TRANSNUCLEAR
AN AREVA COMPANY

April 20, 2007
E-24947

U. S. Nuclear Regulatory Commission
Attn: Document Control Desk
One White Flint North
11555 Rockville Pike
Rockville, MD 20852

Subject: Incorporation of Amendment No. 9 to Certificate of Compliance (CoC) No. 1004 for the Standardized NUHOMS® System into the Updated Final Safety Analysis Report Docket 72-1004

Reference: Letter from Robert A. Nelson (NRC) to Jayant Bondre (TN), dated April 17, 2007, "Amendment No. 9 to Certificate of Compliance No. 1004 for the Standardized NUHOMS® System"

Gentlemen:

The referenced letter forwarded approval of Amendment 9 to CoC No. 1004 and requested that Transnuclear, Inc. (TN) update and submit three copies of the final safety analysis report (FSAR) to conform to the amended certificate, within 90 days. TN has incorporated the provisions of Amendment 9 into the UFSAR as documented in FSAR Change Notice (FCN) 721004-467. TN had submitted Revision 9 of the UFSAR to CoC 1004 on February 3, 2006. The next revision is due on February 3, 2008, per 10 CFR 72.248. TN is on schedule to update the CoC 1004 UFSAR by the February 2008 due date, which will include the provisions of Amendment 9, via FCN 721004-467. Per discussions with the NRC staff on April 17, 2007, in the meantime, Enclosure 1 to this letter provides three copies of that FCN, for NRC staff use.

Should the NRC staff require additional information, please do not hesitate to contact me at 410-910-6881 or Don Shaw at 410-910-6878.

Sincerely,

Jayant Bondre

Jayant Bondre
Director of Engineering and Licensing

cc (w/o enclosure): Mr. James R. Hall (NRC SFST)

Enclosure:

1. Three copies of Transnuclear, Inc. Final Safety Analysis Report (FSAR) Changed Notice No. 721004-467

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NMSS01

AREVA	FSAR Change Notice (FCN)	Form 3.5-4 TIP 3.5 (Revision 1) Page 1 of 30

	FCN No.:	FCN-**721004-467**
	72.48 Review No.:	LR- **721004-467**

Preparer/Date	Verifier/Date
Don Shaw / 4/19/07	P. Sitz 4/19/07

Approved: Don Shaw **Date:** 4/19/07

A marked up copy of the applicable FSAR pages and drawings clearly showing the change implemented by the 72.48 Review must be attached to this form:

- List changed FSAR pages (if applicable) attached to this FSAR Change Notice:

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Page K.6-13
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- List changed FSAR Drawings (if applicable) attached to this FSAR Change Notice:

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Table K.2-1
Intact BWR Fuel Assembly Characteristics

PHYSICAL PARAMETERS:	
Fuel Design:	7x7, 8x8, 9x9, or 10x10 intact BWR fuel assemblies manufactured by General Electric or Exxon/ANF or equivalent reload fuel that are enveloped by the Fuel assembly design characteristics listed in Table K.2-3.
Cladding Material:	Zircaloy
Fuel Damage:	Cladding damage in excess of pinhole leaks or hairline cracks is not authorized to be stored as "Intact BWR Fuel."
Channels:	Fuel may be stored with or without fuel channels
Maximum Assembly length (Unirradiated)	176.2 in
Nominal Assembly Width (excluding channels)	5.44 in
Maximum Assembly Weight	705 lbs
RADIOLOGICAL PARAMETERS(1):	
Group 1: Maximum Burnup:	27,000 MWd/MTU
Minimum Cooling Time:	5-years
Maximum Initial Enrichment:	See Table K.2-4
Minimum Initial Bundle Average Enrichment:	2.0 wt. % U-235
Maximum Initial Uranium Content:	198 kg/assembly
Maximum Decay Heat:	300 W/assembly(2)
Group 2: Maximum Burnup:	35,000 MWd/MTU
Minimum Cooling Time:	8-years
Maximum Initial Enrichment:	See Table K.2-4
Minimum Initial Bundle Average Enrichment:	2.65 wt. % U-235
Maximum Initial Uranium Content:	198 kg/assembly
Maximum Decay Heat:	300 W/assembly(2)
Group 3: Maximum Burnup:	37,200 MWd/MTU
Minimum Cooling Time:	6.5-years
Maximum Initial Enrichment:	See Table K.2-4
Minimum Initial Bundle Average Enrichment:	3.38 wt. % U-235
Maximum Initial Uranium Content:	198 kg/assembly
Maximum Decay Heat:	300 W/assembly(2)
Group 4: Maximum Burnup:	40,000 MWd/MTU
Minimum Cooling Time:	10-years
Maximum Initial Enrichment:	See Table K.2-4
Minimum Initial Bundle Average Enrichment:	3.4 wt. % U-235
Maximum Initial Uranium Content:	198 kg/assembly
Maximum Decay Heat:	300 W/assembly(2)
Alternate Radiological Parameters: Maximum Initial Enrichment:	See Table K.2-4
Fuel Burnup, Initial Bundle Average Enrichment, and Cooling Time:	See Table K.2-11
Maximum Initial Uranium Content:	198 kg/assembly
Maximum Decay Heat:	300 W/assembly(2)

(1) Fuel assemblies fully complying with any of the four groups of parameters or alternate radiological parameters are suitable for storage in the NUHOMS®-61BT DSC. No interpolation of Radiological Parameters is permitted between groups 1 to 4.

(2) *For FANP9 9x9-2 fuel assemblies, the maximum decay heat is limited to 0.21 kW/assembly.*

Table K.2-3
BWR Fuel Assembly Design Characteristics[1] [2]

Transnuclear, ID	**7 x 7-49/0[5]**	**8 x 8-63/1[5]**	**8 x 8-62/2[5]**	**8 x 8-60/4[5]**	**8 x 8-60/1[5]**	**9 x 9-74/2**	**10x10-92/2**	**7x7 – 49/0[5]**	**7x7 48/1Z[5]**	**8x8 – 60/4Z[5]**	***9x9-79/2***
Fuel Type	GE1 GE2 GE3	GE4	GE-5 GE-Pres GE-Barrier GE8 Type I	GE8 Type II	GE9 GE10	GE11 GE13	GE12	ENC III-A	ENC III[3]	ENC Va & ENC Vb	*FANP9* *9x9-2*
Nominal Width (in) (excluding channels)	5.44	5.44	5.44	5.44	5.44	5.44	5.44	5.44	5.44	5.44	*5.44*
Channel Internal Width (in)	5.278	5.278	5.278	5.278	5.278	5.278	5.278	5.278	5.278	5.278	*5.278*
Fissile Material	UO_2	UO_2	UO_2	UO_2	UO_2	UO_2	UO_2	UO_2	UO_2	UO_2	*UO_2*
Number of Fuel Rods	49	63	62	60	60	66 – Full 8 – Partial	78 – Full 14 – Partial	49	48	60	*79*
Number of Water Holes	0	1	2	4	1	2	2	0	1[4]	4[4]	*2*

(1) Any fuel channel thickness from 0.065 to 0.120 inch is acceptable on any of the fuel designs.
(2) *Maximum fuel assembly weight with channel is 705 lb.*
(3) Includes ENC III-E and ENC III-F.
(4) Solid Zirc rods instead of water holes.
(5) May be stored as damaged fuel.

K.3.7A Evaluation of 61BT DSC with FANP9 9x9-2 Fuel Assemblies

All of the design parameters for the design basis fuel assembly used in this chapter (e.g., total fuel assembly weight, temperatures, and pressures) bound the Framatome-ANP 9x9 Version 9x9-2 (FANP9 9x9-2) fuel assembly. As a result, all of the structural evaluation results reported in this chapter are bounding for the FANP9 9x9-2 fuel assembly.

