Duke Power
A Duke Energy Company

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December 10, 2003

U. S. Nuclear Regulatory Commission
Attention: Document Control Desk
Washington, DC 20555

Subject: Duke Energy Corporation
Catawba Nuclear Station Units 1 & 2, Docket Nos. 50-413, 50-414
Response to Request for Additional Information dated November 21, 2003
Regarding Mixed Oxide Fuel Lead Assemblies (TAC Nos. MB7863, MB7864)

By letter dated February 27, 2003 Duke Energy submitted an application to amend the licenses of McGuire and Catawba to allow the use of four mixed oxide fuel lead assemblies. As part of the review of this application the Nuclear Regulatory Commission staff in a letter dated November 21, 2003 requested that Duke provide additional information related to the application. The response to the NRC questions related to radiological consequences is attached to this letter. The remaining responses to questions relating to the NRC staff's environmental review should be provided by January 9, 2004.

This submittal includes information that is proprietary to Framatome ANP and in accordance with 10 CFR 2.790, Duke requests that this information be withheld from public disclosure. Attachment 1 is the proprietary version of the response and Attachment 2 is a non-proprietary version. An affidavit attesting to the proprietary nature of this information from Framatome ANP, the owner of the information, is included. Pages that contain proprietary information are marked and the specific information that is proprietary is enclosed in [brackets].

Inquiries on this matter should be directed to G. A. Copp at (704) 373-5620.

K. S. Canady

attachments

A101

PROPRIETARY INFORMATION ATTACHED

Oath and Affirmation

I affirm that I, K. S. Canady, am the person who subscribed my name to the foregoing, and that all the matters and facts set forth herein are true and correct to the best of my knowledge.

K. S. Canady

Subscribed and sworn to before me on this 10TH day of December, 2003.

Notary Public

My Commission expires:

JAN 22, 2006
Date

cc: w/attachments 1 & 2

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NRIA File/ELL - EC05O
MOX File 1607.2304
Catawba Document Control File 801.01– CN04DM
Catawba RGC Date File (J. M. Ferguson – CN01SA)

AFFIDAVIT

COMMONWEALTH OF VIRGINIA)
) ss.
CITY OF LYNCHBURG)

1. My name is Gayle F. Elliott. I am Manager, Product Licensing in Regulatory Affairs, for Framatome ANP ("FANP"), and as such I am authorized to execute this Affidavit.

2. I am familiar with the criteria applied by FANP to determine whether certain FANP information is proprietary. I am familiar with the policies established by FANP to ensure the proper application of these criteria.

3. I am familiar with the table listing the parameters that the NRC staff will use in assessing fission gas release and fission gas pressure in the lead test assemblies provided as an attachment to a letter from M.S. Tuckman, Duke Energy Corporation, to the U.S. Nuclear Regulatory Commission entitled "Duke Energy Corporation, Catawba Nuclear Station Units 1 & 2, Docket Nos. 50-413, 50-414, Response to Request for Additional Information dated November 21, 2003, Regarding Mixed Oxide Fuel Lead Assemblies (TAC Nos. MB7863, MB7864)" and referred to herein as "Document." Information contained in this Document has been classified by FANP as proprietary in accordance with the policies established by FANP for the control and protection of proprietary and confidential information.

4. This Document contains information of a proprietary and confidential nature and is of the type customarily held in confidence by FANP and not made available to the public. Based on my experience, I am aware that other companies regard information of the kind contained in this Document as proprietary and confidential.

5. This Document has been made available to the U.S. Nuclear Regulatory Commission in confidence with the request that the information contained in this Document be withheld from public disclosure.

6. The following criteria are customarily applied by FANP to determine whether information should be classified as proprietary:

(a) The information reveals details of FANP's research and development plans and programs or their results.

(b) Use of the information by a competitor would permit the competitor to significantly reduce its expenditures, in time or resources, to design, produce, or market a similar product or service.

(c) The information includes test data or analytical techniques concerning a process, methodology, or component, the application of which results in a competitive advantage for FANP.

(d) The information reveals certain distinguishing aspects of a process, methodology, or component, the exclusive use of which provides a competitive advantage for FANP in product optimization or marketability.

