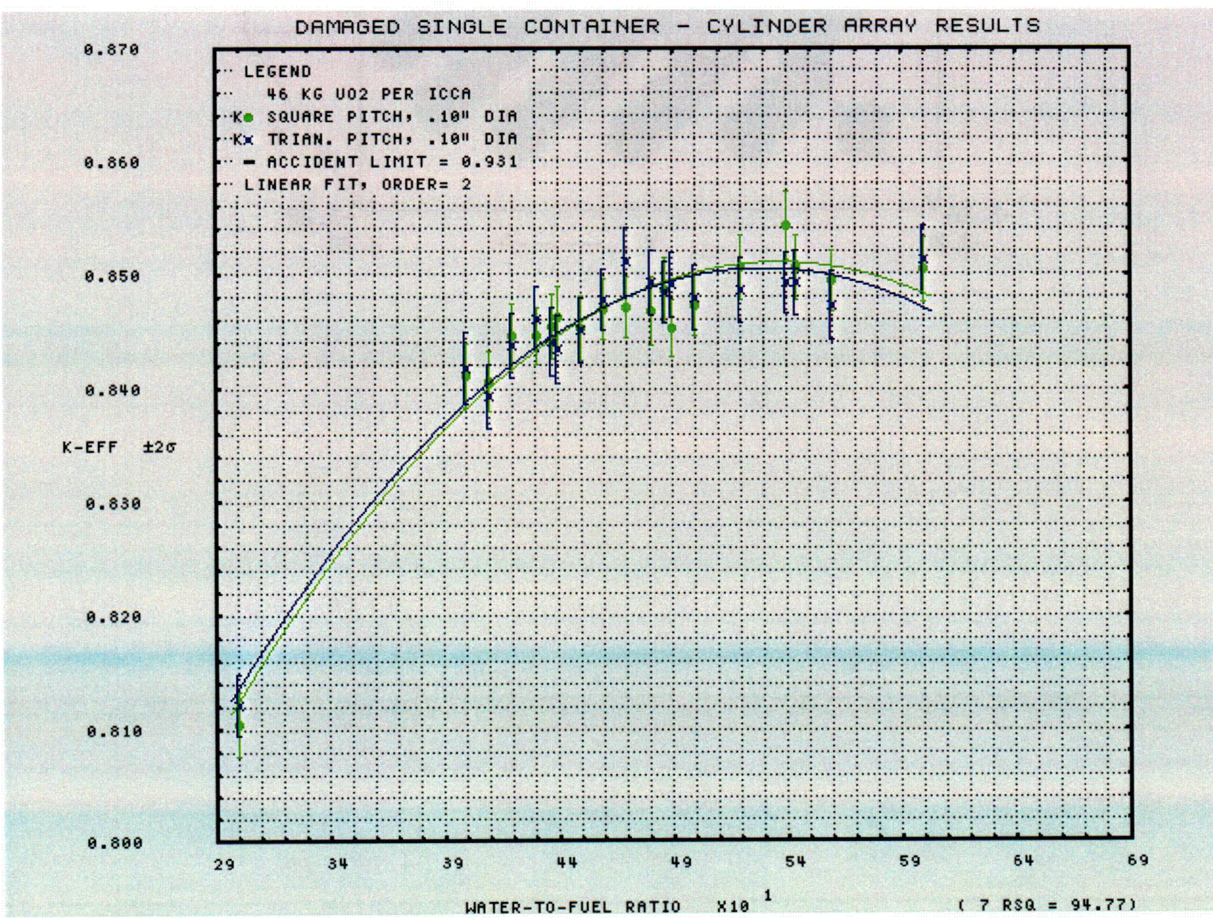
2.1. NPC Damaged Single Package - Rods vs. Spheres

For purposes of this work, these reactivity studies are premised on the damaged single package "base case" unrestricted particle size (rod OD) models **MTTL-600** (triangular rod lattice) **and MTSL-540** (square pitch rod lattice) from Table 6.9.D [ref. 1].

The total payload inside each ICCA is held constant at 46.0 kgs UO2. Both the sphere size (OD) and water-to-fuel ratio are varied for both SPINTERS and TRITERS geometry types to determine the maximum reactivity of the NPC damaged single package. These results are compared to the original optimal rod OD results previously described.

The original results for 0.10" diameter cylinders from the uniform rod array treatment are shown in **Figure 3a** using second order linear regression fits. The curves show no significant difference between the square pitch and triangular pitch models. From the curves, the estimated expected peak value is 0.851. The maximum value reported in Reference 1 is 0.854 is 0.03 higher than the expected maximum.

Figure 3a. Original Results with Uniform Rod Arrays



The fuel height in the ICCA is a function of the mass of UO2, the inside radius of the ICCA, and the W/F ratio. **Table 2** shows the fuel height for a UO2 mass of 46 Kg and an ICCA inside radius of 10.8141 cm.

C04

Table 2. Fuel Height in ICCA as a Function of W/F

Water-to-Fuel Ratio	Weight Fraction Water	Density of UO2 (gm/cc)	Fuel Height (cm)	Top of Fuel Box Type, +Z
4.0	0.26738	2.1920	57.120	7, 5.1135
4.5	0.29107	1.9928	62.829	7, 10.8225
5.0	0.31328	1.8267	68.543	7, 16.5365
5.5	0.33414	1.6862	74.254	8, 0.9091
6.0	0.35377	1.5657	79.968	Full

As seen in this table, increasing the W/F ratio above 6.0 reduces the fuel mass below the 46 Kg limit. The column labeled "Top of Fuel" refers to the GEMER model.

Sample input files for the simple cubic model (SQR20-55.IN) and the TRITERS model (TRI10-55.IN) are provided in Attachment 1 along with the MTSL-540.IN input from the original analysis.

The X spacing of the simple cubic array as a function of W/F ratio and sphere radius is provided in **Table 3a**. In this table, SIDE is one half of the center-to-center spacing between spheres on an axis.

Table 3a. Simple Cubic Array Sphere Spacing

```
                         >> EQUATIONS <<

W_TO_F_SPH = ( ( 2 * SIDE ) ** 3 - [ 4 / 3 * PI * R * R * R ] ) / [ 4 /
    3 * PI * R * R * R ]

                         >>  RESULTS  <<

R               SIDE            W_TO_F_SPH
--------------  --------------  --------------
0.1270000       0.17503569       4.0000005
0.1905000       0.26255354       4.0000008
0.2540000       0.35007137       4.0000001
0.3175000       0.43758921       3.9999998
0.3810000       0.52510705       3.9999998
0.4445000       0.61262491       4.0000001

0.1270000       0.18068586       4.5000002
0.1905000       0.27102878       4.4999999
0.2540000       0.36137171       4.4999999
0.3175000       0.45171465       4.5000001
0.3810000       0.54205766       4.5000021
0.4445000       0.63240050       4.5000000

0.1270000       0.18600317       4.9999999
0.1905000       0.27900475       5.0000000
0.2540000       0.37200634       5.0000001
0.3175000       0.46500793       4.9999999
0.3810000       0.55800956       5.0000011
0.4445000       0.65101109       5.0000001

0.1270000       0.19103270       5.4999999
0.1905000       0.28654905       5.5000001
0.2540000       0.38206540       5.5000001
0.3175000       0.47758176       5.5000001
0.3810000       0.57309814       5.5000014
```

0.4445000	0.66861444	5.5000000
0.1270000	0.19581050	6.0000016
0.1905000	0.29371573	6.0000003
0.2540000	0.39162097	6.0000002
0.3175000	0.48952622	6.0000001
0.3810000	0.58743154	6.0000029
0.4445000	0.68533671	6.0000002

The X spacing of the TRITERS region as a function of W/F ratio and sphere radius is provided in **Table 3b**. In this table, SIDE is one half of the center-to-center spacing between spheres on the X axis.

