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SNAP-19 SUPPORT STRUCTURE
DESIGN DEVELOPMENT
AND
QUALIFICATION TESTS

MND-3169-52

JANUARY 1965

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FOREWORD

The investigations described in this document were conducted by the Structural Dynamics and Test Group of the Vehicle Engineering Department, Martin Company, under AEC Contract No. AT(30-1)3169.

ABSTRACT

This report describes the development tests conducted on the SNAP 19 Support Structure Assembly.

Included are descriptions of test procedures, test results, and comparison with the dynamic analysis. Tests were performed on two full-scale support structures with dummy generators simulating the weight and centers of gravity of operational thermo-electric generators.

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SUMMARY

The SNAP 19 Support Structure, with simulated generators, was tested in order to investigate the ability of the structure to sustain specified space flight environments. The Support Structure is the assembly which mounts the generators on the Nimbus spacecraft and provides vibration isolation for the generators.

Environments of vibration and acceleration were applied in the test program. Random and sinusoidal vibrations were applied to three orthogonal axes of the specimen, and an acceleration test at 30 G's was applied in the thrust axis.

Tests of the Support Structure were conducted in two phases: design development tests and design qualification tests. Development tests were necessary in order to adjust resonant frequencies and to develop the isolation system. Development tests consisted of low level vibration tests and rap tests applied to the top of the simulated generator. Data from these tests showed the effectiveness of various modifications applied to the Support Structure. Final structural response characteristics measured during qualification tests are summarized as follows:

Plane of Vibration	Fundamental Frequency	Input Level	Maximum Response (at resonance)	
			C.G. Top Generator	C.G. Bottom Generator
Thrust	69 cps	10 G's	66 G's	63 G's
Radial	24 cps	5 G's	64 G's	44 G's
Tangential	29 cps	5 G's	52 G's	35 G's

It is concluded from these tests that the SNAP 19 Support Structure can safely sustain flight level vibration and acceleration loads, and the isolation system effectively attenuates vibration inputs to the generators.

I. INTRODUCTION

A. Purpose

The SNAP 19 Support Structure and ejection mechanism, with dummy generators, were subjected to sinusoidal and random vibration tests (see Figures 1, 2 & 3) and an acceleration test (see Figure 4) to investigate the ability of the structure to withstand the mechanical environments specified for space flight qualification.

Objectives of the tests were as follows:

1. To determine the resonant frequency responses of the support structure;
2. To adjust the resonant frequencies in the three axes so that resonances would occur approximately in the band from 30 to 60 cps;
3. To determine the vibratory force inputs to the generators due to amplifications and attenuations caused by the Support Structure;
4. To develop the isolation system in order that vibration loads on the generators are limited to acceptable design limits;
5. To qualify the Support Structure for application to the Nimbus "B" spacecraft.

B. Applicable Documents

1. "Environmental Specifications for Nimbus RTG Power Supply", Revision 1, Control No. MN-10095, dated 20 May 1964.
2. "SNAP 19 Program - Support Structure Dynamic Design Qualification Tests", Revision 1, Control No. MND-3169-13, dated 11 August 1964.
3. Martin-Marietta Drawings:
 - 452A1050010 - Support Structure Assembly
 - 452A1050014 - System, Mechanical Assembly
 - 452A1050015 - Sensory Ring, Structure - Generator Support Interface

II. DESCRIPTION OF SUPPORT STRUCTURE

The Support Structure is a mechanical assembly which performs the following functions:

1. Adapts two tandem-mounted SNAP 19 generators to the sensory ring of the Nimbus B spacecraft;
2. Orients the generators at 16° from the thrust axis for possible emergency ejection from the spacecraft;
3. Regulates vibration inputs to prevent damage to the generators.

Figure 5 is an illustration of the components of the Support Structure. The major sub-assemblies of the support structure are the Standoff Support, the Base Support, and the Piston Assembly, which together weigh 23.9 pounds.

Operational SNAP 19 generators are mounted in series upon the support structure; however, two configurations of the simulated generators were used in tests of the support structure. The first was a solid cylinder simulating the combined weights and centers of gravity of the operational generators, and the second was similar, with fins added to improve the simulation of the geometrical envelope.

