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

November 10, 2011

The Honorable Gregory B. Jaczko
Chairman
U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001

SUBJECT: NINE MILE POINT NUCLEAR STATION, UNIT 2, EXTENDED POWER UPRATE APPLICATION

Dear Chairman Jaczko:

During the 588th meeting of the Advisory Committee on Reactor Safeguards, November 3-5, 2011, we completed our review of the Nine Mile Point Nuclear Station, LLC (NMPNS or the licensee) extended power uprate (EPU) application for Nine Mile Point, Unit 2 (NMP2) and the associated NRC staff's draft final safety evaluation. Our Subcommittee on Power Uprates also reviewed this matter on October 5, 2011. During these reviews, we had the benefit of discussions with representatives of the NRC staff and NMPNS. We also had the benefit of the documents referenced.

CONCLUSIONS AND RECOMMENDATION

1. The NMPNS application for the NMP2 EPU should be approved subject to the conditions imposed in the staff's draft final safety evaluation.

2. Monitoring during power ascension testing will provide reasonable assurance that unanticipated vibration modes induced in the steam dryer will be detected, should they occur.

3. The acoustic coupling model has limited validation; however, its use is acceptable in the NMPNS EPU application because of the large margin in predicted stress in the steam dryer.

BACKGROUND AND DISCUSSION

NMP2 is a boiling water reactor (BWR) plant of the BWR/5 design with a Mark II containment. The current licensed thermal power (CLTP) is approximately 4.3 percent higher than the originally licensed thermal power (OLTP) of 3,323 megawatts-thermal (MWt). NMPNS has

applied for an EPU of approximately 15 percent from the CLTP of 3,467 MWt. This will result in a total uprate of 120% from OLTP to 3,988 MWt. This increase in power will be implemented in the second quarter of 2012.

In 2008, the NMP2 operating license was amended to permit the use of an alternative source term (AST) for design basis accident (DBA) analyses. The AST evaluation was performed at the proposed EPU power level so that DBA analyses could accommodate the EPU submittal. Similarly, the NMP2 technical specifications have been amended to permit operations in the expanded domain corresponding to maximum extended load line limit analysis (MELLLA). The licensee is in the process of completing the major plant modifications needed to support operation at the EPU power level. These modifications will be completed in the second quarter of 2012 and are discussed in detail in the staff's safety evaluation. The uprated power level will be achieved at constant pressure. The higher steam flow will be achieved by increasing the reactor power along specified control rod and core flow lines. There will be no increase in the maximum normal operating reactor vessel dome pressure or the maximum licensed core flow over their pre-EPU values.

The NMPNS EPU application follows the guidelines in the NRC-approved General Electric (GE) licensing topical reports for constant pressure power uprates of BWRs [3–5]. The staff's evaluation of the application follows the methodology prescribed in the review standard for extended power uprates [6].

The entire core loading for the first EPU cycle consists of GE-14 fuel. The core and fuel are conservatively designed with a peak linear heat generation rate of 12 kW/ft (significantly lower than the 13.4 kW/ft peak linear heat generation rate in most BWRs), and a peak nodal burnup of 57 GWd/MTU. All key core parameters for the NMP2 EPU will be within the current experience base. The interim methods licensing topical report (IMLTR) NEDC-33173P-A, "Applicability of GE Methods to Expanded Operating Domains," [7] referenced by the licensee documents the applicability of GE neutronic and thermal-hydraulic methods for BWR EPU and MELLLA applications. The staff has approved the IMLTR with 24 limitations and conditions. The staff conducted one regulatory audit pertaining to the IMLTR and concluded that the NMPNS EPU application complies with all applicable conditions and limitations in the NEDC-33173P-A licensing topical report and that application of GE methods is appropriate.

NMPNS performed loss-of-coolant accident (LOCA) analyses for NMP2 at EPU conditions, using NRC-approved methods [8]. The staff performed independent calculations using the TRACE code with more conservative assumptions and confirmed compliance of the licensee's EPU LOCA analyses results with 10 CFR 50.46 and Appendix K requirements [9-10].

NMPNS performed analyses of NMP2 containment response following a design-basis LOCA and an Appendix R scenario at EPU conditions. The analyses were performed using NRC-accepted GE methods [3], and the results indicate that all containment parameters remain well within design limits. NMPNS is not requesting containment accident pressure credit to assure

adequate net positive suction head for emergency core cooling system pumps. The staff has reviewed the licensee's assessment of the containment temperature and pressure transients and concluded that the licensee has adequately accounted for the increase of mass and energy resulting from the proposed EPU. The staff further concluded that containment systems will continue to provide sufficient pressure and temperature mitigation capability to ensure that containment integrity is maintained and that the proposed EPU is acceptable with respect to primary containment functional design.

