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1	1	QA J. E. Parker		10/2/97	N2-11	1	1 (H)	D.A. Gantt	10/8/97	10/8/97	N2-13
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Criticality Safety Evaluation Report for FFTF 42% Fuel Assemblies

R. F. Richard

Fluor Daniel Northwest, Inc., Richland, WA 99352

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Abstract: This Criticality Safety Evaluation determines the minimum critical number for 42 wt% PuO₂ FFTF fuel assemblies. Also addressed is an assessment of the criticality evaluation needs for IDS and FSF with respect to this fuel.

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Contents

1.0	Introduction/Summary	1
2.0	Conclusion	1
3.0	Description	2
4.0	Special Requirements & Controls	3
5.0	Method of Analysis & Results	3
5.1	Calculations	3
5.2	Results	3
5.2.1	Minimum Critical Number in Water	3
5.2.2	Minimum Critical Number in Sodium	5
5.2.3	Minimum Critical Number in Air	7
5.3	Assessment of 42 wt% Pu Fuel Assembly Storage in CCC/ISC	8
6.0	Storage Facilities	9
6.1	Interim Examination & Maintenance Cell	9
6.2	Interim Decay Storage	10
6.3	Fuel Storage Facility	11
7.0	Contingency Analysis	11
8.0	References	11
Appendix A	Sample MONK6B Input Files	A-1
Appendix B	Independent Review Comments and Checklist	B-1

1.0 Introduction/Summary

An FFTF tritium/isotope production mission will require a new fuel supply. The reference design core will use a mixed oxide fuel nominally enriched to 40 wt% Pu. This enrichment is significantly higher than that of the standard Driver Fuel Assemblies used in past operations. Consequently, criticality safety for handling and storage of this fuel must be addressed. The purpose of this document is to begin the process by determining the minimum critical number for these new fuel assemblies in water, sodium and air. To conservatively bound the fuel for the reference design core, the analysis was done using 42 wt% Pu(5.96 wt% ^{240}Pu) O_2 . This analysis is preliminary and further work can be done to refine the results reported here. Analysis was initially done using 45 wt% PuO_2 fuel assemblies and are also reported. Additionally, a preliminary assessment is done concerning storage of these fuel assemblies in Interim Decay Storage (IDS), Fuel Storage Facility (FSF), and Core Component Containers/Interim Storage Casks (CCC/ISC).

2.0 Conclusion

For 42 wt% PuO_2 fuel assemblies in water the minimum critical number is greater than 3 and less than four, greater than 10 and less than 11 in sodium, and greater than 13 and less than 14 in air. The minimum critical number in sodium and air is based on a conservative model of the assembly arrays with close concrete reflection. Refinement of this analysis could be done in the future that may possibly increase the minimum critical number in sodium and air, if needed.

It is likely that at least six 42 wt% fuel assemblies can be safely stored in a CCC/ISC.

An assessment of existing IDS and FSF criticality documentation resulted in the conclusion that further analysis is required before 42 wt % fuel assemblies can be stored in either.

With 42 wt% PuO_2 fuel the number of fuel units in the IEM Cell shall not exceed 9. Individual pins are not allowed without further analysis. Floor grid structures must be in place when this fuel is present in the Cell.

3.0 Description

For this analysis the fuel assemblies were explicitly modeled with 217 pins. Assembly and pin dimensions used are those of a standard FFTF driver fuel assembly. Dimensions are provided in Table 1.

Table 1. Fuel Assembly Dimensions

Dimension	in (cm)
cladding - inner diameter	0.200 (0.5080)
cladding - outer diameter	0.230 (0.5840)
duct - inner wall to wall	4.335 (11.0109)
duct - outer wall to wall	4.575 (11.6205)

Analyses were done for both 42 wt% Pu fuel and 45 wt% Pu fuel. The isotopic distribution is from DOE/EIS-0229. Masses for both are given in Table 2.

