ENCLOSURE 4

TENNESSEE VALLEY AUTHORITY
BROWNS FERRY NUCLEAR PLANT (BFN) UNIT 1

RESPONSE TO NRC REQUEST FOR ADDITIONAL INFORMATION
INDIVIDUAL PLANT EXAMINATION FOR EXTERNAL EVENTS

TVA CALCULATION NO. CDQ1 999 2004 0156,

"HCLPF CALCULATIONS OF MCC ANCHORAGE FOR SEISMIC IPEEE PROGRAM,"

REV. 0, JUNE 9, 2004.

(SEE ATTACHED)

ORIGINAL

QA Record

TVAN CALCULATION COVERSHEET/CCRIS UPDATE

REV 0 EDMS/RIMS NO.	EDMS TYPE:	EDMS ACCESSION NO (N/A for REV. 0)
W78 040624 010	Calculations(nuclear)	N/A

Calc Title: **HCLPF CALCULATIONS OF MCC ANCHORAGE FOR SEISMIC IPEEE PROGRAM**

CALC ID	TYPE	ORG	PLANT	BRANCH	NUMBER	CUR REV	NEW REV	REVISION APPLICABILITY
CURRENT	CN	NUC	BFN	CEB				Entire calc ☒
NEW	CN	NUC	BFN	CEB	CDQ1 999 2004 0156		000	Selected pages ☐

ACTION	NEW ☒ REVISION ☐	DELETE ☐ RENAME ☐	SUPERSEDE ☐ DUPLICATE ☐	CCRIS UPDATE ONLY ☐ (Verifier Approval Signatures Not Required)	No CCRIS Changes ☐ (For calc revision, CCRIS been reviewed and no CCRIS changes required)

UNITS	SYSTEMS	UNIDS
001	999	N/A

DCN.EDC.N/A	APPLICABLE DESIGN DOCUMENT(S)	CLASSIFICATION
N/A	N/A	E

QUALITY RELATED?	SAFETY RELATED? (If yes, QR = yes)	UNVERIFIED ASSUMPTION	SPECIAL REQUIREMENTS AND/OR LIMITING CONDITIONS?	DESIGN OUTPUT ATTACHMENT?	SAR/TS AFFECTED
Yes ☒ No ☐	Yes ☒ No ☐	Yes ☐ No ☒	Yes ☐ No ☒	Yes ☐ No ☒	Yes ☐ No ☒

PREPARER ID	PREPARER PHONE NO	PREPARING ORG (BRANCH)	VERIFICATION METHOD	NEW METHOD OF ANALYSIS
Farid Elsabee	(256) 729-7000 x18023	CEB	Design Review	☐ Yes ☒ No

PREPARER SIGNATURE	DATE	CHECKER SIGNATURE	DATE
Farid Elsabee	5/24/04	S.J. Eder	5/25/04
VERIFIER SIGNATURE	**DATE**	**APPROVAL SIGNATURE**	**DATE**
J.O. Dizon	5/26/04		6-9-04

STATEMENT OF PROBLEM/ABSTRACT

- This calculation documents the High Confidence Low Probability of Failure (HCLPF) values for the MCC's at BFN Unit 1.

MICROFICHE/EFICHE Yes ☐ No ☒ FICHE NUMBER(S)

☐ LOAD INTO EDMS AND DESTROY

☒ LOAD INTO EDMS AND RETURN CALCULATION TO CALCULATION LIBRARY. ADDRESS: BFN Calculation Library

☐ LOAD INTO EDMS AND RETURN CALCULATION TO:

TVAN CALCULATION COVERSHEET/CCRIS UPDATE

CALC ID	TYPE	ORG	PLANT	BRANCH	NUMBER	REV
NEW	CN	NUC	BFN	CEB	CDQ1 999 2004 0156	000

ALTERNATE CALCULATION IDENTIFICATION

BLDG	ROOM	ELEV	COORD/AZIM	FIRM	Print Report
01	N/A	N/A	N/A	Bechtel	Yes

CATEGORIES F06

KEY NOUNS (A-add, D-delete)

