~~Proprietary Information and Critical Energy Infrastructure Information~~
~~Withhold from Public Disclosure Under 10 CFR 2.390~~
~~This letter is decontrolled when separated from Enclosures 1 and 3~~

Tennessee Valley Authority, 1101 Market Street, Chattanooga, Tennessee 37402

CNL-16-023

February 16, 2016

10 CFR 50.90

ATTN: Document Control Desk
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555-0001

Browns Ferry Nuclear Plant, Units 1, 2, and 3
Renewed Facility Operating License Nos. DPR-33, DPR-52, and DPR-68
NRC Docket Nos. 50-259, 50-260, and 50-296

Subject: **Proposed Technical Specifications (TS) Change TS-505 - Request for License Amendments - Extended Power Uprate (EPU) - Supplement 4, Responses to Requests for Additional Information**

References:
1. Letter from TVA to NRC, CNL-15-169, "Proposed Technical Specifications (TS) Change TS-505 - Request for License Amendments - Extended Power Uprate (EPU)," dated September 21, 2015 (ML15282A152)
2. Letter from NRC to TVA, "Browns Ferry Nuclear Plant, Units 1, 2, and 3 - Request for Additional Information Related to License Amendment Request Regarding Extended Power Uprate (CAC Nos. MF4851, MF4582, and MF4853)," dated January 28, 2016 (ML16019A283)
3. Letter from NRC to TVA, "Browns Ferry Nuclear Plant, Units 1, 2, and 3 - Request for Additional Information Related to License Amendment Request Regarding Extended Power Uprate (CAC Nos. MF4851, MF4582, and MF4853)," dated January 28, 2016 (ML16020A111)

By the Reference 1 letter dated September 21, 2015, Tennessee Valley Authority (TVA) submitted a license amendment request (LAR) for the Extended Power Uprate (EPU) of Browns Ferry Nuclear Plant (BFN) Units 1, 2 and 3. The proposed LAR modifies the renewed operating licenses to increase the maximum authorized core thermal power level from the current licensed thermal power of 3458 megawatts to 3952 megawatts. During the technical review of the LAR, the NRC identified the need for additional information. The Reference 2 and 3 letters provided NRC Requests for Additional Information (RAIs). The due date for the responses to these NRC RAIs is February 16, 2016. The enclosures to this letter provide the responses to each of the NRC RAIs provided in the Reference 2 and 3 letters, with the exception of NRC RAI SFP-RAI 2. Due to the time required to locate test records to support the development of the response to NRC RAI SFP-RAI 2, the due date for this response was extended to February 29, 2016, per communication with the NRC Project Manager.

Enclosure 1 provides the response to the NRC RAI SFP-RAI 1 from Reference 2. AREVA considers portions of the information provided in Enclosure 1 to this letter to be proprietary and, therefore, exempt from public disclosure pursuant to 10 CFR 2.390, Public inspections, exemptions, requests for withholding. An affidavit for withholding information, executed by AREVA, is provided in Enclosure 6. A non-proprietary version of the RAI and response is provided in Enclosure 2. Therefore, on behalf of AREVA, TVA requests that Enclosure 1 be withheld from public disclosure in accordance with the associated AREVA affidavit and the provisions of 10 CFR 2.390.

Enclosure 3 provides the response to the NRC RAI EEEB-RAI 1 from Reference 3. Enclosure 3 contains critical energy infrastructure information that is considered sensitive, unclassified (non-safeguard) information. As a result, TVA requests that Enclosure 3 be withheld from public disclosure in accordance with the provisions of 10 CFR 2.390(d)(1). Enclosure 4 provides a public version of the RAI and response with critical energy infrastructure information removed.

Enclosure 5 provides the responses to the NRC RAIs EEEB-RAI 2, EEEB-RAI 3, EEEB-RAI 4, and ESGB-RAI 1 from Reference 3.

TVA has reviewed the information supporting a finding of no significant hazards consideration and the environmental consideration provided to the NRC in the Reference 1 letter. The supplemental information provided in this submittal does not affect the bases for concluding that the proposed license amendment does not involve a significant hazards consideration. In addition, the supplemental information in this submittal does not affect the bases for concluding that neither an environmental impact statement nor an environmental assessment needs to be prepared in connection with the proposed license amendment. Additionally, in accordance with 10 CFR 50.91(b)(1), TVA is sending a copy of this letter, without the proprietary information and critical energy infrastructure information, to the Alabama State Department of Public Health.

There are no new regulatory commitments associated with this submittal. If there are any questions or if additional information is needed, please contact Mr. Edward D. Schrull at (423) 751-3850.

I declare under penalty of perjury that the foregoing is true and correct. Executed on the 16th day of February 2016.

Respectfully,

J. W. Shea
Vice President, Nuclear Licensing

Enclosures

cc: See Page 3

Enclosures:

1. Response to NRC Request for Additional Information SFP-RAI 1 (Proprietary version)

2. Response to NRC Request for Additional Information SFP-RAI 1 (Non-proprietary version)

3. Response to NRC Request for Additional Information EEEB-RAI 1 (Critical Energy Infrastructure Information)

4. Response to NRC Request for Additional Information EEEB-RAI 1 (without Critical Energy Infrastructure Information)

5. Responses to NRC Requests for Additional Information EEEB-RAI 2, EEEB-RAI 3, EEEB-RAI 4, and ESGB-RAI 1

6. AREVA Affidavit

cc:

NRC Regional Administrator - Region II
NRC Senior Resident Inspector - Browns Ferry Nuclear Plant
State Health Officer, Alabama Department of Public Health (w/o Enclosures 1 and 3)

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ENCLOSURE 1

Response to NRC Request for Additional Information SFP-RAI 1

(Proprietary version)

ENCLOSURE 2

Response to NRC Request for Additional Information SFP-RAI 1

(Non-proprietary version)

Response to RAI for Browns Ferry Nuclear Plant EPU Submittal – SFSP Criticality Safety Analysis

ANP-3465NP
Revision 0

February 2016

AREVA Inc.

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Nature of Changes

Item	Section(s) or Page(s)	Description and Justification
1	All	Initial Issue

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NOMENCLATURE

Abbreviation	Description
BAF	Bottom of Active Fuel
BFN	Browns Ferry Nuclear Plant
CLTP	Current Licensed Thermal Power (3458 MWt)
CSA	Criticality Safety Analysis
EPU	Extended Power Uprate
LAR	License Amendment Request
OLTP	Original Licensed Thermal Power (3293 MWt)
PAR	Procured Analysis Review
RCE	Reload Core Evaluation
REBOL	Reactivity Equivalent Beginning Of Life (lattice design)
SFSP	Spent Fuel Storage Pool
TAF	Top of Active Fuel
TS	Technical Specifications
TVA	Tennessee Valley Authority
UFSAR	Updated Final Safety Analysis Report

1.0 Introduction

In Reference 1, the Tennessee Valley Authority (TVA) submitted a license amendment request (LAR) to modify the operating license for the Browns Ferry Nuclear Plant (BFN) for an extended power uprate (EPU). The amendment, if approved, would allow for an increase in the licensed reactor thermal power from the current licensed thermal power (CLTP) of 3458 MWt to a new licensed thermal power of 3952 MWt, approximately 120% of the original licensed thermal power (OLTP) of 3293 MWt.

During a November 10, 2015 U. S. Nuclear Regulatory Commission (NRC) public meeting with TVA, the NRC requested a copy of the current spent fuel storage pool (SFSP) criticality safety analysis (CSA) report for BFN to support review of the EPU LAR. The requested report was provided as Enclosure 1 of Reference 2. The NRC staff has determined that additional information is needed to complete their review of the EPU LAR (Reference 3). This document contains only the response to the Request for Additional Information (RAI) that contains AREVA content. The RAI response provided in this document is a combined response from AREVA and TVA.

References

1. Letter, JW Shea (TVA) to USNRC, "Proposed Technical Specifications Change to TS-505 – Request for License Amendments – Extended Power Uprate", CNL-15-169, September 21, 2015. (Accession Number ML15282A152)

2. Letter, JW Shea (TVA) to USNRC, "Proposed Technical Specifications (TS) Change TS-505 – Request for License Amendments – Extended Power Uprate (EPU) – Supplement 1, Spent Fuel Pool Criticality Safety Analysis Information", CNL-15-249, December 15, 2015. (Accession Number ML15351A097)

3. Letter, FE Saba (USNRC) to JW Shea (TVA), "Browns Ferry Nuclear Plant, Units 1, 2, and 3 – Request for Additional Information Related to License Amendment Request Regarding Extended Power Uprate (CAC Nos. MF4851, MF4582, and MF4853)", January 28, 2016. (Accession Number ML16019A283)

4. ANP-3160(P) Revision 1, *Browns Ferry Nuclear Plant Units 1, 2, and 3 Spent Fuel Storage Pool Criticality Safety Analysis for ATRIUM™ 10XM Fuel*, AREVA Inc., December 2015. (provided as Enclosure 1 of Supplement 1 to the EPU LAR dated December 15, 2015)

5. EMF-2158(P)(A) Revision 0, *Siemens Power Corporation Methodology for Boiling Water Reactors: Evaluation and Validation of CASMO-4/MICROBURN-B2,* Siemens Power Corporation, October 1999.

2.0 RAIs and Responses

SFP-Request for Additional Information (RAI) 1

Section 50.36(c)(4) of Title 10 of the Code of Federal Regulations (10 CFR) states, in part, that "Design features to be included [in the technical specifications (TSs)] are those features of the facility such as materials of construction and geometric arrangements, which, if altered or modified, would have a significant effect on safety." BFN TS 4.3.1.1(a) requires a k_{eff} (effective neutron multiplication factor (aka k-effective)) of equal or less than 0.95, consistent with 10 CFR 50.68. The NRC staff notes the calculated k_{eff} found in the SFP nuclear criticality safety (NCS) analysis, in Section 2 of ANP-3160(NP), Revision 1 (attached as Enclosure 2 to the letter dated December 15, 2015), is determined, in part, from an upper limit on the reactivity of the fuel lattice used in the NCS analysis. In the NCS analysis, this limit is expressed as the maximum k_{∞} (infinite lattice neutron multiplication factor (aka k-infinity)) calculated for fuel stored in the SFP rack geometry. The calculated k_{eff} is used to demonstrate compliance with the k_{eff} TS requirement. Therefore, the maximum allowable reactivity of fuel that may be stored in the SFP is a key feature in ensuring that the SFP subcriticality safety requirement is met.

Discuss what limits or controls the licensee is implementing to ensure that the reactivity of the fuel stored in the SFP does not exceed the bounds of the NCS analysis, ensuring that the regulatory requirement to maintain the TS value of k_{eff} less than 0.95 continues to be met.

