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GNRO-2002-00049

June 12, 2002

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

SUBJECT: Grand Gulf Nuclear Station, Unit 1
Docket No. 50-416
Response to Requests for Additional Information
Appendix K Measurement Uncertainty Recovery – Power Uprate
Request (TAC MB3972, GGNS LDC 2002-074)

REFERENCE: Entergy letter dated January 31, 2002, Appendix K Measurement
Uncertainty Recovery – Power Uprate Request

Dear Sir or Madam:

Pursuant to 10CFR50.90, Entergy Operations, Inc. (Entergy) requests approval of changes to the Grand Gulf Nuclear Station, Unit 1 (GGNS) Operating License and Technical Specifications associated with an increase in the licensed power level. The changes involve a proposed increase in the power level from 3,833 MWt to 3,898 MWt.

Based on reviews of this submittal by the Electrical, Mechanical, and I&C Branches, the NRC provided requests for additional information (RAIs). Attachments 1 through 3 provide the NRC questions and the Entergy responses. There are no technical changes to the original submittal proposed. The original no significant hazards considerations included in the referenced submittal is not affected by any information contained in this supplemental letter.

A summary of the additional commitments made in these responses associatedwith the implementation of the power uprate request is provided in Attachment 4. Should you have any questions or comments concerning this request, please contact Jerry Burford at (601) 368-5755.

A001

I declare under penalty of perjury that the foregoing is true and correct. Executed on June 12, 2002.

Sincerely,

WAE/FGB

Attachments:
1. Response to I&C RAI
2. Response to Electrical RAI
3. Response to Mechanical RAI
4. Summary of Regulatory Commitments

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Attachment 1

GNRO-2002-00049

Response to I&C RAI

Attachment 1

Response to NRC I&C Branch RAI for GGNS Power Uprate

1. The Staff SER on Caldon Topical Report ER-157P stated that in addition to the guidelines outlined in ER-157P and ER-80P, four additional requirements shall be addressed by licensees referencing ER-157P in their request for power uprate. The staff guidelines for addressing those additional requirements are provided in section I of Attachment 1 to the NRC Regulatory Information Summary (RIS) 200203, dated January 31, 2002. Entergy submittal addressed only one of the four additional requirements distributed in sections 4.2.2, 4.2.3, and 4.2.6. Detailed information addressing each of the four requirements and the applicable RIS guidelines are needed.

Response:

Regulatory Information Summary 2002-03 and the NRC SER for Caldon Topical Report ER-157P requested information regarding the device to be used as the basis for measurement uncertainty recovery power uprate requests. Note that the four requirements from the NRC SER for the Caldon topical report are addressed in response to RIS item I.D below. This information is either addressed below or references are provided to other sections of this submittal.

RIS items I.A, I.B – references to the topical reports and to their NRC approvals are provided in Section 4.2.1 of the original submittal.

RIS item I.C – The LEFM was installed at GGNS in conformance with the requirements of the above topical reports. It is linked to the plant computer andused for continuous calorimetric power determination. The LEFM system incorporates self-verification features to ensure hydraulic profile and signal processing requirements are met within its design basis uncertainty analysis.

RIS item I.D – The NRC identified four criteria in their Safety Evaluation of ER-157P to be addressed by licensees applying for a power uprate using the LEFM√+™ System:

Criterion 1 – Discuss maintenance and calibration procedures, including processes and contingencies for inoperable LEFM instrumentation and the effect on thermal power measurements and plant operation. Response: As noted in Section 4.2.3 of the submittal and in response to RIS item I.F below, work will be controlled by procedures developed in accordance with Caldon recommendations. The incorporation of, and adherence to, these requirements will assure that the LEFM system is properly maintained and calibrated. Contingency plans for operation of the plant with an LEFM out-of-service are described in response to RIS items I.G and I.H below.

Criterion 2 – For plants that currently have the LEFM installed, provide an evaluation of the operational and maintenance history. Response: Since the Caldon LEFM√+™ system was installed at GGNS in May of 2001, the equipment performance has demonstrated full compliance with the stated requirements as follows:

- The LEFM has demonstrated a much more stable flow reading and response than those of the venturis.
- The LEFM maintains a very stable velocity profile as noted in Caldon Engineering Report ER-262, Rev. 0, "Effects of Velocity Profile Changes Measured In-Plant on Feedwater Flow Measurement Systems".
- The installed velocity profile for the LEFM very closely matches the velocity profile determined by the calibration testing at Alden Laboratories.
- The major maintenance performed on the installed LEFM system since installation last May has been the implementation of one software upgrade and the replacement of computer hardware.

Criterion 3 – Confirm that the methodology used to calculate the uncertainty of the LEFM in comparison to the current feedwater instrumentation is based on accepted plant setpoint methodology. Response: The methodology used to calculate the uncertainty of the LEFM flow measurement was developed by Caldon and is in accordance with the NRC-approved ER-157P. The analysis to develop the overall plant calorimetric uncertainty, using the LEFM flow and temperature inputs, is described in response to Question 2 below.

