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RS-03-231

December 10, 2003

U. S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Washington, DC 20555-0001

LaSalle County Station, Units 1 and 2
Facility Operating License Nos. NPF-11 and NPF-18
NRC Docket Nos. 50-373 and 50-374

Subject: Additional Information Regarding Request for Amendment to Technical Specifications Section 5.6.5, "Core Operating Limits Report (COLR)"

References:

(1) Letter from T. W. Simpkin (Exelon Generation Company, LLC) to U. S. NRC, " Request for Amendment to Technical Specifications Section 5.6.5, 'Core Operating Limits Report (COLR),'" dated July 1, 2003

(2) Letter from U. S. NRC to J. L. Skolds (Exelon Generation Company, LLC), "LaSalle County Station, Units 1 and 2 – Request for Additional Information RE: Core Operating Limits Report," dated November 10, 2003

In Reference 1, Exelon Generation Company, LLC (EGC) requested changes to the Technical Specifications (TS) of Facility License Nos. NPF-11 and NPF-18 for LaSalle County Station (LCS), Units 1 and 2. In Reference 2, the NRC requested additional information regarding these proposed changes. The attachments to this letter provide the requested information.

Some of the information contained in Attachment A is classified as proprietary to our fuel supplier, Global Nuclear Fuel (GNF), and is identified as text contained between opening double brackets ([[ ) and closing double brackets ( ]]). The proprietary information is of the type that GNF maintains in confidence and withholds from public disclosure. It has been handled and classified as proprietary as supported by the affidavit in Attachment B. We request that this information be withheld from public disclosure in accordance with the provisions of 10 CFR 2.790, "Public inspections, exemptions, requests for withholding." Attachment C provides a non-proprietary version of the information in Attachment A.

Should you have any questions concerning this letter, please contact Mr. Allan R. Haeger at (630) 657-2807.

A P01

I declare under penalty of perjury that the foregoing is true and correct.

December 10, 2003
Executed on

Kenneth A. Ainger
Manager – Licensing

Attachment A: Response to Request For Additional Information (Proprietary Version)
Attachment B: Affidavit Supporting Withholding from Public Disclosure
Attachment C: Response to Request For Additional Information (Non-Proprietary Version)

cc: Regional Administrator – NRC Region III
Senior Resident Inspector – LaSalle County Station
Office of Nuclear Facility Safety – Illinois Department of Nuclear Safety

Attachment B
Affidavit Supporting Withholding from Public Disclosure

Affidavit

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

(1) I am Fellow and project manager, TRACG Development, 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 attachment, "GNF, EXELON, and FANP RESPONSES TO NRC RAIs ON GEXL97." The NRC request for additional information (RAI) was in regards to NEDC-33106P, "GEXL97 Correlation for ATRIUM-10 Fuel", Rev. 1, June 2003 which was submitted by Exelon Generation Company, LLC 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 2.790(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 2.790 (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 10th day of December, 2003.

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

Attachment C
Response to Request For Additional Information (Non-Proprietary Version)

GNF, EXELON and FANP RESPONSES TO NRC RAIs ON GEXL97

Q1. **Will the initial reload transition core for LSCS Unit 1 contain all three fuel types? If, so what type of mixed vendor core analysis will be done, and is anything planned for submittal to the staff for review prior to loading of the fuel?**

R1. GE14 fuel will first be inserted into the LaSalle County Station (LCS), Unit 1 Cycle 11 (L1C11) core in January 2004. The L1C11 core is projected to consist of 290 GE14 fuel assemblies, 346 Framatome Advanced Nuclear Power (FANP) ATRIUM 10 fuel assemblies, and 128 FANP ATRIUM 9 fuel assemblies and thus the L1C11 core will contain a mix of GE14, FANP ATRIUM 10, and FANP ATRIUM 9 fuel. General Electric (GE) and Global Nuclear Fuel (GNF) analyses for the use of GE14 fuel at LCS will consist of new fuel introduction (NFI) analyses or evaluations and cycle specific reload analyses that are documented in the supplemental reload licensing report (SRLR). These analyses will consider the effects of a mixed core of GNF and FANP fuel. The GE14 NFI portion will consider analyses that are independent of the specific core design. These include analyses or evaluations such as seismic response of the core, decay heat effects, source term impact, anticipated transient without scram (ATWS), reactor pressure vessel fluence impact, and reactor internal pressure differences. The NFI report will not be submitted. Additional reports are produced evaluating thermal/hydraulic compatibility of the different fuel designs in the mixed core and criticality compliance in the new fuel vault and spent fuel pool. The cycle specific reload portion of the analyses is documented in the SRLR and consists of the standard set of analyses that are performed for each reload. The standard set of analyses is determined using the guidelines in Reference 1. These consist of the loading pattern development, rod withdrawal event analyses, minimum critical power ratio (MCPR) safety limit analyses, stability analyses, and cycle specific transient analyses such as the load reject without bypass, feedwater controller failure, and turbine trip without bypass. EGC has submitted to the NRC (Reference 2) the request to add the GEXL97 correlation methodology topical report to the list of approved methodologies in the LCS Technical Specifications. No other submittals are anticipated as all licensing applications are being performed within the bounds of the GNF/GE approved methodology topical report as documented in Reference 1.