K.4 Thermal Evaluation

K.4.1 Discussion

The NUHOMS®-61BT system is designed to passively reject decay heat during storage and transfer for normal, off-normal and accident conditions while maintaining temperatures and pressures within specified regulatory limits. Objectives of the thermal analyses performed for this evaluation include:

- Determination of maximum and minimum temperatures with respect to materials limits to ensure components perform their intended safety functions,
- Determination of temperature distributions for the NUHOMS®-61BT DSC components to support the calculation of thermal stresses for the structural components,
- Determination of maximum internal NUHOMS®-61BT DSC pressures for the normal, off-normal and accident conditions,
- Determination of the maximum fuel cladding temperature, and to confirm that this temperature will remain sufficiently low to prevent unacceptable degradation of the fuel during storage.

The NUHOMS®-61BT DSC falls under the jurisdiction of 10CFR Part 72 when used as a component of an ISFSI. To establish the heat removal capability, several thermal design criteria are established for the basket. These are:

- Maximum temperatures of the confinement structural components must not adversely affect the confinement function.
- The maximum initial storage fuel cladding temperature is determined as a function of the initial fuel age using the guidelines provided by the Commercial Spent Fuel Management Program [4.1]. The temperature threshold accounts for the effects of cladding temperature, decay time, burnup and fission gas build-up at 40 GWD/MTU. Waterside corrosion of 0.002 in. (radially) has been assumed. For normal conditions of storage, a fuel temperature limit of 343°C (649°F) has been established. During loading/unloading, transfer and accident conditions, the fuel temperature limit is 570°C (1058°F) [4.9]. *The NUHOMS® - 61BT DSC with FANP9 9x9-2 fuel assemblies with a maximum per assembly heat load of 0.21 kW/FA (13 kW/DSC) meet the NRC Interim Staff Guidance (ISG) -11, Revision 3 [4.15] during all storage and transfer conditions.*
- The maximum DSC cavity internal pressures during normal, off-normal and accident conditions must be below the design pressures of 10 psig, 20 psig and 65 psig, respectively.

The thermal analysis methodology used to predict the temperature distribution in the NUHOMS®-61BT DSC basket is benchmarked [4.11] against experimental data obtained for the TN-24 cask [4.12]. The results of the benchmarking study show with the cask in a horizontal configuration, the TN methodology predicted fuel cladding temperatures which are 77°F higher than the test data. These results were submitted to the NRC staff [4.13].

K.4.8A Evaluation of 61BT DSC with FANP9 9x9-2 Fuel Assemblies

The method used for the thermal evaluation of the FANP9 9x9-2 fuel is documented below.

1. *Evaluate the effective fuel properties (thermal conductivity (K), heat capacity (Cp) and density (ρ)) of the FANP9 9x9-2 fuel assembly and compare it with the NUHOMS®-61BT DSC design basis fuel. If the FANP9 9x9-2 fuel can be bounded by the design basis fuel, the corresponding thermal analysis results for the NUHOMS®-61BT design basis fuel can be conservatively used for thermal evaluation of the NUHOMS®-61BT DSC with the FANP9 9x9-2 fuel assembly.*

2. *Based on the thermal analysis results of NUHOMS®-61BT DSC for the maximum design basis heat load of 18.3 kW per DSC, use the ratio of heat loads and the temperature difference (ΔT) to calculate the maximum cladding temperatures in the NUHOMS®-61BT DSC with FANP9 9x9-2 fuel assemblies with a maximum heat load 13 kW per DSC. Use these results to demonstrate that the maximum cladding temperatures with FANP9 9x9-2 fuel meet in NRC Interim Staff Guidance (ISG) -11, Revision 3 [4.15] during all storage and transfer conditions.*

A summary of key parameters for the FANP9 9x9-2 Fuel and NUHOMS®-61BT DSC Design Basis Fuel are shown in the table below.

Summary of Key Parameters for FANP9 9x9-2 Fuel and NUHOMS®-61BT DSC Design Basis Fuel

	FANP9 9x9-2 Fuel Assembly Parameters	***NUHOMS®-61BT Design Basis Fuel Parameters***
Maximum Decay Heat Load per Assembly (kW)	*0.21*	*0.3*
Maximum Total Decay Heat load per NUHOMS®-61BT DSC (kW)	*13.0*	*18.3*

As shown in the table, the maximum decay heat per assembly and maximum total decay heat per DSC for the FANP9 9x9-2 fuel are all bounded by the design basis values used for the NUHOMS®-61BT thermal evaluation.

The fuel assembly effective thermal conductivities for the FANP9 9x9-2 fuel were calculated similar to Chapter K.4 and compared with the design basis fuel assembly values. The comparison is documented in the table below:

Summary of Effective Density, Specific Heat and Axial Thermal Conductivity for NUHOMS®-61BT DSC

Assembly Effective Thermal Properties	***NUHOMS®-61BT DSC Fuel Assembly***	***FANP9 9x9-2 Fuel Assembly***
Thermal Properties		
Effective Density, lbm/in³	*0.105*	*0.106*
Heat Capacity Cp, Btu/lbm-°F	*0.0574*	*0.0578*
Thermal Conductivity $K_{eff\ axial}$, Btu/hr-in-°F	*0.0437*	*0.0490*

Similarly, the computed radial (transverse) fuel thermal effective conductivity values as a function of temperature for helium backfill conditions and vacuum drying conditions are tabulated in the table below for the FANP9 9x9-2 fuel assembly and the bounding NUHOMS®-61BT DSC design basis fuel assembly.

Transverse Fuel Thermal Effective Conductivity for Helium Backfill and Vacuum Drying Condition, FANP9 9x9-2 and NUHOMS®-61BT DSC Bounding Fuel Assembly

	Helium Backfill				***Vacuum Drying***		
	FANP9 9x9-2	***61BT Design Basis Fuel Assembly***	***Comparison***		***FANP9 9x9-2***	***61BT Design Basis Fuel Assembly***	***Comparison***
T	$k_{eff,\ FANP9\ 9x9-2}$	$k_{eff,\ 61BT}$	*Difference (%)*	*T*	$k_{eff,\ FANP9\ 9x9-2}$	$k_{eff,\ 61BT}$	*Difference (%)*
°F	*Btu/(hr-in-°F)*	*Btu/(hr-in-°F)*	$\frac{k_{eff,\ FANP9\ 9x9-2} - k_{eff,\ 61BT}}{k_{eff,\ 61BT}}$	*°F*	*Btu/(hr-in-°F)*	*Btu/(hr-in-°F)*	$\frac{k_{eff,\ FANP9\ 9x9-2} - k_{eff,\ 61BT}}{k_{eff,\ 61BT}}$
214.4	*0.01590*	*0.01600*	*-0.6*	*240.0*	*0.005793*	*0.005800*	*-0.1*
312.4	*0.01845*	*0.01860*	*-0.8*	*331.6*	*0.007367*	*0.007300*	*0.9*
410.7	*0.02145*	*0.02150*	*-0.2*	*425.1*	*0.009274*	*0.009200*	*0.8*
509.3	*0.02496*	*0.02490*	*0.2*	*520.1*	*0.011531*	*0.011400*	*1.2*
608.0	*0.02885*	*0.02880*	*0.2*	*616.3*	*0.013951*	*0.014100*	*-1.1*

As seen from these tables, the effective density, heat capacity, and axial thermal conductivities for the FANP9 9x9-2 fuel assembly are bounded by the NUHOMS®-61BT DSC design basis fuel assembly used in the thermal evaluation in this section, and the transverse thermal conductivities for the FANP9 9x9-2 fuel assembly are negligibly different from the design basis fuel assembly used in the thermal evaluation in this section.

