ENCLOSURE 2

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

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

TVA CALCULATION NO. CD-Q0000-940339,

"CALCULATION OF BASIC PARAMETERS FOR A46 AND INDIVIDUAL PLANT EXAMINATION OF EXTERNAL EVENTS (IPEEE) SEISMIC PROGRAM,"

REV. 1, JUNE 14, 1996

(SEE ATTACHED)

QA Record

DNE CALCULATIONS

TITLE: **CALCULATION OF BASIC PARAMETERS FOR A46 AND INDIVIDUAL PLANT EXAMINATION OF EXTERNAL EVENTS (IPEEE) SEISMIC PROGRAM**	PLANT/UNIT **BFN Unit 0**

PREPARING ORGANIZATION **TVA-CIVIL**	KEY NOUNS (Consult RIMS DESCRIPTORS LIST) **A46, IPEEE, SEISMIC, EQUIPMENT**		
BRANCH/PROJECT IDENTIFIERS	Each time these calculations are issued, preparers must ensure that the original (R0) RIMS accession number is filled in.		
	Rev	(for RIMS' use)	RIMS accession number
CD-Q0000-940339	R0		R14 '95 1016 115
APPLICABLE DESIGN DOCUMENTS	R1	(61)	R14 960617 101
BFN-50-C-7102	R2		
SAR SECTION(S) N.A / UNID SYSTEM(S) 000	R3		

Revision 0	R1	R2	R3	Safety-related? Yes ☒ No ☐
DCN No. (or indicate N/A) **N/A**	N/A			Statement of Problem
Prepared **PARTHA S. GHOSAL** P. S. Ghosal	P.S. Ghosal			**This calculation addresses the basis for certain parameters used for A46 and IPEEE study for safe shutdown equipments. Calculations are based on guidelines given in GIP and IPEEE documents.**
Checked J. O. Dizon	J.W. BEASON J W Beason			
Reviewed J. O. Dizon	J.W. BEASON J W Beason			
Approved ~~JOHN R. GLASS~~ J Glass	J. Valente			
Date 10-16-95	14 Jun 96			
List all pages added by this rev	SEE			
List all pages deleted by this rev	REV			
List all pages changed by this rev	LOG			
Calculation Revision: (A)Entire Calculation (B)Selected Pages	A			ORIGINAL

Abstract

These calculations contain unverified assumptions that must be verified later. Yes ☐ No ☒

Revision 0:
This calculation documents the basis of certain parameters (e.g. "Effective Grade", Seismic Capacity and Demand) used for A46 and IPEEE study for seismic qualification of safe shutdown equipments for BFNP.
Total number of pages = 60

REV. 1: ABSTRACT REMAINS UNCHANGED
TOTAL NO OF PAGES: 61

ENGINEERING RECORDS PROCESSING
CALCULATION CONTROL
EDB ANNEX C BFN

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Title: CALCULATION OF BASIC PARAMETERS FOR A46 AND INDIVIDUAL PLANT EXAMINATION OF EXTERNAL EVENTS (IPEEE) SEISMIC PROGRAM	REVISION LOG CD-Q0000-940339

Revision No.	DESCRIPTION OF REVISION	Date Approved
0	Original issue	10-16-95
1	Calculation revised to incorporate new information. Pages added by this revision: 3.1 Pages changed by this revision: 1, 2, 9, 49 Pages deleted by this revision: none	

CALCULATION DESIGN VERIFICATION (INDEPENDENT REVIEW) FORM

CD-Q0000-940339
Calculation No.

0
Revision

Method of design verification (independent review) used (check method used):

1. Design Review X
2. Alternate Calculation ______
3. Qualification Test ______

Comments:

Calculation CD-Q0000-940339 Rev.0 has been independently reviewed and design verified and is found technically adequate in context and analytical methodology based on accepted engineering practices.

J.O. Dizon
Design Verifier
(Independent Reviewer)

10/15/95
Date

CALCULATION DESIGN VERIFICATION (INDEPENDENT REVIEW) FORM

Calculation CD-Q0000-940339 R1

Method of design verification (independent review) used (check method used):

- ■ Design Review
- ☐ Alternate Calculation
- ☐ Qualification Test

Justification (explain below):

Method 1: In the design review method, justify the technical adequacy of the calculation and explain how the adequacy was verified (calculation is similar to another, based on accepted handbook methods, appropriate sensitivity studies included for confidence, etc.).

Method 2: In the alternate calculation method, identify the pages where the alternate calculation has been included in the calculation package and explain why this method is adequate.

Method 3: In the qualification test method, identify the QA documented source(s) where testing adequately demonstrates the adequacy of this calculation and explain.

The above calculation revision so noted has been reviewed by the Design Review Methodology and has been determined to be technically adequate based on the design input information contained herein using accepted handbook and/or computer applications and sound engineering practices and techniques.

Jerry W. Brown (signature) — Design Verifier (Independent Reviewer)

5-31-96 — Date

This sheet added by Revision 1

TABLE OF CONTENTS

1.0 PURPOSE

To calculate basic parameters, which are used in relation to evaluate seismic capacity and seismic demand for qualification of safe shutdown equipments by A46 and IPEEE methodology.

Parameters which have been calculated are:

a) Effective Grade of different structures of BFNP

b) Comparing Equipment Seismic Capacity to Seismic Demand and locate exceedence for A46.

c) Seismic Margin Earthquake (SME) and scale factors to determine higher IPEEE demand.

2.0 ASSUMPTION

There is no unverified assumption in this calculation. All relevant assumptions are documented in the body of the calculation.

3.0 REFERENCES

3.1) Generic Implementation Procedure (GIP) For Seismic Verification Of Nuclear Plant Equipment Revision 2.

3.2) A Methodology For Assessment Of Nuclear Power Plant Seismic Margin (Revision 1) - EPRI NP-6041-SL.

3.3) Browns Ferry Nuclear Plant Master Response Spectra (MARS) Report For Seismic Class I Structures CEB 88-05-C R1.

3.4) Browns Ferry Nuclear Plant Final Safety Analysis Report (FSAR) Amendment 11.

3.5) Regulatory Guide 1.60 "Design Response Spectra for Seismic Design of Nuclear Power Plants".

3.6) NUREG/CR-0098 "Development of Criteria for Seismic Review of Selected Nuclear Power Plants".

3.7) Drawings: 10N253, 10N254, 0-41E572, 0-41E576, 41N590-1, 41N703, 41N1001

3.8) TVA Nuclear Engineering Civil Design Standard DS-C1.7.1 R7 "General Anchorage to Concrete".

3.9) BFNP Design Criteria BFN-50-C-7100 R9 "Design of Civil Structures".

4.0 DESIGN INPUT DATA

- Seismic Response Spectra and GERS values are based on reference 3.1 to 3.4.
- Reactor Building foundation is on rock (Reference 3.9).
- Diesel Generator Building (unit 1,2 & 3) foundation is on 3+ feet of compacted earth backfill and underlying this earth backfill is approximately 32 feet of crushed stone backfill (Reference 3.9).
- Standby Gas Treatment Building is buried under earth and founded on 10+ feet of compacted earth backfill (Reference 3.9).
- Intake Pumping Station structure is founded on bedrock.
- Concrete Compressive Strengths (f'_c) of different class I structures are as follows (Reference 3.9):

Reactor Building -

Inside wall El. 536.92 to El. 557.5	4000 psi
Beams and Slabs at El. 639 & 664	4000 psi
Columns	4000 psi
Reactor Support Pedestal and Shield wall	4000 psi
P - Line wall at steam line compartment	4000 psi

Chimney Shell (excluding foundation & internal structure)------------4300 psi

All Other Structures ---3000 psi

- Concrete Strength gain for anchorage evaluation (Reference 3.8):
  As per Appendix D of Reference 3.8,

  1) The maximum estimated concrete strength gain for evaluation of SSD/SDI shall be limited to 600 lb/in2.

  2) The maximum estimated concrete strength gain for evaluation of Wedge Bolt, Ductile and Undercut Anchors shall be limited to 1900 lb/in2 and evaluated in accordance with Section D.4 of Reference 3.8.

5.0 DOCUMENTATION OF INPUT DATA

All input data used has been properly referenced in this calculation.

6.0 COMPUTATIONS

6.1 EFFECTIVE GRADE DETERMINATION

As per Reference 3.1, "Effective Grade" at a nuclear plant is defined as the average elevation of the ground surrounding the building along its perimeter. If the plant is founded on rock or a very stiff soil site without controlled, compacted backfill, then the "effective grade" is the elevation where the structure receives significant lateral support from the surrounding soil or rock (e.g., the top of the base mat). Similarly, "effective grade" should be taken at the foundation level if crushable foam insulation or other measures are used to isolate the structure from the lateral support of the surrounding soil or rock. If an internal structure of the building is supported primarily at the base mat without significant lateral support from the surrounding structure, then the "effective grade" is the elevation at the top of the base mat.

Based on the above definition, a sketch (see next page) has been prepared showing elevations of building at top of base mat or at foundation level and elevations of significant lateral support (i.e. top of compacted earth fill on the perimeter of the buildings). Effective Grade calculated is based on those elevations.

i) Reactor Building Unit 1

Effective Grade ≈ [(0.17 x 595 + 0.66 x 565.5 + 0.17 x 546) + (0.16 x 546 + 0.84 x 565) + (519) + (595)] / 4 = 560.8 ft

ii) Reactor Building Unit 2

Effective Grade ≈ [(519) + (565) + (519) + (595)] / 4 = 549.5 ft

iii) Reactor Building Unit 3

Effective Grade ≈ [(519) + (565) + (0.17 x 584 + 0.66 x 565.5 + 0.17 x 584) + (595)] / 4 = 562.7 ft

iv) Diesel Generator Building Unit 1 & 2

Effective Grade ≈ [(565.5) + (565.5) + (565.5) + (595)] / 4 = 572.88 ft

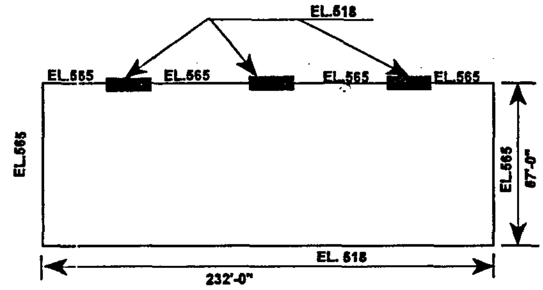
v) Diesel Generator Building Unit 3

Effective Grade ≈ [(565.5) + (584) + (565.5) + (584)] / 4 = 574.75 ft

PAGE REPLACED BY REV. 1

vi) **Intake Pumping Station**

Effective Grade ≈[(67 x 2 x 565) + (232 x 518) + (48 x 518) + (184 x 565)] / 2(67 +232) **R1**
= 541 ft



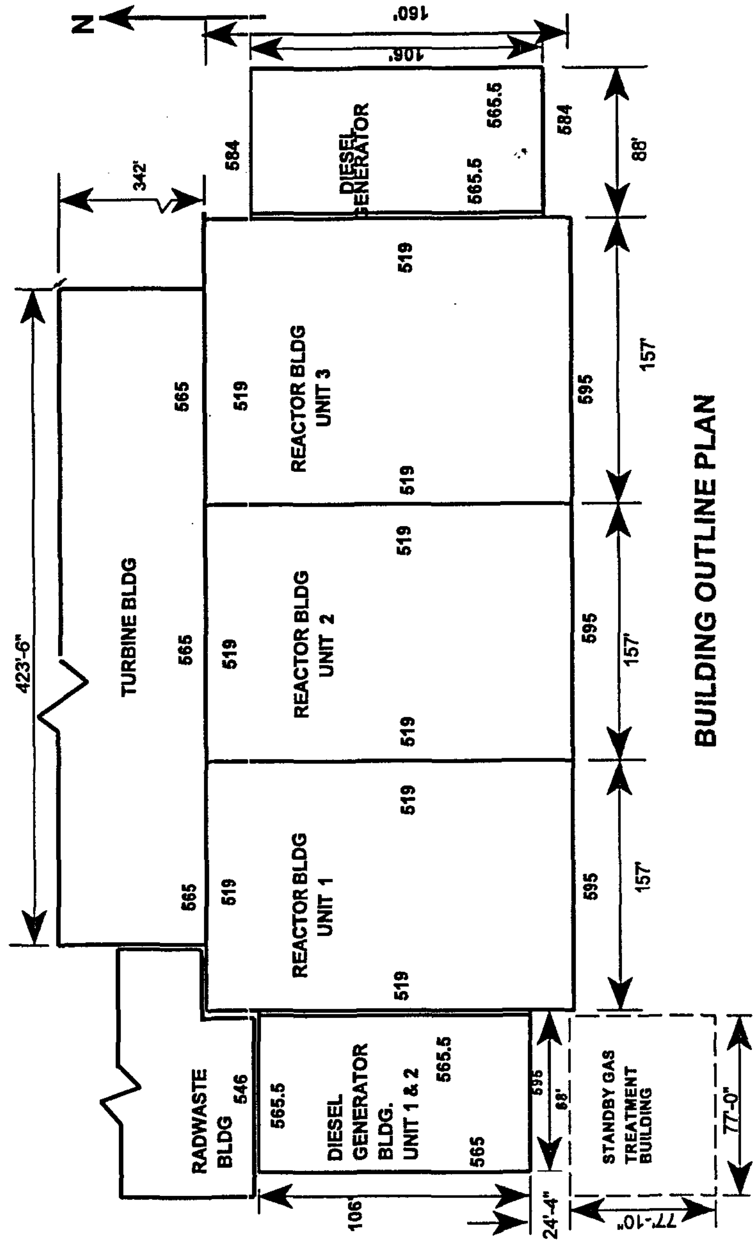
OUTLINE OF INTAKE PUMPING STRUCTURE

vii) **Drywell (all units)**

Effective Grade ≈ Top of mat foundation is 549.93 ≈ 550 ft

SUMMARY OF EFFECTIVE GRADE	
BUILDING	**Effective Grade (ft)**
REACTOR - UNIT 1	561
REACTOR - UNIT 2	550
REACTOR - UNIT 3	563
D. G. BLDG UNIT 1&2	573
D. G. BLDG UNIT 3	575
INTAKE PUMP STN	541
DRYWELL (3 UNITS)	550

CALCULATION OF BASIC PARAMETERS FOR A46 AND INDIVIDUAL PLANT EXAMINATION OF EXTERNAL EVENTS (IPEEE) SEISMIC PROGRAM



Refer Drawings: 0-41E572, 0-41E576, 41N590-1, 41N703 and 41N1001 for dimensions and elevations.

6.2 COMPARING EQUIPMENT SEISMIC CAPACITY TO SEISMIC DEMAND

Seismic adequacy of an item of mechanical or electrical equipment can be verified by demonstrating that the seismic capacity of the equipment is greater than or equal to seismic demand imposed on it. The seismic capacity of equipment can be represented by a "Bounding Spectrum" based on earthquake experience data, or a "Generic Equipment Ruggedness Spectrum" (GERS) based on generic seismic test data. These two methods of representing seismic capacity of equipment can only be used if the equipment meets the intent of the caveats for its equipment class.

The seismic capacity of an item of equipment can be compared to a seismic demand which is defined in terms of either a ground response spectrum or an in-structure response spectrum.

There are two methods (Method A and B) for comparing capacity versus demand. Method A is for making a comparison with a SSE Ground Response Spectra. Method A can be used i) when equipment is mounted below about 40 feet above the effective grade which has already been determined and ii) Equipment has natural frequency greater than about 8 HZ. Method B is for comparison with an in-structure response spectrum. Method B can be used for equipment which is mounted at any elevation of plant and/or for equipment with any natural frequency.

To verify seismic adequacy, in general, the seismic capacity spectrum should envelop the seismic demand spectrum at all frequencies with two special exceptions:

- The seismic capacity spectrum needs only to envelop the seismic demand spectrum for frequencies at and above the conservatively estimated lowest natural frequency of the item of equipment being evaluated.

- Narrow peaks in the seismic demand response spectrum may exceed the seismic capacity response spectrum if the average ratio of the demand spectrum to the capacity spectrum does not exceed unity when computed over a frequency range of 10% of the peak frequency (e.g., 0.8 HZ range at 8 HZ).

So for comparison purposes the following methods are to be followed for BFN A46 evaluations:

Method A:

ITEM / FIGURE NO.	CAPACITY	DEMAND
A.1	Bounding Spectrum ≥	SSE Ground Response Spectrum
A.2 & A.2A	GERS ≥	1.5 X 1.5 X SSE Ground Response Spectrum

Method B:

ITEM / FIGURE NO.	CAPACITY	DEMAND
B.1 & B.1.1	1.5 X Bounding Spectrum ≥	In-Structure SSE Response Spectrum
B.3, B.3.1, B.3A & B.3A.1 (For Median Centered)	GERS ≥	1.5 X In-Structure SSE Response Spectrum

From the data given in GIP (Reference 3.1) Capacity based on Bounding Spectrum and GERS has been plotted against the Browns Ferry SSE Ground Response Spectrum (Figure 2.5 Reference 3.4) and In-Structure Response Spectrum (Reference 3.3) in Figures A.1, A.2, A.2A, B.1, B1.1, B.3, B.3.1, B.3A & B.3A.1. All plots have been made for 5% damping and envelope of North-South and East-West data.

Following observations are made from plots of Figures for capacity versus demand:

Figure A.1: Bounding Spectrum always envelops SSE Ground Response Spectrum. So capacity is greater than demand for equipment located within about 40' from effective grade and has fundamental frequency above about 8hz.

Figure A.2: GERS for given mechanical equipment envelops 1.5 X 1.5 X SSE Ground Response Spectrum. So capacity for given equipment are greater than demand provided caveats are met.

Figure A.2A: GERS for given electrical equipment envelops 1.5 X 1.5 X SSE Ground Response Spectrum. So capacity for given equipment are greater than demand provided caveats are met.