Response:

The plant design feature important to safety in regard to storage of fuel in the BFN spent fuel storage pool (SFSP) is the rack design. This is captured in Technical Specification (TS) 4.3.1.1(b) which is based upon the high density rack design as described in Updated Final Safety Analysis Report (UFSAR) section 10.3.4.

As indicated in the question above, the BFN TS 4.3.1.1(a) requirement of maintaining a k_{eff} of ≤ 0.95 is met by setting a reactivity limit on fuel that is to be stored in the SFSP. ANP-3160(P) (Reference 4) provides a CSA for the ATRIUM™[1] 10XM fuel design that directly addresses meeting this BFN licensing requirement. The approach taken is summarized in Figure 1.1 below, which is based upon Figure 2.1 of the Reference 4 report. Fuel being stored within the BFN SFSP must remain within the basis of the CSA. This is met if the enriched lattices meet the requirements of Table 2.1 of ANP-3160(P).

AREVA performs the required checks to ensure that new ATRIUM 10XM fuel bundle designs remain bounded by the CSA as part of the bundle design process for BFN. Table 2.1 of ANP-3160(P) provides two alternate sets of validation criteria for the enriched lattices:

- Enrichment and Gadolinia loading requirements, or
- Direct Reactivity Comparison (with enrichment < 5.0 wt % U-235).

Meeting either of the above sets of validation criteria ensures that the fuel remains bounded by the CSA.

[1] ATRIUM is a trademark of AREVA Inc.

The enrichment and gadolinia (Gd) loading criteria provided in Table 2.1 of ANP-3160(P) are reproduced below.

Above [ ] *	Maximum Lattice Average Enrichment, wt% U-235	4.70
	Minimum Number of Rods containing Gd_2O_3	8+
	Minimum wt% Gd_2O_3 in these Gd Rod	3.5

At and below [ ] *	Maximum Lattice Average Enrichment, wt% U-235	4.70
	Minimum Number of Rods containing Gd_2O_3	8+
	Minimum wt% Gd_2O_3 in these Gd Rod	3.919

* The separate axial zones are based upon the height of the fuel in the part length fuel rod and represent the change between top and bottom lattice geometries.

\+ These eight gadolinia rods cannot be loaded on the perimeter of the lattice or adjacent to the water channel. An equivalent[1] of two gadolinia rods must be loaded along each side. Gadolinia is not required in natural Uranium blankets and there are no restrictions on the number, concentration, or placement of any additional gadolinia rods.

If each of the enriched lattices within a new ATRIUM 10XM bundle design meets the above criteria, the fuel remains bounded by the CSA and the fuel may be safely stored within the BFN SFSP.

An alternate set of validation criteria is also provided in Table 2.1 of ANP-3160(P) that allows for the direct comparison of in-rack lattice k_∞, as follows:

Zone*	Lattice Geometry	Distance from BAF	Max. in-rack k_∞
2	10XMLCT [ ]	[ ] to TAF	0.8825
1	10XMLCB [ ]	0" to [ ]	0.8825

* The separate axial zones are based upon the height of the fuel in the part length fuel rod and represent the change between top and bottom lattice geometries.

1 Two face adjacent gadolinia rods count as a single rod.

The in-rack k_∞ criteria in the previous table are based upon an explicit CASMO4 calculation subject to the modeling and restrictions provided in Appendix A of the ANP-3160(P) report. These calculations are performed with the NRC approved CASMO4 code described in EMF-2158(P)(A) (Reference 5). The in-rack modeling is performed consistent with the models used in the CSA, with sample inputs provided in Tables A.1 and A.2 of ANP-3160(P).

AREVA provides certification to TVA that the new fuel meets the ANP-3160(P) validation criteria in two separate reports that are part of the deliverables for each cycle.

> Nuclear Fuel Design Report: An example is provided in section 2.4 of ANP-3343(P) provided as Attachment 22 of the EPU LAR submittal dated September 21, 2015 (ML15282A152).
>
> Reload Safety Analysis Report: An example is provided in section 7.4 of ANP-3404(P) provided as Enclosure 3 of Supplement 2 to the EPU LAR dated December 15, 2015 (ML15351A113).

Additionally, as part of the TVA process, an owner acceptance review is performed for any technical product received from a vendor. This review, termed a Procured Analysis Review (PAR), is required by TVA procedures. One of the requirements for a PAR is for the reviewer to document that all regulatory and design requirements pertinent to the procured technical product have been met. The PAR associated with acceptance of the final core design document includes a confirmation that the new reload fuel complies with the requirements of the criticality analysis. AREVA design documentation is utilized by TVA as part of completing that review. The TVA compliance review is similar to the AREVA compliance check, in that it confirms that the new fuel designs for the reload meet the enrichment and gadolinia loading criteria (or the alternate criteria if required) that are provided in Table 2.1 of ANP-3160(P).

In addition, the TVA procedures require the preparation of an overall Reload Core Evaluation (RCE) document, the purpose of which is to document that the reload design is safe and effective and meets all design and licensing criteria. The governing procedure specifically lists SFSP criticality analysis as one of the mandatory elements to be addressed in the RCE.

The TVA processes for reload review and acceptance specifically address confirmation that new fuel designs being delivered for each reload are in compliance with the assumptions of the criticality analysis of record.

[

]

Figure 1.1 Overview of the Browns Ferry SFSP Criticality Safety Analysis

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ENCLOSURE 3

Response to NRC Request for Additional Information EEEB-RAI 1

(Critical Energy Infrastructure Information)

ENCLOSURE 4

Response to NRC Request for Additional Information EEEB-RAI 1

(Without Critical Energy Infrastructure Information)

ENCLOSURE 4

EEEB-RAI-1

In Section 3.0 of Attachment 43, the licensee states:

> *The [TSS] study evaluated the performance of the 500 kV [kilovolt] and 161 kV offsite power systems during a DBE [design-basis event] under EPU [extended power uprate] conditions. Bus voltages observed during the simulation are compared to acceptance criteria to determine adequacy of the offsite power supply. The TSS considered a loss of the largest single supply to the grid, loss of the largest single load, loss of the nuclear unit, and loss of each bulk transmission line in the TVA transmission system, including all the lines coming into the BFN switchyard. The study used base cases from both 2015 (pre-EPU) and 2019 (post-EPU) to address the load flow analysis at EPU conditions.*

A. *Provide acceptable voltage range of BFN 500 kV and 161 kV offsite power acceptance criteria. Also, clarify whether the voltage criteria corresponding to post EPU conditions has been agreed upon by the transmission system operator.*

B. *Provide summary of cases studied with diagrams to verify that the voltage criteria is met under the following post-EPU conditions:*

   i. *loss of the largest load (identify the load),*

   ii. *loss of the largest generator (identify the generator), and*

   iii. *loss of the most critical transmission line (identify the line).*

TVA Response:

ENCLOSURE 4

ENCLOSURE 4

Figure 1 - Interconnection Map

ENCLOSURE 4

Figure 2 - Interconnection Arrangement

ENCLOSURE 4

Figure 3 - BFN 161 kV Substation

ENCLOSURE 5

Responses to NRC Requests for Additional Information
EEEB-RAI 2, EEEB-RAI 3, EEEB-RAI 4, and ESGB-RAI 1

ENCLOSURE 5

EEEB-RAI 2

In Section 2.3.3.1 of Attachment 7, "Safety Analysis Report for Browns Ferry Nuclear Plant Units 1, 2, and 3 Extended Power Uprate," the licensee states:

> *The larger condensate pump motors (1,250 horsepower (hp)), CBP motors (3,000 hp) and reactor recirculation pump motors (8,657 hp) do not change the conclusions of the current Browns Ferry degraded voltage analysis. The analysis encompasses the safety-related 4.16 kV [kilovolts] buses and is independent of voltage profiles for the balance of plant buses [BOP].*

Provide a summary of the degraded voltage analysis corresponding to post-EPU conditions. Also, provide single line diagram(s) showing the safety-related 4.16 kV buses with its connected loads and power sources and the BOP buses with its connected loads and power sources.

TVA Response:

I. EPU Impact

The Class 1E onsite distribution system degraded voltage relays were determined to be adequate for operation at pre-EPU conditions. BFN developed and validated the relay settings based on the equipment ratings and the expected load profile of the safety-related equipment in response to a design basis accident. No EPU modifications are made to safety-related equipment so the ratings are unchanged. Due to the fact that this is a constant pressure power uprate, no increase in flow, pressure, or mission time is required of any AC powered ECCS equipment and therefore, the amount of power required to perform safety-related functions (pump and valve loads) is not increased with EPU and the load profile is unchanged. As such, the degraded voltage analysis currently in place at BFN still applies at EPU conditions.

Furthermore, an analysis shows that the onsite electrical voltage levels and the degraded voltage settings are adequate at EPU conditions.

II. Degraded Voltage Protection Description

In the normal station electrical lineup, the Unit Station Service Transformers (USSTs) 1A, 1B, 2A, 2B, 3A, and 3B are fed from their respective unit generator or from the 500kV switchyard and supply power to operational loads on 4kV Unit Boards 1A, 1B, 1C, 2A, 2B, 2C, 3A, 3B, and 3C. The 4kV Shutdown Boards are fed in the following manner:

USST	Unit Board	Shutdown Bus	Shutdown Board
1B	1A	1	A and B
2B	2A	2	C and D
3B	3A	none	3EA and 3EB
3B	3B	none	3EC and 3ED

USSTs 1B, 2B, and 3B are equipped with automatic Load Tap Changers (LTCs) on the primary winding that can change the voltage by one step every 1.1 seconds. Each step is a change in voltage of 1.25% over a plus or minus 10% range.

In case the USST 1B, 2B, or 3B cannot maintain adequate voltage, each Shutdown Board is provided with degraded voltage (DV) protection. The following is a description of the DV protection scheme for 4kV Shutdown Board A. This same scheme is typical for the remaining 4kV Shutdown Boards. The times stated are nominal. The actual setpoints for the timers and the DV values have been determined by analyses and are consistent with the Browns Ferry Nuclear Plant (BFN) Final Safety Analysis Report accident analyses. The three DV relays sense each of the three phase-to-phase voltages on the shutdown board potential transformer secondary windings. If two of the three relays sense a shutdown board voltage below the setpoint (3920V) for approximately 0.3 seconds, a time delay relay will initiate. The Degraded Voltage Relay is set to actuate when the steady state voltage drops below 3920V and resets when the voltage recovers to greater than 3962V. Due to inaccuracy of the relay, dropout may occur at any voltage between 3940V and 3899V and reset at any voltage between 3941V and 3983V. To ensure that the relay resets, the voltage must recover to at least 3983V or 95.75% of 4160V. If a DV situation exists for approximately four seconds, the emergency diesel generator will start. If the relay is actuated but the voltage at the board recovers within 6.9 seconds, the relay will reset and the board will not transfer to the emergency diesel generator. If a DV situation exists for 6.9 seconds, time delay relays will pickup and initiate 4kV Shutdown Board A power system isolation, load shedding, and eventual closing of the emergency diesel generator breaker when the diesel is up to normal speed and voltage. This initiation is inhibited if the emergency diesel generator breaker 1818 or inter-tie breaker 1824 is closed. A time delay pickup relay (1.3 seconds) allows time for shutdown board power system isolation and subsequent voltage decay before the emergency diesel generator breaker 1818 close signal is issued.

