FINAL REPORT

FLIGHT OFF-LOADING QUAL CONFIDENCE PROGRAM FOR ARRAY A ALSEP SUBPACKAGE 1

Submitted as Partial Fulfillment of the
Report Requirements of
ALSEP CCP-98

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1.0 SUMMARY

A series of tests were conducted in order to determine the effect of off-loading (removing) either the SWE or the LSM from the Subpack I of ALSEP upon the dynamic environment of the remaining subsystems.

The test results indicated that dynamic levels of the remaining subsystems will be substantially increased if either experiment is off-loaded. Consequently, off-loading experiments on ALSEP subpackage 1 is not recommended.

2.0 INTRODUCTION

2.1 Program Requirements

In a TWX (Reference 6.1) from NASA/MSC Bendix was directed to design, instrument, and conduct engineering vibration tests on "experiment off-loaded" configurations of ALSEP Subpackages 1 and 2 for Flight models 1 and 2. The test program was "to provide confidence in the prior qualification and acceptance testing of the four-experiment ALSEP configuration".

The experiment off-loaded" configurations of ALSEP Subpackage 1 was defined in the NASA TWX as follows:

(Baseline)	PSE, LSM, SWE
	PSE, LSM
	PSE, SWE

Test article instrumentation was to be similar to the Proto A vibration tests. Sufficient tests were to be conducted to provide "single data point correlation between off-loaded configurations and four-experiments configurations previously tested". No functional tests of ALSEP System equipment were to be made as part of these tests.

The equipment to be used in the Subpackage 1 assembly was also defined in reference 6.1. The identified equipment was that which was ultimately used, except for the SWE dynamic model. This model was no longer available and a unit, previously rejected for ALSEP Qual SA test, (SN-5) was used instead.

The NASA TWX called for test completion by 7 May 1968 and final report submittal by 15 June 1968. It also specified that no ALSEP schedule impacts were to be associated with this program. Although the Subpackage 1 tests were completed prior to the specified date, delays in the availability of reduced data and support personnel as a result of other ALSEP commitments delayed completion of this report.

Reference 6.1 directed that Bendix conduct an analysis and data correlation of the test results with prior Proto A and Qual SA test results and prepare a report of the results. This document is intended to meet the report requirement for Subpackage 1 experiment off-load tests.

2.2 ALSEP Experiment Off-Loading

The reasons for employing an off-loaded ALSEP in a lunar landing mission would be due to either an experiment failure prior to launch or an unacceptable overweight situation. In the event that a defective experiment is identified during pre-launch operations, a decision may be made to remove it and transport ALSEP to the lunar surface in an off-loaded configuration. If the final weight of ALSEP is deemed as unacceptable for flight, a decision would undoubtedly be made to remove weight in the form of one of the experiments.

The most immediate effect of off-loading is to change the ALSEP Subpackage 1 total weight and center-of-gravity location. Table 2-1 summarizes the present weight and c.g. location of the Subpackage 1. It also shows the total weight for each of the off-loaded configurations defined for these tests in Reference 6.1. It should be noted that the configuration which results from the removal of the LSM has a c.g. location which exceeds the specification tolerance on the specification ALSEP c.g. location. Also the LSM provides the support to prevent ALSEP tip over when ALSEP Subpackage 1 is laid on its side during lunar deployment.

Another effect of off-loading is to change the mass distribution on the sunshield (i.e., the upper structural number of the Subpackage 1 assembly). This test program is intended to provide data on the effects of such change, in the form of experiment removal, on the vibrational inputs to the remaining experiments.

2.3 Program Implementation

The test requirements were identified in References 6.2 and 6.3, including the hardware to be assembled for Subpackage No. 1. With NASA/MSC support the LSM dynamic models and the SWE SN5 unit were authorized for use in these tests. The LSM was returned to Bendix from JPL; the SWS was already at Bendix. Assembly was completed on 22 April 1968 to meet the expected test facility availability dates of the week of 22-26 April.

Readiness to test was made possible only the concurrent availability of ALSEP Subpackage No. 1 structure, associated experiments, ALSEP

TABLE 2-1

Mass Properties Effects Experiment
Off Loading Subpackage 1

	Present Configuration		Off-Loaded Configurations	
	QSA	Flights 1 & 2	with PSE, SWS	with PSE, LSM
Weight	120.9	122.8	100.7	109.1
$\bar{X}_A$	+8.5	+8.5	+7.0	+8.1
$\bar{Y}_A$	-12.6	-12.6	-13.7	-11.8
$\bar{Z}_A$	+10.6	+10.6	+9.2	+11.0
ΔS	2.9	2.9	5.1	3.4

ΔS = Spherical Radius from Spec. c. g. (tolerance = 5.0) manufacturing support and the test facility. The program ground rule, as stated in Reference 6.1, that impact of the ALSEP schedule was not permitted; made it imperative that this date be met. Schedules available at the time indicated that the primary structure and the thermal plate were required for Qual C buld-up prior to the next test facility availability dates.

