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

ACRSR-2114

February 24, 2005

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

SUBJECT: WATERFORD STEAM ELECTRIC STATION, UNIT 3 - EXTENDED POWER UPRATE

Dear Chairman Diaz:

During the 519th meeting of the Advisory Committee on Reactor Safeguards, February 10-11, 2005, we met with representatives of the NRC staff and Entergy to review the utility's license amendment request for an increase in core thermal power for the Waterford Steam Electric Station, Unit 3. Our Subcommittee on Thermal-Hydraulic Phenomena also reviewed this matter during its meeting on January 26, 2005. During our review, we had the benefit of the documents referenced.

CONCLUSIONS AND RECOMMENDATIONS

1. The application by Entergy for an 8% extended power uprate (EPU) at Waterford 3 should be approved, subject to (1) the staff's approval of the alternate source term (AST) application and (2) documentation of the resolution of the boron precipitation issue during long-term cooling for Waterford 3 by the submittal of the analysis details and their acceptance in the staff's safety evaluation (SE).

2. We agree with the staff that the requirement for large-transient testing should be waived for this application.

3. The staff should review the generic potential for boron concentration and precipitation to interfere with core cooling following a loss-of-coolant accident (LOCA).

DISCUSSION

Waterford 3 was originally licensed on March 16, 1985, at 3390 MWt. The current licensed power level of 3441 MWt includes a 1.5% measurement uncertainty uprate authorized on March 29, 2002. The present uprate request

would raise the power 8% above the current level to 3716 MWt. The licensee plans to make all the changes during one outage and implement the uprate early in 2005, as soon as approval is received.

The Waterford uprate application follows a methodology similar to the one for the Arkansas Nuclear One, Unit 2, uprate, approved on April 24, 2002. This is the first application for which the staff has used the new uprate review standard (RS-001). The staff's review has been comprehensive and the rationale for the staff's decisions is clear in the SE.

The power uprate will be achieved by small changes in the hot and cold leg temperatures and in the circulating flow rate in the primary circuit. The operating pressure will not be changed. There will be an increase in the steam and feedwater flow rate on the secondary side. The number of fuel assemblies to be replaced at each refueling will increase roughly in proportion to the power uprate.

There will also be some modifications to balance-of-plant equipment. For example, the high-pressure turbine will be upgraded and higher capacity installed in the generator, switchgear, and main transformers, as needed. Condenser tubes will be stiffened to accommodate the higher steam flow.

To meet the control room habitability requirements, the licensee needs approval of an AST. The AST application is under review with scheduled completion by March, 2005. Although the Committee did not review the AST application, the staff anticipates a successful review.

In response to the licensee's request, the staff proposes to waive the requirement for large-transient testing at the new power level. The licensee will carry out a testing program for each of the planned modifications. Interactions among the modifications have been investigated through analytical modeling. The licensee argues that an integral large-transient test will not provide significant additional information. The staff believes that the proposed test program and previous operating experience will meet the objectives of confirming the functionality of equipment, codes and models, and emergency operating procedures. The potential value of a large-transient test is insufficient to justify imposing a trip event on the plant and the electrical grid.

Because of the increased steam flow associated with the power uprate, we sought evidence that the steam dryers would operate successfully. The licensee provided a detailed description of the construction and operation of these dryers. The flow rates and operating conditions expected after the power uprate are

within the range previously tested, and the dynamic loads are lower than have been experienced, without untoward occurrences, at Palo Verde, where the dryer units and their supports are substantially the same as at Waterford. There is therefore a reasonable expectation that the dryers will operate successfully following the proposed power uprate.

The matter of boron concentration during long-term cooling was discussed during the Subcommittee meeting. The staff and licensee positions had not yet been resolved. We have since heard presentations from both the staff and the licensee.

The licensee and the staff have demonstrated by conservative analyses that there exists, at Waterford, a significant margin to the boron solubility limit. The final resolution of this issue needs to be documented in a revision to the application and in the SE.

These analyses provided assurance that long-term cooling can be successfully achieved at Waterford. However, there may be generic issues, not specific to power uprates, that are related to the precipitation of boric acid and its effects on long-term core cooling. Although the BACCHUS test results suggest that mixing may occur between the core and lower plenum and reduce the boron concentration in the core, there is no quantification of the mechanisms nor an assessment of how applicable the results are to the general case.

