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SHOCK RESISTANCE OF AIR-CONDITIONING UNITS TEST REPORT FOR ELLI--ETC(U)
SEP 79 J B GAMBILL , W E FISHER

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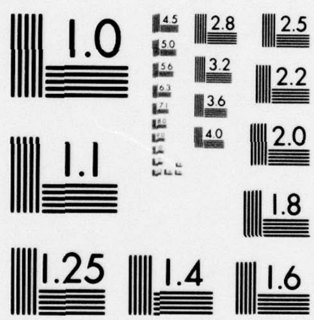

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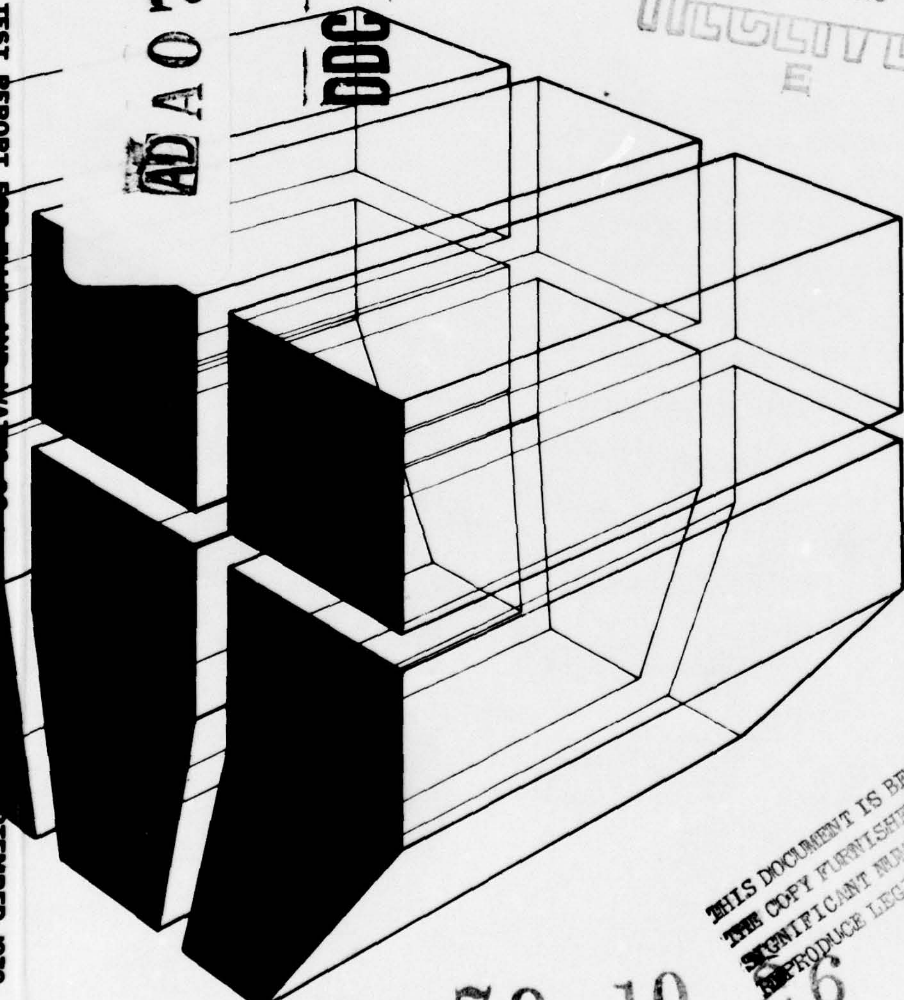
SPECIAL REPORT M-273
September 1979

SHOCK RESISTANCE OF AIR-CONDITIONING UNITS TEST REPORT FOR ELLIS AND WATTS CO. CINCINNATI, OHIO

by
James B. Gambill
Walter E. Fisher



CERL

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This report presents the results of seismic qualification tests performed on air-conditioner units manufactured by the Ellis and Watts Company, Cincinnati, Ohio, to evaluate the units' capability to meet Tennessee Valley Authority seismic design requirements.

Two units were tested on the CERL Biaxial Shock Test Machine. Functional performance remained normal for all units during the test run.

FOREWORD

This study was performed by the Engineering and Materials Division (EM) of the U.S. Army Construction Engineering Research Laboratory (CERL) for the Ellis and Watts Company, Cincinnati, Ohio, under contract 77K33-820916.

Tests were conducted by Dr. W. E. Fisher, James B. Gambill, and William Gordon of EM.

Dr. G. R. Williamson is Chief of EM. COL J. E. Hays is Commander and Director of CERL, and Dr. L. R. Shaffer is Technical Director.

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SHOCK RESISTANCE OF AIR-CONDITIONING UNITS
TEST REPORT FOR ELLIS AND WATTS CO., CINCINNATI, OHIO

1 GENERAL INFORMATION

Purpose

This report presents the results of seismic qualification tests conducted on air-conditioner units manufactured by the Ellis and Watts Company, Cincinnati, OH. The tests were performed by the U.S. Army Construction Engineering Research Laboratory (CERL) to evaluate the units' ability to meet Tennessee Valley Authority (TVA) seismic design requirements for a safe shutdown earthquake (SSE).

Test Criteria Documents

Tennessee Valley Authority Document No. N4-50-D710 (Reissue No. 33-820915), Appendix B, Design Criteria for Seismic Qualification of Category I Fluid System Components and Electrical or Mechanical Equipment, Bellefonte Nuclear Plant (July 11, 1974).

Test Item Description and Mounting

The two air-conditioner units (numbered MOAC-2010 and MOAC-2500 by the Ellis and Watts Company) were tested on the CERL Biaxial Shock Test Machine (BSTM). Table 1 lists pertinent data for each test item. Each air-conditioner unit was tested in an operating mode with the fan and compressor running, the cooling coils charged with refrigerant, and the condenser connected to the cold water main.

Table 1

Test Item Identification Information

Model Number	Serial Number	Dimensions L x W x H (in.)	Weight (lb)
MOAC-2010	7396	94 x 79 x 108	6600
MOAC-2500	7395	94 x 79 x 108	5800

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The test items were attached to the BSTM test platform by mounting 3-in. x 8-in. steel plates to the test platform and drilling and tapping 16 threaded holes into the plates to match the test item attachment points. Grade 8, high-strength steel bolts (1/2 in. to 13 threads/in.), torqued to 100 ft-lb were used to connect the test items to the steel plates. New bolts were used each time the test items were attached to the test platform.

Power was supplied from a fused power line compatible with each air conditioner's motor current requirements.

Test Conditions and Test Equipment

Test Conditions

All tests were performed at an atmospheric pressure of 29.0 $\pm$ 2.0 in. of mercury absolute, a temperature of 70 $\pm$ 20^{o}F, and a relative humidity of 90 percent or less.

Instrumentation and Equipment Certification

Measurement and test equipment for all tests was calibrated with reference and test equipment whose calibration has been certified by the National Bureau of Standards. (All reference standards used for calibration are supported by certificates, reports, or data sheets attesting to the date, accuracy, and conditions under which the results were furnished. Test equipment is supported by similar data when such information is essential to achieve the accuracy control required.)

Certification and reports of all calibration are retained in CERL files and are available for inspection upon request.

Test Equipment

Table E3 of Appendix E lists the test equipment or equivalents used in this testing program.

Biaxial Shock Test Machine

The test items were mounted on the test platform of the BSTM and subjected to the seismic environments defined in the test plan.

The BSTM is a unique shock test system developed under joint sponsorship of the U.S. Army Engineer Division, Huntsville (HND) and CERL. The major components of the BSTM are: (1) a 12- x 12-ft, 12,000-lb aluminum weldment test platform; (2) a closed-loop electrohydraulic excitation system consisting of nine vertical and six horizontal hydraulic actuator assemblies with a total force of 810,000 lb and 450,000 lb, respectively, thirty-six 50-gal hydraulic accumulators, and four 70-gpm high-pressure pumps; (3) a computerized control and data acquisition/reduction system; and (4) a massive post-tensioned reinforced concrete reaction system consisting of a vertical and a horizontal mass to react the vertical and horizontal actuators, respectively. Stable, force-balanced, position control of the hydraulic actuators is assured by the analog electronic control system using multiple feedback parameters from each of the 15 actuators. The computer system synthesizes the test platform displacement waveforms, controls test initiation, and computes shock spectra from horizontal and vertical response accelerometers mounted below the test platform surface. The computer system compares the response shock spectra to the required spectra and corrects the displacement waveforms prior to the next test run. The control system also executes a pre-programmed shutdown when the BSTM's response exceeds its design limits. The BSTM is controllable over a frequency range of 0 to 200 Hz.

Shock excitation can be applied to a specimen along its vertical and horizontal axes independently or simultaneously. Figure 1 is a simplified representation of a single actuator assembly feedback control system. Identical feedback control systems are provided for each of the 15 actuator assemblies so that all vertical and horizontal actuator assemblies respond together. Figure 2 is a functional representation of the machine.

The test shock spectra are defined and described in the test plan. The test platform input command signals were synthesized by a digital computer program (WAVSYN)* to produce table motion that would result in the desired response acceleration shock spectra.

* Safeguard BMD System Modification of the WAVSYN Computer Program, Document No. SAF-82 (Ralph M. Parsons Co., May 1973).

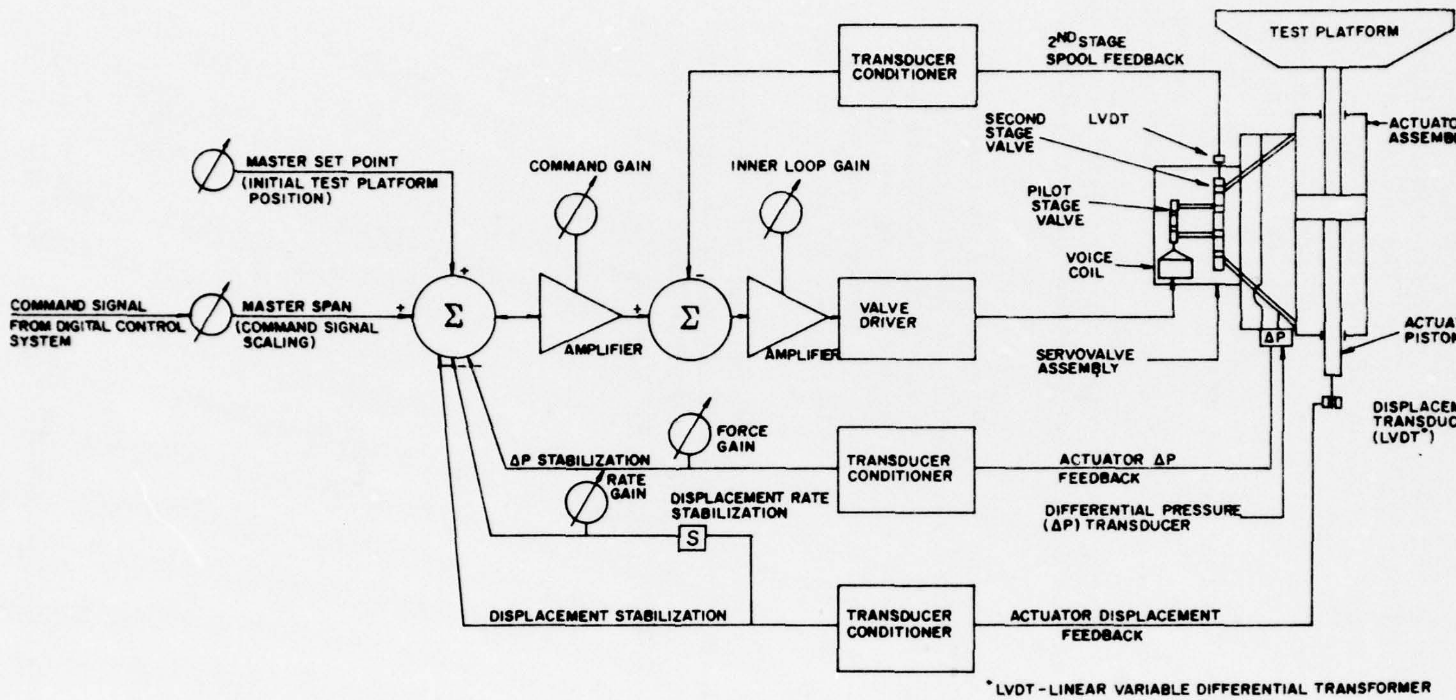


Figure 1. Simplified representation of single-actuator feedback control system.

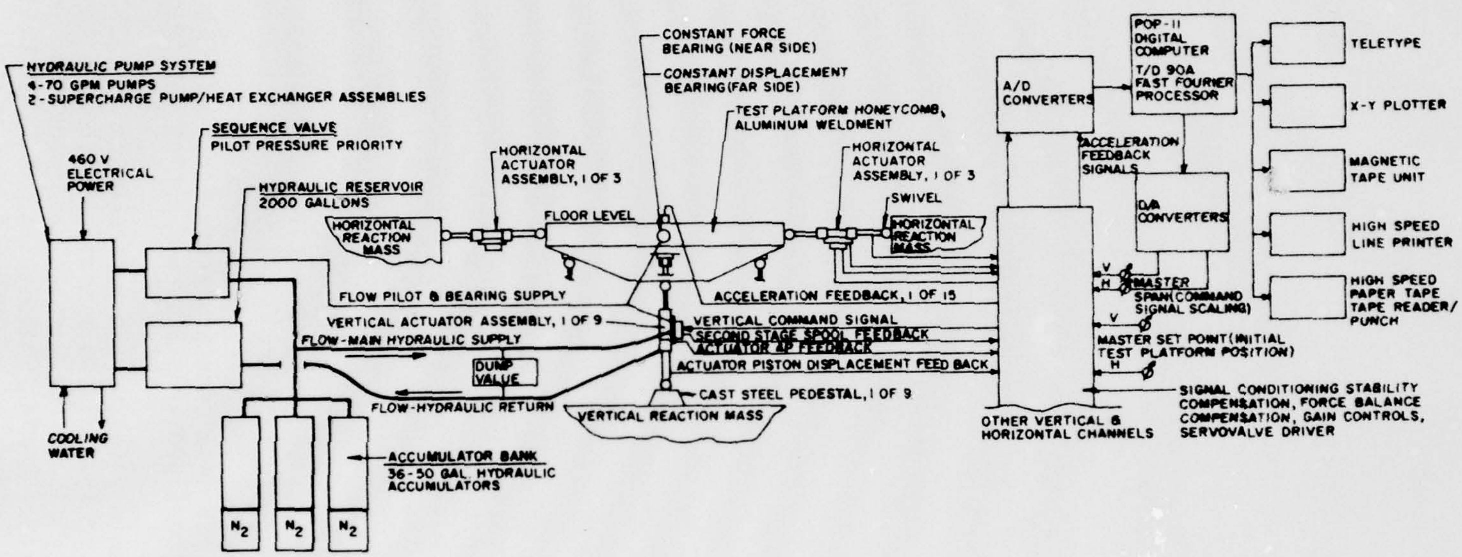


Figure 2. Functional representation of the BSTM.

2 TEST PROGRAM

Receiving Inspection

The two test items were received and receiving inspections performed on 5 October 1978. Receiving Inspection Reports (Figures 3 and 4) were written in accordance with identification information on the name plates attached to each test item. The inspections revealed no shipping damage.

Test Identification

The following conventions were used for test identification and documentation.

1. Longitudinal Orientation. The longest dimension of each test aligned parallel to the axis of horizontal input motion of the test platform.

2. Transverse Orientation. The shorter dimension of each test item aligned parallel to the axis of horizontal motion of the test platform.

Test Description

Test Item MOAC-2010

Test item MOAC-2010 was mounted on the test platform in the longitudinal orientation on 9 November 1978. Ellis and Watts personnel conducted functional checks of the test item before and after each major test. A calibration test was conducted at 100 percent of the full test level, using a single 5-second pulse for the control waveform. Three test runs were conducted at 100 percent of the full test level, using waveforms that consisted of five repetitions of the 5-second pulse separated by 15-second null periods (Figure 5). This produced 16 repetitions of the shock pulse. All test response data were recorded on analog magnetic tape and displayed on oscillographic strip chart recorders. Vertical and horizontal shock spectra were computed from the test platform response accelerometers for comparison to the required spectra. No functional problems occurred during the tests.

Resonance tests were performed on MOAC-2010 in the longitudinal orientation by applying a small-amplitude sinusoidal motion to the test platform first in the vertical axis and then in the longitudinal horizontal axis. During these tests, the test platform input acceleration was maintained at or below 0.1 g peak while the frequency was swept from 1 to 35 to 1 Hz at a sweep rate no greater than 1 octave per minute.

DATA SHEET
Receiving Inspection

Specimen MOAC-2500 Job No. 3rd Ellis & Watts Test Program
Date 5 Oct 78
No. of specimens received 1

RECORD IDENTIFICATION INFORMATION EXACTLY AS IT APPEARS ON THE SPECIMEN

Shipped by ______

Manufacturer Ellis & Watts Co.

Air Conditioner - Model No. MOAC-2500

Part numbers 27R Mark 3AW0910-2

Contract No. 77K33-820916

Refrigerant R22-45 lbs.

Serial No.		460 volts	3 pH 60 Hz
	7396	48 Amp Max	

Examination: Visual, for evidence of damage, poor workmanship, or other defects, and completeness of identification.

Inspection Results: There was no visible evidence of damage to the specimen unless noted below:

Inspected by Jim Gambill Date 5 Oct 78

Approved by ______ Date ______

Sheet 1 of 1

Figure 3. Receiving Inspection Data Sheet for MOAC-2500.

DATA SHEET
Receiving Inspection

Specimen MOAC-2500 Job No. Ellis & Watts Test Program
Date 5 Oct 78
No. of specimens received 1

RECORD IDENTIFICATION INFORMATION EXACTLY AS IT APPEARS ON THE SPECIMEN

Shipped by ______

Manufacturer Ellis & Watts Co.

Air Conditioner - Model No. MOAC-2500

Part numbers 27Q Mark 3AW0910-2

Contract No. 77K33-820916

Refrigerant R22-55 lbs.

Serial No. 7395

460 volt -3 Phase - 60 Hz

58 Amp Max

Examination: Visual, for evidence of damage, poor workmanship, or other defects, and completeness of identification.

Inspection Results: There was no visible evidence of damage to the specimen unless noted below:

Inspected by Jim Gambill Date 5 Oct 78

Approved by ______ Date ______

Sheet 1 of 1

Figure 4. Receiving Inspection Data Sheet for MOAC-2500.

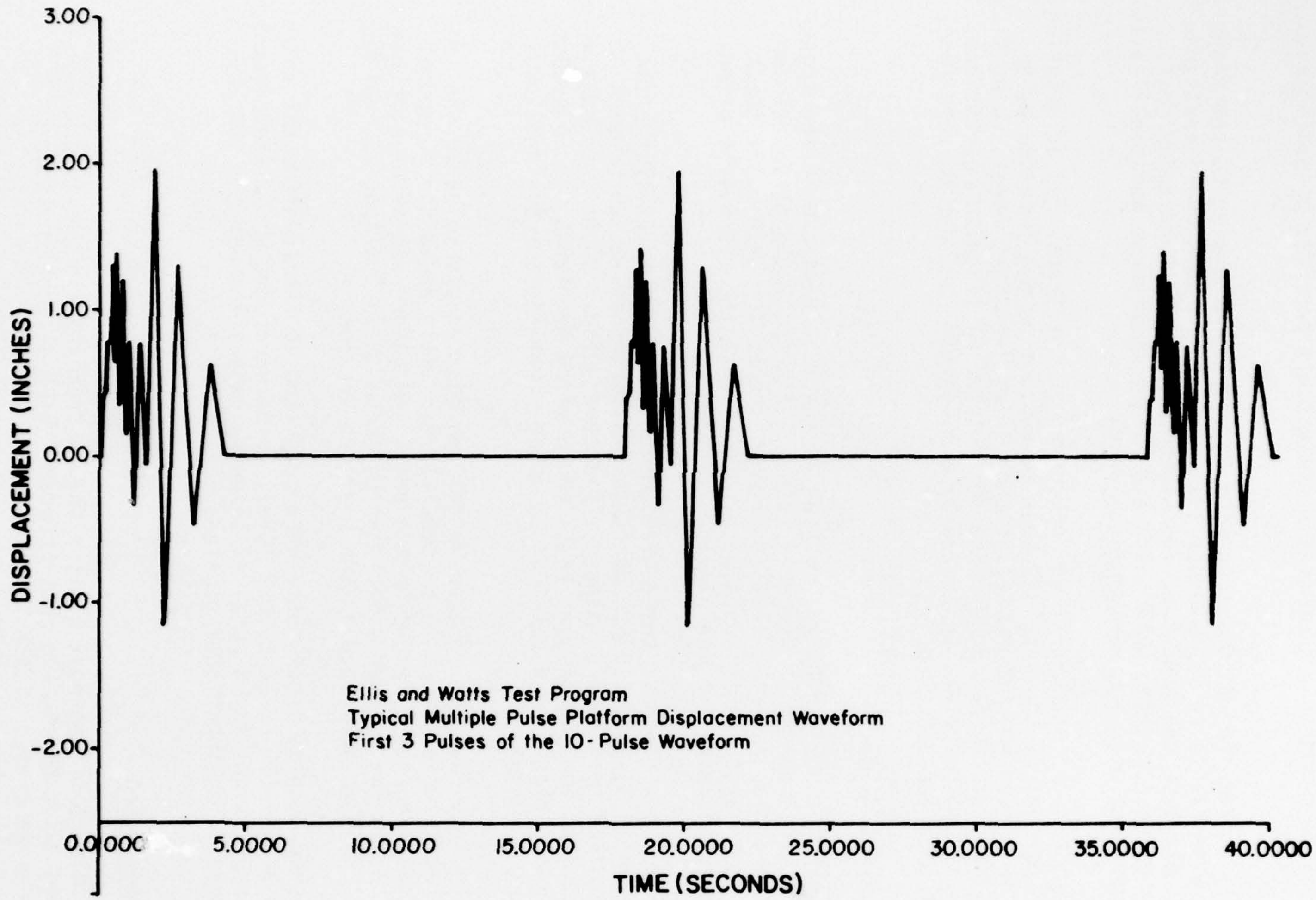


Figure 5. Platform displacement.

Two complete sweeps were conducted in each axis, and the output of all test platform and test item accelerometers was recorded on analog magnetic tape.

Test item MOAC-2010 was rotated 90 degrees clockwise to the transverse orientation on 13 November 1978. Ellis and Watts personnel conducted pre-test and post-test functional checks for each major test. Resonance search tests were conducted in the transverse horizontal axis in accordance with the procedure discussed above.

One biaxial shock test was conducted in the transverse orientation at 100 percent of the required test levels, using one 5-second pulse. Three test runs were conducted at the 100 percent test level, using five repetitions of the 5-second pulse for a total of 16 pulse repetitions. Each 5-second pulse was separated by a 15-second null period. No functional problems occurred.

Test Item MOAC-2500

Test item MOAC-2500 was mounted on the test platform in the transverse orientation on 14 November 1978. Ellis and Watts personnel conducted pre-test and post-test functional checks for each major shock test. Resonance search tests were conducted in the transverse orientation as described in the previous section.

Four biaxial shock tests were conducted in the transverse orientation on 14 November 1978. One test was conducted at 100 percent of the required test levels using one 5-second pulse. Three test runs were conducted at the 100 percent test level, using waveforms with 5-second pulse repetitions for a total of 16 pulse repetitions. No functional problems occurred.

The test item was rotated 90 degrees counter-clockwise to the longitudinal orientation on 15 November 1978. Ellis and Watts personnel conducted functional checks on the test item before and after each major shock test. The resonance tests were conducted in the longitudinal horizontal axis as described in the previous section.

Three biaxial shock tests were conducted in the longitudinal orientation at the 100 percent test level, using waveforms with five 5-second pulse repetitions for a total of 15 pulse repetitions at the 100 percent test level. No functional problems occurred.

