PRELIMINARY
ISSUE
Date 10/18/83

VIRGIL C. SUMMER NUCLEAR STATION

SEISMIC CONFIRMATORY PROGRAM

SAMPLE EXAMPLE 2

EQUIPMENT NAME & SYSTEM:		Air Handling Units (HVAC)
EQUIPMENT TAG NUMBER & LOCATION	:	XAH-33 Auxiliary Bldg. El. 463'
EQUIPMENT VENDOR	:	The Bahnson Company
TESTED BY	:	Wyle Laboratories
QUALIFICATION REPORT #	:	IMS-92-3299-0
MARGIN AGAINST ACRS	:	3.7
MARGIN AGAINST ASLB	:	9.5

GILBERT / COMMONWEALTH
P. O. Box 1498
Reading, Pennsylvania 19603

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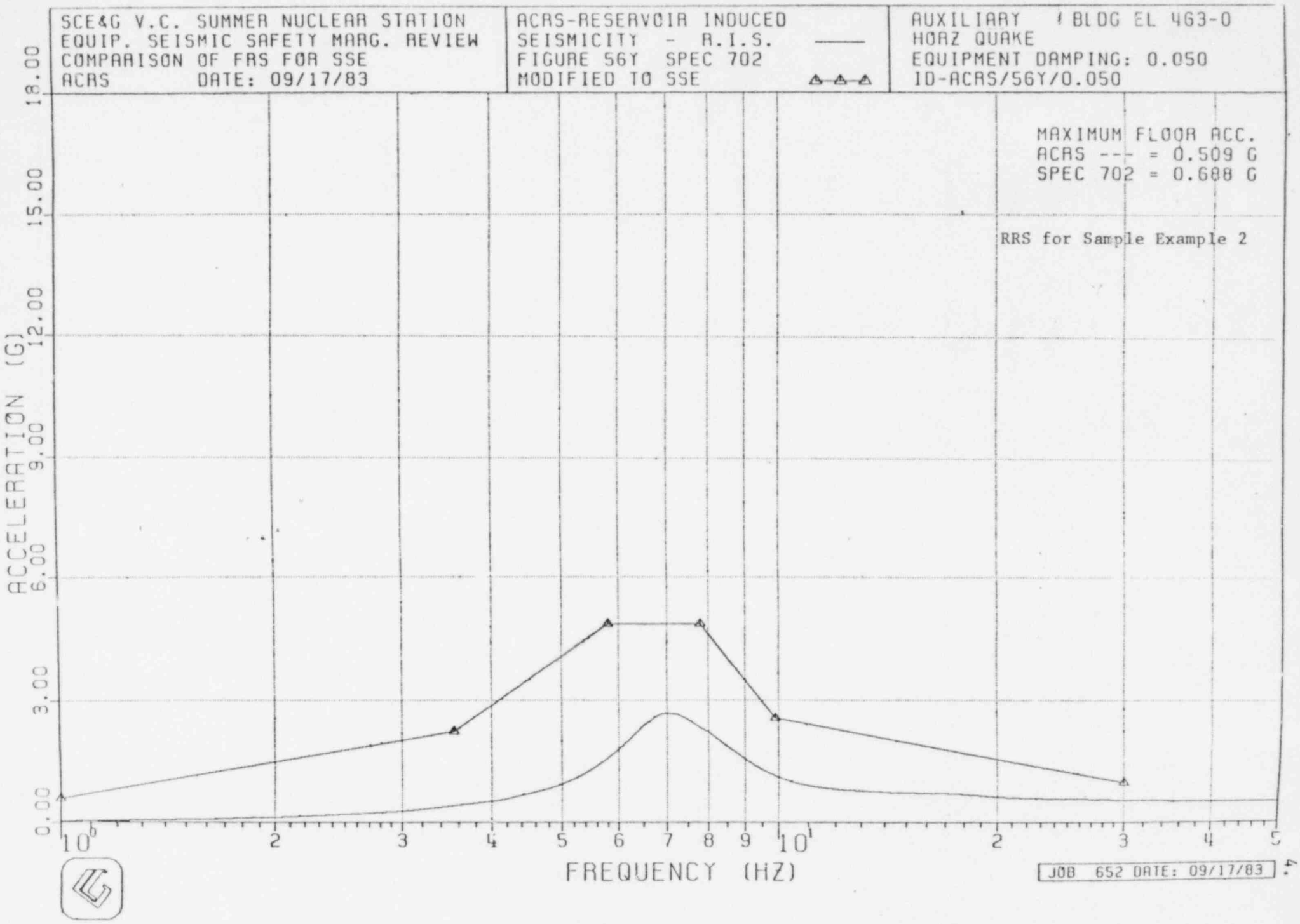
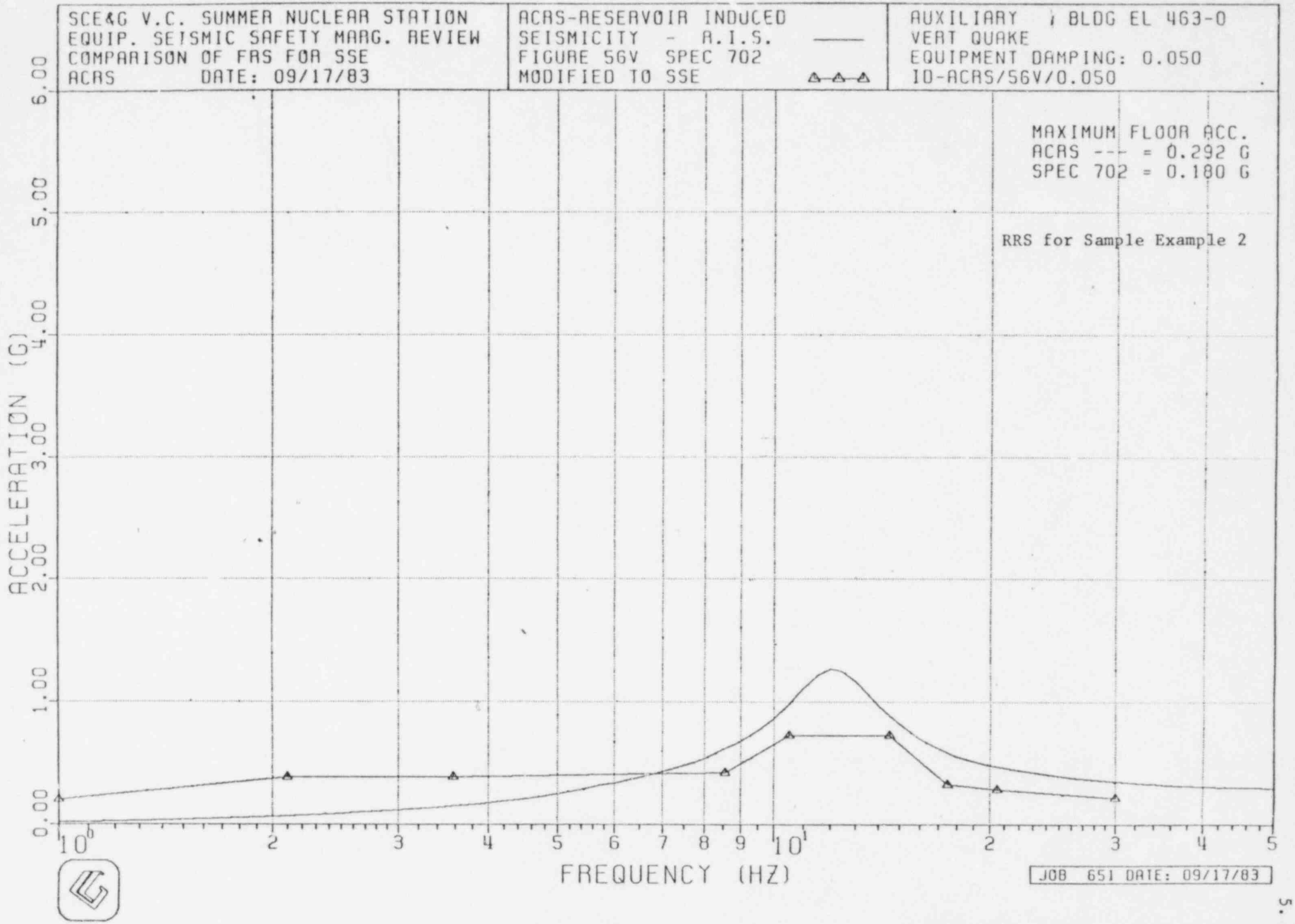
A C R S

REQUIRED RESPONSE SPECTRA (RRS)