In discussing the boron precipitation issue, we also became aware that there is not a good technical basis for evaluating the properties of a boron-water mixture, together with chemicals added from the containment sump, when the concentration is close to the solubility limit. As this mixture boils, the solute may accumulate at the surface of bubbles and significantly change hydraulic properties such as the drift flux and foamability.

Our discussions also revealed that there is not a good understanding of the deposition of boron on the overheated portions of the fuel rods, which are predicted to be exposed for up to 45 minutes during some small-break LOCAs. Splashes and droplets of borated water may be deposited on the exposed fuel rods and spacer grids and the water will evaporate, leaving boric acid deposits that will decompose at the prevailing temperature to form dry boric oxide. We encourage the staff to establish a basis for a quantitative assessment of these phenomena as it considers the potential for boron concentration and precipitation to interfere with core cooling following a LOCA.

Additional comments by ACRS Members Stephen L. Rosen and F. Peter Ford are provided below.

Sincerely,

/RA/

Graham B. Wallis
Chairman

Additional Comments by ACRS Members Stephen L. Rosen and F. Peter Ford:

The licensee has argued that while integral large-transient tests (main turbine trip and generator breaker opening at 100% power) are safe, they are unnecessary. The licensee relies on computer modeling and previous operating experience at 100% (92% EPU) conditions to justify elimination of these tests.

Since integral tests of a plant's response to transient initiators can reveal otherwise undetected flaws, these tests should be conducted to confirm that plant modifications made to support the upgrades have been installed as designed and function properly in an integrated manner to bring the plant to safe and stable conditions. We are not convinced by the licensee's arguments and the staff's conclusion that integral tests are not necessary. An initial startup testing program limited to 92% of full power would not have been adequate. Similarly, we believe that approval of the EPU application should be conditioned on the successful completion of integral large-transient tests (main turbine trip and generator breaker opening at 100% power) shortly after reaching EPU conditions.

References:

1. Memorandum from Herbert N. Berkow to Ralph Caruso, dated January 10, 2005, "Waterford Steam Electric Station, Unit 3 (Waterford 3) - Draft Safety Evaluation (Version 2) for the Proposed Extended Power Uprate
2. Amendment Request NPF-38-249, Extended Power Uprate Waterford Steam Electric Station, Unit 3 Docket No. 50-382 License No. NPF-38, dated November 13, 2003
3. Supplement to Amendment Request NPF-38-249, Extended Power Uprate Waterford Steam Electric Station, Unit 3 Docket No. 50-382 License No. NPF-38, dated January 29, 2004

References (continued)

4. Supplement to Amendment Request NPF-38-249, Extended Power Uprate Waterford Steam Electric Station, Unit 3 Docket No. 50-382 License No. NPF-38, dated March 4, 2004
5. Supplement to Amendment Request NPF-38-249, Extended Power Uprate Waterford Steam Electric Station, Unit 3 Docket No. 50-382 License No. NPF-38, dated April 15, 2004
6. Supplement to Amendment Request NPF-38-249, Extended Power Uprate Waterford Steam Electric Station, Unit 3 Docket No. 50-382 License No. NPF-38, dated May 7, 2004
7. Supplement to Amendment Request NPF-38-249, Extended Power Uprate Waterford Steam Electric Station, Unit 3 Docket No. 50-382 License No. NPF-38, dated May 12, 2004
8. Supplement to Amendment Request NPF-38-249, Extended Power Uprate Waterford Steam Electric Station, Unit 3 Docket No. 50-382 License No. NPF-38, dated May 13, 2004
9. Supplement to Amendment Request NPF-38-249, Extended Power Uprate Waterford Steam Electric Station, Unit 3 Docket No. 50-382 License No. NPF-38, dated May 21, 2004
10. Supplement to Amendment Request NPF-38-249, Extended Power Uprate Waterford Steam Electric Station, Unit 3 Docket No. 50-382 License No. NPF-38, dated May 26, 2004
11. Supplement to Amendment Request NPF-38-249, Extended Power Uprate Waterford Steam Electric Station, Unit 3 Docket No. 50-382 License No. NPF-38, dated July 14, 2004
12. Supplement to Amendment Request NPF-38-249, Extended Power Uprate Waterford Steam Electric Station, Unit 3 Docket No. 50-382 License No. NPF-38, dated July 15, 2004
13. Supplement to Amendment Request NPF-38-249, Extended Power Uprate Waterford Steam Electric Station, Unit 3 Docket No. 50-382 License No. NPF-38, dated July 28, 2004
14. Supplement to Amendment Request NPF-38-249, Extended Power Uprate Waterford Steam Electric Station, Unit 3 Docket No. 50-382 License No. NPF-38, dated August 10, 2004
15. Supplement to Amendment Request NPF-38-249, Extended Power Uprate Waterford Steam Electric Station, Unit 3 Docket No. 50-382 License No. NPF-38, dated August 19, 2004
16. Supplement to Amendment Request NPF-38-249, Extended Power Uprate Waterford Steam Electric Station, Unit 3 Docket No. 50-382 License No. NPF-38, dated August 25, 2004

