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T	F	
☒	☐	1. This product contains no potentially sensitive information.
☐	☒	2. This product contains information that could define a target.
☐	☒	3. This product contains information that could define a specific location.
☐	☒	4. This product contains information that identifies vulnerabilities.

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CONTENTS

TABLES

FIGURES

1. PURPOSE

The objective of this calculation is to perform additional degraded mode criticality evaluations of the Department of Energy's (DOE) Fast Flux Test Facility (FFTF) Spent Nuclear Fuel (SNF) codisposed in a 5-Defense High-Level Waste (5-DHLW) Waste Package (WP). The scope of this calculation is limited to the most reactive degraded configurations of the codisposal WP with an almost intact Ident-69 container (breached and flooded but otherwise non-degraded) containing intact FFTF SNF pins. The configurations have been identified in a previous analysis (CRWMS M&O 1999a) and the present evaluations include additional relevant information that was left out of the original calculations. The additional information describes the exact distribution of fissile material in each container (DOE 2002a). The effects of the changes that have been included in the baseline design of the codisposal WP (CRWMS M&O 2000) are also investigated. The calculation determines the effective neutron multiplication factor (k_{eff}) for selected degraded mode internal configurations of the codisposal waste package.

These calculations will support the demonstration of the technical viability of the design solution adopted for disposing of MOX (FFTF) spent nuclear fuel in the potential repository.

This calculation is subject to the Quality Assurance Requirements and Description (QARD) (DOE 2002b) per the activity evaluation under work package number P6212310M2 in the technical work plan TWP-MGR-MD-000010 REV 01 (BSC 2002).

2. METHOD

The method to perform the criticality calculations consists of using MCNP Version 4B2 (CRWMS M&O 1998a, CRWMS M&O 1998b) to calculate the effective neutron multiplication factor of the codisposal waste package. The calculations are performed using the continuous-energy cross section libraries, which are part of the qualified code system MCNP 4B2 (CRWMS M&O 1998a, CRWMS M&O 1998b). All calculations are performed with fresh fuel composition unless otherwise specified.

Control of the electronic management of data was accomplished in accordance with the controls specified by BSC 2002 (Section 13).

3. ASSUMPTIONS

3.1 For the degraded mode criticality calculations, it is assumed that the iron in the stainless steel degrades to goethite (FeOOH) rather than hematite (Fe_2O_3). The rationale for this assumption is that it is conservative to consider goethite rather than hematite since hydrogen (a moderator) is a component of goethite. All the other constituents of stainless steel are neglected since they are neutron absorbers, and hence their absence provides a conservative (higher) value for the k_{eff} of the system. This assumption is used throughout Section 5.

3.2 Ba-138 cross sections are used instead of Ba-137 cross sections in the MCNP input since the cross sections of Ba-137 are not available in either ENDF/B-V or ENDF/B-VI cross section libraries. The rationale for this assumption is that it is conservative since the thermal neutron capture cross section and the resonance integral of Ba-137 (5.1 and 4 barn, respectively [Parrington et al. 1996, p. 34]) are greater than the thermal neutron capture cross section and the resonance integral of Ba-138 (0.43 and 0.3 barn, respectively [Parrington et al. 1996, p. 34]). This assumption is used throughout Section 5.

3.3 The Ident-69 containers contain stainless steel plates or tubes that divide the containers into several compartments and grid plates to support the fuel pins. Some containers contain only tubes with diameters slightly larger than the fuel pin diameter. These dividers, tubes and grid plates were ignored in order to simplify the model. The ends of the Ident-69 containers were also simplified and modeled as "squared off". The rationale for this assumption is that it is conservative to neglect these components since they will provide some small amount of neutron absorption and hence reduce the k_{eff} of the system. This assumption is used throughout Section 5.

3.4 For the intact FFTF fuel pins, the spiral wire wrap around each fuel pin and the spring above the upper reflector in each fuel pin are neglected. The rationale for this assumption is that it is conservative because these components are made from stainless steel and will provide some small amount of neutron absorption. This assumption is used throughout Section 5.

3.5 For the degraded configuration, the goethite is assumed to form with void occupying 40% or more of its volume. The void can be filled with water, fuel and/or remain as void. The rationale for this assumption is based on the corroborative information given in Coelho et al. (1997). This assumption is used throughout Section 5.

3.6 The geometry of the experimental MOX pins with larger diameters (0.69 cm) stored in some Ident-69 containers is assumed to be similar to that of Type 4.1 fuel pins with the exception of the fuel pellet and pin diameter. This assumption is based on the corroborative information provided in (DOE 2002a). This assumption is used throughout Section 5.

4. USE OF COMPUTER SOFTWARE AND MODELS

4.1 SOFTWARE

4.1.1 MCNP

The MCNP code (CRWMS M&O [1998b]) is used to calculate the k_{eff} of the codisposal waste package. The software specifications are as follow:

- Status: Qualified

- Software name: MCNP

- Software version/revision number: Version 4B2
- Software tracking number (computer software configuration item [CSCI]): 30033 V4B2LV
- Computer type: Hewlett Packard (HP) 9000 Series Workstations
- Operating system: HP-UX 10.20
- Computer processing unit number: Software is installed on the Framatome ANP workstation "gr1" whose CPU number is E 9000/785 2008515632 and "gr0" whose CPU number is E 9000/782 2002611431.

The input and output files for the various MCNP calculations are documented in Attachment I, (Attachment II gives the list of the files on Attachment I). The calculation files described in Sections 5 and 6 are such that an independent repetition of the software use may be performed.

The MCNP software used is: (a) appropriate for the application of k_{eff} calculations, (b) used only within the range of validation as documented in CRWMS M&O (1998a) and Briesmeister (1997), (c) obtained from the Software Configuration Management in accordance with AP-SI.1Q, *Software Management*.

5. CALCULATION

This section describes the calculations performed to calculate the k_{eff} of a waste package containing degraded high-level waste material and FFTF spent nuclear fuel. Section 5.1 describes the waste package. Section 5.2 gives the composition of the materials used in this calculation. The basic formulas used in this calculation are listed in Section 5.3. The investigated configurations of the waste package are outlined in Section 5.4. The MCNP output files attributes are presented in Attachment II. The results of the calculations are presented in Section 6.

Compositions for structural and other nonfuel-related materials are from ASTM (American Society for Testing and Materials) A20/A 20M-99a, *Standard Specification for General Requirements for Steel Plates for Pressure Vessels;* ASTM A 240/ A 240M-99b, *Standard Specification for Heat-Resisting Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels;* ASTM A 276-91a, *Standard Specification for Stainless and Heat-Resisting Steel Bars and Shapes, A 516 / A 516 M - 90, Standard Specification for Pressure Vessel Plates, Carbon Steel, for Moderate- and Lower-Temperature Service, ASTM B 575 - 97, Standard Specification for Low-Carbon Nickel-Molybdenum-Chromium, Low-Carbon Nickel-Chromium-Molybdenum, Low-Carbon Nickel-Chromium-Molybdenum-Copper and Low-Carbon Nickel-Chromium-Molybdenum-Tungsten Alloy Plate, Sheet, and Strip;* and ASTM G 1-90, *Standard Practice for Preparing, Cleaning, and Evaluating Corrosion Test Specimens.* These references are consensus codes or standards, and, therefore, the information taken from them is not subject to verification.

The Savannah River Site high-level waste glass degraded composition (pre-breach clay) is from BSC (2001). This information is a technical output. The Savannah River Site high-level waste glass composition and density are from CRWMS M&O (1999b) and Stout and Leider (1991), respectively. The Savannah River Site high-level waste glass canister dimensions are from Taylor (1997).

Avogadro's number is from Parrington et al. (1996). Atomic weights are also from Parrington et al. (1996); this information is established fact and is therefore considered accepted due to the nature of the references cited therein.

The description of the FFTF spent nuclear fuel is from the *FFTF (MOX) Fuel Characteristics for Disposal Criticality Analysis* report (DOE 2002a). All fuel-related information is from this reference unless otherwise noted.

The tuff composition and the tuff density are taken from Lipman et al. (1966) and Flint (1998), respectively.

This calculation is based in part on unqualified information such as that in DOE (2002a). However, the unqualified information is only used to determine the bounding values and items that are important to criticality safety for the fuel group (mass of fissile, mass of neutron absorber). The fuel group is identified by the National Spent Nuclear Fuel Program by establishing the limits based on the representative fuel type (FFTF) for this group (MOX). Therefore, the input values used to evaluate the codisposal viability of FFTF spent nuclear fuel do not constitute information that has to be qualified prior to use of any results from this calculation for input into documents supporting procurement, fabrication, or construction. They merely establish the bounds for acceptance. Since the input values are not relied upon directly to address radiological safety and waste isolation issues, nor do the design inputs affect a system characteristic that is critical for satisfactory performance, the information does not need to be controlled as to-be-verified.

The number of digits in the values cited herein may be the result of a calculation or may reflect the input from another source; consequently, the number of digits should not be interpreted as an indication of accuracy.

The metric units used in this document are calculated using the English units as given in DOE (2002a). The differences that might exist between the metric units calculated and the metric units cited in DOE (2002a) have no effect on the calculation and should not be interpreted as an indication of accuracy.

5.1 WASTE PACKAGE COMPONENTS DESCRIPTION

5.1.1 FFTF Spent Nuclear Fuel

The following dimensions and information in this section are from DOE (2002a, pp. 1-5). The FFTF standard driver fuel assembly (DFA) contains 217 cylindrical fuel pins and is hexagonally shaped. The assembly is 3,657.6 mm long. The overall height of a fuel pin is 2,372.36 mm for Types 3.1 and 4.1 fuel pins, and 2377.44 mm for Types 3.2 and 4.2 fuel pins (Figure 1). The stainless steel (Type 316) cladding is 0.381 mm (0.015 in.) thick. The inner and outer diameters of the cladding are 5.08 mm (0.200 in.) and 5.842 mm (0.230 in), respectively. Each fuel pin has a 914.4 mm (36 in.) long fuel region containing fuel pellets with an outer diameter of 4.9403 mm (0.1945 in.). The fuel region is centered 1,663.7 mm (65.5 in.) from the bottom of the assembly. Each fuel pin is helically wrapped with a 1.4224 mm (0.056 in.) diameter stainless steel Type 316 wire to provide lateral spacing along its length. The wire pitch (axially) is 304.8 mm (12 in.). The fuel pins are arranged with a triangular pitch within the hexagonal duct. The fuel density is reported as 90.4% of the theoretical density, which corresponds to a fuel density of 10.02 g/cm^3. The mixed oxide (MOX – $UO_{1.96}$ and $PuO_{1.96}$) fuel region is followed by 20.32 mm (0.8 in.) of natural UO_2 insulator pellets and 144.78 mm (5.7 in.) of Inconel 600 reflector on each end. The density of natural uranium insulator pellets is 10.42 ± 0.22 g/cm^3. The reflector outer diameter is 4.8133 mm (0.1895 in.).

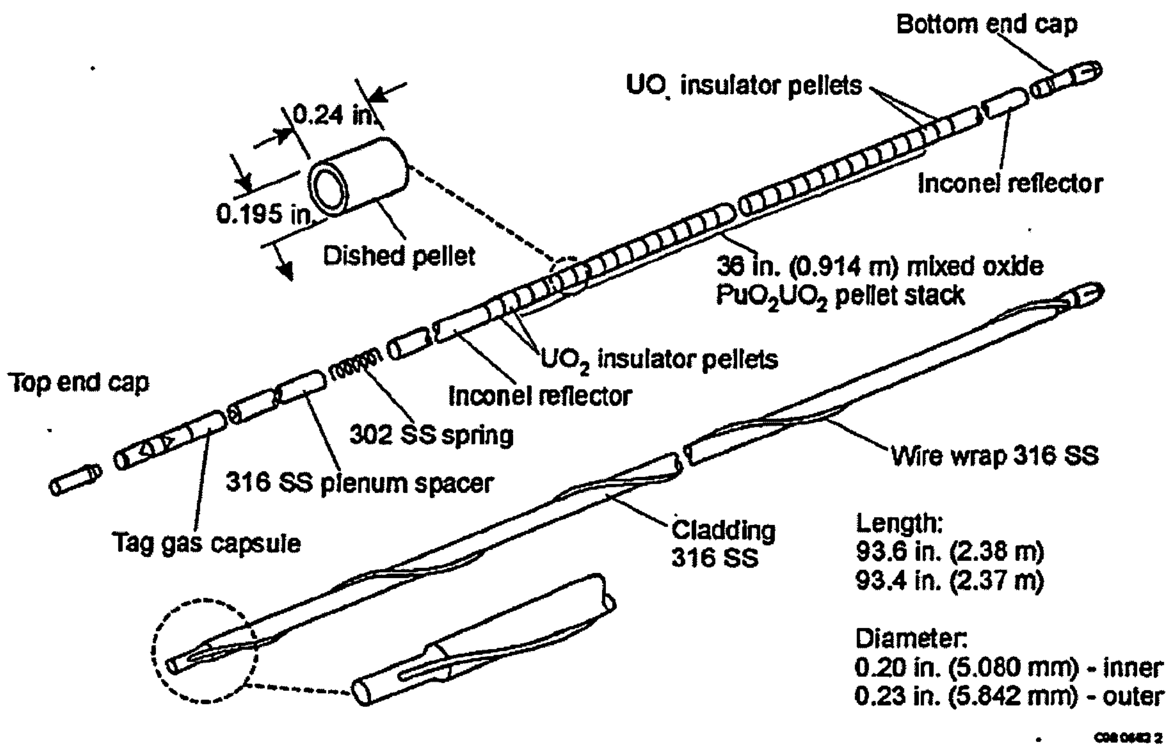


Figure 1. Simplified Axial View of a Standard FFTF Driver Fuel Assembly Fuel Pin

Above the top reflector are a stainless steel Type 302 spring (125.5 mm long by 0.8052 mm in diameter) and a stainless steel Type 316 plenum (862.1 mm long with a 4.9022 mm outer diameter) and a stainless steel Type 316 plenum (862.1 mm long with a 4.9022 mm outer diameter and 0.1397 mm wall thickness). The maximum stainless steel spring volume is 2.7264 cm^3. The fuel pin is closed with top and bottom caps having a 5.842 mm diameter. The length of the top cap is 104.6 mm. The bottom cap length for Type 3.1 and 4.1 fuels is 35.6 mm. The bottom cap length for Type 3.2 and 4.2 fuels is 40.6 mm. Each fuel pin weighs 455 g (~1 lb). The fuel enrichments and isotopic fractions for all four types of fresh FFTF fuel are given in Table 1. Table 2 summarizes dimensions and material specifications for fuel pins. Note that Type 3.1 fuel pin has similar dimensions with Type 4.1 pin (same for Type 3.2 and 4.2 pins).

The DFA comprises a hexagonal duct that surrounds the fuel pins, discriminator, inlet nozzle, neutron shield and flow orifice region, load pads, and handling socket. The duct is stainless steel Type 316 with a wall thickness of 3.048 mm (0.12 in.). The duct-tube outer dimension is 116.205 mm (4.575 in.) across the hexagonal flats and 131.064 mm (5.16 in.) across he opposite hexagonal points. The fuel pin pitch is 7.2644 mm (0.286 in.). The maximum assembly width is determined by the load pads, which are 138.1125 mm (5.4375 in.) wide across the opposite hexagonal points. The assembly is 3657.6 mm (144 in.) high. Total weight of a DFA is 172.819 kg (~381 lb).

Some of the assemblies have been disassembled and the fuel pins placed in fuel pin containers named Ident-69 containers. Although there are several types of pin containers, the most highly loaded one is the compartmented model (Figure 2), which can hold up to 217 fuel pins. The total container length is 3,657.6 mm (144 in.). The Ident-69 containers are made with 5 in. stainless steel Type 304L pipe (actual diameter is 5.563 in., or 141.30 mm) with a transition to 2.5 in. pipe (actual diameter is 2.875 in., or 73.02 mm) at 431.8 mm (17 in.) from the bottom. The inside diameter of the container is 135.763 mm (5.345 in.). The fuel pins are supported on a grid plate with 1.5875 mm (0.0625 in.) diameter holes. The central compartment has inside and outside radii of 20.701 mm (0.815 in.) and 22.225 mm (0.875 in.) respectively. The divider plates have the same thickness as the center tube. The empty weight of an Ident-69 pin container is 59.09 kg (130 lb). A cross-sectional view of a partially loaded fuel pin container is shown in Figure 2.

