Progress Energy

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December 7, 2009

SERIAL: BSEP 09-0127

U. S. Nuclear Regulatory Commission
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Washington, DC 20555-0001

Subject: Brunswick Steam Electric Plant, Unit Nos. 1 and 2
Renewed Facility Operating License Nos. DPR-71 and DPR-62
Docket Nos. 50-325 and 50-324
Response to Request for Additional Information Regarding Request for License Amendments to Revise Local Power Range Monitor Calibration Frequency (TAC Nos. ME1892 and ME1893)

Reference: Letter from Benjamin C. Waldrep to U.S. Nuclear Regulatory Commission, *Request for License Amendments to Revise Local Power Range Monitor Calibration Frequency*, dated August 18, 2009 (ADAMS Accession Number ML092370282)

Ladies and Gentlemen:

By letter dated August 18, 2009, Carolina Power & Light Company (CP&L), now doing business as Progress Energy Carolinas, Inc., submitted a license amendment request to revise Technical Specification 3.3.1.1, "Reactor Protection System (RPS) Instrumentation," Surveillance Requirement (SR) 3.3.1.1.8 to increase the frequency interval between Local Power Range Monitor (LPRM) calibrations from 1100 megawatt-days per metric ton (MWD/T) average core exposure (i.e., equivalent to approximately 907 effective full power hours (EFPH)) to 2000 EFPH. On October 29, 2009, the NRC provided an electronic version of a request for additional information (RAI) concerning the license amendment request. The response to this RAI is enclosed.

No regulatory commitments are contained in this letter. Please refer any questions regarding this submittal to Ms. Annette Pope, Supervisor - Licensing/Regulatory Programs, at (910) 457-2184.

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A001
NRR

I declare, under penalty of perjury, that the foregoing is true and correct. Executed on December 7, 2009.

Sincerely,

Benjamin C. Waldrep

WRM/wrm

Enclosure: Response to Request for Additional Information Regarding Request for License Amendments to Revise Local Power Range Monitor Calibration Frequency cc (with enclosure):

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Response to Request for Additional Information Regarding Request for License Amendments to Revise Local Power Range Monitor Calibration Frequency

Background

By letter dated August 18, 2009, Carolina Power & Light Company (CP&L), now doing business as Progress Energy Carolinas, Inc., submitted a license amendment request, for the Brunswick Steam Electric Plant (BSEP), Unit Nos. 1 and 2, to revise Technical Specification 3.3.1.1, "Reactor Protection System (RPS) Instrumentation," Surveillance Requirement (SR) 3.3.1.1.8 to increase the frequency interval between Local Power Range Monitor (LPRM) calibrations from 1100 megawatt-days per metric ton (MWD/T) average core exposure (i.e., equivalent to approximately 907 effective full power hours (EFPH)) to 2000 EFPH. On October 29, 2009, the NRC provided an electronic version of a request for additional information (RAI) concerning the license amendment request. The response to this RAI follows.

NRC Question 1

Assumption 3.2.2 states,

> "Estimated LPRM non-linearity bias for a 50% core power increase is assumed sufficient to account for the contribution of LPRM detector response non-linearity to core average LPRM detector uncertainty. This assumption is justified for a decrease in core power after detector calibration because non-linearity bias will be greatest at a reduced power approximately midway between the calibration power (equilibrium rated core power) and zero power, where there is no non-linearity bias. Bias at this interpolated mid-point of ~50%, constrained to zero bias at 0% and 100%, is reasonably approximated by the unconstrained bias associated with a power increase of 50%. This assumption is also justified for an increase in LPRM response after detector calibration because increases in LPRM response due to control blade movement are mitigated by the location of LPRM detectors at assembly corners diagonally opposite control blade corners. This placement limits the number of assemblies with an adjacent control blade inserted to only one out of the four fuel assemblies surrounding each detector for normal operating control blade patterns, which do not insert adjacent control blades.
>
> Deviation in LPRM response due to control blade movement is determined to be 11% in Attachment 2 by calculating the RMS relative deviation in LPRM response between LPRM readings before a control blade sequence exchange and LPRM readings after a control blade sequence exchange."