III. Acceptance Criteria/Bases

A. Acceptable Voltage Ranges for Boards

4kV Switchgear	480V Switchgear	480V MCCs[3]
Max: 4400V[2]	508V[2]	508V[2]
Min: 3983V[1]	440V[2]	432V[2,4]

1. This is the reset voltage of the DV relay.
2. Per American National Standards Institute (ANSI) C84.1, 1995, Voltage Ratings for Electric Power Systems, Voltage Range B.
3. The Diesel Auxiliary boards are considered MCCs.
4. In order to maintain acceptable control circuit voltages, the minimum acceptable voltage is 451V for Reactor Motor Operated Valve (RMOV) Board 2D and 439V for RMOV Board 2E.

B. Acceptable Operating Voltage Ranges

Running Motors

4kV	480V*	460V*	440V*
Max: 4400V	528V	506V	484V
Min: 3600V	432V	414V	396V

Static Loads (non-lighting loads)
Max: 528V
Min: 432V (Inverters, battery chargers, electronic controls, lighting)
416V (All other static loads.)

* National Electrical Manufacturers Association (NEMA) MG 1 Section 12.45 requires that motors shall operate with variation in voltage up to plus or minus 10% of rated voltage.

C Minimum Voltage for Starting Motors Using Static Motor Analysis:

4kV Motors	460V Air Compressors	460 V Motors and MOVs	U1 MOVs
3200V (80%)*	368V (80%)*	391V (85%)*	414V (90%)*

* Percentages are based on 4000V and 460V rated motor voltage. For motors other than 460V, the same percentages are applicable.

The minimum motor voltages are based on the following:

Class 1E motors up to 30 horsepower, NEMA Type B, provide 150 percent starting torque at full voltage which corresponds to close to 100 percent torque at 80 percent voltage. For loads, such as fans, as the speed increases, so does the torque requirement. Other loads, such as positive-displacement compressors, start unloaded and do not require a large starting torque from the drive motors. In addition, the electrical industry accepts a starting voltage of 80 percent of rated voltage at the terminals of the NEMA Type B motors. For Unit 1 motor operated valves (MOVs), 90% of rated voltage is considered.

IV. Analysis

The ability of the required equipment (boards and their loads) to perform their intended functions in the DV condition has been analyzed. For this analysis, the DV Dropout voltage is 3900V. This is the minimum Technical Specification value. The DV Reset value is 3983V.

1. Effect on Safety-Related Boards

Board voltages were calculated using Electrical Transient Analyzer Program (ETAP), the power systems analysis software used by BFN, assuming a shutdown board voltage of 3900V and worst case LOCA loading at t=60 seconds. If the ETAP calculated voltage did not meet the minimum required voltage from Acceptance Criteria/Bases Section II.A, then the board voltages were calculated again at 3983V shutdown board voltage and worst case LOCA loading at t=60 seconds. This case assumes that the DV reset voltage has been met. In this case, all of the board voltages met the minimum required voltages from Acceptance Criteria/Bases Section II.A. All of the safety-related boards would be able to perform their intended function at the DV condition. The results are summarized in Table 1.

2. Effect on Safety-Related Board Loads

a. 440/460/480V Motor and Non-Generic Letter (GL) 89-10 Motor Operated Valves (MOVs) Starting Voltage

With a shutdown board voltage of 3983V, all motors that are safety-related and required to mitigate the accident, had adequate starting voltages in accordance with

Acceptance Criteria/Bases Section II.C and would be able to perform their intended function at the DV condition. The results are summarized in Table 2.

b 460V Motor Running Voltage

With a shutdown board voltage of 3900V, all motors had adequate running voltages in accordance with Acceptance Criteria/Bases section II.B and would be able to perform their intended function at the DV condition.

c. 440/480V Motor Running Voltage

With a shutdown board voltage of 3900V, all non-standard voltage, safety-related motors had adequate running voltages in accordance with Acceptance Criteria/Bases Section II.B and would be able to perform their intended function at the DV condition.

d. Static Loads

With a shutdown board voltage of 3983V, all static loads required for safe operation have adequate voltage in accordance with Acceptance Criteria/Bases Section II.B and would be able to perform their intended function at the DV condition.

e. GL 89-10 MOV Starting Voltages

With a shutdown board voltage of 3983V, all of the GL-89-10 MOVs had adequate starting voltages in accordance with Acceptance Criteria/Bases Section II.C or were otherwise individually analyzed to show that they would be able to perform their intended function at the DV condition. The results are summarized in Table 3.

V. Single Line Diagrams

Single line diagrams 0-15E500-1 and 3-15E500-3, showing the safety-related 4.16kV buses with their power sources and the Balance of Plant (BOP) 4.16kV buses with their power sources, are provided. The connected loads, for each of the buses listed below, are shown on the drawing referenced beside each bus.

Safety-Related 4.16kV Buses	
4kV SHUTDOWN BUS 1	
4kV SHUTDOWN BUS 2	
4kV SHUTDOWN BD A	(0-45E724-1)
4kV SHUTDOWN BD B	(0-45E724-2)
4kV SHUTDOWN BD C	(0-45E724-3)
4kV SHUTDOWN BD D	(0-45E724-4)
4kV SHUTDOWN BD 3EA	(3-45E724-6)
4kV SHUTDOWN BD 3EB	(3-45E724-7)
4kV SHUTDOWN BD 3EC	(3-45E724-8)
4kV SHUTDOWN BD 3ED	(3-45E724-9)

BOP 4.16kV Buses	
4kV START BUS 1A	
4kV START BUS 1B	
4kV START BUS 2A	
4kV START BUS 2B	
4kV UNIT BD 1A	(1-45E721)
4kV UNIT BD 1B	(1-45E721)
4kV UNIT BD 1C	(1-45E721)
4kV UNIT BD 2A	(2-45E721)
4kV UNIT BD 2B	(2-45E721)
4kV UNIT BD 2C	(2-45E721)
4kV UNIT BD 3A	(3-45E721)
4kV UNIT BD 3B	(3-45E721)
4kV UNIT BD 3C	(3-45E721)
4kV COMMON BD A	(0-15E500-2)
4kV COMMON BD B	(0-15E500-2)

ENCLOSURE 5

Table 1
Board Voltage Summary

#	Board Name	Board Voltage (Volts) Operation @ 3900V t=60 Sec Loading	Board Voltage (Volts) Operation @ 3983V t=60Sec Loading	Minimum Acceptable Board Voltage (Volts)
1	4kV SHUTDOWN BD A	**3900**	3983	3983
2	4kV SHUTDOWN BD B	**3900**	3983	3983
3	4kV SHUTDOWN BD C	**3900**	3983	3983
4	4kV SHUTDOWN BD D	**3900**	3983	3983
5	4kV SHUTDOWN BD 3EA	**3900**	3983	3983
6	4kV SHUTDOWN BD 3EB	**3900**	3983	3983
7	4kV SHUTDOWN BD 3EC	**3900**	3983	3983
8	4kV SHUTDOWN BD 3ED	**3900**	3983	3983
9	Control Bay Vent Bd A	442	453	432
10	Control Bay Vent Bd B	439	449	432
11	Diesel Auxiliary Bd A	442	452	432
12	Diesel Auxiliary Bd B	445	455	432
13	Shutdown Bd 1A	446	456	440
14	Shutdown Bd 1B	448	458	440
15	Shutdown Bd 2A	445	455	440
16	Shutdown Bd 2B	450	460	440
17	Shutdown Bd 3A	447	457	440
18	Shutdown Bd 3B	443	453	440
19	RMOV Bd 1A	444	455	432
20	RMOV Bd 1B	446	456	432
21	RMOV Bd 1C	446	457	432
22	RMOV Bd 2A	443	454	432
23	RMOV Bd 2B	446	456	432
24	RMOV Bd 2C	448	458	432
25	RMOV Bd 2D	**445**	455	451
26	RMOV Bd 2E	450	460	439
27	RMOV Bd 3A	444	455	432
28	RMOV Bd 3B	436	447	432
29	RMOV Bd 3C	441	452	432
30	RMOV Bd 3D	447	457	432
31	RMOV Bd 3E	443	453	432
32	Diesel Auxiliary Bd 3EA	444	455	432
33	Diesel Auxiliary Bd 3EB	437	448	432
34	Standby Gas Treatment Bd	445	455	440
35	HVAC Bd B	440	450	440

Table 1
Board Voltage Summary (continued)

Shading In Table 1 indicates boards at less than required minimum voltage with the shutdown boards at 3900V.

With operation at the DV dropout setting of 3900V, the 4kV Shutdown Boards and the RMOV Board 2D are less than the minimum acceptable voltage listed in Acceptance Criteria/Bases Section II.A. However, all boards meet the requirements with operation at the DV reset voltage of 3983V. Operation between 3900V and 3983V for the allowed time delay ensures that power is available for starting required equipment without risking damage to that equipment.

Table 2
440/460/480V Motor and Non-GL 89-10 MOV Starting Voltage Summary at Degraded Voltage (DV) Reset (3983V)

Load ID	%VST @ 3983V (480V Base)	Voltage @ 3983V (Volts)	Load Justification
183-6D	81.04	389	See below

All motors that are safety related and required to mitigate the accident, had adequate starting voltages in accordance with Acceptance Criteria/Bases Section II.C, except the motor for Load ID 183-6D. 183-6D is the 3A Air Handling Unit (AHU) that provides cooling to the Electrical Board Room 3A/3B. The 3A AHU is a normal operating load. The load has been verified to be a NEMA B Design motor and NEMA MG 1-12.38 shows that the 20 horsepower motor, rated at 1800 RPM, produces 150 percent locked rotor torque. Because the torque developed in a motor is proportional to the square of the voltage, a voltage of 84.56% (81.04% @ 480V = 84.56% @ 460V) will produce approximately 107.3% torque. Therefore, the DV is acceptable per the acceptance criteria in accordance with Acceptance Criteria/Bases Section II.C.