(e) The information is vital to a competitive advantage held by FANP, would be helpful to competitors to FANP, and would likely cause substantial harm to the competitive position of FANP.

7. In accordance with FANP's policies governing the protection and control of information, proprietary information contained in this Document have been made available, on a limited basis, to others outside FANP only as required and under suitable agreement providing for nondisclosure and limited use of the information.

8. FANP policy requires that proprietary information be kept in a secured file or area and distributed on a need-to-know basis.

9. The foregoing statements are true and correct to the best of my knowledge, information, and belief.

SUBSCRIBED before me this 4th
day of December, 2003.

Ella F. Carr-Payne
NOTARY PUBLIC, STATE OF VIRGINIA
MY COMMISSION EXPIRES: 8/31/05

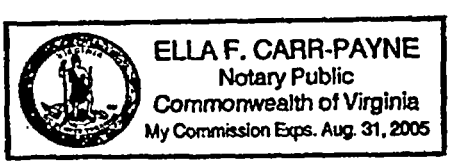

Table 2
MOX Fuel Lead Assembly
Peak Pin Relative Power vs Fuel
Cycle Exposure (burnup)

	Fuel Cycle Exposure EFPD	MOX Fuel Lead Assembly Peak Pin Exposure GWd / Mthm	MOX Fuel Lead Assembly Peak Pin Relative Power F delta-h
Cycle 1	4	0.246	1.426
	12	0.711	1.403
	25	1.448	1.372
	50	2.814	1.327
	100	5.411	1.273
	150	7.883	1.245
	200	10.272	1.230
	250	12.601	1.223
	300	14.928	1.222
	350	17.292	1.222
	400	19.653	1.225
	450	22.010	1.230
	470	22.953	1.231
	490	23.895	1.232
	495	24.131	1.233
Cycle 2	4	25.233	1.363
	12	25.621	1.361
	25	26.247	1.345
	50	27.430	1.315
	100	29.728	1.267
	150	31.955	1.233
	200	34.130	1.212
	250	36.265	1.193
	300	38.370	1.179
	350	40.449	1.167
	400	42.505	1.157
	450	44.544	1.148
	487	46.060	1.144
	507	46.916	1.142
	512	47.131	1.142
Cycle 3	4	47.210	0.675
	12	47.317	0.664
	25	47.488	0.651
	50	47.808	0.629
	100	48.422	0.600
	150	49.265	0.588
	200	50.254	0.586
	250	51.252	0.593
	300	52.316	0.603
	350	53.425	0.616
	400	54.564	0.630
	450	55.735	0.647
	467	56.141	0.654
	487	56.623	0.661
	492	56.746	0.662