Table 2. Fuel Masses (grams)

nuclide	42 wt% Pu	45 wt% Pu
^{238}Pu	0.46	0
^{239}Pu	12944.5	13943.3
^{240}Pu	821.2	894.58
^{241}Pu	5.83	75.61
^{242}Pu	1.39	0
^{241}Am	92.28	0
^{235}U	41.4	39.6
^{238}U	18979	18187
O	4367	4413

4.0 Special Requirements and Controls

The following analysis has determined that the minimum critical number for 42 wt% PuO₂ fuel assemblies in water is between 3 and 4. In sodium it is between 10 and 11, and, in air, between 13 and 14. Based on these results, and to assure the double contingency policy, these fuel assemblies are to be handled as a batch limit of 1 (max) assembly.

5.0 Method of Analysis and Results

5.1 Calculations

Calculations were done for unirradiated fuel assembly arrays in water, sodium and void (air). The fuel assembly ducts, pins and cladding were explicitly modeled. For most calculations the fuel assembly was modeled as a hexagon. A square fuel assembly model was used when there was no spacing between the assemblies allowing for close concrete reflection. For both the hexagonal model and square model the fuel pin pitch is 0.286 in. The modeling includes 12 inches of ordinary concrete reflection surrounding the array. Using ordinary concrete rather than high density concrete has no significant effect on k_{eff} . A parametric evaluation was done by varying the moderator density and fuel assembly spacing. All calculations were done with MONK6B (UKAEA 1988). MONK6B has been validated for Pu systems. Accounting for margins of safety and biasing, a calculated k_{eff} of 0.935 is considered to be critical (Macklin 1991, Miller 1994).

5.2 Results

5.2.1 MCN in Water

Results of the analysis show that, in water the minimum critical number of fuel assemblies is greater than 3 and less than 4. This is true for fuel enrichment of either 42 wt% Pu or 45 wt% Pu. With four assemblies k_{eff} is over the 0.935 calculational limit and under 0.935 for three assemblies. The difference in k_{eff} for 3 assemblies between the two enrichments is 0.0176. Table 3 presents the k_{eff} 's for 2,3 and 4 fuel assemblies for both enrichments. For these cases the assemblies are separated by 0.75 in. Also included in this, and the following tables, are the MONK6B file names for each calculation.

Table 3. Assemblies in Water, Spacing = 0.75 in.

Number of Assemblies	42 wt% Pu			45 wt% Pu		
	k_{eff}	σ_c	file	k_{eff}	σ_c	file
4	0.9413	0.0030	mcn42cw	0.9687	0.0031	mcn45cw
3	0.8753	0.0029	mcn42bw	0.8929	0.0030	mcn45bw
2	0.7571	0.0028	mcn42mw	0.7892	0.0030	mcn45mw

Table 4 shows the affect of varying the distance between three fuel assemblies. The k_{eff} change as the assembly spacing goes from 0.39 in. to 0.75 in. is within the calculated uncertainty. The affect on k_{eff} as spacing decreases below 0.39 in. is not expected to be significant. As the assemblies move farther apart k_{eff} goes down. The results presented here are for the assemblies oriented flat-to-flat. Rotating the assemblies to a vertex-to-vertex orientation has no significant affect on k_{eff} . The calculations were done with ordinary concrete reflection. Substitution of the ordinary concrete with high density concrete had an insignificant affect on k_{eff} .

Table 4. Assemblies (3) in Water, Increasing Spacing

Spacing (in.)	42 wt% Pu			45 wt% Pu		
	k_{eff}	σ_c	file	k_{eff}	σ_c	file
0.39	0.8760	0.0030	mcn42dw	0.8927	0.0029	mcn45dw
0.75	0.8753	0.0029	mcn42bw	0.8929	0.0030	mcn45bw
1.97	0.8134	0.0028	mcn42kw	0.8268	0.0028	mcn45kw
3.94	0.6917	0.0027	mcn42lw	0.7141	0.0028	mcn45lw

Table 5 shows the affect of reducing the water density around three fuel assemblies. For all cases, assembly spacing is 0.75 in. As the water density is reduced, k_{eff} decreases.

