UNITED STATES
NUCLEAR REGULATORY COMMISSION
ADVISORY COMMITTEE ON REACTOR SAFEGUARDS
WASHINGTON, DC 20555 - 0001

July 18, 2014

The Honorable Allison M. Macfarlane
Chairman
U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001

SUBJECT: PEACH BOTTOM ATOMIC POWER STATION UNITS 2 AND 3 EXTENDED POWER UPRATE LICENSE AMENDMENT REQUEST

Dear Chairman Macfarlane:

During the 616th meeting of the Advisory Committee on Reactor Safeguards, July 9-11, 2014, we completed our review of the extended power uprate (EPU) license amendment request (LAR) for Peach Bottom Atomic Power Station (PBAPS), Units 2 and 3, and the NRC staff's draft final safety evaluation. Our Subcommittee on Power Uprates also reviewed this matter on June 10, 2014. During these reviews, we benefitted from discussions with the NRC staff and their consultants; representatives from Exelon Generation Company, LLC (Exelon); its consultants; and a member of the public. We also had the benefit of the documents referenced.

CONCLUSIONS AND RECOMMENDATIONS

1. The Exelon application for the extended power uprate for Peach Bottom, Units 2 and 3, should be approved subject to the conditions in the staff's draft final safety evaluation.

2. Exelon has implemented plant modifications that eliminate the current reliance on containment accident pressure. This enhances safety margins.

3. The license conditions during power ascension provide reasonable assurance that unanticipated vibration induced in the replacement steam dryers (RSDs) will be detected and addressed. Acceptability of the Unit 3 RSD, which is not instrumented, assumes that acoustic pressure loadings can be predicted from strain gauge measurements on the main steam lines. This assumption needs to be validated.

BACKGROUND

Peach Bottom, Units 2 and 3, are boiling water reactor (BWR) plants of the BWR/4 design with Mark I type pressure suppression containments. These units began operation in 1974. The NRC previously granted Exelon an extension to operate Unit 2 until 2033 and Unit 3 until 2034.

The current licensed thermal power (CLTP) for each unit is 3,514 MWt. The NRC previously approved 5% stretch power uprates (in 1994 for Unit 2 and in 1995 for Unit 3) and 1.6% measurement uncertainty uprates (in 2002) for Units 2 and 3. In 2012, Exelon applied for an EPU of 12.4% from the CLTP to 3,951 MWt. If approved, this EPU would result in a total uprate of 20% from their original licensed thermal power. Exelon plans to implement this EPU at Unit 2 in 2014 and at Unit 3 in 2015.

DISCUSSION

The Safety Analysis Report for this EPU follows the guidelines in the NRC-endorsed General Electric (GE) licensing topical reports for BWR constant pressure power uprates. The staff's evaluation of the LAR follows the methodology prescribed in the EPU review standard (RS-001).

The constant pressure power uprate for Units 2 and 3 is primarily accomplished by generating and supplying higher steam mass flow to the turbine-generator. The as-designed equipment and system capabilities, augmented by improved fuel and core designs and newly installed or modified equipment, will accommodate the higher steam mass flow rate and the resultant power increase. EPU operation does not require increasing the maximum normal operating reactor vessel dome pressure because the plant's modified non-safety power generation equipment has sufficient pressure control and turbine flow capability to control turbine inlet pressure conditions.

The higher steam mass flow is achieved by increasing the reactor power within specified rod withdrawal and core flow limits. This requires that a limited number of operating parameters will be changed, some set points will be adjusted, and some instruments will be recalibrated. Plant procedures will be revised, and tests similar to some of the original startup tests will be performed. However, the PBAPS power ascension test plan does not include large transient tests at full EPU power. Such tests are unnecessary because of applicable relevant transients at other uprated BWR 3/4 units similar in design, transients that previously occurred at PBAPS, and prior large transient tests that were completed during initial startup of PBAPS.

Several modifications are being implemented to achieve the increased power and improve plant reliability and operating margins. These modifications include:

- replacement steam dryers,
- additional main steam safety valves,
- new high pressure turbines,
- standby liquid control system modifications,
- reactor feed pump turbine upgrades,
- new feedwater heaters,
- new flow diffusers on reactor water cleanup demineralizers,
- new condensate pump impellers and motors,
- main generator and generator auxiliaries upgrades,
- modifications to main steam line supports, and
- revised instrumentation setpoints.