These tests were run on 23 and 24 April 1968. Required data was not made available for analysis until 29 May (due to other ALSEP test activities), although a limited quantity of selected data was made available within 24 hours of the test.

3.0 TEST DESCRIPTION

3.1 Test Article

The engineering off-loading vibration tests were performed on the ALSEP Array A Subpackage #1 configuration. This configuration was assembled from the following basic ALSEP parts:

Part Name		Dwg. No.
Primary Structure	Qual A S/N2	2330203 K
Thermal Plate (including dummy electronic packages)	Proto 1	2332199
Sunshield Assembly	Qual A A/N2	2330228 G
Antenna	Dummy	2335079
Passive Seismic Experiment (PSE)	Proto 1 dummy	2334274
Lunar Surface Magnetometer (LSM)	Proto A dynamic model	2330657
Solar Wind Experiment (SWE)	Rejected Qual unit	2330658

No thermal reflectors, thermal curtains or ancillary equipment were included on the assembly. Calfax Live-lock fasteners were used in the sunshield and to tie down the experiments and the antenna. These were lockwired where permitted by their locations. Three center fasteners on the sunshield and two fasteners used to tie down the LSM were not lockwired.

A dynamic model of the SWE was not available for this test. The SWE unit used in the test contained operating electronics, which had been functionally tested and found satisfactory prior to these vibration tests. It had been rejected as a Qual unit because it did not conform to the latest SWE revision. The use of this unit, while an excellent dynamic representation of the Qual SA or Flight units, did impose certain constraints on the test program. Installation of the SWE on the sunshield required preloading of its legs. Also, constant monitoring of the pre-load during vibration testing was required. In addition the test environment was to be limited to 1 g sinusoidal vibration to ensure that input to the SWE would not exceed present interface specification levels.

Assembly of Subpackage 1 was complete and the subpackage was delivered to the test facility on 22 April 1968.

3.2 Test Configuration

The specific configurations tested were as defined in reference 6.1. These configurations are obtained by the removal of one of the experiments from the basic ALSEP Array A Subpackage No. 1 configuration. The configurations were designated, for identification purposes, as follows:

Configuration α_1 : PSE, LSM, SWE

Configuration β_1 : PSE, LSM

Configuration γ_1 : PSE, SWE

The experiments listed are those left on the sunshield in each configuration. In removing the experiment, only the experiment and the associated fastener studs were removed; the unused support brackets and fastener receptacles were left on the test article.

3.3 Test Environment

Although it was originally planned to subject each of these configurations to the ALSEP sinusoidal and random vibration qual levels, as defined in reference 6.11, the use of the SN-5 SWE unit necessitated a constraint on these levels. In order to ensure that input levels at the Bendix/SWE interface did not exceed specification levels, the configurations were vibrated at a 1 g sinusoidal level from 5 to 2000 cps at a rate of 3 octaves/minute (Figure 3-1). This was justifiable since theresulting transmissibility data would adequately show the basic effects of experiment off-loading, even at 1 g level vibration input. The results would give an indication of the changes in natural frequency and transmissibility relative to the "full-up" (baseline) configuration.