Table 5. Decreasing Water Density

Water Density fraction	42 wt% Pu			45 wt% Pu		
	k_{eff}	σ_c	file	k_{eff}	σ_c	file
1.0	0.8753	0.0029	mcn42bw	0.8927	0.0029	mcn45dw
0.9	0.8555	0.0029	mcn42nw	0.8788	0.0031	mcn45nw
0.8	0.8383	0.0030	mcn42ow	0.8603	0.0028	mcn45ow
0.7	0.8206	0.0028	mcn42pw	0.8386	0.0031	mcn45pw
0.5	0.7569	0.0027	mcn42qw	0.7798	0.0028	mcn45qw
0.3	0.6874	0.0026	mcn42rw	0.7121	0.0025	mcn45rw
0.1	0.6020	0.0024	mcn42sw	0.6244	0.0025	mcn45sw
dry	0.5678	0.0022	mcn42tw	0.5955	0.0024	mcn45tw

5.2.2 MCN in Sodium

In sodium, the minimum critical number of 42 wt% fuel assemblies is greater than 10 and less than 11 (Table 8). Results are presented in Table 6 for 42 wt% and 45 wt% fuel with 0.75 in. spacing between assemblies.

Table 6. Assemblies in Sodium

Number of Assemblies	42 wt% Pu			45 wt% Pu		
	k_{eff}	σ_c	file	k_{eff}	σ_c	σ_c
16	-	-	-	1.0464	0.0031	mcn45as
14	0.9653	0.0028	mcn42cs	-	-	-
13	0.9368	0.0028	mcn42ds	-	-	-
12	0.9264	0.0028	mcn42bs	0.9702	0.0029	mcn45bs
11	0.8912	0.0027	mcn42es	0.9300	0.0028	mcn45es
10	-	-	-	0.9036	0.0027	mcn45cs
8	-	-	-	0.8204	0.0025	mcn45ds

The effect of changing the spacing between twelve 42 wt% fuel assemblies is presented in Table 7. With decreased spacing k_{eff} increases and with increased spacing k_{eff} decreases.

Table 7. Assembly (12) Spacing vs k_{eff}

Spacing (in.)	k_{eff}	σ_e	file
0.0	0.9616	0.0028	sq3x4s
0.75	0.9264	0.0028	mcn42bs
1.97	0.8380	0.0026	mcn42ls
3.94	0.7437	0.0026	mcn42ms

Table 8 presents the results with no spacing between the 42 wt% assemblies. The k_{eff} limit of 0.935 occurs between 10 and 11 assemblies. For these calculations the assemblies were modeled as squares rather the hexagons. This allowed for closer concrete reflection around the assembly array.

Table 8. Assemblies in Sodium, No Spacing

Number of Assemblies	k_{eff}	σ_e	file
12	0.9616	0.0028	sq3x4s
11	0.9356	0.0028	sq11s
10	0.8991	0.0027	sq10s

As the sodium density is reduced k_{eff} goes down. The results are presented in Table 9 for both enrichments and 0.75 in. spacing.

Table 9. Decreasing Sodium Density

Sodium Density Fraction	42 wt% Pu (12 assemblies)			45 wt% Pu (11 assemblies)		
	k_{eff}	σ_c	file	k_{eff}	σ_c	file
1.0	0.9264	0.0028	mcn42bs	0.9300	0.0028	mcn45es
0.9	0.9236	0.0027	mcn42gs	0.9294	0.0028	mcn45gs
0.7	0.9176	0.0027	mcn42hs	0.9149	0.0027	mcn45hs
0.5	0.9014	0.0027	mcn42is	0.9032	0.0027	mcn45is

5.2.3 MCN in Air

In air the minimum critical number of assemblies is greater than 13 and less than 14 for 42 wt% fuel assemblies (Table 12). Results for both 42 wt% and 45 wt% fuel with 0.75 in. spacing are presented in Table 10.

