ENCLOSURE 8

BROWNS FERRY NUCLEAR PLANT (BFN) UNIT 1 TECHNICAL SPECIFICATION CHANGE (TS 436) - INCREASED MAIN STEAM ISOLATION VALVE (MSIV) LEAKAGE RATE LIMITS

SEISMIC EVALUATION REPORT

QA Record

ORIGINAL

TVAN CALCULATION COVERSHEET

Title Seismic Evaluation Report		Plant BFN Unit 0	Page 1 of see rev. log
Preparing Organization NE/CEB	Key Nouns (For EDM) Seismic, Component Qualification, Piping, Pipe Support		

Calculation Identifier	Each time these calculations are issued, preparer must ensure that the original (R0) RIMS/EDM accession number is filled in.		
CD-N0001-990113	Rev	(for EDM use)	EDM Accession Number
Applicable Design Document(s) BFN-50-C-7100 BFN-50-C-7107, BFN-50-C-7306	R0		R14 990909 102
	R1		R14 000613 106
UNID System(s) 001	R2		
	R3		

	R0	R1	R2	R3		Yes	No
					Quality Related?	■	☐
DCN, EDC, NA	N/A	T41182A, [illegible] 6-8-00			Safety related? If yes, mark Quality Related yes	☐	■
Prepared	F Caramante FC 9/8/99	[signature] 6/7/00					
Checked	[signature] 9/8/99	[signature] 6-8-00 J.N. HUDGINS			These calculations contain unverified assumption(s) that must be verified later?	☐	■
Design Verified	[signature] 9/8/99	[signature] 6-8-00 J.N. HUDGINS			These calculations contain special requirements and/or limiting conditions?	☐	■
Approved	L.R. [signature]	[signature] for LRM			These calculations contain a design output attachment?	☐	■
Approval Date	9-9-99	6-13-00			Calculation Classification	D	
SAR Affected?	Yes ☐ No ■	Yes ☐ No ☒	Yes ☐ No ☐	Yes ☐ No ☐	Microfiche generated	☐	■
Revision applicability	Entire calc ■	Entire calc ☒ Selected pgs ☐	Entire calc ☐ Selected pgs ☐	Entire calc ☐ Selected pgs ☐	Number		

Statement of Problem:

The Main Steam piping downstream of the outboard MSIV's is desired to be capable of with standing an earthquake so that any leakage through the MSIV's from the Reactor side can be contained and diverted to the main condenser. This calculation supports the MSIV leakage tech spec change at BFN.

Abstract

This calculation is documents the "Browns Ferry Nuclear Plant - Increased MSIV Leakage Tech Spec Change Submittal Seismic Evaluation Report", (200918-R-002); August 1999, By EQE International, Oakland, CA. Additionally, Bounding Calculations (200918-C-002) "Seismic evaluation for the Condensers" and (200918-C-001) "Seismic verification of the main steam drain piping and supports associated with the MSIV alternate leakage treatment pathway" are contained in this calculation.

|R1 No change to abstract

☒ Microfilm and return calculation to Calculation Library. Address: POB-1A-BFN

☐ Microfilm and return calculation to:

☐ Microfilm and destroy.

TVAN CALCULATION RECORD OF REVISION		
CALCULATION IDENTIFIER **CD-N0001-990113**		Page 2
Title **Seismic Evaluation Report**		

Revision No.	DESCRIPTION OF REVISION
0	Initial Issue **TOTAL NUMBER OF PAGES = 125**
1	Minor revision to correct Table of Contents page, change Attachment Section 11.0 to 9.0 and delete reference to Appendices and minor changes to the EQE "Seismic Evaluation Report", page A40 show valves 71-6B and 73-6B as open, and add Reference 10 on page A75 and add reference to Reference 10 to pages A44 and A46. Pages Added: None Pages Deleted: None Pages Replaced or Revised: 1, 2, 3, 4, Attachment A pages A40, A44, A46, A75 **TOTAL NUMBER OF PAGES = 125**

TVAN CALCULATION DESIGN VERIFICATION FORM		
Calculation Identifier **CD-N0001-990113**		Revision 1

Method of design verification used:		
1. Design Review	☒	
2. Alternate Calculation	☐	
3. Qualification Test	☐	

Comments:

Minor changes that are not technical in nature therefore a detailed design review within a strict interpretation of the design review was not required.

Jesse N. Hudgins
6-8-00

This replaced by revision 1

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Calculation Identifier: CD-N0001-990113	Revision: 1	Page 4

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R1

TVA

CALCULATION SHEET

Document: CD-N0001-990113	Rev.: 0	Plant: BFN 0	Page: 5
Subject: Seismic Evaluation Report		Prepared By: AB Date: 9/8/1999 Checked By:_____ Date:_____	

SECTION 1.0: PURPOSE

The purpose of this calculation is to document the "Browns Ferry Nuclear Plant - Increased MSIV Leakage Tech Spec Change Submittal Seismic Evaluation Report", (200918-R-002); August 1999, By EQE International, Oakland, CA. Additionally, Bounding Calculations (200918-C-002) "Seismic evaluation for the Condensers" and (200918-C-001) "Seismic verification of the main steam drain piping and supports associated with the MSIV alternate leakage treatment pathway" are contained within this calculation.

SECTION 2.0: ASSUMPTIONS:

There are no unverified assumptions in this calculation.

SECTION 3.0: REQUIREMENTS/LIMITING CONDITION:

This calculation does not generate any requirements or limiting conditions which limit system or plant operation from that currently documented in the design, place special requirements on a safety evaluation, or place special requirements on the physical configuration that are generally outside the stated purpose of the calculation.

SECTION 4.0 REFERENCES:

See Attachment A, Section 5.; Attachment B, Section 3.0 And Attachment C, Section 3.0 for references used by EQE.

SECTION 5.0 DESIGN INPUT DATA:

See Attachment A, B, And C, design input data is identified where it has been used.

SECTION 6.0 SUPPORTING GRAPHICS:

See Attachment A, sheet 5 TABLES and FIGURES; Attachment B, sheet 2 TABLES and FIGURES, and Attachment C, sheet 2 TABLES and FIGURES for graphics used by EQE.

SECTION 7.0 COMPUTATIONS AND ANALYSIS:

See Attachment A, Section 5. for computations and analysis performed by EQE

SECTION 8.0 SUMMARY:

See Attachment A, Section 4.1.3, Attachment B, Section 5.0 and Attachment C, Section 5.0.

This Page Added By Revision 0

SECTION 9.0 ATTACHMENTS:

Attachment A, "Browns Ferry Nuclear Plant - Increased MSIV Leakage Tech Spec Change Submittal Seismic Evaluation Report", (200918-R-002); August 1999, By EQE International, Oakland, CA.

Attachment B, Bounding Calculation (200918-C-002) "Seismic evaluation for the Condensers"; August 1999, By EQE International, Oakland, CA.

Attachment C, Bounding Calculation (200918-C-001) "Seismic verification of the main steam drain piping and supports associated with the MSIV alternate leakage treatment pathway"; August 1999, By EQE International, Oakland, CA.

EQE INTERNATIONAL

Browns Ferry Nuclear Plant Increased MSIV Leakage Tech Spec Change Submittal

Seismic Evaluation Report

Prepared for:

TENNESSEE VALLEY AUTHORITY

EQE Job Number: 50147.16 & 200918.01

August 1999

EQE INTERNATIONAL

APPROVAL COVER SHEET

Title:	Browns Ferry Nuclear Plant Increased MSIV Leakage Tech Spec Change Submittal – Seismic Evaluation Report
Report Number:	200918-R-002
Client:	Tennessee Valley Authority
Project Number:	200918.01

Revision Number	Approval Date	Prepared	Reviewed	Approved
0	8/31/99	J.O. Dixon (signature)	(signature)	J.O. Dixon (signature)

TABLE OF REVISIONS		
Revision No.	**Description of Revision**	**Date**
0	Initial Issue	August 31, 1999

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TABLES

FIGURES

FIGURES (CONT.)

FIGURES (CONT.)

1. INTRODUCTION

This report summarizes the engineering activities performed for the supplemental plant specific Main Steam piping seismic verification to support the increased Main Steam Isolation Valve (MSIV) leakage tech spec change at Browns Ferry Nuclear Plant (BFN). The verification program was performed in accordance with the recommendations of the General Electric Boiling Water Reactor Owners Group (BWROG) Report for Increasing MSIV Leakage Rate Limits and Elimination of Leakage Control Systems (Reference 1). The U.S. Nuclear Regulatory Commission (NRC) has reviewed the BWROG report and issued a safety evaluation report (SER) on its application for addressing the MSIV leakage issues (Reference 2), subject to certain limitations.

Engineering activities associated with the supplemental plant specific seismic verification program, as recommended in the BWROG report, consist of the following key elements:

- Seismic Experience Database Comparisons
- Seismic Verification Walkdowns
- Seismic Assessments of Selected Components

Detailed discussions of each of these activities are presented in the following sections of the report.

2. SEISMIC EXPERIENCE DATABASE COMPARISONS

The seismic experience data are derived from an extensive database on the performance of power plants and industrial facilities in past strong-motion earthquakes. These performance data are compiled by EQE for the Seismic Qualification Utility Group, the Electric Power Research Institute and others, and included over 100 facilities in more than 60 earthquakes that have occurred around the world from 1934 to present. Of interest to the MSIV leakage issues are the performance of the non-seismically analyzed main steam system piping, related components and supports, and condensers.

The BWROG Report (Reference 1) summarizes data on the performance of main steam piping and condensers in past strong-motion earthquakes and compares these piping and condensers with those in typical U.S. GE Mark I, II, and III nuclear plants. The earthquake experience data and similarity comparisons are then used to draw conclusions on how the GE piping and condensers would perform in a design basis earthquake (DBE).

The following sections present experience database comparisons that are plant-specific to Browns Ferry Nuclear Plant for use to support the increased MSIV leakage tech spec change submittal.

2.1 SEISMIC GROUND MOTIONS

Ground motion estimates of 13 database sites were reviewed and accepted by the NRC staff for inclusion in the BWROG's earthquake experience database, and are presented in the referenced NRC Safety Evaluation Report (SER, Reference 2). To establish applicability of the BWROG's earthquake experience-based methodology for demonstrating the seismic ruggedness of non-seismically analyzed main steam piping and associated components at Browns Ferry, comparisons of the ground response spectra of selected database facilities with BFN design basis ground spectrum were made.

The majority of the MSIV alternate leakage treatment (ALT) path and associated piping systems and the condensers at Browns Ferry are located in the lower elevations of the Turbine Building. BFN Turbine Building is classified as a Class II structure, hence, no dynamic analysis of the building was performed. The building below the operating floor is a reinforced concrete framed structure supported on steel H-piles to bedrock. The horizontal ground spectrum is conservatively taken as the BFN 5% damped design basis DBE input spectrum (0.2g Housner spectrum defined at rock outcrop) and scaled by 1.6 to account for soil amplification.

A composite comparison of the ground response spectra of selected earthquake experience database facilities with the Browns Ferry design basis DBE ground spectrum is shown in Figure 2-1. The selected ground motions include the following 10 sites from among the 13 database facilities reviewed and accepted by the NRC:

- Valley Steam Plant - USGS estimate
  1971 San Fernando Earthquake (M6.6)
- Burbank Power Plant - USGS estimate
  1971 San Fernando Earthquake (M6.6)
- El Centro Steam Plant - E/W direction
  1979 Imperial Valley Earthquake (M6.6)
- Moss Landing Power Plant - PG&E estimate
  1989 Loma Prieta Earthquake (M7.1)
- Humboldt Bay Nuclear Power Plant - Average
  1975 Ferndale Earthquake (M5.5)
- Coolwater Power Plant - Longitudinal direction
  1992 Landers Earthquake (M7.3)
- Commerce Refuge to Energy Plant (LA Bulk Mail) - N/S direction
  1987 Whittier Narrows Earthquake (M5.9)
- Grayson Power Plant (Glendale) - N200E direction
  1971 San Fernando Earthquake (M6.6)
- Ormond Beach Power Plant - N270E direction
  1973 Point Mugu Earthquake (M5.8)

- PALCO Cogeneration Plant (Rio Dell) – Average
  1992 Petrolia Earthquake (M6.9)

The individual comparison plots of the 5% damped ground spectra of the above 10 database facilities with the Browns Ferry DBE ground spectrum are shown in Figures 2-2 to 2-11. In general, the earthquake experience database sites have experienced strong ground motions that are in excess of the Browns Ferry DBE at the frequency range of interest (i.e., about 1 Hz. and above), with the exception of the Ormond Beach site. Many of the database site ground motions envelope the conservatively estimated BFN DBE ground spectrum by large factors in various frequency bands within the 1 Hz. and above range.

Based on the above observations and comparison, it is concluded that the Browns Ferry DBE ground spectrum is generally bounded by those of the earthquake experience database sites at the frequencies of interest. Hence, the use of earthquake experience-based approach for demonstrating the seismic ruggedness of non-seismically analyzed main steam piping and associated components at Browns Ferry, consistent with the BWROG's recommendations and limitations of the SER, is appropriate.

2.2 PIPING, EQUIPMENT AND OTHER PLANT FEATURES

The main steam piping and condensers in the earthquake experience database exhibited substantial seismic ruggedness, even when they are typically not designed to resist earthquakes. This is a common conclusion in studies of this type on other plant items such as welded steel piping in general, anchored equipment such as motor control centers, pumps, valves, structures, and so forth. That is, with limited exceptions, normal industrial construction and equipment typically have substantial inherent seismic ruggedness, even when they are not designed for earthquakes. No failures of the main steam piping were found. Anchored condensers have also performed well in past earthquakes with damage limited to minor internal tube leakage.

The BWROG Report (Reference 1) contains detailed discussions and comparisons of main steam piping and condenser design in several earthquake experience database sites and example GE Mark I, II, and III plants in the U.S. The general conclusions of these comparisons are as follows:

- GE plant designs are similar to or more rugged than those in the earthquake experience database that exhibited good earthquake performance;
- The possibility of significant failure in GE BWR main steam piping or condensers in the event of an eastern U.S. design basis earthquake is highly unlikely; and that
- Any such failure would also be contrary to a large body of historical earthquake experience data, and thus unprecedented.

Plant-specific comparisons of the main steam piping, related components and supports, and condensers at Browns Ferry with those in the selected earthquake experience database facilities are provided in Section 4 of this report.

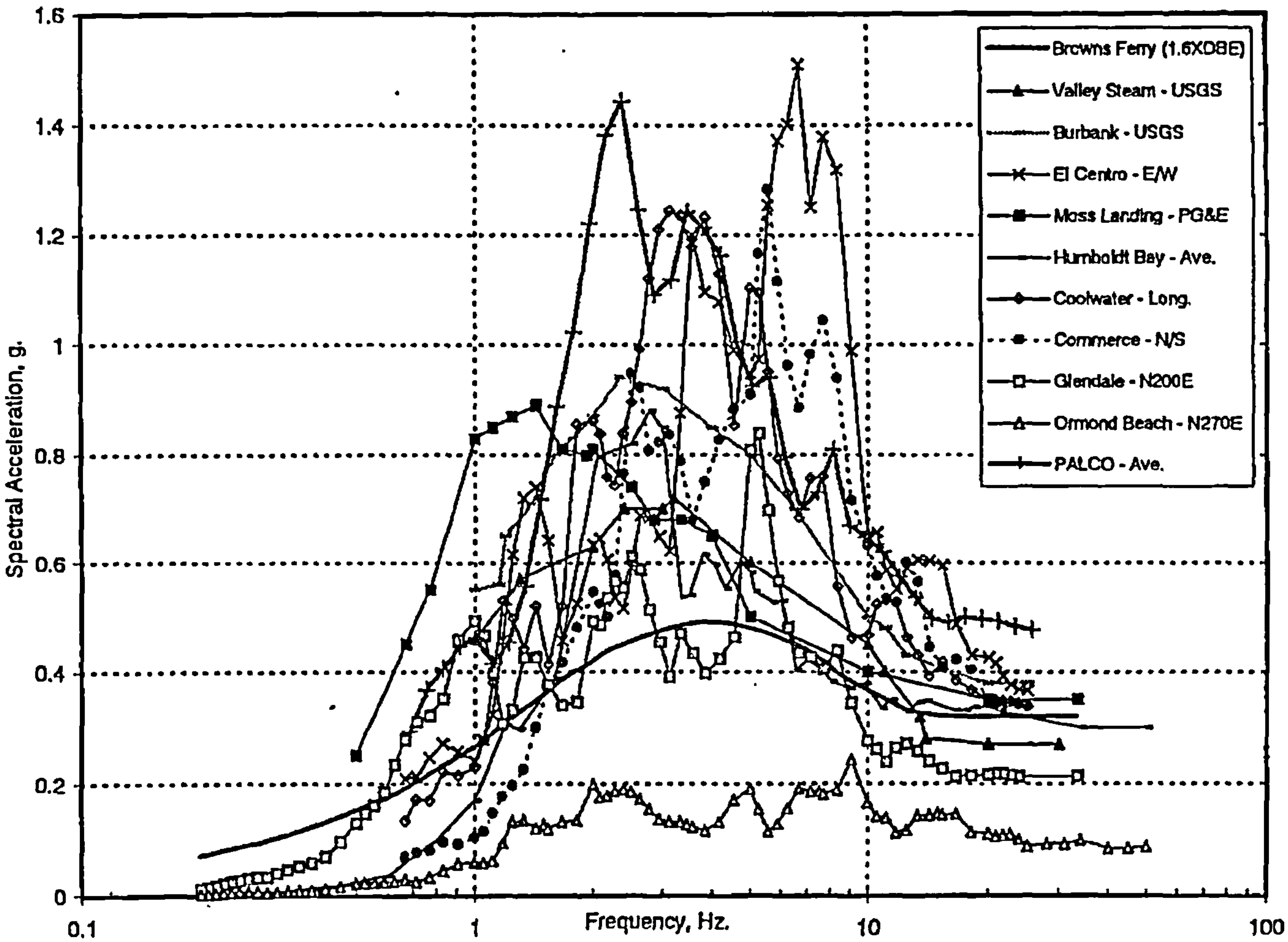

Figure 2-1 Comparison of Browns Ferry DBE Ground Spectrum and Selected Database Site Spectra

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Attachment A

Valley Steam Plant, CA (1971 San Fernando Earthquake)

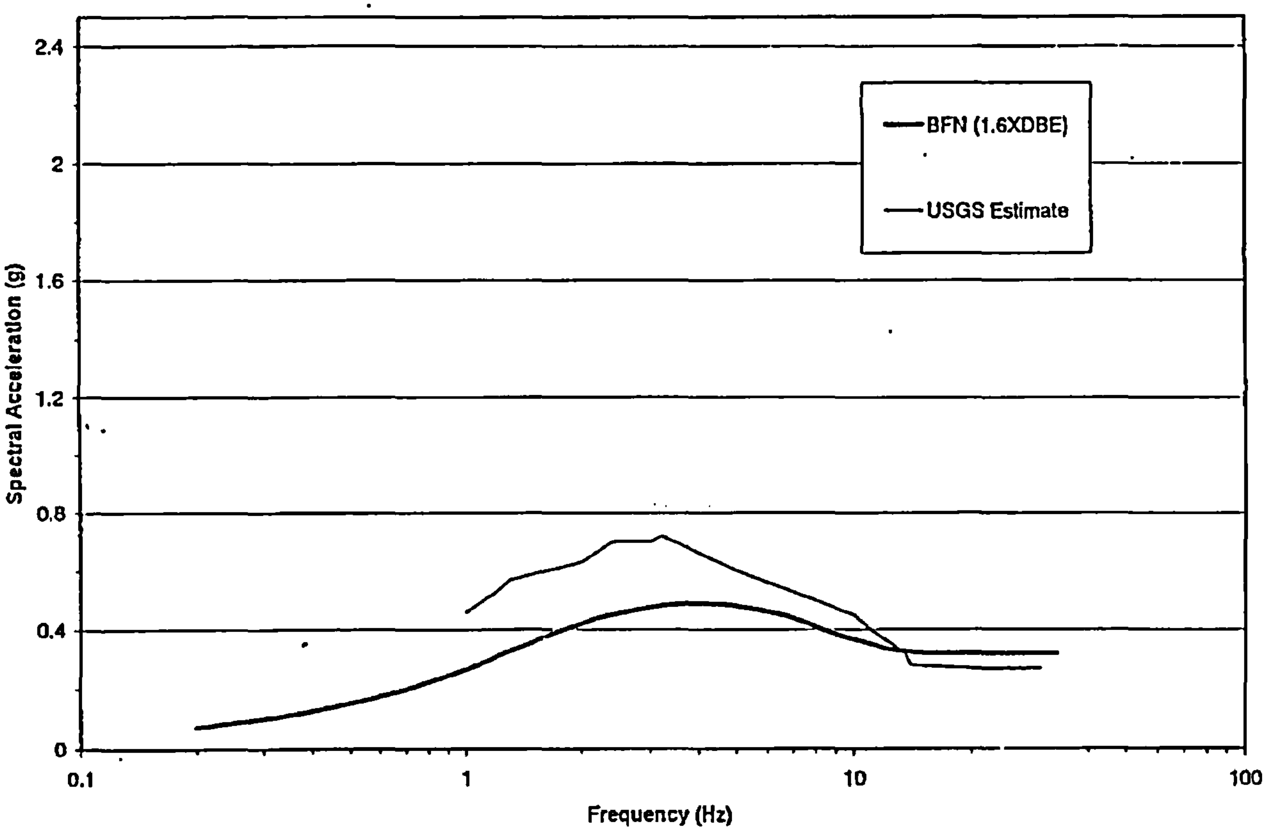

Figure 2-2 Comparison of Browns Ferry DBE and Valley Steam Plant Ground Spectra

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Attachment A

Burbank Power Plant, CA (1971 San Fernando Earthquake)

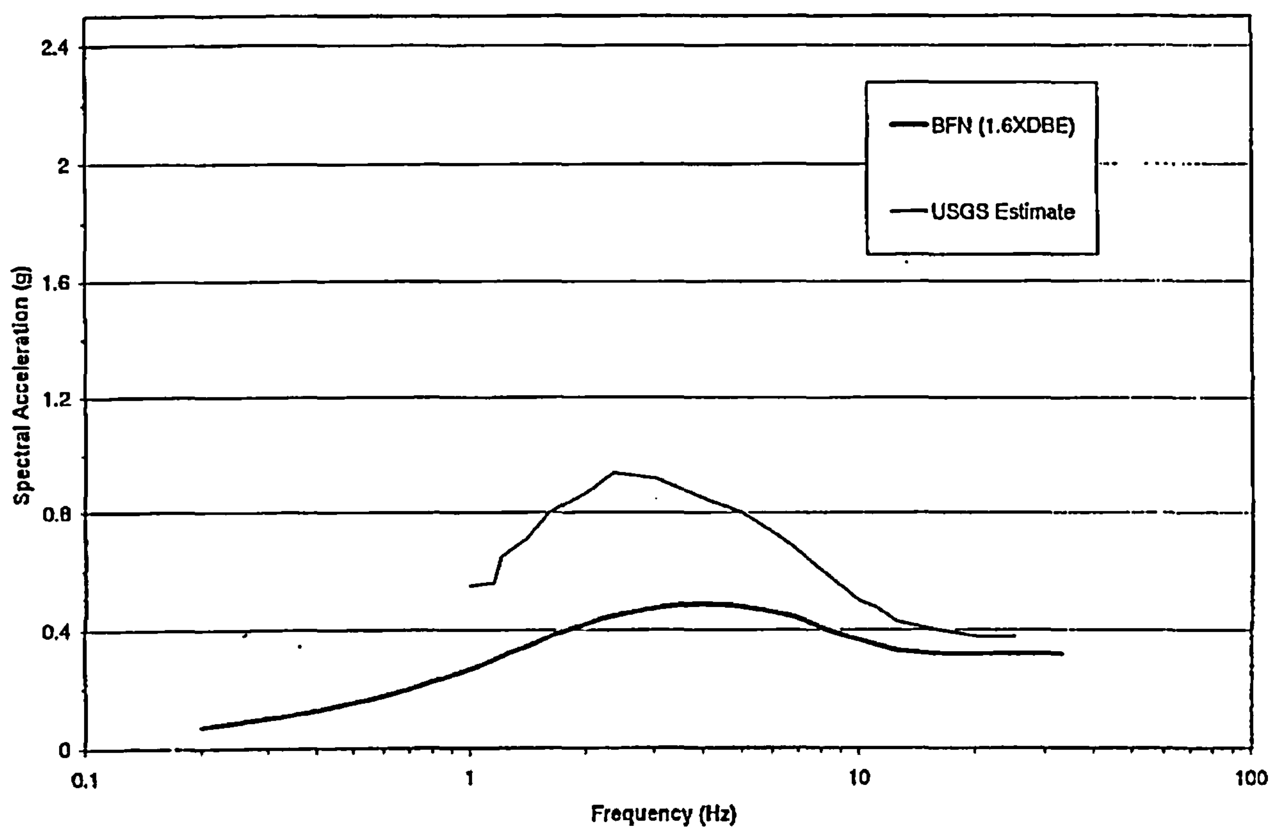

Figure 2-3 Comparison of Browns Ferry DBE and Burbank Power Plant Ground Spectra

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Attachment B

El Centro Steam Plant, CA (1979 Imperial Valley Earthquake)

