EFFECT OF HYDRODYNAMIC LOADS ON SAFETY RELATED EQUIPMENT AND PIPING OUTSIDE CONTAINMENT

TECHNICAL REPORT

prepared by

BURNS AND ROE, INC.

for application to

WASHINGTON PUBLIC POWER SUPPLY SYSTEM

NUCLEAR PROJECT NO. 2

Prepared by: M. N. Fialkow

Reviewed by: M. M. Ettouney

Reviewed by: J. F. O'Donnell

Approved by: B. Bedrosian

Submitted by: J. J. Verderber

Date: 3/N/83

TABLE OF CONTENTS

		PAGE
1.	Introduction	1
2.	Comparison of In-Structure Acceleration Response Spectra	3
3.	Comparison of Peak Building Accelerations	6
4.	Test Results for Peak Building Accelerations	8
5.	Summary and Conclusions	9
6.	References	11

LIST OF FIGURES

FIGURE NO.	TITLE	PAGE
1	Horizontal Acceleration vs. Frequency - El. 567 Original OBE and Revised OBE + SRV	12
2	Horizontal Acceleration vs. Frequency - El. 567 Original SSE and Revised SSE + SRV + Chugging	13
3	Horizontal Acceleration vs. Frequency - El. 435 Original OBE and Revised OBE + SRV	14
4	Horizontal Acceleration vs. Frequency - El. 435 Original SSE and Revised SSE + SRV + Chugging	15
5	Vertical Acceleration vs. Frequency - El. 470 Original OBE and Revised OBE + SRV	16
6	Vertical Acceleration vs. Frequency - El. 470 Original SSE and Revised SSE + SRV + Chugging	17
7	Horizontal Building Accelerations - Peak Values	18
8	Vertical Building Accelerations - Peak Values	19

1. INTRODUCTION

The design for dynamic loads of the piping and equipment located in the reactor building outside primary containment is based on the building response to seismic loads determined using a lumped mass-spring model. Subsequent to this design, building responses due to hydrodynamic loads originating in the wetwell (SRV actuation and chugging) and due to seismic loads were calculated using a finite element model. Hereinafter, the building responses used as the basis of design which were developed with the lumped mass-spring model are referred to by the term "original" and the building responses calculated with the finite element model are referred to by the term "new".

Previous investigations of the hydrodynamic loads (References 1, 2) have indicated that the structural response accelerations in the reactor building outside primary containment caused by these loads are not significant for equipment and piping design. The objective of this report is to provide further quantitative evidence for this position.

In brief, the original design specification relates the basis of dynamic design to the dynamic characteristics of the equipment and the loading. When the fundamental (lowest natural) frequency of the equipment is large enough to qualify the equipment in relation to the dynamic loads as "rigid," the dynamic design depends on the peak building accelerations (horizontal and vertical) at the location of the equipment. Otherwise, the dynamic design depends on the values of the acceleration response spectra corresponding to the natural frequencies of the equipment.

In view of the above, this report includes the following:

a. A comparison of calculated in-structure acceleration response spectra in Section 2.

b. A comparison of calculated peak building response accelerations in Section 3.

c. A summary of in-plant SRV actuation test results for peak building response accelerations in Section 4.

Summary and Conclusions are presented in Section 5 with References in Section 6.

2. COMPARISON OF IN-STRUCTURE ACCELERATION RESPONSE SPECTRA

Comparison of the original seismic response spectra with new comparable response spectra (due to seismic and concurrent hydrodynamic loads) involves consideration of the following cases:

a. Original OBE vs. new (OBE + SRV)

b. Original SSE vs. new (SSE + SRV + chugging)

Structurally, the linkage of the reactor building outside primary containment i.e., of the secondary containment portion of the building, to the primary containment portion of the building is limited: in the horizontal direction this linkage is provided through the basemat and the connection at the stabilizer truss level (Elevation 567) while vertically, only through the basemat. These structural connections are pertinent to the transmission of forces or, more generally, building responses caused by the hydrodynamic loads originating in the wetwell. Consequently, the locations of these connections are representative for building responses caused by hydrodynamic loads.

In line with the preceding, response spectra for the loadings in the above cases are developed for the locations in the reactor building outside containment corresponding to the levels of structural linkage. Horizontal acceleration response spectra are developed at Elevations 567 and 435 and are shown in Figures 1 to 4. Vertical acceleration response spectra are developed at Elevation 470, an elevation close to the base where vertical acceleration data are readily available; the vertical response spectra are shown in Figures 5 and 6. Combination of spectral accelerations due to seismic, SRV actuation and chugging (where applicable) loads, is done by the square root of the sum of the squares method.

Review of these figures shows that the original acceleration response spectra equal or exceed the new comparable spectra except for the vertical direction in a relatively narrow range of frequencies. Attention is directed to specific results discussed below.

a. Horizontal acceleration response spectra - Except for the non-significant frequencies of 1 Hz or less, the original horizontal spectra due to the SSE equal or exceed the new horizontal spectra due to the SSE, SRV actuation, and chugging at all frequencies and at both elevations. Likewise, the original horizontal spectra due to the OBE exceed at all frequencies the new horizontal spectra due to the OBE and SRV actuation.

b. Vertical acceleration response spectra - The original vertical spectrum due to the SSE exceeds the new spectrum due to the SSE, SRV actuation, and chugging at all frequencies except for the non-significant frequencies of 1 Hz or less. Similarly, the original spectrum due to the

OBE exceeds, except at the isolated frequencies of 10 and 11 Hz, the new spectrum due to the OBE and SRV actuation. With regard to the apparent deficiency at 10 and 11 Hz, it is noted that the design vertical load, which includes dead weight effects as well, has a minimum value equal to the gravity (dead) load multiplied by the factor of one plus the original acceleration in g's. Consequently, the design load deficiency at the frequencies of 10 and 11 Hz is less than 7 percent of the original vertical design load. Such a variation is considered to be within the normal design tolerance, i.e., equipment designed for the original OBEloads is adequate to sustain the new loads.

