Entergy Nuclear South
Entergy Operations, Inc.
17265 River Road
Killona, LA 70057
Tel 504-739-6310
Fax 504-739-6698
tmitch1@entergy.com

W3F1-2005-0012

Timothy G. Mitchell
Director, Engineering
Waterford 3

February 16, 2005

U.S. Nuclear Regulatory Commission
Attn: Document Control Desk
Washington, DC 20555

SUBJECT: Supplement to Amendment Request NPF-38-249
Extended Power Uprate
Waterford Steam Electric Station, Unit 3
Docket No. 50-382
License No. NPF-38

REFERENCES:

1. Entergy Letter dated November 13, 2003, "License Amendment Request NPF-38-249 Extended Power Uprate"
2. Entergy Letter dated February 5, 2005, "Supplement to Amendment Request NPF-38-249 Extended Power Uprate"
3. Entergy Letter dated July 28, 2004, "Supplement to Amendment Request NPF-38-249 Extended Power Uprate"
4. Entergy Letter dated July 14, 2004, "Supplement to Amendment Request NPF-38-249 Extended Power Uprate"

Dear Sir or Madam:

By letter (Reference 1), Entergy Operations, Inc. (Entergy) proposed a change to the Waterford Steam Electric Station, Unit 3 (Waterford 3) Operating License and Technical Specifications to increase the unit's rated thermal power level from 3441 megawatts thermal (MWt) to 3716 MWt.

By letter (Reference 2), Entergy submitted a supplemental evaluation for the post loss of coolant accident (LOCA) long-term cooling boric acid precipitation analysis in response to the staff's concern regarding the use of a collapsed water volume (i.e., did not account for voiding in the core) for the mixing volume credited in the analysis results presented in Reference 1, Attachment 5, Section 2.12.5. On February 9, 2005, Entergy and members of the staff discussed the need for Entergy to submit an updated licensing basis for boric acid precipitation based on information contained in Reference 2. As discussed with the staff, the updated licensing basis will account for voiding and will credit 50% lower plenum mixing, mixing of the boric acid makeup tank (BAMT) and refueling water storage pool (RWSP) contents, and an increased boric acid solubility limit due to the presence of trisodium phosphate. The updated licensing basis is provided in the attachment to this letter and supersedes the boric acid precipitation licensing basis analysis previously submitted in Reference 1.

Information in the attachment to this letter also supersedes information provided in the responses to Questions 12 and 13 in Reference 3. While the updated licensing basis will

A001

continue to credit the initiation of simultaneous hot and cold leg injection between two and three hours, the supporting basis is revised (reference the attachment to this letter) from that provided in response to Question 13 in Reference 3.

The no significant hazards consideration discussion included in Reference 4 is not affected by any information contained in the supplemental letter. There are no new commitments contained in this letter.

If you have any questions or require additional information, please contact D. Bryan Miller at 504-739-6692.

I declare under penalty of perjury that the foregoing is true and correct. Executed on February 16, 2005.

Sincerely,

TGM/DBM/cbh

Attachment: Updated Licensing Basis for Boric Acid Precipitation Analysis

cc: Dr. Bruce S. Mallett
U. S. Nuclear Regulatory Commission
Region IV
611 Ryan Plaza Drive, Suite 400
Arlington, TX 76011

NRC Senior Resident Inspector
Waterford 3
P.O. Box 822
Killona, LA 70066-0751

U.S. Nuclear Regulatory Commission
Attn: Mr. Nageswaran Kalyanam MS O-7D1
Washington, DC 20555-0001

Wise, Carter, Child & Caraway
Attn: J. Smith
P.O. Box 651
Jackson, MS 39205

Winston & Strawn
Attn: N.S. Reynolds
1400 L Street, NW
Washington, DC 20005-3502

Louisiana Department of Environmental Quality
Office of Environmental Compliance
Surveillance Division
P. O. Box 4312
Baton Rouge, LA 70821-4312

American Nuclear Insurers
Attn: Library
Town Center Suite 300S
29th S. Main Street
West Hartford, CT 06107-2445

Attachment

To

W3F1-2005-0012

Updated Licensing Basis for Boric Acid Precipitation Analysis

Updated Licensing Basis for Boric Acid Precipitation Analysis

1.0 Introduction

This report describes the Waterford Steam Electric Station, Unit 3 (Waterford 3) Extended Power Uprate (EPU) post-Loss-of-Coolant Accident (LOCA) boric acid precipitation analysis. The analysis (herein referred to as the updated licensing basis analysis) supersedes the original boric acid precipitation analysis that was part of the post-LOCA long-term cooling analysis described in the Waterford 3 EPU license amendment request (Reference 1).