References (continued)

17. Supplement to Amendment Request NPF-38-249, Extended Power Uprate Waterford Steam Electric Station, Unit 3 Docket No. 50-382 License No. NPF-38, dated September 1, 2004
18. Supplement to Amendment Request NPF-38-249, Extended Power Uprate Waterford Steam Electric Station, Unit 3 Docket No. 50-382 License No. NPF-38, dated September 14, 2004
19. Supplement to Amendment Request NPF-38-249, Extended Power Uprate Waterford Steam Electric Station, Unit 3 Docket No. 50-382 License No. NPF-38, dated October 8, 2004
20. Supplement to Amendment Request NPF-38-249, Extended Power Uprate Waterford Steam Electric Station, Unit 3 Docket No. 50-382 License No. NPF-38, dated October 8, 2004
21. Supplement to Amendment Request NPF-38-249, Extended Power Uprate Waterford Steam Electric Station, Unit 3 Docket No. 50-382 License No. NPF-38, dated October 13, 2004
22. Supplement to Amendment Request NPF-38-249, Extended Power Uprate Waterford Steam Electric Station, Unit 3 Docket No. 50-382 License No. NPF-38, dated October 18, 2004
23. Supplement to Amendment Request NPF-38-249, Extended Power Uprate Waterford Steam Electric Station, Unit 3 Docket No. 50-382 License No. NPF-38, dated October 19, 2004
24. Supplement to Amendment Request NPF-38-249, Extended Power Uprate Waterford Steam Electric Station, Unit 3 Docket No. 50-382 License No. NPF-38, dated October 21, 2004
25. Supplement to Amendment Request NPF-38-249, Extended Power Uprate Waterford Steam Electric Station, Unit 3 Docket No. 50-382 License No. NPF-38, dated October 29, 2004
26. Supplement to Amendment Request NPF-38-249, Extended Power Uprate Waterford Steam Electric Station, Unit 3 Docket No. 50-382 License No. NPF-38, dated October 29, 2004
27. Supplement to Amendment Request NPF-38-249, Extended Power Uprate Waterford Steam Electric Station, Unit 3 Docket No. 50-382 License No. NPF-38, dated November 4, 2004
28. Supplement to Amendment Request NPF-38-249, Extended Power Uprate Waterford Steam Electric Station, Unit 3 Docket No. 50-382 License No. NPF-38, dated November 8, 2004
29. Supplement to Amendment Request NPF-38-249, Extended Power Uprate Waterford Steam Electric Station, Unit 3 Docket No. 50-382 License No. NPF-38, dated November 16, 2004
30. Supplement to Amendment Request NPF-38-249, Extended Power Uprate Waterford Steam Electric Station, Unit 3 Docket No. 50-382 License No. NPF-38, dated November 19, 2004

References (continued)

31. Review and Evaluation of MHI BACCHUS PWR Vessel Mixing Tests, WCAP-16317-P, November 2004 (Proprietary)
32. Memorandum from Herbert Berkow to Ralph Caruso, “Waterford Steam Electric Station, Unit 3 (Waterford 3) - Prevention of Boric Acid Precipitation in a Post-LOCA Long Term Cooling Mode for the Proposed Extended Power Uprate”, February 1, 2005 (Proprietary)
33. J. Tuunanen, H. Tuomisto, and P. Raussi, “Experimental and Analytical Studies of Boric Acid Concentrations in a VVER-440 Reactor during the Long-term Cooling Period of Loss-of-Coolant Accidents”, Nuclear Engineering and Design 148 (1994) 217-231