The maximum decay heat load for the FANP9 9x9-2 fuel assemblies for inclusion in the authorized contents of the NUHOMS®-61BT DSC is 13.0 kW per DSC (0.21 kW per fuel

assembly). This is approximately 29% less than the design basis heat load for NUHOMS®-61BT DSC. The FANP9 9x9-2 fuel thermal properties are similar to the design basis fuel for the NUHOMS®-61BT DSC as described in the two preceding tables. Therefore, the thermal evaluation for the design basis fuel in NUHOMS®-61BT DSC during storage and transfer for normal, off-normal and accident conditions remains bounding for the FANP9 9x9-2 fuel assemblies with decay heat loads less than or equal to 13.0 kW/DSC.

The maximum fuel cladding temperatures during storage and transfer operations are shown in the table below for the NUHOMS®-61BT DSC with design basis heat loads (18.3 kW/DSC) from Tables K.4-1, K.4-2 and K.4-4. When these fuel cladding temperatures are compared with the allowable cladding temperatures in ISG-11, Revision 3, all the fuel cladding temperatures, including the vacuum drying operations at 96 hours, are below the ISG-11 allowable values. The following evaluation calculates the expected maximum fuel cladding temperature with FANP9 9x9-2 fuel assemblies with a maximum heat load of 13.0 kW/DSC.

<u>Maximum Fuel Cladding Temperatures with FANP9 9x9-2 Fuel Assemblies During Vacuum Drying Condition</u>

The maximum fuel cladding temperatures within the NUHOMS®-61BT DSC (decay heat load of 18.3 kW per DSC) after 96 hours of vacuum drying condition (Table K.4-4) is used to evaluate the corresponding maximum fuel cladding temperature for loading the NUHOMS®-61BT DSC with the FANP9 9x9-2 fuel assemblies with 13.0 kW/DSC heat load.

According to this chapter, the maximum fuel cladding temperature after 96 hours of the vacuum drying condition is $T_{FC,\ 18.kW,\ 96hrs} = 827°F$ *where the initial temperatures* $T_{a,\ 18.3kW}$ *for the DSC and basket are assumed to be at 100°F. Therefore, the temperature increase (ΔT) after 96 hours of the vacuum drying condition is:*

$$\Delta T_{FC,\ 18.3kW,\ 96hrs} = T_{FC,\ 18.3kW,\ 96hrs} - T_{a,\ 18.3kW,\ 0hr} = 827 - 100 = 727°F$$

For the 13.0 kW per DSC heat load, the corresponding maximum fuel cladding temperature increase after 96 hours of the vacuum drying condition is estimated as:

$$\Delta T_{FC,\ 13kW,\ 96hrs} = 13/18.3 * \Delta T_{FC,\ 18.3kW,\ 96hrs} = 516.4°F$$

Then,

$$T_{FC,\ 13kW,\ 96hr} = 516.4 + 100 = 616.4°F$$

The results show that at the end of 96 hours of the vacuum drying condition for FANP9 9x9-2 fuel assemblies with 13.0 kW/DSC heat load, the maximum fuel cladding temperature during vacuum drying condition also meets the allowable of 752°F from ISG-11.

Maximum Cladding Temperatures during Storage and Transfer

Condition	***Operation***	***Maximum Cladding Temperature with design basis heat load of 18.3 kW/DSC (°F)***	***Maximum Cladding Temperature with FANP9 9x9-2 Fuel with 13 kW/DSC (°F)***	***Allowable Temperature Range per ISG-11 Rev. 3 (°F)***
Storage	*Normal, 100°F Ambient*	*569*	*<569*	*752*
	Off-Normal, 125°F Ambient	*590*	*<590*	*1058*
	Accident – Blocked Vent	*809*	*<809*	*1058*
Transfer	*Normal/Off-Normal Ambient*	*638*	*<638*	*752*
	Vacuum Drying, 96 hrs	*827*	*617*	*752*

This table shows that all maximum fuel cladding temperatures for the FANP9 9x9-2 fuel assembly do not exceed the allowable temperatures from ISG-11 for all storage and transfer operations. Therefore, the inclusion of the FANP9 9x9-2 fuel assembly in the authorized contents of the NUHOMS®-61BT DSC satisfies both the requirements of ISG-11, Revision 3 and this chapter.

All of the design parameters for the design basis fuel assembly used in this chapter (e.g., heat load per assembly, temperatures, and pressures) bound the FANP9 9x9-2 fuel assembly. As a result, all of the thermal evaluation results reported in this chapter are bounding for the FANP9 9x9-2 fuel assembly. In addition, the FANP9 9x9-2 fuel assembly results also meet the guidance provided in ISG-11, Revision 3 [4.15].

K.4.9 References

4.1 Levy et. al., Recommended Temperature Limits for Dry Storage of Spent Light Water Reactor Zircaloy - Clad Fuel Rods in Inert Gas, Pacific Northwest Laboratory, PNL-6189, 1987.

4.2 Rohsenow et. al., Handbook of Heat Transfer Fundamentals, McGraw-Hill Publishing, New York 1985.

4.3 American Society for Mechanical Engineers (ASME) Boiler and Pressure Vessel Code, Section II, Part D, 1998 Edition Including 1999 Addenda.

4.4 Scoping Design Analyses for Optimized Shipping Casks Containing 1-, 2-, 3-, 5-, 7-, or 10-Year Old PWR Spent Fuel, J. A. Bucholz, ORNL/CSD/TM-149, TTC-9316, January 1983.

4.5 ANSYS, Inc., ANSYS Engineering Analysis System User's Manual for ANSYS Revision 5.6, Houston, PA.

4.6 Standard Review Plan for Dry Cask Storage Systems, NUREG-1536, Nuclear Regulatory Commission.

4.7 Transnuclear, Inc., TN-68 Dry Storage Cask Final Safety Analysis Report, Revision 0, Hawthorne, NY, 2000 (Docket No. 72-1027).

4.8 Transnuclear West, Final Safety Analysis Report for the Standardized NUHOMS® Horizontal Modular Storage System for Irradiated Nuclear Fuel, NUH-003 Revision 5, NUH003.0103, Fremont, CA, August 2000.

4.9 Johnson et. al., Technical Basis for Storage of Zircaloy-Clad Spent Fuel in Inert Gases, PNL-4835, Pacific Northwest Laboratory, 1983.

4.10 Consolidated Safety Analysis Report for IF-300 Shipping Cask, CoC 9001.

4.11 Calculation, "TN-24P Benchmarking Analysis Using ANSYS," Transnuclear Calculation No. NUH32PT.0408, Revision 0.

4.12 J. M. Greer, et al, "The TN-24 PWR Spent Fuel Storage Cask: Testing and Analyses," PNL Report No. PNL-6054, Pacific Northwest Laboratory, 1987.

4.13 Application for Amendment No. 5 to the NUHOMS® Certificate of Compliance No. 1004 (TAC No. L23343, Docket No. 72-1004); February 24, 2003.

4.14 NUREG/CR-0497, A Handbook of Material Properties for Use in the Analysis of Light Water Reactor Fuel Rod Behavior, MATPRO-version 11, Revision 2, EG&G Idaho, Inc., TREE-1280, August 1981.

4.15 Interim Staff Guidance (ISG) – 11, Revision 3, "Cladding Considerations for the Transportation and Storage of Spent Fuel," NRC Spent Fuel Project Office, dated November 17, 2003.

