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RBG-45984

August 2, 2002

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

SUBJECT: River Bend Station, Unit 1
Docket No. 50-458
Response to Requests for Additional Information
Appendix K Measurement Uncertainty Recovery – Power Uprate Request (License Amendment Request (LAR) 2002-15)

REFERENCE: Entergy letter dated May 14, 2002, Appendix K Measurement Uncertainty Recovery – Power Uprate Request (LAR 2002-15)

Dear Sir or Madam:

Pursuant to 10CFR50.90, Entergy Operations, Inc. (Entergy) requested approval of changes to the River Bend Station (RBS) 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 3,039 MWt to 3,091 MWt. This letter provides additional clarification and information to address questions asked by NRC reviewers in the Electrical and Instrumentation & Control Branch (EICB).

Responses to the questions from the I&C and the electrical reviewers are provided in Attachments 1 and 2, respectively. 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.

There are no new commitments made in this submittal. 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 August 2, 2002.

Sincerely,

Rick J. King
Director, Nuclear Safety Assurance

RJK/FGB
Attachments:
1. Response to I&C RAI
2. Response to Electrical RAI

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RBG-45984

bcc: File Nos. G9.5, G9.42
RBF1-02-0108

# Attachment 1

## RBG-45984

## Response to I&C RAI

## Attachment 1

## Response to NRC I&C Branch RAI for RBS Power Uprate

Based on the RIS 2002-03 guidance provided by the NRC, and the guidance in the TLTR, the staff requested the following information from the licensee to complete its review of the licensee's submittal.

1. TLTR Table 3-1, "Anticipated Effect of Thermal Power Optimization (TPO) Uprate on Bounding Licensing Criteria," addressed the effect of a less than or equal to 1.5% thermal power increases on key licensing criteria.

   TLTR Section 4.2.1, "Generic Evaluations," stated, "The generic evaluations documented herein (or in supplements to this document) are performed to support a less than or equal to 1.5% increase in the reactor thermal power."

   TLTR Section 4.2.3, "Operating License Amendment Request," stated, "The TSAR [plant-specific Safety Analysis Report] will address plant-specific licensing issues that have not been generically dispositioned. The TSAR also will identify deviations from these generic guidelines that may be desired by the utility, and will provide justification of the plant-specific approach."

   TLTR Section 5.0, "Scope," stated, "This generic TPO Licensing Topical Report (TLTR) and any supplemental generic report(s) will be referenced without further evaluations to the extent that they are applicable by plant-specific submittals for a TPO uprate. ... For those tasks that could not be dispositioned generically, a plant-specific evaluation will be performed. Tables B-3 and J-3 (Appendices B and J) list the areas identified for plant-specific confirmation of acceptable safety compliance. These plant-specific evaluations will be performed at a thermal power level consistent with the thermal power uncertainty reduction achieved for that plant."

   Section C.2.1, "Uprated Core Thermal Power," of TLTR Appendix C, "Specific Assumptions and Bases for TPO Uprate Operating Conditions" stated "The generic TPO uprated core thermal power level (MWt) to be proposed shall be equal to or less than 101.5% of the current licensed thermal power."

   TLTR Appendix F, "Specific Assumptions and Bases for Control Instrumentation, and Setpoint Evaluations," stated "The generic guidelines applicable to instrument setpoints for operation at TPO uprated conditions are listed with the pertinent bases, methods, and assumptions that apply. ... Any plant-unique deviations from these guidelines will be explained and justified in the plant-specific submittal."

   On the basis of these sections of the TLTR, which limit a licensee to a TPO power uprate increase of less than or equal to 1.5% above the Current Licensed Thermal Power (CLTP), the staff concludes that increases above 1.5% CLTP are not within the scope of the TLTR analyses and, therefore, must be addressed by the licensee.

In NEDC-33051P Section 1.1, "Introduction," the licensee stated, "The amount of power uprate (less than or equal to 1.5%) contained in the TLTR was based on the expected reduction in power level uncertainty with the instrumentation technology available in 1999. The present instrumentation technology has evolved to where power level uncertainty is reduced to 0.3%, thereby allowing a power level increase of 1.7%." This justification is not sufficient for the staff to approve the requested 1.7% TPO uprate. Provide an analytical justification for extending the scope of the TLTR beyond the 1.5% limit defined in the TLTR. In performing this analysis, address the anticipated effects of the 1.7% TPO uprate on the bounding licensing criteria summarized in Table 3-1 of the TLTR, and in Section 5 of NEDC-33051P.

Response:

The methodology for the evaluation of RBS for operation at the TPO uprated power level involved various approaches. The discussion in each section of the TSAR presents the applicable approach. Where the generic analysis presented in the TLTR was used as the basis for acceptability, a confirmation was made that the generic analysis performed at the 1.5% uprated power was valid for the RBS 1.7% uprate.