During the NRC's review of the original boric acid precipitation analysis, the NRC staff requested additional information regarding the mixing volume used in the analysis. In particular, the NRC staff questioned the use of a mixing volume that did not explicitly account for the voids present in the core and outlet plenum of the reactor vessel following the postulated LOCA. In response to the request, Entergy Operations, Inc. (Entergy) provided supplemental information (Enclosure 1 to Reference 2). The supplemental information demonstrated that the results of the original EPU boric acid precipitation analysis are conservative relative to the results of an analysis that explicitly accounts for voids in the core and outlet plenum. The supplemental information compensates for the adverse impact of accounting for voids by modifying several conservative features of the original EPU boric acid precipitation analysis.

In subsequent discussions between the NRC and Entergy, the NRC staff requested that Entergy resubmit a revised licensing basis boric acid precipitation analysis for the Waterford 3 EPU based on the analyses described in the supplemental information provided in Enclosure 1 to Reference 2. This report provides that analysis.

The purpose of the updated boric acid precipitation analysis is to demonstrate, in conjunction with the decay heat removal portion of the original Waterford 3 EPU post-LOCA long-term cooling analysis (Reference 1), that Waterford 3 conforms to Criterion 5 of the Emergency Core Cooling System (ECCS) acceptance criteria (Reference 3). The analysis was performed at the rated core power of 3716 MWt (3735 MWt including the power measurement uncertainty). The results of the updated boric acid precipitation analysis demonstrate conformance to Criterion 5 by showing that the maximum boric acid concentration in the core remains below the boric acid solubility limit.

The following sections of this report describe the method of analysis, important plant design data used in the analysis, and the results and conclusions of the updated licensing basis boric acid precipitation analysis.

2.0 Methodology

The original Waterford 3 EPU boric acid precipitation analysis used the Westinghouse post-LOCA long-term cooling evaluation model for Combustion Engineering Pressurized Water Reactors (PWRs), CENPD-254-P-A (Reference 4). The updated licensing basis boric acid precipitation analysis implements three changes to the original Waterford 3 EPU boric acid precipitation analysis. The three changes, which were also included in the analysis described in the supplemental information (Attachment 3 to Enclosure 1 of Reference 2), are described below.

1. Mixing Volume

The mixing volume used in the original Waterford 3 EPU boric acid precipitation analysis consisted of the reactor vessel volume from the core support plate to the bottom of the hot legs in the axial direction and, in the radial direction, inside the core baffle, and above the core baffle, inside the core barrel. In the updated boric acid precipitation analysis described herein the mixing volume consists of the following:

- 50% of the volume of the lower plenum. A summary of the results of Mitsubishi Heavy Industries' BACCHUS mixing tests (Attachment 1 to Enclosure 1 of Reference 2) documents the basis for crediting the participation of the lower plenum in the mixing volume. As noted in the summary, the BACCHUS test facility is suitable for simulating post-LOCA boric acid mixing in the lower plenum and core of a PWR. Additionally, the test results show that most of the lower plenum participates in the mixing process. Therefore, crediting 50% participation of the lower plenum volume is conservative relative to the test results.

- The liquid volume in the core and outlet plenum up to the elevation of the top of the hot legs. The liquid volume in the core is calculated using the CEFLASH-4AS phase separation model (References 5 and 6). The liquid volume in the outlet plenum is calculated by applying the core-to-outlet plenum area ratio to the core exit void fraction, which is calculated using the CEFLASH-4AS phase separation model.