The Standoff Support is a machined aluminum, triangular structure. It is used to mate with the Nimbus structural interface and to raise the Support Structure above the sensory ring insulation.

The Base Support is a ring and tripod assembly which houses the isolation and ejection systems and provides the 16° orientation for the generators. The Base Support is a welded assembly of three legs and a ring, all fabricated from 17-7 PH Corrosion Resistant Steel. Upper and lower springs, joined by a hollow cylindrical hub, have six radial spokes and are pressed into the nine inch diameter ring. Further restraint is provided for the springs by clamp plates which are bolted to the ring.

The Piston Assembly is a flanged cone on a hollow cylindrical shaft. The flange provides a mounting surface for attachment of the generators. The shaft fits into the hub of the upper and lower springs. The bottom of the shaft seats in the bottom of the spring hub, while a jam nut threaded on the upper end of the hub provides a seat for the conical portion of the piston assembly. The piston assembly is retained in the spring hub with a 3/8 inch bolt. Ejection capability in an operational assembly is provided by inserting a helical spring into the hollow shaft of the piston assembly and replacing the standard nut with an explosive nut. The piston assembly is made from 416 Corrosion Resistant Steel.

III. TEST METHODS

A. Procedure and Instrumentation

The qualification test procedure, MND-3169-13, is added to this report as Appendix A.

During development testing a series of rap tests were performed in addition to low level vibration tests. These rap tests were used to investigate the effectiveness of various modifications in changing the structural resonances of the Support Structure. The rap tests were performed by striking the top of the dummy generator in the three major axes and measuring the responses of the Support Structure at significant locations. During these tests, the base of the structure was fastened rigidly to a seismic block. Frequency changes, resulting from the application of various restraints to the Support Structure, were evaluated by comparison to responses of the original specimen. See Section IV for a detailed discussion of the results of these tests.

Early vibration tests in the lateral axes showed that large overturning moments were developed at the fundamental resonances due to the high center of gravity of the specimen. The slide plate separated from the slide table during sinusoidal tests with less than a 5G input. Slide plates with more contact surface were used in attempts to restrain motion in the vertical plane, but without success. The additional weight of the larger slide plates also made it necessary to apply lateral random vibration in two bands: 20 to 1000 cps, and 1000 to 2000 cps. Test duration was four minutes for each band.

Another approach was taken toward testing in the fundamental frequency band at high input levels. The specimen was mounted on a mechanical vibrator (L.A.B. Table - model RVH-72-1500), having constant displacement control. By using this shaker, fixture weight restrictions were eliminated. Figure 6 illustrates the mounting of the specimen, using dogs and a lightweight fixture. Due to a maximum frequency capability of 58 cps for the L.A.B. table, the use of two shakers, the L.A.B. Table and the electro-dynamic shaker, were required.

Since the lateral vibration test arrangements for the first dummy generator assembly were undesirable, lateral vibration tests of the second dummy generator assembly were performed at NASA-Coddard Space Flight Center, where a TEAM Table was used to resist the overturning moment during vibration. (See Figure 7). The use of this type of slide table reduced the required weight of the test fixture and enabled the performance of broad-band random tests. Vibration and acceleration tests in the thrust axis were performed at Martin-Baltimore.

For convenience, the sequence of tests was revised to the following:

1. Vibration in the thrust axis
2. Acceleration in the thrust axis
3. Vibration in the tangential axis
4. Vibration in the radial axis

Test data was obtained by monitoring accelerometer outputs. Figure 8 shows instrument locations. Sinusoidal test data was recorded by oscillograph and by magnetic tape. During random vibration, the control accelerometer response was plotted on an X-Y plotter to assure conformance to the random vibration specifications. Figures 9 and 10 are plots of random vibration input for equalization at 20% of the specified qualification level and at full level, respectively.

Transmissibility data was taken during random tests by plotting normalized accelerometer outputs versus frequency. Examples of transmissibility curves are presented in Figures 11, 12 and 13.