Table 3b. Triangular Array Sphere Spacing

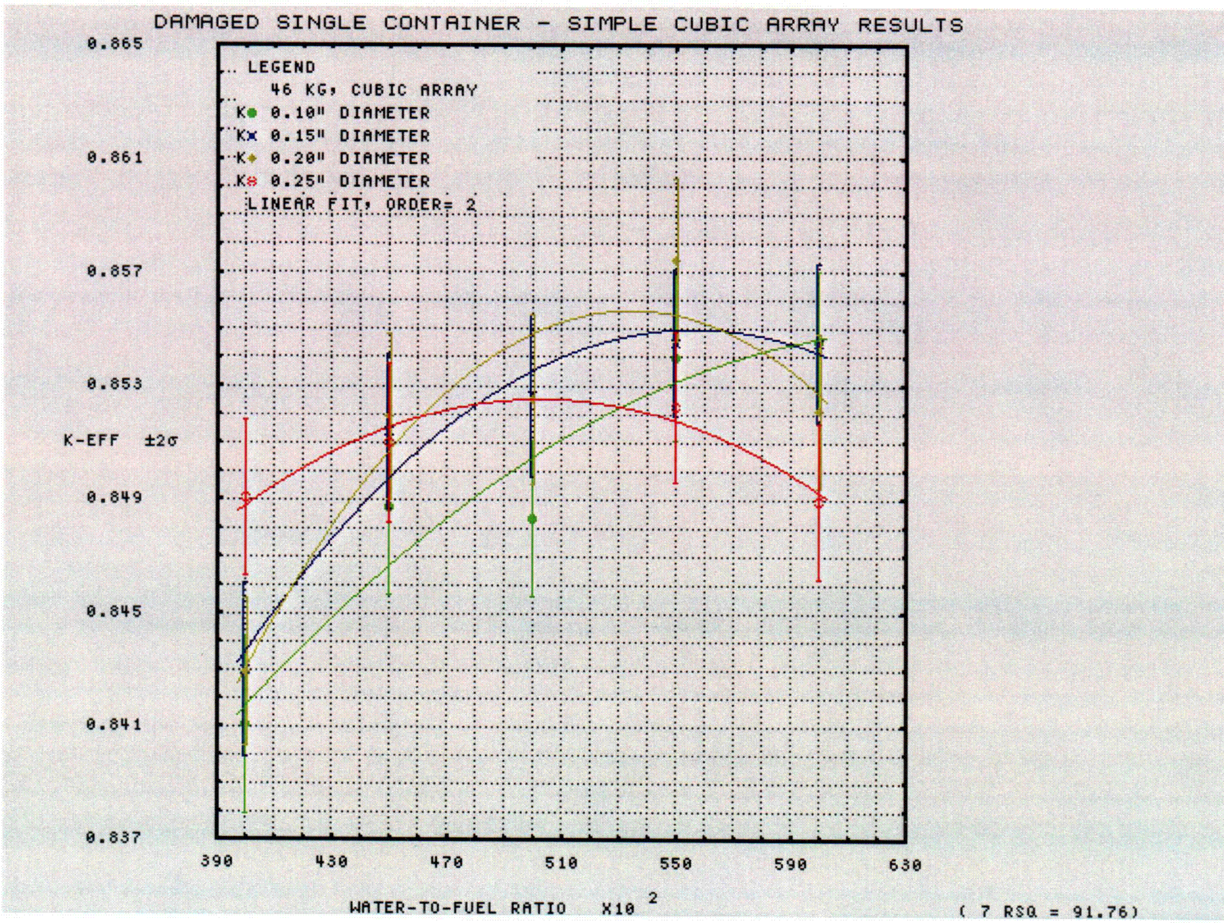
```
                         >> EQUATIONS <<

W_TO_F_SPH_X = ( 3 * SIDE ** 3 - [ 2 * PI / 3 * R * R * R ] ) / [ 2 * PI
     / 3 * R * R * R ]

                         >>  RESULTS  <<
```

R	SIDE	W_TO_F_SPH_X
0.1270000	0.19265170	4.0000001
0.1270000	0.19265170	4.0000001
0.1905000	0.28897755	4.0000001
0.2540000	0.38530340	3.9999999
0.3175000	0.48162924	4.0000001
0.3810000	0.57795510	4.0000000
0.4445000	0.67428094	3.9999999
0.1270000	0.19887052	4.5000002
0.1905000	0.29830581	4.5000019
0.2540000	0.39774104	4.4999998
0.3175000	0.49717629	4.4999999
0.3810000	0.59661156	4.5000001
0.4445000	0.69604682	4.4999999
0.1270000	0.20472298	5.0000002
0.1905000	0.30708447	5.0000002
0.2540000	0.40944596	5.0000000
0.3175000	0.51180744	5.0000001
0.3810000	0.61416899	5.0000016
0.4445000	0.71653043	4.9999998
0.1270000	0.21025869	5.4999998
0.1905000	0.31538804	5.5000001
0.2540000	0.42051739	5.4999999
0.3175000	0.52564672	5.4999998
0.3810000	0.63077608	5.5000001
0.4445000	0.73590542	5.4999999
0.1270000	0.21551733	6.0000001
0.1905000	0.32327598	5.9999999
0.2540000	0.43103466	6.0000001

0.3175000	0.53879331	6.0000000
0.3810000	0.64655197	5.9999997
0.4445000	0.75431064	6.0000003

Figure 3b represents the simple cubic results for sphere diameters of 0.10", 0.15", 0.20", and 0.25" using a second order linear fit.. Similarly, Figure **3c** represents the triangular results for sphere diameters of 0.10", 0.15", 0.20", and 0.25" using a second order linear fit.

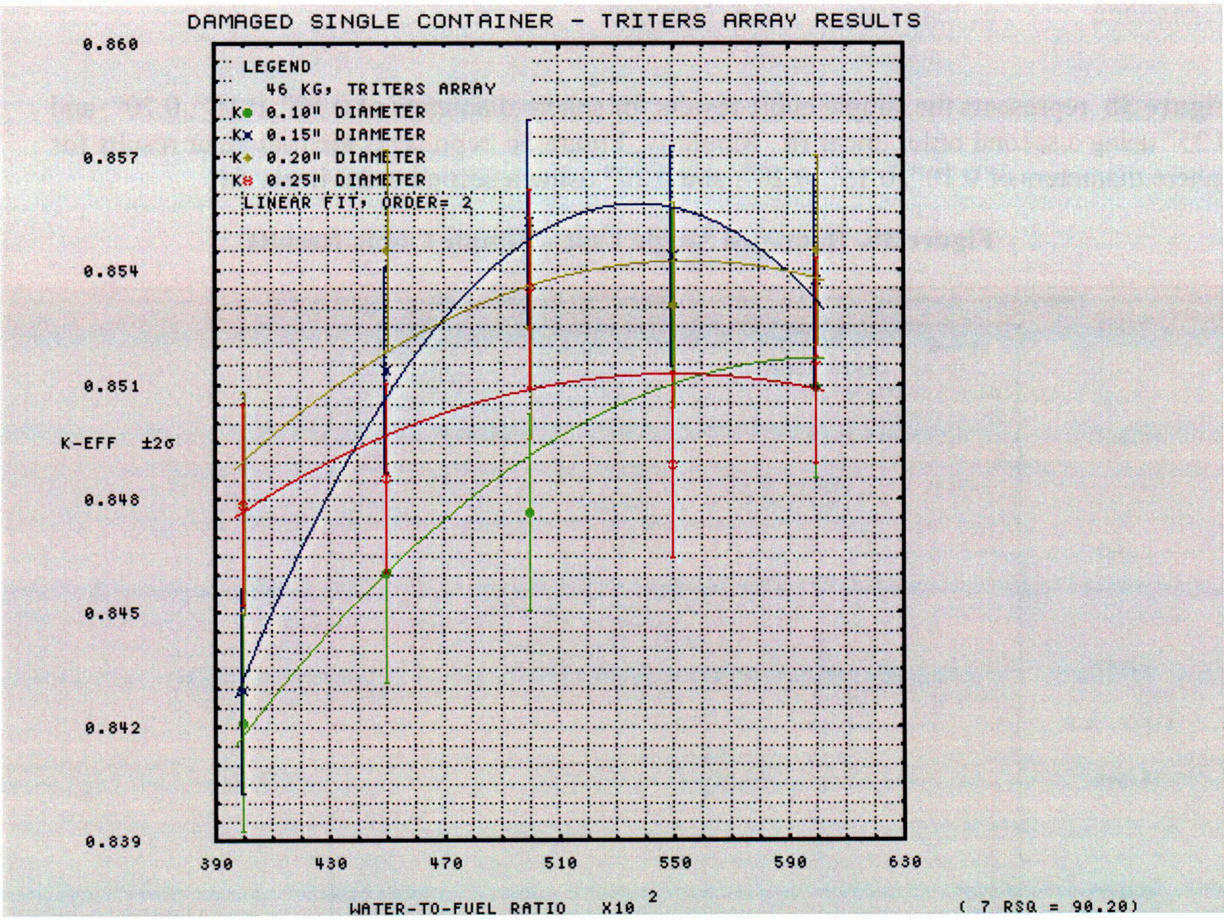
Figure 3b. Damaged Single Unit – Simple Cubic Results



These curves show a maximum expected value of keff of 0.8557. This value occurs for the 0.20" diameter spheres and is about 0.005 greater than the maximum expected value for the rods. Since these calculations are stochastic, there is considerable uncertainty associated with the difference between two results. This uncertainty is discussed following the TRITERS results.

C05

Figure 3c. Damaged Single Unit - TRITERS Results



These curves show a maximum expected value of keff of 0.8557, which is the same as the simple cubic result.. This value occurs for the 0.15" diameter spheres and is about 0.005 greater than the maximum expected value for the rods. Since these calculations are stochastic, there is considerable uncertainty associated with the difference between two results. This uncertainty can be conservatively estimated by calculating the upper confidence limit on the difference between two means for two normal populations having known variances as follows:

First, find the σ for a calculation. The Central Limit Theorem σ is not more than 0.0015 for any of these calculations. The actual σ is therefore σ(CLT) * √n where n is 200 batches. Therefore, the σ for a calculation is 0.0015 * √200 = 0.0212.