SAMPLE EXAMPLE 2

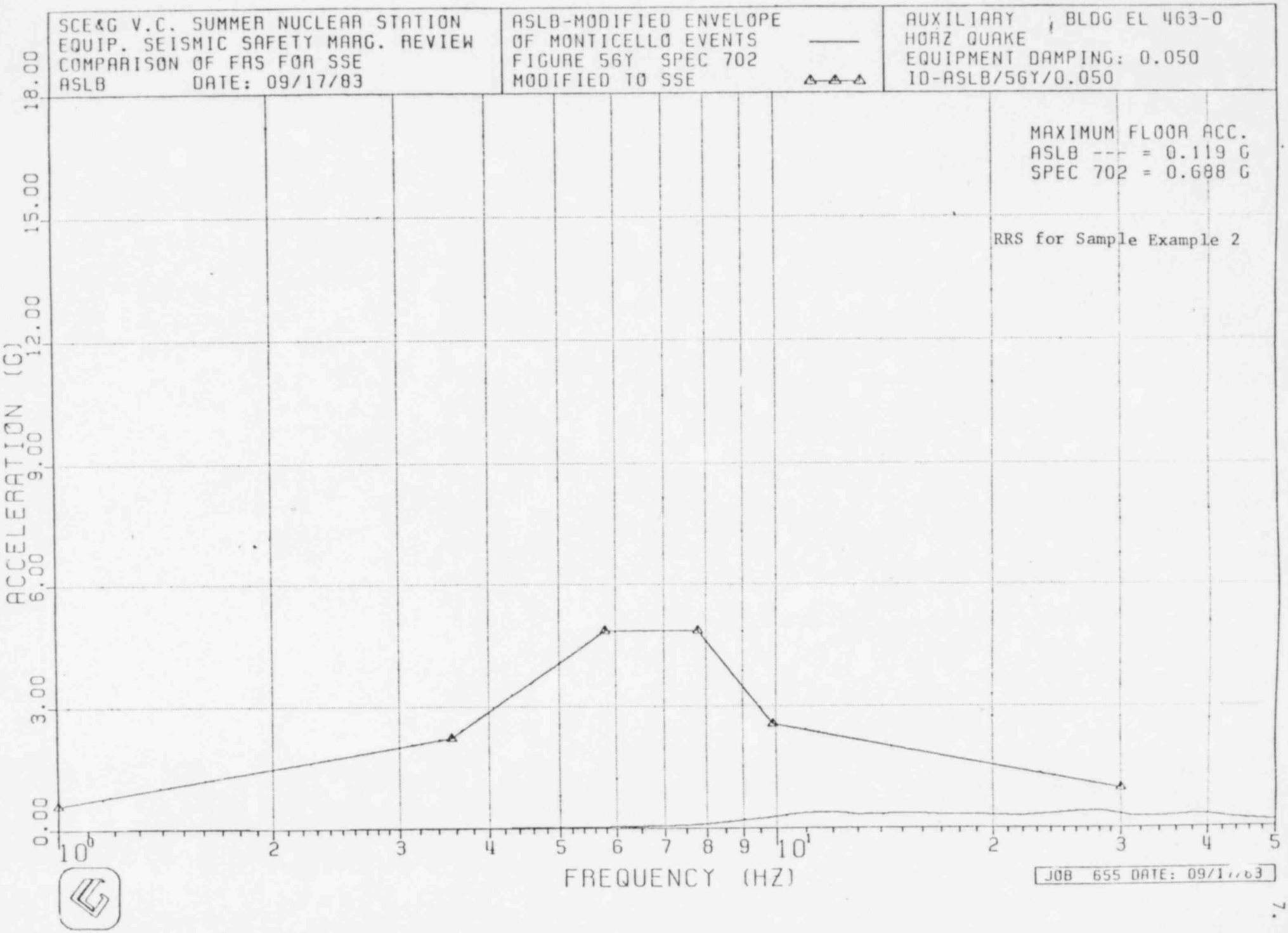

SCE&G V.C. SUMMER NUCLEAR STATION
EQUIP. SEISMIC SAFETY MARG. REVIEW
COMPARISON OF FRS FOR SSE
ACRS DATE: 09/17/83
ACRS-RESERVOIR INDUCED
SEISMICITY - R.I.S. ——
FIGURE 56Y SPEC 702
MODIFIED TO SSE △-△-△
AUXILIARY # BLDG EL 463-0
HORZ QUAKE
EQUIPMENT DAMPING: 0.050
ID-ACRS/56Y/0.050
MAXIMUM FLOOR ACC.
ACRS --- = 0.509 G
SPEC 702 = 0.688 G
RRS for Sample Example 2
ACCELERATION (G)
0.00
3.00
6.00
9.00
12.00
15.00
18.00
10^0
2
3
4
5
6
7
8
9
10^1
2
3
4
5
FREQUENCY (HZ)
JOB 652 DATE: 09/17/83

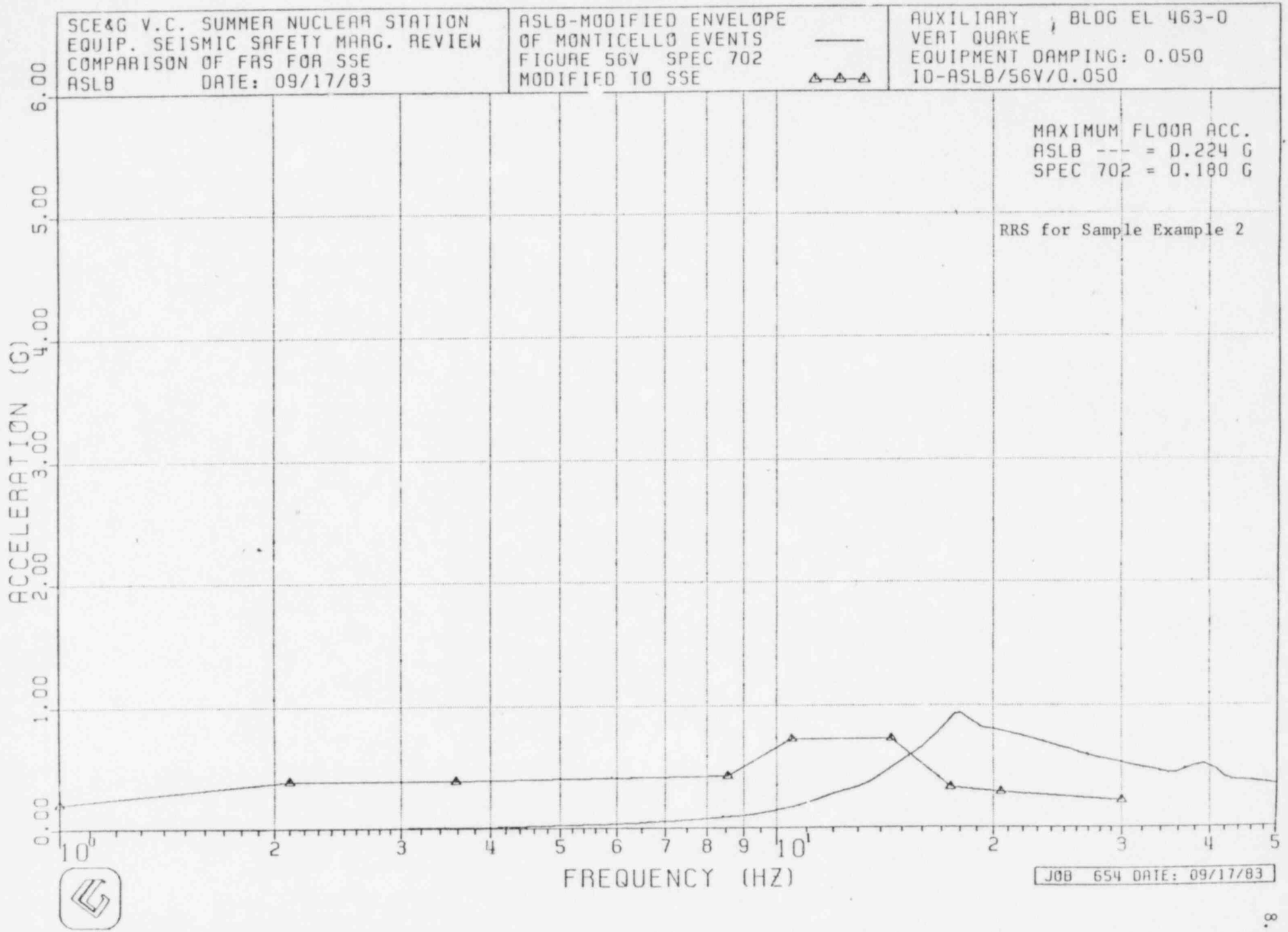

SCE&G V.C. SUMMER NUCLEAR STATION
EQUIP. SEISMIC SAFETY MARG. REVIEW
COMPARISON OF FRS FOR SSE
ACRS DATE: 09/17/83
ACRS-RESERVOIR INDUCED
SEISMICITY - A.I.S.
FIGURE 56V SPEC 702
MODIFIED TO SSE
AUXILIARY BLDG EL 463-0
VERT QUAKE
EQUIPMENT DAMPING: 0.050
ID-ACRS/56V/0.050
MAXIMUM FLOOR ACC.
ACRS --- = 0.292 G
SPEC 702 = 0.180 G
RRS for Sample Example 2
ACCELERATION (G)
0.00
1.00
2.00
3.00
4.00
5.00
6.00
FREQUENCY (HZ)
JOB 651 DATE: 09/17/83