As an example, TSAR Section 4.1 states that the previous containment evaluations are based on 102% of CLTP and therefore bound the RBS uprate of 101.7% of CLTP. In another case, TSAR Section 3.2.1 presents the evaluation for the fracture toughness of the reactor vessel based on a new plant specific analysis performed at the RBS TPO conditions of 101.7% of CLTP. As a third example, TSAR Section 5.3.10 notes the TLTR analysis demonstrated that a 1.5% increase in power does not significantly increase the possibility of reactor scram. The TSAR goes on to describe that this generic disposition is also applicable to the RBS 1.7% uprate application.

2. Item I.1.E in RIS 2002-03 requested that licensees provide a calculation of total power measurement uncertainty at the plant, explicitly identifying all parameters and their individual contribution to the power measurement uncertainty. The applicable discussion in NEDC-33051P Section 1.4, "Basis for TPO Uprate," does not provide the information requested in RIS 2002-03. Additionally, Attachment 1 Section 4.2.5, "Uncertainty Determination Methodology," in the licensee's submittal stated that Caldon has completed the RBS Leading Edge Flow Meter Check Plus (LEFM ✓+) system uncertainty calculation indicating a mass flow inaccuracy of less than or equal to 0.3% of rated flow for the site-specific installation. In Section 4.2.5 of Attachment 1, the licensee stated that the results of the RBS uncertainty analysis will be provided after the results have been verified. This calculation will be reviewed by the staff to confirm that the calculation follows ER-80P guidelines, is based on the accepted setpoint methodology for RBS, and provides the bases for the licensee's statements in Section 4.2.5 of Attachment 1 and Section 1.4 of the TLTR.

> The licensee committed to provide the staff with the RBS uncertainty analysis, the allowed outage time, and contingent actions once the RBS uncertainty analysis is verified. The staff cannot complete its review without this information.

Response:

Since General Electric has no formal process for calculating the core power uncertainty from the input variables, RBS 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. RBS has applied this same approach with regard to the gross core power uncertainty and calculated a 2-sigma core power uncertainty of less than 11 MW to ensure that 102% CLTP (3039 MW) is not exceeded at 95% probability and 95% confidence interval.

Table 1-4 of the GE Safety Analysis Report lists the plant parameters that were applied in the core power uncertainty calculation. With the exception of the recirculation pump motor efficiency, moisture carryover, CRD temperature, 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. For the CRD temperature, a bounding low value of 77°F is used as it 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. An RBS 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 RBS 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, RBS 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)
RBS Heat Balance Parameters and Uncertainties

| Parameter | Nominal Value | Uncertainty ($2\sigma$) | Contribution to core power uncertainty (MWTH) |
|---|---|---|---|
| Steam Dome Pressure (psia) | 1070 | 10.0 | 0.67 |
| Feedwater System Flow (Mlb/hr) | 13.3914 | 0.0388 | 4.47 |
| Feedwater System Temperature (°F) | 425.6 | 0.600 | 2.00 |
| CRD Flow (Mlb/hr) | 0.025 | 0.0012 | 0.20 |
| CRD Temperature (°F) | 77.0 | 0.0 | 0.00 |
| RWCU Flow (Mlb/hr) | 0.124 | 0.0018 | 0.03 |
| RWCU Inlet Temperature (°F) | 535.4 | 9.92 | 0.22 |
| RWCU Outlet Temperature (°F) | 439.1 | 9.92 | 0.20 |
| Recirc Pump Power (MW) | 4.67 | 0.1412 | 0.09 |
| Recirc Pump Efficiency (%) | 93.15 | 4.00 | 0.19 |
| Saturated Steam Enthalpy Correlation | Various | 0.10 | 0.20 |
| Subcooled Liquid Enthalpy Correlation | Various | 0.60 | 1.84 |
| 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 11 MW. As a confirmation of this approach, the methodology reported in NUREG/CR-3659 was applied with the same RBS input variables. The confirmatory calculation is documented in Enclosure 1 to this attachment and concludes the 2-sigma core power uncertainty is 9.77 MW, which compares well with the 10.58 MW value developed by the RBS Monte Carlo approach.

The AOT and contingent actions are provided in response to this question (and to address items I.G and I.H of RIS 2002-03). 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 RBS 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 RBS 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 RBS 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 a 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 3,039 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 3,091 MWt based on feedwater flow measured by the venturis that have been corrected to a 0.3% uncertainty within 72 hours.

With an LEFM out of service for more than the above allowed outage time, RBS will limit power to the previously licensed power level of 3,039 MWt. This will basically limit power to that level for which RBS was previously licensed because it will be utilizing the same instrument inputs as were used prior to the installation of the LEFM.

3. RIS 2002-03 allows licensees to take credit for using the LEFM ✓+ to calibrate existing instruments. In Attachment 1, Section 4.2.2, "LEFM Failure," the licensee stated that the LEFM ✓+ feedwater mass flow and temperature inputs will also be used to adjust or 'calibrate' the inputs from the feedwater venturis and temperature elements. If the LEFM system becomes inoperable, control room operators are promptly alerted by control room indications. The reactor thermal power will then be administratively controlled, following an acceptable allowed outage time, at a power level to be determined consistent with the RBS uncertainty analysis until such time as the LEFM ✓+ system is returned to an operable status. The uncertainties of the venturi and temperature element-based inputs are expected to increase over time due to drift and ambient temperature effects, and must be compensated for in the administrative controls. The administrative controls will be added to the RBS Technical Requirements Manual.