Criteria for successful qualification of vibration and acceleration tests consists of results of visual inspections during and after testing. Recorded data was used to obtain dynamic performance results; i.e., resonant frequencies, effectiveness of the isolation system, and dynamic loads on the generators.

B. Test Equipment

<u>Article</u>	<u>Remarks</u>
Vibrator - Model C25HB MB Manufacturing Co.	Calibrated every 3 months
Vibrator - Model C25H MB Manufacturing Co.	Calibrated every 3 months
Vibration Test Stand Model RVH-72-1500 L.A.B. Corporation	Calibrated as part of the system prior to test
"G" Accelerator Centrifuge Model 1230-1 Genisco Incorporated	Calibrated every 6 months
Recording Oscillograph Model 5-119-P3-50 or equivalent Consolidated Electrodynamics Corp.	Calibrated as part of the system prior to test
Datarite Recording Magazine Model 5-036C or equivalent C.E.C.	Calibrated as part of the system prior to test
Galvanometers for Recording Oscillograph Model No. 7-326 C.E.C.	Calibrated as part of the system prior to test
Crystal Accelerometers Model No. 2235 Endevco Co.	Calibrated as part of the system prior to test

IV. RESULTS

A. General

Testing of SNAP 19 Support Structure involved two phases: design development tests and design qualification tests. The qualification tests were required to determine if the Support Structure could sustain specified vibration and acceleration environments of spaceflight. The utility of the development was measured by the absence of failures during vibration and acceleration tests of the final configuration. Design development tests were required for the following:

1. Determination of resonant frequencies;
2. Adjustment of resonant frequencies to occur approximately between 30 and 60 cps;
3. Determination of attenuation and amplification of input loads to the generators;
4. Adjustment of the isolation system in order that the loads on the generators do not exceed design limits.

It must be emphasized that the results of these tests will not be duplicated when the Support Structure and generators are mounted to the Sensory Ring. No attempt was made, nor was information available, to simulate the compliance of the Sensory Ring. All tests of the Support Structure were performed by mounting the test specimen to a rigid fixture.

B. Qualification Test Results

The final configuration of the Support Structure sustained all environmental test requirements as specified in Reference A, except for sinusoidal vibration in the fundamental resonance band from 16 to 40 cps in the two lateral axes. The structure withstood a 5G input through this frequency band. No tests were attempted above this level because of test difficulties. Table 1 summarizes qualification test results.

C. Design Development Test Results

Low level sinusoidal vibration tests and a series of rap tests were the methods used to evaluate the dynamic characteristics of the Support Structure. These tests were performed in the three orthogonal axes of the structure. By analysis of oscillograph records, tape recordings, and transmissibility plots the effects of modifications to the structure were determined. All resonances were measured at the top or at the center of gravity of the upper generator. See Tables 2 and 3 for summaries of development tests.

The original support structure showed the following resonances:

1. 16 cps (radial)
2. 55 cps (thrust)
3. 90 cps (thrust)
4. 105 cps (thrust)

The information was obtained from a sinusoidal vibration test with 0.5G input in the thrust axis. The existence of a 16 cps resonance in the radial axis indicated the existence of a highly compliant member in the Support Structure. A redesign of the Piston Assembly, incorporating a stiffer conical section, produced favorable results. Vertical resonance occurred at 75 cps, radial resonance at 22 cps, tangential resonance at 36.5 cps. All of the above results occurred with 0.5G inputs.

During vertical tests two resonances at 90 and 105 cps indicated a coupling between the fixture and the specimen. The vertical test fixture was doubled in thickness (see Figures 18 and 19), resulting in vertical resonances at 86 and 320 cps. To lower the 86 cps frequency, the upper and lower springs of the isolation system were reduced in thickness by 0.020 inches. This lowered the apparent fundamental frequency to 80 cps and a further reduction to 73 cps was obtained when the control accelerometer was relocated. The large overturning moment of the generators was coupling with the shaker armature. The control accelerometer had been located near a nodal line; but was relocated at a more representative point on the fixture (at the centroid of the standoff support). This reduced the vertical resonant frequency to 73 cps by changing the input level. The frequency amplitude dependence of this structure is apparent in Figure 20.