A S L B

REQUIRED RESPONSE SPECTRA (RRS)

SAMPLE EXAMPLE 2


SCE&G V.C. SUMMER NUCLEAR STATION
EQUIP. SEISMIC SAFETY MARG. REVIEW
COMPARISON OF FRS FOR SSE
ASLB DATE: 09/17/83
ASLB-MODIFIED ENVELOPE
OF MONTICELLO EVENTS
FIGURE 56Y SPEC 702
MODIFIED TO SSE
AUXILIARY BLDG EL 463-0
HORZ QUAKE
EQUIPMENT DAMPING: 0.050
ID-ASLB/56Y/0.050
MAXIMUM FLOOR ACC.
ASLB --- = 0.119 G
SPEC 702 = 0.688 G
RRS for Sample Example 2
ACCELERATION (G)
0.00
3.00
6.00
9.00
12.00
15.00
18.00
FREQUENCY (HZ)
JOB 655 DATE: 09/17/83


SCE&G V.C. SUMMER NUCLEAR STATION
EQUIP. SEISMIC SAFETY MARG. REVIEW
COMPARISON OF FRS FOR SSE
ASLB DATE: 09/17/83
ASLB-MODIFIED ENVELOPE OF MONTICELLO EVENTS
FIGURE 56V SPEC 702
MODIFIED TO SSE
AUXILIARY BLDG EL 463-0
VERT QUAKE
EQUIPMENT DAMPING: 0.050
10-ASLB/56V/0.050
MAXIMUM FLOOR ACC.
ASLB --- = 0.224 G
SPEC 702 = 0.180 G
RRS for Sample Example 2
ACCELERATION (G)
0.00
1.00
2.00
3.00
4.00
5.00
6.00
10
2
3
4
5
6
7
8
9
10
2
3
4
5
FREQUENCY (HZ)
JOB 654 DATE: 09/17/83

RELEVANT SEISMIC QUALIFICATION

REPORT INFORMATIONS FROM

SEISMIC QUALIFICATION REPORT

NO. 1MS-92-3229-0

IMS-92-3247-0

SEISMIC ANALYSIS REPORT

of

AIR HANDLING UNITS

for

VIRGIL C. SUMMER NUCLEAR STATION - UNIT 1

SOUTH CAROLINA ELECTRIC & GAS COMPANY

GILBERT ASSOCIATES
SP-622-044461-000

Report Date June 1, 1978 R1
CCL Report Number A-114-77-01 R1
CCL Project Number 76-1271
Bahnson S.O. No. N055-122

By _____
David W. Lindley
CORPORATE CONSULTING AND
DEVELOPMENT COMPANY, LTD.

NORTH CAROLINA REGISTERED SEAL 5605 ENGINEER DR. JOHN ROLAND YOW

Checked By _____
Dr. J. Roland Yow, P.E.
CORPORATE CONSULTING AND
DEVELOPMENT COMPANY, LTD.

Approved By _____
THE BAHNSON COMPANY

Prepared By
CORPORATE CONSULTING AND DEVELOPMENT COMPANY, LTD.
Koger Executive Center Raleigh, North Carolina

for

THE BAHNSON COMPANY
WINSTON-SALEM, NC

GILBERT ASSOC., INC. W.O. No.
DATE 2-3-78 REV

1. INTRODUCTION

The Safety Class Air Handling Units for the Virgil C. Summer Nuclear Station - Unit 1 for South Carolina Electric and Gas Company have been seismically qualified by a combination of analysis and testing. The equipment covered by this Seismic Qualification Report (SQR) is:

AIR HANDLING UNIT NO.

XAH-1A-VL
XAH-1B-VL
XAH-2-VL
XAH-4A-VL
XAH-4B-VL
XAH-6-VL
XAH-8-VL
XAH-9A-VL
XAH-9B-VL
XAH-11A-VL
XAH-11B-VL
XAH-12A-AH
XAH-12B-AH
XAH-13A-AH
XAH-13B-AH
XAH-19A-VL
XAH-19B-VL
XAH-24A-AH
XAH-24B-AH
XAH-32-VL
XAH-33-VL

Unit layout drawings for the units listed above are shown in Figures 1.1 through 1.28.

5.0 TEST REQUIREMENTS

5.1 Specimen Mounting

The specimens, as described below, premounted in a Corporate Consulting-fabricated test fixture, shall be installed on the Wyle Multiaxis Seismic Simulator Table. The test fixture shall be welded to the test table. The specimens shall be initially oriented such that their longitudinal axes are colinear with that of the test table. The test fixture shall be rotated 90 degrees for the second axis of testing. The mountings shall simulate as closely as practical their actual in-service mountings.

Item Number	Description
1	Balancing Damper, Airfoil Blade
2	Modulating Damper, Single Leaf Blade
3	Backdraft Damper, Air Foil Blade
4	Grill, Type D, Double Core
5	Grill, Type D, Single Core
6	Collecto Vee Filter
7	Limit Switch, Model [illegible]S1
8	Damper Operator, Model JSD3244-4
9	Damper Operator, Model JSD3153-5
10	Damper Operator, Model BSDDA with a Model #349 Pilot Positioner and a Model #369A Positioner Relay
11	Solenoid Valves (2)

The Balancing Damper shall be preset to an approximate 45-degree throttling position and locked in place using the manual locking quadrant. A 3/8-inch diameter bungee cord shall have one end attached to the center of one blade and the other end attached to the test table to simulate a 45-pound air load.

5.2 Resonant Search

A low-level (approximately 0.2 g horizontally and vertically) biaxial sine sweep shall be performed to establish resonances in both the longitudinal/vertical and the lateral/vertical test orientations. The sweep rate shall be one octave per minute over the frequency range of 1 Hz to 35 Hz.

5.3 Multifrequency Tests

The specimens shall be subjected to 30-second duration simultaneous horizontal and vertical phase incoherent inputs of random motion consisting of frequency bandwidths spaced one-third octave apart over the range of 1.0 Hz to 40 Hz as necessary to envelope the Required Response Spectra (RRS). The amplitude of each one-third octave frequency shall be independently adjusted in each axis until the Test Response Spectra (TRS) envelope the RRS. The control accelerometers shall be recorded

5.0 TEST REQUIREMENTS (Continued)

5.3 Multifrequency Tests (Continued)

FM tape and oscillograph recorders. The resulting table motion shall be analyzed by a spectrum analyzer at a damping of one percent (1%) and plotted at one-third octave frequency intervals over the frequency range of interest.

Five (5) Operating Basis Earthquake (OBE) tests, followed by a full-level Safe Shutdown Earthquake (SSE) test, shall be performed in both the lateral/vertical and the longitudinal/vertical orientations. The OBE test levels shall be two-thirds of the SSE levels. The SSE RRS are as shown in Figures 1 and 2.

5.4 Specimen Response

Twelve (12) specimen response accelerometers shall be located on the specimens under test. The placement of the accelerometers shall be at the discretion of the Corporate Consulting Technical Representative. FM tape and oscillograph recorders shall provide a record of each accelerometer response during the test program. The TRS plots of the specimen response accelerometers from an SSE multifrequency test in each test orientation analyzed at one percent (1%) damping shall be provided. Transmissibility plots of the specimen accelerometers for the resonant search test in each orientation shall be provided.

5.5 Strain

Three (3) uniaxial strain gages shall be installed on the specimens in areas determined by the Corporate Consulting Technical Representative. The outputs from the strain gages shall be recorded on an oscillograph recorder during the simulated seismic test program and the maximum specimen strain from a full-level multifrequency test in each orientation shall be included in the test report.

5.6 Electrical Powering

Electrical power of 115 VAC, 60 Hz, single-phase, shall be provided for operation of the Solenoid Valves prior to, during and after the simulated seismic test program.

5.7 Functional Tests

The Modulating Damper shall have 20 psi control air applied to the Damper Operator to cycle the Damper to the open and closed positions prior to, during and after the simulated seismic excitation.

6.0 TEST PROCEDURES AND RESULTS

6.1 Specimen Mounting Procedures

The specimens, as described in Paragraph 5.0 and shown in Photographs 1 through 6, premounted in a Corporate Consulting-fabricated test fixture, were installed on the Wyle Multiaxis Seismic Simulator Table. The test fixture was welded to the test table such that the specimens were oriented in the longitudinal axis colinear with that of the test table (Photographs 1 and 2). The test fixture was rotated 90 degrees for the second axis of testing (Photograph 3). The mountings simulated as closely as practical their actual in-service mountings.

