NRR-PMDAPEm Resource

From: Wiebe, Joel
Sent: Thursday, January 16, 2014 9:55 AM
To: Leslie Holden
Cc: Kevin Borton
Subject: Request for Proprietary Review of Instrument and Controls Section of MUR
Attachments: Instrument and Controls MUR Section for Proprietary Review.docx

Leslie,

Please have Exelon and your contractor review the attached for proprietary information. This section has been integrated into the Rx Sys SE section because of overlap. However, rather than having you review that again, it appears more efficient to review this section. This will not hold up the MUR package from going to OGC. If you could target a response by mid-next week, I would appreciate it.

Joel

Hearing Identifier: NRR_PMDA
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Mail Envelope Properties (Joel.Wiebe@nrc.gov20140116095500)

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3.2.3 Instrumentation and Controls

3.2.3.1 Regulatory Evaluation

Nuclear power plants are licensed to operate at a specified core thermal power. Appendix K, "ECCS Evaluation Models," 10 CFR Part 50, "Domestic Licensing of Production and Utilization Facilities," requires LOCA and ECCS analyses to assume "that the reactor has been operating continuously at a power level at least 1.02 times the licensed thermal power level (to allow for instrumentation error)." Alternately, Appendix K allows such analyses to assume a value lower than the specified 102 percent, but not less than the licensed thermal power level, "provided the proposed alternative value has been demonstrated to account for uncertainties due to power level instrumentation error." This allowance gives licensees the option to justify a power uprate with reduced margin between the licensed power level and the power level assumed in the ECCS analysis by using more accurate instrumentation to calculate the reactor thermal power.

Because the maximum power level of a nuclear plant is a licensed limit, the NRC must review and approve a proposal to raise the licensed power level under the license amendment process. The LAR should include a justification for the reduced power measurement uncertainty to support the proposed power uprate.

The NRC determined that the two TRs that describe the Cameron LEFM CheckPlus system (References 3 and 4), for the measurement of FW flow are an acceptable way of conforming to the regulations (References 5 and 6), and provide a basis for the proposed uprate of approximately 1.63 percent of the licensed reactor thermal power. The staff also considered the information provided by the licensee, as requested by RIS 2002-03, "Guidance on the Content of Measurement Uncertainty Recapture Power Uprate Applications," dated January 31, 2002 (Reference 11).

In RG 1.105, Revision 3, "Setpoints for Safety-Related Instrumentation," (Reference 12), describes a method acceptable to the NRC staff for complying with the NRC regulations for ssuring that setpoints for safety-related instrumentation are initially within and remain within the TS limits. The method described in RG 1.105 for combining instrument uncertainties can be used for combining the uncertainties associated with the secondary calorimetric calculation. This allows licensees to justify a power uprate with reduced margin between the licensed power level and the power level assumed in the ECCS analysis by using more accurate instrumentation to calculate the reactor thermal power.

3.2.3.2 Technical Evaluation

Neutron flux instrumentation is calibrated to the core thermal power, which is determined by an automatic or manual calculation of the energy balance around the plant nuclear steam supply system. This calculation is called "secondary calorimetric" for a PWR. The accuracy of this calculation depends primarily on the accuracy of feedwater flow and feedwater net enthalpy measurements. Feedwater flow is the most significant contributor to the core thermal power uncertainty. A more accurate measurement of this parameter will result in a more accurate determination of core thermal power.

Feedwater flow rate is typically measured using a venturi. This device generates a differential pressure proportional to the feedwater velocity in the pipe. Because of the high cost of calibrating the venturi and the need to improve flow instrumentation measurement uncertainty, the industry evaluated other flow measurement techniques and found the Cameron LEFM CheckPlus ultrasonic flow meters (UFMs) to be viable alternatives.

