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

May 2, 2008

The Honorable Dale E. Klein
Chairman
U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001

SUBJECT: HOPE CREEK GENERATING STATION EXTENDED POWER UPRATE APPLICATION

Dear Chairman Klein:

During the 551st meeting of the Advisory Committee on Reactor Safeguards, April 10-12, 2008, we completed our review of the PSEG Nuclear LLC (PSEG or the licensee) application for Hope Creek Generating Station (HCGS) Extended Power Uprate (EPU) and the associated NRC staff's draft final Safety Evaluation. Our Subcommittee on Power Uprates also reviewed this matter on March 20-21, 2008. During these reviews, we had the benefit of discussions with representatives of the NRC staff and its consultants, PSEG and its consultants, General Electric-Hitachi (GEH), and Continuum Dynamics, Inc. (CDI). We also had the benefit of the documents referenced.

CONCLUSIONS AND RECOMMENDATIONS

1. The PSEG application for the HCGS 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. We concur with the staff that large-transient tests, such as main steam isolation valve (MSIV) closure or generator load rejection, that would result in a reactor trip should not be required.

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

DISCUSSION

HCGS is a Boiling-Water Reactor (BWR) plant of the BWR/4 design with a Mark I containment. PSEG has applied for an EPU of approximately 15 percent from the Current Licensed Thermal Power (CLTP) of 3,339 megawatts thermal (MWt) to 3,840 MWt. The CLTP is approximately 1.4 percent higher than the Originally Licensed Thermal Power (OLTP) of 3,293 MWt. The 1.4 percent increase (implemented in 2001) was based on measurement uncertainty recapture (Appendix K uprate). The proposed 15 percent EPU is to be implemented in two steps, namely, an 11.5 percent increase from 3,339 MWt to 3,723 MWt to be implemented during the current operating cycle (Cycle 15), and a 3.5 percent increase from 3,723 MWt to 3,840 MWt to be implemented during a subsequent, yet to be specified, operating cycle.

In order to implement the proposed EPU, the licensee has made numerous modifications to non-safety power generation equipment. All physical modifications necessary to operate at the 11.5 percent power uprate level (3,723 MWt) were completed prior to the current cycle (Cycle 15). Technical specifications setpoint changes for operation at EPU conditions will be implemented in mid-cycle following the approval of the EPU license amendment. Additional plant modifications will be necessary before the licensee can implement the full 15 percent EPU.

The HCGS EPU application follows the guidelines contained 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 power/flow operating map for HCGS will be expanded by extending the Maximum Extended Load Line Limit Analysis (MELLLA) boundary line up to the proposed EPU power level, while maintaining the current maximum licensed core flow. The core loading for the first EPU cycle (current Cycle 15) consists of predominantly GE-14 fuel and thrice-burned SVEA-96+ "legacy fuel," along with a small number of twice-burned and four-times-burned SVEA-96+ fuel assemblies. The licensing topical report 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 previously approved NEDC-33173P-A with limitations and conditions of which the licensee identified 14 to be applicable to HCGS EPU Cycle 15 and fully implemented them.

For Cycle 15 EPU conditions, the results of the licensee's analyses show that the legacy fuel will be non-limiting and will not contribute to the safety limit minimum critical power ratio. The staff concluded that the HCGS EPU application complies with all applicable conditions and limitations in the NEDC-33173P-A licensing topical report, and that application of GE methods to the co-resident SVEA-96+ fuel in Cycle 15 is appropriate. All key core parameters for the HCGS EPU will be within the current experience base. We concur with the staff's conclusion.

PSEG performed Emergency Core Cooling System/Loss-Of-Coolant Accident analyses (ECCS/LOCA) for HCGS at EPU conditions, using NRC-approved methods [8]. The results show that the limiting LOCA is still the recirculation line break with battery failure and that all ECCS-LOCA performance acceptance criteria are met for the design-basis LOCA. Independent calculations performed by the staff using more conservative assumptions confirmed the limiting break size and compliance of the licensee's LOCA analyses results with 10 CFR 50.46 and Appendix K requirements [9-10]. We concur with the staff's findings.

PSEG performed analyses of HCGS containment response following a design-basis LOCA and Appendix R scenario at EPU conditions. The analyses were performed using NRC-accepted GE methods. The results indicate that all containment parameters remain below the design limits and that the available net positive suction head for the residual heat removal and core spray pumps will exceed the required net positive suction head values without credit for containment overpressure. We concur with these findings.

HCGS meets the Anticipated Transients Without Scram (ATWS) mitigation requirements specified in 10 CFR 50.62 [11]. Operator actions to mitigate ATWS events are based on the Boiling Water Reactors Owners' Group (BWROG) Emergency Procedures and Severe Accident Guidelines [12]. A staff audit has confirmed that the EPU does not pose a significant additional burden to operators during ATWS. PSEG performed plant-specific ATWS analyses at EPU conditions based on a GE-14 equilibrium core. The results for the limiting ATWS event meet all acceptance limits.

HCGS currently operates under the Option III long-term stability solution developed by the BWROG and approved by the staff [13–15]. The HCGS Oscillation Power Range monitor (OPRM) system is an ASEA Brown Boveri (ABB) Corporation design. The licensing basis is the same for both the GE and ABB OPRM designs. No equipment changes are required for EPU operation. The staff has concluded that the licensee has adequately demonstrated that if instability were to occur in the HCGS EPU core, it would be detected and suppressed. We concur with the staff's assessment.