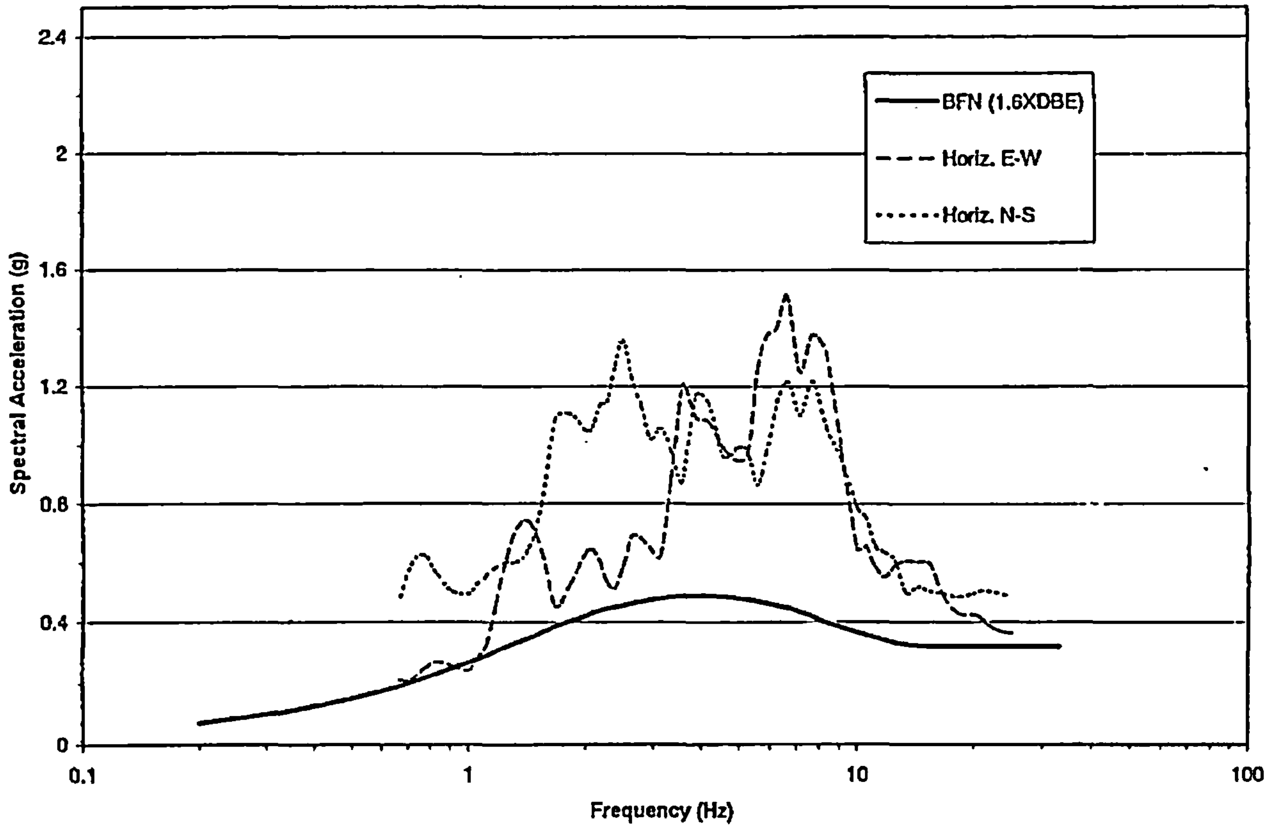

Figure 2-4 Comparison of Browns Ferry DBE and El Centro Steam Plant Ground Spectra

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Attachment A

Moss Landing Power Plant, CA (1989 Loma Prieta Earthquake)

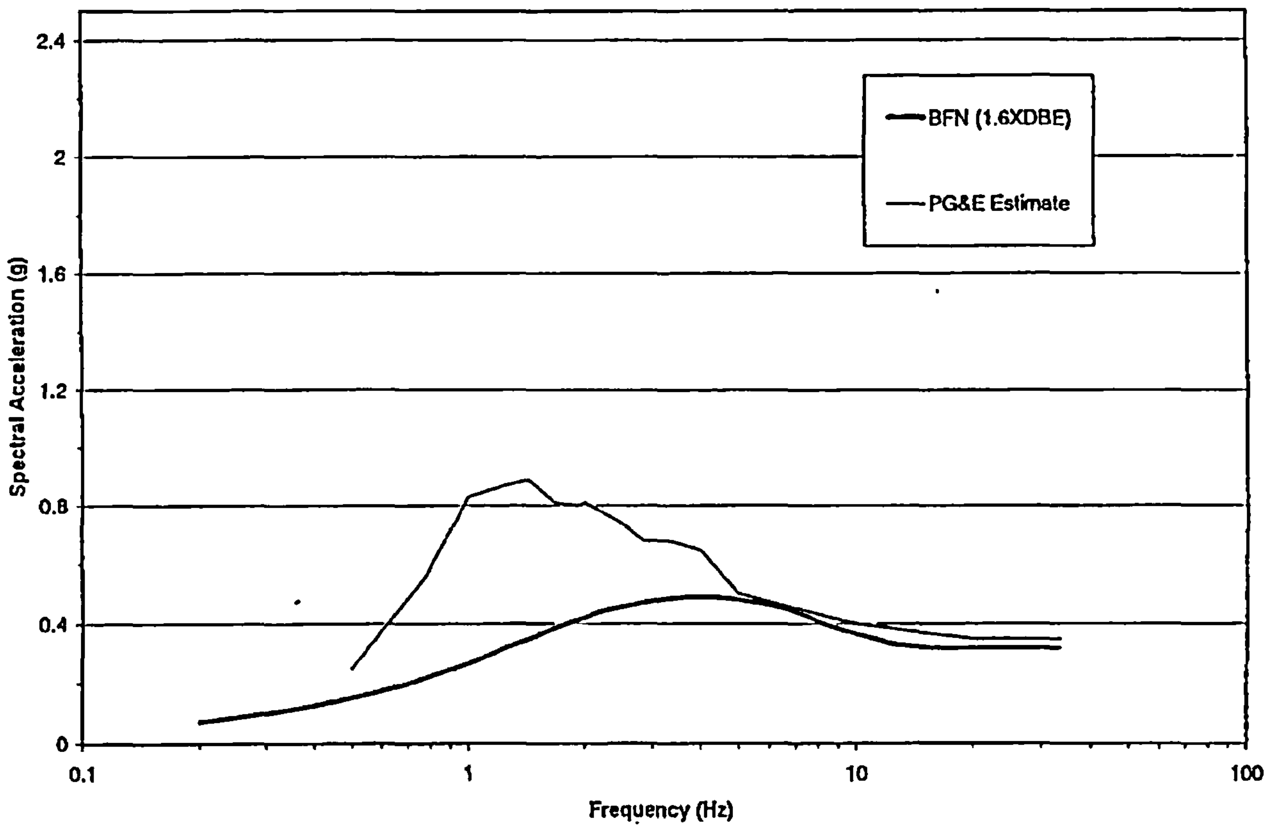

Figure 2-5 Comparison of Browns Ferry DBE and Moss Landing Power Plant Ground Spectra

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Attachment A

Humboldt Bay Nuclear Power Plant, CA (1975 Ferndale Earthquake)

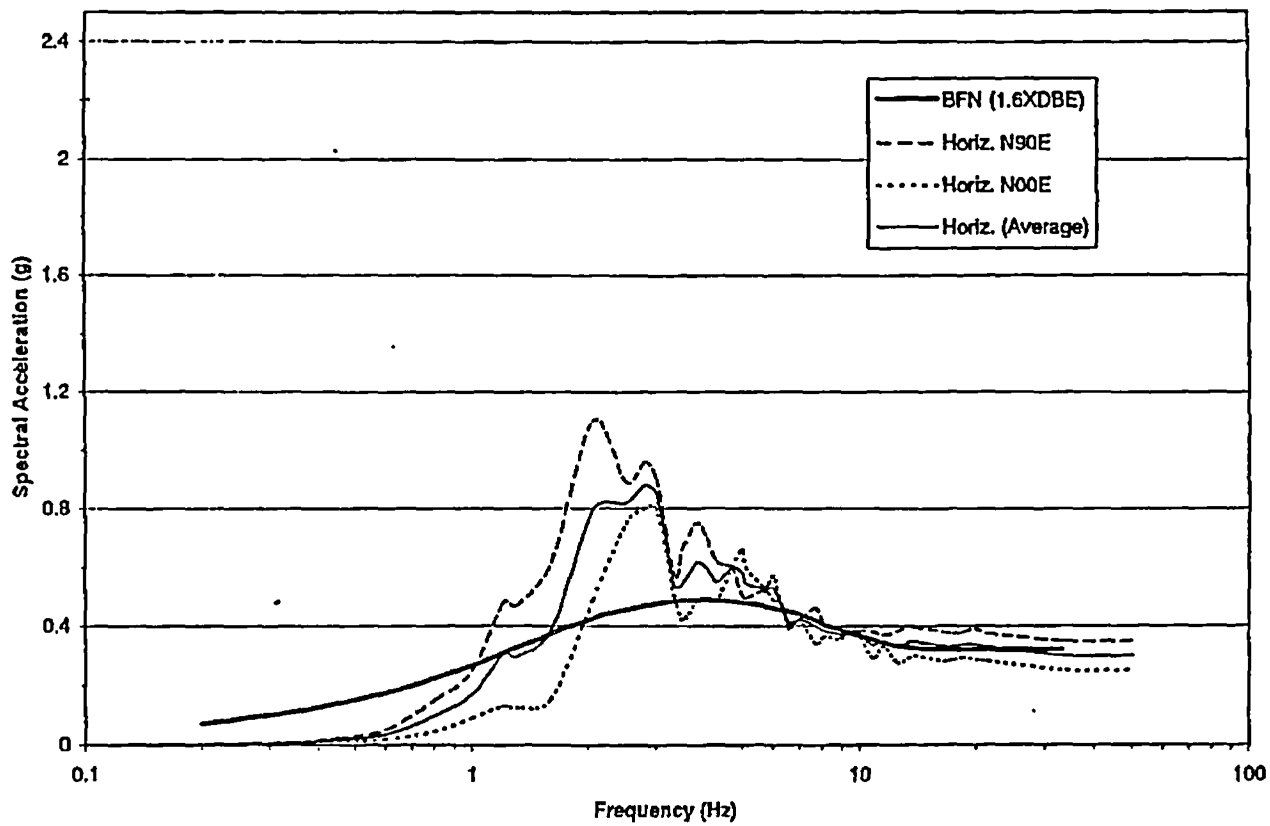

Figure 2-6 Comparison of Browns Ferry DBE and Humboldt Bay Nuclear Power Plant Ground Spectra

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Attachment A

Coolwater Power Plant, CA (1992 Landers Earthquake)

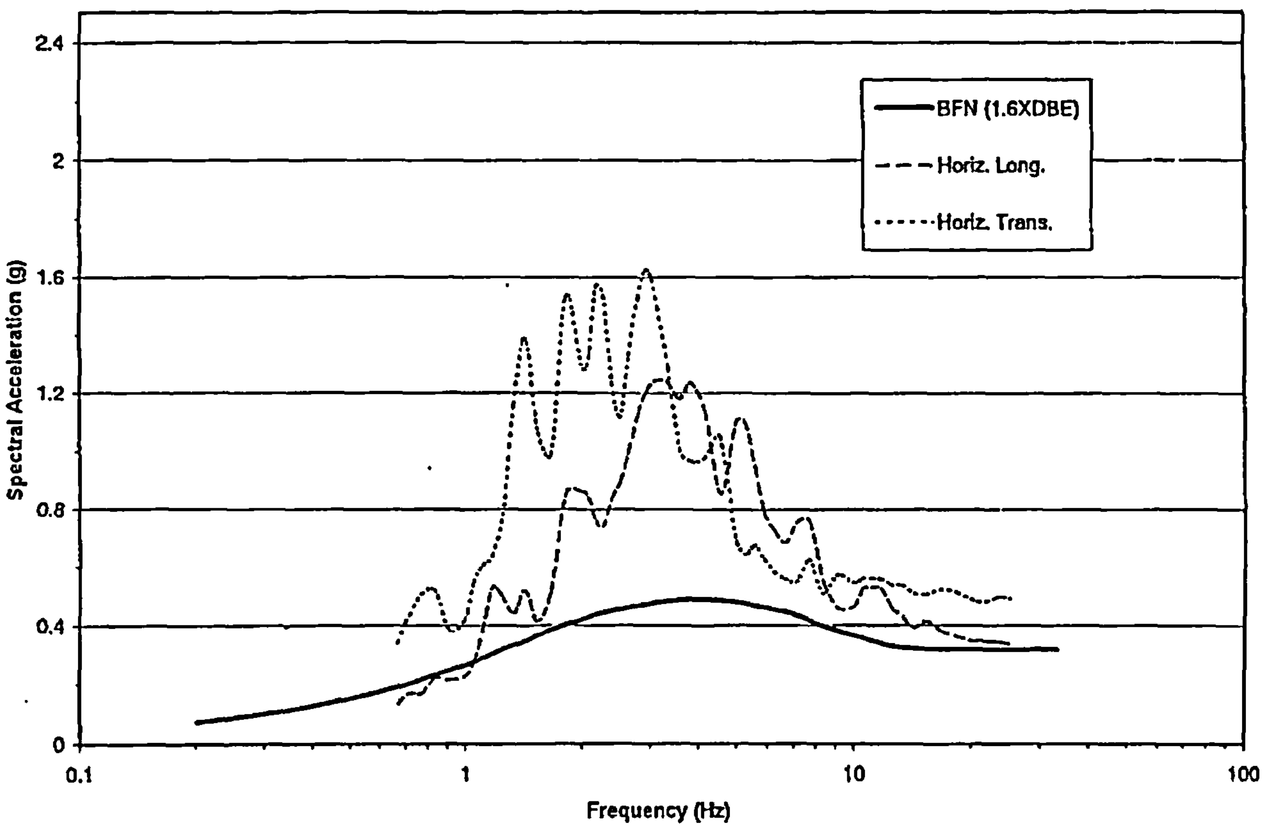

Figure 2-7 Comparison of Browns Ferry DBE and Coolwater Power Plant Ground Spectra

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Attachment A

Commerce Refuge to Energy Plant, CA (1987 Whittler Narrows Earthquake)

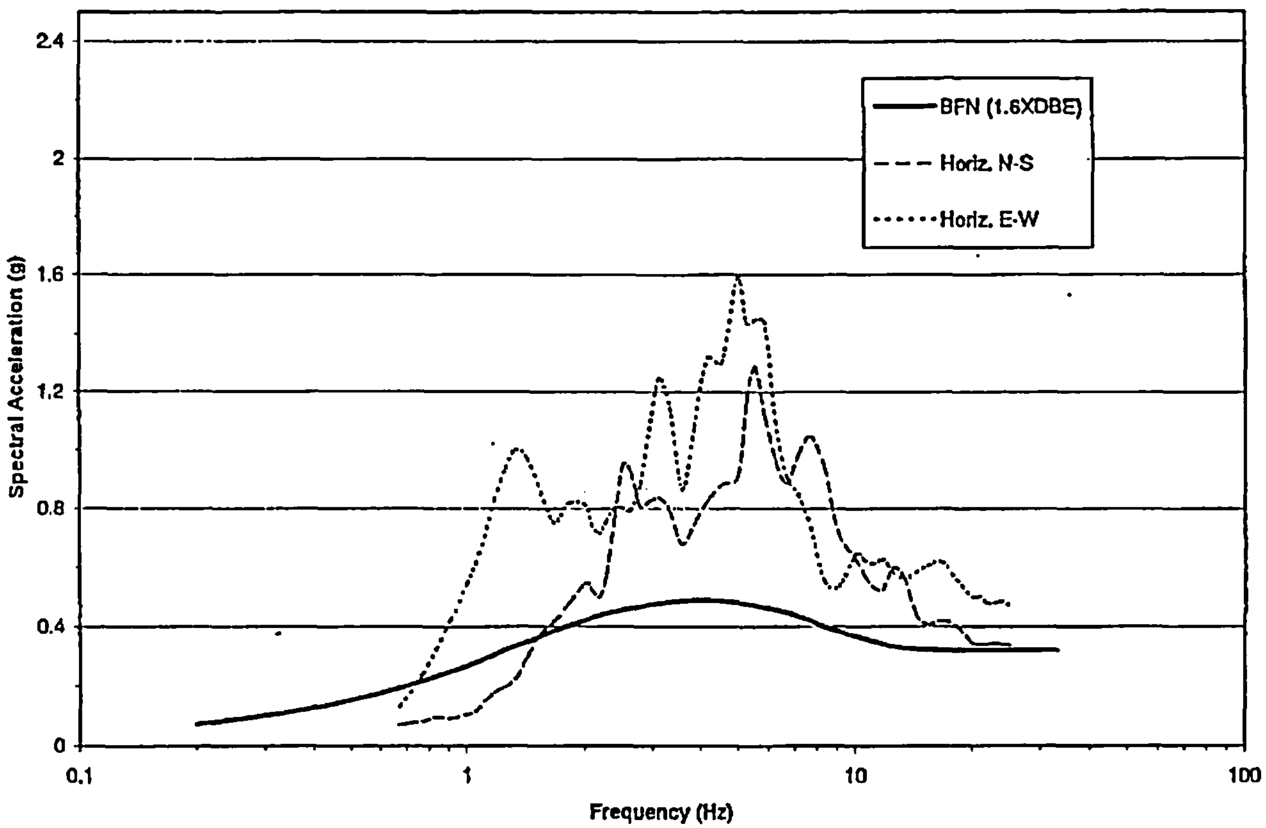

Figure 2-8 Comparison of Browns Ferry DBE and Commerce Refuge to Energy Plant Ground Spectra

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Attachment A

Grayson Power Plant, Glendale, CA (1971 San Fernanado Earthquake)

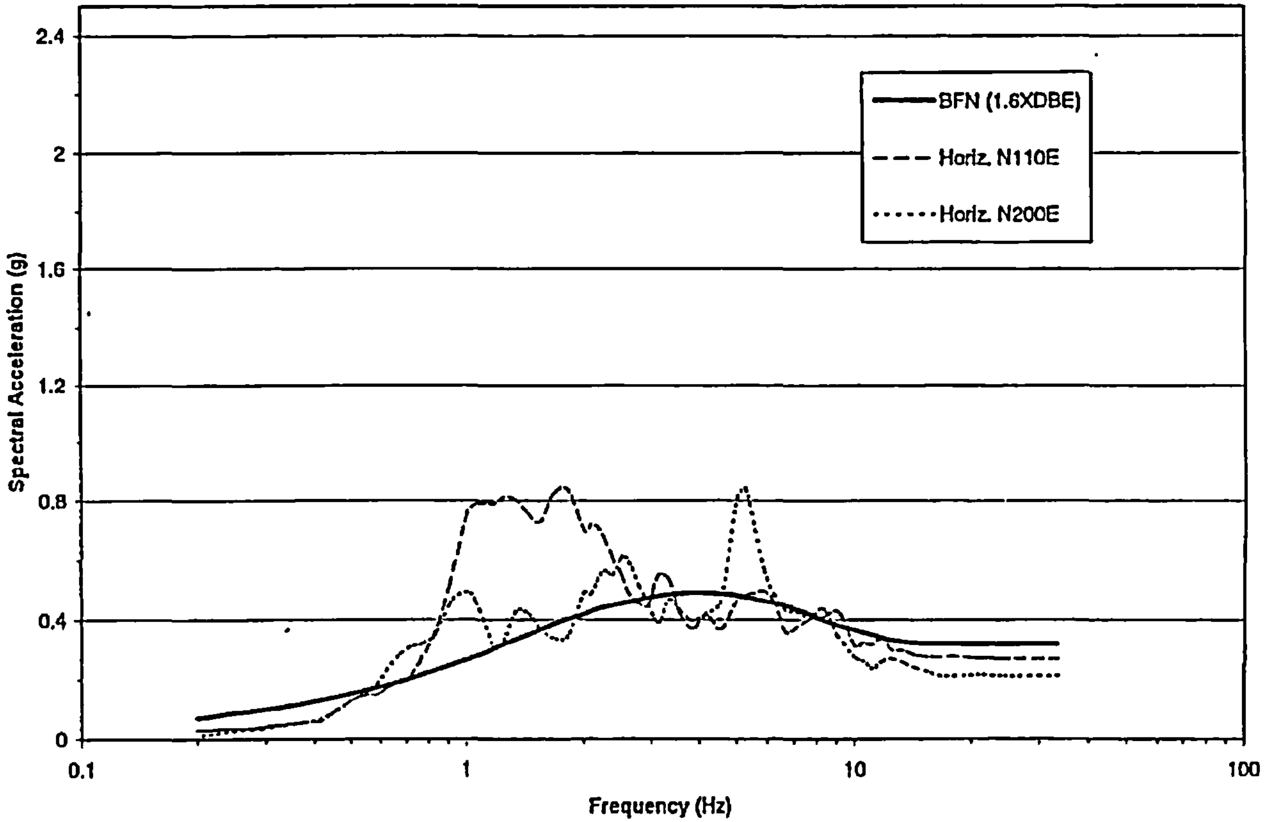

Figure 2-9 Comparison of Browns Ferry DBE and Grayson Power Plant Ground Spectra

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Attachment A

Ormond Beach Power Plant, CA (1973 Point Mugu Earthquake)

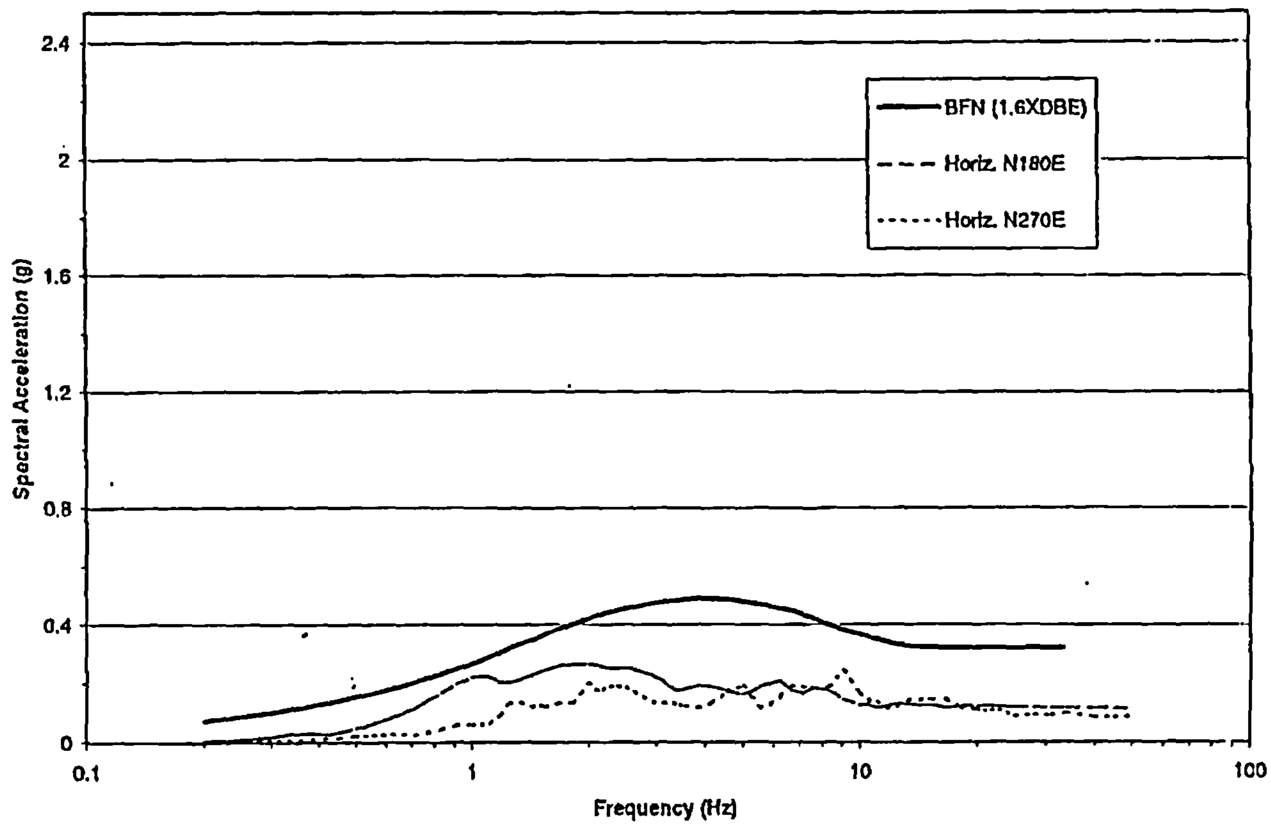

Figure 2-10 Comparison of Browns Ferry DBE and Ormond Beach Power Plant Ground Spectra

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Attachment A

PALCO Cogeneration Plant, CA (1992 Petrolia Earthquake)

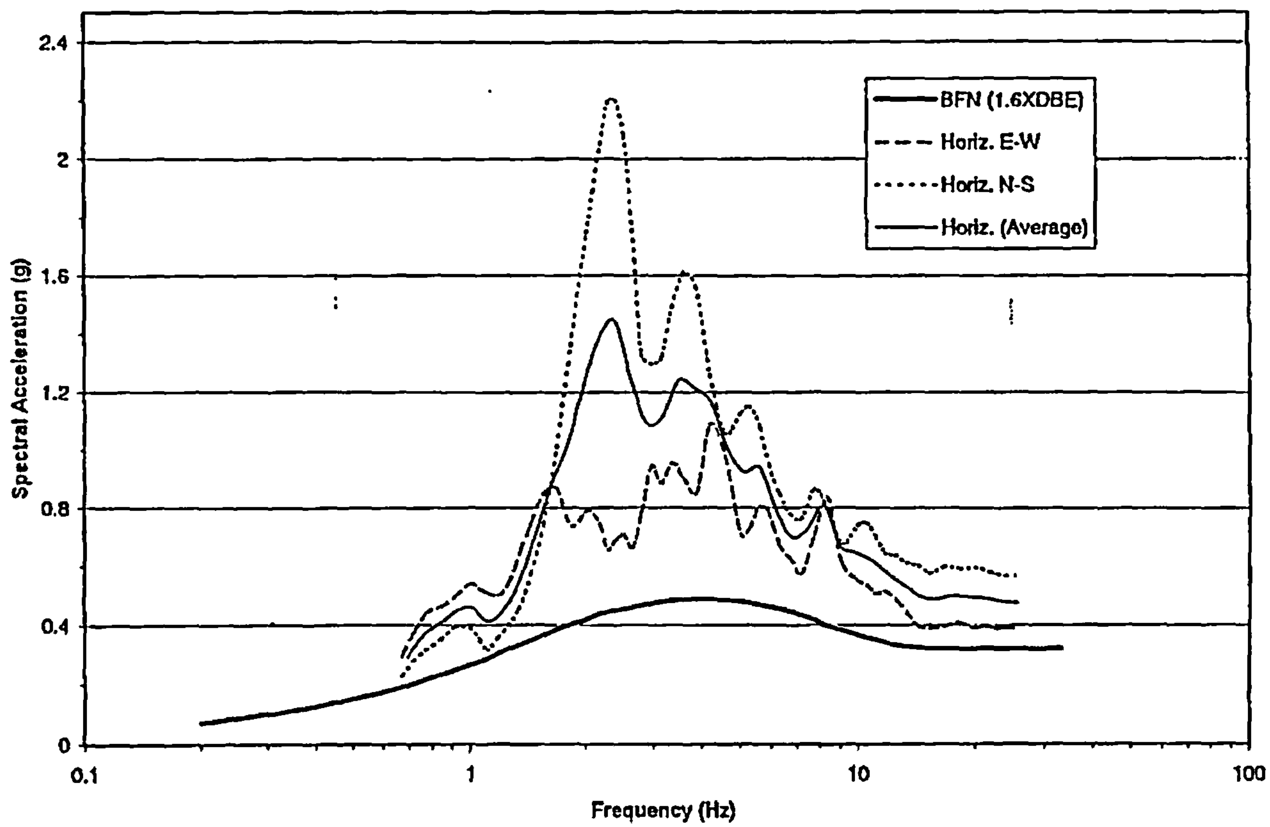

Figure 2-11 Comparison of Browns Ferry DBE and PALCO Cogeneration Plant Ground Spectra

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Attachment A

3. SEISMIC VERIFICATION WALKDOWNS

Very few components of nuclear plant systems are unique to the nuclear facilities. Nuclear plant systems include equipment, piping, tubing, conduit, and many other items that are common components of conventional power plants and industrial facilities. Seismic experience data based methods have been developed to address seismic issues associated with the adequate performance of these equipment and commodities not designed, procured and installed to current nuclear seismic criteria. By reviewing the performance of the database facilities that contain equipment similar to that found in nuclear plants, conclusions can be drawn about the performance of nuclear plant equipment during and after earthquake events.