The addition of 50% of the lower plenum volume and the loss in liquid volume due to accounting for voids in the core and outlet plenum resulted in a net decrease of 100 ft^3 in the value of the mixing volume. Specifically, the value of the mixing volume used in the updated analysis decreased to 1046 ft^3 from the value of 1146 ft^3 used in the original EPU boric acid precipitation analysis.

2. Solubility Limit of Boric Acid

The original Waterford 3 EPU boric acid precipitation analysis used a boric acid solubility limit of 27.6 wt%. This is the solubility limit in a binary solution of water and boric acid at 212°F and 14.7 psia (Figure C-3 of CENPD-254-P-A, Reference 4).

The updated analysis uses a boric acid solubility limit of 36 wt%. This is the solubility limit in a ternary solution of water, boric acid, and trisodium phosphate that is boiling at atmospheric pressure. Attachment 2 to Enclosure 1 of Reference 2 describes the basis for this value. Note that the increase in the solubility limit due to the containment and Reactor Coolant System (RCS) pressures being greater than atmospheric pressure is not credited.

3. Treatment of BAMT Inventory

In accordance with Item 3 on page C-2 of Reference 4, the CENPD-254-P-A evaluation model assumes that the inventory of the Boric Acid Makeup Tanks (BAMTs) is directly deposited in the mixing volume before any consideration is given to other sources of boric acid. In other words, it is assumed that there is no loss of the BAMT inventory out the broken cold leg due to either (1) injection of BAMT inventory into the broken cold leg or (2) spillage of BAMT inventory injected into the three intact cold legs that subsequently flows through the downcomer to the broken cold leg.

In the updated boric acid precipitation analysis, the BAMT inventory, which is injected via the charging pumps, is assumed to mix in the intact cold legs with the safety injection pump flow from the Refueling Water Storage Pool (RWSP). The resultant mixture then supplies the flow to the mixing volume with the excess spilling to the containment sump. This modification is implemented by changing the BORON computer code inputs for the boric acid concentrations of the BAMTs and RWSP to the mixed mean concentration of these two sources.

During the discussions between the NRC staff and Entergy, it was stated that the change to the definition of the mixing volume is not considered a change to the CENPD-254-P-A evaluation model. Instead, it is considered a change to a non-conservative input used in the original EPU boric acid precipitation analysis. CENPD-254-P-A does not explicitly define the portion of the reactor vessel that constitutes the mixing volume. Rather, it states that the boric acid precipitation analysis uses a constant input value for the mixing volume that is "conservatively determined" (Reference 4, Amendment 1, page 20). As described above, the changes to the solubility limit of boric acid and to the treatment of the BAMT inventory are changes to the CENPD-254-P-A evaluation model.

The updated licensing basis boric acid precipitation analysis was performed with the BORON computer code (Reference 4, Appendix C). No modifications were made to BORON in implementing the changes to the analysis methodology described above.

3.0 Plant Design Data

No changes to the plant design data used in the original Waterford 3 EPU boric acid precipitation analysis were made in performing the updated boric acid precipitation analysis. Table 1 lists the important plant design data, excerpted from Table 2.12-12 of Reference 1, that are used in the updated boric acid precipitation analysis.

4.0 Results

The updated licensing basis post-LOCA boric acid precipitation analysis determined that a minimum flow rate of 372 gpm from a High Pressure Safety Injection (HPSI) pump to both the hot and cold legs of the RCS, initiated between two and three hours post-LOCA, maintains the boric acid concentration in the core below the solubility limit of 36 wt% for the limiting break, i.e., a large cold leg break. The analysis also determined that the potential for entrainment of the hot leg injection by the steam flowing in the hot legs ends prior to two hours post-LOCA.

Figure 1 compares the core boiloff rate with the minimum simultaneous hot and cold leg injection flow rate of 372 gpm. It shows that the initiation of 372 gpm of hot and cold leg injection at three hours post-LOCA provides a substantial and time-increasing flushing flow through the core. Figure 2 presents the core boric acid concentration as a function of time for the limiting break. It shows that without simultaneous hot and cold leg injection, the boric acid concentration in the core exceeds the solubility limit at approximately 7.2 hours post-

LOCA. When 372 gpm of simultaneous hot and cold leg injection is initiated at three hours post-LOCA, the maximum boric acid concentration in the core is 20.57 wt%, a margin of more than 15 wt% to the solubility limit of 36 wt%. Figure 2 also shows that a flushing flow rate of 25 gpm started by three hours post-LOCA is sufficient to prevent the core boric acid concentration from reaching the solubility limit.

