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

February 18, 2014

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

SUBJECT: MONTICELLO NUCLEAR GENERATING PLANT MAXIMUM EXTENDED LOAD LINE LIMIT ANALYSIS PLUS (MELLLA+) LICENSE AMENDMENT REQUEST

Dear Chairman Macfarlane:

During the 611th meeting of the Advisory Committee on Reactor Safeguards, February 5-7, 2014, we completed our review of the Monticello Nuclear Generating Plant (MNGP) license amendment request (LAR) to allow operation in the expanded Maximum Extended Load Line Limit Analysis Plus (MELLLA+) domain under the NRC-approved extended power uprate (EPU) conditions of 2,004 MWt. Our Subcommittee on Power Uprates also reviewed this matter on December 3, 2013. During these reviews, we had the benefit of discussions with representatives of the NRC staff, Northern States Power Company Minnesota (NSPM or the licensee), and their contractors. We also had the benefit of the documents referenced.

RECOMMENDATION AND CONCLUSION

1. The NSPM application for MNGP operation in the MELLLA+ domain should be approved, subject to the conditions and limitations identified in the staff's draft safety evaluation.

2. The relatively small and low power density core, the demonstrated MNGP operator response time, and other measures, including the limitations and conditions adopted by the licensee, assure that MNGP will be protected from increased susceptibility to instabilities during MELLLA+ operation.

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. In November 2006, the NRC approved extension of the MNGP license to operate until 2030. On December 9, 2013, the NRC granted MNGP an EPU for operation at its current licensed thermal power (CLTP) of 2,004 MWt, which is approximately 20% higher than the original licensed thermal power of 1,670 MWt. MNGP currently operates in the Maximum Extended Load Line Limit Analysis (MELLLA) domain.

In support of the LAR, NSPM submitted safety analysis report NEDC-33435P. This report documents results from all significant safety evaluations to support MELLLA+ operation at CLTP. These analyses are described in NEDC-33173P-A, which addresses the applicability of the General Electric-Hitachi methods proposed for safety analyses during MELLLA+ operation, and NEDC-33006P-A, which addresses the impact of MELLLA+ operation and the analyses needed to meet safety and regulatory requirements for operation in the MELLLA+ domain. The licensee applied the Detect and Suppress Solution - Confirmation Density (DSS-CD) as approved in NEDC-33075P-A and NEDC-33147P-A to protect against the increased susceptibility of the plant to instabilities in the MELLLA+ operating domain. In NEDC-33435P, the licensee evaluated the applicability of generic assessments in NEDC-33006P-A to MNGP. In cases where such generic assessments were not applicable, the licensee provided plant-specific evaluations to demonstrate the acceptability of MELLLA+ operation.

This application for operation in the MELLLA+ domain, which largely conforms to the approved generic MELLLA+ requirements, is the first to be reviewed by the staff and the ACRS. MELLLA+ expands the operating domain at CLTP for core flow as low as 80% of the rated value. The MELLLA+ expanded operating domain increases operating flexibility by allowing control of reactivity at maximum power by changing flow rather than control rod insertion and withdrawal. With respect to fuel performance, operation in the MELLLA+ domain offers several safety and economic advantages. On the other hand, implementation of MELLLA+ could lead to operation closer to system stability boundaries. As a result, enhanced protection against instabilities must be instituted to enable such operation.

Several features of MNGP are of particular importance for MELLLA+ operation. With a power density of 48.3 kW/liter. MNGP falls within the lower one-third of the power densities of operating BWRs. The large pressure loss inlet orifices, together with the relatively small, low power density core make this plant more stable and less susceptible to both core-wide and regional oscillations. To some extent, this mitigates the increased susceptibility to instabilities brought about by MELLLA+ operation. MNGP uses GE14 fuel, which is an approved fuel. Additional evaluations will be required if an alternative fuel design or analysis method is proposed. The licensee adopted most of the approved generic conditions. For example, the licensee is not requesting any plant-specific deviation for single loop operation in the MELLLA+ domain.

DISCUSSION

Broadening of the MNGP operating domain by allowing operation at lower flow without requiring additional compensating measures could reduce the plant's safety margin. However, limitations and conditions adopted by the licensee maintain acceptable safety margins and satisfy regulatory criteria under MELLLA+ operation. As discussed below, these limitations and conditions affect fuel and nuclear design, thermal and hydraulic design, emergency systems, and transient and accident analyses. In addition to the generic measures specified in NEDC-33006P-A, acceptable safety margins will be maintained by:

- Changes in setpoints, operating limits, and setdowns to assure fuel integrity and adequate core cooling

- Penalties imposed to maintain margins after implementing changes from the approved DSS-CD solution

- Restrictions that no safety relief valves (SRVs) be out-of-service when operating in the MELLLA+ domain

- Demonstrated operator response time to limit instabilities during anticipated transients without scram (ATWS) events

We raised additional questions related to plant response during anticipated operational occurrences (AOOs), uncertainties in operator response time, and uncertainties in predicting ATWS instabilities. As discussed below, licensee responses to these questions provided confidence that safety margins will be maintained.