Next calculate a 95% CL for the difference as [(k(sphere) – k(rod)) + z(95%) * √(2*σ*σ/n)]. Therefore, the 95% confidence limit is estimated to be 0.005 + 0.0035 = 0.0085. **Therefore, based on these calculations, it is not likely that the actual increase would exceed one percent.**

Tabulated results of all additional calculations performed in this addendum are provided in **Table 4.**

TABLE 4 - K-EFFECTIVE DATA (USER SKIP)

FILENAME	KEFF	SIGMA	HIST	SKIP	nσ	DATE	ELAPSED	LOST
SIMPLE CUBIC ARRAY								
SQR10-40	0.84105	0.00156	400000	0	0	06/29/05	13.02	32
SQR10-45	**0.84867**	**0.00155**	**400000**	**0**	**0**	**06/29/05**	**5.68**	**43**
SQR10-50	0.84831	0.00137	400000	0	0	06/29/05	12.87	49
SQR10-55	0.85397	0.00146	400000	0	0	06/29/05	5.57	64
SQR10-60	0.85460	0.00125	400000	0	0	06/29/05	12.55	119
SQR15-40	0.84298	0.00153	400000	0	0	06/29/05	4.85	36
SQR15-45	0.85138	0.00135	400000	0	0	06/29/05	10.47	27
SQR15-50	0.85265	0.00143	400000	0	-1	06/29/05	4.72	49
SQR15-55	0.85449	0.00129	400000	0	0	06/29/05	10.52	50
SQR15-60	**0.85451**	**0.00140**	**400000**	**0**	**0**	**06/29/05**	**4.70**	**123**
SQR20-40	0.84288	0.00130	400000	0	0	06/29/05	10.90	45
SQR20-45	0.85189	0.00147	400000	0	0	06/29/05	4.37	41
SQR20-50	0.85247	0.00149	400000	0	0	06/29/05	4.27	45
SQR20-55	**0.85745**	**0.00143**	**400000**	**0**	**-1**	**06/29/05**	**9.18**	**47**
SQR20-60	0.85208	0.00136	400000	0	0	06/29/05	4.35	121
SQR25-40	0.84903	0.00137	400000	0	-1	06/29/05	9.18	40
SQR25-45	0.85100	0.00141	400000	0	0	06/29/05	4.05	48
SQR25-50	**0.85224**	**0.00129**	**400000**	**0**	**-1**	**06/29/05**	**9.37**	**38**
SQR25-55	**0.85224**	**0.00133**	**400000**	**0**	**0**	**06/29/05**	**9.75**	**57**
SQR25-60	0.84893	0.00138	400000	0	0	06/29/05	4.10	143
SQR30-40	0.84615	0.00146	400000	0	0	06/29/05	9.43	36
SQR30-45	0.84732	0.00139	400000	0	0	06/29/05	3.88	33
SQR30-50	**0.85022**	**0.00132**	**400000**	**0**	**0**	**06/29/05**	**8.52**	**40**
SQR30-55	0.84774	0.00151	400000	0	0	06/29/05	3.85	51
SQR30-60	0.84683	0.00133	400000	0	0	06/29/05	10.25	160
SQR35-40	0.84344	0.00134	400000	0	-1	06/29/05	3.78	37
SQR35-45	0.84552	0.00136	400000	0	0	06/29/05	9.07	35
SQR35-50	**0.84676**	**0.00136**	**400000**	**0**	**0**	**06/29/05**	**3.73**	**35**
SQR35-55	0.84385	0.00117	400000	0	-1	06/29/05	3.77	60
SQR35-60	0.84225	0.00128	400000	0	0	06/29/05	8.97	151
TRIANGULAR ARRAY								
TRI10-40	0.84206	0.00143	400000	0	0	06/27/05	23.23	54
TRI10-45	0.84603	0.00144	400000	0	0	06/27/05	22.28	62
TRI10-50	0.84763	0.00131	400000	0	0	06/27/05	21.75	55
TRI10-55	**0.85308**	**0.00127**	**400000**	**0**	**0**	**06/27/05**	**21.53**	**60**
TRI10-60	0.85092	0.00120	400000	0	0	06/27/05	21.83	154
TRI15-40	0.84291	0.00136	400000	0	0	06/27/05	17.82	49
TRI15-45	0.85137	0.00136	400000	0	0	06/27/05	17.55	47
TRI15-50	**0.85526**	**0.00136**	**400000**	**0**	**-1**	**06/27/05**	**17.42**	**65**
TRI15-55	0.85440	0.00145	400000	0	0	06/27/05	17.02	69
TRI15-60	0.85373	0.00141	400000	0	0	06/27/05	17.53	153

TRI20-40	0.84786	0.00144	400000	0	-1	06/27/05	15.52	44
TRI20-45	**0.85451**	**0.00132**	**400000**	**0**	**-1**	**06/27/05**	**15.52**	**58**
TRI20-50	0.85245	0.00146	400000	0	0	06/27/05	15.28	58
TRI20-55	0.85309	0.00136	400000	0	0	06/27/05	15.38	56
TRI20-60	**0.85453**	**0.00126**	**400000**	**0**	**0**	**06/27/05**	**15.18**	**143**
TRI25-40	0.84781	0.00133	400000	0	-1	06/27/05	14.20	37
TRI25-45	0.84850	0.00125	400000	0	0	06/27/05	14.02	47
TRI25-50	**0.85354**	**0.00129**	**400000**	**0**	**0**	**06/27/05**	**14.27**	**74**
TRI25-55	0.84888	0.00122	400000	0	0	06/27/05	14.02	67
TRI25-60	0.85162	0.00135	400000	0	-1	06/27/05	14.58	149
TRI30-40	0.84668	0.00134	400000	0	0	06/27/05	13.15	61
TRI30-45	0.84824	0.00136	400000	0	0	06/27/05	13.30	48
TRI30-50	**0.85219**	**0.00134**	**400000**	**0**	**0**	**06/27/05**	**13.23**	**60**
TRI30-55	0.85133	0.00132	400000	0	-1	06/27/05	13.52	67
TRI30-60	0.84957	0.00149	400000	0	0	06/27/05	12.90	139
TRI35-40	0.84418	0.00128	400000	0	-2	06/27/05	11.88	49
TRI35-45	**0.85116**	**0.00143**	**400000**	**0**	**-1**	**06/27/05**	**12.45**	**42**
TRI35-50	0.84736	0.00131	400000	0	0	06/28/05	11.47	47
TRI35-55	0.84336	0.00138	400000	0	0	06/28/05	12.38	63
TRI35-60	0.84208	0.00143	400000	0	-1	06/27/05	13.20	140

3. CONCLUSIONS

This work estimates the reactivity effect on the single damaged unit of representing the fuel as spheres separated in a water matrix versus representing the fuel as cylinders separated in a water matrix as was done in the original analysis. Spheres were modeled in both a uniform simple cubic array and a uniform triangular array. These calculations indicate that the expected increase in reactivity is about half a percent. With the uncertainty on these calculations, the increase could be as much as one percent. The previous result with cylinders was 0.8761 (keff + 3σ - bias) which is much less than the 0.95 limit on keff. Even with the addition of the one percent increase, the result with spheres would only be about 0.8861 which is still much less than the 0.95 limit on keff.

Therefore, the single damaged NPC is safe for the approved unrestricted particle size contents of 46 Kg. UO2 per ICCA even if the particles are represented as spheres and are separated to form a uniform array.

4. REFERENCES

1. Criticality Safety Analysis, New Powder Shipping Container, Revision 02, WC Peters, LE Paulson, [GNF-A eDRF No. 0000-0006-6390], 8/19/02.
2. USNRC Certificate of Compliance for Radioactive Material Package, USA/9294/AF-85, rev.03, March 31, 2003.
3. USDOT Competent Authority Certification for a Fissile Radioactive Materials Package, USA/9294/AF-85, rev. 04, April 17, 2003.
4. GEMER Monte Carlo code:
   - MERIT - A Monte Carlo Neutron Transport Program, CM Kang, AS Crowder, GK Craig, EC Hansen, August 1, 1976.
   - GEMER Monte Carlo - Users Manual, WC Peters, September 15, 1981.
   - GEMER.4 - Users Manual, JT Taylor, November 1989.
   - GEMER - Microcomputer Version Users Guide, JT Taylor, June 21, 1994.
   - GEMER01 – Supplemental Users Guide, JT Taylor, August 21, 2001.
   - GEMER02 – Supplemental Users Guide, JT Taylor, June 25, 2002.
   - GEMER Version 1.0 – Supplemental Users Guide, JT Taylor, Qi Ao, LE Paulson, April 26, 2004.