Instrumentation

Table E1 of Appendix E lists the instrumentation and associated equipment used during the test program. Biaxial acceleration measurements were made at six locations on each unit. The locations are tabulated in Tables 2 and 3 and are depicted in Figures 6 and 7,

Table 2

MOAC-2010 -- Accelerometer Locations

Accelerometer	Orientation	Location
A1	Vertical	Center of the top
A2	Horizontal	panel of the unit
A3	Vertical	Center of the top
A4	Horizontal	of the cooling coil
A5	Vertical	Side, above access panel at
A6	Horizontal	structural member support
A7	Vertical	Center of bottom
A8	Horizontal	fan motor mount
A9	Vertical	Top of condenser
A10	Horizontal	near water inlet
A11	Vertical	Center of compressor
A12	Horizontal	mount near access panel

Table 3

MOAC-2500 -- Accelerometer Locations

Accelerometer	Orientation	Location
A1	Vertical	Center of the top
A2	Horizontal	panel of the unit
A3	Vertical	Center of the top
A4	Horizontal	of the cooling coil
A5	Vertical	Side, above access panel at
A6	Horizontal	structural member support
A7	Vertical	Center of bottom
A8	Horizontal	fan motor mount
A9	Vertical	Top of condenser
A10	Horizontal	near water inlet
A11	Vertical	Center of compressor
A12	Horizontal	mount near access panel

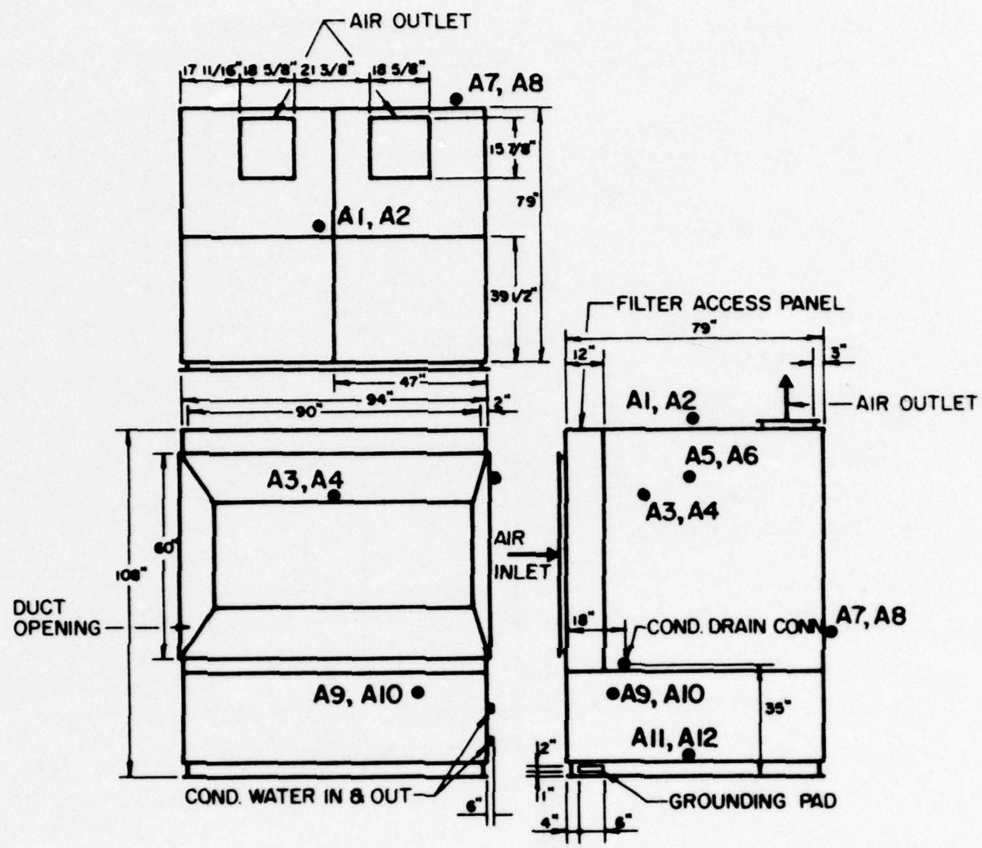


Figure 6. MOAC-2010 accelerometer locations.

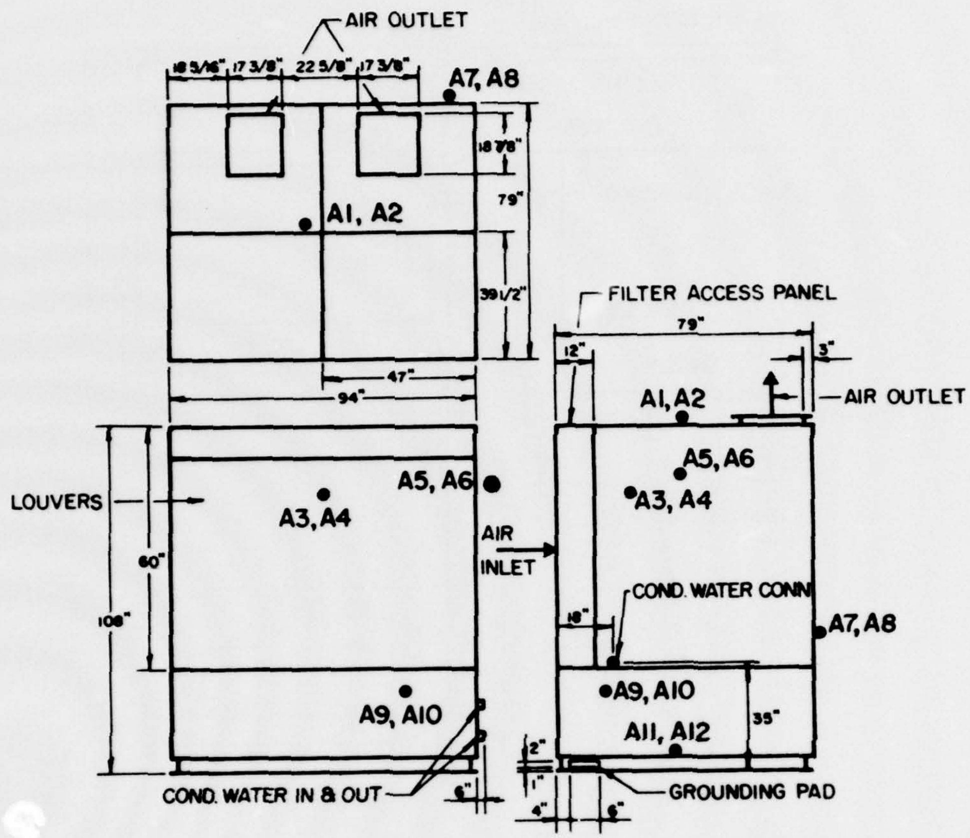


Figure 7. MOAC-2500 accelerometer locations.

respectively. The output signals from all test item and test platform response accelerometers and the horizontal and vertical average test platform displacement were recorded on analog magnetic tape for all resonance and shock tests.

Test Schedule

Table 4 lists the schedule of tests conducted on the three test items.

Table 4

Test Schedule

Test Run	Orientation	Test Level	No. of Shock Pulses	Date
		Test Item MOAC-2010		
1	Longitudinal	100%	1	9 Nov 78
2	Longitudinal	100%	5	9 Nov 78
3	Longitudinal	100%	5	9 Nov 78
4	Longitudinal	100%	5	9 Nov 78
5	Transverse	100%	1	13 Nov 78
6	Transverse	100%	5	13 Nov 78
7	Transverse	100%	5	13 Nov 78
8	Transverse	100%	5	13 Nov 78
		Test Item MOAC-2500		
1	Transverse	100%	1	14 Nov 78
2	Transverse	100%	5	14 Nov 78
3	Transverse	100%	5	14 Nov 78
4	Transverse	100%	5	14 Nov 78
5	Longitudinal	100%	5	15 Nov 78
6	Longitudinal	100%	5	15 Nov 78
7	Longitudinal	100%	5	15 Nov 78

3 TEST RESULTS

Resonance Search Tests

Appendix A contains a tabulation of all resonant frequencies found for each test item and the ratio of the response acceleration to the test platform acceleration.

Shock Tests

Fifteen shock tests were conducted on the two test items at the 100 percent test level; 63 shock pulses were applied. All tests were monitored by the Quality Control Engineer of the Libertyville TVA Office.

Test Item MOAC-2010

No damage, drive belt loss, or other functional failures occurred during the test series. Appendix B provides the shock spectra for all tests. Test runs 1 through 4 were performed in the longitudinal orientation, and test runs 5 through 8 in the transverse orientation. In the longitudinal orientation, run 1 consisted of one 5-second pulse series at the 100 percent test level. Runs 2 through 4 each consisted of five 5-second pulse series at the 100 percent test level for a total of 16 test pulses. In the longitudinal orientation, three of the vertical spectra fell below the requirements. During run 2, one spectrum was approximately 6 percent below the requirement (from 16.5 Hz to 18 Hz), and the other spectrum was below by approximately 6 percent (18 Hz). During run 4, one vertical spectrum was below the requirement by approximately 6.5 percent (16 Hz). In the transverse orientation, run 5 consisted of one 5-second pulse series at the 100 percent test level, and runs 6 through 8 were five 5-second pulse series at the 100 percent test level for a total of 16 test pulses. None of the shock spectra were below the requirements for the 16 test pulses.

For both test orientations, the test item was subjected to more than ten 100 percent test pulses for which the computed shock spectra satisfied the TVA criteria; the test results were accepted as completely satisfying the TVA test criteria. Appendix C contains copies of typical test item response data for one shock pulse for both test orientations.

Test Item MOAC-2500

No damage, drive belt loss, or other functional failures occurred during the entire test series. Appendix B contains the shock spectra for all tests. Test runs 1 through 4 were performed in the transverse orientation, and test runs 5 through 7 in the longitudinal orientation. In the transverse orientation, run 1 consisted of one 5-second pulse series at the 100 percent test level, and runs 3 and 4 each consisted of five 5-second pulse series at the 100 percent test level for a total of 16 test pulses. During run 1, the vertical spectra fell below the requirements by 11 percent (14 Hz). During run 2, one vertical spectrum fell below the requirements by approximately 2 percent (13 Hz). In the longitudinal orientation, runs 5 through 7 each consisted of five 5-second pulse series at the 100 percent test level for a total of 15 test pulses. None of the shock spectra were below the requirements for the 15 test pulses.

For both test orientations, the test item was subjected to more than ten 100 percent test pulses for which the computed shock spectra satisfied the TVA criteria. Appendix C contains copies of typical test item response data for one shock pulse for both test orientations.

Functional Test Results

Appendix D contains the functional test data sheets. No functional problems were experienced during any of the tests on the two test items.

APPENDIX A

RESONANCE TEST DATA

TABLES

Table A1

Resonance Search -- MOAC-2010

Longitudinal Orientation -- Vertical Sweep

Accelerometer	Frequency	Amplification Factor
A1	8 - 8.5 Hz	2.5
	16 - 17 Hz	2.0
	30 - 35 Hz	2.5
A3	None Found	
A5	8.8 Hz	1.67
	31.5 - 33 Hz	1.33
A7	8.8 Hz	1.75
	13 Hz	1.75
	17 Hz	2.25
	23.5 Hz	2.0
A9	16 - 17 Hz	1.75
	31 - 33 Hz	1.25
A11	None Found	

Table A2

Resonance Search -- MOAC-2010

Longitudinal Orientation -- Horizontal Sweep

Accelerometer	Frequency	Amplification Factor
A2	10.5 - 11.5 Hz	2.0
	14 - 20 Hz	3.0
A4	10.5 - 13 Hz	2.0
	14.5 - 20.5 Hz	5.0
A6	14 - 22 Hz	2.3
A8	11 Hz	6.0
	19.5 Hz	4.0
A10	17.5 - 20 Hz	2.4
A12	None Found	

Table A3

Resonance Search -- MOAC-2010

Transverse Orientation -- Horizontal Sweep

Accelerometer	Frequency	Amplification Ratio
A2	17 - 20 Hz	3.33
	34 Hz	2.0
A4	18 - 19.5 Hz	2.08
	33 Hz	1.25
A6	17 - 19 Hz	2.33
	25 - 27 Hz	1.67
	33 - 34 Hz	1.67
A8	18 - 20 Hz	7.5
	33 Hz	2.5
A10	None Found	
A12	None Found	

Table A4

Resonance Search -- MOAC-2500

Transverse Orientation -- Vertical Sweep

Accelerometer	Frequency	Amplification Factor
A1	6 Hz	2.3
	10 Hz	2.3
	17 Hz	3.3
	29 - 31 Hz	8.3
A3	None Found	
A5	2.6 Hz	1.3
	28 - 35 Hz	1.5
A7	10 Hz	1.67
	18 - 21 Hz	2.67
A9	29 - 31 Hz	2.71
A11	None Found	

Table A5

Resonance Sweep -- MOAC-2500

Transverse Orientation -- Horizontal Sweep

Accelerometer	Frequency	Amplification Factor
A2	18 - 23 Hz	2.7
	24 - 35 Hz	1.7
A4	12 Hz	1.4
	18 - 26 Hz	1.5
	27 - 29 Hz	2.5
	30 Hz	5.5
	31 - 35 Hz	2.0
A6	17 - 35 Hz	1.7
A8	15.5 Hz	1.2
	18 - 30 Hz	2.0
	31 - 35 Hz	1.5
A10	27 - 31 Hz	2.5
	32 - 35 Hz	1.4
A12	None Found	

Table A6

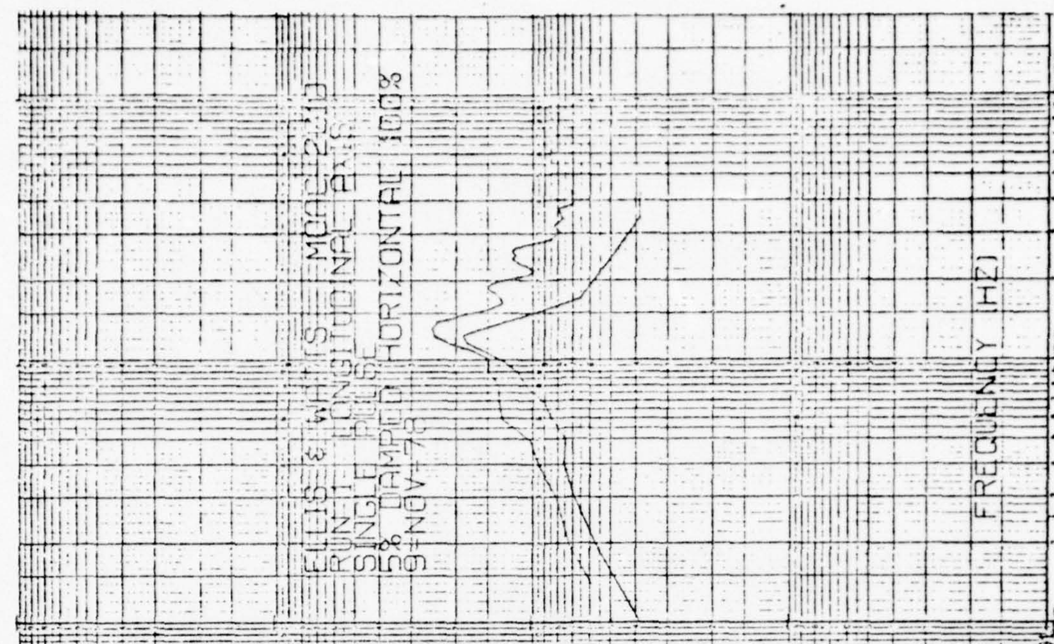
Resonance Sweep -- MOAC-2500

Transverse Orientation -- Horizontal Sweep

Accelerometer	Frequency	Amplification Factor
A2	16 - 18 Hz	1.7
	19 Hz	2.5
A4	15 - 22 Hz	2.5
A6	18 - 22 Hz	1.75
	28 - 30 Hz	1.50
A8	15 - 18 Hz	1.8
	18.5 - 19.5 Hz	2.4
	20 - 22 Hz	1.8
A10	15.5 - 17 Hz	1.33
A12	None Found	

APPENDIX B

TEST MACHINE RESPONSE SPECTRA


ELLIS & WATTS MODEL 2010
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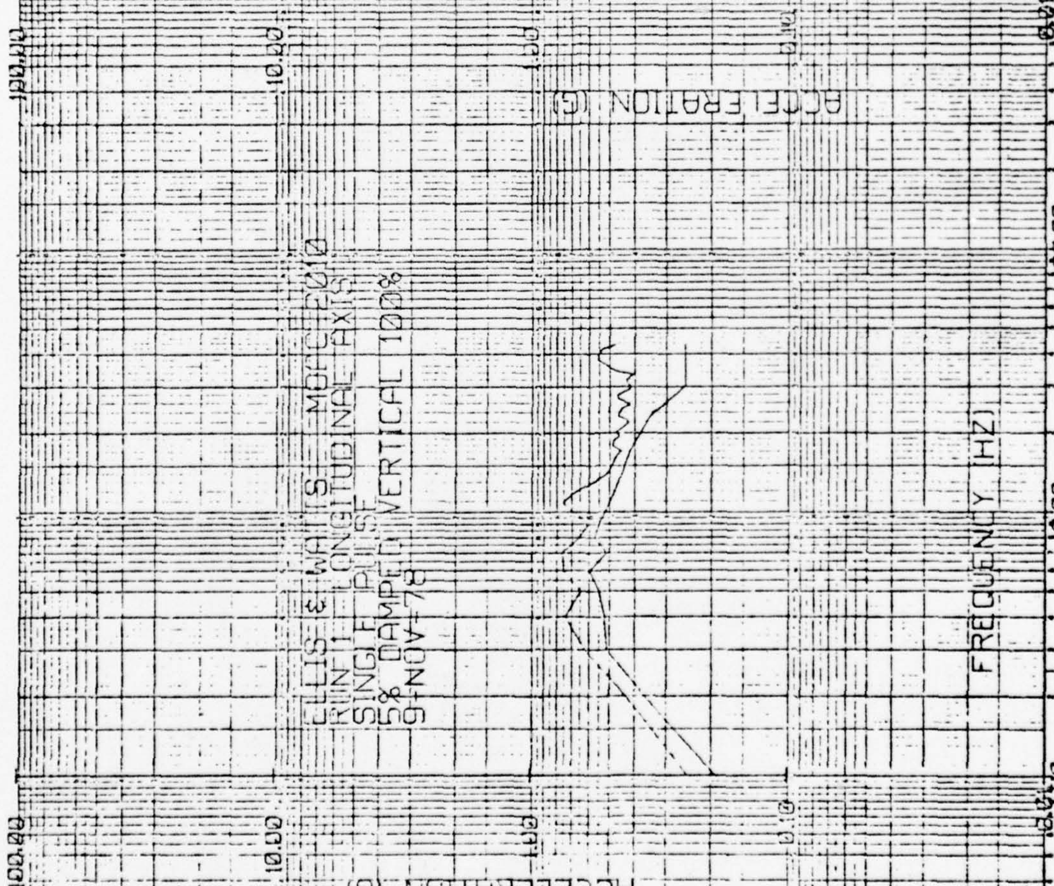
SINGLE PULSE
5% DAMPED HORIZONTAL 100%
9-NOV-78
FREQUENCY (HZ)
ACCELERATION (G)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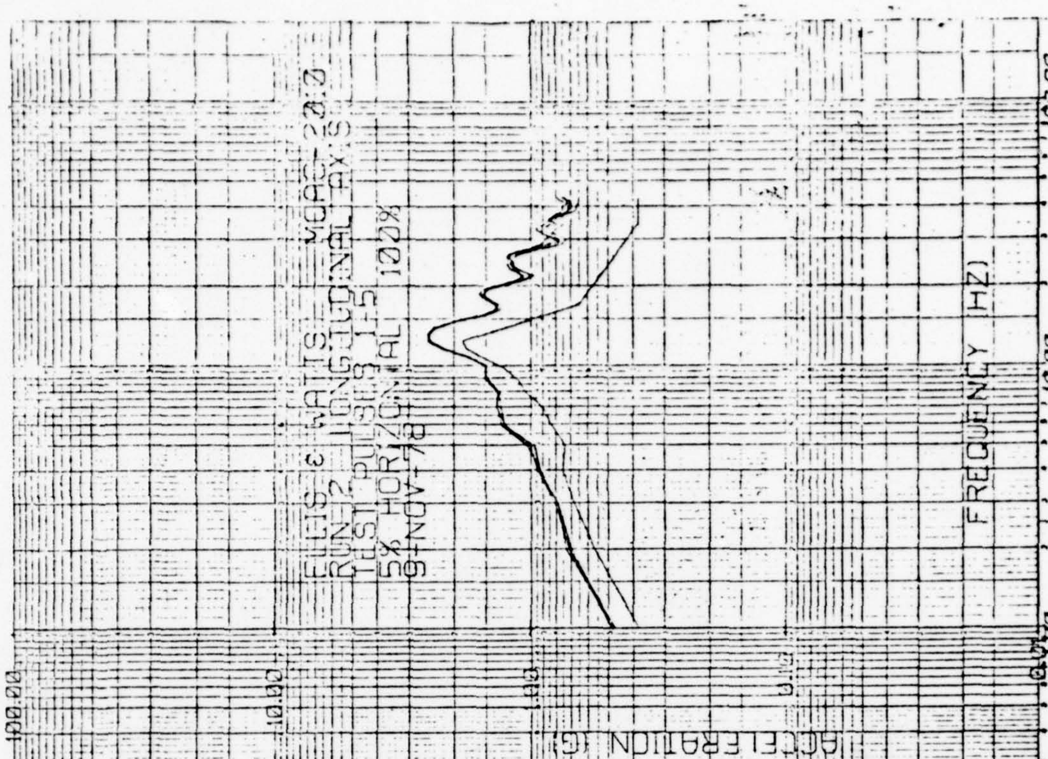
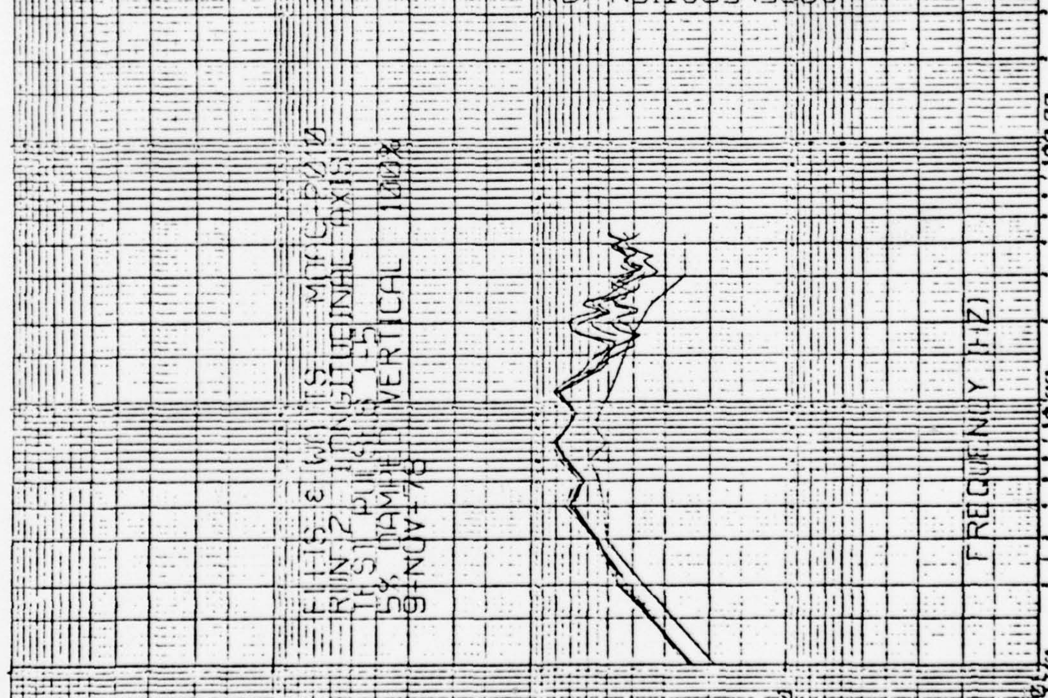
5% DAMPED VERTICAL 100%
9-NOV-78
FREQUENCY (HZ)
ACCELERATION (G)


ELLIS & WATTS MDAC-2010
RUN 2 LONGITUDINAL AXIS
TEST PULSE 1-5
5% HORIZONTAL 100%
9-NOV-78
FREQUENCY (HZ)
ACCELERATION (G)
100.00
10.00
1.00
0.10
0.01