Criterion 4 – For plants where the ultrasonic meter was not installed and flow elements calibrated to a site-specific piping configuration, additional justification should be provided for its use. Response: This criterion is not applicable to GGNS. The calibration factor for the GGNS spool pieces has been established by test at Alden Research Laboratory. These included tests of a full-scale model of the GGNS hydraulic geometry and tests in straight pipe. The calibration factor for the GGNS spool pieces is based on these tests and documented in a Caldon Engineering Report (ER-182). Final acceptance of the site-specific uncertainty analysis considered the completion of the commissioning process. This process verifies bounding calibration test data. This step is the final positive confirmation that actual performance in the field meets the uncertainty assumptions for the instrumentation.

RIS item I.E – This item is addressed in the response to question 2 below.

RIS Item I.F.i – Calibration and maintenance of the instruments that provide input to the plant calorimetric power calculation is performed using the vendor recommendations and technical manual information. Routine preventive maintenance activities include physical inspections, power supply checks, and other recommended tasks. In particular, for the LEFM√+™ System, signal verification and alignment is performed automatically. In addition, the personnel performing initial maintenance on the LEFM have been trained by Caldon.

RIS Item I.F.ii – The LEFM√+™ System is designed and manufactured in accordance with the Caldon 10CFR50 Appendix B Quality Assurance Program. The system software is developed under the Caldon Verification and Validation (V&V) Program, which meets the criteria of ANSI/IEEE-ANS standard 7-4.3.2, "Standard Criteria for

Digital Computers in Safety Systems of Nuclear Power Generating Stations" and ASME NQA-2a-1990, Quality Assurance Requirements for Nuclear Facility Applications." The V&V program is also consistent with the guidance of EPRI TR-103291s, "Handbook for Verification and Validation of Digital Systems." Examples of the quality measures undertaken in the design, manufacture, and testing of the LEFM,√+™ System are provided in Topical Report ER-80P.

RIS Item I.F.iii – GGNS uses the Entergy Corrective Action Program. Corrective actions are controlled in accordance with that program.

RIS Item I.F.iv – All conditions adverse to quality are handled in accordance with the Entergy Corrective Action Program. The LEFM,√+™ System software will be controlled under the GGNS software quality assurance program. GGNS currently maintains a service agreement with Caldon to provide maintenance and to correct any identified hardware or software deficiencies.

RIS Item I.F.v – Caldon has noted that the software is also subject to the Caldon V&V program and that it includes requirements for user notification of important deficiencies.

RIS Item I.G – The AOT for operation at the uprated power level with an LEFM out of service is 72 hours, provided steady state conditions persist during the 72 hours (no power changes in excess of 10% during the period). This requirement will be controlled by the GGNS Technical Requirements Manual. There are five bases for this time period:

- The feedwater venturis are continuously calibrated to the last good value provided by the LEFM. Without the LEFM continuous correction input, the venturi accuracy will gradually degrade over time due to changes in nozzle fouling and transmitter drift. The stability of the GGNS feedwater transmitters is 0.25% URL (100 psig) per six months, which results in a maximum 72-hour drift of only 4.17E-3 psi. With the GGNS venturi calibration constants, this pressure error translates into a maximum flow error of less than 0.0015 Mlb/hr, or 0.009% of rated feed flow. If reactor power is conservatively assumed to be proportional to feedwater flow, this flow error would represent a maximum error in core power of less than 0.35 MW, which is within the margin of the core power measurement uncertainty calculation. The impact of nozzle fouling for a 72-hour period is imperceptible provided steady state conditions are maintained.
- Most repairs can generally be made within an eight-hour shift. Seventy-two hours gives plant personnel time to receive parts, make repairs, and to verify normal operation of the LEFM system within its original uncertainty bounds at the same power level and indications as before the failure.
- The plant will be operated based on the calibrated feedwater venturis as soon as the LEFM is not available. It is considered prudent to avoid unnecessary and frequent reactor power manipulation. The downpower evolution could in many cases be avoided altogether since a repair

would likely be accomplished prior to the expiration of the 72 hour period.

- If the plant experiences a down power of greater than 10% during the 72 hour period, then the permitted maximum power level would be reduced to 3833 MWt upon return to full power, since a plant transient may result in calibration changes of the venturis (e.g., defouling).
- There is no overall plant risk impact of continued operation at 3898 MWt based on feedwater flow measured by the venturis that have been corrected to a 0.3% uncertainty within 72 hours.

RIS Item I.H – With an LEFM out of service for more than the above allowed outage time, GGNS will limit power to the original licensed power level of 3833 MWt. Thiswill basically limit power to that level for which GGNS was previously licensed because it will be utilizing the same instrument inputs as were used prior to the installation of the LEFM.

2. [part 1] RIS guideline (Item E in section I) requested licensees to provide a plant specific calculation of total power measurement uncertainty, explicitly identifying all parameters and their individual contribution to the power measurement uncertainty. The applicable discussion in section 1.4 of the G.E. Safety Analysis Report does not provide the information requested in the RIS guideline.
[part 2] Also, section 4.2.5 in attachment 1 of Entergy's submittal stated, that Caldon has completed the GGNS LEFM Check Plus system uncertainty calculation indicating a mass flow inaccuracy of <0.3% of rated flow for the site-specific installation. Please submit this calculation for staff reviewing making sure the calculation follows ER-80P guidelines, is based on the accepted setpoint methodology as stated in the third requirement in the staff SER, and provides bases for Entergy's statement in Section 4.2.7 and G.E. Safety Analysis Report statements in section 1.4.