ACTION (A/D)	KEY NOUN	A/D	KEY NOUN
	ANCHORAGE		
	SEISMIC QUALIF		
	SEISMIC DESIGN		
	~~IPEEE~~ JB 6/24/04		

CROSS-REFERENCES (A-add, C-change, D-delete)

ACTION (A/C/D)	XREF CODE	XREF TYPE	XREF PLANT	XREF BRANCH	XREF NUMBER	XREF REV
	P	CN	BFN	CEB	CDQ1 999 2003 2570	
	P	CN	BFN	CEB	CDQ1 281 2003 2569	
	P	CN	BFN	CEB	CDQ1 999 2003 0654	
	P	CN	BFN	CEB	CDQ0 000 94 0339	

CCRIS ONLY UPDATES:
Following are required only when making keyword/cross reference CCRIS updates and page 1 of form NEDP-2-1 is not included:

PREPARER SIGNATURE	DATE	CHECKER SIGNATURE	DATE
PREPARER PHONE NO.	EDMS ACCESSION NO. W78 040624 010		

TVAN CALCULATION RECORD OF REVISION	
CALCULATION IDENTIFIER	CDQ1 999 2004 0156
Title	HCLPF CALCULATIONS OF MCC ANCHORAGE FOR SEISMIC IPEEE PROGRAM

Revision No.	DESCRIPTION OF REVISION
000	Original Issue This Revision 0, including TVA calculation cover sheets, contains 17 pages total

TVAN CALCULATION VERIFICATION FORM	
Calculation Identifier **CDQ1 999 2004 0156**	Revision 000
Method of verification used: 1. Design Review ☒ 2. Alternate Calculation ☐ 3. Qualification Test ☐	Verifier [signature] John O. Dizon Date 5/26/04

Comments:

This revision of the calculation has been reviewed by the Design Review Methodology and has been determined to be technically adequate based on the design input information contained herein using accepted handbook and/or computer applications, and sound engineering practices and techniques, supplemented by applicable industry-standard guidelines.

CALCULATION SHEET

Document: CDQ1 999 2004 0156	Rev.00	Plant: BFN	Unit(s): 1
Subject: HCLPF CALCULATIONS OF MCC ANCHORAGE FOR SEISMIC IPEEE PROGRAM		Prepared : F. Elsabee Date: 5/24/04 Checked : S. J. Eder Date: 5/25/04	

HCLPF CALCULATIONS OF MCC ANCHORAGE FOR SEISMIC IPEEE PROGRAM

PREPARER SIGNATURE	DATE	CHECKER SIGNATURE	DATE
	5/24/04		5/25/04
Farid Elsabee (Facility Risk Consultants, Inc.)		Stephen J. Eder (Facility Risk Consultants, Inc.)	

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1.0 PURPOSE

The purpose of this calculation is to determine the High Confidence Low Probability of Failure (HCLPF) capacities for the **Anchorage of MCC's** at BFN Unit 1. This calculation is in support of the seismic portion of the Individual Plant Examination of External Events (IPEEE) program at the BFN Plant which is required per Generic Letter 88-20 (Reference 4.1). The seismic anchorage evaluations are based on the guidelines provided in the Seismic Margin Assessment (SMA) report by EPRI (Reference 4.2). The in-plant walkdowns were performed using the Walkdown Instruction WI-BFN-0-CEB-04 (Reference 4.5). The procedures used also reflect the methods specified in the SQUG Generic Implementation Procedure (GIP, Reference 4.3).

The USI A-46 MCC evaluations determined that the seismic capacity of the MCC's is governed by the capacity of the cabinet anchorage. Therefore, it follows that the HCLPF capacity is similarly controlled by the cabinet anchorage. For this reason, it is sufficient to investigate only the MCC anchorage to determine their HCLPF capacity.