The Balancing Damper was preset to an approximate 45-degree throttling position and locked in place using the manual locking quadrant. A 3/8-inch diameter bungee cord was attached to the center of one blade and the other end attached to the test table (Photograph 1) to simulate a 45-pound air load.

6.2 Resonant Search Procedures

A low-level (approximately 0.2 g horizontally and vertically) biaxial sine sweep was performed to establish resonances in both the longitudinal/vertical and the lateral/vertical test orientations. The sweep rate was one octave per minute over the frequency range of 1 Hz to 35 Hz.

6.2.1 Resonant Search Results

Table I contains the test run descriptions and the input accelerations.

The transmissibility plots of the specimen response accelerometers from the resonant search tests are presented in Appendix I.

6.3 Multifrequency Test Procedures

The specimens were subjected to 30-second duration simultaneous horizontal and vertical inputs of random motion consisting of frequency bandwidths spaced one-third octave apart over the range of 1.0 Hz to 40 Hz as necessary to envelope the RRS. The amplitude of each one-third octave frequency was independently adjusted in each axis until the TRS enveloped the RRS. The control accelerometers were recorded on tape and oscillograph recorders. The resulting table motion was analyzed by a spectrum analyzer at a damping of one percent (1%) and plotted at one-third octave frequency intervals over the frequency range of interest.

Five (5) OBE (two-thirds-level SSE) tests, followed by a full-level SSE test, were performed in both the lateral/vertical and the longitudinal/vertical orientations. The SSE RRS are as shown in Figures 1 and 2.

6.0 TEST PROCEDURES AND RESULTS (Continued)

6.3.1 Multifrequency Test Results

It was demonstrated that the specimens possessed sufficient integrity to withstand, without compromise of structures, the prescribed simulated seismic environment.

TRS plots of the control accelerometers from one of the OBE tests and the SSE test in each orientation are presented in Appendix II.

6.4 Specimen Response Procedures

Twelve (12) specimen response accelerometers were located on the specimens under test as shown in Photographs 6 through 11 and described in Table II. FM tape and oscillograph recorders provided a record of each accelerometer response during the test program. The placement of the accelerometers was at the discretion of the Corporate Consulting Technical Representative.

6.4.1 Specimen Response Results

The transmissibility plots of the specimen response accelerometers from the resonant search tests are presented in Appendix I.

The TRS plots of the specimen response accelerometers from the SSE test in each orientation are presented in Appendix II.

6.5 Strain Procedures

Three (3) uniaxial strain gages were installed on the specimens (Photogr[illegible] 3 and 12 through 14) in areas determined by the Corporate Consulting Techn Representative. The outputs from the strain gages were recorded on an oscillograph recorder during the simulated seismic test program.

6.5.1 Strain Results

The maximum strain (microinches/inch) from the SSE test in each orientatio was as follows:

Test No.	Axes	SG1	SG2	SG3
11	Longitudinal/Vertical	50	250	225
20	Lateral/Vertical	75	550	500

6.6 Electrical Powering Procedures

Electrical power of 115 VAC, 60 Hz, single-phase, was provided for operation of the Solenoid Valves prior to, during and after the simulated seismic test program.

6.0 TEST PROCEDURES AND RESULTS (Continued)

6.7 Functional Test Procedures

20 Psi control air was applied to the Damper Operator to cycle the Modulating Damper to the open and closed positions prior to, during and after the simulated seismic excitation.

6.7.1 Functional Test Results

It was demonstrated that the specimens possessed sufficient integrity to withstand, without compromise of functions, the prescribed seismic excitation.

TABLE I

TEST RUN DESCRIPTIONS AND INPUT ACCELERATIONS

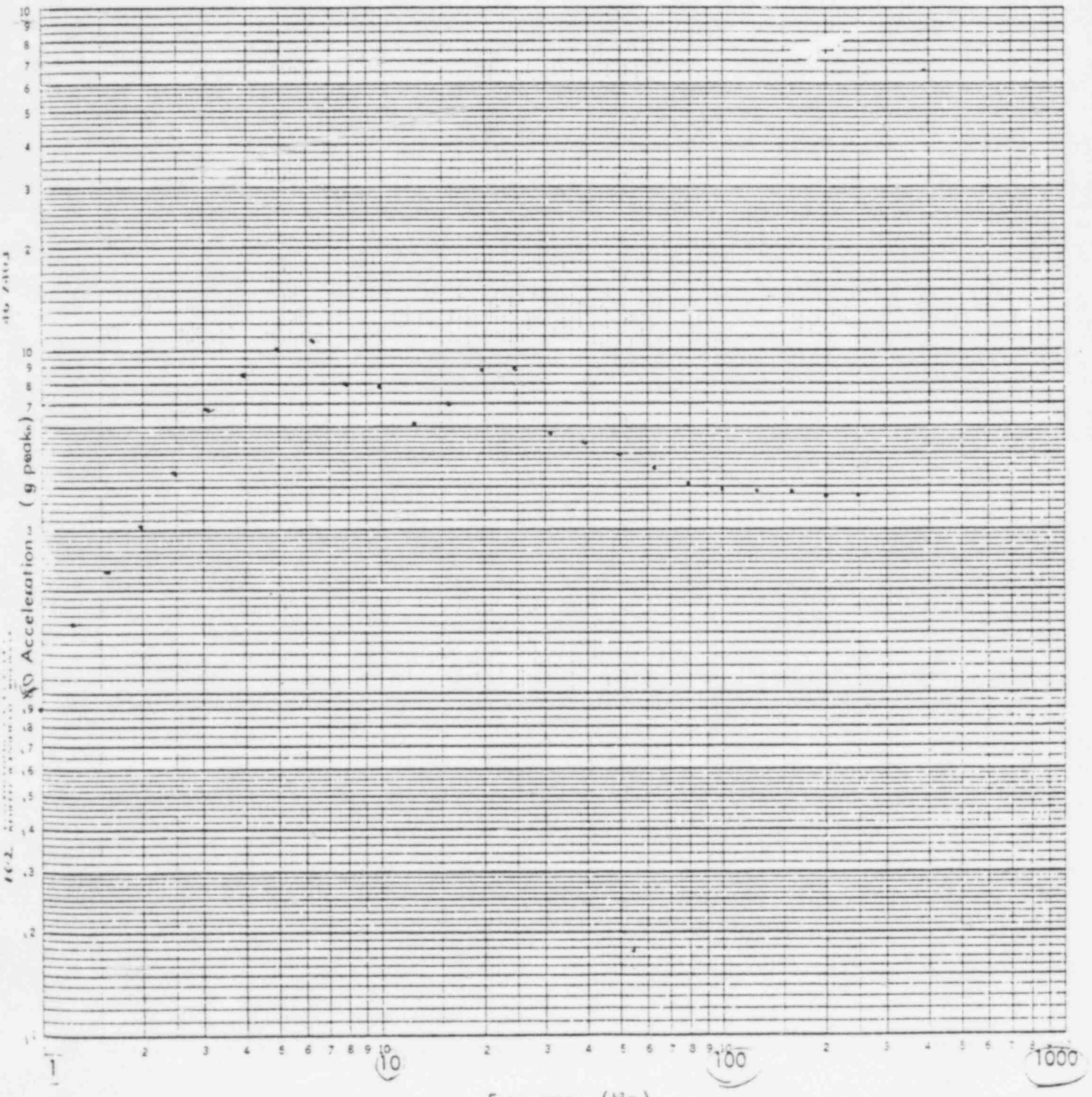
TEST NUMBER	AXES	INPUT (g) HZPA	INPUT (g) VZPA	COMMENTS
1	Long/Vert	---	---	Resonant Search 1-35 Hz, .2 g input
2	Long/Vert	3.27	2.75	< OBE
3	Long/Vert	3.75	1.90	< OBE
4	Long/Vert	3.74	2.45	OBE
5	Long/Vert	3.72	2.50	OBE
6	Long/Vert	3.80	2.55	OBE
7	Long/Vert	3.70	3.35	OBE
8	Long/Vert	3.64	2.80	OBE
9	Long/Vert	3.68	3.59	< SSE
10	Long/Vert	3.79	3.74	< SSE
11	Long/Vert	3.80	3.80	SSE
12	Lat/Vert	---	---	Resonant Search 1-35 Hz, .2 g input
13	Lat/Vert	4.60	2.70	OBE
14	Lat/Vert	---	---	Shut down 2 seconds into Run
15	Lat/Vert	3.94	2.70	OBE
16	Lat/Vert	4.57	2.40	OBE
17	Lat/Vert	4.04	2.42	OBE
18	Lat/Vert	4.34	4.45	OBE
19	Lat/Vert	4.24	3.62	< SSE
20	Lat/Vert	4.00	3.60	SSE

LEGEND:
HZPA = Horizontal Zero Period Acceleration
VZPA = Vertical Zero Period Acceleration
Long = Longitudinal
Vert = Vertical
OBE = Operating Basis Earthquake
SSE = Safe Shutdown Earthquake

FULL SCALE SHOCK SPECTRUM (g Peak)

1.0 ☐ 10 ☐ 100 ☒ 1000 ☐

DAMPING [5%]



AXIS Long/VERT.