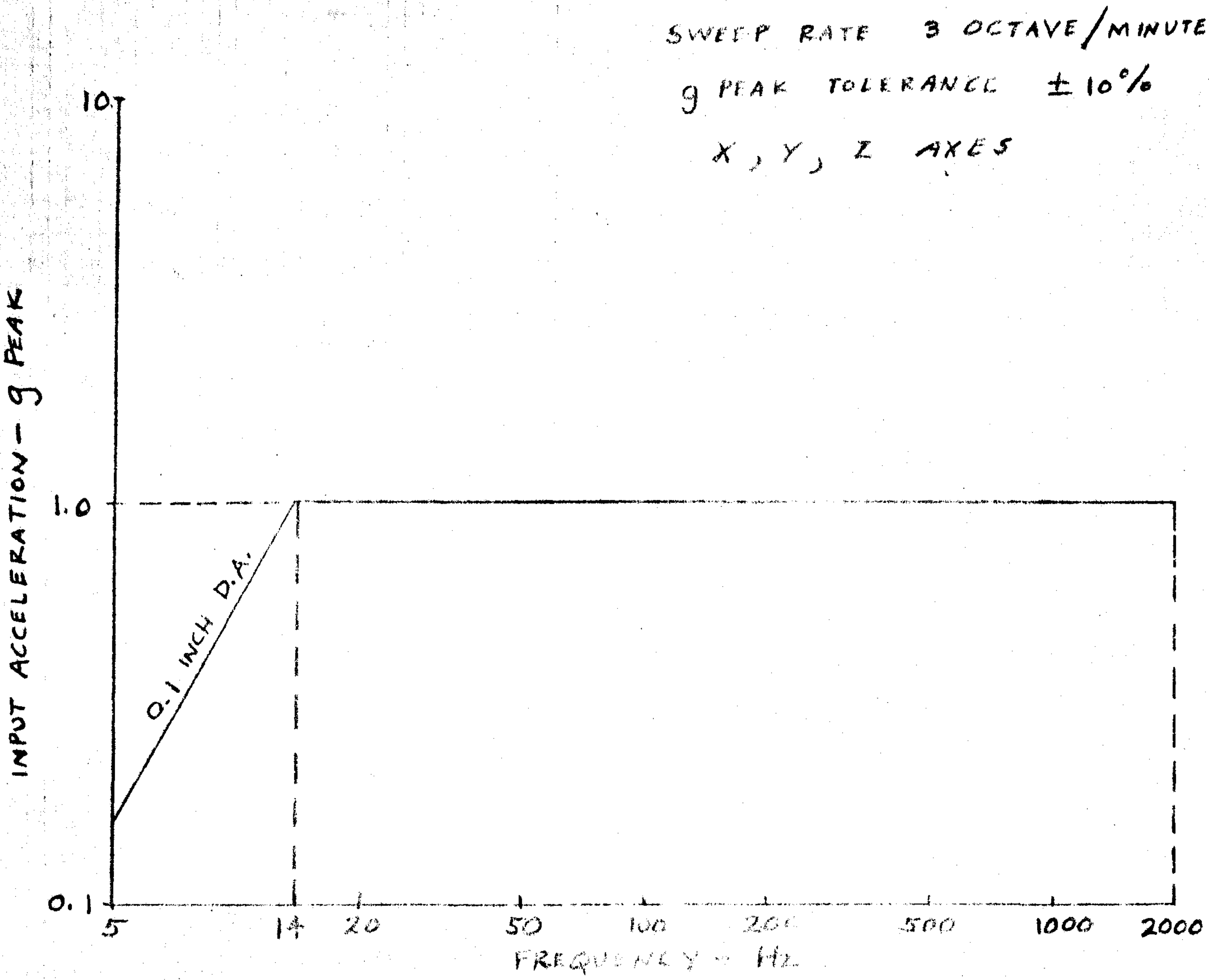


FIGURE 3-1

INPUT-SINUSOIDAL VIBRATION LEVELS

The configurations were subjected to the input discussed above in each of the three (3) ALSEP axis, as defined in Figure 3-2.

3.4 Test Instrumentation

Accelerometers were mounted on the test article to provide data on the vibration input to the experiments mounted on the test article. The accelometers were mounted at the locations shown in Figure 3-3. The triaxial accelerometers for the LSM input were mounted on the LSM pedestal near the pedestal interface with the LSM. The single axis and triaxial accelerometers for the SWE and PSE were mounted on the appropriate support brackets near the bracket interface with the respective experiments.

In addition, a control accelerometer was mounted on the vibration test fixture to which the ALSEP subpackage itself was mounted.

3.5 Test Procedure

The test was initiated on 23 April 1968 and was run in the following sequence:

Z axis	α_1 (refer to section 3.2 for configuration description)
	β_1
	γ_1
Y axis	γ_1
	α_1
	β_1
X axis	β_1
	γ_1
	α_1