2.0 SCOPE

This calculation is applicable to the following MCC's, to determine the applicable HCLPF values as part of the seismic portion of the IPEEE program:

Identification Number	Component	SSEL Number
1-BDBB-281-0001A	250V DC RMOV BOARD 1A	19030
1-BDBB-281-0001B	250V DC RMOV BOARD 1B	19031
1-BDBB-281-0001C	250V DC RMOV BOARD 1C	19033
1-BDBB-265-0001B	480V RB VENT BD 1B	19227
1-BDBB-268-0001A	480V RMOV BD 1A	19423
1-BDBB-268-0001B	480V RMOV BD 1B	19424

In the above table, SSEL refers to the Safe Shutdown Equipment List (SSEL), as documented in Reference 4.4.

The above MCC's are located in the Reactor/Control Building, at Elevations 565', 593' and 621'-3".

- SSEL No. 19030 will be modified to meet the A-46 criteria. Therefore, its capacity after the modification should result in a HCLPF capacity > 0.3g.
- SSEL No. 19423 was evaluated and modified as part of the BFN Unit 2 A-46 review. Therefore, its capacity after the modification should result in a HCLPF capacity > 0.3g.
- SSEL No. 19424 was evaluated and screened out under the BFN Unit 2 IPEEE review. Therefore, its HCLPF capacity is > 0.3g.
- SSEL Nos. 19031, 19033 & 19227 are evaluated herein.

There are no unverified assumptions in this calculation.

There are no known special requirements and/or limiting conditions in this calculation.

3.0 DEFINITIONS

3.1 INDIVIDUAL PLANT EXAMINATION OF EXTERNAL EVENTS (IPEEE)

Supplement 4 to Generic Letter 88-20 (Ref. 4.1) requires that each licensee conducts an IPEEE which addresses: seismic events, internal fires, high winds, floods and transportation/nearby facility accidents.

3.2 SEISMIC MARGIN ASSESSMENT (SMA)

The SMA, which has been chosen for implementation at the BFN plant, is an acceptable method used to perform the seismic portion of the IPEEE. The SMA is designed to (a) demonstrate sufficient margin over and beyond the Safe Shutdown Earthquake (SSE) to ensure plant safety, and (b) find any "weak links" that might limit the plant shutdown capacity to safely withstand a seismic event larger than the design SSE or lead to seismically induced core damage. The SMA for the BFN plants is performed using the EPRI methodology which is described in Reference 4.2. BFN also elected to combine the USI A-46 and IPEEE walkdowns which were performed in accordance with the SQUG GIP (see below) with enhancements based on the EPRI report (Ref. 4.2). The walkdowns were documented in SEWS (see below).

3.3 SEISMIC MARGIN EARTHQUAKE (SME)

The earthquake level against which the plant is evaluated while performing the SMA. The SME is specified in terms of two orthogonal horizontal ground response spectra and one vertical ground response spectrum associated with a specific damping value. This is not a new design earthquake, but one which is used to evaluate existing plants under a SMA.

3.4 REVIEW LEVEL EARTHQUAKE (RLE)

The RLE is synonymous with the SME. The two terms are often used interchangeably. The RLE for the BFN plants is defined as an earthquake having a response spectrum that matches the median (50% Non Exceedance Probability – NEP) CR-0098 spectral shape anchored to a peak ground acceleration of 0.3g.

3.5 HIGH CONFIDENCE LOW PROBABILITY OF FAILURE (HCLPF)

The level of earthquake below which core damage frequency is very unlikely, as determined by a seismic margin study. This level of earthquake is called the high-confidence low-probability-of-failure capacity of the plant. The value is obtained as the smallest capacity value determined for all components on the affected plant success path (aka safe shutdown path). From a mathematical perspective of a probability distribution of capacity, as developed in seismic probabilistic risk assessment (PRA) calculations, the HCLPF capacity values are approximately equal to a 95% confidence of not exceeding about a 5% probability of failure. This value is also applied to a SMA to evaluate each component against the SME. The CDFM approach is an acceptable method of determining the HCLPF of a component.