Figure B.1: This figure is for Reactor Building (outside Drywell) only. 1.5 Times Bounding Spectrum envelops in-structure response at elevation 565 and 519. For elevation 593, peak in-structure response is slightly higher than the 1.5 X Bounding Spectrum curve and it does not meet the exception rule for narrow band exceedences discussed above (i.e., average ratio of in-structure response to 1.5 times Bounding Spectrum is less than unity) . So seismic demands for equipment located at Reactor Building floor elevation 565 and below is less than the capacity based on Bounding Spectrum, but equipment located at Reactor Building above elevation 565 is not enveloped by the 1.5 times Bounding spectrum curve.

Figure B.1.1 This figure is for Diesel Generator (DG) Buildings and Intake Pumping Station (IPS) structure only. 1.5 Times Bounding Spectrum curve does not envelope in-structure response of DG building and IPS structure.

Figure B.3: This figure is for Reactor Building (outside Drywell) only. GERS for the given mechanical equipment always envelops 1.5 times SSE in-structure response spectrum. So seismic capacity of equipment based on GERS is always greater than seismic demand provided all the caveats are met.

Figure B.3.1: This figure is for Diesel Generator Building and Intake Pumping Station (IPS) structure only. GERS for the given mechanical equipment always envelops 1.5 times SSE in-structure response spectrum. So seismic capacity of equipment based on GERS is always greater than seismic demand provided all the caveats are met.

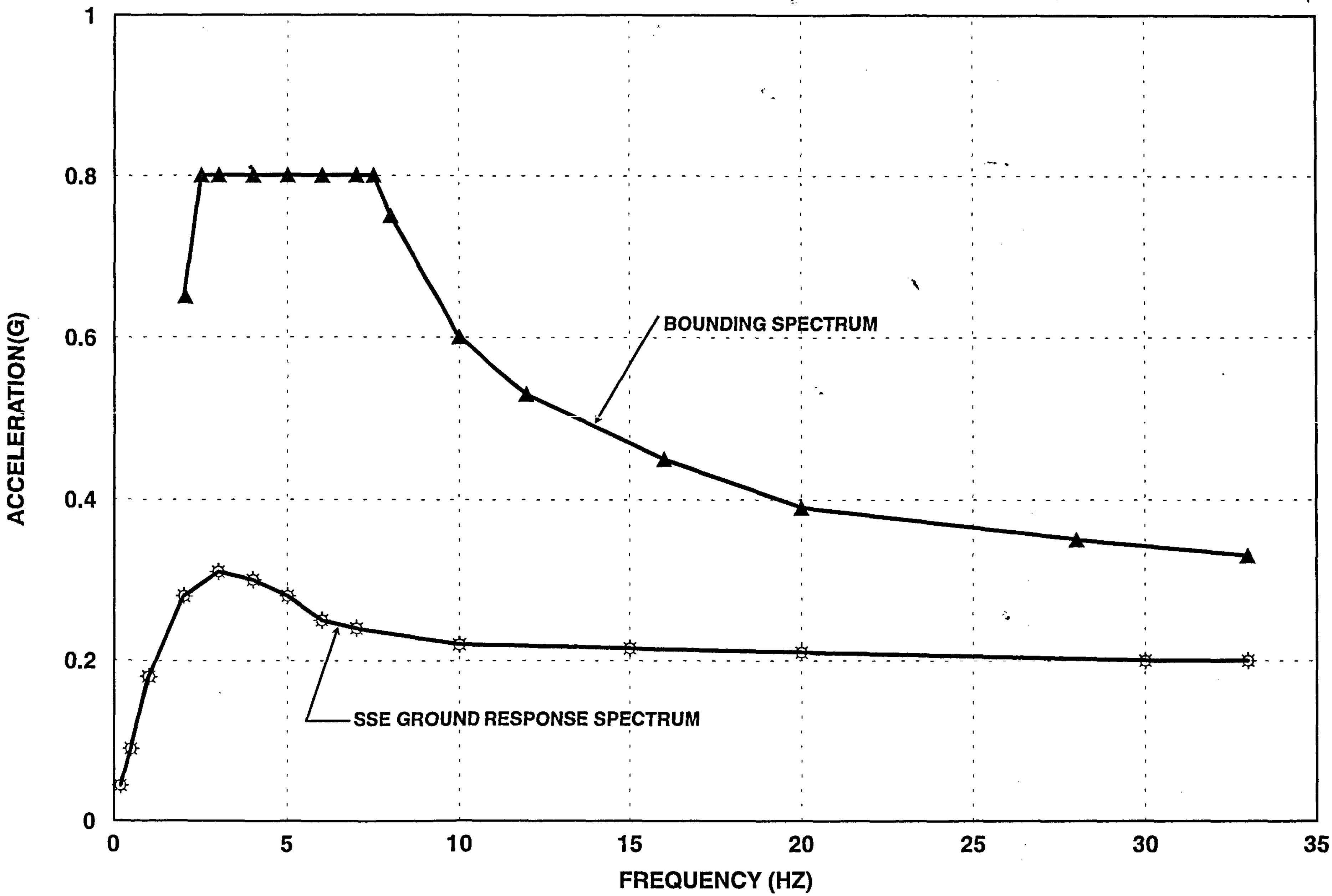
Figure B.3A: This figure is for Reactor Building (outside Drywell) only. GERS for the given electrical equipment does not always envelops 1.5 times SSE in-structure response spectrum. So it is required to be determined on a case by case basis whether seismic capacity of equipment based on GERS is greater than seismic demand provided all the caveats are met.

Figure B.3A.1: This figure is for Diesel Generator Building only. GERS for the given electrical equipment does not always envelops 1.5 times SSE in-structure response spectrum. So it is required to be determined on a case by case basis whether seismic capacity of equipment based on GERS is greater than seismic demand provided all the caveats are met. There are no electrical equipment located in IPS structure which is on SSEL.

In Table 1, attempt has been made to determine basis for seismic capacity and demand for Mechanical equipment contained in the SSEL for BFN units 2 & 3. Similarly, Table 2 has been generated for Electrical equipment contained in the SSEL for BFN units 2 & 3. Note that there are no equipment classes 5 (Horizontal Pumps), 11 (Chillers), 12 (Air Compressors) and 19 (Temperature Sensors) in BFN SSEL.

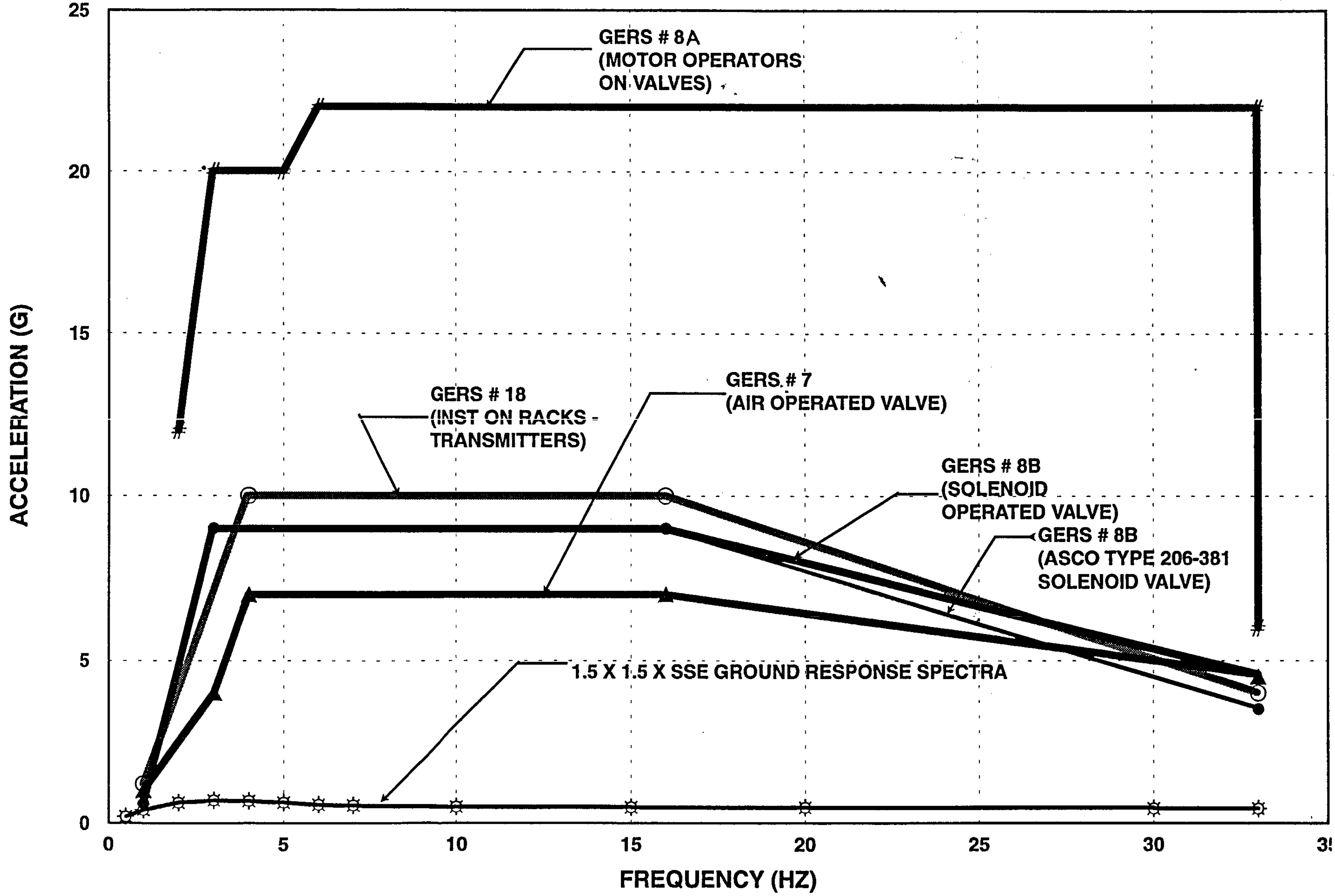
FIGURE A.1

SEISMIC CAPACITY VS SEISMIC DEMAND FOR BFNP 5% DAMPING BOUNDING SPECTRUM (FIG 4-2 OF GIP) VS SSE GROUND RESPONSE SPECTRA



REF. FIG 2.5-15 OF FSAR FOR GROUND RESPONSE SPECTRUM

FIG A.2 (MECHANICAL EQUIPMENT)
SEISMIC CAPACITY VS SEISMIC DEMAND FOR BFNP 5% DAMPING
1.5 X 1.5 X SSE GROUND RESPONSE SPECTRA VS GERS



REFER FIGURE 2.5-15 OF FSAR FOR GROUND RESPONSE SPECTRA

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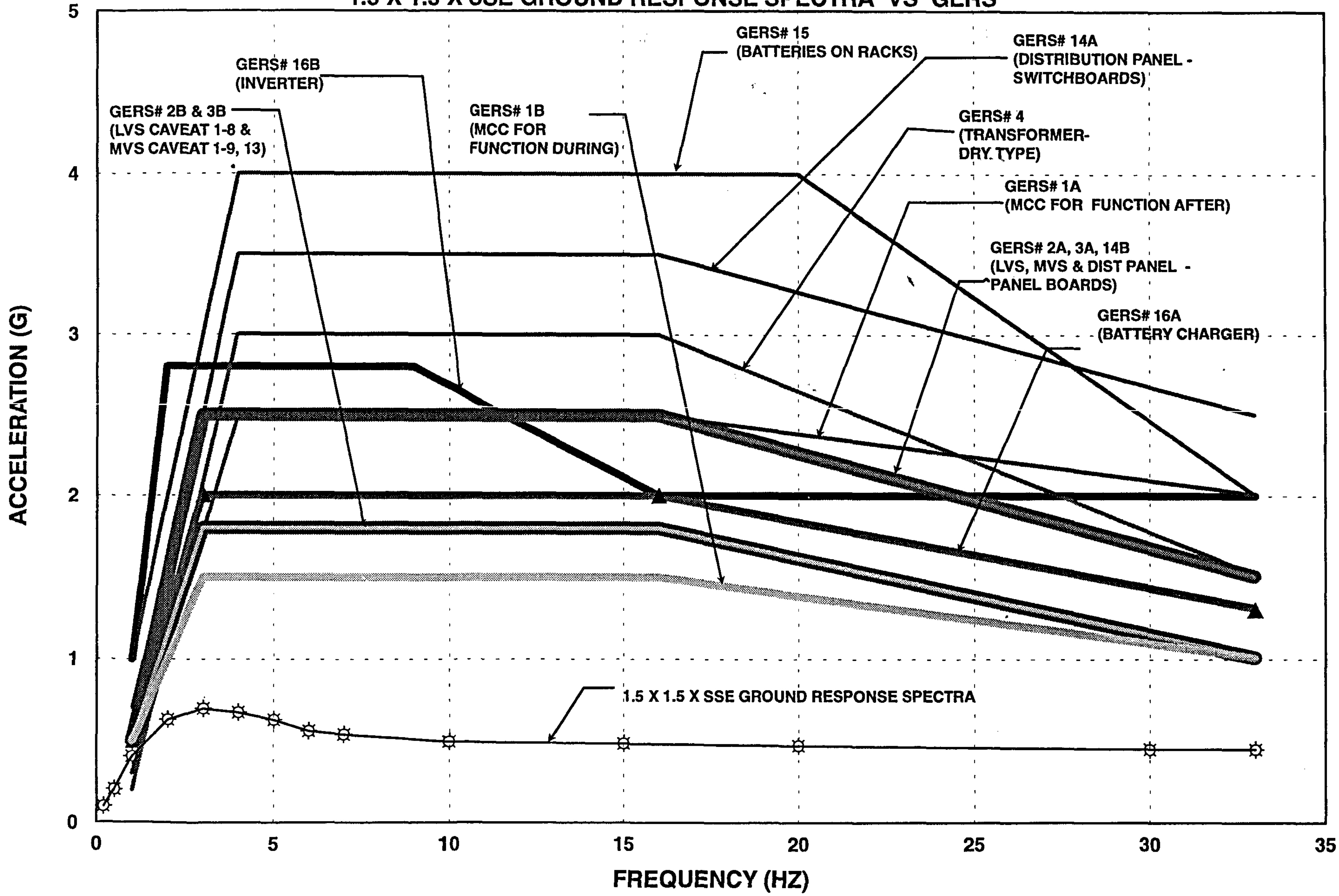
CHKD: [handwritten initials] DATE 10/15/95

FIG A.2A (ELECTRICAL EQUIPMENT)
SEISMIC CAPACITY VS SEISMIC DEMAND FOR BFNP 5% DAMPING
1.5 X 1.5 X SSE GROUND RESPONSE SPECTRA VS GERS



REFER FIGURE 2.5-15 OF FSAR FOR GROUND RESPONSE SPECTRA

REACTOR BUILDING RESPONSE SPECTRA

BROADENED RESPONSE SPECTRA (SSE)					UNBROADENED RESPONSE SPECTRA (SSE)				
FREQUENCY	565	593	621	639	FREQUENCY	565	593	621	639
0.5	0.1158	0.1164	0.1172	0.1176	**0.56**	0.1158	0.1164	0.1172	0.1176
1.1	0.204	0.2116	0.22	0.223	**1.22**	0.204	0.2116	0.22	0.223
2			0.4336	0.443	**2.22**			0.4336	0.443
2.4	0.3944	0.4118	0.4372	0.448	**2.67**	0.3944	0.4118	0.4372	0.448
2.5					**2.78**				
2.8125	0.498	0.5778		0.705	**3.13**	0.498	0.5778		0.705
3.6		0.6474	0.8172	0.884	**4.00**		0.6474	0.8172	0.884
4.8	0.5674	0.9528	1.4058	1.591	**5.33**	0.5674	0.9528	1.4058	1.591
5.1	0.6576	1.2256	1.9358	2.227	**5.67**	0.6576	1.2256	1.9358	2.227
5.294	**0.7184**	**1.3444**			**5.88**	**0.7184**	**1.3444**		
5.357			**2.1462**	**2.48**	**5.95**			**2.1462**	**2.48**
6.47	**0.7184**	**1.3444**			**5.88**	**0.7184**	**1.3444**		
6.5476			**2.1462**	**2.48**	**5.95**			**2.1462**	**2.48**
7.5	0.421	0.7614	1.2332	1.448	**6.82**	0.421	0.7614	1.2332	1.448
8					**7.27**				
8.1	0.3666	0.6068	0.9952	1.187	**7.36**	0.3666	0.6068	0.9952	1.187
8.82	0.388				**8.02**	0.388			
9		0.4644	0.7894	0.966	**8.18**		0.4644	0.7894	0.966
10	0.388				**9.09**	0.388			
10.8	0.388		0.5838		**9.82**	0.388		0.5838	
12	0.3756	0.4272	0.5072	0.618	**10.91**	0.3756	0.4272	0.5072	0.618
13.8	0.5004		0.466	0.522	**12.55**	0.5004		0.466	0.522
13.94		0.4996			**12.67**		0.4996		
14.7	0.5774	0.612	0.4446	0.537	**13.36**	0.5774	0.612	0.4446	0.537

BROADENED RESPONSE SPECTRA (SSE)					UNBROADENED RESPONSE SPECTRA (SSE)				
FREQUENCY	565	593	621	639	FREQUENCY	565	593	621	639
14.87		0.6278		0.537	**13.52**		0.6278		0.537
16	0.5964	0.6424	0.4476	0.537	**14.55**	0.5964	0.6424	0.4476	0.537
20	0.5158	0.6126	0.429	0.517	**18.18**	0.5158	0.6126	0.429	0.517
28	0.346	0.433	0.399	0.47	**25.45**	0.346	0.433	0.399	0.47
33	0.24	0.32	0.38	0.44	**30.00**	0.24	0.32	0.38	0.44