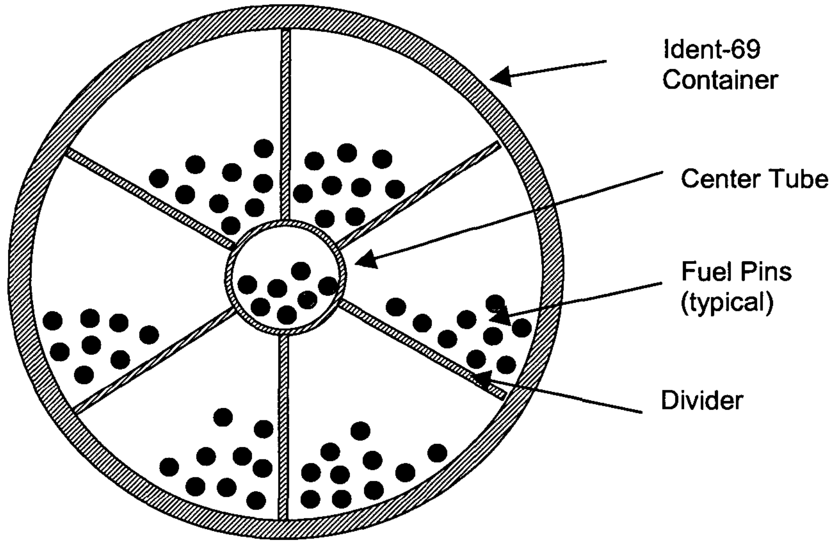


Figure 2. Cross-sectional View of a Partially Loaded Ident-69 Fuel Pin Container (compartmented model)

Table 1. Uranium and Plutonium Content of Fresh Driver Fuel Assembly

			Driver Fuel Type			
			3.1	**3.2**	**4.1**	**4.2**
Plutonium						
	Content (wt % Pu/[Pu+U])		27.37	22.43	29.28	25.14
	Pu mass in assembly (kg)		9.071	7.421	9.722	8.333
	Pu mass in pin (g)		41.8	34.2	44.8	38.4
	Isotopic fraction					
		Pu-239	0.8696	0.8696	0.8711	0.8711
		Pu-240	0.1173	0.1173	0.1163	0.1163
		Pu-241	0.0104	0.0104	0.0102	0.0102
Uranium						
	Content (wt % U/[Pu+U])		72.63	77.57	70.72	74.86
	U mass in assembly (kg)		24.070	25.666	23.481	24.813
	U mass in pin (g)		110.9	118.3	108.2	114.3
	Isotopic fraction					
		U-235	0.007	0.007	0.002	0.002
		U-238	0.993	0.993	0.998	0.998

NOTE: Each assembly nominally holds 1.5 kg of U in insulator pellets

Table 2. Dimensions and Material Specifications for FFTF Fuel Pins

Component	Material	Parameter	Value
Mixed oxide	$PuO_{1.96}$-$UO_{1.96}$	Outer diameter	4.9403 mm
		Length	914.4 mm
		Density	10.02 g/cm3
Insulator	Natural UO_2	Parts/fuel rod	2
		Length	20.32 mm
		Outer diameter	4.9403 mm
		Density	10.42 ± 0.22 g/cm3
		U weight/ assembly	1.5 kg
Reflector	Inconel 600	Parts/fuel rod	2
		Length	144.78 mm
		Outside diameter	4.8133 mm
Spring	SS 302	Volume	2.7264 cm3
Plenum	SS316	Length	862.1 mm
		Outer diameter	4.9022 mm
		Wall thickness	0.1397 mm
Top cap	SS316	Length	104.6 mm
		Outer diameter	5.842 mm
Bottom cap	SS 316	Length	40.6 mm (Type 4.2 and 3.2) 35.6 mm (Type 4.1 and 3.1)
		Outer diameter	5.842 mm
Cladding	SS316	Inner diameter	5.08 mm
		Outer diameter	5.842 mm
		Length	2,232.24 mm

Some of the Ident-69 containers contain experimental MOX fuel pins that have a larger diameter (0.69 cm) and are not separately described in DOE (2002a). For the purpose of the present calculation, the geometry of these pins is assumed similar to that of Type 4.1 pins excepting the diameters of the pellets and cladding. Inner gap width, clad thickness, length of the fuel zone and the geometry of remaining internal components are assumed (Assumption 3.6) unchanged from the Type 4.1 pins (DOE 2002a). Based on information provided in Table A-II of DOE (2002a) for the payload of a representative container (Storage Serial No. ID69-033), the mass of fissile material in each pin is estimated to be 223.9 g (67.7 g Pu and 156.2 g U). The isotopic composition of the fissile materials and the density of the pellets are considered identical to that of Type 4.1 fuel pins.

5.1.2 Description of DOE SNF Canister

The description of the 15-ft DOE SNF canister (also referred to as the 18-in.-diameter DOE SNF canister) is taken from DOE (1999, p. 5, A-2, and A-3). The DOE SNF canister is a right circular cylinder pipe made of stainless steel (Type 316L or UNS S31603) with an outside diameter of 457.2 mm (18 in.) and a wall thickness of 9.525 mm (0.375 in.). The nominal internal length of the DOE SNF canister reserved for fuel loading is 411.7086 cm (162.09 in.). The top and bottom carbon steel impact plates are 50.8 mm (2.0 in.) thick at the centers. Dished heads seal the ends of the DOE SNF canister. The DOE SNF canister pipe extends several inches beyond the dished heads on each end to give a maximum external length of 456.9968 cm (179.92 in.).

The canister contains a stainless steel (316L) basket. The basket is not a standard part of the DOE SNF canister. The basket design is modified for each specific spent fuel type. The basket provides material for controlling criticality, provides structural support and acts as a guide for assemblies during loading. For disposing FFTF SNF a Gd content of 2.75 wt% distributed as $GdPO_4$ in or on the basket structure has been proposed in the preliminary design (CRWMS M&O 1999a).

The DOE SNF canister for FFTF SNF contains six basket locations; one center position surrounded by five outer positions. Either an Ident-69 fuel pin container or a driver fuel assembly (DFA) can be placed in the center position. All outer positions are filled with DFAs only. An isometric view of the DOE SNF canister containing five FFTF assemblies and an Ident-69 fuel pin container is shown in Figure 3.

The basket consists of a cylindrical center tube and five divider plates extending radially from the center tube to the DOE SNF canister wall as shown in Figure 3. The center tube is stainless steel (Type 316L) with a 153 mm inside diameter and 10 mm wall thickness. The divider plates have a thickness of 10 mm. The basket height is 4,125 mm.

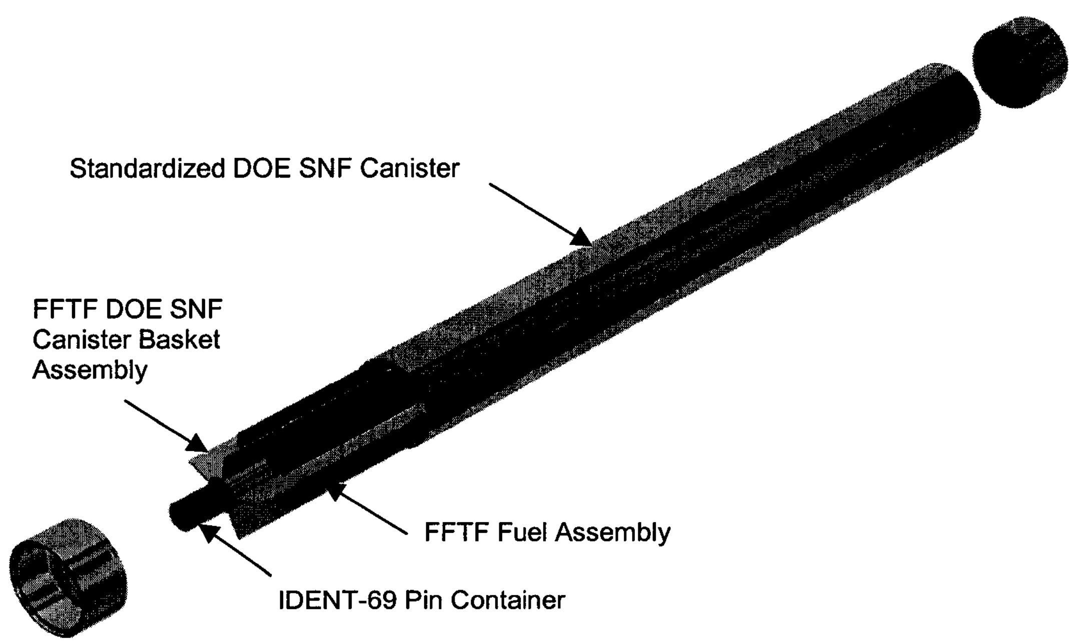


Figure 3. Isometric View of the DOE SNF Canister Containing FFTF SNF

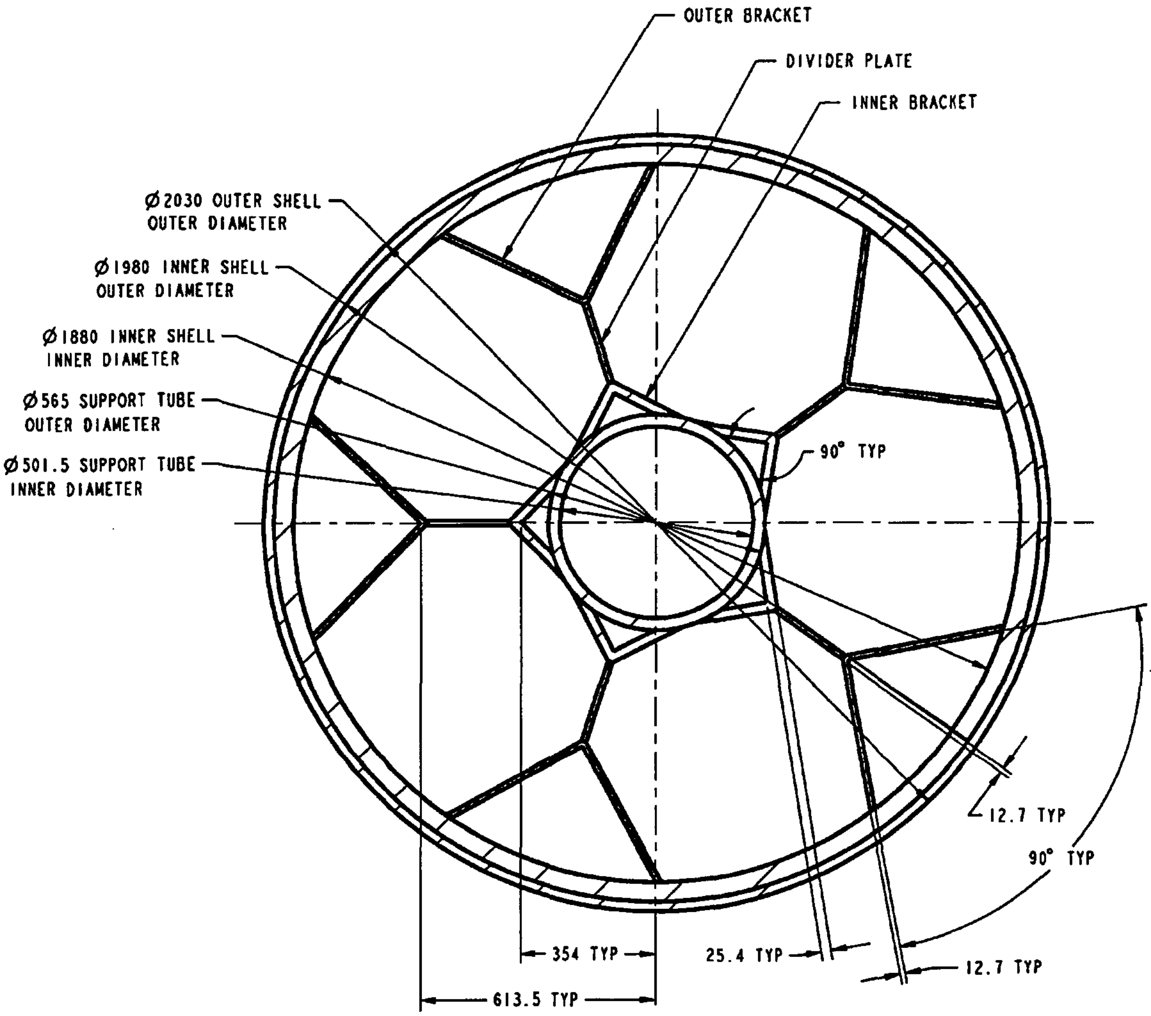
5.1.3 High-Level Waste Glass Pour Canister

There is no long Savannah River Site high-level waste (HLW) glass canister. Therefore, the expected Hanford 15-foot high-level waste glass canister is used in the FFTF SNF codisposal waste package. Since the specific composition of the Hanford high-level waste glass has not yet been specified, it can only be assumed to be the same as the Savannah River Site glass composition. The Hanford 15-foot high-level waste glass canister is a 4,572-mm long stainless steel Type 304L canister with an outer diameter of 610 mm (24.00 in.) (Taylor 1997). The wall thickness is 10.5 mm. These parameters are the same as the SRS canister, except that it is longer. The maximum loaded canister weight is 4,200 kg and the fill volume is 87%.

5.1.4 Waste Package Description

The codisposal waste package (CRWMS M&O 2000) contains five HLW glass pour canisters spaced radially around an 18 in. DOE SNF canister, see Figure 4. The waste package barrier materials are typical of those used for commercial spent nuclear fuel waste containers. The inner barrier shell is composed of 50 mm of Stainless Steel 316 (SA-240 S31600) and serves for structural support and as a corrosion resistant material. The outer barrier shell is composed of 25 mm of Nickel Alloy (Alloy 22, SB-575 N06022) and serves as a corrosion resistant material. The outside diameter of the waste container is 2030 mm and the length of the inner cavity is 4617 mm. The inner barrier lids are 80 mm thick, the closure lid is 10 mm thick, and the outer barrier lid is 25 mm thick. There is a 30-mm thick closure lid gap between the upper inner and closure lid and between the closure lid and the outer barrier lid.

The DOE SNF canister is placed in a 31.75-mm (1.25-in.) -thick carbon steel (ASTM A 516 Grade 70 or UNS K02700) support tube with a 565 mm (22.244 in.) nominal outer diameter. The support tube is connected to the inside wall of the codisposal WP by web-like carbon steel (ASTM A 516 Grade 70 or UNS K02700) support plates that form five emplacement positions for the HLW glass pour canisters equally spaced in angle about the center support tube. The support tube and plates are 4607 mm (181.3780 in.) long, respectively.



NOTE: TYP = typical; dimensions in mm

Figure 4. Cross Sectional View of 5-HLW/DOE Spent Fuel-Long Codisposal WP

5.2 MATERIALS DESCRIPTION

Material nomenclature for the carbon and stainless steels used throughout this document includes: SA 240 S31603 stainless steel (referred to as 316L stainless steel); SA-240 S31600 stainless steel (referred to as 316 NG stainless steel); Unified Numbering System (UNS) N06625 and SA-240 S30403 stainless steel (referred to as 304L stainless steel); SB-575 N06022 (referred to as Alloy 22); and SA-516 K02700 carbon steel (referred to as A516 carbon steel).

Table 3. Composition and Density of Stainless Steel 304L

Element	Composition[a] (wt %)	Value Used (wt %)
C	0.030 (max)	0.030
Mn	2.000 (max)	2.000
P	0.045 (max)	0.045
S	0.030 (max)	0.030
Si	0.750 (max)	0.750
Cr	18-20	19.000
Ni	8-12	10.000
N	0.100 (max)	0.100
Fe	Balance	68.045
Density[b] = 7.94 g/cm^3		

SOURCES: [a] ASTM A 240/A 240M-99b.
[b] ASTM G 1-90, Table X1.1.

Table 4. Composition and Density of Stainless Steel 316L

Element	Composition [a] (wt %)	Value Used (wt %)
C	0.03 (max)	0.030
N	0.10 (max)	0.100
Si	1.00 (max)	1.000
P	0.045 (max)	0.045
S	0.03 (max)	0.030
Cr	16-18	17.000
Mn	2.00 (max)	2.000
Ni	10-14	12.000
Mo	2-3	2.500
Fe	Balance	65.295
Density[b] = 7.98 g/cm^3		

SOURCES: [a] ASTM A 276-91a, p. 2.
[b] ASTM G 1-90, Table X1.1.

Table 5. Composition and Density of Stainless Steel 316NG

Element	Composition [a] (wt %)	Value Used (wt %)
C	0.03 (max)	0.020
N	0.10 (max)	0.080
Si	1.00 (max)	1.000
P	0.045 (max)	0.045
S	0.03 (max)	0.030
Cr	16-18	17.000
Mn	2.00 (max)	2.000
Ni	10-14	12.000
Mo	2-3	2.500

Element	Composition [a] (wt %)	Value Used (wt %)
Fe	Balance	65.325
Density[b] = 7.98 g/cm^3		

SOURCES: [a] ASTM A 276-91a, p. 2.
[b] ASTM G 1-90, Table X1.1.

Table 6. Composition and Density of Alloy 22

Element	Composition [a] (wt %)	Value Used (wt%)
C	0.015 (max)	0.015
Mn	0.50 (max)	0.500
Si	0.08 (max)	0.080
Cr	20-22.5	21.250
Mo	12.5-14.5	13.500
Co	2.50 (max)	2.500
W	2.5-3.5	3.000
V	0.35 (max)	0.350
Fe	2.0-6.0	4.000
P	0.02 (max)	0.020
S	0.02 (max)	0.020
Ni	Balance	54.765
Density[b] = 8.69 g/cm^3		

SOURCES: [a] ASTM B 575-97, Table 1.
[b] ASTM B 575-97, p. 2.

Table 7. Composition and Density of Carbon Steel A516 Grade 70

Element	Composition [a] (wt %)	Value Used (wt %)
C	0.27	0.27
Mn	0.79-1.30	1.045
P	0.035 (max)	0.035
S	0.035 (max)	0.035
Si	0.13-0.45	0.29
Fe	Balance	98.325
Density[b] = 7.85 g/cm^3		

SOURCES: [a] ASTM A 516/A 516M - 90, Table 1.
[b] ASTM A 20/A 20M-99a, p. 9.

Table 8. Composition and Density of Inconel Alloy 600

Element	Composition [a] (wt %)	Value Used (wt %)
Cr	14-17	15.500
Fe	6-10	8.000
Mn	1.0	1.000

C	0.15	0.15
S	0.015 (max)	0.015
Si	0.5 (max)	0.500
Ni	Balance (min 72.0)	74.335
Density[a] = 8.47 g/cm^3		

SOURCE: [a] Inco Alloys International 1988. *Product Handbook*, IAI-38.

Table 9. Composition and Density of Savannah River Site High-Level Waste Glass

Element / Isotope	Composition[a] (wt %)	Element / Isotope	Composition[a] (wt %)
O	4.4770E+01	Ni	7.3490E-01
U-234	3.2794E-04	Pb	6.0961E-02
U-235	4.3514E-03	Si	2.1888E+01
U-236	1.0415E-03	Th	1.8559E-01
U-238	1.8666E+00	Ti	5.9676E-01
Pu-238	5.1819E-03	Zn	6.4636E-02
Pu-239	1.2412E-02	B-10	5.9176E-01
Pu-240	2.2773E-03	B-11	2.6189E+00
Pu-241	9.6857E-04	Li-6	9.5955E-02
Pu-242	1.9168E-04	Li-7	1.3804E+00
Cs-133	4.0948E-02	F	3.1852E-02
Cs-135	5.1615E-03	Cu	1.5264E-01
Ba-137[c]	1.1267E-01	Fe	7.3907E+00
Al	2.3318E+00	K	2.9887E+00
S	1.2945E-01	Mg	8.2475E-01
Ca	6.6188E-01	Mn	1.5577E+00
P	1.4059E-02	Na	8.6284E+00
Cr	8.2567E-02	Cl	1.1591E-01
Ag	5.0282E-02		
Density[b] at 25 °C = 2.85 g/cm^3			

SOURCES: [a] CRWMS M&O 1999b, Attachment I, p. I-7.
[b] Stout and Leider 1991, p. 2.2.1.1-4.

