GNF
Global Nuclear Fuel
A Joint Venture of GE, Toshiba, & Hitachi

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Document Control Desk
US Nuclear Regulatory Commission
Washington, DC 20555

Attention: Alan Wang

Subject: Transmittal of GNF Response to NRC RAIs Regarding the GEXL80 Correlation

Reference: Letter, M. E. Harding (GNF-A) to A. Wang (NRC), "Transmittal of GNF-A Report, NEDC-33107P, "GEXL80 Correlation for SVEA96+ Fuel," dated September 8, 2003.

Global Nuclear Fuel -Americas (GNF-A) is submitting for NRC review and approval responses (proprietary and non-proprietary versions) to the NRC Request for Additional Information (RAI) on the GEXL80 correlation. The RAIs are associated with the submittal referenced above which details the GEXL80 critical power correlation development.

This information is being submitted on behalf of Global Nuclear Fuel - Americas and the applicable NRC review fees should be invoiced accordingly.

If you have any questions, please call me at 910-675-5762.

Sincerely,

Margaret E. Harding

Margaret E. Harding
Manager, Fuel Engineering Services

cc:

T007

Affidavit

I, Margaret E. Harding, state as follows:

(1) I am Manager, Fuel Engineering Services, 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 the attachments (proprietary and non-proprietary versions), "GNF Response to NRC RAIs Regarding the GEXL80 Correlation." The NRC request for additional information (RAI) was in regards to NEDC-33107P, "GEXL80 Correlation for SVEA96+ Fuel", Rev. 0, September 2003, which was submitted by Global Nuclear Fuel - Americas to the NRC for review. GNF proprietary information is indicated by enclosing it in double brackets. 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 and commercial or financial information obtained from a person and privileged or confidential" (Exemption 4). The material for which exemption from disclosure is here sought is all "confidential commercial information," and some portions 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 cost or price information, production capacities, budget levels, or commercial strategies of GNF-A, its customers, or its suppliers;

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

e. 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 17th day of March, 2004.

Margaret E. Harding
Global Nuclear Fuel – Americas, LLC

GNF Response to NRC RAIs Regarding the GEXL80 Correlation

1. **For Tables 3-2 and 3-3, on page 3-3, please provide a 95/95 uncertainty, as well as the upper and lower bounds on these 95/95 values, for each of the power profiles provided in Table 3-3 and for the correlation data bases of Table 3-2.**

Table 3-2. Statistical Summary for SVEA96+ GEXL80

[[

	Total Correlation Database	Development Database	Verification Database
Number of data points			
Mean ECPR			
Standard deviation, (%)			
k Value			
95/95 Upper Tolerance Limit ($\mu + k\sigma$)			

{3}]]

Table 3-3. Statistical Summary for Each Axial Power Shape for SVEA96+ GEXL80 Correlation Database

[[

	Axial Power Shape			
	Cosine	Inlet	Outlet	Double Hump
Number of Data Points				
Mean ECPR				
Standard Deviation (%)				
k Value				
95/95 Upper Tolerance Limit ($\mu + k\sigma$)				

{3}]]

Note: The GEXL80 report contained a typo for the Total Correlation Database ([[{3}]]).

2. **On page 4-6, the R-factor is discussed, as accounting for the need to address the "mini-bundle term variation term". The staff does not fully appreciate the methodology developed for calculating the "mini-bundle term", or the so-called "mismatch factor." Please be prepared to derive each of the terms alluded to in the derivation of the final expression for "delta R", provided on page 4-7.**

The SVEA96+ bundle is divided into four mini-bundles by the water cross as shown in Figure 2-1. The four mini-bundles are four parallel flow channels that all are subject to the same pressure drop. If the SVEA96+ bundle has a quadrant symmetric pin power distribution, the four mini-bundles have the same power and they will also have the same mass flux and critical power performance. If, on the other hand, the pin power distribution is not symmetric the four mini-bundles will have different powers. The mini-bundle with the highest power will have the highest vapor generation and, therefore, its two-phase pressure drop will increase relative to the other three mini-bundles. Since the four mini-bundles all have the same pressure drop, the impact of the higher two-phase pressure drop in the hottest bundle must be offset by a reduced inlet flow and a corresponding lower single phase pressure drop. Similarly the mini-bundle with the lowest power will have less vapor generation, less two-phase pressure drop and correspondingly must have a higher inlet flow and higher single phase pressure drop. Therefore the impact of a power mis-match between the four mini-bundles in the SVEA96+ fuel bundle is that the mini-bundle with the highest power has a mass flux that is less than the average for the bundle, and the mini-bundle with the lowest power has a mass flux that is higher than the average. For a mini-bundle a reduction in the mass flux will produce a corresponding reduction in the mini-bundle critical power (critical power is a monotonically increasing function with mass flux).