Response to part 1:

Since General Electric has no formal process for calculating the core power uncertainty from the input variables, GGNS applied a process consistent with GE's NRC-approved method to generate the uncertainty in core MCPR. This process is applied in the determination of the MCPR safety limit as described in GE report NEDO-10958-A, "General Electric Thermal Analysis Basis". This document describes GE's Monte Carlo approach to generating the uncertainty in the core critical power ratio based on uncertainties in BWR process variables. GGNS has applied this same approach with regard to the gross core power uncertainty and calculated a 2-sigma core power uncertainty of less than 13 MW to ensure that 102% CLTP (3910 MW) is not exceeded at 95% probability and 95% confidence interval.

Table 1-4 of the GE Safety Analysis Report lists the plant parametersthat were applied in the core power uncertainty calculation. With the exception of the recirculation pump motor efficiency, moisture carryover, and thermal losses, each of these parameters is monitored by different plant instrumentation and is therefore modeled as an independent variable in the core power uncertainty calculation. Each parameter is varied in a normal distribution with the uncertainty reported in Table 1-4 of the GE Safety Analysis Report to generate the core power uncertainty. This Monte Carlo approach used one million trials, each of which randomly varied each input to the heat balance to generate the core power uncertainty.

For those variables that are not monitored with instrumentation, conservative bounding values are applied in the plant heat balance. For the recirculation pump motor efficiency, a bounding uncertainty of 4% is applied in the calculation. For the moisture carryover, a bounding value of 0% is used implying 100% efficiency of the steam separators and dryers. This value is conservative for use in the heat balance since it overestimates core power. Similarly, for thermal losses, the generic GE value of 1.1 MWt is applied with no uncertainty. A GGNS evaluation concluded that this value significantly bounds that predicted by the plant design. As such, moisture carryover and thermal losses were not varied in the Monte Carlo evaluation and are effectively biases on the GGNS heat balance calculation.

The plant heat balance applies correlations to the steam tables to calculate the enthalpy at different pressures and temperatures for various heat balance inputs and outputs. As fits to the steam tables, these correlations may slightly deviate from the steam table in some cases. Consequently, GGNS also applied an uncertainty to the enthalpy correlation applied in the core power uncertainty evaluation.

Consistent with the RIS, Table 1-4 of the GE Safety Analysis Report has been updated below to include the relative contribution of each parameter to the total core power uncertainty. This updated table also includes the impact of the uncertainty in the enthalpy correlation described above.

Table 1-4 (revised)
GGNS Heat Balance Parameters and Uncertainties

Parameter	Nominal Value	Uncertainty (2σ)	Contribution to core power uncertainty (%)
Steam Dome Pressure (psia)	1040	2.78	0.1
Feedwater System Flow (Mlb/hr)	16.774	0.29%	78.3
Feedwater System Temperature (°F)	421.880	0.67	19.0
CRD Flow (Mlb/hr)	0.033	0.0033	0.7
CRD Temperature (°F)	120	10.0	0.0
RWCU Flow (Mlb/hr)	0.178	0.0178	0.2
RWCU Inlet Temperature (°F)	533	10.0	0.3
RWCU Outlet Temperature (°F)	437	10.0	0.2
Recirc Pump Power (MW)	5.96	0.596	0.4
Recirc Pump Efficiency (%)	94	4.0	0.1
Saturated Steam Enthalpy Correlation	Various	1E-2%	0.2
Subcooled Liquid Enthalpy Correlation	Various	3E-2%	0.5
Moisture Carry Over (%)	0.0	0.0	0.0
Thermal Losses (MW)	1.1	0.0	0.0

As reported in Section 1.4 of the GE Safety Analysis Report, this evaluation concluded the 2-sigma core power uncertainty is less than 13 MW. As a confirmation of this approach, the methodology reported in NUREG/CR-3659 was applied with the same GGNS input variables. This confirmatory calculation is documented in Enclosure 1 to this attachment and concludes the 2-sigma core power uncertainty is 12 MW, which compares well with the 12.8 MW value developed by the GGNS Monte Carlo approach.

Response to part 2:

Caldon has documented the GGNS LEFM✓+ uncertainty analysis in Caldon Engineering Report: ER-187, "Bounding Uncertainty Analysis for Thermal Power Determination at Grand Gulf Nuclear Power Station Using the LEFM✓+ System". The uncertainties in mass flow and temperature were calculated with the NRC-approved methodologies in Appendix E of ER-80P and Appendix A of ER-157P. This evaluation utilized the results of the GGNS spool piece calibration test for the uncertainty in the profile factor (calibration constant). This calculation concluded that the 2-sigma uncertainties in final feedwater mass flow and final feedwater temperature are 0.29% and 0.67 °F, respectively, as applied in Section 1.4 of the GE Safety Analysis Report.