Table 3
GL 89-10 MOV Starting Voltages

Load ID	Description	Minimum Required Voltage (Volts)	% Starting Voltage 480V Base) @ Degraded Voltage Reset (3983V)	MOV Terminal Voltage (Volts)	Load Justification
191-1E	1-FCV-75-50	414	85.70	**411**	Evaluated at 405V
281-8C	2-FCV-74-48	414	83.82	**398**	Evaluated at 391V
282-3E	2-FCV-68-79	414	83.20	**399**	Evaluated at 378V
381-12E	3-FCV-74-58	414	85.71	**411**	Evaluated at 411V

Shading In Table 3 indicates boards at less than required minimum voltage with the shutdown boards at 3983V.

All of the GL 89-10 MOVs had adequate starting voltage, in accordance with Acceptance Criteria/Bases Section II.C, with the above four exceptions. Each of these valves was then analyzed individually at the DV level stated in the Load Justification column. Calculations were performed to determine the thrust developed by each of the operators at the stated voltages. These developed thrusts were then compared to the thrust required for the valves to perform their intended functions. In all four cases, the developed thrust was greater than the required thrust and therefore these four valves will perform their intended functions at the stated degraded voltages.

EEEB-RAI 3

In Section 2.3.3.2 of Attachment 7, the licensee states:

> *The analytical electrical system computer model developed for Browns Ferry updated the main power transformer size to reflect the recent change of main power transformers and the proposed changes to the main generators and condensate pumps.*

Provide a description of the proposed changes, including the ratings, to the main generators.

TVA Response:

1. The generator stators were re-wound to be able to accommodate the new Extended Power Uprate (EPU) conditions.

   - The Browns Ferry Nuclear Plant (BFN) Unit 1 stator was re-wound and the generator was re-rated to 1330 MVA at 0.95 Power Factor (PF).
   - The BFN Unit 2 stator was re-wound and the generator was re-rated to 1332 MVA at 0.93 PF.
   - The BFN Unit 3 stator was re-wound and the generator was re-rated to 1332 MVA at 0.93 PF.

2. Increase generator hydrogen pressure from 65 psig to 75 psig to support EPU operation.
   - Change pressure regulating valve settings and pressure alarm setting.
   - Replace pressure switches as needed for new operating range.
   - Change generator field over-excitation relay settings.
   - Eliminate hydrogen flow integrator to mitigate hydrogen leakage.

   Work will be completed prior to EPU implementation on each of the units.

EEEB-RAI 4

In Section 2.3.2.2 of Attachment 7, the licensee states:

> *The Unit 1, Unit 2 and Unit 3 isolated phase bus (IPB) duct work, cooling coils and fans have been modified to increase the continuous current rating to provide for operation at EPU output.*

Provide the IBP duct current rating and the continuous current requirement for EPU conditions to show the adequacy of the IBP duct to support operation under EPU conditions. Also, provide a description of the modifications made to the IPB duct, cooling coils and fans to increase the continuous current rating for operating at EPU conditions.

TVA Response:

1. The isolated phase bus (IPB) duct current rating and the continuous current requirement for Extended Power Uprate (EPU) conditions are as follows:

Unit	IPB Duct Current Rating (Amps)	IPB Duct Continuous Current Requirement (Amps)	Conclusion
1	36,740	34,903	IPB duct current rating is adequate to support EPU conditions.
2	36,796	34,956	IPB duct current rating is adequate to support EPU conditions.
3	36,796	34,956	IPB duct current rating is adequate to support EPU conditions.

2. In preparation for EPU conditions, the IPB forced cooling system was modified for the additional heat generated as a result of the increased current carrying capabilities. The cooling coil size was increased and the existing cooling fan and motor was replaced with two new cooling fans and motors. The IPB supply duct work was modified to accommodate the second fan, new back-draft dampers, and new balancing dampers. These changes have been installed on all three units.

ESGB-RAI 1

In Section 10.3.6 of the Updated Final Safety Analysis Report, and in information provided in the supplemental letter dated December 15, 2015, it is indicated that a Boral neutron absorber monitoring program is used at BFN, Units 1, 2, and 3. The intent of the monitoring program is to manage potential reduction of neutron-absorbing capacity and loss of material due to general corrosion. However, in the sources mentioned, there is minimal information describing the Boral monitoring program. For this reason, please provide a brief description of the monitoring program. The information provided should include the following discussion:

A. If test specimens (i.e., coupons) are used:

i. Define the periodicity for evaluation.
ii. Provide the number of coupons available.
iii. Describe any adverse conditions identified from coupon evaluation thus far.
iv. Discuss the ambient conditions for the coupons in the spent fuel pool (e.g., surrounded by freshly discharged spent fuel assemblies).
v. Discuss whether coupons are returned to the spent fuel pool after inspection.

B. If coupons are not used, discuss the periodicity of surveillance.

C. Describe the types of tests performed during the periodic inspection.

a. Describe the test procedure.
b. Discuss whether neutron-attenuation testing is performed to determine the boron-10 (B-10) areal density of the absorber material during periodic testing.

D. Define the acceptance criteria for the surveillance program, including what constitutes an adverse condition.

E. Describe those measures taken to address a failure to meet the acceptance criteria for either the surveillance program and/or the B-10 areal density.

F. Address any adverse conditions, other than identified corrosion, that may be identified during testing, and whether different acceptance criteria apply to those other adverse conditions.

TVA Response:

In October 1983, TVA installed a series of Boral test coupons in the Browns Ferry Nuclear Plant (BFN) Unit 3 spent fuel storage pool. A monitoring program was initiated with the purpose of tracking long-term corrosion of the Boral Cermet inserts used in the BFN Units 1, 2, and 3 high density fuel storage racks (HDFSR). This program was initiated to comply with a TVA licensing commitment specified in Reference 1. The surveillance interval has varied during the course of the program and the periodicity of performance is re-evaluated after each coupon set inspection based on the inspection results. This monitoring program currently has a maximum surveillance interval of ten years based on the requirements of Section XI.M40 of Reference 2. (Response to item A.i of RAI). The key parameters measured during each surveillance, the acceptance criteria and a summary of past BFN inspection results are discussed below.

The following definitions support the subsequent discussion:

> Boral Cermet - A Boron Carbide-Aluminum (B_4C-Al) matrix sandwiched between two thin (0.01 inches) sheets of aluminum cladding. A coupon consists of this Boral Cermet encased in stainless steel, and simulates the configuration of an HDFSR cell.
>
> Coupon Test Assembly (CTA) - Each CTA consists of one or more coupons fastened to a stainless steel rope. The CTA is lowered into the Spent Fuel Storage Pool (SFSP) next to an HDFSR cell containing a previously exposed bundle, and is next fastened to the railing at the side of the SFSP.
>
> Boral Plate Test Assembly (BPTA) - Similar to the CTA described above except it consists of bare Boral Cermet Plate(s) rather than encased coupons (the stainless steel outer sheath is removed from the front and back of the coupon).

BFN currently has nine Boral Cermet test coupons resident in the Unit 3 SFSP. These nine coupons are installed in four CTA's as shown in Figure 1. BFN currently has six BPTAs resident in the Unit 3 SFSP as shown in Figure 2. BPTA #1 (coupon number 22) and BPTA #2 (coupon number 41) were installed as new test assemblies in the Unit 3 SFSP on November 24, 1987 at the end of the October 1987 coupon inspection surveillance. BPTA #3 (coupon number 30) was unsheathed during the October 1987 coupon inspection surveillance and was re-inserted into the Unit 3 SFSP on November 24, 1987. BPTA #4 (coupon number 29) was unsheathed during the June 1988 coupon inspection surveillance and was re-inserted into the Unit 3 SFSP on July 20, 1988. BPTA #5 (coupon number 21) was unsheathed during the June 1989 coupon inspection surveillance and was re-inserted into the Unit 3 SFSP on June 30, 1989. BPTA #6 (coupon number 28) was unsheathed during the March 1991 coupon inspection surveillance and was re-inserted into the Unit 3 SFSP on April 9, 1991 (Response to RAI item A.ii of RAI). Figure 3 illustrates how the test coupons at BFN are hung from the side of the Unit 3 SFSP to be in proximity to the HDFSRs. (Partial response to Item A.iv of the RAI).

In October 1983, a total of 16 Boral Cermet test coupons were installed in the Unit 3 SFSP. The 16 coupons were contained in two CTAs (CTA #1 and CTA #2) as shown in Figure 1. The test coupons were supplied by the HDFSR manufacturer and are of the same metallurgical condition as the HDFSR in thickness, chemistry, finish and temper. Each test coupon had a hole drilled through the stainless steel sheath covering the Boral Cermet, which allows exposure of the Boral

Cermet to the SFSP water environment and simulates the configuration of the Boral Cermet in the BFN HDFSRs. Closure welds on the coupons were performed using the same procedures used for the construction of the HDFSRs. Prior to installation, pre-exposure thickness measurements were recorded on each test coupon at pre-categorized locations for later comparison to measurements that would be taken after the coupons were exposed to an initial two-year period of immersion in the BFN SFSP. In addition, radiography measurements of each pre-exposed coupon Boral Cermet was performed and recorded for comparison to measurements which would be performed on exposed coupons that would be later unsheathed (removal of coupon stainless steel sheath surrounding the Boral Cermet) per the test program.

October 1985 Coupon Inspection (Partial Response to Item A.iii and A.v of RAI)

In October 1985, two surveillance coupons, identified as coupons #19 and #31 (See Figure 1) were withdrawn from the Unit 3 SFSP per the BFN test procedure (ST-8322). The coupons had fixed contamination and were shipped to a hot cell for examination. Dye penetrant testing was performed on the stainless steel sheath of each coupon with no anomalies reported. Thickness measurements were performed and comparisons to pre-exposure measurements indicated some slight deformation of the stainless steel sheath.

As required by procedure, the stainless steel sheath was cut away, exposing the Boral Cermet plate. Both coupons exhibited blistering of the aluminum cladding on both faces. All the blisters were observed in the central area of the coupons and varied in size, with the largest measuring approximately 1/2 inch in diameter. Thickness measurements were taken of the blistered areas. The measurements ranged from 96-153 mils, as compared to the nominal thickness of the Boral Cermet plate of 80 mils. Visual observations were made on the state of the B_4C-Al matrix and the aluminum cladding. These examinations showed no indication of degradation of the B_4C-Al matrix. However, the hot lab did not have the equipment necessary for further detailed evaluation. Due to the unexpected results of this examination, an expansion of the test plan was established to evaluate the acceptability of the HDFSRs. The HDFSR manufacturer (General Electric (GE)) and the Boral-Cermet manufacturer (Brooks and Perkins (B&P)) were contracted to perform additional examination and testing with TVA oversight.