a. Explain why the bias at the interpolated mid-point is reasonably approximated by the unconstrained bias associated with a power increase of 50%.

b. Explain the correlation between LPRM response after detector calibration and LPRM response due to control blade movement.

c. In Attachment 2, it appears that to calculate the percent deviation before and after a control blade sequence exchange, the difference between the LPRM readings was divided by the reading after the exchange as opposed to dividing by the reading before the exchange. Explain why this approach was taken.

d. Explain why the Root Mean Square was used to determine the deviation in LPRM response as opposed to averaging the absolute values of the differences in LPRM readings.

Response to NRC Question 1a

Approximating bias at the interpolated mid-point by the unconstrained bias associated with a power increase of 50 percent, as described in Assumption 3.2.2 of BSEP Calculation 0B21-1305 Revision 1, is reasonable in the context of the uncertainty analysis because it is conservative. The approximation is otherwise inaccurate in the context of best estimate detector bias as discussed below.

LPRM signal non-linearity bias is zero at both zero flux and at the calibration flux, and is 0.49 percent for a power increase from 100 percent to 120 percent as documented in BSEP Calculation 0B21-1305. These three bias points and the quadratic polynomial defined by the points are shown below in Figure 1.

The interpolated mid-point discussed in Assumption 3.2.2 is analogous to a reduction in power from 100 percent to 50 percent. Maximum absolute bias between zero percent and 100 percent of -0.51 percent occurs at this 50 percent mid-point based on the quadratic polynomial shown in Figure 1. Regardless of whether detector non-linearity exactly follows the quadratic polynomial, it illustrates that bias is constrained between zero percent and 100 percent because it must return to zero at zero percent and 100 percent, and that absolute bias in this range reaches a maxima at approximately 50 percent.

The uncertainty analysis linearly extrapolates 0.49 percent bias for a 20 percent power increase to 1.225 percent for a 50 percent power increase from 100 percent to 150 percent, and to -1.225 percent for a 50 percent power reduction from 100 percent to 50 percent. This extrapolation to 50 percent and 150 percent is shown by the dotted line in Figure 1. The sign of the bias is not important because the uncertainty analysis takes no credit for bias direction reducing uncertainty; therefore, subsequent discussion will ignore sign for clarity.

For the simple case of no change in power around an LPRM detector since the detector was last calibrated, zero detector non-linearity bias is incurred.

If power around the detector is reduced after detector calibration, the greatest detector non-linearity will be incurred for a power reduction from 100 percent to approximately 50 percent. Assumption 3.2.2 assumes this worst case by establishing detector non-linearity bias as 1.225 percent at the 50 percent midpoint, and further based on a linear extrapolation of the known detector bias associated with a power increase from 100 percent to 120 percent, to a bias of 1.225 percent at 50 percent. This assumed detector bias of 1.225 percent at 50 percent is conservative relative to the detector bias of 0.51 percent at 50 percent projected by the quadratic polynomial.

If power around the detector is increased after detector calibration, detector non-linearity is not constrained because power around the detector is greater than the previously discussed zero bias points at zero percent and 100 percent. The uncertainty analysis also assumes a detector non-linearity bias of 1.225 percent in this case, which bounds a 42 percent increase in power from 100 percent to 142 percent based on the quadratic polynomial projecting non-linearity bias of 1.225 percent at approximately 142 percent in Figure 1. As described in Assumption 3.2.2, because the detectors are calibrated at equilibrium rated core power conditions, power increases around a detector after calibration will be caused by control blade movement (i.e., this is discussed further in Response 1b below). Power increases due to control blade movement are estimated to be only 11 percent by the Root Mean Square (RMS) deviation method described in Assumption 3.2.2, which leaves ample margin to the increase of approximately 42 percent accounted for by the assumed non-linearity bias.