3. GE Safety Analysis Report in Section 5.3 stated that, in some cases, changes in the allowable value (AV) and nominal trip setpoints (NTSP) of instrumentation settings will occur in the measured units. The GE safety analysis also stated in the same section that the corresponding setpoint in terms of steam flow is decreased to approximately 138% of the TPO rated steam flow. Please confirm that the safety system instrumentation NTSPs and AVs included in the Technical Specifications do not need revision due to the proposed power uprate.

Response:

As stated in the submittal, the TS AVs and NTSPs do not require any revision due to the power uprate. In the specific case of the steam flow parameter described above, GE was noting that the allowable value in terms of % power was affected. However, the AV for this parameter, as shown in TS Table 3.3.6.1-1, is presented in terms of psid. The current TS AV values in terms of psid were shown to remain valid.

4. For an inoperable LEFM, section 4.2.2 in Attachment 1 and comment column in Attachment 4 state that "... the reactor thermal power will be administratively controlled at a level consistent with the accuracy of the available instrumentation until such time as the LEFM system is returned to an operable status." The Staff understands that, in case of an inoperable LEFM, the "available instrumentation" will be the venturi whose measurement uncertainty is the basis of the current licensed thermal power of 3833 MWt. Please explain why the contingency plan does not require plant operation at 3833 MWt instead of "consistent with the accuracy of the available instrumentation."

Response:

The phrase "consistent with the accuracy of the available instrumentation" was written with regard to the feedwater venturis. As such, GGNS does intend to reduce power to 3833 MWt upon the LEFM system becoming inoperable for a duration longer than the allowed outage time (AOT). However, the basis for the current licensed thermal power of 3833 MWt is really 10CFR50 Appendix K. That said, the GGNS contingency plan is more clearly presented in the response to RIS Items I.G and I.H included in the answer to RAI question 1 above.

Enclosure 1 to Attachment 1
Core Power Uncertainty Confirmation

This attachment develops the GGNS core power uncertainty with the methods in NUREG/CR-3659 for comparison to the result presented in Section 1.4 of the GE Safety Analysis Report.

The GGNS heat balance at the uprated condition is given by the following formula.

$$Q_{core} = (\dot{m}_{fw} + \dot{m}_{crd}) \cdot \left[\hat{h}_s - M_{co} \cdot (\hat{h}_s - \hat{h}_L)\right] + Q_{\substack{thermal \\ loss}} + \dot{m}_{RWCU}\left(\hat{h}_{\substack{RWCU \\ inlet}} - \hat{h}_{\substack{RWCU \\ outlet}}\right) - \dot{m}_{fw}\hat{h}_{fw} - \dot{m}_{crd}\hat{h}_{crd} - e_{recirc}Q_{\substack{recirc \\ pump}} \quad (1)$$

where:

Q_{core}	=	the power generated by the core (3898 MWt)
$\dot{m}_{RWCU}$	=	RWCU mass flow (0.178 Mlb/hr)
$\hat{h}_s$	=	saturated steam enthalpy (1191.47 Btu/lb)
M_{co}	=	moisture carryover fraction (0.00)
$\hat{h}_L$	=	saturated liquid enthalpy
$Q_{\substack{thermal \\ loss}}$	=	thermal losses from system (1.1 MW)
$\hat{h}_{\substack{RWCU \\ inlet}}$	=	RWCU inlet enthalpy (527.97 Btu/lb)
$\hat{h}_{\substack{RWCU \\ outlet}}$	=	RWCU outlet enthalpy (416.06 Btu/lb)
e_{recirc}	=	efficiency of the recirc pumps (0.94)
$Q_{\substack{recirc \\ pump}}$	=	power into the recirc pumps (11.92 MW)
$\dot{m}_{fw}$	=	feedwater system mass flow (16.774 Mlb/hr)
$\hat{h}_{fw}$	=	feedwater enthalpy (399.575 Btu/lb)
$\dot{m}_{crd}$	=	CRD system flow (0.033 Mlb/hr)
$\hat{h}_{crd}$	=	CRD enthalpy (90.47 Btu/lb)

The moisture carryover and thermal losses are not directly measured. Instead, the heat balance assumes a moisture carryover fraction of 0% to conservatively overestimate reactor power. Similarly, the thermal losses have been determined to be a conservative overbound to the actual losses. Thus, both of these parameters act as conservative biases on the calculated core power and are not combined in the uncertainty model.

For the uncertainty calculation, the GGNS heat balance in Equation 1 reduces to the following equation.

$$Q_{core} = (\dot{m}_{fw} + \dot{m}_{crd}) \cdot \hat{h}_s + \dot{m}_{RWCU}\left(\hat{h}_{\substack{RWCU\\inlet}} - \hat{h}_{\substack{RWCU\\outlet}}\right) - \dot{m}_{fw}\hat{h}_{fw} - \dot{m}_{crd}\hat{h}_{crd} - e_{recirc}Q_{\substack{recirc\\pump}} \qquad (2)$$

All mass flows and fluid temperatures are measured via independent instruments. As such, all input variables are modeled as independent. Only the pressure dependence of the calculated enthalpies are dependent since the steam dome pressure measured from the same instrumert is applied in each calculation. However, considering the very small dependence of enthalpy on pressure and small uncertainty in steam dome pressure, this dependency is not expected to significantly affect the results. This dependency, however, is consdered in the GGNS Monte Carlo evaluation.