3. COMPARISON OF PEAK BUILDING ACCELERATIONS

Original and new peak building accelerations in the reactor building outside primary containment are compared for the same two cases as in preceding Section 2, namely

a. Original OBE vs. new (OBE + SRV),

b. Original SSE vs. new (SSE + SRV + chugging).

Profiles showing the variation of the peak acceleration with elevation in the building are developed from readily available data for each of the four loadings in the above cases. The profiles of horizontal peak acceleration are shown in Figure 7 and the profiles of vertical peak acceleration are shown in Figure 8.

Review of these figures shows that at all elevations, the original peak building accelerations are greater than the new comparable peak accelerations. Thus, Figure 7 shows that

a. The original horizontal peak accelerations due to OBE exceed the new combined horizontal peak accelerations due to OBE and SRV at all elevations.

b. The original horizontal peak accelerations due to SSE exceed the new combined horizontal peak accelerations due to SSE plus SRV and chugging at all elevations.

Figure 8 demonstrates the same findings with respect to the vertical peak accelerations.

As previously noted, the dynamic design of the general category of relatively rigid equipment is controlled by peak building acceleration. The results of this section demonstrate that the addition of hydrodynamic loads has no impact on the design of such equipment.

4. TEST RESULTS FOR PEAK BUILDING ACCELERATIONS

SRV actuation test programs have been implemented in two foreign BWR plants of Mark II containment configuration. These are the Caorso plant in Italy and the Tokai-2 plant in Japan. The program at the Tokai-2 plant is especially significant as the primary containment at this plant is a steel vessel similar to the one at the subject plant. A description of the test programs and results is given in References 3 to 6. A summary of the maximum test accelerations in the plants is given in the Burns and Roe proprietary technical report (Reference 1).

The maximum building accelerations recorded at the outside building walls at Caorso is equal to 0.007g. Similar results were obtained at Tokai-2. Inasmuch as the subject plant is structurally similar to those at Caorso and Tokai-2, maximum accelerations of the same small order of magnitude are anticipated in the reactor building outside primary containment due to SRV actuation. Such small accelerations are not considered to be significant in design of equipment and piping.

5. SUMMARY AND CONCLUSIONS

The study has investigated comparatively horizontal and vertical response accelerations in the reactor building outside primary containment caused by the original (seismic) and the new (seismic and hydrodynamic - SRV actuation and chugging) loads.

It has been determined that the original acceleration response spectra for the seismic (OBE/SSE) loads exceed the corresponding new spectra for the comparable combinations of seismic (OBE/SSE) plus hydrodynamic loads, except for the vertical direction in a narrow range of frequencies. It is shown that in this range the increase in design load due to addition of hydrodynamic loads is small (less than 7%) and within the normal design tolerance.

Also, the study indicates that the original peak building accelerations due to seismic loads exceed at all elevations the corresponding new peak accelerations due to the comparable combinations of seismic and hydrodynamic loads. It is further noted in the report that peak building accelerations actually recorded during in-plant SRV actuation tests at reactor buildings similar to the reactor building at WPPSS Nuclear Project No. 2 are too small to be considered significant in design of equipment and piping.

Based on these findings, the loadings used for the design of the piping and equipment in the reactor building outside containment, namely the original seismic loads, are effectively more severe than, or at least as severe as, the comparable loadings due to combinations of new seismic and hydrodynamic loads. Consequently, it is not necessary to reanalyze this piping and equipment as to capacity under the latter set of loads.

6. REFERENCES

(1) "SRV Loads - Improved Definition and Application Methodology for Mark II Containments," Technical Report, Proprietary, Burns and Roe, Inc., July 1980.

