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MFN 06-295

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U.S. Nuclear Regulatory Commission
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Subject: **Response to Portion of NRC Request for Additional Information Letter No. 49 Related to ESBWR Design Certification Application – TRACG Application for ESBWR Stability Evaluation and NEDC-33239P, "GE14 for ESBWR Nuclear Design Report" – RAI Numbers 4.4-14 and 21.6-54**

Enclosures 1 and 2 contain GE's response to the subject NRC RAI transmitted via the Reference 1 letter.

Enclosures 1 and 2 contain GNF proprietary information as defined by 10 CFR 2.390. GNF customarily maintains this information in confidence and withholds it from public disclosure.

The affidavit contained in Enclosure 4 identifies that the information contained in Enclosures 1 and 2 has been handled and classified as proprietary to GNF. GE hereby requests that the information of Enclosures 1 and 2 be withheld from public disclosure in accordance with the provisions of 10 CFR 2.390 and 9.17. A non proprietary version of Enclosure 1 is contained in Enclosure 3. Due to the nature of the data files contained in Enclosure 2, the Enclosure 2 cover page, which contains a description of the files, provides the extent of available non-proprietary information.

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If you have any questions about the information provided here, please let me know.

Sincerely,

Kathy Sedney for

David H. Hinds
Manager, ESBWR

Enclosures:

1. MFN 06-295 - Response to Portion of NRC Request for Additional Information Letter No. 49 Related to ESBWR Design Certification Application – TRACG Application for ESBWR Stability Evaluation and NEDC-33239P, "GE14 for ESBWR Nuclear Design Report" – RAI Numbers 4.4-14 and 21.6-54 – GNF Proprietary Information
2. MFN 06-295 – Panacea 3D Nodal Exposures, Nodal Void History, and Nodal Powers for BOC, MOC, and EOC & Fission Rate Distribution and Power Distribution Files for Lattices 81802 and 81902 (CD) – GNF Proprietary Information
3. MFN 06-295 - Response to Portion of NRC Request for Additional Information Letter No. 49 Related to ESBWR Design Certification Application – TRACG Application for ESBWR Stability Evaluation and NEDC-33239P, "GE14 for ESBWR Nuclear Design Report" – RAI Numbers 4.4-14 and 21.6-54 – Non Proprietary Version
4. Affidavit – Jens G. M. Andersen – dated August 22, 2006

Reference:

1. MFN 06-116, Letter from U. S. Nuclear Regulatory Commission to Mr. David H. Hinds, *Request for Additional Information Letter No. 21 Related to ESBWR Design Certification Application,* April 24, 2006

cc:	WD Beckner	USNRC (w/o enclosures)
	AE Cubbage	USNRC (with enclosures)
	LA Dudes	USNRC (w/o enclosures)
	AA Lingenfelter	GNF/Wilmington (w/o enclosures)
	GB Stramback	GE/San Jose (with enclosures)
	eDRFs	0000-0057-2412 and 0000-0057-2422

ENCLOSURE 3

MFN 06-295

Response to Portion of NRC Request for Additional

Information Letter No. 49

Related to ESBWR Design Certification Application

TRACG Application for ESBWR Stability Evaluation and

NEDC-33239P, "GE14 for ESBWR Nuclear Design Report"

RAI Numbers 4.4-14 and 21.6-54

Non Proprietary Version

NRC RAI 4.4-14

Provide the value for each parameter provided in Table 4.4-14 for the core design provided in the ESBWR DCD.

Table RAI 4.4-14

Parameter	*Units*	*Value*
Inlet K	*"ODYSY"*	
Inlet K (periphery)	*"ODYSY"*	
# fuel rods		
channel height	*cm*	
Heat transfer area per unit axial length	*cm*	
Channel flow area	*cm^2*	
Hydraulic diameter	*cm*	
Density of the fuel	*g/cm^3*	
Fuel pellet diameter	*cm*	
Cladding heat capacity	*cal/cm^3 °C*	
Cladding thermal conductivity	*cal/cm s °C*	
Cladding thickness	*cm*	
Gap heat transfer coefficient	*cal/cm^2 s °C*	
Gap width	*cm*	
System Pressure	*psia*	
Core Inlet Coolant Temperature	*C*	
Total Core Thermal Power	*MWth*	
Total Flow rate (active + bypass)	*Mlb/h*	
Fraction of total flow rate through bypass at rated power	*%*	

GE Response

The GE-supplied values are provided in the table below. Note that the channel height is over the heated length only. (A) is for the lower part of a fuel bundle, while (B) applies above the part-length rods. For part-length rod dimensions, please see Figure 1-1 of NEDC-33239P and the response to RAI 21.6-54. (1) corresponds to the low end of the core flow range. (2) is at the high end of the core flow range. System pressure is the vessel dome pressure in psia. Core bypass flow includes water rod flow. This response does not change the DCD.

