



**Aerospace
Systems Division**

ALSEP Array E Engineering Model
Subpackage No. 1 with PSE - Design
Limit Vibration Test Results

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ATM-1083	
PAGE <u>1</u>	OF <u> </u>
DATE 2/15/72	

This technical memorandum represents the engineering vibration test report for EEM Subpackage No. 1 with PSE.

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Approved by: J. McNaughton
J. McNaughton



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1.0 INTRODUCTION

The engineering model of array E subpackage no. 1 with PSE (EEM-SP1/PSE) was subjected to the design limit vibration levels as specified for ALSEP. The primary purpose of the test was to verify the structural integrity of the system and to verify that the component environments are consistent with component specifications given in reference 1.

2.0 TEST ARTICLE

EEM-SP1/PSE consists primarily of EEM components with the exception of the modified EDM primary structure and the SN-2 PSE. The CSE and the individual experiments (LSP & LMS) were dynamic simulators. A detail breakdown of the major components is given in Table 1. A photograph of subpack 1 is shown in Figure 1.

3.0 TEST DESCRIPTION

EEM Subpack 1 was subjected to sinusoidal and random vibration tests as outlined in Table 2. The subpack experienced sinusoidal sweep, launch and boost random, and lunar descent random environments in all three axes (X, Y, Z) for a total of nine individual vibration tests.

4.0 INSTRUMENTATION

Eighteen accelerometers were mounted on Subpack 1 and monitored during each of the EEM vibration tests. Figure 2 shows a layout of Subpack 1 with the exact locations of the accelerometers. Additional information regarding locations and response directions is listed in Table 3 and reference 3.

5.0 RESULTS

Response data is given in Figures 8-34 for each of the three orthogonal axes and for each experiment (i. e., the PSE, LSP, and LMS). Response envelopes giving g-peak and power spectral density values due to sinusoidal and random inputs are shown. For the LMS and the LSP experiments specification levels to which the individual components are designed and tested (ref. 1), are also shown. Solid curves represent response data such that the output is in the same direction as the input (e. g., response in X-direction due to input in X-direction). Dashed lines represent cross-axis response data (e. g., response in X-direction due to input in Y-direction).



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The response data for the PSE is shown in the same manner, but comparison must be made not with specification levels, but with previous test data (Qual, SA and EDM) for meaningful interpretation. However since the PSE orientation on Array E is different by an angular rotation of 45 degrees relative to all previous arrays, a direct comparison of vibration test data is of questionable value. Therefore it was decided to use PSE SN-2 with pre-test and post test inspection of the ten critical points in the PSE structure to verify that the environment was not destructive (Ref. 4). Post test inspection of the PSE shows that the instrument passed both the vibration and leak tests (Ref. 5).

Table 4 is included to show the maximum response levels for the individual components. Both g-peak and g(rms) levels due to sinusoidal and random vibration, respectively, are shown.

Figures 8 - 16 show response levels for the PSE due to sinusoidal, launch and boost random, and lunar descent random inputs. With respect to sine input, Figure 8 shows the maximum X-response to be 10.0 g-peak at 62 Hz. Figures 9 and 10 show Y and Z sinusoidal response to be 4.3 and 3.9 g-peak respectively. Figures 11 - 13 show the launch and boost random response for X, Y, and Z axis. A maximum power spectral density level of $0.10 \text{ g}^2/\text{Hz}$ exists at 1100 Hz for the X-response. Figures 14 - 16 show the lunar descent random response for the X, Y, and Z axes. Again at 1100 Hz a maximum level of $.04 \text{ g}^2/\text{Hz}$ exists.

Figures 17 - 25 show response levels for the LSP due to the various input environments. The sinusoidal response in Figure 17 shows a maximum X-response of 7.6 g-peak at 62 Hz, which is below the specification level limit (Ref. 1) of 9.0 g-peak. Figures 18 and 19 also show that the Y and Z sinusoidal response levels are in good agreement with the specification levels. Figures 20 - 22 show that the response levels due to launch and boost random input are consistent with specification levels across most of the frequency band except for small spikes at 300 Hz and 1200 Hz. Figures 23 - 25 show that the power spectral density levels due to the lunar descent random input are also in good agreement with the specification levels across most of the frequency band except for a spike at about 1200 Hz. These excursions should not represent cause for concern since the LSP geophones are packaged in a foam material which protects them from high frequency vibrations.

Figures 26 - 34 show response levels for the LMS due to the sine and random vibration environments. Figure 25 shows the maximum X-response due to sinusoidal input to be consistent with specification levels. Figures 27 and 28 show the Y and Z sinusoidal response to be 5.0 g-peak at 35 Hz and 48 Hz respectively compared to



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3.0 g-peak specification levels at these frequencies. It should be pointed out that the specification levels were established prior to a design decision to support the LMS at three points instead of four. The consequence of such a change would be to increase the lateral motion of the LMS during Y and Z-axes vibration. However, no problems are anticipated since the LMS internal resonant frequencies are much higher than 50 Hz. Figures 29 - 34 show the power spectral density response levels for the launch and boost random and the lunar descent random input levels. The response levels are consistent with specification levels across most of the frequency band except for a spike at 1100 Hz. Since there are no internal LMS resonances near this frequency, no problems are anticipated.

6.0 CONCLUSIONS

Vibration testing of EEM-SP1/PSE was completed 12 August 1971. In general the individual component response levels due to the specified ALSEP design limit vibration were in good agreement with component specification. Minor excursions were seen outside the specification envelope at about 1000 Hz for the random testing. Post Test inspection (Ref. 5.) of the PSE shows that the instrument passed both the vibration and leak tests. Hence the structural integrity of the system has been verified (no structural failures occurred) and that the individual component environments are consistent with component specifications.

7.0 REFERENCES

1. ATM 964 ALSEP Array E Component Non-Operating Vibration Specification 2/2/71.
2. BxA letter No. 9712-311 ALSEP Array E EEM Vibration Test Plan 4/27/71
3. BxA letter No. 9712-383 EEM Instrumentation Plan for Vibration Testing 6/10/71
4. BxA letter No. 9712-457 PSE Mechanical Inspection for Array E (EEM) 7/13/71
5. BxA letter No. 978-10-4606 Post Test Teardown and Inspection for ALSEP Array E Vibration Test 8/25/71



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TABLE 1

EEM SP 1/PSE HARDWARE

Primary Structure	EDM (modified)
Sunshield Assembly	EEM (reworked)
Antenna mast	EEM
Curtain	EEM
Rear curtain retainer	EEM
Thermal plate	EEM
CSE	EEM (dynamic simulator)
PSE	SN-2
LSP (geophones)	EEM (dynamic simulator)
LMS	EEM (dynamic simulator)

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TABLE 2

EEM SP 1/PSE DESIGN LIMIT VIBRATION TEST LEVELS

<u>Test</u>	<u>Axis</u>	<u>Test Levels</u>
Sinusoidal	X	Fig. 3.
Random (L&B)	X	Fig. 4
Random (L.D.)	X	Fig. 7
Sinusoidal	Y	Fig. 3
Random (L&B)	Y	Fig. 5
Random (L.D.)	Y	Fig. 7
Sinusoidal	Z	Fig. 3
Random (L&B)	Z	Fig. 6
Random (L.D.)	Z	Fig. 7



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TABLE 3
EEM SP 1/PSE INSTRUMENTATION

<u>Location No.</u>	<u>Acc. No.</u>	<u>Location</u>	<u>Accelerometers</u>	<u>Response Direction</u>
A	1, 2, 3	PSE, rear mtg. brkt.	3	X, Y, Z
B	4, 5, 6	PSE, right mtg. brkt.	3	X, Y, Z
E	7, 8, 9	LSP	3	X, Y, Z
F	10, 11, 12	LMS	3	X, Y, Z
α	13, 14, 15	CSE/Th. Plate, near XMTRS. & DPX. SW.	3	X, Y, Z
β	16, 17, 18	CSE/Th. Plate, near DDP/MUX & C/D	3	X, Y, Z

NOTE: Accelerometers 13, 15, 16, and 17 malfunctioned during vibration tests. Therefore, α and β data envelopes are not presented in this report. Data available from accelerometers 14 and 18 is, in general, consistent with CSE specification levels.



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TABLE 4

EEM SPI/PSE VIBRATION RESPONSE VALUES

<u>RESPONSE</u>		I N P U T								
		Sinusoidal			Launch & Boost Random			Lunar Descent Random		
		X	Y	Z	X	Y	Z	X	Y	Z
PSE (A) 1-2-3	X	8.0	1.7	2.3	4.0	1.7	1.6	2.2	1.7	1.3
	Y	2.1	3.9	0.6	4.0	2.2	1.3	2.5	2.5	1.1
	Z	1.4	1.7	4.0	2.2	1.3	1.2	1.3	1.2	1.0
PSE (B) 4-5-6	X	10.0	1.8	1.5	4.6	1.7	1.4	2.6	1.7	1.1
	Y	1.5	4.3	0.6	2.5	2.2	1.4	1.6	2.2	1.2
	Z	1.5	1.8	3.9	4.0	2.0	2.0	2.5	2.1	1.6
LSP (E) 7-8-9	X	7.8	1.8	1.2	6.5	2.4	1.7	4.0	2.3	1.3
	Y	3.8	3.3	0.6	6.0	2.2	1.8	3.2	2.2	1.2
	Z	1.2	1.2	3.5	3.5	2.2	1.7	2.0	1.7	1.6
LMS(F) 10-11-12	X	6.7	1.5	2.3	7.8	2.3	3.0	3.8	1.9	1.9
	Y	2.3	5.0	1.0	3.2	2.0	1.7	1.8	2.2	1.5
	Z	5.7	2.4	4.6	5.0	1.5	2.1	2.5	1.5	1.7

NOTE: SINE LEVELS ARE G-PEAK VALUES.

RANDOM LEVELS ARE G(RMS) VALUES.



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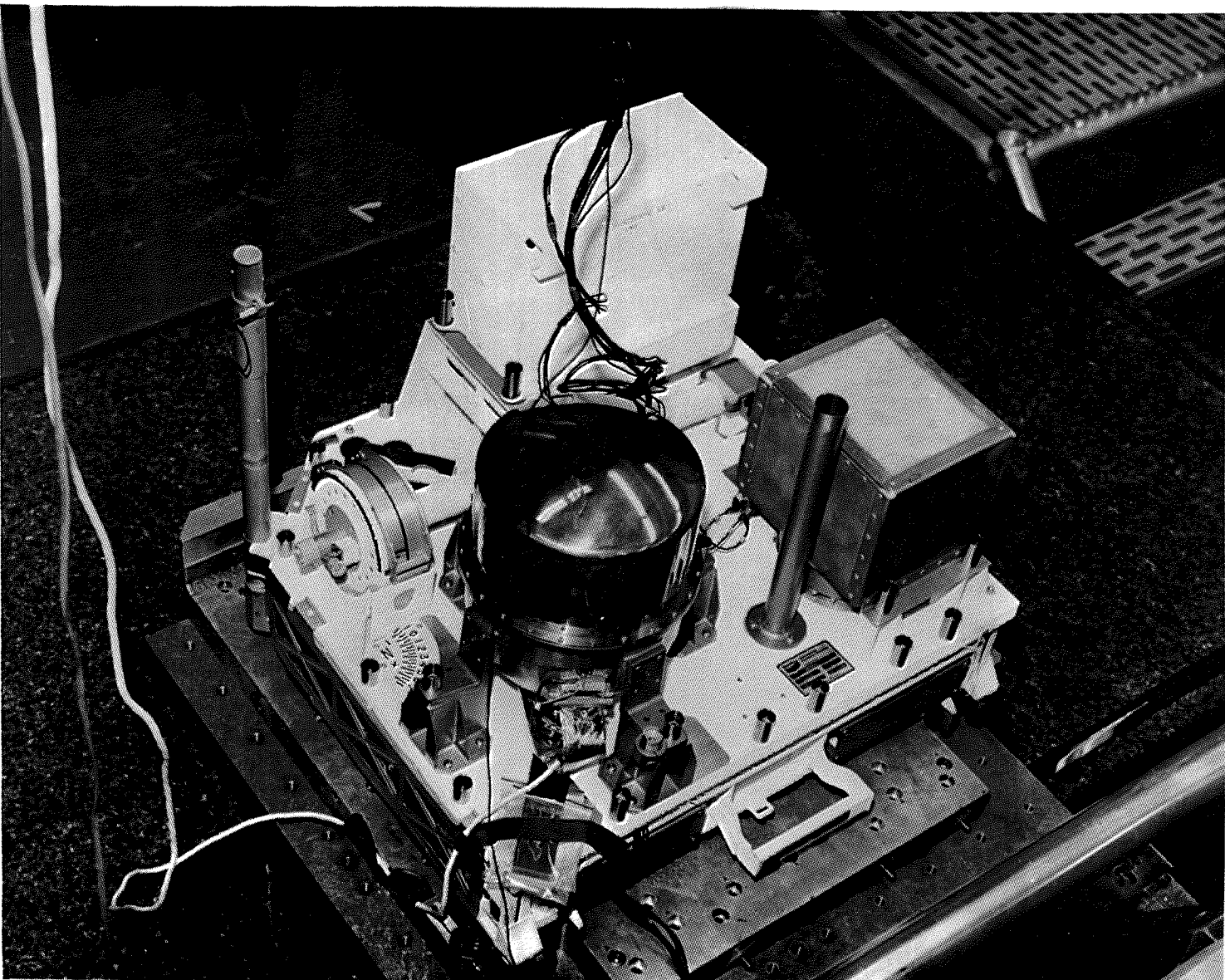


FIGURE 1 - EEM-SP1/PSE

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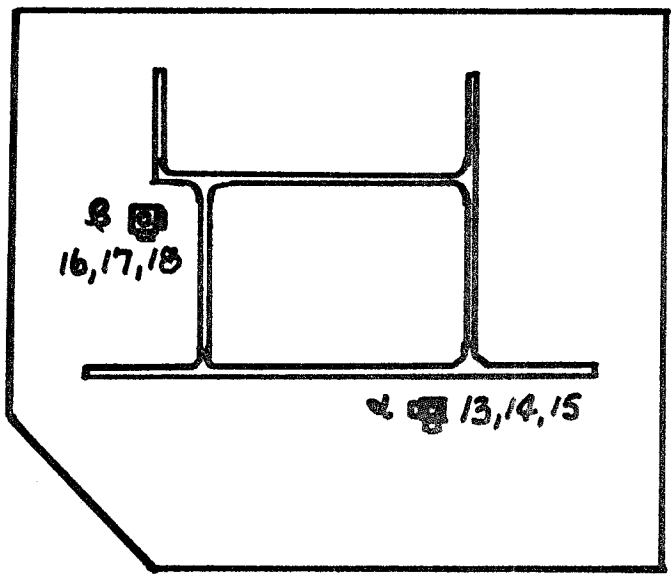
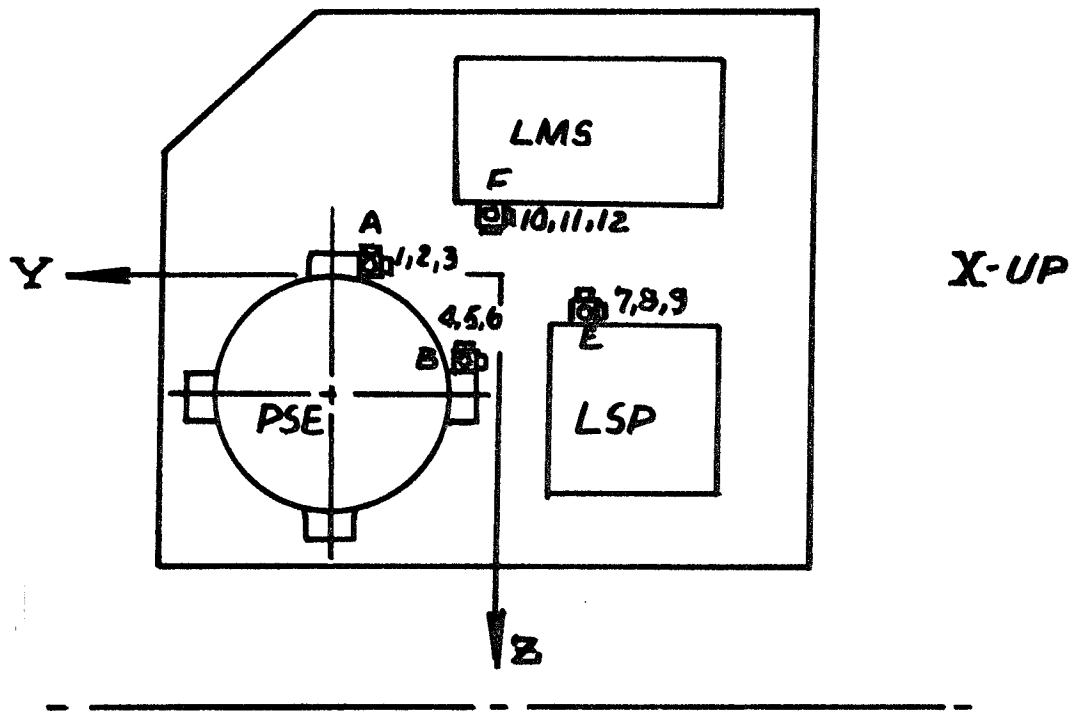