The GEXL methodology calculates the critical power based on the bundle R-factor and the bundle average mass flux. Using this average mass flux, however, does not account for the lower mass flux in the hottest mini-bundle and the corresponding lower critical power. Therefore an adjustment to the critical power must be developed to account for the impact of any power mis-match between the mini-bundles. The thermal/hydraulic model for the SVEA96+ bundle characterizes the pressure drop as function of power and mass flux. A relationship between power and flow for a constant pressure drop can be derived from this thermal/hydraulic model. Therefore the mismatch in mini-bundle mass flux can be determined for a given mini-bundle power mis-match and average bundle thermal/hydraulic conditions. Since critical power is a monotonically increasing function with mass flux, the mini-bundle mass flux mis-match can be equated to a corresponding reduction in mini-bundle critical power. This reduction in the mini-bundle critical power is then incorporated as a penalty on the R-factor for the mini-bundle.

3. **After reading Section 5.0 of the September 8, 2003, submittal, it is not clear to the staff how the ECPR distribution and the standard mean were obtained. Please provide the technical justification, i.e., the calculations, displaying these results.**

   As stated at the end of Section 5.0, the standard mean was chosen based on the GEXL80 critical power comparison to SVEA96+ dryout test data as determined by PSEG. GNF does not have access to this proprietary study, however, the PSEG recommendation letter (Reference 4 in the GEXL80 document) provides justification for the mean and standard deviation.

4. **On page 5-1, equation 5-1 for the ECPR is provided in the form of a ratio of two correlations, each having unique uncertainty associated with it. As such, these two correlations are not totally independent of each other, since the GEXL80 correlation is derived from a data set generated by a sub-channel code incorporating the ABB2.0 correlation (as alluded to in the 3rd. sentence of the first paragraph on page 5-4). How is the uncertainty of each correlation captured, and the lack off independency between the two correlations accounted for in the overall statistical calculation of uncertainty. Please be specific and detailed in this regard.**

   See response to Question 3 above.

5. **On page A-1, the R-factor calculational process is discussed. In this discussion, the subject of "control state" is raised. Please define the control state.**

   Control state refers to the number of nodes controlled and is used to integrate rod power as indicated in Table A-1.

6. **On pages A-9 to A-10, three figures are briefly discussed. Please be prepared to discuss these same figures in detail.**

   These figures address the 'mini-bundle variation term.' See response to Question 2 above.

7. **Table 3-2. The standard deviation for the Total Correlation Database does not appear to be in agreement with the individual standard deviations of the power profiles in Table 3-3. Also, it is surprising that the standard deviation of the Total Correlation Database is smaller than either the Development or the Verification databases. Please provide the NRC a data disk to enable us to verify the calculations.**

   This observation is incorrect. The standard deviation of the Total Correlation Database [[(   ) {3}]] is between the values of the Development [[(   ) {3}]] and Verification [[(   ) {3}]] databases. To address the agreement of the Total Correlation Database with the individual standard deviations of the power profiles in Table 3-3, the following statistical method is provided in the GEXL Development Technical Design Procedure (TDP-0117).

   If the data consists of m sets of data, e.g., m different axial power shapes, correlation statistics can be developed for each set using:

$$\overline{\mathrm{ECPR}_j} = \frac{1}{n_j}\sum_{i=1}^{n_j}\mathrm{ECPR}_i \qquad \sigma_j = \sqrt{\frac{1}{n_j - 1}\sum_{i=1}^{n_j}(\mathrm{ECPR}_i - \overline{\mathrm{ECPR}_j})^2} \qquad (1)\ (2)$$

where the summation is over the data in set j.

The following relation exists:

$$\overline{\mathrm{ECPR}} = \frac{\sum_{j=1}^{m} n_j \overline{\mathrm{ECPR}_j}}{\sum_{j=1}^{m} n_j} \qquad \sigma^2 = \frac{\sum_{j=1}^{m}(n_j - 1)\sigma_j^2}{\left(\sum_{j=1}^{m} n_j\right) - 1} + \frac{\sum_{j=1}^{m} n_j(\overline{\mathrm{ECPR}}_j^2 - \overline{\mathrm{ECPR}}^2)}{\left(\sum_{j=1}^{m} n_j\right) - 1} \qquad (3)\ (4)$$

The first term in equation (4) is the average of the standard deviation for the data sets. The second term is the variance of the means for the data sets and represents the trend error in predicting the axial power shape effects.