K.5.4A Evaluation of 61BT DSC with FANP9 9x9-2 Fuel Assemblies

The initial heavy metal content of the FANP9 9x9x-2 fuel assembly is 0.180 MTU per assembly while the shielding design basis fuel assembly is 0.198 MTU. In addition, the initial Co59 content from the four fuel assembly source regions (i.e., bottom, in-core, plenum and top) for the FANP9 9x9-2 is less than that of the shielding design basis fuel assembly. Therefore, the design basis radiation and thermal source terms for all burnup, initial enrichment and cooling lime combinations allowed to be stored in the NUHOMS®-61BT DSC remain bounding for the FANP9 9x9-2 fuel assembly. As a result, all of the dose rates reported in the tables in this section and dose rate limits reported in the Technical Specifications remain bounding for the FANP9 9x9-2 fuel assembly type.

Table K.5-1
Fuel Assembly Designs Considered

Manufacturer[1]	Array	Version	Active Fuel Length (in)	Number Fuel Rods per Assembly	Number Water Holes per Assembly	Fuel Loading (MTU)[2]
GE	7x7	GE1/GE2	144	49	NA	0.198
GE	7x7	GE3	144	49	NA	0.198
Exxon/ANF	7x7	ENC III-A	144	49	0	0.184
Exxon/ANF	7x7	ENC III[3]	144	48	1[4]	0.184
Exxon/ANF	8x8	ENC Va & Vb	144	60	4[4]	0.177
GE	8x8	GE4	146	63	1	0.188
GE	8x8	GE5	150	62	2	0.186
GE	8x8	GE-Pres	150	62	2	0.186
GE	8x8	GE-Barrier	150	62	2	0.186
GE	8x8	GE8 Type I	150	62	2	0.186
GE	8x8	GE8 Type II	150	60	1	0.183
GE	8x8	GE9	150	60	1	0.184
GE	8x8	GE10	150	60	1	0.184
GE	9x9	GE11	146-Full 90-Partial	66-Full 8-Partial	2	0.177
GE	9x9	GE13	146-Full 90-Partial	66-Full 8-Partial	2	0.177
Framatome	*9x9*	*FANP9 9x9-2*	*150*	*79-Full* *0-Partial*	*2*	*0.180*
GE	10x10	GE12	150-Full 93-Partial	78-Full 14-Partial	2	0.187

(1) Or equivalent reload fuel that is enveloped by the fuel assembly design characteristics listed in this table.
(2) Fissile Material is limited to UO2.
(3) Includes ENC III-E and ENC III-F.
(4) Solid Zirc Rod(s)

- only 90% credit for poison plates made of a Boron-Aluminum alloy or Boralyn® and 75% credit for poison plates made with Boral® or Metamic® is taken for the B10 content in the poison plates,
- maximum gaps between poison plates are modeled in their worst case configuration,
- the stainless steel basket rails which hold the basket together are modeled as water,
- Unit 84, and associated arrays and units are added to model the "uncovered" row of fuel above the poison plates.

In all other respects, the model is the same as that described in Sections K.6.3.1 and K.6.3.2. The model is more fully discussed in Section K.6.6.3.

A typical input file is included in Section K.6.6.3. The results of these calculations are listed in Table K.6-8 and Table K.6-9.

D. Evaluation of 61BT with FANP9 9x9-2 Fuel Assemblies

Section K.6.4.2A documents the determination of the most reactive fuel lattice, which is used for the remainder of the criticality evaluation for the NUHOMS®-61BT DSC to demonstrate criticality safety for the system with all of its authorized contents. Additional analysis identical to that documented in Section K.6.4.2A was performed to demonstrate that the criticality design basis fuel assembly bounds the FANP9 9x9-2 fuel assembly. Using the same models (except the fuel assembly is replaced with the FANP9 9x9-2 assembly) the calculated reactivity for the FANP9 9x9-2 assembly without a fuel channel and with a 0.065, 0.080 and 0.120 inch-thick fuel channels were evaluated. The results of the calculations are provided in the table below. The evaluation was performed using the same CSAS25 control module of the SCALE4.4 computer code, with 44 Group ENDF-V cross section library.

As demonstrated in the table, the design basis fuel assembly for criticality remains bounding. Therefore, all of the results of the criticality evaluation presented in this chapter remain bounding for the FANP9 9x9-2 fuel assembly. The CSAS25 input file for the FANP9 9x9-2 criticality evaluation is listed in Section K.6.6.5.

K.6.4.3 Criticality Results

Table K.6-10 lists the results that bound all loading, transfer, and storage normal and off-normal conditions. These criticality calculations were performed with CSAS25 of SCALE-4.4. For each case, the result includes (1) the KENO-calculated k_{KENO}; (2) the one sigma uncertainty σ_{KENO}; and (3) the final k_{eff}, which is equal to $k_{KENO} + 2\sigma_{KENO}$. As stated before, the NUHOMS®-61BT system can transfer and store up to 16 damaged and 45 (or more) undamaged BWR fuel assemblies listed in Table K.6-3. Table K.6-10 lists the minimum poison plate B10 loading required as a function of fuel lattice average initial enrichment for intact assemblies and maximum pellet enrichment in the case of damaged fuel.

The criterion for subcriticality is that

$$k_{KENO} + 2\sigma_{KENO} < USL,$$

where USL is the upper subcritical limit established by an analysis of benchmark criticality experiments. From Section 6.5, the minimum USL over the parameter range (in this case, pitch) is 0.9414. From Table K.6-10 for the most reactive case,