Q2. **What steps were taken to ensure that the ANFB correlation results calculated by a 3D nodal code were consistent with the SPCB correlation results calculated by a 2D subchannel code?**

R2. The thermal hydraulics portions of the codes are used to generate the operating conditions – enthalpy, pressure, and flow for a specific power distribution (assembly power and axial power shape). The codes (either MICROBURN-B or XCOBRA) were used as convenient sources to develop the operating conditions and to complete critical power calculations. The operating conditions could be developed in any fashion as long as the conditions used to develop the data are used in the development of the GEXL correlation coefficients or parameters. For

a consistent set of inputs (i.e., operating conditions and power distributions), the ANFB correlation (or SPCB correlation) will produce the same results whether calculated with MICROBURN-B or XCOBRA.

Q3. Was the consistency cross-checked either by generating "data" using the ANFB correlation in the XCOBRA code or by using the SPCB correlation in the MICROBURN code?

R3. There was no need to perform such a cross check since the same correlation is applied in both codes. For a given set of operating conditions, the same result would follow. As discussed in the response to Q2, the use of two different codes does not invalidate the correlation to correlation comparison. The ATRIUM-9B data were generated with the ANF-B correlation while the ATRIUM-10 data were generated with the SPCB correlation.

Q4. What bias or additional uncertainty is introduced by the difference in the "data" source? How is the bias or uncertainty evaluated or determined?

R4. The use of MICROBURN or XCOBRA as the data source introduces no bias or additional uncertainty since the same calculation is performed with the same set of conditions regardless of code.

Q5. Is the GEXL14 correlation to be used for the reload batch of GNF GE14 fuel to be inserted in LSCS Unit 1 in January 2004?

R5. GE14 fuel will first be inserted into the L1C11 core in January 2004. The L1C11 core is projected to consist of 290 GE14 fuel assemblies, 346 FANP ATRIUM 10 fuel assemblies, and 128 FANP ATRIUM 9 fuel assemblies. The L1C11 core will contain a mix of GE14, FANP ATRIUM 10, and FANP ATRIUM 9 fuel. All licensing calculations will be performed by GNF using the GEXL14 correlation (Reference 3) to apply to the GE14 fuel in L1C11, the GEXL97 correlation (Reference 4) to apply to FANP ATRIUM 10 fuel in L1C11, and the GEXL96 correlation (Reference 5) to apply to FANP ATRIUM 9 fuel. Operation of the core will be monitored using these same correlations for the applicable assembly design. The GEXL14 topical report (Reference 3) was not included because the GEXL14 correlation coefficients documented in the report are directly included in the GE14 compliance document that was supplied to the NRC (Reference 6) to demonstrate compliance with Amendment 22 of Reference 1.

Q6. The technical design bases justification contained in NEDC-33106P for the applicability of the GEXL97 critical power prediction includes an acknowledgment that the uncertainty in the GEXL97 correlation's fit to the hypothetical database and the uncertainty in the hypothetical database with respect to the underlying experimental database are not independent. Is this a reference to the covariance term associated with dependent databases?

R6. The reference to the covariance term is associated with dependent databases. The term is described in Reference 4 (GEXL 97) in Equation 5-3 within a second order Taylor's series expansion for estimating the uncertainty of the GEXL97 correlation relative to the FANP database. Since it can not be proved that the

databases are independent, it is conservatively assumed that they are fully correlated and a covariance of 1.0 is used. This is consistent with GEXL96 development.

Q7. Is the hypothetical data base generated by Framatome, or by the licensee, or by GNF? If not generated by Framatome, what are the procedures for quality assurance control on the input and output verification? Also confirm that an approved version of the XCOBRA code is used and provide the reference, if different from the TS reference.

R7. Framatome developed the calculated critical power ratio (CPR) database for the ATRIUM-10 fuel. XCOBRA has been approved by the NRC. Approval for the XCOBRA code is provided in XN-NF-80-19(P)(A) Volume 3 Revision 0, Exxon Nuclear Methodology for Boiling Water Reactors, THERMEX: Thermal Limits Methodology Summary Description, February 1987.

Q8. Is there an additional uncertainty resulting from using two separate GEXL type correlations for the legacy fuel in a mixed vendor reload core environment, with another GEXL correlation to be used for the fresh GE14 fuel?

R8. There is no additional GEXL uncertainty resulting from using three separate GEXL correlations in a mixed vendor reload core. For a mixed core the fuel specific GEXL correlation is used for each fuel type (e.g., the GEXL14 correlation is used for GE14 fuel while the GEXL97 correlation is used for ATRIUM10 fuel). For known power and flow conditions for a fuel bundle, the uncertainty in the critical power is given by the uncertainty of the fuel specific GEXL correlation. The uncertainty in the power and flow condition in the fuel is given by the uncertainties in the total power, the power distribution, the total flow and flow distribution for the core and are included in the safety limit calculation.