ELLIS & WATTS MDAC-2010
RUN 2 LONGITUDINAL AXIS
TEST PULSE 1-5
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9-NOV-78
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ACCELERATION (G)
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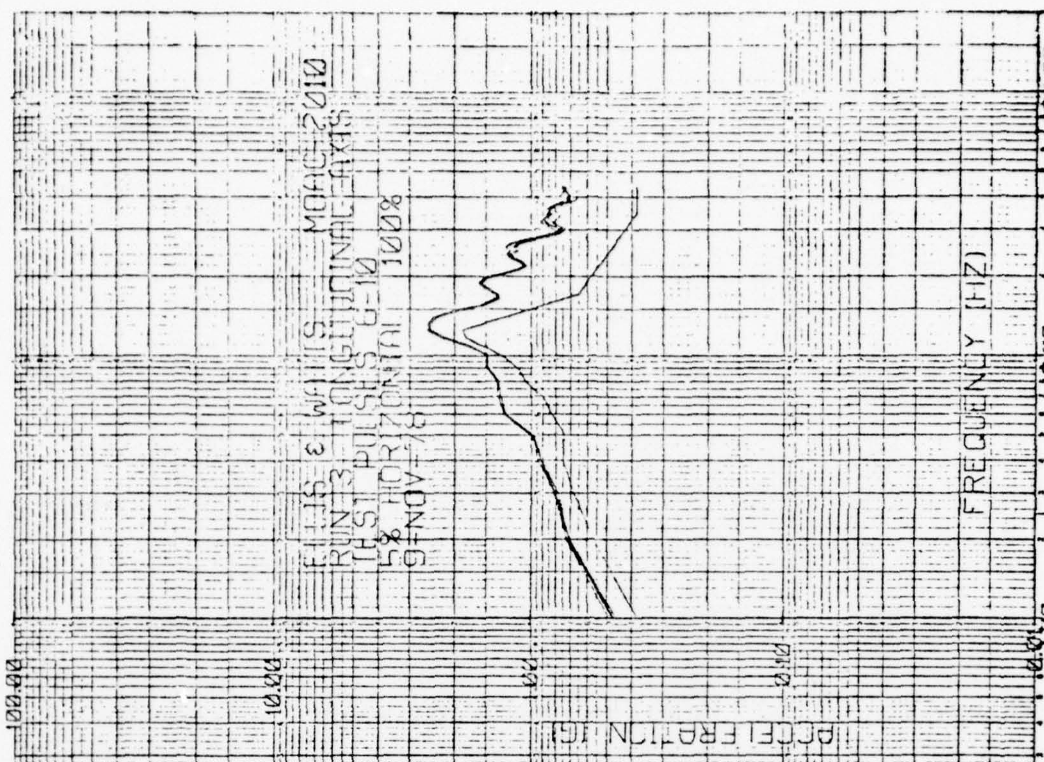
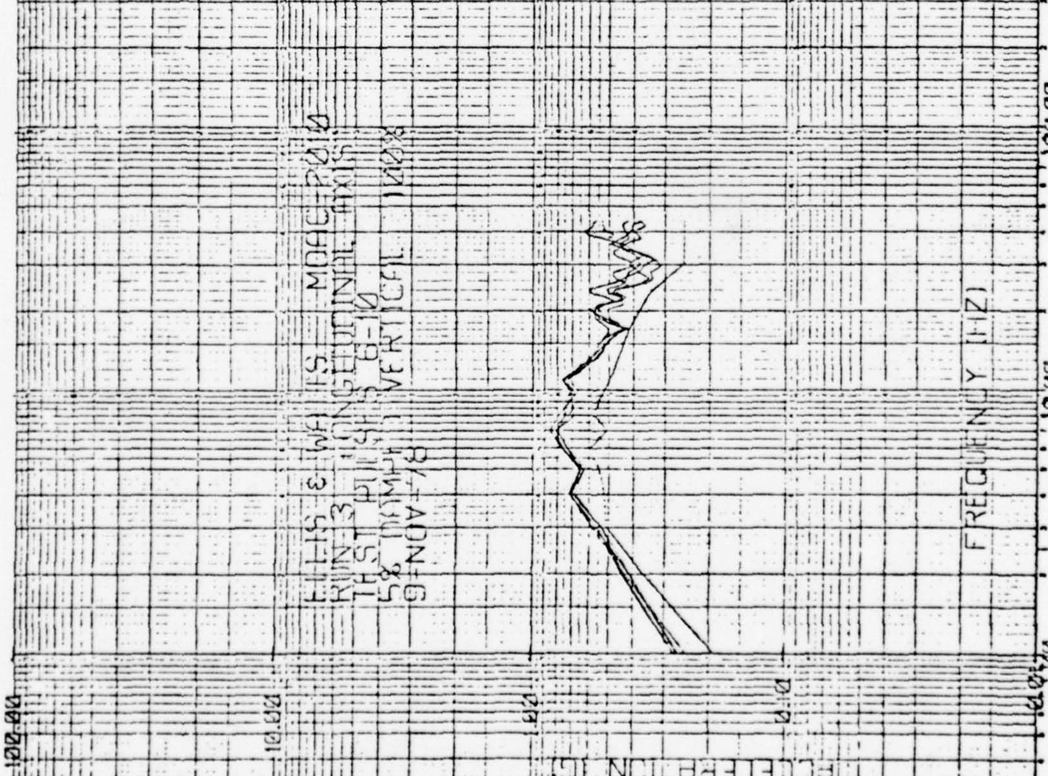


ELLIS & WATTS MOAC-2010
RUN 3 LONGITUDINAL AXIS
TEST PULSES 6-10
5% HORIZONTAL 100%
9-NOV-78
FREQUENCY (HZ)
ACCELERATION (G)



ELLIS & WATTS MOAC-2010
RUN 3 LONGITUDINAL AXIS
TEST PULSES 6-10
5% DAMPING VERTICAL 100%
9-NOV-78
FREQUENCY (HZ)
ACCELERATION (G)


FREQUENCY (HZ)
ACCELERATION (G)
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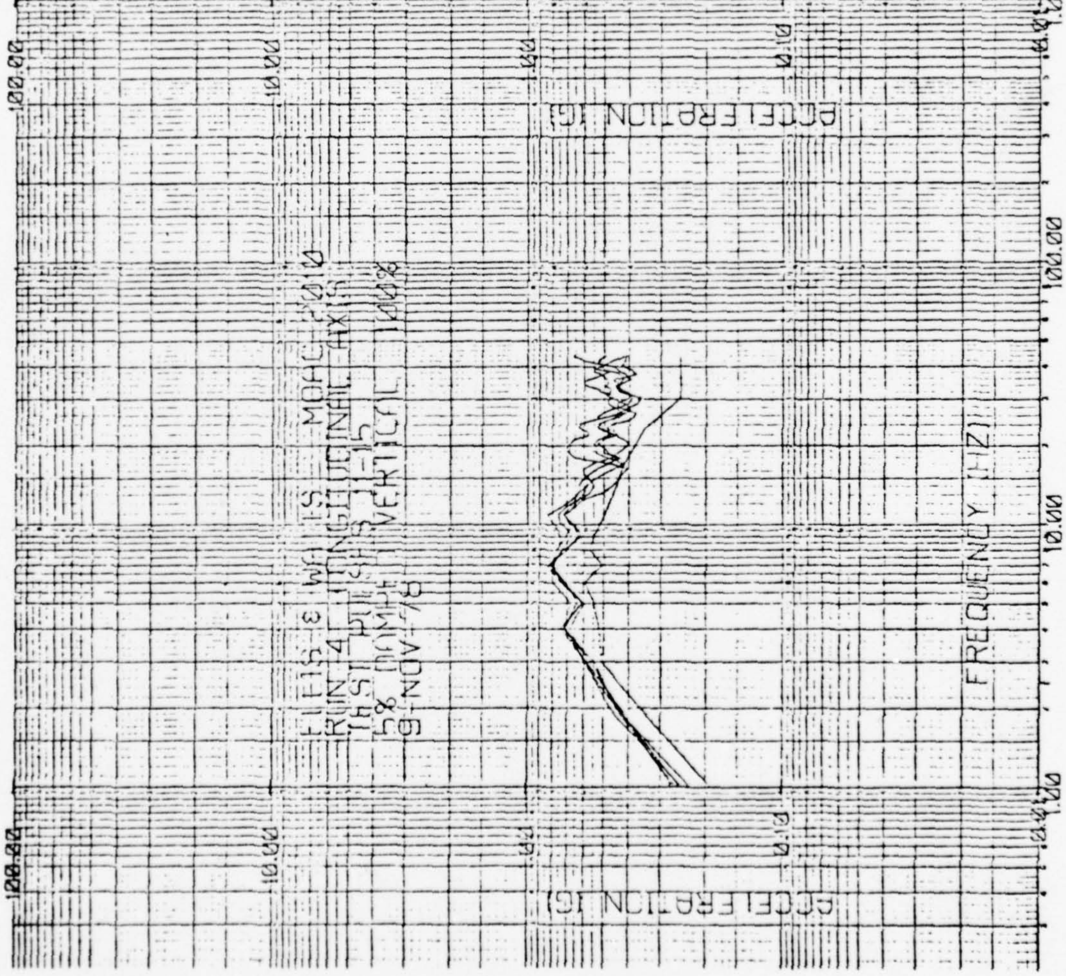
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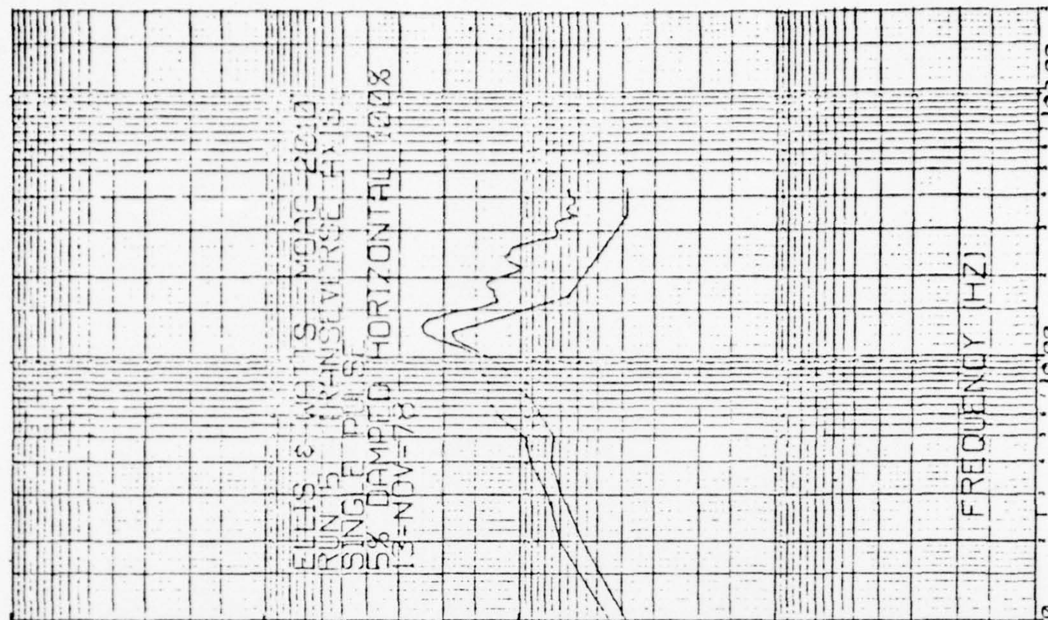
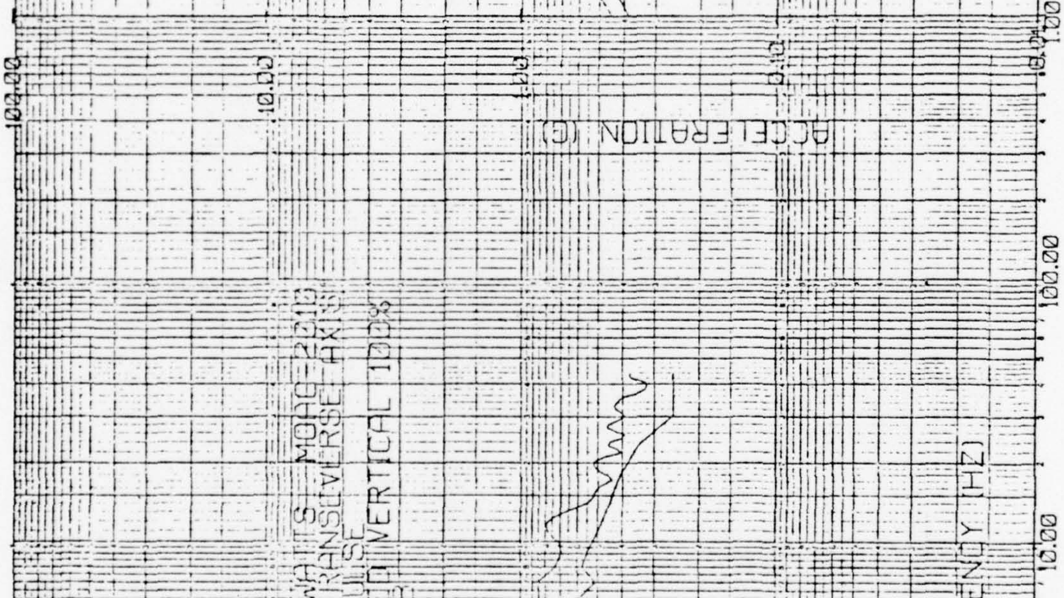
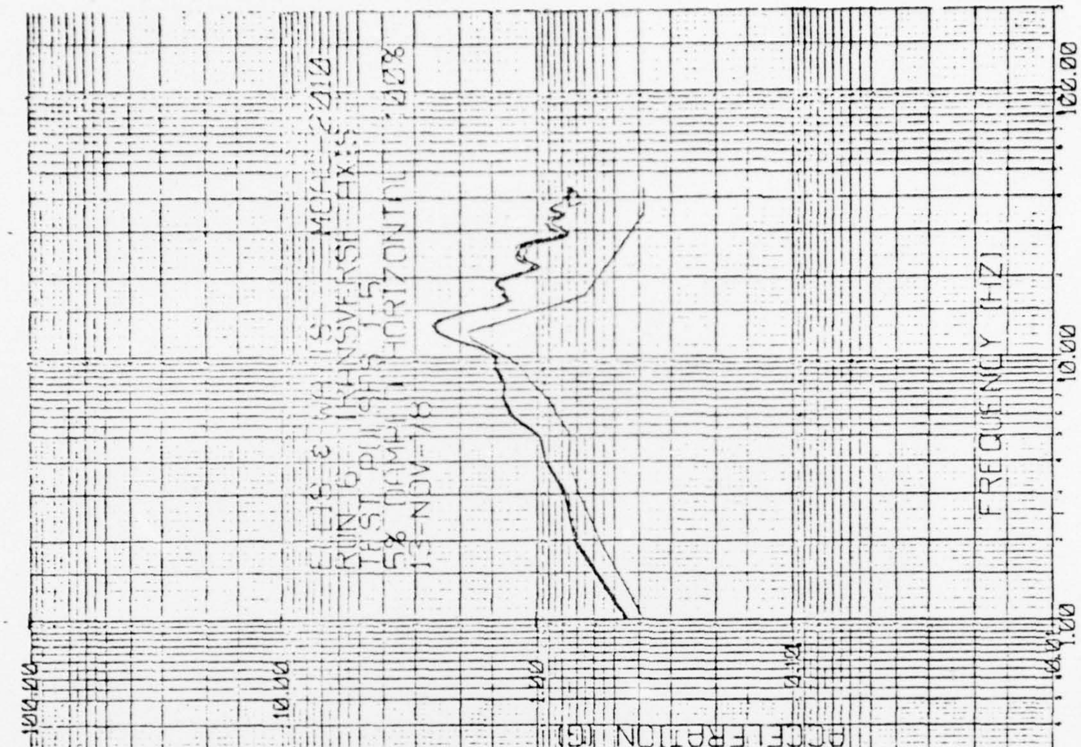
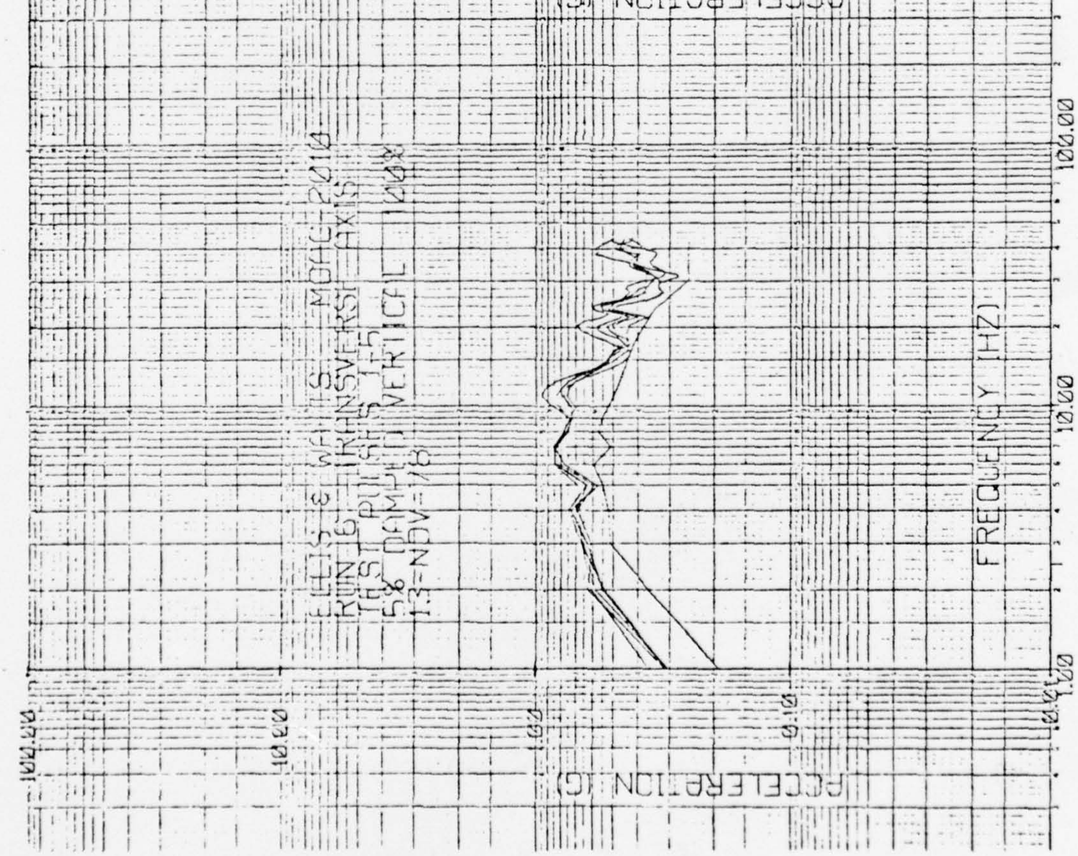
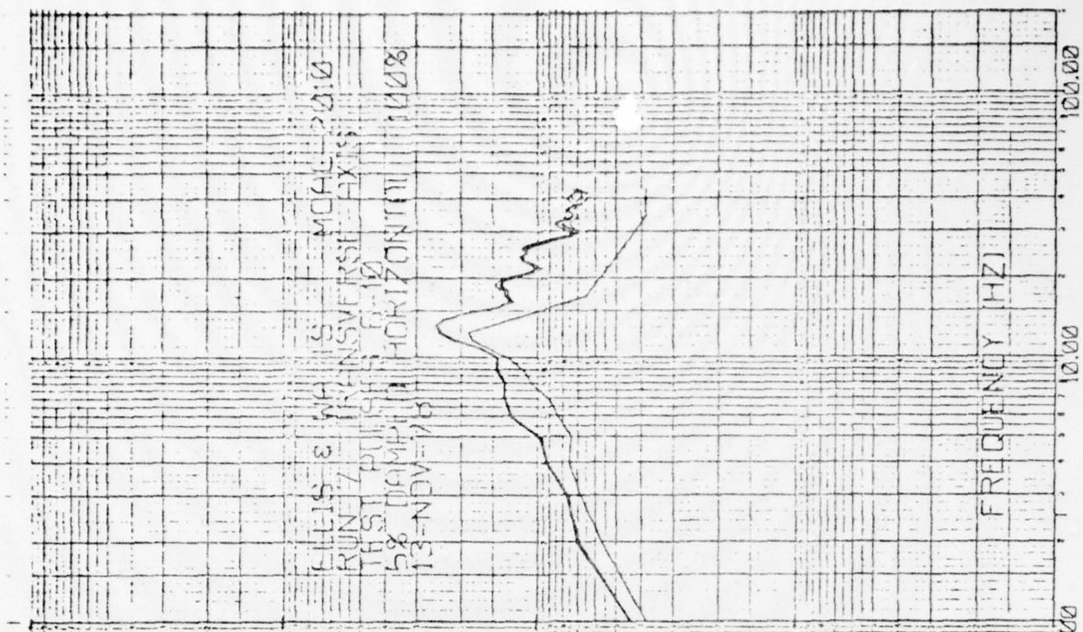
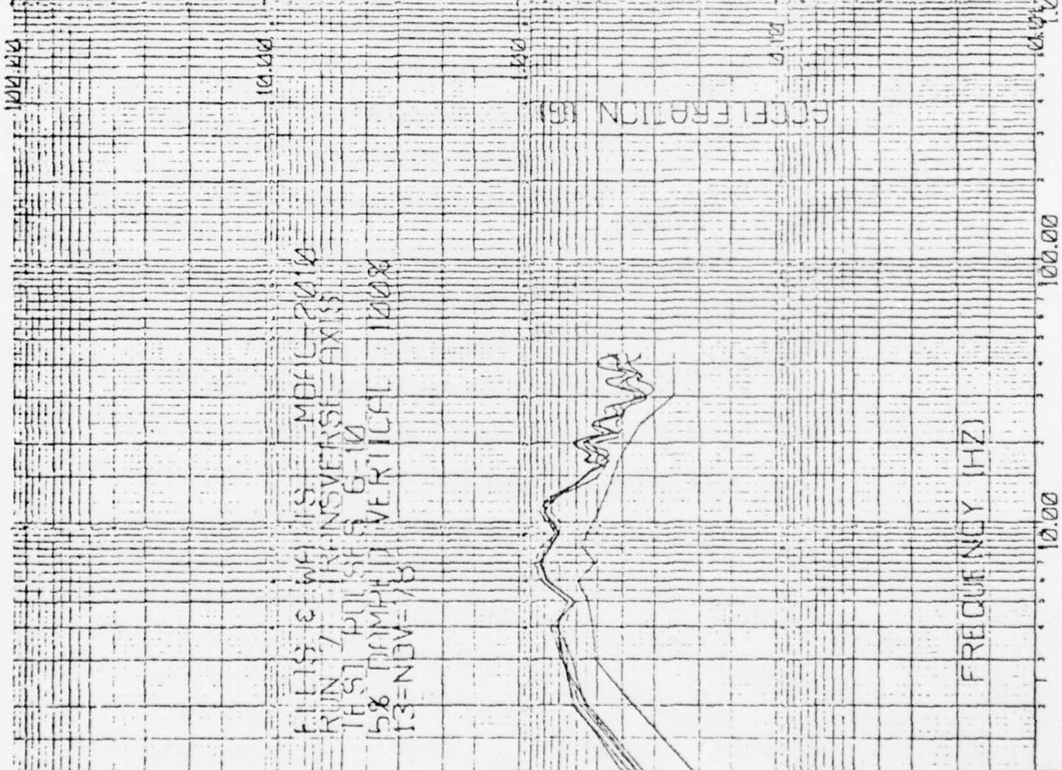

ELLIS & WATTS MOHC-2010
RUN 5 TRANSVERSE AXIS
SINGLE PULSE
5% DAMPED HORIZONTAL 100%
13-NOV-78
FREQUENCY (HZ)
ACCELERATION (G)
1.00
10.00
100.00
0.01
0.10
1.00
10.00
100.00

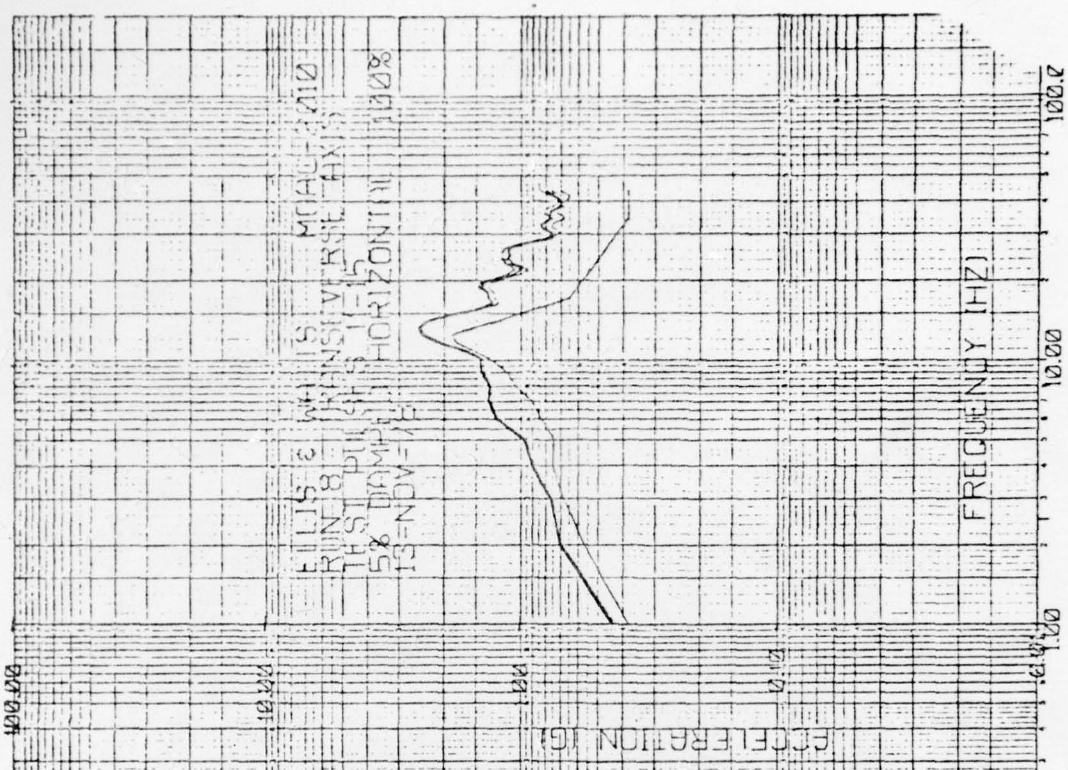

ELLIS & WATTS MOHC-2010
RUN 5 TRANSVERSE AXIS
SINGLE PULSE
5% DAMPED VERTICAL 100%
13-NOV-78
FREQUENCY (HZ)
ACCELERATION (G)
1.00
10.00
100.00
0.01
0.10
1.00
10.00
100.00


ELLIS & WATTS MOAC 2010
RUN 6 TRANSVERSE AXIS
TEST PULSE 1.5
5% DAMPED HORIZONTAL
13-NOV-78
ACCELERATION (G)
FREQUENCY (HZ)