Attachment 1. Sample GEMER Input

Sample input - base case MTSL-540.in (optimal rod OD = 0.100", W/F = 5.4)

```
2002 NPC SC,HET Lat,FRad=0.1270, 46.0kg U(5.00)O2,WTF=5.40,MixHt=72.751cm
   200  /* # BATCHES
  2000  /* # NEUTRONS PER BATCH
    10  /* # BATCHES TO SKIP
     0  /* # INITIAL 'SEED' (IF NON-ZERO)
     0  /* # 'IDUMP'
     1  /* # 'NRSTRT'
     0  /* # 'NBTED' (NON-ZERO IS PRINT EDITS)
     0  /* # 'KRED' (NUMBER OF COMBINED REGIONS IN EDITS)
  0  293   0    0
\CSXSEC\UO2\GUO2-50.00
\CSXSEC\NOU\GNOU-0.SS
\CSXSEC\NOU\GNOU-0.CAD
\CSXSEC\NOU\GNOU-0.POL 0.98
\CSXSEC\NOU\GNOU-0.F07 0.90
\CSXSEC\NOU\GNOU-0.WAT
\CSXSEC\NOU\GNOU-0.F11 0.90
\CSXSEC\NOU\GNOU-0.F15 0.90
\CSXSEC\NOU\GNOU-0.F40 0.90
\CSXSEC\NOU\GNOU-0.ORC
\CSXSEC\NOU\GNOU-0.WAT 1.00
KENO GEOM
     0  /* 'KREFM'
     0  /* 'NBOX'
     1  /* 'NBXMAX'
     1  /* 'NBYMAX'
     1  /* 'NBZMAX'
     1  /* 'NXX'
     1  /* 'NTYPST'
     1  /* 'NEMBRG'
     0  /* 'NGMCHK'
     0.0     0.0     0.0     0.0     0.0     0.0
BOX TYPE      1  /* 0.100 pellet, var. W/F
CYLINDER     1  0.127000  30.48  -30.48  16*0.5
CUBOID        6 0.284734 -.284734 0.284734 -.284734 30.48 -30.48 16*0.5
BOX TYPE      2  /*  inner canister: bottom fuel_region # 1 w/ gap: body assy
CYLINDER     -1  10.8141    0.31750   0.00        16*0.5
CYLINDER      2  10.9233    0.31750   0.00        16*0.5
CYLINDER      0  12.40920   0.31750   0.00000     16*0.5
CYLINDER      2  12.40920   0.31750  -0.44200     16*0.5
CYLINDER      2  12.46120   0.31750  -0.44200     16*0.5
CYLINDER      0  12.70000   0.31750  -0.44200     16*0.5
CYLINDER      2  12.76350   0.31750  -0.50550     16*0.5
BOX TYPE      3  /*  inner canister: fuel_region # 2: body assy
CYLINDER     -1  10.8141   25.46350   0.00        16*0.5
CYLINDER      2  10.9233   25.46350   0.00        16*0.5
CYLINDER      3  10.96140  25.46350   0.00000     16*0.5
CYLINDER      4  12.40920  25.46350   0.00000     16*0.5
CYLINDER      2  12.46120  25.46350   0.00000     16*0.5
CYLINDER      0  12.70000  25.46350   0.00000     16*0.5
CYLINDER      2  12.76350  25.46350   0.00000     16*0.5
BOX TYPE      4  /*  inner canister: fuel_region # 3: 0.15 in cd gap: body assy
CYLINDER     -1  10.8141    0.38100   0.00        16*0.5
CYLINDER      2  10.9233    0.38100   0.00        16*0.5
CYLINDER      0  10.96140   0.38100   0.00000     16*0.5
CYLINDER      4  12.40920   0.38100   0.00000     16*0.5
```

```
CYLINDER      2  12.46120   0.38100   0.00000    16*0.5
CYLINDER      0  12.70000   0.38100   0.00000    16*0.5
CYLINDER      2  12.76350   0.38100   0.00000    16*0.5
BOX TYPE      5  /*  inner canister: fuel_region # 4: body assy
CYLINDER     -1  10.8141   25.46350   0.00       16*0.5
CYLINDER      2  10.9233   25.46350   0.00       16*0.5
CYLINDER      3  10.96140  25.46350   0.00000    16*0.5
CYLINDER      4  12.40920  25.46350   0.00000    16*0.5
CYLINDER      2  12.46120  25.46350   0.00000    16*0.5
CYLINDER      0  12.70000  25.46350   0.00000    16*0.5
CYLINDER      2  12.76350  25.46350   0.00000    16*0.5
BOX TYPE      6  /*  inner canister: fuel_region # 5: 0.15 in cd gap: body assy
CYLINDER     -1  10.8141    0.38100   0.00       16*0.5
CYLINDER      2  10.9233    0.38100   0.00       16*0.5
CYLINDER      0  10.96140   0.38100   0.00000    16*0.5
CYLINDER      4  12.40920   0.38100   0.00000    16*0.5
CYLINDER      2  12.46120   0.38100   0.00000    16*0.5
CYLINDER      0  12.70000   0.38100   0.00000    16*0.5
CYLINDER      2  12.76350   0.38100   0.00000    16*0.5
BOX TYPE      7  /*  inner canister: fuel_region # 6: body assy
CYLINDER     -1  10.8141   20.74445   0.00       16*0.5
CYLINDER      0  10.8141   21.33840   0.00       16*0.5
CYLINDER      2  10.9233   21.33840   0.00       16*0.5
CYLINDER      3  10.96140  21.33840   0.00000    16*0.5
CYLINDER      4  12.40920  21.33840   0.00000    16*0.5
CYLINDER      2  12.46120  21.33840   0.00000    16*0.5
CYLINDER      0  12.70000  21.33840   0.00000    16*0.5
CYLINDER      2  12.76350  21.33840   0.00000    16*0.5
BOX TYPE      8  /*  inner canister: fuel_region # 7: body assy
CYLINDER      0  10.8141    3.49250   0.00       16*0.5
CYLINDER      2  10.9233    3.49250   0.00       16*0.5
CYLINDER      3  10.96140   3.49250   0.00000    16*0.5
CYLINDER      4  12.40920   3.49250   0.00000    16*0.5
CYLINDER      2  12.46120   3.49250   0.00000    16*0.5
CYLINDER      0  12.70000   3.49250   0.00000    16*0.5
CYLINDER      2  12.76350   3.49250   0.00000    16*0.5
BOX TYPE      9  /*  inner canister: fuel_region # 8: lid assy
CYLINDER      0  10.8141    0.63250   0.00       16*0.5
CYLINDER      2  10.9233    0.63250   0.00       16*0.5
CYLINDER      3  10.96140   0.63250   0.00000    16*0.5
CYLINDER      4  12.40920   0.63250   0.00000    16*0.5
CYLINDER      2  12.46120   0.63250   0.00000    16*0.5
CYLINDER      0  12.70000   0.63250   0.00000    16*0.5
CYLINDER      2  12.76350   0.63250   0.00000    16*0.5
BOX TYPE     10  /*  inner canister: fuel_region # 9 w/ gap: lid assy
CYLINDER      0  10.8141    0.31750   0.00       16*0.5
CYLINDER      2  10.9233    0.31750   0.00       16*0.5
CYLINDER     11  12.40920   0.31750   0.00000    16*0.5
CYLINDER      2  12.46120   0.31750   0.00000    16*0.5
BOX TYPE     11  /*  inner canister: fuel_region #10 w/ ring: lid assy
CYLINDER      0  10.8141    0.44200   0.00       16*0.5
CYLINDER      2  10.9233    0.44200   0.00       16*0.5
CYLINDER      2  12.40920   0.44200   0.00000    16*0.5
CYLINDER      2  12.46120   0.44200   0.00000    16*0.5
BOX TYPE     12  /*  inner canister: fuel_region #11 w/ top: lid assy
CYLINDER      0  10.8141    1.78050   0.00       16*0.5
CYLINDER      2  10.9233    1.91640   0.00       16*0.5
CYLINDER     11  12.40920   1.91640   0.00000    16*0.5
BOX TYPE      13  /*  inner canister cuboid: body section (7# region)
CUBOID         5  12.7636 -12.7636  12.7636 -12.7636  73.3450  -0.5055  16*0.5