LEFM Technology and Measurement

The Cameron LEFM CheckPlus system uses a transit time methodology to measure fluid velocity. The basis of the transit time methodology for measuring fluid velocity and temperature is that ultrasonic pulses transmitted through a fluid stream travel faster in the direction of the fluid flow than opposite the flow. The difference in the upstream and downstream traversing times of the ultrasonic pulse is proportional to the fluid velocity in the pipe, and the temperature is determined using a pre-established correlation between the mean propagation velocity of the ultrasound pulses in the fluid and the fluid pressure.

The system uses multiple diagonal acoustic paths instead of a single diagonal path, allowing velocities measured along each path to be numerically integrated over the pipe cross-section to determine the average fluid velocity in the pipe. This fluid velocity is multiplied by a velocity profile correction factor, the pipe cross-section area, and the fluid density to determine the FW mass flow rate in the piping. The mean fluid density may be obtained using the measured pressure and the derived mean fluid temperature as an input to a table of thermodynamic properties of water. The velocity profile correction factor is derived from calibration testing of the LEFM CheckPlus system in a plant-specific piping model at a calibration laboratory.

The Cameron LEFM CheckPlus system uses 16 transducers, 8 each in two orthogonal planes of the spool piece. In the Cameron LEFM CheckPlus system, when the fluid velocity measured by an acoustic path in one plane is averaged with the fluid velocity measured by its companion path in the second plane, the transverse components of the two velocities are canceled and the result reflects only the axial velocity of the fluid. This makes the numerical integration of four pairs of averaged axial velocities and computation of volumetric flow inherently more accurate than a result obtained using four acoustic paths in a single plane. Also, because there are twice as many acoustic paths in the CheckPlus System, than in the Check System, and there are two independent clocks to measure the transit times, errors associated with uncertainties in path length and transit time measurements are reduced.

The NRC staff's review in the area of instrumentation and control covers the proposed plant specific implementation of the feedwater flow measurement technique and the power increase gained as a result of implementing this technique. The staff conducted its review to confirm that the licensee's implementation of the proposed feedwater flow measurement device is consistent with staff-approved TR ER-157P and that the licensee adequately addressed the four additional requirements listed in the staff's SE. The NRC staff also reviewed the power measurement uncertainty calculations to ensure: (1) the conservatively proposed uncertainty value of 0.37 percent correctly accounts for all uncertainties associated with power level instrumentation errors, and (2) the uncertainty calculations meet the relevant requirements of Appendix K to 10 CFR Part 50, as described in Regulatory Evaluation, above.

The licensee provided the following information about the Cameron LEFM CheckPlus System feedwater flow measurement technique and its implementation at Byron and Braidwood, Units 1 and 2. The Cameron LEFM CheckPlus System consists of an electronic cabinet (with its own cooling system) installed in the main steam line tunnel and measurement spool pieces installed in each of the four main feedwater flow lines upstream of the existing feedwater venturi flow meters. Each measurement section consists of 16 ultrasonic, multipath, transit time transducers, and FW pressure input.

The electronic cabinet controls magnitude, sequences transducer operations, makes time measurements, and calculates volumetric flow, temperature, and mass flow. The system software measures velocities at precise locations. The FW mass flow rate and temperature are transmitted to the plant process computer for use in calorimetric measurement of reactor thermal output. In the event of system failure the control room operators are alerted.

The UFM values for feedwater mass flow and temperature will be directly substituted for the existing venturi-based flow and RTD temperature inputs used in the plant calorimetric measurement calculations. The existing venturi-based FW flow and RTD temperature will continue to be used for other plant functions and may be used for plant calorimetric calculations in the event of a UFM failure.

Evaluation of Information provided in response to RIS 2002-03, Attachment 1, Section I, guidance Items A through H

<u>Items A through C</u>

Items A, B, and C, in Section I of Attachment 1 to RIS 2002-03 guide licensees to identify the approved TRs, provide references to the NRC's approval of the measurement technique, discuss the plant-specific implementation of the guidelines in the TR, and identify the NRC staff's approval of the FW flow measurement technique.