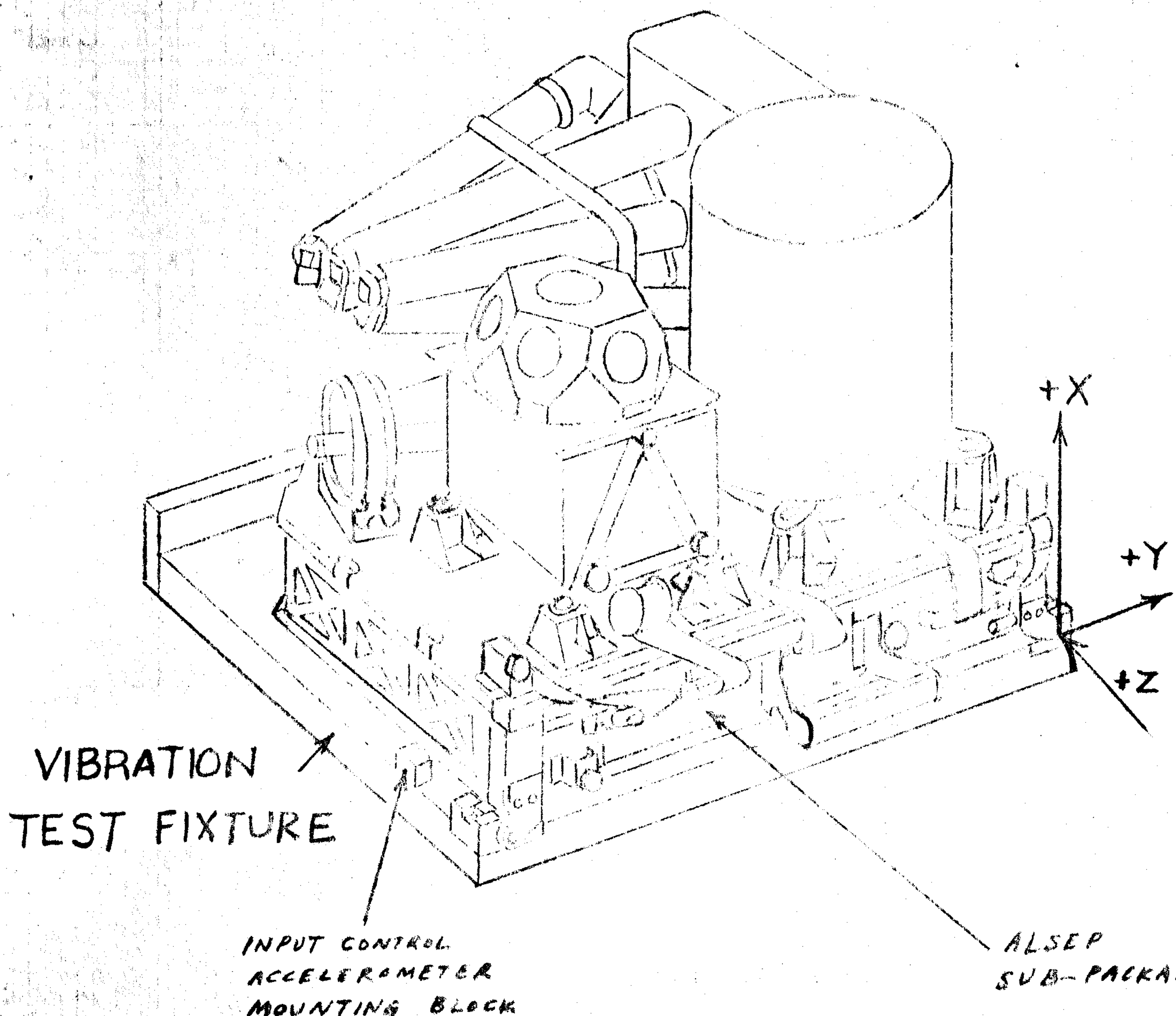
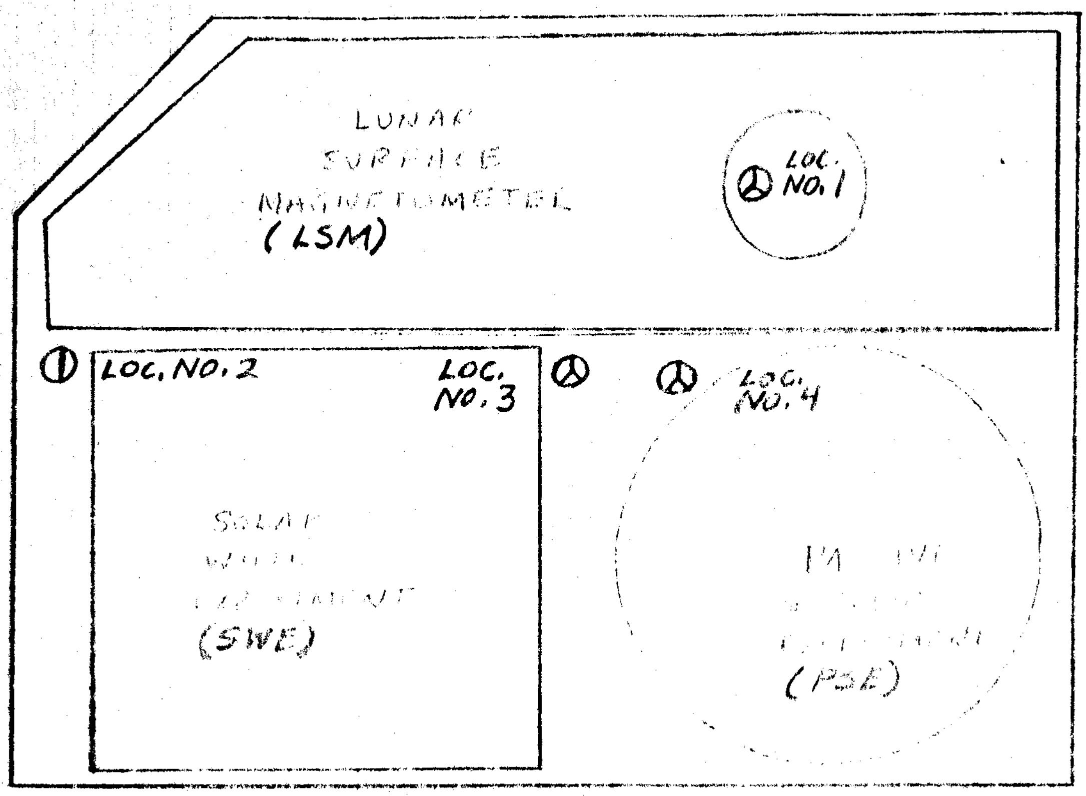


FIGURE 3-2

IDENTIFICATION OF ALSEP AXES
SUBPACKAGE-1



① SINGLE AXIS ACCELEROMETER (ALIGNED WITH INPUT AXIS)

⊗ TRIAXIAL ACCELEROMETER

ACCELEROMETERS LOCATED ON SUPPORT BRACKETS OR PEDESTAL, AS CLOSE TO BENDIX / EXPERIMENT INTERFACE AS POSSIBLE.