Table 10. Assemblies in Air

Number of Assemblies	42 wt% Pu			45 wt% Pu		
	k_{eff}	σ_c	file	k_{eff}	σ_c	file
16	0.9369	0.0027	mcn42ad	0.9721	0.0027	mcn45ad
15	0.9078	0.0027	mcn42hd	-	-	-
14	0.8879	0.0026	mcn42cd	0.9274	0.0027	mcn45cd
12	-	-	-	0.9017	0.0027	mcn45bd

The effect on k_{eff} of changing the spacing between 15 fuel assemblies in air is shown in Table 11.

Table 11. Assembly Spacing vs k_{eff} in Air

Spacing (in.)	42 wt% Pu (15 assemblies)		
	k_{eff}	σ_c	file
0.0	0.9749	0.0027	sq15d
0.75	0.9078	0.0027	mcn42hd
1.97	0.7775	0.0026	mcn42ed
3.94	0.7055	0.0025	mcn42fd

K_{eff} increases as the spacing between assemblies decreases. Table 12 presents the results for no spacing between the 42 wt% fuel assemblies in air.

Table 12. No Spacing Between 42 Wt% Assemblies

Number of assemblies	k_{eff}	σ_c	file
16	1.0125	0.0028	sq4x4d
15	0.9749	0.0027	sq15d
14	0.9382	0.0027	sq14d
13	0.9101	0.0027	sq13d

The maximum allowable k_{eff} , 0.935, occurs between 13 and 14 assemblies. These results are conservative because the assemblies were modeled as squares rather than hexagons allowing for tighter concrete reflection.

5.3 Assessment of 42 wt% Pu Fuel Assembly Storage in CCC/ISC

All fuel assemblies will eventually be stored in CCC/ISCs. Much analysis has previously been performed pertaining to the storage of standard Series I and II FFTF Driver Fuel Assemblies (DFAs), pin containers and metal fuel in CCC/ISCs. To establish a preliminary estimate of the number of 42 wt% fuel assemblies that can be stored in a CCC/ISC, two calculations were performed. In one calculation six metal assemblies in a CCC/ISC are replaced

with six 42 wt% fuel. In the second calculation in a CCC/ISC with five metal and two DFAs, the five metal assemblies are replaced with five 42 wt% Pu assemblies. As for the metal assembly cases, no 42 wt% assemblies are in the center storage position when 42 wt% assemblies and DFAs are mixed. All cases are with intact fuel assemblies and are water moderated. The concrete of the ISC provides reflection. The results are presented in Table 13. Cases grm6c and grm5f are from a previous CCC/ISC analysis (Richard 1997).

Table 13. Fuel Assemblies in CCC/ISC

CCC/ISC Loading	k_{eff}	σ_c	file
6 42 wt% assemblies	0.8327	0.0028	cccw6
6 metal assemblies	0.8537	0.0029	grm6c
5 42 wt% + 2DFAs	0.8492	0.0029	cccw5
5 metal + 2 DFAs	0.8593	0.0029	grm5f

These results show that a moderated CCC/ISC with 42 wt% PuO₂ intact fuel assemblies has a lower k_{eff} than a CCC/ISC with metal assemblies or one with five metal assemblies and two DFAs. This is a good indication that it is likely that at least six 42 wt% PuO₂ fuel assemblies could be stored in a CCC. However, further analysis is required to assess the effect of hot cell rot and to determine loading restrictions, if any.

6.0 Storage Facilities

A fuel assembly will reside in a variety of locations as it awaits insertion into the core and after discharge from the core. Each storage location has specific criticality requirements that must be met. This section addresses the current requirements of IDS and FSF and what will be necessary to allow storage of 42 wt% PuO₂ fuel assemblies.

6.1 Interim Examination & Maintenance Cell

Based on the minimum critical number results of Section 5.2, the number of 42 wt% fuel units in the IEM Cell shall not exceed 9. Analyses of individual loose pins were not done.