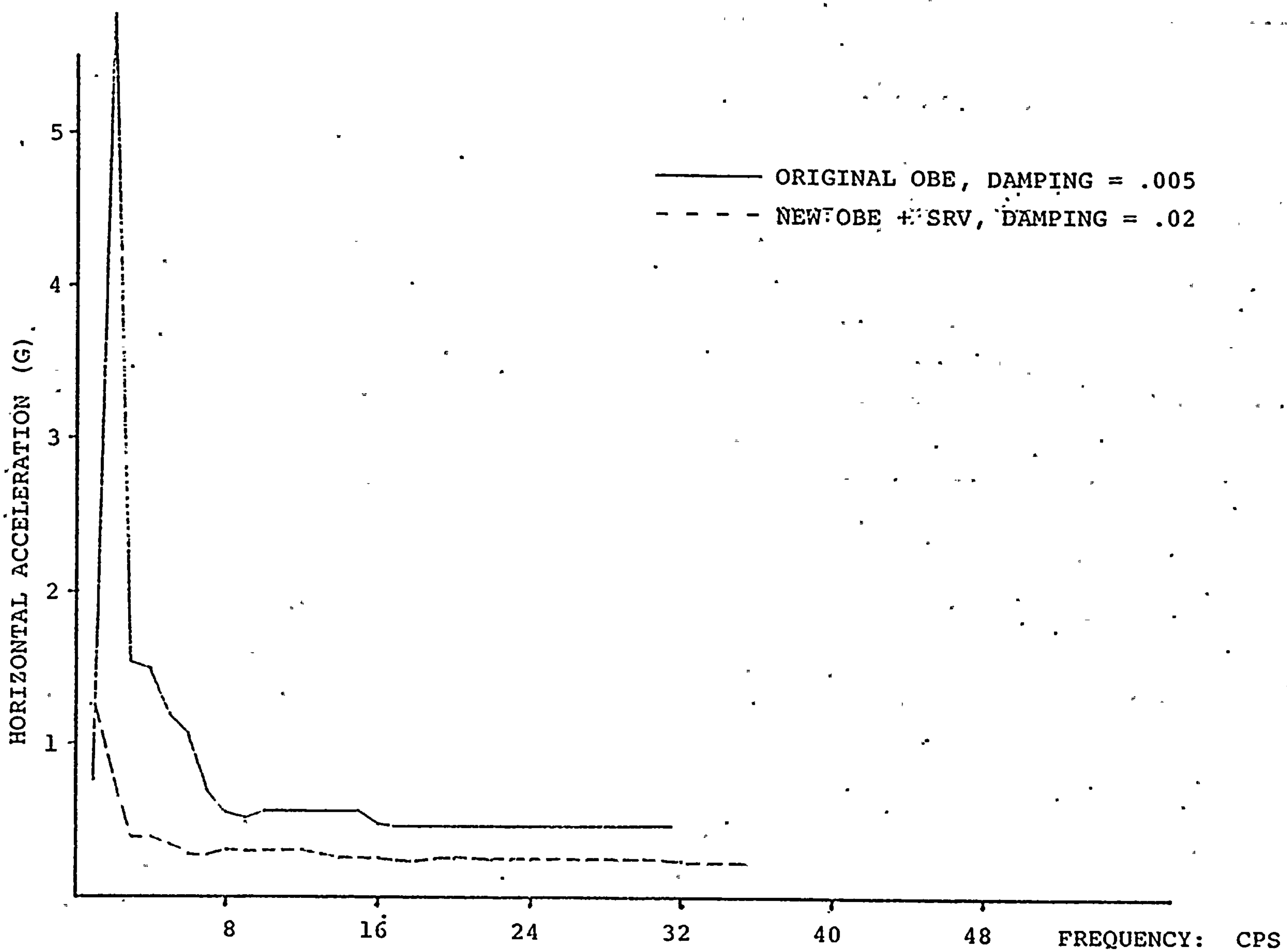
(2) "Chugging Loads - Revised Definition and Application Methodology to Mark II Containments," (Based on 4TCO Test Results), Technical Report, Burns and Roe, Inc., July 1981.

(3) General Electric Company Report, "Caorso SRV Discharge Tests Phase I Test Report," NEDE-25100-P, May 1979.

(4) General Electric Company Report, "Caorso SRV Discharge Tests Phase II ATR Report," NEDE-25118, August 1979.

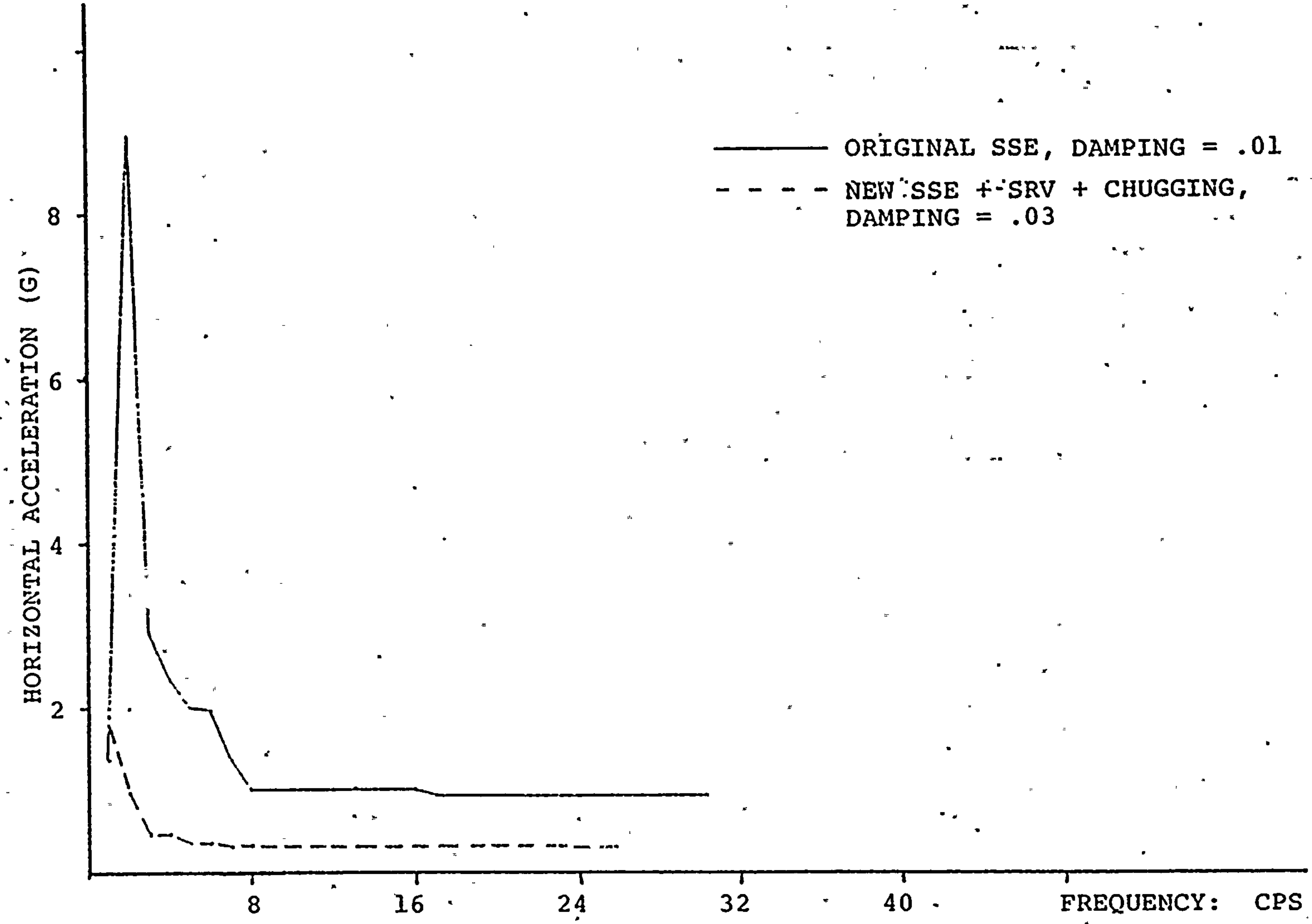
(5) Japan Atomic Power Company, "Tokai-2, Main Steam Safety Relief Valve Operational Test Report," August 1978.