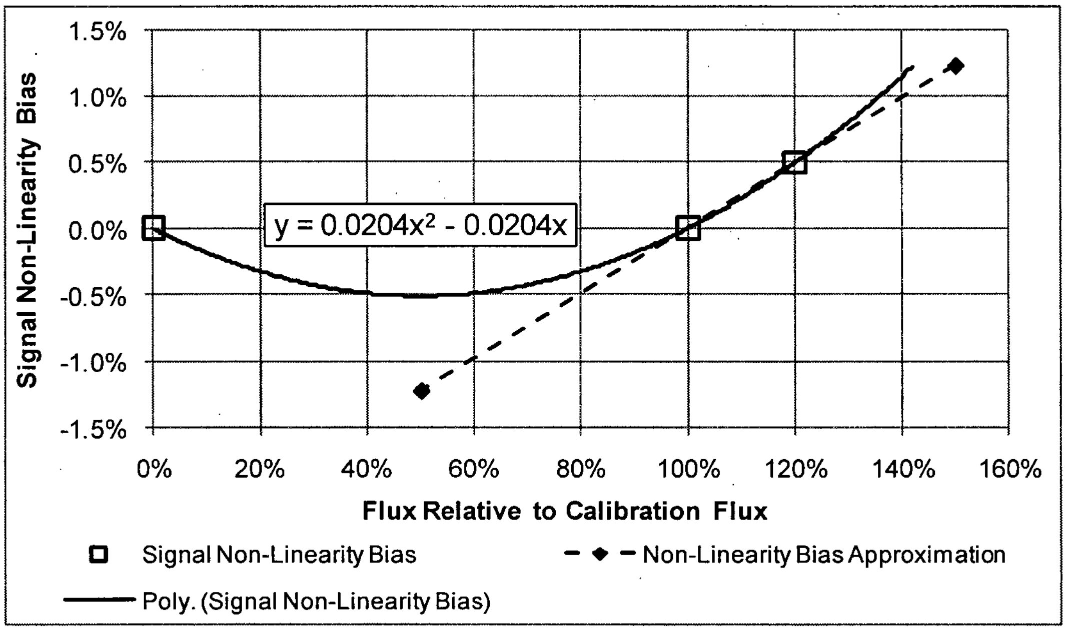

Figure 1: Signal Non-Linearity Bias

Response to NRC Question 1b

Changes in LPRM response after detector calibration are examined in the uncertainty analysis because these changes introduce detector non-linearity bias. Changes in power around detectors that result from control blade movement will cause the largest increases in detector response because the detectors are calibrated at equilibrium rated core power conditions, that is, power around a detector cannot be increased by increasing core power without exceeding the licensed core rated thermal power. Increases in power around a detector resulting from power redistribution due to fuel burnup or core flow adjustment to compensate for core reactivity changes between calibrations are small compared to those resulting from control blade movement. However, these smaller changes are also implicitly accounted for in the uncertainty analysis because the LPRM readings before and after control blade sequence exchanges compared in the analysis do not correspond to detector calibrations immediately before and immediately following the sequence exchanges.

LPRM response changes due to a reduction in power around the detector are of less concern in accounting for detector non-linearity bias because, as described in Response 1a, detector non-linearity resulting from a power reduction is constrained by zero bias at the calibration power and zero bias at zero power. The uncertainty analysis bounds the largest expected non-linearity bias for any power reduction by bounding the maximum power reduction non-linearity bias, which occurs at a power reduction of approximately 50 percent.

In summary, the relation between LPRM response after detector calibration and LPRM response due to control blade movement is that the deviation in detector response due to control blade movement is useful in evaluating bounds on non-linearity bias caused by increases in detector response.

Response to NRC Question 1c

The more conservative of the two approaches was taken. The RMS relative deviation in LPRM response due to control blade movement is 10.1 percent calculated dividing by the readings before the exchanges, versus 10.8 percent (i.e., reported as 11 percent in the analysis) dividing by the readings after the exchanges.