Table 3
MOX Fuel Lead Assembly
Axial Power Profile

Fuel Cycle Exposure EFPD		4	100	200	300	400	490	4	100	200	300	400	507	4	100	200	300	400	487
	Axial Level	MOX LTA Axial Power Profile																	
Top of Core	24	0.540	0.466	0.479	0.530	0.591	0.647	0.579	0.479	0.497	0.559	0.631	0.705	0.561	0.468	0.492	0.554	0.622	0.679
	23	0.755	0.669	0.681	0.731	0.780	0.815	0.848	0.721	0.733	0.793	0.851	0.895	0.848	0.729	0.755	0.819	0.876	0.910
	22	0.909	0.832	0.845	0.892	0.931	0.951	1.001	0.885	0.895	0.949	0.992	1.013	0.999	0.892	0.920	0.980	1.022	1.039
	21	1.009	0.954	0.965	1.002	1.025	1.029	1.079	0.992	0.998	1.038	1.062	1.063	1.066	0.990	1.016	1.062	1.086	1.086
	20	1.046	1.016	1.022	1.044	1.052	1.043	1.101	1.049	1.047	1.069	1.076	1.063	1.091	1.049	1.065	1.094	1.100	1.088
	19	1.059	1.053	1.050	1.057	1.052	1.036	1.107	1.085	1.070	1.076	1.069	1.048	1.101	1.089	1.093	1.103	1.095	1.075
	18	1.079	1.091	1.079	1.071	1.056	1.035	1.116	1.118	1.090	1.078	1.061	1.036	1.106	1.118	1.109	1.102	1.083	1.060
	17	1.086	1.115	1.093	1.072	1.050	1.028	1.117	1.138	1.098	1.073	1.050	1.025	1.107	1.140	1.118	1.095	1.070	1.045
	16	1.096	1.138	1.108	1.077	1.050	1.028	1.120	1.156	1.106	1.070	1.042	1.019	1.108	1.156	1.123	1.088	1.058	1.034
	15	1.081	1.134	1.100	1.062	1.034	1.014	1.104	1.155	1.100	1.058	1.029	1.009	1.103	1.165	1.123	1.080	1.047	1.026
	14	1.099	1.160	1.121	1.076	1.045	1.026	1.110	1.171	1.111	1.061	1.030	1.011	1.101	1.173	1.124	1.074	1.040	1.021
	13	1.098	1.165	1.125	1.077	1.046	1.028	1.103	1.173	1.114	1.060	1.028	1.011	1.097	1.176	1.125	1.070	1.035	1.018
	12	1.082	1.154	1.118	1.069	1.038	1.022	1.085	1.162	1.109	1.055	1.024	1.008	1.090	1.173	1.123	1.066	1.032	1.015
	11	1.096	1.168	1.136	1.087	1.055	1.038	1.085	1.165	1.120	1.064	1.031	1.015	1.084	1.168	1.122	1.065	1.031	1.015
	10	1.095	1.166	1.142	1.096	1.064	1.047	1.075	1.156	1.123	1.071	1.037	1.020	1.076	1.157	1.119	1.066	1.032	1.017
	9	1.089	1.155	1.142	1.103	1.072	1.056	1.061	1.140	1.124	1.078	1.045	1.027	1.068	1.143	1.117	1.070	1.037	1.023
	8	1.072	1.129	1.130	1.101	1.075	1.060	1.040	1.114	1.118	1.083	1.053	1.034	1.058	1.122	1.111	1.075	1.046	1.032
	7	1.086	1.128	1.142	1.125	1.104	1.089	1.038	1.098	1.123	1.100	1.073	1.053	1.050	1.096	1.101	1.078	1.056	1.044
	6	1.084	1.103	1.131	1.131	1.119	1.109	1.026	1.066	1.112	1.108	1.089	1.072	1.038	1.061	1.084	1.079	1.067	1.059
	5	1.058	1.049	1.090	1.109	1.112	1.111	1.001	1.014	1.079	1.098	1.095	1.086	1.022	1.014	1.053	1.069	1.073	1.073
	4	1.056	1.009	1.055	1.092	1.112	1.123	0.991	0.965	1.041	1.081	1.095	1.100	0.998	0.953	1.002	1.039	1.061	1.074
	3	1.004	0.917	0.960	1.009	1.047	1.075	0.939	0.873	0.949	1.007	1.043	1.069	0.940	0.857	0.909	0.962	1.004	1.034
Bottom of Core	2	0.875	0.761	0.791	0.840	0.886	0.925	0.782	0.696	0.763	0.829	0.885	0.935	0.787	0.687	0.733	0.793	0.850	0.896
	1	0.547	0.469	0.497	0.547	0.604	0.661	0.489	0.426	0.478	0.542	0.609	0.683	0.501	0.425	0.461	0.516	0.577	0.636
Average		1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