In its June 23, 2011, application, the licensee identified Cameron TR ER-80P, Revision 0, "Improving Thermal Power Accuracy and Plant Safety While Increasing Operating Power Level Using the System," issued March 1997 (Reference 3), and its supplement, TR ER-157P, Revision 8 and Revision 8, Errata, "Supplement to TR ER-80P: Basis for a Power Uprate with the LEFM √TM or LEFM CheckPlusTM System," issued May 2008 (Reference 4), as applicable to the Cameron LEFM CheckPlus System. The licensee also referenced the NRC approval of the TRs ER-80P and ER-157P in SEs dated March 8, 1999 (Reference 5), and August 16, 2010 (Reference 6).

The licensee stated in its submittal that the Cameron LEFM CheckPlus system will be permanently installed in Byron and Braidwood, Units 1 and 2, according to the requirements of TR ER-157P. The Cameron LEFM CheckPlus system was installed in Braidwood, Unit 1, during the spring of 2012. The Cameron LEFM CheckPlus system for Braidwood, Unit 2, was installed during the spring of 2011. The Cameron LEFM CheckPlus system for Byron, Unit No. 1, was installed during the spring of 2011. The Cameron LEFM CheckPlus system for Byron, Unit No. 2 was installed during the fall of 2011.

On the basis of its review of the licensee's submittals, as reflected in the above discussion, the staff finds that the licensee has sufficiently addressed the plant-specific implementation of the Cameron LEFM CheckPlus system using proper TR guidelines. Therefore, the staff concludes that the licensee's description of the feedwater flow measurement technique and implementation of the power uprate using this technique contains the information requested by Items A through C of Section I of Attachment 1 to RIS 2002-03. This information was evaluated against the regulatory criteria in RIS 2002-03 and was found to be acceptable.

<u>Item D</u>

Item D in Section I of Attachment 1 to RIS 2002-03 guides licensees to address four criteria when implementing the FW flow measurement uncertainty technique. The NRC staff SEs on

TRs ER-80P (Reference 3), and ER-157P (Reference 4), both include these four plant-specific criteria (Reference 6; see Section 3.2.4), to be addressed by a licensee referencing these TRs for a power uprate. The licensee's submittal addresses each of the four criteria as described below.

1. "Discuss maintenance and calibration procedures that will be implemented with the incorporation of the LEFM, including processes and contingencies for inoperable LEFM instrumentation and the effect on thermal power measurements and plant operation."

   Licensee Response:

   Implementation of the MUR power uprate license amendment will include developing the necessary procedures and documents required for continued calibration and maintenance of the LEFM system. Plant maintenance and calibration procedures will be revised to incorporate Cameron's maintenance and calibration requirements prior to raising power above the current licensed thermal power of 3586.6 MWt. The Braidwood and Byron Technical Requirement Manuals (TRMs) will be revised to address contingencies for inoperable LEFM instrumentation.

   A modification package has been developed for each installation outlining the steps to install and test the LEFM CheckPlus system. When each unit is shutdown for their respective refueling outages the LEFM CheckPlus systems will be installed. Following installation, testing will include an in-service leak test, comparisons of feedwater flow and thermal power calculated by various methods, and final commissioning testing. The LEFM CheckPlus system installation and commissioning will be performed according to Cameron procedures. Commissioning and start-up of the LEFM CheckPlus System will be performed by qualified Cameron personnel with site personnel assistance. The commissioning process provides final positive confirmation that actual field performance meets the uncertainty bounds established for the instrumentation. Final site-specific uncertainty analyses acceptance will occur after completion of the commissioning process.

   The Braidwood and Byron, Units 1 and 2, EFM CheckPlus system were calibrated in a site-specific model test at ARL. The testing at ARL provides traceability to National Standards (References 13 and 14). The spool piece calibration factor uncertainty is based on Cameron engineering reports. The calibration tests included a site-specific model of each of the Units hydraulic geometry.