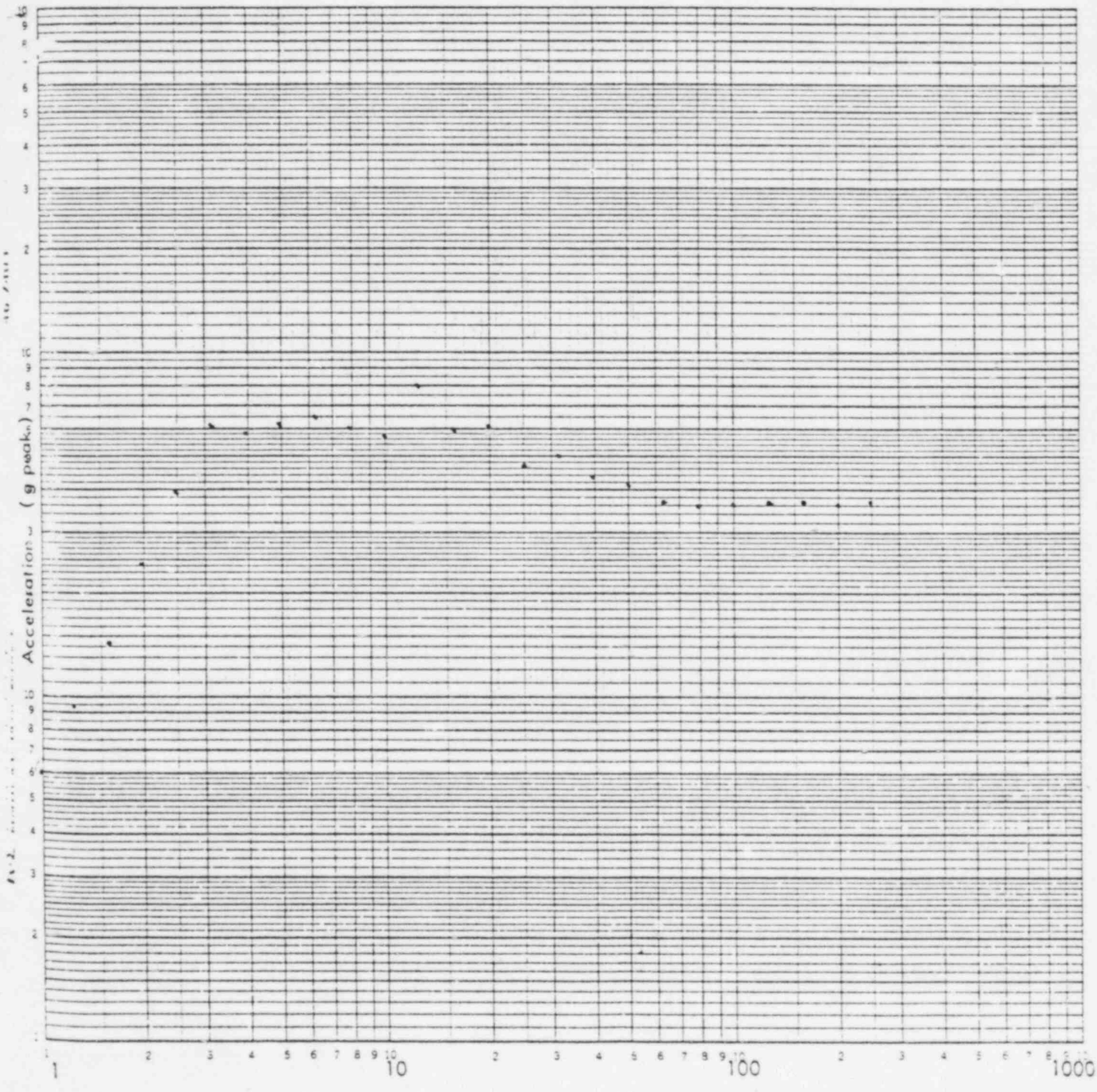
LOCATION NO. HCA

TEST RUN NO. 11

FULL SCALE SHOCK SPECTRUM (g Peak)

1.0 ☐ 10 ☐ 100 ☒ 1000 ☐

DAMPING 5 %



AXIS LONG/VERT

LOCATION NO. VCA

TEST RUN NO. 11

FULL SCALE SHOCK SPECTRUM (g Peak)

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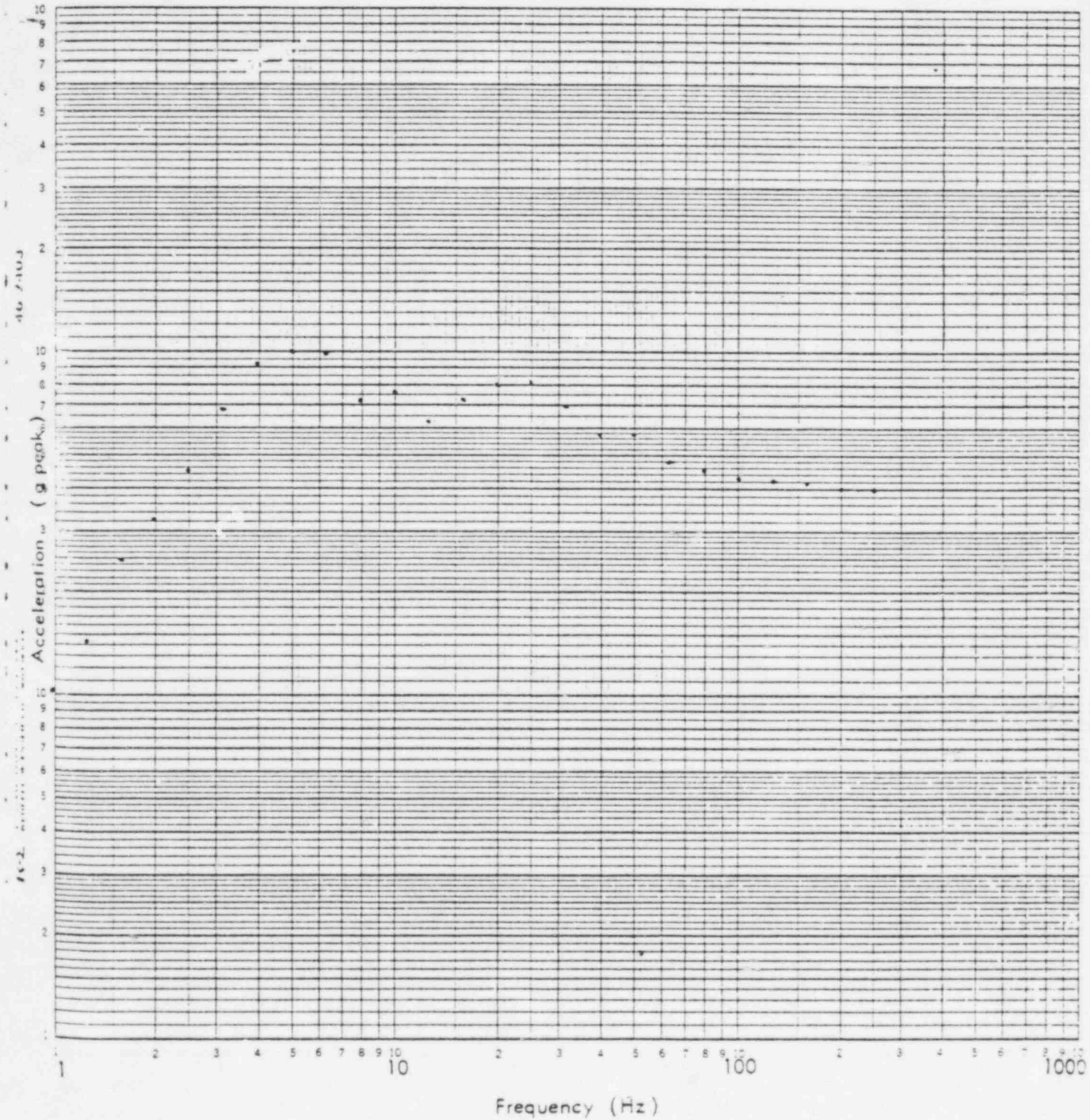
DAMPING [5 %]



AXIS LAT / VERT

LOCATION NO. HCP

TEST RUN NO. 20

FULL SCALE SHOCK SPECTRUM (g Peak)