FIGURE 3-3

INSTRUMENTATION LOCATION

SUBPACKAGE-1

Each configuration was subjected to the environment described in 3.4. Data from all accelerometers was recorded for the full sine scan duration.

Reduced data in the form of transmissibility vs. frequency plots were requested for each test run.

4.0 RESULTS

Reference 6.4 includes all the vibration data recorded during the off-loading tests. Figures 4-1, 4-2 and 4-3 are given as examples of the data obtained. They show transmissibility (the ratio of response acceleration to input acceleration) as a function of frequency at location No. 4 (PSE) for the α_1, β_1, and γ_1 configurations respectively.

Table 4-1 summarizes the data showing the first few mode transmissibilities and corresponding frequencies. Some of the cross-axis response data was not significant and was not included in the tabulation.

Comparing the β_1 configuration data with the α_1 data yields an indication of the affect of off-loading the SWE upon the dynamic environments of the LSM and PSE. The LSM environment did not change substantially except for the y-response to y-input at 2000 cps. At that frequency the transmissibility increased from 5.3 to 6.3 due to off-loading the SWE. The PSE environment became significantly more severe as shown by the data in Table 4-1. The greatest incremental increase in transmissibility was 2.2 which occurred at 200 cps for y-response to x-input. The highest transmissibility was 5.0 (increased from a value of 4.4 for α_1) which occurred at 360 cps for x-response to y-input.

The consequences of removing the LSM can be estimated by comparing the γ_1 and the α_1 data. The dynamic environment of both the SWE and the PSE was significantly increased. For the SWE the worst case examples are:

1) An increase in TR from 1.7 to 3.2 at 95 cps for x-response to z-input.

2) An increase in TR from 6.5 to 8.4 at 55 cps for x-response to x-input.

For the PSE the worst examples are:

1) An increase in TR from 5.8 to 7.5 at 55 cps for x-response to z-input.

2) An increase in TR from 2.9 to 4.2 at 75 cps for z-response to z-input.