This analysis does not address the situation of the 42 wt% fuel assemblies being in the Cell simultaneously with 31 wt% Driver Fuel assemblies or metal assemblies. The 31 wt% assemblies are clearly bounded by the 42 wt% assemblies and having both in the Cell at the same time may possibly be allowed with restrictions less stringent than those for the 42 wt% fuel.

Further analysis is needed for conformation. Also, having both metal fuel and 42 wt% fuel in the Cell at the same time will require analysis before that is allowed.

6.2 Interim Decay Storage

The current IDS k_{eff} criticality limit is 0.90. This limit allows the following fuel types to be loaded into the 112 storage positions in Rings B, C, D and E of the IDS array without restriction :

- MFF-2, MFF-3 and MFF-4;
- Assemblies of identical design to MFF-4 which contain uranium metal enriched to 34.0 wt% ^{235}U ;
- DFAs containing mixed oxide enriched to 35.0 wt% PuO_2 with a ^{240}Pu content of 10.0 wt% (min.);
- Type A Assemblies;
- CRBR-3 and CRBR-5 assemblies after irradiation.

If DFAs are limited to 33.0 wt% PuO_2 with a ^{240}Pu content of 10.0 wt% (min.), the following assemblies may be stored in Rings B, C, D and E of IDS with a limit of 8:

- MFF-5 and MFF-6;
- Assemblies of identical design to MFF-2 which contain uranium metal enriched to 38.0 wt% ^{235}U ;
- DFAs containing mixed oxide enriched to 39 wt% PuO_2 (max.) with a ^{240}Pu content of 10.0 wt% (min.);
- IFR-1.

Also, table 4 of the A/B pin list allows MFF-8A in IDS .

It is apparent from the current restrictions that 42 wt% PuO_2 fuel assemblies can not, at this time, be stored in IDS. Existing analyses show that filling IDS with 112 40 wt% PuO_2 with 11.5 wt% ^{240}Pu fuel assemblies will result in a k_{eff} of 0.957. Since the proposed FFTF Tritium/Isotope production mission requires a fuel enrichment of 40 wt% PuO_2 with 5.96 wt% ^{240}Pu , an alternative IDS loading scheme will be required. Currently mixed oxide fuel up to 35.0 wt% PuO_2 with ≥ 10.0 wt % ^{240}Pu can be loaded into the storage positions of Rings B, C, D and E without restriction (provided there are no higher enriched assemblies in IDS, such as the MFF's). Limiting the number of 42 wt% PuO_2 fuel assemblies allowed in IDS sufficiently would result in k_{eff} less than 0.90. Another alternative could be to add a neutron poison to IDS. It may be possible to take burnup credit for irradiated fuel. These options, or others, will require analysis to determine the best IDS loading for 42 wt% fuel assemblies without exceeding the 0.90 k_{eff} limit.

6.3 Fuel Storage Facility

FSF was originally designed to store mixed oxide fuel enriched up to 29.3 wt% PuO₂. Currently up to 31 wt% PuO₂ fuel is allowed in FSF with the requirement that rows 1, 2 and 5 are sealed off and remain empty (Morford 1984). This assures that k_{eff} will remain below 0.95. As with IDS, with a new FFTF mission, FSF will be required to store the higher enriched fuel. To accomplish this could entail adding more neutron poison or restricting the 42 wt% fuel to specific rows. Burnup credit for irradiated fuel may be possible. An effort was initiated in the past, but not completed, to take credit for burnup in order to open the sealed rows (Morford 1993). The work was not completed and was based on fuel with enrichments less than 29.3 wt%. Like IDS, analysis will be required to determine the best fuel loading scenario for FSF.

7.0 Contingency Analysis

This analysis has determined the minimum critical number of 42 wt% fuel assemblies in water, sodium and air. To assure the double contingency policy, these assemblies must be handled in batches that are less than half that required for a minimum critical number. This necessitates a batch limit of 1 (max) assembly.

8.0 References

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Appendix A
Sample MONK6B Input Files

Following are MONK6B sample input files used in this analysis. First is the water moderated, three PuO₂ fuel assembly case from Table 3 in section 5.2.1. The name of this input file is mcn42bw.