(6) Japan Atomic Power Company, "Reactor Building Response to Actuation of Main Steam Line Safety-Relief Valve(s) at Tokai-2 Nuclear Power Plant," TOK2-RV-0630.



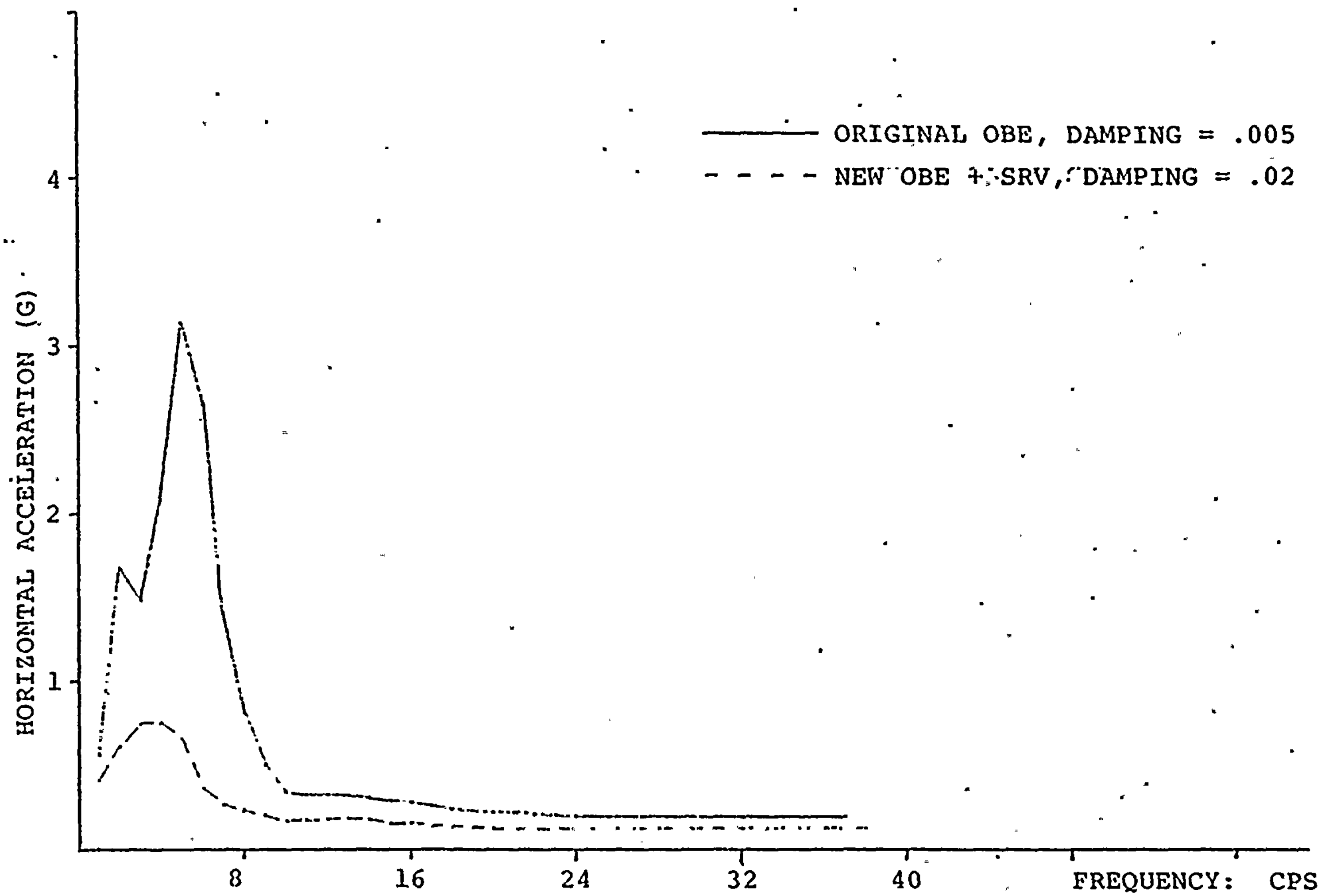
HORIZONTAL ACCELERATION vs. FREQUENCY - EL. 567'
RESPONSE SPECTRA OUTSIDE CONTAINMENT
WPPSS - NUCLEAR PROJECT NO. 2 - REACTOR BUILDING