$$k_{KENO} + 2\sigma_{KENO} = 0.9340 + 2\,(0.0012) = 0.9364 < 0.9414.$$

K.6.6.5 Input File for Criticality Analysis of FANP9 9x9-2

```
=csas25
61B Most Reactive Fuel Analysis with FANP 9x9, Prakash 02/2005
44groupndf5 latticecell
uo2     1 0.95 293 92235 4.4 92238 95.6 end
zirc2   2 1.0  293 end
h2o     3 1.0  293 end
carbonsteel 4 1.0 293 end
ss304   5 1.0  293 end
h2o     6 1.0  293 end
h2o     7 1.0  293 end
b-10    8 den=0.046 1.0 293 end
al      8 0.9  293 end
end comp
squarepitch 1.45288 0.90551 1 3 1.07696 2 0.92456 6 end
NUH61BTH Most Reactive - FANP 9x9 No channel
read param
gen=500 npg=1000 nsk=5 nub=yes run=yes plt=yes
end param
read geom
unit 1      com='Fuel Rod'
cylinder  1   1  0.452755     381.0         0.0
cylinder  6   1  0.46228      381.0         0.0
cylinder  2   1  0.53848      381.0         0.0
cuboid    3   1  4p0.72644    381.0         0.0
unit 2      com='FANP 9x9 Center Assembly'
array 1 -6.53796 -6.53796 0.0
cuboid    3   1  4p7.62       381.0         0.0
cuboid    5   1  4p7.9629     381.0         0.0
cuboid    8   1  4p8.3566     381.0         0.0
unit 3      com='FANP 9x9 Assembly'
array 1 -6.53796 -6.53796 0.0
cuboid    3   1  4p7.62       381.0         0.0
cuboid    5   1  4p7.9629     381.0         0.0
cuboid    8   1  7.9629 -8.3566 2p8.3566       381.0         0.0
unit 4      com='FANP 9x9 Assembly'
array 1 -6.53796 -6.53796 0.0
cuboid    3   1  4p7.62       381.0         0.0
cuboid    5   1  4p7.9629     381.0         0.0
cuboid    8   1  8.3566 -7.9629 2p8.3566       381.0         0.0
unit 5      com='FANP 9x9 Assembly'
array 1 -6.53796 -6.53796 0.0
cuboid    3   1  4p7.62       381.0         0.0
cuboid    5   1  4p7.9629     381.0         0.0
cuboid    8   1  4p8.3566     381.0         0.0
unit 6      com='FANP 9x9 Assembly'
array 1 -6.53796 -6.53796 0.0
cuboid    3   1  4p7.62       381.0         0.0
cuboid    5   1  4p7.9629     381.0         0.0
cuboid    8   1  8.3566 -7.9629 2p8.3566       381.0         0.0
unit 7      com='FANP 9x9 Assembly'
array 1 -6.53796 -6.53796 0.0
cuboid    3   1  4p7.62       381.0         0.0
cuboid    5   1  4p7.9629     381.0         0.0
cuboid    8   1  7.9629 -8.3566 2p8.3566       381.0         0.0
unit 8      com='FANP 9x9 Assembly'
```

```
array 1 -6.53796 -6.53796 0.0
cuboid    3   1  4p7.62       381.0          0.0
cuboid    5   1  4p7.9629     381.0          0.0
cuboid    8   1  4p8.3566     381.0          0.0
unit 9     com='FANP 9x9 Assembly'
array 1 -6.53796 -6.53796 0.0
cuboid    3   1  4p7.62       381.0          0.0
cuboid    5   1  4p7.9629     381.0          0.0
cuboid    8   1  2p8.3566       7.9629 -8.3566 381.0          0.0
unit 10    com='FANP 9x9 Assembly'
array 1 -6.53796 -6.53796 0.0
cuboid    3   1  4p7.62       381.0          0.0
cuboid    5   1  4p7.9629     381.0          0.0
cuboid    8   1  7.9629 -8.3566 7.9629 -8.3566 381.0          0.0
unit 11    com='FANP 9x9 Assembly'
array 1 -6.53796 -6.53796 0.0
cuboid    3   1  4p7.62       381.0          0.0
cuboid    5   1  4p7.9629     381.0          0.0
cuboid    8   1  8.3566 -7.9629 7.9629 -8.3566 381.0          0.0
unit 12    com='FANP 9x9 Assembly'
array 1 -6.53796 -6.53796 0.0
cuboid    3   1  4p7.62       381.0          0.0
cuboid    5   1  4p7.9629     381.0          0.0
cuboid    8   1  4p8.3566     381.0          0.0
unit 13    com='FANP 9x9 Assembly'
array 1 -6.53796 -6.53796 0.0
cuboid    3   1  4p7.62       381.0          0.0
cuboid    5   1  4p7.9629     381.0          0.0
cuboid    8   1  2p8.3566 8.3566 -7.9629       381.0          0.0
unit 14    com='FANP 9x9 Assembly'
array 1 -6.53796 -6.53796 0.0
cuboid    3   1  4p7.62       381.0          0.0
cuboid    5   1  4p7.9629     381.0          0.0
cuboid    8   1  7.9629 -8.3566 8.3566 -7.9629 381.0          0.0
unit 15    com='FANP 9x9 Assembly'
array 1 -6.53796 -6.53796 0.0
cuboid    3   1  4p7.62       381.0          0.0
cuboid    5   1  4p7.9629     381.0          0.0
cuboid    8   1  7.9629 -8.3566 2p8.3566       381.0          0.0
unit 16    com='FANP 9x9 Assembly'
array 1 -6.53796 -6.53796 0.0
cuboid    3   1  4p7.62       381.0          0.0
cuboid    5   1  4p7.9629     381.0          0.0
cuboid    8   1  8.3566 -7.9629 8.3566 -7.9629 381.0          0.0
unit 17    com='FANP 9x9 Assembly'
array 1 -6.53796 -6.53796 0.0
cuboid    3   1  4p7.62       381.0          0.0
cuboid    5   1  4p7.9629     381.0          0.0
cuboid    8   1  8.3566 -7.9629 2p8.3566       381.0          0.0
unit 18    com='FANP 9x9 Assembly'
array 1 -6.53796 -6.53796 0.0
cuboid    3   1  4p7.62       381.0          0.0
cuboid    5   1  4p7.9629     381.0          0.0
cuboid    8   1  8.3566 -7.9629 8.3566 -7.9629 381.0          0.0
unit 19    com='FANP 9x9 Assembly'
array 1 -6.53796 -6.53796 0.0
cuboid    3   1  4p7.62       381.0          0.0
```

```
cuboid    5   1  4p7.9629     381.0          0.0
cuboid    8   1  2p8.3566 8.3566 -7.9629       381.0          0.0
unit 20    com='FANP 9x9 Assembly'
array 1 -6.53796 -6.53796 0.0
cuboid    3   1  4p7.62       381.0          0.0
cuboid    5   1  4p7.9629     381.0          0.0
cuboid    8   1  7.9629 -8.3566 8.3566 -7.9629 381.0          0.0
unit 21    com='FANP 9x9 Assembly'
array 1 -6.53796 -6.53796 0.0
cuboid    3   1  4p7.62       381.0          0.0
cuboid    5   1  4p7.9629     381.0          0.0
cuboid    8   1  8.3566 -7.9629 2p8.3566       381.0          0.0
unit 22    com='FANP 9x9 Assembly'
array 1 -6.53796 -6.53796 0.0
cuboid    3   1  4p7.62       381.0          0.0
cuboid    5   1  4p7.9629     381.0          0.0
cuboid    8   1  4p8.3566     381.0          0.0
unit 23    com='FANP 9x9 Assembly'
array 1 -6.53796 -6.53796 0.0
cuboid    3   1  4p7.62       381.0          0.0
cuboid    5   1  4p7.9629     381.0          0.0
cuboid    8   1  7.9629 -8.3566 2p8.3566       381.0          0.0
unit 24    com='FANP 9x9 Assembly'
array 1 -6.53796 -6.53796 0.0
cuboid    3   1  4p7.62       381.0          0.0
cuboid    5   1  4p7.9629     381.0          0.0
cuboid    8   1  8.3566 -7.9629 7.9629 -8.3566 381.0          0.0
unit 25    com='FANP 9x9 Assembly'
array 1 -6.53796 -6.53796 0.0
cuboid    3   1  4p7.62       381.0          0.0
cuboid    5   1  4p7.9629     381.0          0.0
cuboid    8   1  2p8.3566       7.9629 -8.3566 381.0          0.0
unit 26    com='FANP 9x9 Assembly'
array 1 -6.53796 -6.53796 0.0
cuboid    3   1  4p7.62       381.0          0.0
cuboid    5   1  4p7.9629     381.0          0.0
cuboid    8   1  7.9629 -8.3566 7.9629 -8.3566 381.0          0.0
unit 27    com='FANP 9x9 Assembly'
array 1 -6.53796 -6.53796 0.0
cuboid    3   1  4p7.62       381.0          0.0
cuboid    5   1  4p7.9629     381.0          0.0
cuboid    8   1  8.3566 -7.9629 8.3566 -7.9629 381.0          0.0
unit 28    com='FANP 9x9 Assembly'
array 1 -6.53796 -6.53796 0.0
cuboid    3   1  4p7.62       381.0          0.0
cuboid    5   1  4p7.9629     381.0          0.0
cuboid    8   1  2p8.3566 8.3566 -7.9629       381.0          0.0
unit 29    com='FANP 9x9 Assembly'
array 1 -6.53796 -6.53796 0.0
cuboid    3   1  4p7.62       381.0          0.0
cuboid    5   1  4p7.9629     381.0          0.0
cuboid    8   1  7.9629 -8.3566 8.3566 -7.9629 381.0          0.0
unit 30    com='FANP 9x9 Assembly'
array 1 -6.53796 -6.53796 0.0
cuboid    3   1  4p7.62       381.0          0.0
cuboid    5   1  4p7.9629     381.0          0.0
cuboid    8   1  8.3566 -7.9629 7.9629 -8.3566 381.0          0.0
```

```
unit 31    com='FANP 9x9 Assembly'
array 1 -6.53796 -6.53796 0.0
cuboid    3   1  4p7.62       381.0         0.0
cuboid    5   1  4p7.9629     381.0         0.0
cuboid    8   1  2p8.3566       7.9629 -8.3566 381.0         0.0
unit 32    com='FANP 9x9 Assembly'
array 1 -6.53796 -6.53796 0.0
cuboid    3   1  4p7.62       381.0         0.0
cuboid    5   1  4p7.9629     381.0         0.0
cuboid    8   1  7.9629 -8.3566 7.9629 -8.3566 381.0         0.0
unit 33    com='FANP 9x9 Assembly'
array 1 -6.53796 -6.53796 0.0
cuboid    3   1  4p7.62       381.0         0.0
cuboid    5   1  4p7.9629     381.0         0.0
cuboid    8   1  8.3566 -7.9629 8.3566 -7.9629 381.0         0.0
unit 34    com='FANP 9x9 Assembly'
array 1 -6.53796 -6.53796 0.0
cuboid    3   1  4p7.62       381.0         0.0
cuboid    5   1  4p7.9629     381.0         0.0
cuboid    8   1  2p8.3566 8.3566 -7.9629       381.0         0.0
unit 35    com='FANP 9x9 Assembly'
array 1 -6.53796 -6.53796 0.0
cuboid    3   1  4p7.62       381.0         0.0
cuboid    5   1  4p7.9629     381.0         0.0