   As stated in the licensee submittal, the accuracy of the LEFM ✓+ is +/- 0.3%. Provide a comparison of the existing RBS flow meter and temperature calibration instrumentation accuracies and the associated LEFM ✓+ calibration accuracies, as they relate to the uncertainty in determining calorimetric power. Any decrease in calibration accuracy will determine the power level at which the RBS will be operated if the LEFM ✓+ becomes inoperable.

   For example, if the venturi-based flow meters and temperature elements are calibrated using NIST standard instruments with an accuracy of (for example) +/- 0.1%, and these calibrations result in the +/- 1.7% accuracy in calorimetric power that is being eliminated by the LEFM ✓+ system, then calibrating these instruments using a calibration instrument with a +/- 0.3% accuracy (i.e., the LEFM) should result in flow and temperature measurements that would have a net effect of slightly less than +/-1.7%

accuracy (1.8%?) in calorimetric power determinations if these 'calibrated' instruments are used in lieu of the LEFM ✓+ instrumentation. Consequently, the reactor power would have to be decreased by more than 1.8%(?) RTP until the LEFM ✓+ was returned to operability.

Response:

As noted above in the response to question 2, the contingent actions planned when an LEFM has been out of service beyond its allowed outage time will be to revert to the current licensed thermal power (i.e., 3039 MWt). This establishes the maximum power level at a value consistent with the accuracy of the currently licensed instrumentation.

## Enclosure 1 to Attachment 1
## Core Power Uncertainty Confirmation

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

The RBS heat balance at the uprated condition is given by the following formula (Equation 1).

$$\mathrm{CTP} = \frac{\mathrm{WFW} \times ((\mathrm{HG} - \mathrm{FM} \times \mathrm{HFG}) - \mathrm{HFW}) + \mathrm{WCR} \times ((\mathrm{HG} - \mathrm{FM} \times \mathrm{HFG}) - \mathrm{HCR}) + \mathrm{WCU} \times (\mathrm{HCU1} - \mathrm{HCU2})}{\mathrm{C1}} + \mathrm{QRAD} - \mathrm{QP}$$

Where:

Table 1: Uncertainty Analysis Inputs

| Parameter | Description | Units | Nominal Value | Uncertainty (2σ) |
|---|---|---|---|---|
| PDOME | Steam Dome Pressure | Psia | 1070 | 10.00 |
| WFW | Feedwater Flow Rate | Mlbm/hr | 13.3914 | 0.0388 |
| WCR | CRD Flow Rate | Mlbm/hr | 0.025 | 0.0012 |
| WCU | RWCU Flow Rate | Mlbm/hr | 0.124 | 0.0018 |
| FM | Moisture Carryover Fraction* | None | 0.0 | 0.0 |
| TFW | Feedwater Temperature | °F | 425.6 | 0.6 |
| TCR | Control Rod Drive Temperature* | °F | 77.00 | 0.0 |
| TCU1 | RWCU Suction Temperature | °F | 535.4 | 9.92 |
| TCU2 | RWCU Discharge Temperature | °F | 439.1 | 9.92 |
| QRAD | Miscellaneous Thermal Losses* | MWTH | 1.1 | 0.0 |
| ETA | Recirculation Pump Efficiency | None | 0.9315 | 0.04 |
| QP | Recirculation Pump Power | MWTH | 9.34 | 0.2824 |
| HG | Saturated Steam Enthalpy | BTU/lbm | Various | 0.10 |
| HSC | Sub-cooled Liquid Enthalpy | BTU/lbm | Various | 0.60 |

| | |
|---|---|
| HFG | Latent Heat of Vaporization |
| HCR | Control Rod Drive Enthalpy |
| HCU1 | RWCU Suction Enthalpy |
| HCU2 | RWCU Discharge Enthalpy |

* The moisture carryover, CRD enthalpy and thermal losses are not directly measured. Instead, the heat balance will assumes a moisture carryover fraction of 0% to conservatively overestimate reactor power. Similarly, the CRD temperature and 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 RBS heat balance in Equation 1 reduces to the following equation:

$$\mathrm{CTP} = \frac{\mathrm{WFW} \times (\mathrm{HG} - \mathrm{HFW}) + \mathrm{WCR} \times (\mathrm{HG} - \mathrm{HCR}) + \mathrm{WCU} \times (\mathrm{HCU1} - \mathrm{HCU2})}{\mathrm{C1}} + \mathrm{QRAD} - \mathrm{QP} \qquad (2)$$

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 instrument 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 considered in the RBS 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.