Extensive work has been performed documenting the performance of power plant equipment performance and the common sources of seismic damage to equipment and piping. In general, equipment, piping and tubing systems in the seismic experience database have performed very well in earthquakes, even though they were typically designed for deadweight and operating loads only, with little or no consideration for seismic loads. Performance of piping and equipment in past earthquakes are summarized in Appendix D of the BWROG Report (Reference 1). Earthquake experience-based methods provide the basis for the seismic review of the main steam piping and equipment within the MSIV alternate leakage treatment (ALT) boundary at BFN.

3.1 SEISMIC VERIFICATION REVIEW GUIDELINES

Various design attributes of the as-installed scope of equipment, piping, and tubing were reviewed and evaluated by the Seismic Walkdown Teams to ensure that the BFN installations are representative of database design practice and that components are free of known seismic vulnerabilities. Earthquake experience has identified conditions that have resulted in failure of piping and tubing systems and components. The conditions evaluated in the walkdown reviews included:

- Piping, Pipe Support and Equipment Design Attributes
- Seismic Anchor Movement Issues
- Seismic Interaction Issues (II/I & Proximity)
- Valve Design Attributes

The above design attributes and conditions are briefly discussed below.

3.1.1 Piping, Pipe Support and Equipment Design Attributes

The Seismic Walkdown reviewed the piping and tubing systems, and associated supports to ensure that the design attributes and conditions are consistent with good design and industry standard practices. The systems were also screened to ensure that they are free from known seismic vulnerabilities identified from earthquake experience data. These design attributes include:

- Piping with dead weight support spacing greatly in excess of the B31.1 suggested spans, or tubing with excessive sagging.
- Heavy, unsupported in-line components.
- Piping constructed of non-ductile materials such as cast iron or PVC.
- Non-standard fittings or unusual attachments that could cause excessive localized stresses.
- Pipe supports that exhibit non-ductile behavior.
- Presence of severe corrosion.

In addition, anchorage of terminal equipment to piping and tubing systems were reviewed for adequacy.

3.1.2 Seismic Anchor Movement Issues

The experience database includes instances of seismic damage to piping, tubing and supports that were attributed to seismic anchor movement. Damage was the result of excessive movement of terminal end equipment, differential movement between supports in adjacent buildings, and excessive movements imposed on branch lines by flexible headers. These attributes were evaluated during the piping walkdowns.

3.1.3 Seismic Interaction Issues (II/I and Proximity)

The seismic interaction review was a visual inspection of structures, piping, or equipment adjacent to the components under evaluation. The seismic interaction review evaluated conditions where seismically induced failures (II/I) and displacements of adjacent structures, piping, or equipment (proximity) could adversely affect the required seismic performance of the system and components under consideration.

3.1.4 Valve Design Attributes

Screening guidelines are provided for valves that are relied upon to establish the ALT pathway or are part of the Seismic Verification Boundary. The guidelines are consistent with the SQUG Generic Implementation Procedure (GIP, Reference 5) and include provisions for air-operated diaphragm valves, spring-operated pressure relief valves, piston-operated valves of light-weight construction, motor-operated valves, and substantial piston-operated valves.

3.2 SEISMIC VERIFICATION BOUNDARY

The walkdown scope included the Main Steam drain path that will be established to convey leakage past the outboard Main Steam Isolation Valves (MSIV) to the isolated condenser and includes piping, instrumentation, valves and equipment that would be required to maintain the drain pathway.

The Seismic Verification Boundary for the MSIV Alternate Leakage Treatment path was developed in consultation with TVA Browns Ferry Systems Engineering, and is shown in

Figure 3-1. The associated flow diagrams are listed on Table 3-1, and the piping isolation boundaries defining the seismic verification boundary are shown on Table 3-2. The Seismic Verification Boundary generally consists of the following portions of the Main Steam (MS) system beyond the outboard MSIV's:

1. Main Steam drain path to the condenser for any leakage past the isolated outboard MSIVs.
2. Main Steam piping from the outboard MSIV to the Main Steam Stop Valves (MSV).
3. Main Steam Bypass piping from the Main Steam lines to the Bypass Valve chest.
4. Main Condensers.
5. Additional piping and instrumentation within the Seismic Verification Boundary includes:
    - Stop Valve Above Seat Drains to Condenser
    - Steam Sample System
    - HPCI/RCIC Steam Drains to Main Steam
    - Auxiliary Boiler Drains to Main Steam
    - Main Steam Instrumentation
    - Main Steam Supply to the Reactor Feed Pumps
    - Main Steam Supply to the Steam Jet Air Ejectors
    - Main Steam Supply to the Off-Gas Preheaters

The above Seismic Verification Boundary was originally developed for Unit 3 seismic walkdown. The Unit 2 Seismic Verification Boundary was less than that shown above for Unit 3. The original Unit 2 boundary assumed the addition of an isolation valve to isolate the steam path to the RFP Turbines and that the steam feed shutoff valve 8-575 would be qualified as an isolation boundary to the Steam Seal system. The Unit 2 Seismic Verification Boundary will be expanded and additional walkdown will be performed during the Unit 2 Cycle 11 outage to remove the assumptions of the isolation valves noted above, hence, eliminating the unit differences with Unit 3 Seismic Verification Boundary.

3.3 WALKDOWN RESULTS

Field walkdowns of the main steam lines, ALT drain path and associated appendages within the Seismic Verification Boundary were conducted during the Unit 3 recovery outage in April 1995, and during the Unit 2 refueling outage in April 1996 by EQE engineers. Plant specific guidance, systems expertise and support were provided by BFN Site Engineering staff. All members of the MSIV Seismic Verification Walkdown Teams are degreed engineers, have ten to twenty years of experience in structural engineering and/or earthquake engineering application to nuclear power plants, and are familiar with the earthquake experience methodology. EQE engineers have performed the complete MSIV Seismic Verification Walkdowns in accordance with the recommendations of the GE NEDC-31858P (BWROG Report, Reference 1) at several other plants.

Results of the Seismic Verification Walkdowns, including the identified walkdown open items or "Outliers", are discussed in detail in References 3 and 4 for Browns Ferry, Unit 3 and Unit 2, respectively. A brief summary of the walkdown results is presented below, with walkdown outliers summarized in Table 3-3 and 3-4 for Browns Ferry, Unit 3 and Unit 2, respectively.

3.3.1 Unit 3 Seismic Walkdown

The main steam drain piping included in the Unit 3 MSIV alternate leakage treatment (ALT) path to the condenser generally conform to ANSI B31.1 design guidelines. Piping are typically insulated, and constructed from carbon steel, SA-106 Grade B, with butt-welded or socket-welded joints. In addition, pipe supports consist of a combination of rigid struts and U-bolt brackets, floor-mounted stanchions, and spring or rod hangers. The as-installed configurations are inherently rugged and are similar to those found in the earthquake experience database facilities that have performed well during past earthquakes.

The piping systems within the Unit 3 MSIV Seismic Verification Boundary were divided into the following 13 portions for walkdown purposes:

1. Main Steam drain line in the Turbine Building
2. Main Steam lines in the Turbine Building
3. Main Steam and Main Steam drain lines in the Reactor Building MSIV vault
4. HPCI/RCIC/Auxiliary Boiler drains in the Reactor Building and above the Torus
5. Main Steam PT instrumentation lines
6. Main Steam sampling lines to the Sample Station
7. Main Steam bypass lines
8. Main Steam stop valve above seat drains
9. Steam supply to Steam Seal Regulators
10. Steam supply to RFP Turbines
11. Steam supply to Steam Jet Air Ejectors
12. Steam supply to Off-Gas Preheaters
13. Condensers

Conditions not meeting the Seismic Verification Review guidelines, as discussed in Section 3.1 of this report, were identified and documented as "Outliers" for further evaluation and resolution by the Seismic Walkdown Teams. These conditions included limited numbers of piping overspans, equipment anchorage or support integrity issues, proximity or falling interaction concerns, flexibility concerns due to seismic anchor movements or differential displacements, boundary valve integrity issues, and general maintenance or housekeeping items. Table 3-3 presents a summary of Unit 3 MSIV walkdown outliers.

3.3.2 Unit 2 Seismic Walkdown

Similar to Unit 3, the main steam drain piping included in the Unit 2 MSIV alternate leakage treatment (ALT) path to the condenser generally conform to ANSI B31.1 design guidelines. Piping are typically insulated, and constructed from carbon steel, SA-106 Grade B, with butt-welded or socket-welded joints. Pipe supports consist of a combination of rigid struts and U-bolt brackets, floor-mounted stanchions, and spring or rod hangers. The as-installed configurations are inherently rugged and are similar to those found in the earthquake experience database facilities that have performed well during past earthquakes.

The piping systems within the scope of the original Unit 2 MSIV Seismic Verification Walkdown Boundary were divided into the following 11 portions for walkdown purposes:

1. Main Steam drain line in the Turbine Building
2. Main Steam lines in the Turbine Building
3. Main Steam and Main Steam drain lines in the Reactor Building MSIV vault
4. HPCI/RCIC/Auxiliary Boiler drains in the Reactor Building and above the Torus
5. Main Steam PT instrumentation lines
6. Main Steam sampling lines to the Sample Station
7. Main Steam bypass lines
8. Main Steam stop valve above seat drains
9. Steam supply to Steam Feed valve 8-575 (proposed isolation boundary)
10. Steam supply to RFP Turbines (with proposed manual isolation valve to be located on the Turbine Building operating deck, El. 617')
13. Condensers

Conditions not meeting the Seismic Verification Review guidelines, as discussed in Section 3.1 of this report, were identified and documented as "Outliers" for further evaluation and resolution by the Seismic Walkdown Teams. As in the Unit 3 walkdown, these conditions included limited numbers of piping overspans, equipment anchorage or support integrity issues, proximity or falling interaction concerns, flexibility concerns due to seismic anchor movements or differential displacements, boundary valve integrity issues, and general maintenance or housekeeping items. Table 3-4 presents a summary of the Unit 2 MSIV walkdown outliers.

As mentioned in Section 3.2 above, the original Unit 2 Seismic Verification Boundary will be expanded and additional walkdown will be performed during the Unit 2 Cycle 11 outage to remove the assumptions of the isolation valves, hence, eliminating the unit differences with Unit 3 Seismic Verification Boundary.

3.3.3 Additional Seismic Walkdown

As mentioned in Section 3.2 above, the Unit 2 Seismic Verification Boundary will be expanded to include portions of the steam supply lines from the Main Steam Header to the turbine drives for the Reactor Feed Pumps, the Steam Jet Air Ejectors, the Off-Gas Preheaters, and the Steam Seal Regulators, i.e., extension of piping portions 9 and 10, and portions 11 and 12, as in the Unit 3 walkdown scope. The resulting Unit 2 Seismic Verification Boundary will then be consistent with that of Unit 3, hence, eliminating any unit differences between them. Additional seismic verification walkdown for the expanded scope will be performed during the Unit 2 Cycle 11 outage to verify the seismic ruggedness of the MS piping and associated components, and all identified outliers will be resolved during the same outage. Design Change Notice (DCN) will address any physical changes to restore the drain path into compliance.

Table 3-1

BROWNS FERRY MSIV LEAKAGE BOUNDARY FLOW DIAGRAMS

Drawing Number	System Description
Unit 2	
2-47E801-1	Main Steam System
2-47E801-2	Main Steam System
2-47E805-3	Heater Drains & Vents and Miscellaneous Piping Systems
2-47E807-1	Turbine Drains and Miscellaneous Piping Systems
2-47E807-2	Turbine Drains and Miscellaneous Piping Systems
2-47E812-1	High Pressure Coolant Injection System
2-47E813-1	Reactor Core Isolation Cooling System
0-47E815-1 2-47E815-4	Auxiliary Boiler System
2-47E610-43-1	Sampling and Water Quality System
Unit 3	
3-47E801-1	Main Steam System
3-47E801-2	Main Steam System
3-47E805-3	Heater Drains & Vents and Miscellaneous Piping Systems
3-47E807-1	Turbine Drains and Miscellaneous Piping Systems
3-47E807-2	Turbine Drains and Miscellaneous Piping Systems
3-47E812-1	High Pressure Coolant Injection System
3-47E813-1	Reactor Core Isolation Cooling System
3-47E815-5	Auxiliary Boiler System
3-47E610-43-6	Sampling and Water Quality System

Table 3-2
BFN MSIV LEAKAGE BOUNDARY POINTS

Leakage Boundary Point *	Flow Diagram/ Drawing *	Comment
FCV-1-15	47E801-1	MSIV for Main Steam Line A
FCV-1-27	47E801-1	MSIV for Main Steam Line B
FCV-1-38	47E801-1	MSIV for Main Steam Line C
FCV-1-52	47E801-1	MSIV for Main Steam Line D
FCV-1-56	47E801-1	Outboard Containment Isolation valve for Primary Containment steam drains
1-521 1-527	47E801-1	Normally closed Main Steam Drain manual isolation valves
43-631	2-47E610-43-1 3-47E610-43-6	Normally closed Main Steam Sample System manual isolation valve
43-631A	2-47E610-43-1 3-47E610-43-6	Normally closed Main Steam Sample System manual isolation valve
43-632	2-47E610-43-1 3-47E610-43-6	Normally closed Main Steam Sample System manual isolation valve
FCV-1-74	47E801-2	Main Turbine Stop Valve for Steam Line A
FCV-1-78	47E801-2	Main Turbine Stop Valve for Steam Line B
FCV-1-84	47E801-2	Main Turbine Stop Valve for Steam Line C
FCV-1-88	47E801-2	Main Turbine Stop Valve for Steam Line D
FCV-1-61 FCV-1-62 FCV-1-63 FCV-1-64 FCV-1-65 FCV-1-66 FCV-1-67 FCV-1-68 FCV-1-69	47E801-2	Main Steam Bypass Valve Chest
FCV-73-6B	47E812-1	Normally open air operated isolation valve – HPCI
FCV-71-6B	47E813-1	Normally open air operated isolation valve – RCIC
12-635	2-47E815-4 3-47B815-5	Normally closed manual isolation valve – Aux. Boiler

Table 3-2 (CONT.)
BFN MSIV LEAKAGE BOUNDARY POINTS

Leakage Boundary Point *	Flow Diagram/ Drawing *	Comment
12-637	2-47E815-4 3-47B815-5	Normally closed manual isolation valve – Aux. Boiler
12-623	2-47E815-4 3-47B815-5	Normally closed manual isolation valve – Aux. Boiler
12-625	2-47E815-4 3-47B815-5	Normally closed manual isolation valve – Aux. Boiler
2-12-822	0-47E815-1	Normally closed manual isolation valve – Aux. Boiler (Unit 2 only)
FCV-6-100	47E807-1	Normally closed motor operated isolation valve - Stop valve above seat drains
FCV-6-101	47E807-1	Normally closed motor operated isolation valve - Stop valve above seat drains
FCV-6-102	47E807-1	Normally closed motor operated isolation valve - Stop valve above seat drains
FCV-6-103	47E807-1	Normally closed motor operated isolation valve - Stop valve above seat drains
FCV-1-127	47E801-2	Reactor Feed Pump Turbine A Stop Valve
FCV-1-135	47E801-2	Reactor Feed Pump Turbine B Stop Valve
FCV-1-143	47E801-2	Reactor Feed Pump Turbine C Stop Valve
FCV-6-153	47E807-2	Normally closed motor operated isolation valve - RFP
FCV-6-155	47E807-2	Normally closed motor operated isolation valve - RFP
FCV-6-157	47E807-2	Normally closed motor operated isolation valve - RFP
FCV-6-122	47E807-2	Normally closed motor operated isolation valve - RFP
FCV-6-127	47E807-2	Normally closed motor operated isolation valve - RFP
FCV-6-132	47E807-2	Normally closed motor operated isolation valve - RFP
PCV-1-151	47E801-2	Normally open air operated isolation valve - SJAE
PCV-1-166	47E801-2	Normally open air operated isolation valve - SJAE
PCV-1-153	47E801-2	Normally open air operated isolation valve - SJAE
PCV-1-167	47E801-2	Normally open air operated isolation valve - SJAE
6-826	47E805-3	Check valve – SJAE
6-822	47E805-3	Check valve – SJAE

Table 3-2 (CONT.)

BFN MSIV LEAKAGE BOUNDARY POINTS

Leakage Boundary Point *	Flow Diagram/ Drawing *	Comment
FCV-1-145	47E807-2	Normally closed motor operated isolation valve – Steam Seal Regulator
FCV-1-154	47E807-2	Normally closed motor operated isolation valve – Steam Seal Regulator
FCV-1-147	47E807-2	Air operated pressure regulating valve – Steam Seal Regulator
CKV-1-742	47E801-2	Check valve (NEW) – Off-Gas Preheater A
CKV-1-744	47E801-2	Check valve (NEW) – Off-Gas Preheater B
Condenser A	---	The condenser is the ultimate boundary for the MSIV leakage path.
Condenser B	---	The condenser is the ultimate boundary for the MSIV leakage path.
Condenser C	---	The condenser is the ultimate boundary for the MSIV leakage path.
Miscellaneous test, vent, drain and instrument connections	47E801-1 47E801-2	---

NOTE:

* Boundary component ID's and flow diagram/drawing nos. are generally applicable to both Units 2 and 3, unless noted otherwise specifically (i.e., 2- for Unit 2; 3- for Unit 3; and 0- for common)

Table 3-3
BROWNS FERRY UNIT 3
MSIV WALKDOWN "OUTLIERS"

SYSTEM DESCRIPTION	ID[1]	OUTLIER[2]	A	F	P	D	V
Main Steam Drain Line-Turbine Bldg.	1						
MS Drain Taps	1-1	MS Line differential motion				X	
MS Drain Taps	1-2	Impact with conduit supports			X		
FCV 1-58	1-3	Extended valve operators					X
FCV 1-58/59 Conduit	1-4	Unknown routing at TB/RB joint				X	
Main Steam Lines -- Turbine Bldg.	2						
MS Stop Valves	2-1	Valve performance	X				X
MSH-17	2-2	Missing eyebolt nut	X				
MSH-17,18 & 19	2-3	Grating clearance			X		
Main Steam Drain Line- MSIV Vault	3						
FCV 1-15, 27, 38 & 52	3-1	Valve performance	X				X
FCV 1-56	3-2	Manual operator					X
HPCI/RCIC Drain	4						
HPCI Drain at MS drain connection	4-1	Inadequate bending leg	X				
MS PT 1-72, 76, 82, 86 & 93	5						
MS instrument tubing	5-1	Overspan on 1" pipe to PT 1-86		X			
1/2 Line to PT 1-86	5-2	Interaction with steel & pipe			X		
Main Steam Sample to Station	6						
Sample lines B & D	6-1	Missing tubing support clamps		X			
Sample lines A, B, C, D	6-2	Inadequate flex legs at MS line				X	
PT 16A/B	6-3	Inadequate flex legs at MS line				X	
Sample Station	6-4	Temperature bath anchorage	X				
Main Steam Bypass	7						
Main Steam Bypass Valve	7-1	Valve performance	X				X
SV Above Seat Drains	8						
FCV 6-100, 101, 102, 103	8-1	Short rod hangers		X			
Steam to Steam Seal Regulator	9						
MS to FCV 1-146	9-1	Overspan piping		X			
PCV 1-147	9-2	Handwheel proximity to WF			X		
PCV 1-147 airline	9-3	Inadequate flexibility & blockwall			X	X	
PCV 1-147	9-4	Extended valve operator					X

Table 3-3 (CONT.)
BROWNS FERRY UNIT 3
MSIV WALKDOWN "OUTLIERS"

SYSTEM DESCRIPTION	ID[1]	OUTLIER[2]	A	F	P	D	V
Steam Supply to RFP Turbines	10						
Steam supply line	10-1	Inadequate flex leg at MS header				X	
Steam supply line	10-2	Stanchion supports		X			
Steam supply line	10-3	TB crane overhead			X		
RFP Stop Valve above seat drains	10-4	Large mass on the 1/2 & 3/4 inch lines	X				
Tubing to PI 1-126	10-5	Missing tubing clamps – overspan		X			
Steam Supply to SJAE	11						
SJAE 3A/B	11-1	Anchorage	X				
SJAE 3B	11-2	Loose anchor bolt nut	X				
Drain to Condenser	11-3	Drain ties to multi system collector					X
Steam to Off-Gas Preheaters	12						
PCV 1-175A/B	12-1	Masonry wall			X		
Steam supply line to FCV 1-178A/B	12-2	Vert. restraint of line at FCV 1-178				X	
PCV 1-175A/B, FCV 1-178A/B	12-3	Valve performance					X
Condenser	13						
Condenser and anchorage adequacy	13-1	Evaluate condenser/anchorage	X				

KEY TO ISSUES:

A Anchorage or Support Capacity

F Failure and Falling (II/I)

P Proximity and Impact

D Differential Displacement

V Valve Screening

NOTES:

1 - ID - Refers to MSIV Walkdown package identifier.

2 - "Outliers" are plant conditions which require further evaluation.

Table 3-4

BROWNS FERRY UNIT 2
MSIV WALKDOWN "OUTLIERS"

SYSTEM DESCRIPTION	ID[1]	OUTLIER[2]	A	F	P	D	V
Main Steam Drain Line-Turbine Bldg.	1						
MS Drain Taps		1-1: MS Line differential motion				X	
FCV-1-58		1-2: Extended valve operators					X
Main Steam Lines – Turbine Bldg.	2						
MS Stop Valves		2-1: Valve performance	X				X
RB MSIV Vault - MS and MS Drain	3						
FCV-1-15, -27, -38 & -52		3-1: Valve performance					X
HPCI/RCIC/Aux. Boiler Drains	4A						
HPCI Drain at MS drain connection		4-1: Inadequate bending leg	X			X	
HPCI Drain in RB Steam Vault		4-2: Piping overspan	X				
HPCI Drain in RB SE Corner Rm		4-3: Piping overspan	X				
HPCI/RCIC/Aux. Boiler Drains	4B						
HPCI & Aux. Boiler drain lines supports		4-4: Miscellaneous maintenance items	X				
HPCI Drain above the Torus		4-5: Piping overspan	X				
RCIC Drain above the Torus		4-6: Inadequate support	X				
MS PT-1-72, -76, -82 & -86	5						
1/2" PT Piping from Steam Lines		5-1: Interaction with platform steel				X	
Main Steam Sampling	6						
PT-16A/B Piping		6-1: Interaction with Feedwater piping			X		
Sample lines A, B, C, D		6-2: Inadequate flex legs at MS line				X	
PT-16A/B		6-3: Inadequate flex legs at MS line				X	
Sample Station		6-4: Temperature bath anchorage	X			X	
PT-16A/B		6-5: Interaction with oil drum			X		
Main Steam Bypass	7						
Main Steam Bypass Valve		7-1: Valve performance	X				X
SV Above Seat Drains	8						
FCV-6-100, -101, -102 & -103		8-1: Short rod hangers	X				
1" Drain Piping from Steam Line D		8-2: Interaction with MS piping/steel			X		

Table 3-4 (CONT.)