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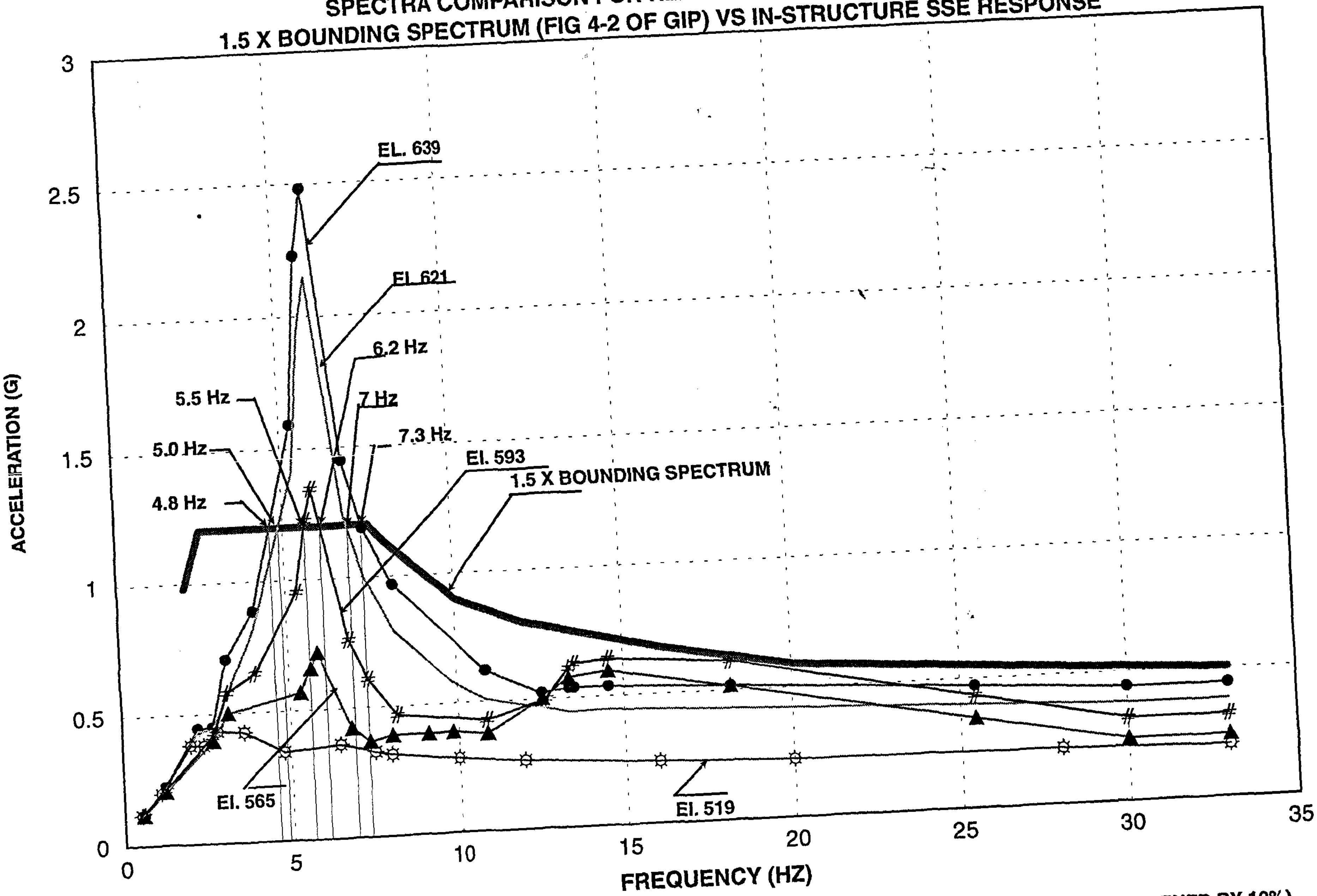
FIG B.1
SEISMIC CAPACITY VS SEISMIC DEMAND
SPECTRA COMPARISON FOR REACTOR BLDG 5% DAMPING
1.5 X BOUNDING SPECTRUM (FIG 4-2 OF GIP) VS IN-STRUCTURE SSE RESPONSE



REFER FIGURE J-EW-100.6, J-EW-7.6, J-EW-6.6, J-EW-5.6, J-EW-4.6 OF MARS REPORT FOR RESPONSE SPECTRA (UNBROADENED BY 10%)

DIESEL GENERATOR & IPS BUILDING RESPONSE SPECTRA

BROADENED RESPONSE SPECTRA (SSE)						UNBROADENED RESPONSE SPECTRA (SSE)						
FREQUENCY	DG 561	DG 583	DG 594	DG 607	IPS 565	FREQUENCY	DG 561	DG 583	DG 594	DG 607	FREQUENCY	IPS 565
0.5	0.2016	0.2018	0.2018	0.202	0.1159	0.59	0.2016	0.2018	0.2018	0.202	0.56	0.1159
1.2	0.3658	0.3696	0.3698	0.3686	0.2224	1.41	0.3658	0.3696	0.3698	0.3686	1.33	0.2224
1.5	0.4884	0.4930	0.495	0.4946	0.2879	1.76	0.4884	0.4930	0.495	0.4946	1.67	0.2879
1.785	0.624	0.632	0.636	0.638		2.10	0.624	0.632	0.636	0.638	1.98	
2.4					0.3792	2.82					2.67	0.3792
2.415	0.624	0.632	0.636	0.638		2.84	0.624	0.632	0.636	0.638	2.68	
2.6775	0.724	0.744	0.752	0.7464		3.15	0.724	0.744	0.752	0.7464	2.98	
3.6225	0.724	0.744	0.752	0.7464		4.26	0.724	0.744	0.752	0.7464	4.03	
3.9	0.7124	0.7388	0.7468	0.7366		4.59	0.7124	0.7388	0.7468	0.7366	4.33	
4.14	0.712					4.87	0.712				4.60	
5.1	0.708	0.766	0.792	0.8004	0.3883	6.00	0.708	0.766	0.792	0.8004	5.67	0.3883
5.8639	0.708					6.90	0.708				6.52	
6.0		0.8936	0.944	0.8684		7.06		0.8936	0.944	0.8684	6.67	
6.9	0.8284	1.028	1.0606	0.9124		8.12	0.8284	1.028	1.0606	0.9124	7.67	
7.225	0.882	1.090	1.16			8.50	0.882	1.090	1.16		8.03	
7.8108	0.882					9.19	0.882				8.68	
8.4		1.3702	1.491	1.3164	0.4214	9.88		1.3702	1.491	1.3164	9.33	0.4214

CALCULATION OF BASIC PARAMETERS FOR A46 AND INDIVIDUAL PLANT EXAMINATION OF EXTERNAL EVENTS (IPEEE) SEISMIC PROGRAM

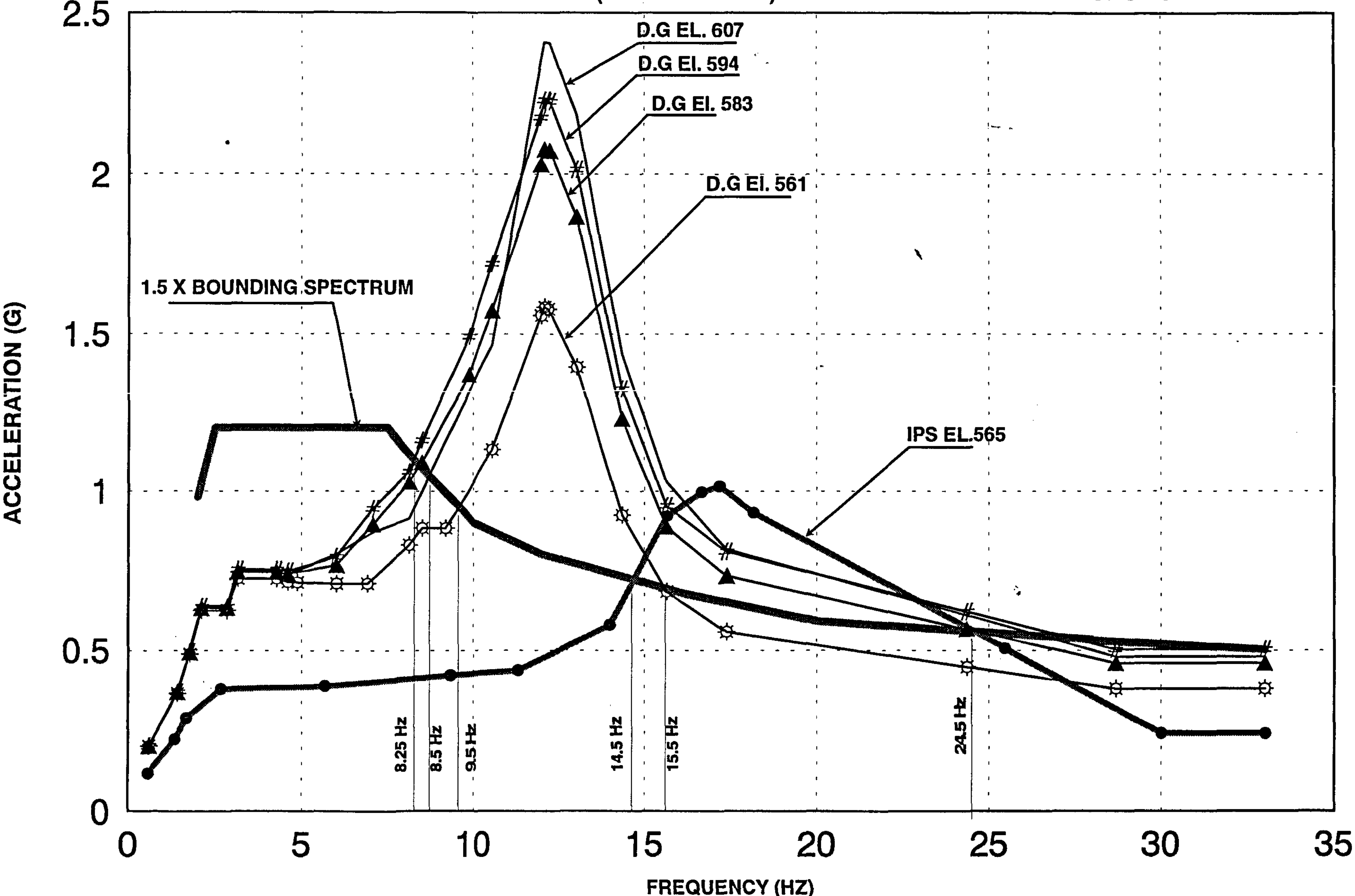
BROADENED RESPONSE SPECTRA (SSE)						UNBROADENED RESPONSE SPECTRA (SSE)						
FREQUENCY	DG 561	DG 583	DG 594	DG 607	IPS 565	FREQUENCY	DG 561	DG 583	DG 594	DG 607	FREQUENCY	IPS 565
9	1.131	1.572	1.7192	1.4632		10.59	1.131	1.572	1.7192	1.4632	10.00	
10.2	1.558	2.03	2.176	2.3484	0.4363	12.00	1.558	2.03	2.176	2.3484	11.33	0.4363
10.2935	**1.584**	**2.076**	**2.23**	**2.409**		12.11	**1.584**	**2.076**	**2.23**	**2.409**	11.44	
12.6					0.5781						14.00	0.5781
13.9265	**1.584**	**2.076**	**2.23**	**2.409**		12.11	**1.584**	**2.076**	**2.23**	**2.409**	15.47	
14.0386	1.578					12.21	1.578				15.60	
14.1		2.0716	2.2256	2.406	0.9197	12.26		2.0716	2.2256	2.406	15.67	0.9197
15	1.394	1.8658	2.0138	2.1844	0.9955	13.04	1.394	1.8658	2.0138	2.1844	16.67	0.9955
15.4639					**1.014**	13.45					17.18	**1.014**
16.5	0.9234	1.2286	1.3246	1.4354		14.35	0.9234	1.2286	1.3246	1.4354		
18	0.6818	0.8852	0.9526	1.0292		15.65	0.6818	0.8852	0.9526	1.0292		
18.9003					**1.014**	16.44					17.18	**1.014**
20	0.5570	0.732	0.808	0.8158	0.9295	17.39	0.5570	0.732	0.808	0.8158	18.18	0.9295
28	0.448	0.565	0.62	0.609	0.5058	24.35	0.448	0.565	0.62	0.609	25.45	0.5058
33	0.38	0.46	0.502	0.48	0.24	28.70	0.38	0.46	0.502	0.48	30.00	0.24

FIG B.1.1 (DG & IPS)

SEISMIC CAPACITY VS SEISMIC DEMAND

SPECTRA COMPARISON FOR DG AND IPS BLDG 5% DAMPING

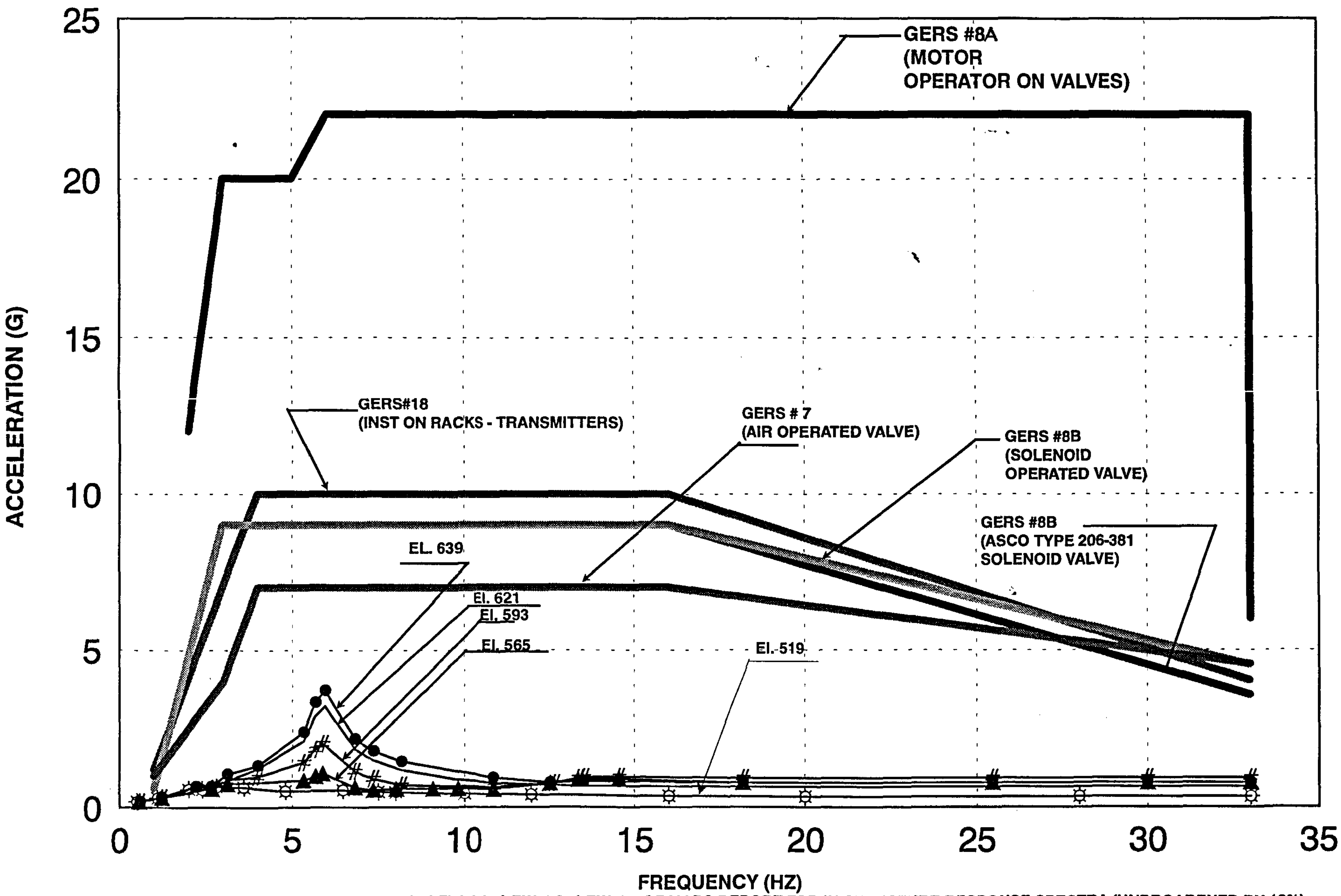
1.5 X BOUNDING SPECTRUM (FIG 4-2 OF GIP) VS IN-STRUCTURE SSE RESPONSE



NOTE: REFER FIGURE F-NS-1.6, F-NS-4.6, F-NS-5.6, F-NS-6.6, A.2-EW-5.6 OF MARS REPORT FOR IN-STRUCTURE RESPONSE SPECTRA (DG BLDG UNBROADENED BY 15% & IPS UNBROADENED BY 10%)

FIG B.3 (MECHANICAL EQUIPMENT)

SEISMIC CAPACITY VS SEISMIC DEMAND
SPECTRA COMPARISON FOR REACTOR BLDG 5% DAMPING
GERS VS 1.5 X IN-STRUCTURE SSE RESPONSE SPECTRA



REFER FIGURE J-EW-100.6, J-EW-7.6, J-EW-6.6, J-EW-5.6, J-EW-4.6 OF MARS REPORT FOR IN-STRUCTURE RESPONSE SPECTRA (UNBROADENED BY 10%)

FIG B.3.1 (DG & IPS) (MECHANICAL EQUIPMENT)
SEISMIC CAPACITY VS SEISMIC DEMAND
SPECTRA COMPARISON FOR DG AND IPS BLDG 5% DAMPING
GERS VS 1.50 X SSE IN-STRUCTURE RESPONSE SPECTRA