3.6 CONSERVATIVE DETERMINISTIC FAILURE MARGIN (CDFM) APPROACH

The deterministic approach used to calculate a seismic margin capability, for which a HCLPF of the component is demonstrated, is with the use of a set of pre-established CDFM criteria and procedures. The CDFM approach is developed around the following guidelines: (a) The SME is conservatively specified; (b) The predicted structural and equipment response to the SME is median-centered; and (c) The assessment of component capacity is conservative. [For example, for expansion anchor bolts, the CDFM capacity should be defined at about the 98% exceedance probability in order to achieve a HCLPF; and thus, the factor of safety against the mean ultimate capacity should be set at a level consistent with about 2% probability of failure. See Appendix O of Ref. 4.2 for specific safety factors to be used.]

3.7 SCREENED OUT COMPONENTS

For these screened out components, it can only be stated that the HCLPF ground motion level exceeds the SME level. Components which are not screened out require a HCLPF capacity estimate to be determined.

3.8 GENERIC IMPLEMENTATION PROCEDURE (GIP)

The GIP (Ref. 4.3) provides the detailed technical approach, generic procedures and documentation guidance for use by USI A-46 licensees to verify the seismic adequacy of mechanical and electrical safe shutdown equipment. In this regard, the GIP serves as the acceptance criteria and also contains all of the activities necessary for the resolution of USI A-46.

3.9 SAFE SHUTDOWN EQUIPMENT LIST (SSEL)

This list contains all mechanical and electrical equipment within the selected success paths necessary to bring the plant from a normal operation condition to a safe shutdown condition to ensure safety during and following a Safe Shutdown Earthquake (SSE), as defined in Section 3 of the GIP (Ref. 4.3) as well as Section 3 of the EPRI SMA report (Ref. 4.2). Equipment items in the SSEL require screening verification and walkdown to ensure its seismic adequacy with respect to its functionality and structural integrity.

3.10 SEISMIC VERIFICATION WALKDOWN

An engineering review to verify the seismic adequacy of the as-installed condition of a specific item of equipment or component to determine its acceptance or required further evaluations and/or modifications, based on visual inspection for predetermined engineering attributes. Seismic verification walkdowns are to be performed by Seismic Review Teams.

3.11 SEISMIC REVIEW TEAM (SRT)

Seismic Review Team is responsible for the screening verification and walkdown of SSEL equipment items. A minimum of two Seismic Capability Engineers with structural or mechanical engineering background is required on each team, one of which must be a licensed professional engineer. SRT may also consist of systems engineers or plant operations personnel, as necessary.

3.12 SEISMIC CAPABILITY ENGINEER (SCE)

Seismic Capability Engineers are degreed engineers or equivalents, who have completed a SQUG-developed training course on seismic adequacy verification of nuclear power plant equipment. These engineers should have at least five years of experience in earthquake engineering applicable to nuclear power plants and in structural or mechanical engineering. Refer to Section 2 of the GIP for specific qualifications and training requirements.

3.13 ENGINEERING ATTRIBUTE

Engineering attribute is a predetermined or known seismic vulnerability condition (such as support anchorage, GIP caveats for various types of equipment, etc.) that warrants verification or engineering evaluation during walkdown to ensure its seismic adequacy as it may potentially affect the seismic performance of an equipment item or component.

3.14 SEISMIC INTERACTION

Seismic interaction is the physical interaction of any plant structures, features or equipment with a nearby item of safe shutdown equipment caused by relative motions from an earthquake. Seismic interaction effects which are included within the scope of the GIP or seismic IPEEE are (i) proximity; (ii) structural failure and falling; and (iii) flexibility of attached lines and cables.

3.15 SCREENING EVALUATION WORKSHEETS (SEWS)

The Screening Evaluation Worksheets (SEWS) provide a convenient summary and checklist for documenting the seismic verification walkdowns performed in accordance to the acceptance criteria provided in the GIP (Ref. 4.3) and EPRI NP-6041-SL (Ref. 4.2). Appropriate SEWS forms for the various equipment classes and other plant features can be found in Appendix G of the GIP and Appendix F of EPRI NP-6041-SL.