Fuel and Nuclear Design

The MELLLA+ analyses indicate that GE14 fuel could be subjected to increased temperatures and stresses during some events. To mitigate the impact of these events, more restrictive setpoints are adopted that affect plant operating limits, such as the safety limit minimum critical power ratio (SLMCPR), a limit established to prevent cladding damage due to fuel overheating. NSPM analyses related to the effect of the proposed operating domain extension on the nuclear design of the fuel assemblies, control systems, and reactor core were also reviewed.

Operating Limits

The operating limit minimum critical power ratio (OLMCPR), maximum average planar linear heat generation rate, and linear heat generation rate (LHGR) limits are set to assure that specified acceptable fuel design limits are not exceeded during normal operation or anticipated transients.

The licensee provided results to demonstrate that CLTP with 105% flow, which was approved for the EPU, was more limiting than conditions encountered in MELLLA+ operation at CLTP with 80% core flow. As a consequence, the OLMCPR will not increase for limiting AOOs. The licensee attributed these counterintuitive results to increased control rod reactivity effects at lower core flows (e.g., as control rods enter from the bottom of the vessel, their negative reactivity insertion is higher due to the larger bottom peaked power distributions that occur at lower flows).

The effects of MELLLA+ operation on fuel peak clad temperature (PCT) have been evaluated. To maintain the current Appendix K margin when operating in the MELLLA+ domain, the licensee proposes to increase the LHGR setdown value. Loss of coolant accident analysis results for various power and flow conditions demonstrate that the proposed LHGR setdown yields PCT values for MELLLA+ operation that are bounded by predictions for EPU conditions.

Monitoring and Control

Maneuvering within the MELLLA+ operating domain is performed by either controlling the recirculation flow or moving control rods. Other than the changes associated with implementing the DSS-CD solution, no changes were required for the neutron monitoring system, the reactor protection system, or the recirculation flow instrumentation for MELLLA+ operation. No additional design or operating requirements were needed for reactivity control systems, the control rod system, and the standby liquid control system.

Thermal and Hydraulic Design

The methods that the licensee used to assess the MNGP core thermal and hydraulic design were either NRC-approved or acceptable extensions of an NRC-approved code. Because MNGP has a small core with low power density, ATWS events with timely operator actions are predicted to cause cladding temperatures well below the regulatory limit. The models used in TRACG04 are acceptable for this application. MELLLA+ applications with larger cores and higher power densities may result in instabilities that require the use of heat transfer models in TRACG04 for conditions that are still under NRC review.

Operation in the MELLLA+ domain has the potential to result in unstable power oscillations during AOOs. To help protect MNGP from a coupled neutronic thermal-hydraulic instability, the licensee implemented the DSS-CD solution with required limitations and conditions. The DSS-CD solution uses a confirmation density algorithm to detect the inception of power oscillations and generate a power suppression trip signal prior to significant oscillation amplitude growth and minimum critical power ratio (MCPR) degradation. False scrams are minimized by requiring density confirmation from multiple oscillation power range monitor cells. Implementation of the DSS-CD solution required that MNGP increase OLMCPR requirements to allow for a slightly larger instability transient. In implementing this requirement, the licensee has imposed a penalty and increased the required initial MCPR margin to ensure that the ultimate safety limit (e.g., the SLMCPR) and final MCPR remain unchanged. Another requirement associated with DSS-CD implementation is that an automatic backup scram system be installed that is immediately armed when the DSS-CD is out of service.

Emergency Systems

The only MNGP emergency system that required changes for MELLLA+ operation was the overpressure protection system. Flow-induced vibrations were addressed using generic analyses. Plant-specific analyses were performed to address overpressure protection.

For MNGP, the limiting overpressure event is the main steam isolation valve closure with scram on high flux. Analyses indicate that the reactor vessel bottom head peak pressure is unchanged for this event in the MELLLA+ domain. The predicted peak pressure response is dependent on several inputs, including the upper analytical limit for the SRV setpoints and an assumed 3% drift tolerance of the SRVs. This drift tolerance is consistent with SRV performance testing at MNGP.

For ATWS analyses, the licensee concluded that the required number of operable SRVs must be increased to meet vessel pressure limits and committed that no SRVs be out-of-service while operating in the MELLLA+ domain.