$$U_{\mathrm{CTP}}^2 = \left[\begin{array}{l} \left(\left(\frac{\partial \mathrm{CTP}}{\partial \mathrm{WFW}}\right)^2 \times \sigma_{\mathrm{WFW}}^2\right) + \left(\left(\frac{\partial \mathrm{CTP}}{\partial \mathrm{HG}}\right)^2 \times \sigma_{\mathrm{HG}}^2\right) + \left(\left(\frac{\partial \mathrm{CTP}}{\partial \mathrm{WCR}}\right)^2 \times \sigma_{\mathrm{WCR}}^2\right) + \left(\left(\frac{\partial \mathrm{CTP}}{\partial \mathrm{WCU}}\right)^2 \times \sigma_{\mathrm{WCU}}^2\right) \\ + \left(\left(\frac{\partial \mathrm{CTP}}{\partial \mathrm{HCU1}}\right)^2 \times \sigma_{\mathrm{HCU1}}^2\right) + \left(\left(\frac{\partial \mathrm{CTP}}{\partial \mathrm{HCU1}}\right)^2 \times \sigma_{\mathrm{HCU2}}^2\right) + \left(\left(\frac{\partial \mathrm{CTP}}{\partial \mathrm{HFW}}\right)^2 \times \sigma_{\mathrm{HFW}}^2\right) + \left(\left(\frac{\partial \mathrm{CTP}}{\partial \mathrm{HCR}}\right)^2 \times \sigma_{\mathrm{HCR}}^2\right) \\ + \left(\left(\frac{\partial \mathrm{CTP}}{\partial \mathrm{QRAD}}\right)^2 \times \sigma_{\mathrm{QRAD}}^2\right) + \left(\left(\frac{\partial \mathrm{CTP}}{\partial \mathrm{ETA}}\right)^2 \times \sigma_{\mathrm{ETA}}^2\right) + \left(\left(\frac{\partial \mathrm{CTP}}{\partial \mathrm{QP}}\right)^2 \times \sigma_{\mathrm{QP}}^2\right) \end{array}\right] \qquad (3)$$

The partial differentials are derived below.

$$\frac{\partial \mathrm{CTP}}{\partial \mathrm{WFW}} = \mathrm{HG} - \mathrm{HFW} = 1190.25 \,\tfrac{\mathrm{BTU}}{\mathrm{lbm}} - 403.70 \,\tfrac{\mathrm{BTU}}{\mathrm{lbm}} = 786.55 \,\tfrac{\mathrm{BTU}}{\mathrm{lbm}}$$

$$\frac{\partial \mathrm{CTP}}{\partial \mathrm{HG}} = \mathrm{WFW} + \mathrm{WCR} = 13.3914 \,\tfrac{\mathrm{Mlbm}}{\mathrm{hr}} + 0.025 = 13.4164 \,\tfrac{\mathrm{Mlbm}}{\mathrm{hr}}$$

$$\frac{\partial \mathrm{CTP}}{\partial \mathrm{WCR}} = \mathrm{HG} - \mathrm{HCR} = 1190.25 \,\tfrac{\mathrm{BTU}}{\mathrm{lbm}} - 48.00 \,\tfrac{\mathrm{BTU}}{\mathrm{lbm}} = 1142.25 \,\tfrac{\mathrm{BTU}}{\mathrm{lbm}}$$

$$\frac{\partial \mathrm{CTP}}{\partial \mathrm{WCU}} = \mathrm{HCU1} - \mathrm{HCU2} = 530.87 \,\tfrac{\mathrm{BTU}}{\mathrm{lbm}} - 418.48 \,\tfrac{\mathrm{BTU}}{\mathrm{lbm}} = 112.39 \,\tfrac{\mathrm{BTU}}{\mathrm{lbm}}$$

$$\frac{\partial \mathrm{CTP}}{\partial \mathrm{HCU1}} = \mathrm{WCU} = 0.124 \,\tfrac{\mathrm{Mlbm}}{\mathrm{hr}}$$

$$\frac{\partial \mathrm{CTP}}{\partial \mathrm{HCU2}} = -\mathrm{WCU} = -0.124 \,\tfrac{\mathrm{Mlbm}}{\mathrm{hr}}$$

$$\frac{\partial \mathrm{CTP}}{\partial \mathrm{HFW}} = -\mathrm{WFW} = -13.3914 \,\tfrac{\mathrm{Mlbm}}{\mathrm{hr}}$$

$$\frac{\partial CTP}{\partial HCR} = -WCR = -0.025\,\frac{Mlbm}{hr}$$

$$\frac{\partial CTP}{\partial ETA} = -\left(QP \times 3.413\,\frac{\frac{MBTU}{hr}}{MWTH}\right) = -\left(9.3398\ MW \times 3.413\,\frac{\frac{MBTU}{hr}}{MWTH}\right) = -31.8733\,\frac{MBTU}{hr}$$

$$\frac{\partial CTP}{\partial QP} = -ETA = -0.9315$$

$$\frac{\partial CTP}{\partial QRAD} = 1.0$$

To complete the calculation, the enthalpy uncertainties must be computed. Equation 14 in NUREG/CR-3659 is used as the basis for determining the enthalpy uncertainties, and is:

$$\sigma_h = \sqrt{\left(\frac{\partial h}{\partial T}\right)^2 (\sigma_T)^2 + \left(\frac{\partial h}{\partial P}\right)^2 (\sigma_P)^2 + \left(\frac{\partial h}{\partial I_O}\right)^2 \left(\sigma_{I_O}\right)^2}$$