Q9. What nodal plant simulator and/or on-line core performance system will be used to predict and monitor the reload core operating performance? If the GE PANACEA, and/or the GE 3D MONICORE models are to be used, please provide the code version and point to the appropriate reference(s).

R9. The FANP POWERPLEX III core monitoring system will be used to predict and monitor the reload core operating performance. This system is based on the FANP CASMO4/MICROBURN B2 methodology as described in Reference 7. The GEXL14, GEXL97, and GEXL96 critical power correlations/subroutine as developed by GNF has been installed in the POWERPLEX III core monitoring code. The installation of these correlations/subroutine has been validated to a matrix of critical power data supplied by GNF to Exelon. As such, with POWERPLEX III software monitoring the reload core, the GEXL14 correlation will be used to determine critical power ratio (CPR) for the GE14 fuel, the GEXL97 correlation will be used to determine the CPR for the ATRIUM 10 fuel, and the GEXL 96 correlation will be used to determine the CPR of the ATRIUM 9B fuel. The Exelon Generation Company, LLC (EGC) installation of the critical

power correlations (GEXL14, GEXL96, GEXL97) has been performed under the EGC quality assurance program for software installation, control, and validation.

Q10. Is the inclusion of double humped power shapes due to the presence of part-length fuel rods in the ATRIUM-10 fuel design, or was it included for other reasons?

R10. The inclusion of the double humped power shape is not due to the presence of part-length rods. The ability of critical power correlations to adequately determine the critical power for double humped power shapes is a relatively new issue as a result of double hump axial power shape critical power dryout tests performed in Europe. When the issue arose, GNF performed a survey of operating cores and determined that double humped axial power shapes can occur for partially controlled conditions, but such bundles typically have low power and will be non-limiting. [[

{3}]] This is the case for GE14 fuel. For ATRIUM10 fuel, data with a double humped axial power shape were included in the correlation database, and there is no need for further evaluation of this issue.

Q11. Is the XCOBRA code used to generate the hypothetical data base an approved version? If, so confirm the XCOBRA-T reference in the TS, or provide the correct reference.

R11. Section 5.6.5 of the LCS Technical Specifications lists the XCOBRA-T methodology document as Reference 11, "XCOBRA-T: A Computer Code for BWR Transient Thermal Hydraulic Core Analysis, XN-NF-84-105 (P) (A)." Also see the response to Q7.

Q12. Please discuss the criteria used to select development versus verification data points.

R12. GESTAR (Reference 1) requires that the test database be divided into a development set and a verification set and that the verification set not be used in the initial fitting of the GEXL coefficients. The GEXL97 verification dataset is selected from the "Standard Critical Power" data and is representative of each of the four axial power shapes. Also see the responses to Q13 and Q20.

Q13. Describe the "Statistical Design of Experiments" or an equivalent process that was used to determine the hypothetical data sets. Please provide a reference to accepted methods, such as "Statistical Methods for Nuclear Material Management," NUREG/CR-4604, PNL-5849 or equivalent.

R13. The process for defining the hypothetical data sets is the same process that would be used to define the data sets for an experimental facility. This process is defined in GNF Technical Design Procedure TDP-0117, "GEXL Correlation Development." The process is defined to cover the range of operating conditions that can be expected for a fuel bundle.

[[

{3}]] Also see the response to Q33.

These considerations are the basis for the test matrix outlined in TDP-0117.

In Table 2-2 of the GEXL97 topical report (Reference 4) the database was generated by working through a combination of parameters for each collection type for the local peaking patterns representing each unique rod position in the lattice. Based on the layout of Table 2-2 and the information given in Table 3-1

of Reference 4, the approximate number of critical power data points that should have been generated can be estimated for a specific combination of parameters. For example, for collection type "Standard Critical Power and Reproducibility Databases" for the cosine shape, there were [[{3}]] data points generated at each specified mass flux. This equates to (1 axial power shape) x (1 pressure value) x ([[{3}]] local peakings) x ([[{3}]] specified inlet subcooling parameters). The local peakings represent [[{3}]] of the [[{3}]] unique rod positions and do not include the two part length rod positions or two unique positions that are represented by the high R-factor data. Boiling transition data for part length rods can only be achieved using an inlet power shape and thus are not represented in the mentioned cosine data. The high R-factor critical power data was generated under a different "collection type" as designated in Table 3-1.

Q14. Please provide the technical justification that the number of data points chosen for selected thermal hydraulic parameters, such as pressure, mass flow and inlet sub-cooling, would be statistically sufficient to derive the correlation.

R14. The range of the data was chosen to cover the expected range of operation. These ranges include flow, inlet sub-cooling, pressure, and power shape. For the hypothetical database, the total correlation database consisted of [[{3}]] points. This compares to 1028 data points for the underlying ATRIUM-10 database. ATLAS data collected for past fuel products has consisted of approximately [[{3}]] data points and was based on a similar data collection test matrix as used for GEXL97 development. Data is collected according to the test matrix for each unique fuel rod position in the fuel lattice in order to collect sufficient data to determine all additive constants.