The licensee asserts that HCGS response during an ATWS instability event at EPU conditions is not expected to differ significantly from that at CLTP. The staff concluded that the analyzed operator actions would effectively mitigate an ATWS instability event at HCGS and that similar operator actions will be required at EPU conditions. The effect of EPU on the plant's response during ATWS instability events will likely be less than the uncertainties associated with modeling such events and the paucity of the data validating such models. Such uncertainties are tempered by the low frequency and the resulting low risk significance of these events. Hence, we agree with the staff's conclusion regarding the effectiveness of operator actions in mitigating an ATWS instability event during HCGS EPU operation.

PSEG does not plan to undertake large-transient tests, such as main steam isolation valve closure and generator load rejection that would result in a reactor trip. Such tests would not directly address confirmation of the performance of systems that support the proposed EPU operation. We concur with the staff's recommendation that these large transient tests not be required.

EPU conditions require higher steam and feedwater flow rates that may lead to an increase in flow-accelerated corrosion for some components. HCGS has an active flow-accelerated corrosion program, which meets the guidance provided in Generic Letter 89-08 [16] and Electric Power Research Institute (EPRI) guidelines [17]. The program includes predictive analyses, using the EPRI CHECWORKS model (upgraded in 2007) and periodic inspections. The licensee asserts, and the staff agrees, that at EPU conditions, the HCGS flow-accelerated corrosion program remains consistent with the industry guidelines and should provide reasonable assurance that unacceptably high corrosion rates would be detected before the corroded components reach unsafe conditions. We concur with this assessment.

The proposed EPU will also increase flow rates in certain components that could vibrate and lead to failure. EPU operating experience suggests that the steam dryer is the most likely component to be affected by such phenomena. The HCGS steam dryer is a curved hood design that was upgraded on site to improve its structural integrity before commercial operation. It has been inspected on a recurring basis and has shown no indications of fatigue damage during its operation for over 20 years, including several years at CLTP (101.4 percent of OLTP). The main steam line velocities at HCGS are 145 feet per second (fps) at CLTP and 167 fps at EPU; the latter is comparable to the steam line velocity (168 fps) at the Vermont Yankee Nuclear Power Station at EPU conditions. It is also comparable to the steam line velocity (168 fps) at Quad Cities Unit 2 at OLTP. The HCGS steam lines do not have resonant dead-end branch lines; they have historically been quieter than those at other plants which experienced dryer cracking.

PSEG analyses show sufficient margin to steam dryer failure at EPU conditions. Hence, the licensee plans no modifications to the dryer. Additionally, PSEG does not plan to directly instrument the dryer to monitor its state of stress as power is increased to EPU level. Instead, PSEG will rely on strain measurements in the steam lines, along with an Acoustic Circuit Model (ACM) 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. Frequency-dependent biases and uncertainties in the model were derived from the Quad Cities Unit 2 data. HCGS-specific one-eighth-scale model tests were performed and the tests show that a flow-induced resonance may occur in one of the main steam line safety/relief valves at 118 Hertz for EPU operating conditions. The results of these tests were used to establish dryer load "bump-up factors" from CLTP to EPU and hence the projected loading on the dryer at EPU conditions.

A detailed finite element model of the HCGS dryer was developed based on measurements of a similar dryer, supplemented by detailed records of the field modifications made to the HCGS dryer before commercial operation. The finite element model was used to determine the HCGS dryer state of stress corresponding to the calculated loadings at OLTP, as well as the projected loadings at EPU. The analysis used conservative assumptions for damping and weld factors, with proper accounting 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 HCGS steam dryer at EPU will satisfy the American Society of Mechanical Engineers fatigue design criteria (13,600 pounds per square inch) with adequate margin. We concur with the staff's conclusion.

The licensee has developed a slow and deliberate program for power ascension, with defined hold points. The program provides a careful approach to EPU power 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 at EPU conditions. The licensee will transmit relevant data and evaluations to the NRC staff during the power ascension. We agree with the staff that the power ascension test program will provide adequate indications of satisfactory equipment performance as the power is increased to EPU conditions. Notwithstanding uncertainties in the acoustic circuit model predictions and the limited data available to validate it, the deliberate power ascension program, coupled with the predicted large-stress margin for the HCGS steam dryer at EPU conditions, provides reasonable assurance that if unexpected vibration modes are induced in the steam dryer, they will be detected and analyzed before further increase in power. However, additional validation of the acoustic circuit model may be needed in other EPU applications in which the steam dryer stress margins may be lower.

The higher decay heat levels at EPU conditions can reduce the available operator response times during accidents. The licensee has made minor changes in the HCGS emergency operating procedures to accommodate EPU modifications. However, no new manual actions or changes in the mitigating strategies and credited operator response times are required.

The HCGS EPU application was not submitted as a risk-informed license application. Nevertheless, PSEG has submitted assessments of risk associated with the HCGS EPU operation. The staff considered this risk information in the decision-making process, primarily to determine if special circumstances exist that could potentially rebut the presumption of adequate protection supported by the compliance of HCGS EPU operation with the deterministic requirements and regulations. The staff has concluded that the proposed HCGS EPU will not create any special circumstances. We concur with the staff's conclusion.

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

Sincerely,

/RA/

William J. Shack
Chairman

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