BROWNS FERRY UNIT 2
MSIV WALKDOWN "OUTLIERS"

SYSTEM DESCRIPTION	ID[1]	OUTLIER[2]	A	F	P	D	V
Steam to Steam Feed Valve	9						
Rod Hanger Downstream of Valve 8-575		9-1: Disengaged rod hanger	X				
Verification Boundary Valve 8-575 (Proposed in the Original Scope)		9-2: Normally open manual valve					X
Steam Supply to RFP Turbines	10						
Steam supply line		10-1: Inadequate flex leg at MS header				X	
Steam supply line		10-2: Stanchion supports		X			
Steam supply line		10-3: TB overhead crane		X	X		
Verification Boundary Valve 1-RFPT (Proposed in the Original Scope)		10-4: Installation of valve					X
Condensers	13						
Condenser anchorage		13-1: Evaluate anchorage	X				

KEY TO ISSUES:

A Anchorage or Support Capacity

F Failure and Falling (II/I)

P Proximity and Impact

D Differential Displacement

V Valve Screening

NOTES:

1 - ID - Refers to MSIV Walkdown package identifier.

2 - "Outliers" are plant conditions which require further evaluation.

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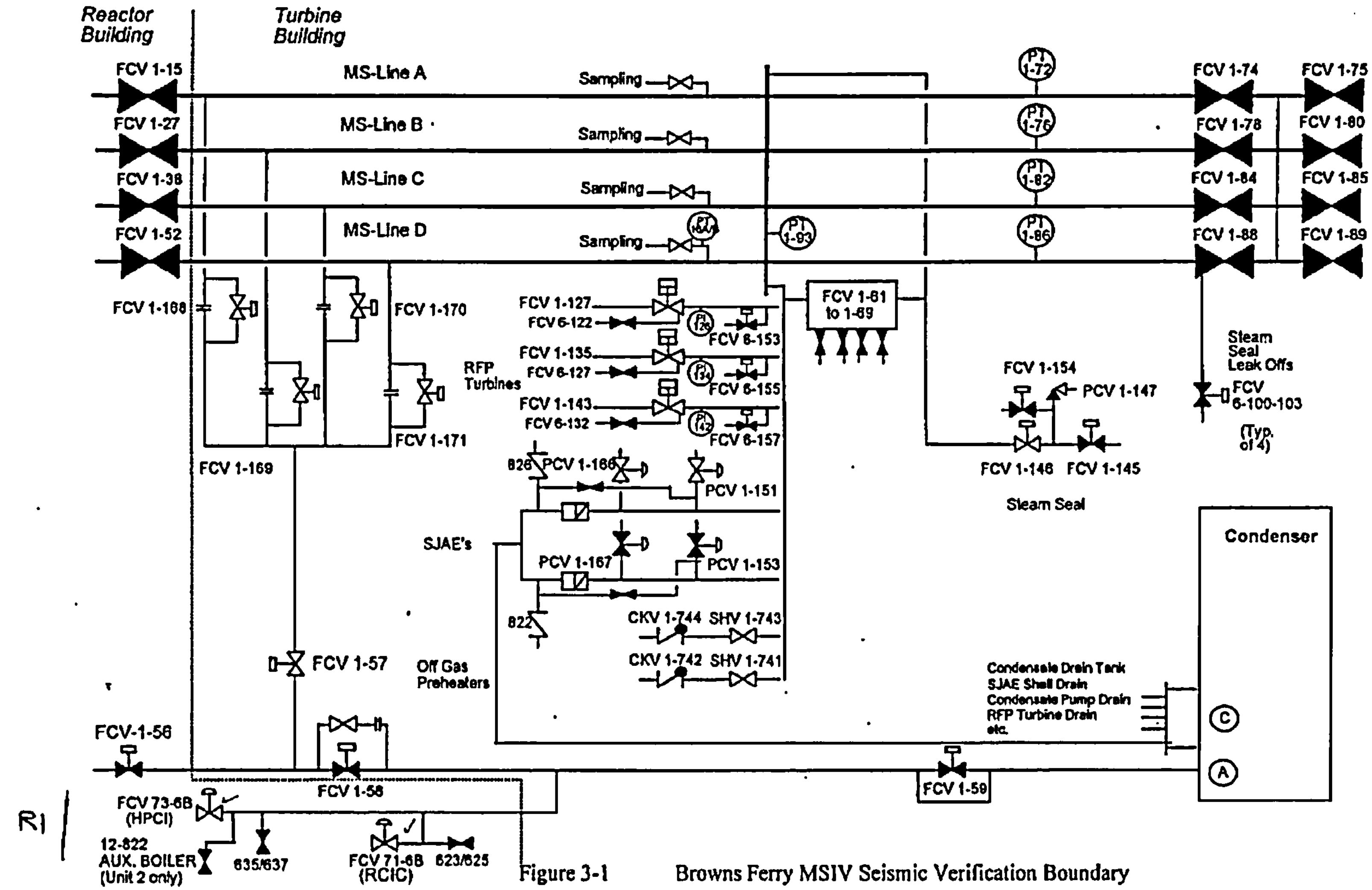

Figure 3-1 Browns Ferry MSIV Seismic Verification Boundary

4. SEISMIC ASSESSMENTS

As part of the supplemental plant specific seismic verification program to support the increased MSIV leakage tech spec change at BFN, various engineering evaluations and assessments were performed to verify the seismic adequacy of the Alternate Leakage Treatment (ALT) piping, related components and supports, and condensers. The following sections discuss the technical bases and methods used in these evaluations and assessments. Results of the seismic evaluations are also presented.

4.1 OUTLIER RESOLUTION

Conditions which did not meet the walkdown screening guidelines (Section 3.1) or which were judged by the Seismic Walkdown Team to require further review were documented as "Outliers" during the Units 2 and 3 Seismic Verification Walkdowns at Browns Ferry Nuclear Plant. For BFN Unit 3, the walkdown outliers have been resolved on a deterministic basis and dispositioned as described in more detail below. The proposed resolution for Unit 2 outliers will follow similar Unit 3 approaches and/or utilize existing Unit 3 analyses, as applicable. The Unit 3 outlier resolution are documented in BFN calculations (References 6 and 7).

4.1.1 Seismic Demand

The BFN Turbine Building is classified as a Class II structure, hence, no dynamic analysis of the building was performed and no in-structure response spectra were available for the structure. For seismic evaluations and outlier resolution, the horizontal seismic demand for components located within about 40 feet of the Turbine Building effective grade elevation (EL. 568') is conservatively taken as the BFN 5% damped design basis DBE input spectrum (0.2g Housner curve) scaled by 1.6 to account for soil amplification per BFN General Design Criteria (Reference 8) for soil founded structures, and 1.5 for building amplification per GIP. For components located above 40 feet of the Turbine Building effective grade elevation, an additional amplification factor of 1.5 is conservatively applied. In the vertical direction, seismic demand is taken as 2/3 that of the horizontal direction, with a soil amplification factor of 1.1 instead of 1.6.

4.1.2 Seismic Capacity

For outlier resolution and evaluation of ALT piping, and related components and supports, the following load combinations and stress allowables, as applicable, were used:

Component	Load Combination	Stress Allowables
Piping	D + P + I + A (Primary + Secondary)	2.0 Sy
Pipe Supports	D + T + I + A	AISC
Equipment Anchorage	D + I	AISC, GIP
Valve	3g load check	GIP

where,
D – Dead load
P – Pressure load
T – Thermal load
I – Seismic (DBE) inertial load
A – Load due to seismic anchor movement
Sy – Material yield strength at temperature
AISC – American Institute of Steel Construction
GIP – Generic Implementation Procedure

4.1.3 Summary of Results

Table 4-1 provides a summary of the proposed resolution methods for the outliers associated with the Unit 2 MSIV Seismic Verification Walkdown. Similarly, the results of the resolution of outliers associated with the Unit 3 MSIV Seismic Verification Walkdown are summarized in Table 4-2.

As mentioned in Section 3.3.3 above, additional Unit 2 Seismic Verification Walkdown for the expanded scope will be performed during its Cycle 11 outage to verify the seismic ruggedness of the MS piping and associated components. Any additional outliers identified during this walkdown will be addressed and resolved within the same outage period. Design Change Notice (DCN) will address any physical changes to restore the drain path into compliance.

4.2 ALTERNATE LEAKAGE TREATMENT PIPING AND SUPPORTS

Majority of the MSIV alternate leakage treatment (ALT) piping systems and related components at Browns Ferry, i.e., those portions downstream of the outboard Main Steam Isolation Valves (MSIV's) and the outboard Main Steam Drain Isolation Valve (MSDIV), are located in the Turbine Building and are not designated as Seismic Class I systems. In general, these piping systems are not seismically analyzed, and are typically designed to the requirements of USAS B31.1-1967.

As part of the plant specific seismic verification of the non-seismic ALT piping, related supports and components using the earthquake experience-based approach as outlined in the BWROG Report, the following reviews were performed to demonstrate that the piping and related supports fall within the bounds of the experience database:

- Review of the design codes and standards, piping design parameters, and support configurations.
- Seismic verification walkdown to identify potential piping concerns.

The Browns Ferry ALT piping systems consist of welded steel pipe and standard support components. Support spacing generally meets the B31.1 recommended span. The design bases for the portions of piping associated with the ALT pathway to the condensers are tabulated in Table 4-3. Table 4-4 presents a general summary of the piping data that constitute the seismic experience data. Comparison of Browns Ferry and selected database piping parameters is presented in Table 4-5, along with Figure 4-1, which presents a comparison of D/t ratios of the BFN ALT drain piping with those found in the database. Overall, the BFN piping design is similar to and well represented by those found in the experience database sites that have shown to perform well in past earthquakes.

Browns Ferry FSAR does not reference Appendix A to 10 CFR Part 100. The seismic adequacy of the ALT piping is addressed by performing seismic verification walkdowns to identify specific design attributes associated with poor seismic performance, following the guidelines outlined in Section 3.1 of this report. Bounding evaluations were performed for typical support configurations using evaluation criteria as discussed in Section 4.1. Table 4-6 summarizes the results of the support and anchorage evaluations for the selected bounding configurations (Reference 10). 2/E: THIS CALC, ATT C | R1

The seismic evaluations, consisting of verification walkdowns, bounding support evaluations, and resolution of the identified walkdown outliers, provide reasonable assurance that the ALT drain path piping, related supports and components will remain functional in the event of a Design Basis Earthquake (DBE) at Browns Ferry.

4.3 TURBINE BUILDING

Performance of the turbine building and other non-seismic structures during a seismic event is of interest to the MSIV leakage issue only to the extent that the building structure and its internal components should survive and not degrade the capabilities of the selected main steam and condenser pathways. A BWROG (Reference 1) survey of this type of industrial structures has, in general, confirmed that excellent past seismic performance exists. There are no known cases of structural collapse of either turbine buildings at power stations or structures of similar construction.

The majority of the MSIV alternate leakage treatment (ALT) piping and the condensers at Browns Ferry are located in the Turbine Building, while small portions of the ALT piping are located in the Reactor Building which is a seismically designed, Class I structure. BFN Turbine Building is classified as a Class II structure in the BFN FSAR. The BFN Design Criteria for Class II structures are that they shall not degrade the integrity of any Class I structure. Those portions of Class II structures required to remain structurally competent in order to support the operation of Class I structures or equipment shall be designed for earthquake in accordance to the Uniform Building Code. Table 4-7 provides the design basis of the BFN Turbine Building and the applicable design codes used.

BFN Turbine Building below the operating floor at El. 617 feet is a reinforced concrete framed structure supported on steel H-piles to the bedrock at El. 519 feet. Piles are spaced far enough apart within each cluster to ensure that the maximum average unit bearing stress on the rock area is limited to 500 psi. Stresses in the piles are limited to one third of the yield stress. The concrete beams and slabs are designed to ACI 318-63 code using the working stress method. Similarly, the columns are also designed to ACI 318-63 code using the working stress method and checked by the ultimate strength design method using a load factor of 1.8.

The superstructure above the operating deck consists of transverse welded steel rigid frames spanning approximately 107 feet. An expansion joint is provided between a two-bay frame for Units 1 and 2, and a single-bay frame for Unit 3. For longitudinal expansion, the superstructure is provided with joints by using double rows of frames spaced at 4 feet apart. The steel frames, which form the Turbine Building structure above the concrete structure, are braced to provide rigidity in the direction of the Reactor Building as well as to provide support for the turbine cranes. These frames are designed to resist lateral forces from the overhead cranes and wind loads, in addition to supporting the vertical dead and live loads. The design of the steel superstructure is based on 1963 AISC code. All material conforms to ASTM-36, except for anchor rods which are ASTM A-307 steel. Shop connections are ASTM A-502 Gr. 1 rivets or welded, and field connections are ASTM A-325 high-strength bolts.

Based on the above design bases for the BFN Turbine Building, and the excellent seismic performance of this similar type of industrial structure in past strong-motion earthquakes as documented in the BWROG Report, the Browns Ferry Turbine Building is expected to remain structurally intact following a DBE.

4.4 CONDENSER

The BFN condensers consist of three single-pass, single pressure, radial flow type surface condensers. Each condenser is located beneath each of the three low pressure turbines, and is structurally independent. Table 4-8 lists the design data for BFN condensers and for the two experience database sites listed in the BWROG Report. In addition, design characteristic comparisons of the BFN condensers with the selected database condensers are shown in Figures 4-2 to 4-5. The BFN condenser design data is comparable to the data for these two database sites. The BFN condensers were also evaluated for structural integrity subject to seismic DBE loads. Results of the evaluation indicate that the condenser shell stresses are small. Maximum stress ratios, based on AISC allowables, are 0.12 for combined axial and bending and 0.10 for shear (Reference 10). IE: THIS CALC, ATT B |R1

The condenser support anchorage consists of a center key and six support feet that are arranged as shown in Figure 4-6. The center support is a fixed anchor, and consists of a built-up wide flange H section embedded 4 feet into the concrete pedestal which is connected to the Turbine Building base mat, and welded to the bottom plate of the condenser. The support plates consist of 2 to 3 anchors of 2- to 2-1/2- inch diameter bolts. Each anchor bolt has greater than 5 feet nominal length with approximately 48 inches of embedment into the concrete pedestal which is connected to the Turbine Building base mat. These supports are designed to resist vertical operating loads, and are slotted radially from the center key to allow for thermal growth. Shear forces are transferred to the wide flange shaped anchor in the center and to the anchor bolts and shear keys to the support feet and carried through the concrete pedestal to the Turbine Building base mat.

The BFN condenser anchorage was compared with the performance of similar condenser in the earthquake experience database. The shear areas of the condenser anchorage, in the directions parallel and transverse to the turbine generator axis, divided by the seismic demand, were used to compare with those presented in the BWROG Report (Reference 1), and are shown in Figures 4-7 and 4-8, respectively. The BFN condenser anchorage shear area to seismic demand is substantially greater than the selected database sites. The condenser support anchorage was also

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evaluated and the results indicate that the combined seismic DBE and operational demand is less than the anchorage capacity based on the AISC allowables. Maximum stress ratios are 0.70 for bolt tension in the perimeter support feet, and 0.86 for shear in the center support built-up section (Reference 7).

The above comparisons of the condenser seismic experience data and the anchorage capacity evaluations demonstrate that the conclusions presented in the BWROG Report (Reference 1) can be applied to the BFN condensers. That is, a significant failure of the condenser in the event of a DBE at BFN is highly unlikely and contrary to the large body of historical earthquake experience data.

Table 4-1

BROWNS FERRY UNIT 2
MSIV "OUTLIERS" RESOLUTION SUMMARY

SYSTEM DESCRIPTION	OUTLIER	OUTLIER DESCRIPTION	RESOLUTION METHOD
Main Steam Drain Line-Turbine Bldg.			
MS Drain Taps	1-1	MS line differential motion	Modify supports per DCN
FCV 1-58	1-2	Extended valve operators	To be resolved per BFN Calc. CD-N0001-980038
Main Steam Lines			
MS Stop Valves	2-1	Valve performance	To be resolved per BFN Calc. CD-N0001-980038
Main Steam Drain Line- MSIV Vault			
FCV 1-15, 27, 38 & 52	3-1	Valve performance	To be resolved per BFN Calc. CD-N0001-980039
HPCI/RCIC/Aux. Boiler Drains – MSIV Pit			
HPCI Drain at MS drain connection	4-1	Inadequate bending leg	Modify supports per DCN
HPCI Drain in RB Steam Vault	4-2	Piping overspan	Install new supports per DCN
HPCI Drain in RB SE Corner Room	4-3	Piping overspan	Install new supports per DCN
HPCI/Aux. Boiler drain line supports	4-4	Misc. maintenance items	Misc. maintenance items to be addressed by WR C340989
HPCI Drain above the Torus	4-5	Piping overspan	Install new supports per DCN
RCIC Drain above the Torus	4-6	Inadequate support (RCIC-09)	Modify support per DCN
MS PT 1-72, 76, 82, 86 & 93			
1/2 in. PT Piping from Steam Lines	5-1	Interaction with platform steel	Re-route piping/instrumentation line per DCN
Main Steam Sample to Station			
PT-16A/B Piping	6-1	Interaction with Feedwater piping	Re-route piping and modify support per DCN
Sample lines A, B, C, D	6-2	Inadequate flex legs at MS line	Remove existing supports and install new supports per DCN

Table 4-1 (CONT.)

BROWNS FERRY UNIT 2
MSIV "OUTLIERS" RESOLUTION SUMMARY

SYSTEM DESCRIPTION	OUTLIER	OUTLIER DESCRIPTION	RESOLUTION METHOD
Main Steam Sample to Station (cont.)			
PT 16A/B	6-3	Inadequate flex legs at MS line	Modify supports per DCN
Sample Station	6-4	Temperature bath anchorage	Provide equipment anchorage per DCN
PT-16A/B	6-5	Interaction with oil drum	Initiate Work Request to relocate the oil drum
Main Steam Bypass			
Main Steam Bypass Valve	7-1	Valve performance	To be resolved per BFN Calc. CD-N0001-980038
SV Above Seat Drains			
FCV 6-100, 101, 102, 103	8-1	Short rod hangers	Modify rod hangers per DCN
1" Drain piping from Steam Line D	8-2	Interaction with MS piping/steel	Re-route drain piping and modify support per DCN
Steam to Steam Seal Regulator			
Rod hanger downstream of Valve 8-575	9-1	Disengaged rod hanger	Maintenance Item to be addressed by WR C341864
Verification Boundary Valve 8-575 (Proposed)	9-2	Valve performance	Walkdown scope to be expanded to remove the assumption
Steam Supply to RFP Turbines			
Steam supply line	10-1	Inadequate flex leg at MS header	Modify supports per DCN
Steam supply line	10-2	Stanchion supports	Modify supports per DCN
Steam supply line	10-3	TB overhead crane	To be resolved per BFN Calc. CD-N0001-980039
Verification Boundary Valve 1-RFPT (Proposed)	10-4	Installation of boundary valve	Walkdown scope to be expanded to remove the assumption
Condenser			
Condenser and anchorage adequacy	13-1	Evaluate condenser/anchorage	To be resolved per BFN Calc. CD-N0001-980038

Table 4-2

BROWNS FERRY UNIT 3
MSIV "OUTLIERS" RESOLUTION SUMMARY

SYSTEM DESCRIPTION	OUTLIER	OUTLIER DESCRIPTION	RESOLUTION METHOD
Main Steam Drain Line-Turbine Bldg.			
MS Drain Taps	1-1	MS line differential motion	Relocated three supports per DCN T40871A and BFN Calc. No. CD-N0001-980039
MS Drain Taps	1-2	Impact with conduit supports	Resolved per BFN Calc. No. CD-N0001-980038
FCV 1-58	1-3	Extended valve operators	Resolved per BFN Calc. No. CD-N0001-980038
FCV 1-58/59 Conduit	1-4	Unknown routing at TB/RB joint	Resolved per BFN Calc. No. CD-N0001-980038
Main Steam Lines			
MS Stop Valves	2-1	Valve performance	Resolved per BFN Calc. No. CD-N0001-980038
MSH-17	2-2	Missing eyebolt nut	Nut replaced per WR C164362
MSH-17,18 & 19	2-3	Grating clearances	Modified grating clearances per DCN T40871A
Main Steam Drain Line-MSIV Vault			
FCV 1-15, 27, 38 & 52	3-1	Valve performance	Resolved per BFN Calc. No. CD-N0001-980039
FCV 1-56	3-2	Manual operator	Valve replaced by DCN W17935A
HPCI/RCIC/Aux. Boiler Drains - MSIV Pit			
HPCI Drain at MS drain connection	4-1	Inadequate bending leg	Modified two supports per DCN T40871A and BFN Calc. No. CD-N0001-980039
MS PT 1-72, 76, 82, 86 & 93			
MS instrument tubing	5-1	Overspan on 1" pipe to PT 1-86	Missing clamp replaced per DCN T40871A
1/2 in. Line to PT 1-86	5-2	Interaction with steel & pipe	Re-route piping/instrumentation line per DCN T40871A and BFN Calc. No. CD-N0001-980039

Table 4-2 (CONT.)

BROWNS FERRY UNIT 3
MSIV "OUTLIERS" RESOLUTION SUMMARY

SYSTEM DESCRIPTION	OUTLIER	OUTLIER DESCRIPTION	RESOLUTION METHOD
Main Steam Sample to Station			
Sample lines B & D	6-1	Missing tubing support clamps	Missing clamps replaced per WR C193204
Sample lines A, B, C, D	6-2	Inadequate flex legs at MS line	Added four supports and removed four supports per DCN T40871A and BFN Calc. No. CD-N0001-980039
PT 16A/B	6-3	Inadequate flex legs at MS line	Modified two supports per DCN T40871A and BFN Calc. No. CD-N0001-980039
Sample Station	6-4	Temperature bath anchorage	Anchorage provided per DCN T40871A and BFN Calc. No. CD-N0001-980039
Main Steam Bypass			
Main Steam Bypass Valve	7-1	Valve performance	Resolved per BFN Calc. No. CD-N0001-980038
SV Above Seat Drains			
FCV 6-100, 101, 102, 103	8-1	Short rod hangers	Modified rod hangers per DCN T40871A and BFN Calc. No. CD-N0001-980039
Steam to Steam Seal Regulator			
MS to FCV 1-146	9-1	Overspan piping	Resolved per BFN Calc. No. CD-N0001-980039
PCV 1-147	9-2	Hand wheel in proximity to WF section	Resolved per BFN Calc. No. CD-N0001-980039
PCV 1-147 air line	9-3	Inadequate flexibility & blockwall interaction	Resolved per BFN Calc. No. CD-N0001-980039
PCV 1-147	9-4	Extended valve operator	Resolved per BFN Calc. No. CD-N0001-980039

. . . Table 4-2 (CONT.)

BROWNS FERRY UNIT 3
MSIV "OUTLIERS" RESOLUTION SUMMARY

SYSTEM DESCRIPTION	OUTLIER	OUTLIER DESCRIPTION	RESOLUTION METHOD
Steam Supply to RFP Turbines			
Steam supply line	10-1	Inadequate flex leg at MS header	Remove hanger per DCN T40871A and BFN Calc. No. CD-N0001-980039
Steam supply line	10-2	Stanchion supports	Replace two spring hangers per DCN T40871A and BFN Calc. No. CD-N0001-980039
Steam supply line	10-3	TB crane overhead	Resolved per BFN Calc. No. CD-N0001-980039
RFT Stop Valve above seat drains	10-4	Lass mass on 1/2 and 3/4 inch lines	Resolved per BFN Calc. No. CD-N0001-980039
Tubing to PI 1-126	10-5	Missing tubing clamps – overspan	Missing clamps replaced per WR-C193201
Steam Supply to SJAE's			
SJAE 3A/B	11-1	Anchorage and cracked pedestal	Anchorage resolved per BFN Calc. No. CD-N0001-980039; Cracked concrete pedestal repaired per WR-C193206
SJAE 3B	11-2	Loose anchor bolt nut	Re-torqued loose nut per WR-C193205
Drain to Condenser	11-3	Drain ties to multi-system collector	Re-route piping per DCN T40871A and BFN Calc. No. CD-N0001-980039
Steam Supply to Off-Gas Preheaters			
PCV 1-175A/B	12-1	Masonry wall	To be resolved by the proposed installation of NEW boundary valves to Preheaters A & B
Steam supply line to FCV 1-178A/B	12-2	Vertical restraint of line at FCV 1-178	Resolved per BFN Calc. No. CD-N0001-980039
PCV 1-175A/B, FCV 1-178A/B	12-3	Valve performance	To be resolved by the proposed installation of NEW boundary valves to Preheaters A & B
Condenser			
Condenser and anchorage adequacy	13-1	Evaluate condenser/anchorage	Resolved per BFN Calc. No. CD-N0001-980038

Table 4-3

Design Basis for Browns Ferry ALT Related Piping and Supports

Piping Description	Design Temp. (°F)	Design Press. (psig)	Pipe Size (NPS)	Pipe Sch.	D/t	Piping Material	Typical Support Types	Piping Design Basis
MS Lines from outboard MSIV's to MS Header and to Turbine Stop Valves	562	1146	24 1	80 160	20 5	ASTM A-106 Grade B	Spring hangers Vertical struts	USAS B31.1- 1967
Main Steam Header	562	1146	24	80	20	ASTM A-155 Grade KC-70	Spring hangers	USAS B31.1- 1967
MS Stop Valve Above Seat Leak-off	562	1146	1	160	5	ASTM A-106 Grade B	Rod hangers	USAS B31.1- 1967
Turbine Bypass Valve Header	562	1146	18	80	19	ASTM A-106 Grade B	Rigid supports Rod and Spring hangers	USAS B31.1- 1967
MS Steam Supply to RFP Turbine Stop Valves	562	1146	6 4	80 80	15 13	ASTM A-106 Grade B	Rod and Spring hangers Stanchion supports	USAS B31.1- 1967
MS Steam Supply from MS Header to SJAE's to the Condenser	562	1146	3 2 1-1/2 1	160 160 160 160	8 7 7 5	ASTM A-106 Grade B	Rod and Spring hangers	USAS B31.1- 1967

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Attachment A

Table 4-3 (CONT.)