Table 4
SAS2H Input Deck Listing

```
=sas2h    parm=(halt08,skipshipdata)
fuel type=MOX-0BP    enr=0.25 puload=5.00 burnup=16.9 gwd/mtu
44groupndf5 latticecell
uo2 1 0.8939 1085.34 92234 0.0017 92235 0.2500 92236 0.0012
92238 99.7471 end
puo2 1 0.0450 1085.34 94238 0.0250 94239 92.5000 94240 6.9250
94241 0.5000 94242 0.0500 end
 kr-83 1 0 1-20 1085.34 end
 kr-85 1 0 1-20 1085.34 end
 sr-90 1 0 1-20 1085.34 end
  y-89 1 0 1-20 1085.34 end
 zr-93 1 0 1-20 1085.34 end
 zr-94 1 0 1-20 1085.34 end
 zr-95 1 0 1-20 1085.34 end
 mo-94 1 0 1-20 1085.34 end
 nb-94 1 0 1-20 1085.34 end
 nb-95 1 0 1-20 1085.34 end
 mo-95 1 0 1-20 1085.34 end
 tc-99 1 0 1-20 1085.34 end
rh-103 1 0 1-20 1085.34 end
rh-105 1 0 1-20 1085.34 end
ru-106 1 0 1-20 1085.34 end
sn-126 1 0 1-20 1085.34 end
xe-131 1 0 1-20 1085.34 end
xe-132 1 0 1-20 1085.34 end
xe-133 1 0 1-20 1085.34 end
xe-134 1 0 1-20 1085.34 end
xe-135 1 0 1-20 1085.34 end
xe-136 1 0 1-20 1085.34 end
cs-133 1 0 1-20 1085.34 end
cs-134 1 0 1-20 1085.34 end
cs-135 1 0 1-20 1085.34 end
cs-137 1 0 1-20 1085.34 end
ba-136 1 0 1-20 1085.34 end
la-139 1 0 1-20 1085.34 end
pr-143 1 0 1-20 1085.34 end
nd-143 1 0 1-20 1085.34 end
ce-144 1 0 1-20 1085.34 end
nd-144 1 0 1-20 1085.34 end
nd-145 1 0 1-20 1085.34 end
nd-146 1 0 1-20 1085.34 end
nd-147 1 0 1-20 1085.34 end
pm-147 1 0 1-20 1085.34 end
sm-147 1 0 1-20 1085.34 end
nd-148 1 0 1-20 1085.34 end
pm-148 1 0 1-20 1085.34 end
```

Table 4
SAS2H Input Deck Listing

```
sm-148 1 0 1-20 1085.34 end
pm-149 1 0 1-20 1085.34 end
sm-149 1 0 1-20 1085.34 end
nd-150 1 0 1-20 1085.34 end
sm-150 1 0 1-20 1085.34 end
sm-151 1 0 1-20 1085.34 end
eu-151 1 0 1-20 1085.34 end
sm-152 1 0 1-20 1085.34 end
eu-153 1 0 1-20 1085.34 end
eu-154 1 0 1-20 1085.34 end
gd-154 1 0 1-20 1085.34 end
eu-155 1 0 1-20 1085.34 end
gd-155 1 0 1-20 1085.34 end
gd-157 1 0 1-20 1085.34 end
gd-158 1 0 1-20 1085.34 end
gd-160 1 0 1-20 1085.34 end
arbm-m5 6.50 3 0 0 0 40000 98.873 41000 1.0
8016 0.127 2 1 656.16 end
h2o 3 den=0.711 1.0 580.43 end
arbm-bormod 0.711 1 1 0 0 5000 100 3  900.0e-6 580.43 end
end comp
squarepitch 1.2598 0.8191 1 3 0.9500 2 0.8357 0 end
npin=264 fuel=365.76 ncyc=2 nlib=4 prin=6 inpl=1
numh=24 numi=1 ortu=0.6121 srtu=0.5715 end
power=29.745 burn=233.29 down= 0.00 end
power=29.745 burn= 30.30 down= 0.00 tmpfuel=1085.34
tmpclad=656.16 end
end
```

Attachment 2

Duke Response to NRC Staff
Request for Additional Information
Dated November 21, 2003

(NON-PROPRIETARY)

Attachment 2
Duke Response to NRC Staff
Request for Additional Information
Dated November 21, 2003

1. The table below lists the parameters that the NRC staff will use in assessing fission gas release (isotopic gap fractions) and fission gas pressure in the lead test assemblies (LTAs). This data has been extracted from the February 27, 2003 submittal. The NRC staff also completed some fields using generic data from NUREG-1754, "A New Comparative Analysis of LWR Fuel Designs." The NRC staff requests that Duke complete the missing data items and confirm that the values in the table are those that have been or will be used for safety analyses and thus become part of the design basis for the LTA irradiation.

   Response

   Table 1 lists all the parameters identified by the NRC staff as needed to assess the fission gas release and fission gas pressure in the MOX fuel lead assemblies. Previously missing or corrected data items are included in Table 1 in a new column titled "Actual Value." Where the NRC-determined values ("NRC Value" column) in the table were correct, the "Actual Value" column indicates "Same." Proprietary values are enclosed in brackets.