The complete database consisted of [[{3}]] points, and although all of them were used in the development of the GEXL97 correlation, not all were used in the overall statistics characterizing the GEXL97 correlation. This was due to the conservative nature of that data and included the high R-factor data ([[{3}]] points), very low mass flux data ([[{3}]] points), and part length rod data ([[{3}]] points).

Q15. How was it determined that the [[{3}]] data sets that were generated are adequate to cover the required range of variables?

R15. The [[{3}]] data sets were chosen to cover all the unique local peaking distributions. The range of fluid parameters and axial peakings were covered for each data set. Also see the response to Q13.

Q16. How did the range of the underlying experimental database (axial flux shape, pressure, mass flux, sub-cooling, R-factor input) for the SPCB correlation compare to the stated range of application required for the GEXL97 correlation application?

R16. The SPC ATRIUM-10 correlation range of applicability is:

Pressure (psia):	571 – 1432
Inlet Subcooling (Btu/lbm):	6 – 149
Mass Flux (Mlb/hr-ft^2):	0.09 – 1.5
Local peaking:	1.5

No hypothetical data was generated for use in the GEXL97 development that was outside the SPCB correlation range of applicability. According to FANP, the range of the experimental data base for ATRIUM-10 fuel supports the range of inputs used in the XCOBRA-calculated data provided to EGC.

Q17. The internal water channel (water box) of the ATRIUM-10 fuel bundle which displaces a [[{3}]] appears to be represented by GNF as [[{3}]] geometry, to be consistent with the underlying assumptions of the GEXL correlation model. What additional uncertainty is introduced by this approximation and how is it represented for use in the GNF GETAB models?

R17. The critical power calculated by the GEXL correlation is a function of the mass flux, hydraulic diameter, thermal diameter plus a number of other parameters such as pressure and boiling length. The bundle active flow area is preserved using this [[{3}]] representation of the water channel, thermal diameter is essentially a scaling factor within the correlation, and studies have shown that small differences in hydraulic diameter do not affect the critical power calculation. For this reason, no additional uncertainty is introduced by this [[{3}]] rod approximation of the ATRIUM-10 water channel. Therefore, there is no issue for the GEXL correlation.

The simulation of the water box by a [[{3}]] is only done in the TGBLA lattice calculation. The TGBLA lattice calculations of the ATRIUM10 fuel bundle, including the simulation for the water box by a [[{3}]], has been benchmarked using the exact geometry with the Monte Carlo code MCNP. These calculations have been used to determine the accuracy of the rod power distribution. The effect of this uncertainty is accounted for in the R-factor uncertainty in the safety limit calculation.

Q18. The GEXL thermal diameter and hydraulic diameter parameters appear to be determined as an average value over the 150-inch active length (heated length) of the fuel assembly. What effect does this approximation have on the part length fuel rods which are [[{3}]] inches in heated length?

R18. The thermal diameter in the GEXL correlation is based on the thermal diameter in the fully rodded section of the bundle, i.e., below the top of the part length rods. The GEXL correlation is developed from data using this definition for the thermal diameter and applied consistently. This is the standard process for GNF and non-GNF fuel.

Q19. The plot appears to show 49 axial points. Is this from an interpolation for the plotting routine, or are this many axial points input to the correlation?

R19. See the response to Q38.

Q20. Please provide a chart or table that shows how the verification data stacks up next to the development data for different levels of pressure, mass flux, and sub-cooling for the various power shapes.

R20. The verification database had data representative of all four power shapes, exterior and interior rod positions, and thermal hydraulic parameters for expected fuel operation. In Table 2-1 of the GEXL97 development report (Reference 4) the verification database is represented by Data Set 3 ((1,3) pin position) by the cosine power shape data, Data Set 11 ((3,4) pin position) by the inlet peaked power shape data, Data Set 16 ((4,6) pin position) by the outlet peaked power shape data, and by Data Set 19 ((5,8) pin position) by the double humped axial power shape data.

The following table shows the various thermal hydraulic parameters of the verification database. All verification data had a pressure of 1000 psia.

[[

	Mass Flux (Mlb/hr-ft^2)						Inlet Sub-cooling (Btu/lbm)			
APS										
Inlet										
Cosine										
DblHmp										
Outlet										

{3}]]

The following tables show the 95/95 upper limit for the statistics in Table 3-3, and also the breakdown of Table 3-3 combined correlation statistics into the development database and verification database. The 95/95 statistics demonstrate that GEXL97 correlation was developed so that the outlet peaked power shape predictions closely duplicate the simulated test data and are biased conservatively for the inlet peaked power shapes.

Table 3-3. Statistical Summary for Each Axial Power Shape
for ATRIUM-10 GEXL 97 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 ($\mu + k\sigma$)				
95/95 Upper Tolerance Limit (Composite)				

{3}]]

Statistical Summary for Each Axial Power Shape
ATRIUM-10 GEXL97 Development Database

[[

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

{3}]]

Statistical Summary for Each Axial Power Shape
ATRIUM-10 GEXL97 Verification Database

[[

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

{3}]]

Q21. Why is the sparser database considered adequate for the ATRIUM-10 GEXL97 correlation development? What criteria are used to specify the minimum number of points needed?

R21. See the responses to Q13 through Q16.