NOTE: [c] See Assumption 3.2.

Table 10. Pre-Breach Clay Composition

Element	Mass of Element after 53,210 Years of Emplacement (kg)
O	9.6653E+03
Al	3.3561E+02
B	1.01E-29
Ba	2.1378E+01
Ca	6.6361E+01
Cl	0.000E+00
Cr	8.0944E+00

F	1.0334E+00
Fe	1.0672E+04
H	7.1390E+01
C	0.000E+00
P	5.0542E+00
K	6.1540E-18
Mg	9.9435E+01
Mn	1.6787E+02
Mo	0.000E+00
N	4.4093E-18
Na	0.000E+00
Ni	4.0852E+02
S	1.5141E-17
Si	3.4202E+03
U	0.000E+00
Total (kg)	2.4942E+04
Density (g/cm^3)	3.8804E+00

SOURCE: BSC 2001, Attachment I, Case "f11x1403"

NOTE: See Attachment I, spreadsheet "FFTF.xls", sheet "pre-breach_clay"

Table 11. Composition and Density of Dry Tuff

Mineral	Composition [c] (wt %)	Element	Composition [a] (wt %)
SiO_2	76.83	Si	0.359
Al_2O_3	12.74	Al	0.067
FeO	0.84	Fe	0.007
MgO	0.25	Mg	0.002
CaO	0.56	Ca	0.004
Na_2O	3.59	Na	0.027
K_2O	4.93	K	0.041
TiO_2	0.1	Ti	0.001
P_2O_5	0.02	P	0.0001
MnO	0.07	Mn	0.001
		H	0.000
		O	0.492
Density[b]=2.245 g/cm^3			

SOURCES: [a] Calculated from Lipman 1966.
[b] Calculated from Flint 1998.
[c] Calculated from Lipman 1966.
NOTE: Calculated in Attachment I, spreadsheet "FFTF.xls"

5.3 FORMULAS

The basic equation used to calculate the number density values, in the spreadsheet included in Attachment I, and used in the cases described throughout Section 5 is shown below:

$$N = (m/V) \times N_a / M$$

where: N is the number density in atoms/(barn-cm)
m is the mass in grams
V is the volume in cm^3
N_a is the Avogadro's number (6.022 E+23 atoms/mole, Parrington et al. 1996, p. 59)
M is the atomic mass in g/mole.

Volumes of cylinder segments (volume = area of circle segment × length of the cylinder) are also calculated throughout Attachment I. These calculations are based on the equation for the segment of a circle shown below (Beyer 1987, p.125):

$$\text{Segment of a Circle} = \left(R^2 \cos^{-1}\left(\frac{R-h}{R} \right) - (R-h)\sqrt{2Rh - h^2} \right)$$

where: R is the cylinder radius,
h is the height of the segment.

5.4 DESCRIPTION OF THE CONFIGURATIONS INVESTIGATED

As mentioned in Section 1, the scope of the present calculation is limited to the reevaluation of the most reactive configuration of the degraded codisposal WP containing FFTF SNF identified in previous analyses. The most reactive degraded configuration (limiting case) for the codisposal WP design containing FFTF SNF is described in Section 7.4.7 of CRWMS M&O 1999a. It comprises an intact Ident-69 container surrounded by degraded material resulted from the degradation of the 4 DFAs containing Type 4.1 fuel pins and the supporting basket structure inside the DOE SNF canister. The fissile material is contained inside the DOE SNF canister by its stainless steel shell that is not completely degraded. The remaining space of the WP is filled by water mixed with a clayey material surrounding the DOE SNF canister. The clayey material (clay) results from the degradation of the HLW glass canisters and supporting structures and its composition is described in Table 10.

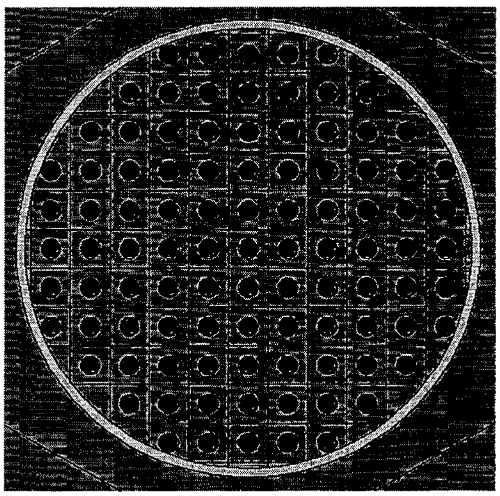
The new information given in the revision of the *FFTF(MOX) Fuel Characteristics for Disposal Criticality Analysis* (DOE 2002a) comprise the exact fissile content in each Ident-69 container. This information is sufficient to support a new criticality analysis of the possible arrangements of the fuel pins inside the Ident-69 container using a consistent approach in identifying the most reactive inner arrangement. As a first stage of the present calculation a comprehensive parametric analysis of the Ident-69 internal arrangements has been performed. In a second stage, the WP degraded configuration that produced the highest k_{eff} in previous analyses is investigated using the most reactive arrangements of the fuel pins inside the Ident-69 container.

5.4.1 Description of the Parametric Analyses on Ident-69 Container

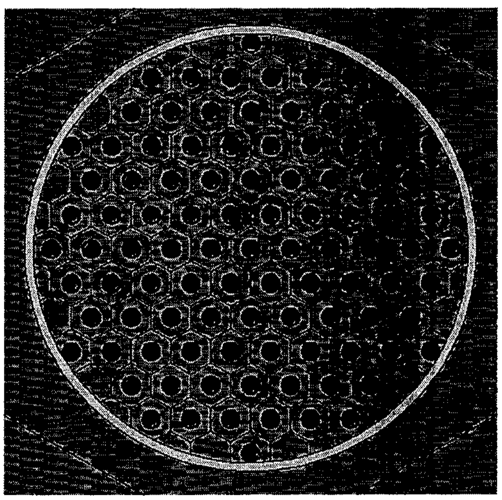
The number and types of pins placed inside each container are now available in DOE (2002a) but because the exact fuel pins arrangements inside each Ident-69 container are not known, a generic approach is followed in order to screen the possible configurations. Due to the variety of loading possibilities and varying numbers of pins from container to container, a bounding Ident-69 pin container needs to be determined. The Ident-69 container is analyzed with respect to the number of pins and optimal spacing between pins. Both hexagonal and square lattice arrays of pins are investigated.

The pins are placed in an array with uniform spacing filling the entire container, neglecting the supporting inner structures (tubes in some Ident-69 models or inner duct and dividers in the compartmented Ident-69 model). The Ident-69 container is analyzed fully flooded and placed concentrically in a DOE SNF canister flooded and reflected by water. No other inner structures, DFAs and/or absorbers are modeled. The pins are considered to be of a single type inside an Ident-69 container, and various containers are investigated (containing Type 3.1, 4.1 or experimental MOX pins with larger diameter).

The first set of runs studied the effect of increasing the array pitch keeping a constant number of pins inside the Ident-69 fuel pin container until the maximum possible spacing for the given number of pins is reached. The Type 3.1 fuel pin is analyzed using the intact fuel composition and internal geometry. Both square and hexagonal lattices are analyzed using a maximum number of pins that uniformly and symmetrically fill the space inside the Ident-69 container. Figure 5 presents two cross-sectional views of the Ident-69 container containing a square lattice and a hexagonal lattice with maximum possible spacing for 97 intact pins.



Square array (97 pins)
Max. pitch = 1.2 cm



Hex array (97 pins)
Max. pitch =1.25 cm

Figure 5. Cross-sectional Views of Ident-69 Container Representations Used in Parametric Analyses

The results for the parametric analysis performed for Type 3.1 pins, presented in Section 6 (Table 12 and 13) show that the arrays are undermoderated (the highest k_{eff} is obtained for the largest pitch possible inside Ident-69 container for a fixed number of fuel pins) for both hexagonal and square arrays.

A fuel pin with flooded internal spaces and a homogenized saturated composition in which all pellet internal voids (porosity and pellet dishes) are filled with water (see the calculated composition in spreadsheet: "FFTF.xls", Attachment I) is also investigated. The values of the k_{eff} presented in Section 6 (Table 14) for the configurations with the largest pitch for a given number of pins confirm that the saturated fuel composition always results in more reactive configurations. The saturated fuel composition is thus selected for the remaining analyses.

Subsequent analyses are performed for saturated Type 4.1 fuel pins and experimental MOX fuel pins using only the configurations with the maximum possible pitch for each number of pins (both for square and hexagonal lattice). The maximum possible pitch for the arrays with larger diameter (0.69 cm) MOX experimental fuel pins is slightly smaller for the same number of pins than that for Type 4.1 pins. The results are included in Table 15 for saturated Type 4.1 pins and Table 16 for the saturated MOX experimental type fuel.

5.4.2 Analysis of the Most Reactive Degraded Configuration of the WP with an Intact Ident-69 container

As stated in CRWMS M&O (1999a, p. 73) the design/loading solution of the codisposal WP containing FFTF SNF was driven by a degraded configuration of the WP that encompasses an almost intact Ident-69 container (breached container that allows water in but still confines the intact fuel pins). The most reactive arrangement was selected by configuring the variable parameters (geometry and composition) in such a way that the k_{eff} value is maximized.

The characteristics of the previously identified configuration are described in the following. A mixture formed from degradation of the DFAs (containing Type 4.1 pins) and the basket supporting structure surrounds the Ident-69 container inside the DOE SNF canister shell. Volume fraction of water in this mixture is 0.198. The contents of the waste package external to the DOE SNF canister are analyzed as completely degraded to clay like material. The position of the DOE SNF canister is at the bottom of the WP and the DOE SNF canister is surrounded by a dry pre-breach clay composition. The Ident-69 container holds a hexagonal array of 61 pins of Type 4.1 with a pitch of 1.6 cm. The footprint of the degraded fuel material from the DFAs (containing also Type 4.1 pins) is preserved and matches the axial position of the intact fuel in Ident-69 container. Full density water is flooding the Ident-69 and is also present above the mixture inside the DOE SNF canister. The Pu decay has also been taken into account producing a maximum in k_{eff} at 24,100 years after emplacement. The high value of the k_{eff} calculated (above the interim criticality limit), required limitation of the number of loaded DFAs to 4 and the presence of Gd (a minimum of2.75 wt % of the DOE SNF canister basket structure) distributed as $GdPO_4$ on or in the DOE SNF canister internal basket structure. The design solution adopted for placing the neutron absorber outside the

Ident-69 container was dictated by the fact that a sealed canister (Ident-69 container) reopened to introduce neutron absorber and then resealed, was not considered a viable option.

The MCNP model developed for analyzing this configuration in CRWMS M&O 1999c has been updated and modified in the present study to take into account the information that became recently available. WP dimensions, geometry and materials, updated composition of the clay material from geochemistry calculation, fissile content and number of the fuel pins inside Ident-69 containers are among the characteristics that have been modified from previous analyses. Spreadsheet "FFTF.xls" (Attachment I) contains the updated number densities calculated using the material compositions presented in Section 5.2 (Tables 3 to 11). The results of the parametric analysis on the Ident-69 container presented in Section 6.1 have been used to screen the possible arrangements inside the codisposal WP. Figure 6 presents a cross-sectional view of the new configuration model and Figure 7 presents an enlarged view of the DOE SNF canister containing the intact Ident-69 container.

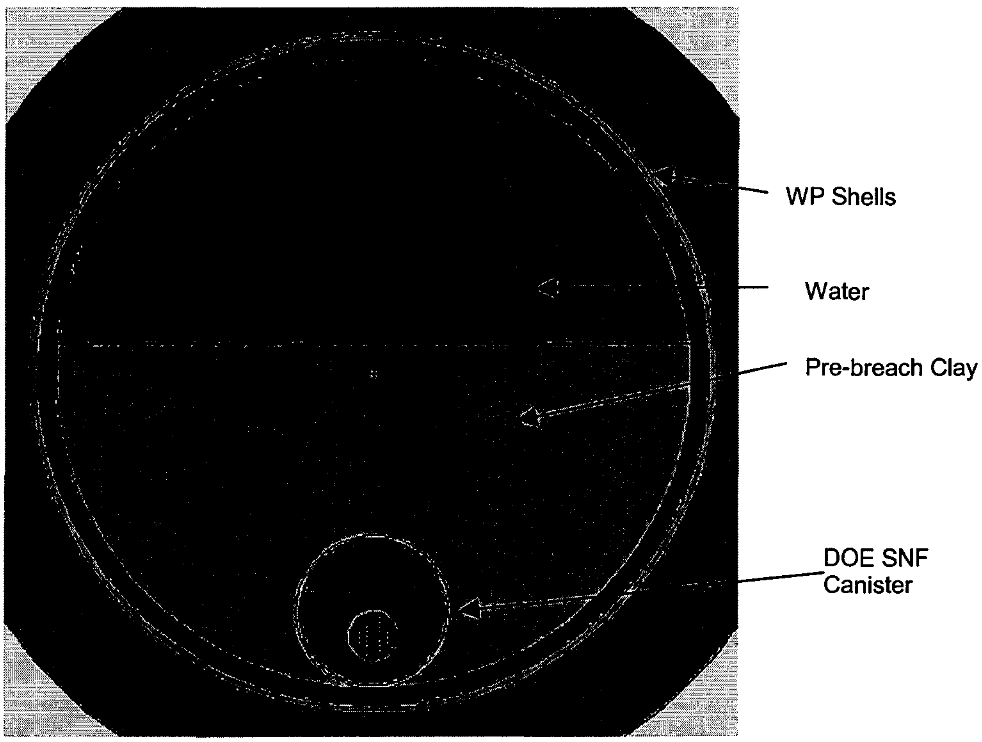


Figure 6. Cross-sectional View of the WP Degraded Configuration with an Intact Ident-69 Container

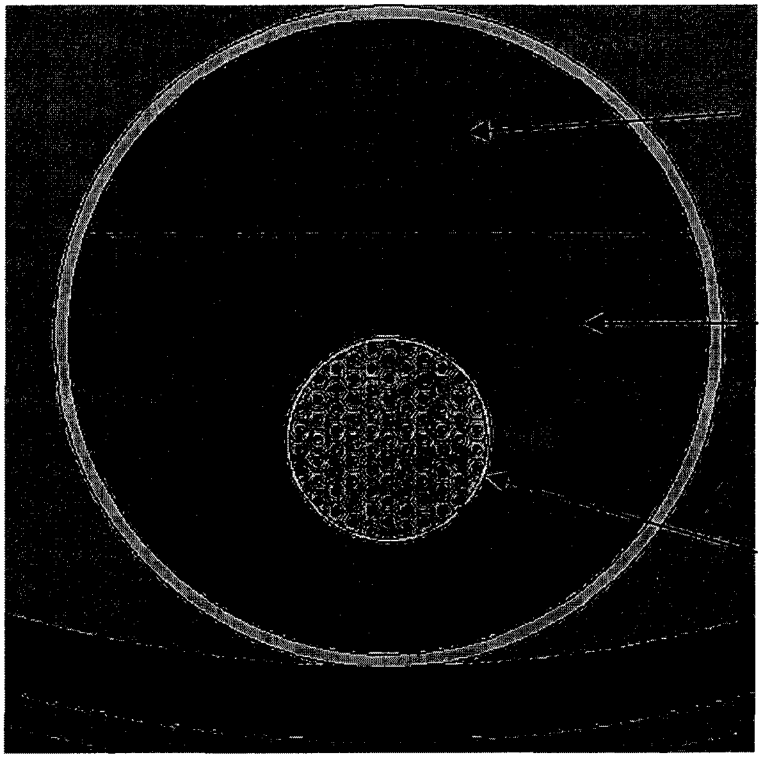


Figure 7. Enlarged View of the DOE SNF Canister for the WP Degraded Configuration Investigated

The results of the parametric analysis on the Ident-69 container presented in Section 6.1 show that the Ident-69 container has a high k_{eff} over of large spectrum of internal arrangements that includes both square and hexagonal lattices with variable number of pins and spacings. The geometry of the degraded WP configuration illustrated in Figure 7 has some fissile material mixed with neutron absorber distributed around the Ident-69 container. This complex geometry required a full investigation of the criticality potential of the configuration using the most reactive arrangement inside the Ident-69 container for each number and type of fuel pins. The results are presented in Section 6.2.1 taking also into account the influence of the decay of Pu isotopes on k_{eff}.

Finally, the configuration resulting in the highest k_{eff} for the system is further studied in detail. The additional amount of Gd necessary to bring the k_{eff} of the system below the interim criticality limit of 0.93 (CRWMS M&O 1999a) is evaluated. With this amount, the arrangement and composition of the materials in the degraded configuration are slightly varied to show the conservatism of the assumptions used in defining this configuration. The results are presented in Section 6.2.2.

6. RESULTS

This section documents the results for the selected degraded configurations reevaluated for criticality of the FFTF SNF codisposal waste package. The k_{eff} results represent the average collision, absorption, and track length estimator from the MCNP calculations. The standard deviation (σ) represents the standard deviation of k_{eff} about the average combined collision, absorption, and track length estimate due to Monte Carlo calculation statistics. The average energy of a neutron causing fission (AENCF) is the energy per source particle lost to fission divided by the weight per source neutron lost to fission from the "problem summary section" of the MCNP output. The MCNP input and output files developed for this calculation are included in ASCII format in Attachment I. The H/X ratio is the ratio of mole of hydrogen to mole of fissile materials (U-235 and Pu-239).

The status of the technical product information quality may be confirmed by review of the DIRS database.

For all the cases, no credit is taken for the fuel burnup, i.e., fuel is assumed to be fresh (non-irradiated) unless otherwise specified.

6.1 RESULTS FOR PARAMETRIC ANALYSES ON THE IDENT-69 CONTAINER

Tables 12 through 16 present the results of the calculations described in Section 5.4.1. Table 12 and 13 give the k_{eff} of the configurations containing a single Ident-69 container with dry Type 3.1 fuel pins placed in square or hexagonal arrays (see Fig. 5). The pitch for each symmetrical array is increased until the outer pins come in close proximity with the shell of the Ident-69 container. The container is flooded and surrounded by full density water. No other internal structures are considered inside Ident-69 container.