   Preventive maintenance will be performed based on vendor recommendations. The preventive maintenance program and LEFM CheckPlus system continuous self-monitoring feature ensure that the LEFM remains bounded by the TR ER-80P, as supplemented by ER-157P, analysis and assumptions. Establishing and continued adherence to these requirements assures that the LEFM CheckPlus system is properly maintained and calibrated. The preventive maintenance activities will be identified via the associated plant modification package. Typical activities performed include power supply checks, pressure transmitter checks, and clock verifications. Maintenance of the LEFM system will be performed by personnel who are qualified.

Instrumentation, other than the LEFM system, that contributes to the power calorimetric computation will be periodically calibrated and maintained using existing site procedures. Maintenance and test equipment, tolerance settings, calibration frequencies, and instrumentation accuracy were evaluated and accounted for in the thermal power uncertainty calculation.

Staff Evaluation and Conclusion

Because the description of the calibration and maintenance procedures (and associated documentation) states that Exelon will incorporate the appropriate Cameron requirements, the staff concludes that the licensee has adequately addressed Criterion 1 (of plant specific criteria indentified in the SE on the TR).

2. “For plants that currently have LEFMs installed, provide an evaluation of the operational and maintenance history of the installed instrumentation and confirmation that the installed instrumentation is representative of the LEFM system and bounds the analysis and assumptions set forth in TR ER-80P.”

   Licensee Response:

   At the time of the submittal, only Byron, Unit No. 1, and Braidwood, Unit 2, had installed the LEFM CheckPlus systems. Based on the results of the modification and commissioning testing the LEFM CheckPlus systems as installed are in conformance with the analysis and assumptions given in Cameron’s TR ER-80P, ER-157P, and the Byron and Braidwood unit specific “Bounding Uncertainty Analysis for Thermal Power Determination Reports”, as well as the performance parameters identified in the Alden Laboratory Meter Factor Calculation and Accuracy Assessments. As of June 17, 2011, there has been no performance, operational, or maintenance issues that would indicate any non-conformance with the above.

   NRC Staff Evaluation and Conclusion

   The NRC staff was informed of a trending issue after June 17, 2011. Based on the NRC staff’s evaluation of the trending issue in Section 3.1.1 of this SE and consideration of the licensee’s response described above the staff finds the licensee’s response adequate to address Criterion 2.

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 (with regard to the development of instrument uncertainty). If an alternative approach is used, the application should be justified and applied to both venturi and ultrasonic flow measurement instrumentation installations for comparison.”

   Licensee Response:

   Cameron has performed Unit specific bounding uncertainty analysis for Byron and Braidwood Stations, Unit 1 and 2. Copies of these analyses are provided in the licensee’s June 23, 2012, submittal. The calculations in these analyses are consistent with Cameron's TR ER-80P, as supplemented by ER-157P, ISA-P67.04.02-2000, “Methodologies for the Determination of Setpoints for Nuclear Safety-Related

Instrumentation" and Exelon standard NES-EIC-20.04. This approach has been approved by the NRC. The core thermal power uncertainty calculation which takes into account the uncertainty associated with the feedwater flow venturis is performed in accordance with Exelon standard NES-EIC-20.04 and is consistent with ISA-RP67.04.02-2000.

The fundamental approach used is to statistically combine inputs to determine the overall uncertainty. Channel statistical allowances are calculated for the instrument channels. Dependent parameters are arithmetically combined to form statistically independent groups, which are then combined using the square root of the sum of the squares approach to determine the overall uncertainty.

<u>NRC Staff Evaluation and Conclusion</u>

The staff confirmed that the methodology used to calculate uncertainty as described above is based on accepted plant setpoint methodology; therefore, the NRC staff concludes that the licensee has adequately addressed Criterion 3.

4. "Licensees for plant installations where the ultrasonic meter (including LEFM) was not installed with flow elements calibrated to a site specific piping configuration (flow profiles and meter factors not representative of the plant specific installation), should provide additional justification for use. This justification should show that the meter installation is either independent of the plant specific flow profile for the stated accuracy, or that the installation can be shown to be equivalent to known calibrations and plant configurations for the specific installation including the propagation of flow profile effects at higher Reynolds numbers. Additionally, for previously installed calibrated elements, the licensee should confirm that the piping configuration remains bounding for the original LEFM installation and calibration assumptions."