The uncertainty applied to the saturated steam enthalpy uses a modified form of the equation above as the temperature input is not required to determine the saturation enthalpy. Thus the uncertainty associated with the saturated steam enthalpy is:

$$\sigma_{HG} = \sqrt{\left(\frac{\partial HG}{\partial P}\right)^2 (\sigma_P)^2 + \left(\frac{\partial HG}{\partial I_O}\right)^2 \left(\sigma_{I_O}\right)^2} = \sqrt{\left(\frac{\Delta HG}{\Delta P}\right)^2 (\sigma_P)^2 + \left(\frac{\Delta HG}{\Delta I_O}\right)^2 \left(\sigma_{I_O}\right)^2}$$

Where: HG is the enthalpy of saturated steam (BTUlbm).

P is the steam dome pressure (psia).

$I_O$ is the accuracy of the steam table information.

The nominal dome pressure for the heat balance calculation is 1070 psia. At this pressure the saturation temperature is 552.86 °F. The saturation temperatures that bound this value (552 °F and 554 °F) will be used to establish the change in saturation steam enthalpy relative to the change in pressure. The steam dome pressure measurement uncertainty is obtained from Table 1. The terms associated with accuracy of the steam tables will be replaced with $\sigma_{HG}$ from Table 1. Thus the total steam uncertainty is:

$$\sigma_{HG} = \sqrt{\left(\frac{1189.9\,\frac{BTU}{lbm} - 1190.6\,\frac{BTU}{lbm}}{1079.96\ psia - 1062.59\ psia}\right)^2 \left(\frac{10\ psi}{2}\right)^2 + \left(\frac{0.1\,\frac{BTU}{lbm}}{2}\right)^2} = 0.2706\,\frac{BTU}{lbm}$$

The uncertainty applied to the control rod system water enthalpy is determined as:

$$\sigma_{HCR} = \sqrt{\left(\frac{\Delta HCR}{\Delta TCR}\right)^2 (\sigma_{TCR})^2 + \left(\frac{\Delta HCR}{\Delta P}\right)^2 (\sigma_P)^2 + \left(\frac{\Delta HCR}{\Delta I_O}\right)^2 (\sigma_{I_O})^2}$$

Where: HCR is the enthalpy of CRD system water (BTU/lbm).

TCR is the temperature of the CRD system water (°F).

P is the steam dome pressure (psia).

$I_O$ is the accuracy of the steam table information.

The nominal conditions used in the heat balance to describe the CRD system water are a pressure of 1070 psia and a temperature of 77 °F. The steam tables will be used to develop the data to calculate the relative change in the enthalpy.

| CRD System Water Enthalpy (BTU/lbm) | | | |
|---|---|---|---|
| | 1050 psia | 1070 psia | 1100 psia |
| 80 °F | **50.89** | 50.95 | **51.03** |
| 77 °F | 47.91 | 47.97 | 48.05 |
| 70 °F | **40.56** | 41.02 | **41.10** |

The values of $\sigma_{TCR}$ and $\sigma_P$ are obtained from Table 1 above. Also, the terms associated with the steam table accuracy will be replaced with the value of $\sigma_{HSC}$ in Table 1 above. The CRD enthalpy is calculated as:

$$\sigma_{HCR} = \sqrt{\left(\frac{50.95\,\frac{BTU}{lbm} - 41.02\,\frac{BTU}{lbm}}{80°F - 70°F}\right)^2 (0.0°F)^2 + \left(\frac{47.91\,\frac{BTU}{lbm} - 48.05\,\frac{BTU}{lbm}}{1100\text{ psia} - 1050\text{ psia}}\right)^2 \left(\frac{10.0\text{ psi}}{2}\right)^2 + \left(\frac{0.60\,\frac{BTU}{lbm}}{2}\right)} = 0.3003\,\frac{BTU}{lbm}$$

The uncertainty applied to the feedwater enthalpy is determined as:

$$\sigma_{HFW} = \sqrt{\left(\frac{\Delta HFW}{\Delta TFW}\right)^2 (\sigma_{TFW})^2 + \left(\frac{\Delta HFW}{\Delta P}\right)^2 (\sigma_P)^2 + \left(\frac{\Delta HFW}{\Delta I_O}\right)^2 (\sigma_{I_O})^2}$$

Where: HFW is the feedwater enthalpy (BTU/lbm).

TFW is the feedwater temperature (°F).

P is the steam dome pressure (psia).

$I_O$ is the accuracy of the steam table information.

