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

ACRSR-2195

May 22, 2006

The Honorable Nils J. Diaz
Chairman
U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001

SUBJECT: BEAVER VALLEY EXTENDED POWER UPRATE APPLICATION

Dear Chairman Diaz:

During the 532nd meeting of the Advisory Committee on Reactor Safeguards, May 4-5, 2006, we discussed the Extended Power Uprate (EPU) Application for the Beaver Valley Power Station (Beaver Valley), Units 1 and 2 and the associated NRC staff's Safety Evaluation. Our Subcommittee on Power Uprates also discussed this application on April 24-25, 2006. During our review, we had the benefit of discussions with the staff and representatives of FirstEnergy Nuclear Operating Company (FENOC), the licensee. We also had the benefit of the documents referenced.

RECOMMENDATION

The application for a power uprate at Beaver Valley should be approved.

BACKGROUND

FENOC has applied for an upgrade of Beaver Valley Units 1 and 2 from the current power level of 2689 MWt to 2900 MWt, an increase of approximately 8 percent. The uprated power level will be comparable to that of similar units at North Anna, V.C. Summer, Shearon Harris, and Vandellos (Spain). The power increases can be implemented with minor changes in the plant configuration and operating practices.

In anticipation of its power uprate request, FENOC initiated a number of licensing actions. These include an enrichment limit increase for the new fuel storage racks, a slightly positive moderator temperature coefficient at low power, an increase in the boron concentration in the accumulators and refueling water storage tank, selective implementation of the alternative source term model, and a relaxation of the axial offset control requirements. The licensee replaced the reactor vessel head and steam generators in Unit 1 during the outage completed in April 2006. The new steam generator tubes are manufactured from Alloy 690, which has greater corrosion resistance than the Alloy 600 tubes used in the original steam generators. The steam generators in Unit 2 do not require replacement at this time. The additional plant modifications to enable the 8 percent upgrades include replacement of the high-pressure turbines, staking of the Unit 2 main condenser, modifications to the fill at the Unit 2 cooling tower, replacement of the turbine-generator rotors, rewinding of the Unit 1 turbine generator rotors, and modifications to some valves.

The licensee will continue to use the Westinghouse RFA fuel design for the EPU condition. This fuel design is based on a 17x17 assembly with intermediate flow mixing grids. These mixing grids provide enhanced margin to departure from nucleate boiling in the upper portions of the fuel rod. This enhanced cooling capability is part of the reason that the reactor can be operated at uprated conditions with minimal impact on thermal margins for anticipated operational transients. The plant has six operating cycles of experience with these fuel assemblies. The cores of the units have been completely converted to this fuel design.

Safety Analysis Results

The nominal core outlet temperature for Unit 1 will be increased for the EPU condition by 4 ^{o}F to 611 ^{o}F. For Unit 2, the core outlet temperature will be unchanged but the inlet temperature will be reduced by 5 ^{o}F. The core flow rates will be unchanged. On the secondary side, the mass flow rates will increase almost proportionally to the power uprate. The increased primary system temperature could increase the rate of corrosion of components. The increased secondary side flow rate could lead to accelerated corrosion and fluid/structure interactions.

A variety of transients have been analyzed for the EPU condition. The results of these analyses satisfy the regulatory criteria.

A spectrum of loss-of-coolant accidents (LOCA) was analyzed for EPU conditions. For the large-break LOCA, FENOC used a best-estimate methodology. The predicted peak clad temperatures have significant margin to the regulatory limit of 2200 ^{o}F. The limiting quantity of hydrogen generated is close to the regulatory limit of 1 percent but the methodology for calculating hydrogen generation is conservative. Small-break LOCA analyses were also performed for a spectrum of break sizes. The results satisfy regulatory criteria with substantial margin.

In addition to demonstrating compliance with acceptance criteria, analyses were performed to examine the potential for boric acid precipitation in the core region during the long-term cooling phase following a LOCA in the cold leg. As a result of these analyses, changes will be made in the emergency operating procedures to shorten the time at which the operators will initiate hot-leg injection of emergency coolant to flush the core region. With these changes, the analyses indicate that adequate margin to the boron solubility limit will exist.

In our report of February 24, 2005 related to the Waterford 3 uprate, we indicated the need for the staff to develop a better understanding of the properties of highly concentrated boric acid in a boiling system. A more detailed treatment of the thermal-hydraulic conditions within the core region is needed to better define the conditions leading to recirculation and mixing within the vessel and lower plenum. In its response to our letter, the staff stated that this issue should be addressed by the industry as part of satisfying the long-term cooling requirements of 10 CFR 50.46. We look forward to reviewing progress on this issue.