2. Please provide projected power histories for the LTAs. These would typically tabulate or plot peak rod average power, kW/ft, versus time (days) since start of irradiation (or versus average burnup, MWd/MThm). If a projected power history specifically for the LTAs is not available, please provide the average kW/ft data and the appropriate peaking factors.

   Response

   Table 2 provides the fuel pin average burnup and pin average relative power factors for the peak pin in the MOX fuel lead assembly for three cycles of irradiation. The pin average relative power factors are normalized to a core average of 1.0.

3. Please provide the axial power profile expected in the LTAs. These would typically tabulate or plot normalized power versus height.

   Response
   Table 3 contains axial power profiles for the MOX fuel lead assemblies at 18 burnup points over three cycles of irradiation. The MOX fuel lead assembly is located in core location C08 in the first cycle, E08 in the second cycle, and C14 in the third cycle. See Figure Q11-1 in Duke's November 4, 2003 response to the NRC Staff Request for Additional Information dated July 25, 2003 for a quarter-core map showing lead assembly core locations.

4. In the response to Question 3(f) in the letter dated 11/3/2003, Duke identified that the SCALE/SAS2H code suite was used to establish the source term used in the safety analyses.

Please provide a listing of the SAS2H input data file(s) for the case(s) that generated the fuel assembly inventory used in the fuel handling accident shown in Table Q3(f)-1. The staff is particularly interested in the SAS2H case that would have generated the MOX fuel cross-section library used in the safety analysis work.

Response

Table 4 is a listing of the SAS2H input deck used to generate the isotopic information shown in Table Q3(f)-1 of Duke's November 4, 2003 response to the NRC Staff Request for Additional Information dated July 25, 2003.

Table 1
MOX Fuel Lead Assembly
Fuel Parameters

Parameter	NRC Value	Actual Value
Number of fuel rods per assembly	264	Same
Fuel rod pitch, in.	0.496	Same
Cladding OD, in.	0.374	Same
Cladding ID, in.	0.329	Same
Cladding thickness, in.	0.0225	Same
Cladding material	M5	Same
Fuel diameter, in.	0.3225	Same
Fuel pellet length, in.	? 0.45 ?	[ ]
Fuel pellet volume reduction due to dish and chamfer, %.	1.0	1.11 (Note 1)
Fuel pellet dish diameter, in.	? 0.158 ?	[ ]
Fuel pellet dish depth, in.	? 0.0113 ?	[ ]
Fuel rod length, in.	152.40	Same
Active fuel length, in.	144.0	Same
Plenum length, in.	? 10 ?	[ ]
Pellet initial density, % TD	95	Same
Pellet oxygen to metal ratio (a realistic value is preferred to a manufacturing limit)	?	[ ]
Rod internal void volume, cu. in.	?	[ ]
Plenum spring diameter	? 0.3225 ?	[ ]
Plenum spring wire diameter, in.	? 0.05 ?	[ ]
Turns in plenum spring	? 28 ?	[ ]
Helium fill gas pressure, psi	? 350 ?	[ ] psig

Table 1
MOX Fuel Lead Assembly
Fuel Parameters

Parameter	NRC Value	Actual Value
RCS pressure, psia	2310	2250
Reactor Power, MWt	3411	Same
Coolant Flow, lb/ft^2 - hr	? 2.55E6 ?	1.43E6 (Note 2)
Coolant inlet temperature, F	555	Same
Coolant outlet temperature, F	616	619 (Note 3)
Channel temperature rise, F (for the limiting LTA)	?	(Note 4)
Temperature at which pellets were sintered, F	? 2911 ?	[ ]
Limit on pellet density increase, % TD	? 0.9 ?	[ ] (95/95 limit)
Limit on pellet swelling, %	? 5 ?	NA (Note 5)
Fuel surface roughness, in.	? 3E-5 ?	[ ]
Cladding ID surface roughness, in.	? 2E-5 ?	[ ]
Initial crud thickness, in.	? 0 ?	0.0
Lattice geometry	17 x 17	Same
Maximum fuel rod burnup, MWd/MThm	50,000	60,000 (Note 6)
Heavy metal loading per assembly, kg	462.6	Same
Hot pin and hot assembly radial peaking factors	1.60	Note 7
Highest allowable total peaking for MOX fuel assembly (F_Q)	2.4	Note 7
Core axial peaking factor	2.4	Note 7