Use of equation (3) for combining individual ECPR Means from Table 3-3 above:
[[

$$\overline{\mathrm{ECPR}} = \frac{\sum_{j=1}^{m} n_j \overline{\mathrm{ECPR}_j}}{\sum_{j=1}^{m} n_j} =$$

$\overline{\mathrm{ECPR}}$= {3}]]

Use of equation (4) for combining individual uncertainties:

$$\sigma^2 = \frac{\sum_{j=1}^{m}(n_j - 1)\sigma_j^2}{\sum_{j=1}^{m} n_j - 1} + \frac{\sum_{j=1}^{m} n_j(\overline{\mathrm{ECPR}}_j^2 - \overline{\mathrm{ECPR}}^2)}{\sum_{j=1}^{m} n_j - 1}$$

First term of equation (4):
[[

$$\frac{\sum_{j=1}^{m}(n_j - 1)\sigma_j^2}{\sum_{j=1}^{m} n_j - 1} =$$

= . {3}]]

Second term of equation (4) (the combined ECPR mean was calculated above using equation (3)):

$$\frac{\sum_{j=1}^{m} n_j(\overline{\text{ECPR}}_j^2 - \overline{\text{ECPR}}^2)}{\sum_{j=1}^{m} n_j - 1} =$$

[[

{3}]] (More significant digits than shown above for mean ECPR were used in this calculation)

Combining the two terms of equation (4):

[[

$$\sigma^2 = \frac{\sum_{j=1}^{m}(n_j - 1)\sigma_j^2}{\sum_{j=1}^{m} n_j - 1} + \frac{\sum_{j=1}^{m} n_j(\overline{\text{ECPR}}_j^2 - \overline{\text{ECPR}}^2)}{\sum_{j=1}^{m} n_j - 1} =$$

{3}]]

Taking the square root:[[$\sigma =$ {3}]], convert to percent by multiplying by 100, and reduce to two significant digits:

[[$\sigma =$ % {3}]]

Note that the ECPR mean and standard deviation calculated above using equations (3) and (4) are equivalent to those values shown for the Total Correlation Database in Table 3-2.

8. Table 3-2. Please identify all statistical tests that compare the Development database and the Verification database. Specifically, show such tests for each power profile and for all profiles combined. Please report the outcome of such tests and relevant intermediate steps.

Shown below are the histograms for the development and verification databases.
[[

{3}]]

The mean and standard deviations for the Development and Verification databases are shown in the response to Question 1 ([[{3}]], respectively). A Two-Tailed Two-Sample T test was completed with a 95% confidence interval where the null hypothesis was H0: $\mu 1 = \mu 2$ and the alternate hypotheis was H1: $\mu 1 \neq \mu 2$, where μ is the population mean. This hypothesis test yielded P=0.047. The 'P' value represents the probability of rejecting the null hypothesis when it is true. The smaller the P-value, the smaller the probability of making a mistake by rejecting the null hypothesis. In this case ($P<0.05$), typically the null hypothesis would be rejected and the alternative accepted: the means are not equal. However, in this instance the difference between the means is 0.008, which is insignificant compared to the correlation uncertainty. Thus the null hypothesis is accepted and the means are considered equal since they can not be easily differentiated.

9. **Table 3-2 and 3-3. These tables need to be expanded to include a 95/95 tolerance limit for each database (Total Correlation, Development, and Verification) and for each power profile in the Total Correlation Database.**

   See the response to Question 1 above.

10. **Section 4.2. The report claims that the range of application is valid for <u>pressure</u> [[{3}]] psia. Table 2-2, however, shows that the study uses very few points for which pressure is different from [[{3}]] psia and none for pressure above [[{3}]] psia. The range of application for <u>mass flux</u> is claimed to be valid for [[{3}]] Mlbm/hr-ft^2. Table 2-2 shows that the study uses very few points below [[{3}]] Mlbm/hr-ft^2. The range of application for <u>inlet subcooling</u> is claimed to be valid for [[{3}]] Btu/lbm. Table 2-2 shows that the study uses very few points above [[{3}]] and none below [[{3}]] Btu/lbm.**

    The bulk of the data is collected in the expected operating range for the bundle: [[{3}]] psia,[[{3}]] Mlbm/hr-ft^2, [[{3}]] Btu/lbm. Additional data was collected outside these ranges for trend analyses in the development of the GEXL80 correlation. The additional data was collected at pressures of [[{3}]] psia, mass flux of [[{3}]] Mlb/hr-ft^2, and inlet subcoolings of [[{3}]] Btu/lbm. Trends show that the GEXL80 correlation is well behaved within the database ranges and outside these ranges, specifically where the application ranges have been extended slightly outside the database. The application ranges for GEXL80 are:
    [[

    {3}]]

11. The paucity of data at the low and high value of the claimed range of applicability needs further elaboration. The extrapolation beyond [[{3}]] psia and below [[{3}]] Btu/lbm is worrisome even in light of the explanation offered in Section 4.2. Note that such extrapolations have not been accepted by the staff in the past.

The use of "Database" and "data" above refers to calculated hypothetical data points generated using the NRC approved Westinghouse ABBD2.0 correlation, which itself has an underlying experimental database that is proprietary to Westinghouse

The licensee, having access to the proprietary data, must also verify that the application ranges of the calculated hypothetical database **must not exceed** *the upper and lower bounds of the actual experimental database.*

The licensee has directly compared the range of applicability of the GEXL80 correlation to the Westinghouse experimental database. The licensee has verified that the experimental database ranges were not exceeded.