3.16 OUTLIER

An outlier is an item of equipment which does not comply with all of the screening guidelines provided in the respective acceptance criteria. Outliers identified during the seismic verification walkdowns for USI A-46 shall be documented in the Outlier Seismic Verification Sheet (OSVS) for further evaluation and resolution (Section 5, GIP).

4.0 REFERENCES

4.1 USNRC, Generic Letter 88-20, Supplement No. 4, "Individual Plant Examination of External Events (IPEEE) for Severe Accident Vulnerabilities," Final, April 1991.

4.2 Electric Power Research Institute (EPRI) Report NP-6041-SL, "A Methodology for Assessment of Nuclear Power Plant Seismic Margin (Revision 1)," August 1991.

4.3 "Generic Implementation Procedure (GIP) for Seismic Verification of Nuclear Plant Equipment", Revision 2A.

4.4 CDQ1-999-2003-0654, "Composite Safe Shutdown Equipment List (SSEL) for USI A-46 and Seismic IPEEE Programs – Browns Ferry Nuclear Plant, Unit 1," Revision 2.

4.5 WI-BFN-0-CEB-04, "Seismic Verification Walkdown Instruction for USI A-46 and Seismic IPEEE Programs," Revision 0.

4.6 CDQ0-000-940339, "Calculation of Basic Parameters for A46 and Individual Plant Examination of External Events (IPEEE) Seismic Program," Revision 1.

4.7 CDQ1-281-2003-2569, "Anchorage Evaluation for 250V DC RMOV Board 1B for USI A-46 Resolution," Revision 0.

4.8 CDQ1-999-2003-2570, "Anchorage Evaluation for 480V RB Vent BD 1B and 250V DC RMOV Board 1C for USI A-46 Resolution," Revision 0.

5.0 Anchorage Evaluation

5.1 General Calculation Method

The general method used for determining the anchorage HCLPF capacities are based on the guidelines provided in EPRI report NP-6041-SL (Reference 4.2).

The stress to allowable ratios of the anchorage, previously calculated for the components in support of the resolution of USI A-46, are normally used as the basis for the HCLPF capacity determination. The ratios are modified to reflect the higher level of the RLE vs the SSE level used for the A-46 review. The conservative scaling factor of 1.88 developed in Reference 4.6 is first used to scale up the A-46 stress to allowable ratio. Note that when this scaling factor is applied to the previous A-46 calculations, the A-46 SSE values are increased by 1.88/1.25 = 1.504 only, since the HCLPF calculations do not need the 1.25 factor used in the A-46 calculations to account for the median centered curves being used at BFN plants. Furthermore, the IPEEE scaling factor is applied only to the SSE values and care is to be taken when the controlling stress ratio is based on the combined effect of SSE and DW where DW subtracts from the SSE effects. For such situations, one conservative approach is to neglect the DW effect which reduces the SSE loads when the IPEEE scaling is performed. Consider the following:

A-46 calculation contains: $Tsse/Tall - T_{DW}/Tall \leq 1$

When scaling for IPEEE, use: $1.504*Tsse/Tall \leq 1$ or $1.504Tsse/Tall - T_{DW}/Tall \leq 1$

Whichever is simpler to implement

If the resulting stress ratio, after scaling the SSE effects, remains below 1.0, the component is screened out and the HCLPF capacity level is greater than 0.3g. When the stress ratio exceeds 1.0, a more detailed calculation of the HCLPF capacity level is needed.

The detailed calculation will either use a more refined value for the RLE scaling factor or will reduce some of the conservatism which may have been used in the A-46 calculations while still meeting the requirements of References 4.2 and 4.3. If the stress ratio cannot be kept below 1.0, a new HCLPF capacity value (below the 0.3g level) will be calculated for the component of concern.