Peach Bottom operates in the Maximum Extended Load Line Limit Analysis operating domain. Additional energy requirements for the EPU are met by a combination of an increase in bundle enrichment, an increase in the reload fuel batch size, or changes in the fuel loading pattern to maintain the desired plant operating cycle length. Exelon uses NRC-approved methods to assure that the requisite core and fuel design limits are met for a representative equilibrium core design at EPU conditions and for cycle-specific reload core evaluations.

Peach Bottom is in the process of changing from GE14 to GNF2 fuel, and the Units 2 and 3 cores will be comprised entirely of GNF2 fuel assemblies at the time of EPU implementation. Hence, there is no consideration of mixed cores for this LAR.

Using the NRC-approved SAFER/GESTR methodology, Exelon evaluated the effects of the EPU by performing a spectrum of loss of coolant accident (LOCA) analyses for different break sizes, locations, and power shapes. The GESTR-LOCA and SAFER methods do not consider fuel thermal conductivity degradation with fuel burnup. Therefore, for the limiting large and small break LOCAs, Exelon later provided updated results obtained with the SAFER/PRIME code, which properly accounts for thermal conductivity degradation with burnup. The SAFER/PRIME predictions for peak cladding temperatures, cladding oxidation, and hydrogen generation remained below the acceptance values specified in 10 CFR 50.46(b).

This LAR was not submitted as a risk-informed license application. Nevertheless, Exelon submitted assessments of risk metrics associated with operation at EPU conditions. The staff considered this risk information and determined that the EPU would not create any special circumstances that could potentially invalidate the presumption of adequate protection justified by compliance of EPU operation with deterministic requirements and regulations.

Exelon evaluated the effects of EPU conditions on relevant materials degradation mechanisms including intergranular stress corrosion cracking, irradiation assisted stress corrosion cracking, flow-accelerated corrosion, fatigue, radiation embrittlement, and flow-induced vibration. The staff concluded that these mechanisms will be managed adequately.

Containment Accident Pressure (CAP) Evaluation

The Peach Bottom licensing basis currently relies on the use of CAP to ensure sufficient net positive suction head (NPSH) for the emergency core cooling system pumps following LOCAs and other transient events. A maximum CAP credit of about 6 psig for up to 78 hours is currently allowed for the design basis large break LOCA. The EPU increases reactor decay heat, which increases the heat transferred to the suppression pool during these accidents and events. This would require an increase in CAP credit. As part of the LAR, Exelon has chosen to eliminate the need to rely on CAP credit through plant system modifications; methodology changes; and changes to input assumptions that are factored into the safety analyses for the LOCAs, steam line breaks, anticipated transients without scram, station blackout, and Appendix-R events.

The plant modifications associated with CAP credit elimination include: (1) a residual heat removal (RHR) system heat exchanger cross-tie modification; (2) a high pressure service water system cross-tie modification; (3) condensate storage tank modifications; and (4) a standby liquid control system modification. The RHR system modification will enable the operator to align a second RHR heat exchanger for post-LOCA containment heat removal. This additional cooling capacity results in a peak suppression pool temperature at uprated power conditions that is lower than the current peak temperature at CLTP. The procedure utilized to initiate alignment of the second heat exchanger has been reviewed and validated as acceptable for this purpose.

Exelon performed the EPU containment analysis following the guidance in Regulatory Guide 1.82 Revision 3 and SECY-11-0014. Additional plant features, such as passive heat sinks, were included in the EPU model to better represent the plant response. Changes to both feedwater flow modeling and high pressure coolant injection flow modeling were made to better represent plant modifications and known plant performance. Based on Peach Bottom operating experience, Exelon was able to reduce the fouling factor for the RHR heat exchanger.

In the current licensing basis, input values for the containment analyses are conservative and biased towards maximizing the suppression pool temperature, minimizing the suppression pool static head, and maximizing the piping and strainer head loss. Input parameters in the EPU analyses were varied from the CLTP evaluations, and sensitivity studies were performed to ensure that CAP credit is not needed. The staff reviewed the Exelon analysis and concluded that changes in input parameters were justified or were more conservative than inputs selected for the current licensing basis analyses.