Because three different Boral lots existed in the 16 coupons in the BFN SFSP, one coupon from each lot was retrieved for testing. These three coupons, identified as #16, #32 and #38 (See Figure 1) along with the originally removed #19 and #31 coupons were shipped to the University of Michigan (U of M) Phoenix Memorial Laboratory. Thickness measurements were taken at the pre-characterization locations on each coupon stainless steel sheath. Coupon #16 exhibited a slight increase between the pre-exposure and post-exposure measurements.

After removing the stainless steel sheath, visual examination revealed that while coupons #32 and #38 were not affected, coupon #16 showed blistering. Neutron attenuation measurements and neutron radiographs performed at U of M on all samples were all uniform and showed no evidence of loss of material, even at the blister sites. All five coupons were sent to B&P for B-10 loading analysis. Results were compared to measurements taken during manufacturing of the parent Boral strip and no degradation was evident in the B-10 levels of the coupons.

Scanning electron microscopy (SEM) was performed on coupon #16 at GE's Vallecitos Nuclear Facility by a TVA metallurgical engineer and GE personnel with the expectation that the SEM investigation would uncover sufficient material information to identify the cause of the blistering.

While no conclusive information was obtained to ascertain the cause of the blistering, an important observation was made.

> Close examination under the scanning electron microscope revealed corrosion pits at the outer edge of each blister. This observation led to the examination of a spare coupon at TVA's laboratory. This coupon had never been immersed in the SFSP. Examination of this coupon under the SEM showed evidence of inclusions and other surface imperfections on the aluminum cladding. According the TVA metallurgical engineers, these could serve as initiation sites for pitting corrosion.

Note that the five coupons removed in October 1985 were destructively examined and were not returned to the BFN Unit 3 SFSP.

The results of the initial test surveillance performed in October 1985 led to the following recommendations for expansion of the Boral coupon surveillance program.

1. All coupons remaining in the SFSP (a total of 11) should be retrieved and thickness measurements taken of the stainless steel sheath.
2. Six selected coupons should be unsheathed and reinstalled in the SFSP as bare Boral Plates (BPTA). The remaining five coupons should be reinstalled with the sheaths. Both sheathed and unsheathed blistered coupons should be returned to the SFSP. Experience has shown that coupons with blisters have also shown an increase in the stainless steel thickness measurements. Therefore, selection of the coupons to be unsheathed should be based on measurements taken of the stainless steel. Photographs should be taken of the Boral plates before they are reinstalled in the SFSP. If blisters are found, measurements should be taken of these as baseline data.
3. All the coupons should be retrieved after six months. Thickness measurements of the sheathed coupons should be obtained. The bare Boral plates (BPTAs) should be photographed and examined for blistering, pitting corrosion, and any other visible anomaly. Measurements should be obtained of any blisters found. Blisters previously existing on the plates should be examined for growth and degradation. Boral plate width measurements should also be taken to track edge corrosion. The coupons should then be reinstalled into the SFSP in order to continue their exposure to the SFSP environment.
4. Depending on the outcome of the first six month examination, a surveillance schedule should be set up to track any observed problems.
5. If significant changes are found during surveillance examinations, the need for additional neutron attenuation tests, neutron radiographs, B-10 loading tests and SEM examinations should be evaluated.

Acceptance Criteria for Boral Cermet Coupon Surveillance (Response to Items D and F of RAI)

As a result of the above recommendations from the initial October 1985 coupon inspection, the BFN site procedure for conducting the surveillance was modified. The acceptance criteria are designed to identify degradation of the Boral Cermet due to corrosion or blistering, and swelling of the Boral plates that could possibly affect fuel storage and handling. The following qualitative acceptance criteria are included in Section 8.0 of BFN procedure 0-TI-116, High Density Fuel Storage System Surveillance Program:

"No quantitative acceptance criteria are applicable. The Metallurgical Engineer will make a qualitative evaluation and include it with the results of this instruction. This evaluation should consider the following:

- Is there measurable structural corrosion damage of the stainless steel material?
- Any cracking of the stainless steel material which indicates degradation of the SFSP high density storage racks?
- Results of dye Penetrant Examination (exterior and interior) whenever required.
- Any areas of local corrosion attack (whenever yes, how deep)?
- General corrosion resulting in significant loss of thickness whenever extrapolated to the designed life of the component, which indicates excessive general corrosion of the component?
- Is the Boral Cermet in satisfactory condition?
- Does the extrapolated edge corrosion exceed 3.0 mm?
- Does the general corrosion of the aluminum outer surface whenever extrapolated indicate possible debonding of the composite?
- Are there areas of excessive local attack that could affect the moderation performance of the Cermet during the life of the component?
- Is there any visible blistering on the Boral Cermet Plate(s)?
- On existing blisters, are there any indications of growth or degradation from previous baseline data?
- Is there any pitting corrosion indicated on the Boral Cermet Plate(s)?
- Are there any other visible anomalies noted on the Boral Cermet Plate(s)?"

(Response to Item E of RAI) An adverse condition would be the discovery of significant cracking, corrosion, pitting, loss of Boral Cermet material, significant growth rate of existing blistering of Boral Cermet or significant new blistering of the Boral Cermet. Upon discovery of such an adverse condition, the following actions would be taken:

1. The condition would be entered into the TVA Corrective Action Program.
2. An evaluation would be conducted to determine if additional testing of the test coupons, e.g. blackness testing, is necessary to validate that the minimum Boron-10 areal density of 0.013 grams/cm^2 used in the BFN SFSP criticality analysis continues to be met.
3. An evaluation would be conducted to determine if more frequent and expanded surveillance of the HDSFR is needed.

Subsequent Boral Coupon Inspections (Partial Response to items A.ii and A.v of RAI)

Since 1985, there have been a total of 11 additional inspections on the Boral test coupons installed in the BFN Unit 3 spent fuel pool. These inspections are summarized below:

Inspection	Summary
January 1987	Limited data available from search of TVA records. Thickness measurements for 4 coupons. No anomalies reported.
October 1987	• Four new test coupons were installed. Coupon #23 (sheathed coupon) designated as CTA #3. Coupon #24 (sheathed coupon) designated as CTA #4. (See Figure 1). Coupon 22 (unsheathed coupon) designated as BPTA #1. Coupon #41 (unsheathed coupon) designated at BPTA #2. (See Figure 2). Pre-exposure thickness and linear dimension measurements were performed prior to installation. • Coupon #30 was unsheathed and redesignated as BPTA #3. Upon unsheathing coupon #30, small blisters (5 total) were observed and recorded. The blisters were evaluated to not have an effect on function of the Boral Cermet. • Thickness measurements were performed and recorded on all other coupons. No anomalies reported. • All coupons reinserted into the Unit 3 SFSP. • Recommendation was to continue with six month periodicity of inspection.
June 1988	• All sheathed coupons (12 total) and all three BPTAs removed for examination. • No blisters noted on BPTA #1 and BPTA #2. • No significant change in size of blisters on BPTA #3. • Coupon #29 chosen for unsheathing. Upon unsheathing, five small blisters noted on Coupon #29. All blisters smaller than on BPTA #3 (coupon 30). Coupon #29 redesignated as BPTA #4. • No significant changes were found in terms of edge corrosion, blister formation or blister degradation to warrant further additional testing. On existing blisters, there was no indication of growth or degradation from previous baseline data. There was no cracking of the stainless steel material evident on either the exterior or interior surfaces of the unsheathed coupon. There was no significant edge corrosion noted on existing Boral plates. Based on the results of the examination, the recommendation was to extend the next inspection until June 1989. • All coupons returned to SFSP.

ENCLOSURE 5

Inspection	Summary
June 1989	• All sheathed coupons (11 total) and all four BPTAs removed for examination. • Six small blisters noted on BPTA #1 (coupon 22). No blisters noted on BPTA #2 (coupon 41). No significant growth noted of blisters on BPTA #3 (coupon 30) and BPTA #4 (coupon 29). • Coupon # 21 selected for unsheathing. Upon unsheathing, six small blisters noted. Coupon #21 redesignated as BPTA #5. • Thickness measurements recorded on sheathed coupons and on BPTAs. No anomalies noted. • All coupons returned to SFSP.
March 1991	• All sheathed coupons (10 total) and all five BPTAs removed for examination. • Thickness measurements performed on all sheathed coupons. Coupon #28 selected for unsheathing. Upon unsheathing, six small blisters noted. Coupon #28 redesignated as BPTA #6. • Some blister growth noted on coupons 21 (BPTA #5), 22 (BPTA #1), 29 (BPTA #4) and 30 (BPTA #3) compared with June 1989 inspection. Blister growth not considered significant. • No blisters noted on coupon #41 (BPTA #2). • Thickness measurements recorded on sheathed coupons and on BPTAs. No anomalies noted. • All coupons returned to SFSP.
July 1992	• All sheathed coupons (9 total) and all six BPTAs removed for examination. • Thickness measurements performed on all sheathed coupons. No significant change was observed in measurements of the sheathed coupons so decision was made to not unsheathe any additional coupons. • Isolated new blistering was measured on only coupon #28 (BPTA #6). Existing blisters observed on five of the coupons (21, 22, 28, 29 and 30) showed little growth. This was seen as an indication that the blistering process appears to be self-limiting. • No blisters noted on coupon #41 (BPTA #2). • Thickness measurements recorded on BPTAs. No anomalies noted. • Edge corrosion showed very slight growth or very slight decrease between 1992 data and baseline (pre-exposure) data. Extrapolated to 40 years, the maximum corrosion was estimated at a maximum of 1.831 mm. • All coupons returned to SFSP.
August 1993	• All sheathed coupons (9 total) and all six BPTAs removed for examination. • Thickness measurements performed on all sheathed coupons. No significant change was observed in measurements of the sheathed coupons so decision was made to not unsheathe any additional coupons. • No new blistering noted. Existing blisters observed on five of the coupons (21, 22, 28, 29 and 30) showed little growth. This was seen as an indication that the blistering process appears to be self-limiting. • No blisters noted on coupon #41 (BPTA #2). • Thickness measurements recorded on BPTAs. No anomalies noted. • All coupons returned to SFSP.