Table 12. Results of Parametric Variations on Intact Ident-69 Container Loaded with Type 3.1 Fuel Pins (Square Lattice)

Case (MCNP Input File)	Description		k_{eff}	σ	$k_{eff}+2\sigma$	AENCF (MeV)	H/X (unit cell)
	Number of Pins	Lattice Pitch (cm)					
Square lattice; Type 3.1 fuel pins (dry fuel); 61 pins							
sq-61-100	61	1	0.5180	0.0008	0.5196	0.1986	47.14
sq-61-110	61	1.1	0.5549	0.0008	0.5565	0.1706	60.66
sq-61-120	61	1.2	0.5899	0.0008	0.5914	0.1480	75.47
sq-61-125	61	1.25	0.6034	0.0008	0.6050	0.1393	83.36
sq-61-130	61	1.3	0.6192	0.0008	0.6208	0.1317	91.57
sq-61-135	61	1.35	0.6323	0.0008	0.6340	0.1260	100.10
sq-61-140	61	1.4	0.6456	0.0008	0.6472	0.1204	108.96
sq-61-145	61	1.45	0.6599	0.0009	0.6616	0.1142	118.14
sq-61-150	61	1.5	0.6720	0.0009	0.6738	0.1098	127.63
sq-61-153	61	1.53	0.6798	0.0008	0.6814	0.1053	133.49
Square lattice; Type 3.1 fuel pins (dry fuel); 69 pins							

Case (MCNP Input File)	Description		k_{eff}	σ	$k_{eff}+2σ$	AENCF (MeV)	H/X (unit cell)
	Number of Pins	Lattice Pitch (cm)					
sq-69-100	69	1	0.5362	0.0008	0.5378	0.1996	47.14
sq-69-110	69	1.1	0.5770	0.0008	0.5787	0.1689	60.66
sq-69-120	69	1.2	0.6129	0.0008	0.6144	0.1471	75.47
sq-69-125	69	1.25	0.6281	0.0008	0.6297	0.1391	83.36
sq-69-130	69	1.3	0.6441	0.0008	0.6458	0.1321	91.57
sq-69-135	69	1.35	0.6609	0.0008	0.6626	0.1249	100.10
sq-69-140	69	1.4	0.6769	0.0009	0.6786	0.1176	108.96
sq-69-145	69	1.45	0.6901	0.0008	0.6917	0.1128	118.14
Square lattice; Type 3.1 fuel pins (dry fuel); 81 pins							
sq-81-100	81	1	0.5710	0.0008	0.5725	0.1941	47.14
sq-81-110	81	1.1	0.6128	0.0009	0.6145	0.1644	60.66
sq-81-120	81	1.2	0.6533	0.0008	0.6549	0.1422	75.47
sq-81-125	81	1.25	0.6716	0.0008	0.6732	0.1345	83.36
sq-81-129	81	1.29	0.6851	0.0009	0.6869	0.1291	89.90
Square lattice; Type 3.1 fuel pins (dry fuel); 89 pins							
sq-89-90	89	0.9	0.5429	0.0007	0.5443	0.2344	34.90
sq-89-100	89	1	0.5870	0.0008	0.5887	0.1954	47.14
sq-89-110	89	1.1	0.6326	0.0008	0.6342	0.1653	60.66
sq-89-120	89	1.2	0.6727	0.0008	0.6743	0.1431	75.47
sq-89-125	89	1.25	0.6935	0.0008	0.6951	0.1336	83.36
sq-89-127	89	1.27	0.6998	0.0009	0.7016	0.1315	86.61
Square lattice; Type 3.1 fuel pins (dry fuel); 97 pins							
sq-97-80	97	0.8	0.5076	0.0007	0.5091	0.2892	23.95
sq-97-90	97	0.9	0.5549	0.0008	0.5565	0.2353	34.90
sq-97-100	97	1	0.6024	0.0009	0.6042	0.1961	47.14
sq-97-110	97	1.1	0.6495	0.0008	0.6512	0.1653	60.66
sq-97-120	97	1.2	0.6956	0.0009	0.6973	0.1416	75.47
Square lattice; Type 3.1 fuel pins (dry fuel); 109 pins							
sq-109-80	109	0.8	0.5246	0.0007	0.5260	0.2909	23.95
sq-109-90	109	0.9	0.5770	0.0007	0.5785	0.2346	34.90
sq-109-100	109	1	0.6273	0.0008	0.6290	0.1958	47.14
sq-109-110	109	1.1	0.6779	0.0009	0.6796	0.1638	60.66
sq-109-111	109	1.11	0.6830	0.0008	0.6847	0.1609	62.08

Case (MCNP Input File)	Description		k_{eff}	σ	k_{eff}+2σ	AENCF (MeV)	H/X (unit cell)
	Number of Pins	Lattice Pitch (cm)					
Square lattice; Type 3.1 fuel pins (dry fuel); 137 pins							
sq-137-80	137	0.8	0.5642	0.0008	0.5658	0.2930	23.95
sq-137-90	137	0.9	0.6199	0.0008	0.6216	0.2340	34.90
sq-137-100	137	1	0.6817	0.0008	0.6832	0.1910	47.14

Table 13. Results of Parametric Variations on Intact Ident-69 Container Loaded with Type 3.1 Fuel Pins (Hexagonal Lattice)

Case (MCNP Input File)	Description		k_{eff}	σ	k_{eff}+2σ	AENCF (MeV)	H/X (unit cell)
	Number of Pins	Lattice Pitch (cm)					
Hexagonal lattice; Type 3.1 fuel pins (dry fuel); 61 pins							
hx-61-100	61	1	0.4919	0.0007	0.4934	0.2209	38.51
hx-61-110	61	1.1	0.5264	0.0008	0.5279	0.1909	50.22
hx-61-120	61	1.2	0.5589	0.0008	0.5606	0.1676	63.05
hx-61-130	61	1.3	0.5885	0.0008	0.5902	0.1489	76.99
hx-61-140	61	1.4	0.6202	0.0008	0.6218	0.1311	92.05
hx-61-150	61	1.5	0.6460	0.0009	0.6477	0.1210	108.22
hx-61-155	61	1.55	0.6568	0.0009	0.6586	0.1161	116.73
hx-61-162	61	1.62	0.6737	0.0008	0.6753	0.1091	129.10
Hexagonal lattice; Type 3.1 fuel pins (dry fuel); 73 pins							
hx-73-100	73	1	0.5240	0.0008	0.5256	0.2215	38.51
hx-73-110	73	1.1	0.5610	0.0009	0.5627	0.1872	50.22
hx-73-120	73	1.2	0.5979	0.0008	0.5996	0.1627	63.05
hx-73-130	73	1.3	0.6310	0.0008	0.6326	0.1438	76.99
hx-73-140	73	1.4	0.6628	0.0008	0.6644	0.1292	92.05
hx-73-145	73	1.45	0.6786	0.0008	0.6803	0.1234	100.00
hx-73-147	73	1.47	0.6853	0.0009	0.6870	0.1197	103.25
Hexagonal lattice; Type 3.1 fuel pins (dry fuel); 85 pins							
hx-85-100	85	1	0.5465	0.0008	0.5481	0.2217	38.51
hx-85-110	85	1.1	0.5882	0.0009	0.5899	0.1891	50.22
hx-85-120	85	1.2	0.6287	0.0008	0.6303	0.1615	63.05
hx-85-130	85	1.3	0.6636	0.0008	0.6652	0.1421	76.99
hx-85-135	85	1.35	0.6828	0.0008	0.6845	0.1350	84.38

Case (MCNP Input File)	Description		k_{eff}	σ	$k_{eff}+2\sigma$	AENCF (MeV)	H/X (unit cell)
	Number of Pins	Lattice Pitch (cm)					
hx-85-141	85	1.41	0.7045	0.0009	0.7063	0.1254	93.62
Hexagonal lattice; Type 3.1 fuel pins (dry fuel); 91 pins							
hx-91-90	91	0.9	0.5154	0.0008	0.5170	0.2678	27.91
hx-91-100	91	1	0.5607	0.0008	0.5622	0.2223	38.51
hx-91-110	91	1.1	0.6018	0.0009	0.6035	0.1864	50.22
hx-91-120	91	1.2	0.6437	0.0008	0.6454	0.1607	63.05
hx-91-125	91	1.25	0.6621	0.0008	0.6637	0.1520	69.88
hx-91-129	91	1.29	0.6772	0.0008	0.6789	0.1433	75.55
Hexagonal lattice; Type 3.1 fuel pins (dry fuel); 97 pins							
hx-97-90	97	0.9	0.5292	0.0008	0.5307	0.2625	27.91
hx-97-100	97	1	0.5748	0.0008	0.5763	0.2178	38.51
hx-97-110	97	1.1	0.6188	0.0008	0.6204	0.1849	50.22
hx-97-120	97	1.2	0.6624	0.0008	0.6640	0.1586	63.05
hx-97-125	97	1.25	0.6810	0.0009	0.6828	0.1502	69.88
Hexagonal lattice; Type 3.1 fuel pins (dry fuel); 109 pins							
hx-109-80	109	0.8	0.4990	0.0008	0.5005	0.3307	18.43
hx-109-90	109	0.9	0.5444	0.0007	0.5458	0.2658	27.91
hx-109-100	109	1	0.5943	0.0008	0.5959	0.2187	38.51
hx-109-110	109	1.1	0.6402	0.0008	0.6418	0.1856	50.22
hx-109-120	109	1.2	0.6877	0.0009	0.6894	0.1590	63.05
hx-109-122	109	1.22	0.6974	0.0009	0.6992	0.1533	65.75
Hexagonal lattice; Type 3.1 fuel pins (dry fuel); 121 pins							
hx-121-80	121	0.8	0.5129	0.0007	0.5143	0.3339	18.43
hx-121-90	121	0.9	0.5618	0.0008	0.5634	0.2687	27.91
hx-121-100	121	1	0.6122	0.0008	0.6138	0.2206	38.51
hx-121-110	121	1.1	0.6636	0.0008	0.6652	0.1853	50.22
hx-121-116	121	1.16	0.6949	0.0008	0.6964	0.1672	57.78
Hexagonal lattice; Type 3.1 fuel pins (dry fuel); 151 pins							
hx-151-80	151	0.8	0.5467	0.0008	0.5483	0.3371	18.43
hx-151-90	151	0.9	0.6025	0.0008	0.6041	0.2693	27.91
hx-151-100	151	1	0.6610	0.0009	0.6627	0.2180	38.51
hx-151-104	151	1.04	0.6895	0.0008	0.6911	0.2009	43.06

The results show that all arrays are undermoderated, and the highest k_{eff} for a given number of pins is obtained for the largest pitch possible in the Ident-69 container. Table 14 summarizes the largest k_{eff} for each combination number of pins with its maximum possible pitch within the Ident-69 container. It includes similar calculations for a fuel composition that assumes total flooding of the pin's inner spaces and of the void volumes within the fuel pellets (saturated fuel composition).

Table 14. Highest k_{eff} Results for Dry and Saturated Type 3.1 Fuel Pins Inside Ident-69 Container

Case (MCNP Input File)	Description		k_{eff}	σ	k_{eff}+2σ	AENCF (MeV)	H/X (unit cell)
	Number of Pins	Lattice Pitch (cm)					
Square lattice; Type 3.1 fuel pins (dry fuel)							
sq-61-153	61	1.53	0.6798	0.0008	0.6814	0.1053	133.49
sq-69-145	69	1.45	0.6901	0.0008	0.6917	0.1128	118.14
sq-81-129	81	1.29	0.6851	0.0009	0.6869	0.1291	89.90
sq-89-127	89	1.27	0.6998	0.0009	0.7016	0.1315	86.61
sq-97-120	97	1.2	0.6956	0.0009	0.6973	0.1416	75.47
sq-109-111	109	1.11	0.6830	0.0008	0.6847	0.1609	62.08
sq-137-100	137	1	0.6817	0.0008	0.6832	0.1910	47.14
Square lattice; saturated Type 3.1 fuel pins							
sq-61-153-sat	61	1.53	0.6855	0.0008	0.6871	0.1053	135.56
sq-69-145-sat	69	1.45	0.6962	0.0009	0.6979	0.1105	120.21
sq-81-129-sat	81	1.29	0.6925	0.0009	0.6942	0.1263	91.98
sq-89-127-sat	89	1.27	0.7105	0.0009	0.7123	0.1272	88.68
sq-97-120-sat	97	1.2	0.7055	0.0008	0.7071	0.1383	77.55
sq-109-111-sat	109	1.11	0.6942	0.0009	0.6960	0.1560	64.16
sq-137-100-sat	137	1	0.6951	0.0009	0.6968	0.1848	49.21
Hexagonal lattice; Type 3.1 fuel pins (dry fuel)							
hx-61-162	61	1.62	0.6737	0.0008	0.6753	0.1091	129.10
hx-73-147	73	1.47	0.6853	0.0009	0.6870	0.1197	103.25
hx-85-141	85	1.41	0.7045	0.0009	0.7063	0.1254	93.62
hx-91-129	91	1.29	0.6772	0.0008	0.6789	0.1433	75.55
hx-97-125	97	1.25	0.6810	0.0009	0.6828	0.1502	69.88
hx-109-122	109	1.22	0.6974	0.0009	0.6992	0.1533	65.75
hx-121-116	121	1.16	0.6949	0.0008	0.6964	0.1672	57.78
hx-151-104	151	1.04	0.6895	0.0008	0.6911	0.2009	43.06
Hexagonal lattice; saturated Type 3.1 fuel pins							
hx-151-104-sat	151	1.04	0.7015	0.0006	0.7027	0.1937	45.13

Case (MCNP Input File)	Description		k_{eff}	σ	$k_{eff}+2σ$	AENCF (MeV)	H/X (unit cell)
	Number of Pins	Lattice Pitch (cm)					
hx-121-116-sat	121	1.16	0.7062	0.0006	0.7075	0.1612	59.86
hx-109-122-sat	109	1.22	0.7083	0.0007	0.7096	0.1506	67.82
hx-97-125-sat	97	1.25	0.6915	0.0007	0.6929	0.1444	71.95
hx-91-129-sat	91	1.29	0.6867	0.0006	0.6879	0.1399	77.62
hx-85-141-sat	85	1.41	0.7123	0.0007	0.7136	0.1227	95.69
hx-73-147-sat	73	1.47	0.6925	0.0006	0.6937	0.1181	105.33
hx-61-162-sat	61	1.62	0.6783	0.0007	0.6796	0.1072	131.18

The results show that the saturated fuel composition always result in higher k_{eff}. This finding is further used for analyzing the Ident-69 container with Type 4.1 fuel pins and MOX fuel pins (with a higher fissile content). The results are included in Tables 15 and 16.

Table 15. Highest k_{eff} Results for Saturated Type 4.1 Fuel Pins Inside Ident-69 Container

Case (MCNP Input File)	Description		k_{eff}	σ	$k_{eff}+2σ$	AENCF (MeV)	H/X (unit cell)
	Number of Pins	Lattice Pitch (cm)					
Square lattice; saturated Type 4.1 fuel pins							
sq-61-153-41-sat	61	1.53	0.6889	0.0007	0.6903	0.1077	128.31
sq-69-145-41-sat	69	1.45	0.7014	0.0007	0.7028	0.1137	113.78
sq-81-129-41-sat	81	1.29	0.6978	0.0007	0.6993	0.1289	87.05
sq-89-127-41-sat	89	1.27	0.7145	0.0008	0.7161	0.1308	83.93
sq-97-120-41-sat	97	1.2	0.7066	0.0008	0.7081	0.1433	73.39
sq-109-111-41-sat	109	1.11	0.6965	0.0008	0.6980	0.1607	60.71
sq-137-100-41-sat	137	1	0.6985	0.0007	0.7000	0.1880	46.56
Hexagonal lattice; saturated Type 4.1 fuel pins							
hx-61-162-41-sat	61	1.62	0.6814	0.0008	0.6830	0.1099	124.16
hx-73-147-41-sat	73	1.47	0.6959	0.0008	0.6974	0.1197	99.69
hx-85-141-41-sat	85	1.41	0.7148	0.0007	0.7162	0.1249	90.56
hx-91-129-41-sat	91	1.29	0.6898	0.0008	0.6913	0.1433	73.46
hx-97-125-41-sat	97	1.25	0.6946	0.0007	0.6960	0.1470	68.10
hx-109-122-41-sat	109	1.22	0.7115	0.0007	0.7129	0.1539	64.18
hx-121-116-41-sat	121	1.16	0.7101	0.0007	0.7116	0.1667	56.64
hx-151-104-41-sat	151	1.04	0.7057	0.0008	0.7072	0.1981	42.71

Table 16. Highest k_{eff} Results for Saturated Experimental MOX Fuel Pins Inside Ident-69 Container

Case (MCNP Input File)	Description		k_{eff}	σ	k_{eff}+2σ	AENCF (MeV)	H/X (unit cell)
	Number of Pins	Lattice Pitch (cm)					
Square lattice; saturated experimental MOX type fuel pins							
sq-61-151-MOX-sat_I	61	1.51	0.7077	0.0008	0.7093	0.1411	77.74
sq-69-144-MOX-sat_I	69	1.44	0.7179	0.0009	0.7197	0.1501	69.52
sq-81-128-MOX-sat_I	81	1.28	0.7061	0.0009	0.7080	0.1745	52.18
sq-89-126-MOX-sat_I	89	1.26	0.7213	0.0009	0.7230	0.1790	50.16
sq-97-119-MOX-sat_I	97	1.19	0.7099	0.0009	0.7117	0.1981	43.33
sq-109-110-MOX-sat_I	109	1.1	0.6960	0.0009	0.6977	0.2267	35.12
sq-137-100-MOX-sat_I	137	1	0.6986	0.0008	0.7002	0.2673	26.76
Hexagonal lattice; saturated experimental MOX type fuel pins							
hx-61-160-MOX-sat_I	61	1.6	0.7003	0.0009	0.7021	0.1432	75.72
hx-73-146-MOX-sat_I	73	1.46	0.7078	0.0009	0.7095	0.1614	60.95
hx-85-140-MOX-sat_I	85	1.4	0.7255	0.0009	0.7272	0.1705	55.03
hx-91-128-MOX-sat_I	91	1.28	0.6949	0.0008	0.6966	0.1979	43.93
hx-97-124-MOX-sat_I	97	1.24	0.6976	0.0009	0.6993	0.2048	40.46
hx-109-121-MOX-sat_I	109	1.21	0.7116	0.0008	0.7133	0.2146	37.92
hx-121-115-MOX-sat_I	121	1.15	0.7063	0.0008	0.7080	0.2367	33.04
hx-151-102-MOX-sat_I	151	1.02	0.6938	0.0008	0.6954	0.2916	23.31

The calculated effective multiplication factors that are listed in Tables 15 and 16 show the complicated interaction between the pin spacing and the discrete number of pins that can be contained in the Ident-69 container for that spacing. Thus, two parameters have been varied simultaneously but not continuously in these parametric analyses. The k_{eff} exhibits a discontinuous behavior for both square and hexagonal arrays. The effective multiplication factor has high values over a large number of possible combinations of number of pins/spacing that are typically encountered in the existing containers.