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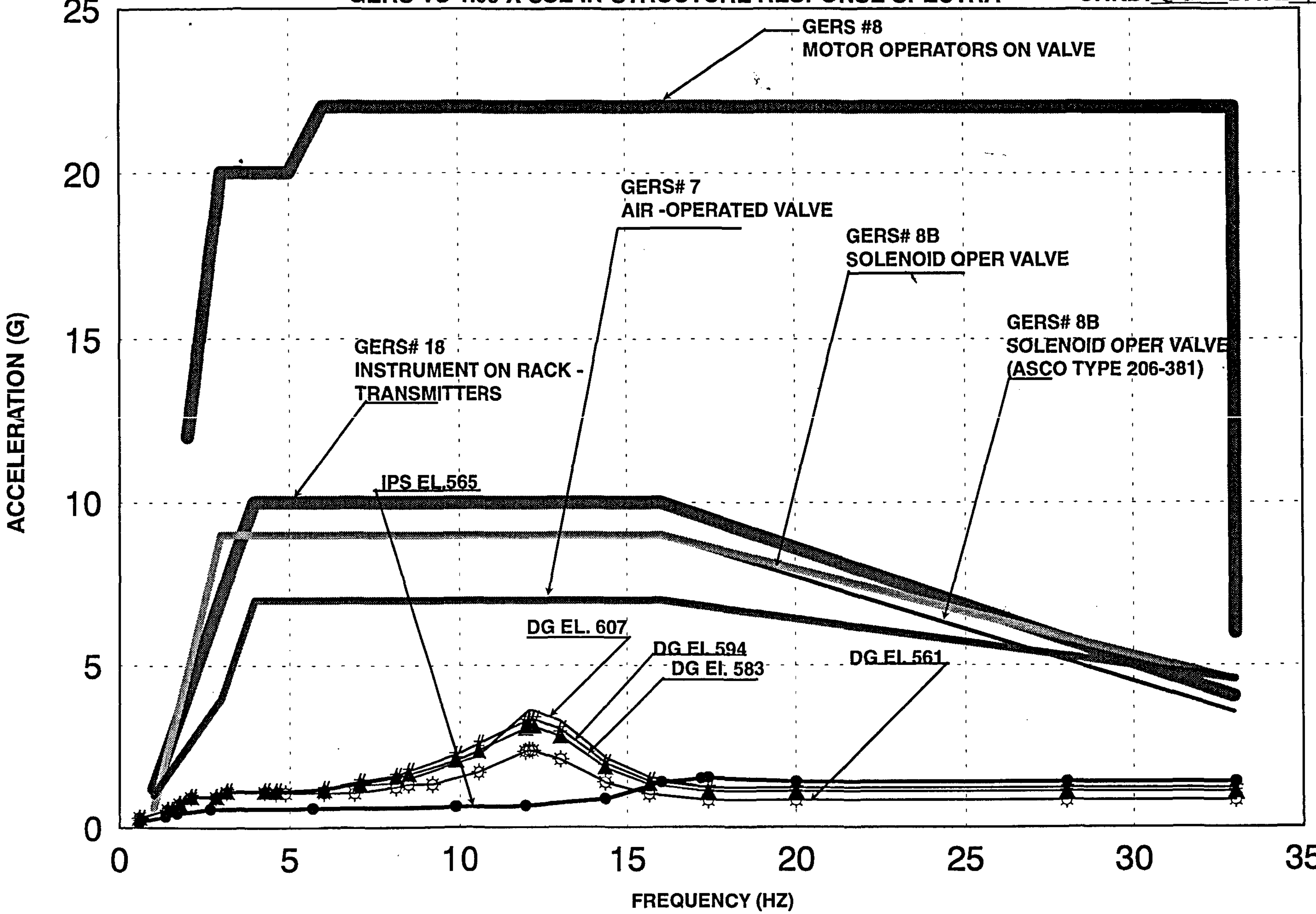
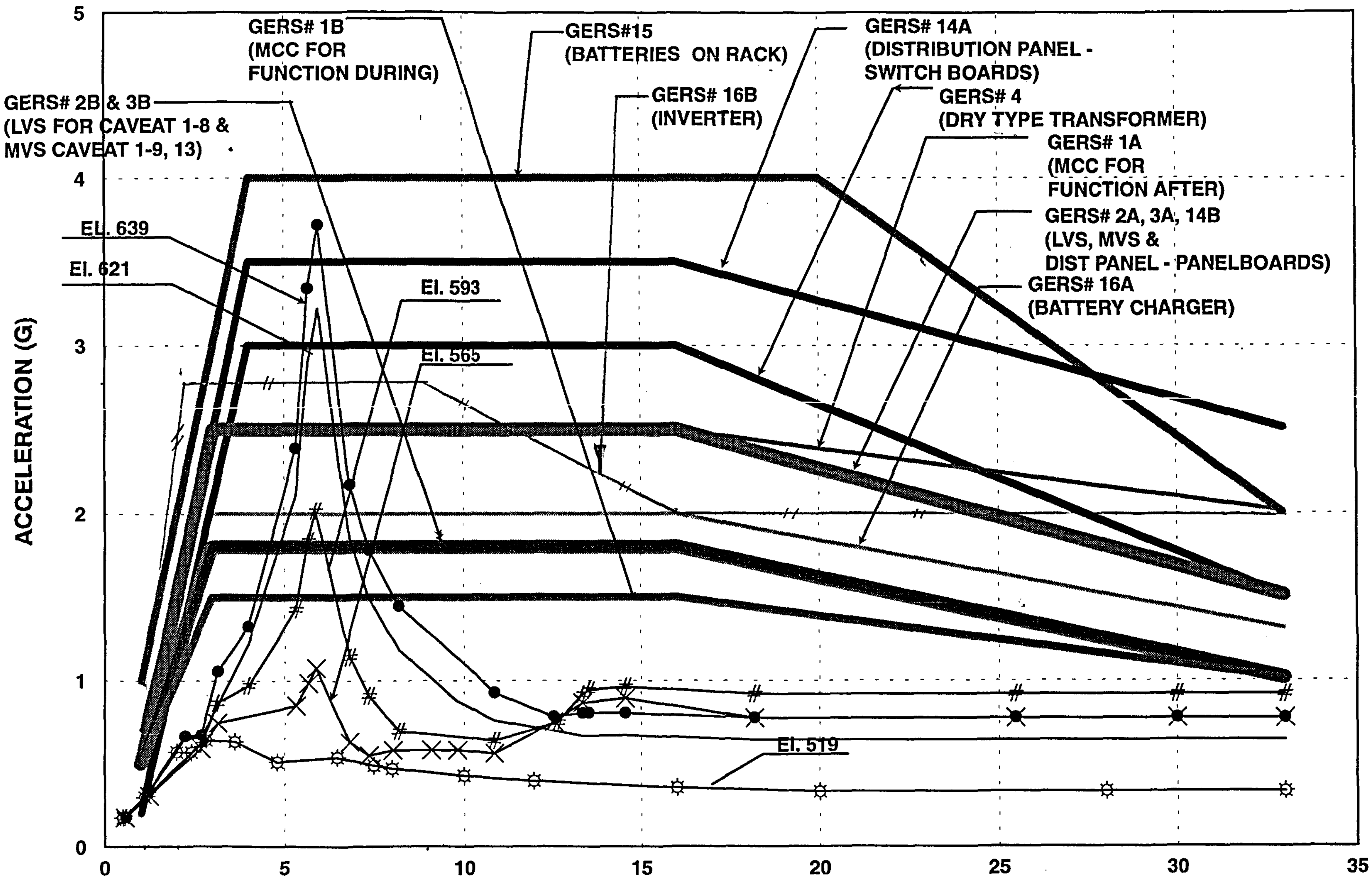
PREP: P. Sa. DATE 10-4-95
CHKD: JOD DATE 10/15/95



REF. FIGURE F-NS-1.6, F-NS-4.6, F-NS-5.6, F-NS-6.6, A.2-EW-5.6 OF MARS REPORT FOR IN-STRUCTURE RESPONSE SPECTRA (UNBROADENED 15% FOR DG & 10% FOR IPS)

FIG B.3A (ELECTRICAL EQUIPMENT)
SEISMIC CAPACITY VS SEISMIC DEMAND
SPECTRA COMPARISON FOR REACTOR BLDG 5% DAMPING
GERS VS 1.5 X IN-STRUCTURE SSE RESPONSE SPECTRA



REFER FIGURE J-EW-100.6, J-EW-7.6,J-EW-6.6, J-EW-5.6, J-EW-4.6 OF MARS REPORT FOR IN-STRUCTURE RESPONSE SPECTRA (SPECTRA UNBROADENED BY 10%)

FIG B.3A.1 (DG) (ELECTRICAL EQUIPMENT)

SEISMIC CAPACITY VS SEISMIC DEMAND
SPECTRA COMPARISON FOR DIESEL GENERATOR BLDG 5% DAMPING
GERS VS 1.50 X SSE IN-STRUCTURE RESPONSE SPECTRA

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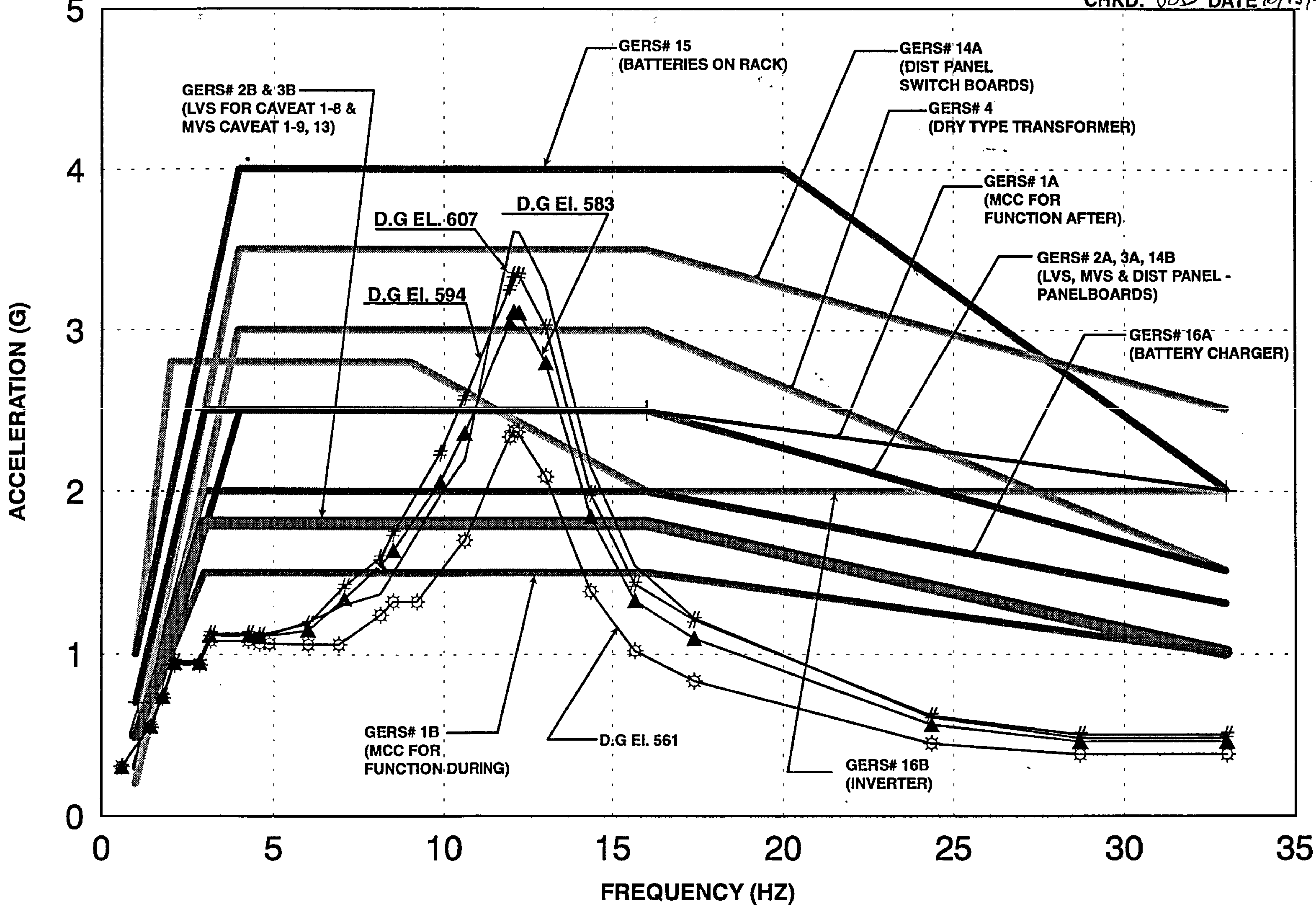
CHKD: JOD DATE 10/15/95



REFER FIGURE F-NS-1.6, F-NS-4.6, F-NS-5.6, F-NS-6.6 OF MARS REPORT FOR IN-STRUCTURE RESPONSE SPECTRA (UNBROADENED BY 15%)

Table 1
SEISMIC CAPACITY AND DEMAND OF MECHANICAL EQUIPMENT

EQUIP CLASS	EQUIP TYPE	WITHIN 40 FEET & FREQUENCY > 8HZ (METHOD A)		AT ANY ELEV. & FREQ (METHOD B)		EARTHQUAKE EXPERIENCE DATA BASE		REMARKS
		CAPACITY	DEMAND	CAPACITY	DEMAND	B. SPECTRA	GERS	
6	VERTICAL PUMPS	BOUNDING SPECTRUM	SSE GROUND RESPONSE SPECTRUM	1.5 X B.S	IN-STRUC SSE RESPONSE SPECTRA	PUMPS: DEEP-WELL & CENTRIFUGAL. MOTOR: 5 TO 7000 HP, 95 TO 16000 GPM, IMPELLER SHAFT: ≯ 20 FT CANTILEVER	NO GERS	1) ALL VERTICAL PUMPS IN SSEL ARE LOCATED WITHIN 40 FT FROM GROUND ELEVATION.
7	FLUID-OPERATED VALVES	BOUNDING SPECTRUM	SSE GROUND RESPONSE SPECTRUM	1.5 X B.S	IN-STRUC SSE RESPONSE SPECTRA	ACTUATED BY: AIR, WATER OR OIL. VALVE OPERATOR, CANTILEVER LENGTH AND WEIGHT LIMITS PER FIG.B.7-1 & B.7-2 OF REF. 3.1 (GIP)	AIR OPERATED GATE OR GLOBE VALVES OF SPRING OPPOSED, DIAPHRAGM TYPE PNEUMATIC ACTUATORS. SIZE: 12 TO 40" HT WEIGHT ≤500#	1) MOST EQUIPMENT CLASS 7 IN SSEL ARE LOCATED WITHIN 40 FT FROM GROUND ELEVATION.
				GERS	1.5 x IN-STRUC SSE RESPONSE SPECTRA			
8A	MOTOR OPERATED VALVES	BOUNDING SPECTRUM	SSE GROUND RESPONSE SPECTRUM	1.5 X B.S	IN-STRUC SSE RESPONSE SPECTRA	INCLUDE MOTOR OPERATOR. VALVE MAY BE ANY TYPE, SIZE OR ORIENTATION. VALVE OPERATOR, CANTILEVER LENGTH AND WEIGHT LIMITS PER FIG B.8-1 OF REF. 3.1 (GIP)	ELECTRIC MOTOR OPERATORS FOR GATE, GLOBE, PLUG, BALL OR BUTTERFLY TYPE VALVES. WT:150 TO 3500 #. REALISTIC PIPING AMPLIFICATION SHOULD BE INCLUDED AS APPROPRIATE.	1) MOST EQUIPMENT CLASS 8A IN SSEL ARE LOCATED WITHIN 40 FT FROM GROUND ELEVATION.
				GERS	1.5 X IN-STRUC SSE RESPONSE SPECTRA			
8B	SOLENOID OPERATED VALVES	BOUNDING SPECTRUM	SSE GROUND RESPONSE SPECTRUM	1.5 X B.S	IN-STRUC SSE RESPONSE SPECTRA	INCLUDE SOLENOID OPERATOR. LIGHTER THAN MOV. VALVE OPERATOR, CANTILEVER LENGTH AND WEIGHT LIMITS PER FIG B.8-1 OF REF. 3.1 (GIP)	CONSIST OF:SOLENOID ACTUATOR & VALVE CONTAINING AN ORIFICE. WT: UP TO 45 LBS, PIPE DIA ≤ 1", PRESSURE ≤ 600 PSI. REALISTIC PIPING AMPLIFICATION SHOULD BE INCLUDED AS APPROPRIATE.	1) MOST EQUIPMENT CLASS 8B IN SSEL ARE LOCATED WITHIN 40 FT FROM GROUND ELEVATION
				GERS	1.5 X IN-STRUC SSE RESPONSE SPECTRA			

EQUIP CLASS	EQUIP TYPE	WITHIN 40 FEET & FREQUENCY > 8HZ (METHOD A)		AT ANY ELEV. & FREQ (METHOD B)		EARTHQUAKE EXPERIENCE DATA BASE		REMARKS
		• CAPACITY	DEMAND	CAPACITY	DEMAND	B. SPECTRA	GERS	
9	FANS	BOUNDING SPECTRUM	SSE GROUND RESPONSE SPECTRUM	1.5 X B.S	IN-STRUC SSE RESPONSE SPECTRA	AXIAL & CENTRIFUGAL FAN. MOTORS 1HP TO 200 HP.FLOW: 1,000 TO 50,000 CFM, WT:100 - 1000 # DIFF PRESSURE: 1/2" TO 5" OF WATER	NO GERS	1) ALL EQUIPMENT CLASS 9 IN SSEL ARE LOCATED IN DG BLDG ONLY (WITHIN 40 FT).
10	AIR HANDLER	BOUNDING SPECTRUM	SSE GROUND RESPONSE SPECTRUM	1.5 X B.S	IN-STRUC SSE RESPONSE SPECTRA	ENCLOSURE SIZE: 2' - 10'. FANS & COIL BOLTED INSIDE.	NO GERS	1) ALL EQUIPMENT CLASS 10 IN SSEL ARE LOCATED IN RB (WITHIN 40 FT). 2) 1.5 TIMES BS > IN-STRUCTURE SSE RESPONSE SPECTRA
18	INST ON RACKS	BOUNDING SPECTRUM	SSE GROUND RESPONSE SPECTRUM	1.5 X BS	IN-STRUC SSE RESPONSE SPECTRA	RACKS: STEEL MEMBERS BOLTED OR WELDED TOGETHER INTO A FRAME. SIZE: 4-8 FT HT X 3-10 FT WIDE. COMPONENTS: PRESS SWITCHES, TRANSMITTERS, GAUGES, RECORDERS, HAND SWITCHES, MANIFOLD & SOLENOID VALVES.	INCLUDES: PRESSURE, TEMP, LEVEL & FLOW TRANSMITTER. SIZE: UP TO 40 #. MAX DIMENSION OF A TRANSMITTER IS ≤ 12"	1) ALL EQUIPMENT CLASS 18 IN SSEL ARE LOCATED IN RB (WITHIN 40 FT FROM GROUND ELEVATION). 2) 1.5 TIMES BS > IN-STRUCTURE SSE RESPONSE SPECTRA.
				GERS	1.5 X IN-STRUC SSE RESPONSE SPECTRA			
21	TANK & HEAT EXCHANGER	SEE SECTION 7 OF GIP (REFERENCE 3.1)				NO B. SPECTRA	NO GERS	SEE TABLES 7-1 & 7-6 FOR APPLICABLE RANGE OF PARAMETERS AND ASSUMPTIONS FOR VERTICAL AND HORIZONTAL TANKS RESPECTIVELY