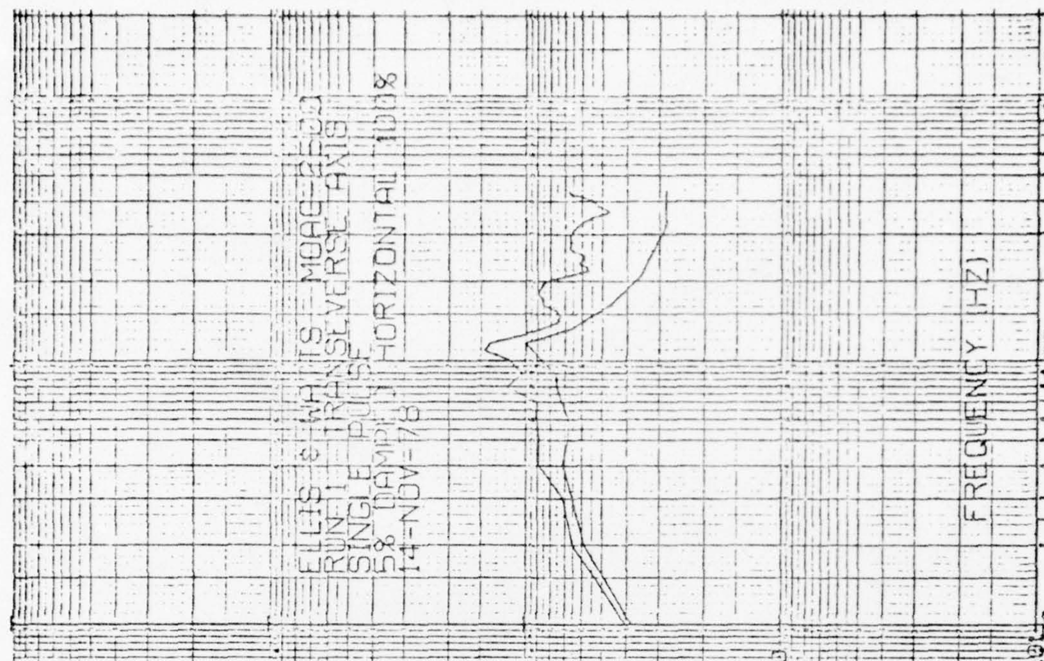

ELLIS & WATTS MOAC 2010
RUN 6 TRANSVERSE AXIS
TEST PULSE 1.5
5% DAMPED VERTICAL
13-NOV-78
ACCELERATION (G)
FREQUENCY (HZ)

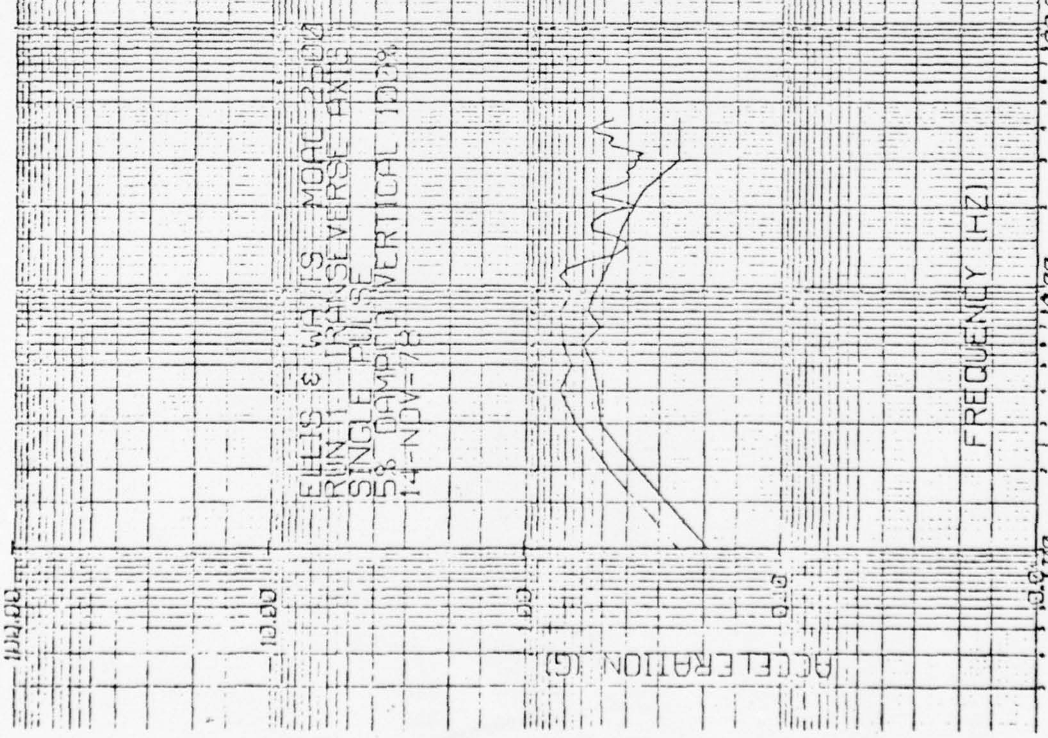

ELLIS & WALLIS MDAC-2010
RUN 7 TRANSVERSE AXIS
TEST PULSES 6-10
5% DAMPING HORIZONTAL 100%
13-NOV-78
FREQUENCY (HZ)
ACCELERATION (G)
1.00
10.00
100.00
0.10
0.01

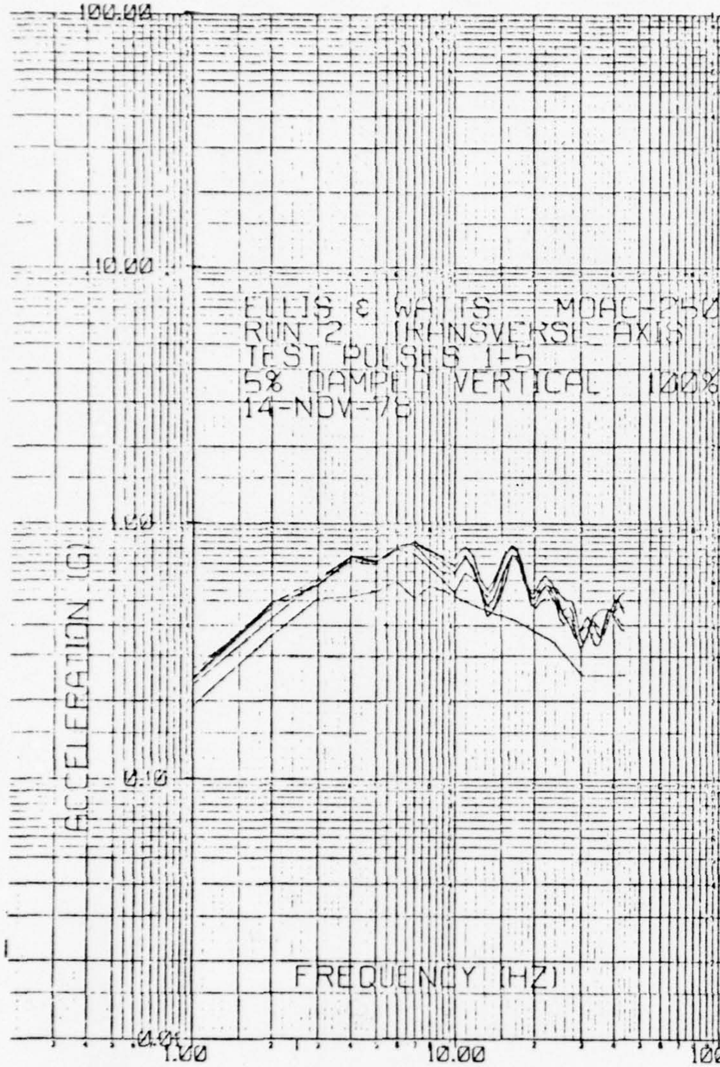

ELLIS & WALLIS MDAC-2010
RUN 7 TRANSVERSE AXIS
TEST PULSES 6-10
5% DAMPING VERTICAL 100%
13-NOV-78
FREQUENCY (HZ)
ACCELERATION (G)
1.00
10.00
100.00
0.10
0.01

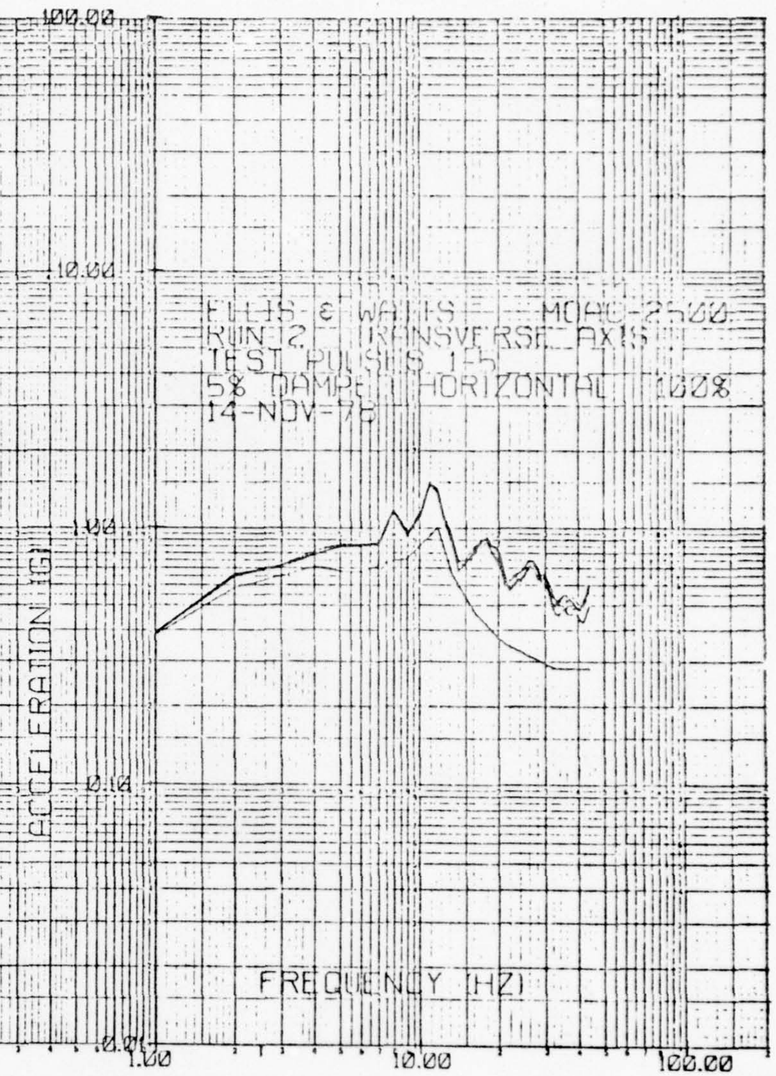

MDAC-2010
TEST PULSES 11-15
5% DAMPED HORIZONTAL 100%
13-NOV-78
FREQUENCY (HZ)
ACCELERATION (G)
1.00
10.00
100.0
100.00
0.10

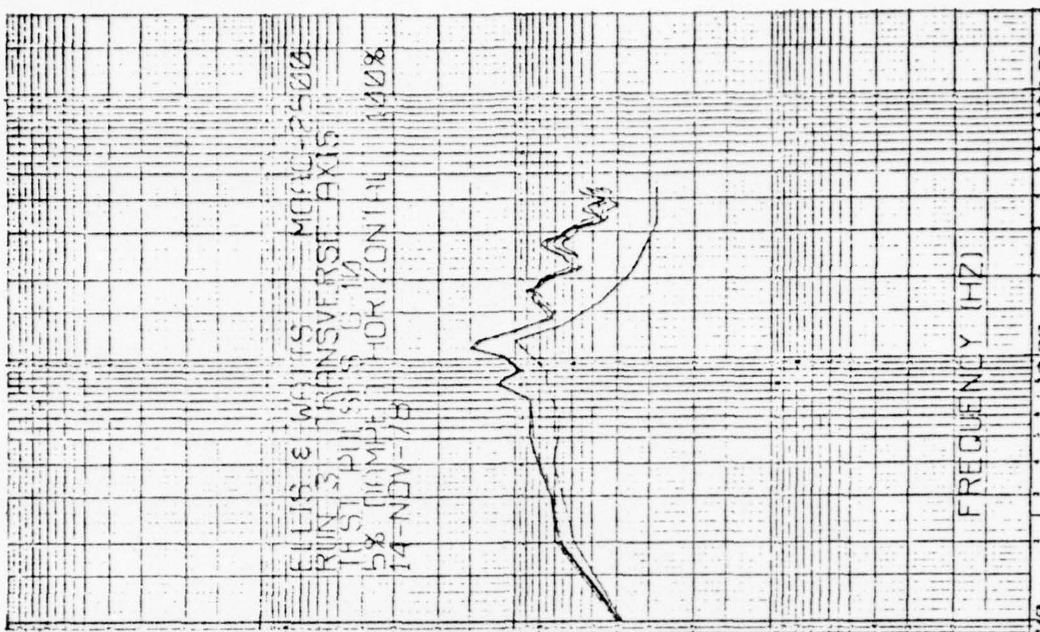

MDAC-2010
RUN 8
TEST PULSES 11-15
5% DAMPED VERTICAL 100%
13-NOV-78
FREQUENCY (HZ)
ACCELERATION (G)
1.00
10.00
100.00
0.10

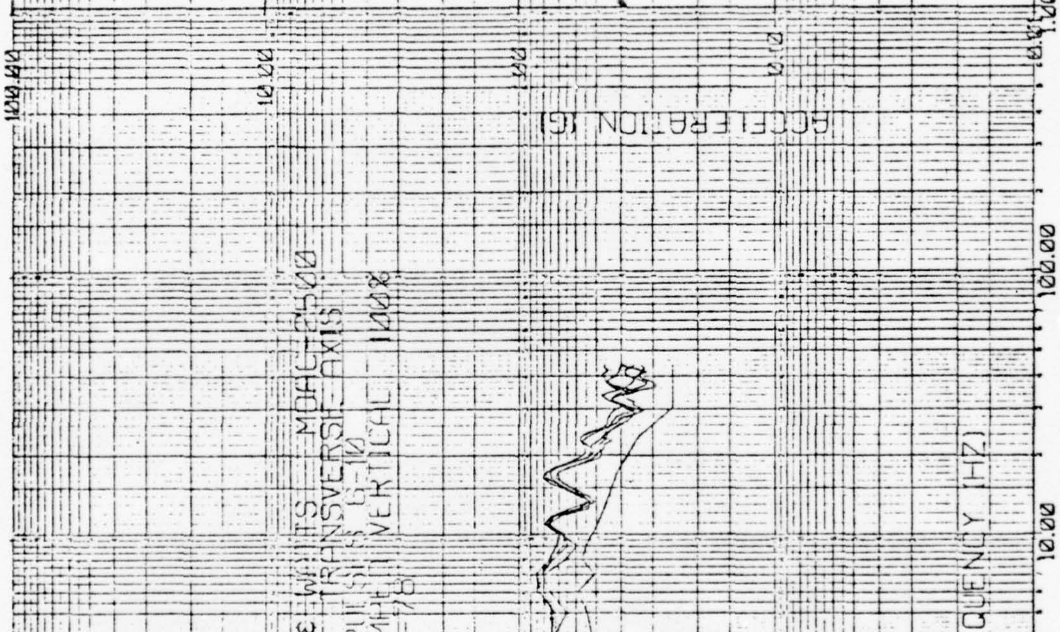

ELLIS & WATTS MOAC 2500
RUN 1 TRANSVERSE AXIS
SINGLE PULSE
5% DAMPED HORIZONTAL 100%
14-NOV-78
FREQUENCY (HZ)
ACCELERATION (G)
1.00
10.00
100.00

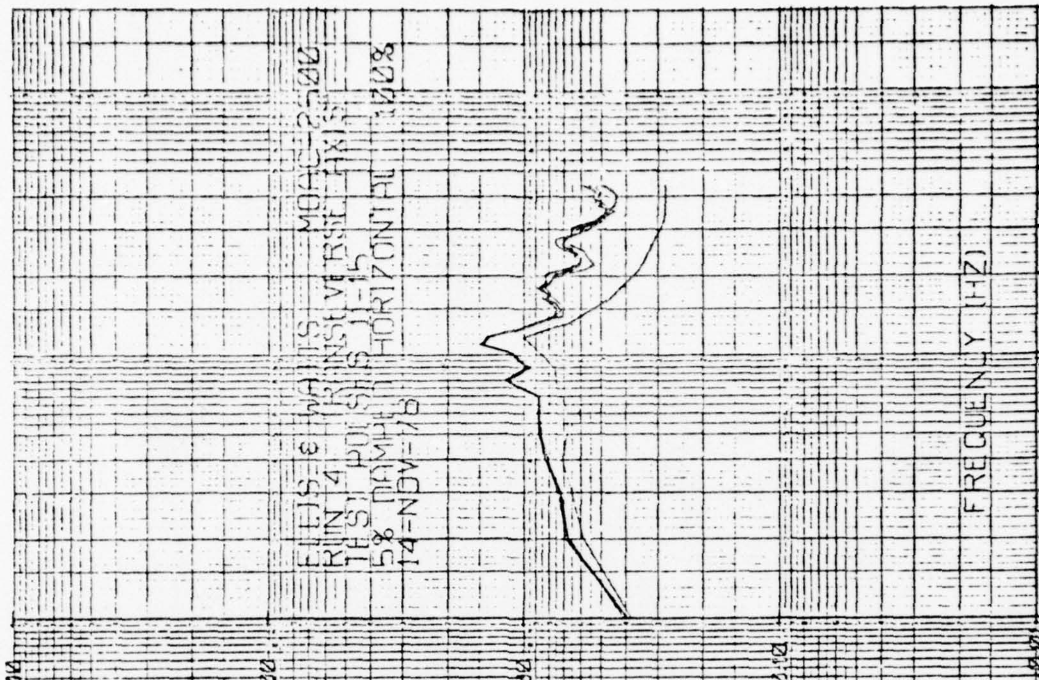

ELLIS & WATTS MOAC 2500
RUN 1 TRANSVERSE AXIS
SINGLE PULSE
5% DAMPED VERTICAL 100%
14-NOV-78
FREQUENCY (HZ)
ACCELERATION (G)
1.00
10.00
100.00

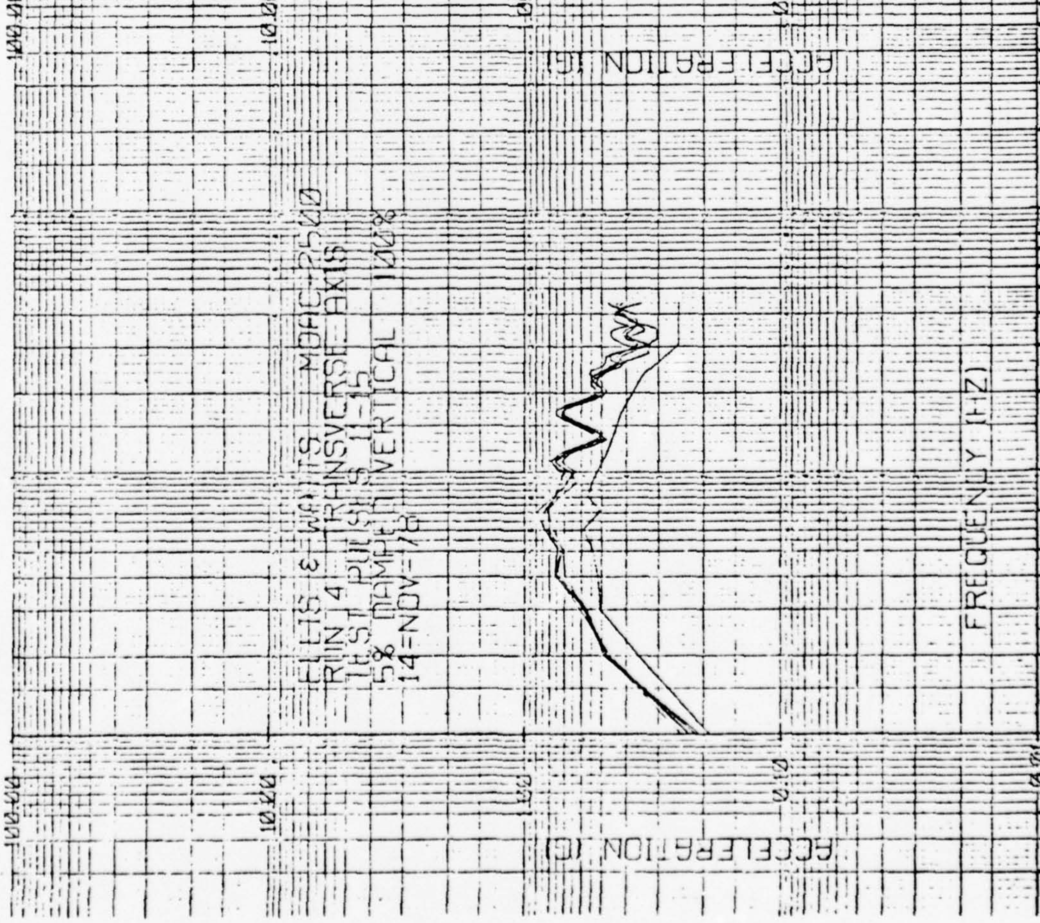

ELLIS & WATTS MOAC-2500
RUN 2 TRANSVERSE AXIS
TEST PULSES 1-5
5% DAMPED VERTICAL 100%
14-NOV-78
ACCELERATION (G)
FREQUENCY (HZ)
100.00
10.00
1.00
0.10
0.01
1.00
10.00
100.00

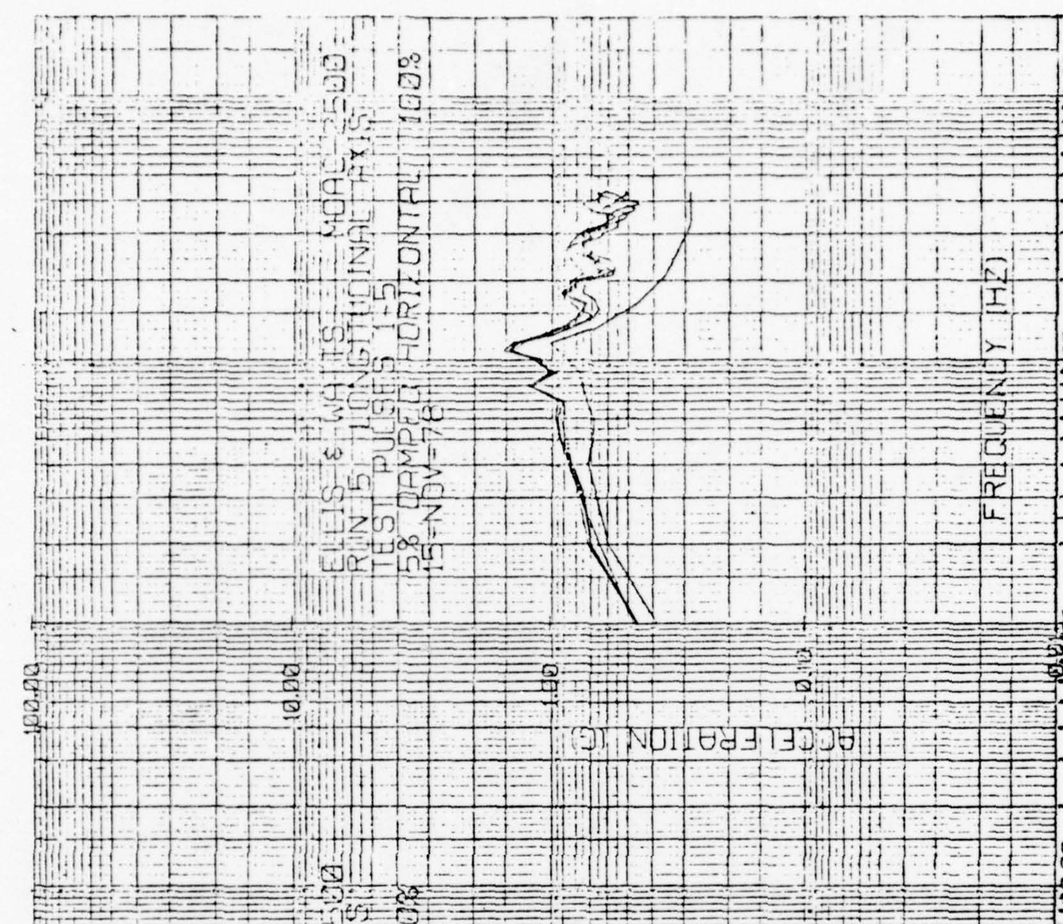

ELLIS & WATTS MOAC-2500
RUN 2 TRANSVERSE AXIS
TEST PULSES 1-5
5% DAMPED HORIZONTAL 100%
14-NOV-78
ACCELERATION (G)
FREQUENCY (HZ)
100.00
10.00
1.00
0.10
0.01
1.00
10.00
100.00