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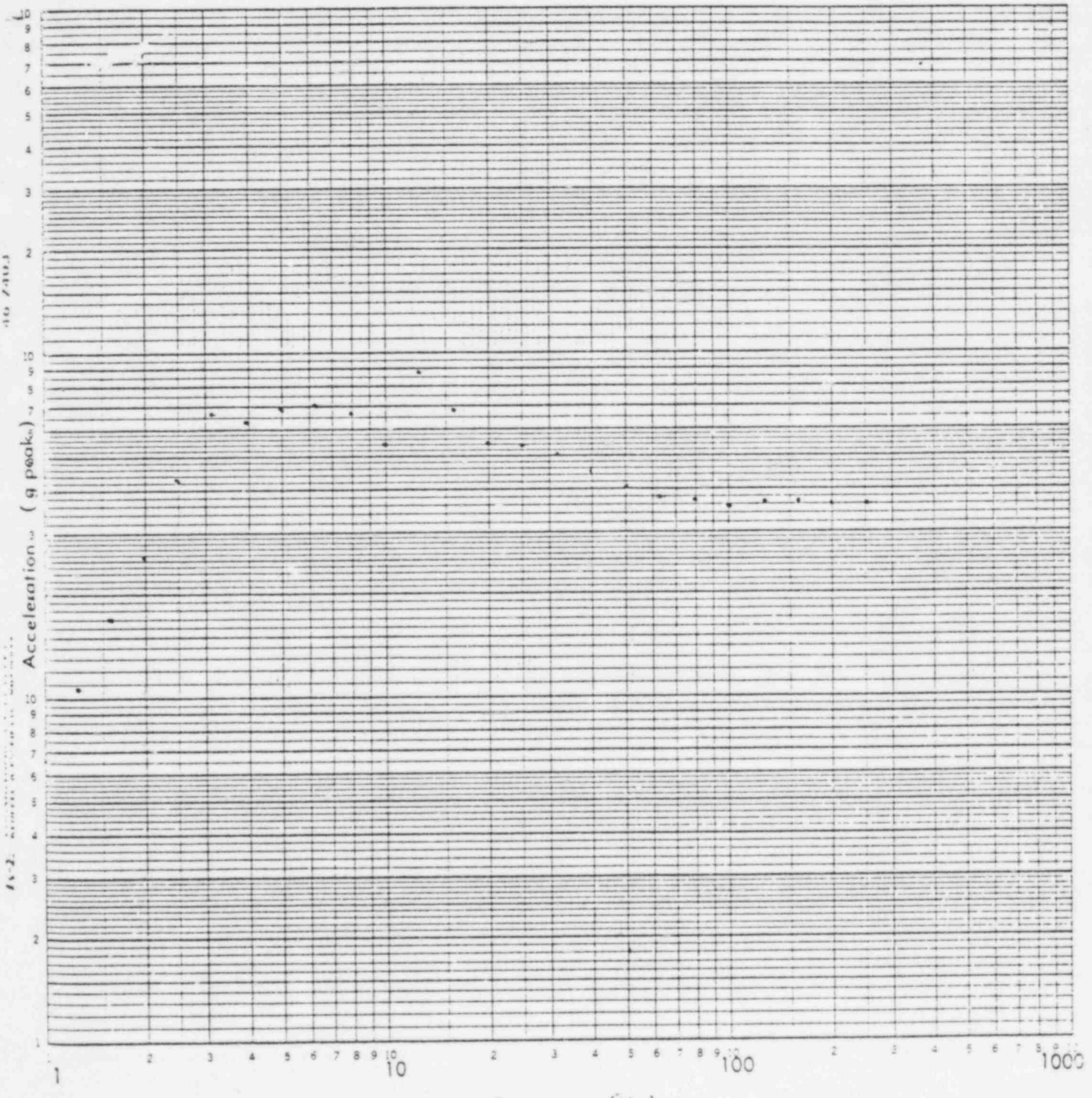
DAMPING 5 %



AXIS LAT/VERT

LOCATION NO. VCN

TEST RUN NO. 20

COMPARISON PLOTS

OF

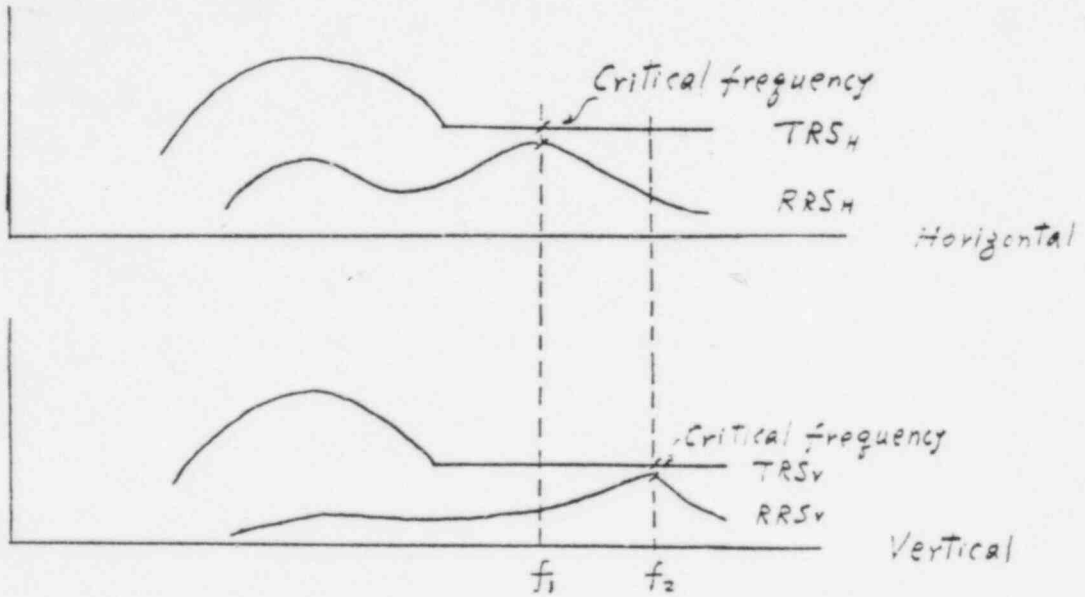
TRS AND RRS (ACRS)

AND

MARGIN CALCULATION

Margin for Equipment Qualified by Biaxial Test

Equipment margin can be calculated as shown below.



Calculate margin m_1, m_2 for frequencies f_1 and f_2 as

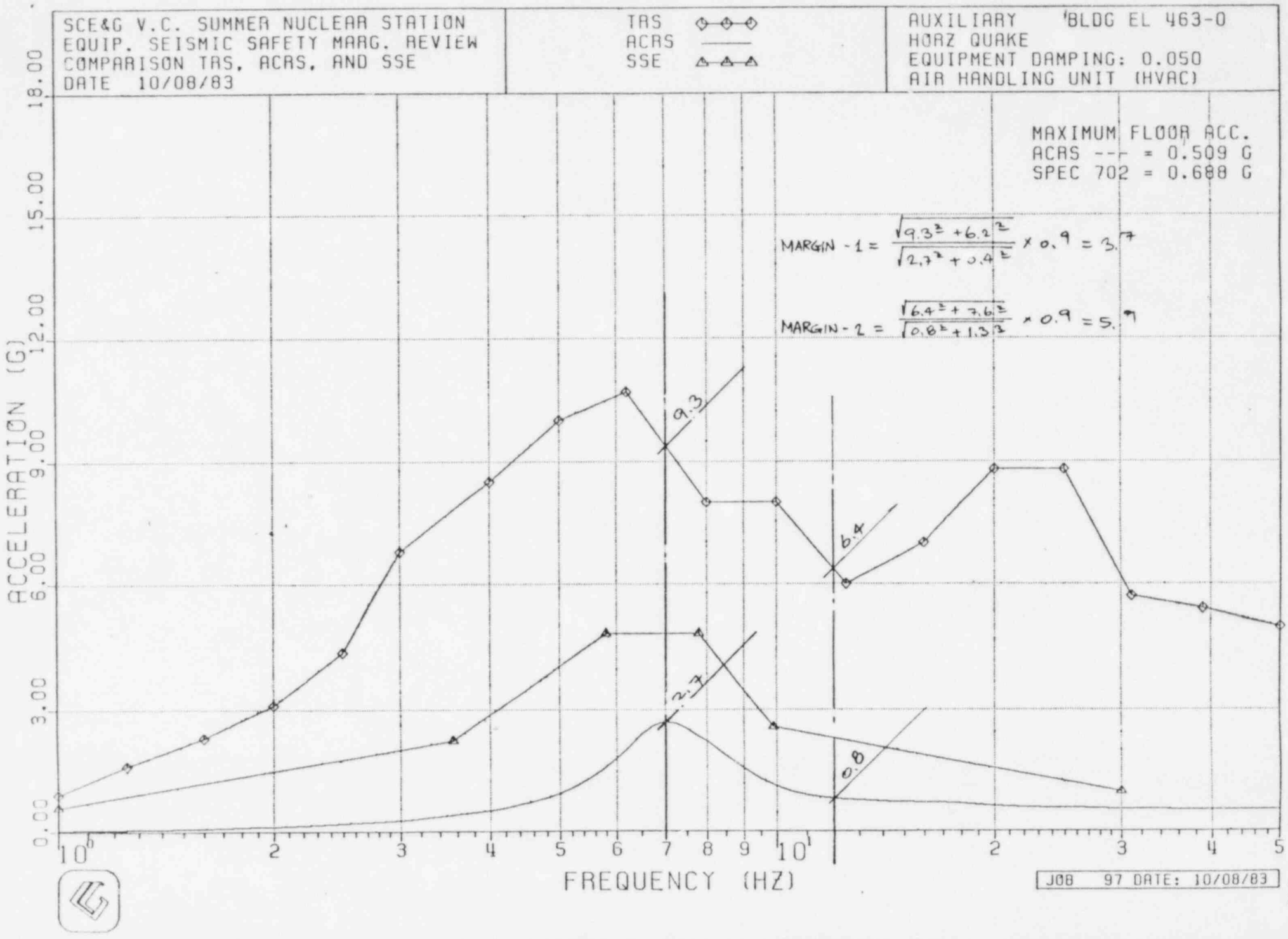
$$m_1 = \sqrt{(TRS_{Hf_1})^2 + (TRS_{Vf_1})^2} \Big/ \sqrt{(RRS_{Hf_1})^2 + (RRS_{Vf_1})^2} \quad \text{X } 0.9$$