Table 2
SEISMIC CAPACITY AND DEMAND OF ELECTRICAL EQUIPMENTS

EQUIPT CLASS	EQUIPMENT TYPE	WITHIN 40 FEET & FREQUENCY > 8 HZ (METHOD A)		AT ANY ELEV. & FREQ (METHOD B)		EARTHQUAKE EXPERIENCE DATA BASE		REMARKS
		CAPACITY	DEMAND	CAPACITY	DEMAND	B. SPECTRUM	GERS	
1	MCC	BOUNDING SPECTRUM	SSE GROUND RESPONSE SPECTRUM	1.5 X B.S	IN-STRUC SSE RESPONSE SPECTRA	MOTOR: < 600 V. MCC: SINGLE OR DOUBLE SIDED, DIM: 20-24" W X 18-24" D X 90" TALL, WT: , 650 # / SECTION, MULTIPLE SECTIONS BOLTED TOGETHER. CONSTRUCTION PER NEMA STANDARDS	MOTOR: 600V AC & 250V DC. DIM: 20"W X 20"D X 90"HT PER SECTION, THICKNESS ≥ 14GA. WT: 200-800 LBS / SECTION. COMPONENTS: CONTACTORS, OVERLOAD RELAYS, OTHER RELAYS, CIRCUIT BREAKERS, DISCONNECT SWITCHES, CONTROL OR DIST TRANSFORMERS & PANEL BOARD. GERS: FUNCTION DURING & FUNCTION AFTER	1) 1.5 X BS < IN-STRUCTURE RESPONSE SPECTRA EXCEPT RB EL. 565 2) GERS < 1.5 X IN-STRUCTURE RESPONSE SPECTRA EXCEPT RB EL. 565
				GERS	1.5 X IN-STRUC SSE RESPONSE SPECTRA			
2	LOW VOLTAGE SWITCH GEAR	BOUNDING SPECTRUM	SSE GROUND RESPONSE SPECTRUM	1.5 X B.S	IN-STRUC SSE RESPONSE SPECTRA	< 600 VOLTS, SWITCHGEAR ASSY: 20-36" W X 60" D X 90" HT, WT: 2000 #. MULTIPLE SECTIONS BOLTED TOGETHER. CONSTRUCTION PER ANSI STANDARDS.	RATING: MAX 600V AC OR 250V DC. DIM: 20-30" W X 60" D X 80-90" HT, THICKNESS ≥ 14 GA, WT: 1000-1600 #. LIMITED TO ITE/BROWN BOVERI, WESTINGHOUSE OR GE. GERS: MEETS CAVEATS 1-8, AND MEETS ALL CAVEATS 1-10.	1) 1.5 X BS < IN-STRUCTURE RESPONSE SPECTRA 2) GERS < 1.5 X IN-STRUCTURE RESPONSE SPECTRA 3) ALL EQUIPMENT CLASS 2 ON SSEL LOCATED @ RB621.
				GERS	1.5 X IN-STRUC SSE RESPONSE SPECTRA			
3	MEDIUM VOLTAGE SWITCH GEAR	BOUNDING SPECTRUM	SSE GROUND RESPONSE SPECTRUM	1.5 X B.S	IN-STRUC SSE RESPONSE SPECTRA	INCLUDES ELEC SWITCHING & FAULT PROTECTION CIRCUIT BREAKERS FOR SYSTEM 2400 -4160 VOLTS. DIM: 90" D X 24-36" W X 90" HT. WT: 2000-3000 LBS PER SECTION. CIRCUIT BREAKER WT: 600-1200 # EACH. CAPACITY: 1200-3000 AMP. CONSTRUCTION PER ANSI STANDARDS.	RATED: 5000V AC. ENCLOSURE DIM: 30"W X 60"D X 90" HT, THICK: ≥ 12 GA. WT: 3000-5000 LB / CUBICLE FOR CIRCUIT BREAKER. GERS: MEETS CAVEATS 1-9 & 13; AND MEETS ALL CAVEATS 1-13.	1) 1.5 X BS < IN-STRUCTURE RESPONSE SPECTRA 2) GERS < 1.5 X IN-STRUCTURE RESPONSE SPECTRA
				GERS	1.5 X IN-STRUC SSE RESPONSE SPECTRA			

EQUIPT CLASS	EQUIPMENT TYPE	WITHIN 40 FEET & FREQUENCY > 8 HZ (METHOD A)		AT ANY ELEV. & FREQ (METHOD B)		EARTHQUAKE EXPERIENCE DATA BASE		REMARKS
		CAPACITY	DEMAND	CAPACITY	DEMAND	B. SPECTRUM	GERS	
4	TRANSFORMER	BOUNDING SPECTRUM	SSE GROUND RESPONSE SPECTRUM	1.5 X B.S	IN-STRUC SSE RESPONSE SPECTRA	INCLUDE: SUBSTATION TYPE 4160/480 VOLTS & DIST TYPE 480 / 120 VOLTS. RANGE FROM 10" X 10" X 10" & WT: 50-100# (FOR WALL MOUNTED DIST TYPE) TO 40-100" W X 40-100" D X 60-100" HT & WT: 2000-15000$# (FOR SUB).	INCLUDE ONLY DRY TYPE WITH 7.5 - 225 KVA CAPACITY & VOLTAGE RATING 120-480 VOLTS AC. WALL MOUNTED OR FLOOR MOUNTED.	1) 1.5 X BS < IN-STRUCTURE RESPONSE SPECTRA 2) GERS < 1.5 X IN-STRUCTURE RESPONSE SPECTRA EXCEPT RB EL. 565 AND DG EL.565
				GERS	1.5 X IN-STRUC SSE RESPONSE SPECTRA			
13	MOTOR-GENERATOR	BOUNDING SPECTRUM	SSE GROUND RESPONSE SPECTRUM	1.5 X B.S	IN-STRUC SSE RESPONSE SPECTRA	WT: 50 TO 5000 LBS. MOTOR, GENERATOR, FLYWHEEL & CONDUITS INCLUDED IN EQUIP CLASS	NO GERS	1) 1.5 X BS < IN-STRUCTURE RESPONSE SPECTRA 2) ALL EQUIPMENT CLASS 13 ON SSEL LOCATED @ RB621 & 639
14	DISTRIBUTION PANELS	BOUNDING SPECTRUM	SSE GROUND RESPONSE SPECTRUM	1.5 X B.S	IN-STRUC SSE RESPONSE SPECTRA	RANGE: AC-600V, DC-250V. TYPES: SWITCHBOARD (NORMALLY FLOOR-MOUNTED 20-40" D&W X 90" HT, WT:500 LB) & PANELBOARDS (NORMALLY WALL-MOUNTED 20-40" HT & W X 6-12" D, WT: 30-200 LB) CONST PER NEMA STANDARDS	RANGE: AC-600V, DC-250V. TYPES:SWITCHBOARD (NORMALLY FLOOR-MOUNTED 20"D X36"W X 90" HT) & PANELBOARDS (NORMALLY WALL-MOUNTED 48" H X 24" W X 12" D). GERS: SWITCHBOARDS & PANELBOARDS	1) 1.5 X BS < IN-STRUCTURE RESPONSE SPECTRA
				GERS	1.5 X IN-STRUC SSE RESPONSE SPECTRA			
15	BATTERIES ON RACKS	BOUNDING SPECTRUM	SSE GROUND RESPONSE SPECTRUM	1.5 X B.S	IN-STRUC SSE RESPONSE SPECTRA	INCLUDE BATTERIES & SUPPORT STRUC. WT: 50-450 LB/BATTERY. TYPES: LEAD-ACID STORAGE BATTERY--CALCIUM FLAT PLATE & PLANTE OR MANCHEX, ANTIMONY FLAT PLATE OR TUBULAR.	INCLUDES STORAGE BATTERY SETS OF LEAD-CALCIUM TYPE. RACKS: TWO-STEP OR SINGLE-TIER WITH LONGITUDINAL CROSS-BRACES.	1) 1.5 X BS < IN-STRUCTURE RESPONSE SPECTRA 2) GERS > 1.5 X IN-STRUCTURE RESPONSE SPECTRA
				GERS	1.5 X IN-STRUC SSE RESPONSE SPECTRA			

EQUIPT CLASS	EQUIPMENT TYPE	WITHIN 40 FEET & FREQUENCY > 8 HZ (METHOD A)		AT ANY ELEV. & FREQ (METHOD B)		EARTHQUAKE EXPERIENCE DATA BASE		REMARKS
		CAPACITY	DEMAND	CAPACITY	DEMAND	B. SPECTRUM	GERS	
16	BATTERY CHARGERS AND INVERTER (BCI)	BOUNDING SPECTRUM	SSE GROUND RESPONSE SPECTRUM	1.5 X B.S	IN-STRUC SSE RESPONSE SPECTRA	HOUSED IN FLOOR OR WALL-MOUNTED CABINET. LIMITED TO SOLID STATE BCI. WALL-MOUNTED: 10-20" D,W &HT; WT: 50-200 #. FLOOR-MOUNTED: 20-40" W,D X 60-80" HT; WT: 100S - 1000S #. RANGE: AC 120-480 V, DC 24-240 V. INCLUDES SHEET METAL ENCLOSURE (NEMA AND UL STANDARDS), ALL INTERNAL COMPONENTS, JUNCTION BOXES & ATTACHED CABLES OR CONDUITS, BCI UNITS OF SOLID STATE TECHNOLOGY	CHARGER RANGE: 25-600 AMP,24-250V DC & 120-480 V AC. HOUSED IN NEMA TYPE FLOOR OR WALL MOUNTED ENCLOSURE. INVERTER CAPACITY: 0.5 - 15 KVA / 120V DC & 120-480V AC. HOUSED IN NEMA TYPE FLOOR-MOUNTED ENCLOSURE. BCI UNITS OF SOLID STATE TECHNOLOGY	1) 1.5 X BS < IN-STRUCTURE RESPONSE SPECTRA 2) GERS < 1.5 X IN-STRUCTURE RESPONSE SPECTRA EXCEPT RB EL.593
				GERS	1.5 X IN-STRUC SSE RESPONSE SPECTRA			
17	ENGINE GENERATOR	BOUNDING SPECTRUM	SSE GROUND RESPONSE SPECTRUM	1.5 X B.S	IN-STRUC SSE RESPONSE SPECTRA	AC POWER. 200 - 5000 KVA: OUTPUT: 480V,2400V, 4160V; 400-4000 HP	NO GERS	1) ALL EQUIPMENT CLASS IN SSEL ARE LOCATED IN DG BLDG ONLY (WITHIN 40 FT).
20	INSTR & CONTRL PANELS & CABINETS	BOUNDING SPECTRUM	SSE GROUND RESPONSE SPECTRUM	1.5 X B.S	IN-STRUC SSE RESPONSE SPECTRA	SWITCH BOARD & BENCH BOARDS. FREESTANDING, BRACED AGAINST WALL OR TO EACH OTHER	NO GERS	1)MOST EQUIPMENT CLASS 20 IN SSEL ARE LOCATED IN CONT BAY EL 617 (NOT WITHIN 40 FT) . 2) 1.5 TIMES BS < IN-STRUCTURE SSE RESPONSE SPECTRA.

6.3 IPEEE (SEISMIC) STUDY

6.3.1 SCREENING PROCESS

Based on screening criteria given on EPRI NP-6041-SL (Reference 3.2), type of structures and equipments located at Browns Ferry Nuclear Plant have been evaluated. Table 3 and Table 4 lists the basis of seismic margin evaluation for structures and equipment. Initial screening is accomplished by this method.

Table 3

SUMMARY OF CIVIL STRUCTURES SCREENING CRITERIA FOR SEISMIC MARGIN EVALUATION
(Based on Table 2-3 of Reference 3.2)

TYPES OF STRUCTURES	EVALUATION REQUIRED (YES/NO)	EXPLANATION
Concrete Containment (Post-tensioned and Reinforced)	NO	Not required for peak spectral acceleration < 0.8g, Only major penetrations to be evaluated for peak spectral acceleration 0.8-1.2g.
Freestanding Steel Containment	YES	Torus should be reviewed and evaluated for earthquakes exceeding the design basis.
Containment Internal Structures	NO	Design is based on SSE of 0.1g or greater.
Shear Walls, Footings and Containment Shield Walls	NO	Design is based on SSE of 0.1g or greater.
Diaphragms	NO	Design is based on SSE of 0.1g or greater.
Category I Concrete Frame Structures	NO	Design is based on SSE of 0.1g or greater.
Category I Steel Frame Structures	NO	Design is based on SSE of 0.1g or greater.
Masonry Walls	YES	Essential block walls should be reviewed for seismic event specified to exceed the SSE (PG 5-15 Ref. 3.2).
Control Room Ceilings	YES	Inspect for adequacy of bracing and safety wiring. Nothing else required for <0.8g (PG A-7 Ref. 3.2).
Impact Between Structures	NO	Proper joint material are in place between structures (e.g., Reactor Building and Diesel Generator Building). Nothing required for 0.3 SSE.
Category II/I Structures	NO	There is no safety related equipment located at category II structure.

TYPES OF STRUCTURES	EVALUATION REQUIRED (YES/NO)	EXPLANATION
Dams, Levies, Dikes	YES	Establish that Dikes located along the river have been qualified for static and dynamic condition.
Soil Failure Modes, Soil-liquefaction and Slope Instability	YES	Needs to be addressed separately

Table 4

SUMMARY OF EQUIPMENT AND SUBSYSTEM SCREENING CRITERIA FOR SEISMIC MARGIN EVALUATION
(Based on Table 2-4 Reference 3.2)

EQUIPMENT TYPE	EVALUATION REQUIRED (YES/NO)	EXPLANATION
NSSS Primary Coolant System (Piping and Vessels)	NO	No suspected intergranular stress corrosion cracking. No review required for 0.3g sites. (pg A-8 Ref. 3.2)
NSSS Supports	NO	Supports are designed for combined loading determined by dynamic SSE and pipe break analysis. No review required for 0.3g sites. (pg A-8 Ref. 3.2)
Reactor Internals	NO	Generally designed for an envelope of various severe loading conditions similar to other NSSS Systems. Covered by IPE Internal events. (pg A-9 Ref. 3.2)
Control Rod Drive Housings and Mechanisms	NO	CRD Housing has lateral seismic support. (pg A-10 Ref. 3.2)
Category I Piping	YES	Minimal level of walkdown of representative piping required. (pg A-11 Ref. 3.2)
Active Valves	NO	Not required for 0.3g sites. (pg A-12 Ref. 3.2)
Passive Valves	NO	Not required for 0.3g sites. (pg A-12 Ref. 3.2)
Heat Exchangers	YES	Needs to consider only anchorage and support. (pg A-13 Ref. 3.2)
Atmospheric Storage Tanks	YES	Needs to evaluate the tank anchorage. (pg A-14 Ref. 3.2)
Pressure Vessels	YES	Needs to consider only anchorage and support. (pg A-14 Ref. 3.2)

EQUIPMENT TYPE	EVALUATION REQUIRED (YES/NO)	EXPLANATION
Buried Tanks	YES	Needs to evaluate piping connections. (pg A-14 Ref. 3.2)
Batteries and Racks	YES	Visual inspection to verify if batteries mounted in braced racks designed for seismic loads, rigid spacers between batteries and end restraints exist, batteries tightly supported by side rails.
Diesel Generators (Includes Engine and Skid-mounted Equipment)	YES	Visual inspection of anchorages and attachment of peripheral equipment. (pg A-15 Ref. 3.2)
Horizontal Pumps	NO	No evaluation required for ≤ 0.5g sites
Vertical Pumps	NO	No evaluation required for ≤ 0.3g sites
Fans	YES	Units supported on vibration isolators require evaluation
Air Handlers	YES	Units supported on vibration isolators require evaluation
Chillers	YES	Units supported on vibration isolators require evaluation
Air Compressors	YES	Units supported on vibration isolators require evaluation
HVAC Ducting and dampers	YES	Walkdown of representative ducting system required
Cable Trays	NO	No evaluation required for ≤ 0.3g sites
Electrical Conduit	NO	No evaluation required for ≤ 0.5g sites

EQUIPMENT TYPE	EVALUATION REQUIRED (YES/NO)	EXPLANATION
Active Electrical Power Dist. Panels, Cabinets, Switchgear, MCC	YES	a) Walkdown should verify that the instruments are properly attached to cabinet b) Relays, contactors, switches, and breakers must be evaluated for chatter and trip if functionality during strong shaking is required
Passive Electrical Power Distribution Panels, Cabinets	YES	Walkdown should verify that the instruments are properly attached to cabinet
Transformers	YES	a) Anchorage evaluation required b) Liquid-filled transformers require evaluation of overpressure safety switches. For dry transformers coils should be restrained within the cabinet
Battery Chargers	YES	Solid state units require anchorage checks. Others require evaluation
Inverters	YES	Solid state units require anchorage checks. Others require evaluation
Instrumentation and Control Panels and Racks	YES	a) Walkdown should verify that the instruments are properly attached to cabinet b) Relays, contactors, switches, and breakers must be evaluated for chatter and trip if functionality during strong shaking is required
Temperature Sensors	NO	No evaluation required for acceleration < 0.8g, emphasis should be on attachments for accn 0.8g - 1.2g
Pressure and Level Sensors	NO	No evaluation required for acceleration < 0.8g, emphasis should be on attachments for accn 0.8g - 1.2g

6.3.2 CALCULATION OF SEISMIC MARGIN EARTHQUAKE

Browns Ferry is a 0.3 g focused plant as far as IPEEE seismic evaluation is concerned.