BOX TYPE      14  /*  inner canister cuboid: body section (40# region)
CUBOID         9  12.7636 -12.7636  12.7636 -12.7636  3.49260   0.0000  16*0.5
BOX TYPE      15  /*  inner canister upper cylinder: lid section
```

```
CYLINDER      11  12.7636  3.30840   0.0000  16*0.5
BOX TYPE      16  /*  foam cutout  (void) - 40 #/ft3 foam lid section
CYLINDER      11  13.5510  3.30840   0.0000  16*0.5
BOX TYPE      17  /*  npc body or lid - 10 ga. 304ss layer
CUBOID         2  54.3687 -54.3687  54.3687 -54.3687  0.31240   0.0000  16*0.5
BOX TYPE      18  /*  npc body or lid - 1 inch duraboard (void) layer, 10 ga. 304ss
CUBOID        11  51.5163 -51.5163  51.5163 -51.5163  2.54000   0.0000  16*0.5
CUBOID        11  54.0563 -54.0563  54.0563 -54.0563  2.54000   0.0000  16*0.5
CUBOID         2  54.3687 -54.3687  54.3687 -54.3687  2.54000   0.0000  16*0.5
BOX TYPE      19  /*  npc body - 4 inch bot. foam layer (11 #/ft3)  - face burn
CUBOID         7  42.6086 -42.6086  42.6086 -42.6086  0.00000   0.0000  16*0.5
CUBOID        11  54.0563 -54.0563  54.0563 -54.0563  0.00000  -7.6200  16*0.5
CUBOID         2  54.3687 -54.3687  54.3687 -54.3687  0.00000  -7.6200  16*0.5
BOX TYPE      20  /*  npc body - 29.0750 inch foam layer (7,11 #/ft3) - face burn
CUBOID         5  42.6086 -42.6086  42.6086 -42.6086 73.85050   0.0000  16*0.5
CUBOID         7  42.6086 -42.6086  42.6086 -42.6086 73.85050   0.0000  16*0.5
CUBOID        11  54.0563 -54.0563  54.0563 -54.0563 73.85050   0.0000  16*0.5
CUBOID         2  54.3687 -54.3687  54.3687 -54.3687 73.85050   0.0000  16*0.5
BOX TYPE      21  /*  npc body - 1.375 inch foam layer (40 #/ft3) - face burn
CUBOID         9  42.6086 -42.6086  42.6086 -42.6086  3.49250   0.0000  16*0.5
CUBOID        11  54.0563 -54.0563  54.0563 -54.0563  3.49250   0.0000  16*0.5
CUBOID         2  54.3687 -54.3687  54.3687 -54.3687  3.49250   0.0000  16*0.5
BOX TYPE      22  /*  npc body - 30.45 inch two-part body
CUBOID        11  54.3687 -54.3687  54.3687 -54.3687 77.34300   0.0000  16*0.5
BOX TYPE      23  /*  npc lid - 1.375 inch foam layer (40 #/ft3) - lid burn
CUBOID        11  43.8963 -43.8963  43.8963 -43.8963  3.49250   0.0000  16*0.5
CUBOID        11  54.0563 -54.0563  54.0563 -54.0563  3.49250   0.0000  16*0.5
CUBOID         2  54.3687 -54.3687  54.3687 -54.3687  3.49250   0.0000  16*0.5
BOX TYPE      24  /*  npc lid - 3.5 inch foam layer (15 #/ft3)  - lid burn
CUBOID        11  43.8963 -43.8963  43.8963 -43.8963  2.54000   0.0000  16*0.5
CUBOID        11  54.0563 -54.0563  54.0563 -54.0563  8.89000   0.0000  16*0.5
CUBOID         2  54.3687 -54.3687  54.3687 -54.3687  8.89000   0.0000  16*0.5
BOX TYPE      25  /*  complete npc - body assembly
CUBOID        11  54.3688 -54.3688  54.3688 -54.3688 87.81540   0.0000  16*0.5
BOX TYPE      26  /*  complete npc - lid assembly
CUBOID        11  54.3688 -54.3688  54.3688 -54.3688 15.23490   0.0000  16*0.5
BOX TYPE      27  /*  npc water reflected single-unit
CUBOID         0  54.3688 -54.3688  54.3688 -54.3688 103.0503   0.0000  16*0.5
CUBOID         6  84.8488 -84.8488  84.8488 -84.8488 133.5303 -30.4800  16*0.5
BOX TYPE      28  /*  global unit: 2N=150:5x5x6 cuboid, 30.48-cm h2o refl.
CUBOID         0  271.844 -271.844  271.844 -271.844 618.3020   0.0000  16*0.5
CUBOID         6  302.324 -302.324  302.324 -302.324 648.7820 -30.4800  16*0.5
27  1 1 1  1 1 1  1 1 1  1
BEGIN COMPLEX
/*  build inner canister - main body sections (7 #/ft3 region)
COMPLEX  13  2  0.00000  0.00000  0.00000   1   1   1  0.0  0.0  0.0
COMPLEX  13  3  0.00000  0.00000  0.31750   1   1   1  0.0  0.0  0.0
COMPLEX  13  4  0.00000  0.00000  25.7810   1   1   1  0.0  0.0  0.0
COMPLEX  13  5  0.00000  0.00000  26.1621   1   1   1  0.0  0.0  0.0
COMPLEX  13  6  0.00000  0.00000  51.6256   1   1   1  0.0  0.0  0.0
COMPLEX  13  7  0.00000  0.00000  52.0066   1   1   1  0.0  0.0  0.0
/*  build inner canister - upper body section (40 #/ft3 section)
COMPLEX  14  8  0.00000  0.00000  0.00000   1   1   1  0.0  0.0  0.0
/*  build inner canister - lid section
COMPLEX  15  9  0.00000  0.00000  0.00000   1   1   1  0.0  0.0  0.0
COMPLEX  15 10  0.00000  0.00000  0.63250   1   1   1  0.0  0.0  0.0
COMPLEX  15 11  0.00000  0.00000  0.95000   1   1   1  0.0  0.0  0.0
COMPLEX  15 12  0.00000  0.00000  1.39200   1   1   1  0.0  0.0  0.0
/*  embed 3x3 array of canisters into lid:  11.75 inch - centers
COMPLEX  16 15 -29.8450 -29.8450  0.00000   3   3   1 29.8450  29.8450  0.0
/*  embed 3x3 array of foam cut_outs: 11.75 inch - centers
COMPLEX  23 16 -29.8450 -29.8450  0.00000   3   3   1 29.8450  29.8450  0.0
/*  embed 3x3 array of canisters into inner body: 11.75 inch - centers
```

```
COMPLEX  20 13 -29.8450 -29.8450  0.50550   3   3   1 29.8450  29.8450  0.0
COMPLEX  21 14 -29.8450 -29.8450  0.00000   3   3   1 29.8450  29.8450  0.0
/*  embed two-part body section stackup
COMPLEX  22 20   0.0000   0.0000  0.00000   1   1   1  0.0  0.0  0.0
COMPLEX  22 21   0.0000   0.0000 73.85050   1   1   1  0.0  0.0  0.0
/*  build npc - body assembly
COMPLEX  25 17   0.0000   0.0000  0.00000   1   1   1  0.0  0.0  0.0
COMPLEX  25 18   0.0000   0.0000  0.31240   1   1   1  0.0  0.0  0.0
COMPLEX  25 19   0.0000   0.0000  10.4724   1   1   1  0.0  0.0  0.0
COMPLEX  25 22   0.0000   0.0000  10.4724   1   1   1  0.0  0.0  0.0
/*  build npc - lid assembly
COMPLEX  26 23   0.0000   0.0000  0.00000   1   1   1  0.0  0.0  0.0
COMPLEX  26 24   0.0000   0.0000  3.49250   1   1   1  0.0  0.0  0.0
COMPLEX  26 18   0.0000   0.0000  12.3825   1   1   1  0.0  0.0  0.0
COMPLEX  26 17   0.0000   0.0000  14.9225   1   1   1  0.0  0.0  0.0
/*  complete npc stackup - water reflected single unit
COMPLEX  27 25   0.0000   0.0000  0.00000   1   1   1  0.0  0.0  0.0
COMPLEX  27 26   0.0000   0.0000  87.8154   1   1   1  0.0  0.0  0.0
END GEOM
END GEMER
```