cuboid    8   1  7.9629 -8.3566 8.3566 -7.9629 381.0         0.0
unit 36    com='FANP 9x9 Assembly'
array 1 -6.53796 -6.53796 0.0
cuboid    3   1  4p7.62       381.0         0.0
cuboid    5   1  4p7.9629     381.0         0.0
cuboid    8   1  8.3566 -7.9629 7.9629 -8.3566 381.0         0.0
unit 37    com='FANP 9x9 Assembly'
array 1 -6.53796 -6.53796 0.0
cuboid    3   1  4p7.62       381.0         0.0
cuboid    5   1  4p7.9629     381.0         0.0
cuboid    8   1  2p8.3566       7.9629 -8.3566 381.0         0.0
unit 38    com='FANP 9x9 Assembly'
array 1 -6.53796 -6.53796 0.0
cuboid    3   1  4p7.62       381.0         0.0
cuboid    5   1  4p7.9629     381.0         0.0
cuboid    8   1  7.9629 -8.3566 7.9629 -8.3566 381.0         0.0
unit 39   com='FANP 9x9 Assembly'
array 1 -6.53796 -6.53796 0.0
cuboid    3   1  4p7.62       381.0         0.0
cuboid    5   1  4p7.9248     381.0         0.0
cuboid    8   1  8.3185 -7.9248 8.3185 -7.9248 381.0         0.0
unit 40  com='FANP 9x9 Assembly'
array 1 -6.53796 -6.53796 0.0
cuboid    3   1  4p7.62       381.0         0.0
cuboid    5   1  4p7.9248     381.0         0.0
cuboid    8   1  7.9248 -8.3185 8.3185 -7.9248 381.0         0.0
unit 41  com='FANP 9x9 Assembly'
array 1 -6.53796 -6.53796 0.0
cuboid    3   1  4p7.62       381.0         0.0
cuboid    5   1  4p7.9248     381.0         0.0
cuboid    8   1  8.3185 -7.9248 7.9248 -8.3185 381.0         0.0
unit 42  com='FANP 9x9 Assembly'
array 1 -6.53796 -6.53796 0.0
```

```
cuboid    3   1  4p7.62        381.0          0.0
cuboid    5   1  4p7.9248      381.0          0.0
cuboid    8   1  7.9248 -8.3185 7.9248 -8.3185 381.0          0.0
unit 43   com='FANP 9x9 Assembly'
array 1 -6.53796 -6.53796 0.0
cuboid    3   1  4p7.62        381.0          0.0
cuboid    5   1  4p7.9248      381.0          0.0
cuboid    8   1  8.3185 -7.9248 8.3185 -7.9248 381.0          0.0
unit 44  com='FANP 9x9 Assembly'
array 1 -6.53796 -6.53796 0.0
cuboid    3   1  4p7.62        381.0          0.0
cuboid    5   1  4p7.9248      381.0          0.0
cuboid    8   1  7.9248 -8.3185 8.3185 -7.9248 381.0          0.0
unit 45  com='FANP 9x9 Assembly'
array 1 -6.53796 -6.53796 0.0
cuboid    3   1  4p7.62        381.0          0.0
cuboid    5   1  4p7.9248      381.0          0.0
cuboid    8   1  8.3185 -7.9248 7.9248 -8.3185 381.0          0.0
unit 46  com='FANP 9x9 Assembly'
array 1 -6.53796 -6.53796 0.0
cuboid    3   1  4p7.62        381.0          0.0
cuboid    5   1  4p7.9248      381.0          0.0
cuboid    8   1  7.9248 -8.3185 7.9248 -8.3185 381.0          0.0
unit 47   com='FANP 9x9 Assembly'
array 1 -6.53796 -6.53796 0.0
cuboid    3   1  4p7.62        381.0          0.0
cuboid    5   1  4p7.9248      381.0          0.0
cuboid    8   1  8.3185 -7.9248 8.3185 -7.9248 381.0          0.0
unit 48  com='FANP 9x9 Assembly'
array 1 -6.53796 -6.53796 0.0
cuboid    3   1  4p7.62        381.0          0.0
cuboid    5   1  4p7.9248      381.0          0.0
cuboid    8   1  7.9248 -8.3185 8.3185 -7.9248 381.0          0.0
unit 49  com='FANP 9x9 Assembly'
array 1 -6.53796 -6.53796 0.0
cuboid    3   1  4p7.62        381.0          0.0
cuboid    5   1  4p7.9248      381.0          0.0
cuboid    8   1  8.3185 -7.9248 7.9248 -8.3185 381.0          0.0
unit 50  com='FANP 9x9 Assembly'
array 1 -6.53796 -6.53796 0.0
cuboid    3   1  4p7.62        381.0          0.0
cuboid    5   1  4p7.9248      381.0          0.0
cuboid    8   1  7.9248 -8.3185 7.9248 -8.3185 381.0          0.0
unit 51   com='FANP 9x9 Assembly'
array 1 -6.53796 -6.53796 0.0
cuboid    3   1  4p7.62        381.0          0.0
cuboid    5   1  4p7.9248      381.0          0.0
cuboid    8   1  8.3185 -7.9248 8.3185 -7.9248 381.0          0.0
unit 52  com='FANP 9x9 Assembly'
array 1 -6.53796 -6.53796 0.0
cuboid    3   1  4p7.62        381.0          0.0
cuboid    5   1  4p7.9248      381.0          0.0
cuboid    8   1  7.9248 -8.3185 8.3185 -7.9248 381.0          0.0
unit 53  com='FANP 9x9 Assembly'
array 1 -6.53796 -6.53796 0.0
cuboid    3   1  4p7.62        381.0          0.0
cuboid    5   1  4p7.9248      381.0          0.0
```

```
cuboid    8   1  8.3185 -7.9248 7.9248 -8.3185 381.0          0.0
unit 54  com='FANP 9x9 Assembly'
array 1 -6.53796 -6.53796 0.0
cuboid    3   1  4p7.62       381.0          0.0
cuboid    5   1  4p7.9248     381.0          0.0
cuboid    8   1  7.9248 -8.3185 7.9248 -8.3185 381.0          0.0
unit 55  com='center 9x9 array'
array 2 -24.6761 -24.6761 0.0
cuboid    5   1  4p24.9428    381.0          0.0
cuboid    8   1  4p25.7302    381.0          0.0
unit 56  com='right 9x9 array'
array 3 -24.6761 -24.6761 0.0
cuboid    5   1  4p24.9428    381.0          0.0
unit 57  com='top 9x9 array'
array 4 -24.6761 -24.6761 0.0
cuboid    5   1  4p24.9428    381.0          0.0
unit 58  com='left 9x9 array'
array 5 -24.6761 -24.6761 0.0
cuboid    5   1  4p24.9428    381.0          0.0
unit 59  com='bottom 9x9 array'
array 6 -24.6761 -24.6761 0.0
cuboid    5   1  4p24.9428    381.0          0.0
unit 60  com='upper right 2x2 array'
array 7 -16.2433 -16.2433 0.0
cuboid    5   1  4p16.51      381.0          0.0
unit 61  com='upper left 2x2 array'
array 8 -16.2433 -16.2433 0.0
cuboid    5   1  4p16.51      381.0          0.0
unit 62  com='lower right 2x2 array'
array 9 -16.2433 -16.2433 0.0
cuboid    5   1  4p16.51      381.0          0.0
unit 63  com='lower right 2x2 array'
array 10 -16.2433 -16.2433 0.0
cuboid    5   1  4p16.51      381.0          0.0
unit 64  com='0.31" poison plate'
cuboid    8   1  2p16.51 2p0.3937 381.0      0.0
unit 65  com='0.31" poison plate'
cuboid    8   1  2p0.3937 2p16.51 381.0      0.0
unit 66  com='water rod'
cylinder  3  1  0.46228   381.0     0.0
cylinder  2  1  0.53975   381.0     0.0
cuboid    3  1  4P0.72644 381.0     0.0
global unit 67
cylinder  3   1  84.757       381.0          0.0
    hole 55   0.0       0.0      0.0
    hole 56   50.673    0.0      0.0
    hole 57   0.0       50.673   0.0
    hole 58  -50.673    0.0      0.0
    hole 59   0.0      -50.673   0.0
    hole 60   42.2404   42.2404  0.0
    hole 61  -42.2404   42.2404  0.0
    hole 62  -42.2404  -42.2404  0.0
    hole 63   42.2404  -42.2404  0.0
    hole 64   42.2404   25.3366  0.0
    hole 64  -42.2404   25.3366  0.0
    hole 64  -42.2404  -25.3366  0.0
    hole 64   42.2404  -25.3366  0.0
```

```
    hole 65   25.3366  42.2404 0.0
    hole 65  -25.3366  42.2404 0.0
    hole 65  -25.3366 -42.2404 0.0
    hole 65   25.3366 -42.2404 0.0
cylinder  5   1  86.027       381.0         0.0
cuboid    7   1  4p86.03      381.0         0.0
end FANPom
read array
   com='FANP 9x9 fuel assembly slice, sd, fuel regions'
   ara=1      nux=9      nuy=9      nuz=1
   fill
        1  1  1  1  1  1  1  1  1
        1  1  1  1  1  1  1  1  1
        1  1  1  1  1  1  1  1  1
        1  1  1  1  1  1  1  1  1
        1  1  1  1 66  1  1  1  1
        1  1  1 66  1  1  1  1  1
        1  1  1  1  1  1  1  1  1
        1  1  1  1  1  1  1  1  1
        1  1  1  1  1  1  1  1  1
   end fill
   com='Center 9x9 Array of Fuel'
   ara=2      nux=3      nuy=3      nuz=1
   fill
        18 19 20
         6  2  3
        11  9 10
   end fill
   com='Right 9x9 Array of Fuel'
   ara=3      nux=3      nuy=3      nuz=1
   fill
        27 28 29
         4  5  3
        30 31 32
   end fill
   com='Top 9x9 Array of Fuel'
   ara=4      nux=3      nuy=3      nuz=1
   fill
        16 13 14
        17 12 15
        11  9 10
   end fill
   com='Left 9x9 Array of Fuel'
   ara=5      nux=3      nuy=3      nuz=1
   fill
        33 34 35
         6  8  7
        36 37 38
   end fill
   com='Bottom 9x9 Array of Fuel'
   ara=6      nux=3      nuy=3      nuz=1
   fill
        18 19 20
        21 22 23
        24 25 26
   end fill
   com='Upper Right 2x2 Array of Fuel'
```

```
   ara=7       nux=2       nuy=2       nuz=1
   fill
        39 40
        41 42
   end fill
   com='Upper Left 2x2 Array of Fuel'
   ara=8       nux=2       nuy=2       nuz=1
   fill
        43 44
        45 46
   end fill
   com='Lower Left 2x2 Array of Fuel'
   ara=9       nux=2       nuy=2       nuz=1
   fill
        47 48
        49 50
   end fill
   com='Lower Right 2x2 Array of Fuel'
   ara=10      nux=2       nuy=2       nuz=1
   fill
        51 52
        53 54
   end fill
end array
read bounds
   xyf=specular
   zfc=water
end bounds
read plot
   ttl='cask material plot  - plan view'
   pic=mat
   nch=' fzmcsblxg'
   xul=-87   yul=87    zul=200
   xlr=87    ylr=-87   zlr=200
   uax=1.0    vdn=-1.0
   nax=650
end plot
end data
end
```