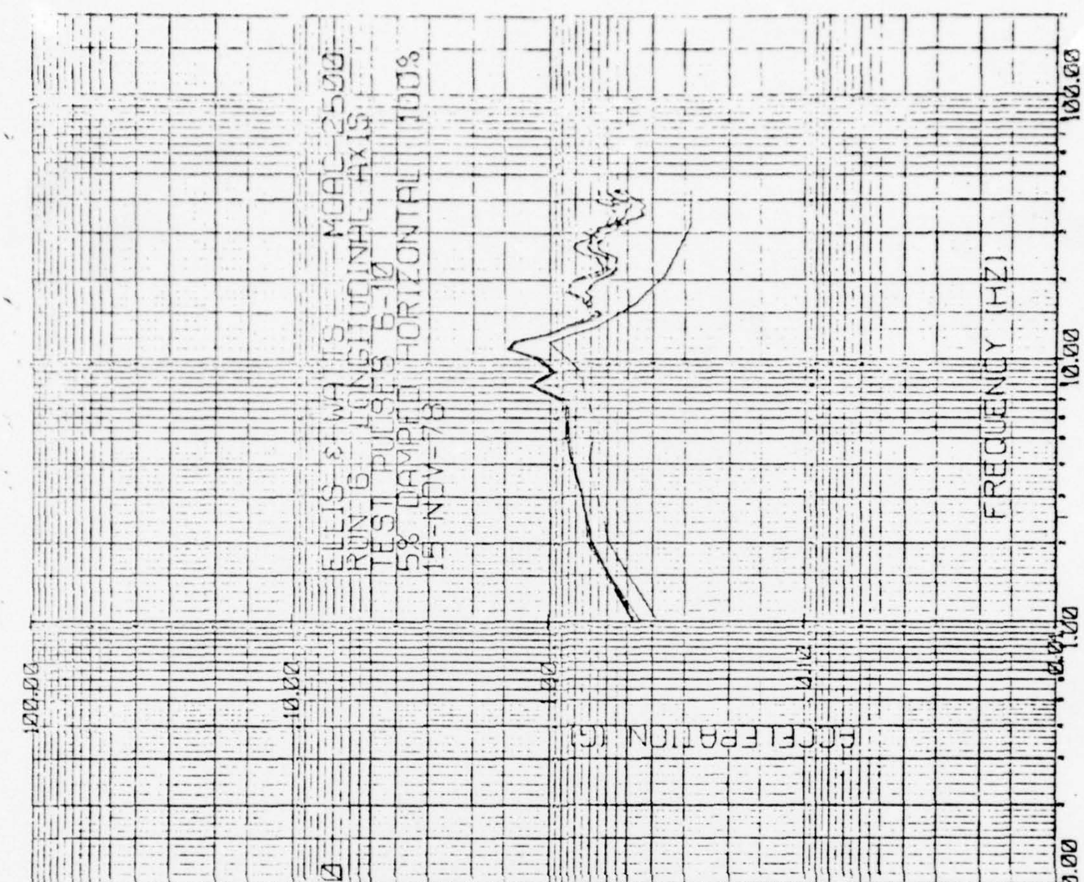

ELLIS & WATTS MDAC-2500
RUN 3 TRANSVERSE AXIS
TEST PULSE G-10
5% DAMPED HORIZONTAL 100%
14-NOV-78
FREQUENCY (HZ)
ACCELERATION (G)
1.00
10.00
100.00
0.01
0.10
1.00
10.00
100.00

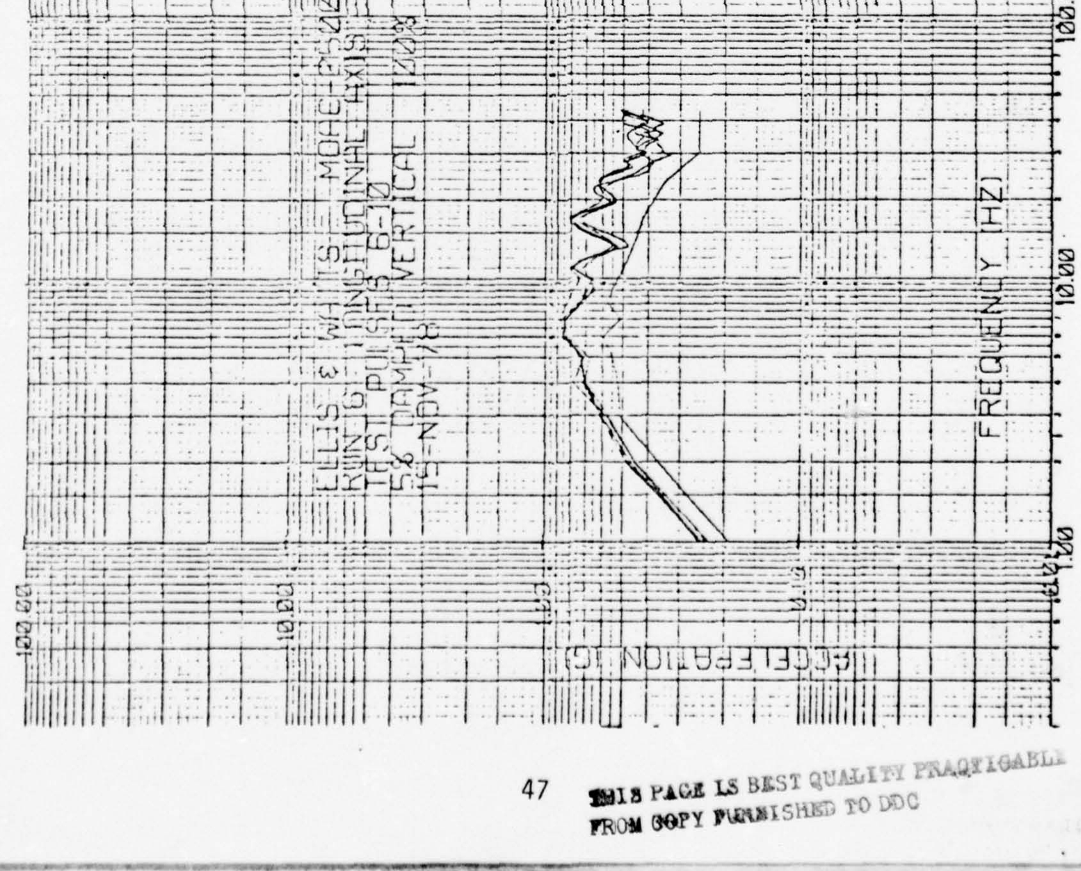

ELLIS & WATTS MDAC-2500
RUN 3 TRANSVERSE AXIS
TEST PULSE G-10
5% DAMPED VERTICAL 100%
14-NOV-78
FREQUENCY (HZ)
ACCELERATION (G)
1.00
10.00
100.00
0.01
0.10
1.00
10.00
100.00

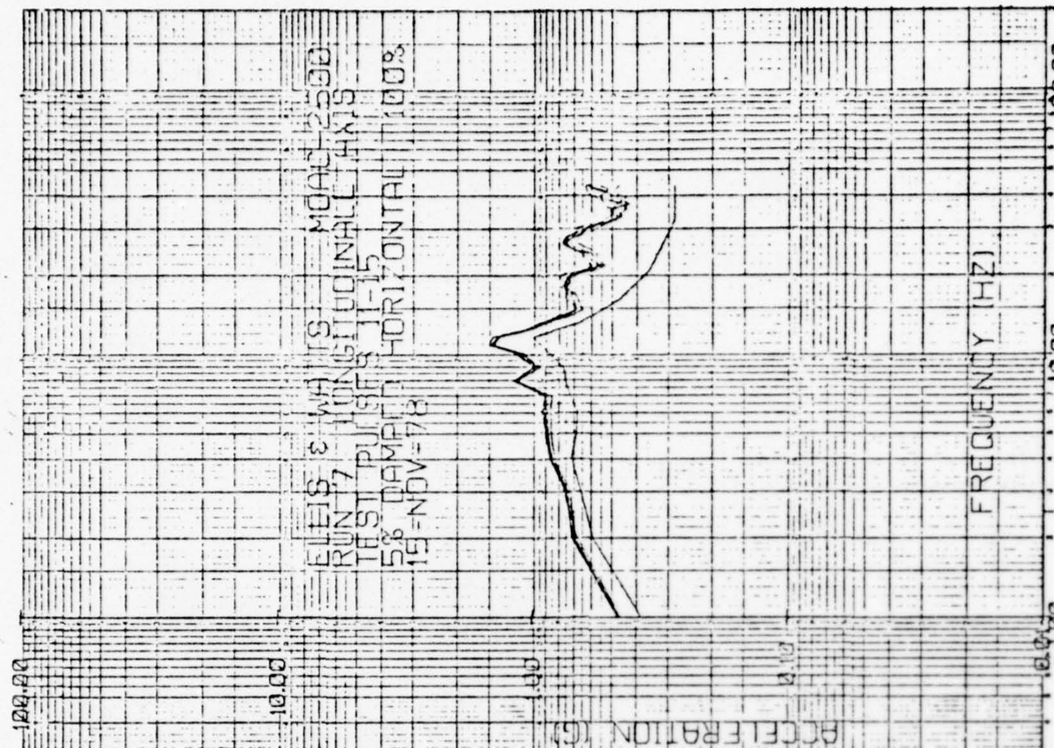

ELLIS & WATTS MDAC-2500
RUN 4 TRANSVERSE AXIS
TEST PULSES 11-15
5% DAMPED HORIZONTAL 100%
14-NOV-78
ACCELERATION (G)
FREQUENCY (HZ)
0.01
0.10
1.00
10.00
100.00

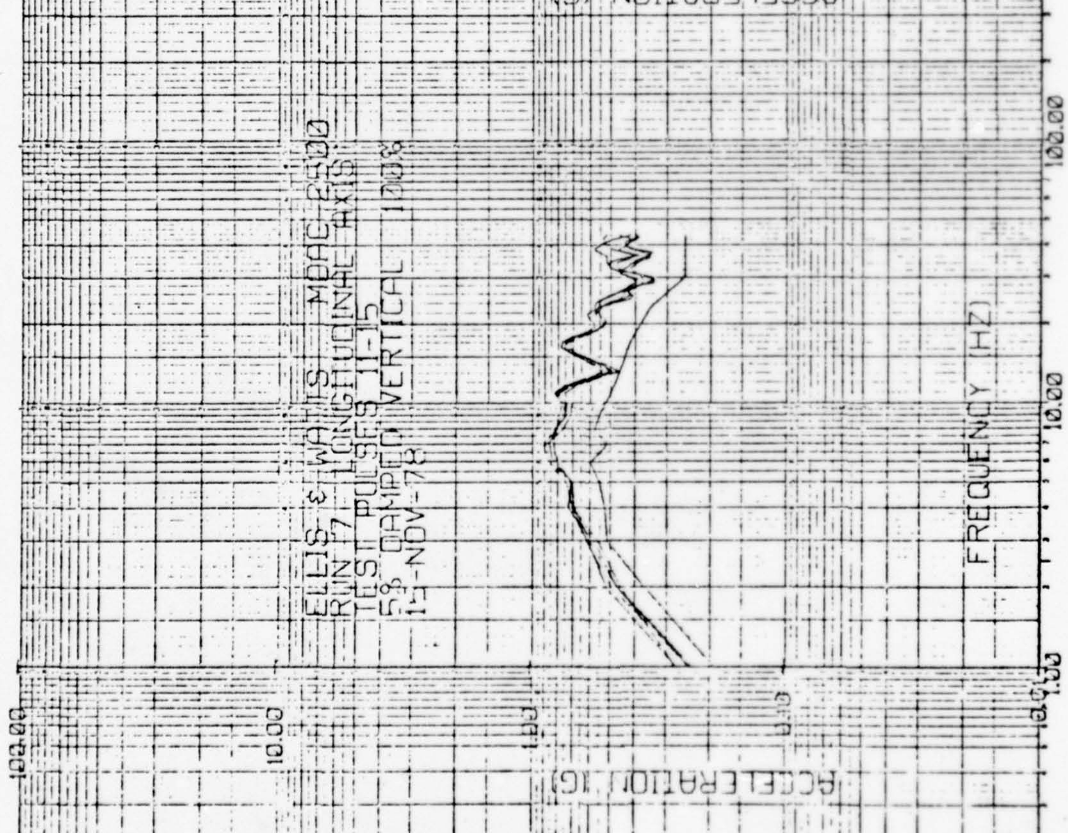

ELLIS & WATTS MDAC-2500
RUN 4 TRANSVERSE AXIS
TEST PULSES 11-15
5% DAMPED VERTICAL 100%
14-NOV-78
ACCELERATION (G)
FREQUENCY (HZ)
0.01
0.10
1.00
10.00
100.00


ELLIS & WATTS MOAC 2500
RUN 5 LONGITUDINAL AXIS
TEST PULSES 1-5
5% DAMPED VERTICAL 100%
15-NOV-78
ACCELERATION (G)
FREQUENCY (HZ)
ELLIS & WATTS MOAC 2500
RUN 5 LONGITUDINAL AXIS
TEST PULSES 1-5
5% DAMPED HORIZONTAL 100%
15-NOV-78
ACCELERATION (G)
FREQUENCY (HZ)


ELLIS & WATTS MOAC-2500
RUN 6 LONGITUDINAL AXIS
TEST PULSES 6-10
5% DAMPED HORIZONTAL 100%
15-NOV-78
FREQUENCY (HZ)
ACCELERATION (G)
1.00
10.00
100.00
0.10
0.01


ELLIS & WATTS MOAC-2500
RUN 6 LONGITUDINAL AXIS
TEST PULSES 6-10
5% DAMPED VERTICAL 100%
15-NOV-78
FREQUENCY (HZ)
ACCELERATION (G)
1.00
10.00
100.00
0.10
0.01


ELLIS & WATTS MDAC 2500
RUN 7 LONGITUDINAL AXIS
TEST PULSES 11-15
5% DAMPED HORIZONTAL 100%
15-NOV-78
FREQUENCY (HZ)
ACCELERATION (G)


ELLIS & WATTS MDAC 2500
RUN 7 LONGITUDINAL AXIS
TEST PULSES 11-15
5% DAMPED VERTICAL 100%
15-NOV-78
FREQUENCY (HZ)
ACCELERATION (G)

APPENDIX C

RESPONSE ACCELERATION TEST RECORDS

FIGURES

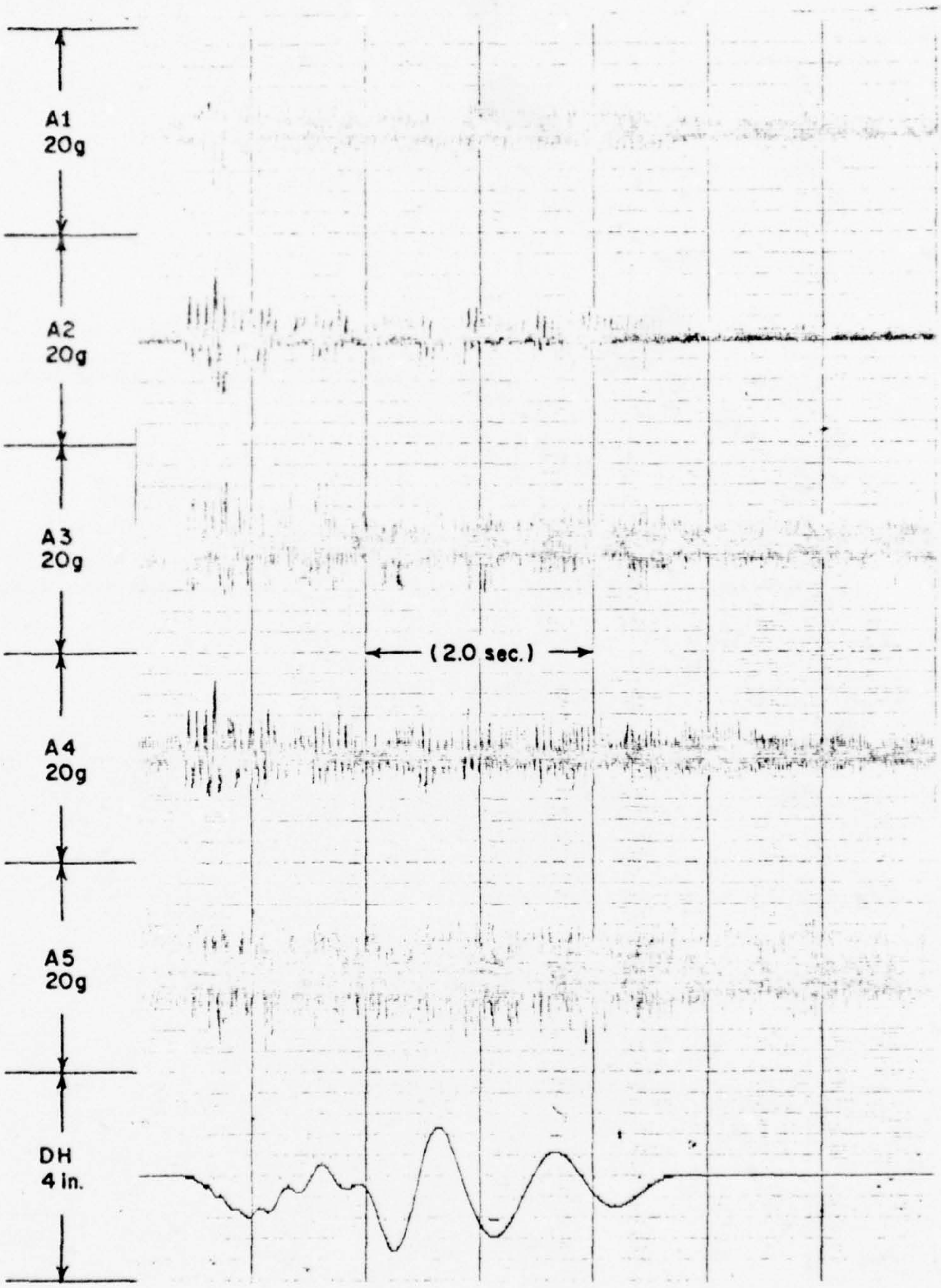


Figure C1. MOAC-2010: longitudinal orientation -- typical 100 percent pulse series.

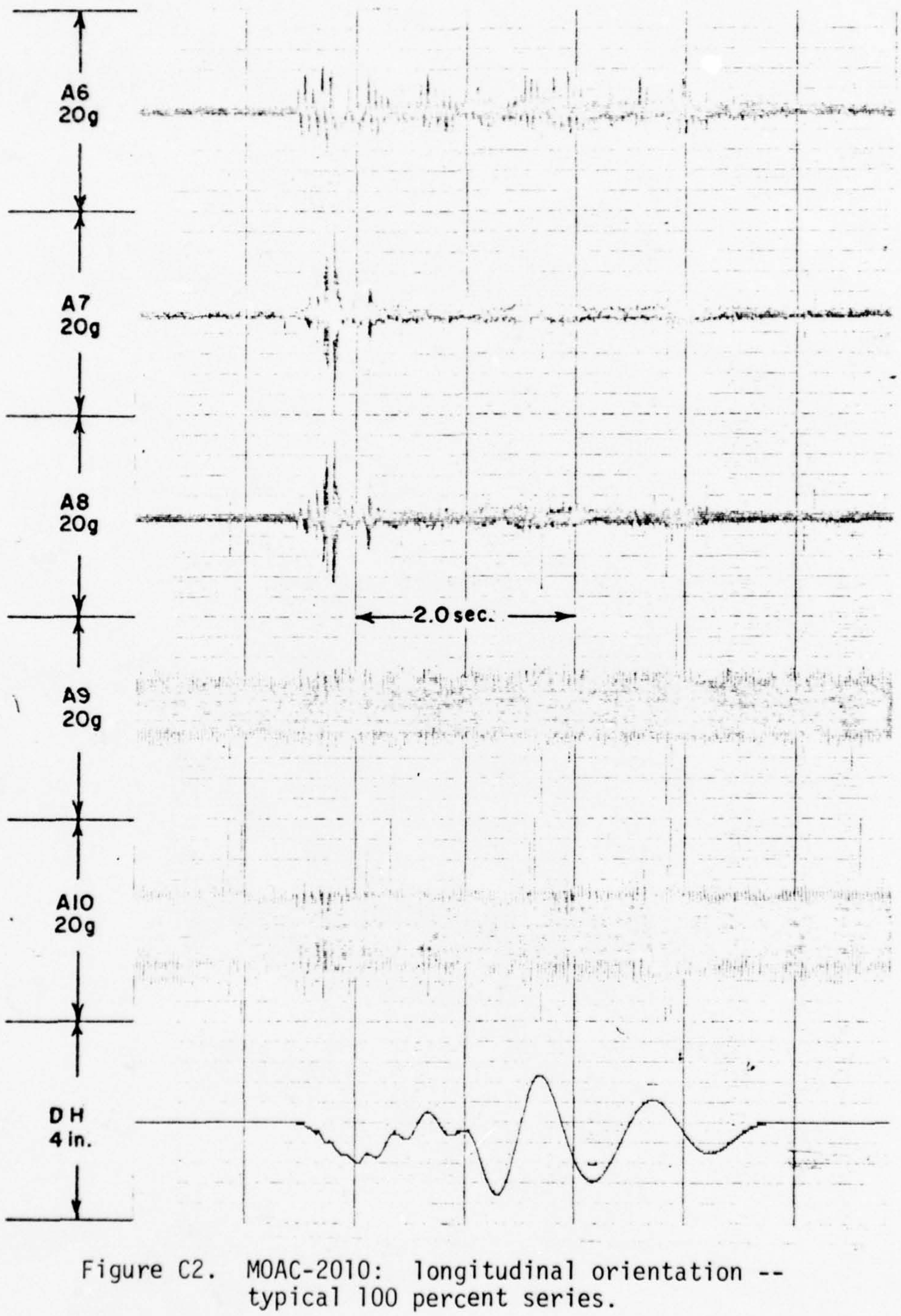


Figure C2. MOAC-2010: longitudinal orientation -- typical 100 percent series.

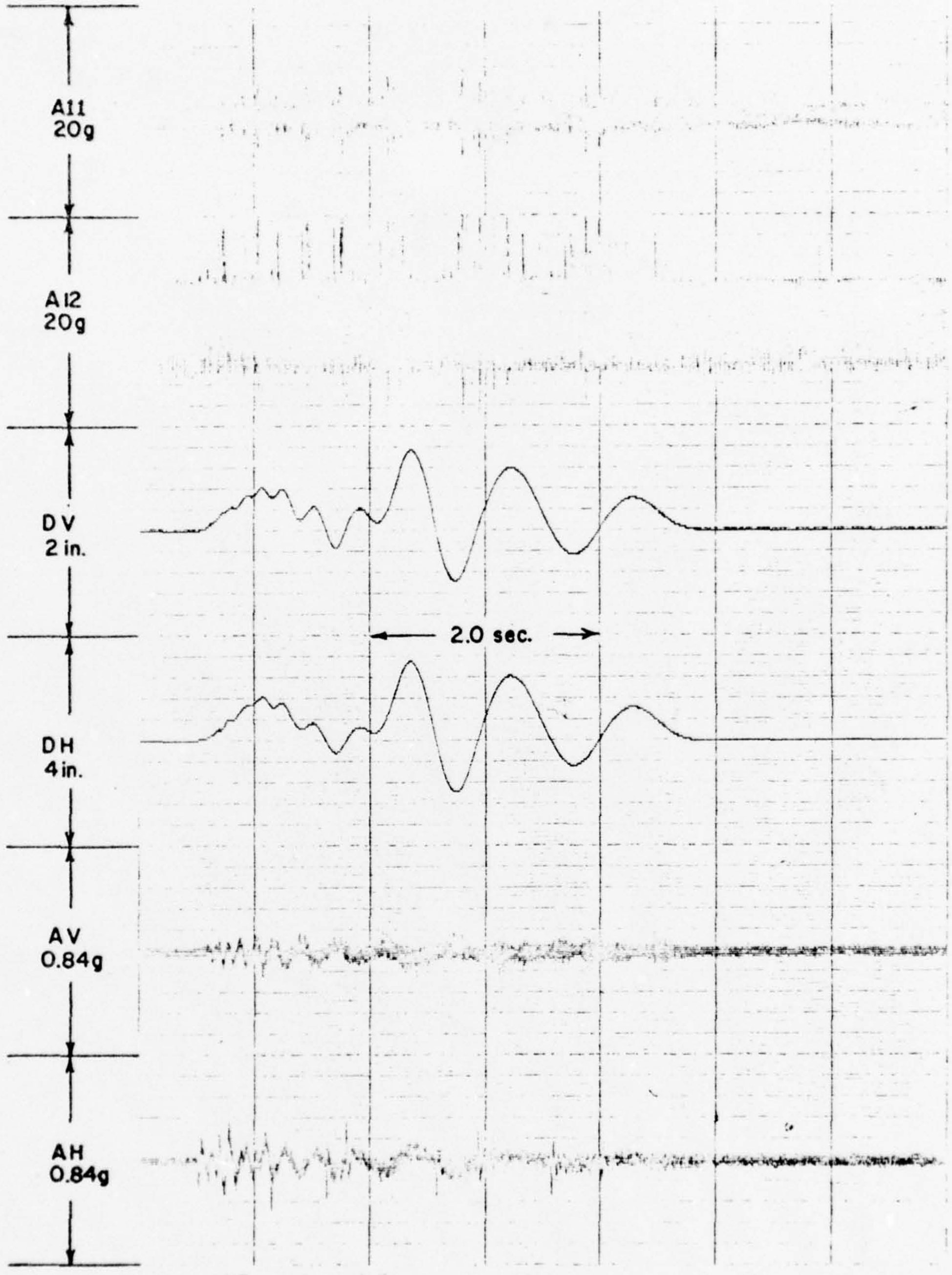


Figure C3. MOAC-2010: longitudinal orientation -- typical 100 percent pulse series.