Figure 2 EEM-SP1/PSE Instrumentation



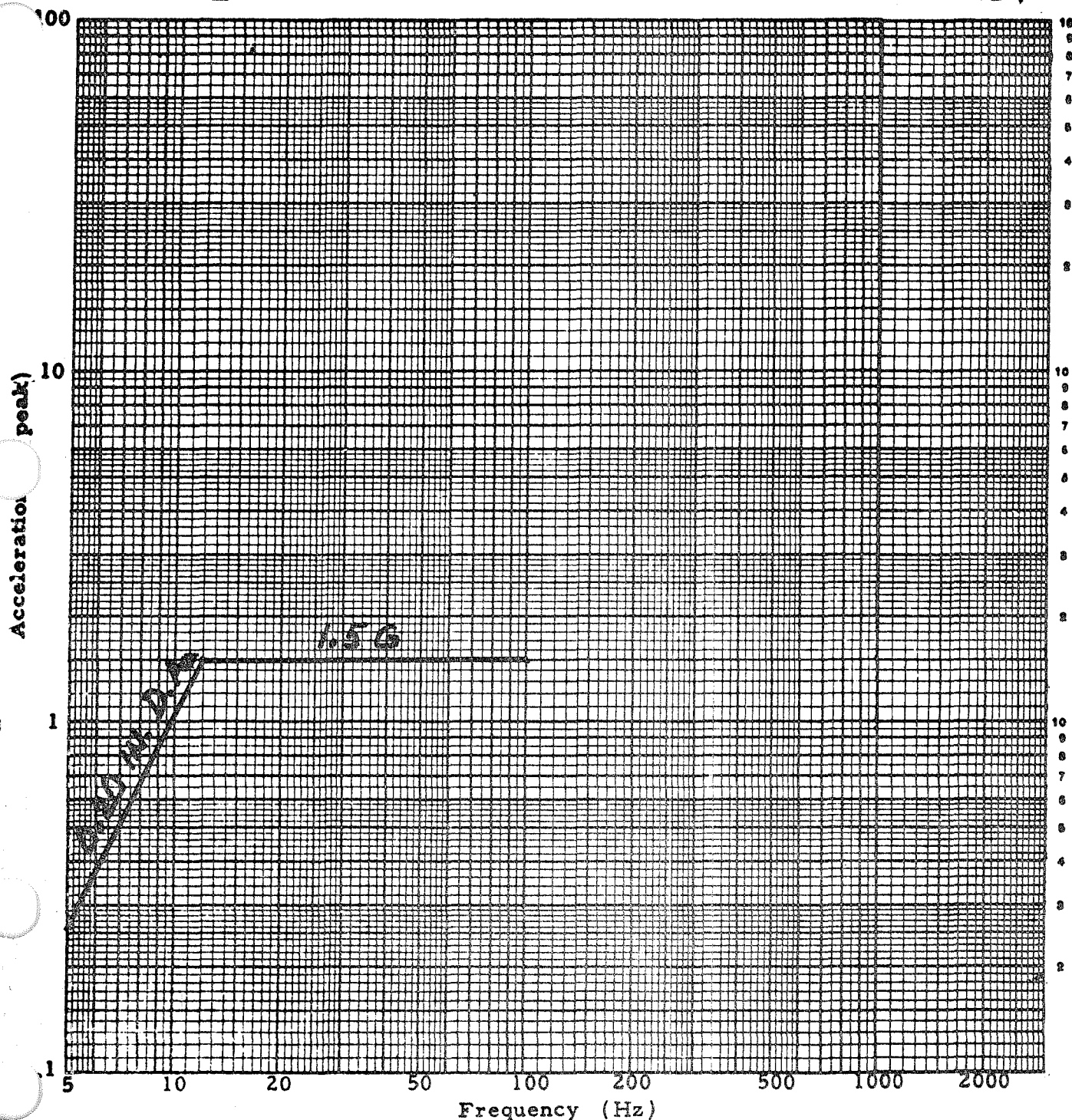
DESIGN LIMIT LEVEL
SINUSOIDAL VIBRATION

Axis: X,Y,Z

Sweep Rate: 3 OCT/MIN.

SP-1 & 2

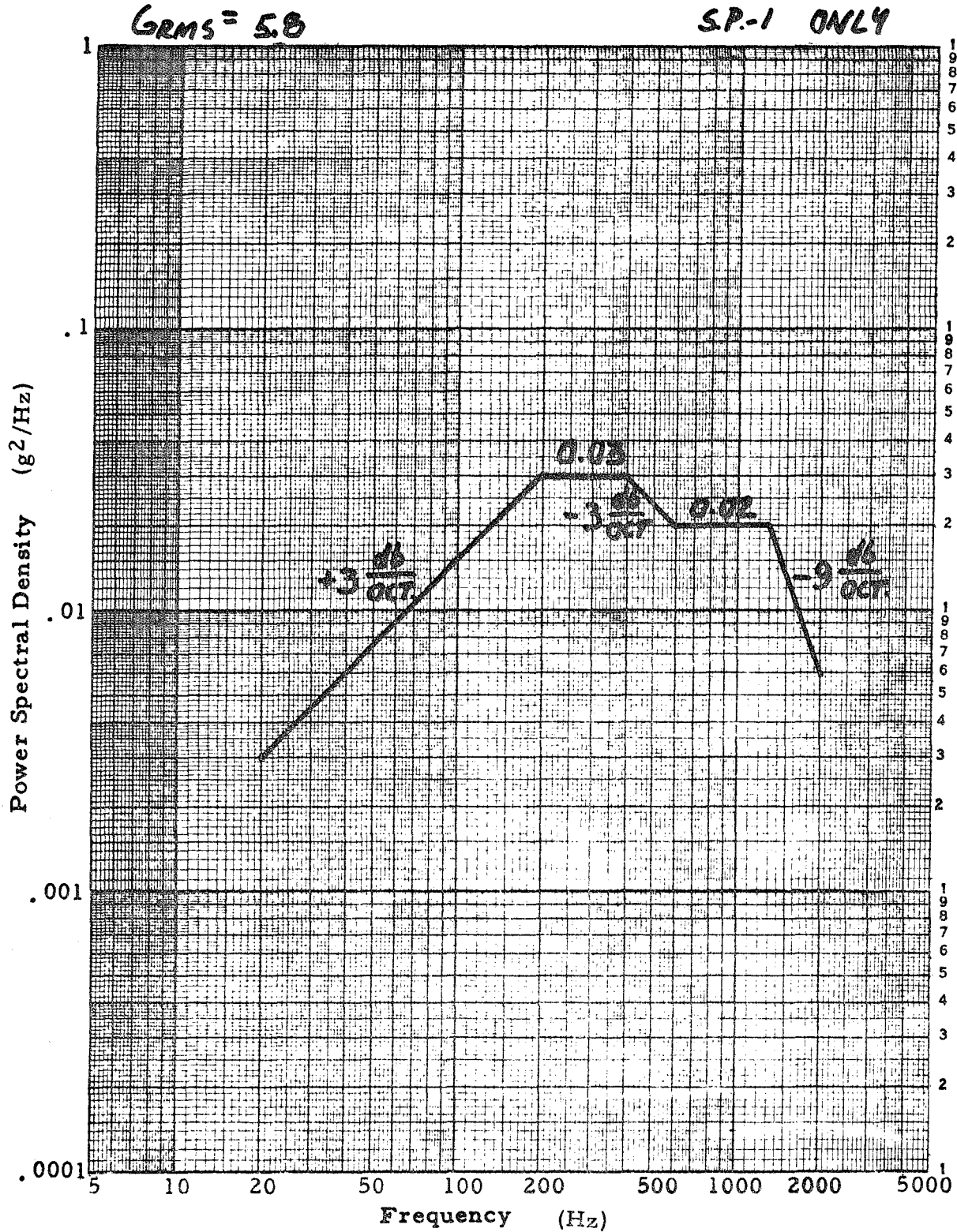
SWEEP: 5-100-5 Hz.



DESIGN LIMIT LEVEL L₁B
RANDOM VIBRATION SPECTRUM

Axis: **X**

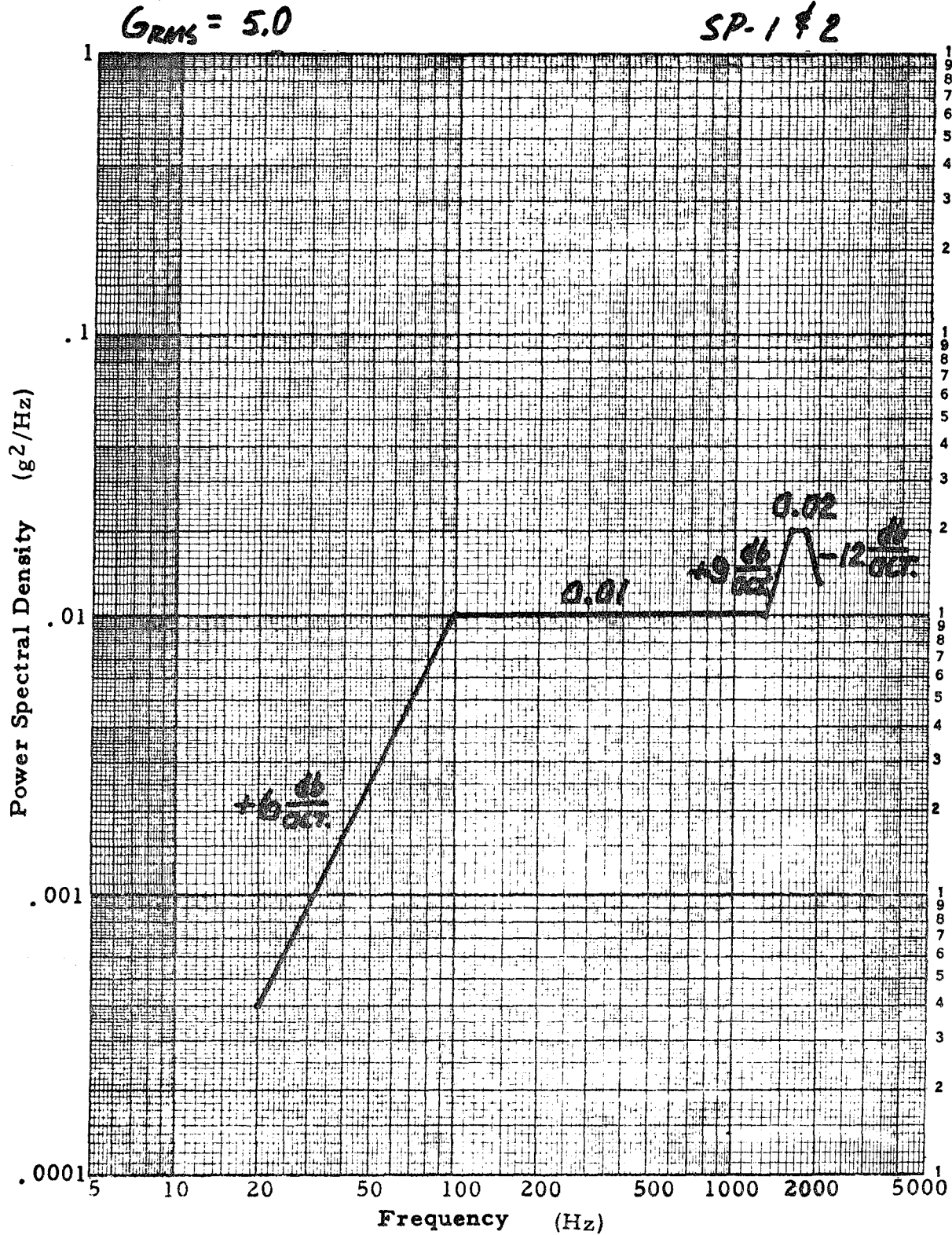
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DESIGN LIMIT LEVEL L₁B
RANDOM VIBRATION SPECTRUM