All input files end with the extension .i, while all output files end with the extension .o or .prt. The MONK6B input and output files are saved on cfs. The 42 wt% files are saved as /w98142/mcn42/trit42.tar.Z. The 45 wt% files are saved as /w98142/mcn45/trit45.tar.Z.

- * This MONK6B input describes 3 tritium core fuel assemblies
- * These assemblies have 217 pins and the fuel is 42wt% Pu
- * The assemblies pins are modeled explicitly in a hexagonal duct.
- *
- * This is one of a series of calculations to determine the minimum
- * critical number of these assemblies
- *
- * 1.88 cm separation exists between adjacent assemblies
- *
- * fuel assembly array is surrounded by 12 inches of reflecting concrete
- *
- * water moderation
- *

FISSION

* Number of Materials	Number of Nuclides
6	22

- * Material compositions

NUCNAMES

* Keyword	Nuclide	Concentration (atoms/b-cm)
-----------	---------	----------------------------

- * unirradiated 45wt% fuel

CONC	PU238	0.0000003
	PU239	0.008111
	PU240	0.000512
	PU241	0.000004
	PU242	0.000001
	AM241	0.000057
	U235	0.000026
	U238	0.011942
	O	0.04088

- * Stainless Steel

CONC	MN	0.00155
	MO	0.00126

	FE	0.05536
	CR	0.01641
	NI	0.01122
	C	0.0002003
* Inconel Steel		
CONC	FE	0.01085
	CR	0.01452
	NI	0.061446
* water		
CONC	H1NH2O	0.06689
	O	0.03344
* Sodium		
CONC	NA23	0.023644
* Concrete		
CONC	H	0.014868
	O	0.041519
	SI	0.006037
	FE	0.0001968
	NA23	0.000304
	C	0.003814
	CA	0.011588
	MG	0.000587
	AL27	0.000735

*

*

CM

*

* The following input describes the geometry

CLUSTER 10

* This cluster describes the array of dfas

* first fuel assembly

* lower 6 inch inconel reflector region

1 ZROD BH2 6.75 15.24

* 36 inch fuel region

2 ZROD ORIGIN 0 0 15.24 BH1 6.75 91.44

* upper 6 inch inconel reflector region

3 ZROD ORIGIN 0 0 106.68 BH2 6.75 15.24

* second fuel assembly

* lower 6 inch inconel reflector region

4 ZROD ORIGIN 6.75 11.7 0 BH2 6.75 15.24

* 36 inch fuel region

5 ZROD ORIGIN 6.75 11.7 15.24 BH1 6.75 91.44

* upper 6 inch inconel reflector region

6 ZROD ORIGIN 6.75 11.7 106.68 BH2 6.75 15.24

* third fuel assembly

* lower 6 inch inconel reflector region

7 ZROD ORIGIN -6.75 11.7 0 BH2 6.75 15.24

* 36 inch fuel region

8 ZROD ORIGIN -6.75 11.7 15.24 BH1 6.75 91.44

* upper 6 inch inconel reflector region

9 ZROD ORIGIN -6.75 11.7 106.68 BH2 6.75 15.24

* cluster boundary

10 ZROD ORIGIN 0 5.85 0.0 4 18.00 121.92

*

* cluster of assemblies within 12 inches concrete reflection

NEST 2

* 3 assemblies from part 1

1 ZROD ORIGIN 0 5.85 0 P1 18.00 121.92

* 12 inches of concrete reflection

2 ZROD ORIGIN 0 5.85 -30.48 6 38.5 182.88

*

*

* Hole 1: fuel region hole input

* hole type	number of materials	material numbers
-------------	---------------------	------------------

TRIANGLE	3	1 2 4
----------	---	-------

* lattice pitch	inner radius	outer radius
-----------------	--------------	--------------