6.2 RESULTS FOR THE MOST REACTIVE DEGRADED CONFIGURATION WITH AN INTACT IDENT-69 CONTAINER

6.2.1 Parametric Analysis with Type 4.1 and Experimental MOX Fuel Pins

The results for the parametric analysis performed for the configuration described in Section 5.4.2 are listed in Tables 17 and 18. As discussed in Section 6.1, the parametric analysis performed on the Ident-69 (pin possible arrangements) has not resulted in an explicit bounding configuration. This justifies the screening approach that was adopted in this calculation to study the most reactive degraded configuration of the WP. Table 17 presents the results obtained by inserting in the updated model of the WP configuration (illustrated in Figures 6 and 7) various internal arrangements of the Ident-69 container with saturated Type 4.1 fuel pins. The same combinations of maximum number of pins/spacing analyzed in Table 15 for both square and hexagonal arrays are used to investigate the k_{eff} of the full system. The degraded mixture outside Ident-69 container contains the four degraded DFAs, the degraded basket structure (including all Gd) and water. The volume fractions of materials and corresponding number densities are calculated in spreadsheet "FFTF.xls", Attachment I. The effect of the Pu decay is also considered by calculating the k_{eff} at three representative decay times (0, 24,100 and 48,200 years).

Table 17. Results for the Degraded WP Configuration with Saturated Type 4.1 Fuel Pins Inside Ident-69 Container

Case (MCNP Input File)	Description			k_{eff}	σ	$k_{eff}+2\sigma$	AENCF (MeV)	H/X[a]
	Number of Pins	Lattice Pitch (cm)	Time (years)					
Square lattice; saturated Type 4.1 fuel pins								
4D+I-sq61-153-41-s-c1	61	1.53	0	0.9402	0.0008	0.9417	0.1904	128.31
d-24100-4D+I-sq61-153-41-s-c1	61	1.53	24100	0.9587	0.0007	0.9601	0.1519	129.79
d-48200-4D+I-sq61-153-41-s-c1	61	1.53	48200	0.9456	0.0008	0.9471	0.1387	129.79
4D+I-sq69-145-41-s-c1	69	1.45	0	0.9452	0.0008	0.9467	0.1921	113.78
d-24100-4D+I-sq69-145-41-s-c1	69	1.45	24100	0.9654	0.0008	0.9671	0.1538	115.09
d-48200-4D+I-sq69-145-41-s-c1	69	1.45	48200	0.9563	0.0008	0.9579	0.1399	115.09
4D+I-sq81-129-41-s-c1	81	1.29	0	0.9436	0.0008	0.9451	0.1977	87.05
d-24100-4D+I-sq81-129-41-s-c1	81	1.29	24100	0.9679	0.0009	0.9697	0.1581	88.05
d-48200-4D+I-sq81-129-41-s-c1	81	1.29	48200	0.9582	0.0008	0.9598	0.1431	88.05
4D+I-sq89-127-41-s-c1	89	1.27	0	0.9500	0.0009	0.9518	0.1987	83.93
d-24100-4D+I-sq89-127-41-s-c1	89	1.27	24100	0.9758	0.0008	0.9774	0.1591	84.90
d-48200-4D+I-sq89-127-41-s-c1	89	1.27	48200	0.9646	0.0008	0.9661	0.1449	84.90

Case (MCNP Input File)	Description			k_{eff}	σ	$k_{eff}+2\sigma$	AENCF (MeV)	H/X[a]
	Number of Pins	Lattice Pitch (cm)	Time (years)					
4D+l-sq97-120-41-s-c1	97	1.2	0	0.9480	0.0008	0.9496	0.2018	73.39
d-24100-4D+l-sq97-120-41-s-c1	97	1.2	24100	0.9733	0.0008	0.9749	0.1620	74.23
d-48200-4D+l-sq97-120-41-s-c1	97	1.2	48200	0.9661	0.0009	0.9678	0.1482	74.23
4D+l-sq109-111-41-s-c1	109	1.11	0	0.9424	0.0009	0.9441	0.2097	60.71
d-24100-4D+l-sq109-111-41-s-c1	109	1.11	24100	0.9683	0.0008	0.9698	0.1673	61.41
d-48200-4D+l-sq109-111-41-s-c1	109	1.11	48200	0.9606	0.0008	0.9623	0.1523	61.41
4D+l-sq137-100-41-s-c1	137	1	0	0.9351	0.0009	0.9369	0.2211	46.56
d-24100-4D+l-sq137-100-41-s-c1	137	1	24100	0.9653	0.0008	0.9670	0.1767	47.10
d-48200-4D+l-sq137-100-41-s-c1	137	1	48200	0.9621	0.0008	0.9637	0.1611	47.10
Hexagonal lattice; saturated Type 4.1 fuel pins								
4D+l-hx-61-162-41-s-c1	61	1.62	0	0.9426	0.0008	0.9442	0.1897	124.16
d-24100-4D+l-hx-61-162-41-s-c1	61	1.62	24100	0.9575	0.0008	0.9592	0.1533	125.59
d-48200-4D+l-hx-61-162-41-s-c1	61	1.62	48200	0.9454	0.0008	0.9470	0.1395	125.59
4D+l-hx-73-147-41-s-c1	73	1.47	0	0.9447	0.0008	0.9462	0.1935	99.69
d-24100-4D+l-hx-73-147-41-s-c1	73	1.47	24100	0.9657	0.0008	0.9672	0.1554	100.84
d-48200-4D+l-hx-73-147-41-s-c1	73	1.47	48200	0.9546	0.0008	0.9561	0.1410	100.84
4D+l-hx-85-141-41-s-c1	85	1.41	0	0.9500	0.0007	0.9515	0.1984	90.56
d-24100-4D+l-hx-85-141-41-s-c1	85	1.41	24100	0.9744	0.0008	0.9760	0.1577	91.61
d-48200-4D+l-hx-85-141-41-s-c1	85	1.41	48200	0.9657	0.0008	0.9673	0.1433	91.61
4D+l-hx-91-129-41-s-c1	91	1.29	0	0.9423	0.0009	0.9440	0.2015	73.46
d-24100-4D+l-hx-91-129-41-s-c1	91	1.29	24100	0.9669	0.0009	0.9686	0.1617	74.30
d-48200-4D+l-hx-91-129-41-s-c1	91	1.29	48200	0.9604	0.0007	0.9618	0.1461	74.30
4D+l-hx-97-125-41-s-c1	97	1.25	0	0.9412	0.0009	0.9429	0.2038	68.10
d-24100-4D+l-hx-97-125-41-s-c1	97	1.25	24100	0.9682	0.0009	0.9699	0.1639	68.88
d-48200-4D+l-hx-97-125-41-s-c1	97	1.25	48200	0.9610	0.0008	0.9626	0.1494	68.88
4D+l-hx-109-122-41-s-c1	109	1.22	0	0.9466	0.0009	0.9483	0.2084	64.18
d-24100-4D+l-hx-109-122-41-s-c1	109	1.22	24100	0.9735	0.0008	0.9752	0.1663	64.92
d-48200-4D+l-hx-109-122-	109	1.22	48200	0.9667	0.0008	0.9682	0.1507	64.92

Case (MCNP Input File)	Description			k_{eff}	σ	$k_{eff}+2\sigma$	AENCF (MeV)	H/X[a]
	Number of Pins	Lattice Pitch (cm)	Time (years)					
41-s-c1								
4D+I-hx-121-116-41-s-c1	121	1.16	0	0.9438	0.0008	0.9454	0.2127	56.64
d-24100-4D+I-hx-121-116-41-s-c1	121	1.16	24100	0.9708	0.0009	0.9725	0.1709	57.30
d-48200-4D+I-hx-121-116-41-s-c1	121	1.16	48200	0.9669	0.0008	0.9685	0.1549	57.30
4D+I-hx151-104-41-s-c1	151	1.04	0	0.9387	0.0008	0.9403	0.2263	42.71
d-24100-4D+I-hx151-104-41-s-c1	151	1.04	24100	0.9651	0.0008	0.9667	0.1811	43.20
d-48200-4D+I-hx151-104-41-s-c1	151	1.04	48200	0.9609	0.0007	0.9624	0.1650	43.20

NOTE: [a] Calculated for the unit cell of the array inside Ident-69 container

Table 18 presents the results obtained by replacing the Type 4.1 pins with experimental MOX fuel pins of larger diameter inside the Ident-69 container. The combinations of maximum number of pins/spacing presented in Table 16 for both square and hexagonal arrays are used to investigate the k_{eff} of the full system. The number densities outside the Ident-69 container are similar with the values used for cases in Table 17. The effect of the Pu decay is also considered by calculating the k_{eff} at three representative decay times (0, 24,100 and 48,200 years).

Table 18. Results for the Degraded WP Configuration with Saturated Large Diameter MOX Fuel Pins Inside Ident-69 Container

Case (MCNP Input File)	Description			k_{eff}	σ	$k_{eff}+2\sigma$	AENCF (MeV)	H/X[a]
	Number of Pins	Lattice Pitch (cm)	Time (years)					
Square lattice; saturated large diameter MOX fuel pins								
4D+I-sq61-151-MOX-s-c1	61	1.51	0	0.9483	0.0008	0.9499	0.2024	77.74
d-24100-4D+I-sq61-151-MOX-s-c1	61	1.51	24100	0.9749	0.0008	0.9765	0.1618	78.62
d-48200-4D+I-sq61-151-MOX-s-c1	61	1.51	48200	0.9649	0.0008	0.9665	0.1480	78.62
4D+I-sq69-144-MOX-s-c1	69	1.44	0	0.9531	0.0008	0.9547	0.2041	69.52
d-24100-4D+I-sq69-144-MOX-s-c1	69	1.44	24100	0.9779	0.0008	0.9794	0.1642	70.31
d-48200-4D+I-sq69-144-MOX-s-c1	69	1.44	48200	0.9726	0.0008	0.9742	0.1489	70.31
4D+I-sq81-128-MOX-s-c1	81	1.28	0	0.9461	0.0009	0.9478	0.2147	52.18
d-24100-4D+I-sq81-128-MOX-s-c1	81	1.28	24100	0.9734	0.0008	0.9750	0.1702	52.78
d-48200-4D+I-sq81-128-MOX-s-c1	81	1.28	48200	0.9683	0.0008	0.9699	0.1551	52.78

Case (MCNP Input File)	Description			k_{eff}	σ	$k_{eff}+2\sigma$	AENCF (MeV)	H/X[a]
	Number of Pins	Lattice Pitch (cm)	Time (years)					
4D+I-sq89-126-MOX-s-c1	89	1.26	0	0.9489	0.0009	0.9506	0.2172	50.16
d-24100-4D+I-sq89-126-MOX-s-c1	89	1.26	24100	0.9785	0.0009	0.9802	0.1741	50.73
d-48200-4D+I-sq89-126-MOX-s-c1	89	1.26	48200	0.9705	0.0008	0.9720	0.1580	50.73
4D+I-sq97-119-MOX-s-c1	97	1.19	0	0.9445	0.0007	0.9459	0.2243	43.33
d-24100-4D+I-sq97-119-MOX-s-c1	97	1.19	24100	0.9721	0.0008	0.9737	0.1785	43.82
d-48200-4D+I-sq97-119-MOX-s-c1	97	1.19	48200	0.9668	0.0008	0.9684	0.1631	43.82
4D+I-sq109-110-MOX-s-c1	109	1.1	0	0.9363	0.0008	0.9378	0.2337	35.12
d-24100-4D+I-sq109-110-MOX-s-c1	109	1.1	24100	0.9648	0.0008	0.9665	0.1871	35.52
d-48200-4D+I-sq109-110-MOX-s-c1	109	1.1	48200	0.9587	0.0007	0.9602	0.1699	35.52
4D+I-sq137-100-MOX-s-c1	137	1	0	0.9319	0.0008	0.9334	0.2531	26.76
d-24100-4D+I-sq137-100-MOX-s-c1	137	1	24100	0.9569	0.0008	0.9585	0.2006	27.06
d-48200-4D+I-sq137-100-MOX-s-c1	137	1	48200	0.9532	0.0008	0.9547	0.1837	27.06
Hexagonal lattice; saturated large diameter MOX fuel pins								
4D+I-hx-61-160-MOX-s-c1	61	1.6	0	0.9463	0.0008	0.9478	0.2010	75.72
d-24100-4D+I-hx-61-160-MOX-s-c1	61	1.6	24100	0.9721	0.0008	0.9736	0.1614	76.58
d-48200-4D+I-hx-61-160-MOX-s-c1	61	1.6	48200	0.9637	0.0008	0.9653	0.1910	76.58
4D+I-hx-73-146-MOX-s-c1	73	1.46	0	0.9485	0.0008	0.9501	0.2087	60.95
d-24100-4D+I-hx-73-146-MOX-s-c1	73	1.46	24100	0.9751	0.0008	0.9767	0.1671	61.64
d-48200-4D+I-hx-73-146-MOX-s-c1	73	1.46	48200	0.9693	0.0008	0.9709	0.1746	61.64
4D+I-hx-85-140-MOX-s-c1	85	1.4	0	0.9523	0.0009	0.9540	0.2145	55.03
d-24100-4D+I-hx-85-140-MOX-s-c1	85	1.4	24100	0.9802	0.0007	0.9817	0.1714	55.65
d-48200-4D+I-hx-85-140-MOX-s-c1	85	1.4	48200	0.9750	0.0008	0.9765	0.1684	55.65
4D+I-hx-91-128-MOX-s-c1	91	1.28	0	0.9399	0.0008	0.9415	0.2223	43.93
d-24100-4D+I-hx-91-128-MOX-s-c1	91	1.28	24100	0.9658	0.0008	0.9675	0.1776	44.43
d-48200-4D+I-hx-91-128-MOX-s-c1	91	1.28	48200	0.9628	0.0008	0.9643	0.1642	44.43
4D+I-hx-97-124-MOX-s-c1	97	1.24	0	0.9394	0.0008	0.9410	0.2260	40.46
d-24100-4D+I-hx-97-124-MOX-s-c1	97	1.24	24100	0.9672	0.0008	0.9689	0.1801	40.92
d-48200-4D+I-hx-97-124-	97	1.24	48200	0.9632	0.0008	0.9648	0.1610	40.92

Case (MCNP Input File)	Description			k_{eff}	σ	$k_{eff}+2\sigma$	AENCF (MeV)	H/X[a]
	Number of Pins	Lattice Pitch (cm)	Time (years)					
MOX-s-c1								
4D+I-hx-109-121-MOX-s-c1	109	1.21	0	0.9393	0.0008	0.9408	0.2327	37.92
d-24100-4D+I-hx-109-121-MOX-s-c1	109	1.21	24100	0.9687	0.0008	0.9709	0.1852	38.35
d-48200-4D+I-hx-109-121-MOX-s-c1	109	1.21	48200	0.9665	0.0008	0.9680	0.1551	38.35
4D+I-hx-121-115-MOX-s-c1	121	1.15	0	0.9376	0.0007	0.9391	0.2399	33.04
d-24100-4D+I-hx-121-115-MOX-s-c1	121	1.15	24100	0.9626	0.0008	0.9642	0.1905	33.41
d-48200-4D+I-hx-121-115-MOX-s-c1	121	1.15	48200	0.9607	0.0008	0.9623	0.1515	33.41
4D+I-hx151-102-MOX-s-c1	151	1.02	0	0.9259	0.0008	0.9275	0.2612	23.31
d-24100-4D+I-hx151-102-MOX-s-c1	151	1.02	24100	0.9493	0.0008	0.9508	0.2089	23.57
d-48200-4D+I-hx151-102-MOX-s-c1	151	1.02	48200	0.9462	0.0008	0.9478	0.1464	23.57

NOTE: [a] Calculated for the unit cell of the array inside Ident-69 container

The results in Tables 17 and 18 show that the analyzed WP configuration is significantly more reactive than the models evaluated in CRWMS M&O 1999a. The k_{eff} of the system follow the same trend identified in CRWMS M&O 1999a, peaking at a decay time of 24,100 years. The highest $k_{eff}+2\sigma$ (0.9817) is obtained for the WP containing an Ident-69 container with experimental MOX fuel pins (85 pins placed in a hexagonal array; pitch = 1.4 cm).

6.2.2 Additional Evaluations

The configuration resulting in the highest k_{eff} in Table 18 (case "d-24100-4D+I-hx-85-140-MOX-s-c1") is further evaluated to find the additional amount of Gd absorber that need to be introduced from the beginning in the DOE SNF canister in order to keep k_{eff} below the interim criticality limit. The additional Gd is assumed homogeneously distributed as $GdPO_4$ in the available space around the Ident-69 container and DFAs inside the DOE SNF canister. Aluminum shot can be used as filler to homogeneously distribute the $GdPO_4$ but for the present calculation its presence was neglected and it was conservatively replaced with water in the degraded configuration. The initial basket structure made from stainless steel (2.75 wt% Gd) inside DOE SNF canister is completely degraded and its constituents are mixed with the additional Gd in the final degraded configuration. Table 19 contains two MCNP cases in which the additional amount of Gd (as $GdPO_4$ – see spreadsheet "FFTF.xls", Attachment I) is distributed within the mixture containing goethite and fuel.