Axis: **Y**

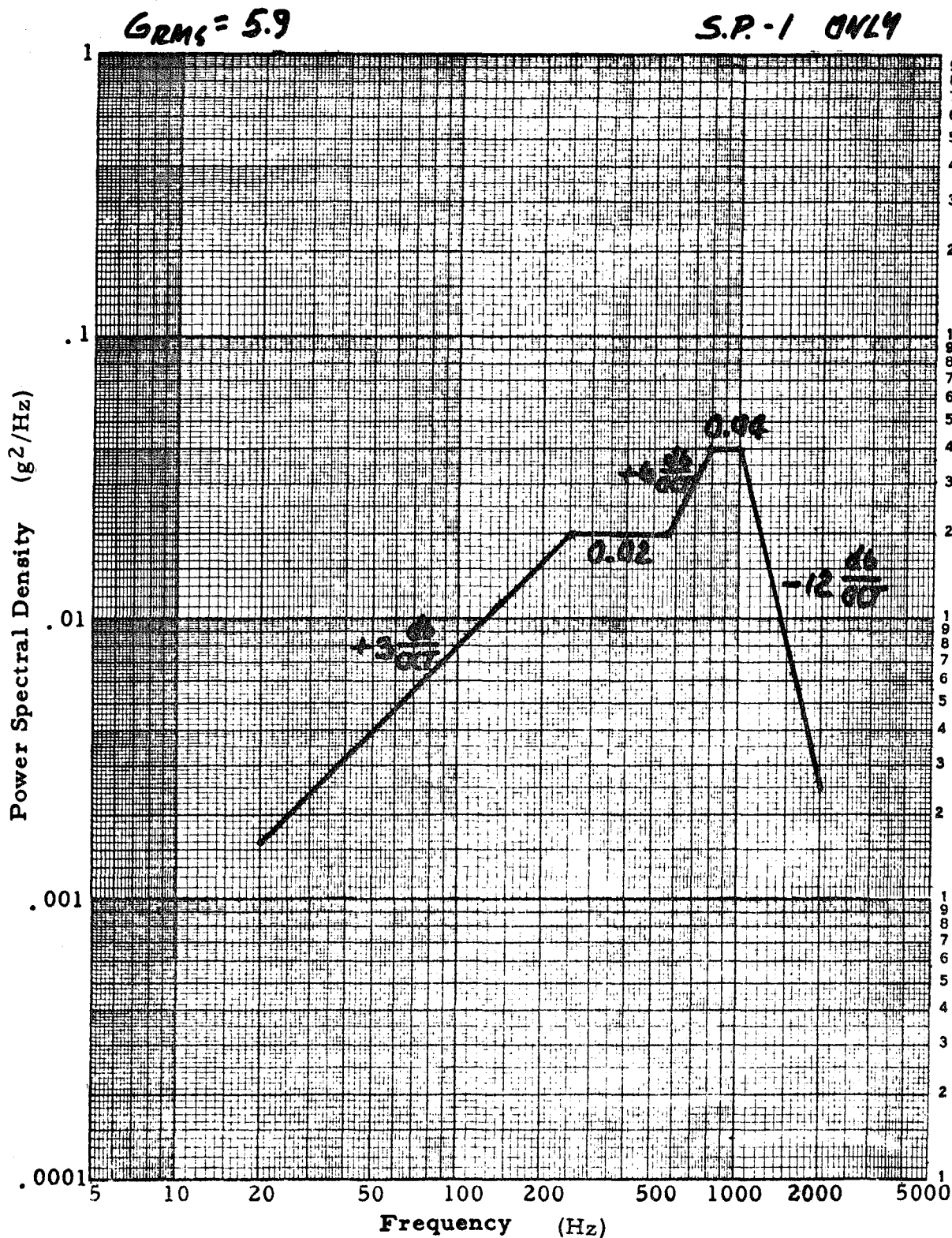
Duration: **1.0 MIN.**



DESIGN LIMIT LEVEL $L^{\frac{1}{2}}B$
RANDOM VIBRATION SPECTRUM

Axis: **2**

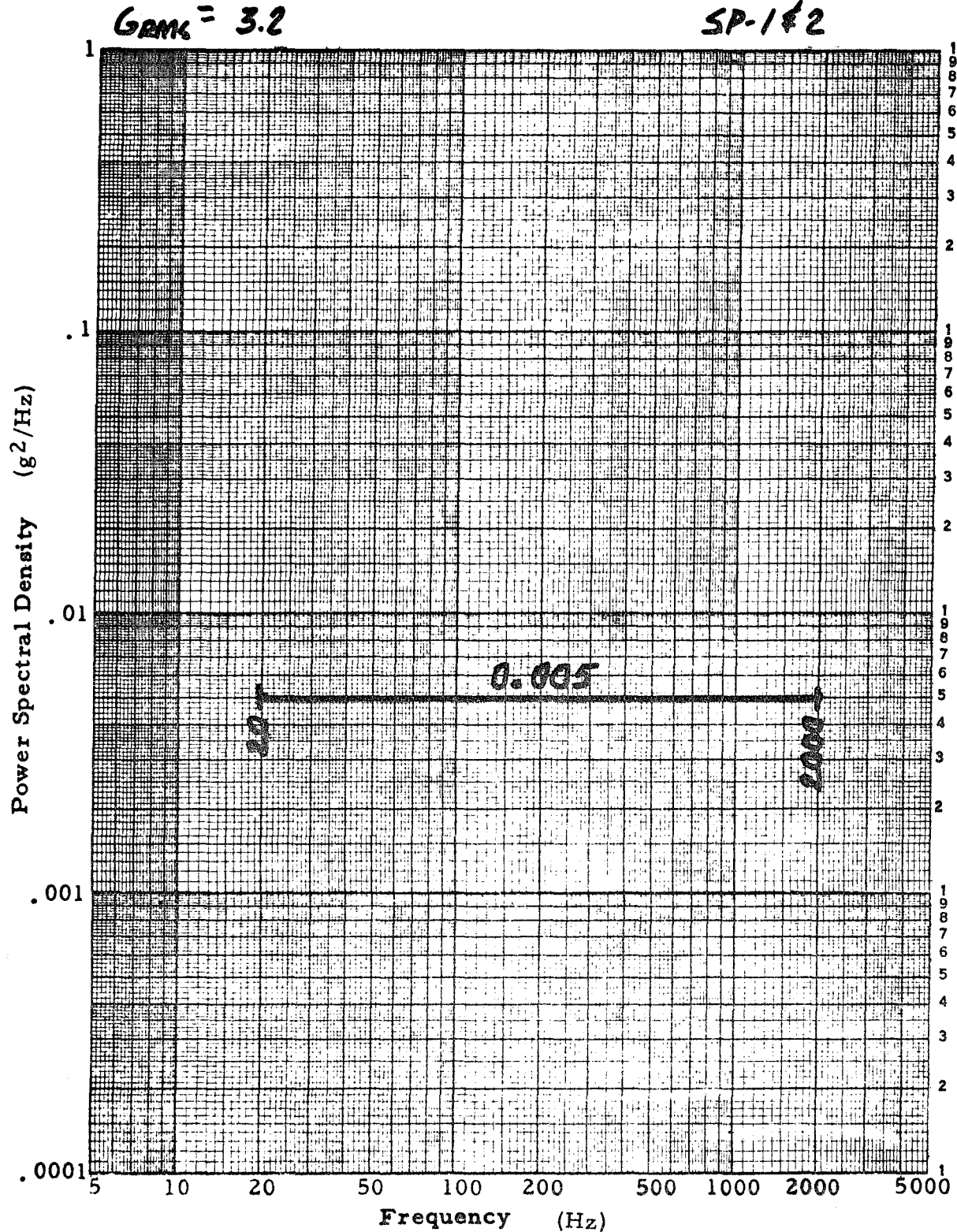
Duration: **1.0 MIN.**



DESIGN LIMIT LUNAR DESCENT RANDOM VIBRATION SPECTRUM

Axis: *X, Y, Z*

Duration: *12.5 MIN/AXIS.*

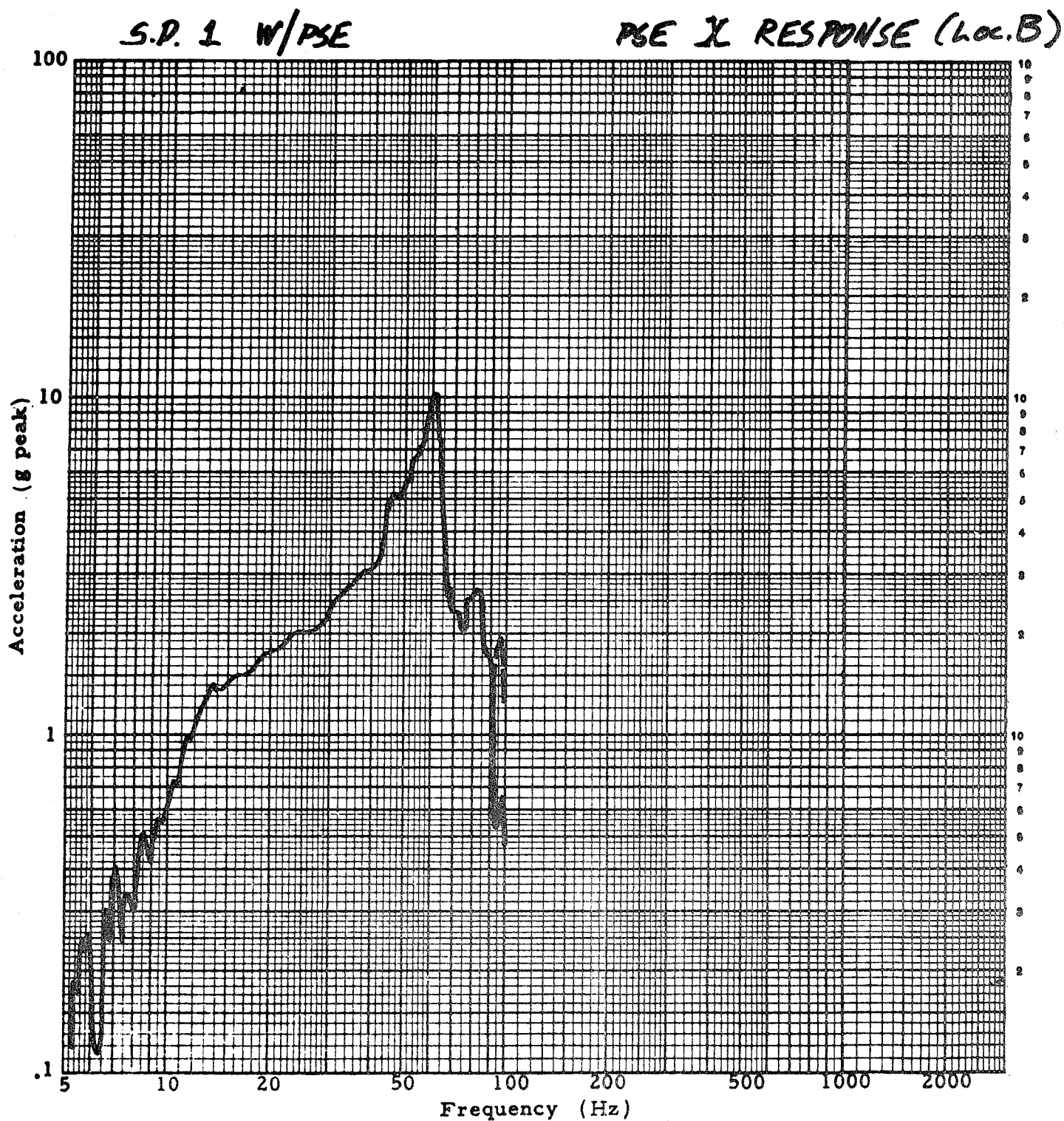


SINUSOIDAL VIBRATION

ACC. NO. 4

Axis:

Sweep Rate:

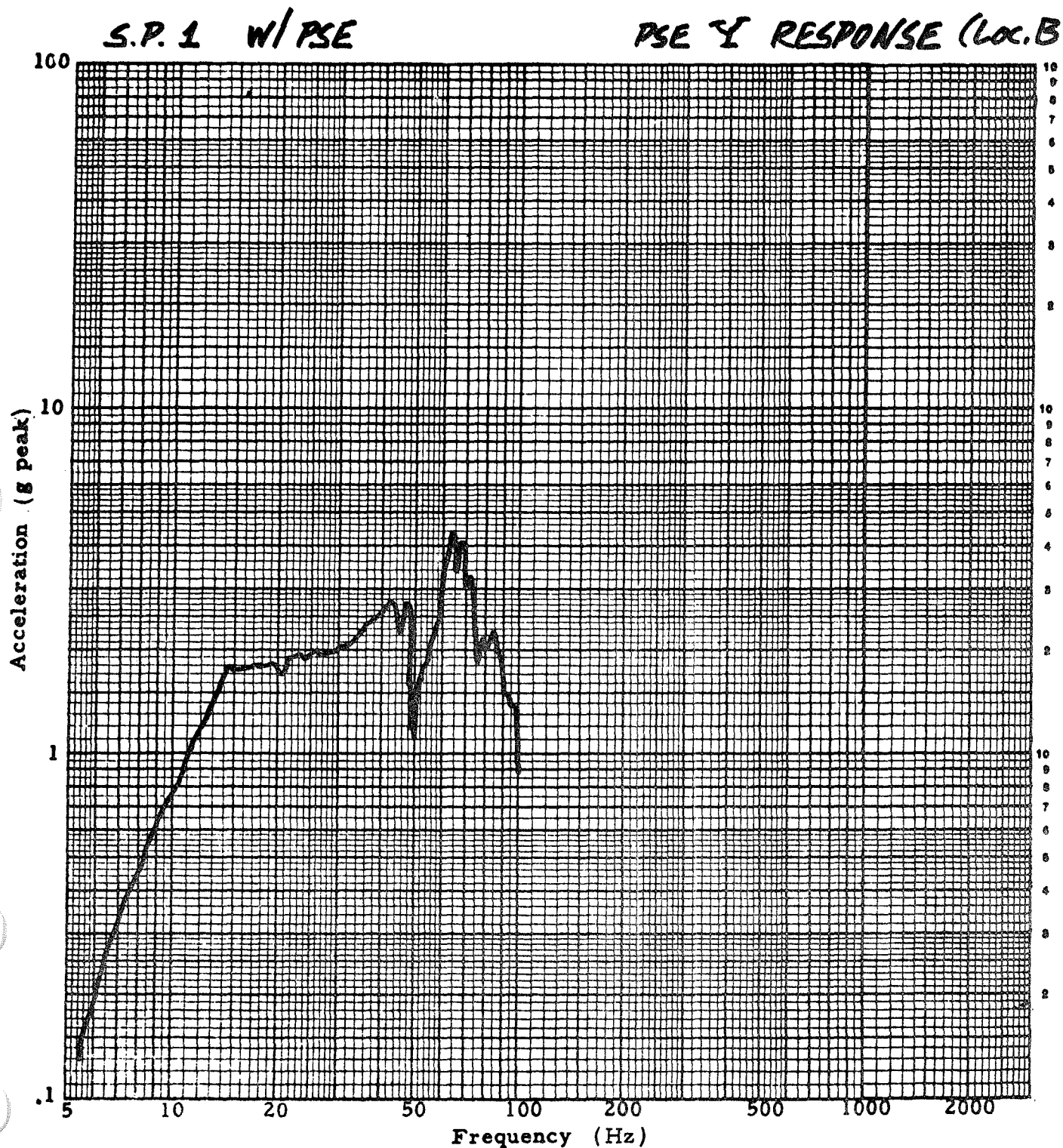


SINUSOIDAL VIBRATION

ALL NO.5

Axis:

Sweep Rate:





SINUSOIDAL VIBRATION

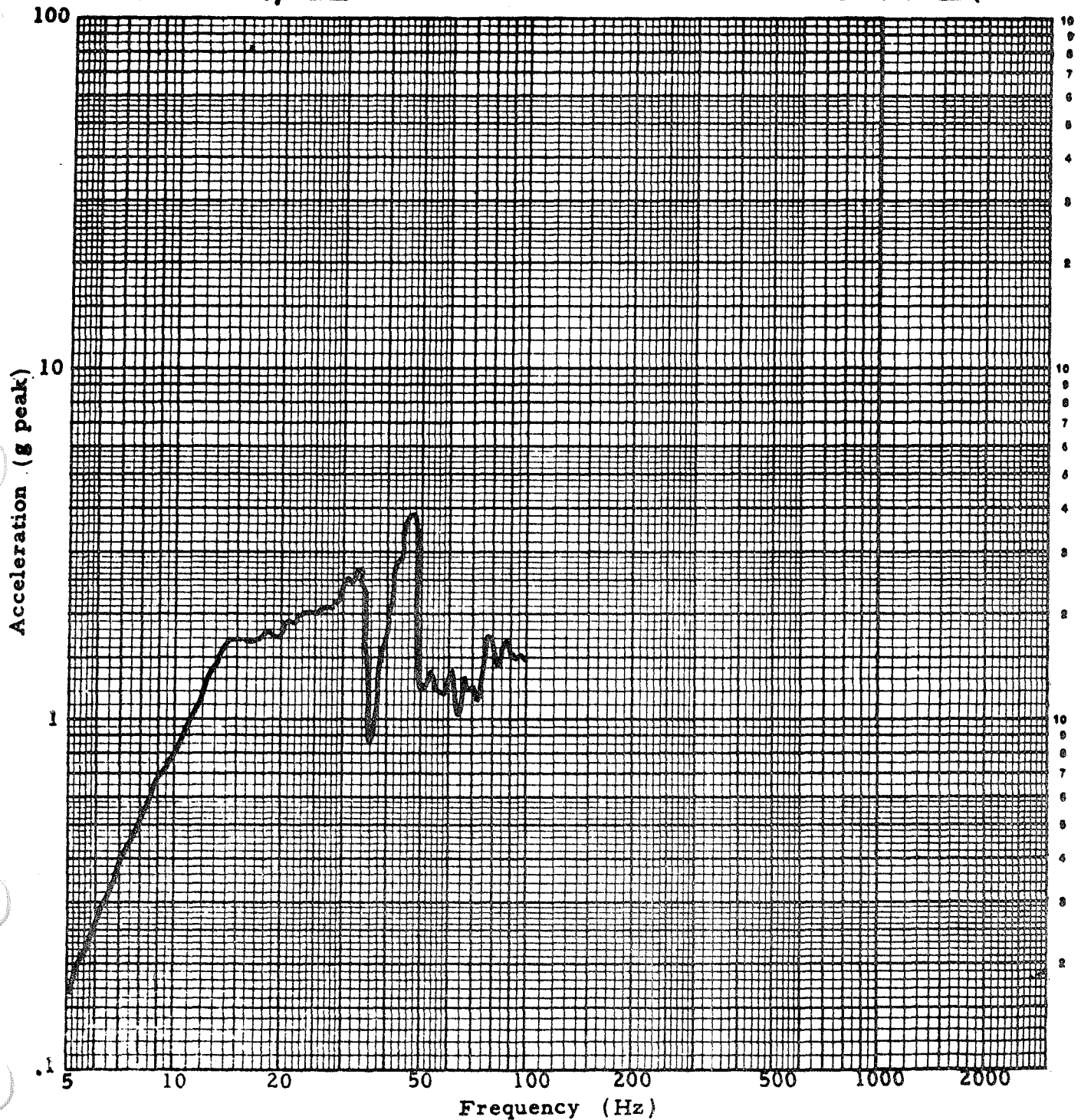
ACC. NO. 6

Axis:

Sweep Rate:

S.P. 1 W/PSE

PSE 2 RESPONSE (Loc. B)





ALL. NO. 4

Axis:

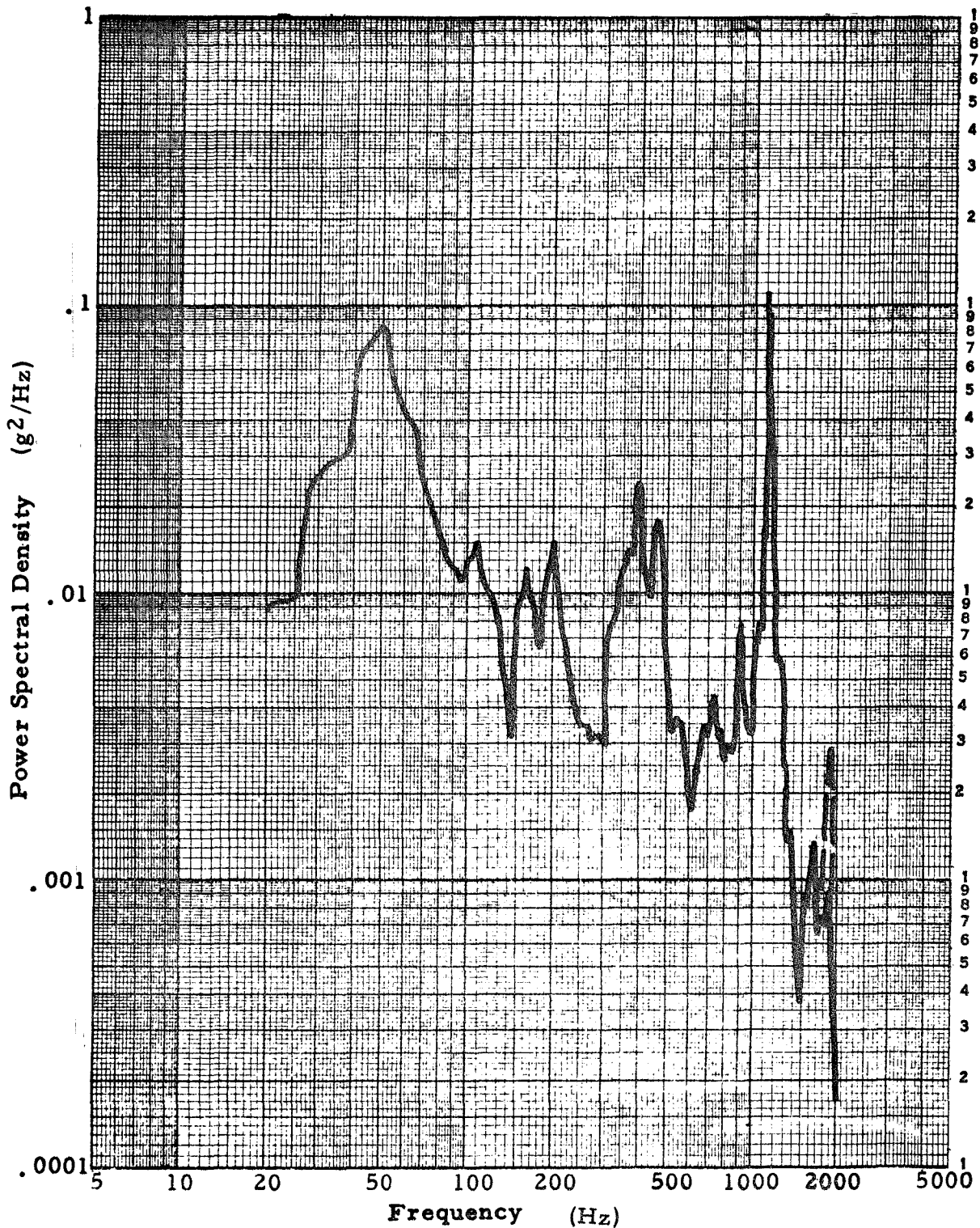
RANDOM VIBRATION SPECTRUM

LAUNCH & BOOST

S.P. 1 W/PSE

Duration:

PSE X RESPONSE (Loc. B)





ALL NO. 5

Axis:

RANDOM VIBRATION SPECTRUM

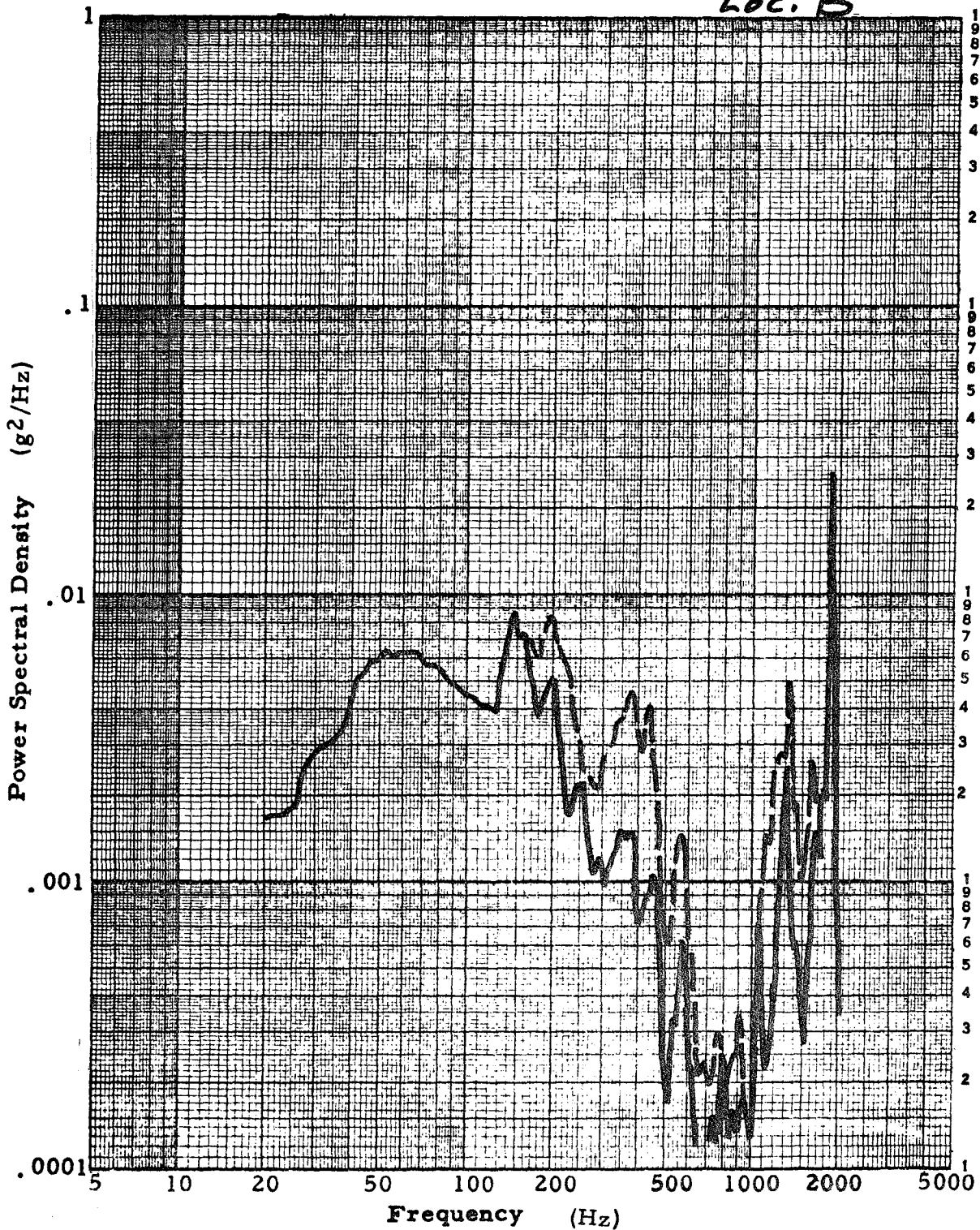
LAUNCH & BOOST

S.P. 1 / W/PSE

Duration:

PSE Y RESPONSE

LOC. B



ALL NO. 6

Axis:

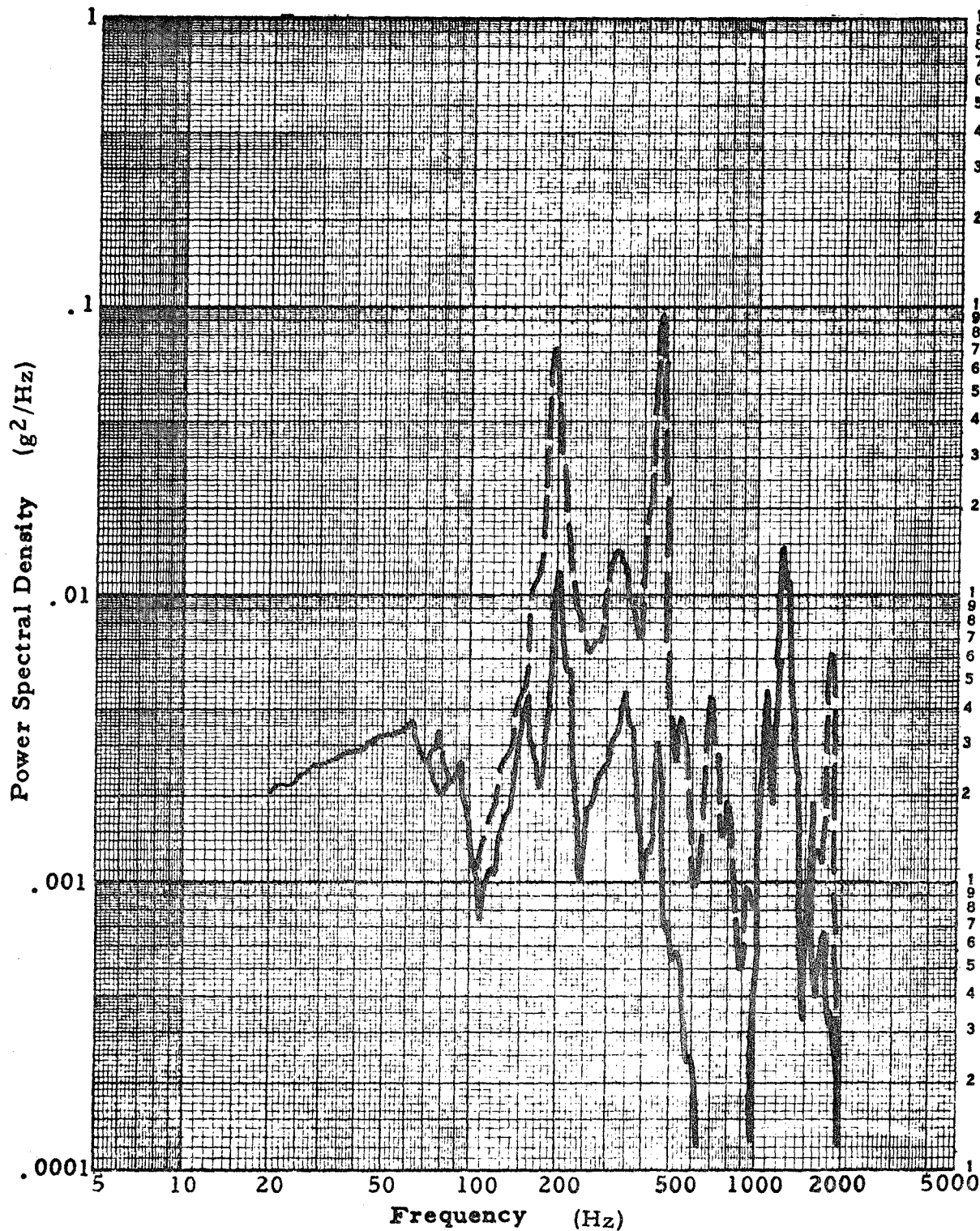
RANDOM VIBRATION SPECTRUM

LAUNCH & BOOST

S.P. 1 W/PSE

Duration:

PSE 2 RESPONSE (Loc.B)



ACL. NO. 4

Axis:

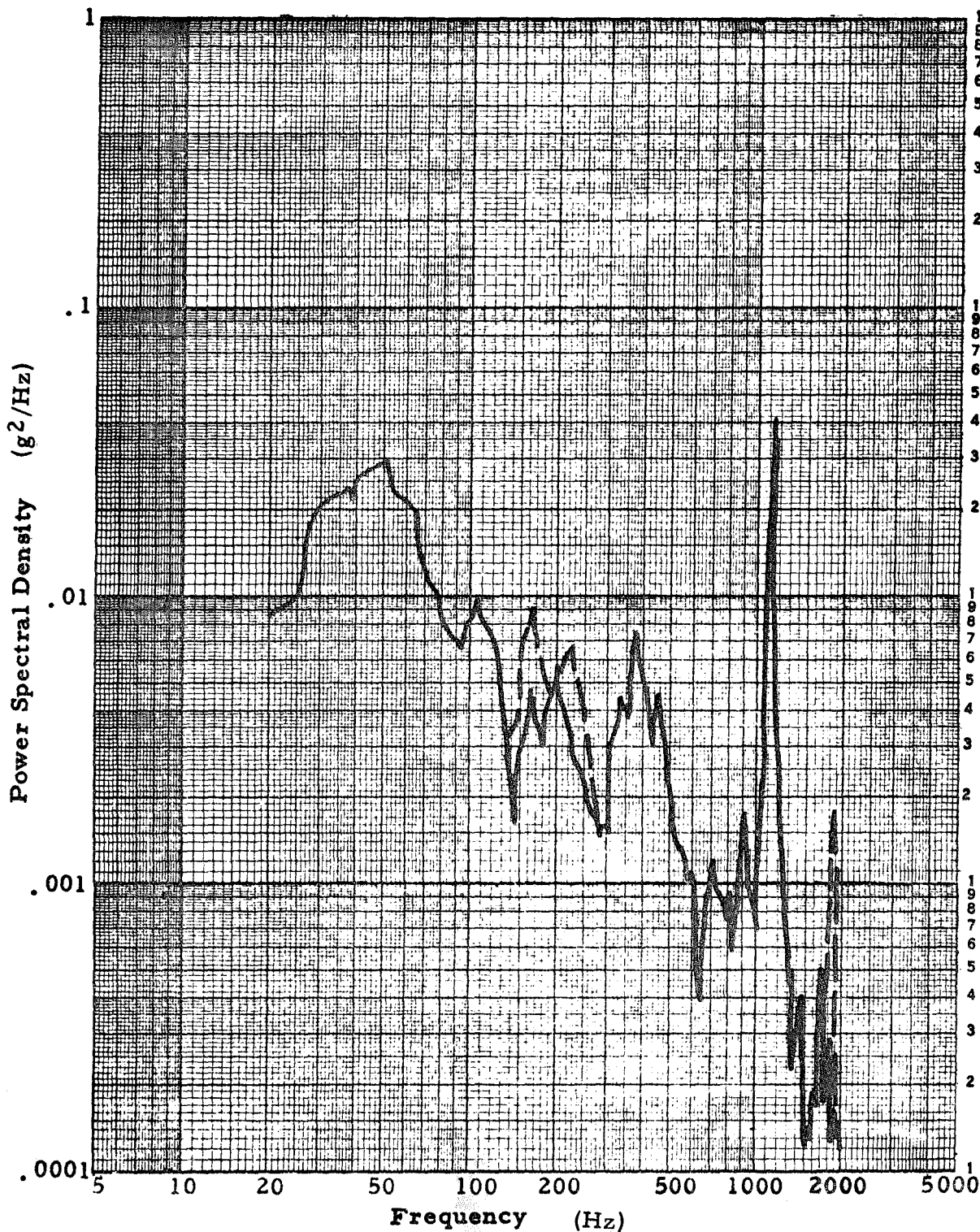
RANDOM VIBRATION SPECTRUM

LUNAR DESCENT

Duration:

S.P. 1 w/ PSE

PSE X RESPONSE (Loc.B)





ALL NO. 5

Axis:

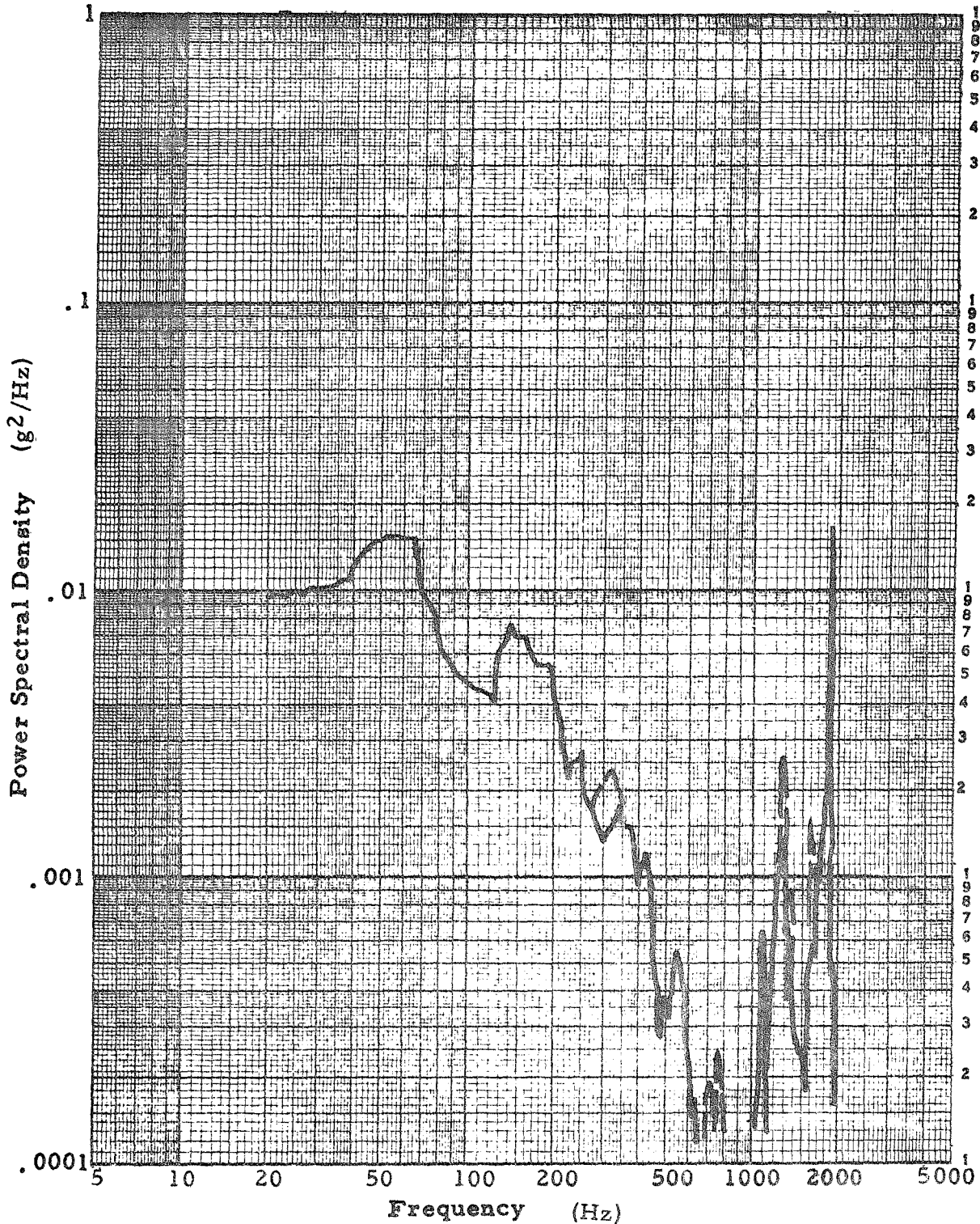
RANDOM VIBRATION SPECTRUM

LUNAR DESCENT

S.P. 1 W/PSE

Duration:

PSE Y RESPONSE (Loc.B)





ALL. NO. 6

Axis:

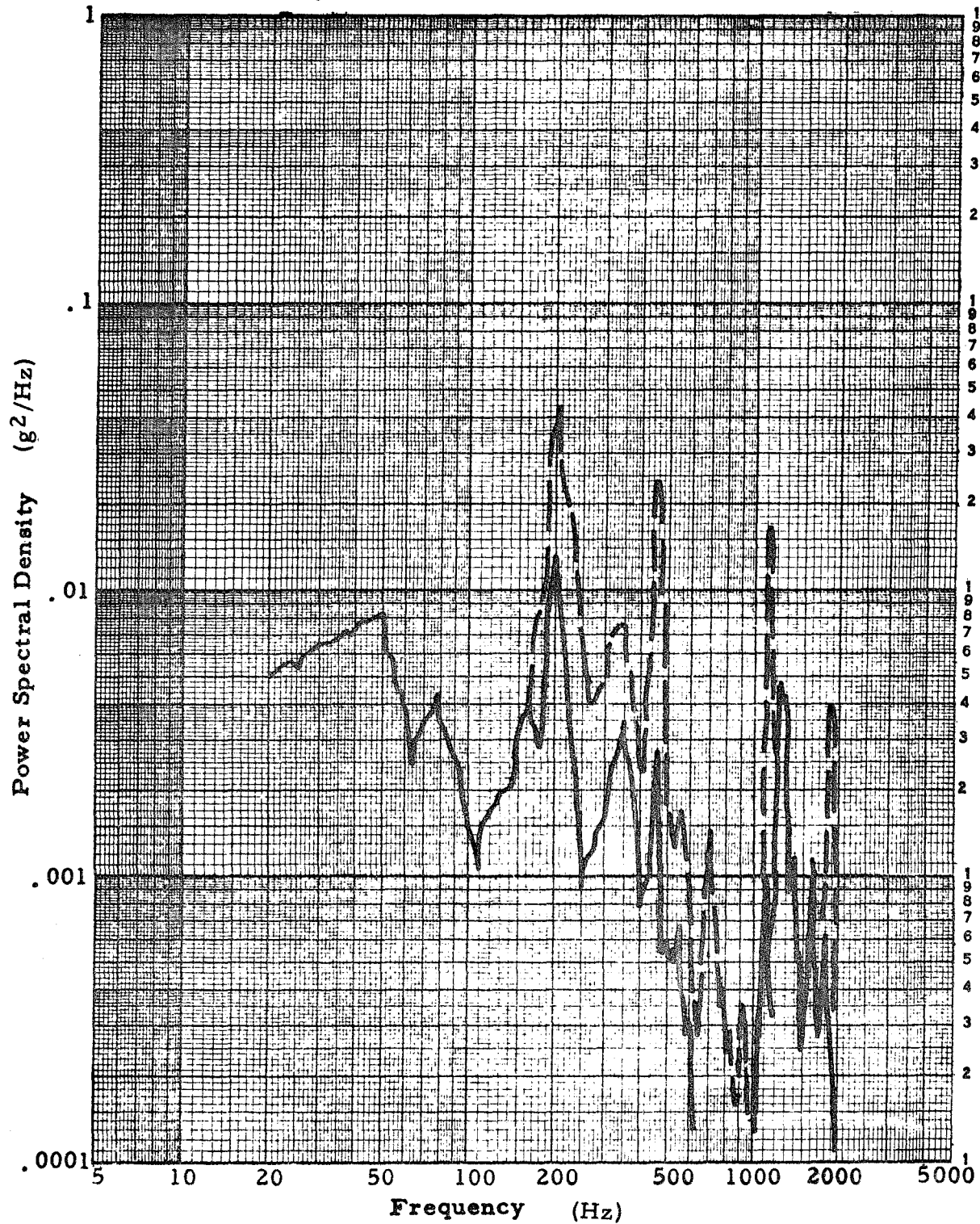
RANDOM VIBRATION SPECTRUM

LUNAR DESCENT

Duration:

S.P. 1 W/PSE

PSE 2 RESPONSE (Loc. B)

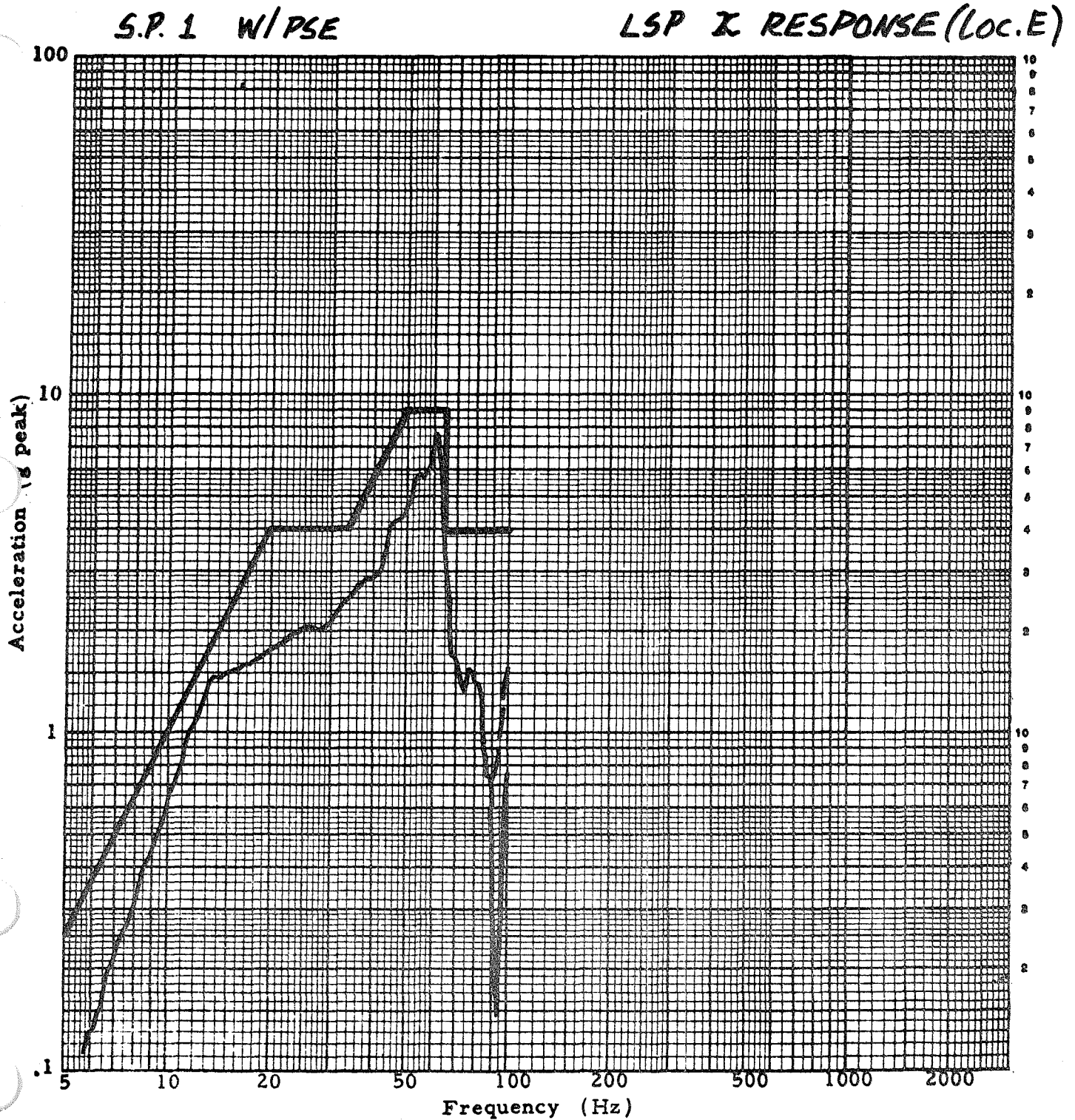


SINUSOIDAL VIBRATION

ALL. NO. 7

Axis:

Sweep Rate:



SINUSOIDAL VIBRATION

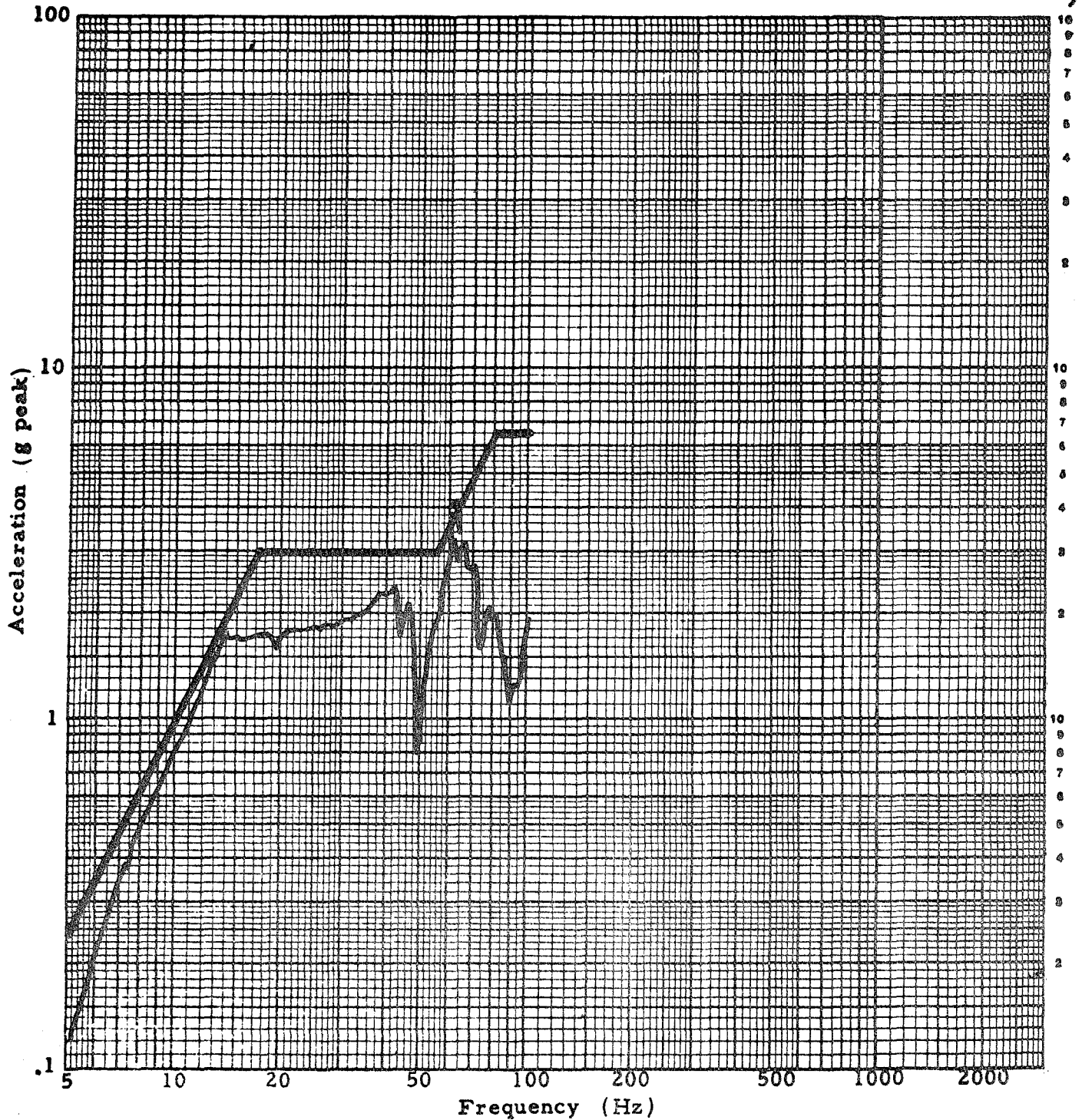
ACC. NO. 8

Axis:

Sweep Rate:

S.P. 1 W/PSE

LSP & RESPONSE (Loc.E)



ALL. NO. 9

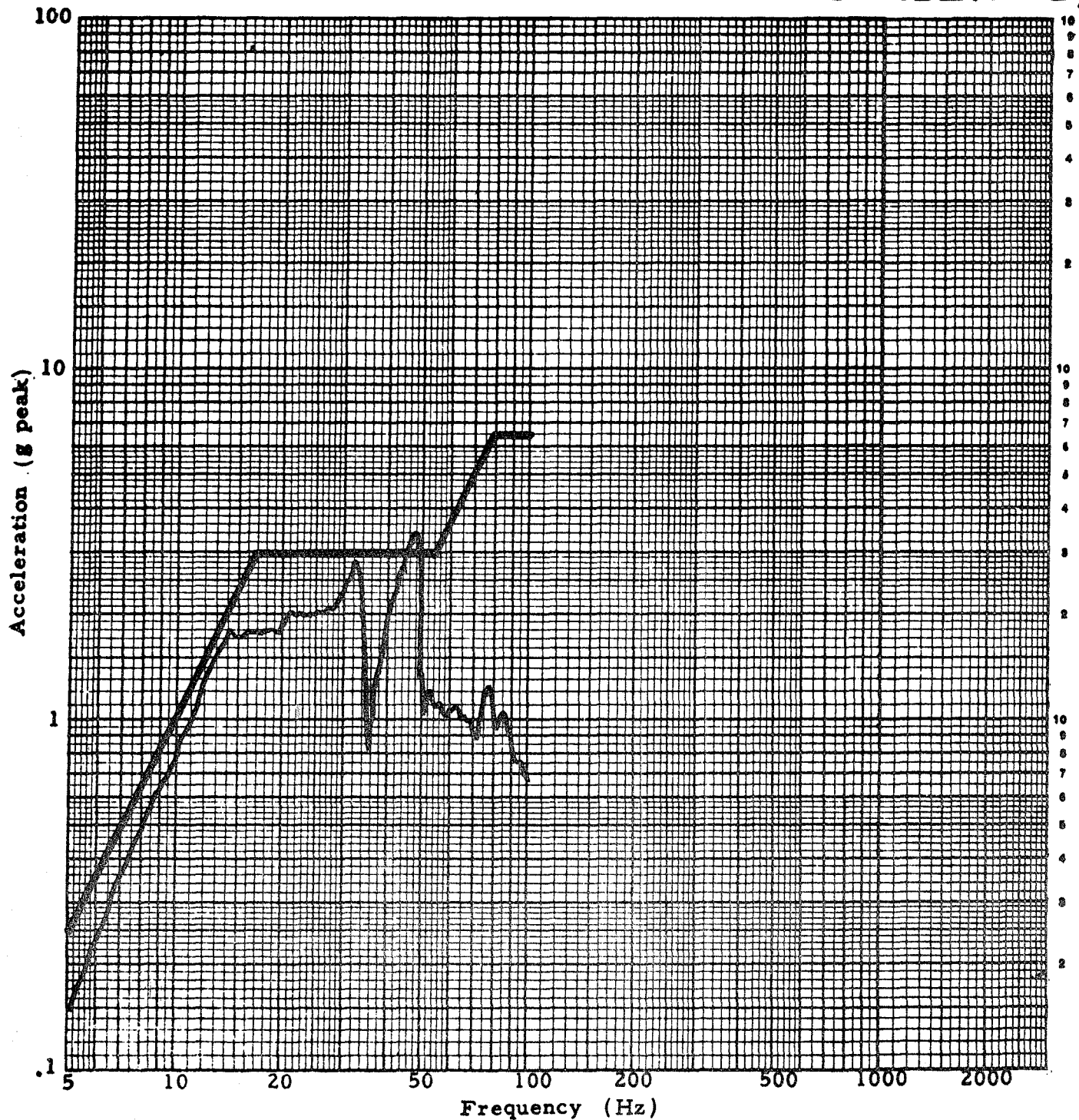
SINUSOIDAL VIBRATION

Axis:

Sweep Rate:

S.P. 1 W/PSE

LSP 2 RESPONSE (Loc. E)





ALL. NO. 7

Axis:

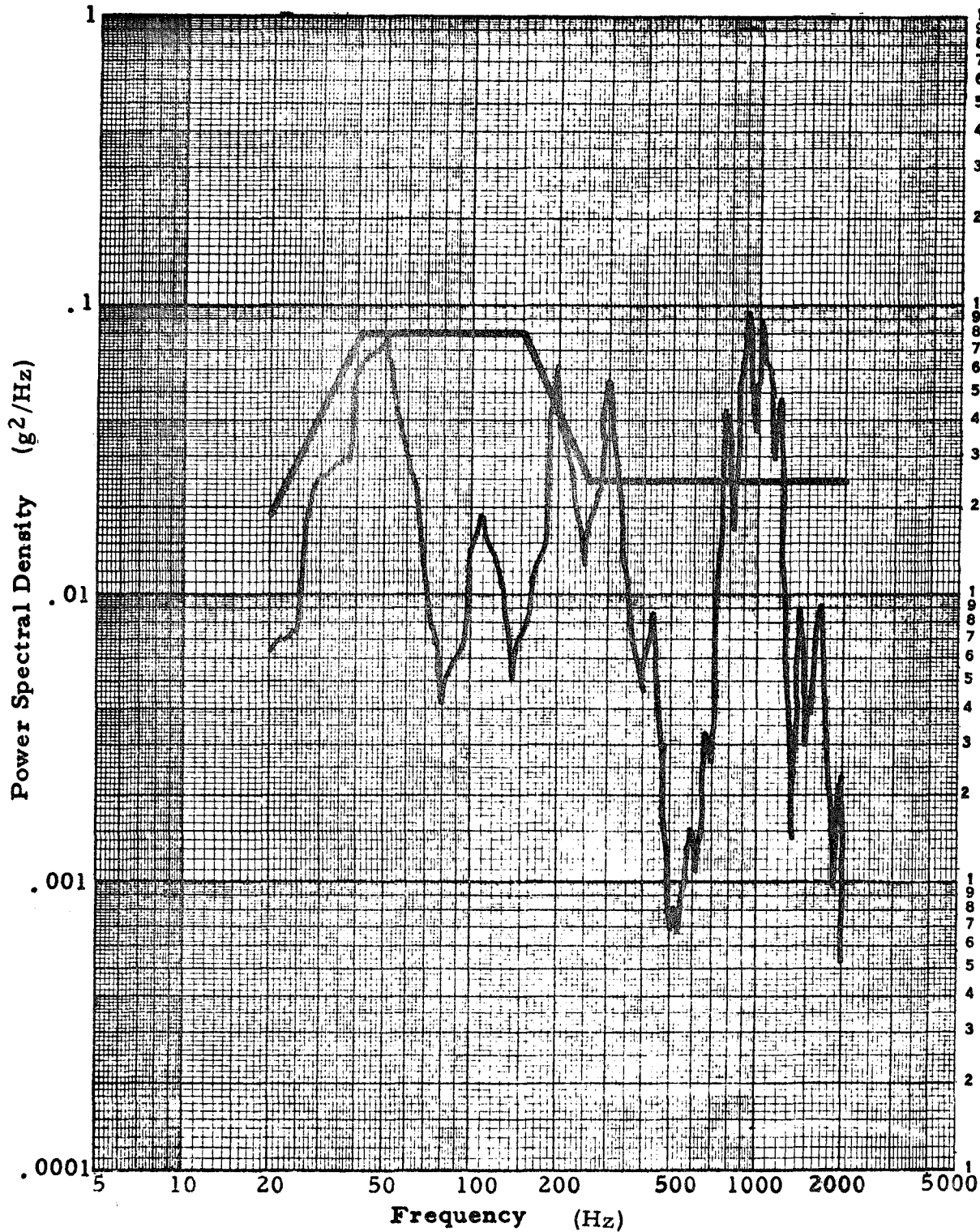
RANDOM VIBRATION SPECTRUM

LAUNCH & BOOST

S.P. 1 W/PSE

Duration:

LSP X RESPONSE (Loc.E)



ALL. NO. 8

Axis:

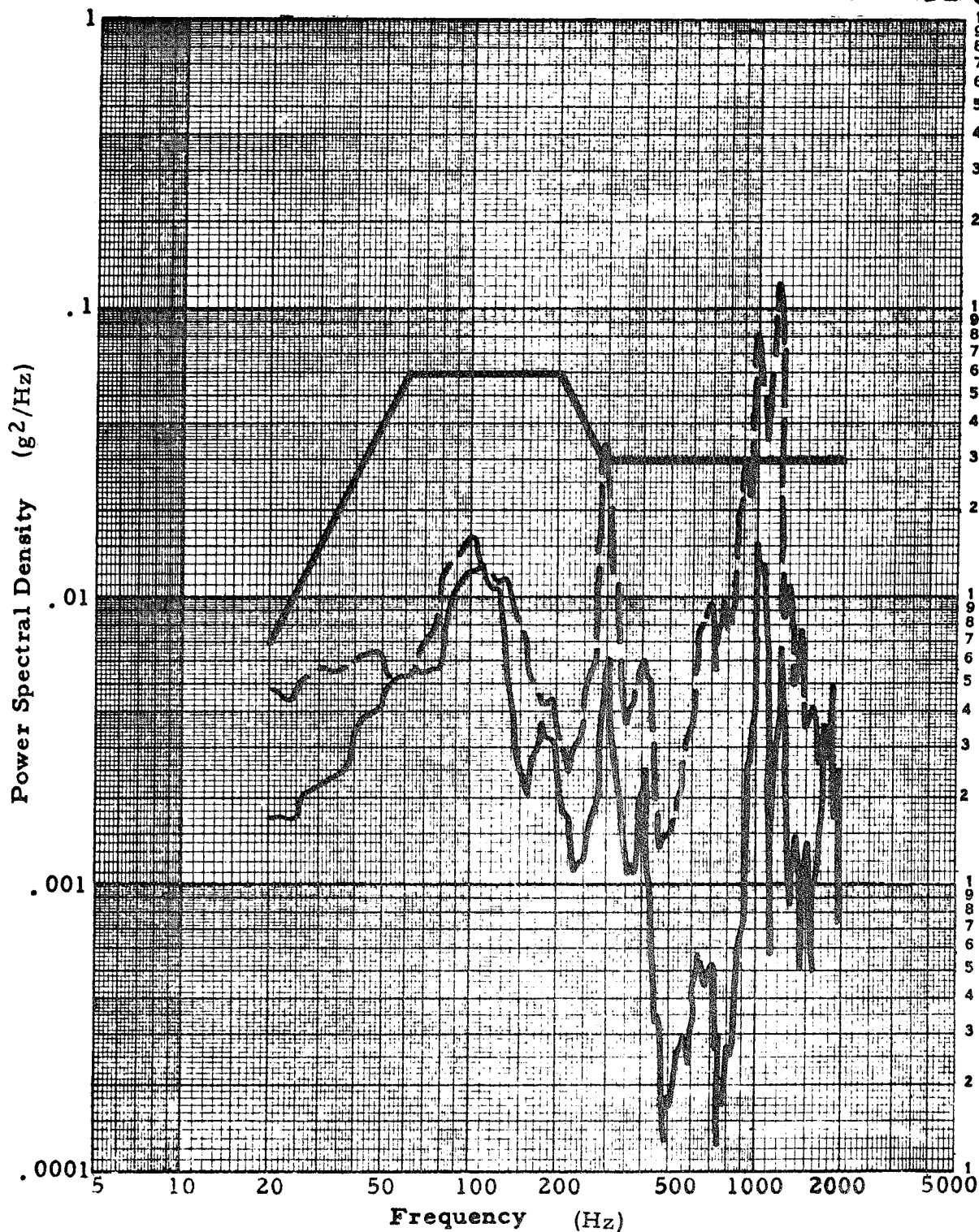
RANDOM VIBRATION SPECTRUM

LAUNCH & BOOST

S.P. 1 W/ PSE

Duration:

LSP. & RESPONSE (Loc. E)



ALL NO. 9

Axis:

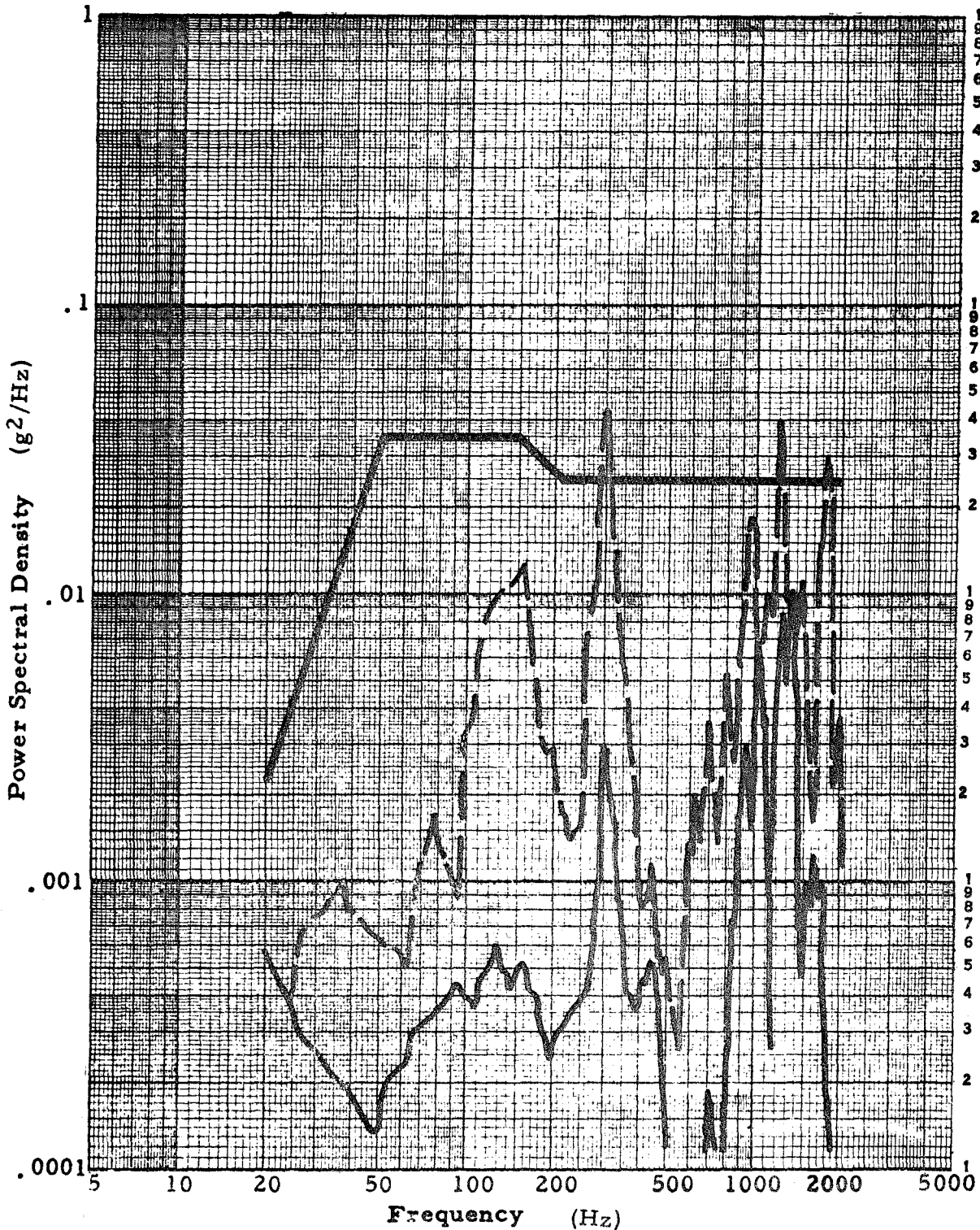
RANDOM VIBRATION SPECTRUM

LAUNCH & BOOST

S.P. 1 W/PSE

Duration:

LSP & RESPONSE (Loc.E)





ALL. NO. 7

Axis:

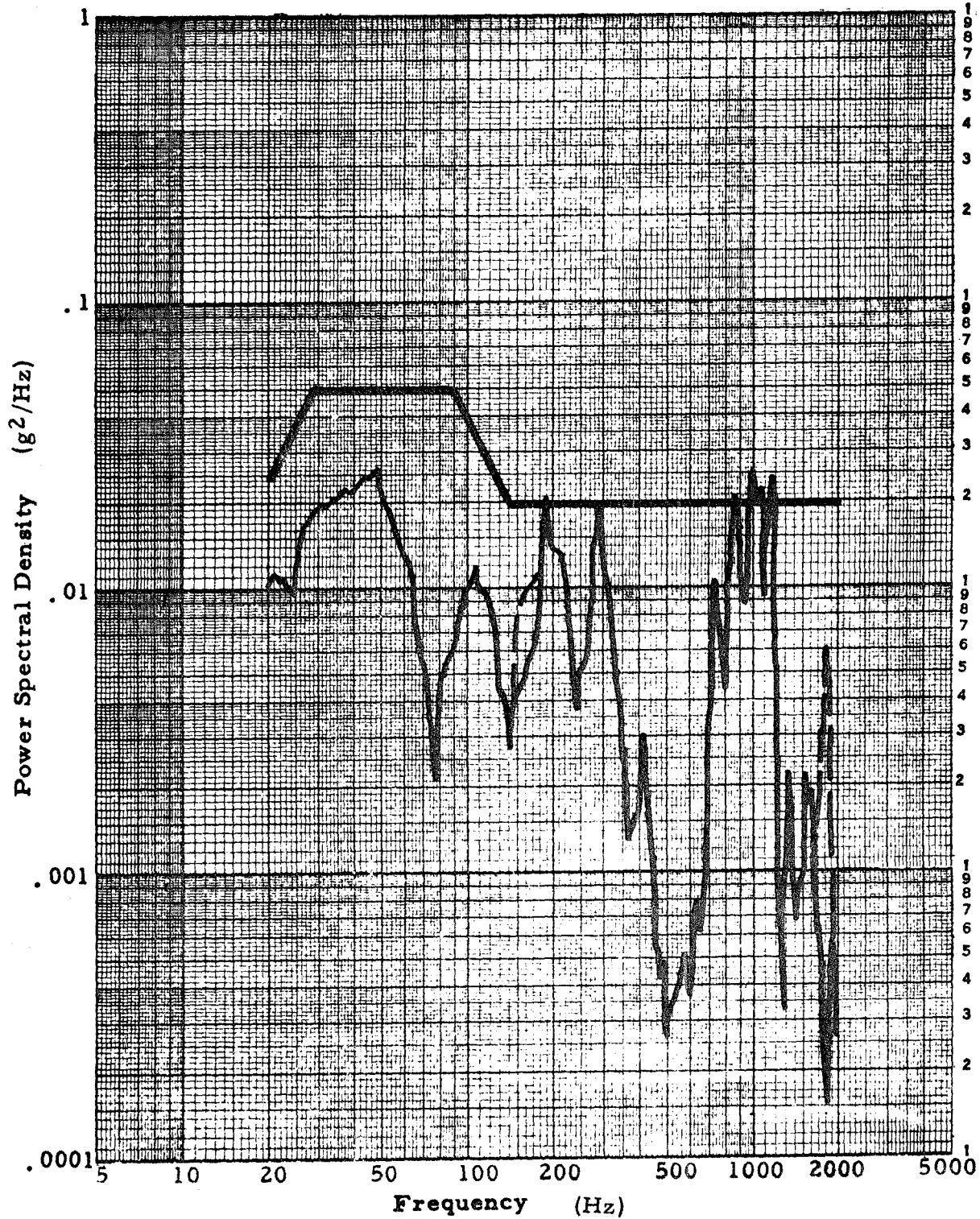
RANDOM VIBRATION SPECTRUM

LUNAR DESCENT

S.P. 1 W/PSE

Duration:

LSP X RESPONSE (Loc. E)



ALL. NO. 8

Axis:

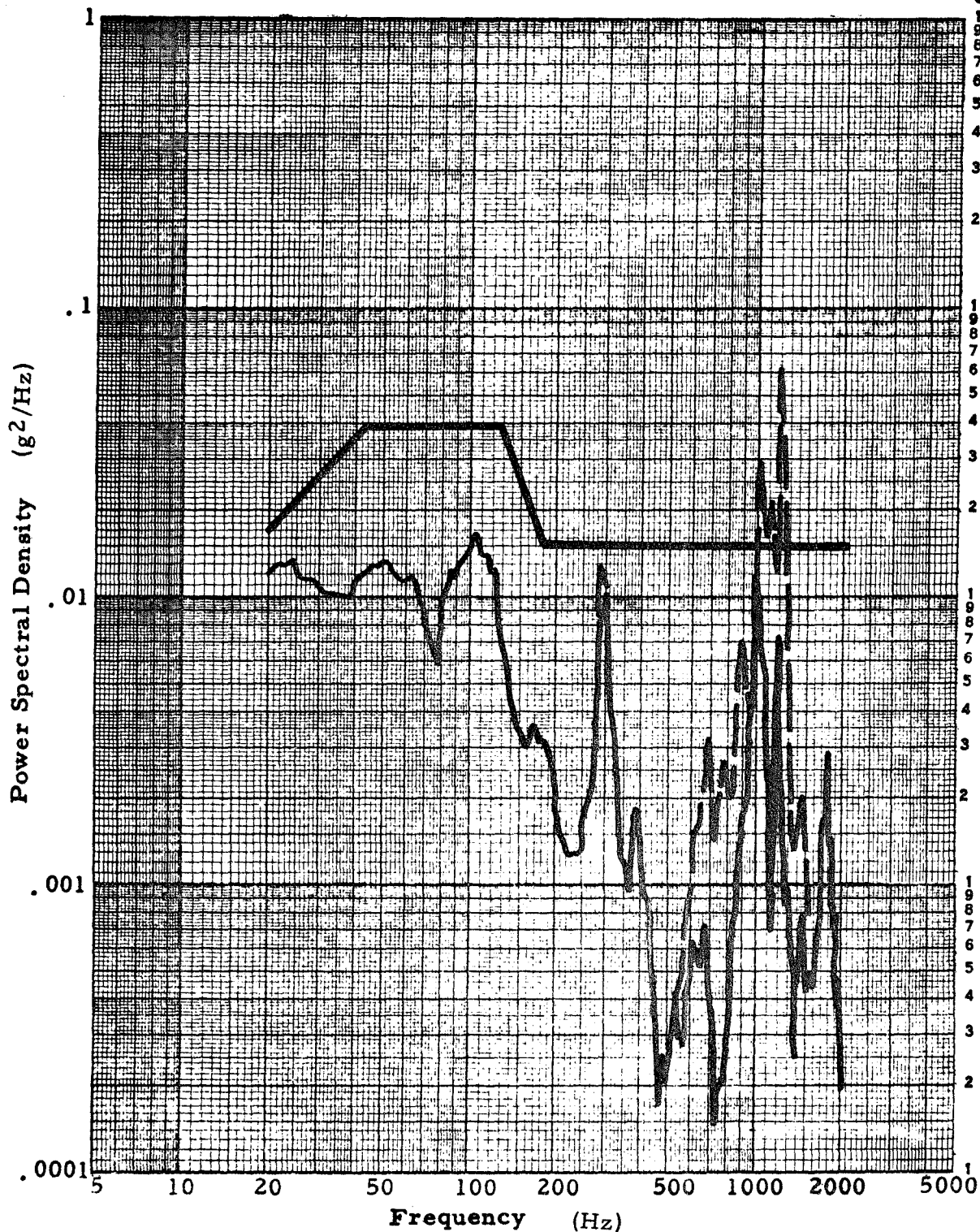
RANDOM VIBRATION SPECTRUM

LUNAR DESCENT

Duration:

S.P. 1 W/PSE

LSP & RESPONSE (Loc.E)





ALL IN. 9

Axis:

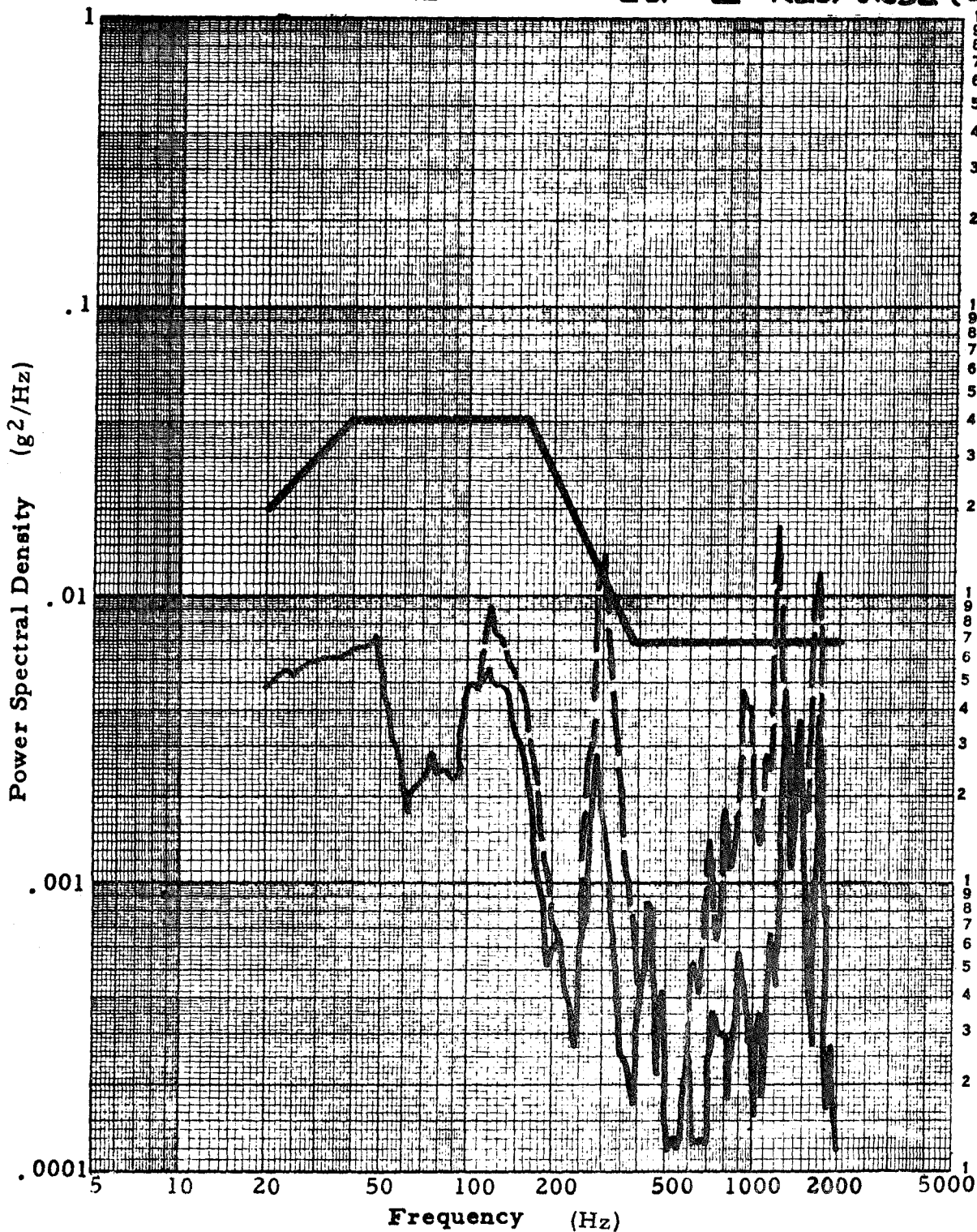
RANDOM VIBRATION SPECTRUM

LUNAR DESCENT

S.P. 1 W/PSE

Duration:

LSP 2 RESPONSE (L.A.E)



ALL. NO. 10

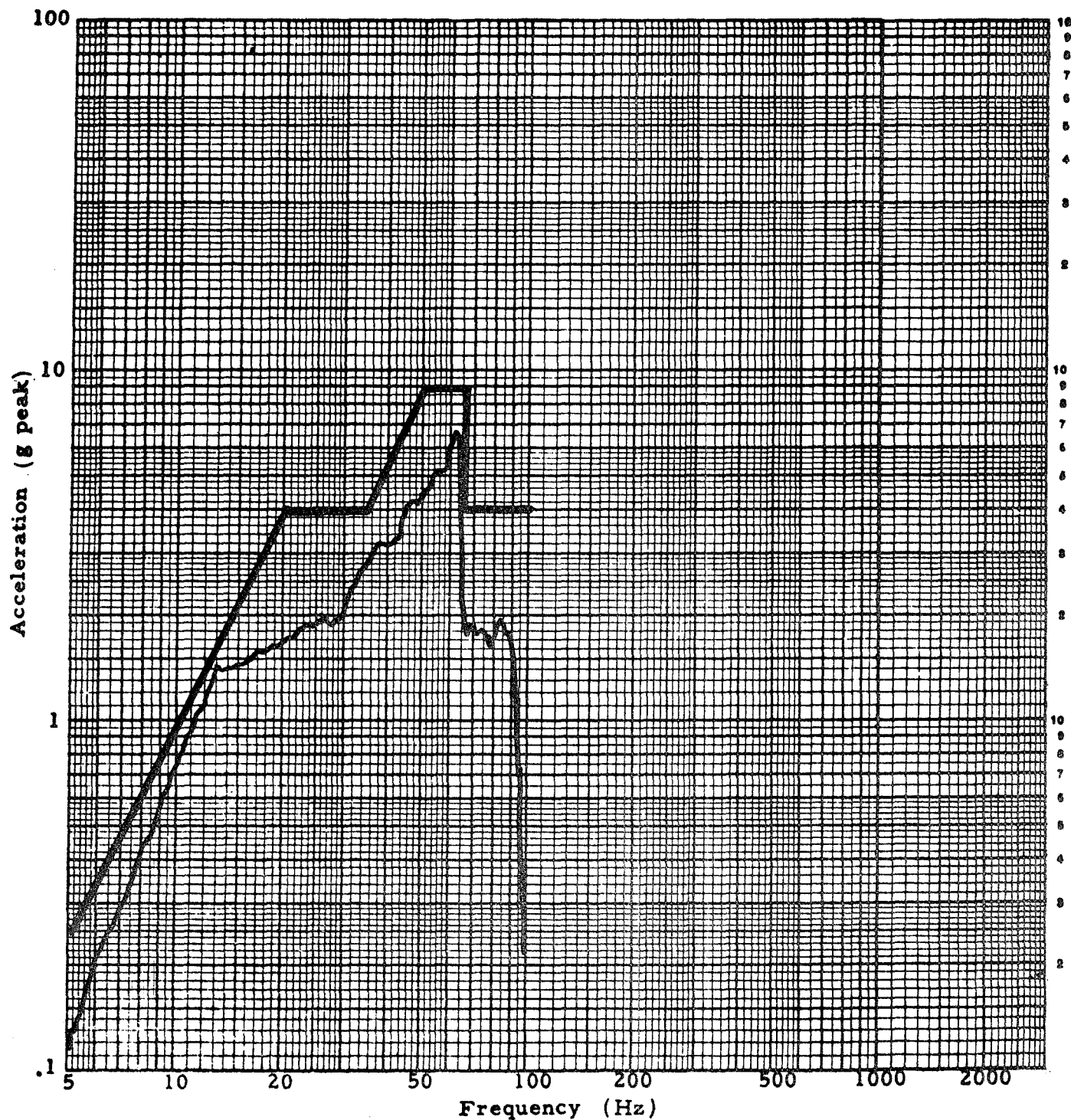
SINUSOIDAL VIBRATION

Axis:

Sweep Rate:

S.P. 1 W/PSE

LMS X RESPONSE (Loc.F)



ALL. NO. 11

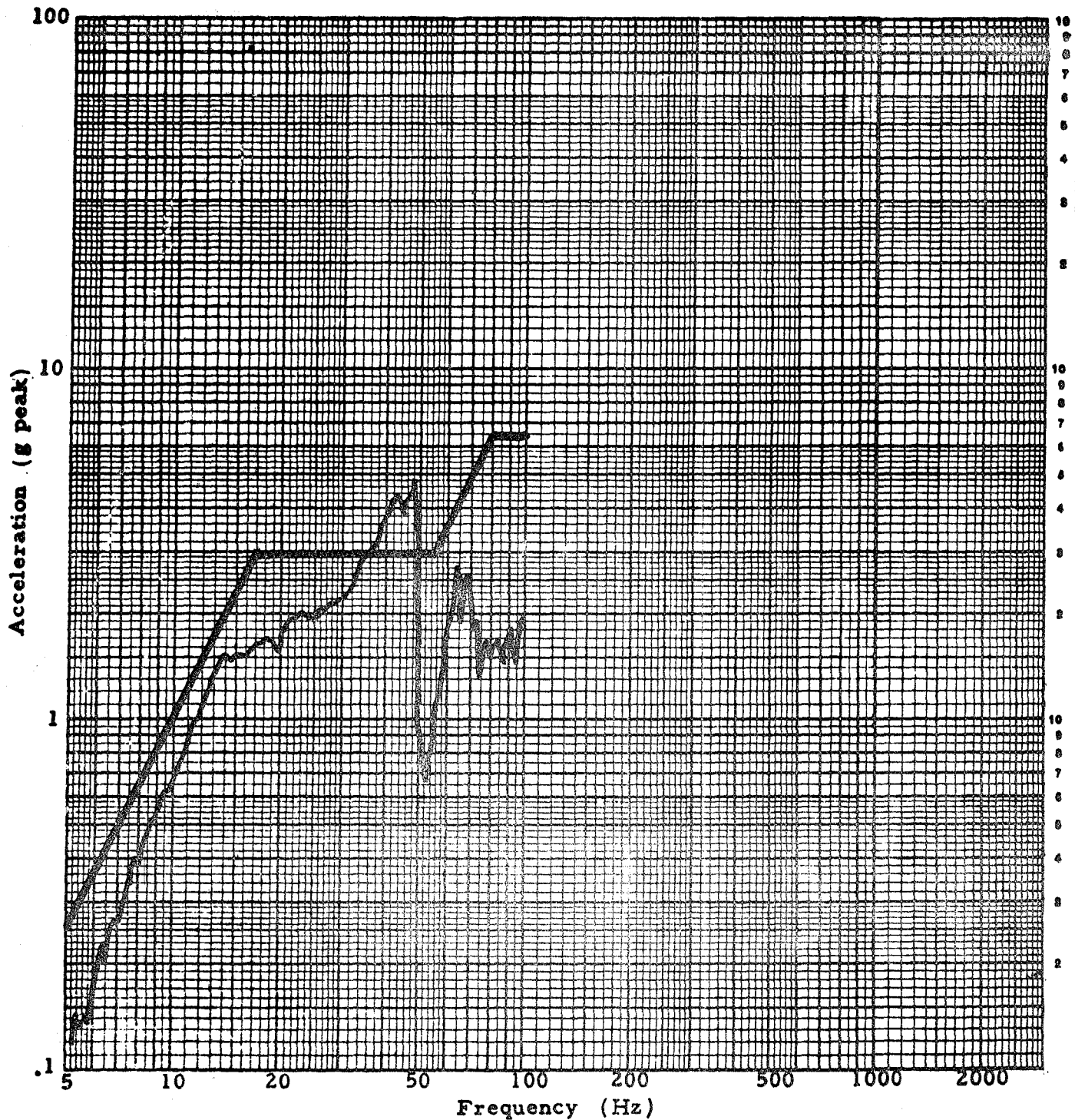
SINUSOIDAL VIBRATION

Axis:

Sweep Rate:

S.P. 1 W/PSE

LMS & RESPONSE (Loc.F)



ALL. NO. 12

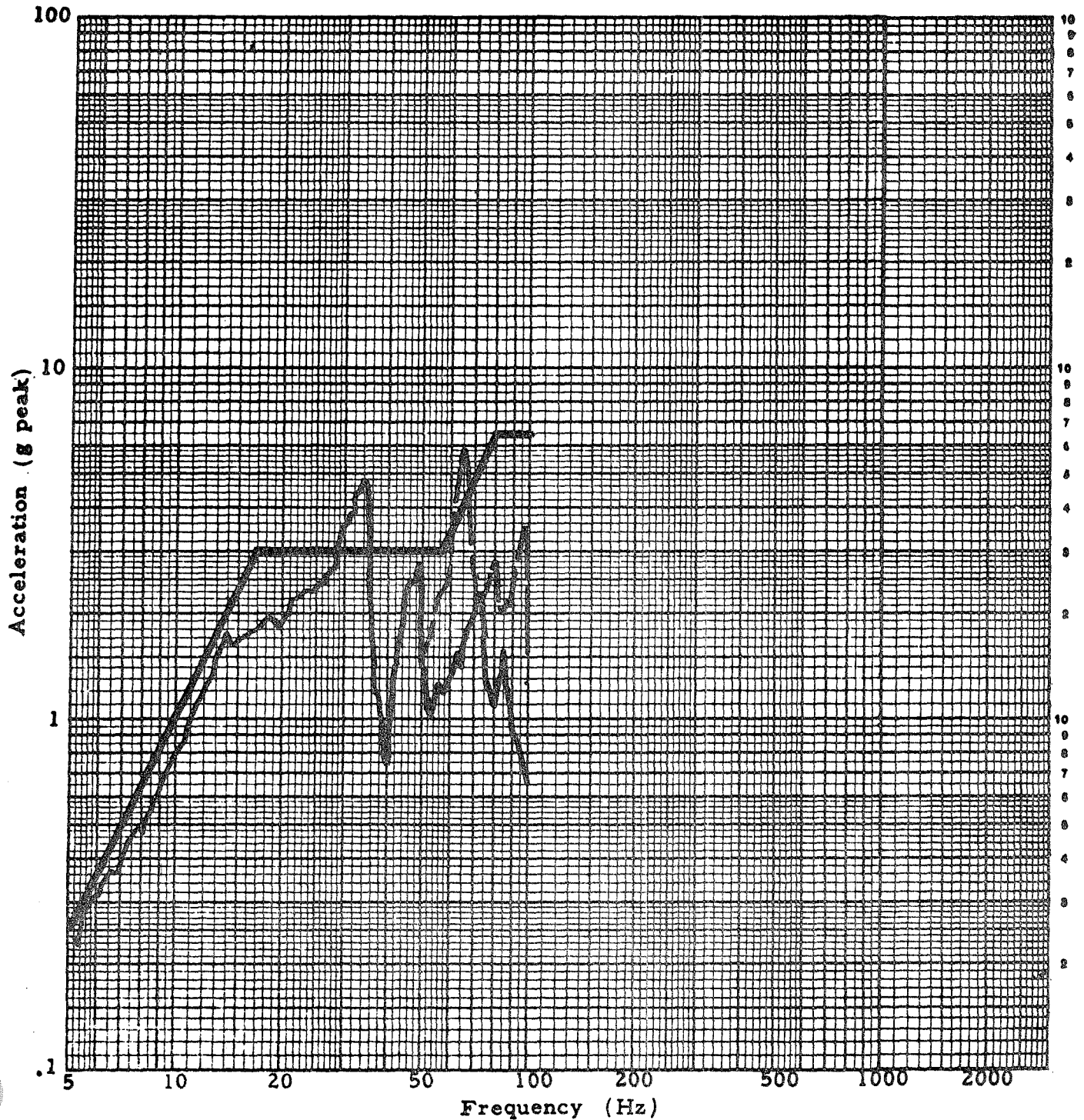
SINUSOIDAL VIBRATION

Axis:

Sweep Rate:

S.P. 1 W/PSE

LMS 2 RESPONSE (LOC.F)





ACC. NO. 10

Axis:

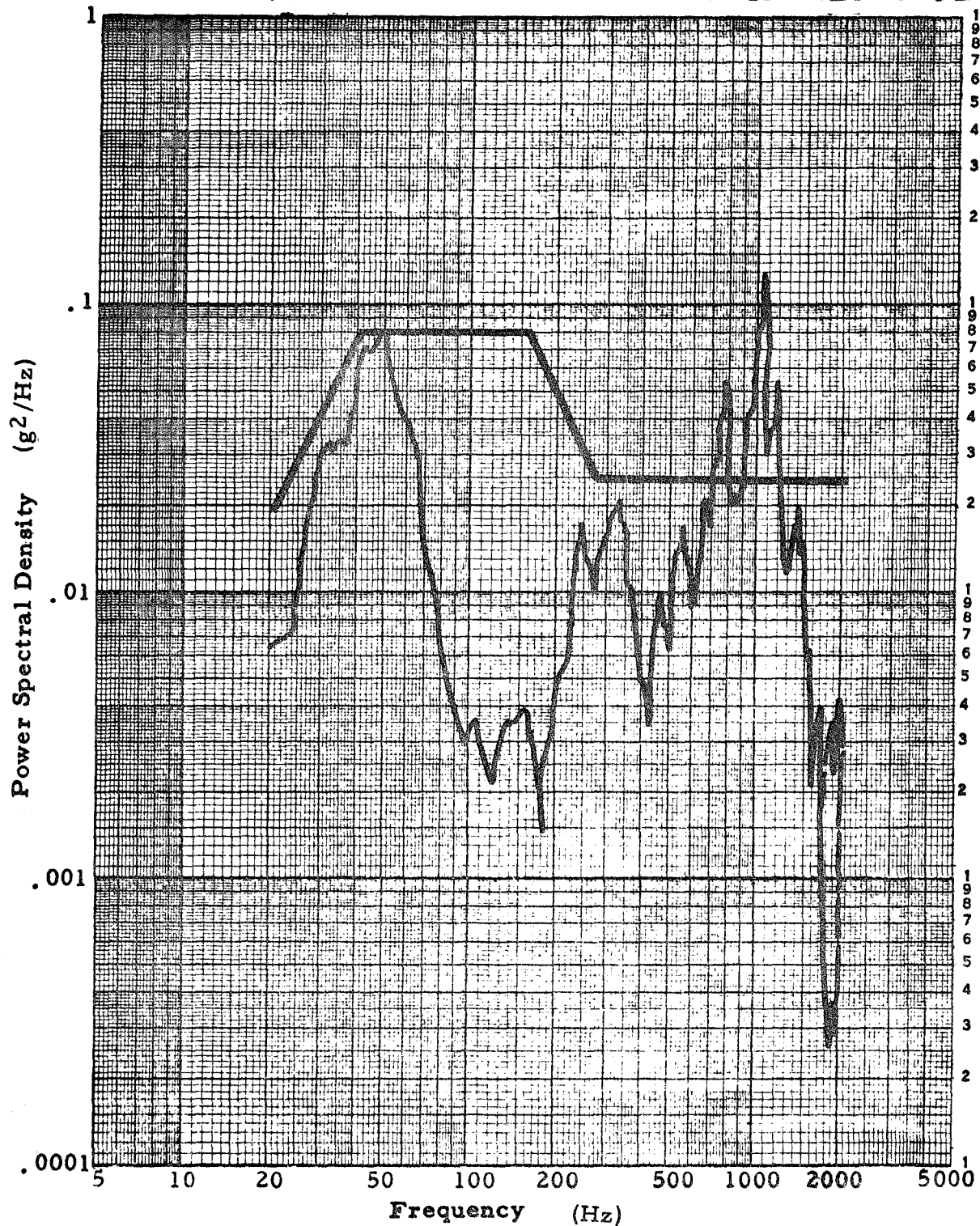
RANDOM VIBRATION SPECTRUM

LAUNCH & BOOST

Duration:

S.P. 1 W/PSE

LMS X RESPONSE (loc.F)





ALLAN 11

Axis:

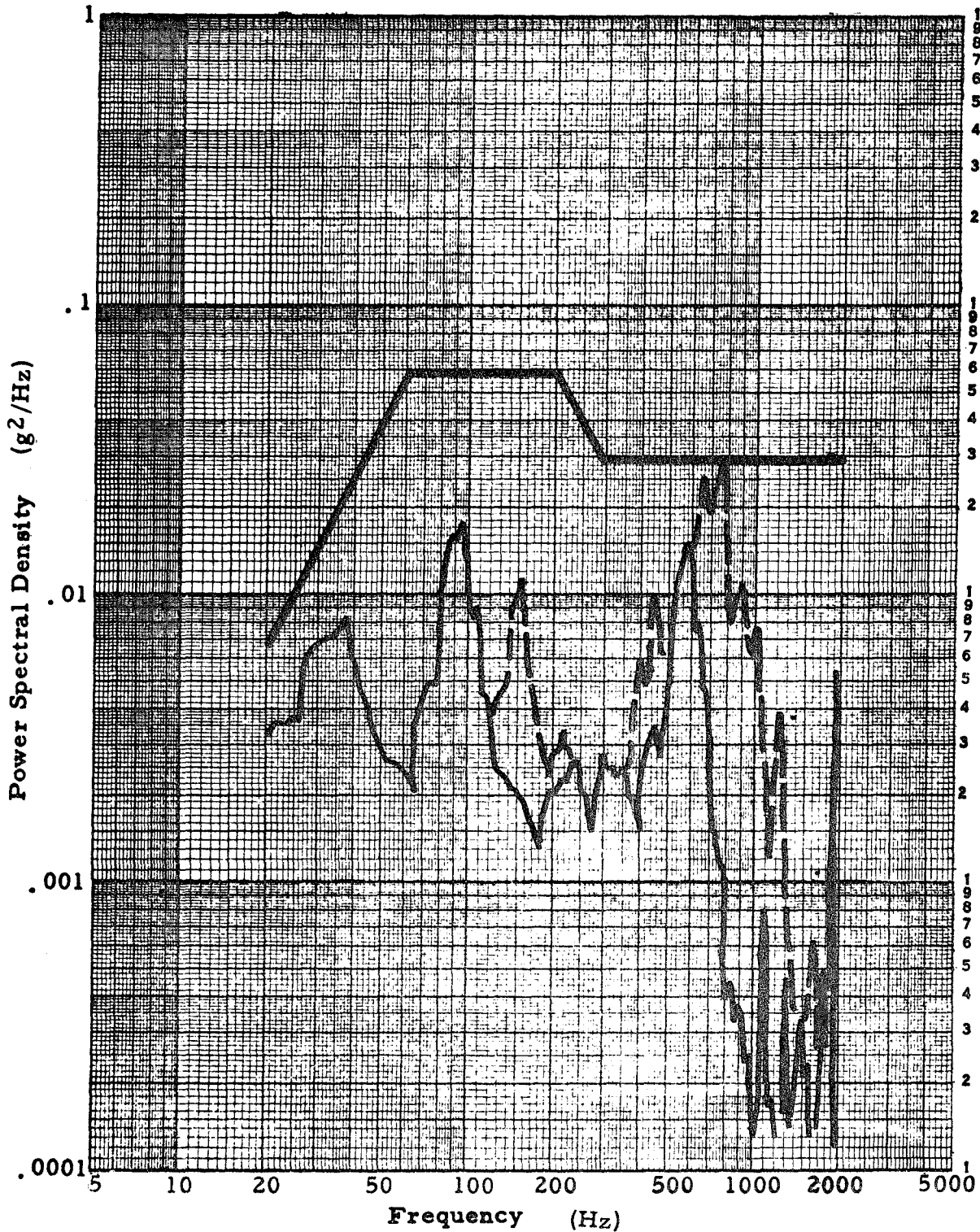
RANDOM VIBRATION SPECTRUM

LAUNCH & BOOST

S.P. 1 W/PSE

Duration:

LMS Y RESPONSE (Loc.F)



ALL NO. 12

Axis:

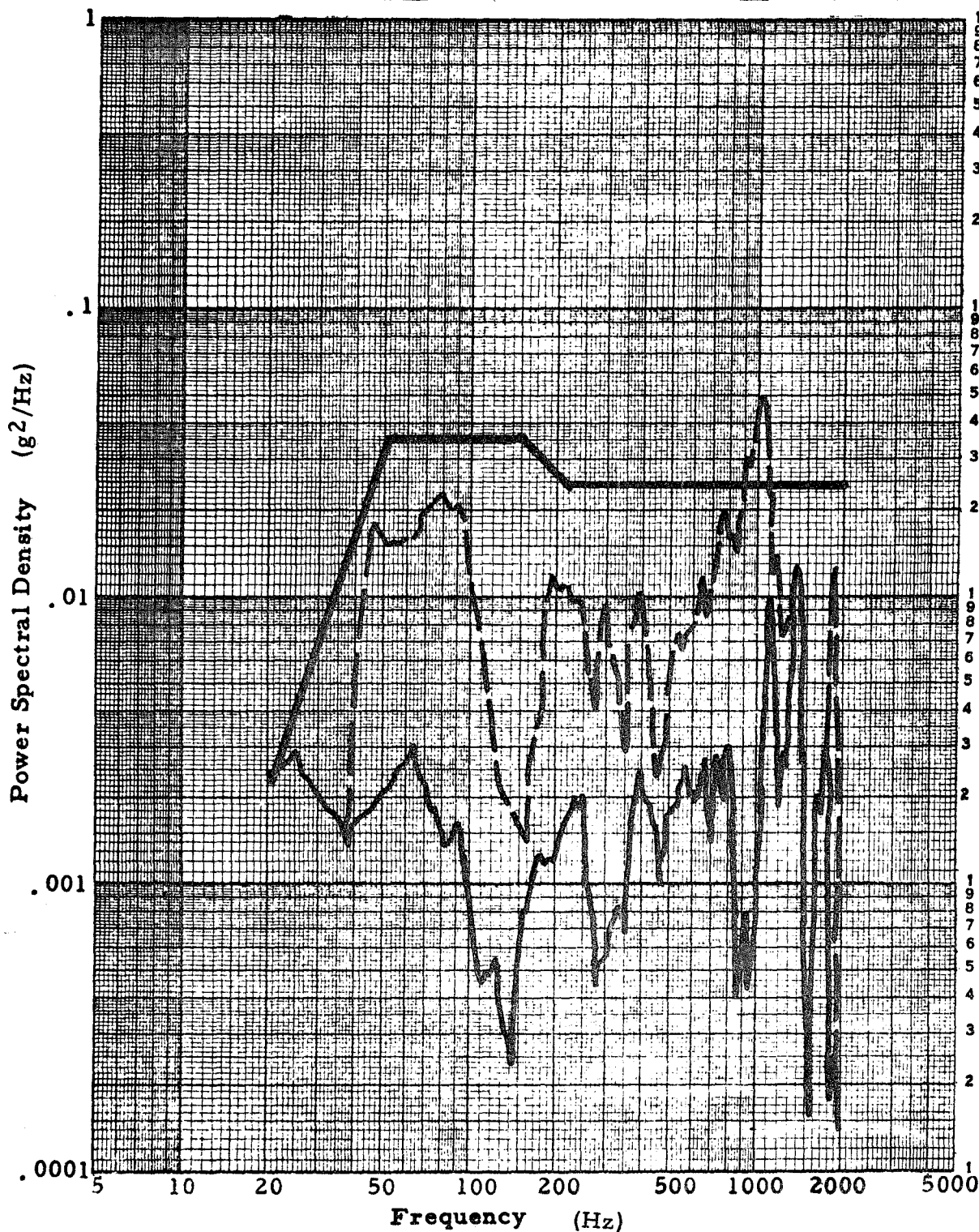
RANDOM VIBRATION SPECTRUM

LAUNCH & BOOST

S.P. 1 W/PSE

Duration:

LMS 2 RESPONSE (Loc.F)



ALL. NO. 10

Axis:

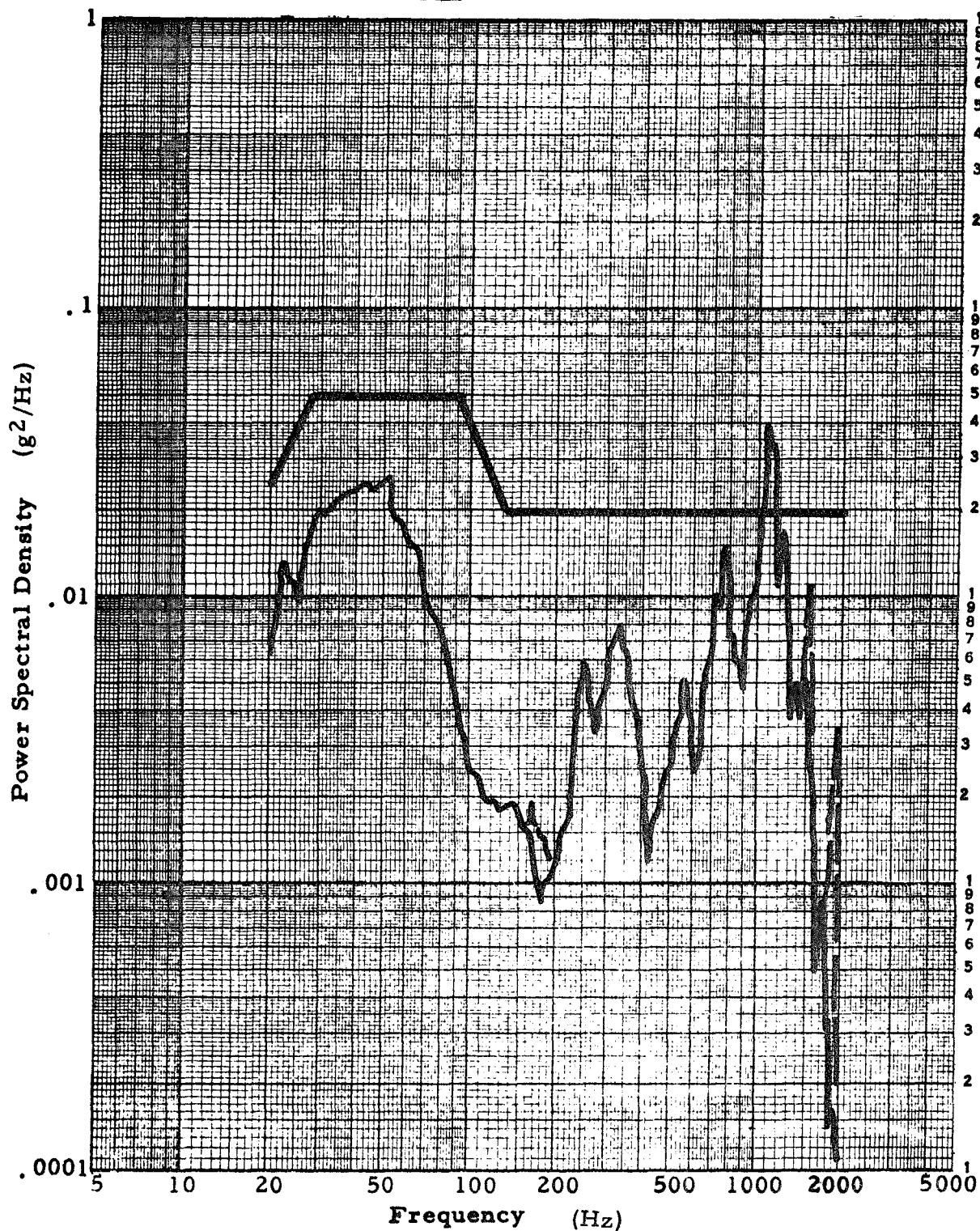
RANDOM VIBRATION SPECTRUM

LUNAR DESCENT

S.P. 1 W/PSE

Duration:

LMS X RESPONSE (Loc.F)





ALL NO. 11

Axis:

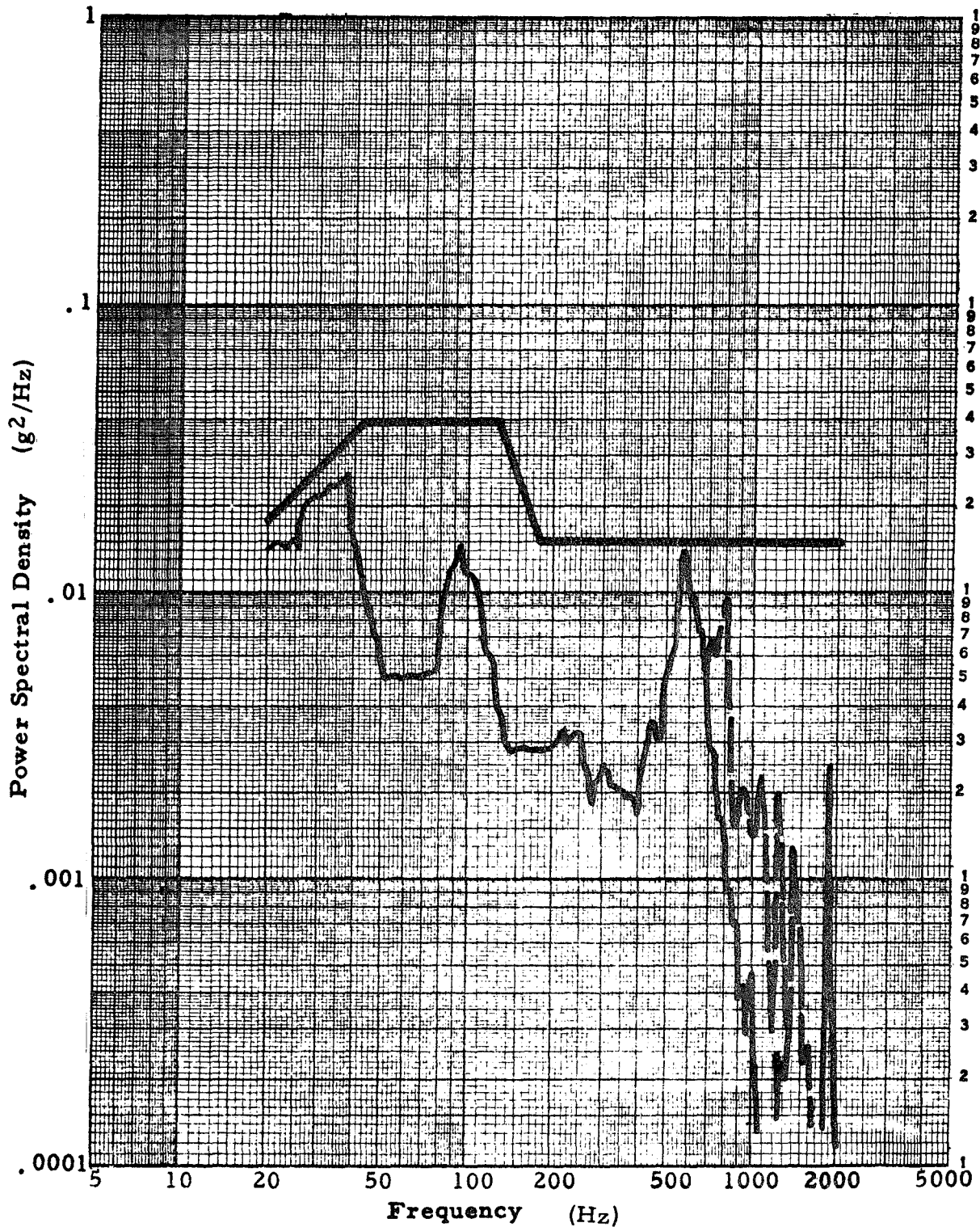
RANDOM VIBRATION SPECTRUM

LUNAR DESCENT

Duration:

S.P. 1 W/PSE

LMS Σ RESPONSE (Loc.F)



ACL NO. 12

Axis:

RANDOM VIBRATION SPECTRUM

**LUNAR DESCENT
S.P. 1 W/PSE**

Duration:

LMS 2 RESPONSE (Loc.F)