FIGURE 1



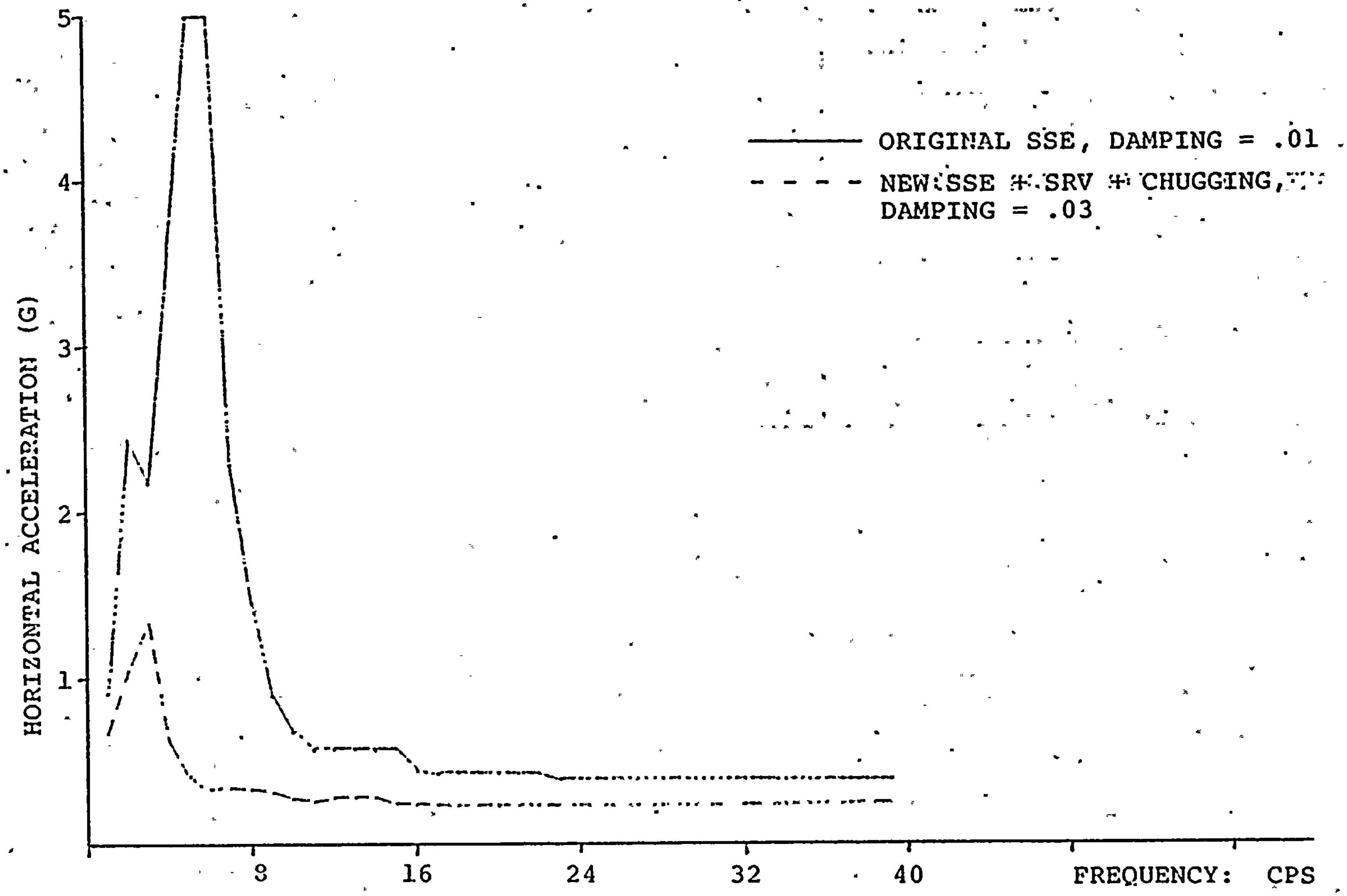
HORIZONTAL FREQUENCY vs. FREQUENCY - EL 567'
RESPONSE SPECTRA OUTSIDE CONTAINMENT
WPPSS - NUCLEAR PROJECT NO. 2 - REACTOR BUILDING