Parameter	Units	GE Value
Inlet K	"ODYSY"	[[ ]]
Inlet K (periphery)	"ODYSY"	[[ ]]
# fuel rods		92
channel height	cm	304.8
Heat transfer area per unit axial length	cm	(A) 296.59, (B) 251.46
Channel flow area	cm^2	(A) 91.59, (B) 103.34
Hydraulic diameter	cm	(A) 1.00, (B) 1.29
Density of the fuel	g/cm^3	10.40
Fuel pellet diameter	cm	0.8763
Cladding heat capacity	cal/cm^3 °C	0.502 @ 277 °C
Cladding thermal conductivity	cal/cm s °C	0.0379 @ 277 °C
Cladding thickness	cm	0.066
Gap heat transfer coefficient	cal/cm^2 s °C	0.10 to 0.24
Gap width	cm	0.00889
System Pressure	psia	1040
Core Inlet Coolant Temperature	°C	(1) 272.4, (2) 269.7
Total Core Thermal Power	MWth	4500
Total Flow rate (active + bypass)	Mlb/h	(1) 71.72, (2) 83.98
Fraction of total flow rate through bypass at rated power	%	12.7

NRC RAI 21.6-54

Provide the following design information related to NEDC-33239P, "GE14 for ESBWR Nuclear Design Report," February 2006, for the staff's independent calculations:

- *A.* *PANACEA 3D exposure data, fuel composition, and void history data at BOC, EOC and MOC*
- *B.* *Hot Full Power (HFP) temperature of the fuel (UO2), clad, and coolant*
- *C.* *The size of the perturbation for temperature and void used to calculate Doppler, moderator and void coefficients*
- *D.* *Fuel density for UO2 and UO2+Gad*
- *E.* *Bundle structural materials and associated densities*
- *F.* *Dimensions, compositions, densities and typical operating temperatures for the control rods*
- *G.* *Dimensions for the letters in diagram in Figure 1-1 for bundles 90018 and 90019*
- *H.* *Additional information defining exactly what is meant by the terms "shutdown margin" and "control rod worth"*
- *I.* *Additional fission rate distribution and power distribution for lattices 81802 and 81902 for higher exposures (5, 15, 30, 45, and 60 Gwd/ST)*
- *J.* *Are the local peaking values presented in Figure 3-7 through Figure 3-13 based on fission rate or deposited energy (i.e. with gamma energy redistribution)?*

GE Response

Responses to each of the itemized requests follow. These responses do not result in DCD changes.

A. Panacea 3D nodal exposures, nodal void history, and nodal powers for BOC, MOC, and EOC are provided in the following Excel Spreadsheet files contained in Enclosure 2. For each file there is a tab representing an axial elevation. Slice 1 represents the bottom of the core. Slice 25 represents the top of the core.

Cycle Exposure	Data Filename
3D Nodal Exposures	
BOC (0 MWd/ST)	3D_Nodal_Exposure_BOC.xls
MOC (8000 MWd/ST)	3D_Nodal_Exposure_MOC.xls
EOC (16772 MWd/ST)	3D_Nodal_Exposure_EOC.xls
3D Nodal Void History	
BOC (0 MWd/ST)	3D_Nodal_Void_Hist_BOC.xls
MOC (8000 MWd/ST)	3D_Nodal_Void_Hist_MOC.xls
EOC (16772 MWd/ST)	3D_Nodal_Void_Hist_EOC.xls
3D Nodal Powers	
BOC (0 MWd/ST)	3D_Nodal_Power_BOC.xls
MOC (8000 MWd/ST)	3D_Nodal_Power_MOC.xls
EOC (16772 MWd/ST)	3D_Nodal_Power_EOC.xls

Fuel composition of the DCD equilibrium design can be found from a combination of tables and figures in reference NEDC-33239P, "GE14 for ESBWR Nuclear Design Report". Figure 3-1 and Figure 3-4 provide the lattice and axial elevations of both of the bundle designs. Figure 3-2 and Figure 3-5 provide the corresponding rod definitions and elevations of enrichment changes. Figure 3-25 and Figure 3-26 provide the loading pattern and BOC bundle average exposures for the two different bundle designs.