Since the new piston design had improved the performance, a corrosion resistant steel (CRES) piston assembly was manufactured, making some deviations from the first test modification. This CRES design reduced the thrust fundamental frequency to 70 cps at 0.5G and 2G inputs, and 65 cps with 5G and 10G inputs. Two G inputs produced resonant frequencies of 27 cps and 32 cps in the radial and tangential axes, respectively.

The original configuration of the Support Structure had a Standoff Support which was a welded assembly. This configuration successfully passed full-level sinusoidal and random vibration in the thrust axis, but failed twice during random vibration and once during sinusoidal vibration in the radial axis. All three failures occurred in the welded areas at the apex of the structure, as shown in Figure 14. A machined Standoff Structure eliminated welding in these critical areas. The same previous configuration of the Support Structure also had a failure of the Base Support, at the junction of the ring and the long leg of the tripod. This failure occurred during vibration in the radial axis and was attributed to a repaired weld which was not heat treated after repair. This particular specimen failed after an accumulated vibration history of approximately 48 minutes at levels between 5 and 23 G's. Figures 6, 15, 16 and 17 show details of this failure.

In order to satisfy the requirement that fundamental resonances in the three major axes occur approximately between 30 and 60 cps, a series of rap tests was performed to measure the effects of various temporary modifications to the Support Structure. Significant results of these tests are presented in Table 3. By rigidly fastening the Ring to the seismic block, so that the only effective members of the structure were the upper and lower springs and the piston assembly with the jam nut, the structural resonances were 41.0 cps radially, 38.7 cps tangentially, and 94.8 cps vertically. These figures are significant since they were obtained at low vibration levels at approximately $1/4$ to $1/2$ "g". Since resonant frequency will drop with increasing level of input (see Figure 20) these frequencies are not attainable at high input levels.

Secondly, the addition of any structure (tripod legs and standoff support) to this configuration will make the new system more compliant and thereby lower the resonant frequencies. During assembly of the Support Structure, drawings specified that the jam nut, which seated the piston assembly, should be torqued. By tightening this jam nut by impact instead of torque, variations in resonant frequencies, due to input levels, were reduced. Evidence of slight wear between the jam nut and the piston assembly during vibration tests are shown in Figures 21, 22 and 23. The black residue is a metallic oxide, which was formed by the abrasion of the piston assembly with the jam nut and with the inside of the spring hub. This wearing was not detrimental to the performance of the support structure.

By restraining the outer edge of the ring during rap tests on the complete Support Structure, the radial frequency increased from 31.5 cps to 38.3 cps. The thrust frequency increased from 80 to 85 cps. The tangential frequency remained at 38 cps. However, to provide such a restraint on the system would require a major redesign.

A vibration damper assembly had been installed on the original Support Structure configuration. This damper incorporated an adjustable friction clamp around the external portion of the spring hub. The effectiveness of this design was evaluated at 0.5G, 1G and 2G inputs with varying adjustments applied to the damper. The responses showed no significant changes to justify the use of this assembly in the isolation system. Therefore, the damper assembly was eliminated from the design.

The only other development to the isolation system was the reduction in thickness of the upper and lower springs. By increasing the compliance of the isolation system, the dynamic loads were reduced on the generators.

Through the use of transmissibility plots, attenuation and amplification characteristics of the Support Structure were measured. Transmissibility data of sinusoidal vibration tests could only be made at reduced levels due to a linear sweep rate requirement of the transmissibility plotting equipment. Figure 24 shows the transmissibility plotter during test. To use a linear sweep rate at full level would result in overtesting. Therefore plots are presented from analysis of random vibration excitation. Figures 11 shows the attenuation obtained by the Support Structure in the thrust axis. Except during fundamental resonance, the isolation system has attenuated the inputs from the support structure. Figures 12 and 13 show transmissibility plots in the radial and tangential axes of the support structure.