Inspection	Summary
August 1994	• All sheathed coupons (9 total) and all six BPTAs removed for examination. • Thickness measurements performed on all sheathed coupons. No significant change was observed in measurements of the sheathed coupons so decision was made to not unsheathe any additional coupons. • No new blistering noted. Existing blisters observed on five of the coupons (21, 22, 28, 29 and 30) showed little growth. This was seen as an indication that the blistering process appears to be self-limiting. • No blisters noted on coupon #41 (BPTA #2). • Thickness measurements recorded on BPTAs. No anomalies noted. • All coupons returned to SFSP.
December 1995	• All sheathed coupons (9 total) and all six BPTAs removed for examination. • Thickness measurements performed on all sheathed coupons. No significant change was observed in measurements of the sheathed coupons so decision was made to not unsheathe any additional coupons. • No new blistering noted. Existing blisters observed on five of the coupons (21, 22, 28, 29 and 30) showed little growth. This was seen as an indication that the blistering process appears to be self-limiting. • No blisters noted on coupon #41 (BPTA #2). • Thickness measurements recorded on BPTAs. No anomalies noted. General plate thicknesses, when extrapolated to the component's design lifetime of 40 years, indicate a maximum increase of just over one millimeter. This indicates there is no concern in the debonding of the composite (boron carbide-aluminum) of the Boral plates. • All coupons returned to SFSP.
October 2003	• All sheathed coupons (9 total) and all six BPTAs removed for examination. • Thickness measurements performed on all sheathed coupons. No significant change was observed in measurements of the sheathed coupons so decision was made to not unsheathe any additional coupons. • No new blistering noted. Existing blisters observed on five of the coupons (21, 22, 28, 29 and 30) showed little growth. This was seen as an indication that the blistering process appears to be self-limiting. • No blisters noted on coupon #41 (BPTA #2). • Thickness measurements recorded on BPTAs. No anomalies noted. • All coupons returned to SFSP.
August 2010	• Six sheathed coupons (#33, 34, 35, 36, 39 and 40) and three BPTAs (BPTA #4, BPTA #5, and BPTA #6) removed for examination. • Thickness measurements performed on all sheathed coupons. No significant change was observed in measurements of the sheathed coupons so decision was made to not unsheathe any additional coupons. • No new blistering noted. Existing blisters observed on the three removed BPTA coupons (21, 28, and 29) showed little or no growth. This was seen as an indication that the blistering process appears to be self-limiting. • Thickness measurements recorded on BPTAs. No anomalies noted. • All inspected coupons returned to SFSP.

(Response to item C.b of RAI) As noted in the previous discussion concerning the initial coupon inspection interval in October 1985 as well as the above discussion concerning subsequent inspection results through August 2010, neutron attenuation testing was performed on the five test coupons removed in 1985 with no loss of material. Further analysis by B&P on the five coupons showed no degradation of the B-10 levels in the coupons. The coupon inspections performed from 1987 through 2010 have shown no new degradation phenomenon and only small growth of blisters identified on unsheathed Boral Cermet coupons. Therefore, TVA has determined that additional neutron attenuation testing of the coupons has not been necessary through all previous testing from 1987 through 2010.

BFN Boral Coupon Surveillance Procedure (Response to item C.a of RAI)

The BFN Procedure for performance of periodic inspection of the Boral coupons installed in the BFN SFSP is 0-TI-116. Key inspection steps from the procedure are summarized as follows:

The Metallurgical Engineer shall examine the coupons in their original condition as they are removed from the SFSP to determine whether sampling of surface corrosion products will be appropriate. This will be done before any cleaning or decontamination, other than rinsing with demineralized water, is carried out on the coupons.

1. After removal from the SFSP, the thickness measurements from sheathed coupons are obtained and are recorded.
2. A minimum of one coupon is selected to be unsheathed whenever degradation is such that further investigation is warranted. The criterion for selection is based on the present post-exposure thickness measurement in comparison with pre-exposure thickness measurement. If a coupon is determined to require unsheathing, the following is performed:
    a. Quality Control (QC) to perform dye penetrant tests of the outer surfaces of the coupon(s) selected for unsheathing. QC to record all indications. The Metallurgical Engineer shall evaluate all indications to determine the mode of cracking of any indications found and deemed cracks.
    b. Open the coupon(s) selected for unsheathing by grinding along four sides through the welds (or by cutting within 1/2 inch of the welded edge) to allow the coupon to be opened, exposing the Boral Cermet inside. The Metallurgical Engineer shall determine whether the blister criteria has been satisfied, whether any additional coupons need to be unsheathed, and whether sampling the products for corrosion (if any) on the Boral Cermet or stainless steel cladding would be appropriate. This determination shall be made before any cleaning or decontamination is attempted.
    c. QC to perform dye penetrant tests of the inside surfaces of the stainless steel cladding. QC to record all indications. The Metallurgical Engineer shall evaluate all indications to determine the mode of cracking of any indications found and deemed cracks.
3. The steps are performed for BPTAs after they are removed from the SFSP:
    a. Photograph the Boral Cermet Plate(s) and examine them for blistering, pitting corrosion and any other visible anomalies.
    b. Record the location of any blistering of the Boral Cermet Plates(s).
    c. Obtain Boral Cermet Plate(s) linear measurements to track edge corrosion.
    d. Obtain thickness measurements of the Boral Cermet Plate(s).

e. By visual examination the Metallurgical Engineer shall report and describe any areas of isolated or local corrosion attack. Loss of thickness or loss of edge of the Boral Cermet Plate(s) shall be described in the evaluation. Any further examination of the Boral Cermet shall be decided by the Metallurgical Engineer.

4. Return the BPTAs and CTAs to the Unit 3 SFSP. The CTAs and BPTAs are positioned as best as possible so they are facing the HDFSR.

The BFN SFSP monitoring program procedure does not specify that recently irradiated fuel needs to be shuffled so that recently discharged bundles are placed in close proximity to the Boral test coupons. (Partial Response to item A.iv of RAI).

Conclusion

TVA has maintained a comprehensive test program since 1983 for monitoring the performance of Boral Cermet in the BFN HDSFRs. The results of inspections of the test coupons since 1985 have shown no significant degradation to the Boral Cermet used in the HDSFRs which could compromise the ability of the fuel racks to maintain the fuel in the BFN spent fuel storage pools subcritical by a substantial margin as specified in BFN Technical Specification 4.3.1.

References:

1. Safety Evaluation by the Office of Nuclear Reactor Regulation Supporting Amendment No. 42 to Facility Operating License No. DPR-33 Amendment No. 39 to Facility Operating License No. DPR-52 Amendment No. 16 to Facility Operating License No. DPR-68 Tennessee Valley Authority Browns Ferry Nuclear Plant, Unit Nos. 1, 2 and 3 Docket Nos. 50-259, 50-260 and 50-296, dated September 21, 1978. (ML020040269).