B. Hot Full Power (HFP) temperature of the fuel (UO_2), clad, and coolant

Fuel, operating	[[ ]]	
Coolant	559K	
Clad	[[ ]]	(varies with fuel temperature in HELIOS model)
Other Structure	[[ ]]	(for lattice physics calculations)
Doppler temperature	[[ ]]	

C. The elevated temperature for Doppler calculations is 1500°C. Because the nominal reference temperature is 475°C, the delta Doppler perturbation is 1025°C.

The moderator temperature calculations were performed at temperatures 20°C, 60°C, 100°C, 160°C, 220°C, and 286°C. Results of these calculations can be found in Table 3-53 and Table 3-54 of reference NEDC-33239P, "GE14 for ESBWR Nuclear Design Report".

Void coefficient calculations were performed at temperatures 100°C, 160°C, 220°C, and 286°C with a core wide void perturbation of 5% voids. Results of these calculations can be found in Table 3-55 and Table 3-56 of reference NEDC-33239P, "GE14 for ESBWR Nuclear Design Report".

D. Fuel densities

The NRC calculation for the fuel density for the Gd pins is for the UO_2 only. The density in the NRC's spreadsheet does not include the density of the gadolinia. It is a partial density for UO_2. In the following output, the density for gadolinia-bearing fuel pins includes the mass of the gadolinia.

Fuel Densities (from data provided in Figures 3-2 and 3-3 of NEDC-33239P)

Natural uranium (0.71 wt%)	[[	g/cm³	
Enriched uranium (2.4-4.9 wt%)		g/cm³	
Enriched uranium with Gd (4.4, 4.9 wt%)	]]	g/cm³	(includes fuel and Gd_2O_3)

E. Material densities are provided below.

Densities
zircaloy 0.237 lb/in^3
Stainless steel 0.290 lb/in^3
Alloy X-750 0.300 lb/in^3
Water at 70 degF 0.0361 lb/in^3

F. Dimensions, compositions, densities and typical operating temperatures for the control rods are provided below.

Dimensions

The following figure is Figure 1-1 from NEDC-33239P. The dimensions with respect to the nomenclature:
K = 12.45 cm, ½ span of control rod.
J = 3.937 cm, central support span (i.e. tie rod span).
L = 0.8331 cm, control rod wing thickness
T = 0.1143 cm, sheath thickness
Y = 0.5588 cm, absorber tube outer diameter
V = 0.06858 cm, absorber tube thickness
R1 = 0.0762 cm, central support span radius
R2 = 0.41656 cm, control rod wing tip radius
18 = number of B_4C absorber rods per wing

Compositions

Absorber tube = Stainless Steel
Absorber material = B_4C, 0.198 B-10
Sheath = Stainless Steel
Tie Rod = Stainless Steel

Densities

Absorber tube = 7.93 g/cm^3
Absorber material = 1.7528 g/cm^3
Sheath = 7.93 g/cm^3
Tie Rod = 7.93 g/cm^3

Typical Operating Temperatures

NEDC-33239P does not state the typical operating temperature of the control rod, however the analysis does provide the out of channel moderator temperature:
Hot = 286°C
Cold = 20°C