The nominal conditions used in the heat balance to describe the feedwater are a pressure of 1070 psia and a temperature of 425.6 °F. The steam tables will be used to develop the data to calculate the relative change in the enthalpy.

| Feedwater Enthalpy (BTU/lbm) | | | |
|---|---|---|---|
| | 1050 psia | 1070 psia | 1100 psia |
| 430 °F | **408.5** | 408.516 | **408.54** |
| 425.6 °F | 403.704 | 403.722 | 403.748 |
| 420 °F | **397.60** | 397.62 | **397.65** |

The values of $\sigma_{TFW}$ and $\sigma_P$ are obtained from Table 1 above. Also, the terms associated with the steam table accuracy will be replaced with the value of $\sigma_{HSC}$ in Table 1 above. The feedwater enthalpy is calculated as:

$$\sigma_{HFW} = \sqrt{\left(\frac{408.516\,\frac{BTU}{lbm} - 397.62\,\frac{BTU}{lbm}}{430°F - 420°F}\right)^2 \left(\frac{0.6°F}{2}\right)^2 + \left(\frac{403.748\,\frac{BTU}{lbm} - 403.704\,\frac{BTU}{lbm}}{1100\ psia - 1050\ psia}\right)^2 \left(\frac{10.0\ psi}{2}\right)^2 + \left(\frac{0.60\,\frac{BTU}{lbm}}{2}\right)} = 0.4437\,\frac{BTU}{lbm}$$

The uncertainty applied to the RWCU suction enthalpy is determined as:

$$\sigma_{HCU1} = \sqrt{\left(\frac{\Delta HCU1}{\Delta TCU1}\right)^2 (\sigma_{TCU1})^2 + \left(\frac{\Delta HCU1}{\Delta P}\right)^2 (\sigma_P)^2 + \left(\frac{\Delta HCU1}{\Delta I_O}\right)^2 (\sigma_{I_o})^2}$$

Where: HCU1 is the RWCU suction enthalpy (BTU/lbm).

TCU1 is the RWCU suction temperature (°F).

P is the steam dome pressure (psia).

$I_O$ is the accuracy of the steam table information.

The nominal conditions used in the heat balance to describe the RWCU suction enthalpy are a pressure of 1070 psia and a temperature of 535.4 °F. The steam tables will be used to develop the data to calculate the relative change in the enthalpy.

| RWCU Suction Enthalpy (BTU/lbm) | | | |
|---|---|---|---|
| | 1050 psia | 1070 psia | 1100 psia |

| | | | |
|---|---|---|---|
| 540 °F | **536.60** | 536.56 | **536.51** |
| 535.4 °F | 530.83 | 530.79 | 530.75 |
| 530 °F | **524.05** | 524.02 | **523.98** |

The values of $\sigma_{TCU1}$ and $\sigma_{P}$ are obtained from Table 1. Also, the terms associated with the steam table accuracy will be replaced with the value of $\sigma_{HSC}$ in Table 1. The RWCU suction enthalpy is calculated as:

$$\sigma_{HCU1} = \sqrt{\left(\frac{536.56\,\frac{BTU}{lbm} - 524.02\,\frac{BTU}{lbm}}{540°F - 530°F}\right)^2 \left(\frac{9.92°F}{2}\right)^2 + \left(\frac{530.83\,\frac{BTU}{lbm} - 530.75\,\frac{BTU}{lbm}}{1100\text{ psia} - 1050\text{ psia}}\right)^2 \left(\frac{10.0\text{ psi}}{2}\right)^2 + \left(\frac{0.60\,\frac{BTU}{lbm}}{2}\right)} = 5.56\,\frac{BTU}{lbm}$$

The uncertainty applied to the RWCU discharge enthalpy is determined as:

$$\sigma_{HCU2} = \sqrt{\left(\frac{\Delta HCU2}{\Delta TCU2}\right)^2 (\sigma_{TCU2})^2 + \left(\frac{\Delta HCU2}{\Delta P}\right)^2 (\sigma_P)^2 + \left(\frac{\Delta HCU2}{\Delta I_O}\right)^2 (\sigma_{I_O})^2}$$

Where: HCU2 is the RWCU discharge enthalpy (BTU/lbm).

TCU2 is the RWCU discharge temperature (°F).

P is the steam dome pressure (psia).

$I_O$ is the accuracy of the steam table information.

The nominal conditions used in the heat balance to describe the RWCU discharge enthalpy are a pressure of 1070 psia and a temperature of 439.1 °F. The steam tables will be used to develop the data to calculate the relative change in the enthalpy.

| RWCU Discharge Enthalpy (BTU/lbm) | | | |
|---|---|---|---|
| | 1050 psia | 1070 psia | 1100 psia |
| 440 °F | **419.49** | 419.506 | **419.53** |
| 439.1 °F | 418.501 | 418.517 | 418.541 |
| 430 °F | **408.50** | 408.516 | **408.54** |

The values of $\sigma_{TCU2}$ and $\sigma_{P}$ are obtained from Table 1. Also, the terms associated with the steam table accuracy will be replaced with the value of $\sigma_{HSC}$ in Table 1. The RWCU discharge enthalpy is calculated as:

$$\sigma_{HCU2} = \sqrt{\left(\frac{419.506\,\frac{BTU}{lbm} - 408.516\,\frac{BTU}{lbm}}{440°F - 430°F}\right)^2 \left(\frac{9.92°F}{2}\right)^2 + \left(\frac{418.541\,\frac{BTU}{lbm} - 418.501\,\frac{BTU}{lbm}}{1100\text{ psia} - 1050\text{ psia}}\right)^2 \left(\frac{10.0\text{ psi}}{2}\right)^2 + \left(\frac{0.60\,\frac{BTU}{lbm}}{2}\right)} = 5.46\,\frac{BTU}{lbm}$$