This is the first time that a licensee has made plant modifications sufficient to eliminate the need for CAP credit as part of an EPU, and we commend them for taking this initiative.

Replacement Steam Dryer (RSD)

Steam dryers in operating BWRs have experienced vibration fatigue damage when steam flow was increased as part of power uprates. Although the steam dryer does not perform a safety function, it must retain its structural integrity to avoid generating loose parts that may adversely affect other plant equipment. To address this concern, Exelon plans to replace the steam dryer in each unit. The average velocity in the main steam line at EPU conditions will be 155 feet per second. Although this is comparable to velocities at some EPU plants, it is lower than the velocities at most BWRs that have received EPUs, making Peach Bottom less susceptible to vibration fatigue concerns.

The Westinghouse-designed “Nordic” steam dryers, with their octagonal shape, three concentric rings of panels, and symmetric fluid flow paths, are robust with regard to structural loads. Fabrication details, such as full-penetration welds, are also well-suited to withstand dynamic loads. Similar steam dryers installed in BWRs in Sweden and Finland have operated successfully for more than 25 years at temperatures and steam flow velocities equal to or significantly greater than those expected at Peach Bottom under EPU conditions.

The design used an acoustic model to determine dynamic pressure loads on the steam dryer due to acoustic resonances in the main steam line, a detailed finite element structural analysis to obtain structural response and peak stresses in the dryer, and subscale model testing to project these results to EPU operating conditions.

The Unit 2 dryer will be installed during the October 2014 refueling outage. It will be instrumented with accelerometers, pressure transducers, and strain gauges. Strain gauges have already been installed on the four main steam lines at Units 2 and 3. Data from the Unit 2 on-dryer instruments will be used to benchmark the end-to-end steam dryer evaluation methodology[1] at CLTP and to monitor dryer performance during power ascension to EPU levels.

The staff has imposed a license condition as part of the proposed EPU for Unit 2 that requires benchmarking of the end-to-end dryer analysis methodology based on the on-dryer instrumentation data collected at or near CLTP conditions during initial power ascension. Power ascension beyond CLTP will not be permitted until acceptable dryer peak stress levels are confirmed based on the data. During the Unit 2 ascension to CLTP, measurements of the acoustic pressures on the dryer will be compared to the acoustic model predictions and will be input to the finite element structural model to estimate peak alternating stresses at critical locations in the dryer. The end-to-end analysis methodology will thus be fully benchmarked against direct strain gauge measurements to establish applicable bias errors and uncertainties in the stresses.

The loads and stresses at CLTP conditions will then be projected to EPU conditions using frequency-based scaling factors. These scaling factors, which were obtained from testing 1/8-scale models of the steam system, account for increases in steam velocity and, more importantly, will incorporate the acoustic resonances that may take place during power ascension from CLTP to EPU conditions. The estimated loads at EPU conditions and the bias errors and uncertainties determined from benchmarking at the CLTP levels will then be used to confirm that cyclic stresses at EPU conditions are within ASME Code limits. The scaling factors used to estimate the loads will thus be verified during Unit 2 power ascension testing.

Exelon and the staff indicate that Units 2 and 3 are sufficiently similar such that the Unit 2 dryer can be considered a prototype for Unit 3. The staff has concluded that instrumentation of the Unit 3 dryer is therefore unnecessary. This conclusion needs to be validated separately, based on the Unit 2 power ascension measurements for 1) the acoustic pressure model which estimates the dryer loadings using main steam line strain gauge data as input, and 2) the finite element stress analysis which estimates the peak stress levels from the dryer loadings calculated using the acoustic pressure model. Both elements of this evaluation are important to demonstrate the applicability of the Unit 2 dryer bias and uncertainty factors for the analysis of the Unit 3 dryer performance.

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1 “End-to-end” benchmarking implies validation of the analysis process from steam line strain gauge measurements through dynamic pressure loads, measured by pressure transducers and accelerometers on the dryer, to strain gauge measurements on the hood and skirt from which peak stresses are calculated at critical locations.