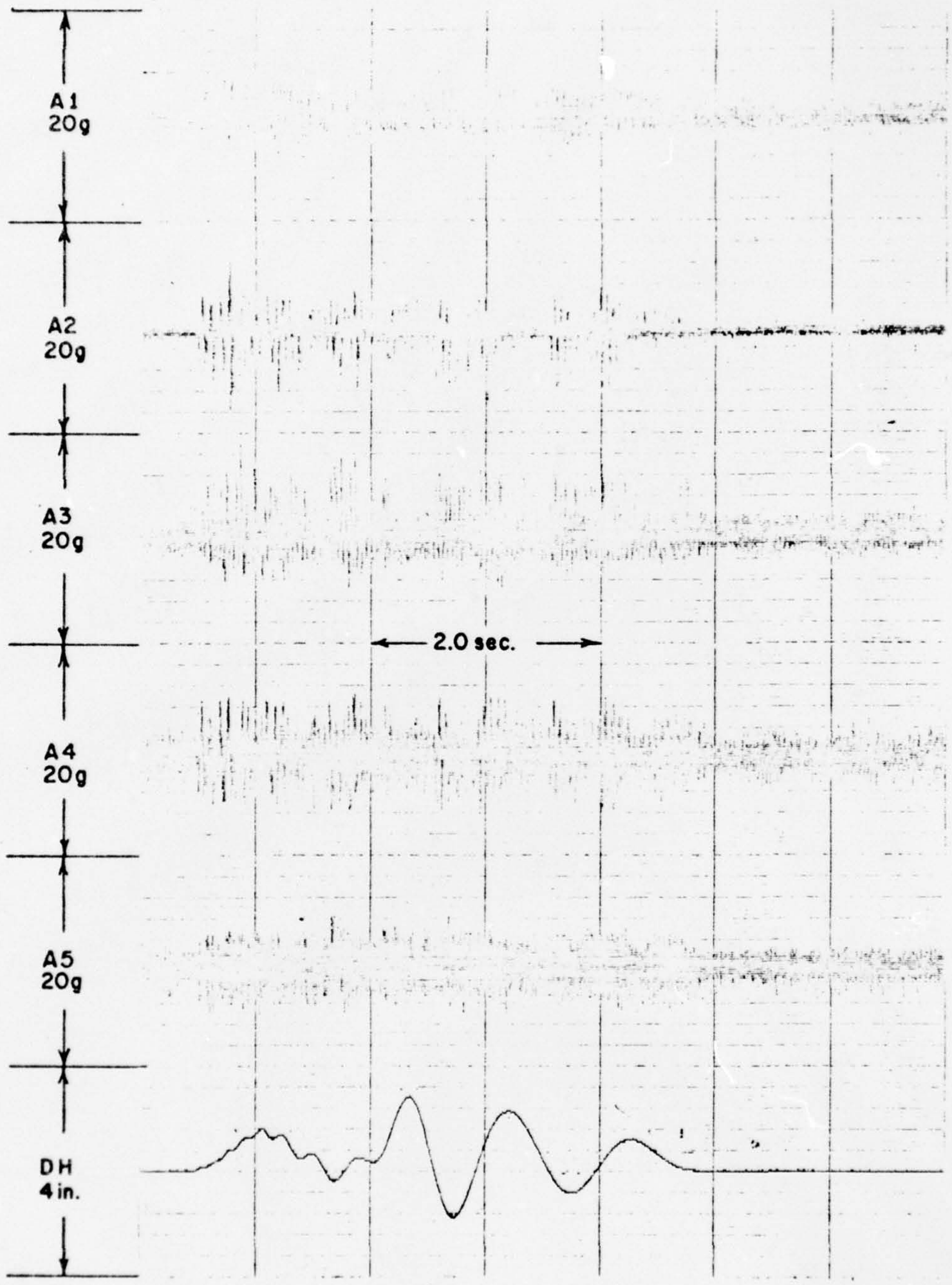


Figure C4. MOAC-2010: transverse orientation -- typical 100 percent pulse series.

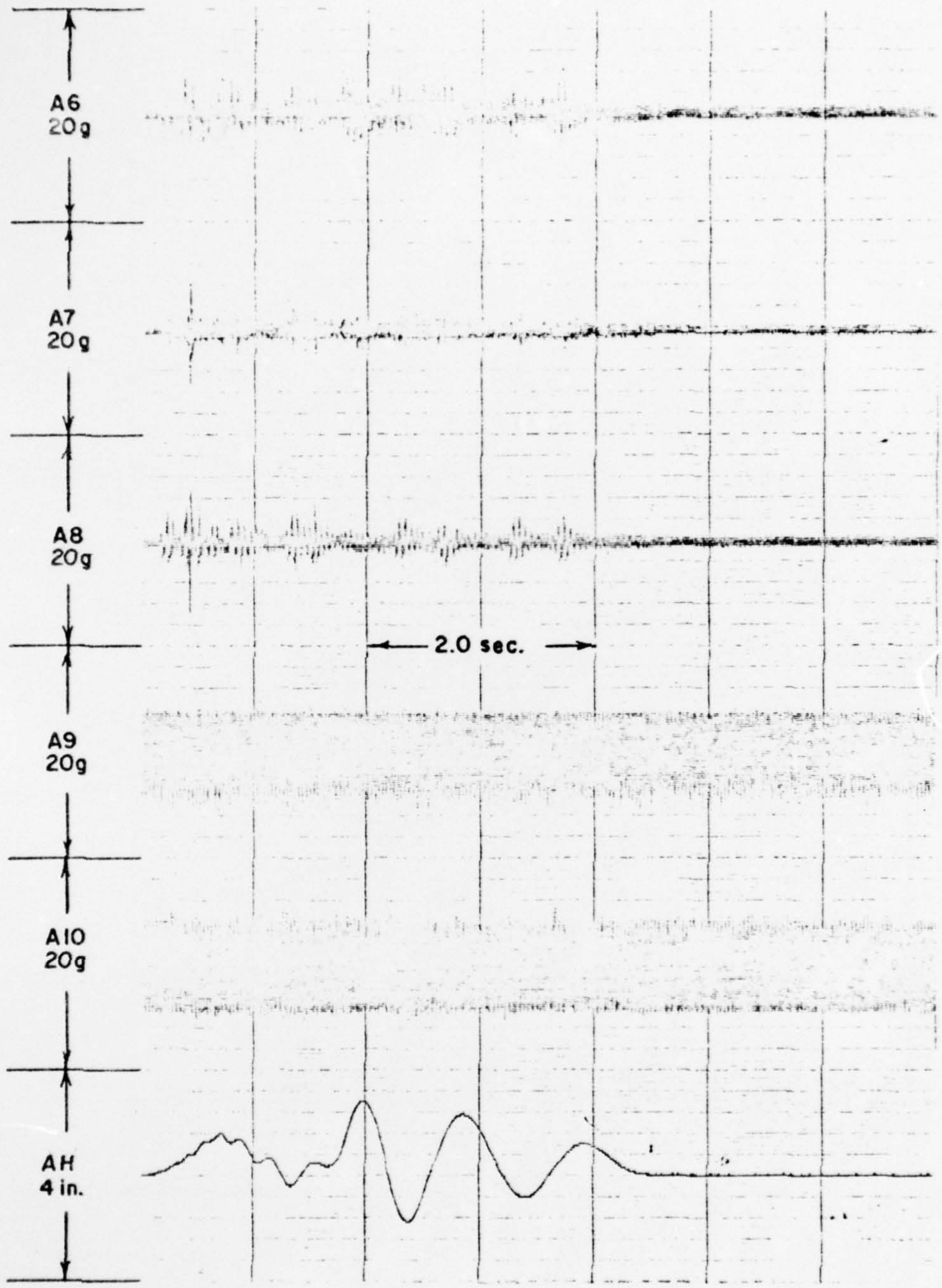


Figure C5. MOAC-2010: transverse orientation -- *typical 100 percent pulse series.*

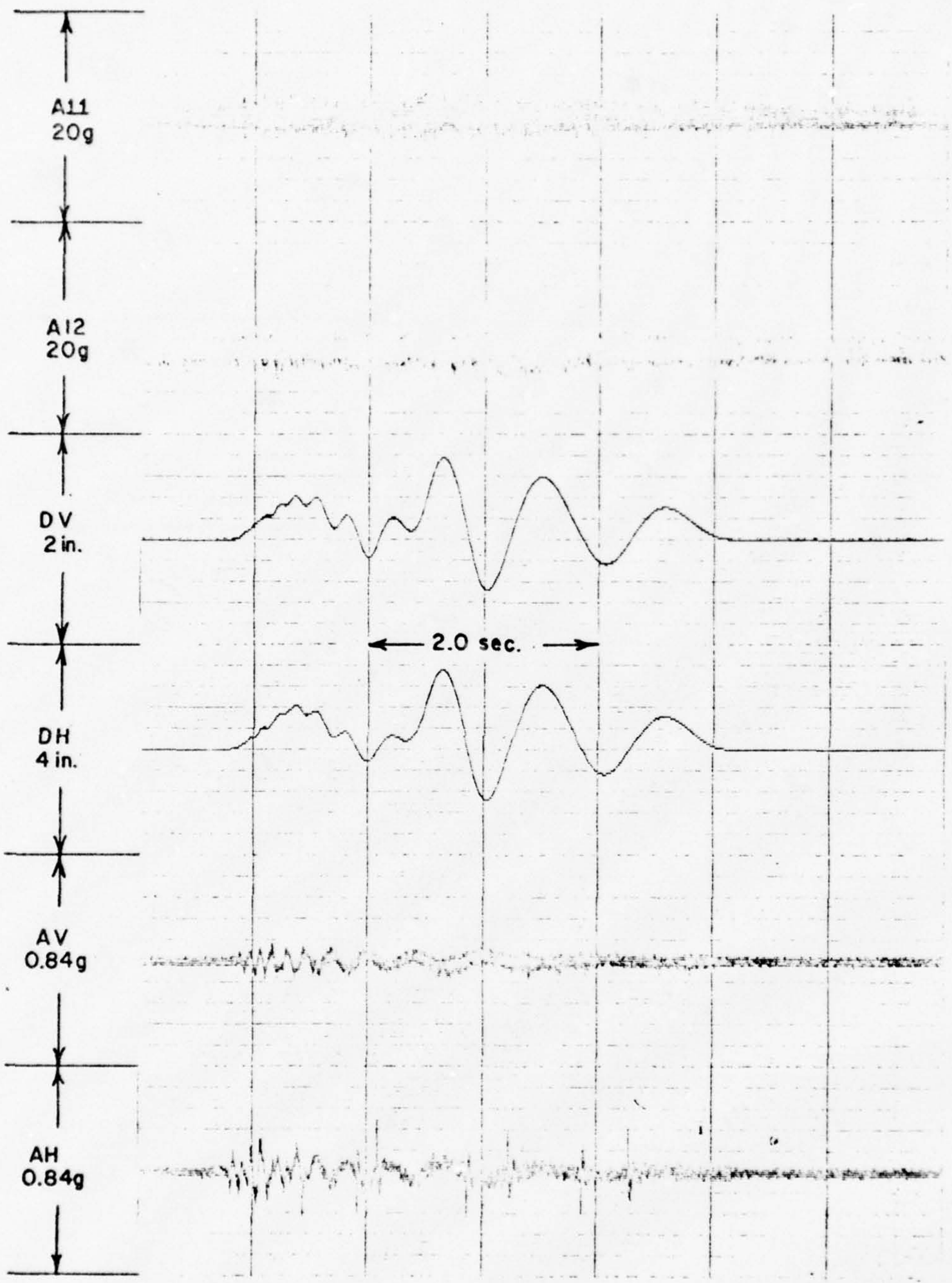


Figure C6. MOAC-2010: transverse orientation -- typical 100 percent pulse series.

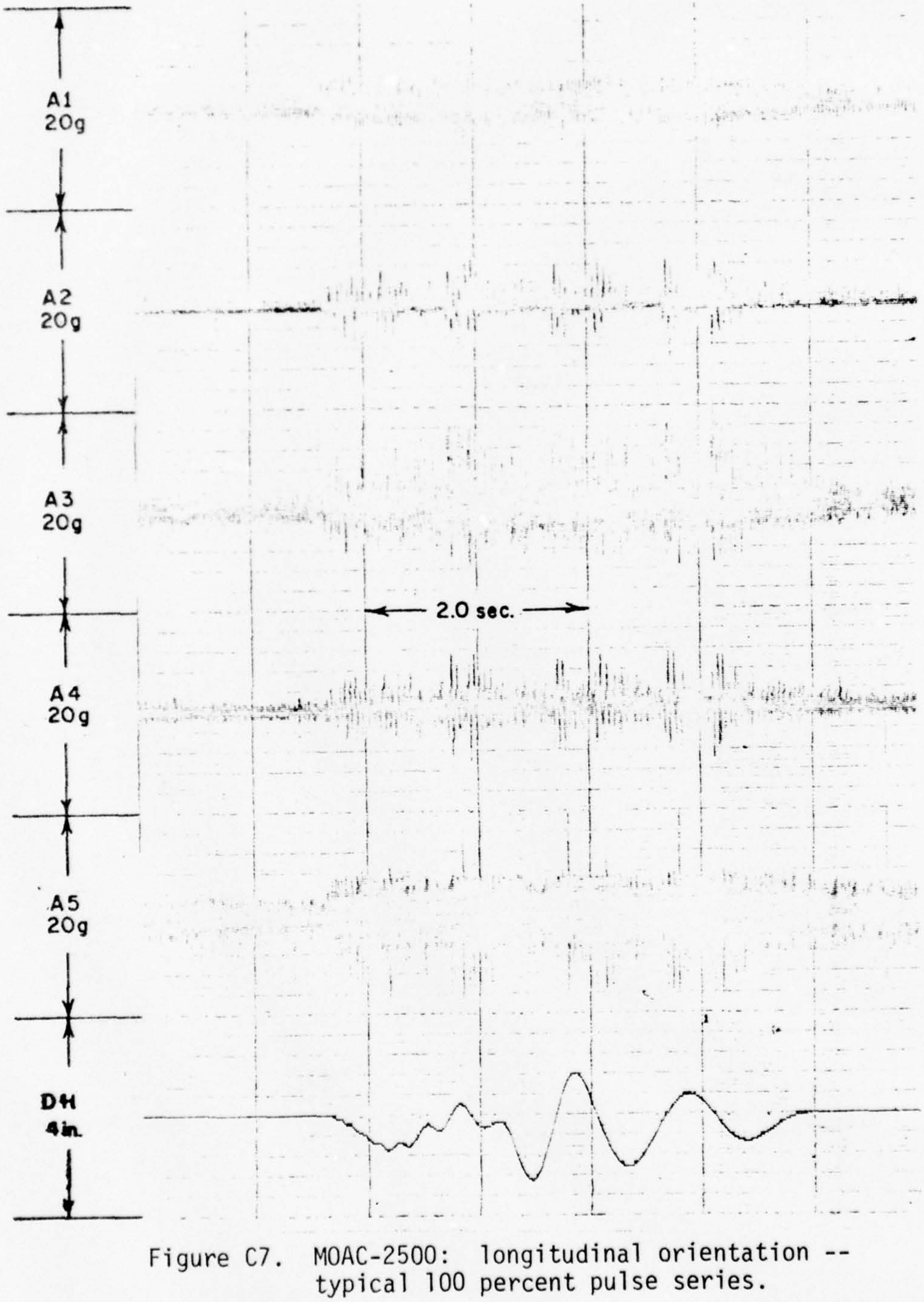


Figure C7. MOAC-2500: longitudinal orientation -- typical 100 percent pulse series.

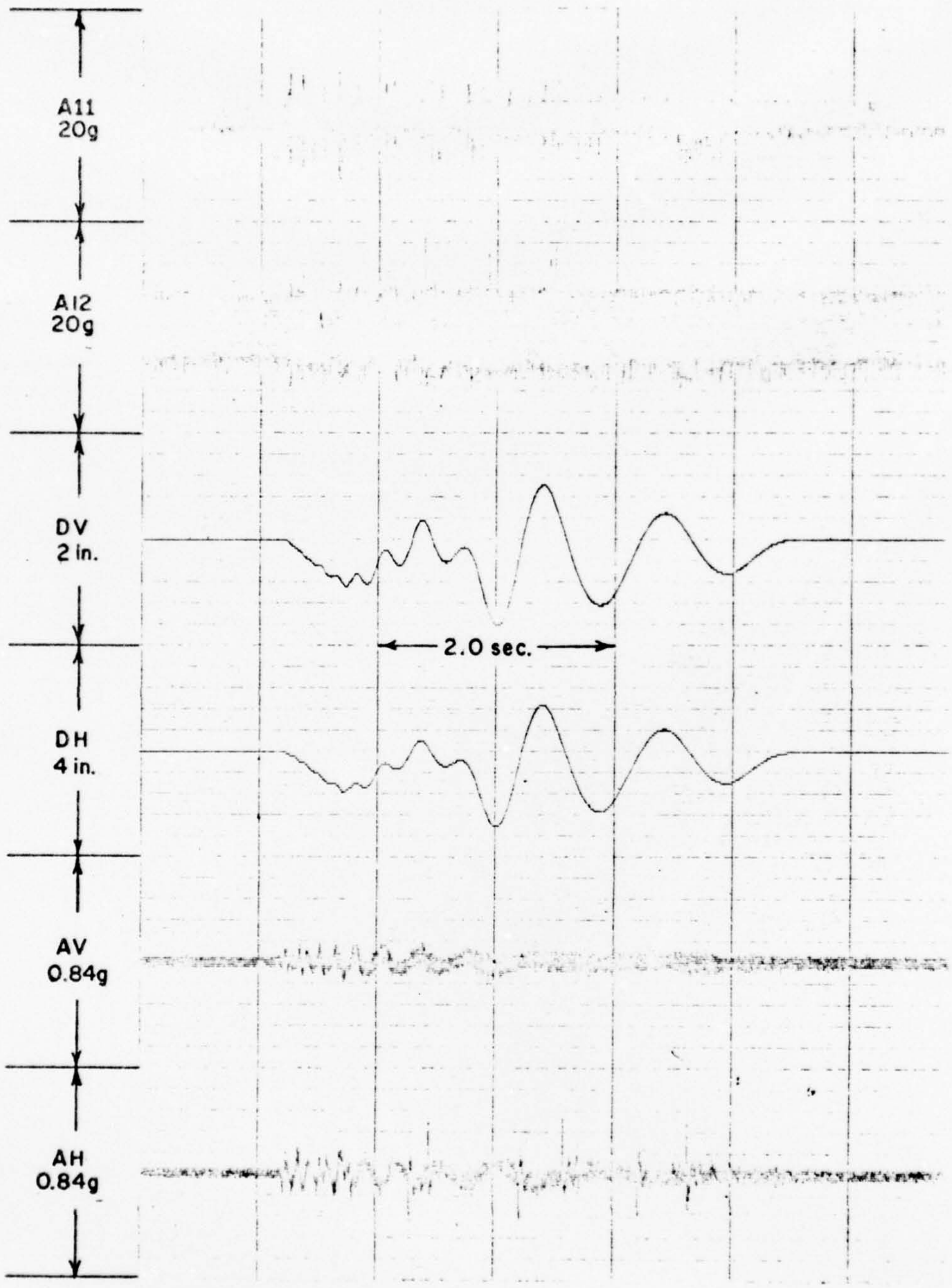


Figure C8. MOAC-2500: longitudinal orientation -- typical 100 percent pulse series.

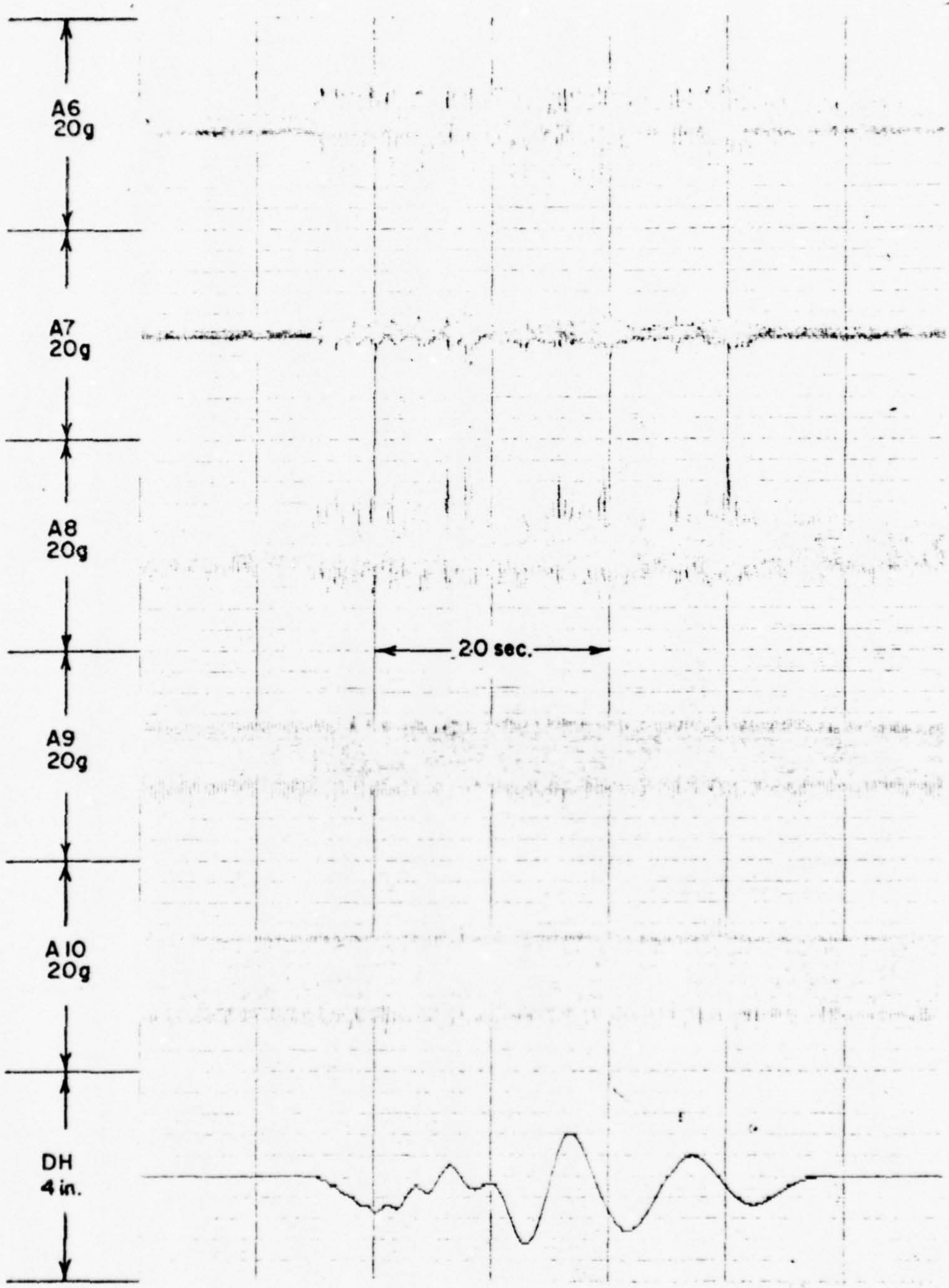


Figure C9. MOAC-2500: longitudinal orientation -- typical 100 percent pulse series.

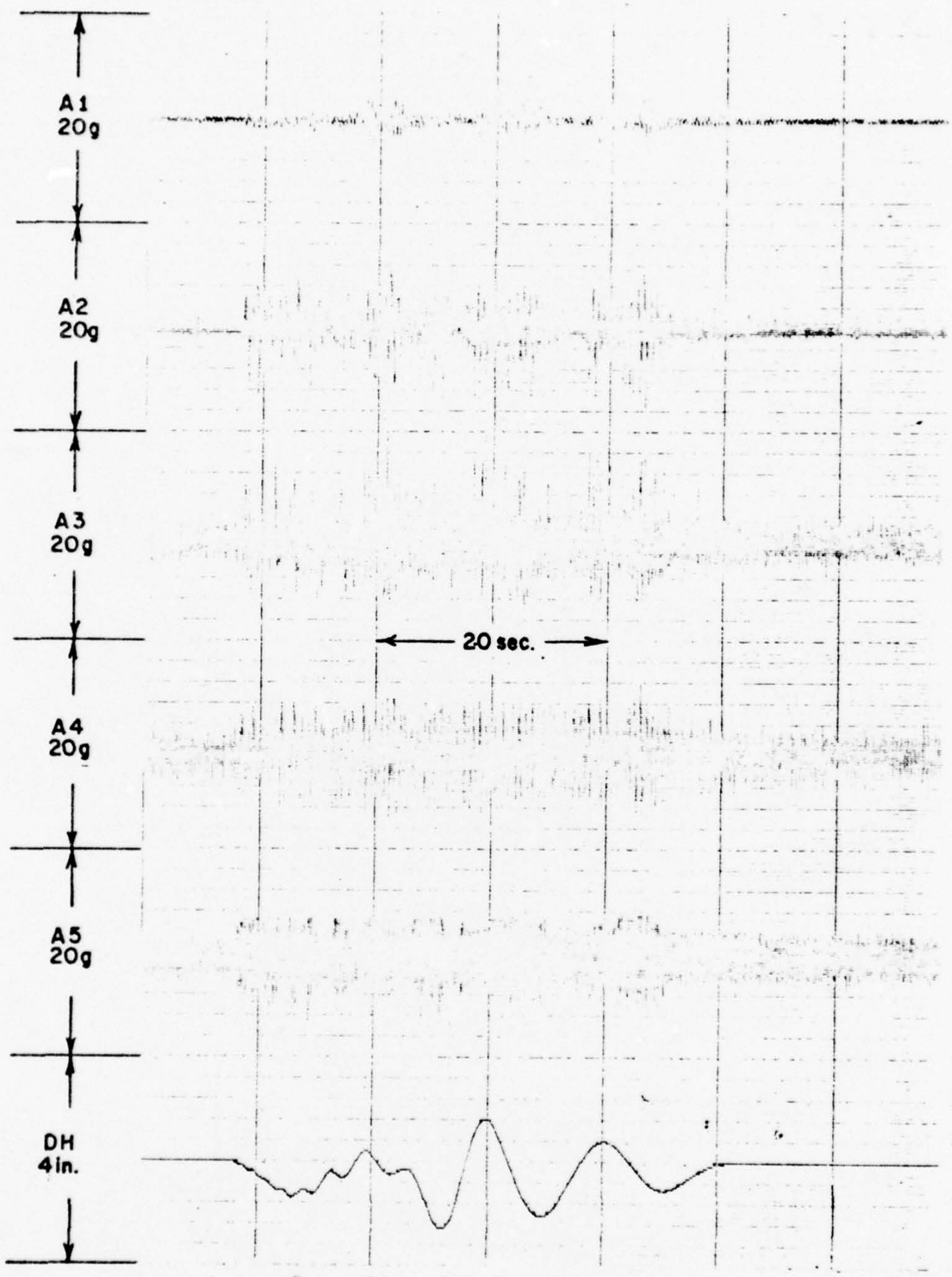


Figure C10. MOAC-2500: transverse orientation -- typical 100 percent pulse series.