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

$$\left(\frac{\partial CTP}{\partial WFW}\right)^2 \sigma_{WFW}^2 = \left(786.55\,\tfrac{BTU}{lbm}\right)^2 \left(0.0388\,\tfrac{Mlb}{hr}\right)^2 = 931.3569\,\left(\tfrac{MBTU}{hr}\right)^2$$

$$\left(\frac{\partial CTP}{\partial HG}\right)^2 \sigma_{HG}^2 = \left(13.4164\,\tfrac{Mlbm}{hr}\right)^2 \left(2\times 0.2076\,\tfrac{BTU}{lbm}\right)^2 = 31.0304\left(\tfrac{MBTU}{hr}\right)^2$$

$$\left(\frac{\partial CTP}{\partial WCR}\right)^2 \sigma_{WCR}^2 = \left(1142.25\,\tfrac{BTU}{lbm}\right)^2 \left(0.0012\,\tfrac{Mlb}{hr}\right)^2 = 1.8788\,\left(\tfrac{MBTU}{hr}\right)^2$$

$$\left(\frac{\partial CTP}{\partial WCU}\right)^2 \sigma_{WCU}^2 = \left(112.39\,\tfrac{BTU}{lbm}\right)^2 \left(0.0012\,\tfrac{Mlb}{hr}\right)^2 = 0.0409\,\left(\tfrac{MBTU}{hr}\right)^2$$

$$\left(\frac{\partial CTP}{\partial HCU1}\right)^2 \sigma_{HCU1}^2 = \left(0.124\,\tfrac{Mlbm}{hr}\right)^2 \left(2\times 5.56\,\tfrac{BTU}{lbm}\right)^2 = 1.9013\,\left(\tfrac{MBTU}{hr}\right)^2$$

$$\left(\frac{\partial CTP}{\partial HCU2}\right)^2 \sigma_{HCU2}^2 = \left(-0.124\,\tfrac{Mlbm}{hr}\right)^2 \left(2\times 5.46\,\tfrac{BTU}{lbm}\right)^2 = 1.8335\,\left(\tfrac{MBTU}{hr}\right)^2$$

$$\left(\frac{\partial CTP}{\partial HCFW}\right)^2 \sigma_{HFW}^2 = \left(-13.3914\,\tfrac{Mlbm}{hr}\right)^2 \left(2\times 0.4437\,\tfrac{BTU}{lbm}\right)^2 = 141.2182\,\left(\tfrac{MBTU}{hr}\right)^2$$

$$\left(\frac{\partial CTP}{\partial HCR}\right)^2 \sigma_{HCR}^2 = \left(0.025\,\tfrac{Mlbm}{hr}\right)^2 \left(2\times 0.3003\,\tfrac{BTU}{lbm}\right)^2 = 0.0002\,\left(\tfrac{MBTU}{hr}\right)^2$$

$$\left(\frac{\partial CTP}{\partial ETA}\right)^2 \sigma_{ETA}^2 = \left(-9.3398\text{ MWTH}\times 3.413\,\frac{\frac{MBTU}{hr}}{MWTH}\right)^2 (0.0.3726)^2 = 1.4107\,\left(\tfrac{MBTU}{hr}\right)^2$$

$$\left(\frac{\partial CTP}{\partial QP}\right)^2 \sigma_{QP}^2 = (-.9315)^2 \left(0.2824\text{ MWTH}\times 3.413\,\frac{\frac{MBTU}{hr}}{MWTH}\right)^2 = 0.8061\,\left(\tfrac{MBTU}{hr}\right)^2$$

$$\left(\frac{\partial CTP}{\partial QRAD}\right)^2 \sigma_{QRAD}^2 = (1.0)^2 \left(0.0\text{ MWTH}\times 3.413\,\frac{\frac{MBTU}{hr}}{MWTH}\right)^2 = 0.00\left(\tfrac{MBTU}{hr}\right)^2$$

$$U_{CTP}^2 = \begin{bmatrix} 931.3659\left(\tfrac{MBTU}{hr}\right)^2 + 31.0304\left(\tfrac{MBTU}{hr}\right)^2 + 1.8788\left(\tfrac{MBTU}{hr}\right)^2 + 0.0409\left(\tfrac{MBTU}{hr}\right)^2 + 1.9013\left(\tfrac{MBTU}{hr}\right)^2 + 1.8335\left(\tfrac{MBTU}{hr}\right)^2 \\ + 141.2182\left(\tfrac{MBTU}{hr}\right)^2 + 0.0002\left(\tfrac{MBTU}{hr}\right)^2 + 1.4107\left(\tfrac{MBTU}{hr}\right)^2 + 0.8601\left(\tfrac{MBTU}{hr}\right)^2 + 0.0000\left(\tfrac{MBTU}{hr}\right)^2 \end{bmatrix} = 1111.48\left(\tfrac{MBTU}{hr}\right)^2$$

$$U_{CTP} = 33.34\,\tfrac{MBTU}{hr}$$

$$U_{CTP} = \left( \frac{33.34\ \text{MBtu/hr}}{3.413\, \frac{\frac{\text{MBTU}}{\text{hr}}}{\text{MWTH}}} \right) = 9.77\ \text{MWTH}$$

# Attachment 2

## RBG-45984

## Response to Electrical RAI

## Attachment 2

## Response to NRC Electrical Branch RAI for RBS Power Uprate

1. Provide details about the grid stability analysis including assumptions and results and conclusions for the power uprated conditions.