V. CONCLUSIONS AND RECOMMENDATIONS

1. The SNAP 19 Support Structure can sustain the environments of vibration and acceleration specified for space flight acceptance.
2. The Support Structure successfully passed the Prototype or Design Qualification Tests as specified in Appendix A, except for the fundamental resonance band from 16 to 40 cps in the radial and tangential axes. The test specimen completed vibration tests at reduced levels (5G input) in this frequency band. Response characteristics occurring during these tests will not be duplicated when the structure is mounted to the Sensory Ring due to the significant difference in compliance between the Sensory Ring and the rigid test fixtures. It is recommended that testing at module component specification level be considered as unnecessarily severe and that the Support Structure with generators should be considered a subsystem of the Sensory Ring rather than a module component. Therefore, the vibration specification levels would be limited to a maximum of 5 g's in the bands of fundamental radial and tangential resonance.
3. It is possible that the Sensory Ring will require local structural reinforcement to sustain the large dynamic loads developed by the Support Structure and generators.
4. The isolation system attenuates inputs to the generators effectively, particularly in the thrust axis where specified vibration inputs are maximum.

VI. TABLES

TABLE 1
SUMMARY OF DESIGN QUALIFICATION TEST RESULTS

TEST	RADIAL AXIS	TANGENTIAL AXIS	THRUST AXIS
Sinusoidal Vibration 10-16 cps 16-40 cps 40-2000 cps	passed @ spec. Level passed @ 5 "g" input passed @ spec. Level	passed @ spec. Level passed @ 5 "g" input passed @ spec. Level	passed @ spec. Level passed @ spec. Level passed @ spec. Level
Random Vibration	passed @ spec Level	passed @ spec Level	passed @ spec level
Acceleration	Not required	Not required	passed @ spec Level
Fundamental Frequency	24 cps @ 5G	29 cps @ 5G	69 cps @ 10 G
Maximum Load in Axis of Vibration C.G. of Top Generator C.G. of Bottom Generator	64 "g"'s 44 "g"'s	52 "g"'s 35 "g"'s	66 "g"'s 66 "g"'s

TABLE 2 - SUMMARY OF VIBRATION TEST CONDITIONS

INPUT AXIS	INPUT LEVEL G's	SWEEP RANGE (cps)	FUNDAMENTAL RESONANCE (cps)	REMARKS
THRUST	1/2	10-2000	55	
↑	1/2	10-2000	75	Stiffened Piston Ass'y. replaced titanium piston
	1/2	10-2000	86	2" Alum. fixture replaced 1" Aluminum fixture
	1/2	10-2000	80	Upper & Lower Spring thickness reduced by 0.020"
	1/2	10-2000	73	Input accelerometer relocated
	1/2	10-2000	70	CRES Piston Ass'y replaced first stiffened modification
	1	10-2000	70	
	10	10-100	65	Qualification Levels
	23	100-400	"	"
	10	400-2000	"	"
	2	10-2000	75	Machined Standoff replaced all-welded design. Finned Simulated Generators first used.
↓	10	10-100	69	Final Qualification Test (Sinusoidal)
	23	100-400		
	10	400-2000		
THRUST	0.2 3 ² /cps	20-2000	-	Final Qualification Test (Random)
TANGENTIAL	1/2	10-2000	36.5	Mild Steel Piston Ass'y. installed (first stiffened modifi.)
↑	2	10-350	32	CRES Piston Ass'y installed & Upper & Lower Spring thickness reduced by 0.020"
	2	10-2000	33	Machined Standoff structure installed - Finned Generator
↓	10	40-2000	-	Final Qualification Test (Sinusoidal)
	5	10-40	29	
TANGENTIAL	0.2 3 ² /cps	20-2000	-	Final Qualification Test (Random)

TABLE 2 - (continued)