NMPNS has performed plant-specific anticipated transients without scram (ATWS) analyses at EPU conditions. The licensee has concluded that NMP2 meets the ATWS acceptance criteria specified in 10 CFR 50.62 [11] and asserts that the level of protection at EPU conditions is not expected to differ significantly from that at CLTP levels. NMP2 operator actions to mitigate ATWS events are based on the Boiling Water Reactors Owners' Group (BWROG) emergency procedures and severe accident guidelines [12]. The staff has noted that NMP2 has excellent ATWS mitigation design features including automatic trips, upper plenum boron injection, and motor-driven feedwater pumps.

In addition, a staff audit has confirmed that the proposed EPU does not pose a significant additional burden to operators during an ATWS event. The staff found that NMP2 operators have a good understanding of stability and ATWS issues and that the plant emergency operating procedures (EOPs) are adequate for EPU conditions. Operator responses to an ATWS in NMP2 simulator exercises were well within the 120-second delay assumed in the safety calculation.

NMP2 currently operates under the Option III long-term stability solution developed by the BWROG and approved by the staff [13–14]. This instrumentation has been in operation at NMP2 for over 10 years and demonstrated its ability to detect and suppress the very low amplitude oscillations encountered during an instability event at the plant in 2003. In that event, the period-based detection algorithm initiated an automatic scram because of core-wide oscillations. The post-review analysis determined that unexpected confirmation count resets prior to the scram resulted in a trip delay of approximately 15 to 20 seconds. Two parameter settings were subsequently changed to address the confirmation count resets in accordance with BWROG recommendations. The staff has concluded that the licensee has adequately demonstrated that if instability were to occur in the NMP2 EPU core, it would be detected and suppressed.

The licensee has evaluated the effects of EPU conditions on relevant materials degradation mechanisms including intergranular stress corrosion cracking (IGSCC), irradiation assisted stress corrosion cracking (IASCC), flow-accelerated corrosion (FAC), fatigue, radiation embrittlement, and flow-induced vibration (FIV).

IGSCC and IASCC

The increased fast neutron flux within the core will significantly increase the potential for IASCC and IGSCC. The increased rate of radiolysis of the coolant could increase steady state and transient concentrations of oxidizing species and increase the aggressiveness of the coolant. Similarly, the higher flux will increase the rate of radiation hardening of austenitic stainless steels within the reactor vessel and increase their susceptibility. Unless mitigation practices are adjusted to account for these effects, the potential for IASCC of austenitic stainless steel core internals and IGSCC of weldments in austenitic stainless steel reactor coolant piping will increase.

NMP2 has a favorable starting condition because the reactor coolant piping is fabricated from a low carbon content Type 316 stainless steel. This alloy is much more resistant to IGSCC of weldments than the higher carbon content Type 304 stainless steel used in older BWRs. However, indications of stress corrosion cracking in the stainless steel core shroud and in the dissimilar metal welds in the recirculation inlet and feedwater nozzles have been found and mitigated. In the case of the nozzles, mitigation has included a combination of periodic in-service inspections (ISI), a mechanical stress improvement process, and weld overlay. In the case of the shroud, mitigation has consisted of ISI and the use of improved water chemistry.

Since 2000, the licensee has applied both hydrogen water chemistry and noble metal chemical additions to reduce the electrochemical potential and reduce susceptibility to IASCC and IGSCC. To compensate for the increased neutron flux at EPU conditions, the licensee will increase the rate of hydrogen injection from 15 standard cubic feet per minute (scfm) to 17.6 scfm and will monitor and control the hydrogen to oxygen molar ratio in the coolant. In addition, the licensee will continue to follow the BWR Vessel Internals Project recommendations and EPRI Water Chemistry Guidelines to assure effectiveness. The staff has concluded that the effects of EPU conditions on the potential for IASCC and IGSCC will be adequately managed.

Flow-Accelerated Corrosion

EPU conditions require higher steam and feedwater flow rates that may lead to an increase in FAC for some components. NMP2 employs a FAC corrosion program which meets the guidance provided in Generic Letter 89-08 [15] and Electric Power Research Institute (EPRI) guidelines [16]. The program includes predictive analyses using the EPRI CHECWORKS model and periodic inspections. The licensee asserts, and the staff agrees, that at EPU conditions, the NMP2 FAC program is consistent with the industry guidelines and should provide reasonable assurance that unacceptably high FAC rates will be detected before the corroded components reach unsafe conditions.