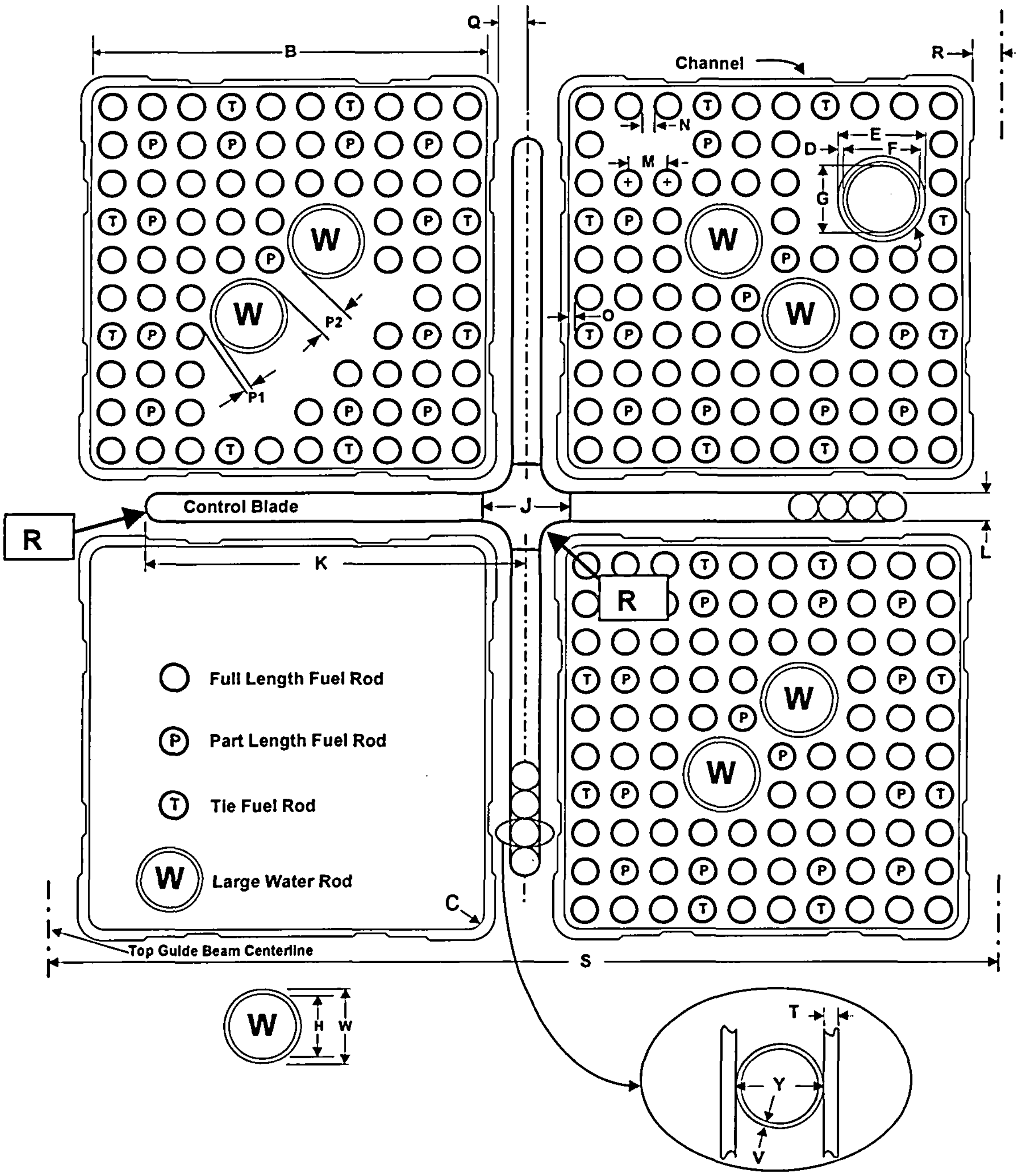

Figure 1-1 from NEDC-33239P

G. See the following table 21.6-54-1. Dimensional data for bundles 90019 and 90018 are taken from NEDC-33239P Figures 3-2, 3-3, 3-5, and 3-6.

Table 21.6-54-1,
Item G, Dimensions Corresponding to Dimensional Designations in Figure 1-1 of NEDC-33239P

GE14 N Lattice Dimensions (MFN 04-063)
Labels correspond to NEDC-33239P

Channel Dimenions		inches	cm	
				Note: HELIOS model has square channel corners
Corner Thickness	TCH	[[		
Median Thickness	TCM			
Small Thickness	TCS			
Long Median Width	WML			
Short Median Width	WMS			
Small Width	WCS			
Large Ramp Width	WRL			
Small Ramp Width	WRS			
Inside Channel Width	B			
Inside Corner Radius	C		]]	
Fuel Rod Dimensions				
Cladding Thickness	D	0.026	0.066	
Cladding OD	E	[[		
Cladding ID	F		]]	
Pellet OD (cold)	G	0.345	0.876	
Water Rod Dimensions				
Rod OD	W	[[		
Rod ID	H		]]	
Control Blade Dimensions				
				Note: HELIOS model based on homogenous blade
Tie Rod Span	J	1.550	3.937	
Blade Length	K	4.902	12.451	
Blade Thickness	L	0.328	0.833	
Blade Sheath Thickness	T	0.045	0.114	