Design Basis for Browns Ferry ALT Related Piping and Supports

Piping Description	Design Temp. (°F)	Design Press. (psig)	Pipe Size (NPS)	Pipe Sch.	D / t	Piping Material	Typical Support Types	Piping Design Basis
MS Steam Supply to Steam Seal Regulators	562	1146	4	80	13	ASTM A-106 Grade B	Rod hangers	USAS B31.1- 1967
MS Steam Supply from MS Header to the Off-Gas Preheaters A & B	562	1146	2	160	7	ASTM A-106 Grade B	Rod hangers	USAS B31.1- 1967
			2	160	7	ASTM A-335 Grade P11	New piping associated with the proposed installation of new boundary valves to Preheaters A & B	
MS Outboard Drains from MS Lines to the Main Drain Line	562	1146	3 2 1	160 160 160	8 7 5	ASTM A-106 Grade B	Stanchion supports	USAS B31.1- 1967
			3 2	160 160	8 7	ASTM A-333 Grade 1		
Main Drain Line to the Condenser	562 / 450	1146 / 400	4 3 1	80 160 160	13 8 5	ASTM A-106 Grade B	Rod and Spring hangers Stanchion supports	USAS B31.1- 1967

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Attachment A

Table 4-3 (CONT.)

Design Basis for Browns Ferry ALT Related Piping and Supports

Piping Description	Design Temp. (°F)	Design Press. (psig)	Pipe Size (NPS)	Pipe Sch.	D / t	Piping Material	Typical Support Types	Piping Design Basis
HPCI Drain to MS Drain; RCIC Drain to HPCI Drain; Aux. Boiler Drains to HPCI/RCIC/ Reactor Building Drain Line	450	400	2 1	160 160	7 5	ASTM A-106 Grade B	Rigid supports	USAS B31.1- 1967
	270	415	1	160	5			
Misc. PT Instrument Lines Sample Lines to Sample Station	562	1146	1	160	5	ASTM A-106 Grade B	Rigid supports	USAS B31.1- 1967
			¼" tubing	.049" (wall t)	--	ASTM A-213 SS Gr. TP-304	Rigid supports (tube clamps)	--

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Attachment A

Table 4-4

Seismic Experience Database Piping Data

Facility	Pipe Size (NPS)	Pipe O.D. (inch)	Schedule	Wall Thickness (inch)	D/t
Valley Steam Plant Units 1 & 2	24	24.0	20	0.375	64
	20	20.0	20	0.375	53
	18	18.0	30	0.437	41
	16	16.0	30	0.375	43
	14	14.0	30	0.375	37
	12	12.75	40	0.406	31
	12	12.75	30	0.330	39
	10	10.75	160	1.125	10
	8	8.625	160	0.906	10
	6	6.625	40	0.280	24
	4	4.50	160	0.531	8
	4	4.50	40	0.237	19
	3	3.50	160	0.437	8
	3	3.50	80	0.300	12
	3	3.50	40	0.216	16
	2	2.375	160	0.343	7
	2	2.375	40	0.154	15
	1½	1.90	160	0.281	7
	1½	1.90	40	0.145	13
	1	1.315	40	0.133	10
	¾	1.05	160	0.218	5
	¾	1.05	40	0.113	9

Table 4-4 (CONT.)
Seismic Experience Database Piping Data

Facility	Pipe Size (NPS)	Pipe O.D. (inch)	Schedule	Wall Thickness (inch)	D/t
El Centro Steam Plant	20	20.0	STD	0.375	53
	18	18.0	160	1.781	10
	18	18.0	XS	0.500	36
	18	18.0	STD	0.375	48
	14	14.0	40	0.437	32
	14	14.0	STD	0.375	37
	12	12.75	160	1.312	10
	12	12.75	STD	0.375	34
	10	10.75	40	0.365	29
	8	8.625	160	0.906	10
	8	8.625	120	0.718	12
	8	8.625	40	0.322	27
	6	6.625	120	0.562	12
	6	6.625	40	0.280	24
	4	4.50	80	0.337	13
	4	4.50	40	0.237	19
	3	3.50	160	0.437	8
	3	3.50	80	0.300	12
	3	3.50	40	0.216	16
	2	2.375	160	0.343	7
	2	2.375	80	0.218	11
	2	2.375	40	0.154	15
	1½	1.90	160	0.281	7
	1½	1.90	80	0.200	10
	1½	1.90	40	0.145	13
	1	1.315	80	0.179	7
	1	1.315	40	0.133	10
	¾	1.05	80	0.154	7
	¾	1.05	40	0.113	9

Table 4-4 (CONT.)

Seismic Experience Database Piping Data

Facility	Pipe Size (NPS)	Pipe O.D. (inch)	Schedule	Wall Thickness (inch)	D/t
Moss Landing Units 1, 2 & 3	16	16.0	--	1.394	11
	12	12.75	--	1.148	11
	8	8.625	160	0.906	10
	8	8.625	30	0.277	31
	6	6.625	160	0.562	12
	6	6.625	40	0.280	24
	4	4.50	160	0.531	8
	4	4.50	80	0.337	13
	4	4.50	40	0.237	19
	3	3.50	160	0.437	8
	3	3.50	80	0.300	12
	3	3.50	40	0.216	16
	2	2.375	160	0.343	7
	2	2.375	80	0.218	11
	2	2.375	40	0.154	15
	1½	1.90	160	0.281	7
	1½	1.90	80	0.200	10
	1	1.315	160	0.250	5
	1	1.315	80	0.179	7
	¾	1.05	160	0.218	5
	¾	1.05	80	0.154	7

Table 4-4 (CONT.)
Seismic Experience Database Piping Data

Facility	Pipe Size (NPS)	Pipe O.D. (inch)	Schedule	Wall Thickness (inch)	D/t
Moss Landing Units 4 & 5	24	24.0	40	0.687	35
	24	24.0	--	1.066	23
	--	18.8	--	2.287	8
	16	16.0	40	0.500	32
	16	16.0	--	0.902	18
	--	13.2	--	1.668	8
	8	8.625	160	0.906	10
	8	8.625	40	0.322	27
	6	6.625	160	0.562	12
	6	6.625	40	0.280	24
	4	4.50	160	0.531	8
	4	4.50	80	0.337	13
	4	4.50	40	0.237	19
	3	3.50	160	0.437	8
	3	3.50	80	0.300	12
	3	3.50	40	0.216	16
	2	2.375	160	0.343	7
	2	2.375	80	0.218	11
	2	2.375	40	0.154	15
	1½	1.90	160	0.281	7
	1½	1.90	80	0.200	10
	1½	1.90	40	0.145	13
	1	1.315	160	0.250	5
	1	1.315	80	0.179	7
	1	1.315	40	0.133	10
	¾	1.05	160	0.218	5
	¾	1.05	80	0.154	7
	¾	1.05	40	0.113	9

Table 4-4 (CONT.)
Seismic Experience Database Piping Data

Facility	Pipe Size (NPS)	Pipe O.D. (inch)	Schedule	Wall Thickness (inch)	D/t
Moss Landing Units 6 & 7	30	30.0	--	0.632	47
	26	26.0	--	1.128	23
	18	18.0	--	3.444	5
	12	12.75	--	2.444	5
	12	12.75	--	0.601	21
	8	8.625	--	1.650	5
	8	8.625	40	0.322	27
	6	6.625	--	1.268	5
	6	6.625	40	0.280	24
	4	4.50	--	0.861	5
	4	4.50	80	0.337	13
	4	4.50	40	0.237	19
	3	3.50	80	0.300	12
	3	3.50	40	0.216	16
	2½	2.875	--	0.550	5
	2½	2.875	80	0.276	10
	2½	2.875	40	0.178	16
	2	2.375	--	0.519	5
	2	2.375	80	0.218	11
	2	2.375	40	0.154	15
	1½	1.90	--	0.428	4
	1½	1.90	80	0.200	10
	1½	1.90	40	0.145	13
	1	1.315	--	0.301	4
	1	1.315	80	0.179	7
	1	1.315	40	0.133	10
	¾	1.05	160	0.218	5
	¾	1.05	80	0.154	7
	¾	1.05	40	0.113	9
	½	1.05	--	0.210	4
	¼	0.54	--	0.153	4

Table 4-4 (CONT.)

Seismic Experience Database Piping Data

Facility	Pipe Size (NPS)	Pipe O.D. (inch)	Schedule	Wall Thickness (inch)	D/t
Ormond Beach Units 1 & 2	30	30.0	-	1.298	23
	30	30.0	-	0.719	42
	21	21.0		3.793	6
Humboldt Bay Unit 3	12	12.75	80	0.687	19
	10	10.75	80	0.593	18
	6	6.625	80	0.432	15

Table 4-5

Comparison of Browns Ferry and Selected Database Piping Parameters

Piping Parameter	Browns Ferry.	Database Sites
Pipe Diameter (inch)	1.315 – 24.0	1.05 – 30.0
Wall Thickness (inch)	0.25 – 1.218	0.113 – 3.793
Diameter-to-Thickness Ratio (D/t)	5 - 20	4 – 64

Table 4-6

Bounding Evaluations of Typical Support Configurations

Support Type	Critical Component	Stress Ratio
Cantilever bracket	Anchor bolts	.73
Rod hanger	Overhead weld attachment	.70

Table 4-7

Browns Ferry Turbine Building Design Basis

Design Attribute	Description
Lateral Force Resisting System Above the Operating Deck	The Turbine Building above the operating deck is framed by transverse welded steel rigid frames with fixed bases and braced in the direction of the Reactor Building to provide the resistance to lateral forces.
Lateral Force Resisting System Below the Operating Deck	The Turbine Building below the operating deck is a reinforced concrete structure. Concrete walls serve as shear walls for the lateral loads in the direction of the Reactor Building.
Design Codes	General: Uniform Building Code (UBC) Concrete: American Concrete Institute (ACI 318-1963) Steel: American Institute of Steel Construction (AISC) -1963
Seismic Design Basis	UBC zone 1
Wind Design Basis	Wind speed of 100 mph

Table 4-8

Comparison of Browns Ferry and Selected Database Condensers

Design Attributes	Moss Landing Units 6 & 7	Ormond Beach Units 1 & 2	Browns Ferry
Condenser Manufacturer	Ingersoll-Rand	Southwestern	Foster Wheeler
Flow Type	Single Pass	Single Pass	Single Pass
Condenser Dimensions (LxWxH)	65 ft. x 36 ft. x 47 ft.	52 ft. x 27 ft. x 20 ft.	58 ft. x 32 ft. x 47 ft.
Condenser Surface Area	435,000 sq. ft.	210,000 sq. ft.	222,000 sq. ft.
Condenser Shell Material	Cu Bearing ASTM A-285C	Cu Bearing ASTM A-285C	ASTM A-285C
Condenser Shell Thickness	3/4"	3/4"	7/8"
Condenser Operating Weight	3,115 kips	1,767 kips	2,076 kips
Tube Material	Al-Brass	90-10 Cu-Ni	Al-6XN
Tube Size	1" dia.	1" dia.	7/8" dia.
Tube Length	65 ft.	53 ft.	50 ft.
Tube Wall Thickness	18 BWG	20 BWG	22 BWG

Table 4-8 (CONT.)

Comparison of Browns Ferry and Selected Database Condensers

Design Attributes	Moss Landing Units 6 & 7	Ormond Beach Units 1 & 2	Browns Ferry
Number of Tubes	25,590	15,220	19,480
Tube Sheet Material	Muntz	Muntz	ASTM A-285C
Tube Sheet Thickness	1-1/2"	1-1/4"	1-1/4"
No. of Tube Support Plates	15	14	15
Tube Support Plate Material	Not Given	Cu Bearing ASTM A-285C	ASTM A-285C
Tube Support Plate Thickness	3/4"	5/8"	7/8"
Tube Support Plate Spacing	48 in.	36 in.	39 in.
Water Box Material	2% Ni Cast Iron ASTM A-48 Class 30	Cu Bearing ASTM A-285C	ASTM A-285C
Expansion Joint	Rubber Belt	Stainless Steel	Rubber Belt
Hotwell Capacity	20,000 gal.	34,338 gal.	28,000 gal. (max.)

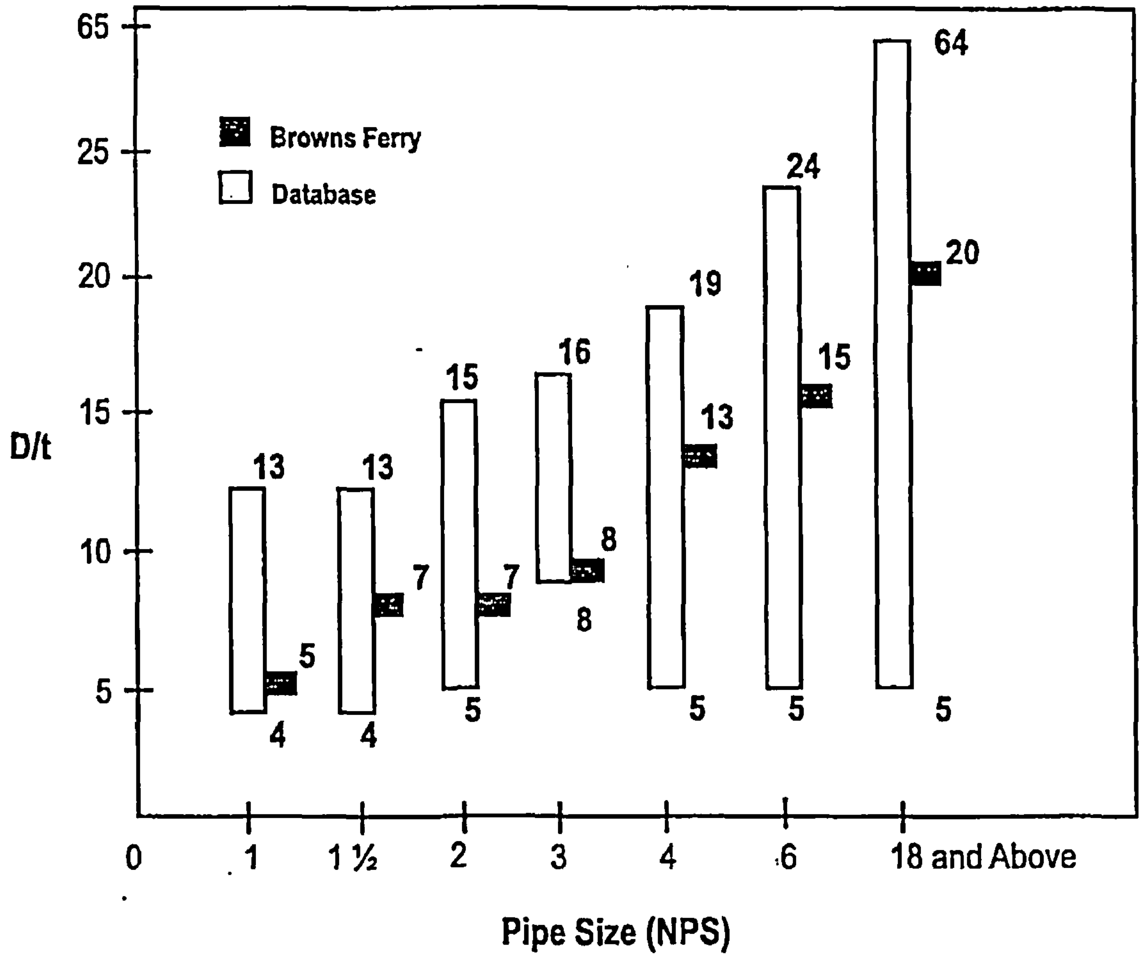

Figure 4-1 Comparison of Browns Ferry and Selected Database Piping D/t Ratios

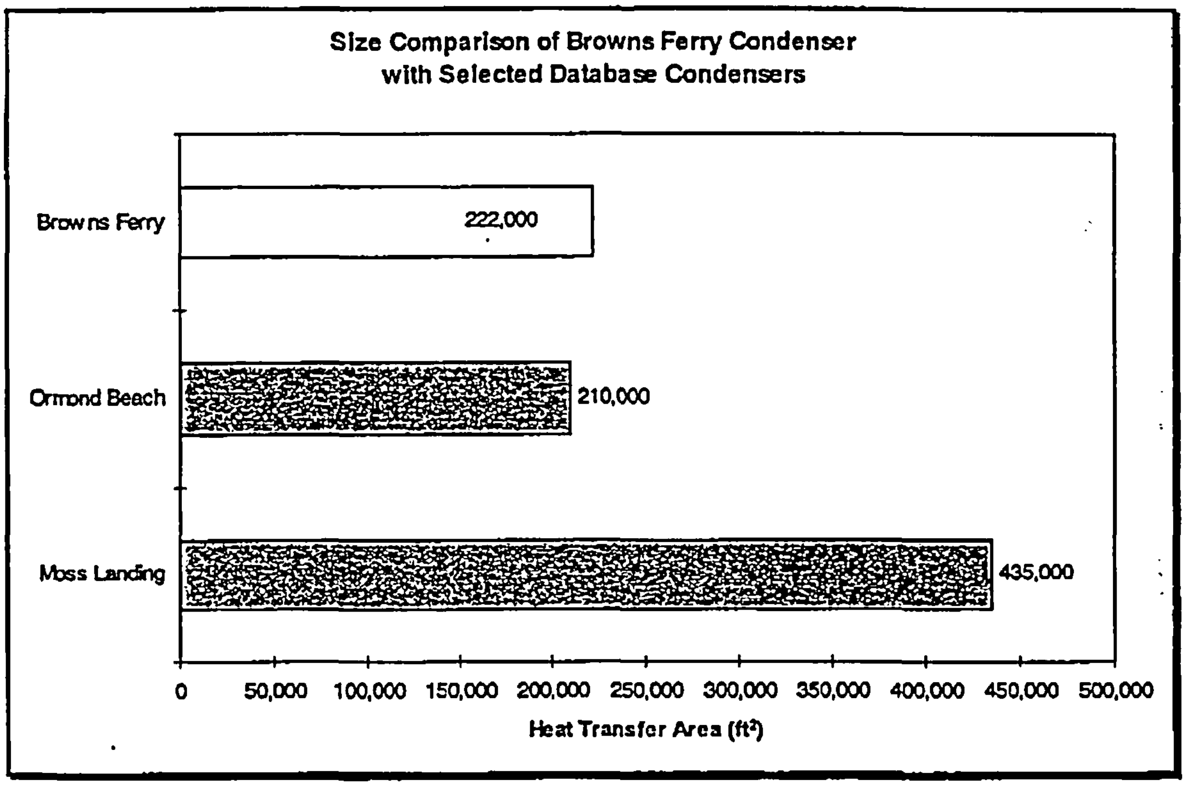

Figure 4-2 Size Comparison of Browns Ferry Condenser with Selected Database Condensers

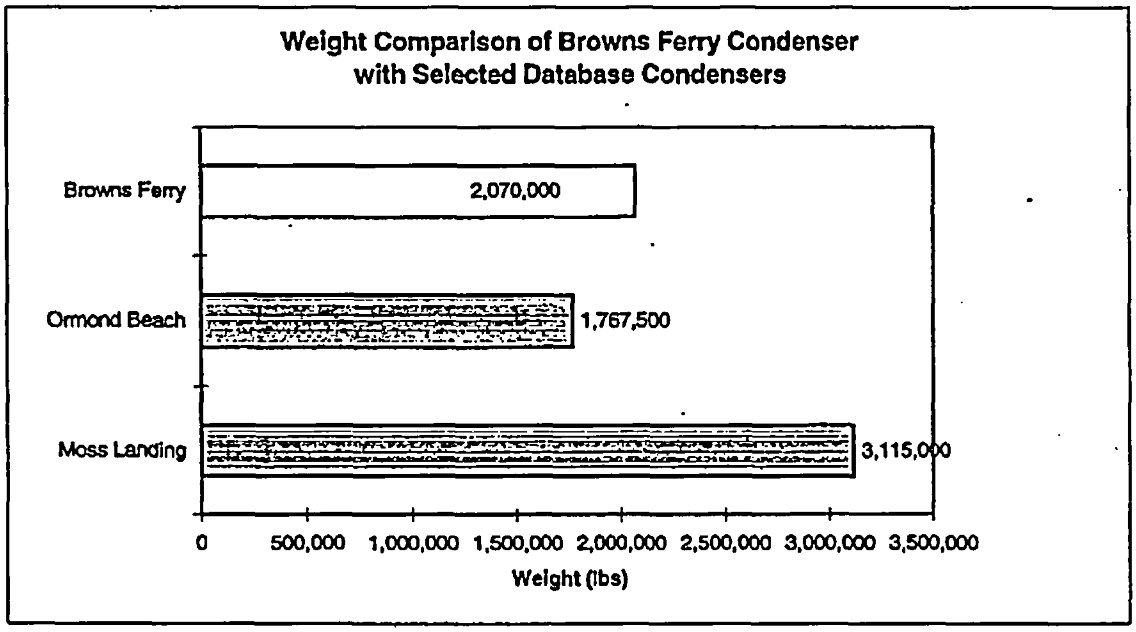

Figure 4-3 Weight Comparison of Browns Ferry Condenser with Selected Database Condensers

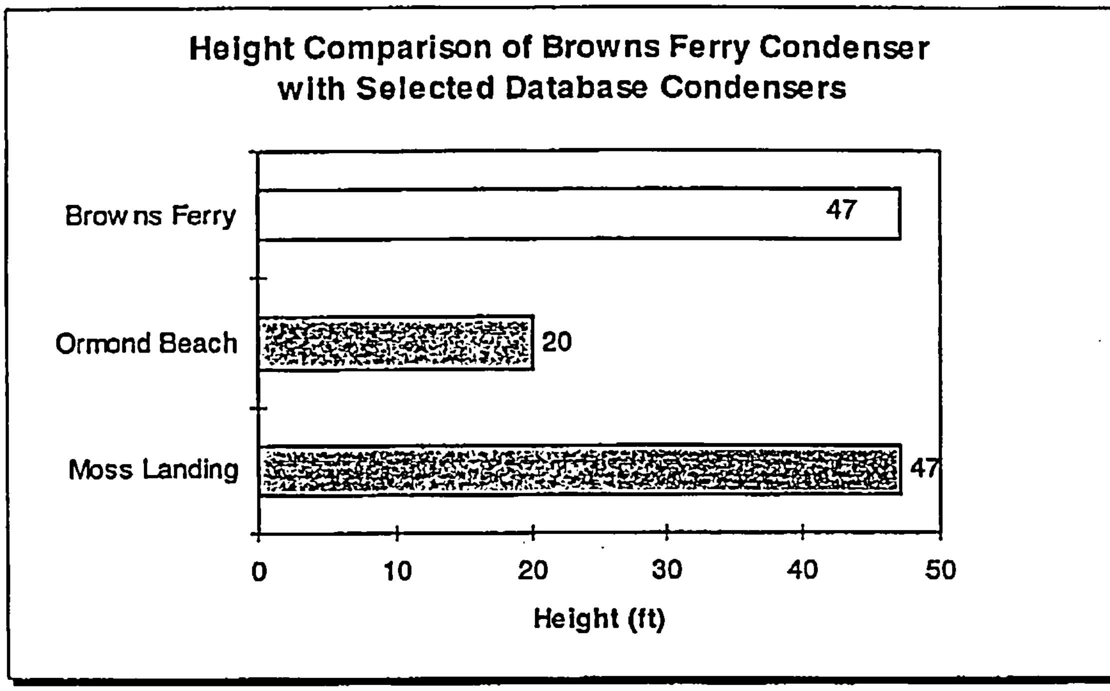

Figure 4-4 Height Comparison of Browns Ferry Condenser with Selected Database Condensers

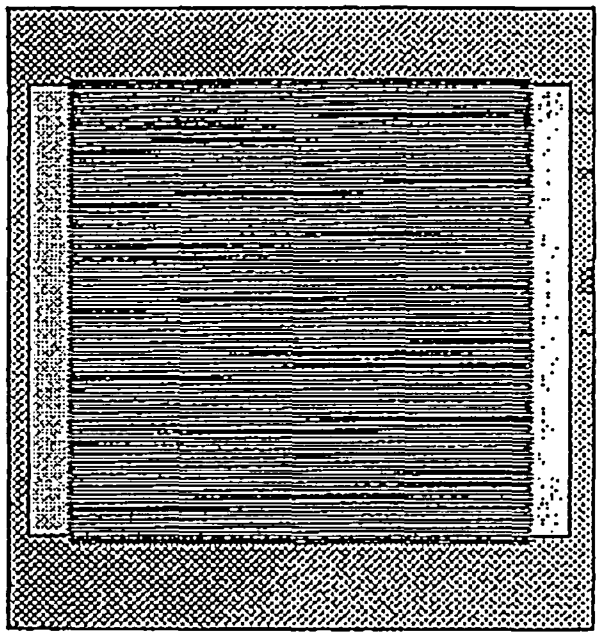

Figure 4-5 Plan Dimension Comparison of Browns Ferry Condenser with Selected Database Condensers