Transient and Accident Analyses

The licensee also completed evaluations to assess the impact of MELLLA+ operation on the radiological consequences of design basis accidents and other special events, such as station blackout. The evaluation concluded that MELLLA+ operation is bounded by existing analyses because the accident is not impacted if it occurs in the MELLLA+ domain or the accident is bounded by events in the MELLLA domain.

In addition, the licensee analyzed two types of ATWS events: isolation ATWS that may lead to emergency depressurization (ATWSED), and ATWS with instability (ATWSI). Plant-specific analysis results show that reactor vessel peak pressure remains within applicable limits, PCT remains below 2200 °F, fuel cladding oxidation is much less than the 17% local cladding oxidation limit, suppression pool peak temperature is less than design limits, and containment peak pressure remains less than the containment design pressure. The potential for thermal-hydraulic instability in conjunction with ATWS events was evaluated using approved methods and criteria.

For ATWSED events, the licensee used two approaches: the licensing basis methodology, which uses the ODYN code, and a best-estimate methodology, which uses the TRACG04 code. For the more limiting licensing basis ATWSED calculation, reactor water level is controlled at five feet above the top of the fuel, and the suppression pool is allowed to heat up even after the heat capacity temperature limit (HCTL) is reached. The licensing basis ATWSED calculations for either EPU or MELLLA+ conditions result in suppression pool temperatures that exceed the HCTL, with temperatures exceeding the limit earlier for MELLLA+ operation. With all SRVs operable, results of the licensing basis analysis meet ATWS acceptance criteria. Therefore, the MNGP response to an ATWS event initiated in the MELLLA+ operating domain is acceptable, provided that all SRVs are operable.

The licensee evaluated stability during ATWSI events, including those initiated by turbine trip and recirculation pump trip. Analysis results show that the mitigation actions in the emergency operating procedures (e.g., flow runback to uncover the feedwater spargers and early boron injection) are effective in the MELLLA+ operating domain when MNGP-specific timing for operator actions is used. The TRACG04 calculations indicate that all applicable criteria are satisfied. However, the calculations satisfy acceptance criteria by taking two deviations from the approved methodology in NEDC-33006P-A:

- Operator actions to initiate feedwater flow reduction were assumed to occur within 90 seconds of the ATWS initiation. This timing provides adequate margin to the onset of instability in the turbine trip scenario. As a result, the trip of both recirculation pumps becomes limiting. The 90-second operator intervention time is less than the assumed value of 120 seconds in NEDC-33006P-A, and much less than the conservative time (250 seconds) used in past MNGP ATWS analyses.

- The assumed steady-state peak rod power has been set at 95% of the LHGR limit. Past MNGP ATWS analyses assumed a peak rod power at LHGR limits.

With respect to the first deviation, analyses indicate that a 90-second operator response time precludes large oscillations for turbine trip ATWSI events. The licensee provided a commitment to train and test licensed reactor operators to initiate actions within this allotted time. Results of feasibility evaluations performed by the licensee demonstrate that this response time is achievable with margin. With respect to the second deviation, MNGP operating data indicate that an assumed steady-state peak rod power at 95% of the LHGR limit is appropriate for an ATWSI calculation.

In response to questions raised during our review, the licensee provided more detailed information related to uncertainties in estimating the operator response time, and the staff provided additional information related to uncertainties in model predictions prior to the onset of instabilities in ATWSI events. This information increased our confidence that operation with these two deviations is acceptable.

SUMMARY

In summary, there is reasonable assurance that the health and safety of the public will not be adversely affected by the licensee's operation in the MELLLA+ expanded operating domain. The NSPM application for MNGP operation in the expanded MELLLA+ domain using GE14 fuel should be approved, subject to the conditions and limitations identified in the staff's draft safety evaluation. If MNGP pursues the use of an alternative fuel design or analysis method additional evaluations will be required.

Sincerely,

/RA/

John W. Stetkar
Chairman

REFERENCES

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5. GE Nuclear Energy, "Detect And Suppress Solution-Confirmation Density Licensing Topical Report," NEDC-33075P-A, Revision 6, January 2008. (ML080310384).

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7. GE-Hitachi, Final SE for NEDC-33173P-A, “Applicability of GE Methods to Expanded Operating Domains,” dated April 30, 2012 (ML12115A236).

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

9. NUREG-0800, “Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants,” U.S. Nuclear Regulatory Commission.

10. GE-Hitachi, NEDC-33006P-A, Revision 3, “General Electric Boiling Water Reactor Maximum Extended Load Line Limit Analysis Plus,” dated June 2009 (ML09180145).

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