Amplification factor is calculated based on comparison between BFNP Ground Response (based on 0.2g Housner) to 0.3g Review Level Earthquake (RLE) Ground response based on NUREG CR-0098 median spectral shape.

For Rock site:

Ground Acceleration(A) = 0.3g
Ground Velocity(V) = 0.3 x 36 = 10.8 in / sec [V/A = 36 For rock]
Ground Displacement(D) = $6V^2 / A = 6 X(10.8)^2 / 0.3 X 386$ = 6.04 inch [$AD/V^2 = 6$]

For median centered 5% damping amplification factors are:
Acceleration = 2.12
Velocity = 1.65
Displacement = 1.39

So, amplified displacement = 6.04 x 1.39 = 8.39 in
amplified velocity = 10.8 x 1.65 = 17.82 in/sec
amplified acceleration = 0.3 x 2.12 = 0.636g (say 0.64g)

For Soil site:

Ground Acceleration(A) = 0.3g
Ground Velocity(V) = 0.3 x 48 = 14.4 in / sec [V/A = 48 For Soil]
Ground Displacement(D) = $6V^2 / A = 6 X(14.4)^2 / 0.3 X 386$ = 10.74 inch [$AD/V^2 = 6$]

For median centered 5% damping amplification factors are:
Acceleration = 2.12
Velocity = 1.65
Displacement = 1.39

So, amplified displacement = 10.74 x 1.39 = 14.93 in
amplified velocity = 14.4 x 1.65 = 23.76 in/sec
amplified acceleration = 0.3 x 2.12 = 0.636g (say 0.64g)

Table 5 and Figure C.1 show the response spectra plot from which amplification factor is determined for rock foundation.
Maximum acceleration due to 0.3g = 0.64g
Corresponding acceleration due to ground response @ 8.333 Hz frequency = 0.249g (say 0.25g)
So, amplification factor = 0.64 / 0.25 = 2.56 (For rock foundation)

Table 6 and Figures C.2 shows the response spectra plot from which amplification factor is determined for soil foundation.
Maximum acceleration due to 0.3g = 0.64g
Corresponding acceleration due to ground response @ 7.692 Hz frequency = 0.2629g
So, amplification factor = 0.64 / 0.262 = 2.44 (For soil foundation)

Conservatively amplification factors for rock foundation has been utilized for IPEEE evaluations at BFN.

Table 7 provides a summary of the basic parameters relevant to the implementation of USI A-46 and Seismic IPEEE programs.

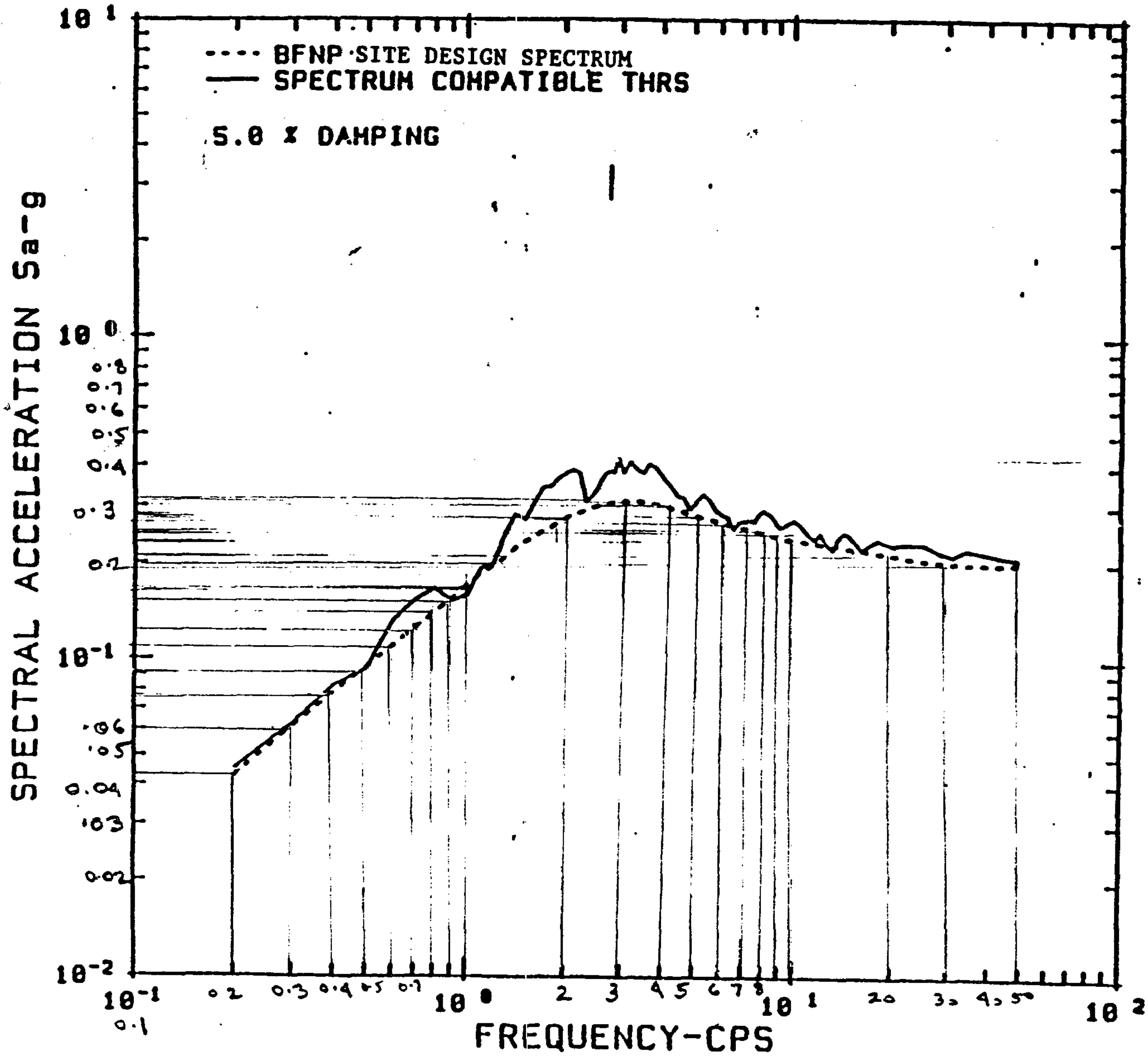
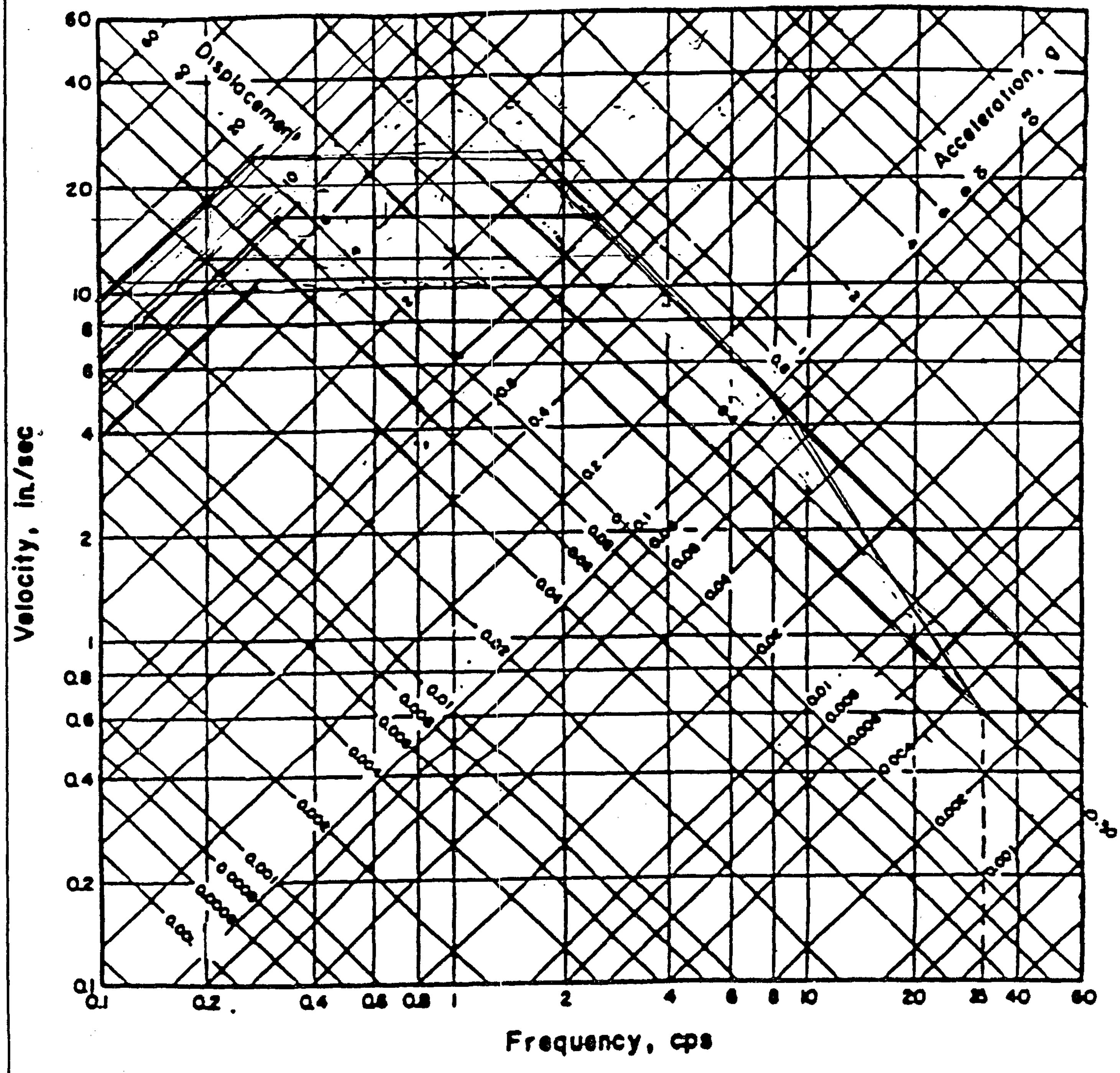


Figure 2.5-15 Comparison of Site Spectrum and Spectrum of Acceleration Time History - 5 percent damping

CALCULATION OF BASIC PARAMETERS FOR A46 AND INDIVIDUAL PLANT EXAMINATION OF EXTERNAL EVENTS (IPEEE) SEISMIC PROGRAM



RESPONSE SPECTRUM FOR SOIL
HORIZONTAL SME
(5%, 7% AND 10% DAMPING)

NUREG CR-0098 SPECTRA (FOR IPEEE)

.3 g PGA
50% NEP

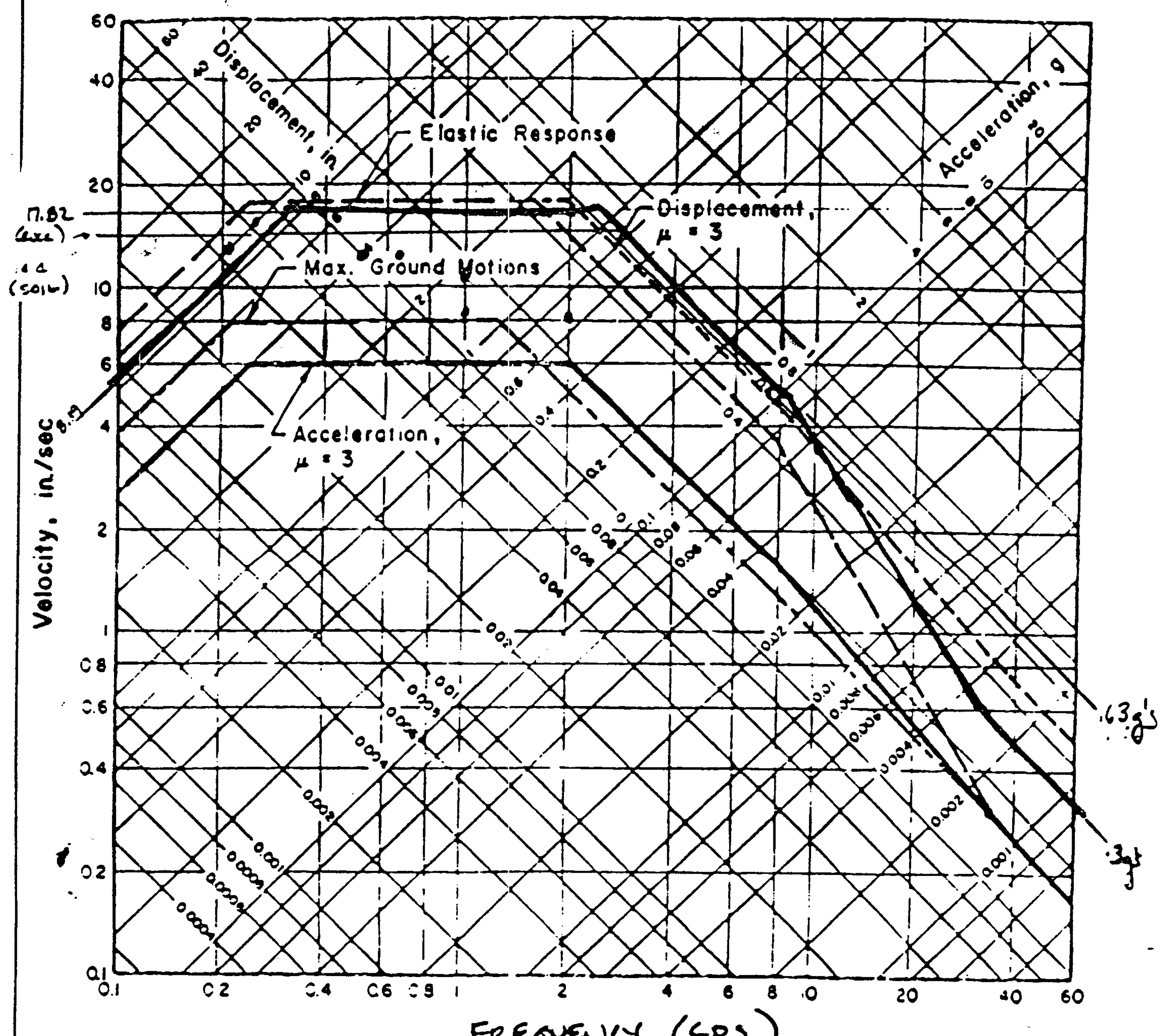


Table 5

FREQUENCY (CPS)	Ground acceleration with 5% Damping (Rock Foundation)		
	0.2g Housner (BFNP Ground Spectra)	0.3g Median Centered (calculated as per NUREG CR-0098)	Calculation basis A $=\omega V = \omega^2 D$ (V=17.82", D=8.39", $\omega=2\pi f$)
0.2	0.04476	0.034	$4\pi^2 f^2(8.39)/386.4 = 0.034$
0.333	0.0681375	0.095	$4\pi^2 f^2(8.39)/386.4 = 0.095$
0.5	0.095125	0.145	$2\pi f(17.82)/386.4 = 0.145$
0.666	0.12	0.193	$2\pi f(17.82)/386.4 = 0.193$
1	0.16635	0.289	$2\pi f(17.82)/386.4 = 0.289$
1.111	0.1815875	0.321	$2\pi f(17.82)/386.4 = 0.321$
1.25	0.2	0.362	$2\pi f(17.82)/386.4 = 0.362$
1.428	0.2179	0.413	$2\pi f(17.82)/386.4 = 0.413$
1.666	0.2409375	0.482	$2\pi f(17.82)/386.4 = 0.482$
2	0.262775	0.579	$2\pi f(17.82)/386.4 = 0.579$
2.2	0.2845625	0.636	constant acceleration
2.857	0.29455	0.636	constant acceleration
3.333	0.30245	0.636	constant acceleration
4	0.309525	0.636	constant acceleration
5	0.3	0.636	constant acceleration
6.666	0.27968	0.636	constant acceleration
7.142	0.2714375	0.636	constant acceleration
7.692	0.2619	0.636	constant acceleration
8.333	0.24934	0.636	constant acceleration
10	0.22929	0.58	By interpolation
11.111	0.218625	0.55	By interpolation
12.5	0.207325	0.52	By interpolation
14.285	0.2021	0.47	By interpolation
16.666	0.2	0.42	By interpolation

FREQUENCY (CPS)	Ground acceleration with 5% Damping (Rock Foundation)		
	0.2g Housner (BFNP Ground Spectra)	0.3g Median Centered (calculated as per NUREG CR-0098)	Calculation basis A $=\omega V = \omega^2 D$ (V=17.82", D=8.39", $\omega=2\pi f$)
20	0.2	0.38	By interpolation
22	0.2	0.35	By interpolation
25	0.2	0.34	By interpolation
30	0.2	0.32	By interpolation
33	0.2	0.3	By interpolation