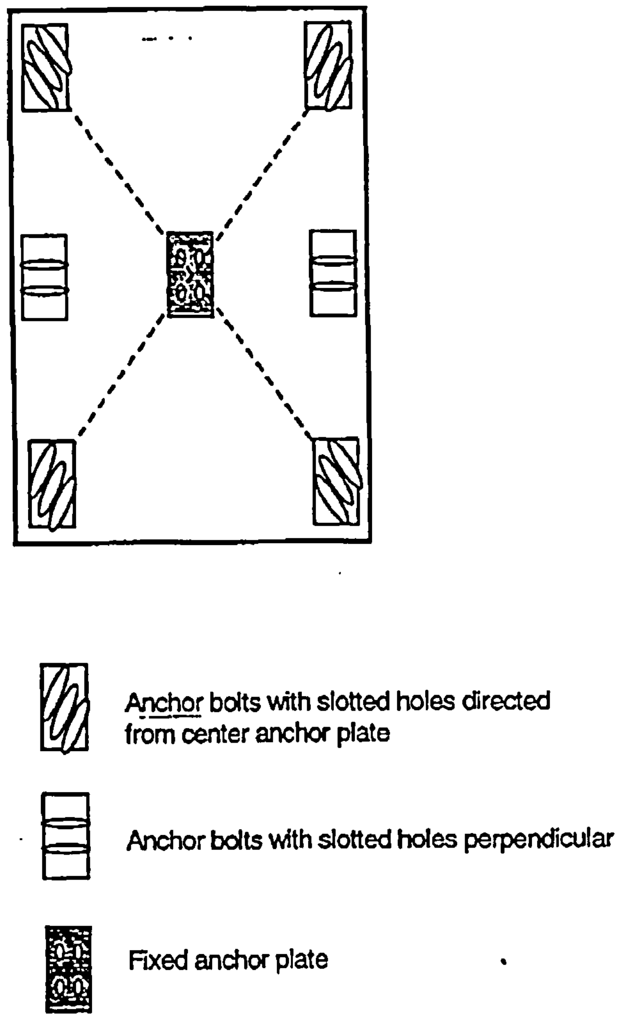

Figure 4-6 Schematic Plan View of Browns Ferry Condenser Anchorage

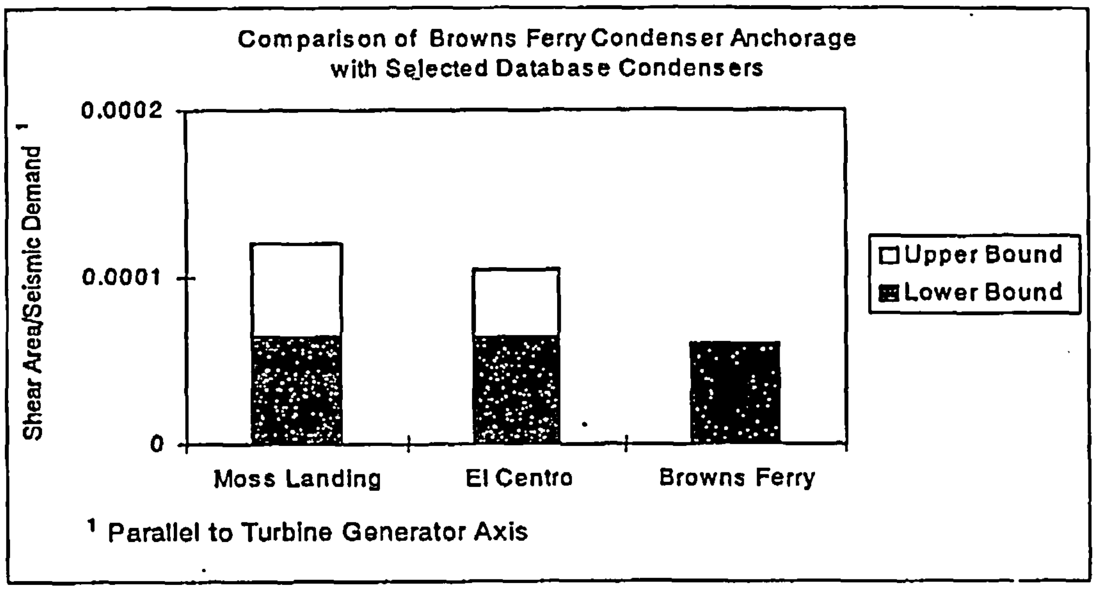

Figure 4-7 Comparison of Browns Ferry and Selected Database Condenser Anchorage to Seismic Demand for Direction Parallel to the Turbine Generator Axis

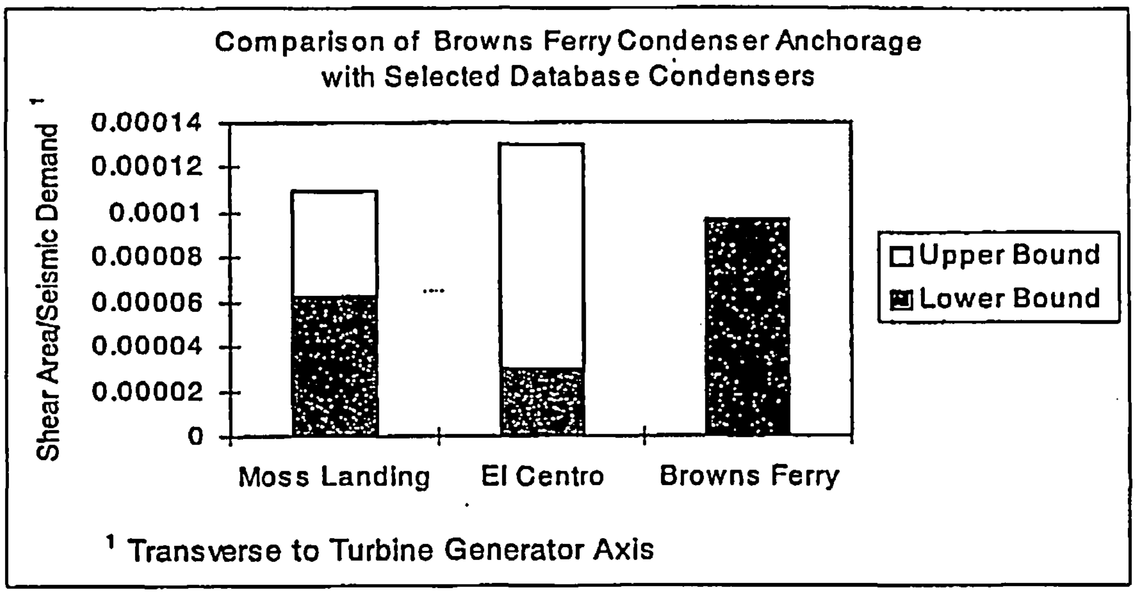

Figure 4-8 Comparison of Browns Ferry and Selected Database Condenser Anchorage to Seismic Demand for Direction Transverse to the Turbine Generator Axis

5. REFERENCES

1. "BWROG Report for Increasing MSIV Leakage Rate Limits and Elimination of Leakage Control Systems", GE NEDC-31858P, Revision 2, September 1993.

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3. "Browns Ferry - Unit 3, MSIV Seismic Verification Summary Report", EQE Report No. 200621-R-001, Revision 0, September 1998.

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5. "Generic Implementation Procedure (GIP) for Seismic Verification of Nuclear Plant Equipment", Rev. 2A, March 1993, Prepared by Winston & Strawn, EQE, et al., for the Seismic Qualification Utility Group (SQUG).

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7. BFN Calculation No. CD-N0001-980038, "Main Steam Seismic Ruggedness Evaluation".

8. BFN General Design Criteria, BFN-50-C-7102, "Seismic Design", Revision 3.

9. BFN Detailed Design Criteria, BFN-50-C-7306, "Qualification Criteria for Seismic Class II Piping, Pipe Supports, and Components", Revision 1.

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CALCULATION COVER SHEET

EQE INTERNATIONAL

Calculation No. 200918-C-002

Project: TVA BFN MSIV LEAKAGE TECH SPEC CHANGE

Calculation Title: ADDITIONAL SEISMIC EVALUATIONS FOR THE BFN CONDENSERS

References: See Section 3.0

Attachments:

Total Number of Pages (Including Cover Sheet): 15

Revision Number	Approval Date	Description of Revision	Originator	Checker	Approver
0	8/30/99	ORIGINAL ISSUE	F.R. BEIGI	J.O. DIZON	J.O. DIZON

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Tables

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1.0 PURPOSE

The purpose of this calculation is to document the results of the additional seismic evaluation performed on the BFN condensers, as part of the seismic adequacy verification of the components associated with the MSIV Alternate Leakage Treatment (ALT) pathway.

2.0 SCOPE & METHODOLOGY

The BFN condensers are the terminal boundary points of the MSIV alternate leakage treatment (ALT) pathway, hence, they are necessary to maintain structural integrity following a Design Basis Earthquake (DBE). The condensers are located in the Turbine Building and are not designated as Seismic Class I systems.

As part of the plant specific seismic verification of the non-seismic components using the earthquake experience-based approach as outlined in the BWROG Report (Reference 1), the following reviews are performed to demonstrate that the BFN condensers fall within the bounds of the experience database and/or exhibit adequate seismic capacity:

- Review of the condenser design codes and standards, design characteristics and parameters, and support/anchorage configurations.
- Verification walkdown to identify potential seismic interaction concerns.
- Engineering evaluations of the condenser and support configurations.

The BFN condensers are evaluated using both seismic experience data from past earthquakes and engineering analysis. Analytical evaluations of the condenser and support anchorage are performed in accordance with the guidelines in the Generic Implementation Procedure (GIP, Reference 5), and the general requirements of the American Institute of Steel Construction (AISC, Reference 6), as applicable.

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3.0 REFERENCES

1. "BWROG Report for Increasing MSIV Leakage Rate Limits and Elimination of Leakage Control Systems", GE NEDC-31858P, Revision 2, September 1993.

2. Safety Evaluation of GE Topical Report, NEDC-31858P, Revision 2, "BWROG Report for Increasing MSIV Leakage Rate Limits and Elimination of Leakage Control Systems", U.S. Nuclear Regulatory Commission, March 3, 1999.

3. "Browns Ferry - Unit 2, MSIV Seismic Verification Summary Report", EQE Report No. 200918-R-001, Revision 0, August 1999.

4. "Browns Ferry - Unit 3, MSIV Seismic Verification Summary Report", EQE Report No. 200621-R-001, Revision 0, September 1998.

5. "Generic Implementation Procedure (GIP) for Seismic Verification of Nuclear Plant Equipment", Rev. 2A, March 1993, Prepared by Winston & Strawn, EQE, et al., for the Seismic Qualification Utility Group (SQUG).

6. AISC, "Manual of Steel Construction", Eighth Edition, 1980.

7. TVA Calculation No. CD-N0001-980039, "Main Steam Seismic Ruggedness Verification".

8. TVA Calculation No. CD-N0001-980038, "Main Steam Seismic Ruggedness Evaluation".

9. ASME, "Boiler and Pressure Vessel Code, Section III, Division I, Appendices", 1980 Edition.

4.0 SEISMIC EVALUATIONS

The BFN condensers consist of three single-pass, single pressure, radial flow type surface condensers. Each condenser is located beneath each of the three low pressure turbines, and is structurally independent. Table 1 lists the design data for BFN condensers and for the two experience database sites listed in the BWROG Report (i.e., Moss Landing 6 & 7, and Ormond Beach 1 & 2). Design characteristic comparisons of the BFN condensers with the above two selected database condensers are presented in details in Reference 8. These include size (surface area), weight, height, and plan comparisons. The BFN condenser design data is comparable to the data for these two database sites.

The BFN condenser anchorage was compared with the performance of similar condenser in the earthquake experience database. The shear areas of the condenser anchorage, in the directions parallel and transverse to the turbine generator axis, divided by the seismic demand, were used to compare with those presented in the BWROG Report (Reference 1). The BFN condenser anchorage shear area to seismic demand is substantially greater than the selected database sites. The condenser support anchorage was also evaluated and the results indicate that the combined seismic DBE and operational demand is less than the anchorage capacity based on the AISC allowables. Maximum stress ratios are 0.70 for bolt tension in the perimeter support feet, and 0.86 for shear in the center support built-up section. Detailed description of the BFN condenser support anchorage and anchorage evaluations are presented in Reference 8.

A composite comparison of the ground response spectra of selected earthquake experience database sites with the conservatively estimated BFN DBE ground spectrum (i.e., 0.2g Housner input spectrum at rock outcrop scaled by 1.6 to account for soil amplification) is shown in Figure 1. In general, the earthquake experience database sites have experienced strong ground motions that are in excess of the BFN DBE at the frequency range of interest (i.e., about 1 Hz. and above), with the exception of the Ormond Beach site. Many of the database site ground motions envelope the conservatively estimated BFN DBE ground spectrum by large factors in various frequency bands within the 1 Hz. and above range. Figures 2 and 3 show the individual comparison plots of the conservatively estimated BFN DBE ground spectrum with the Moss Landing and Ormond Beach site spectra, respectively.

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SHEET NO. 6

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The Ormond Beach Power Plant was affected by the magnitude 5.8, Point Mugu Earthquake in 1973, which was considered to be a relatively moderate earthquake, and was substantially lower than the 1989 Loma Prieta Earthquake (Magnitude 7.1) as experienced in the Moss Landing Power Plant as well as those experienced by most of the other database sites.

To ensure that adequate seismic margins exist in the BFN condensers in the event of a plant DBE, additional seismic evaluation was performed to verify the overall structural integrity of the condensers, as shown in pages 7 to 9 of this calculation. Results of the evaluation indicate that the condenser shell stresses due to the seismic DBE loads are small. Maximum stress ratios, based on AISC allowables, are 0.12 for combined axial and bending and 0.10 for shear.

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SHEET NO. 7

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CALC. NO. C-002 SUBJECT Condenser Shell Evaluation CHK'D JOB DATE 8/30/99

CONDENSER SHELL

Check combined stresses in the condenser shell due to seismic Loads (DBE).

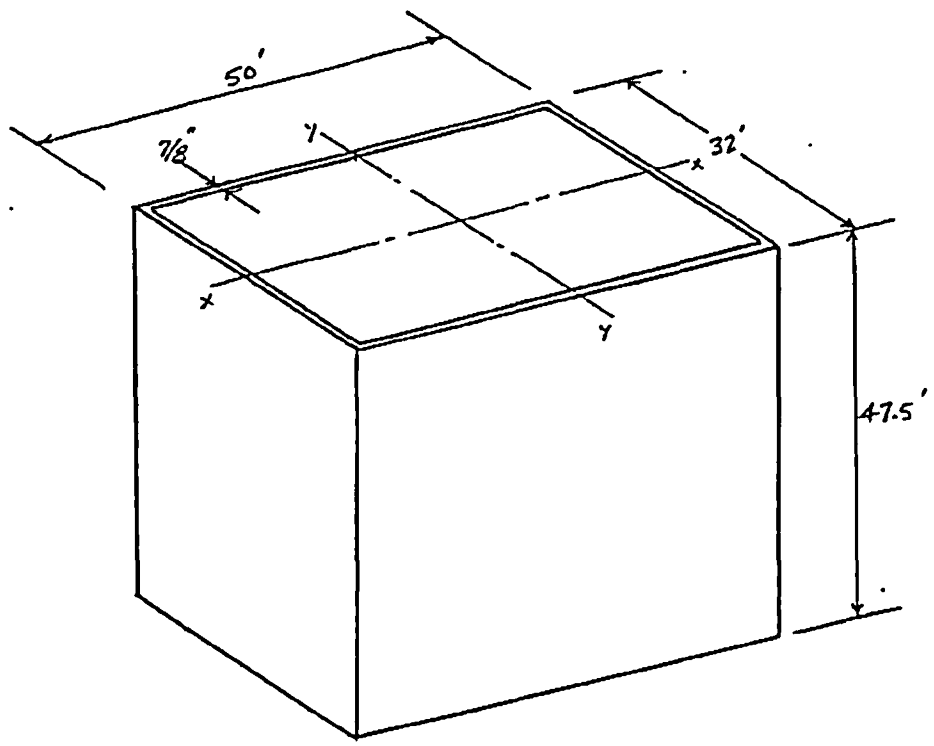
From Figure 1, BFN 5% damped DBE Ground spectrum

a_h = horizontal acceleration = 0.32g
a_v = vertical acceleration = 0.2g (2/3 × horiz.)

P = Condenser dead wt., including contents = 2070^k (Ref. 8)

C.G. = center of gravity of overall condenser = 12.72' (Ref. 8)

Condenser overall dimensions = 50' × 32' × 47.5' (h) (Ref. 8)
shell thickness = 7/8"
shell Material = ASTM A285C (F_y = 30 ksi) (Ref. 9)



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CONDENSER SHELL (CONT'd)

- section properties:

$A = (7/8'')(2)(50' + 32')(12) = 1722 \quad IN^2$

$I_{xx} = 2 \times \frac{7/8\,(32' \times 12)^3}{12} + 2 \times (7/8 \times 50' \times 12)\left(\frac{32' \times 12}{2}\right)^2 = 4.70 \times 10^7 \quad IN^4$

$\Rightarrow S_{xx} = \frac{I_{xx}}{(32' \times 12)/2} = 2.45 \times 10^5 \quad IN^3$

$I_{yy} = 2 \times \frac{7/8\,(50' \times 12)^3}{12} + 2 \times (7/8 \times 32' \times 12)\left(\frac{50' \times 12}{2}\right)^2 = 9.20 \times 10^7 \quad IN^4$

$\Rightarrow S_{yy} = \frac{I_{yy}}{(50' \times 12)/2} = 3.07 \times 10^5 \quad IN^3$

- Axial + Bending stresses

$f_a = \frac{P(1+a_v)}{A} = \frac{2070^k(1+0.2)}{1722} = 1.44 \quad ksi$

$f_{bx} = \frac{M}{S_{xx}} = \frac{(2070^k \times 0.32g)(12.72' \times 12)}{2.45 \times 10^5} = 0.41 \quad ksi$

$f_{by} = \frac{M}{S_{yy}} = \frac{(2070^k \times .32g)(12.72' \times 12)}{3.07 \times 10^5} = 0.33 \quad ksi$

Combined stress = $f_a + f_{bx} + f_{by} = 1.44 + .41 + .33 = 2.18 \quad ksi$

AISC Allowables (Ref. 6)

$\therefore F_b = 0.6 \times 30^{ksi} = 18 \quad ksi \gg 2.18 \quad ksi$ ok

$D/C = \frac{2.18}{18} = 0.12 \ll 1.0$ ok

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CONDENSER SHELL (Cont'd)

- Shear

$P_H = P \times a_h = 2070^k \times 0.32g = 662.4^k$

$A_V = 2 \times (32' \times 12)\ 7/8'' = 672\ IN^2$

$f_V = \frac{662.4}{672} = 1.0$ ksi

$F_V = 0.4 \times 30 = 12$ ksi $\gg f_V = 1.0$ ksi ok

$D/C = \frac{1.0}{12} = 0.1 \ll 1.0$ ok

EQE INTERNATIONAL

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Table 1

Comparison of Browns Ferry and Selected Database Condensers

Design Attributes	Moss Landing Units 6 & 7	Ormond Beach Units 1 & 2	Browns Ferry
Condenser Manufacturer	Ingersoll-Rand	Southwestern	Foster Wheeler
Flow Type	Single Pass	Single Pass	Single Pass
Condenser Dimensions (LxWxH)	65 ft. x 36 ft. x 47 ft.	52 ft. x 27 ft. x 20 ft.	58 ft. x 32 ft. x 47 ft.
Condenser Surface Area	435,000 sq. ft.	210,000 sq. ft.	222,000 sq. ft.
Condenser Shell Material	Cu Bearing ASTM A-285C	Cu Bearing ASTM A-285C	ASTM A-285C
Condenser Shell Thickness	3/4"	3/4"	7/8"
Condenser Operating Weight	3,115 kips	1,767 kips	2,076 kips
Tube Material	Al-Brass	90-10 Cu-Ni	Al-6XN
Tube Size	1" dia.	1" dia.	7/8" dia.
Tube Length	65 ft.	53 ft.	50 ft.
Tube Wall Thickness	18 BWG	20 BWG	22 BWG

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Table 1 (cont.)

Comparison of Browns Ferry and Selected Database Condensers

Design Attributes	Moss Landing Units 6 & 7	Ormond Beach Units 1 & 2	Browns Ferry
Number of Tubes	25,590	15,220	19,480
Tube Sheet Material	Muntz	Muntz	ASTM A-285C
Tube Sheet Thickness	1-1/2"	1-1/4"	1-1/4"
No. of Tube Support Plates	15	14	15
Tube Support Plate Material	Not Given	Cu Bearing ASTM A-285C	ASTM A-285C
Tube Support Plate Thickness	3/4"	5/8"	7/8"
Tube Support Plate Spacing	48 in.	36 in.	39 in.
Water Box Material	2% Ni Cast Iron ASTM A-48 Class 30	Cu Bearing ASTM A-285C	ASTM A-285C
Expansion Joint	Rubber Belt	Stainless Steel	Rubber Belt
Hotwell Capacity	20,000 gal.	34,338 gal.	28,000 gal. (max.)

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Figure 1
Comparison of Browns Ferry DBE Ground Spectrum with Selected Database Site Spectra

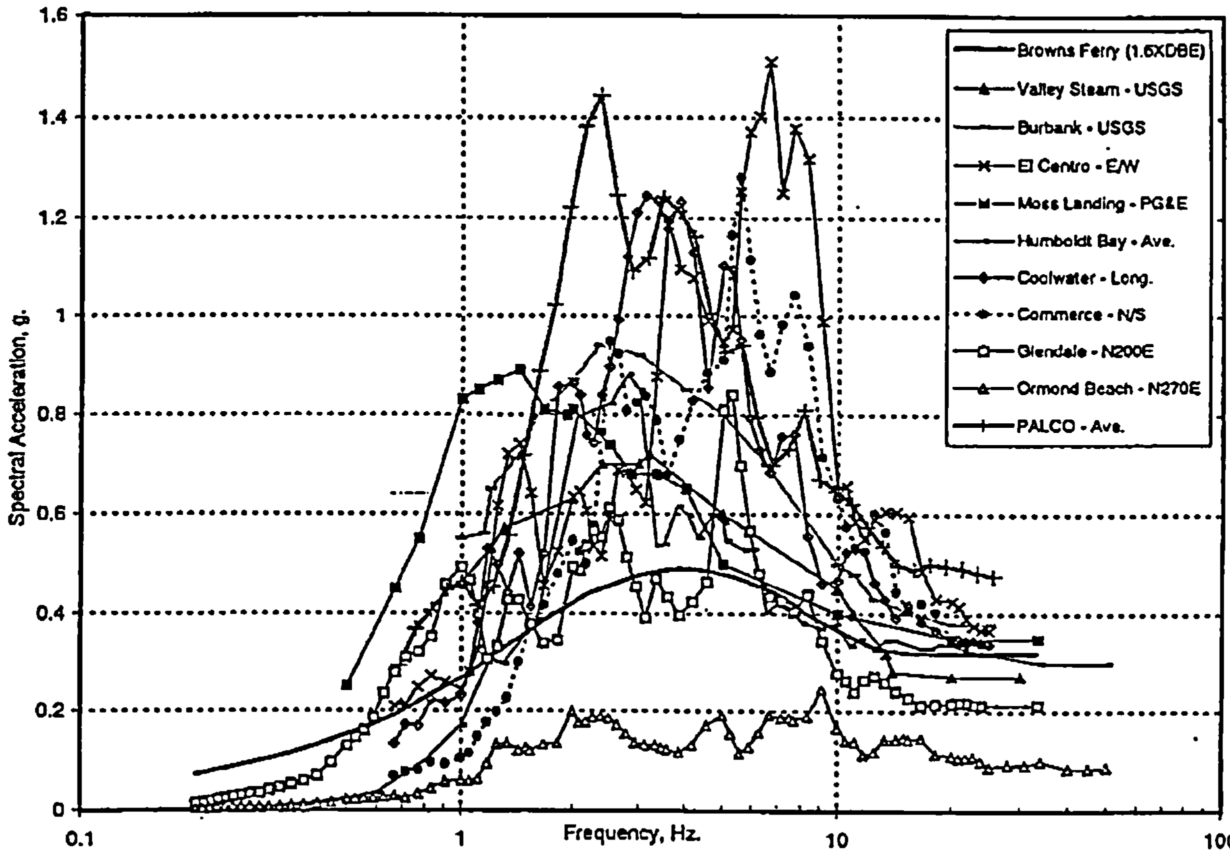

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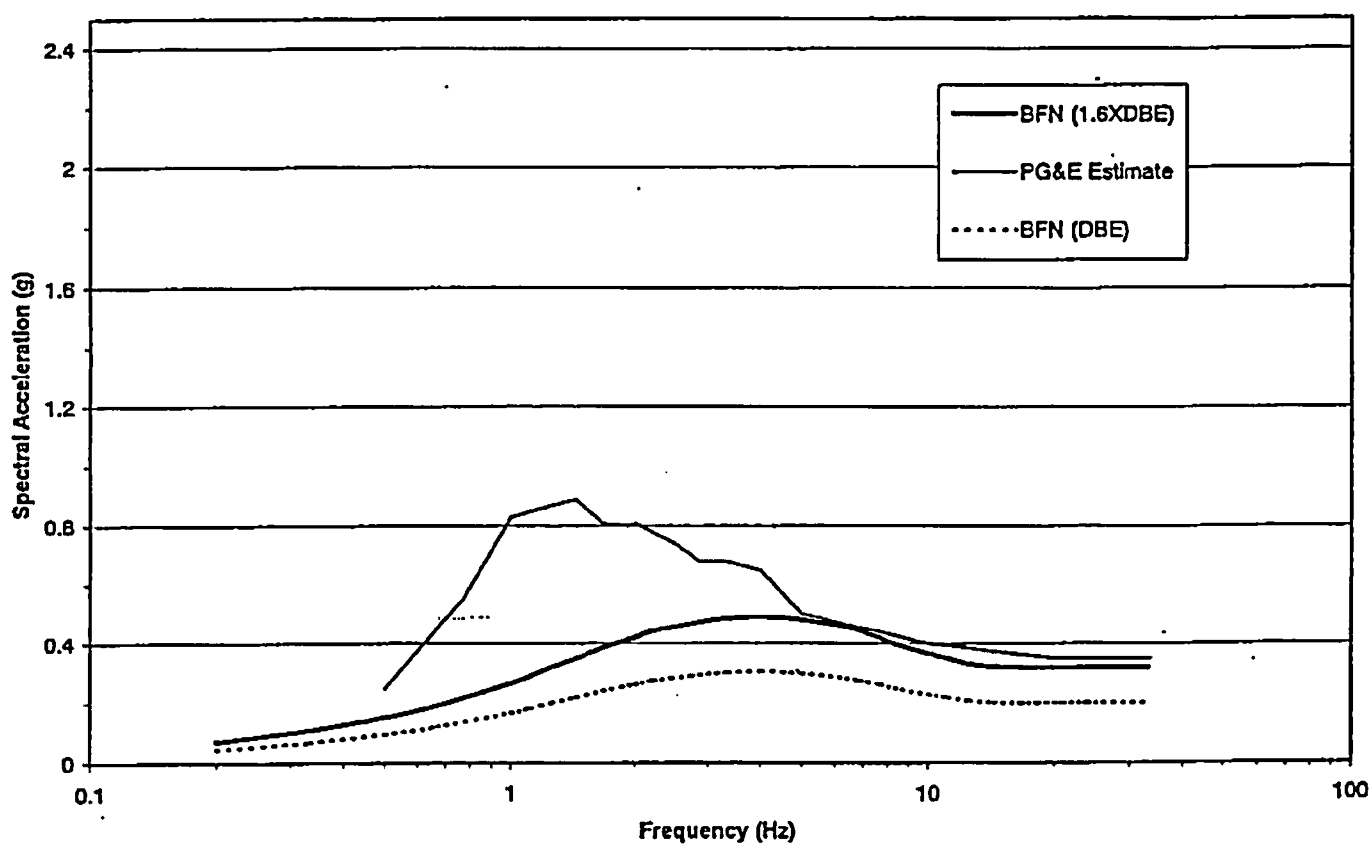
Figure 2
Comparison of Browns Ferry DBE and Moss Landing Power Plant Ground Spectra