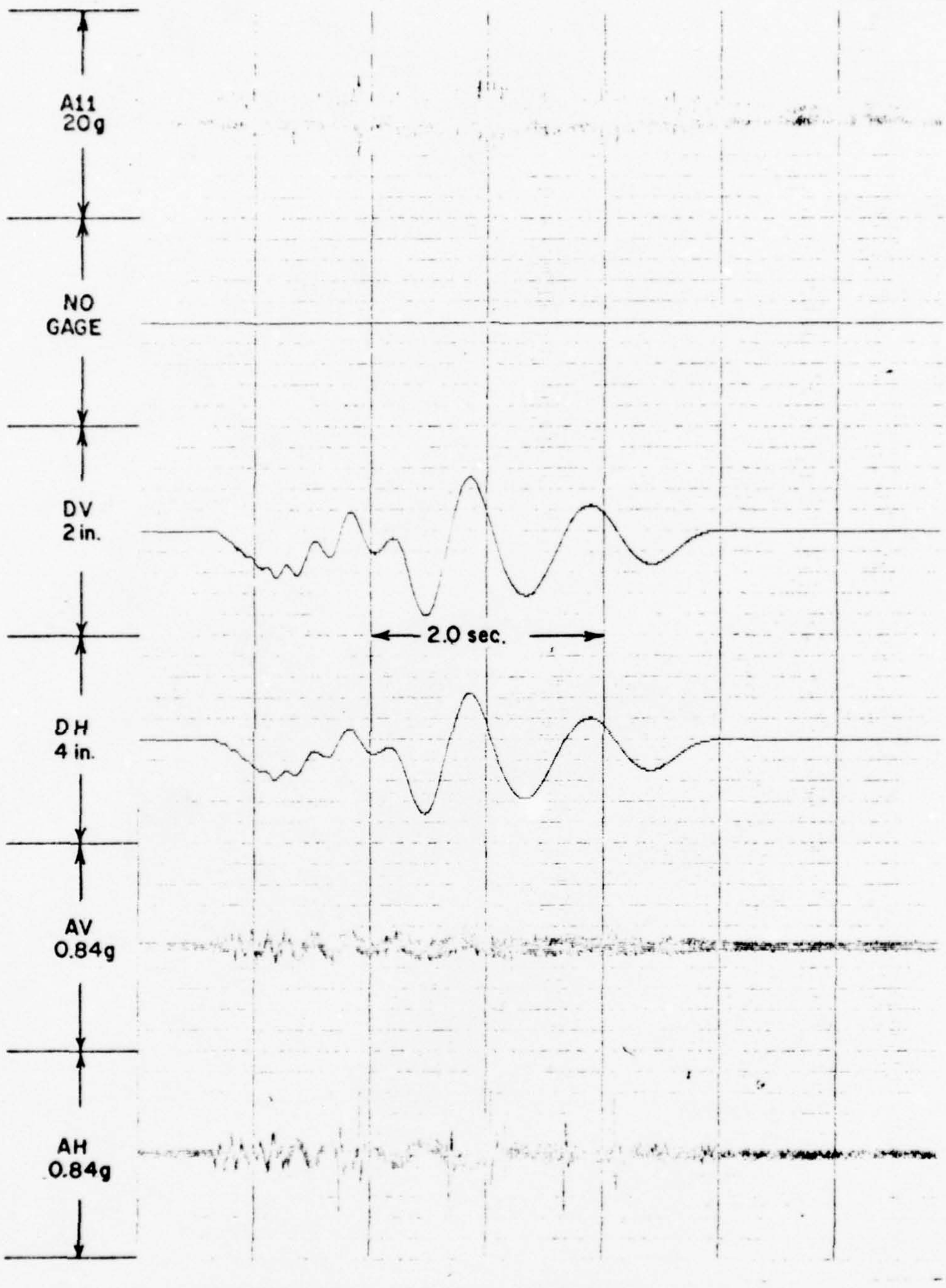


Figure C11. MOAC-2500: transverse orientation -- typical 100 percent pulse series.

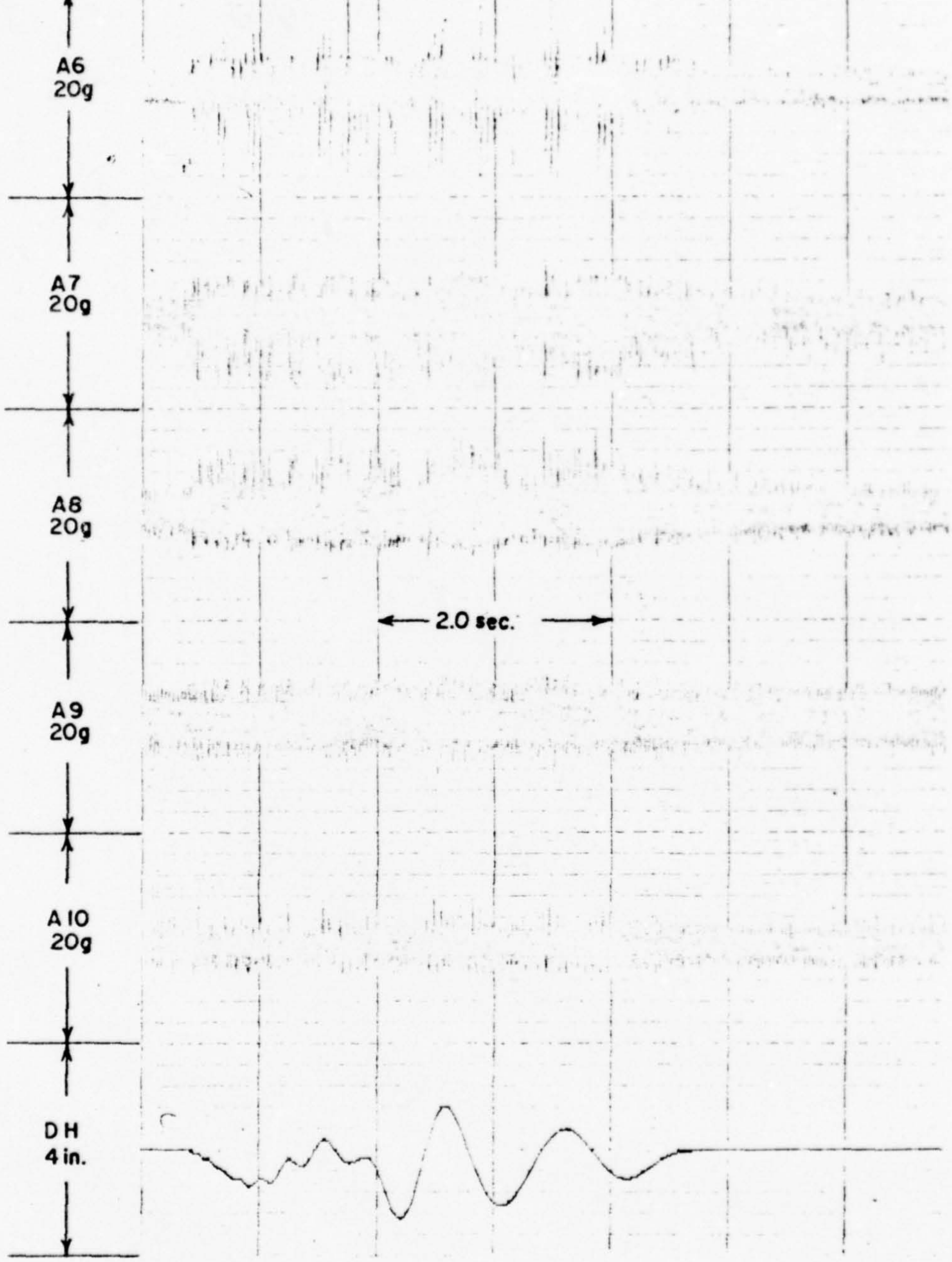


Figure C12. MOAC-2500: transverse orientation -- typical 100 percent pulse series.

APPENDIX D

FUNCTIONAL TEST DATA

FIGURES

EWC MODEL NO. MOAC 2010 DATE 11-9-78 SERIAL NO. 7396

11/13

TEST (NOTE 1)		A	B	C			
TIME		9:45 A.M.	2:00 P.M.	4:30 P.M.			
FAN R.P.M.		1190	1190	1190			
UNIT AMPS PHASE A		40	40	40			
UNIT AMPS PHASE B		38	38	39			
UNIT AMPS PHASE C		37	37	38			
UNIT VOLTS PHASE A		498	498	495			
UNIT VOLTS PHASE B		498	498	495			
UNIT VOLTS PHASE C		498	497	495			
AMBIENT °F		72	70	70			
FAN & MOTOR OPERATION		OK	OK	OK			
RETURN AIR °F	Dry Bulb	70.5	69.5	70			
	Wet Bulb	55	55.5	58.5			
SUPPLY AIR °F	Dry Bulb	48	47.5	48			
	Wet Bulb	44.5	45.5	46.5			
STRUCTURAL DAMAGE		NONE	NONE	NONE			
DISCHARGE PSIG		212	210	212			
SUCTION PSIG		62	61	65			

TESTED BY: Paul J. Cunningham DATE 11-13-78

WITNESSED BY: Thomas E. Day DATE 11-15-78

All Controls Functioning Properly After Test

NOTE 1:

TEST A - BEFORE SEISMIC TEST

TEST B - AFTER FIRST SEISMIC TEST 1st HORIZONTAL DIRECTION

TEST C - AFTER FIRST SEISMIC TEST 2nd HORIZONTAL DIRECTION

Unit Mounted To Test Table With 16 1/2-13 Grade 8 Bolts Torqued To 100 Ft/Lbs

ELLIS AND WATTS COMPANY CINCINNATI, OHIO 45244	TEST DATA SHEET NO. 1

Figure D1. Sample functional data sheet.

EWC MODEL NO. MOAC 2500 DATE 11-14-78 SERIAL NO. 7395

11/15

TEST (NOTE 1)		A	B	C			
TIME		4:00 P.M.	6:00 P.M.	9:30 P.M.			
FAN R.P.M.		930	930	930			
UNIT AMPS PHASE A		42	40	39			
UNIT AMPS PHASE B		43	41	41			
UNIT AMPS PHASE C		42	42	42			
UNIT VOLTS PHASE A		500	500	500			
UNIT VOLTS PHASE B		500	500	500			
UNIT VOLTS PHASE C		500	500	500			
AMBIENT °F		72.5	71	72			
FAN & MOTOR OPERATION		OK	OK	OK			
RETURN AIR °F	Dry Bulb	72.5	71	72			
	Wet Bulb	56.5	54.5	55.5			
SUPPLY AIR °F	Dry Bulb	60.5	59.5	59			
	Wet Bulb	50	49.5	49.5			
STRUCTURAL DAMAGE		NONE	NONE	NONE			
DISCHARGE PSIG		220	220	210			
SUCTION PSIG		58	60	60			

TESTED BY: Paul J. Cunningham DATE 11-15-78

WITNESSED BY: Thomas E. Day DATE 11-15-78

All Controls Functioning Properly After Test

NOTE 1:

TEST A - BEFORE SEISMIC TEST

TEST B - AFTER FIRST SEISMIC TEST 1st HORIZONTAL DIRECTION

TEST C - AFTER FIRST SEISMIC TEST 2nd HORIZONTAL DIRECTION

Unit Mounted To Test Table With 16 1/2 - 13 Grade 8 Bolts Torqued To 100 Ft/Lbs

ELLIS AND WATTS COMPANY CINCINNATI, OHIO 45244	TEST DATA SHEET NO. 1

Figure D2. Sample functional data sheet.

APPENDIX E:

TEST PLAN

TEST PLAN
for
Seismic Qualification of
Air-Conditioner Units

MOAC-2010, Contract 77K33-820916
Mark No. 3AW0910-2

MOAC-2500, Contract 77K33-820916
Mark No. 3AW0910-1

for the

Ellis and Watts Company
Cincinnati, Ohio

by

Construction Engineering Research Laboratory

9 December 1977

CONTENTS

TABLES

FIGURES

1. Purpose.

The purpose of this test plan is to present the procedures by which the U.S. Army Construction Engineering Research Laboratory (CERL) will test two air-conditioner units. All tests will be performed to verify that the units meet the Tennessee Valley Authority (TVA) performance requirements for operation during and following a safe shutdown earthquake. The two units will be supplied by the Ellis and Watts Company, Cincinnati, Ohio, and all testing will be performed by CERL at Champaign, Illinois.

2. Test Criteria Documents.

Tennessee Valley Authority Document No. N4-50-D710 (Reissue No. 33-820916) Appendix B, Design Criteria for Seismic Qualification of Category I Fluid System Components and Electrical or Mechanical Equipment, Bellefonte Nuclear Plant, July 11, 1974.

3. Description of Test Specimens.

Each of the two test specimens is a self-contained air-conditioning unit and is numbered by the Ellis and Watts Company as MOAC 2500 and MOAC 2010.

4. Customer Technical Representatives.

Technical representatives from the Ellis and Watts Company shall be present during all tests. They shall verify the functional setup and the proper operation of each air-conditioner unit before testing begins. They shall perform all functional tests and record all functional data for each air-conditioner unit after each test to show that no abnormalities exist due to the seismic test. They shall perform all necessary functional inspections, e.g.: (a) inspect for visible structural damage; (b) monitor operation of motor, fan, and compressor; (c) monitor cycling of dampers; and (d) test for leakage of the coil at operating pressure.

Instrumentation for functionality checks will be properly calibrated as indicated by section 7.b of the test plan.

The results of all functionality checks will be documented.

Review and concurrence with all functional data shall be made by the CERL test engineers.

5. Test Package Mounting.

The test items shall be attached to the test platform of the CERL Biaxial Shock Test Machine (BSTM) by normal in-service mounting means. Three-inch-thick steel plates will be used to adapt the test specimen attachment points to the bolt hole pattern on the test platform.

Power shall be supplied by CERL from a suitable fused power line compatible with each air-conditioner unit's motor current requirements.

All materials needed to functionally operate and monitor the air-conditioner units shall be supplied by the Ellis and Watts Company.

6. Receiving Inspection.

Upon receipt of each air-conditioner unit, an inspection shall be performed and a Receiving Inspection Data Sheet (Figure E1) shall be completed. If any physical damage is found, the Ellis and Watts Company representative shall be notified.

7. Test Conditions and Test Equipment.

a. Ambient Conditions. Unless otherwise specified herein, all tests required by the specification shall be performed at an atmospheric pressure of 29 + 2 in. of mercury absolute, a temperature of 70 $\pm$ 20°F, and a relative humidity of 90 percent or less.

b. Instrumentation and Equipment. Measurement and test equipment to be used in the performance of these tests shall be calibrated with reference and test equipment whose calibration has been certified as being traceable to the National Bureau of Standards. All reference standards used in the above calibration system shall be supported by certificates, reports, or data sheets attesting to the date, accuracy, and conditions under which the results were furnished. The test equipment shall be supported by like data when such information is essential to achieve the accuracy control required by the subject contract.

Certifications and reports of all calibrations performed shall be retained in CERL files and are available for inspection upon request.

c. Test Equipment. The test equipment or equivalents that will be used in the performance of these tests are listed in Table E1, with the exception of equipment used to perform functional tests which are listed in Table E2. Certification of calibration of functional test equipment shall be retained in EWC files and be available for inspection upon request.

DATA SHEET

Receiving Inspection

Specimen________________________ Job No.______________

Date__________________________

No. of specimens received________________________

RECORD IDENTIFICATION INFORMATION EXACTLY AS IT APPEARS ON THE SPECIMEN

Shipped by ________________________

Manufacturer ________________________

____

Part numbers ________________________

____

____

Serial numbers__________ __________ __________

__________ __________ __________

__________ __________ __________

Examination: Visual, for evidence of damage, poor workmanship, or other defects, and completeness of identification.

Inspection Results: There was not visible evidence of damage to the specimen unless noted below:

____

____

____

Inspected by _______Date__________

Approved by _______Date__________

Sheet _______of_______

Figure E1. Sample Receiving Inspection Data Sheet.

Table E1

Equipment and Instrumentation

Equipment	Manufacturer/Model	Description	Accuracy
Biaxial Shock Test Machine			±20% to ±5% of shock spectrum values from 1 to 9 Hz, respectively; ±5% at shock spectrum values from 8 to 20 Hz; ±5% to ±30% at shock spectrum values from 20 to 200 Hz, respectively
Vertical Reaction Mass	Schless Construction Company	Reinforced concrete octahedral-shaped parallelepiped 30 ft across the flats and 16 ft deep	
Horizontal Reaction Mass	Schless Construction Company	Reinforced concrete hollow rectangular-shaped parallelepiped 30 ft wide, 80 ft long, 8 ft deep with 14-ft-wide by 22-ft-long opening	
Vertical Hydraulic Actuators	MTS/204.705	2 3/4-in., double-amplitude-stroke, 90,000-lb force	
Horizontal Hydraulic Actuators	MTS/204.725	5 1/2-in., double-amplitude-stroke, 75,000-lb force	
Vertical & Horizontal Servovalves	MTS/251.53	300 gpm	
Test Platform	MTS	Aluminum weldment, 12 ft by 12 ft in plan, 4 ft thick over the control area, and weighs 12,000 lb	
Vertical Analog Control System	MTS/449	Controlled with independent gain rate controls for vertical, roll, and pitch motions	
Horizontal Analog Control System	MTS/449	Controlled with independent rate controls for horizontal and yaw motions	
Computer	Digital Equipment Corporation PDP-11	16,000 words of memory	

Table E1 (Cont'd.)

Fast Fourier Transform Unit	Time Data/90A	4000 words of ROM memory	
Control Unit	Time Data/1923-3000	Allows wide range of operations to be performed by pushbutton	
Teletype	Digital Equipment Corporation ASR-33	10 characters/sec	
Paper Tape Reader/Punch	Digital Equipment Corporation	300 characters/sec	
Disc File	Digital Equipment Corporation RK-11	1.2 million storage words	
Magnetic Type Unit	Digital Equipment Corporation TU-10	9 channel 800 bits/inch	
Line Printer	Digital Equipment Corporation LP-11	80 columns 356 lines/min	
A/D Converter	MTS	12-bit two's component word code	
Programmable Clock	MTS	Frequency at 1 MHz	
X-Y Recorder	Hewlett Packard/700413	0.5 mx to 10x/in.	
Hydraulic Pumps		Variable displacement pressure pumps with maximum 70 gpm output	
Accumulator Tank	MTS	36 30-ft piston accumulators providing 1800-gallon total oil and gas	
Reservoir	MTS	2000-gal capacity	
Vertical Accelerometers	Kistler/515	Servo accelerometers	
Horizontal Accelerometers	Kistler/515	Servo accelerometers	
Accelerometer Conditioning Unit	Kistler/515	0.1 to 50 g/V	
Computer/Analyzer System	Time/Data/904		
Signal Conditioning			
Amplified Resistance Bridge Conditioner	Endevco/4476.2	DC to 10 kHz	±5%

Table E1 (Cont'd.)

Servo Accelerometer	Endevco/4479.2		
Current Amplifier	Endevco/4478.1A	DC to 300 Hz (-2db)	±2%
Current-Regulated Bridge Conditioner	Endevco/4471.2A	Limited only by Transducer	
Potentiometer	Endevco/4471.3	Limited only by Transducer	
Voltage-Regulated Bridge Conditioner	Endevco/4471.1A	Limited only by Transducer	
Universal Signal Conditioner	Endevco/4470	0-30 Vdc or 0.5 to 5 madc	±0.1%
Master Module			
FM Multiplex and Discriminator System	Vidar/71099	DC to 100 Hz, 70 channels	±2%
Tape Recorder	Bell and Howell V12-3700	14-channel, 400 to 2,000,000 Hz	±2%
Oscillograph	Bell & Howell/5-133	24-channel DC to 5,000 Hz	±5%
Oscilloscope	Tektronix/556		
Digital Voltmeter	Dana/5900-1		±0.001%

Table E2

Equipment and Instrumentation

Equipment	Manufacturer/Model	Description	Accuracy
Thermometer	Brooklyn Thermometer Co. - ASTM57F	Glass -5 to +122°F	± 1/2°
Clamp-on Ammeter	Weston - Model 749		2% of full scale
Voltmeter	Triplett - Model 630NA		3% meter
Strobatac	General Radio - Type 1531		5 percent of full scale
Pressure Gauges	Marsh	0-500 PSIG	3 percent of full scale

8. Biaxial Shock Test Machine Description.

Each air-conditioner unit shall be mounted on the test platform of the BSTM and subjected to the seismic environments defined in this test plan.

Excitation shall be provided by nine vertical and six horizontal electrohydraulic actuators. Four 70-gpm pumps provide pressurized fluid that is stored in thirty-six 50-gal accumulators at a pressure of 3150 psi. A servovalve mounted on each actuator delivers the stored energy to the actuators that provide a total maximum force output in the vertical and horizontal (longitudinal) directions of 810,000-force lb and 450,000-force lb, respectively. Pitch, roll, yaw, and translation will be minimized.

The test platform excitation is controlled by an electronic control system that provides input command signals to each servovalve. A combination of digital and analog electronics is used in the control system. Stable position control under dynamic conditions is assured by the analog control system using a combination of force, rate, and position feedback information from each of the 15 actuators. The digital computer system is used to synthesize the test platform input commands required to produce the specified shock environments and to compute the test platform response shock spectra from accelerometers mounted below the platform's surface.

9. Instrumentation.

Each air-conditioner unit shall be instrumented with biaxial accelerometers positioned at locations acceptable to the Ellis and Watts Company technical personnel. Various functional parameters, as directed by Ellis and Watts, shall be measured to determine each unit's functional performance. All test item and test platform response data shall be recorded on an analog magnetic tape recorder as a permanent record. All test data shall be displayed on multi-channel oscillographic recorders immediately after each test for visual observation.

10. Test Procedures.

a. *Resonance Search.* Prior to the full-scale qualification test, an exploratory resonance search shall be performed. Each air-conditioner unit will be individually mounted on the test platform and subjected to a low-amplitude sinewave motion in one axis. The test will include at least two continuous sinewave sweeps from 1 to 35 to 1 Hz at a frequency sweep rate of not greater than 1 octave per minute. The test will be performed separately on the horizontal and vertical axes. The air-conditioner unit shall then be rotated 90 degrees and the test repeated for the other horizontal axis.

b. *Full-Scale Qualification Tests.* Multi-frequency testing shall be used for the full-scale qualification tests. The command signals used to drive the test platform shall consist of a superposition of amplitude modulated sinewave components, covering the frequency range from 1 to 40 Hz, and a time span of approximately 5 seconds. This 5-second waveform shall be repeated 10 times with a null period between each waveform to produce the total command signal (Figure E2). The multi-frequency command signal shall be generated by a computerized synthesis procedure which generates a time history that will produce shock spectra meeting or exceeding the required qualification spectra supplied by the Ellis and Watts Company in compliance with TVA test requirements.

The qualification test shall be performed by mounting the first air-conditioner unit on the test platform, making all necessary functional connections and putting the unit into operation. The vertical and horizontal command signals, consisting of one of the 10-pulse repetitions described previously, shall then be applied to the test platform simultaneously, but with the amplitudes reduced to 25 percent of their full-scale values. Shock spectra shall be computed from the test platform's accelerometers' response data and compared to 25 percent of the required spectra. Adjustments will be made to compensate for regions of the shock spectra which are below the required values and the input command signals recomputed. The test will then be repeated with amplitudes set to 50 percent of their full-scale values. The above process will then be repeated for 75 percent of the full-scale values. The final test shall be conducted using the 10 pulse repetitions described previously with the amplitudes set to 100 percent of the required values. Horizontal and vertical shock spectra shall be computed for each of the 10 pulse repetitions and compared to the required spectra.