2. NUREG-1801, “Generic Aging Lessons Learned (GALL) Report,” Revision 2, December 2010. (ML103490041).

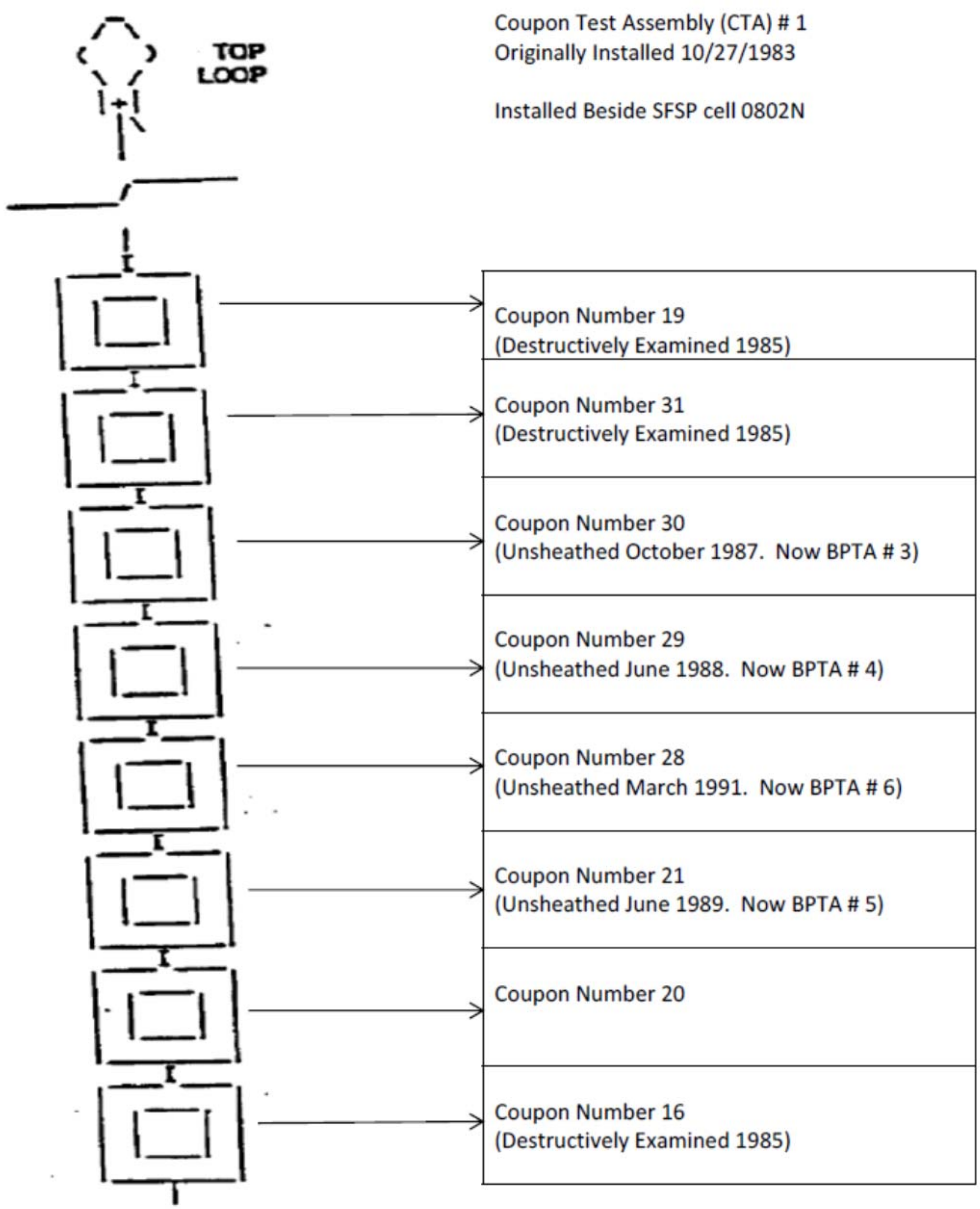


Figure 1
Coupon Test Assembly

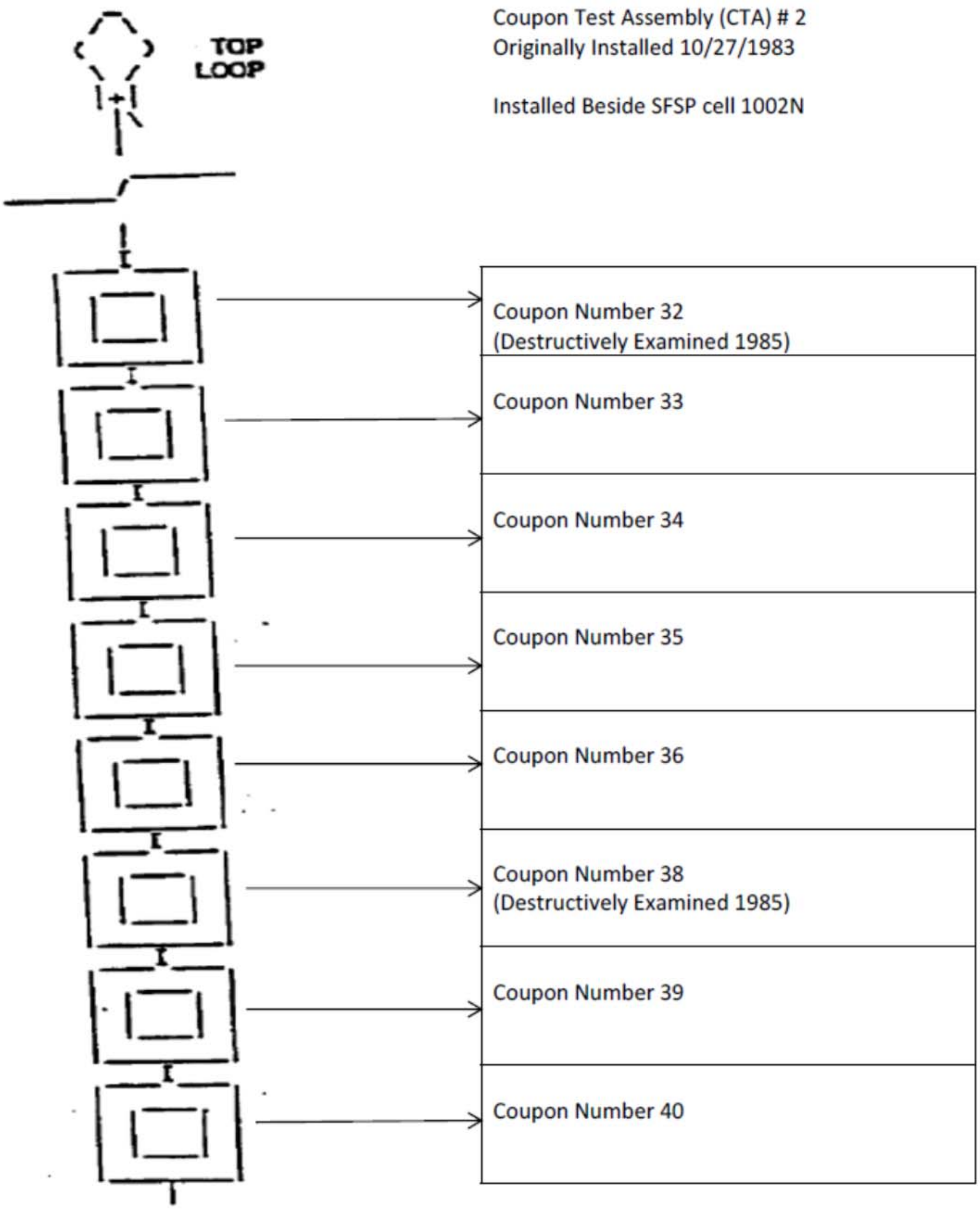
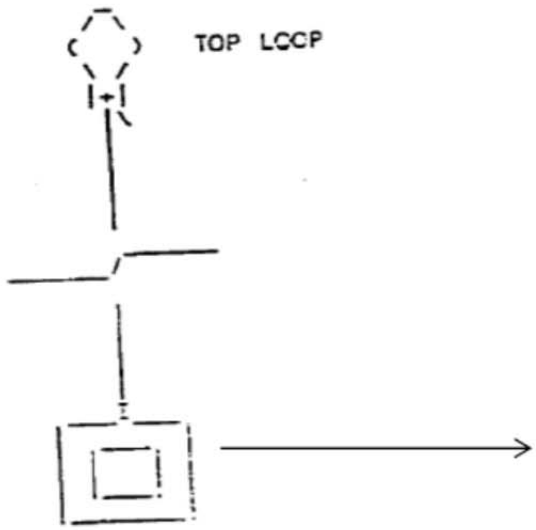


Figure 1
Coupon Test Assembly (continued)

Coupon Test Assembly (CTA) # 3
Originally Installed 11/24/1987

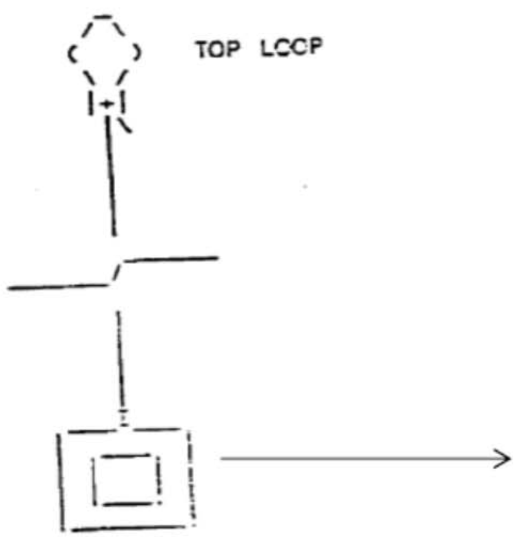
Installed Beside SFSP cell 0402N



Coupon Number 23

Coupon Test Assembly (CTA) # 4
Originally Installed 11/24/1987

Installed Beside SFSP cell 0202N

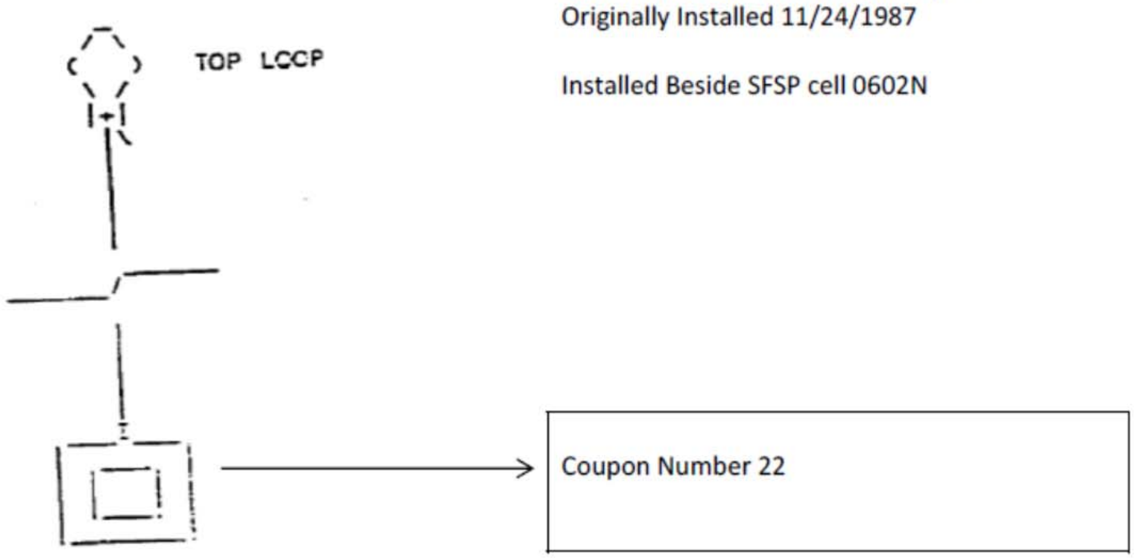


Coupon Number 24

Figure 1
Coupon Test Assembly (continued)

Boral Plate Test Assembly (BPTA) # 1
Originally Installed 11/24/1987

Installed Beside SFSP cell 0602N



Boral Plate Test Assembly (BPTA) # 2
Originally Installed 11/24/1987

Installed Beside SFSP cell 1203N

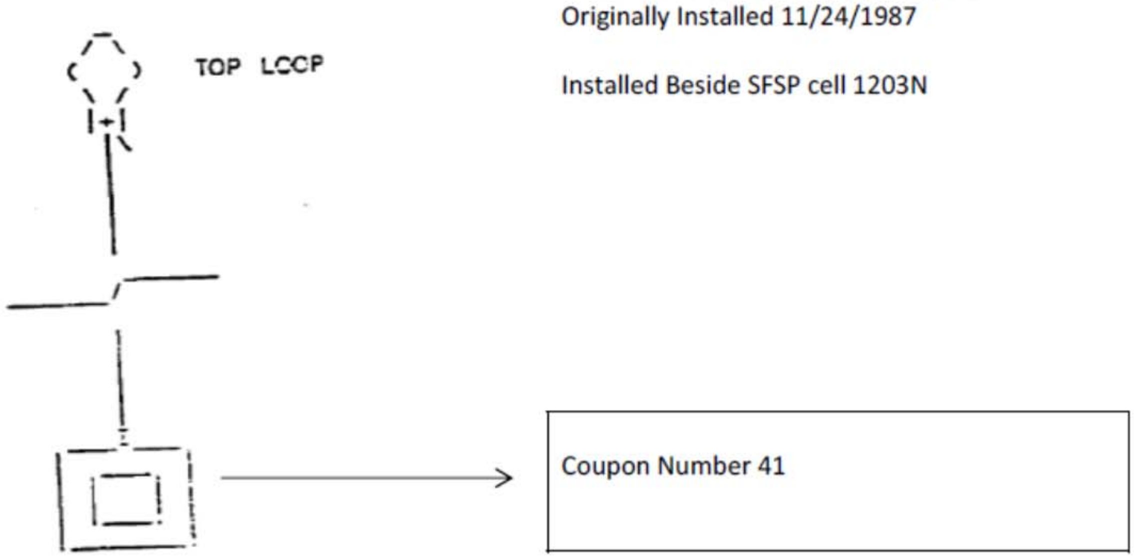
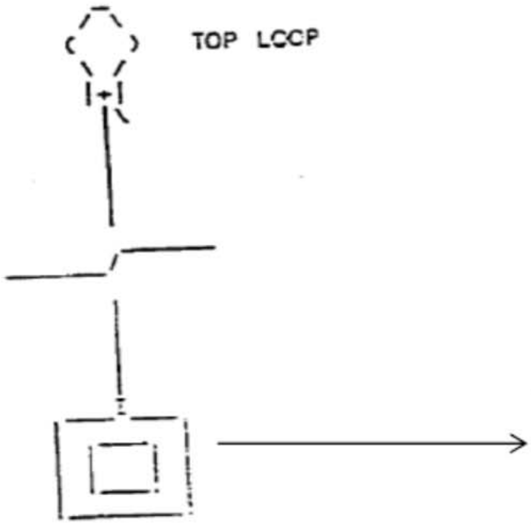