Response:

RBS provided a description of the grid stability and reliability evaluation in response to an RAI received on the stretch power uprate request. The response to questions 13 and 14 provided in the April 3, 2000 letter (accession number ML003701673) describe the impact of the power uprate on the grid stability analyses presented in the Updated Safety Analysis Report (USAR). That analysis is applicable and bounding for the current 1.7% uprate request. That evaluation considered both General Design Criterion (GDC) 17 and Branch Technical Position PSB-1, "Adequacy of Station Electrical Distribution System Voltage."

2. Provide in detail (including the ratings) the effect 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. Ratings for the main generator, isophase bus and main transformer were provided in Table 6-1 of Attachment 2 of the original submittal. The guaranteed output rating of the generator is given below:

1151.1 MVA – 22 kV
1043.1 MW – 30.209 kA (current output)
0.91 PF – 60 HZ

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 1151.1 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 also has adequate capacity for the proposed changes. Power = (22,000*32,000) = 704 MVA (per phase) is well above the nameplate capacity of the transformers or generator. Nameplate ratings are listed below:

System Voltage – 22 kV, 3 phase, 60 Hz
Current Ratings (main section) – 32 kA
(branch section) – 16 kA

2c. The Generator Output Nameplate Rating is 1151.1 MVA and is unchanged by the TPO. The two Main Transformers are each rated for 518.6 MVA nameplate with a maximum rating of 788.5 MVA (FOA) with the additional cooling installed at RBS. Hence the main transformers are adequate for the TPO uprate.

2d/e The normal source for plant loads is provided by the four Preferred Station Service Transformers (1RTX-XSR1C, XSR1D, XSR1E, and XSR1F) which are supplied by the utility grid via the 230 kV switchyard. The alternate source for plant loads is provided by the three Normal Station Service Transformers (1STX-XNS1A, XNS1B, and XNS1C) which are supplied by the main generator via the isolated phase bus.

Operation at the higher power level has no impact on the majority of electrical loads. Plant loads are computed based on the equipment nameplate rating with the exception of certain large motors. A review was completed to determine how the original loads were developed and if the basis for the existing loads would be affected by the uprate.

Ratings for the startup transformers (RBS refers to these as Preferred Station Service Transformers, 1RTX-XSR1E, 1RTX-XSR1F, 1RTX-XSR1C, and 1RTX-XSR1D) and the auxiliary transformers (RBS refers to these as Normal Station Service Transformers 1STX-XNS1A, 1STX-XNS1B, and 1STX-XNS1C) are given below:

Preferred Station Service Transformers:

| | |
|---|---|
| 1RTX-XSR1E and 1RTX-XSR1F | 230 – 13.8 KV,<br>51 / 68 / 85 MVA,<br>OA / FOA / FOA |
| 1RTX-XSR1C and 1RTX-XSR1D | 230 – 4.16 KV,<br>10 / 12.5 MVA,<br>OA / FA |

Normal Station Service Transformers:

| | |
|---|---|
| 1STX-XNS1A and 1STX-XNS1B | 22 – 13.8 KV,<br>47.5 MVA,<br>FOA |
| 1STX-XNS1C | 22 – 4.16 – 4.16 KV,<br>16 MVA,<br>FOA |

3. Provide in detail the effect of the power uprate on the Station Blackout coping capability.

Response:

The evaluation of the RBS SBO coping capability was performed prior to the recent stretch power uprate submittal. The evaluation was described in the July 30, 1999 letter that submitted NEDC-32778P supporting the stretch power uprate request.

The containment conditions evaluated for a station blackout event were representative of 102% of the 105% (stretch power) uprate initial conditions, and as such remain bounding for TPO.

The Auxiliary Building conditions during a station blackout were also evaluated for the stretch power uprate and were reviewed again considering the TPO uprate. The input that was dependent upon reactor conditions was the heat load to the Auxiliary Building. The impact of the TPO power uprate on the heat load was evaluated and it was concluded there was no significant impact of the heat release to the Auxiliary Building because:

1. The piping heat release was calculated using the most conservative suppression pool temperature response, which bounds the temperatures calculated for the TPO uprate. Therefore, there is no change required to the heat loads from piping containing suppression pool water.
2. RCIC steam piping heat loads were originally based upon a steam temperature of 575°F, which bounded the stretch power uprate steam temperature of 553°F. Since the steam temperature is not changing for TPO, the existing heat loads are bounding.