5.2 Anchorage HCLPF Capacity Calculation

1-BDBB-281-0001B	250V DC RMOV BOARD 1B	19031	MCC bolted to sill channel
1-BDBB-281-0001C	250V DC RMOV BOARD 1C	19033	MCC welded to sill channel
1-BDBB-265-0001B	480V RB VENT BD 1B	19227	MCC welded to sill channel

1-BDBB-281-0001B:

Per Reference 4.7, the controlling component is the ¼" bolt connection between the MCC base and the sill channel. Since the stress ratio to allowable in tension for the bolt is 0.95, the IPEEE scaling factor will definitely result in a stress ratio greater than 1.0. Therefore a detailed HCLPF capacity calculation is needed.

Based on Reference 4.7 and using the scaling factor of 1.88, the demand level for the RLE is:

$Sa_{EW} = 2*0.6722g*1.88 = 2.53g$

$PGA_{NS} = 2*0.15g*1.88 = 0.564g$

$PGA_{VERT} = 2*0.08g*1.88 = 0.3g$

$V_{EW} = 2.53*3465/32 = 274$ lbs

$V_{NS} = 0.564*3465/32 = 61.1$ lbs

$\mathbf{V = (274^2 + 61.1^2)^{1/2} = 281}$ **lbs**

$T_{EW} = (2.53*3465*50) / (16*17) = 1611.5$ lbs

$T_{vert} = 0.3*3465 / 32 = 32.5$ lbs

$\mathbf{T = (1611.5^2 + 32.5^2)^{1/2} - (3465/32) = 1504}$ **lbs**

The bolt capacity is:

Using the AISC Part 2 capacities as done in Reference 4.7, except use the gross area of the bolts as required by AISC instead of the conservative approach used in Ref. 4.7:

Gross $A = 0.049\ in^2$

$fv = 281/0.049 = 5.7\ ksi < 1.7*10ksi = 17ksi$

$Ftall = 1.7*Ft_{PartI} = 1.7*26 - 1.8fv = 44.2 - 10.26 = 33.94\ ksi < 1.7*20=34\ ksi$

ft = 1504 / 0.049 = 30.7 ksi

ft / Ftall = 30.7 / 33.94 = 0.9 < 1.0 ☑ OK

Therefore the HCLPF capacity is > 0.3g

1-BDBB-281-0001C & 1-BDBB-265-0001B:

The calculation of Reference 4.8 evaluated the anchorage of both MCC's by enveloping the conditions of both units. Per the calculation, the controlling components are the concrete anchors along the front and back edge of the MCC line up.

The pull out load to allowable ratio was calculated as 0.36. Note that this factor is based on the GIP criteria for expansion anchor bolts which is much more severe than that allowed by Reference 4.2 for the SMA.

Based on the Ref. 4.8 calculation, use the RLE scaling factor of 1.504 to increase the A-46 SSE load only while neglecting the counter effect of DW:

$T = (591^2+23^2)^{½} *1.504 / (2,360*0.56) = 0.67 < 1.0$ ☑ OK

Therefore the two MCC's can be screened out and the HCLPF capacity is > 0.3g

6.0 Conclusion

The following table summarizes the HCLPF anchorage capacities of the MCC's based on the above evaluations

SSEL Number	Identification Number	Component	HCLPF Capacity
19030	1-BDBB-281-0001A	250V DC RMOV BOARD 1A	Anchorage modified. HCLPF > 0.3g
19031	1-BDBB-281-0001B	250V DC RMOV BOARD 1B	HCLPF capacity calculated as > 0.3g
19033	1-BDBB-281-0001C	250V DC RMOV BOARD 1C	HCLPF capacity screened out as > 0.3g
19227	1-BDBB-265-0001B	480V RB VENT BD 1B	HCLPF capacity screened out as > 0.3g
19423	1-BDBB-268-0001A	480V RMOV BD 1A	Anchorage modified. HCLPF > 0.3g
19424	1-BDBB-268-0001B	480V RMOV BD 1B	HCLPF capacity screened out as > 0.3g