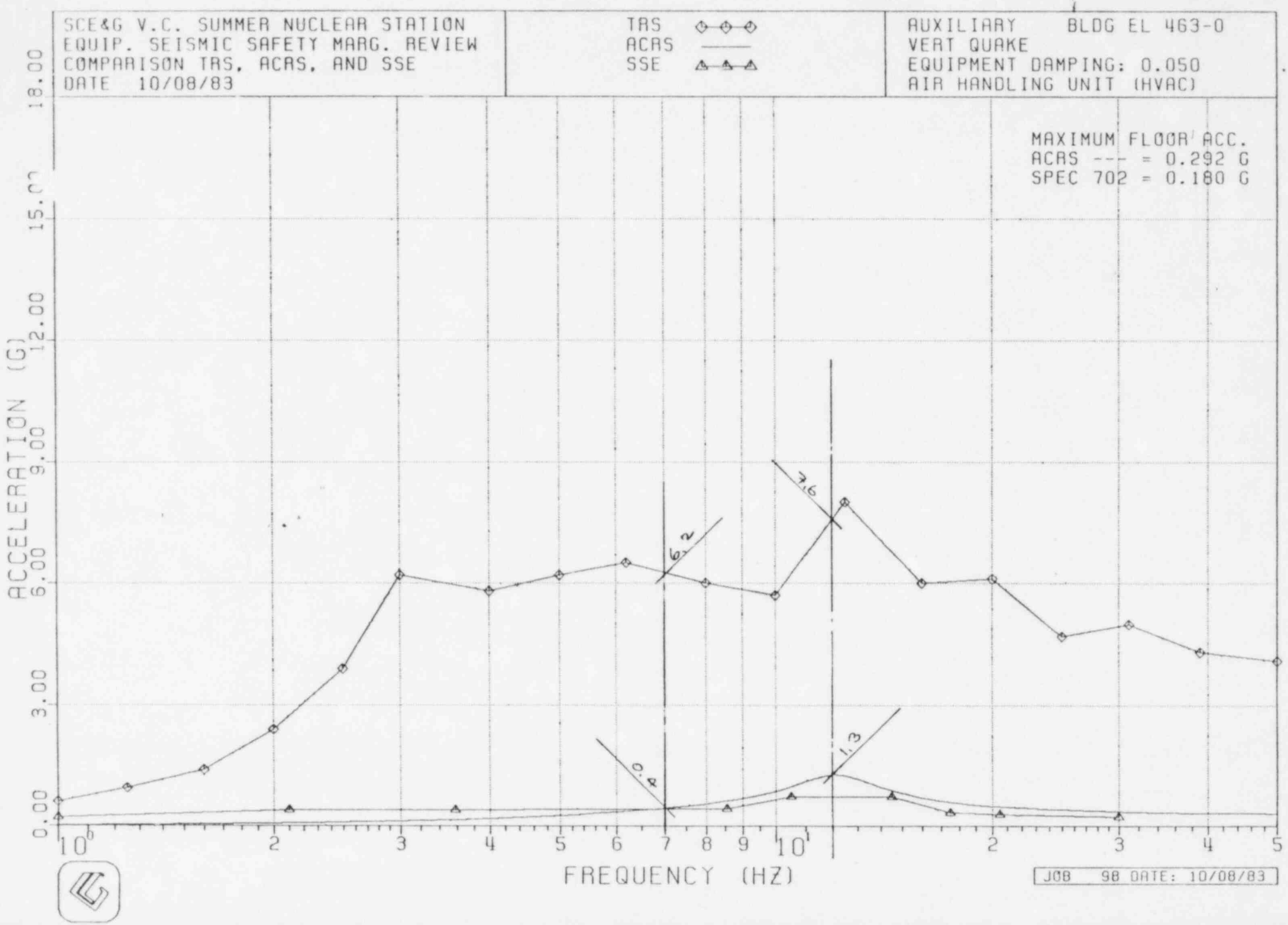
$$m_2 = \sqrt{(TRS_{Hf_2})^2 + (TRS_{Vf_2})^2} \Big/ \sqrt{(RRS_{Hf_2})^2 + (RRS_{Vf_2})^2} \quad \text{X } 0.9$$

The smaller value of m_1 and m_2 is defined as the margin of the equipment.

Critical frequency is defined as the frequency which has the smallest TRS/RRS ratio.

A constant 0.9 is applied to incorporate the 10% increase of RRS.


SCE&G V.C. SUMMER NUCLEAR STATION
EQUIP. SEISMIC SAFETY MARG. REVIEW
COMPARISON TRS, ACRS, AND SSE
DATE 10/08/83
TRS
ACRS
SSE
AUXILIARY BLDG EL 463-0
HORZ QUAKE
EQUIPMENT DAMPING: 0.050
AIR HANDLING UNIT (HVAC)
MAXIMUM FLOOR ACC.
ACRS = 0.509 G
SPEC 702 = 0.688 G
MARGIN - 1 = $\frac{\sqrt{9.3^2 + 6.2^2}}{\sqrt{2.7^2 + 0.4^2}} \times 0.9 = 3.7$
MARGIN - 2 = $\frac{\sqrt{6.4^2 + 7.6^2}}{\sqrt{0.8^2 + 1.3^2}} \times 0.9 = 5.9$
9.3
6.4
2.7
0.8
ACCELERATION (G)
FREQUENCY (HZ)
0.00
3.00
6.00
9.00
12.00
15.00
18.00
J08 97 DATE: 10/08/83


SCE&G V.C. SUMMER NUCLEAR STATION
EQUIP. SEISMIC SAFETY MARG. REVIEW
COMPARISON TRS, ACRS, AND SSE
DATE 10/08/83
TRS
ACRS
SSE
AUXILIARY BLDG EL 463-0
VERT QUAKE
EQUIPMENT DAMPING: 0.050
AIR HANDLING UNIT (HVAC)
MAXIMUM FLOOR ACC.
ACRS --- = 0.292 G
SPEC 702 = 0.180 G
ACCELERATION (G)
0.00
3.00
6.00
9.00
12.00
15.00
18.00
7.6
6.2
1.3
0.4
FREQUENCY (HZ)
JOB 98 DATE: 10/08/83