Figure 2
Boral Plate Test Assembly

Boral Plate Test Assembly (BPTA) # 3
Originally Installed 11/24/1987

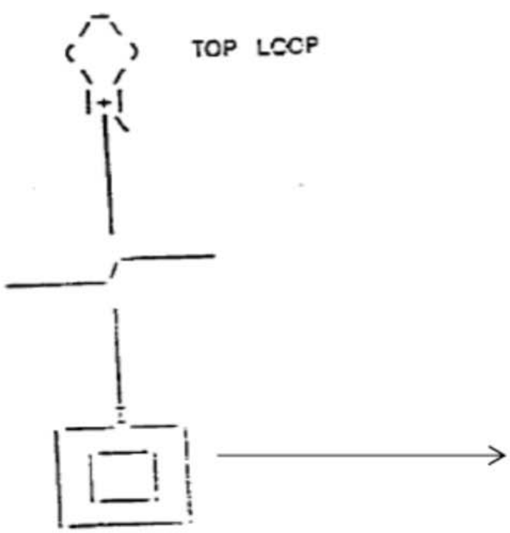
Installed Beside SFSP cell 1003N



Coupon Number 30

Boral Plate Test Assembly (BPTA) # 4
Originally Installed 7/20/1988

Installed Beside SFSP cell 1602N

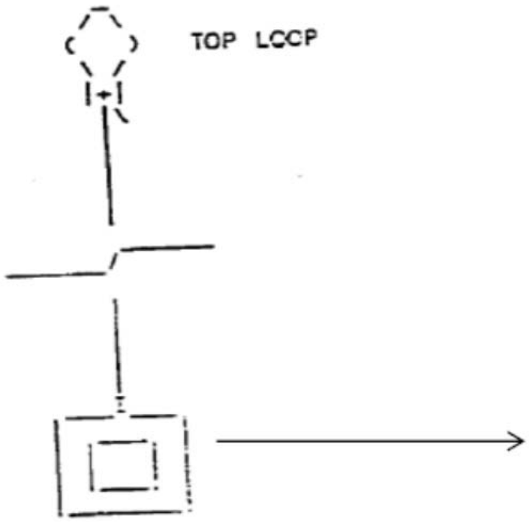


Coupon Number 29

Figure 2
Boral Plate Test Assembly (continued)

Boral Plate Test Assembly (BPTA) # 5
Originally Installed 6/30/1989

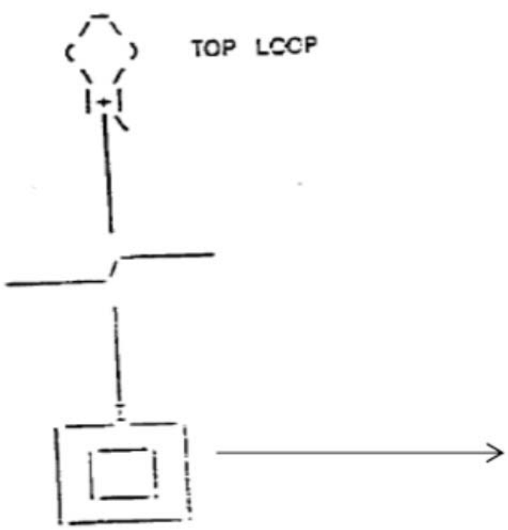
Installed Beside SFSP cell 1402N



Coupon Number 21

Boral Plate Test Assembly (BPTA) # 6
Originally Installed 04/09/1991

Installed Beside SFSP cell 1202N



Coupon Number 28

Figure 2
Boral Plate Test Assembly (continued)

ENCLOSURE 5

SFSP Side View

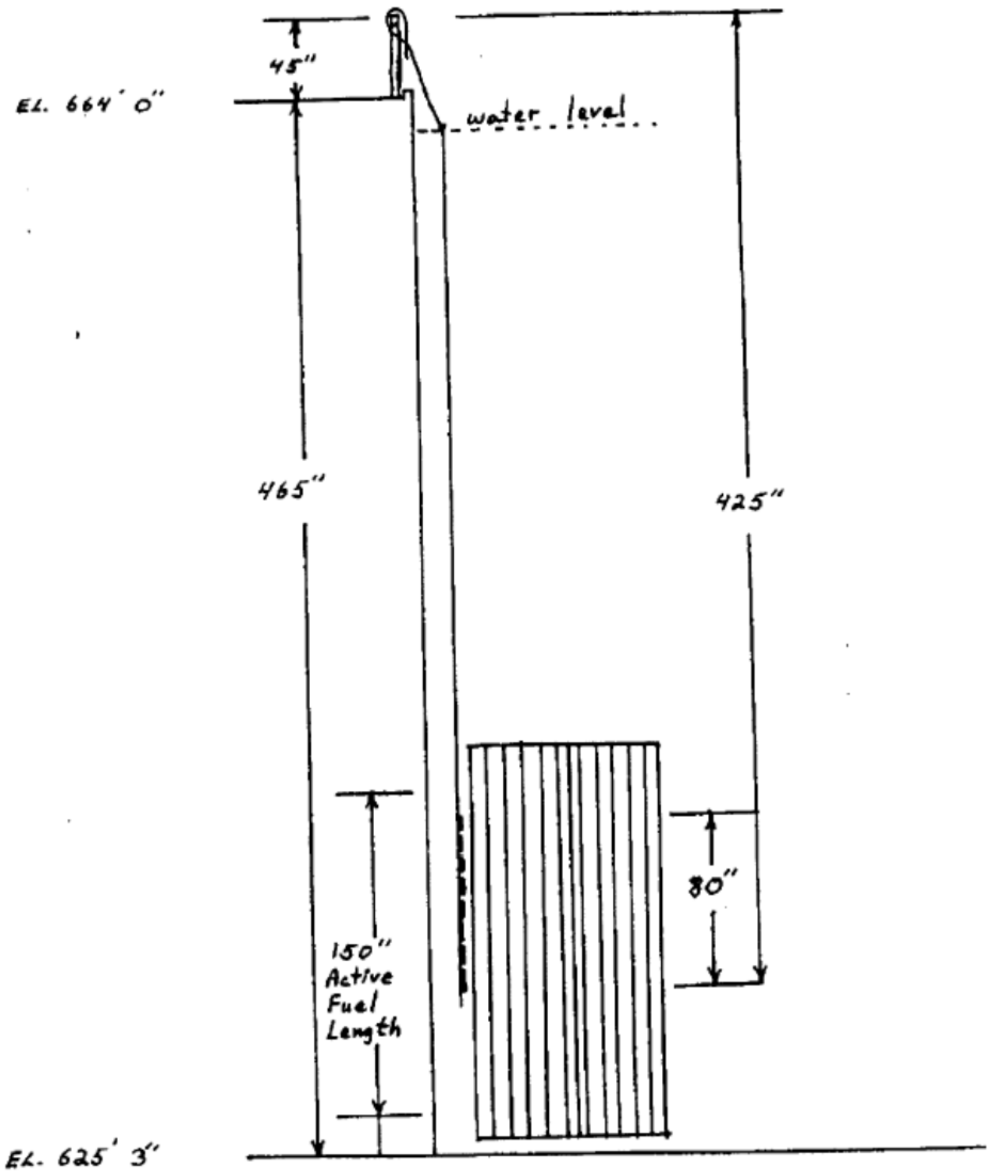


Figure 3
Coupon Test Assembly and Boral Plate Test Assembly Installation

ENCLOSURE 6

AREVA Affidavit

AFFIDAVIT

STATE OF WASHINGTON)
) ss.
COUNTY OF BENTON)

1. My name is Alan B. Meginnis. I am Manager, Product Licensing, for AREVA Inc. and as such I am authorized to execute this Affidavit.

2. I am familiar with the criteria applied by AREVA to determine whether certain AREVA information is proprietary. I am familiar with the policies established by AREVA to ensure the proper application of these criteria.

3. I am familiar with the AREVA information contained in the report ANP-3465P, Revision 0, "Response to RAI for Browns Ferry Nuclear Plant EPU Submittal – SFSP Criticality Safety Analysis," dated February 2016 and referred to herein as "Document." Information contained in this Document has been classified by AREVA as proprietary in accordance with the policies established by AREVA for the control and protection of proprietary and confidential information.

4. This Document contains information of a proprietary and confidential nature and is of the type customarily held in confidence by AREVA and not made available to the public. Based on my experience, I am aware that other companies regard information of the kind contained in this Document as proprietary and confidential.

5. This Document has been made available to the U.S. Nuclear Regulatory Commission in confidence with the request that the information contained in this Document be withheld from public disclosure. The request for withholding of proprietary information is made in accordance with 10 CFR 2.390. The information for which withholding from disclosure is

requested qualifies under 10 CFR 2.390(a)(4) "Trade secrets and commercial or financial information."

6. The following criteria are customarily applied by AREVA to determine whether information should be classified as proprietary:

(a) The information reveals details of AREVA's research and development plans and programs or their results.

(b) Use of the information by a competitor would permit the competitor to significantly reduce its expenditures, in time or resources, to design, produce, or market a similar product or service.

(c) The information includes test data or analytical techniques concerning a process, methodology, or component, the application of which results in a competitive advantage for AREVA.

(d) The information reveals certain distinguishing aspects of a process, methodology, or component, the exclusive use of which provides a competitive advantage for AREVA in product optimization or marketability.

(e) The information is vital to a competitive advantage held by AREVA, would be helpful to competitors to AREVA, and would likely cause substantial harm to the competitive position of AREVA.

The information in the Document is considered proprietary for the reasons set forth in paragraphs 6(b), 6(d) and 6(e) above.

7. In accordance with AREVA's policies governing the protection and control of information, proprietary information contained in this Document have been made available, on a limited basis, to others outside AREVA only as required and under suitable agreement providing for nondisclosure and limited use of the information.

8. AREVA policy requires that proprietary information be kept in a secured file or area and distributed on a need-to-know basis.

9. The foregoing statements are true and correct to the best of my knowledge, information, and belief.

Alan B. Mege[signature]

SUBSCRIBED before me this 3rd day of February, 2016.

Mary Anne Heilman[signature]

Mary Anne Heilman
NOTARY PUBLIC, STATE OF WASHINGTON
MY COMMISSION EXPIRES: 6/6/2016

Mary Anne Heilman
Commission Expires
Notary Public
06-06-16
State of Washington