FIGURE 2



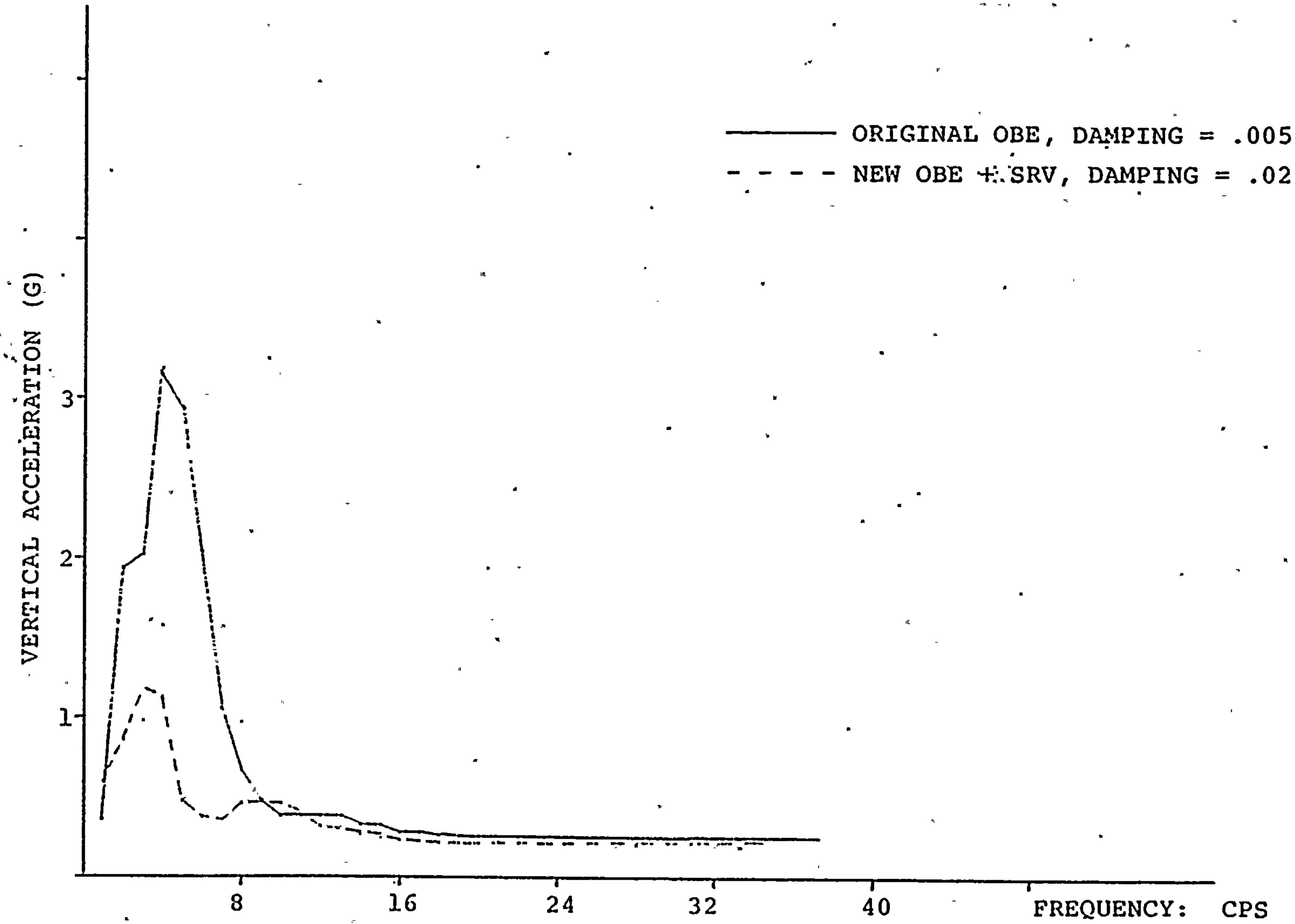
HORIZONTAL ACCELERATION vs. FREQUENCY - EL. 435'
RESPONSE SPECTRA OUTSIDE CONTAINMENT
WPPSS - NUCLEAR PROJECT NO. 2 - REACTOR BUILDING