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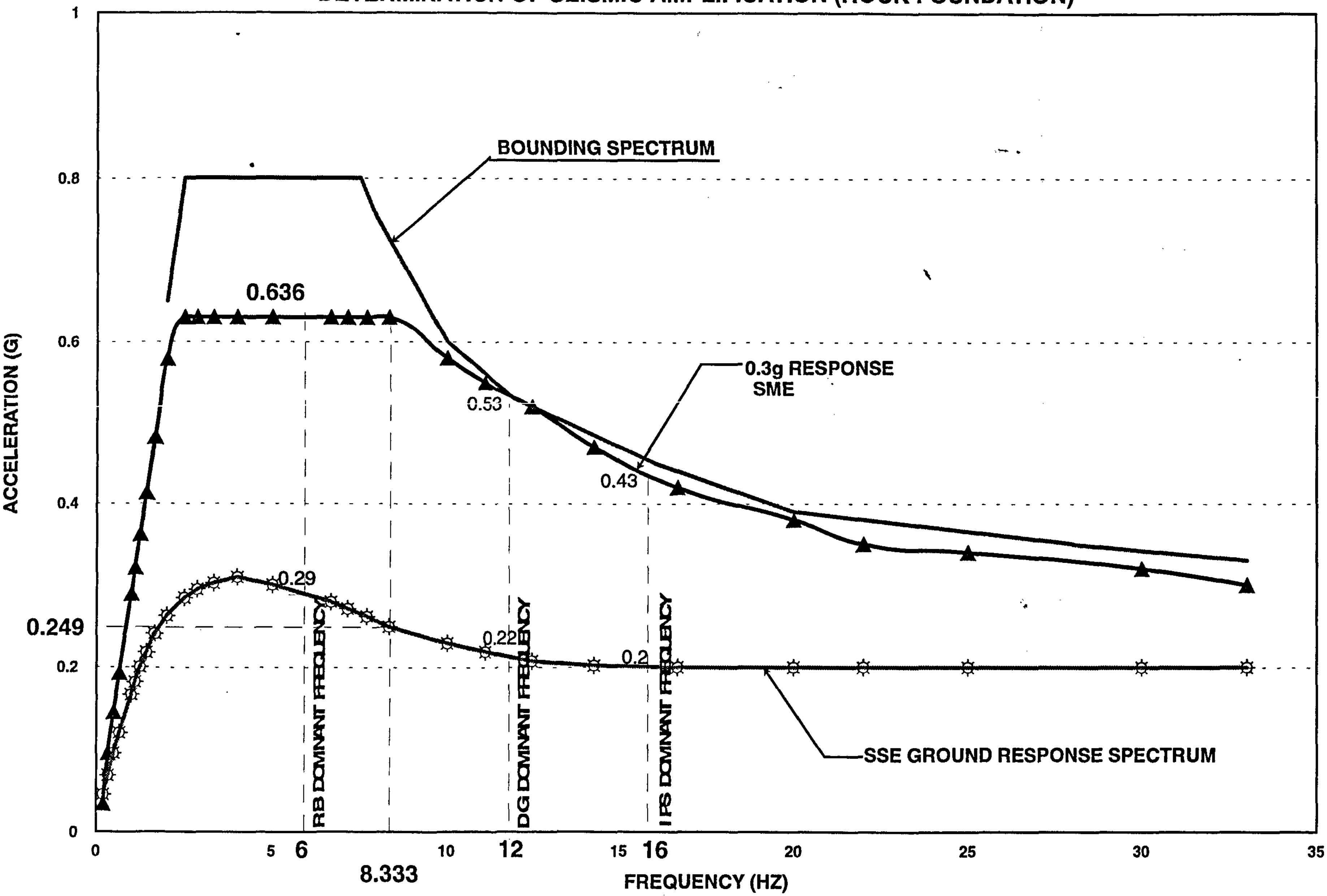
FIGURE C.1
GROUND RESPONSE VS 0.3g RESPONSE FOR BFNP 5% DAMPING
DETERMINATION OF SEISMIC AMPLIFICATION (ROCK FOUNDATION)



REFER FIG 2.5-15 OF REF.4 FOR GROUND RESPONSE SPECTRUM & FIG. 4-2 OF REF.1 FOR BOUNDING SPECTRUM

Table 6

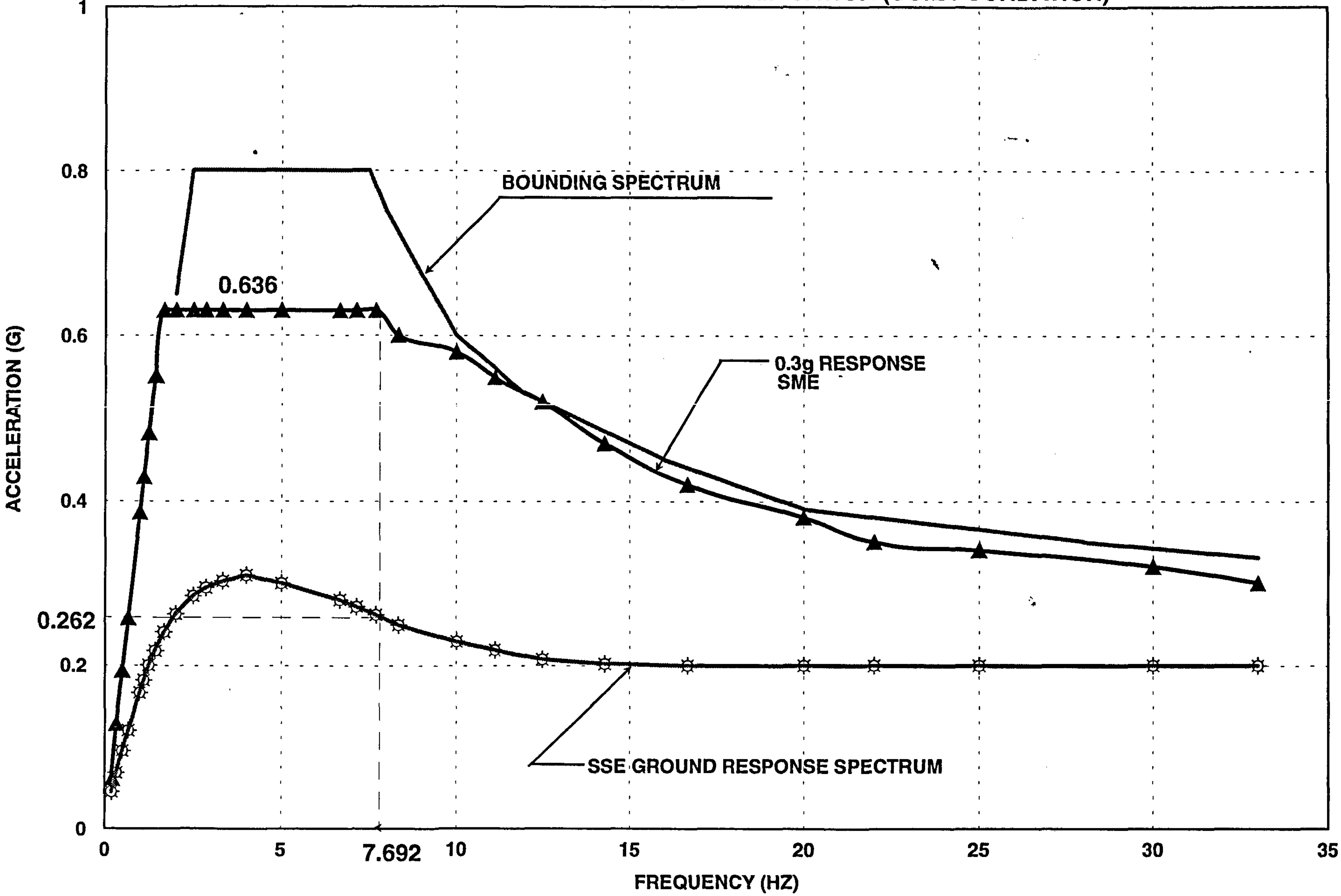
FREQUENCY (CPS)	Ground acceleration with 5% Damping (Soil Foundation)		
	0.2g Housner (BFNP Ground Spectra)	0.3g Median Centered (calculated as per NUREG CR-0098)	Calculation basis A $=\omega V = \omega^2 D$ (V=23.76", D=14.93", $\omega=2\pi f$)
0.2	0.04476	0.061	$4\pi^2 f^2(14.93)/386.4=0.061$
0.333	.0681375	0.128	$2\pi f(23.76)/386.4 =0.128$
0.5	.095125	0.193	$2\pi f(23.76)/386.4 = 0.193$
0.666	0.12	0.257	$2\pi f(23.76)/386.4 = 0.257$
1.0	0.16635	0.386	$2\pi f(23.76)/386.4 = 0.386$
1.111	0.1815875	0.429	$2\pi f(23.76)/386.4 = 0.429$
1.25	0.20	0.482	$2\pi f(23.76)/386.4 = 0.482$
1.428	0.2179	0.551	$2\pi f(23.76)/386.4 = 0.551$
1.666	0.2409375	0.643	$2\pi f(23.76)/386.4 = 0.643$
2.0	0.262775	0.579	constant acceleration
2.5	0.2845625	0.636	constant acceleration
2.857	0.29455	0.636	constant acceleration
3.333	0.30245	0.636	constant acceleration
4.0	0.309525	0.636	constant acceleration
5.0	0.30	0.636	constant acceleration
6.666	0.27968	0.636	constant acceleration
7.142	0.2714375	0.636	constant acceleration
7.692	0.2619	0.636	constant acceleration
8.333	0.24934	0.636	By interpolation
10.0	0.22929	0.58	By interpolation
11.111	0.218625	0.55	By interpolation
12.5	0.207325	0.52	By interpolation
14.285	0.2021	0.47	By interpolation
16.666	0.2	0.42	By interpolation

FREQUENCY (CPS)	Ground acceleration with 5% Damping (Soil Foundation)		
	0.2g Housner (BFNP Ground Spectra)	0.3g Median Centered (calculated as per NUREG CR-0098)	Calculation basis A =ωV = ω^2D (V=23.76", D=14.93", ω=2πf)
20.0	0.2	0.38	By interpolation
22.0	0.2	0.35	By interpolation
25.0	0.2	0.34	By interpolation
30.0	0.2	0.32	By interpolation
33.0	0.2	0.30	By interpolation

FIGURE C.2

GROUND RESPONSE VS 0.3g RESPONSE FOR BFNP 5% DAMPING

DETERMINATION OF SEISMIC AMPLIFICATION (SOIL FOUNDATION)



REFER FIG 2.5-15 OF REF. 3.4 FOR GROUND RESPONSE SPECTRUM & FIG 4-2 OF REF. 3.1 FOR BOUNDING SPECTRUM

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6.3.3 IPEEE DEMAND

As per Reference 3.2, IPEEE seismic demand is defined as a NUREG CR-0098 spectral shape (50% NEP) anchored to a PGA of 0.3g (i.e. SME level).

To derive a scaling factor to apply to the existing SSE in-structure response spectra to get SME level spectra, domoinant mode scaling will be used. The scale factor will be defined as the ratio of SME acceleration over SSE acceleration at the frequency of interest, i.e. the dominant fundamental building response frequency.

Scale Factor = $g_{\text{SME (@dominant frequency)}} / g_{\text{SSE (@dominant frequency)}}$

Prior to applying the scale factor, the SME in-structure will be reduced to account for a higher level of structural damping (7%) than that used in the existing building analysis (5%). 7% damping is based on review of existing stress level in the structure (some element stresses are at more than 50% level). R1

Reduction Factor = $[(5\%) / (7\%)]^{1/2} = 0.85$

Based on review of in-structure response spectra (Reference 3.3) the dominant fundamental frequencies for each buildings are:

Reactor building (outside Drywell) ≈ 6 Hz (N-S & E-W)
Diesel Generator Building ≈ 12 Hz (N-S & E-W)
Intake Pumping Station ≈ 16 Hz (N-S & E-W)

The above values are based on the peaks of all the floor response spectra for each building. To account for the possibility that 12-16 Hz may be soil modes instead of building modes, conservatively use the worst case ratio of SME/SSE i.e. at 8.33 Hz.

6.3.4 COMBINED SCALE FACTOR FOR IPEEE

Combined scale factor is calculated by multiplying scale factor to reduction factor.

- Reactor Building: 0.85 x (0.64 / 0.29) = 1.88
- Diesel Generator Building: 0.85 x (0.64 / 0.25) = 2.18
- Intake Pumping Station: 0.85 x (0.64 / 0.25) = 2.18

In-structure floor spectra should be scaled upward by these factors to define IPEEE demand at a 0.3g (50% NEP) level for a NUREG CR-0098 spectral shape.

Table 7
SUMMARY OF BASIC PARAMETERS FOR A-46/IPEEE EVALUATIONS

BLDG	ELEV. (FT)	SSE (N-S & E-W)		SSE (VERTICAL)		A46 EXCEEDENCE	IPEEE SCALE FACTOR	REMARKS
		Peak	ZPA	Peak	ZPA			
Reactor	519	0.43	0.20	0.29	0.14	None	1.88	Refer FIG B.1
	565	0.72	0.24	0.29	0.16	None		Refer FIG B.1
	593	1.34	0.32	0.42	0.16	5.5-6.2 Hz		Refer FIG B.1
	621	2.15	0.38	0.66	0.16	5-7 Hz		Refer FIG B.1
	639	2.48	0.44	0.73	0.18	4.8-7.3 Hz		Refer FIG B.1
Diesel Generator	561	1.58	0.39	0.42	0.17	9.5-15.5 Hz	2.18	Refer FIG B.1.1
	583	2.13	0.46	0.52	0.18	8.3-24.5 Hz		Refer FIG B.1.1
Intake Pumping Station	518	0.43	0.20	0.21	0.13	None	2.18	No equipment located
	565	1.01	0.25	0.21	0.13	14.5-24.5 Hz		Refer FIG B.1.1

General Notes:

- ZPA values taken from the table of maximum absolute acceleration response values (Refer Table J-1, F-1 and A-1 of MARS report).
- Horizontal Peak & ZPA values shown are the envelopes of N-S & E-W values.
- A-46 exceedence shown are the envelopes of N-S & E-W values.

7.0 SUMMARY OF RESULTS AND CONCLUSION

General observations can be summarized as follows:

1. Diesel Generator buildings and Intake Pumping Structures are within 40 feet from effective grade elevation.

2. Reactor building up to El. 593' is within about 40 feet from the effective grade elevation.

3. Bounding spectrum envelopes both the SSE (A46) & SME (IPEEE) Ground response spectrum, i.e., for equipment located at or below 40 feet from effective grade elevation and having a frequency > 8 Hz, capacity exceeds demand for both A46 and IPEEE.

4. GERS for mechanical equipment envelope 1.5 X In-structure response spectra (A46) & IPEEE demand based on scaled response.

8.0 PREREQUISITES AND LIMITING CONDITIONS

None

9.0 ATTACHMENT A

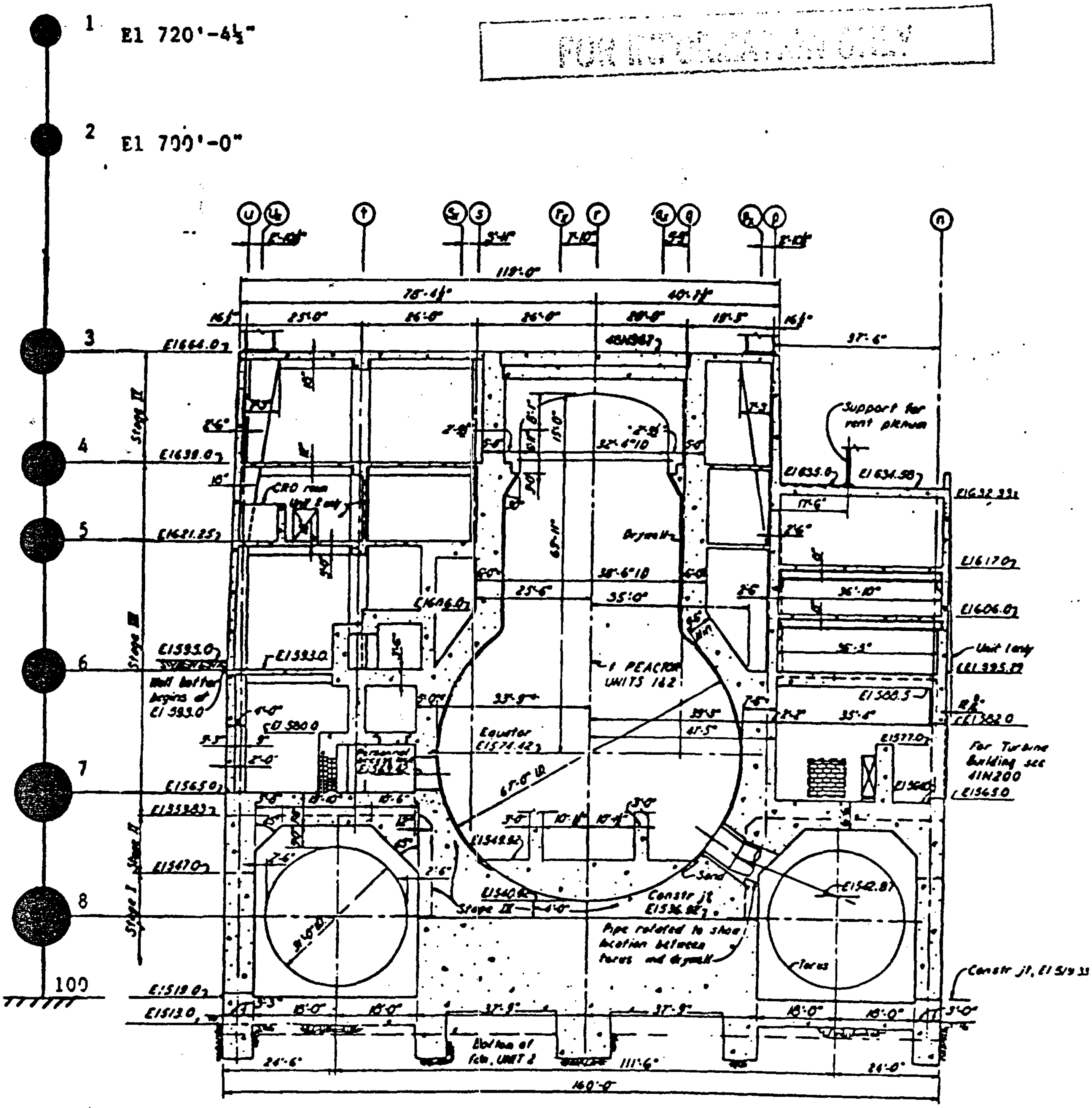

Figure J-1 Reactor Building (Outside Drywell) Model

REF: MARS REPORT. VOL. 4.