Bendix Aerospace Systems Division

VIBRATION RESPONSE SURVEY
PSE Inside Corner Bracket

Test: Off-Loading
Test Item: Proto I, Array A
Test Date: 24 Apr 68

Configuration: α_1
Input Axis: X
Response Axis: X

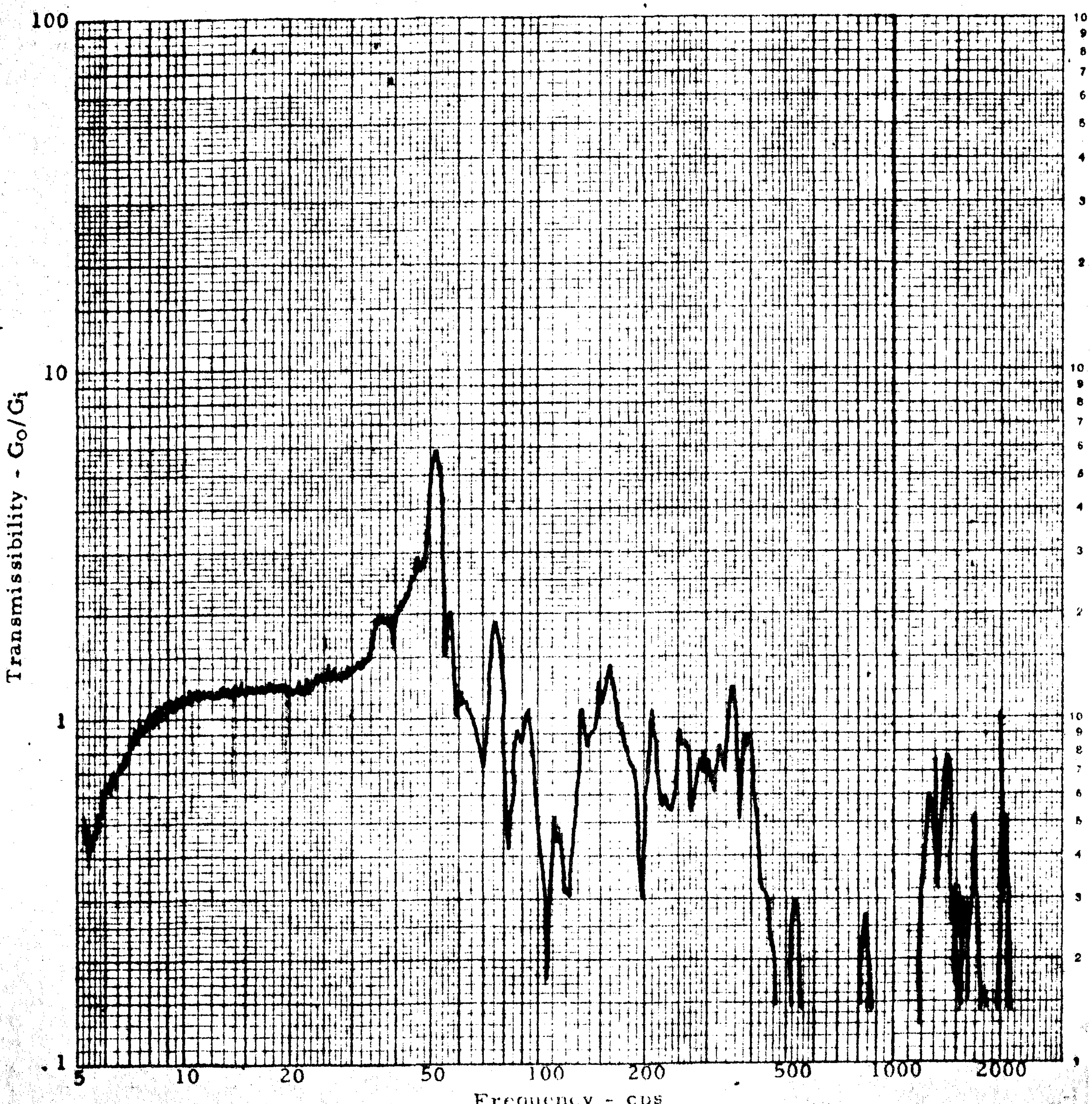


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FIG. 4-1

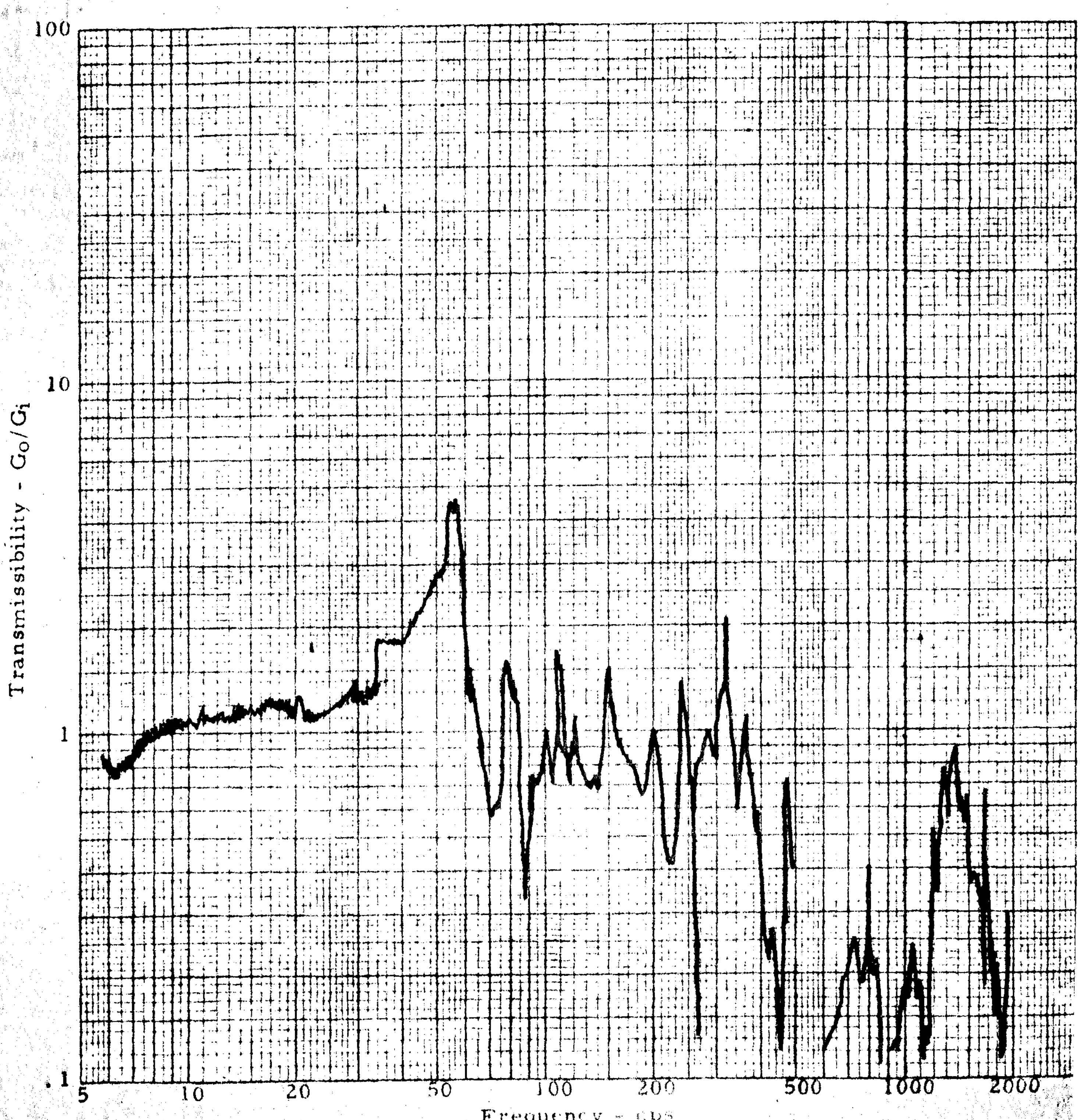
Aerospace Systems Division

SYSTEMS TEST DEPARTMENT

VIBRATION RESPONSE SURVEY
PSE Inside Corner Bracket

Test: Off-Loading
Test Item: Proto 1, Array A
Test Date: 25 Apr 68

Configuration: β_1
Input Axis: X
Response Axis: X



Aerospace Systems Division

SYSTEMS TEST DEPARTMENT

VIBRATION RESPONSE SURVEY
PSE Inside Corner Bracket

Test: Off-Loading

Test Item: Proto I, Array A

Test Date: 23 Apr 68

Configuration: Y_1

Input Axis: X

Response Axis: X

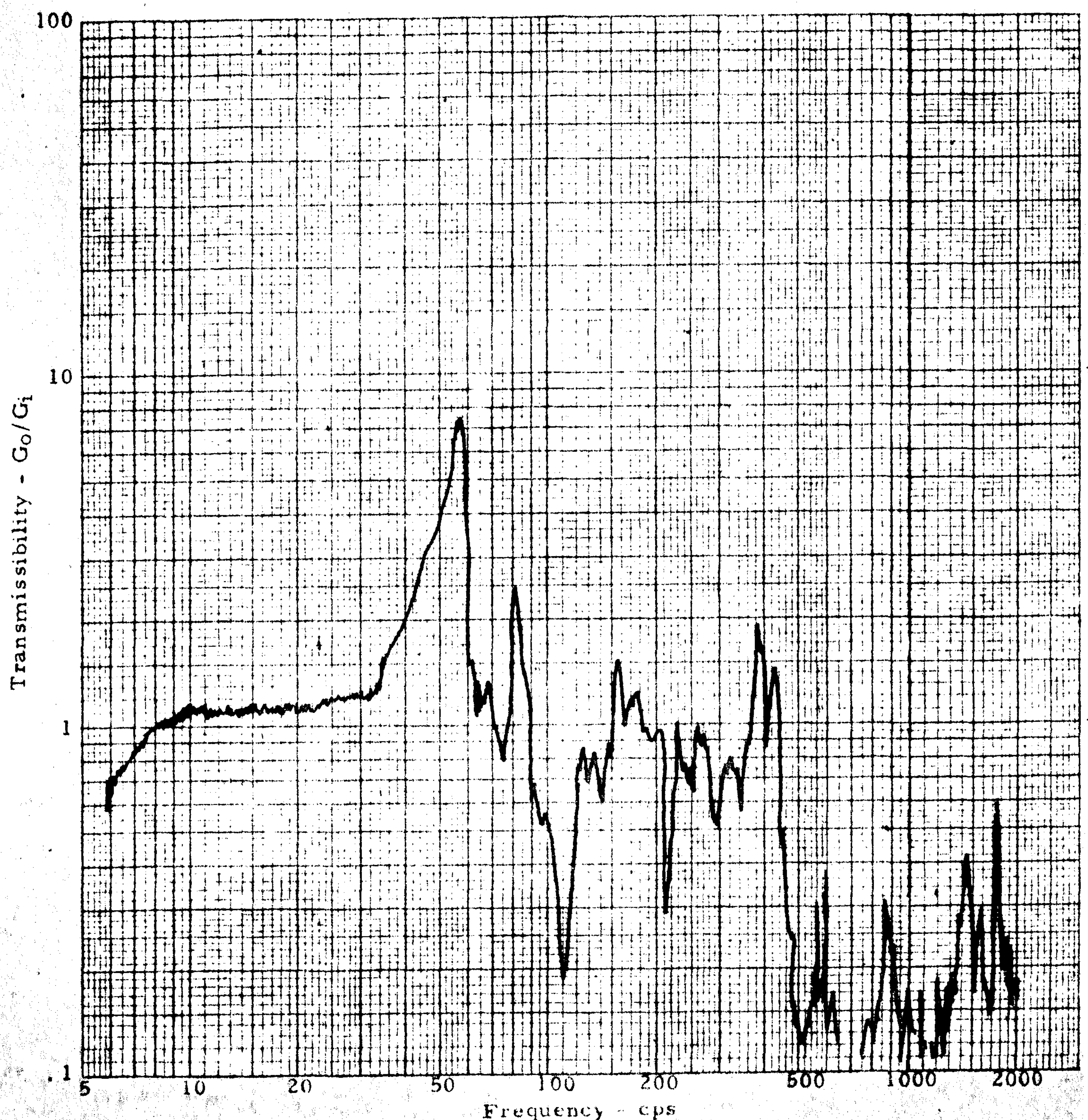


TABLE 4-1

LOCATION No	INPUT DIRECTION	RESPONSE DIRECTION	MODE	α_1 TR(g_o/g_i)	α_1 f (cps)	β_1 TR(g_o/g_i)	β_1 f (cps)	γ_1 TR(g_o/g_i)	γ_1 f (cps)
1	X	X	1	4.0	52	3.0	52		
1	X	X	2	2.0	110	1.8	103		
1	X	X	3	1.8	380	1.5	360		
1	Y	Y	1	2.8	85	2.5	85		
1	Y	Y	2	1.7	330	1.3	340		
1	Y	Y	3	5.8	2000	6.6	2000		
1	Z	Z	1	1.8	70	2.6	70		
1	Z	Z	2	2.3	170	2.5	170		
2	X	X	1	4.1	52			5.0	53
2	X	X	2	3.4	150			4.4	150
2	Y	Y	1	2.6	78			2.3	80
2	Y	Y	2	2.4	220			2.1	220
2	Y	Y	3	3.6	950			3.2	980
2	Z	Z	1	2.6	60			2.6	60