FIGURE 3

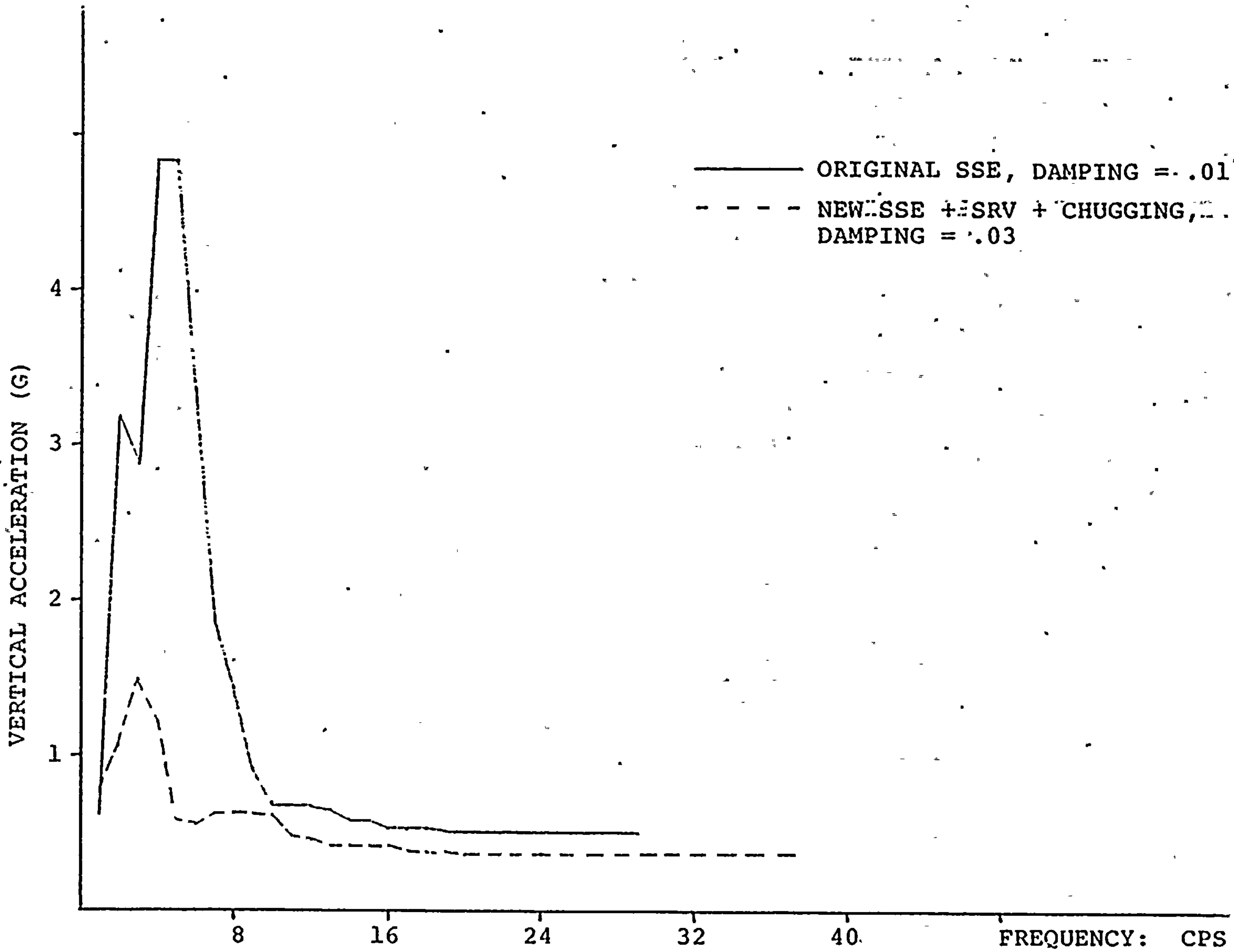


HORIZONTAL ACCELERATION vs. FREQUENCY - EL. 435'
RESPONSE SPECTRA - OUTSIDE CONTAINMENT
WPPSS - NUCLEAR PROJECT NO. 2 - REACTOR BUILDING

FIGURE 4



VERTICAL ACCELERATION vs. FREQUENCY - EL. 470'
RESPONSE SPECTRA OUTSIDE CONTAINMENT
WPPSS - NUCLEAR PROJECT NO. 2 - REACTOR BUILDING
FIGURE 5



VERTICAL ACCELERATION vs. FREQUENCY - EL. 470'
RESPONSE SPECTRA OUTSIDE CONTAINMENT
WPPSS - NUCLEAR PROJECT NO. 2 - REACTOR BUILDING
FIGURE 6

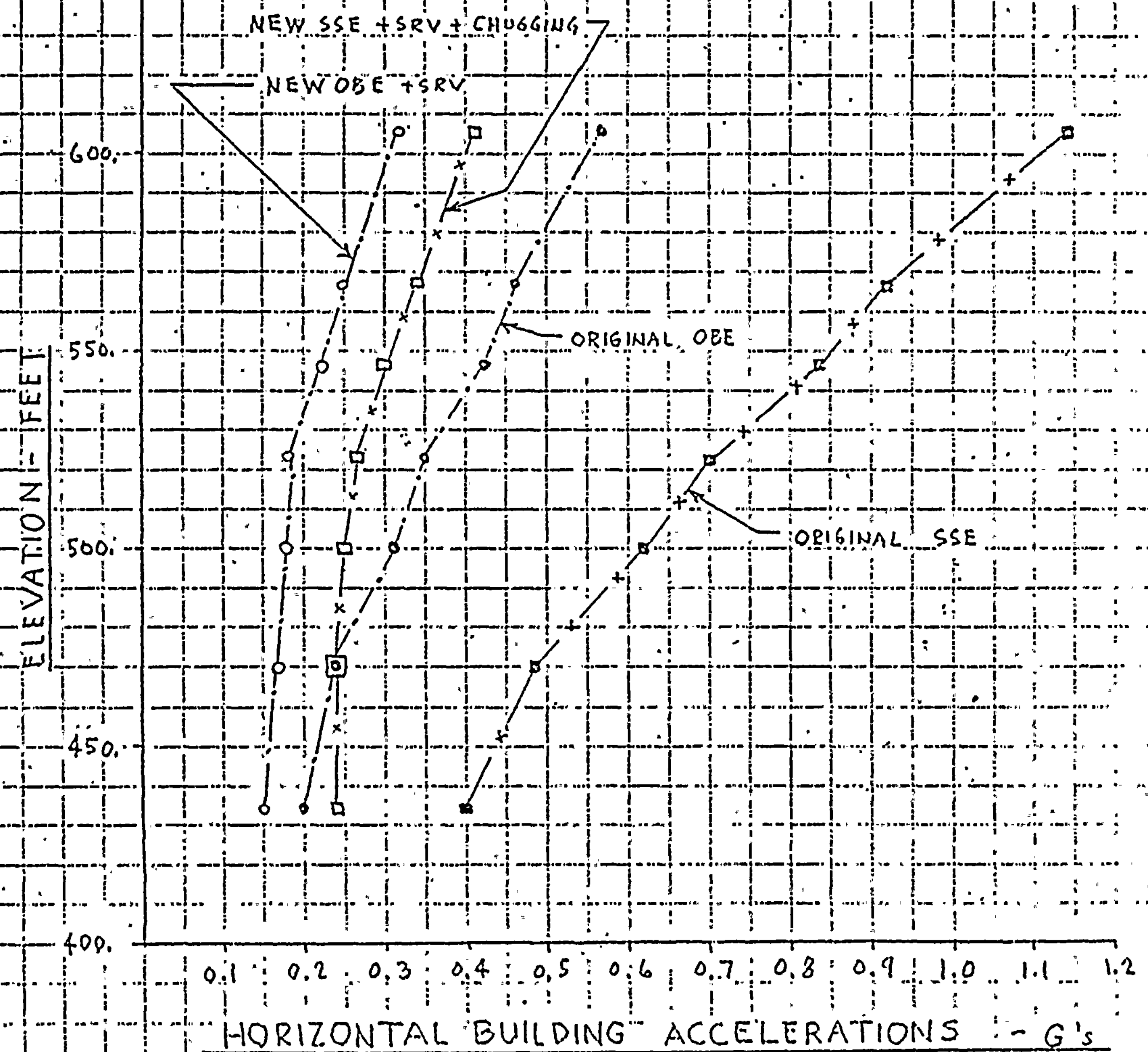
W.O. No. 3900-03 Date [redacted]/22/83 Book No. SV96[redacted] Page No. ____
Drawing No. ____ Calc. No. 6:19-118 Sheet 2 of ____
By MJ Checked ____ Approved ____
Title WPPSS - HANFORD NO. 2 - REACTOR BLDG.