TABLE J-1

OBE MAXIMUM ABSOLUTE ACCELERATION VALUES FOR REACTOR BUILDING (OUTSIDE DRYWELL)

NODE NO.	ELEVATION (FT)	ACCELERATION (G)		
		N-S	E-W	VERT
3	664.00	0.25	0.26	0.10
4	639.00	0.20	0.22	0.09
5	621.25	0.17	0.19	0.08
6	593.00	0.15	0.16	0.08
7	565.00	0.11	0.12	0.08
8	537.00	0.10	0.10	0.07
100	519.00	0.10	0.10	0.07

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TABLE J-2

OBE MAXIMUM RELATIVE DISPLACEMENT VALUES FOR REACTOR BUILDING (OUTSIDE DRYWELL)

NODE NO.	ELEVATION (FT)	DISPLACEMENT (IN)		
		N-S	E-W	VERT
3	664.00	0.066	0.070	0.005
4	639.00	0.057	0.061	0.005
5	621.25	0.049	0.052	0.005
6	593.00	0.030	0.032	0.003
7	565.00	0.014	0.015	0.002
8	537.00	0.005	0.005	0.001
100	519.00	0.0	0.0	0.0

REF: MARS REPORT VOL. 4

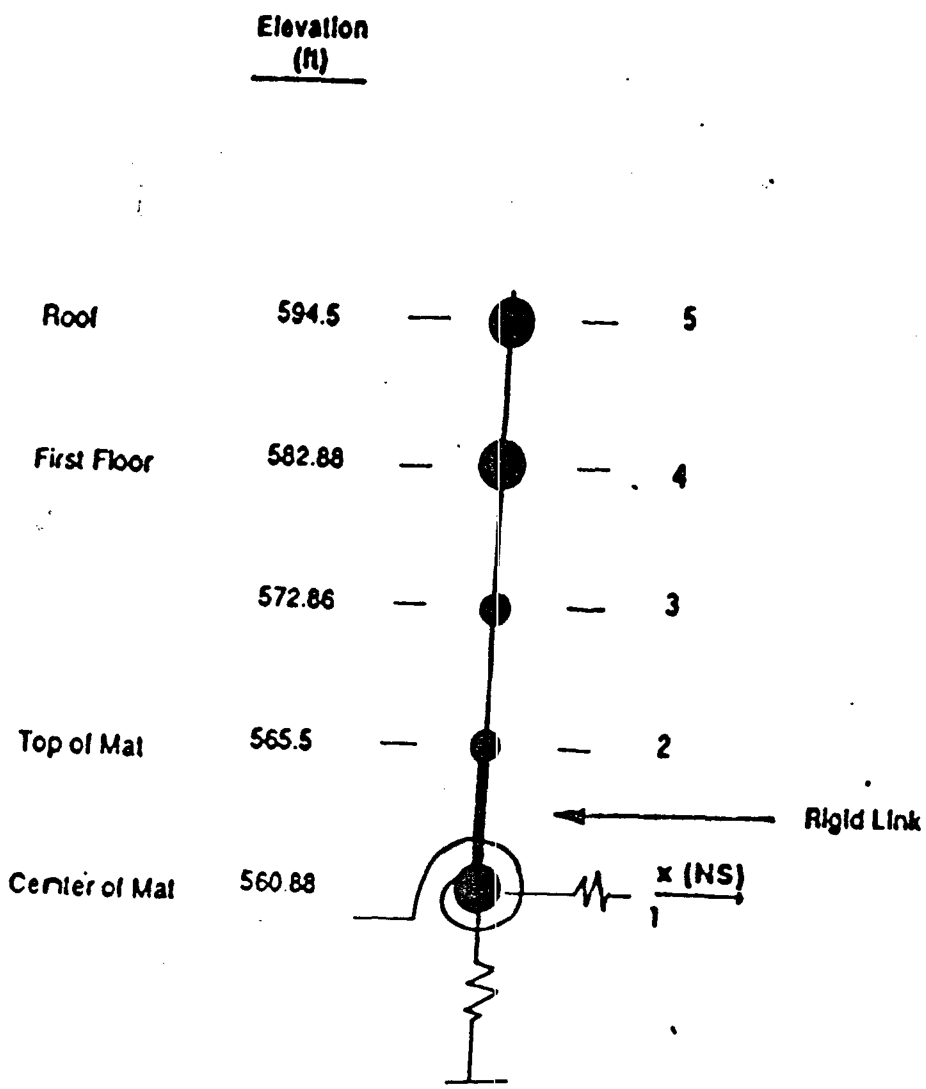

Figure F-1 Lumped-Mass Models for the Units 1 and 2 DGB

REF: MARS REPORT VOL. 2

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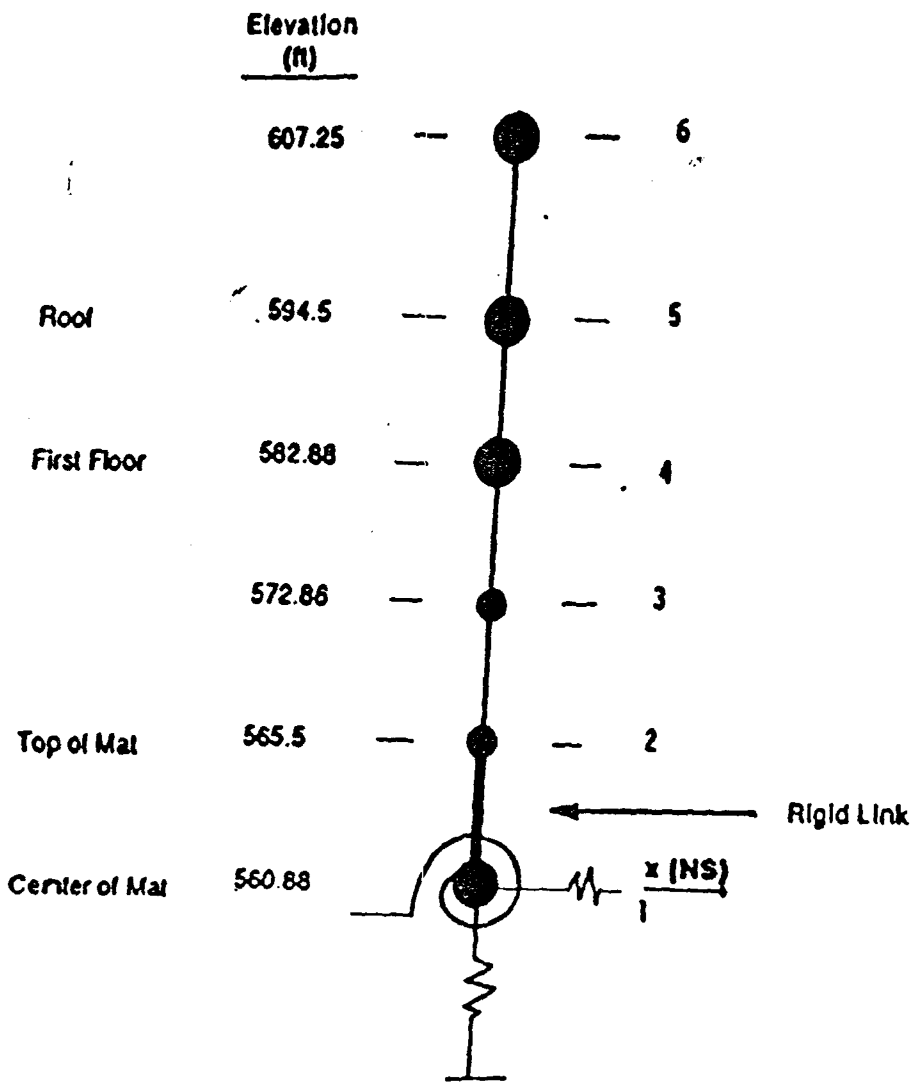

Figure F-2 Lumped-Mass Models for the Unit 3 DGB

REF: MARS REPORT VOL. 2

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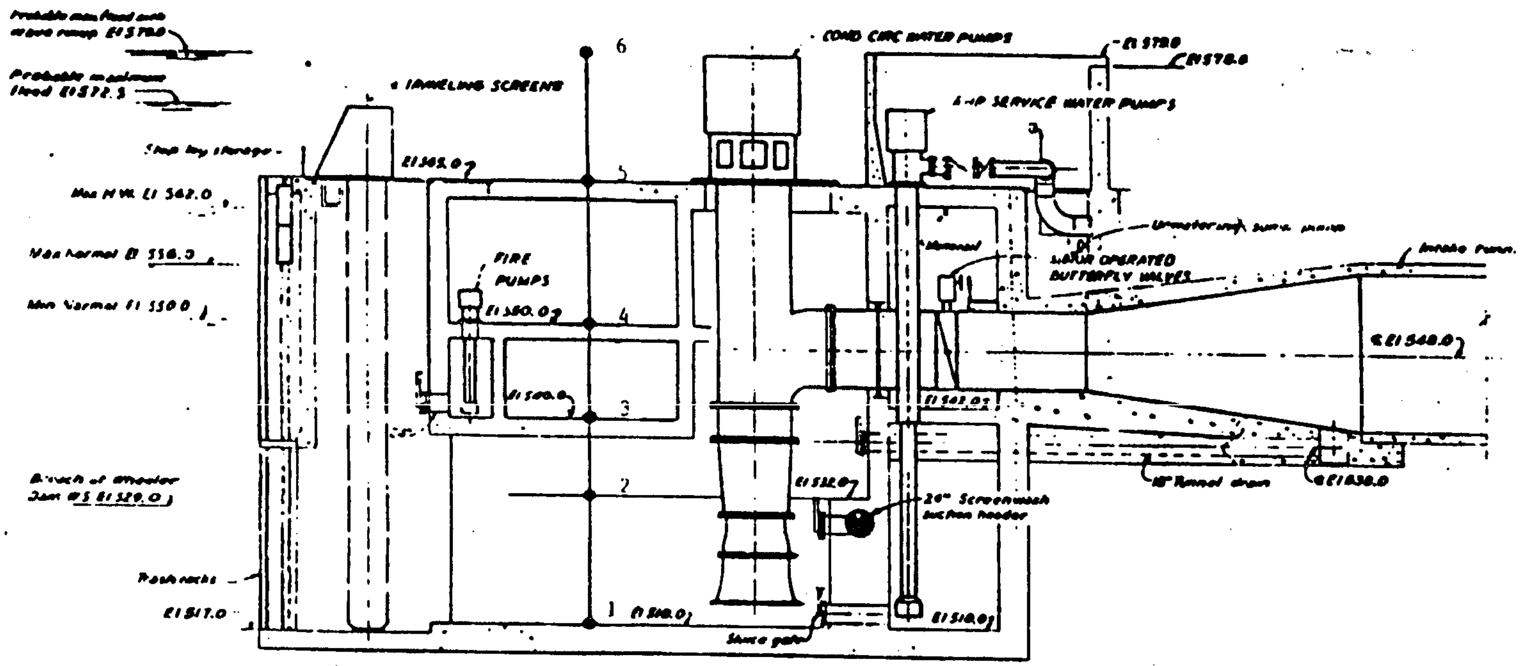
TABLE F-1

OBE Maximum Absolute Accelerative (ZPA) Response Values

	ZPA(g)		
	N-S	E-W	Vert
Units 1 and 2 DGB			
El 594.50'	0.251	0.238	0.093
El 582.88'	0.230	0.222	0.091
El 560.88'	0.190	0.186	0.083
Unit 3 DGB			
El 607.25'	0.240	0.245	0.090
El 594.50'	0.230	0.233	0.086
El 582.88'	0.221	0.220	0.086
El 560.88'	0.193	0.188	0.080

REF: MARS REPORT VOL.2

CALCULATION OF BASIC PARAMETERS FOR A46 AND INDIVIDUAL PLANT EXAMINATION OF EXTERNAL EVENTS (IPEEE) SEISMIC PROGRAM



ELEVATION

View Looking West

Figure A-1 Lumped Mass Model of the Intake Pumping Station

REF: MARS REPORT VOL. 1

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TABLE A-3

SSE Maximum Absolute Accelerations
Response Values (Water El. 529.0)

INTAKE PUMPING STRUCTURE

Elevation	Accelerations (g) N-S	E-W	Vert
518.0*	0.20	0.20	0.13
532.0	0.20	0.20	0.13
540.0	0.21	0.21	0.13
550.0	0.22	0.22	0.13
565.0	0.26	0.25	0.13
579.0	0.33	0.27	0.13

TABLE A-4

SSE Maximum Relative Displacements
Relative To Base (Water El 529.0)

Elevation	Relative Displacements (10^{-2} in) N-S	E-W	Vert
518.0	0.0	0.0	0.0
532.0	0.29	0.31	0.0
540.0	0.48	0.54	0.0
550.0	0.66	0.73	0.0
565.0	0.90	0.92	0.0
579.0	1.15	0.95	0.0

*: Base

REF: MARS REPORT VOL. 1

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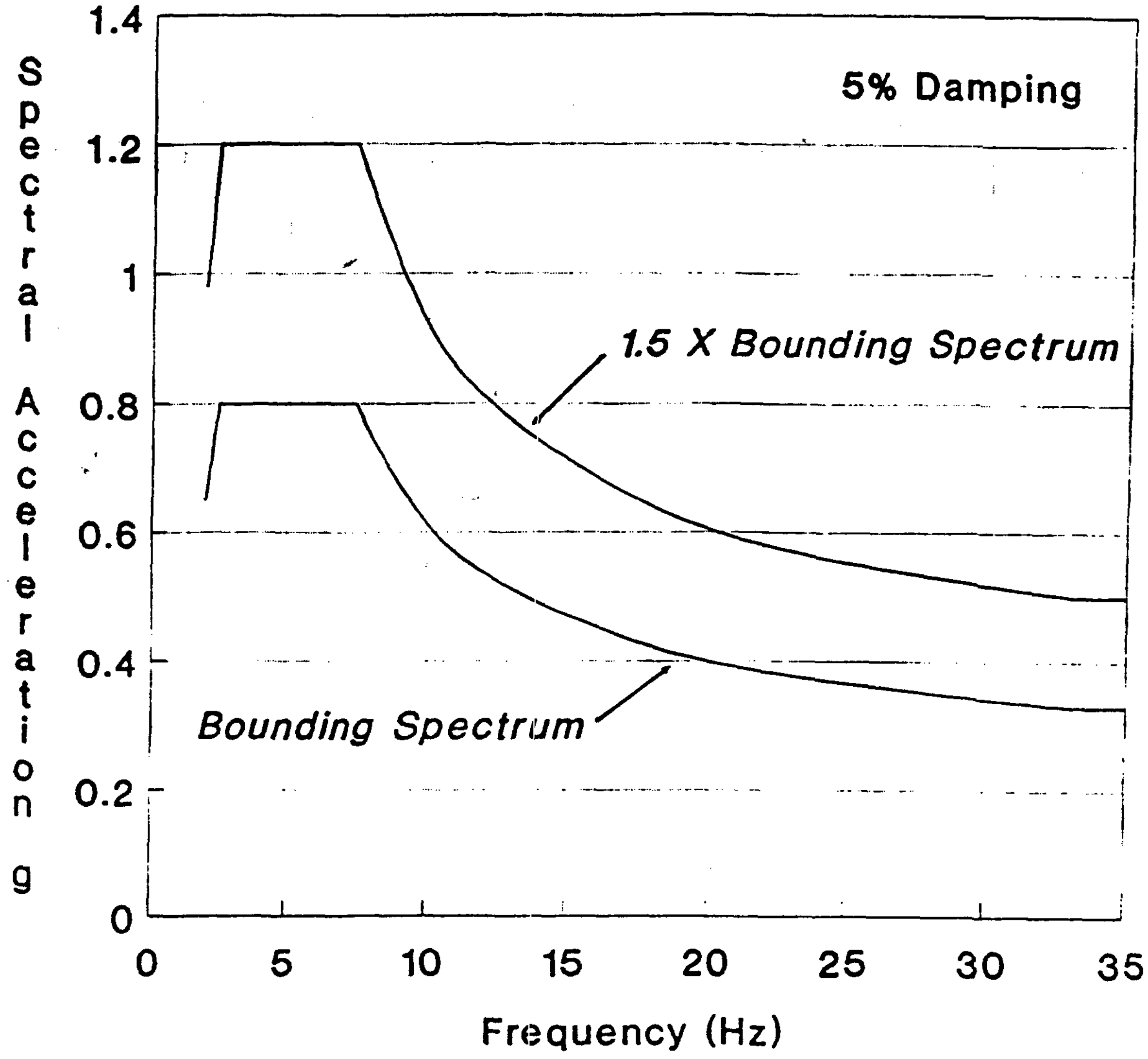

Frequency (Hz)	2.0	2.5	7.5	8.0	10	12	16	20	28	33
1.5 X Bounding Spectrum (g)	.98	1.2	1.2	1.13	.90	.80	.68	.59	.53	.50
Bounding Spectrum (g)	.65	.80	.80	.75	.60	.53	.45	.39	.35	.33

Figure 4-2. Seismic Capacity Bounding Spectrum Based on Earthquake Experience Data (Source: Reference 5)

SOURCE: GIP (REF. 1)

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