Additional margin to the solubility limit exists that is not considered in this updated licensing basis analysis.

- Entrainment that would carry boric acid out of the core is not considered.
- The conservative assumptions for decay heat and steam generation described in CENPD-254-P-A continue to be used rather than more realistic decay heat values.
- Calculations show that the containment pressure will be greater than 20 psia between two and three hour post-LOCA. Reactor core pressure will be somewhat above that due to the pressure drop through the RCS to the break location. This higher pressure increases the solubility limit by approximately 4 wt%.

These additional conservatisms have not been credited in the updated licensing basis analysis; therefore, the results remain conservative relative to the potential for boric acid precipitation.

The time of three hours post-LOCA for initiating simultaneous hot and cold leg injection maintained 4 wt% margin to the solubility limit in the original Waterford 3 EPU boric acid precipitation analysis. Maintaining the same margin to the solubility limit in the updated analysis would allow a later time for initiating simultaneous hot and cold leg injection. Despite this fact, the maximum time of three hours post-LOCA for this action is not changed in the updated analysis.

5.0 Conclusions

The results of the Waterford 3 EPU updated licensing basis boric acid precipitation analysis demonstrate that the maximum boric acid concentration in the core remains below the boric acid solubility limit when a simultaneous hot and cold side injection minimum flow rate of 372 gpm is initiated between two and three hours post-LOCA. Consequently, the updated analysis, in conjunction with the decay heat removal portion of the original Waterford 3 EPU post-LOCA long-term cooling analysis, demonstrates that Waterford 3 conforms to Criterion 5 of the ECCS acceptance criteria at the rated core power of 3716 MWt (3735 MWt including the power measurement uncertainty).

6.0 References

1. Entergy Letter W3F1-2003-0074, J.E. Venable (Entergy) to Document Control Desk (NRC), "License Amendment Request NPF-38-249, Extended Power Uprate, Waterford Steam Electric Station, Unit 3, Docket No. 50-382, License No. NPF-38," November 13, 2003.

2. Entergy Letter W3F1-2005-0007, R.A. Dodds (Entergy) to Document Control Desk (NRC), "Supplement to Amendment Request NPF-38-249, Extended Power Uprate, Waterford Steam Electric Station, Unit 3, Docket No. 50-382, License No. NPF-38," February 5, 2005.

3. Code of Federal Regulations, Title 10, Part 50, Section 50.46, "Acceptance Criteria for Emergency Core Cooling Systems for Light Water Nuclear Power Reactors."

4. CENPD-254-P-A, "Post-LOCA Long Term Cooling Evaluation Model," June 1980.

5. CENPD-137P, "Calculative Methods for the C-E Small Break LOCA Evaluation Model," August, 1974.

6. CENPD-137, Supplement 1-P, "Calculative Methods for the C-E Small Break LOCA Evaluation Model," January 1977.

Table 1

**Post-LOCA Boric Acid Precipitation Analysis
Core and Plant Design Data**

Quantity	Value	Units
Reactor power level (including uncertainty)	3735	MWt
RCS liquid mass	480,000	lbm
Initial RCS boron concentration	2000	ppm
Boric acid makeup tanks (BAMTs)		
liquid volume, total	22,920	gal
boric acid concentration	6187	ppm
Refueling water storage pool (RWSP)		
liquid volume	548,016	gal
boron concentration	3000	ppm
Safety injection tanks		
number	4	—
liquid volume per tank	1886	ft^3
boron concentration	3000	ppm
Charging pumps		
number	3	—
flow rate per pump	44	gpm
Flow rates for emptying the RWSP		
HPSI pump flow rate	770	gpm
LPSI pump flow rate	4084	gpm
CS pump flow rate	1750	gpm

Figure 1
Post-LOCA Long-Term Cooling Analysis
Comparison of Core Boiloff Rate and Minimum
Simultaneous Hot and Cold Leg Injection Flow Rate