Q22. For response by EGC: How does the R-factor in the generic GEXL correlation form relate to the F-effective factor in the SPCB correlation form?

R22. The F-effective factor in the SPCB correlation is determined from the pin by pin power peaking distribution within a fuel assembly and is then used as input to the SPCB correlation. The R-factor in the generic GEXL correlation is also determined from the pin by pin power peaking within a fuel assembly and is then used as input to the GEXL correlation. However, the form of the FANP F-effective is different from the form of the GEXL R-factor. Both the FANP F-effective and GEXL R-factor are based upon the pin by pin power peaking within the assembly but the process used in their determination is specific to the input required for the respective critical power correlations (SPCB and GEXL). Although the formulation of the FANP F-effective is different than the formulation of the GEXL R-factor, both the F-effective and R-factor are formulated to characterize the influence of neighboring pin power peaking on the pin of interest when determining the critical power.

Q23. Is the required R-factor range for the GEXL97 correlation within the range of the experimental SPCB database?

R23. The SPCB correlation does not contain an R-factor parameter. Also, the R-factor is not an experimentally collected value. The R-factors are calculated from the local rod-to-rod peaking. The peaking factors for the [[{3}]] unique rod-to-rod peaking distributions consisted of a maximum bundle rod average peaking of [[{3}]] for the standard full length rod peakings, bundle rod average peaking of [[{3}]] for full length rod high R-factor peakings, and a lattice rod peaking of [[{3}]] for the part length rods, and these are within the range of applicability of the SPC ATRIUM-10 correlation. Also see the response to Q16.

Q24. Please provide the technical justification that the R-factor in GEXL97 can capture the effect of the part-length rods, the rods adjacent to the large internal water channel, etc.

R24. The GEXL97 database was chosen to capture all sensitivities associated with unique rod positions in the lattice. Data was generated for all unique rod positions including the unique part length rod positions and the unique rod positions adjacent to the large internal water channel. Comparisons of data versus calculated critical power show that GEXL97 captures the effects of the data. The R-factor methodology was specifically designed to cover part length rods when part length rods were first introduced for GE11 fuel. This methodology is summarized in Appendix A of the GEXL97 development document (Reference 4) and covered in detail in Reference 8.

Q25. The applicable range of values obtained for the bundle R-factor [[{3}]] would appear to depend on the number of data points in the hypothetical database. Please demonstrate the sensitivity of the R-factor range to the number of data points, since the GEXL97 data point collection is much smaller than the GEXL96 matrix.

R25. The R-factor application range is dependent upon the range of the data collected, not on the number of data points in the hypothetical database. The expected R-factor operating range of the legacy fuel remaining in the reactor in the next reload cycle is also considered when setting the R-factor application range. This information was presented during the GEXL97 development design review and is also shown in the response to Q34. Also see the response to Q13 through Q16.

Q26. Does the generated data set cover the complete expected normal operational range and the Chapter 15 transient range?

R26. The following figure shows where transient behavior typically falls within the GEXL application ranges.

[[

{3}]]

Figure 26-1. Correlation Critical Power Application Range

In accordance with TDP-0117, the development data covers the complete expected normal operational range and the transient range. The majority of the hypothetical data was collected within expected operational ranges, but data was also collected outside these ranges to support transient comparisons and trends development for the correlation. The design review confirmed that transient ranges were covered for GEXL97.

Q27. What procedure is used in choosing coefficients to minimize "bias, standard deviation, and trend errors." Is this an iterative procedure and, if so, what criteria are used to determine the "optimum" coefficients?

Q28. How are the "apparent" R-factors calculated from the "optimum" coefficients?

Q29. How are the "preliminary additive constants" adjusted to [[

{3}]]

R27-29. TDP-0117 is used for GE/GNF fuel GEXL correlation development and also covers GEXL development for legacy fuel. The choosing of the coefficients is an iterative process and the optimum coefficients are chosen based on the correlation that best predicts the data. The data base is chosen such that critical power data are generated for all unique rod locations as shown in Figure 2-1 (Reference 4). For data with boiling transition, the apparent R-factors are calculated by GSTAT and represent the R-factor which best describe the data. The additive constant "l_i" is then determined by equating Equation A-1 in Appendix A to the apparent R-factor:

[[{3}]]

Preliminary additive constants are then adjusted by choosing an optimum value which [[
{3}]] for data having the same unique rod position, but different rod-to-rod peaking distributions and different axial power shapes.

Q30. In Section 3.3, page 3-3, it is stated that the correlation was "tuned" to give a mean ECPR less than [[{3}]] so that the correlation, on average, is slightly [[{3}]]. Table 3-2 indeed shows that the total database mean ECPR is less than [[{3}]]. However, Table 3-3 shows the axial power shape mean ECPR values ranging from [[{3}]] to [[{3}]]. What is the significance of this axial power shape sensitivity, and how are the non-conservative ECPR values handled for the power shapes that show this difference?

R30. It is not uncommon to see variations in ECPR for the individual axial power shapes. The experience basis for past GEXL correlations has shown ECPRs that range from [[{3}]]. The spread in the GEXL97 axial power shape ECPR values is accounted for in the larger correlation uncertainty for the entire database. The database (Reference 9) from the original development of the GEXL correlation showed similar variations in ECPR for the individual power shapes.