Exelon will transmit relevant data and evaluations to the staff for review during the power ascension. The Peach Bottom license conditions are similar to those imposed on other licensees during power ascension to monitor steam dryer structural integrity. The power ascension program, the large margin in predicted stress, and confirmatory inspections provide reasonable assurance that unexpected vibration modes will be detected and analyzed prior to further increases in power and that the dryers at both units will be adequately protected from fatigue failures.

SUMMARY

There is reasonable assurance that operation of Peach Bottom, Units 2 and 3, at the proposed EPU power level will present no undue risk to public health and safety. The Exelon LAR for the Peach Bottom, Units 2 and 3, EPU should be approved subject to the license conditions in the staff's draft final safety evaluation.

Sincerely,

/RA/

John W. Stetkar
Chairman

REFERENCES

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2. Memorandum from Michele G. Evans to E. Hackett, "Peach Bottom Atomic Power Station, Units 2 and 3 – Advisory Committee on Reactor Safeguards Review of Proposed Extended Power Uprate Amendment Draft Safety Evaluation (TAC NOS. ME9631 AND ME9632), May 9, 2014 (ML14098A442).

3. Responses from staff and licensee to ACRS question on containment evaluations, (ML14181B077 and ML14188A692).

4. GE Nuclear Energy, "Constant Pressure Power Uprate," Licensing Topical Report NEDC-33004P-A, Revision 4, Class III (Proprietary), July 2003 (ML032170343).

5. GE Nuclear Energy, "Generic Guidelines for General Electric Boiling Water Reactor Extended Power Uprate," Licensing Topical Report NEDC-32424P-A, Class III (Proprietary), February 1999 (ML081690229).

6. GE Nuclear Energy, “Generic Evaluations of General Electric Boiling Water Reactor Extended Power Uprate,” Licensing Topical Reports NEDC-32523P-A, Class III (Proprietary) February 2000; NEDC-32523P-A, Supplement 1, Volume I, February 1999, and Volume II, April 1999 (ML003712826).

7. NRC Review Standard 001 (RS-001), “Review Standard for Extended Power Uprate,” Revision 0, December 2003 (ML033640024).

8. SECY-11-0014, “Use of Containment Accident Pressure in Analyzing Emergency Core Cooling System and Containment Heat Removal System Pump Performance in Postulated Accidents,” January 31, 2011 (ML102590196).

9. SECY-11-0014, Enclosure 1, “The Use of Containment Accident Pressure in Reactor Safety Analysis,” January 31, 2011 (ML102110167).

10. Regulatory Guide 1.82, “Water Sources for Long-Term Recirculation Cooling Following a Loss-of-Coolant Accident,” Rev. 3, November 2003 (ML033140347).

11. GEH BWROG Topical Reports NEDC-33347P Revision 0 (Proprietary Version) and NEDO-33347 Revision 0 (Non-Proprietary Version),"Containment Overpressure Credit for Net Positive Suction Head (NPSH)," January 2008, (proprietary version: ML080520263; non-proprietary version: ML080520262).

12. Replacement Steam Dryer Evaluation for Peach Bottom Atomic Power Station Units 2 and 3, July 25, 2011(Proprietary) (ML12286A163) [Attachment 17 to the Exelon 9/28/2012 Letter].

13. WCAP-17611-P, Revision 1, “Peach Bottom Unit 2 and Unit 3 Replacement Steam Dryer Four-Line Subscale Acoustic Test Data Evaluation and Derivation of CLTP-to-EPU Scaling Spectra,” August 2012,(ML12286a166) [Enclosure B.5 to Attachment 17 to the Exelon 9/28/2012 Letter].

14. WCAP-17639-P, Revision 3, “Instrumentation Description for the Peach Bottom Unit 2 Replacement Steam Dryer,” February 2014, (Proprietary) (ML14070A152).

15. WCAP 17626-P, Revision 1, “Processing of Peach Bottom Unit 2 and Unit 3 MSL Strain Gauge Data and Computation of Predicted EPU Signature,” February 2014, (Proprietary) (ML14070A151).

6. GE Nuclear Energy, “Generic Evaluations of General Electric Boiling Water Reactor Extended Power Uprate,” Licensing Topical Reports NEDC-32523P-A, Class III (Proprietary) February 2000; NEDC-32523P-A, Supplement 1, Volume I, February 1999, and Volume II, April 1999 (ML003712826).

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