C. SUBJECT: COMPARISON OF PEAK BLDG. ACCELERATIONS OUTSIDE CONTAINMENT

2. PEAK BLDG. RESPONSES: HORIZONTAL ACCELERATIONS

c. PLOTS OF HORIZONTAL ACCELERATIONS

	LEGEND	DAMPING
(1) ORIGINAL OBE	o	.005
(2) COMBINATION OF NEW OBE & SRV	o	.02
(3) ORIGINAL SSE	□	.01
(4) COMBINATION OF NEW SSE, SRV & CHUGGING	□	.03



PEAK VALUES - REACTOR BLDG OUTSIDE CONTAINMENT

FIGURE 7

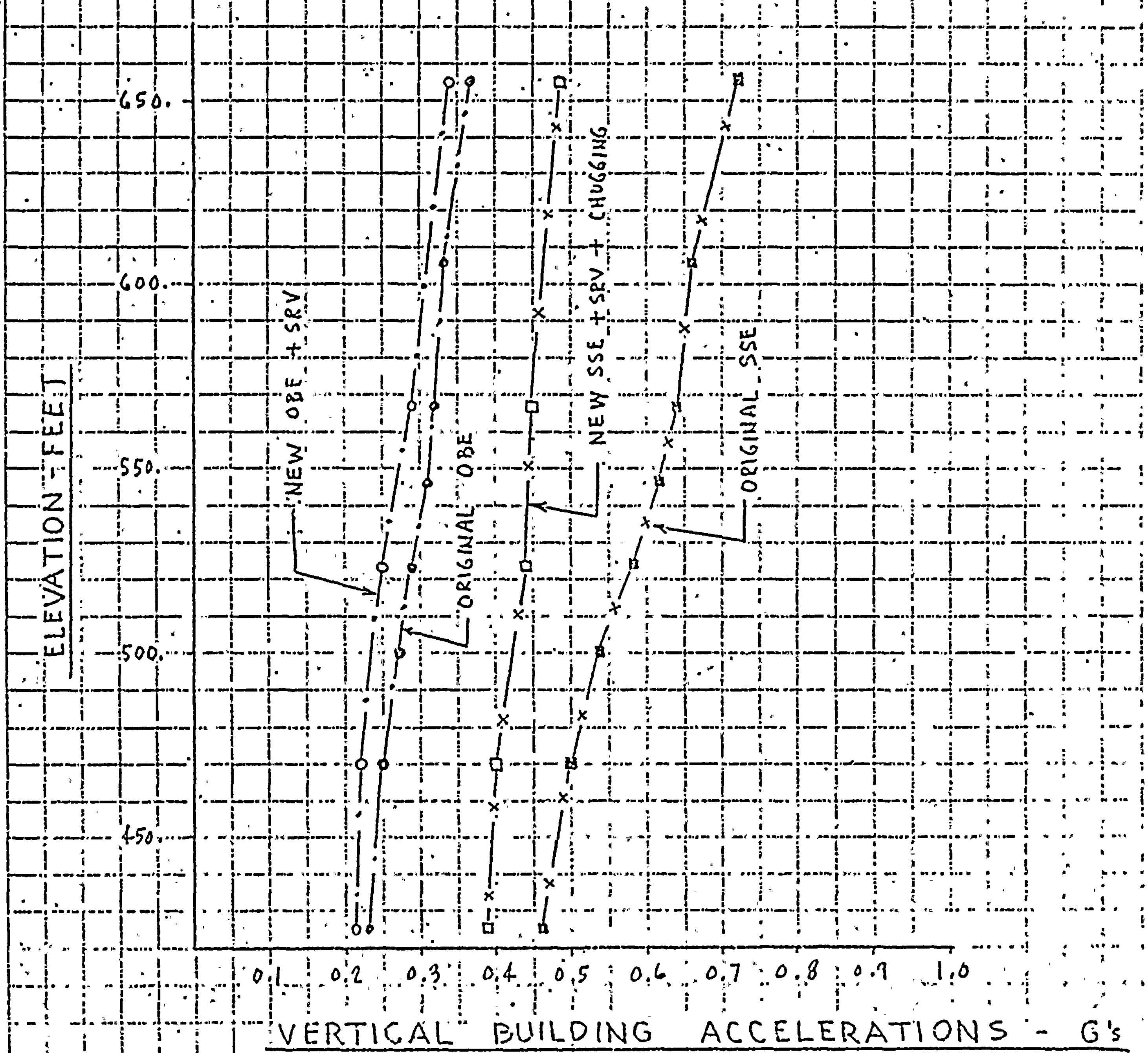
W.O. No. 3900-03 Date [redacted]22/83 Book No. SV96[redacted] Page No.
Drawing No. Calc. No. 6.19-118 Sheet 4 of
By ___ Checked ___ Approved
Title WPPSS- HANFORD NO. 2 - REACTOR BLDG.

C. SUBJECT: COMPARISON OF PEAK BLDG. ACCELERATIONS OUTSIDE CONTAINMENT

3. PEAK BLDG. RESPONSES: VERTICAL ACCELERATIONS

C. PLOTS OF VERTICAL ACCELERATIONS

	LEGEND	DAMPING
(1) ORIGINAL OBE	o	.005
(2) COMBINATION OF NEW OBE & SRV	o	.02
(3) ORIGINAL SSE	⊠	.01
(4) COMBINATION OF NEW SSE, SRV, & CHUGGING	□	.03



PEAK VALUES - REACTOR BLDG OUTSIDE CONTAINMENT

FIGURE 8