Licensee Response:

Criterion 4 does not apply to Byron or Braidwood Stations, Units 1 or 2. Byron and Braidwood Stations LEFM CheckPlus systems were calibrated at Alden Research Laboratory. Cameron engineering reports for each of the Units evaluating the calibration test data from Alden Research Laboratory have been completed and have been provided. The calibration factors used for each Units LEFMs are based on the analysis contained in reports docketed as part of the LAR.

<u>NRC Staff Evaluation and Conclusion</u>

Because the LEFM installations at Braidwood and Byron, Units 1 and 2, were calibrated to unit specific piping configurations, the Nyron staff agrees that Criterion 4 does not apply to Braidwood or Byron, Units 1 or 2.

<u>Item E</u>

Item E in Section I of Attachment 1 to RIS 2002-03 guides licensees in the submittal of a plant-specific total power measurement uncertainty calculation, explicitly identifying all parameters and their individual contributions to the power uncertainty.

To address Item E of RIS 2002-03, the licensee provided Cameron engineering reports ER-800, ER-801, ER-802, and ER-803 (References 15, 16, 17, and 18). These reports provide calculations that demonstrate that the total thermal power uncertainty for the bounding unit is 0.37 percent. All units will be uprated to the value of the most bounding plant.

The NRC staff reviewed and audited (Reference 19), the calculations and determined that the licensee identified the parameters associated with the thermal power measurement uncertainty, provided individual measurement uncertainties, and calculated the overall thermal power uncertainty. The licensee's calculations arithmetically summed uncertainties for parameters that are not statistically independent and statistically combined with other parameters. The licensee combined random uncertainties using the square root sum of squares approach and added systematic biases to the result to determine the overall uncertainty. This methodology is consistent with the vendor determination of the Cameron LEFM CheckPlus system uncertainty, as described in the referenced TRs, and is consistent with the guidelines in RG 1.105, "Setpoints for Safety-Related Instrumentation," (Reference 12).

The NRC staff finds that the licensee has provided calculations of the total power measurement uncertainty at the plants, explicitly identifying parameters and their individual contribution to the power uncertainty. Therefore, the staff concludes that the licensee has provided the information requested in Item E of Section I of Attachment 1 to RIS 2002-03, and this information is consistent with the RG 1.105, above.

<u>Item F</u>

Item F in Section I of Attachment 1 to RIS 2002-03 guides licensees to provide information to address the specified aspects of the calibration and maintenance procedures related to all instruments that affect the power calorimetric.

In its June 23, 2011, submittal, the licensee addressed each of the five aspects of the calibration and maintenance procedures listed in Item F of RIS 2002-03:

1. Maintaining Calibration

The licensee stated that calibration will use procedures based on the appropriate LEFM CheckPlus technical manuals. Other calorimetric process instrumentation and computer points are maintained and calibrated using approved procedures.

2. Controlling Hardware and Software Configuration

The Cameron LEFM CheckPlus system is designed and manufactured in accordance with the vendor's quality assurance program. The licensee committed to maintaining, after installation, the software and hardware configuration by using existing procedures and processes, which include verification and validation of software configuration changes.

3. Performing Corrective Actions

Station personnel will monitor plant instrumentation that affects the power calorimetric input, including UFM inputs. Any problems detected will be handled according to the Station's corrective action process.

4. Reporting Deficiencies to the Manufacturer

The licensee states that any conditions found to be adverse to the quality of the LEFM CheckPlus system will be documented and reported to the vendor, as needed, to support corrective action.

5. Receiving and Addressing Manufacturer Deficiency Reports

Cameron has procedures to notify users of important LEFM deficiencies. The licensee stated that it has existing processes to address the receipt of Cameron's deficiency reports.