INPUT AXIS	INPUT LEVEL G's	SWEEP RANGE (cps)	FUNDAMENTAL RESONANCE (cps)	REMARKS
RADIAL	1/2	10-2000	22	Mild Steel Piston Assy installed (first stiffened modification)
↑	1/2	10-2000	26	CRES Piston Assy replaced first stiffened modif. - Upper & lower spring thickness reduced by 0.020".
	2	20-35	27	Vertical restraint used on slide plate
	5	20-24	24	Vertical restraint used on slide plate
	6	10-24	—	Base support failed at Ring - Specimen mounted on L.A.B. Table
	2	10-2000	27	New specimen with CRES Piston Assy & thin Upper & Lower Springs.
	5	16-35	—	Standoff structure failed (all-welded design)
	10	35-2000	—	Qualification Levels except 16-35 cps band omitted.
	0.4" D.A. 2	10-15 15-35	— 22	
	0.28 1/2 cps	20-1000	—	Standoff structure failed after 30 seconds (all-welded design)
	0.28 1/2 cps	20-1000	—	A new standoff structure failed upon reaching full level (all-welded)
	2	10-2000	28	Machined standoff structure installed - Finned Generator
↓	10	40-2000	—	Final Qualification Test (sinusoidal) - One (1) Clamp Plate yielded at 28 cps. Clamp Plates replaced by heavier design.
	5	10-40	24	
RADIAL	0.28 1/2 cps	20-2000	—	Final Qualification Test (Random)

TABLE 3 - SUMMARY OF RAP TESTS

CONFIGURATION	MODIFICATION	RAP MAGNITUDE (G)	FREQUENCY (CPS)		
			RADIAL	TANGENTIAL	THRUST
Nº 1 - Original Sheet Metal Standoff Structure Base Support CRES Piston Ass'y.	None	$\frac{1}{8}$	31.0	39.0	81.0
Nº 1 - Standoff Structure removed.	Ring of Base Support rigidly fastened. Tripod not in the system.	$\frac{1}{8}$	41.0	38.7	94.8
Nº 1 - Standoff Structure removed.	Tripod legs rigidly fastened.	$\frac{1}{8}$	35.6	41.0	89.3
Nº 1 - Standoff Structure removed	Tripod legs rigidly fastened. Outer edge of Ring restrained.	$\frac{1}{8}$	39.5	—	—
Nº 2 - Reinforced Sheet Metal Standoff Structure. Reinforced Base Support CRES Piston Ass'y	Jam Nut @ Specified Torque	$\frac{1}{10}$	33.3	—	—
Nº 2	Same as above	2	31.2	—	—

TABLE 3 - (continued)

CONFIGURATION	MODIFICATION	RAP MAGNITUDE (G)	FREQUENCY (cps)		
			RADIAL	TANGENTIAL	THRUST
Nº 2	Jam Nut tightened by impact	1/10	33.3	38.9	81.0
Nº 2	Same as above	2	33.3	38.2	80.6
Nº 3 - Machined Standoff Structure Base Support (same design as Nº 1 configuration) CRES Piston Assy.	Jam nut tightened by impact	1/10	34.7	41.7	88.0
Nº 3	Same as above	3	34.0	41.0	87.0

VII. ILLUSTRATIONS

FIGURE 1 VIBRATION TEST IN THE THRUST AXIS

FIGURE 2 VIBRATION TEST IN THE RADIAL AXIS

FIGURE 3 VIBRATION TEST IN THE TANGENTIAL AXIS

FIGURE 4 ACCELERATION TEST IN THE THRUST AXIS

Figure 5 SNAP-19 SUPPORT STRUCTURE
WITH SIMULATED GENERATORS

WLB

FIGURE 6 MOUNTING OF SPECIMEN ON LAB TABLE - FAILURE OF BASE SUPPORT

FIGURE 7 VIBRATION TEST IN THE RADIAL AXIS, USING A TEAM TABLE AT NASA

Figure 8 ACCELEROMETER LOCATIONS
MONITORED DURING QUALIFICATION TESTS

ARB

ENVIRONMENTAL TESTING LABORATORY

ENVIRONMENTAL TESTING LABORATORY

QUALIFICATION

PROJECT NUCLEAR- SNAD 19
SPECIMEN SUPPORT STRUCTURE
DATE 11-12-64 (NASA-DUMMY CONFIG.)
PLANE OF VIBRATION THRUST AXIS
SPECIFIED TEST LEVEL 20.0 G(RMS)
FLAT SPECTRUM
EFF. BW = 2006.25N (18.75N - 2025N)

TEST

N=260 = 100 G.F.S.

TEST DURATION 4.0 MIN.