[[

{3}]]

These variations in ECPR for the individual power shapes are also seen in later GEXL correlations.

[[

{3}]]

Q31. In Figure 3-2, the pattern for Sigma (%) is unusual. Is this due to the small number of points in the low range of the mass flux?

Q32. In Figure 3-4, the pattern for Sigma (%) is unusual. Is this due to the small number of points in the upper range of the inlet sub-cooling?

R31-32. The basis for choosing the database is described in the response to question 13. The bulk of the data are taken in the expected operating range, i.e., mass fluxes of [[{3}]] Mlb/ft^2-hr and subcoolings of [[{3}]] Btu/lbm. In this range, the GEXL97 comparisons to the supplied FANP ATRIUM 10 CPR data is performed for the full combination of mass flux, subcooling, rod-to-rod peakings, and axial power shape. Limited data are obtained for low mass fluxes below [[{3}]] Mlb/ft^2-hr and for subcooling higher than [[{3}]] Btu/lbm. These low mass flux and high inlet sub-cooling ranges are outside the expected range of operation, and thus full "corner to corner" comparisons over the entire test matrix are not performed. Data were taken in these ranges to support trends analyses in the GEXL97 development. Since full "corner-to-corner" comparisons over the entire test matrix are not performed in the low mass flux and high subcooling ranges, the scatter in the GEXL97 determined CPR to the FANP calculated CPR is small. However, for the normal range of mass flux and subcooling with comparison data for the full "corner to corner" test matrix, scatter in the GEXL97 determined CPR to the FANP calculated CPR is larger. The key driver for this larger difference is the expanded combinations of rod-to-rod peakings and axial power shapes paired with either subcooling or mass flux data points. Therefore it is easier to correlate the data for the smaller number of data points.

Q33. On page 4-3, it is stated that the correlation is valid over a specified range of pressure, mass flux, inlet sub-cooling, and R-factor values. The study, however, uses very few points for pressures other than [[{3}]] psia, mass fluxes below [[{3}]] Mlbm/hr-ft^2, or inlet subcooling above [[{3}]] Btu/lbm. Also, no data points are given for subcooling below [[{3}]] Btu/lbm. Please discuss the reasons for not including more points.

R33. The basis for choosing the database is described in the responses to Question 13 and 26. These responses discuss the points raised in Q33, except for the lack of data points for inlet subcooling below [[{3}]] Btu/lbm.

Based on experience and physical principles, the GEXL97 inlet subcooling trend behavior is expected to be linear even below the [[{3}]] Btu/lbm range for which data was provided to GNF. However, to confirm that the correlation is valid for lower values of inlet subcooling, additional GEXL97 critical power comparisons to data provided by FANP were generated for an inlet subcooling value of approximately [[{3}]] Btu/lbm. This value bounds the operation of LCS for both normal operation and analyzed transients. The comparison of the additional generated low subcooling data to that predicted by GEXL97 is slightly conservative at this very low subcooling, and the trends are consistent with the previously generated database.

Q34. Please discuss why the overall GEXL97 R-factor range [[{3}]] is significantly smaller than the GEXL96 range [[{3}]].

R34. The GEXL R-factor range is defined based on the range of data in the database, the behavior of the correlation past the boundaries of the database, and also on the expected operation of the legacy fuel remaining in the core in the next reload cycle. The GEXL97 R-factor trend behavior is linear even below the [[{3}]] lower application range boundary; however, the lower range was set at [[{3}]] based on expected operation and to avoid any large extrapolations beyond the lower end of the R-factor database ([[{3}]]). Additional GEXL97 critical power comparisons to data provided by FANP were generated for an R-factor of [[{3}]] to confirm the R-factor application range. The combination of this additional data with the correlation database had a negligible effect (less than 0.0005) on the overall mean and standard deviation of the GEXL97 correlation statistics.

The expected operation in the next cycle of the ATRIUM-10 legacy fuel is shown in the following figures. The R-factor trends are shown to a value of 1.0 in Figure 4-1 of the GEXL97 report (Reference 4).

[[

{3}]]

[[

{3}]]

Q35. Please be prepared to discuss the core study for the next reload cycle that provides justification that the expected CPR and R-factor shows a sufficient margin to the Operating Limit MCPR.

R35. The following plots show the ATRIUM-10 and GE14 bundle exposure versus CPR at different points of cycle exposure for L1C11. Also shown is the lowest CPR for the GE14 fuel and the ATRIUM-10 fuel over the cycle. This figure also shows the operating limit MCPR for the cycle. These figures demonstrate adequate margin to the operating limit for the ATRIUM-10 fuel and that the

GE14 fuel is limiting. This information comes directly from the reference loading pattern information generated by PANACEA for the next cycle.