Fatigue

The licensee performed plant-specific fatigue evaluations for components that will experience an increase in pressure, temperature, and/or flow rate due to the proposed EPU; and that have an OLTP 40-year cumulative usage factor (CUF) greater than 0.33. The staff found the licensee's evaluation methodology to be acceptable and in compliance with NRC approved power uprate licensing topical reports. With the exception of the feedwater nozzles, the evaluations showed that the code of record allowable limits will be met. Based on the design stress values, the feedwater nozzles meet the American Society of Mechanical Engineers (ASME) Code fatigue CUF allowable value of 1.0 for the 40-year plant life, but could exceed it for a 60-year plant life. The licensee stated that if the plant fatigue monitoring program predicts that the fatigue CUF cannot be maintained below 1.0; then corrective actions such as re-analysis, enhanced inspection, repair, or replacement will be implemented. The staff found the licensee's approach to be acceptable.

Radiation Embrittlement

The staff has reviewed the licensee's evaluation of the changes in neutron fluence due to the proposed EPU and concluded that the industry integrated surveillance program remains bounding for the NMP2 reactor pressure vessel, and the material surveillance programs will continue to meet regulatory requirements. The licensee has evaluated the effect of the increased fluence due to EPU conditions on the NMP2 reactor pressure vessel. The Charpy upper shelf energy (USE) for the limiting beltline material is projected to be 61 ft-lbs after the 60-year (54 effective full power years) life of the plant. This is well above the minimum 50 ft-lbs required by the ASME code. The staff has reviewed the licensee's evaluation of the effects of the proposed EPU and concluded that the USE values will continue to be acceptable and the proposed pressure-temperature limits will continue to meet regulatory requirements.

Flow Induced Vibration

The proposed EPU will also increase flow induced vibration in certain components that could lead to high-cycle fatigue failure. EPU operating experience has revealed that the steam dryer is the most likely component to be affected. The main steam line velocity at NMP2 will be 177 feet per second (fps) at EPU conditions. This is higher than comparable steam line velocities at Susquehanna (153 fps) and Hope Creek (167 fps), but is lower than that at Quad Cities Unit 2 (202 fps). The NMP2 steam lines do not have resonance-inducing dead-end branch lines and have historically been quieter than those at other plants which have experienced steam dryer cracking. NMPNS identified several indications of possible flaws during the in-vessel visual inspection of the NMP2 steam dryer during the spring 2008 refueling outage. NMPNS will complete repairs and structural modifications to the NMP2 steam dryer to assure that the resulting steam dryer stresses satisfy the recommended EPU margin (minimum alternating stress intensity ratio > 2.0).

One-eighth-scale model tests of NMP2 geometry have been performed. These tests indicated that flow-induced resonances should not occur at flow velocities associated with EPU operating conditions. The results of these tests were used to establish steam dryer load “bump-up factors” from CLTP to EPU and the projected loads on the dryer at EPU conditions.

NMP2 will rely on measurements of acoustic loads in the steam lines along with an Acoustic Circuit Model (ACM) [17] to determine the loading distribution on the dryer. The ACM methodology was validated using limited benchmarking data from the instrumented Quad Cities Unit 2 dryer, which has a square hood geometry rather than the curved hood geometry of the NMP2 dryer. Notwithstanding this and other differences, the frequency-dependent biases and uncertainties applied to the NMP2 model were derived from the Quad Cities Unit 2 data.

A finite element model of the NMP2 dryer was developed and used to determine the stresses corresponding to the calculated loads at the CLTP conditions as well as the projected loads at EPU power level. The analysis used conservative assumptions for damping and weld factors and accounted for bias errors and uncertainties in the finite element analysis, including a load frequency shift of plus or minus 10 percent. Based on these calculations, the licensee concluded, and the staff concurred, that the peak stress intensity in the NMP2 steam dryer at EPU conditions will satisfy the ASME design criteria (13,600 psi) with a margin greater than a factor of 2.

The licensee will implement a slow and deliberate program for power ascension, with defined hold points. The program provides a careful approach to EPU power level to ensure satisfactory equipment performance. It includes monitoring and analysis to trend the steam dryer performance and a long-term inspection program to verify performance of the steam dryer and piping system. The licensee will transmit relevant data and evaluations to the NRC staff during the power ascension. The power ascension program, coupled with the large margin in predicted stress, provides reasonable assurance that unexpected vibration modes will be detected and analyzed before further increases in power.