Using Equation 5 from NUREG/CR-3659 to generate the uncertainty in core power from Equation 2 above yields the following result.

$$U^2_{Q_{core}} = \left[\begin{array}{l} \left(\frac{\partial Q}{\partial \dot{m}_{fw}}\right)^2 \sigma^2_{mfw} + \left(\frac{\partial Q}{\partial \dot{m}_{crd}}\right)^2 \sigma^2_{\dot{m}_{crd}} + \left(\frac{\partial Q}{\partial \hat{h}_s}\right)^2 \sigma^2_{hs} + \left(\frac{\partial Q}{\partial \dot{m}_{RWCU}}\right)^2 \sigma^2_{\dot{m}_{RWCU}} + \left(\frac{\partial Q}{\partial \hat{h}_{\substack{RWCU\\inlet}}}\right)^2 \sigma^2_{\hat{h}_{\substack{RWCU\\inlet}}} \\ + \left(\frac{\partial Q}{\partial \hat{h}_{\substack{RWCU\\outlet}}}\right)^2 \sigma^2_{\hat{h}_{\substack{RWCU\\outlet}}} + \left(\frac{\partial Q}{\partial \hat{h}_{fw}}\right)^2 \sigma^2_{\hat{h}_{fw}} + \left(\frac{\partial Q}{\partial \hat{h}_{crd}}\right)^2 \sigma^2_{\hat{h}_{crd}} + \left(\frac{\partial Q}{\partial e_{recirc}}\right)^2 \sigma^2_{e_{recirc}} + \left(\frac{\partial Q}{\partial Q_{\substack{recirc\\pump}}}\right)^2 \sigma^2_{Q_{\substack{recirc\\pump}}} \end{array}\right] \qquad (3)$$

The partial differentials are derived below.

$$\frac{\partial Q_{core}}{\partial \hat{h}_s} = \dot{m}_{fw} + \dot{m}_{crd} = 16.774 + 0.033 = 16.807 \text{ Mlb/hr}$$

$$\frac{\partial Q_{core}}{\partial \dot{m}_{fw}} = \hat{h}_s - \hat{h}_{fw} = 1191.41 - 399.575 = 791.84 \text{ Btu/lb}$$

$$\frac{\partial Q_{core}}{\partial \dot{m}_{crd}} = \hat{h}_s - \hat{h}_{crd} = 1191.41 - 90.47 = 1100.94 \text{ Btu/lb}$$

$$\frac{\partial Q_{core}}{\partial \dot{m}_{RWCU}} = \hat{h}_{\substack{RWCU\\inlet}} - \hat{h}_{\substack{RWCU\\outlet}} = 527.97 - 416.06 = 111.91 \text{ Btu/lb}$$

$$\frac{\partial Q_{core}}{\partial \hat{h}_{\substack{RWCU\\inlet}}} = \dot{m}_{RWCU} = 0.178 \text{ Mlb/hr}$$

$$\frac{\partial Q_{core}}{\partial \hat{h}_{\substack{RWCU\\outlet}}} = -\dot{m}_{RWCU} = -0.178 \text{ Mlb/hr}$$

$$\frac{\partial Q_{core}}{\partial \hat{h}_{fw}} = -\dot{m}_{fw} = -16.774 \text{ Mlbs/hr}$$

$$\frac{\partial Q_{core}}{\partial \hat{h}_{crd}} = -\dot{m}_{crd} = -0.033 \text{ Mlb/hr}$$

$$\frac{\partial Q_{core}}{\partial e_{recirc}} = -Q_{\substack{recirc\\pump}} = -11.92 \text{ MW}$$

$$\frac{\partial Q_{core}}{\partial Q_{\substack{recirc\\pump}}} = -e_{recirc} = -0.94$$

The uncertainty in the enthalpies based on the uncertainty in temperature and pressure are derived below.

$$\sigma_{hs} = \left[\left(\frac{1191.9 - 1191.2 \text{ Btu/lb}}{1028.49 - 1045.43 \text{ psia}}\right)^2\left(\frac{2.78 \text{ psi}}{2}\right)^2 + \left(\frac{1.0E-4}{2}\right)^2\right]^{1/2} = 0.0574 \text{ Btu/lb}$$

$$\sigma_{hcrd} = \left[\left(\frac{100.59 - 80.7 \text{ Btu/lb}}{130 - 110^\circ\text{F}}\right)^2\left(\frac{10^\circ\text{F}}{2}\right)^2 + \left(\frac{90.77 - 90.52 \text{ Btu/lb}}{1100 - 1000 \text{ psia}}\right)^2\left(\frac{2.78 \text{ psi}}{2}\right)^2 + \left(\frac{3.0E-4}{2}\right)^2\right]^{1/2} = 4.97 \text{ Btu/lb}$$

$$\sigma_{hfw} = \left[\left(\frac{408.5 - 386.77 \text{ Btu/lb}}{430 - 410^\circ\text{F}}\right)^2\left(\frac{0.67^\circ\text{F}}{2}\right)^2 + \left(\frac{397.65 - 397.55 \text{ Btu/lb}}{1100 - 1000 \text{ psia}}\right)^2\left(\frac{2.78 \text{ psi}}{2}\right)^2 + \left(\frac{3.0E-4}{2}\right)^2\right]^{1/2} = 0.364 \text{ Btu/lb}$$

Similar to σ_{hcrd}, $\sigma_{\hat{h}_{RWCU\,inlet}} = \sigma_{\hat{h}_{RWCU\,outlet}} \cong 5$ Btu/lb.