[[

{3}]]

[[

{3}]]

[[

{3}]]

Q36. For highly peaked pin power profiles, it is stated that an evaluation showed the trend of the GEXL97 correlation follows the general trend of the Framatome predicted critical power performance. Please be prepared to further discuss these evaluations and justifications. Additional Comment: The staff is not satisfied with the technical justification provided in Section 4.2 of the submittal regarding the operation of the GEXL97 correlation outside the range of the experimental data for the ATRIUM-10 SPCB correlation.

R36. These trend comparisons were made for mass fluxes higher than [[{3}]] Mlb/ft^2-hr. However, the application range of the GEXL97 correlation is limited to [[{3}]] Mlb/ft^2-hr, which is the upper bound of the database. Except for the low end of the inlet subcooling, the GEXL97 application range has not been extrapolated beyond the SPCB correlation database or the hypothetical database used in the GEXL97 development. Also see the response to Q34.

Q37. What controls on the iterative process assure convergence?

R37. To solve the critical power based on the critical quality correlation, GEXL uses the concept of [[{3}]]. A convergence criteria of [[{3}]] on the [[{3}]] calculation, as well as a maximum limit on the number of critical power iterations, assures convergence on critical power.

Q38. It is stated that the calculation of local quality is done, assuming 24 axial nodes. However, Figure 2-2 gives a plot of the axial power shapes used in the generation of the database, showing 49 axial points. Appendix A, page A-1, states that a 25-node axial power shape is used to calculate R-factors for the 150 inch fueled bundle length. Are these different values actually used in the three separate calculations, and what is the effect of this inconsistency?

R38. For consistency with past development work, the ATLAS axial power shapes obtained for GE14/GEXL14 development were used in the development of the GEXL97 correlation. ATLAS uses a 49 node power shape (node boundary values) for data collection and this is consistent with what was used as input to GSTAT for the GEXL97 development. GSTAT uses 24 heat balance nodes (node centerline values) for the critical power determination and interpolates the bundle power shape to obtain the power in the bundle at a given location.

Appendix A not only refers to R-factor calculation in the GEXL97 development, but also R-factor calculation in the downstream use of GEXL97. For post-development critical power calculations using GEXL97, axial power shapes are generated by PANACEA. PANACEA typically assumes a 150 inch bundle and 6 inch nodes, thus a 25 (150/6=25) node axial power shape is used to calculate R-factors in downstream applications.

Q39. For the R-factor calculation, the number of unique rod positions is stated to be [[{3}]], as shown in Figure 2-1. However, [[{3}]] part-length rod locations separated by only [[{3}]] fuel rod from the IWC are not identified as unique. Please justify the exclusion of the [[{3}]] part-length rods.

R39. The [[{3}]] mentioned part length rod locations are considered symmetric locations to the [[{3}]] part length rod (PLR) positions for which data was collected. Rod locations more than one row away from the position of interest are not considered in the R-factor calculations. PLR locations are considered non-limiting locations since a lattice peaking on the order of [[1.9 {3}]], which is highly unlikely, would be required to obtain boiling transition on the PLR. Also, the PLR locations would possibly be close to the limit at end of cycle because of the very conservative R-factor (also see the response to Q40), and this is highly unlikely considering ATRIUM-10 legacy fuel will be at the end of its second cycle.

Q40. Table 4-2 lists the additive constants used for the R-factor calculation. Please discuss how the value(s) of [[{3}]] for the part-length rod positions were determined.

R40. TDP-0117 details the calculation of the PLR additive constants. Hypothetical data was generated for the PLR positions and an apparent R-factor was calculated for this data using GSTAT. The RFGEN code was then used to calculate a raw R-factor based on a [[{3}]] as prescribed in the TDP. The PLR additive constant becomes the [[{3}]] calculated by GSTAT. [[

{3}]] The R-factor methodology for bundles having PLRs is summarized in Appendix A of the GEXL97 development document (Reference 4) and covered in detail in Reference 8.

Q41. Please provide an explanation for the non-normality of the ECPR histogram and give a technical justification for the use of the GEXL97 critical power correlation in GETAB methodology given that the underlying assumption of normality cannot be demonstrated.

Q42. On page 5-1, it is stated that if a normal distribution does not apply, and that in this case the impact on the safety limit calculation, if any, is conservative at the low end and that the high end would be bounded by the assumption of normality. It is also stated that the large total correlation uncertainty used in the safety limit calculation provides additional conservatism. Please elaborate on the technical justification for stating this conservatism.

R41-42. Small ECPR errors exist for the individual power shapes as shown in Table 3-3. These errors are not atypical compared to past experience and these ECPR errors are accounted for in the larger correlation uncertainty for the total database. The relatively small [[{3}]] of the outlet and double humped axial power shapes and somewhat larger, but [[{3}]] of the cosine and inlet peaked data is what leads to the non-normality of the ECPR histogram for the total database.

The safety limit is determined by summing the probability that each rod is in boiling transition and determining the point where the sum over all the rods of the probability the rod is in boiling transition equals 0.1% of the total number of rods.

$$\mathrm{NRSBT} = \sum_{\mathrm{All\,rods}} p_i = 0.001 N_R \,,$$

where: N_R is the total number of rods
p_i is the probability rod "i" is in boiling transition
NRSBT is the number of rods subject to boiling transition

For a rod "i" with a given critical power ratio, "CPR_i", the likelihood of that rod being in boiling transition is given by the probability that the ECPR is greater than the CPR value:

$$p_i = \int_{CPR_i}^{\infty} f(x)\,dx \,,$$

where: f is the ECPR probability density function.