On the basis of its review of the above statements, the staff finds that the licensee has addressed the calibration and maintenance aspects of the Cameron LEFM CheckPlus System and all other instruments affecting the power calorimetric. Therefore, the staff concludes that the licensee has provided the information identified in Item F of Section I of Attachment 1 to RIS 2002-03, and that the information meets the regulatory guidance.
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<u>Items G and H</u>

Items G and H in Section I of Attachment 1 to RIS 2002-03, guide licensees to provide a proposed allowed outage time (AOT) for the instrument and to propose actions to reduce power if the AOT is exceeded.

In its June 23, 2011, submittal, the licensee proposed a 72-hour AOT for operating above 3586.6 MWt (i.e., the current licensed thermal power limit) if the UFM becomes non-operational. The licensee specifically noted that any failure of the UFM, including failures of a single path or plane, will be treated as a complete failure of the UFM system and thus start the plant's allowable 72 hours to remain above 3586.6 MWt. In addition, the ability of the plant to stay above 3585.6 MWt is contingent upon its ability to maintain steady-state conditions. If the plant should reduce power below 3585.6 MWt during the AOT, the plant will not be permitted to return above that value until the UFM function is fully restored.

During the 72-hour AO, in the event of a UFM failure, the plant would use the existing feedwater venturis for the calorimetric calculation. Because the FW venturis are regularly normalized to the UFM measurements, their measurements should be equivalent to the UFM over the 72-hour AOT. Use of calibrated feedwater venturis to remain at the uprated power level during the 72 hours that follow a UFM being declared non-operational is consistent with previous measurement uncertainty recapture submittals that the staff has approved. Venturi nozzle fouling and transmitter drift were considered as potential sources of error within the AOT window.

The basis for the 72-hour AOT includes the fact that there has been no evidence of feedwater venturi fouling at Braidwood and Byron, Units 1 and 2. This conclusion was reached by Exelon based on a review of historical records and analysis of FW flow. Since there has been no observed FW venturi fouling, it is unlikely that fouling or sudden de-fouling will occur in the 72-hour AOT. In addition, Exelon analyzed the expected drift of the feedwater venturi and determined that this drift would be insignificant during a 72-AOT.

On the basis of its review of the licensee's submittals, the staff finds that the licensee has provided sufficient justification for the proposed AOT and the proposed actions to reduce power level if the AOT is exceeded. Therefore, the staff concludes that the licensee has provided the information requested by Items G and H of Section I of Attachment 1 to RIS 2002-03, and the information provided meets the regulatory guidance.

Request for Additional Information (RAI)

By letter dated October 12, 2011 (Reference 20), the NRC requested additional information from the licensee. By letter dated November 1, 2011 (Reference 2), Exelon responded with additional information. The response in addition to the audit (Reference 19), allowed the NRC staff to understand the conformance of the implementation with respect to the TR (References 3, 4, 5, and 6), confirmed that the assumptions listed in the TR were valid for Braidwoodn and Byron MUR application, or described how plant specific information was used in the application, confirmed that either a sufficiently large number of samples were used such that the two sigma values were 95/95 values, or Students-t was used as a multiplier for establishing the 95/95 confidence interval, and explained that number discrepancies resulted from misquoting the TR, but these errors did not affect the application since the numbers were provided for comparison purposes. The NRC staff determined that the responses were appropriate resolved the staff's questions.

3.2.3.3 Conclusion

The NRC staff reviewed the licensee's proposed plant-specific implementation of the feedwater flow measurement device and the power uncertainty calculations and determined that the licensee's proposed license amendment is consistent with the staff-approved TR ER-157P. The staff has also determined that the licensee adequately accounted for instrumentation uncertainties in the reactor thermal power measurement uncertainty calculations and demonstrated that the calculations meet the relevant requirements of 10 CFR Part 50, Appendix K, as described in Section 2 of this SE. The staff finds the instrumentation and control aspects supporting the proposed thermal power to be acceptable.