Sample input – simple cubic sphere case SQR20-55.in (sphere OD = 0.200", W/F = 5.5)

```
2005 NPC SC,HET Lat,FRad=0.0254, 5.0kg U( 46.)O2,WTF=5.50,MixHt=74.254cm
   200  /* # BATCHES
  2000  /* # NEUTRONS PER BATCH
    10  /* # BATCHES TO SKIP
     0  /* # INITIAL 'SEED' (IF NON-ZERO)
     0  /* # 'IDUMP'
     1  /* # 'NRSTRT'
     0  /* # 'NBTED' (NON-ZERO IS PRINT EDITS)
     0  /* # 'KRED' (NUMBER OF COMBINED REGIONS IN EDITS)
  0  293   0   0
\CSXSEC\UO2\GUO2-50.00
\CSXSEC\NOU\GNOU-0.SS
\CSXSEC\NOU\GNOU-0.CAD
\CSXSEC\NOU\GNOU-0.POX 0.98
\CSXSEC\NOU\GNOU-0.F07 0.90
\CSXSEC\NOU\GNOU-0.WAT
\CSXSEC\NOU\GNOU-0.F11 0.90
\CSXSEC\NOU\GNOU-0.F15 0.90
\CSXSEC\NOU\GNOU-0.F40 0.90
\CSXSEC\NOU\GNOU-0.ORC
\CSXSEC\NOU\GNOU-0.WAT 1.00
KENO GEOM
     0  /* 'KREFM'
     0  /* 'NBOX'
     1  /* 'NBXMAX'
     1  /* 'NBYMAX'
     1  /* 'NBZMAX'
     1  /* 'NXX'
     1  /* 'NTYPST'
     1  /* 'NEMBRG'
     0  /* 'NGMCHK'
     0.0      0.0      0.0      0.0      0.0      0.0
BOX TYPE       1  /* 0.200 pellet, var. W/F
SPHERE         1 0.254000                               16*0.5
CUBOID         6 0.382065 -.382065 0.382065 -.382065 0.382065 -.382065 16*0.5
BOX TYPE       2  /*  inner canister: bottom fuel_region # 1 w/ gap: body assy
CYLINDER      -1  10.8141     0.31750   0.00        16*0.5
CYLINDER       2  10.9233     0.31750   0.00        16*0.5
CYLINDER       0  12.40920    0.31750   0.00000     16*0.5
```

```
CYLINDER      2  12.40920   0.31750  -0.44200    16*0.5
CYLINDER      2  12.46120   0.31750  -0.44200    16*0.5
CYLINDER      0  12.70000   0.31750  -0.44200    16*0.5
CYLINDER      2  12.76350   0.31750  -0.50550    16*0.5
BOX TYPE      3  /*  inner canister: fuel_region # 2: body assy
CYLINDER     -1  10.8141   25.46350   0.00       16*0.5
CYLINDER      2  10.9233   25.46350   0.00       16*0.5
CYLINDER      3  10.96140  25.46350   0.00000    16*0.5
CYLINDER      4  12.40920  25.46350   0.00000    16*0.5
CYLINDER      2  12.46120  25.46350   0.00000    16*0.5
CYLINDER      0  12.70000  25.46350   0.00000    16*0.5
CYLINDER      2  12.76350  25.46350   0.00000    16*0.5
BOX TYPE      4  /*  inner canister: fuel_region # 3: 0.15 in cd gap: body assy
CYLINDER     -1  10.8141    0.38100   0.00       16*0.5
CYLINDER      2  10.9233    0.38100   0.00       16*0.5
CYLINDER      0  10.96140   0.38100   0.00000    16*0.5
CYLINDER      4  12.40920   0.38100   0.00000    16*0.5
CYLINDER      2  12.46120   0.38100   0.00000    16*0.5
CYLINDER      0  12.70000   0.38100   0.00000    16*0.5
CYLINDER      2  12.76350   0.38100   0.00000    16*0.5
BOX TYPE      5  /*  inner canister: fuel_region # 4: body assy
CYLINDER     -1  10.8141   25.46350   0.00       16*0.5
CYLINDER      2  10.9233   25.46350   0.00       16*0.5
CYLINDER      3  10.96140  25.46350   0.00000    16*0.5
CYLINDER      4  12.40920  25.46350   0.00000    16*0.5
CYLINDER      2  12.46120  25.46350   0.00000    16*0.5
CYLINDER      0  12.70000  25.46350   0.00000    16*0.5
CYLINDER      2  12.76350  25.46350   0.00000    16*0.5
BOX TYPE      6  /*  inner canister: fuel_region # 5: 0.15 in cd gap: body assy
CYLINDER     -1  10.8141    0.38100   0.00       16*0.5
CYLINDER      2  10.9233    0.38100   0.00       16*0.5
CYLINDER      0  10.96140   0.38100   0.00000    16*0.5
CYLINDER      4  12.40920   0.38100   0.00000    16*0.5
CYLINDER      2  12.46120   0.38100   0.00000    16*0.5
CYLINDER      0  12.70000   0.38100   0.00000    16*0.5
CYLINDER      2  12.76350   0.38100   0.00000    16*0.5
BOX TYPE      7  /*  inner canister: fuel_region # 6: body assy
CYLINDER     -1  10.8141   21.33840   0.00       16*0.5
CYLINDER      2  10.9233   21.33840   0.00       16*0.5
CYLINDER      3  10.96140  21.33840   0.00000    16*0.5
CYLINDER      4  12.40920  21.33840   0.00000    16*0.5
CYLINDER      2  12.46120  21.33840   0.00000    16*0.5
CYLINDER      0  12.70000  21.33840   0.00000    16*0.5
CYLINDER      2  12.76350  21.33840   0.00000    16*0.5
BOX TYPE      8  /*  inner canister: fuel_region # 7: body assy
CYLINDER     -1  10.8141    0.90910   0.00       16*0.5
CYLINDER      0  10.8141    3.49250   0.00       16*0.5
CYLINDER      2  10.9233    3.49250   0.00       16*0.5
CYLINDER      3  10.96140   3.49250   0.00000    16*0.5
CYLINDER      4  12.40920   3.49250   0.00000    16*0.5
CYLINDER      2  12.46120   3.49250   0.00000    16*0.5
CYLINDER      0  12.70000   3.49250   0.00000    16*0.5
CYLINDER      2  12.76350   3.49250   0.00000    16*0.5
BOX TYPE      9  /*  inner canister: fuel_region # 8: lid assy
CYLINDER      0  10.8141    0.63250   0.00       16*0.5
CYLINDER      2  10.9233    0.63250   0.00       16*0.5
CYLINDER      3  10.96140   0.63250   0.00000    16*0.5
CYLINDER      4  12.40920   0.63250   0.00000    16*0.5
CYLINDER      2  12.46120   0.63250   0.00000    16*0.5
CYLINDER      0  12.70000   0.63250   0.00000    16*0.5
CYLINDER      2  12.76350   0.63250   0.00000    16*0.5
BOX TYPE     10  /*  inner canister: fuel_region # 9 w/ gap: lid assy
CYLINDER      0  10.8141    0.31750   0.00       16*0.5
```

```
CYLINDER       2  10.9233    0.31750   0.00        16*0.5
CYLINDER      11  12.40920   0.31750   0.00000     16*0.5
CYLINDER       2  12.46120   0.31750   0.00000     16*0.5
BOX TYPE      11  /*  inner canister: fuel_region #10 w/ ring: lid assy
CYLINDER       0  10.8141    0.44200   0.00        16*0.5
CYLINDER       2  10.9233    0.44200   0.00        16*0.5
CYLINDER       2  12.40920   0.44200   0.00000     16*0.5
CYLINDER       2  12.46120   0.44200   0.00000     16*0.5
BOX TYPE      12  /*  inner canister: fuel_region #11 w/ top: lid assy
CYLINDER       0  10.8141    1.78050   0.00        16*0.5
CYLINDER       2  10.9233    1.91640   0.00        16*0.5
CYLINDER      11  12.40920   1.91640   0.00000     16*0.5
BOX TYPE       13  /*  inner canister cuboid: body section (7# region)
CUBOID          5  12.7636 -12.7636  12.7636 -12.7636  73.3450  -0.5055  16*0.5
