



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

September 16, 2013

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

**SUBJECT: MONTICELLO NUCLEAR GENERATING PLANT EXTENDED POWER  
UPRATE LICENSE AMENDMENT REQUEST**

Dear Chairman Macfarlane:

During the 607<sup>th</sup> meeting of the Advisory Committee on Reactor Safeguards, September 5-7, 2013, we completed our review of the extended power uprate (EPU) license amendment request (LAR) for Monticello Nuclear Generating Plant (MNGP) and the associated NRC staff's draft final safety evaluation. Our Subcommittee on Power Uprates also reviewed this matter on July 25 and 26, 2013. During these reviews, we had the benefit of discussions with representatives of the NRC staff and the Northern States Power Company Minnesota (NSPM or the licensee). We also had the benefit of the documents referenced.

**RECOMMENDATION AND CONCLUSIONS**

1. The NSPM application for the MNGP EPU should be approved subject to the conditions and commitments identified in the staff's draft final safety evaluation.
2. The license condition for monitoring during power ascension testing provides reasonable assurance that unanticipated vibration modes induced in the steam dryer will be detected and addressed.
3. Application of the guidance in SECY-11-0014 for containment accident pressure (CAP) credit and the required analyses in this LAR provide reasonable assurance related to pump survivability and the availability of required net positive suction head (NPSH). Including the evaluation of the potential for circuit issues associated with an Appendix R fire helps to identify actions that may be necessary to reduce the likelihood of inadvertent containment venting that could result in a loss of CAP.
4. The requirement for CAP may limit the capability to implement future venting actions that may be proposed in response to the Near Term Task Force recommendations.

## **BACKGROUND**

MNGP is a boiling water reactor (BWR) plant of the BWR/3 design with a Mark I containment. The plant began operation in 1970. Although not licensed to Appendix A General Design Criteria, evaluations show that MNGP conforms with the intent of the 1967 Atomic Energy Commission draft General Design Criteria. In November 2006, the NRC granted MNGP an extension to operate until 2030.

The current licensed thermal power (CLTP) of 1,775 MWt (with a gross electrical output of 600 MWe) is approximately 6.3% higher than the original licensed thermal power (OLTP) of 1,670 MWt. NSPM applied for an EPU of approximately 13% from the CLTP, which would result in a total uprate of 20% from the OLTP to 2,004 MWt. NSPM plans to begin implementing this EPU during 2013.

## **DISCUSSION**

The Constant Pressure Power Uprate (CPPU) for MNGP is primarily accomplished by generating and supplying higher steam mass flow to the turbine-generator. As-designed equipment and system capabilities, along with improvements in analytical methods, improved fuel and core designs, and newly installed or modified equipment accommodate the higher steam mass flow rate and the resultant power increase. EPU operation does not involve 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 licensee proposes that a higher steam mass flow be achieved by increasing the reactor power along specified control rod and core flow lines. This also requires that a limited number of operating parameters be changed, some set points be adjusted, and some instruments be recalibrated. Plant procedures will be revised, and tests similar to some of the original startup tests will be performed. The MNGP power ascension test plan does not include performing large transient tests at full EPU power. The licensee and the staff state that such tests can be omitted because relevant experience at other BWR 3/4 units similar in design to the MNGP exists, because transients had previously occurred at MNGP, and because of prior large transient tests that were completed at MNGP. We concur.

The initial power ascension test plan is focused on assessing steam dryer and selected piping system performance. MNGP modifications that have already been implemented (or will be implemented prior to ascending to EPU power) include: a replacement steam dryer (RSD), addition of vibration monitoring accelerometers on main steam and feedwater piping, a new digital power range neutron monitoring system, a new high pressure turbine, new feedwater pumps and motors, new feedwater heaters, new condensate pumps and motors, and revised instrumentation setpoints. Power transmission system upgrades include new main and auxiliary

transformers, new external busses, new internal busses and switchgear, and installation of the required controls and cooling features to operate the new equipment. No changes to the type of fuel will be made for the EPU. The MNGP core has been comprised entirely of GE14 fuel assemblies since Cycle 24 (the plant is currently in Cycle 27), and this will continue to be the case during EPU implementation.

MNGP currently operates in the Maximum Extended Load Line Limit Analysis (MELLLA) operating domain. Due to core flow limitations at MNGP, ascension to full EPU power is planned after NRC approval of a separate LAR for operation in the MELLLA Plus (MELLLA+) operating domain.