Containment Analysis

The containment systems for both units have been converted to a slightly higher, but still subatmospheric, operating pressure. Containment pressurization calculations that were performed for the design basis LOCA and steam line break confirm that the peak pressure is below the design limit.

For Unit 1, containment overpressure credit has been granted by the staff to provide net positive suction head for the containment spray pumps that recirculate coolant from the containment sump. Containment spray flow through heat exchangers provides long-term removal of heat during a LOCA. The duration of time for which overpressure credit is required is less than 20 minutes. FENOC provided results from tests performed on this pump design that demonstrate an ability to operate for this period without damage. Under EPU conditions, the amount of overpressure and duration of credit required are only slightly increased. We concur with the staff's decision to grant overpressure credit under these conditions. Because of a difference in the location of the pumps in Unit 2, no overpressure credit is required.

Reactor Vessel Integrity

The power uprate will lead to additional fluence and embrittlement of the reactor vessel at the end of life for the two units. Based on results obtained from surveillance capsules, FENOC has estimated the shift in the pressurized thermal shock reference temperature (RT_{PTS}) at the end of extended life. These estimates have been independently confirmed by the staff. The final value of RT_{PTS} for each vessel is less than the pressurized thermal shock screening criterion of 270°F. The upper shelf energies exceed 50 ft-lbs. We conclude that radiation-induced vessel embrittlement is a manageable issue at the power uprate conditions.

Component Vibration

FENOC has performed a systematic assessment of components for which vibration could be induced by higher velocities following the power uprates. The main steam condenser at Unit 2 will be staked; the Unit 1 condenser was staked previously. There is extensive industry operating experience with the steam generators in use at both units for the conditions that will be encountered at Beaver Valley without any indication of vibration-induced failures. The steam dryers in these units are subject to much lower flow velocities than those in boiling water reactors for which flow-induced vibrations have been a power uprate issue. FENOC has committed to performing pre-EPU and post-EPU walkdowns to identify vibration issues should they occur.

Flow-Accelerated Corrosion

FENOC has used the CHECWORKS code to predict the rate of wall thinning that could result from the higher flow rates following the EPU. The predicted changes in corrosion rates are small. These results are used primarily to prioritize monitoring activities. The affected components are on the secondary side of the plant. FENOC has a program in which components with materials that are subject to flow-accelerated corrosion are replaced with chromium-molybdenum steels, as the opportunities arise. Flow-accelerated corrosion under EPU conditions can be effectively managed under the existing monitoring program.

Risk Assessment

The licensee performed quantitative assessments of the changes in risk associated with EPU for internal events, fires, and seismic events for operation at full power. These assessments were confined to changes in core damage frequency (CDF) and the large early release frequency (LERF) and did not consider the impact of the increase in the radioactive inventory on risk. The changes associated with the power uprates at the two Beaver Valley units have very little impact on the CDF and LERF. Changes in the time periods available for critical operator actions were assessed using table-top and simulator exercises. These were then reflected as changes in human error rates in the probabilistic risk assessments. The assessed changes in failure probabilities are small.

Power Ascension and Testing

FENOC has developed a testing plan to assure the proper performance of modified components, settings and controls following power uprate. For each Unit, the power ascension will be performed in three steps. The first step of 3 percent will be made in the current operating cycle for Unit 1 and the next operating cycle for Unit 2. The plant will continue to operate at the 3 percent increased power level until the following refueling outage. In the subsequent outage, the final ascension to full EPU will be performed in two steps of 2.5 percent each. Following each step, the licensee will evaluate the plant operation and determine whether the unit is operating as expected. We concur with the staff's conclusion that large integral transient tests are not warranted.

Summary

The proposed power uprates at Beaver Valley Units 1 and 2 will have very little impact on the manner in which the units are operated. There are no identified areas in which safety margins would be substantially reduced or conflict with regulatory criteria. The Beaver Valley power uprate application should be approved.

Sincerely,

/RA/

Graham B. Wallis
Chairman

References:

1. Memorandum from Catherine Haney to John Larkins, "Beaver Valley Power Station, Unit Nos. 1 and 2 (BVPS-1 and 2) - Revised Draft Safety Evaluation for Proposed Extended Power Uprate (TAC Nos MC4645 and MC4646)," dated April 13, 2006.

2. Letter from L. William Pearce to U.S. Nuclear Regulatory Commission, "Beaver Valley Power Station, Unit No. 1 and No. 2, BV-1 Docket No. 50-334, License No. DPR-66, BV-2 Docket No. 50-412, License No. NPF-73, License Amendment Request Nos. 302 and 173," dated October 4, 2004.

3. Report dated February 24, 2005, from Graham B. Wallis, Chairman, ACRS, to Nils J. Diaz, Chairman, NRC, Subject: Waterford Steam Electric Station, Unit 3 - Extended Power Uprate.

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* See previous concurrence.

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