2	Z	Z	2	2.4	72			3.1	75
2	Z	Z	3	1.5	180			2.2	160
3	X	X	1	6.5	52			2.4	56
3	Y	X	1	3.6	83			3.5	80
3	Y	X	2	4.1	240			3.6	230
3	Y	Y	1	2.5	95			2.5	80
3	Y	Y	2	2.7	240			2.5	240
3	Z	X	1	2.9	60			3.9	62
3	Z	Y	2	1.7	85			3.2	93
3	Z	X	3	2.7	215			2.0	210
3	Z	Z	1	2.5	70			3.2	72
4	X	X	1	5.8	52	4.4	56	7.5	58
4	X	X	2	1.9	75	1.6	80	2.4	80
4	X	X	3	0.8	320	2.1	320	0.8	320
4	X	Y	1	1.2	53	1.5	56	1.6	55
4	X	Y	2	2.0	120	2.0	105	1.9	120
4	X	Y	3	0.5	195	2.7	220	1.7	245
4	X	Z	1	1.2	210	2.8	220	1.7	215

TABLE 4-1

LOCATION No	INPUT DIRECTION	RESPONSE DIRECTION	MODE	α_1 TR (g_o/g_i)	α_1 f (cps)	β_1 TR (g_o/g_i)	β_1 f (cps)	γ_1 TR (g_o/g_i)	γ_1 f (cps)
4	Y	X	1	2.6	85	3.6	115	2.8	85
4	Y	X	2	4.4	360	5.0	370	3.3	280
4	Y	Y	1	3.2	83	3.0	85	3.2	85
4	Y	Y	2	6.5	240	5.3	240	4.8	250
4	Y	Z	1	6.9	240	4.5	230	5.6	240
4	Y	Z	2	2.4	2000	4.0	2000	3.4	2000
4	Z	X	1	2.3	57	1.4	58	3.0	60
4	Z	X	2	1.7	100	1.6	90	2.4	90
4	Z	X	3	1.5	205	0.6	190	1.4	205
4	Z	X	4	1.4	370	0.7	310	1.7	380
4	Z	Y	1	1.7	90	1.7	90	1.4	90
4	Z	Y	2	2.1	260	2.3	260	1.3	260
4	Z	Z	1	2.9	75	3.2	77	4.2	75
4	Z	Z	2	2.4	250	2.3	250	1.4	250

5.0 CONCLUSIONS AND RECOMMENDATIONS

Based upon the data obtained from 1 g sinusoidal sweep tests applied to a partial dummy test article, off-loading either the SWE or the LSM will substantially increase the dynamic environment levels of the remaining subsystems. It is therefore recommended