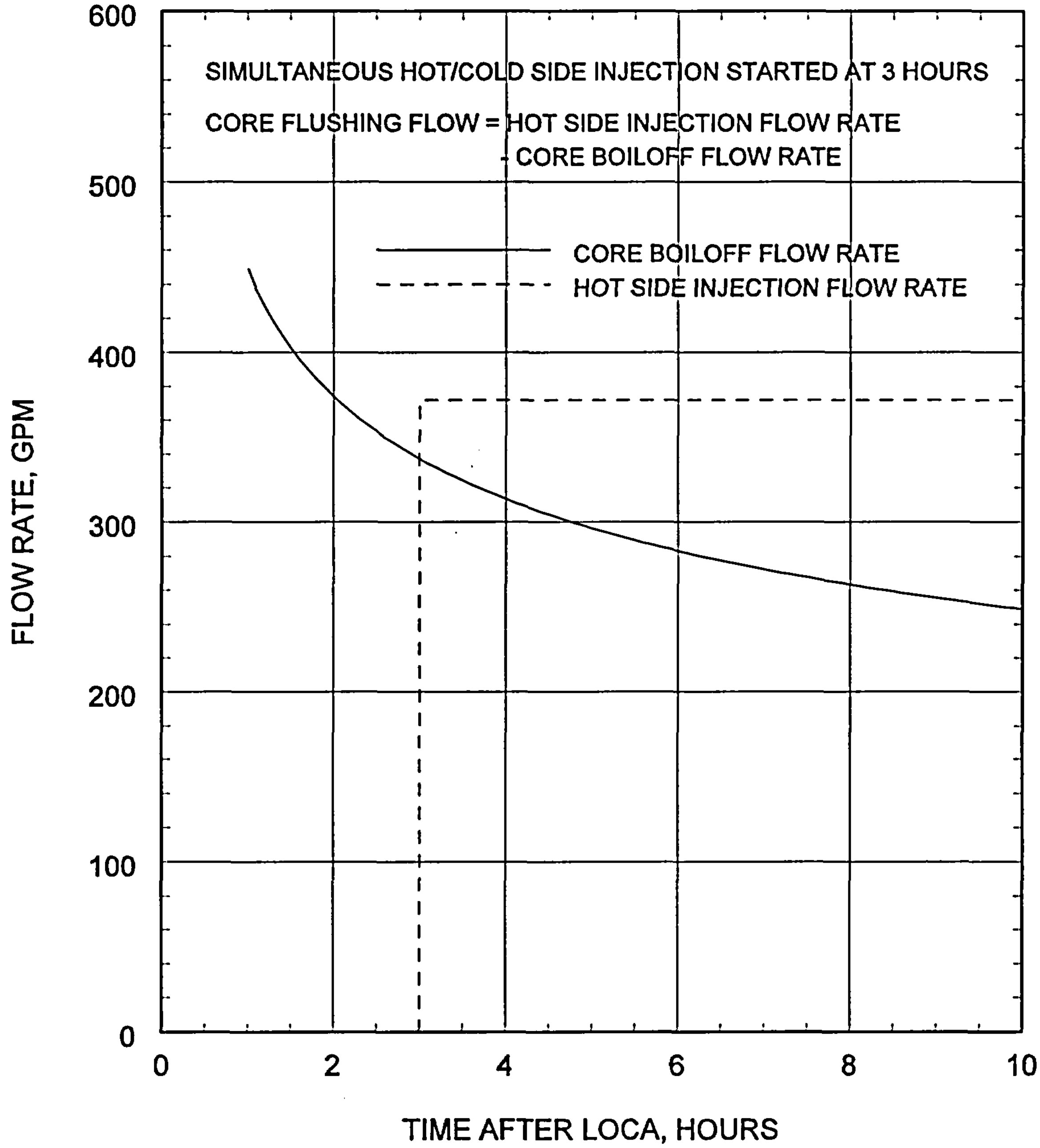

Figure 2
Post-LOCA Long-Term Cooling Analysis
Boric Acid Concentration in the Core Versus Time