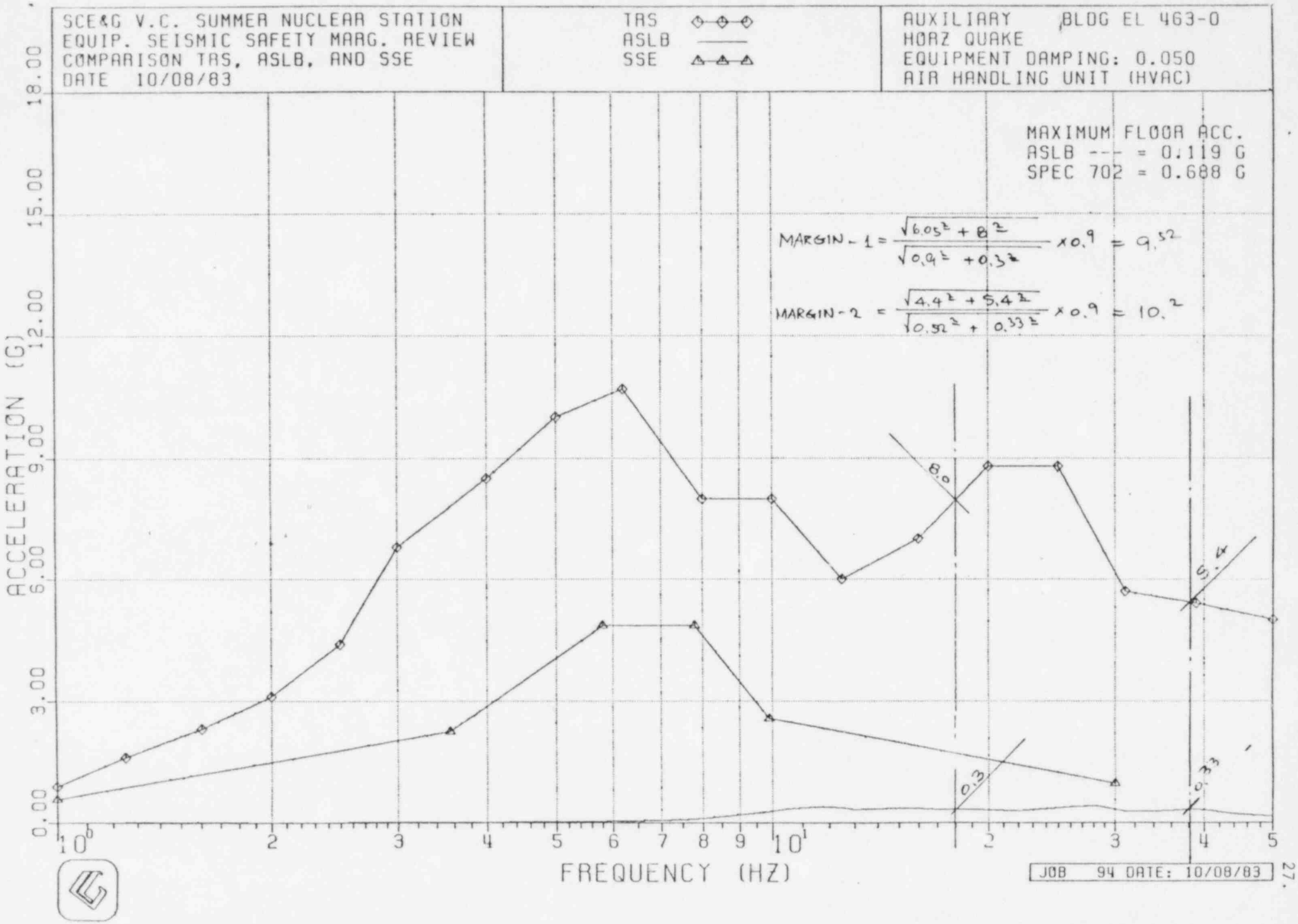
COMPARISON PLOTS

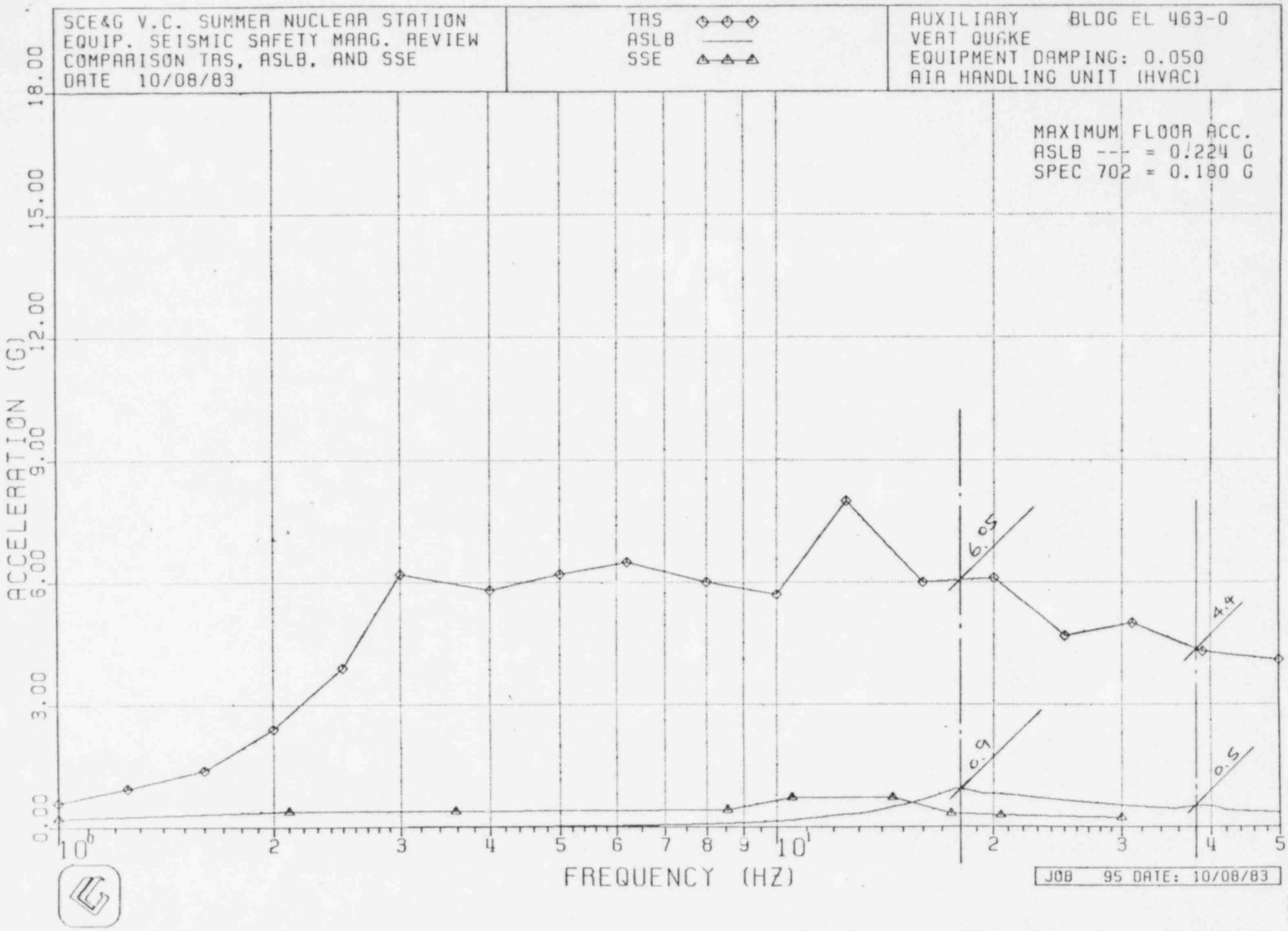
OF

TRS AND RRS (ASLB)

AND

MARGIN CALCULATION


SCE&G V.C. SUMMER NUCLEAR STATION
EQUIP. SEISMIC SAFETY MARG. REVIEW
COMPARISON TRS, ASLB, AND SSE
DATE 10/08/83
TRS
ASLB
SSE
AUXILIARY BLDG EL 463-0
HORZ QUAKE
EQUIPMENT DAMPING: 0.050
AIR HANDLING UNIT (HVAC)
MAXIMUM FLOOR ACC.
ASLB --- = 0.119 G
SPEC 702 = 0.688 G
MARGIN-1 = $\frac{\sqrt{6.05^2 + 8^2}}{\sqrt{0.9^2 + 0.3^2}} \times 0.9 = 9.52$
MARGIN-2 = $\frac{\sqrt{4.4^2 + 5.4^2}}{\sqrt{0.52^2 + 0.33^2}} \times 0.9 = 10.^2$
8.0
5.4
0.3
0.33
ACCELERATION (G)
0.00
3.00
6.00
9.00
12.00
15.00
18.00
10^0
2
3
4
5
6
7
8
9
10^1
2
3
4
5
FREQUENCY (HZ)
JOB 94 DATE: 10/08/83


SCE&G V.C. SUMMER NUCLEAR STATION
EQUIP. SEISMIC SAFETY MARG. REVIEW
COMPARISON TRS, ASLB, AND SSE
DATE 10/08/83
TRS
ASLB
SSE
AUXILIARY BLDG EL 463-0
VERT QUAKE
EQUIPMENT DAMPING: 0.050
AIR HANDLING UNIT (HVAC)
MAXIMUM FLOOR ACC.
ASLB --- = 0.224 G
SPEC 702 = 0.180 G
ACCELERATION (G)
0.00
3.00
6.00
9.00
12.00
15.00
18.00
FREQUENCY (HZ)
JOB 95 DATE: 10/08/83