0.72136	0.2540	0.2920
---------	--------	--------

* duct dimensions

WRAP

* number of pins	center to	center to
------------------	-----------	-----------

* on side	inner duct	outer duct
-----------	------------	------------

9	5.50545	5.81025
---	---------	---------

* material inside	pin	interstitial
-------------------	-----	--------------

* pins	material	material
--------	----------	----------

1	2	4
---	---	---

* duct material rest of space

2	4
---	---

* end of dfa fuel region input

*

* Hole 2: axial inconel reflector hole input

* hole type	number of materials	material numbers
-------------	---------------------	------------------

TRIANGLE	3	2 3 4
----------	---	-------

```

* lattice pitch      inner radius      outer radius
  0.72136           0.2540           0.2920
* duct dimensions
WRAP
* number of pins      center to      center to
*   on side          inner duct      outer duct
   9                5.50545         5.81025
* materials inside    pin            interstitial
*   pin              material         material
   2                 2               4
* duct material      rest of space
   3                 4
* end of dfa axial inconel reflector region
*
* End of geometry input
*
* Superhistory option using 10 generations per superhistory
* and nu nu multiplication factor = 1.0
SUPERHIST 10 1.0
* First stage Last stage Neutrons per stage Time limit Source
  -3      10      1000      180      -1
*
* Starting Source
LINE 0 0 16 0 0 106
END
CODE 6
FSN*AC
-7.00 7.00 30.00 7.00 7.00 30.00 -7.00 -7.00 30.00
-18.0 18.00 30.00 18.00 18.00 30.00 -18.00 -18.00 30.00
END

```

The following MONK6B input file is an array of 11 fuel assemblies modeled as squares. The array has close concrete reflection. The file name is sq11s. The results of this case are presented in Table 8 of section 5.2.2.

- * 11 DFAs (square model)
- * in sodium
- * 42 wt% fuel
- * 12 inches concrete reflection
- *

FISSION

* NUMBER OF MATERIAL		NUMBER OF NUCLIDES
6		22
NUCNames		
* KEY WORD	NUCLIDE	CONCENTRATION(# DENSITY)
* FUEL PIN		
CONC	PU238	0.0000003
	PU239	0.008111
	PU240	0.000512
	PU241	0.000004
	PU242	0.000001
	U235	0.000026
	U238	0.011942
	AM241	0.000057
	O	0.04088
* STAINLESS STEEL		
CONC	MN	0.00155
	MO	0.00126
	FE	0.05536
	CR	0.01641
	NI	0.01122
	C	0.0002003
* CARBON STEEL		
CONC	FE	0.083491
	C	0.003921
* INCONEL STEEL		
CONC	FE	0.01085
	CR	0.01452
	NI	0.061446
* CONCRETE(210#/cf)		
CONC	H	0.0063
	O	0.04046

SI	0.00258
FE	0.01837
CA	0.00354
MG	0.00057
AL27	0.00210
TI	0.00125

* SODIUM
CONC NA23 0.023644

*

*

CM

*

* THE FOLLOWING INPUT DESCRIBE THE GEOMETRY

* Part 1:PIN MODEL FOR DFA IN SODIUM

NEST 4

1 CYLINDER 1 0.254 45.72 -45.72
2 CYLINDER 4 0.254 60.96 -60.96
3 CYLINDER 2 0.292 60.96 -60.96
4 CUBOID 6 0.36322 0.36322 61.0 -0.36322 -0.36322 -61.0