Table 1
MOX Fuel Lead Assembly
Fuel Parameters

Parameter	NRC Value	Actual Value
Nominal average Pu concentration, w/o percent Pu, in a radially zoned fuel assembly containing pellets with nominal Pu concentration. (4.37 x TD = 4.15 w/o-% fissile)	4.37 4.94 (176 rods) 3.35 (76 rods) 2.4 (12 rods)	Same Same Same Same
Unirradiated isotopic composition, % of base element		
Pu-238	0.025	Same
Pu-239	92.5	Same
Pu-240	6.925	Same
Pu-241	0.5	Same
Pu242	0.05	Same
U-235	0.25	Same
U-234	0.0017	Same
U-236	0.0012	Same
U-238	99.741	Same

Note 1 – The LAR incorrectly gives only the volume reduction of the end dish. The total volume reduction of the end dish and chamfer is correctly noted in the MOX Fuel Design Report as 1.11%.

Note 2 – Coolant flow calculated at inlet conditions for the total core cross sectional area.

Note 3 – Core outlet temperature.

Note 4 – This parameter varies as the power distribution changes as follows:

EFPD (Cycle 1)	4	100	200	300	400	490
Assembly Peaking Factor	1.291	1.146	1.109	1.107	1.121	1.134
Delta T (°F)	77	70	67	66	67	67

where Delta T is the axial temperature rise predicted for the MOX fuel lead assembly by the core nuclear analysis code.

Table 1
MOX Fuel Lead Assembly
Fuel Parameters

Note 5 – No specified limit on pellet swelling. Best estimate value = [ ]

Note 6 – One or more lead assemblies are proposed for a third cycle of operation leading to a maximum peak rod burnup of 60,000 GWd/MThm; whereas batches of MOX fuel will undergo two cycles of irradiation with a maximum peak rod burnup of 50,000 GWd/MThm.

Note 7 – Peaking factors identified in Table 3-2 are conservatively high peaking factors used in LOCA analysis. Realistic peaking factors for a MOX fuel lead assembly in a representative core are provided in the responses to Questions 2 and 3.

Table 2
MOX Fuel Lead Assembly
Peak Pin Relative Power vs Fuel
Cycle Exposure (burnup)

	Fuel Cycle Exposure EFPD	MOX Fuel Lead Assembly Peak Pin Exposure GWd / Mthm	MOX Fuel Lead Assembly Peak Pin Relative Power F delta-h
Cycle 1	4	0.246	1.426
	12	0.711	1.403
	25	1.448	1.372
	50	2.814	1.327
	100	5.411	1.273
	150	7.883	1.245
	200	10.272	1.230
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	300	14.928	1.222
	350	17.292	1.222
	400	19.653	1.225
	450	22.010	1.230
	470	22.953	1.231
	490	23.895	1.232
	495	24.131	1.233
Cycle 2	4	25.233	1.363
	12	25.621	1.361
	25	26.247	1.345
	50	27.430	1.315
	100	29.728	1.267
	150	31.955	1.233
	200	34.130	1.212
	250	36.265	1.193
	300	38.370	1.179
	350	40.449	1.167
	400	42.505	1.157
	450	44.544	1.148
	487	46.060	1.144
	507	46.916	1.142
	512	47.131	1.142
Cycle 3	4	47.210	0.675
	12	47.317	0.664
	25	47.488	0.651
	50	47.808	0.629
	100	48.422	0.600
	150	49.265	0.588
	200	50.254	0.586
	250	51.252	0.593
	300	52.316	0.603
	350	53.425	0.616
	400	54.564	0.630
	450	55.735	0.647
	467	56.141	0.654
	487	56.623	0.661
	492	56.746	0.662