Other Issues

The higher decay heat levels at EPU conditions will reduce the times available for operator response. The licensee has made changes in the NMP2 normal and emergency operating procedures to accommodate higher decay heat levels. However, no new manual actions or changes in the mitigating strategies and credited operator response times are required.

The NMPNS EPU application was not submitted as a risk-informed license application. Nevertheless, NMPNS has submitted assessments of risk associated with operation of NMP2 at EPU conditions. The staff considered this risk information in its decision-making process to determine if special circumstances exist that could potentially rebut the presumption of adequate protection justified by the compliance of NMP2 EPU operation with deterministic requirements and regulations. The staff has concluded that the proposed NMP2 EPU will not create any special circumstances.

In summary, we agree with the staff's reasonable assurance determination that the health and safety of the public will not be endangered by the licensee's operation at the proposed EPU power level and that such activities will be conducted in compliance with the Commission's regulations. The NMPNS application for the NMP2 EPU should be approved subject to the conditions imposed in the staff's draft final safety evaluation.

We commend the licensee on the quality of the application and the staff for its thorough review.

Sincerely,

/RA/

Said Abdel-Khalik
Chairman

REFERENCES

1. Draft NRC Safety Evaluation on NMP2 EPU, dated September 7, 2011 (ML112440153).

2. NMPNS License Amendment Request (LAR) Pursuant to 10 CFR 50.90: Extended Power Uprate, dated May 27, 2009 (ML091610091).

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

4. 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 [Known as ELTR1].

5. 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 [Known as ELTR2].

6. NRC Review Standard 001 (RS-001), "Review Standard for Extended Power Uprate," Revision 0, December 2003 (ML033640024).

7. GE Nuclear Energy, "Applicability of GE Methods to Expanded Operating Domains," Licensing Topical Report, NEDC-33173P-A; September 2010 (ML102920140).

8. GE Nuclear Energy, "General Electric Model for LOCA Analysis in Accordance with 10 CFR 50 Appendix K," NEDE-20566-P-A; September 1986 (ML092110816).

9. 10 CFR 50.46, "Acceptance Criteria for Emergency Core Cooling System for Light Water Nuclear Power Reactors."

10. 10 CFR Part 50, Appendix K, "ECCS Evaluation Models."

11. 10 CFR 50.62, "Requirements for Reduction of Risk from Anticipated Transients Without Scram (ATWS) Events for Light-Water Cooled Nuclear Power Plants."

12. BWROG Emergency Procedure and Severe Accident Guidelines (EPG/SAGs), Revision 2 (2001).

13. GE Nuclear Energy, "BWR Owners' Group Long-Term Stability Solutions Licensing Methodology," NEDO-31960-A, November 1995.

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15. Nuclear Regulatory Commission Generic Letter 89-08 (GL89-08), "Erosion/Corrosion-Induced Pipe Wall Thinning," May 2, 1989.

16. Electric Power Research Institute," Recommendations for an Effective Flow-Accelerated Corrosion Program," EPRI NSAC-202L-R3; May 2006.

17. Continuum Dynamics, Inc. ACM Rev. 4.1: Methodology to Predict Full Scale Steam Dryer Loads from In-Plant Measurements (Rev. 2). C.D.I. Report No. 10-09P (Proprietary), December 10, 2010 (ML1035005207).

9. 10 CFR 50.46, "Acceptance Criteria for Emergency Core Cooling System for Light Water Nuclear Power Reactors."

10. 10 CFR Part 50, Appendix K, "ECCS Evaluation Models."

11. 10 CFR 50.62, "Requirements for Reduction of Risk from Anticipated Transients Without Scram (ATWS) Events for Light-Water Cooled Nuclear Power Plants."

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13. GE Nuclear Energy, "BWR Owners' Group Long-Term Stability Solutions Licensing Methodology," NEDO-31960-A, November 1995.

14. GE Nuclear Energy, "BWR Owners' Group Long-Term Stability Solutions Licensing Methodology," NEDO-31960-A, Supplement 1, November 1995.

15. Nuclear Regulatory Commission Generic Letter 89-08 (GL89-08), "Erosion/Corrosion-Induced Pipe Wall Thinning," May 2, 1989.

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Letter to the Honorable Gregory B. Jaczko, NRC Chairman, from Said Abdel-Khalik, ACRS Chairman dated November 10, 2011

SUBJECT: NINE MILE POINT NUCLEAR STATION, UNIT 2, EXTENDED POWER UPRATE APPLICATION

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