Figure 14 ALL-WELDED STANDOFF
STRUCTURE WITH TYPICAL FAILURE

7/13

FIGURE 15 FAILURE OF BASE SUPPORT

FIGURE 16 METALLOGRAPHIC STRUCTURE OF LONGITUDINAL CROSS-SECTION OF FRACTURED TOP FLANGE, SHOWING REPAIR WELD

FIGURE 17 FATIGUE FAILURE OF BASE SUPPORT

FIGURE 18 VIBRATION TEST IN THRUST AXIS WITH 1 INCH FIXTURE

FIGURE 19 VIBRATION TEST IN THRUST AXIS WITH 2 INCH TEST FIXTURE

Figure 20-RESONANT FREQUENCY SHIFT
DUE TO INPUT LEVEL

WLB

FIGURE 21 WEAR OF JAM NUT AND PISTON ASSEMBLY

FIGURE 22 RESIDUE DEPOSITED IN HUB OF UPPER AND LOWER SPRINGS

FIGURE 23 MAGNETIC RESIDUE FORMED BY WEAR BETWEEN JAM NUT AND PISTON ASSEMBLY

FIGURE 24 TRANSMISSIBILITY PLOTTER

APPENDIX A

SNAP 19 Support Structure Dynamic
Design Qualification Test Procedure
Revision 1, Dated 11 August 1964

MHD-3169-3

SNAP 19 PROGRAM
SUPPORT STRUCTURE
DYNAMIC DESIGN QUALIFICATION TESTS
REVISION 1
AUG. 11, 1964

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Contract AT(30-1)3169

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A. Test Objectives

The SNAP 19 generator support structure and ejection mechanism, with dummy generators installed, will be subjected to sinusoidal and random vibration tests and an acceleration test to prove the ability of the structure to withstand the critical mechanical environments of space flight.

Further objectives of the vibration tests are:

1. To determine the resonant frequency response of the support structure, and
2. To determine the vibratory force input to the generators due to transmissibility of the support structure.

B. Test Requirements

The test specimen will be subjected to the vibration and acceleration environments specified in MN-10095, "Environmental Specification for Nimbus RTG Power Supply".

The maximum allowable tolerances on test conditions shall be as follows:

Vibration Amplitude	$\pm 10\%$
Vibration Frequency	$\pm 2\%$
Acceleration Level	$\pm 3g$
Random Power Spectral Density	± 3 db
Time	$\pm 5\%$

C. Equipment and Instrumentation

<u>Article</u>	<u>Remarks</u>
Vibrator - Model C258B EB Manufacturing Co.	Calibrated every 3 months
Centrifuge - Model 1240-1 Gensco Corp.	Calibrated as part of a system
Recording Oscillograph - Model 5-119-F3-50 or equivalent Consolidated Electrodynamics Co.	Calibrated as part of a system prior to test

<u>Article</u>	<u>Remarks</u>
Datarite Recording Magazine Model 5-036C or equivalent C.E.C.	Calibrated as part of a system prior to test
Galvanometers for Recording Oscillograph - Model No. as required C.E.C.	Calibrated as part of a system prior to test
Crystal Accelerometers - Model No. as required Endevco Co.	Calibrated as part of a system prior to test
Dynamometer or equivalent amplifier - Endevco Co.	Calibrated every 3 months
Test Fixture - Martin Dug. No. 38-3000515	

D. Test Procedures

1. Vibration

1.1 Low Level Sinusoidal Vibration

- 1.1.1 Mount the support structure and ejection mechanism assembly to the head of the G2548 shaker by means of the test fixture, oriented for excitation along the thrust axis.
- 1.1.2 Mount the control accelerometer on the fixture at a point adjacent to the support structure mounting, and affix accelerometers to the support structure and dummy generators at such locations as to measure the structure response and response at the base of the generators.
- 1.1.3 Apply a sinusoidal vibration frequency sweep from 10 to 2000 cps at 1g peak. The frequency range shall be swept at the rate of 1 octave per minute, and accelerometer responses will be continuously recorded by means of the oscillograph.
- 1.1.4 Inspect the test specimen for any signs of damage, deformation, or loosening of connections, after this and all subsequent vibration runs.