Table 3
MOX Fuel Lead Assembly
Axial Power Profile

Fuel Cycle Exposure EFPD		4	100	200	300	400	490	4	100	200	300	400	507	4	100	200	300	400	487
	Axial Level	MOX LTA Axial Power Profile																	
Top of Core	24	0.540	0.466	0.479	0.530	0.591	0.647	0.579	0.479	0.497	0.559	0.631	0.705	0.561	0.468	0.492	0.554	0.622	0.679
	23	0.755	0.669	0.681	0.731	0.780	0.815	0.848	0.721	0.733	0.793	0.851	0.895	0.848	0.729	0.755	0.819	0.876	0.910
	22	0.909	0.832	0.845	0.892	0.931	0.951	1.001	0.885	0.895	0.949	0.992	1.013	0.999	0.892	0.920	0.980	1.022	1.039
	21	1.009	0.954	0.965	1.002	1.025	1.029	1.079	0.992	0.998	1.038	1.062	1.063	1.066	0.990	1.016	1.062	1.086	1.086
	20	1.046	1.016	1.022	1.044	1.052	1.043	1.101	1.049	1.047	1.069	1.076	1.063	1.091	1.049	1.065	1.094	1.100	1.088
	19	1.059	1.053	1.050	1.057	1.052	1.036	1.107	1.085	1.070	1.076	1.069	1.048	1.101	1.089	1.093	1.103	1.095	1.075
	18	1.079	1.091	1.079	1.071	1.056	1.035	1.116	1.118	1.090	1.078	1.061	1.036	1.106	1.118	1.109	1.102	1.083	1.060
	17	1.086	1.115	1.093	1.072	1.050	1.028	1.117	1.138	1.098	1.073	1.050	1.025	1.107	1.140	1.118	1.095	1.070	1.045
	16	1.096	1.138	1.108	1.077	1.050	1.028	1.120	1.156	1.106	1.070	1.042	1.019	1.108	1.156	1.123	1.088	1.058	1.034
	15	1.081	1.134	1.100	1.062	1.034	1.014	1.104	1.155	1.100	1.058	1.029	1.009	1.103	1.165	1.123	1.080	1.047	1.026
	14	1.099	1.160	1.121	1.076	1.045	1.026	1.110	1.171	1.111	1.061	1.030	1.011	1.101	1.173	1.124	1.074	1.040	1.021
	13	1.098	1.165	1.125	1.077	1.046	1.028	1.103	1.173	1.114	1.060	1.028	1.011	1.097	1.176	1.125	1.070	1.035	1.018
	12	1.082	1.154	1.118	1.069	1.038	1.022	1.085	1.162	1.109	1.055	1.024	1.008	1.090	1.173	1.123	1.066	1.032	1.015
	11	1.096	1.168	1.136	1.087	1.055	1.038	1.085	1.165	1.120	1.064	1.031	1.015	1.084	1.168	1.122	1.065	1.031	1.015
	10	1.095	1.166	1.142	1.096	1.064	1.047	1.075	1.156	1.123	1.071	1.037	1.020	1.076	1.157	1.119	1.066	1.032	1.017
	9	1.089	1.155	1.142	1.103	1.072	1.056	1.061	1.140	1.124	1.078	1.045	1.027	1.068	1.143	1.117	1.070	1.037	1.023
	8	1.072	1.129	1.130	1.101	1.075	1.060	1.040	1.114	1.118	1.083	1.053	1.034	1.058	1.122	1.111	1.075	1.046	1.032
	7	1.086	1.128	1.142	1.125	1.104	1.089	1.038	1.098	1.123	1.100	1.073	1.053	1.050	1.096	1.101	1.078	1.056	1.044
	6	1.084	1.103	1.131	1.131	1.119	1.109	1.026	1.066	1.112	1.108	1.089	1.072	1.038	1.061	1.084	1.079	1.067	1.059
	5	1.058	1.049	1.090	1.109	1.112	1.111	1.001	1.014	1.079	1.098	1.095	1.086	1.022	1.014	1.053	1.069	1.073	1.073
	4	1.056	1.009	1.055	1.092	1.112	1.123	0.991	0.965	1.041	1.081	1.095	1.100	0.998	0.953	1.002	1.039	1.061	1.074
	3	1.004	0.917	0.960	1.009	1.047	1.075	0.939	0.873	0.949	1.007	1.043	1.069	0.940	0.857	0.909	0.962	1.004	1.034
Bottom of Core	2	0.875	0.761	0.791	0.840	0.886	0.925	0.782	0.696	0.763	0.829	0.885	0.935	0.787	0.687	0.733	0.793	0.850	0.896
	1	0.547	0.469	0.497	0.547	0.604	0.661	0.489	0.426	0.478	0.542	0.609	0.683	0.501	0.425	0.461	0.516	0.577	0.636
Average		1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