Table K.6-2
Authorized Contents for NUHOMS®-61BT System

Assembly Type (1)	Array
Intact Fuel	
General Electric 7x7 /GE1	7x7
General Electric 7x7 /GE2	7x7
General Electric 7x7 /GE3	7x7
Exxon/ANF 7x7 /ENC III-A	7x7
Exxon/ANF 7x7 /ENC III(2)	7x7
General Electric 8x8 /GE4	8x8
General Electric 8x8 /GE5	8x8
General Electric 8x8 /GE-Pres	8x8
General Electric 8x8 /GE-Barrier	8x8
General Electric 8x8 /GE8 Type I	8x8
General Electric 8x8 /GE8 Type II	8x8
General Electric 8x8 /GE9	8x8
General Electric 8x8 /GE10	8x8
Exxon/ANF 8x8 /ENC Va and Vb	8x8
General Electric 9x9 /GE11	9x9
General Electric 9x9 /GE13	9x9
Framatome ANP 9x9/FANP9 9x9-2	*9x9*
General Electric 10x10 /GE12	10x10
Damaged Fuel with up to 7 damaged rods per assembly	
General Electric 7x7 /GE1	7x7
General Electric 7x7 /GE2	7x7
General Electric 7x7 /GE3	7x7
Exxon/ANF 7x7 /ENC III-A	7x7
Exxon/ANF 7x7 /ENC III(2)	7x7
General Electric 8x8 /GE4	8x8
General Electric 8x8 /GE5	8x8
General Electric 8x8 /GE-Pres	8x8
General Electric 8x8 /GE-Barrier	8x8
General Electric 8x8 /GE8 Type I	8x8
General Electric 8x8 /GE8 Type II	8x8
General Electric 8x8 /GE9	8x8
General Electric 8x8 /GE10	8x8
Exxon/ANF 8x8 /ENC Va and Vb	8x8

(1) Reload fuel from other manufacturers with the same parameters as those listed in Table K.6-3 are also considered as authorized contents.