The terms in the total core power uncertainty in Equation 3 are calculated separately below.

$$\left(\frac{\partial Q}{\partial \dot{m}_{fw}}\right)^2 \sigma^2_{\dot{m}fw} = (791.84 \text{ Btu/lb})^2 (0.0029 * 16.774 \text{ Mlb/hr})^2 = 1483.7 \text{ MBtu}^2/\text{hr}^2$$

$$\left(\frac{\partial Q}{\partial \dot{m}_{crd}}\right)^2 \sigma^2_{\dot{m}_{crd}} = (1100.94 \text{ Btu/lb})^2 (0.1 * 0.033 \text{ Mlb/hr})^2 = 13.2 \text{ MBtu}^2/\text{hr}^2$$

$$\left(\frac{\partial Q}{\partial \hat{h}_s}\right)^2 \sigma^2_{hs} = (16.807 \text{ Mlb/hr})^2 (2 * 0.0574 \text{ Btu/lb})^2 = 3.72 \text{ MBtu}^2/\text{hr}^2$$

$$\left(\frac{\partial Q}{\partial \dot{m}_{RWCU}}\right)^2 \sigma^2_{\dot{m}_{RWCU}} = (111.91 \text{ Btu/lb})^2 (0.1 * 0.178 \text{ Mlb/hr})^2 = 3.97 \text{ MBtu}^2/\text{hr}^2$$

$$\left(\frac{\partial Q}{\partial \hat{h}_{RWCU\,inlet}}\right)^2 \sigma^2_{\hat{h}_{RWCU\,inlet}} = (0.178 \text{ Mlb/hr})^2 (2 * 5 \text{ Btu/lb})^2 = 3.168 \text{ MBtu}^2/\text{hr}^2$$

$$\left(\frac{\partial Q}{\partial \hat{h}_{RWCU\,outlet}}\right)^2 \sigma^2_{\hat{h}_{RWCU\,outlet}} = (-0.178 \text{ Mlb/hr})^2 (2 * 5 \text{ Btu/lb})^2 = 3.168 \text{ MBtu}^2/\text{hr}^2$$

$$\left(\frac{\partial Q}{\partial \hat{h}_{fw}}\right)^2 \sigma^2_{\hat{h}_{fw}} = (-16.744 \text{ Mlb/hr})^2 (2 * 0.364 \text{ Btu/lb})^2 = 148.6 \text{ MBtu}^2/\text{hr}^2$$

$$\left(\frac{\partial Q}{\partial \hat{h}_{crd}}\right)^2 \sigma^2_{\hat{h}_{crd}} = (-0.033 \text{ Mlb/hr})^2 (2 * 4.97 \text{ Btu/lb})^2 = 0.108 \text{ MBtu}^2/\text{hr}^2$$

$$\left(\frac{\partial Q}{\partial e_{recirc}}\right)^2 \sigma^2_{e_{recirc}} = \left(-11.92\,\text{MW} * 3.413\,\frac{\text{MBtu/hr}}{\text{MW}}\right)^2 (0.04 * 0.94)^2 = 2.34\,\text{MBtu}^2/\text{hr}^2$$

$$\left(\frac{\partial Q}{\partial Q_{\substack{recirc\\pump}}}\right)^2 \sigma^2_{Q_{\substack{recirc\\pump}}} = (-0.94)^2 \left(0.1 * 11.92\,\text{MW} * 3.413\,\frac{\text{MBtu/hr}}{\text{MW}}\right)^2 = 3.82\,\text{MBtu}^2/\text{hr}^2$$

$$U^2_{Q_{core}} = 1483.7 + 13.2 + 3.72 + 3.97 + 3.168 + 3.168 + 148.6 + 0.108 + 2.34 + 3.82 = 1665\ \text{MBtu}^2/\text{hr}^2$$

$$U_{Q_{core}} = 40.8\ \text{MBtu/hr}$$

$$U_{core} = \frac{40.8\ \text{MBtu/hr}}{3.413\,\frac{\text{MBtu/hr}}{\text{MW}}} = 12\ \text{MW}$$

Attachment 2

GNRO-2002-00049

Response to Electrical RAI

Attachment 2

Response to NRC Electrical Branch RAI for GGNS Power Uprate

1. Provide details about the grid stability analysis including assumptions and results and conclusions.

Response:

Grid stability analyses for GGNS have been performed in accordance with the guidance of NUREG-0800, Section 8.2.III.1.f.