Table 4
SAS2H Input Deck Listing

```
=sas2h    parm=(halt08,skipshipdata)
fuel type=MOX-0BP    enr=0.25 puload=5.00 burnup=16.9 gwd/mtu
44groupndf5 latticecell
uo2 1 0.8939 1085.34 92234 0.0017 92235 0.2500 92236 0.0012
92238 99.7471 end
puo2 1 0.0450 1085.34 94238 0.0250 94239 92.5000 94240 6.9250
94241 0.5000 94242 0.0500 end
 kr-83 1 0 1-20 1085.34 end
 kr-85 1 0 1-20 1085.34 end
 sr-90 1 0 1-20 1085.34 end
  y-89 1 0 1-20 1085.34 end
 zr-93 1 0 1-20 1085.34 end
 zr-94 1 0 1-20 1085.34 end
 zr-95 1 0 1-20 1085.34 end
 mo-94 1 0 1-20 1085.34 end
 nb-94 1 0 1-20 1085.34 end
 nb-95 1 0 1-20 1085.34 end
 mo-95 1 0 1-20 1085.34 end
 tc-99 1 0 1-20 1085.34 end
rh-103 1 0 1-20 1085.34 end
rh-105 1 0 1-20 1085.34 end
ru-106 1 0 1-20 1085.34 end
sn-126 1 0 1-20 1085.34 end
xe-131 1 0 1-20 1085.34 end
xe-132 1 0 1-20 1085.34 end
xe-133 1 0 1-20 1085.34 end
xe-134 1 0 1-20 1085.34 end
xe-135 1 0 1-20 1085.34 end
xe-136 1 0 1-20 1085.34 end
cs-133 1 0 1-20 1085.34 end
cs-134 1 0 1-20 1085.34 end
cs-135 1 0 1-20 1085.34 end
cs-137 1 0 1-20 1085.34 end
ba-136 1 0 1-20 1085.34 end
la-139 1 0 1-20 1085.34 end
pr-143 1 0 1-20 1085.34 end
nd-143 1 0 1-20 1085.34 end
ce-144 1 0 1-20 1085.34 end
nd-144 1 0 1-20 1085.34 end
nd-145 1 0 1-20 1085.34 end
nd-146 1 0 1-20 1085.34 end
nd-147 1 0 1-20 1085.34 end
pm-147 1 0 1-20 1085.34 end
sm-147 1 0 1-20 1085.34 end
nd-148 1 0 1-20 1085.34 end
pm-148 1 0 1-20 1085.34 end
```

Table 1
MOX Fuel Lead Assembly
Fuel Parameters

```
sm-148 1 0 1-20 1085.34 end
pm-149 1 0 1-20 1085.34 end
sm-149 1 0 1-20 1085.34 end
nd-150 1 0 1-20 1085.34 end
sm-150 1 0 1-20 1085.34 end
sm-151 1 0 1-20 1085.34 end
eu-151 1 0 1-20 1085.34 end
sm-152 1 0 1-20 1085.34 end
eu-153 1 0 1-20 1085.34 end
eu-154 1 0 1-20 1085.34 end
gd-154 1 0 1-20 1085.34 end
eu-155 1 0 1-20 1085.34 end
gd-155 1 0 1-20 1085.34 end
gd-157 1 0 1-20 1085.34 end
gd-158 1 0 1-20 1085.34 end
gd-160 1 0 1-20 1085.34 end
arbm-m5 6.50 3 0 0 0 40000 98.873 41000 1.0
8016 0.127 2 1 656.16 end
h2o 3 den=0.711 1.0 580.43 end
arbm-bormod 0.711 1 1 0 0 5000 100 3  900.0e-6 580.43 end
end comp
squarepitch 1.2598 0.8191 1 3 0.9500 2 0.8357 0 end
npin=264 fuel=365.76 ncyc=2 nlib=4 prin=6 inpl=1
numh=24 numi=1 ortu=0.6121 srtu=0.5715 end
power=29.745 burn=233.29 down= 0.00 end
power=29.745 burn= 30.30 down= 0.00 tmpfuel=1085.34
tmpclad=656.16 end
end
```