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

June 19, 2017

The Honorable Kristine Svinicki
Chairman
U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001

SUBJECT: BROWNS FERRY POWER STATION UNITS 1, 2, AND 3 EXTENDED POWER UPRATE LICENSE AMENDMENT REQUEST

Dear Chairman:

During the 644th meeting of the Advisory Committee on Reactor Safeguards, June 7-9, 2017, we completed our review of the extended power uprate (EPU) license amendment request (LAR) for Browns Ferry Nuclear Plant (Browns Ferry), Units 1, 2, and 3, and the associated NRC staff's draft safety evaluation report. Our Subcommittee on Power Uprates also reviewed this matter on May 3, 2017. During these reviews, we benefitted from discussions with representatives of the staff and the Tennessee Valley Authority (TVA or the licensee). We also benefitted from the referenced documents.

RECOMMENDATION AND CONCLUSION

1. The TVA application for the extended power uprate of Browns Ferry, Units 1, 2, and 3, should be approved subject to the license conditions in the staff's draft final safety evaluation.

2. Analyses, tests and monitoring during power ascension, and confirmatory inspections provide reasonable assurance that the Browns Ferry replacement steam dryers will be adequately protected from fatigue failures.

BACKGROUND

Browns Ferry, Units 1, 2, and 3, are boiling water reactor (BWR) plants of the BWR/4 design with Mark I containments. Each unit has a current licensed thermal power (CLTP) of 3,458 MWt. TVA has applied for an EPU that will allow each unit to operate at 3,952 MWt, resulting in a total uprate of 20% from their originally licensed thermal power of 3,293 MWt. During 2018, the licensee plans to start implementing this increase in power, beginning with Unit 3, followed by Units 1 and 2.

In general, the Browns Ferry EPU application follows the guidelines in the NRC-approved General Electric (GE) licensing topical reports for BWR constant pressure power uprates. At the time of EPU implementation, the Browns Ferry units will use AREVA ATRIUM 10XM fuel,

with some legacy ATRIUM 10 fuel. NRC-approved AREVA methods are used to address the effects of EPU conditions on AREVA fuel.

DISCUSSION

A constant pressure power uprate is accomplished by supplying higher steam mass flow to the turbine-generator. The higher steam mass flow is achieved by increasing the reactor power within specified control rod withdrawal and core flow limits. The existing equipment and system capabilities, augmented by improved fuel and core designs and newly installed or modified equipment, will accommodate the higher steam mass flow rate and the resultant power increase. EPU operation does not require increasing the maximum normal operating reactor vessel dome pressure. The plant's modified power generation equipment has sufficient pressure control and turbine flow capability to control turbine inlet pressure conditions.

Several modifications are being implemented to achieve the increased power and improve plant reliability and operating margins. These modifications include:

- replacement steam dryers
- moisture separator upgrades
- main turbine upgrades
- standby liquid control system upgrades
- reactor feedwater pump and turbine upgrades
- feedwater heater upgrades
- an additional condensate demineralizer
- new condensate pump impellers and motors
- main generator and generator auxiliaries upgrades
- revised instrumentation set points and
- enhancements to the installed hardened wetwell vents

Browns Ferry operates in the maximum extended load line limit analysis operating domain. Additional energy requirements for the EPU are met by increases in bundle enrichment, increases in the reload fuel batch size, and changes in fuel loading pattern to maintain the desired plant operating cycle length. Analyses are used to assure that the requisite core and fuel design limits are met for a representative equilibrium core design at EPU conditions and for cycle-specific reload core evaluations.

TVA 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. AREVA assisted in evaluations requiring fuel-specific input, such as flow-induced vibration effects on fuel assemblies and neutron fluence effects on the reactor pressure vessel. The staff concluded that degradation mechanisms will be managed adequately.

As part of this EPU, tests similar to some of the original startup tests will be performed. The Browns Ferry power ascension test plan does not include large transient tests at full EPU power. Such tests are unnecessary because of applicable relevant transients at other uprated BWRs similar in design, transients that previously occurred at Browns Ferry, and large transient tests that were completed during initial startup of Browns Ferry.

Containment Accident Pressure (CAP) Evaluation

The current Browns Ferry licensing basis relies on the use of CAP to ensure sufficient net positive suction head for the emergency core cooling system pumps following LOCAs and other transient events. An EPU increases reactor decay heat, which increases heat transferred to the suppression pool during accidents, transients, and special events. This would require an increase in CAP credit.