Table 19. Results for Additional Gd Placed in the DOE SNF Canister

Case (MCNP Input File)	Description	Additional Gd (Kg)	k_{eff}	σ	k_{eff}+2 σ	AENCF (MeV)	H/X[a]
d-24100-4D+I-hx-85-140-MOX-s-c1	See Table 18. Ident-69 contains 85 MOX pins, hex lattice, pitch=1.4 cm, t=24,100 years	0	0.9802	0.0007	0.9817	0.1714	55.65
d-24100-4D+I-hx-85-140-MOX-s-c-Gd3x	Similar with above but additional Gd as $GdPO_4$ distributed in the void space of the goethite-fuel mixture. Water volume reduced by $GdPO_4$ addition	30.8	0.9082	0.0008	0.9098	0.1886	55.65
d-24100-4D+I-hx-85-140-MOX-s-c-Gd4x	Similar with above case but more Gd.	41.0	0.8942	0.0008	0.8958	0.1926	55.65

NOTE: [a] Calculated for the unit cell of the array inside Ident-69 container

The results show that adding a significant amount (30.8 kg) of Gd as $GdPO_4$ (49.3 kg) is an effective solution in reducing the k_{eff} of the system below the interim criticality limit of 0.93. This change also requires additional verifications of the assumptions used to derive the characteristics of the most reactive configuration. The following table (Table 20) list the additional cases used to justify the assumptions and considerations that characterized the initial most reactive degraded configuration described in Section 5.4.2.

Table 20. Results for the Additional Cases

Case (MCNP Input File)	Description	k_{eff}	σ	k_{eff}+2σ	AENCF (MeV)	H/X[a]
d-24100-4D+I-hx-85-140-MOX-s-c-Gd3x	Base Case taken from Table 19. 30.8 kg of additional Gd distributed in the mixture. Ident-69 contains 85 MOX pins (hex lattice, pitch=1.4 cm); t=24,100 years	0.9082	0.0008	0.9098	0.1886	55.65
Effect of Ident-69 container position in the DOE SNF Canister						
d-24100-4D+I-hx85-140-MOX-s-c-Gd3x-Id-b-surf	Similar with base case but Ident-69 container placed right below the degraded mixture surface (base case has Ident-69 placed in the middle of the mixture – see Figure 7)	0.8694	0.0008	0.8710	0.1931	55.65
4D+I-hx85-140-MOX-s-c-Gd3x-Id-botm	Similar with base case but Ident-69 placed at the bottom of DOE SNF Canister.	0.8996	0.0008	0.9013	0.1842	55.65
Effect of DOE SNF canister position in the codisposal WP						
d-24100-4D+I-hx85-140-MOX-s-c-Gd3x-C-m	Similar with base case but DOE SNF canister placed in the middle of the pre-breach clay (base case has DOE SNF canister placed at the bottom of the WP)	0.9081	0.0008	0.9097	0.1894	55.65

Case (MCNP Input File)	Description	k_{eff}	σ	$k_{eff}+2σ$	AENCF (MeV)	H/X[a]
d-24100-4D+I-hx85-140-MOX-s-c-Gd3x-C-s	Similar with base case but DOE SNF canister placed below the surface of the pre-breach clay	0.9063	0.0007	0.9078	0.1901	55.65
Effect of water content in the pre-breach clay						
d-24100-4D+I-hx85-140-MOX-s-c-Gd3x-w-clay20	Similar with base case but pre-breach clay is mixed with 20 vol% water	0.9021	0.0008	0.9037	0.1897	55.65
d-24100-4D+I-hx85-140-MOX-s-c-Gd3x-w-clay40	Similar with base case but pre-breach clay is mixed with 40 vol% water	0.9003	0.0008	0.9019	0.1910	55.65
Effect of water density change in Ident-69 container						
d-24100-4D+I-hx85-140-MOX-s-c-Gd3x-wd09	Similar with base case but water density in Ident-69 container and in the saturated fuel pins is 0.9 g/cm^3	0.8796	0.0008	0.8812	0.1981	50.09
d-24100-4D+I-hx85-140-MOX-s-c-Gd3x-wd08	Similar with base case but water density in Ident-69 container and saturated fuel pins is 0.8 g/cm^3	0.8510	0.0007	0.8524	0.2076	44.52
d-24100-4D+I-hx85-140-MOX-s-c-Gd3x-wd06	Similar with base case but water density in Ident-69 container and saturated fuel pins is 0.6 g/cm^3	0.7988	0.0008	0.8004	0.2276	33.39
d-24100-4D+I-hx85-140-MOX-s-c-Gd3x-wd0	Similar with base case but no water in Ident-69 container and fuel pins	0.6769	0.0006	0.6781	0.2769	0
Effect of water density change in the mixture outside Ident-69 container						
d-24100-4D+I-hx85-140-MOX-s-c-Gd3x-outid-wd09	Similar with base case but water density in the mixture is 0.9 g/cm^3 (simulates presence of an unspecified moderator displacer)	0.9066	0.0008	0.9081	0.1919	55.65
d-24100-4D+I-hx85-140-MOX-s-c-Gd3x-outid-wd08	Similar with base case but water density in the mixture is 0.8 g/cm^3	0.9078	0.0008	0.9095	0.1924	55.65
d-24100-4D+I-hx85-140-MOX-s-c-Gd3x-outid-wd06	Similar with base case but water density in the mixture is 0.6 g/cm^3	0.9054	0.0008	0.9070	0.1974	55.65
d-24100-4D+I-hx85-140-MOX-s-c-Gd3x-outid-wd0	Similar with base case but no water in the mixture (replaced by void)	0.8930	0.0008	0.8945	0.2140	55.65
Effect of changing reflector at WP outer surface						
d-24100-4D+I-hx85-140-MOX-s-c-Gd3x-sio2	Similar with base case but water reflector (thickness =30 cm) is replaced with a dry tuff reflector (thickness=1 m)	0.9128	0.0008	0.9143	0.1880	55.65
d-24100-4D+I-hx85-140-MOX-s-c-Gd3x-refl	Similar with base case but perfect reflection at WP outer surface	0.9247	0.0008	0.9262	0.1851	55.65
Effect of pin settling inside Ident-69 container						
d-24100-4D+I-	Similar with base case but pins are	0.7955	0.0008	0.7970	0.2255	N/A

Case (MCNP Input File)	Description	k_{eff}	σ	$k_{eff}+2\sigma$	AENCF (MeV)	H/X[a]
hx85-140-MOX-s-c-Gd3x-setl-10	settled at the bottom of Ident-69 container (pin spacing = 1 cm)					
d-24100-4D+l-hx85-140-MOX-s-c-Gd3x-setl-08	Similar with base case but pins are settled at the bottom of Ident-69 container (pin spacing = 0.8 cm)	0.7260	0.0007	0.7273	0.2563	N/A
Effect of modeling the inner duct in Ident-69 container						
d-24100-4D+l-hx85-140-MOX-s-c-Gd3x-intube	Similar with base case but the inner duct of the compartmented Ident-69 container is included in the MCNP model preserving its actual volume and mass	0.8952	0.0008	0.8967	0.1915	55.65
Effect of increasing void fraction in goethite mixture outside Ident-69 container						
d-24100-4D+l-hx85-140-MOX-s-c-Gd3x-gt05	Similar with base case but void in goethite increased to a volume fraction of 0.5 from 0.4. (note that fuel, $GdPO_4$ and water are filling this void in the mixture)	0.8927	0.0008	0.8942	0.1670	55.65

NOTE: [a] Calculated for the unit cell of the array inside Ident-69 container

The results included in Table 20 suggest that the most reactive configuration is significantly affected by some of the varied parameters. With the exception of the WP reflector change, all other variations produced a decrease in k_{eff} in comparison with the base case. This confirms the validity of the assumptions and simplifications used in developing the MCNP model and also justify the current selection of the geometry and composition for the most degraded configuration.

The presence of the dry tuff reflector outside the WP slightly increases the k_{eff} but the value calculated for $k_{eff}+2\sigma$ (0.9143) is well below the interim criticality limit of 0.93. Even assuming a perfect reflector at the outer surface of the WP does not bring the k_{eff} of the most reactive case above the interim critical limit of 0.93.

The results describing the effect of water density change inside Ident-69 container show that the system is very sensitive to the water density reduction. This finding suggests that the insertion of any moderator displacer inside the Ident-69 container could be very effective in reducing the reactivity of the system.

The reduction of the water density in the mixture outside the Ident-69 container has a small effect by reducing the k_{eff}. It simulates, to some extent, the introduction of a moderator displacer inside the degraded mixture surrounding the Ident-69 container. The results show that by using a moderator displacer (filler material) to distribute the additional amount of initial neutron absorber ($GdPO_4$) could slightly decrease the k_{eff} of the system in the degraded state.

6.2.3 Summary of Results

The results presented in Sections 6.1, 6.2.1 and 6.2.2 show that the previous calculations on the most degraded configuration for the FFTF SNF codisposal WP have not identified the full spectrum of possible values for the k_{eff}. Utilization of the new information regarding the actual content of the Ident-69 containers demonstrates that the higher diameter experimental MOX fuel pins placed inside the Ident-69 container results in the highest values of the k_{eff} for the given configuration. The new results are reasonable compared to the inputs and they are suitable for the intended use.

The most important findings of the current analysis can be summarized as follows:

- The reactivity of the Ident-69 increases with the pitch for a given number of pins (the system is always undermoderated) and with the enrichment of the fuel. The Ident-69 containers loaded with experimental MOX fuel pins are the most reactive. The arrays of saturated fuel pins (water filling all void spaces inside a fuel pin) are more reactive than the arrays with dry fuel pins.

- The envelope of the maximum k_{eff} values for the investigated configuration shows a broad maximum for various combinations of number of pins/lattice pitch. Differences in results between hexagonal lattice arrays and square lattice arrays are small for the spectrum of combinations investigated, requiring a final analysis considering each type of lattice.

- Among the 3 decay times analyzed (0, 24,100 and 48,200 years), the decay of Pu isotopes produces the highest k_{eff} values at a decay time of 24,100 years.

- The maximum values of $k_{eff}+2\sigma$ for the most reactive configuration using 2.75 wt% Gd in the initial basket structure are well above the interim criticality limit of 0.93. Adding at least 30.8 kg of Gd (49.3 kg $GdPO_4$) uniformly distributed in the initial void spaces outside the Ident-69 container and the 4 DFAs results in lowering the $k_{eff}+2\sigma$ of the most reactive degraded configuration identified in Table 18 to 0.9098. Using a filler to homogeneously distribute the absorber further reduce the reactivity of the system.

- The assumptions and simplifications used in defining the geometry and composition of the most reactive degraded configuration have been individually investigated with MCNP. The results confirm the solutions adopted and the validity of the developed model. Based on current information, all other possible degraded configurations analyzed in the previous calculations are enveloped by the current bounding calculation.

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8. ATTACHMENTS

Attachment I: One Compact Disk (CD) containing the MCNP input and output files for the cases denoted in Section 6.

Attachment II: Description of files contained in Attachment I (17 pages).

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SPECIAL INSTRUCTION SHEET file list 9-3-02 mfc

1. QA: QA
Page: 1 of: 1

Complete Only Applicable Items

This is a placeholder page for records that cannot be scanned.

2. Record Date	3. Accession Number
8/14/02	ATT. TO: MOL.20021028.0128
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D. R. MOSCALU	ENGINEERED SYSTEMS PROJECT

6. Title/Description
CRITICALITY CALCULATION FOR THE MOST REACTIVE DEGRADED CONFIGURATIONS OF THE FFTF SNF CODISPOSAL WP CONTAINING AN INTACT IDENT-69 CONTAINER

7. Document Number(s)	8. Version Designator
CAL-DSD-NU-000002	REVISION A

9. Document Type	10. Medium
DESIGN DOCUMENT	DISK

11. Access Control Code
PUB

12. Traceability Designator
CAL-DSD-NU-000002

13. Comments
CD-R - ATTACHMENT I OF THE CALCULATION ENTITLED: "CRITIALITY CALCULATION FOR THE MOST REACTIVE DEGRADED CONFIGURATIONS OF THE FFTF SNL CODISPOSAL WP CONTAINING AN INTACT IDENT-69 CONTAINER"

DI#: CAL-DSD-NU-000002 REV 2

CONTAINS: 530 FILES (162 MB)
DESCRIPTION: (ASCII FILES: INPUTS & OUTPUTS/OS MCMP)
1 EXCEL FILE

THIS DOCUMENT CONTAINS AN ELECTRONIC ATTACHMENT

ATTACHMENT II

Table II-1. MCNP Output Files Contained on the Electronic Media (Attachment I)

File Name/Directory Denomination	File Size (bytes)	Date of Last Update	Time
Directory of :CD\Table_12			
sq-61-100	10,570	6/6/02	5:30p
sq-61-100.out	369,554	6/7/02	4:54p
sq-61-110	10,574	6/6/02	5:34p
sq-61-110.out	369,655	6/7/02	2:05p
sq-61-120	10,569	6/6/02	5:35p
sq-61-120.out	369,655	6/7/02	11:22a
sq-61-125	10,579	6/6/02	5:36p
sq-61-125.out	369,655	6/7/02	8:44a
sq-61-130	10,574	6/6/02	5:37p
sq-61-130.out	369,655	6/7/02	6:09a
sq-61-135	10,577	6/6/02	5:39p
sq-61-135.out	368,076	6/6/02	9:39p
sq-61-140	10,570	6/6/02	5:40p
sq-61-140.out	369,236	6/7/02	1:06a
sq-61-145	10,579	6/6/02	5:41p
sq-61-145.out	368,076	6/7/02	3:35a
sq-61-150	10,573	6/6/02	5:43p
sq-61-150.out	369,236	6/8/02	12:37p
sq-61-153	10,578	6/6/02	5:44p
sq-61-153.out	369,120	6/8/02	8:09p
sq-69-100	10,565	6/7/02	9:01a
sq-69-100.out	371,074	6/8/02	3:13p
sq-69-110	10,569	6/7/02	9:03a
sq-69-110.out	371,175	6/8/02	6:54a
sq-69-120	10,565	6/7/02	9:06a
sq-69-120.out	370,741	6/7/02	11:01p
sq-69-125	10,574	6/7/02	9:13a
sq-69-125.out	370,640	6/7/02	3:55p
sq-69-130	10,735	6/7/02	9:17a
sq-69-130.out	371,047	6/7/02	1:23p

File Name/Directory Denomination	File Size (bytes)	Date of Last Update	Time
sq-69-135	10,573	6/7/02	9:20a
sq-69-135.out	369,236	6/9/02	2:52p
sq-69-140	10,566	6/7/02	10:36a
sq-69-140.out	369,220	6/9/02	7:02p
sq-69-145	10,578	6/7/02	10:51a
sq-69-145.out	369,221	6/9/02	11:46p
sq-81-100	10,564	6/7/02	11:01a
sq-81-100.out	369,655	6/8/02	8:02a
sq-81-110	10,572	6/7/02	11:04a
sq-81-110.out	369,539	6/8/02	4:51a
sq-81-120	10,566	6/9/02	10:03a
sq-81-120.out	369,554	6/9/02	3:27p
sq-81-125	10,573	6/7/02	11:07a
sq-81-125.out	369,236	6/7/02	8:41p
sq-81-129	10,574	6/7/02	5:00p
sq-81-129.out	369,113	6/8/02	12:39p
sq-89-100	10,566	6/8/02	9:29a
sq-89-100.out	369,750	6/8/02	1:57p
sq-89-110	10,571	6/7/02	11:21a
sq-89-110.out	369,649	6/8/02	3:52a
sq-89-120	10,567	6/7/02	11:24a
sq-89-120.out	369,215	6/8/02	7:04a
sq-89-125	10,574	6/7/02	11:27a
sq-89-125.out	369,432	6/7/02	8:29p
sq-89-127	10,575	6/7/02	1:07p
sq-89-127.out	369,432	6/7/02	11:46p
sq-89-90	10,572	6/7/02	1:11p
sq-89-90.out	368,257	6/8/02	9:02a
sq-97-100	10,571	6/7/02	1:21p
sq-97-100.out	369,655	6/8/02	2:09p
sq-97-110	10,575	6/7/02	1:23p
sq-97-110.out	369,655	6/8/02	5:47p
sq-97-120	10,571	6/7/02	1:25p
sq-97-120.out	369,337	6/8/02	10:43p
sq-97-80	10,570	6/7/02	1:27p

File Name/Directory Denomination	File Size (bytes)	Date of Last Update	Time
sq-97-80.out	369,655	6/9/02	3:29a
sq-97-90	10,575	6/7/02	1:29p
sq-97-90.out	368,394	6/9/02	7:57a
sq-109-100	10,571	6/6/02	4:13p
sq-109-100.out	371,175	6/7/02	12:29a
sq-109-110	10,581	6/6/02	4:47p
sq-109-110.out	370,756	6/6/02	9:54p
sq-109-111	10,586	6/10/02	4:56p
sq-109-111.out	369,465	6/6/02	7:25p
sq-109-80	10,576	6/6/02	4:51p
sq-109-80.out	371,493	6/7/02	3:23a
sq-109-90	10,580	6/6/02	4:54p
sq-109-90.out	371,175	6/7/02	10:27a
sq-137-100	10,567	6/6/02	5:16p
sq-137-100.out	369,560	6/8/02	8:40p
sq-137-80	10,567	6/6/02	5:08p
sq-137-80.out	369,560	6/7/02	12:53a
sq-137-90	10,571	6/6/02	5:12p
sq-137-90.out	369,560	6/6/02	8:25p
Directory of :\CD\Table_13			
hx-61-100	10,760	6/8/02	10:32a
hx-61-100.out	369,438	6/8/02	9:42p
hx-61-110	10,763	6/8/02	10:48a
hx-61-110.out	369,655	6/9/02	2:08a
hx-61-120	10,756	6/8/02	10:37a
hx-61-120.out	369,554	6/9/02	6:04a
hx-61-130	10,747	6/8/02	10:38a
hx-61-130.out	369,560	6/9/02	9:28a
hx-61-140	10,764	6/8/02	10:40a
hx-61-140.out	369,655	6/9/02	1:25p
hx-61-150	10,764	6/8/02	10:42a
hx-61-150.out	369,120	6/9/02	5:46p
hx-61-155	10,765	6/8/02	10:42a
hx-61-155.out	368,076	6/9/02	10:13p
hx-61-162	10,783	6/8/02	10:43a