* Part 2:FOR EMPTY PIN

NEST 1

1 CUBOID 6 0.36322 0.36322 61.0 -0.36322 -0.36322 -61.0

* part 3:array of dfa pins

ARRAY 15 15 1 (2)*2 (1)*11 (2)*2 (1)*195 (2)*2 (1)*11 (2)*2

* Part 4: square dfa

NEST 3

1 CUBOID TYPE 3 5.4483 5.4483 61.0 -5.4483 -5.4483 -61.0
2 CUBOID 6 5.6140 5.6140 61.6952 -5.6140 -5.6140 -61.6952

* stainless steel duct

3 CUBOID 2 5.9188 5.9188 62.0 -5.9188 -5.9188 -62.0

* Part 5: array of dfas

ARRAY 3 4 1 (4)*11 7

* Part 6:array with concrete reflection

NEST 2

1 CUBOID TYPE 5 17.7564 23.6752 62.0 -17.7564 -23.6752 -62.0

* high density concrete reflection

2 CUBOID 5 48.2364 54.1552 92.48 -48.2364 -54.1552 -92.48

* Part 7: sodium space

NEST 1

1 CUBOID 6 5.9188 5.9188 62.0 -5.9188 -5.9188 -62.0

* END OF GEOMETRY INPUT

SUPERHIST 10 1.0

* FIRST STAGE LAST STAGE NEUT PER STAGE TIME LIM SOURCE

-3 10 1000 240 -1

* STARTING SOURCE

MULTIFISS

STD

REGION 1 IN PART 6 /

END

* SCAN PICTURE INPUT

CODE 6

FSCIRN

-6.0 6.0 0.0 6.0 6.0 0.0 -6.0 -6.0 0.0

-6.0 6.0 50.0 6.0 6.0 50.0 -6.0 -6.0 50.0

-32.0 32.0 0.0 32.0 32.0 0.0 -32.0 -32.0 0.0

END

Appendix B
Independent Review Comments and Checklist

CHECKLIST FOR INDEPENDENT TECHNICAL REVIEW

DOCUMENT REVIEWED

NUMBER: HNF-SD-SQA-CSA-532 Rev.0

TITLE: Criticality Safety Evaluation Report for FFTF 42 wt% Fuel Assemblies

Reviewer(s) WARREN D. WITTEKIND

I. Method(s) of Review

- ☒ Input data checked for accuracy
- ☐ Independent calculation performed
 - ☐ Hand calculation
 - ☐ Alternate computer code: _____
- ☐ Comparison to experiment or previous results
- ☐ Alternate method (define) _____

II. Checklist (either check or enter NA if not applied)

- ☒ Task completely defined
- ☒ Activity consistent with task specification
- ☒ Necessary assumptions explicitly stated and supported
- ☒ Resources properly identified and referenced
- ☒ Resource documentation appropriate for this application
- ☐ Input data explicitly stated
- ☒ Input data verified to be consistent with original source
- ☒ Geometric model adequate representation of actual geometry
- ☒ Material properties appropriate and reasonable
- ☒ Mathematical derivations checked including dimensional consistency
- ☒ Hand calculations checked for errors
- ☒ Assumptions explicitly stated and justified
- ☒ Computer software appropriate for task and used within range of validity
- ☒ Use of resource outside range of established validity is justified
- ☒ Software runstreams correct and consistent with results
- ☒ Software output consistent with input
- ☒ Results consistent with applicable previous experimental or analytical findings
- ☒ Results and conclusions address all points and are consistent with task requirements and/or established limits or criteria
- ☒ Conclusions consistent with analytical results and established limits
- ☒ Uncertainty assesment appropriate and reasonable
- ☐ Other (define) _____

III. Comments:

IV. REVIEWER: Warren D. Wittekind DATE: 30 September 1997

DISTRIBUTION SHEET

To Distribution	From Criticality and Shielding	Page 1 of 1
		Date September 29, 1997
Project Title/Work Order		EDT No. 622979
Criticality Safety Evaluation Report for FFTF 42 Wt% Fuel Assemblies		ECN No.

Name	MSIN	Text With All Attach.	Text Only	Attach./ Appendix Only	EDT/ECN Only
J. E. Baker	N2-57	X			
J. D. Briggs	G3-42	X			
W. A. Dautel	N2-13	X			
J. Greenborg	H0-35	X			
S. W. Hiller	N2-02	X			
D. L. Nielsen	N2-53	X			
J. N. Paglieri	N2-57	X			
J. E. Parker	N2-11	X			
P. R. Prevo	N2-57	X			
R. F. Richard	H0-35	X			
P. L. Scott	N2-02	X			
W. D. Wittekind	H0-35	X			
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Central Files (1 + original)	A3-88	X			
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