As part of this application, however, TVA eliminated their current reliance on CAP credit by considering the effects of planned EPU modifications and known performance of plant systems and components. TVA performed their EPU containment analysis following the guidance in Regulatory Guide 1.82, Revision 3 and SECY-11-0014. The EPU analysis predicted less integral heat being deposited in the suppression pool by considering the planned increase of the isotopic enrichment of Boron-10 in the standby liquid control system and a more realistic evaluation of the rate that this system injects into the reactor pressure vessel. Based on Browns Ferry operating experience, TVA reduced conservatisms in the fouling factor for the residual heat removal heat exchanger, increasing its analyzed heat transfer capability. The analysis also included more realistic assumptions for high pressure coolant injection operation and the performance of the containment spray and residual heat removal pumps. TVA performed sensitivity studies to provide confidence that CAP credit was not needed.

The staff reviewed the TVA analysis and concluded that changes in input parameters were justified or were more conservative than values selected for the current licensing basis analyses. Staff imposed a license condition to monitor heat exchanger fouling resistance and tube plugging to ensure that the assumed heat exchanger effectiveness continues to remain valid.

Replacement Steam Dryer (RSD)

Steam dryers in operating BWRs have experienced vibration fatigue damage when steam flow was increased as part of power uprates. 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 other plant equipment. To address this concern, TVA plans to replace the steam dryer in each unit. The average velocity in the main steam line at EPU conditions will be 161 feet per second (nearly 16% higher than the average velocity at CLTP conditions). Although this higher value is comparable to velocities at some EPU plants, it is lower than the velocities at most BWRs that have received EPUs.

The Browns Ferry RSDs are curved hood six-bank designs based upon a dryer that was installed in a BWR/4 with similar operating conditions (the prototype for the Browns Ferry RSDs). The design was evaluated using a model to determine dynamic pressure loads on the steam dryer due to acoustic resonances in the main steam line and a detailed finite element structural analysis to estimate peak stresses in the dryer. The analyses will be validated based on main steam line strain gauge data during power ascension on all three units. The analysis methodology will be benchmarked using data from strain gauges, pressure transducers, and accelerometers installed on the Unit 3 dryer (the lead EPU unit). TVA and the staff have determined that the RSDs and piping configurations are sufficiently similar such that on-dryer instrumentation of Units 1 and 2 is unnecessary.

The staff has imposed a license condition as part of the proposed EPU for Unit 3 that requires a review of the benchmarking data collected at or near CLTP conditions during initial power

ascension before proceeding to EPU conditions. The RSDs on all three units will also be inspected during the first two scheduled refueling outages after reaching EPU conditions. The inspection plan will include all accessible critical locations identified in the vibration and stress analyses.

The Browns Ferry license conditions are similar to those imposed on other licensees during power ascension to monitor steam dryer structural integrity. The power ascension program, the large margin in predicted stress, and confirmatory inspections provide reasonable assurance that unexpected vibration modes will be detected and analyzed prior to further increases in power and that the dryers at all three units will be adequately protected from fatigue failures.

SUMMARY

There is reasonable assurance that operation of Browns Ferry, Units 1, 2, and 3, at the proposed EPU power level will present no undue risk to public health and safety. The TVA LAR for the Browns Ferry EPU should be approved subject to the license conditions in the staff's draft final safety evaluation.

Dr. March-Leuba did not participate in the Committee's deliberations regarding this matter.

Sincerely,

/RA/

Dennis Bley
Chairman

REFERENCES

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9. U.S. Nuclear Regulatory Commission, RS-001, “Review Standard for Extended Power Uprate,” Revision 0, December 2003 (ML033640024).

10. U.S. Nuclear Regulatory Commission, SECY-11-0014, “Use of Containment Accident Pressure in Analyzing Emergency Core Cooling System and Containment Heat Removal System Pump Performance in Postulated Accidents,” January 31, 2011 (ML102780586).

11. U.S. Nuclear Regulatory Commission, Regulatory Guide 1.82, “Water Sources for Long-Term Recirculation Cooling Following a Loss-of-Coolant Accident,” Revision 3, November 2003 (ML033140347).

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