- 1.1.5 Remount the support structure and ejection mechanism on the slide plate of the shaker, for excitation along a lateral axis.
- 1.1.6 Relocate accelerometers as necessary for control and for measurement of responses at the support structure and generators.
- 1.1.7 Perform a 1g sinusoidal vibration frequency sweep from 10 to 2000 cps, at a rate of 1 octave per minute. Record accelerometer responses by means of the oscillograph.
- 1.1.8 Rotate the support structure and ejection mechanism for excitation in the remaining lateral axis.
- 1.1.9 Relocate accelerometers as necessary for control and for measurement of responses at the support structure and generators.
- 1.1.10 Again perform a 1g sinusoidal vibration frequency sweep from 10 to 2000 cps, at a rate of 1 octave per minute. Record accelerometer response, by means of the oscillograph.
- 1.1.11 Repeat the sinusoidal vibration test of steps 1.1.1 through 1.1.10, with the exception that the vibration input shall be 0.4 inch D.A. displacement from 10 to 16 cps, and 5g peak from 16 to 2000 cps.

1.2 Qualification Level Vibration

- 1.2.1 Mount the support structure and ejection mechanism assembly to the head of the C25HB shaker, for excitation along the thrust axis.
- 1.2.2 Mount accelerometers on the fixture and specimen, using the locations determined in low level sinusoidal testing.

- 1.2.3 Apply a sinusoidal vibration frequency sweep at the following levels:

10 - 22 cps	0.4 inch D.A. displacement
22 - 100 cps	10g peak
100 - 400 cps	23g peak
400 - 2000 cps	10g peak

The frequency range of 10 to 2000 cps shall be swept at a rate of 1 octave per minute, and accelerometer responses will be recorded by means of the oscillograph.

- 1.2.4 Upon completion of the sinusoidal frequency sweep, equalize for a random vibration input with a flat spectrum band limited from 20 to 2000 cps. Acceleration spectral density shall not deviate by more than ± 3 db over the frequency range. Application of random vibrational energy during equalization shall be limited to 20% of the actual test value.

- 1.2.5 Apply a random vibration spectrum with a spectral density of $0.2 \text{ g}^2/\text{cps}$, flat from 20 to 2000 cps (20g rms overall) for a duration of 4 minutes.

- 1.2.6 Inspect the test specimen for any signs of damage, deformation, or loosening of connections.

- 1.2.7 Remove the support structure and ejection mechanism on the slide plate of the shaker, for excitation in a lateral axis.

- 1.2.8 Relocate accelerometers, using the positions established in low level sinusoidal vibration

- 1.2.9 Apply a sinusoidal vibration frequency sweep from 10 to 22 cps at 0.4 inch D.A. displacement, and from 22 to 2000 cps at 10g peak. The frequency range of 10 to 2000 cps shall be swept at a rate of 1 octave per minute, and accelerometer responses will be recorded by means of the oscillograph.
- 1.2.10 Equalize for a random vibration input as described in 1.2.4, and apply the test of 1.2.5.
- 1.2.11 Inspect the test specimen for any signs of damage, deformation, or loosening of connections.
- 1.2.12 Repeat steps 1.2.7 through 1.2.11 for the remaining lateral axes.

2. Acceleration

- 2.1 Mount the support structure and ejection mechanism assembly on the centrifuge, oriented so that acceleration will be applied in the thrust direction.
- 2.2 Accelerate to and maintain a 30g level for a period of not less than 5 minutes.
- 2.3 At the conclusion of the acceleration test, inspect the test specimen for any signs of damage, deformation, or loosening of connections.

E. Data Acquisition

During all sinusoidal vibration testing, the vibration input and response of the various accelerometers will be continuously recorded by means of the oscillograph. During random vibration, the control accelerometer response will be plotted on an X-Y plotter to assure conformance to the random spectrum.

F. Data Analysis

Recorded sinusoidal vibration data will be used to establish frequency response and magnification (g) distributions for the assembly components.

Data from the random vibration and acceleration tests will consist of the results of visual inspection at the conclusion of the tests.