A slightly larger relative deviation would be expected to be calculated dividing by the readings after the exchanges if slightly more LPRM readings have a decreased reading after control blade sequence exchanges, because the change in reading would generally be divided by a smaller denominator; and vice-versa if more LPRM readings have an increased response after the exchanges. However, the method selected should not significantly influence the result, as is the case. During a control blade sequence exchange, control blades inserted prior to the exchange are withdrawn and an approximately equal number of different control blades are inserted elsewhere in the core. Considering that the deviation was evaluated over many sequence exchanges, an approximately equal number of LPRM detectors in the database are expected to have increased and decreased readings after the control blade sequence exchanges, relative to before the control blade sequence exchanges.

Response to NRC Question 1 Part D

The deviation in LPRM response due to control blade movement was calculated to assess applicability of the assumed detector non-linearity bias to increases in LPRM response. Detector non-linearity bias is zero for detectors that experience no change in LPRM response since the last calibration, small for detectors that experience small relative increases and larger for detectors that experience larger relative increases. An RMS deviation was used because the statistical uncertainty analysis considers these core wide LPRM response changes to be a random deviation.

The relative deviation in LPRM response due to control blade movement is 10.8 percent (i.e., reported as 11 percent in the analysis) calculated as an RMS deviation and it is 7.5 percent if calculated by averaging the absolute values of the relative differences in LPRM readings, where the average absolute relative difference is calculated dividing by the readings after the exchanges.

Both results have ample margin to the deviation of approximately 42 percent accounted for by the detector non-linearity bias assumed for increases in LPRM response, as described in Response 1a. Note also that this 11 percent deviation is not a direct input to the uncertainty analysis. It is calculated only to confirm that the analysis considers an appropriate detector non-linearity bias.

NRC Question 2

In Section 4.6, it states, "The exposure at which the average decay constant above the threshold was equal to half the decay constant determined from the derivative of the quadratic fit was determined to be 2.8 snvt."

What is the basis of this methodology for determining the threshold?

Response to NRC Question 2

The sensitivity decay model used by the core monitoring system assumes a decay constant of zero below the threshold followed by an instantaneous step change from zero to the equilibrium negative decay constant above the threshold. This is not the case for a real detector. In reality, the decay constant smoothly transitions from a value of zero to the equilibrium negative decay constant value as detector exposure increases. There is no instantaneous step change in decay constant when the threshold exposure is reached. Therefore, the basis for the methodology is to establish the threshold exposure half way between the exposure at which the actual detector decay constant is zero and the exposure at which the actual detector decay constant reaches the equilibrium negative decay constant above the threshold. Thus, as the detector crosses this threshold exposure, the actual decay constant becomes closer to the equilibrium negative decay constant than to the assumed decay constant of zero below the threshold. Establishing the threshold in this manner improves the accuracy of the approximate sensitivity decay model used by the core monitoring system, because the difference in the decay constant used by the step change model and the actual decay constant is minimized as the detector exposure progresses through the transition from a decay constant of zero to the equilibrium negative decay constant.

Calculating the threshold using this methodology first requires determining the detector decay constant as a function of exposure over the exposure range that the decay constant transitions from zero to the equilibrium negative decay constant above the threshold. The detector decay constant is simply the slope of the natural log of the calibration current versus detector exposure. The natural log of the calibration current versus exposure can be readily curve fit to a quadratic polynomial over the transition exposure range. The derivative of this quadratic polynomial then gives the decay constant in this transition exposure range because the derivative is, by definition, the slope of the natural log of the calibration current (i.e., the decay constant) as a function of detector exposure.

The exposure at which the derivative is equal to half the equilibrium negative decay constant (i.e., defined as the average decay constant above the threshold) is the exposure at which the decay constant is half way between zero and the equilibrium negative decay constant. This exposure is the desired threshold exposure, as explained above.