File Name/Directory Denomination	File Size (bytes)	Date of Last Update	Time
hx-61-162.out	368,177	6/10/02	1:14a
hx-73-100	10,767	6/8/02	10:54a
hx-73-100.out	368,495	6/8/02	9:52p
hx-73-110	10,774	6/8/02	10:56a
hx-73-110.out	369,655	6/9/02	1:37a
hx-73-120	10,772	6/8/02	10:56a
hx-73-120.out	369,438	6/9/02	5:33a
hx-73-130	10,768	6/8/02	10:58a
hx-73-130.out	368,495	6/9/02	8:47a
hx-73-140	10,768	6/8/02	10:59a
hx-73-140.out	369,236	6/9/02	12:11p
hx-73-145	10,776	6/8/02	11:00a
hx-73-145.out	369,120	6/9/02	5:10p
hx-73-147	10,776	6/8/02	11:00a
hx-73-147.out	369,221	6/9/02	9:13p
hx-85-100	10,765	6/8/02	3:08p
hx-85-100.out	369,648	6/9/02	11:16p
hx-85-110	10,772	6/8/02	3:08p
hx-85-110.out	369,655	6/10/02	1:42a
hx-85-120	10,770	6/8/02	3:09p
hx-85-120.out	369,655	6/10/02	3:01a
hx-85-130	10,772	6/8/02	3:10p
hx-85-130.out	369,337	6/10/02	4:17a
hx-85-135	10,778	6/8/02	3:11p
hx-85-135.out	369,120	6/10/02	5:32a
hx-85-141	10,778	6/8/02	3:12p
hx-85-141.out	369,337	6/10/02	6:46a
hx-91-100	10,771	6/8/02	3:17p
hx-91-100.out	371,175	6/10/02	11:18a
hx-91-110	10,774	6/8/02	3:17p
hx-91-110.out	369,539	6/10/02	3:14p
hx-91-120	10,774	6/8/02	3:17p
hx-91-120.out	369,554	6/10/02	5:08p
hx-91-125	10,774	6/8/02	3:16p
hx-91-125.out	369,554	6/10/02	7:42p

File Name/Directory Denomination	File Size (bytes)	Date of Last Update	Time
hx-91-129	10,774	6/8/02	3:16p
hx-91-129.out	369,236	6/10/02	10:13p
hx-91-90	10,771	6/8/02	3:16p
hx-91-90.out	370,232	6/10/02	4:23a
hx-97-100	10,767	6/8/02	3:23p
hx-97-100.out	371,175	6/9/02	2:32a
hx-97-110	10,774	6/8/02	3:23p
hx-97-110.out	369,914	6/9/02	1:11p
hx-97-120	10,772	6/8/02	3:22p
hx-97-120.out	370,857	6/9/02	10:57p
hx-97-125	10,780	6/8/02	3:22p
hx-97-125.out	370,640	6/10/02	6:42a
hx-97-90	10,761	6/8/02	3:22p
hx-97-90.out	371,493	6/10/02	1:06p
hx-109-100	10,770	6/7/02	3:55p
hx-109-100.out	371,175	6/7/02	11:37p
hx-109-110	10,938	6/7/02	3:55p
hx-109-110.out	369,179	6/8/02	7:27a
hx-109-120	10,777	6/7/02	3:56p
hx-109-120.out	370,857	6/8/02	3:05p
hx-109-122	10,781	6/7/02	3:56p
hx-109-122.out	370,857	6/9/02	12:42a
hx-109-80	10,770	6/7/02	3:56p
hx-109-80.out	371,392	6/9/02	12:46p
hx-109-90	10,772	6/7/02	3:57p
hx-109-90.out	371,493	6/9/02	11:41p
hx-121-100	10,773	6/7/02	4:47p
hx-121-100.out	371,074	6/8/02	7:50p
hx-121-110	10,779	6/7/02	4:48p
hx-121-110.out	369,364	6/9/02	6:06a
hx-121-116	11,638	6/7/02	4:50p
hx-121-116.out	373,010	6/9/02	4:25p
hx-121-80	10,774	6/7/02	4:51p
hx-121-80.out	371,392	6/8/02	2:01a
hx-121-90	10,774	6/7/02	4:53p

File Name/Directory Denomination	File Size (bytes)	Date of Last Update	Time
hx-121-90.out	371,493	6/8/02	10:45a
hx-151-100	10,777	6/8/02	10:18a
hx-151-100.out	370,165	6/9/02	2:01a
hx-151-104	10,783	6/8/02	10:20a
hx-151-104.out	371,175	6/9/02	12:34p
hx-151-80	10,777	6/8/02	10:21a
hx-151-80.out	371,493	6/9/02	11:58p
hx-151-90	10,779	6/8/02	10:23a
hx-151-90.out	369,682	6/10/02	8:27a
Directory of :\CD\Table_14			
hx-109-122	10,781	6/10/02	3:59p
hx-109-122.out	370,857	6/10/02	3:59p
hx-121-116	11,638	6/10/02	4:19p
hx-121-116.out	373,010	6/10/02	4:19p
hx-151-104	10,783	6/10/02	4:44p
hx-151-104.out	371,175	6/10/02	4:44p
hx-61-162	10,783	6/10/02	4:45p
hx-61-162.out	368,177	6/10/02	4:45p
hx-73-147	10,776	6/10/02	4:47p
hx-73-147.out	369,221	6/10/02	4:47p
hx-85-141	10,778	6/10/02	4:48p
hx-85-141.out	369,337	6/10/02	4:48p
hx-97-125	10,780	6/10/02	4:49p
hx-97-125.out	370,640	6/10/02	4:49p
hx-109-122-sat	10,898	6/10/02	3:50p
hx-109-122-sat.out	370,824	6/10/02	8:04p
hx-121-116-sat	10,895	6/10/02	3:28p
hx-121-116-sat.out	370,824	6/10/02	11:15p
hx-151-104-sat	10,899	6/10/02	3:29p
hx-151-104-sat.out	370,824	6/11/02	1:25a
hx-163-99-sat	10,878	6/10/02	3:48p
hx-163-99-sat.out	368,327	6/11/02	3:37a
hx-61-162-sat	10,899	6/10/02	3:41p
hx-61-162-sat.out	370,506	6/11/02	5:41a
hx-73-147-sat	10,892	6/10/02	3:43p

File Name/Directory Denomination	File Size (bytes)	Date of Last Update	Time
hx-73-147-sat.out	369,114	6/11/02	7:44a
hx-85-141-sat	10,894	6/10/02	3:45p
hx-85-141-sat.out	370,506	6/11/02	9:46a
hx-91-129-sat	10,867	6/10/02	3:46p
hx-91-129-sat.out	369,569	6/11/02	11:52a
hx-97-125-sat	10,896	6/10/02	3:47p
hx-97-125-sat.out	370,824	6/11/02	1:58p
sq-109-111	10,586	6/10/02	4:56p
sq-109-111.out	369,465	6/6/02	7:25p
sq-137-100	10,567	6/6/02	5:16p
sq-137-100.out	369,560	6/8/02	8:40p
sq-61-153	10,578	6/6/02	5:44p
sq-61-153.out	369,120	6/8/02	8:09p
sq-69-145	10,578	6/7/02	10:51a
sq-69-145.out	369,221	6/9/02	11:46p
sq-81-129	10,574	6/7/02	5:00p
sq-81-129.out	369,113	6/8/02	12:39p
sq-89-127	10,575	6/7/02	1:07p
sq-89-127.out	369,432	6/7/02	11:46p
sq-97-120	10,571	6/7/02	1:25p
sq-97-120.out	369,337	6/8/02	10:43p
sq-109-111-sat	10,677	6/10/02	5:14p
sq-109-111-sat.out	370,952	6/10/02	7:58p
sq-137-100-sat	10,899	6/10/02	5:17p
sq-137-100-sat.out	371,555	6/10/02	10:36p
sq-61-153-sat	10,910	6/10/02	5:18p
sq-61-153-sat.out	371,332	6/11/02	1:06a
sq-69-145-sat	10,914	6/10/02	5:19p
sq-69-145-sat.out	371,332	6/11/02	3:37a
sq-81-129-sat	10,914	6/10/02	5:20p
sq-81-129-sat.out	371,650	6/11/02	6:18a
sq-89-127-sat	10,915	6/10/02	5:21p
sq-89-127-sat.out	371,427	6/11/02	8:49a
sq-97-120-sat	10,911	6/10/02	5:22p
sq-97-120-sat.out	371,332	6/11/02	11:22a

File Name/Directory Denomination	File Size (bytes)	Date of Last Update	Time
Directory of :\CD\Table_15			
hx-109-122-41-sat	12,083	5/6/02	8:35a
hx-109-122-41-sat.out	348,659	5/6/02	10:41a
hx-121-116-41-sat	12,022	5/6/02	8:40a
hx-121-116-41-sat.out	349,752	5/6/02	1:28p
hx-151-104-41-sat	12,085	5/6/02	8:42a
hx-151-104-41-sat.out	349,847	5/6/02	6:20p
hx-61-162-41-sat	12,085	5/6/02	8:44a
hx-61-162-41-sat.out	349,750	5/6/02	9:15p
hx-73-145-41-sat	12,078	5/6/02	8:47a
hx-73-145-41-sat.out	348,659	5/6/02	10:39p
hx-85-141-41-sat	12,080	5/6/02	8:50a
sq-109-111-41-sat	12,106	5/8/02	10:30a
sq-109-111-41-sat.out	350,037	5/8/02	3:04p
sq-137-100-41-sat	12,089	5/8/02	10:53a
sq-137-100-41-sat.out	349,942	5/8/02	4:32p
sq-61-153-41-sat	12,096	5/8/02	10:52a
sq-61-153-41-sat.out	349,938	5/8/02	5:55p
sq-69-145-41-sat	12,100	5/9/02	8:33a
sq-69-145-41-sat.out	350,037	5/9/02	9:57a
sq-81-129-41-sat	12,100	5/8/02	1:25p
sq-81-129-41-sat.out	350,037	5/8/02	8:43p
sq-89-127-41-sat	12,101	5/9/02	8:32a
sq-89-127-41-sat.out	350,132	5/9/02	11:21a
sq-97-120-41-sat	12,097	5/8/02	1:34p
sq-97-120-41-sat.out	349,047	5/8/02	11:31p
hx-85-141-41-sat.out	349,847	5/7/02	12:03a
hx-91-129-41-sat	12,076	5/6/02	9:09a
hx-91-129-41-sat.out	348,659	5/7/02	1:28a
hx-97-125-41-sat	12,082	5/6/02	9:11a
hx-97-125-41-sat.out	349,847	5/7/02	2:53a
Directory of :\CD\Table_16			
hx-109-121-MOX-sat_l	11,012	5/30/02	9:44a
hx-109-121-MOX-sat_l.out	347,182	5/30/02	6:39p
hx-121-115-MOX-sat_l	10,946	5/30/02	10:23a

File Name/Directory Denomination	File Size (bytes)	Date of Last Update	Time
hx-121-115-MOX-sat_l.out	345,923	5/30/02	11:30a
hx-151-102-MOX-sat_l	11,002	5/30/02	10:21a
hx-151-102-MOX-sat_l.out	346,192	5/30/02	12:40p
hx-61-160-MOX-sat_l	11,007	5/30/02	10:22a
hx-61-160-MOX-sat_l.out	347,182	5/30/02	1:43p
hx-73-146-MOX-sat_l	11,158	5/30/02	10:23a
hx-73-146-MOX-sat_l.out	347,372	5/30/02	2:56p
hx-85-140-MOX-sat_l	10,995	5/30/02	10:23a
hx-85-140-MOX-sat_l.out	347,182	5/30/02	4:28p
hx-91-128-MOX-sat_l	10,955	5/30/02	10:23a
hx-91-128-MOX-sat_l.out	347,071	5/31/02	9:18a
hx-97-124-MOX-sat_l	11,002	5/30/02	10:22a
hx-97-124-MOX-sat_l.out	347,182	5/31/02	11:11a
sq-109-110-MOX-sat_l	10,814	6/3/02	8:52a
sq-109-110-MOX-sat_l.out	371,270	6/4/02	9:36a
sq-137-100-MOX-sat_l	10,746	6/3/02	8:51a
sq-137-100-MOX-sat_l.out	371,493	6/4/02	12:30p
sq-61-151-MOX-sat_l	10,972	6/3/02	8:51a
sq-61-151-MOX-sat_l.out	371,460	6/4/02	4:30p
sq-69-144-MOX-sat_l	10,969	6/3/02	8:50a
sq-69-144-MOX-sat_l.out	371,460	6/3/02	11:56a
sq-81-128-MOX-sat_l	10,807	6/3/02	8:54a
sq-81-128-MOX-sat_l.out	371,270	6/3/02	5:22p
sq-89-126-MOX-sat_l	10,770	6/3/02	8:50a
sq-89-126-MOX-sat_l.out	371,175	6/3/02	10:42p
sq-97-119-MOX-sat_l	10,817	6/3/02	8:58a
sq-97-119-MOX-sat_l.out	371,270	6/4/02	4:09a
Directory of :\CD\Table_17			
4D+l-sq109-111-41-s-c1	16,529	6/3/02	12:57p
4D+l-sq109-111-41-s-c1.out	810,214	6/3/02	10:53p
4D+l-sq137-100-41-s-c1	16,490	6/3/02	1:01p
4D+l-sq137-100-41-s-c1.out	850,198	6/4/02	12:46a
4D+l-sq61-153-41-s-c1	16,496	6/3/02	1:00p
4D+l-sq61-153-41-s-c1.out	741,771	6/3/02	2:22p
4D+l-sq69-145-41-s-c1	16,498	6/3/02	1:03p

File Name/Directory Denomination	File Size (bytes)	Date of Last Update	Time
4D+I-sq69-145-41-s-c1.out	753,195	6/3/02	3:42p
4D+I-sq81-129-41-s-c1	16,497	6/3/02	1:04p
4D+I-sq81-129-41-s-c1.out	770,331	6/3/02	5:03p
4D+I-sq89-127-41-s-c1	16,500	6/3/02	1:05p
4D+I-sq89-127-41-s-c1.out	781,755	6/3/02	6:58p
4D+I-sq97-120-41-s-c1	16,493	6/3/02	1:06p
4D+I-sq97-120-41-s-c1.out	793,228	6/3/02	8:56p
d-24100-4D+I-sq109-111-41-s-c1	16,632	5/30/02	4:55p
d-24100-4D+I-sq109-111-41-s-c1.out	768,288	5/30/02	8:20p
d-24100-4D+I-sq137-100-41-s-c1	16,624	5/30/02	5:23p
d-24100-4D+I-sq137-100-41-s-c1.out	808,590	5/30/02	10:59p
d-24100-4D+I-sq61-153-41-s-c1	16,632	6/2/02	11:12a
d-24100-4D+I-sq61-153-41-s-c1.out	699,728	5/31/02	4:01p
d-24100-4D+I-sq69-145-41-s-c1	16,636	5/31/02	1:42p
d-24100-4D+I-sq69-145-41-s-c1.out	711,032	5/31/02	6:26p
d-24100-4D+I-sq81-129-41-s-c1	16,635	5/31/02	1:41p
d-24100-4D+I-sq81-129-41-s-c1.out	728,168	5/31/02	8:50p
d-24100-4D+I-sq89-127-41-s-c1	16,637	5/31/02	1:41p
d-24100-4D+I-sq89-127-41-s-c1.out	739,495	5/31/02	11:15p
d-24100-4D+I-sq97-120-41-s-c1	16,631	5/31/02	1:39p
d-24100-4D+I-sq97-120-41-s-c1.out	751,016	6/1/02	1:42a
d-48200-4D+I-sq109-111-41-s-c1	16,656	5/31/02	3:29p
d-48200-4D+I-sq109-111-41-s-c1.out	767,516	5/31/02	11:00p
d-48200-4D+I-sq137-100-41-s-c1	16,648	5/31/02	3:48p
d-48200-4D+I-sq137-100-41-s-c1.out	807,500	6/1/02	12:22a
d-48200-4D+I-sq61-153-41-s-c1	16,654	6/2/02	11:56a
d-48200-4D+I-sq61-153-41-s-c1.out	743,616	6/2/02	1:24p
d-48200-4D+I-sq69-145-41-s-c1	16,656	5/31/02	3:54p
d-48200-4D+I-sq69-145-41-s-c1.out	709,406	5/31/02	5:49p
d-48200-4D+I-sq81-129-41-s-c1	16,655	5/31/02	4:10p
d-48200-4D+I-sq81-129-41-s-c1.out	727,532	5/31/02	7:07p
d-48200-4D+I-sq89-127-41-s-c1	16,657	5/31/02	4:11p

File Name/Directory Denomination	File Size (bytes)	Date of Last Update	Time
d-48200-4D+I-sq89-127-41-s-c1.out	738,956	5/31/02	8:23p
d-48200-4D+I-sq97-120-41-s-c1	16,651	5/31/02	4:12p
d-48200-4D+I-sq97-120-41-s-c1.out	750,283	5/31/02	9:41p
4D+I-hx109-122-41-s-c1	16,745	6/3/02	11:30a
4D+I-hx109-122-41-s-c1.out	811,869	6/3/02	2:29p
4D+I-hx121-116-41-s-c1	16,789	6/3/02	11:30a
4D+I-hx121-116-41-s-c1.out	829,100	6/3/02	5:17p
4D+I-hx151-104-41-s-c1	16,749	6/3/02	11:31a
4D+I-hx151-104-41-s-c1.out	871,845	6/3/02	8:09p
4D+I-hx61-162-41-s-c1	16,728	6/3/02	11:32a
4D+I-hx61-162-41-s-c1.out	743,325	6/3/02	10:46p
4D+I-hx73-147-41-s-c1	16,742	6/3/02	11:32a
4D+I-hx73-147-41-s-c1.out	760,461	6/4/02	1:24a
4D+I-hx85-141-41-s-c1	16,788	6/3/02	11:33a
4D+I-hx85-141-41-s-c1.out	777,692	6/4/02	4:06a
4D+I-hx91-129-41-s-c1	16,784	6/3/02	11:33a
4D+I-hx91-129-41-s-c1.out	786,260	6/4/02	6:47a
4D+I-hx97-125-41-s-c1	16,790	6/3/02	11:34a
4D+I-hx97-125-41-s-c1.out	794,828	6/4/02	9:29a
d-24100-4D+I-hx109-122-41-s-c1	16,849	5/28/02	4:12p
d-24100-4D+I-hx109-122-41-s-c1.out	769,010	5/28/02	6:41p
d-24100-4D+I-hx121-116-41-s-c1	16,848	5/28/02	4:40p
d-24100-4D+I-hx121-116-41-s-c1.out	786,024	5/28/02	7:57p
d-24100-4D+I-hx151-104-41-s-c1	16,852	5/28/02	5:14p
d-24100-4D+I-hx151-104-41-s-c1.out	829,085	5/28/02	9:13p
d-24100-4D+I-hx61-162-41-s-c1	16,831	5/28/02	5:17p
d-24100-4D+I-hx61-162-41-s-c1.out	700,344	5/28/02	10:25p
d-24100-4D+I-hx73-147-41-s-c1	16,845	5/28/02	5:12p
d-24100-4D+I-hx73-147-41-s-c1.out	717,480	5/28/02	11:36p
d-24100-4D+I-hx85-141-41-s-c1	16,847	5/28/02	4:10p
d-24100-4D+I-hx85-141-41-s-c1.out	734,616	5/29/02	12:49a
d-24100-4D+I-hx91-129-41-s-c1	16,843	5/28/02	5:09p
d-24100-4D+I-hx91-129-41-s-c1.out	743,071	5/29/02	2:02a