Absorber Tube Wall Thickness	V	0.027	0.069
Absorber Tube OD	Y	0.220	0.559
Number of Tubes per Wing		18	18
Bundle Lattice Dimensions			
Rod Pitch	M	0.510	1.295
Rod-to-rod Gap	N	[[	
Rod to Channel Gap	O		
Water Rod to Fuel Rod Spacing	P1		
Water Rod to Water Rod Spacing	P2		]]
Fuel Cell Dimensions			
1/2 Wide Gap	Q	[[	
1/2 Narrow Gap	R		]]
4-Bundle Pitch	S	12.20	30.988

H. Reference NEDC-33239P commonly refers to "cold shutdown margin". This term refers to the amount of reactivity margin to criticality when the worst rod (or pair of rods) are withdrawn fully from the core. While not identified in reference NEDC-33239P, "control rod worth" is sometimes used to communicate rods with high reactivity control. However, multiple individual rod withdrawals are explicitly modeled in order to find the minimum shutdown margin. The limiting exposure dependent cold shutdown margin can be found in Figure 3-33 of reference NEDC-33239P. Figures 3-34 to 3-36 illustrate the radial values of cold shutdown margin at BOC, MOC, and EOC.

I. The following files contained in Enclosure 2 provide the fission rate distribution and power distribution for lattices 81802 and 81902 for the requested exposures at 0, 40, and 70 voids. Also included are values at 0 GWd/ST for comparison.

Lattice	**Data Filename**
Fission Rate Distribution	
81802	90018_81802_FRR.txt
81902	90019_81902_FRR.txt
Power Distribution	
81802	90018_81802_RPR.txt
81902	90019_81902_RPR.txt

J. The local peaking values presented in Figure 3-7 through Figure 3-13 are based on deposited energy (with gamma energy redistribution).

ENCLOSURE 4

MFN 06-295

Affidavit

Affidavit

I, Jens G. M. Andersen, state as follows:

(1) I am Consulting Engineer, Thermal Hydraulic Methods, Global Nuclear Fuel – Americas, L.L.C. ("GNF-A") and have been delegated the function of reviewing the information described in paragraph (2) which is sought to be withheld, and have been authorized to apply for its withholding.

(2) The information sought to be withheld is contained in Enclosures 1 and 2 of GE letter MFN 06-295, David H. Hinds to U. S. Nuclear Regulatory Commission, *Response to Portion of NRC Request for Additional Information Letter No. 49 Related to ESBWR Design Certification Application – TRACG Application for ESBWR Stability Evaluation and NEDC-33239P, "GE14 for ESBWR Nuclear Design Report" – RAI Numbers 4.4-14 and 21.6-54,* dated August 22, 2006. The proprietary information in Enclosure 1, *Response to Portion of NRC Request for Additional Information Letter No. 49 Related to ESBWR Design Certification Application – TRACG Application for ESBWR Stability Evaluation and NEDC-33239P, "GE14 for ESBWR Nuclear Design Report" – RAI Numbers 4.4-14 and 21.6-54,* is delineated by double underlined dark red font text and is enclosed inside double square brackets. Figures and large equation objects are identified with double square brackets before and after the object. The proprietary information in Enclosure 2, *Panacea 3D Nodal Exposures, Nodal Void History, and Nodal Powers for BOC, MOC, and EOC & Fission Rate Distribution and Power Distribution Files for Lattices 81802 and 81902* (CD) – *GNF Proprietary Information*, contains the designation "GNF Proprietary Information {3}" on the CD label. In each case, the superscript notation{3} refers to Paragraph (3) of this affidavit, which provides the basis for the proprietary determination.

(3) In making this application for withholding of proprietary information of which it is the owner or licensee, GNF-A relies upon the exemption from disclosure set forth in the Freedom of Information Act ("FOIA"), 5 USC Sec. 552(b)(4), and the Trade Secrets Act, 18 USC Sec. 1905, and NRC regulations 10 CFR 9.17(a)(4) and 2.390(a)(4) for "trade secrets " (Exemption 4). The material for which exemption from disclosure is here sought also qualify under the narrower definition of "trade secret," within the meanings assigned to those terms for purposes of FOIA Exemption 4 in, respectively, Critical Mass Energy Project v. Nuclear Regulatory Commission, 975F2d871 (DC Cir. 1992), and Public Citizen Health Research Group v. FDA, 704F2d1280 (DC Cir. 1983).