The Safety Analysis Report for the Monticello Constant Pressure Power Uprate follows the guidelines in the NRC-endorsed General Electric (GE) licensing topical reports for BWR CPPUs. The staff's evaluation of the application follows the methodology prescribed in the EPU review standard (RS-001). In addition, the staff used applicable rules, regulatory guides, Standard Review Plan (SRP) sections, and staff positions on applicable topics.

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

The licensee 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 and concluded that they would be adequately managed. The staff accepted their approach, which includes additional measures for monitoring the RSD during power ascension to full EPU power. We concur with this conclusion.

### ***Containment Accident Pressure (CAP)***

The current MNGP licensing basis includes design basis accident calculations that take credit for CAP in assessing the available net positive suction head (NPSHa) for core spray (CS) and residual heat removal (RHR) pumps to avoid excessive cavitation [e.g., for the limiting design basis loss of coolant accident (DBLOCA), CAP credit of up to 6.1 psig for approximately four days is currently allowed]. EPU implementation at MNGP increases the heat transferred to the suppression pool, which will increase the pool water temperature, reduce NPSHa at the suction inlet of the RHR and CS pumps, and reduce NPSH margin.

This application is the first EPU request using SECY-11-0014 CAP guidance, as well as the BWR Owners Group (BWROG) guidance. NSPM evaluated NPSH margin using conservative assumptions for the limiting DBLOCA, and realistic assumptions for non-design basis events, such as Appendix R fire, anticipated transient without scram (ATWS), and station blackout (SBO) events. The licensee's analyses for each event consisted of the following steps: (a) containment analysis using the Super HEX (SHEX) computer code to calculate the transient wetwell pressure and the corresponding transient suppression pool temperature, (b) calculation of the NPSHa at the inlet of the RHR and CS pumps using the transient suppression pool temperature with varying transient wetwell pressure as inputs, and (c) evaluation of NPSH margin. These deterministic calculations were performed using conservative assumptions consistent with Regulatory Guide 1.82, Revision 3.

The deterministic analysis with conservative inputs showed more limiting results in NPSH margin than a statistical analysis performed by the BWROG for MNGP. In accordance with SECY-11-0014 guidance, NSPM also demonstrated that results obtained from the deterministic analyses were conservative by providing comparisons with a best estimate analysis using the GOTHIC code. Application of SECY-11-0014 guidance indicates that the maximum CAP credit will need to increase for MNGP at EPU conditions; however, it is less than 10 psig for 5 days for the limiting DBLOCA.

Consistent with SECY-11-0014 guidance, evaluations were also performed to provide assurance that operator actions to control CAP are acceptable and documented in appropriate plant procedures. As part of the BWROG program to address the use of CAP, the pump manufacturer completed tests at the flow rate and NPSH margin that causes the maximum erosion of the pump impeller. Results indicate that cavitation erosion will not challenge the ability of the pumps to operate.

To address SECY-11-0014 guidance that circuit issues associated with an Appendix R fire should not result in a loss of required CAP, NSPM considered multiple spurious operation (MSO) scenarios in accordance with the guidance in NEI 00-01, Revision 2 and Regulatory Guide 1.189, Revision 2. MSO scenarios that could challenge Appendix R fire-required CAP were precluded from occurring through modifications and configuration changes.

NSPM performed GOTHIC calculations to demonstrate that the leakage rate to lose all NPSH margin is greater than 228 standard cubic feet per minute (scfm), which is approximately 30 times the MNGP technical specification limit (10 CFR 50 Appendix J). In addition to the Appendix J testing program, this margin is ensured through on-line monitoring of nitrogen makeup to the containment and NSPM implementation of a one-time test each startup that will demonstrate leakage will be less than 150 scfm.

In summary, the licensee adequately addressed the effects of the proposed EPU on containment heat removal. The licensee implemented new SECY-11-0014 guidance for using CAP credit. Analyses indicate that under EPU conditions, the emergency core cooling system and containment heat removal systems will continue to meet General Design Criterion-38, with respect to rapidly reducing the containment pressure and temperature following the design basis and non-design basis events and maintaining these parameters at acceptably low levels.

However, the magnitude and duration of CAP credit has increased due to EPU conditions. This may further limit the capability to implement future venting actions that may be proposed in response to the Near Term Task Force recommendations. We look forward to interacting with the staff to ensure that such actions can be performed reliably without adversely affecting plant risk.

### ***Replacement Steam Dryer (RSD)***

The proposed EPU will 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. 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 the capability of other plant equipment. The main steam line (MSL) velocity at MNGP will be 179 feet per second (fps) at EPU conditions. This is higher than steam line velocities at Susquehanna (153 fps), similar to that at Nine Mile Point Unit 2 (177 fps), and lower than that at Quad Cities Unit 2 (202 fps).