File Name/Directory Denomination	File Size (bytes)	Date of Last Update	Time
d-24100-4D+l-hx97-125-41-s-c1	16,849	5/28/02	4:44p
d-24100-4D+l-hx97-125-41-s-c1.out	751,859	5/29/02	3:15a
d-48200-4D+l-hx109-122-41-s-c1	16,874	5/31/02	10:23a
d-48200-4D+l-hx109-122-41-s-c1.out	768,791	5/31/02	11:22a
d-48200-4D+l-hx121-116-41-s-c1	16,865	5/31/02	10:24a
d-48200-4D+l-hx121-116-41-s-c1.out	785,888	5/31/02	12:38p
d-48200-4D+l-hx151-104-41-s-c1	16,869	5/31/02	10:25a
d-48200-4D+l-hx151-104-41-s-c1.out	829,046	5/31/02	2:16p
d-48200-4D+l-hx61-162-41-s-c1	16,848	5/31/02	10:26a
d-48200-4D+l-hx61-162-41-s-c1.out	700,208	5/31/02	4:43p
d-48200-4D+l-hx73-147-41-s-c1	16,862	5/31/02	10:28a
d-48200-4D+l-hx73-147-41-s-c1.out	717,344	5/31/02	7:09p
d-48200-4D+l-hx85-141-41-s-c1	16,864	5/31/02	10:29a
d-48200-4D+l-hx85-141-41-s-c1.out	734,383	5/31/02	9:36p
d-48200-4D+l-hx91-129-41-s-c1	16,860	5/31/02	10:30a
d-48200-4D+l-hx91-129-41-s-c1.out	743,048	6/1/02	12:03a
d-48200-4D+l-hx97-125-41-s-c1	16,866	5/31/02	10:31a
d-48200-4D+l-hx97-125-41-s-c1.out	751,616	6/1/02	2:07a
Directory of :\CD\Table_18			
4D+l-hx109-121-MOX-s-c1	16,785	6/3/02	10:07a
4D+l-hx109-121-MOX-s-c1.out	811,051	6/3/02	2:39p
4D+l-hx121-115-MOX-s-c1	16,780	6/3/02	10:19a
4D+l-hx121-115-MOX-s-c1.out	827,950	6/3/02	4:07p
4D+l-hx151-102-MOX-s-c1	16,782	6/3/02	10:34a
4D+l-hx151-102-MOX-s-c1.out	871,209	6/4/02	2:37p
4D+l-hx61-160-MOX-s-c1	16,761	6/3/02	2:50p
4D+l-hx61-160-MOX-s-c1.out	742,371	6/4/02	11:15a
4D+l-hx73-146-MOX-s-c1	16,773	6/3/02	11:14a
4D+l-hx73-146-MOX-s-c1.out	759,507	6/3/02	5:45p
4D+l-hx85-140-MOX-s-c1	16,771	6/3/02	2:50p
4D+l-hx85-140-MOX-s-c1.out	776,643	6/3/02	8:02p
4D+l-hx91-128-MOX-s-c1	16,772	6/3/02	11:22a
4D+l-hx91-128-MOX-s-c1.out	785,211	6/3/02	10:18p

File Name/Directory Denomination	File Size (bytes)	Date of Last Update	Time
4D+I-hx97-124-MOX-s-c1	16,777	6/3/02	11:26a
4D+I-hx97-124-MOX-s-c1.out	793,779	6/4/02	12:34a
d-24100-4D+I-hx109-121-MOX-s-c1	16,896	6/6/02	9:17a
d-24100-4D+I-hx109-121-MOX-s-c1.out	811,742	6/6/02	10:03a
d-24100-4D+I-hx121-115-MOX-s-c1	16,910	6/4/02	2:30p
d-24100-4D+I-hx121-115-MOX-s-c1.out	829,312	6/5/02	1:01p
d-24100-4D+I-hx151-102-MOX-s-c1	16,913	6/4/02	2:31p
d-24100-4D+I-hx151-102-MOX-s-c1.out	872,152	6/5/02	1:50p
d-24100-4D+I-hx61-160-MOX-s-c1	16,892	6/4/02	2:31p
d-24100-4D+I-hx61-160-MOX-s-c1.out	743,213	6/5/02	3:06p
d-24100-4D+I-hx73-146-MOX-s-c1	16,904	6/4/02	2:31p
d-24100-4D+I-hx73-146-MOX-s-c1.out	760,349	6/4/02	3:21p
d-24100-4D+I-hx85-140-MOX-s-c1	16,902	6/4/02	2:32p
d-24100-4D+I-hx85-140-MOX-s-c1.out	776,325	6/4/02	4:05p
d-24100-4D+I-hx91-128-MOX-s-c1	16,903	6/4/02	2:32p
d-24100-4D+I-hx91-128-MOX-s-c1.out	786,154	6/4/02	4:54p
d-24100-4D+I-hx97-124-MOX-s-c1	16,908	6/4/02	2:32p
d-24100-4D+I-hx97-124-MOX-s-c1.out	794,606	6/4/02	6:29p
d-48200-4D+I-hx109-121-MOX-s-c1	16,861	6/4/02	5:06p
d-48200-4D+I-hx109-121-MOX-s-c1.out	811,166	6/4/02	7:19p
d-48200-4D+I-hx121-115-MOX-s-c1	16,859	6/4/02	5:06p
d-48200-4D+I-hx121-115-MOX-s-c1.out	829,948	6/5/02	3:39p
d-48200-4D+I-hx151-102-MOX-s-c1	16,861	6/4/02	5:07p
d-48200-4D+I-hx151-102-MOX-s-c1.out	871,946	6/5/02	5:14p
d-48200-4D+I-hx61-160-MOX-s-c1	16,839	6/4/02	5:07p
d-48200-4D+I-hx61-160-MOX-s-c1.out	744,268	6/5/02	6:37p
d-48200-4D+I-hx73-146-MOX-s-c1	16,852	6/4/02	5:07p
d-48200-4D+I-hx73-146-MOX-s-c1.out	760,012	6/5/02	8:00p
d-48200-4D+I-hx85-140-MOX-s-c1	16,850	6/4/02	5:08p
d-48200-4D+I-hx85-140-MOX-s-	778,424	6/5/02	9:24p

File Name/Directory Denomination	File Size (bytes)	Date of Last Update	Time
c1.out			
d-48200-4D+I-hx91-128-MOX-s-c1	16,850	6/4/02	5:08p
d-48200-4D+I-hx91-128-MOX-s-c1.out	785,716	6/5/02	10:54p
d-48200-4D+I-hx97-124-MOX-s-c1	16,855	6/4/02	5:08p
d-48200-4D+I-hx97-124-MOX-s-c1.out	794,666	6/6/02	12:20a
4D+I-sq109-110-MOX-s-c1	16,581	6/3/02	4:40p
4D+I-sq109-110-MOX-s-c1.out	810,315	6/4/02	2:21a
4D+I-sq137-100-MOX-s-c1	16,577	6/3/02	4:41p
4D+I-sq137-100-MOX-s-c1.out	850,299	6/4/02	3:05a
4D+I-sq61-151-MOX-s-c1	16,584	6/3/02	4:57p
4D+I-sq61-151-MOX-s-c1.out	741,771	6/3/02	7:03p
4D+I-sq69-144-MOX-s-c1	16,580	6/3/02	4:46p
4D+I-sq69-144-MOX-s-c1.out	753,195	6/3/02	9:03p
4D+I-sq81-128-MOX-s-c1	16,580	6/3/02	4:51p
4D+I-sq81-128-MOX-s-c1.out	770,331	6/3/02	11:09p
4D+I-sq89-126-MOX-s-c1	16,582	6/3/02	4:53p
4D+I-sq89-126-MOX-s-c1.out	781,755	6/4/02	12:57a
4D+I-sq97-119-MOX-s-c1	16,580	6/3/02	4:56p
4D+I-sq97-119-MOX-s-c1.out	793,179	6/4/02	1:38a
d-24100-4D+I-sq109-110-MOX-s-c1	16,703	6/4/02	2:28p
d-24100-4D+I-sq109-110-MOX-s-c1.out	811,576	6/5/02	7:00p
d-24100-4D+I-sq137-100-MOX-s-c1	16,699	6/4/02	2:28p
d-24100-4D+I-sq137-100-MOX-s-c1.out	851,560	6/5/02	8:35p
d-24100-4D+I-sq61-151-MOX-s-c1	16,706	6/6/02	8:29a
d-24100-4D+I-sq61-151-MOX-s-c1.out	742,714	6/6/02	9:12a
d-24100-4D+I-sq69-144-MOX-s-c1	16,702	6/4/02	2:29p
d-24100-4D+I-sq69-144-MOX-s-c1.out	754,976	6/4/02	6:08p
d-24100-4D+I-sq81-128-MOX-s-c1	16,702	6/4/02	2:29p
d-24100-4D+I-sq81-128-MOX-s-c1.out	772,011	6/4/02	7:32p
d-24100-4D+I-sq89-126-MOX-s-c1	16,704	6/4/02	2:29p
d-24100-4D+I-sq89-126-MOX-s-c1.out	782,481	6/5/02	3:56p
d-24100-4D+I-sq97-119-MOX-s-c1	16,702	6/4/02	2:29p

File Name/Directory Denomination	File Size (bytes)	Date of Last Update	Time
d-24100-4D+I-sq97-119-MOX-s-c1.out	794,122	6/5/02	5:27p
d-48200-4D+I-sq109-110-MOX-s-c1	16,655	6/4/02	5:10p
d-48200-4D+I-sq109-110-MOX-s-c1.out	810,098	6/5/02	10:05p
d-48200-4D+I-sq137-100-MOX-s-c1	16,651	6/4/02	5:10p
d-48200-4D+I-sq137-100-MOX-s-c1.out	851,544	6/5/02	10:53p
d-48200-4D+I-sq61-151-MOX-s-c1	16,658	6/4/02	5:10p
d-48200-4D+I-sq61-151-MOX-s-c1.out	1,483,408	6/5/02	4:04p
d-48200-4D+I-sq69-144-MOX-s-c1	16,654	6/4/02	5:10p
d-48200-4D+I-sq69-144-MOX-s-c1.out	1,508,276	6/5/02	5:32p
d-48200-4D+I-sq81-128-MOX-s-c1	16,654	6/4/02	5:11p
d-48200-4D+I-sq81-128-MOX-s-c1.out	771,173	6/5/02	7:02p
d-48200-4D+I-sq89-126-MOX-s-c1	16,656	6/4/02	5:11p
d-48200-4D+I-sq89-126-MOX-s-c1.out	782,582	6/5/02	8:33p
d-48200-4D+I-sq97-119-MOX-s-c1	16,654	6/4/02	5:11p
d-48200-4D+I-sq97-119-MOX-s-c1.out	794,122	6/5/02	9:19p
Directory of :\CD\Table_19			
d-24100-4D+I-hx85-140-MOX-s-c-Gd3x	16,981	6/13/02	9:00a
d-24100-4D+I-hx85-140-MOX-s-c-Gd3x.out	777,675	6/12/02	4:22p
d-24100-4D+I-hx85-140-MOX-s-c-Gd4x	16,988	6/12/02	4:57p
d-24100-4D+I-hx85-140-MOX-s-c-Gd4x.out	777,660	6/12/02	5:41p
d-24100-4D+I-hx85-140-MOX-s-c1	16,902	6/4/02	2:32p
d-24100-4D+I-hx85-140-MOX-s-c1.out	776,325	6/4/02	4:05p
Directory of :\CD\Table_20			
d-24100-4D+I-hx85-140-MOX-s-c-Gd3x	16,981	6/13/02	9:00a
d-24100-4D+I-hx85-140-MOX-s-c-Gd3x.out	777,675	6/12/02	4:22p
d-24100-4D+I-hx85-140-MOX-s-c-Gd3x-ld-b-surf	17,049	6/13/02	9:46a
d-24100-4D+I-hx85-140-MOX-s-c-Gd3x-ld-b-surf.out	777,675	6/13/02	1:08p
d-24100-4D+I-hx85-140-MOX-s-c-Gd3x-ld-botm	17,047	6/13/02	9:40a
d-24100-4D+I-hx85-140-MOX-s-c-Gd3x-ld-botm.out	777,647	6/13/02	12:24p

File Name/Directory Denomination	File Size (bytes)	Date of Last Update	Time
d-24100-4D+l-hx85-140-MOX-s-c-Gd3x-C-m	17,025	6/13/02	9:31a
d-24100-4D+l-hx85-140-MOX-s-c-Gd3x-C-m.out	778,730	6/13/02	12:36p
d-24100-4D+l-hx85-140-MOX-s-c-Gd3x-C-s	17,043	6/13/02	9:14a
d-24100-4D+l-hx85-140-MOX-s-c-Gd3x-C-s.out	778,614	6/13/02	10:48a
d-24100-4D+l-hx85-140-MOX-s-c-Gd3x-w-clay20	17,102	6/13/02	9:59a
d-24100-4D+l-hx85-140-MOX-s-c-Gd3x-w-clay20.out	777,925	6/13/02	10:55a
d-24100-4D+l-hx85-140-MOX-s-c-Gd3x-w-clay40	17,121	6/13/02	10:05a
d-24100-4D+l-hx85-140-MOX-s-c-Gd3x-w-clay40.out	777,774	6/13/02	12:04p
d-24100-4D+l-hx85-140-MOX-s-c-Gd3x-wd0	16,922	6/13/02	4:26p
d-24100-4D+l-hx85-140-MOX-s-c-Gd3x-wd0.out	774,521	6/13/02	5:37p
d-24100-4D+l-hx85-140-MOX-s-c-Gd3x-wd06	17,201	6/14/02	10:58a
d-24100-4D+l-hx85-140-MOX-s-c-Gd3x-wd06.out	778,511	6/14/02	11:44a
d-24100-4D+l-hx85-140-MOX-s-c-Gd3x-wd08	17,183	6/14/02	9:03a
d-24100-4D+l-hx85-140-MOX-s-c-Gd3x-wd08.out	778,728	6/14/02	9:54a
d-24100-4D+l-hx85-140-MOX-s-c-Gd3x-wd09	17,179	6/14/02	8:56a
d-24100-4D+l-hx85-140-MOX-s-c-Gd3x-wd09.out	778,517	6/14/02	10:37a
d-24100-4D+l-hx85-140-MOX-s-c-Gd3x-refl	17,022	6/13/02	1:25p
d-24100-4D+l-hx85-140-MOX-s-c-Gd3x-refl.out	777,804	6/13/02	2:13p
d-24100-4D+l-hx85-140-MOX-s-c-Gd3x-sio2	17,454	6/13/02	1:23p
d-24100-4D+l-hx85-140-MOX-s-c-Gd3x-sio2.out	783,208	6/13/02	2:58p
d-24100-4D+l-hx85-140-MOX-s-c-Gd3x-outid-wd0	17,029	6/18/02	4:24p
d-24100-4D+l-hx85-140-MOX-s-c-Gd3x-outid-wd0.out	778,224	6/18/02	5:24p
d-24100-4D+l-hx85-140-MOX-s-c-Gd3x-outid-wd06	17,029	6/18/02	2:08p
d-24100-4D+l-hx85-140-MOX-s-c-Gd3x-outid-wd06.out	777,906	6/18/02	3:48p
d-24100-4D+l-hx85-140-MOX-s-c-Gd3x-outid-wd08	17,029	6/18/02	11:19a
d-24100-4D+l-hx85-140-MOX-s-c-Gd3x-outid-wd08.out	777,969	6/18/02	4:32p
d-24100-4D+l-hx85-140-MOX-s-c-Gd3x-outid-wd09	17,035	6/18/02	11:12a

File Name/Directory Denomination	File Size (bytes)	Date of Last Update	Time
d-24100-4D+I-hx85-140-MOX-s-c-Gd3x-outid-wd09.out	778,825	6/18/02	12:38p
d-24100-4D+I-hx85-140-MOX-s-c-Gd3x-setl-08	17,011	6/19/02	9:25a
d-24100-4D+I-hx85-140-MOX-s-c-Gd3x-setl-08.out	778,073	6/19/02	10:18a
d-24100-4D+I-hx85-140-MOX-s-c-Gd3x-setl-10	17,011	6/19/02	8:59a
d-24100-4D+I-hx85-140-MOX-s-c-Gd3x-setl-10.out	778,088	6/19/02	11:05a
d-24100-4D+I-hx85-140-MOX-s-c-Gd3x-intube	18,789	6/21/02	10:53a
d-24100-4D+I-hx85-140-MOX-s-c-Gd3x-intube.out	787,316	6/21/02	12:19p
d-24100-4D+I-hx85-140-MOX-s-c-Gd3x-gt05	17,073	6/18/02	3:56p
d-24100-4D+I-hx85-140-MOX-s-c-Gd3x-gt05.out	778,845	6/18/02	5:25p
Directory of :\CD\Excel_spreadsheet			
FFTF.xls	412,672	7/26/02	10:44a