(4) Some examples of categories of information which fit into the definition of proprietary information are:

a. Information that discloses a process, method, or apparatus, including supporting data and analyses, where prevention of its use by GNF-A's competitors without license from GNF-A constitutes a competitive economic advantage over other companies;

b. Information which, if used by a competitor, would reduce his expenditure of resources or improve his competitive position in the design, manufacture, shipment, installation, assurance of quality, or licensing of a similar product;

c. Information which reveals aspects of past, present, or future GNF-A customer–funded development plans and programs, of potential commercial value to GNF-A;

d. Information which discloses patentable subject matter for which it may be desirable to obtain patent protection.

The information sought to be withheld is considered to be proprietary for the reasons set forth in paragraphs (4)a. and (4)b., above.

(5) To address the 10 CFR 2.390 (b) (4), the information sought to be withheld is being submitted to NRC in confidence. The information is of a sort customarily held in confidence by GNF-A, and is in fact so held. Its initial designation as proprietary information, and the subsequent steps taken to prevent its unauthorized disclosure, are as set forth in (6) and (7) following. The information sought to be withheld has, to the best of my knowledge and belief, consistently been held in confidence by GNF-A, no public disclosure has been made, and it is not available in public sources. All disclosures to third parties including any required transmittals to NRC, have been made, or must be made, pursuant to regulatory provisions or proprietary agreements which provide for maintenance of the information in confidence.

(6) Initial approval of proprietary treatment of a document is made by the manager of the originating component, the person most likely to be acquainted with the value and sensitivity of the information in relation to industry knowledge, or subject to the terms under which it was licensed to GNF-A. Access to such documents within GNF-A is limited on a "need to know" basis.

(7) The procedure for approval of external release of such a document typically requires review by the staff manager, project manager, principal scientist or other equivalent authority, by the manager of the cognizant marketing function (or his delegate), and by the Legal Operation, for technical content, competitive effect, and determination of the accuracy of the proprietary designation. Disclosures outside GNF-A are limited to regulatory bodies, customers, and potential customers, and their agents, suppliers, and licensees, and others with a legitimate need for the information, and then only in accordance with appropriate regulatory provisions or proprietary agreements.

(8) The information identified in paragraph (2) is classified as proprietary because it contains details of GNF-A's fuel design and licensing methodology.

The development of the methods used in these analyses, along with the testing, development and approval of the supporting methodology was achieved at a significant cost, on the order of several million dollars, to GNF-A or its licensor.

(9) Public disclosure of the information sought to be withheld is likely to cause substantial harm to GNF-A's competitive position and foreclose or reduce the availability of profit–making opportunities. The fuel design and licensing methodology is part of GNF-A's comprehensive BWR safety and technology base, and its commercial value extends beyond the original development cost. The value of the technology base goes beyond the extensive physical database and analytical methodology and includes development of the expertise to determine and apply the appropriate evaluation process. In addition, the technology base includes the value derived from providing analyses done with NRC–approved methods.

The research, development, engineering, analytical, and NRC review costs comprise a substantial investment of time and money by GNF-A or its licensor.

The precise value of the expertise to devise an evaluation process and apply the correct analytical methodology is difficult to quantify, but it clearly is substantial.

GNF-A's competitive advantage will be lost if its competitors are able to use the results of the GNF-A experience to normalize or verify their own process or if they are able to claim an equivalent understanding by demonstrating that they can arrive at the same or similar conclusions.

The value of this information to GNF-A would be lost if the information were disclosed to the public. Making such information available to competitors without their having been required to undertake a similar expenditure of resources would unfairly provide competitors with a windfall, and deprive GNF-A of the opportunity to exercise its competitive advantage to seek an adequate return on its large investment in developing and obtaining these very valuable analytical tools.

I declare under penalty of perjury that the foregoing affidavit and the matters stated therein are true and correct to the best of my knowledge, information, and belief.

Executed at Wilmington, North Carolina this 22nd day of August 2006.

Jens G. M. Andersen
Global Nuclear Fuels – Americas, LLC