BOX TYPE       14  /*  inner canister cuboid: body section (40# region)
CUBOID          9  12.7636 -12.7636  12.7636 -12.7636  3.49260   0.0000  16*0.5
BOX TYPE       15  /*  inner canister upper cylinder: lid section
CYLINDER       11  12.7636  3.30840   0.0000  16*0.5
BOX TYPE       16  /*  foam cutout  (void) - 40 #/ft3 foam lid section
CYLINDER       11  13.5510  3.30840   0.0000  16*0.5
BOX TYPE       17  /*  npc body or lid - 10 ga. 304ss layer
CUBOID          2  54.3687 -54.3687  54.3687 -54.3687  0.31240   0.0000  16*0.5
BOX TYPE       18  /*  npc body or lid - 1 inch duraboard (void) layer, 10 ga. 30
CUBOID         11  51.5163 -51.5163  51.5163 -51.5163  2.54000   0.0000  16*0.5
CUBOID         11  54.0563 -54.0563  54.0563 -54.0563  2.54000   0.0000  16*0.5
CUBOID          2  54.3687 -54.3687  54.3687 -54.3687  2.54000   0.0000  16*0.5
BOX TYPE       19  /*  npc body - 4 inch bot. foam layer (11 #/ft3)  - face burn
CUBOID          7  42.6086 -42.6086  42.6086 -42.6086  0.00000   0.0000  16*0.5
CUBOID         11  54.0563 -54.0563  54.0563 -54.0563  0.00000  -7.6200  16*0.5
CUBOID          2  54.3687 -54.3687  54.3687 -54.3687  0.00000  -7.6200  16*0.5
BOX TYPE       20  /*  npc body - 29.0750 inch foam layer (7,11 #/ft3) - face bur
CUBOID          5  42.6086 -42.6086  42.6086 -42.6086 73.85050   0.0000  16*0.5
CUBOID          7  42.6086 -42.6086  42.6086 -42.6086 73.85050   0.0000  16*0.5
CUBOID         11  54.0563 -54.0563  54.0563 -54.0563 73.85050   0.0000  16*0.5
CUBOID          2  54.3687 -54.3687  54.3687 -54.3687 73.85050   0.0000  16*0.5
BOX TYPE       21  /*  npc body - 1.375 inch foam layer (40 #/ft3) - face burn
CUBOID          9  42.6086 -42.6086  42.6086 -42.6086  3.49250   0.0000  16*0.5
CUBOID         11  54.0563 -54.0563  54.0563 -54.0563  3.49250   0.0000  16*0.5
CUBOID          2  54.3687 -54.3687  54.3687 -54.3687  3.49250   0.0000  16*0.5
BOX TYPE       22  /*  npc body - 30.45 inch two-part body
CUBOID         11  54.3687 -54.3687  54.3687 -54.3687 77.34300   0.0000  16*0.5
BOX TYPE       23  /*  npc lid - 1.375 inch foam layer (40 #/ft3) - lid burn
CUBOID         11  43.8963 -43.8963  43.8963 -43.8963  3.49250   0.0000  16*0.5
CUBOID         11  54.0563 -54.0563  54.0563 -54.0563  3.49250   0.0000  16*0.5
CUBOID          2  54.3687 -54.3687  54.3687 -54.3687  3.49250   0.0000  16*0.5
BOX TYPE       24  /*  npc lid - 3.5 inch foam layer (15 #/ft3) - lid burn
CUBOID         11  43.8963 -43.8963  43.8963 -43.8963  2.54000   0.0000  16*0.5
CUBOID         11  54.0563 -54.0563  54.0563 -54.0563  8.89000   0.0000  16*0.5
CUBOID          2  54.3687 -54.3687  54.3687 -54.3687  8.89000   0.0000  16*0.5
BOX TYPE       25  /*  complete npc - body assembly
CUBOID         11  54.3688 -54.3688  54.3688 -54.3688 87.81540   0.0000  16*0.5
BOX TYPE       26  /*  complete npc - lid assembly
CUBOID         11  54.3688 -54.3688  54.3688 -54.3688 15.23490   0.0000  16*0.5
BOX TYPE       27  /*  npc water reflected single-unit
CUBOID          0  54.3688 -54.3688  54.3688 -54.3688 103.0503   0.0000  16*0.5
CUBOID          6  84.8488 -84.8488  84.8488 -84.8488 133.5303 -30.4800  16*0.5
BOX TYPE       28  /*  global unit: 2N=150:5x5x6 cuboid, 30.48-cm h2o refl.
CUBOID          0  271.844 -271.844  271.844 -271.844 618.3020   0.0000  16*0.5
CUBOID          6  302.324 -302.324  302.324 -302.324 648.7820 -30.4800  16*0.5
27  1 1 1  1 1 1  1 1 1  1
BEGIN COMPLEX
/*  build inner canister - main body sections (7 #/ft3 region)
COMPLEX  13  2  0.00000  0.00000  0.00000   1   1   1  0.0  0.0  0.0
```

```
COMPLEX  13  3  0.00000  0.00000  0.31750   1   1   1  0.0   0.0   0.0
COMPLEX  13  4  0.00000  0.00000  25.7810   1   1   1  0.0   0.0   0.0
COMPLEX  13  5  0.00000  0.00000  26.1621   1   1   1  0.0   0.0   0.0
COMPLEX  13  6  0.00000  0.00000  51.6256   1   1   1  0.0   0.0   0.0
COMPLEX  13  7  0.00000  0.00000  52.0066   1   1   1  0.0   0.0   0.0
/*  build inner canister - upper body section (40 #/ft3 section)
COMPLEX  14  8  0.00000  0.00000  0.00000   1   1   1  0.0   0.0   0.0
/*  build inner canister - lid section
COMPLEX  15  9  0.00000  0.00000  0.00000   1   1   1  0.0   0.0   0.0
COMPLEX  15 10  0.00000  0.00000  0.63250   1   1   1  0.0   0.0   0.0
COMPLEX  15 11  0.00000  0.00000  0.95000   1   1   1  0.0   0.0   0.0
COMPLEX  15 12  0.00000  0.00000  1.39200   1   1   1  0.0   0.0   0.0
/*  embed 3x3 array of canisters into lid:  11.75 inch - centers
COMPLEX  16 15 -29.8450 -29.8450  0.00000   3   3   1 29.8450  29.8450  0.0
/*  embed 3x3 array of foam cut_outs: 11.75 inch - centers
COMPLEX  23 16 -29.8450 -29.8450  0.00000   3   3   1 29.8450  29.8450  0.0
/*  embed 3x3 array of canisters into inner body: 11.75 inch - centers
COMPLEX  20 13 -29.8450 -29.8450  0.50550   3   3   1 29.8450  29.8450  0.0
COMPLEX  21 14 -29.8450 -29.8450  0.00000   3   3   1 29.8450  29.8450  0.0
/*  embed two-part body section stackup
COMPLEX  22 20   0.0000   0.0000  0.00000   1   1   1  0.0   0.0   0.0
COMPLEX  22 21   0.0000   0.0000 73.85050   1   1   1  0.0   0.0   0.0
/*  build npc - body assembly
COMPLEX  25 17   0.0000   0.0000  0.00000   1   1   1  0.0   0.0   0.0
COMPLEX  25 18   0.0000   0.0000  0.31240   1   1   1  0.0   0.0   0.0
COMPLEX  25 19   0.0000   0.0000  10.4724   1   1   1  0.0   0.0   0.0
COMPLEX  25 22   0.0000   0.0000  10.4724   1   1   1  0.0   0.0   0.0
/*  build npc - lid assembly
COMPLEX  26 23   0.0000   0.0000  0.00000   1   1   1  0.0   0.0   0.0
COMPLEX  26 24   0.0000   0.0000  3.49250   1   1   1  0.0   0.0   0.0
COMPLEX  26 18   0.0000   0.0000  12.3825   1   1   1  0.0   0.0   0.0
COMPLEX  26 17   0.0000   0.0000  14.9225   1   1   1  0.0   0.0   0.0
/*  complete npc stackup - water reflected single unit
COMPLEX  27 25   0.0000   0.0000  0.00000   1   1   1  0.0   0.0   0.0
COMPLEX  27 26   0.0000   0.0000  87.8154   1   1   1  0.0   0.0   0.0
END GEOM
END GEMER
```