The licensee replaced the original steam dryer during the Spring 2011 refueling outage. The RSD is a Westinghouse-designed "Nordic" steam dryer. It is octagonal in shape and contains three concentric rings of dryer panels. This provides symmetry of fluid flow paths through the dryer and results in an overall robustness and integrity with regard to structural loads. The shape of the structure and its fabrication details (nearly all welds are full-penetration) 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 MSL flow velocities equal to or significantly greater than those planned for MNGP at EPU conditions.

The RSD was instrumented and operated with accelerometers, pressure transducers, and strain gauges. In addition, strain gauges were installed on the four MSLs. In 2011, during the Cycle 26 power ascension to CLTP levels, these instruments provided time history data to support benchmarking of the Acoustic Circuit Enhanced (ACE) Version 2.0 methodology that was used, in conjunction with multiple structural analyses and scale model testing, to qualify the steam dryer for acoustic loads at EPU operating conditions. Measurements of pressure pulsations in the MSL are used with the ACE acoustic model to calculate pressure pulsations on the MNGP

steam dryer, and a structural finite element model of the dryer is used to determine peak stress. The ACE acoustic methodology was benchmarked against direct strain gauge measurements in the RSD to establish applicable bias errors and uncertainties in the stress. The loads at CLTP conditions inferred from MSL signals are projected to EPU conditions using frequency based scaling factors. These scaling factors are based on small-scale testing on models of the steam system and account for increases in steam velocity and more importantly, the safety relief valve 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 are used to determine the peak stress. The scaling factors used to estimate the loads will be verified during the power ascension testing.

Based on these calculations, NSPM concluded that the peak stress in the RSD at EPU conditions meets ASME design criteria. However, no strain gauge or pressure measurements were made on the steam dryer skirt. Direct application of the acoustic model to Quad Cities data showed that the model underpredicted pressures on the skirt in the low frequency range. To address this, a separate acoustic model was developed and benchmarked solely to Quad Cities measurements of pressure on the skirt. The skirt model shows good agreement with the Quad Cities data and was used to estimate stresses on the skirt for the MNGP dryer.

To provide assurance against fatigue cracking, the staff generally expects that the ratio of the ASME allowable cyclic stress to the maximum cyclic stress predicted for the dryer be greater than unity for dryers with full benchmarking and greater than two for uninstrumented components. For the upper dryer (hood) portion, which was instrumented, the minimum alternating stress ratio was well above unity at projected EPU conditions. For the lower dryer (skirt) portion, which was not instrumented, the minimum alternating stress ratio including safety relief valve resonance was slightly below two at projected EPU conditions. Because of the good agreement between end-to-end strain simulations and because the dryer was partially instrumented, the staff found this small non-adherence to the factor of two for skirt stresses required for completely uninstrumented dryers acceptable. We concur with the staff's conclusion.

After installation of the RSD, the licensee began implementing a slow and deliberate program for power ascension, with defined hold points. As of August 2011, sections of this test plan were implemented that allowed steam dryer data to be gathered to support operation under CLTP conditions. Power ascension to EPU conditions will occur over a period of time with small (equal to or less than 5% power) gradual increases in power and hold periods. In addition, the power ascension plan 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. Limit curves that define the maximum allowable MSL pressure (or strain) as a function of frequency have been developed based on finite element analysis to ensure that steam dryer

allowable stresses aren't exceeded. During power ascension testing, the licensee will monitor MSL strain gauge signals. If the MSL pressure or strain limit curves at any frequency are exceeded, power will be immediately reduced to the previous power level pending further evaluation. Steam dryer loads and stresses will be re-evaluated based on the MSL pressure measurements, and the stresses so determined will be compared to the ASME code fatigue endurance limit to confirm dryer integrity. The power level will be increased to the next hold point only after confirmation that the maximum expected stress at the next hold point will be below the ASME code endurance limit.

The licensee will transmit relevant data and evaluations to the NRC staff during the power ascension. The MNGP limit curve approach is similar to that used by other licensees during power ascension to monitor steam dryer structural integrity. The power ascension program, coupled with the large margin in predicted stress and confirmatory inspections, provides reasonable assurance that unexpected vibration modes will be detected and analyzed before further increases in power.

## **SUMMARY**

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 NSPM application for the MNGP EPU should be approved subject to the remaining regulatory conditions and commitments identified in the staff's draft final safety evaluation. We commend the licensee on the quality of this application and the staff for their thorough review.

Sincerely,

*/RA/*

J. Sam Armijo  
Chairman

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