For the Dynamic Stability Study, the analysis tripped GGNS and applied faults which lasted up to 15 cycles. Only one case during an off-peak condition went unstable after 14 cycles which is not considered a problem since it is beyond the time for back up breakers to respond assuming a failed or stuck breaker in conjunction with the fault occurring (typically, back up breakers trip within 7 cycles). The 11 MW difference between the analysis (1350 MW) and the new calculated peak (1361 MW) will have negligible impact on how the turbine generator will reactto a fault, since this modification does not change any of the parameters or controls on the turbine generator. The 11 MW will also have negligible impact on how the grid reacts to the turbine generator tripping, since the 500 kV system has the capacity to account for this additional generation loss. Entergy Transmission Planning was contacted about this power uprate and they did not require additional studies since it was purely a steam increase.

For the Steady State Stability Study, the analysis assumed multiple failures over and beyond the NUREG requirements for the 500 kV line and it met the 0.975 per unit requirement for minimum voltage. The cases which are required to credit the 500 kV lines as a valid GDC17 source during an accident do not take credit for the station's generation capacity, therefore the 11 MW difference has no impact on the steady state stability studies.

2. Provide in detail (including the ratings) the evaluation of the power uprate on the following equipment:
   a. Main Generator
   b. Isophase Bus
   c. Main Power Transformer
   d. Startup Transformer
   e. Auxiliary Transformer

Response:

2a. The nameplate rating of the generator is given below:

1525 MVA – 22 kV
1372.5 MW – 40.02 kA
0.9 PF – 60 HZ

Siemens Westinghouse Power Corporation (SWPC) has stated that HP turbine (including all turbine auxiliary systems) is capable of operating at 106% Uprate flow without modification to inlet stage blading. Based on information provided by SWPC, the Appendix K power uprate, which involves an approximate 2% increase in steam flow, will not affect turbine auxiliary system parameters. Other HP & LP turbine parameters, such as extraction steam pressures, will remain within the ranges specified for the original turbine design.

Similarly, the Appendix K power uprate does not affect the generator auxiliaries listed below since the generator will continue to operate below its design rating of 1525 MVA.

- Hydrogen Gas System
- Primary Water System
- Seal Oil System
- Excitation System

The turbine generator performance is bounded by existing design and is not impacted by Appendix K power uprate.

2b. The isolated phase bus duct (Main Transformer Delta Bus) also has adequate capacity for the proposed changes. Power = (22,000*24,500) = 539 MVA (per phase) is well above the capacity of the transformers or generator. Nameplate ratings are listed below:

System Voltage – 22 kV, 3 phase, 60 Hz
Current Ratings (Delta Bus) – 24,500 Amps

2c. The Generator Output Nameplate Rating is 1525 MVA and is unchanged by the TPO. The Main Transformers are rated for 510 MVA (1ϕ)/1530 MVA (3ϕ) @ 65° C (FOA) winding temperature rise. Hence the main transformers are adequate for the TPO uprate.

2d/e GGNS does not have start-up or auxiliary transformers. GGNS has two 500/34.4 kV service transformers fed directly from the 500 kV switchyard. The service transformers are rated at 168 MVA @ 65° C (FOA) each which is well above our total station load of approximately 84 MVA. UFSAR Section 8.1 gives an introduction to the electric power system at GGNS with the main one line included (UFSAR Figure 8.1-001).

Attachment 3

GNRO-2002-00049

Response to Mechanical RAI

Attachment 3
Response to NRC Mechanical Branch RAI for GGNS Power Uprate

1. In reference to Section 2.5 of Attachment 2 to the amendment request, provide a summary describing the effect of the proposed power uprate on the structural integrity of the Control Rod Drive Mechanisms (CRDMs). Confirm that the existing design basis analysis for stress and fatigue cumulative usage of the CRDMs remains unchanged for the proposed 1.7 percent power uprate.

Response:

The components of the CRD mechanism, which form part of the primary pressure boundary, have been designed in accordance with the applicable ASME B&PV Code, Section III. The CRD mechanism structural and functional integrity is acceptable for a bottom head pressure of at least the reactor vessel design pressure.

The CRD mechanism has been evaluated for the proposed 1.7 percent power uprate operating conditions and found to be acceptable. The CRD mechanism is not affected by the different TPO conditions reflected in Table 1-1 of the TSAR. Therefore, the existing design basis analysis for stress and fatigue cumulative usage of the CRD mechanisms remains unchanged for the proposed 1.7 percent power uprate.

2. Provide a summary of the components that were modified and the code editions/code cases (if applicable) other than the code of record that was used for the power uprate evaluation.

Response:

For this TPO analysis, the only changes that affect the reactor pressure vessel components are the feedwater nozzle temperatures and flow rates and the steam outlet nozzle flow rates. The steam outlet nozzle was not modified.

The feedwater nozzle had a modification to its safe end The fatigue curves used for the TPO analysis are consistent with those from the code at the time of the modification, which is the 1980 Edition of the ASME B&PV Code.

3. In reference to Section 3.2.2, you indicated that "If there is an increase in annulus pressurization, jet reaction, pipe restraint or fuel lift loads, the changes are considered in the analysis of the components affected due to Upset, Emergency and Faulted conditions." Provide a summary discussion of how these loads are affected by the proposed power uprate. Confirm whether and how these loads are incorporated and deemed acceptable in the TPO uprate evaluation of the reactor vessel and internal components.