					SHEET NO.	14
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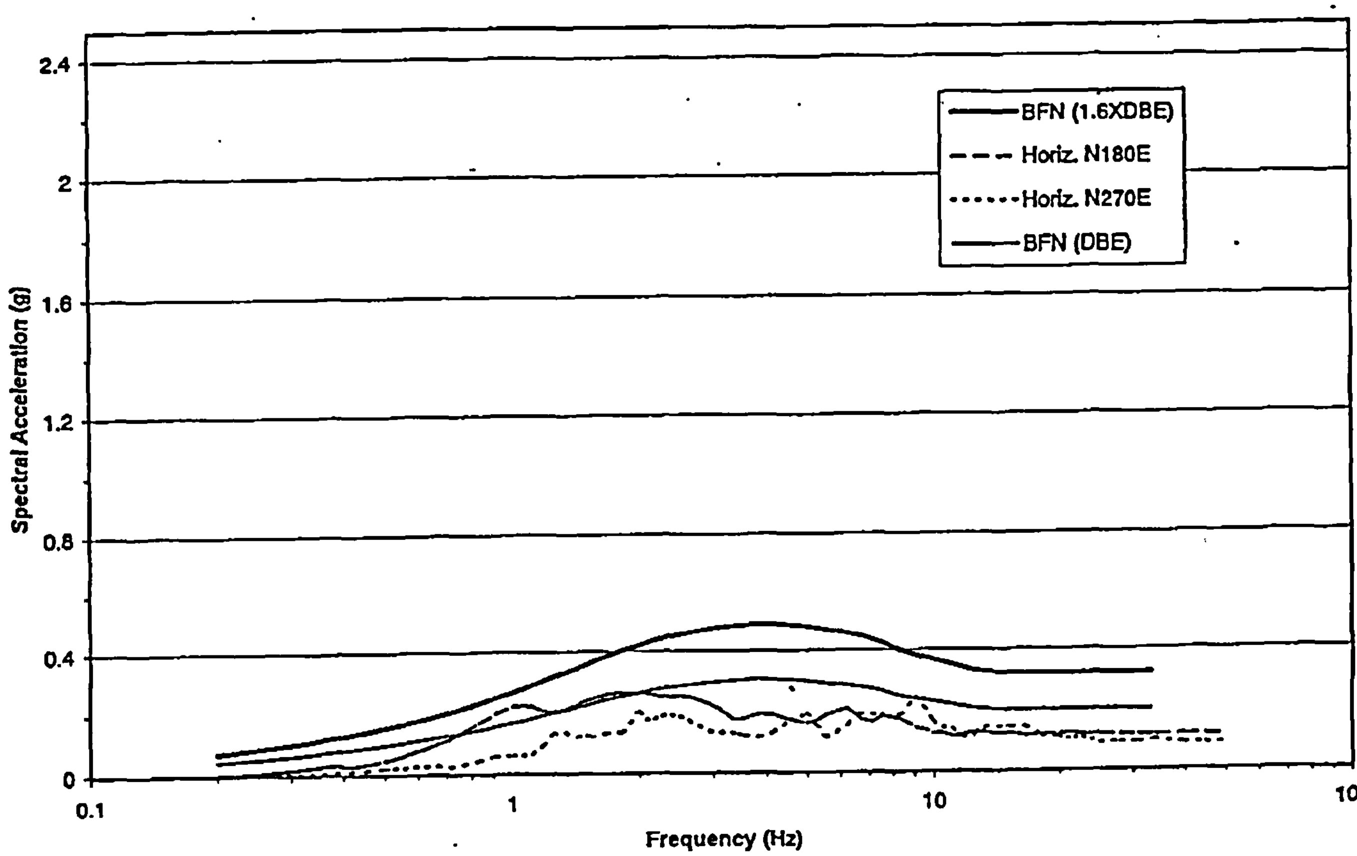
Figure 3
Comparison of Browns Ferry DBE and Ormond Beach Power Plant Ground Spectra



5.0 CONCLUSIONS

The comparisons of the condenser seismic experience data, supplemented by the additional condenser evaluation and the anchorage capacity evaluations demonstrate that the conclusions presented in the BWROG Report (Reference 1) can be applied to the BFN condensers. That is, a significant failure of the condenser in the event of a DBE at BFN is highly unlikely and contrary to the large body of historical earthquake experience data.

CALCULATION COVER SHEET

EQE INTERNATIONAL

Calculation No.	200918-C-001
Project:	TVA BFN MSIV LEAKAGE TECH SPEC CHANGE
Calculation Title:	SEISMIC VERIFICATION OF THE MS DRAIN PIPING AND SUPPORTS ASSOCIATED WITH THE MSIV ALTERNATE LEAKAGE TREATMENT PATHWAY
References:	See Section 3.0
Attachments:	

Total Number of Pages (Including Cover Sheet): 29

Revision Number	Approval Date	Description of Revision	Originator	Checker	Approver
0	8/30/99	ORIGINAL ISSUE ----	F.R. BEIGI FBeigi	J.O. DIZON J.O.Dizon	J.O. DIZON J.O.Dizon

						SHEET NO.	2
JOB NO.	200918	JOB	BFN MSIV TECH SPEC CHANGE	BY	7Bei	DATE	8-23-99
CALC. NO.	C-001	SUBJECT	SEISMIC VERIFICATION OF THE MSIV ALT PIPING AND SUPPORTS	CHK	JOD	DATE	8/30/99

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1.0 PURPOSE

The purpose of this calculation is to document the seismic adequacy verification of the main steam drain piping and related supports that are associated with the MSIV Alternate Leakage Treatment (ALT) pathway.

2.0 SCOPE & METHODOLOGY

The MSIV alternate leakage treatment (ALT) piping systems and related components at Browns Ferry, i.e., those portions downstream of the outboard Main Steam Isolation Valves (MSIV's) and the outboard Main Steam Drain Isolation Valve (MSDIV), are located in the Turbine Building and are not designated as Seismic Class I systems.

As part of the plant specific seismic verification of the non-seismic ALT piping, related supports and components using the earthquake experience-based approach as outlined in the BWROG Report (Reference 1), the following reviews will be performed to demonstrate that the piping and related supports fall within the bounds of the experience database:

- Review of the design codes and standards, piping design parameters, and support configurations.
- Seismic verification walkdown to identify potential piping concerns.
- Seismic evaluations of selected bounding support configurations.

Support evaluations will be performed in accordance to the general requirements of the American Institute of Steel Construction (AISC, Reference 6).

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JOB NO.	200918	JOB	BFN MSIV TECH SPEC CHANGE	BY	7Bci	DATE	8-23-99
CALC. NO.	C-001	SUBJECT	SEISMIC VERIFICATION OF THE MSIV ALT PIPING AND SUPPORTS	CHK	JBS	DATE	8/30/99

3.0 REFERENCES

1. "BWROG Report for Increasing MSIV Leakage Rate Limits and Elimination of Leakage Control Systems", GE-NEDC-31858P, Revision 2, September 1993.

2. Safety Evaluation of GE Topical Report, NEDC-31858P, Revision 2, "BWROG Report for Increasing MSIV Leakage Rate Limits and Elimination of Leakage Control Systems", U.S. Nuclear Regulatory Commission, March 3, 1999.

3. "Browns Ferry - Unit 2, MSIV Seismic Verification Summary Report", EQE Report No. 200918-R-001, Revision 0, August 1999.

4. "Browns Ferry - Unit 3, MSIV Seismic Verification Summary Report", EQE Report No. 200621-R-001, Revision 0, September 1998.

5. "Generic Implementation Procedure (GIP) for Seismic Verification of Nuclear Plant Equipment", Rev. 2A, March 1993, Prepared by Winston & Strawn, EQE, et al., for the Seismic Qualification Utility Group (SQUG).

6. AISC, "Manual of Steel Construction", Eighth Edition, 1980.

7. USAS B31.1 - Power Piping, 1967. Also, ANSI/ASME B31.1 – Power Piping, 1983.

8. TVA Calculation No. CD-N0001-980039, "Main Steam Seismic Ruggedness Verification".

9. TVA Calculation No. CD-N0001-980038, "Main Steam Seismic Ruggedness Evaluation".

4.0 SEISMIC EVALUATIONS

In general, the Browns Ferry ALT piping systems are typically designed to the requirements of USAS B31.1-1967 code (Reference 7), and consist of welded steel pipe and standard support components. Support spacing generally meets the B31.1 recommended span. The design bases for the portions of piping associated with the ALT pathway to the condensers are tabulated in Table 1. Table 2 presents a general summary of the piping data that constitute the seismic experience data. Figure 1 shows the comparison of the selected database site spectra with Browns Ferry DBE ground spectrum which indicates that the BFN DBE ground spectrum is generally bounded by those of the earthquake experience database sites at the frequencies of interest. Hence, the use of earthquake experience-based approaching for demonstrating the seismic ruggedness of non-seismically analyzed piping and related components at BFN, consistent with the BWROG's recommendations, is appropriate. Comparison of Browns Ferry and selected database piping parameters is presented in Table 3, along with Figure 2, which presents a comparison of D/t ratios of the BFN ALT drain piping with those found in the database. Overall, the BFN piping design is similar to and well represented by those found in the experience database sites that have shown to perform well in past earthquakes.

Browns Ferry FSAR does not reference Appendix A to 10 CFR Part 100. As such, bounding analysis for the selected portion of the ALT piping system is not required (Reference 2). The seismic adequacy of the ALT piping is addressed by performing seismic verification walkdowns to identify specific design attributes associated with poor seismic performance, following the guidelines as presented in the BWROG Report (Reference 1). The results of the walkdowns, including the resolution of the identified outliers, were presented in the respective MSIV Walkdown Summary Reports for Units 2 and 3 (References 3 and 4).

Furthermore, bounding evaluations are performed for typical support configurations as shown in pages 6 to 15 of this calculation. Table 4 summarizes the results of the support and anchorage evaluations.

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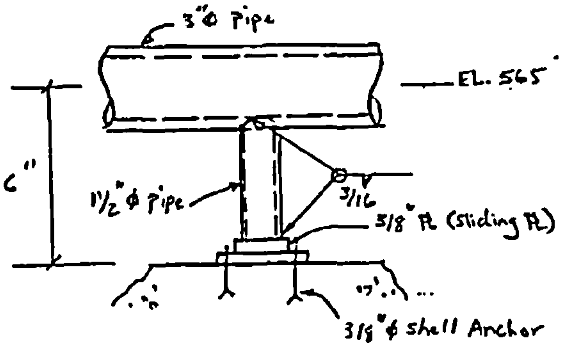
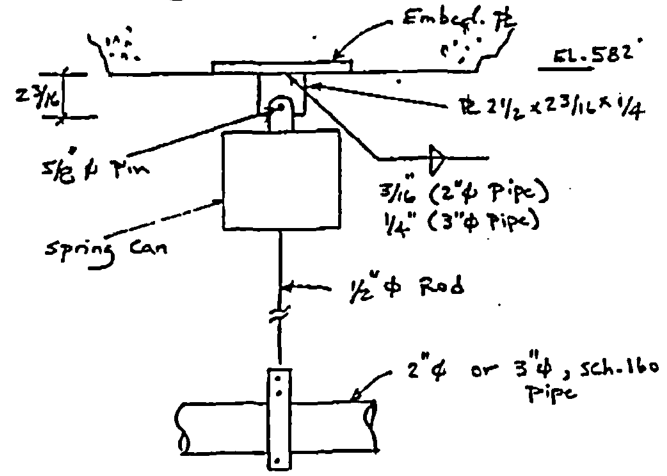
Support Assessment

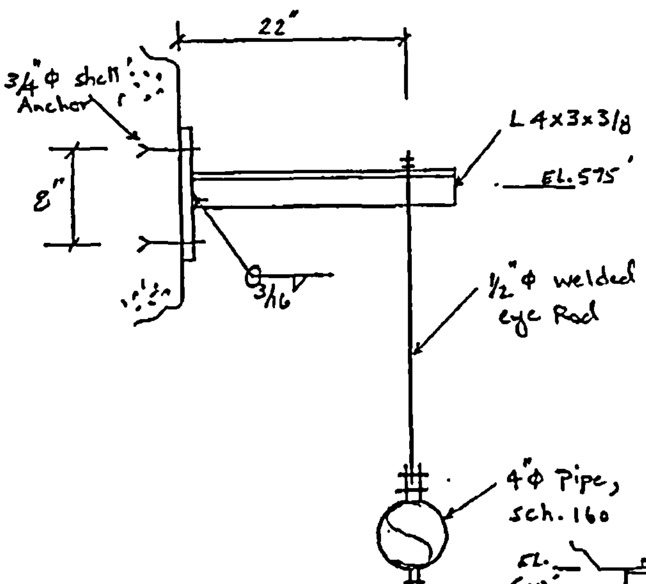
Typical support configurations on the Main Steam Drain piping are shown below. These also represent the bounding configurations w.r.t. dimensions shown and the member sizes.



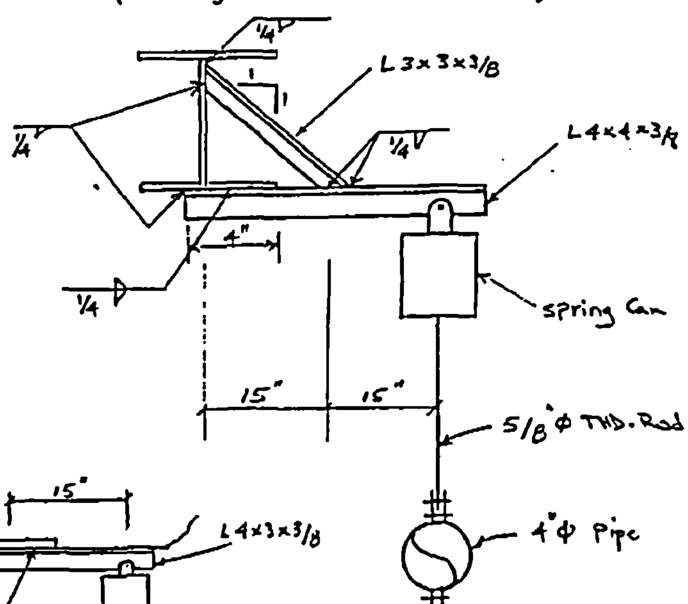
Type 1
(Ref. Hanger Mark No. MDH-12, 13, 18)



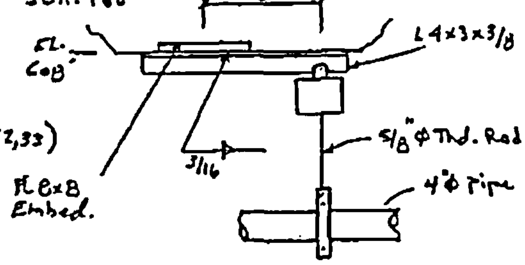
Type 2
(Ref. Hanger Mark No. MDH-15, 16, 17)



Type 3
(Ref. Hanger Mark No. MDH-19 to 25, 32, 33)



Type 4
(Ref. MDH-26 supplemented by walkdown notes)



Type 5 (Ref. MDH-31)

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Support Assessment (cont'd)

- For conservatism and bounding purposes, in order to calculate the lower bound margin of safety for each support type shown, consider that all piping are insulated by 2" thick Calcium silicate and the attachment point of the support is at EL-608 of the TB building. Also, all pipe sizes will be considered to be 3"φ & 4"φ. Note that the wt. of steam in these lines is negligible.

- Applicable vertical acceleration is based on the BFN DBE Spectra.

The Horizontal peak accel corresponding to 1.6x Housner Design Spectrum @ EL. 519' (or TB ground response spectrum) is: $a^{Peak}_{h_{ground}} = 0.5g$ (See fig.1, p.27)

Therefore the vertical peak accel. @ ground is calculated as: $a^{Peak}_{v_{ground}} = 0.5g \times \frac{2}{3} \times \frac{1.1}{1.6} = 0.23\,g$ (Refs. 8 + 9)

The above vertical accel. needs to be amplified for consideration of the support location within the building. Conservatively, use an amplification factor of 1.5 (very conservative for vertical direction)

$$a^{Peak}_{v} = 0.23\,g \times 1.5 = 0.35\,g$$

- other relevant inputs are:

$\omega_{4\phi}$ = weight of 4"φ pipe + 2" CaSi Insulation

$$= 22.51\ \text{lb/ft} + \left(\frac{\pi}{4}(8.5^2 - 4.5^2)\frac{1}{12^2}\right) 11\ \text{lb/ft}^3$$

$$= 25.6\ \text{lb/ft}$$

$$\omega_{3\phi} = 14.32\ \text{lb/ft} + \left(\frac{\pi}{4}(7.5^2 - 3.5^2)\frac{1}{12^2}\right) 11\ \text{lb/ft}^3$$

$$= 17\ \text{lb/ft}$$

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Support Assessment (cont'd)

- Per References 3 & 4 MSIV ALT piping spans correspond to ANSI B31.1 (Ref. 7)

$$\ell_{4''\phi} = 14'$$

$$\ell_{3''\phi} = 12'$$

- Therefore the DL + Seismic load to be considered for the support evaluations are:

$$P_{4''\phi} = (\omega_{4''\phi} \times \ell_{4''\phi})(1 + a_V^{Peak})$$

$$= (25.6 \times 14')(1 + 0.35g)$$

$$= 484^{\#}$$

$$P_{3''\phi} = (\omega_{3''\phi} \times \ell_{3''\phi})(1 + a_V^{Peak})$$

$$= (17 \times 12')(1 + 0.35g)$$

$$= 275^{\#}$$

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Support Assessment (cont'd)

Type 1

only the compression in the 1½" φ support pipe needs to be checked.

Area of 1½" φ sch. 40 pipe = 0.799 in^2

length of 1½" φ support pipe ≅ 6"

$\frac{Kl}{r} = \frac{2.0 \times 6"}{0.623} = 19.3 \Rightarrow F_a = 20.66$ ksi $\times 1.33 = 27.5$ ksi (Ref. 6)

$f_a = \frac{P_{3'0}}{A} = \frac{275}{.799} = 344$ psi

$\frac{f_a}{F_a} = \frac{.344}{27.5} = 0.01 \ll 1.0$ ok

Type 2

The critical components in the load path for this support are the weld @ the welding lug to embed plate, the 5/8" φ pin and the ½" φ threaded rod.

- weld

$l_w = 2 \times 2½" = 5"$

$F_W = 0.3 \times 60 \times 0.707 \times ¼" \times 1.33 = 4.23$ K/in (weld Material)
$= 0.4 \times 36 \times ¼ \times 1.33 = 4.79$ K/in (Base Material)

$f_w = \frac{275}{5"} = 55$ lb/in

$\frac{f_w}{F_w} = \frac{0.055}{4.23} = 0.01 \ll 1.0$ ok

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Support Assessment (cont'd)

- ½"φ A36 Threaded rod

Root Area = .126 in^2

$f_t = \frac{275^{\#}}{.126} = 2.2$ ksi

$F_t = 19.1 \times 1.33 = 25.4$ ksi
(t per Ref. 6)

$\frac{f_t}{F_t} = \frac{2.2}{25.4} = 0.09 \ll 1.0$ ok

- 5/8"φ pin

Area $= \frac{\pi}{4}(5/8)^2 = 0.31\ in^2$

$f_v = \frac{275}{.31} = .89$ ksi

$F_v = 10 \times 1.33 = 13.3$ ksi
(t Ref. 6)

$\frac{f_v}{F_v} = \frac{.89}{13.3} = 0.07 \ll 1.0$ ok

Type 3

- Check member bending

$M_{max} = 484^{\#} \times 22'' = 10648$ lb-in

$S_{min} = 0.866\ in^3$ (L4x3x3/8)

EQE INTERNATIONAL

SHEET NO. 11

JOB NO. 200918 JOB BFN MSIV BY 7Beji DATE 8-20-99

CALC. NO. C-001 SUBJECT Support Evaluations CHK'D JOD DATE 8/30/99

Support Assessment (cont'd)

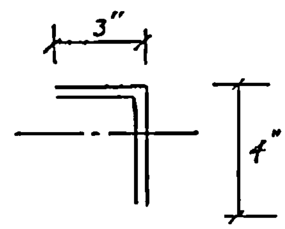
$f_b = \frac{M}{S} = \frac{10648}{.866} = 12.3$ ksi

$F_b = 0.6\ F_Y = 21.6$ ksi (Conservative, i.e., no 1.33 factor used)

$\frac{f_b}{F_b} = \frac{12.3}{21.6} = 0.57 < 1.0$ ok

- check weld @ member - baseplate

$S_{W_{min}} = \frac{4^2 (4\times3'' + 4'')}{6(2\times3'' + 4'')} \times 2 = 8.53\ \text{IN}^2$



$\ell_W = (4+3)2 = 14''$

$f_W = \left[\left(\frac{10648}{8.53}\right)^2 + \left(\frac{484^{\#}}{14''}\right)^2\right]^{1/2} = 1.25$ k/in

$F_{W_1} = 60 \times 0.3 \times 0.707 \times 3/16 \times 1.33 \doteq 3.17$ k/in governs (weld Mat.)

OR :

$F_{W_2} = 0.4 \times 36 \times 3/16 \times 1.33 = 3.6$ k/in (Base Mat.)

$\frac{f_W}{F_{W_1}} = \frac{1.25}{3.17} = 0.39 < 1.0$ ok

- Anchor bolt

T = tension per A.B. $= \frac{10648}{8''} = 1331^{\#}$

V = shear per A.B. $= \frac{484}{2} = 242^{\#}$

EQE INTERNATIONAL

SHEET NO. 12

JOB NO. 200918 JOB BFN MSIV BY TBeji DATE 8-20-99
CALC. NO. C-001 SUBJECT Support Evaluations CHK'D JOD DATE 8/30/99

Support Assessment (cont'd)

$T_{all} = 4.69^k \times \frac{3000}{4000} \times 0.6 = 2.11^k$

- 0.6: Reduction factor for unknown anchorage type, Ref. 5
- 3000/4000: Reduction for concrete strength (conservatively assumed $f'_c = 3000$ psi)
- 4.69: Allowable Tensile load for 3/4" ϕ Expansion anchor per Ref. 5, App. C

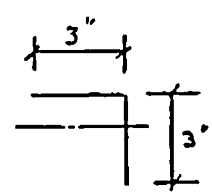
$V_{all} = 5.48^k \times \frac{3000}{4000} \times 0.6 = 2.47^k$

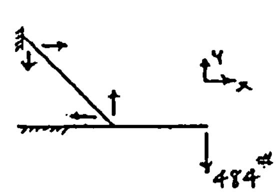
$\frac{T}{T_{all}} + \frac{V}{V_{all}} = \frac{1.331}{2.11} + \frac{.242}{2.47} = 0.73 < 1.0$ ok

- 1/2" ϕ Rod and 5/8" ϕ Pin not critical by comparison to calc. performed for type 2 support.