Sample input – triangular sphere case TRI10-55.in (sphere OD = 0.100", W/F = 5.5)

```
2005 NPC SC,HET Lat,FRad=0.0127, 5.0kg U( 46.)O2,WTF=5.50,MixHt=74.254cm
   200  /* # BATCHES
  2000  /* # NEUTRONS PER BATCH
    10  /* # BATCHES TO SKIP
     0  /* # INITIAL 'SEED' (IF NON-ZERO)
     0  /* # 'IDUMP'
     1  /* # 'NRSTRT'
     0  /* # 'NBTED' (NON-ZERO IS PRINT EDITS)
     0  /* # 'KRED' (NUMBER OF COMBINED REGIONS IN EDITS)
  0  293   0   0
\CSXSEC\UO2\GUO2-50.00
\CSXSEC\NOU\GNOU-0.SS
\CSXSEC\NOU\GNOU-0.CAD
\CSXSEC\NOU\GNOU-0.POX 0.98
\CSXSEC\NOU\GNOU-0.F07 0.90
\CSXSEC\NOU\GNOU-0.WAT
\CSXSEC\NOU\GNOU-0.F11 0.90
\CSXSEC\NOU\GNOU-0.F15 0.90
\CSXSEC\NOU\GNOU-0.F40 0.90
\CSXSEC\NOU\GNOU-0.ORC
\CSXSEC\NOU\GNOU-0.WAT 1.00
```

```
KENO GEOM
     0  /* 'KREFM'
     0  /* 'NBOX'
     1  /* 'NBXMAX'
     1  /* 'NBYMAX'
     1  /* 'NBZMAX'
     1  /* 'NXX'
     1  /* 'NTYPST'
     1  /* 'NEMBRG'
     0  /* 'NGMCHK'
     0.0      0.0      0.0      0.0      0.0      0.0
BOX TYPE      1  /* 0.100 pellet, var. W/F
TRITERS       6 0.210259 0.127000                                     16*0.5
CUBOID        1 0.0       -0.0      0.0       -0.0       0.0  -0.0    16*0.5
BOX TYPE      2  /*  inner canister: bottom fuel_region # 1 w/ gap: body assy
CYLINDER     -1  10.8141     0.31750   0.00         16*0.5
CYLINDER      2  10.9233     0.31750   0.00         16*0.5
CYLINDER      0  12.40920    0.31750   0.00000      16*0.5
CYLINDER      2  12.40920    0.31750  -0.44200      16*0.5
CYLINDER      2  12.46120    0.31750  -0.44200      16*0.5
CYLINDER      0  12.70000    0.31750  -0.44200      16*0.5
CYLINDER      2  12.76350    0.31750  -0.50550      16*0.5
BOX TYPE      3  /*  inner canister: fuel_region # 2: body assy
CYLINDER     -1  10.8141    25.46350   0.00         16*0.5
CYLINDER      2  10.9233    25.46350   0.00         16*0.5
CYLINDER      3  10.96140   25.46350   0.00000      16*0.5
CYLINDER      4  12.40920   25.46350   0.00000      16*0.5
CYLINDER      2  12.46120   25.46350   0.00000      16*0.5
CYLINDER      0  12.70000   25.46350   0.00000      16*0.5
CYLINDER      2  12.76350   25.46350   0.00000      16*0.5
BOX TYPE      4  /*  inner canister: fuel_region # 3: 0.15 in cd gap: body assy
CYLINDER     -1  10.8141     0.38100   0.00         16*0.5
CYLINDER      2  10.9233     0.38100   0.00         16*0.5
CYLINDER      0  10.96140    0.38100   0.00000      16*0.5
CYLINDER      4  12.40920    0.38100   0.00000      16*0.5
CYLINDER      2  12.46120    0.38100   0.00000      16*0.5
CYLINDER      0  12.70000    0.38100   0.00000      16*0.5
CYLINDER      2  12.76350    0.38100   0.00000      16*0.5
BOX TYPE      5  /*  inner canister: fuel_region # 4: body assy
CYLINDER     -1  10.8141    25.46350   0.00         16*0.5
CYLINDER      2  10.9233    25.46350   0.00         16*0.5
CYLINDER      3  10.96140   25.46350   0.00000      16*0.5
CYLINDER      4  12.40920   25.46350   0.00000      16*0.5
CYLINDER      2  12.46120   25.46350   0.00000      16*0.5
CYLINDER      0  12.70000   25.46350   0.00000      16*0.5
CYLINDER      2  12.76350   25.46350   0.00000      16*0.5
BOX TYPE      6  /*  inner canister: fuel_region # 5: 0.15 in cd gap: body assy
CYLINDER     -1  10.8141     0.38100   0.00         16*0.5
CYLINDER      2  10.9233     0.38100   0.00         16*0.5
CYLINDER      0  10.96140    0.38100   0.00000      16*0.5
CYLINDER      4  12.40920    0.38100   0.00000      16*0.5
CYLINDER      2  12.46120    0.38100   0.00000      16*0.5
CYLINDER      0  12.70000    0.38100   0.00000      16*0.5
CYLINDER      2  12.76350    0.38100   0.00000      16*0.5
BOX TYPE      7  /*  inner canister: fuel_region # 6: body assy
CYLINDER     -1  10.8141    21.33840   0.00         16*0.5
CYLINDER      2  10.9233    21.33840   0.00         16*0.5
CYLINDER      3  10.96140   21.33840   0.00000      16*0.5
CYLINDER      4  12.40920   21.33840   0.00000      16*0.5
CYLINDER      2  12.46120   21.33840   0.00000      16*0.5
CYLINDER      0  12.70000   21.33840   0.00000      16*0.5
CYLINDER      2  12.76350   21.33840   0.00000      16*0.5
BOX TYPE      8  /*  inner canister: fuel_region # 7: body assy
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CYLINDER     -1  10.8141    0.90910   0.00      16*0.5
CYLINDER      0  10.8141    3.49250   0.00      16*0.5
CYLINDER      2  10.9233    3.49250   0.00      16*0.5
CYLINDER      3  10.96140   3.49250   0.00000   16*0.5
CYLINDER      4  12.40920   3.49250   0.00000   16*0.5
CYLINDER      2  12.46120   3.49250   0.00000   16*0.5
CYLINDER      0  12.70000   3.49250   0.00000   16*0.5
CYLINDER      2  12.76350   3.49250   0.00000   16*0.5
BOX TYPE      9  /*  inner canister: fuel_region # 8: lid assy
CYLINDER      0  10.8141    0.63250   0.00      16*0.5
CYLINDER      2  10.9233    0.63250   0.00      16*0.5
CYLINDER      3  10.96140   0.63250   0.00000   16*0.5
CYLINDER      4  12.40920   0.63250   0.00000   16*0.5
CYLINDER      2  12.46120   0.63250   0.00000   16*0.5
CYLINDER      0  12.70000   0.63250   0.00000   16*0.5
CYLINDER      2  12.76350   0.63250   0.00000   16*0.5
BOX TYPE     10  /*  inner canister: fuel_region # 9 w/ gap: lid assy
CYLINDER      0  10.8141    0.31750   0.00      16*0.5
CYLINDER      2  10.9233    0.31750   0.00      16*0.5
CYLINDER     11  12.40920   0.31750   0.00000   16*0.5
CYLINDER      2  12.46120   0.31750   0.00000   16*0.5
BOX TYPE     11  /*  inner canister: fuel_region #10 w/ ring: lid assy
CYLINDER      0  10.8141    0.44200   0.00      16*0.5
CYLINDER      2  10.9233    0.44200   0.00      16*0.5
CYLINDER      2  12.40920   0.44200   0.00000   16*0.5
CYLINDER      2  12.46120   0.44200   0.00000   16*0.5
BOX TYPE     12  /*  inner canister: fuel_region #11 w/ top: lid assy
CYLINDER      0  10.8141    1.78050   0.00      16*0.5
CYLINDER      2  10.9233    1.91640   0.00      16*0.5
CYLINDER     11  12.40920   1.91640   0.00000   16*0.5
BOX TYPE     13  /*  inner canister cuboid: body section (7# region)
CUBOID        5  12.7636 -12.7636  12.7636 -12.7636  73.3450  -0.5055  16*0.5
BOX TYPE     14  /*  inner canister cuboid: body section (40# region)
CUBOID        9  12.7636 -12.7636  12.7636 -12.7636  3.49260   0.0000  16*0.5
BOX TYPE     15  /*  inner canister upper cylinder: lid section
CYLINDER     11  12.7636  3.30840   0.0000  16*0.5
BOX TYPE     16  /*  foam cutout  (void) - 40 #/ft3 foam lid section
CYLINDER     11  13.5510  3.30840   0.0000  16*0.5
BOX TYPE     17  /*  npc body or lid - 10 ga. 304ss layer
CUBOID        2  54.3687 -54.3687  54.3687 -54.3687  0.31240   0.0000  16*0.5
BOX TYPE     18  /*  npc body or lid - 1 inch duraboard (void) layer, 10 ga. 304ss
CUBOID       11  51.5163 -51.5163  51.5163 -51.5163  2.54000   0.0000  16*0.5
CUBOID       11  54.0563 -54.0563  54.0563 -54.0563  2.54000   0.0000  16*0.5
CUBOID        2  54.3687 -54.3687  54.3687 -54.3687  2.54000   0.0000  16*0.5
BOX TYPE     19  /*  npc body - 4 inch bot. foam layer (11 #/ft3)  - face burn
CUBOID        7  42.6086 -42.6086  42.6086 -42.6086  0.00000   0.0000  16*0.5
CUBOID       11  54.0563 -54.0563  54.0563 -54.0563  0.00000  -7.6200  16*0.5
CUBOID        2  54.3687 -54.3687  54.3687 -54.3687  0.00000  -7.6200  16*0.5
BOX TYPE     20  /*  npc body - 29.0750 inch foam layer (7,11 #/ft3) - face burn
CUBOID        5  42.6086 -42.6086  42.6086 -42.6086 73.85050   0.0000  16*0.5
CUBOID        7  42.6086 -42.6086  42.6086 -42.6086 73.85050   0.0000  16*0.5
CUBOID       11  54.0563 -54.0563  54.0563 -54.0563 73.85050   0.0000  16*0.5
CUBOID        2  54.3687 -54.3687  54.3687 -54.3687 73.85050   0.0000  16*0.5
BOX TYPE     21  /*  npc body - 1.375 inch foam layer (40 #/ft3) - face burn
CUBOID        9  42.6086 -42.6086  42.6086 -42.6086  3.49250   0.0000  16*0.5
CUBOID       11  54.0563 -54.0563  54.0563 -54.0563  3.49250   0.0000  16*0.5
CUBOID        2  54.3687 -54.3687  54.3687 -54.3687  3.49250   0.0000  16*0.5
BOX TYPE     22  /*  npc body - 30.45 inch two-part body
CUBOID       11  54.3687 -54.3687  54.3687 -54.3687 77.34300   0.0000  16*0.5
BOX TYPE     23  /*  npc lid - 1.375 inch foam layer (40 #/ft3) - lid burn
CUBOID       11  43.8963 -43.8963  43.8963 -43.8963  3.49250   0.0000  16*0.5
CUBOID       11  54.0563 -54.0563  54.0563 -54.0563  3.49250   0.0000  16*0.5
CUBOID        2  54.3687 -54.3687  54.3687 -54.3687  3.49250   0.0000  16*0.5
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BOX TYPE      24  /*  npc lid - 3.5 inch foam layer (15 #/ft3) - lid burn
CUBOID        11  43.8963 -43.8963  43.8963 -43.8963  2.54000   0.0000  16*0.5
CUBOID        11  54.0563 -54.0563  54.0563 -54.0563  8.89000   0.0000  16*0.5
CUBOID         2  54.3687 -54.3687  54.3687 -54.3687  8.89000   0.0000  16*0.5
BOX TYPE      25  /*  complete npc - body assembly
CUBOID        11  54.3688 -54.3688  54.3688 -54.3688 87.81540   0.0000  16*0.5
BOX TYPE      26  /*  complete npc - lid assembly
CUBOID        11  54.3688 -54.3688  54.3688 -54.3688 15.23490   0.0000  16*0.5
BOX TYPE      27  /*  npc water reflected single-unit
CUBOID         0  54.3688 -54.3688  54.3688 -54.3688 103.0503   0.0000  16*0.5
CUBOID         6  84.8488 -84.8488  84.8488 -84.8488 133.5303 -30.4800  16*0.5
BOX TYPE      28  /*  global unit: 2N=150:5x5x6 cuboid, 30.48-cm h2o refl.
CUBOID         0  271.844 -271.844  271.844 -271.844 618.3020   0.0000  16*0.5
CUBOID         6  302.324 -302.324  302.324 -302.324 648.7820 -30.4800  16*0.5
27  1 1 1  1 1 1  1 1 1  1
BEGIN COMPLEX
/*  build inner canister - main body sections (7 #/ft3 region)
COMPLEX  13  2  0.00000  0.00000  0.00000   1   1   1  0.0  0.0  0.0
COMPLEX  13  3  0.00000  0.00000  0.31750   1   1   1  0.0  0.0  0.0
COMPLEX  13  4  0.00000  0.00000  25.7810   1   1   1  0.0  0.0  0.0
COMPLEX  13  5  0.00000  0.00000  26.1621   1   1   1  0.0  0.0  0.0
COMPLEX  13  6  0.00000  0.00000  51.6256   1   1   1  0.0  0.0  0.0
COMPLEX  13  7  0.00000  0.00000  52.0066   1   1   1  0.0  0.0  0.0
/*  build inner canister - upper body section (40 #/ft3 section)
COMPLEX  14  8  0.00000  0.00000  0.00000   1   1   1  0.0  0.0  0.0
/*  build inner canister - lid section
COMPLEX  15  9  0.00000  0.00000  0.00000   1   1   1  0.0  0.0  0.0
COMPLEX  15 10  0.00000  0.00000  0.63250   1   1   1  0.0  0.0  0.0
COMPLEX  15 11  0.00000  0.00000  0.95000   1   1   1  0.0  0.0  0.0
COMPLEX  15 12  0.00000  0.00000  1.39200   1   1   1  0.0  0.0  0.0
/*  embed 3x3 array of canisters into lid:  11.75 inch - centers
COMPLEX  16 15 -29.8450 -29.8450  0.00000   3   3   1 29.8450  29.8450  0.0
/*  embed 3x3 array of foam cut_outs: 11.75 inch - centers
COMPLEX  23 16 -29.8450 -29.8450  0.00000   3   3   1 29.8450  29.8450  0.0
/*  embed 3x3 array of canisters into inner body: 11.75 inch - centers
COMPLEX  20 13 -29.8450 -29.8450  0.50550   3   3   1 29.8450  29.8450  0.0
COMPLEX  21 14 -29.8450 -29.8450  0.00000   3   3   1 29.8450  29.8450  0.0
/*  embed two-part body section stackup
COMPLEX  22 20   0.0000   0.0000  0.00000   1   1   1  0.0  0.0  0.0
COMPLEX  22 21   0.0000   0.0000 73.85050   1   1   1  0.0  0.0  0.0
/*  build npc - body assembly
COMPLEX  25 17   0.0000   0.0000  0.00000   1   1   1  0.0  0.0  0.0
COMPLEX  25 18   0.0000   0.0000  0.31240   1   1   1  0.0  0.0  0.0
COMPLEX  25 19   0.0000   0.0000  10.4724   1   1   1  0.0  0.0  0.0
COMPLEX  25 22   0.0000   0.0000  10.4724   1   1   1  0.0  0.0  0.0
/*  build npc - lid assembly
COMPLEX  26 23   0.0000   0.0000  0.00000   1   1   1  0.0  0.0  0.0
COMPLEX  26 24   0.0000   0.0000  3.49250   1   1   1  0.0  0.0  0.0
COMPLEX  26 18   0.0000   0.0000  12.3825   1   1   1  0.0  0.0  0.0
COMPLEX  26 17   0.0000   0.0000  14.9225   1   1   1  0.0  0.0  0.0
/*  complete npc stackup - water reflected single unit
COMPLEX  27 25   0.0000   0.0000  0.00000   1   1   1  0.0  0.0  0.0
COMPLEX  27 26   0.0000   0.0000  87.8154   1   1   1  0.0  0.0  0.0
END GEOM
END GEMER
```