that ALSEP subpackage 1 experiments not be off-loaded for any reason, unless further testing is made using qualification hardware and test levels in accordance with ALSEP vibration specifications. If such tests yield results contrary to those shown herein, then the above recommendation can be reversed.

6.0 REFERENCES

The following documents are references applicable to the test program reported herein.

6.1 NAS TWX BG 741/T60/2-20 Attn: R. A. Long, Subject: Contract NAS9-5829 CCP98 dated 2-26-68.

6.2 Bendix AER 63, Flight Off-Loading Program for Array A, dated 29 March 1968 (Bendix Memo 9712-755 dated 3-28-68).

6.3 Bendix Memo 9712-828, Addendum to Test Requirements for Off-Loading Program - Array A, dated 4-22-68.

6.4 Bendix TR 3104, Experiment Off-Loading and Fastener Vibration Acceptance, dated 13 May 1968.

6.5 Bendix Dwg 2330200, Subpackage 1 Assembly Array A (as a reference only, since it does not define the specific Subpackage 1 assembly tested).

6.6 Bendix Dwg 2330203 (Rev. K), Primary Structure.

6.7 Bendix Dwg 2330228 (Rev. G), Sunshield Assembly.

6.8 Bendix Dwg 2332199, Thermal Plate Assembly

6.9 Bendix Dwg 2335079, Antenna Assembly

6.10 Bendix Dwg 2334274, Mock-Up (Passive Seismic).

6.11 NASA-MSC Houston Letter TD3/L023/68/B-26 (JAC) dated February 5, 1968, Subject: Contract NAS9-5829 ALSEP Vibration Test Requirements.