The impact of the non-normality can therefore be evaluated by comparing the integrated probability of boiling transition as a function of CPR value for the actual ECPR histogram and the assumed normal distribution. This comparison is shown in the figure below.

For the nominal conditions the limiting rod will be at the safety limit, which is typically around 1.10. All other rods will have higher CPR values. From the above figure it is clearly seen that the probability of the rods being in boiling transition is conservatively calculated when using the normal distribution.
[[

{3}]]

When the uncertainties in plant operating parameters and power distribution are accounted for in the safety limit methodology, the leading bundles that contribute to the safety limit will have a CPR distribution around the safety limit. From the above figure it is seen that the probability of boiling transition is [[{3}]] predicted for CPR values greater than [[{3}]] and non-conservatively for CPR values between [[{3}]]. Since most of the rods that contribute to the safety limit will be in the range close to the safety limit, the overall impact of using the normal distribution will be conservative.

Q43. Also, please discuss further the reasons for the differences between the statistical results presented here versus the GEXL96 evaluation results. Can the differences be correlated to differences in the bundle geometries, or to differences in the axial power shapes used?

R43. The same axial power shapes were used in the generation of the GEXL96 and GEXL97 databases. There are a number of factors that could contribute to the difference in the statistical results including the presence of part length rods in the ATRIUM-10 bundle, and an underlying difference in the database of the ATRIUM-9B and ATRIUM-10 fuel. The ATRIUM-9B data were generated with the ANF-B correlation while the ATRIUM-10 data were generated with the SPCB correlation.

Q44. On page 5-3, it is stated that the analysis of the trends in Figures 3-2 through 3-4 show that there are no systematic trend errors in the GEXL97 correlation. However, Figures 3-2 and 3-4 exhibit unusual trends for the mass flux and inlet subcooling. Is there further clarification related to the two questions in Section 3 regarding these figures?

R44. Systematic trend errors refer to ECPR trends. There are no ECPR systematic trend errors observed in Figures 3-2 and 3-4. The abnormalities for these figures are for the standard deviation. See also the responses to Q31 through Q33.

Q45. What version of TGBLA is used and please provide the reference.

R45. TGBLA06A is used to generate the 2D rod-to-rod power distributions for critical power analysis using the GEXL97 correlation with ATRIUM-10 fuel. The NRC approved TGBLA methods can be found in MFN-035-99, S. Richards (NRC) to G. Watford (GE), *Amendment 26 to GE Licensing Topical Report NEDE-24011-P-A, "GESTAR II" - Implementing Improved GE Steady State Methods (TAC No. MA6482), November 10, 1999.*

Q46. If the square internal water channel of the ATRIUM-10 fuel bundle is modeled as nine equivalent cylindrical water rods, how can the effect on a fuel rod adjacent to the square water channel be modeled correctly?

R46. See the response to Q17.

Q47. Figure A-3 shows the ATRIUM-10 fuel lattice matrix, with the locations of the part-length rods and the internal water channel (IWC). It is noted that two of the unique fuel rod locations are between the IWC and a part-length fuel rod. What geometry, as identified in Figure A-2, is used for the R-factor calculation for these locations?

R47. A typo exists in Figure A-3. The correct figure is attached. The geometry reference for R-factor calculation as a function of fuel rod location is provided in Table A-1, "R-factor Calculation by Lattice Position." As indicated for the [[{3}]] part length rod location, Figure A-2c and equation A-4 should be used to calculate the R-factor for this location.

[[

{3}]]

Figure A-3. ATRIUM-10 Lattice

REFERENCES

1. NEDE-24011-P-A-14, "General Electric Standard Application for Reactor Fuel," June 2000

2. Letter from T. W. Simpkin (Exelon Generation Company, LLC) to U. S. NRC, "Request for Amendment to Technical Specifications Section 5.6.5 Core Operating Limits Report (COLR)," dated July 1, 2003

3. NEDC-32851P, "GEXL14 Correlation for GE14 Fuel," Rev. 2, September 2001

4. NEDC-33106P, GEXL97 Correlation for ATRIUM-10 Fuel," Revision 1, June 2003

5. NEDC-32981P-A, "GEXL96 Correlation for ATRIUM-9B Fuel," Rev. 1, May 2002

6. NEDC-32868P, "GE14 Compliance with Amendment 22 of NEDE-24011-P-A (GESTAR II)," Rev. 1, September 2000

7. EMF-2158(P)(A), "Siemens Power Corporation Methodology for Boiling Water Reactors: Evaluation and Validation of CASMO-4/MICROBURN-B2"

8. NEDC-32505-P-A, "R-factor Calculation Method for GE11, GE12 and GE13 Fuel," Rev. 1, July 1999

9. NEDE-10958P-A, "General Electric BWR Thermal Analysis Basis (GETAB): Data, Correlation and Design Application," January 1977