Response:

In summary, the effect of 1.7% power uprate on the annulus pressurization, jet reaction, or fuel lift loads for the reactor internals is insignificant. The results of the TPO evaluations have confirmed that the annulus pressurization, jet reaction, and fuel lift loads are bounded by the current design basis.

The TPO evaluation considered the applicable loads on the reactor vessel and internals, including annulus pressurization (AP) jet reaction, and fuel lift loads. Pipe restraint loads are imposed on the shield wall and do not affect the vessel or internals.

The jet reaction load is a function of the vessel pressure. Since there is no vessel pressure change due to TPO, the jet reaction loads remain unaffected.

The evaluation of the reactor internals pressure difference documents that a net positive fuel lift margin exists for the fuel bundle due to the combined effect of reactor pressure difference and weight. The fuel lift loads in the TPO condition remain bounded by the pre-TPO conditions.

The effect of TPO on the annulus pressurization loads is bounded by the current licensed thermal power analysis, which was performed at 102% CLTP conditions.

4. In reference to Section 3.3, provide a summary describing the effect of the proposed power uprate on the existing stress and fatigue analysis of the reactor internals. Confirm that the existing design basis analysis of the reactor internals remains unchanged for the proposed 1.7 percent power uprate.

Response:

For the TPO, there is no increase in nominal vessel pressure or temperature, except for the feedwater temperature increase of ~2°F (from 420°F to 422°F). However, there is a slight increase in the reactor internal pressure difference (RIPD) due to TPO in the Normal/Upset conditions for some components. The magnitude of changes are very minimal and they are reported in TSAR Table 3-2 for the component stresses / loads associated with the affected components. In each case, the loads are within allowables.

5. In reference to Section 3.5.1, you state that "the effect of the TPO uprate with no nominal vessel dome pressure increase is negligible for the reactor coolant pressure boundary portion of all piping except for portions of the FW lines, and piping connected to the FW and MS lines." Identify the piping systems attached to FW lines which are affected by the proposed power uprate, and include a summary of the TPO uprate evaluation for these piping systems.

Response:

There are no piping systems attached to FW that are affected by TPO since the FW piping system itself is unaffected by TPO. Therefore, the piping systems attached to the FW piping are acceptable, and no further evaluation of such piping systems was performed.

The table in Section 3.5.1 discusses that the current licensing basis bounds TPO conditions. The nominal reactor dome pressure at the TPO uprate condition is identical to current licensing basis. Compared to current licensed thermal power conditions, FW flow increases approximately 2%, FW temperature increases approximately 2 degrees F, and FW pressure increases less than 2 psi. The change in FW flow has no effect on FW piping since the piping system does not have any fast closing valves that could produce water hammer loads. The changes in temperature and pressure are considered negligible for FW pipe stresses and pipe support loads.

6. In reference to Section 3.5.2, list the most critical balance of plant (BOP) piping systems that were evaluated for the power uprate. Provide summary of evaluations performed for BOP piping, components, and pipe supports, nozzles, penetrations, guides, valves, pumps, heat exchangers, and anchorage for pipe supports.

Response:

The BOP piping system evaluation consisted of establishing the magnitude of pressure, temperature and flow increases and their effects on the overall pipe stress and support loads. The maximum temperature increase was limited to 2 degrees F, the pressure increase to 2 psig and flow to less than 2% increase. These changes are considered negligible for pipe stresses, pipe supports and other components in the system. This was confirmed by performing an enveloping evaluation for the effect of pressure increase versus pipe size and the consideration of the conservative assumptions in the typical thermal analysis calculations. Additionally any effects of increased flow on flow accelerated corrosion (FAC) are covered by the existing program for monitoring pipe wall thinning. This confirmed that the changes in temperature, pressure and flow have negligible effects on existing analysis and components.

7. In reference to Section 3.5.2, you state that "GGNS piping and related supports remain within allowable stress limits in accordance with ASME Section III, 1974 Edition though the Summer 1975 addenda, and ANSI B31.1 Summer 1973 addenda, as appropriate." Clarify whether the ANSI B31.1, 1973 Edition through the Summer 1973 addenda or only the ANSI B31.1 Summer 1973 addenda was used in the power uprate evaluation.

Response:

ANSI B31.1, 1973 Edition through Summer 1973 addenda was used in the power uprate evaluation.

Attachment 4

GNRO-2002-00049

Summary of Commitments

Summary of Regulatory Commitments

The following table identifies those actions committed to by Entergy in this document. Other statements in this submittal are provided for information purposes and are not considered to be regulatory commitments.

COMMITMENT	TYPE (Check one)	
	ONE-TIME ACTION	**CONTINUING COMPLIANCE**
Calibration and Maintenance work will be performed in accordance with Caldon recommendations		X
The LEFM,√+™ System software will be controlled under the GGNS software quality assurance program.		X
This requirement (LEFM AOT) will be controlled by the GGNS Technical Requirements Manual		X
If the plant experiences a down power of greater than 10% during the 72 hour period, then the permitted maximum power level would be reduced to 3833 MWt upon return to full power, since a plant transient may result in calibration changes of the venturis (e.g., defouling).		X
With an LEFM out of service for more than the above allowed outage time, GGNS will limit power to the original licensed power level of 3833 MWt		X