Type 4

Member bending stress ok by comparison to Type 3 (15" lever arm compared to 22" for type 3).
- check brace welded connection





$M = 484^{\#} \times 15'' = 7260^{\#''}$

$S_w = \frac{3^2(4\times3+3)}{6(2\times3+3)} = 2.5 \ in^2$

$l_w = 3+3 = 6''$

axial force in brace $= \frac{7260}{15''}\sqrt{2} = 684^{\#}$

Vertical component of the axial force in brace $= 684 \times \frac{1}{\sqrt{2}} = 484^{\#}$

Horizontal —— " —— " —— " —— $= 684 \times \frac{1}{\sqrt{2}} = 484^{\#}$

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SHEET NO. 13

JOB NO. 200918 JOB BFN MSIV BY 7Beigi DATE 8-30-99

CALC. NO. C-001 SUBJECT Support Evaluations CHK'D JOD DATE 8/30/99

Support Assessment (cont'd)

$f_{w_{1y}} = \frac{M}{S_w} = \frac{7260}{2.5} = 2.9 \text{ k/in}$

$f_{w_{2y}} = \frac{484}{6"} = .08 \text{ k/in}$

$f_{w_{3x}} = \frac{484}{6'} = .08 \text{ k/in}$

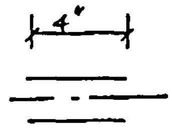
$f_w = ((2.9+.08)^2 + (.08)^2)^{1/2} = 2.98 \text{ k/in}$

$F_W = 4.23 \text{ k/in}$ (See Type 2 support Calc.)

$\frac{f_w}{F_W} = \frac{2.98}{4.23} = 0.70 < 1.0$ ok

- check weld @ L4x4 to the flange of the I-beam

$l_w = 2 \times 4" = 8"$



$f_{w_1} = \frac{484}{8"} = 60.5 \text{ lb/in}$

$f_{w_2} = \frac{484}{8"} = 60.5 \text{ lb/in}$

$f_w = (.061^2 + .061^2)^{1/2} = .09 \text{ k/in} \ll F_w$ ok

- 5/8"ϕ Rod and 5/8"ϕ pin are not critical by comparison to calc. performed for Type 2 support.

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SHEET NO. 14

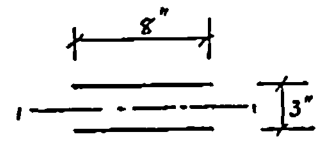
JOB NO. 200918 JOB DFN MSIV BY 7Beigi DATE 8-20-99
CALC. NO. C-001 SUBJECT Support Evaluations CHK'D JBD DATE 8/30/99

Support Assessment (cont'd)

Type 5

- Check weld @ L4x3 to embed pl.

$M = 484^{\#} \times 15'' = 7260^{\#''}$



$S_{W_{1-1}} = 3'' \times 8'' = 24 \ in^2$

$l_W = 2 \times 8'' = 16''$

$f_{W_1} = \frac{M}{S_{W_{1-1}}} = \frac{7260}{24} = .3 \ K/IN$

$f_{W_2} = \frac{484}{16} = .03 \ K/IN$

$f_W = f_{W_1} + f_{W_2} = .3 + .03 = .33 \ K/IN$

$F_W = 3.17 \ K/IN$ (see Type 3 support Calc.)

$\frac{f_W}{F_W} = \frac{.33}{3.17} = 0.1 \ll 1.0$ ok

- Member bending stress is ok by comparison to Type 3 support member bending calculation (15" lever arm for type 5 vs. 22" for Type 3)

- 5/8"ϕ Rod and pin are not critical by comparison to calc. performed for Type 2 support.

EQE INTERNATIONAL

SHEET NO. 15

JOB NO. 200918 JOB BFN MSIV BY 7/3eiji DATE 8-20-99

CALC. NO. C-001 SUBJECT Support Evaluations CHK'D JOB DATE 8/30/99

Support Assessment (cont'd)

The following Table summarizes the maximum D/c ratios (Demand/capacity) for the typical supports on the MSIV drain piping.

Support Type	critical stress component	D/c
Type 1	Axial compression in support member	.01
Type 2	Tension in A36 Threaded rod	.09
Type 3	Anchor bolts	0.73
Type 4	Weld stress	0.70
Type 5	Weld stress	0.10

EQE INTERNATIONAL

JOB NO. 200918
CALC. NO. C-001
JOB BFN MSIV TECH SPEC CHANGE
SUBJECT SEISMIC VERIFICATION OF THE MSIV ALT PIPING AND SUPPORTS
BY [illegible] DATE 8-23-99
CHK [illegible] DATE 8/30/99
SHEET NO. 16

Table 1

Design Basis for Browns Ferry ALT Related Piping and Supports

Piping Description	Design Temp. (°F)	Design Press. (psig)	Pipe Size (NPS)	Pipe Sch.	D / t	Piping Material	Typical Support Types	Piping Design Basis
MS Lines from outboard MSIV's to MS Header and to Turbine Stop Valves	562	1146	24 1	80 160	20 5	ASTM A-106 Grade B	Spring hangers Vertical struts	USAS B31.1-1967
Main Steam Header	562	1146	24	80	20	ASTM A-155 Grade KC-70	Spring hangers	USAS B31.1-1967
MS Stop Valve Above Seat Leak-off	562	1146	1	160	5	ASTM A-106 Grade B	Rod hangers	USAS B31.1-1967
Turbine Bypass Valve Header	562	1146	18	80	19	ASTM A-106 Grade B	Rigid supports Rod and Spring hangers	USAS B31.1-1967
MS Steam Supply to RFP Turbine Stop Valves	562	1146	6 4	80 80	15 13	ASTM A-106 Grade B	Rod and Spring hangers Stanchion supports	USAS B31.1-1967
MS Steam Supply from MS Header to SJAE's to the Condenser	562	1146	3 2 1-1/2 1	160 160 160 160	8 7 7 5	ASTM A-106 Grade B	Rod and Spring hangers	USAS B31.1-1967

Table 1 (cont.)

Design Basis for Browns Ferry ALT Related Piping and Supports

Piping Description	Design Temp. (°F)	Design Press. (psig)	Pipe Size (NPS)	Pipe Sch.	D/t	Piping Material	Typical Support Types	Piping Design Basis
MS Steam Supply to Steam Seal Regulators	562	1146	4	80	13	ASTM A-106 Grade B	Rod hangers	USAS B31.1-1967
MS Steam Supply from MS Header to the Off-Gas Preheaters A & B	562	1146	2	160	7	ASTM A-106 Grade B	Rod hangers	USAS B31.1-1967
			2	160	7	ASTM A-335 Grade P11	New piping associated with the proposed installation of new boundary valves to Preheaters A & B	
MS Outboard Drains from MS Lines to the Main Drain Line	562	1146	3 2 1	160 160 160	8 7 5	ASTM A-106 Grade B	Stanchion supports	USAS B31.1-1967
			3 2	160 160	8 7	ASTM A-333 Grade 1		
Main Drain Line to the Condenser	562 / 450	1146 / 400	4 3 1	80 160 160	13 8 5	ASTM A-106 Grade B	Rod and Spring hangers Stanchion supports	USAS B31.1-1967

Table 1 (cont.)

Design Basis for Browns Ferry ALT Related Piping and Supports

Piping Description	Design Temp. (°F)	Design Press. (psig)	Pipe Size (NPS)	Pipe Sch.	D / t	Piping Material	Typical Support Types	Piping Design Basis
HPCI Drain to MS Drain; RCIC Drain to HPCI Drain; Aux. Boiler Drains to HPCI/RCIC/ Reactor Building Drain Line	450	400	2 1	160 160	7 5	ASTM A-106 Grade B	Rigid supports	USAS B31.1- 1967
	270	415	1	160	5			
Misc. PT Instrument Lines Sample Lines to Sample Station	562	1146	1	160	5	ASTM A-106 Grade B	Rigid supports	USAS B31.1- 1967
			¼" tubing	.049" (wall t)	--	ASTM A-213 SS Gr. TP-304	Rigid supports (tube clamps)	--

Table 2

Seismic Experience Database Piping Data

Facility	Pipe Size (NPS)	Pipe O.D. (inch)	Schedule	Wall Thickness (inch)	D/t
Valley Steam Plant Units 1 & 2	24	24.0	20	0.375	64
	20	20.0	20	0.375	53
	18	18.0	30	0.437	41
	16	16.0	30	0.375	43
	14	14.0	30	0.375	37
	12	12.75	40	0.406	31
	12	12.75	30	0.330	39
	10	10.75	160	1.125	10
	8	8.625	160	0.906	10
	6	6.625	40	0.280	24
	4	4.50	160	0.531	8
	4	4.50	40	0.237	19
	3	3.50	160	0.437	8
	3	3.50	80	0.300	12
	3	3.50	40	0.216	16
	2	2.375	160	0.343	7
	2	2.375	40	0.154	15
	1½	1.90	160	0.281	7
	1½	1.90	40	0.145	13
	1	1.315	40	0.133	10
	¾	1.05	160	0.218	5
	¾	1.05	40	0.113	9

Table 2 (cont.)

Seismic Experience Database Piping Data

Facility	Pipe Size (NPS)	Pipe O.D. (inch)	Schedule	Wall Thickness (inch)	D/t
El Centro Steam Plant	20	20.0	STD	0.375	53
	18	18.0	160	1.781	10
	18	18.0	XS	0.500	36
	18	18.0	STD	0.375	48
	14	14.0	40	0.437	32
	14	14.0	STD	0.375	37
	12	12.75	160	1.312	10
	12	12.75	STD	0.375	34
	10	10.75	40	0.365	29
	8	8.625	160	0.906	10
	8	8.625	120	0.718	12
	8	8.625	40	0.322	27
	6	6.625	120	0.562	12
	6	6.625	40	0.280	24
	4	4.50	80	0.337	13
	4	4.50	40	0.237	19
	3	3.50	160	0.437	8
	3	3.50	80	0.300	12
	3	3.50	40	0.216	16
	2	2.375	160	0.343	7
	2	2.375	80	0.218	11
	2	2.375	40	0.154	15
	1½	1.90	160	0.281	7
	1½	1.90	80	0.200	10
	1½	1.90	40	0.145	13
	1	1.315	80	0.179	7
	1	1.315	40	0.133	10
	¾	1.05	80	0.154	7
	¾	1.05	40	0.113	9

Table 2 (cont.)

Seismic Experience Database Piping Data

Facility	Pipe Size (NPS)	Pipe O.D. (inch)	Schedule	Wall Thickness (inch)	D/t
Moss Landing Units 1, 2 & 3	16	16.0	--	1.394	11
	12	12.75	--	1.148	11
	8	8.625	160	0.906	10
	8	8.625	30	0.277	31
	6	6.625	160	0.562	12
	6	6.625	40	0.280	24
	4	4.50	160	0.531	8
	4	4.50	80	0.337	13
	4	4.50	40	0.237	19
	3	3.50	160	0.437	8
	3	3.50	80	0.300	12
	3	3.50	40	0.216	16
	2	2.375	160	0.343	7
	2	2.375	80	0.218	11
	2	2.375	40	0.154	15
	1½	1.90	160	0.281	7
	1½	1.90	80	0.200	10
	1	1.315	160	0.250	5
	1	1.315	80	0.179	7
	¾	1.05	160	0.218	5
	¾	1.05	80	0.154	7

EQE INTERNATIONAL						SHEET NO. 22
JOB NO.	200918	JOB	BFN MSIV TECH SPEC CHANGE	BY	7Rei	DATE 8-23-99
CALC. NO.	C-001	SUBJECT	SEISMIC VERIFICATION OF THE MSIV ALT PIPING AND SUPPORTS	CHK	JDD	DATE 8/30/99

Table 2 (cont.)

Seismic Experience Database Piping Data

Facility	Pipe Size (NPS)	Pipe O.D. (inch)	Schedule	Wall Thickness (inch)	D/t
Moss Landing Units 4 & 5	24	24.0	40	0.687	35
	24	24.0	--	1.066	23
	--	18.8	--	2.287	8
	16	16.0	40	0.500	32
	16	16.0	--	0.902	18
	--	13.2	--	1.668	8
	8	8.625	160	0.906	10
	8	8.625	40	0.322	27
	6	6.625	160	0.562	12
	6	6.625	40	0.280	24
	4	4.50	160	0.531	8
	4	4.50	80	0.337	13
	4	4.50	40	0.237	19
	3	3.50	160	0.437	8
	3	3.50	80	0.300	12
	3	3.50	40	0.216	16
	2	2.375	160	0.343	7
	2	2.375	80	0.218	11
	2	2.375	40	0.154	15
	1½	1.90	160	0.281	7
	1½	1.90	80	0.200	10
	1½	1.90	40	0.145	13
	1	1.315	160	0.250	5
	1	1.315	80	0.179	7
	1	1.315	40	0.133	10
	¾	1.05	160	0.218	5
	¾	1.05	80	0.154	7
	¾	1.05	40	0.113	9

EQE INTERNATIONAL

SHEET NO. 23

JOB NO.	200918	JOB	BFN MSIV TECH SPEC CHANGE	BY	7Beigi	DATE	8-23-99
CALC. NO.	C-001	SUBJECT	SEISMIC VERIFICATION OF THE MSIV ALT PIPING AND SUPPORTS	CHK	JOD	DATE	8/30/99

Table 2 (cont.)

Seismic Experience Database Piping Data

Facility	Pipe Size (NPS)	Pipe O.D. (inch)	Schedule	Wall Thickness (inch)	D/t
Moss Landing Units 6 & 7	30	30.0	--	0.632	47
	26	26.0	--	1.128	23
	18	18.0	--	3.444	5
	12	12.75	--	2.444	5
	12	12.75	--	0.601	21
	8	8.625	--	1.650	5
	8	8.625	40	0.322	27
	6	6.625	--	1.268	5
	6	6.625	40	0.280	24
	4	4.50	--	0.861	5
	4	4.50	80	0.337	13
	4	4.50	40	0.237	19
	3	3.50	80	0.300	12
	3	3.50	40	0.216	16
	2½	2.875	--	0.550	5
	2½	2.875	80	0.276	10
	2½	2.875	40	0.178	16
	2	2.375	--	0.519	5
	2	2.375	80	0.218	11
	2	2.375	40	0.154	15
	1½	1.90	--	0.428	4
	1½	1.90	80	0.200	10
	1½	1.90	40	0.145	13
	1	1.315	--	0.301	4
	1	1.315	80	0.179	7
	1	1.315	40	0.133	10
	¾	1.05	160	0.218	5
	¾	1.05	80	0.154	7
	¾	1.05	40	0.113	9
	½	1.05	--	0.210	4
	¼	0.54	--	0.153	4

Table 2 (cont.)

Seismic Experience Database Piping Data

Facility	Pipe Size (NPS)	Pipe O.D. (inch)	Schedule	Wall Thickness (inch)	D/t
Ormond Beach Units 1 & 2	30	30.0	-	1.298	23
	30	30.0	-	0.719	42
	21	21.0		3.793	6
Humboldt Bay Unit 3	12	12.75	80	0.687	19
	10	10.75	80	0.593	18
	6	6.625	80	0.432	15

EQE INTERNATIONAL

JOB NO.	200918	JOB	BFN MSIV TECH SPEC CHANGE	BY	7Bei	DATE	8-27-99
CALC. NO.	C-001	SUBJECT	SEISMIC VERIFICATION OF THE MSIV ALT PIPING AND SUPPORTS	CHK	JoD	DATE	8/30/99

SHEET NO. 25

Table 3

Comparison of Browns Ferry and Selected Database Piping Parameters

Piping Parameter	Browns Ferry	Database Sites
Pipe Diameter (inch)	1.315 – 24.0	1.05 – 30.0
Wall Thickness (inch)	0.25 – 1.218	0.113 – 3.793
Diameter-to-Thickness Ratio (D/t)	5 - 20	4 – 64

EQE INTERNATIONAL

SHEET NO. 26

JOB NO.	200918	JOB	BFN MSIV TECH SPEC CHANGE	BY	FBeig	DATE	8-23-99
CALC. NO.	C-001	SUBJECT	SEISMIC VERIFICATION OF THE MSIV ALT PIPING AND SUPPORTS	CHK	JOD	DATE	8/30/99

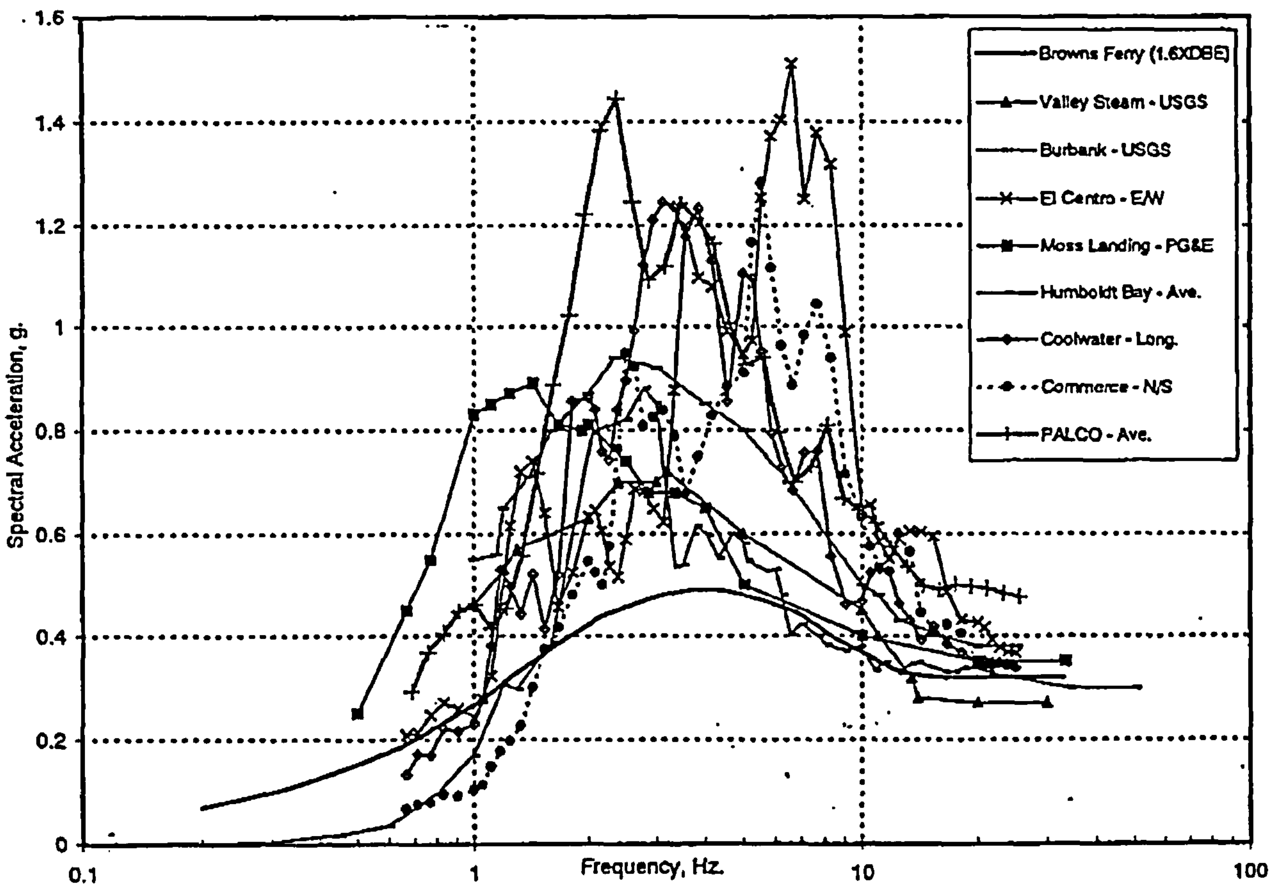
Table 4

Bounding Evaluations of Typical Support Configurations

Support Type	Critical Component	Stress Ratio
Cantilever bracket	Anchor bolts	.73
Rod hanger	Overhead weld attachment	.70

						SHEET NO.	27
JOB NO.	200918	JOB	BFN MSIV TECH SPEC CHANGE	BY	7Baj	DATE	8-23-99
CALC. NO.	C-001	SUBJECT	SEISMIC VERIFICATION OF THE MSIV ALT PIPING AND SUPPORTS	CHK	JD	DATE	8/30/99

Figure 1
Comparison of Database Site Spectra to Browns Ferry DBE Ground Spectra



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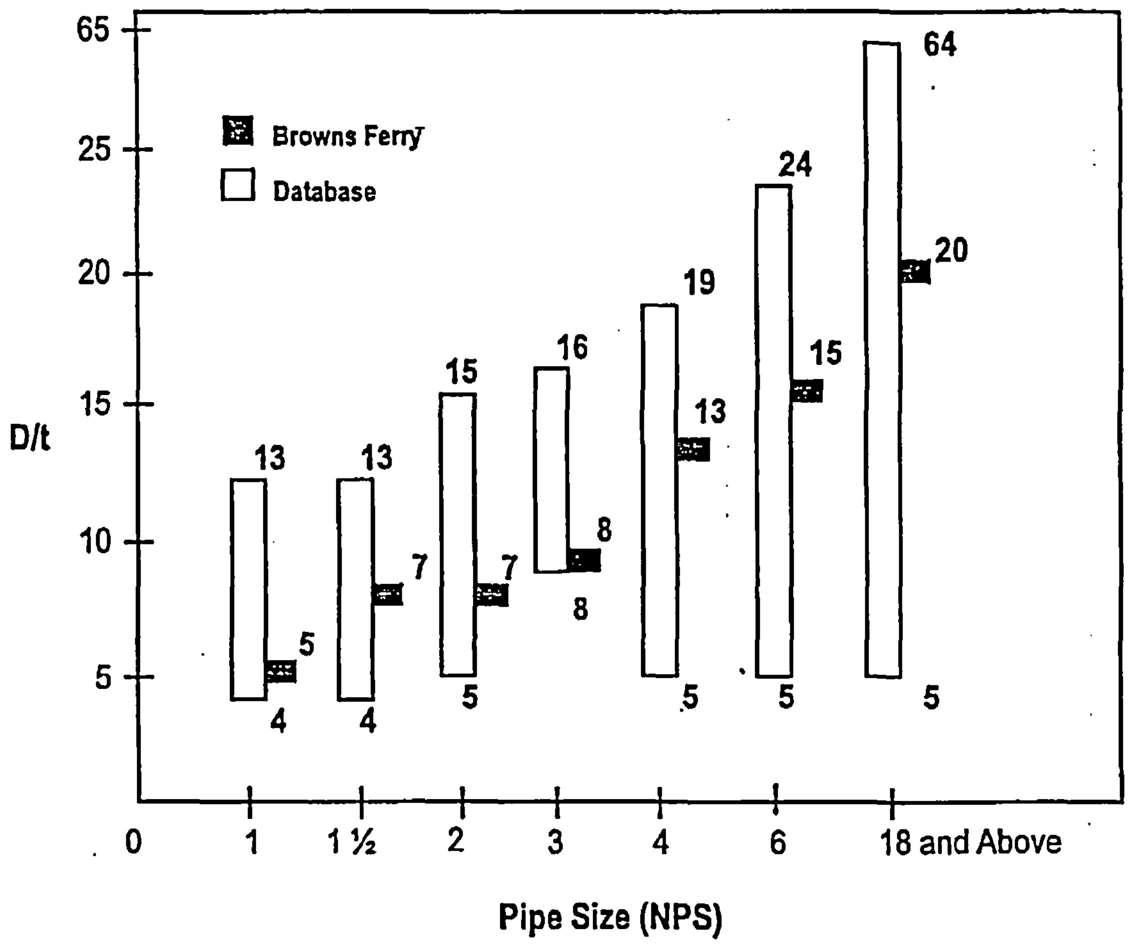
Attachment C

					SHEET NO.	28
JOB NO.	203916	JOB	BFN MSIV TECH SPEC CHANGE	BY	DATE	8-23-99
CALC. NO.	C-001	SUBJECT	SEISMIC VERIFICATION OF THE MSIV ALT PIPING AND SUPPORTS	CHK	DATE	8/30/99

Figure 2
Comparison of Browns Ferry and Selected Database Piping D/t Ratios



5.0 CONCLUSIONS

Based on the results of the seismic verification walkdowns and bounding support evaluations, and upon the resolution of the identified walkdown outliers, it is reasonable to assume that the ALT piping, related supports and components have adequate seismic capacity in the event of a Design Basis Earthquake (DBE) at Browns Ferry.

ENCLOSURE 9

BROWNS FERRY NUCLEAR PLANT (BFN) UNIT 1
TECHNICAL SPECIFICATION CHANGE (TS 436) -
INCREASED MAIN STEAM ISOLATION VALVE (MSIV)
LEAKAGE RATE LIMITS

SUMMARY OF COMMITMENTS

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1. Prior to Unit 1 restart, plant operating procedures will be revised to provide procedural requirements for the establishment of the Alternate Leakage Treatment path to the condenser.

2. The Unit 1 outliers will be resolved prior to Unit 1 restart. This includes qualification of 1-PCV-1-147 and the addition of in-line check valves (1-CKV-1-742 and 1-CKV-1-744) for the Offgas Preheaters.