(2) Includes ENC III-E and ENC III-F.

Table K.6-3
Parameters for BWR Assemblies

Manufacturer[1]	Array	Version	Active Fuel Length (in)	Number Fuel Rods per Assembly	Pitch (in)	Fuel Pellet OD (in)	Clad Thickness (in)	Clad OD (in)	Water Rod OD (in)	Water Rod ID (in)
GE	7x7	GE1	144	49	0.738	0.488	0.0355	0.570	NA	NA
GE	7x7	GE2	144	49	0.738	0.487	0.032	0.563	NA	NA
GE	7x7	GE3	144	49	0.738	0.487	0.032	0.563	NA	NA
Exxon/ANF	7x7	ENC III-A	144	49	0.738	(2)	0.0355[4]	0.570	NA	NA
Exxon/ANF	7x7	ENC III	144	48	0.738	(3)	0.0355[4]	0.570	0.572[5]	NA
GE	8x8	GE4	146	63	0.640	0.416	0.034	0.493	0.591	0.531
GE	8x8	GE5	150	62	0.640	0.410	0.032	0.483	0.591	0.531
GE	8x8	GE-Pres	150	62	0.640	0.410	0.032	0.483	0.591	0.531
GE	8x8	GE-Barrier	150	62	0.640	0.410	0.032	0.483	0.591	0.531
GE	8x8	GE8 Type I	150	62	0.640	0.410	0.032	0.483	0.591	0.531
GE	8x8	GE8 Type II	150	60	0.640	0.411	0.032	0.483	2@0.0591 2@0.0483	2@0.531 2@0.4312
GE	8x8	GE9	150	60	0.640	0.411	0.032	0.483	1.34	1.26
GE	8x8	GE10	150	60	0.640	0.411	0.032	0.483	1.34	1.26
Exxon/ANF	8x8	ENC Va and Vb	144	60	0.642	0.4195	0.036	0.5015	0.5015[5]	NA
GE	9x9	GE11	146-Full 90-Partial	66-Full 8-Partial	0.566	0.376	0.028	0.440	0.98	0.92
GE	9x9	GE13	146-Full 90-Partial	66-Full 8-Partial	0.566	0.376	0.028	0.440	0.98	0.92
Framatome	*9x9*	*FANP9 9x9-2*	*150*	*79*	*0.572*	*0.3565*	*0.030*	*0.424*	*0.425*	*0.364*
GE	10x10	GE12	150-Full 93-Partial	78-Full 14-Partial	0.510	0.345	0.026	0.404	0.98	0.92

(1) Reload fuel from other manufacturers with these parameters are also acceptable.
(2) Variable Fuel Pellet OD – evaluated from 0.468 to 0.488 in same assembly
(3) Variable Fuel Pellet OD – evaluated from 0.468 to 0.491 in same assembly.
(4) Variable Fuel Clad Thickness from 0.0355 to 0.0455 in – Thinnest clad thickness listed and conservatively used in the analysis.
(5) Solid Zirc rod(s)

Table K.6-6
Most Reactive Fuel Type

(Continued)

Manufacturer	Array	Version	k_{KENO}	1σ	k_{eff}
FANP	*9x9*	*FANP 9*	*0.9072*	*0.0015*	*0.9102*
FANP	*9x9 0.120 channel*	*FANP 9*	*0.9066*	*0.0013*	*0.9092*
FANP	*9x9 0.080 channel*	*FANP 9*	*0.9074*	*0.0013*	*0.9100*
FANP	*9x9 0.065 channel*	*FANP 9*	*0.9065*	*0.0011*	*0.9087*
GE	10x10	GE12	0.9095	0.0013	0.9121
GE	10x10 0.120 channel	GE12	0.9094	0.0010	0.9114
GE	10x10 0.080 channel	GE12	0.9092	0.0013	0.9118
GE	10x10 0.065 channel	GE12	0.9076	0.0011	0.9098
GE	7x7 w/variable enrichment	GE2, GE3	0.8947	0.0012	0.8971
GE	8x8 w/variable enrichment	GE5	0.8951	0.0011	0.8973
GE	8x8 w/variable enrichment	GE9	0.9008	0.0013	0.9034

(1) Small Fuel Pellet (0.468") OD (Note Large Pellet (0.488") OD identical to GE1 analysis)
(2) Small Fuel Pellet (0.468") OD
(3) Large Fuel Pellet (0.491") OD

Point detectors are placed at the following locations as measured from each face of the "box": 6.095 m (20ft), 10 m, 20 m, 30 m, 40 m, 50 m, 60 m, 70 m, 80 m, 90 m, 100 m, 200 m, 300 m, 400 m, 500 m, and 600 m. Each point detector is placed 91.4 cm (3 feet) above the ground.

The MCNP results for each detector from the front of 2x10 back-to-back array are summarized in Table K.10-6. The MCNP results as a function of distance from the back of the two 1x10 front-to-front array are summarized in Table K.10-7. The MCNP results as a function of distance from the side of the 2x10 back-to-back array and the two 1x10 front-to-front arrays are summarized in Table K.10-8. The results from Table K.10-6, Table K.10-7 and Table K.10-8 are plotted in Figure K.10-1.

K.10.2A *Evaluation of 61BT DSC with FANP9 9x9-2 Fuel Assemblies*

As addressed in the Shielding Evaluation discussion in Section K.5.4A, the design basis source terms and calculated dose rates with the design basis fuel bound those for the FANP9 9x9-2 fuel. Therefore, the Occupational Exposure and Off-site dose evaluations presented in this chapter remain bounding.

highly unlikely. Any fire within the ISFSI boundary while the DSC is in the HSM would be bounded by the fire during transfer cask movement. The HSM concrete acts as a significant insulating fire wall to protect the 61BT-DSC from the high temperatures of the fire.

K.11.2.10.2 Accident Analysis

The evaluation of the hypothetical fire event is presented in Section K.4.6.5. The fire thermal evaluation is performed primarily to demonstrate the confinement integrity and fuel retrievability of the 61BT-DSC. This is assured by demonstrating that the DSC temperatures and internal pressures will not exceed those of the blocked vent condition (see Section K.11.2.7) during the fire scenario. Peak temperatures for the NUHOMS®-61BT system components are summarized in Table K.4-6.

K.11.2.10.3 Accident Dose Calculations

The 61BT-DSC confinement boundary will not be breached as a result of the postulated fire/explosion scenario. Accordingly, no 61BT-DSC damage or release of radioactivity is postulated. Because no radioactivity is released, no resultant dose increase is associated with this event.

The fire scenario may result in the loss of cask neutron shielding should the fire occur while the 61BT-DSC is in the cask. The effect of loss of the neutron shielding due to a fire is bounded by that resulting from a cask drop scenario. See Section K.11.2.5.3 for evaluation of the dose consequences of a cask drop.

K.11.2.10.4 Corrective Actions

Evaluation of HSM or cask neutron shield damage as a result of a fire is to be performed to assess the need for temporary shielding (for HSM or cask, if fire occurs during transfer operations) and repairs to restore the transfer cask and HSM to pre-fire design conditions.

K.11.2.11 Evaluation of 61BT DSC with FANP9 9x9-2 Fuel Assemblies

As addressed in the discussion for the Structural Evaluation (Section K.3.7A), Thermal Evaluation (Section K.4.8A), and Shielding Evaluation (Section K.5.4A) above, the critical parameters for these analyses with design basis fuel bound those for the FANP9 fuel. Therefore, the off-normal and accident analyses results presented in this chapter remain bounding.