After completion of the 100 percent test run and all specimen functional tests, the air-conditioner unit will be rotated 90 degrees to the other horizontal orientation and the process repeated.

The entire test procedure will be repeated for the second air-conditioner unit.

During the qualification tests, each unit's response data and the test platform response data shall be recorded on analog magnetic tape and displayed on oscillographic strip chart recorders for visual observation.

11. Development of the Qualification Test Shock Spectra.

Shock spectra supplied to CERL consisted of two horizontal and one vertical spectra for unit MOAC-2010 and two horizontal and one vertical spectra for unit MOAC-2500. The spectra are plotted at 5 percent damping in Figures E3, E4, and E5.

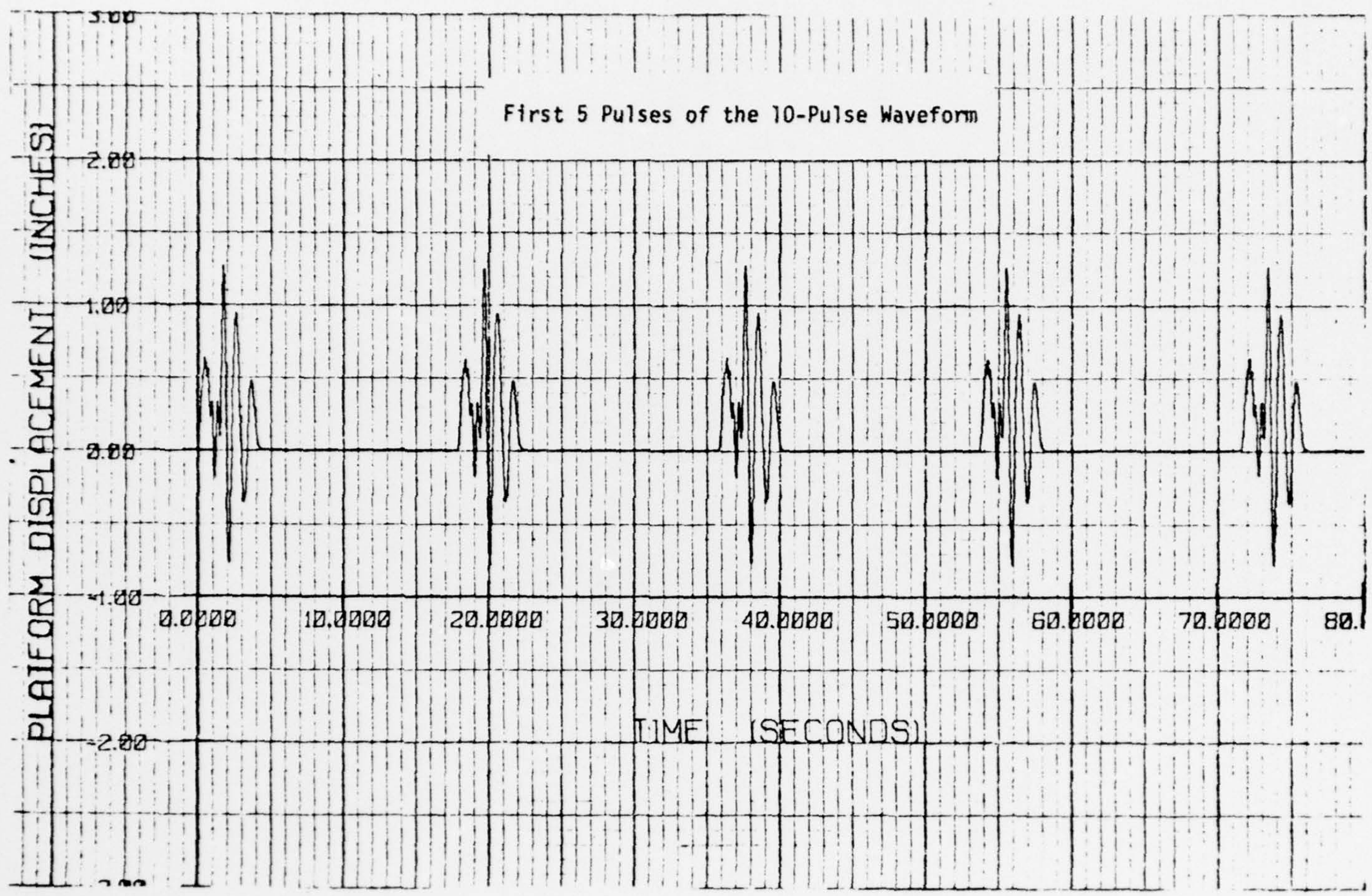


Figure E2. Typical test platform displacement waveform.

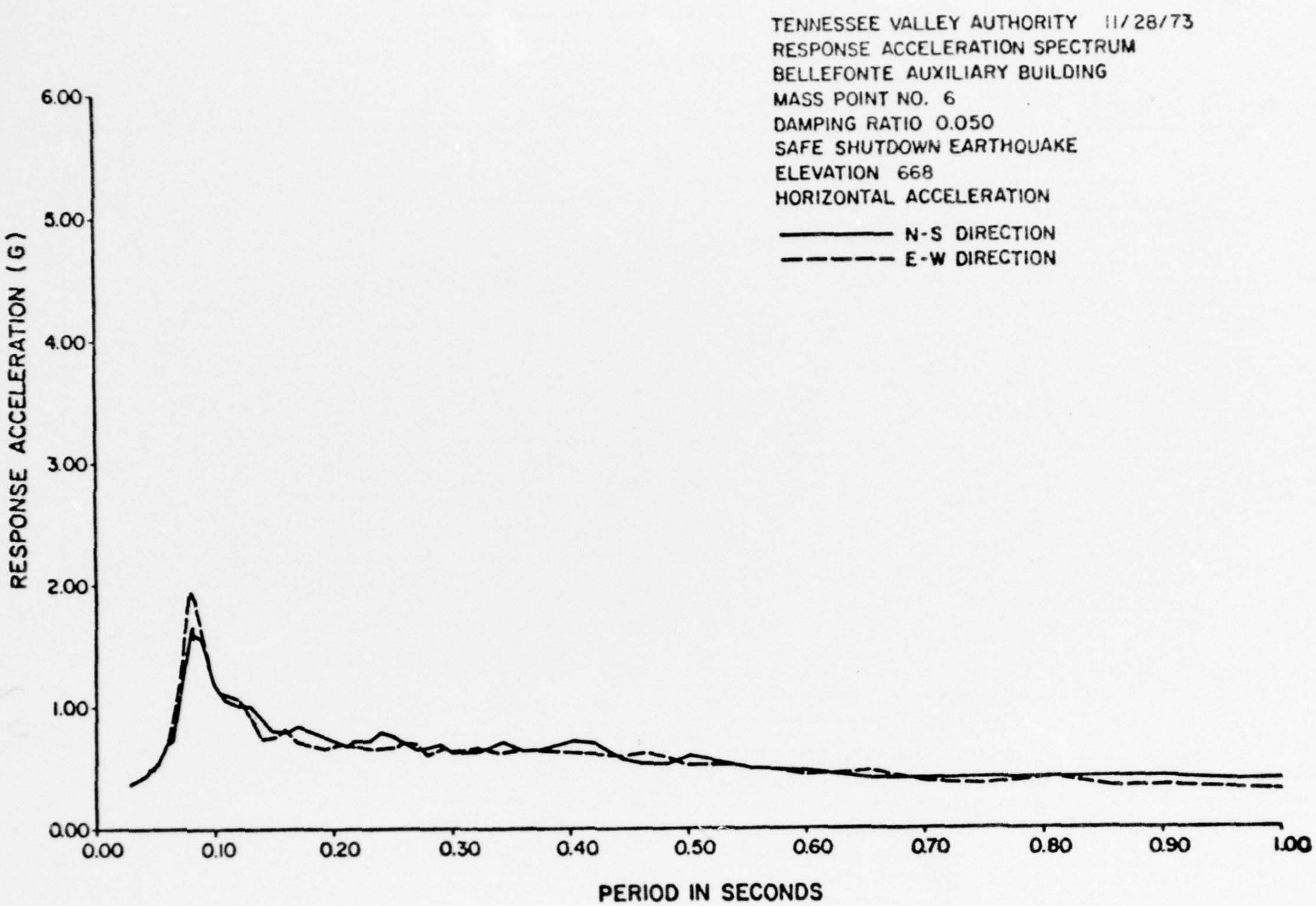


Figure E3. Horizontal spectra for MOAC-2010.

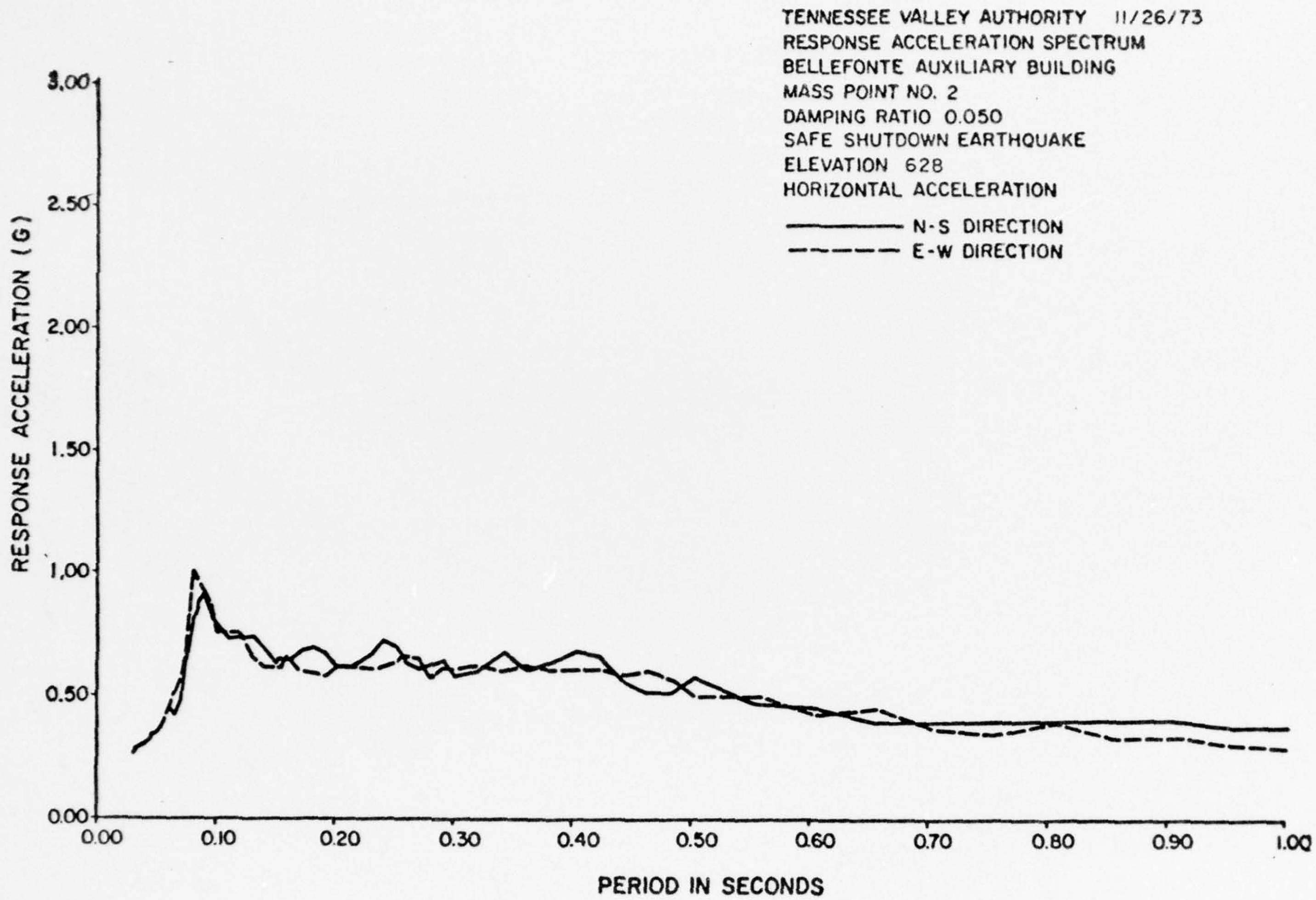


Figure E4. Horizontal spectra for MOAC-2500.

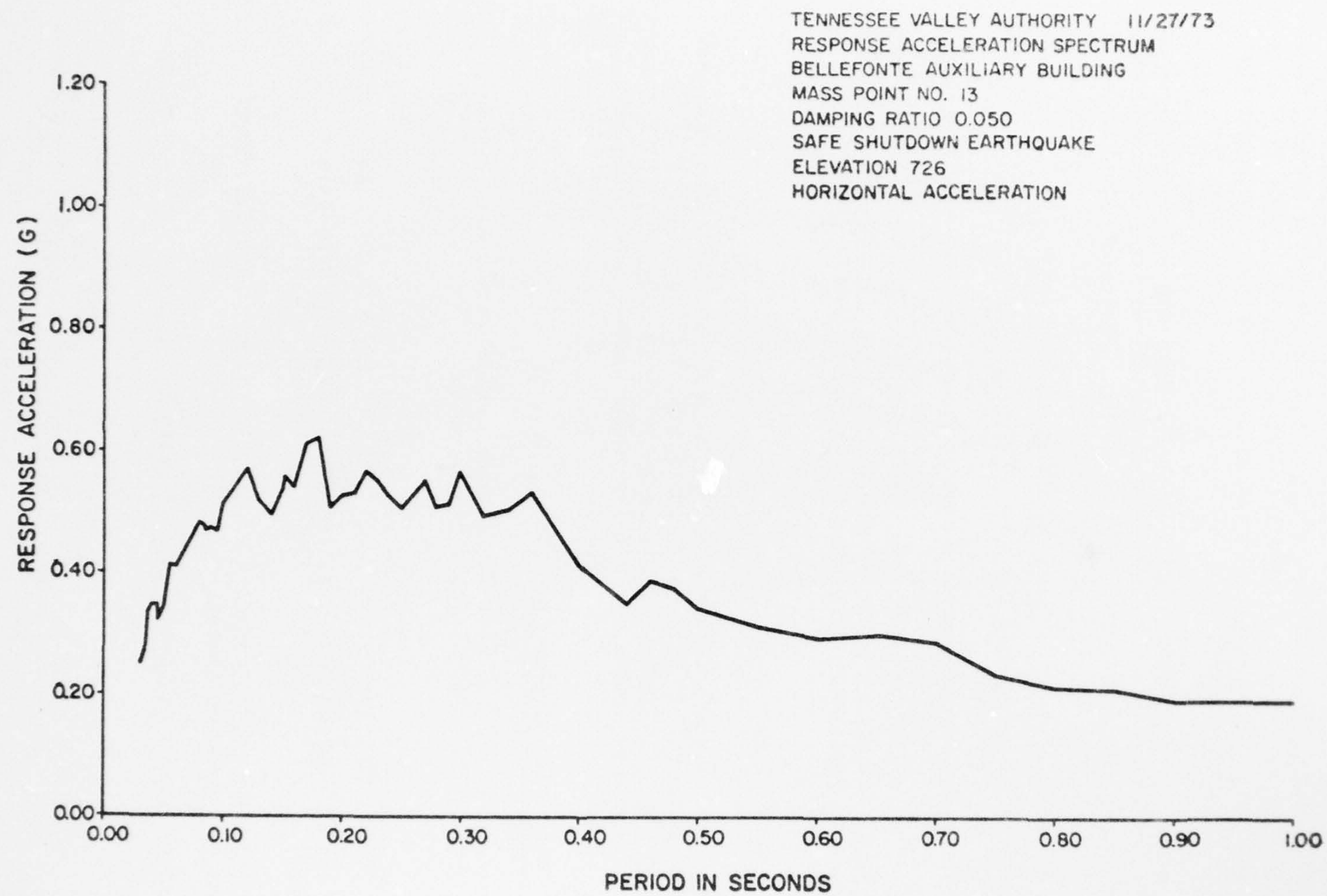


Figure E5. Vertical spectra for MOAC-2010 and MOAC-2500.

The input test levels to the BSTM are defined in terms of 0 percent damped shock spectra. Figures E6, E7, and E8 are the 0 percent damped spectra obtained from the 5 percent damped spectra. These figures also show smoothed spectra which will be used to develop the command signals for the required tests.

The command signals are developed using a digital synthesis procedure* which superimposes 13 amplitude-modulated sinewave components covering the frequency range of 1 to 40 Hz. The resultant command signals have the general form of Figure E2.

12. <u>Pre-Test and Post-Test Functional Inspection.</u>

Ellis and Watts Company technical representatives shall conduct a pre-test functional and visual inspection of each test item before the start of the test program. They shall conduct a post-test functional and visual inspection after each complete test. The data shall be recorded on functional data sheets as shown in Figure E9.

13. <u>Notice of Deviation.</u>

If any damage or other problems occur to the test specimens during the test program, a Notice of Deviation Form (Figure E10) will be filled out and logged as a part of the permanent test data, and Ellis and Watts and TVA representatives shall be consulted before proceeding with further tests.

14. <u>Test Sequence Steps.</u>

The steps listed in Table E3 shall comprise the main steps of the test program for each air-conditioner unit.

15. <u>Test Data.</u>

The following items shall form the permanent data file for the test program:

(a) All inspection data sheets, functional test data sheets, and Notice of Deviation sheets.

(b) Analog magnetic tapes of the test data for all tests performed.

---

* <u>Development of Waveform Synthesis Technique and Modification of the WAVSYN Computer Program</u>, HNDTR-73-8-ED-R (U.S. Army Corps of Engineers, Huntsville Division, 1 May 1973).

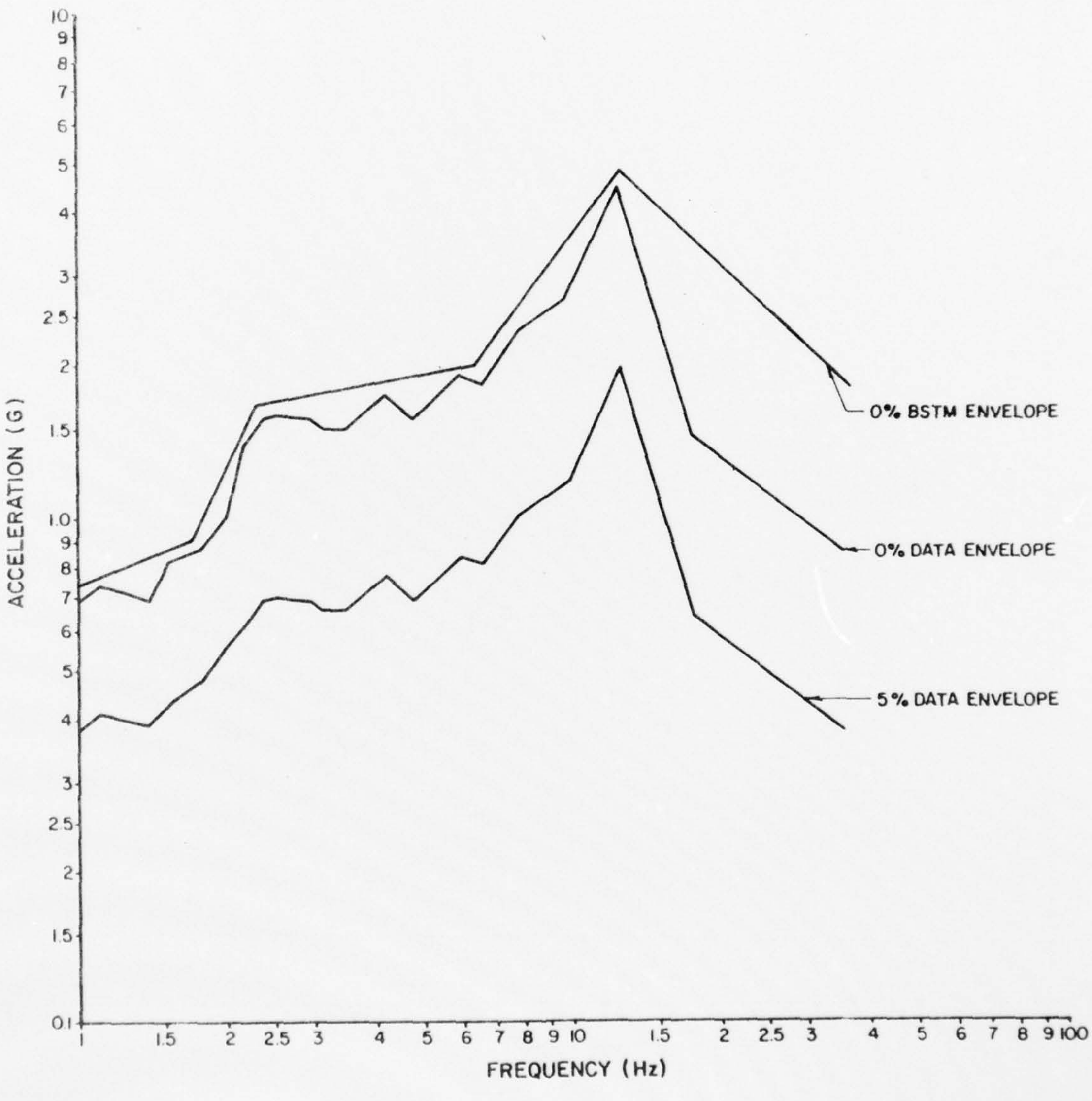


Figure E6. Horizontal envelope spectra and proposed BSTM envelope for testing MOAC-2010.

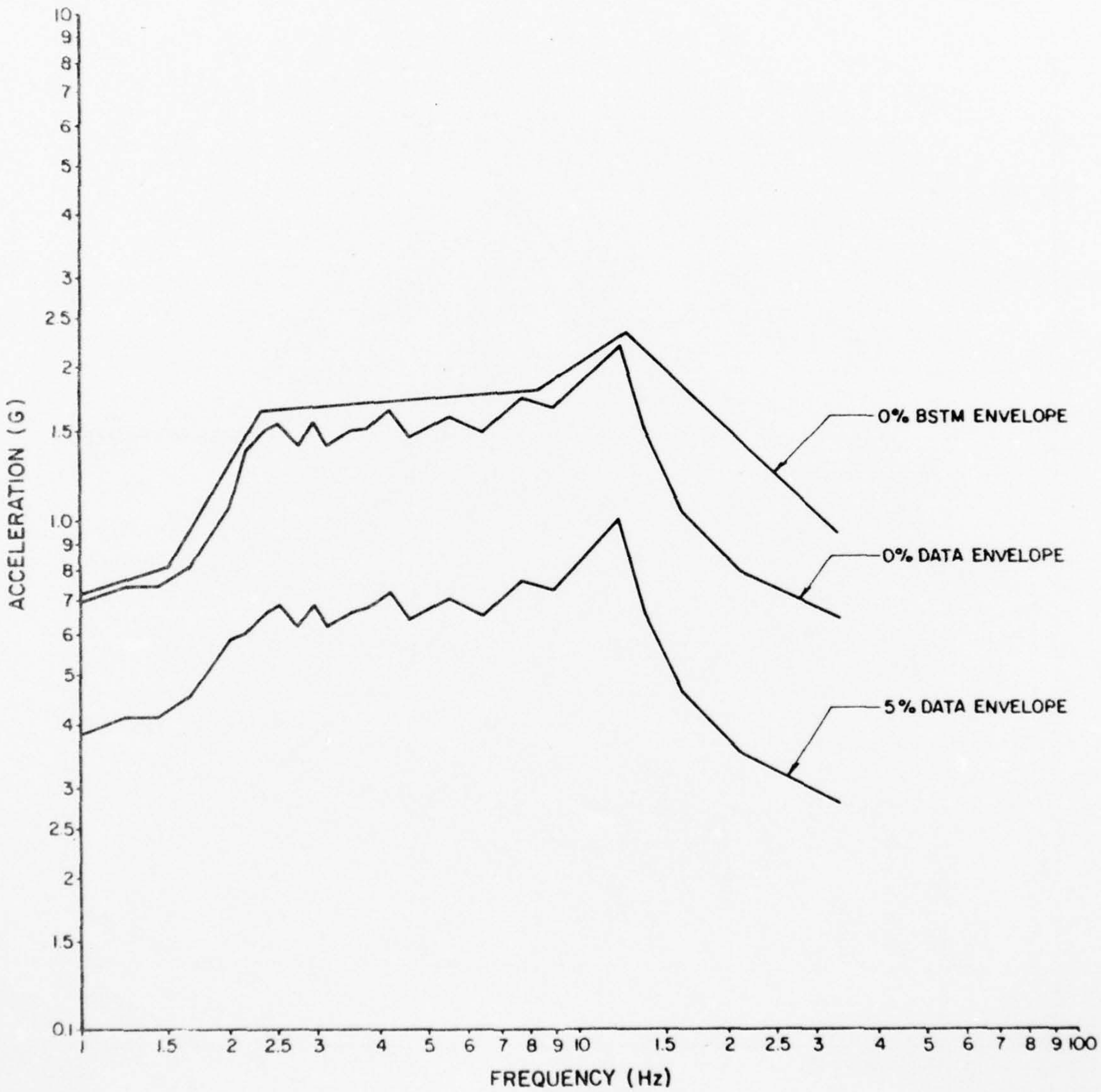


Figure E7. Horizontal envelope spectra and proposed BSTM envelope for testing MOAC-2500.

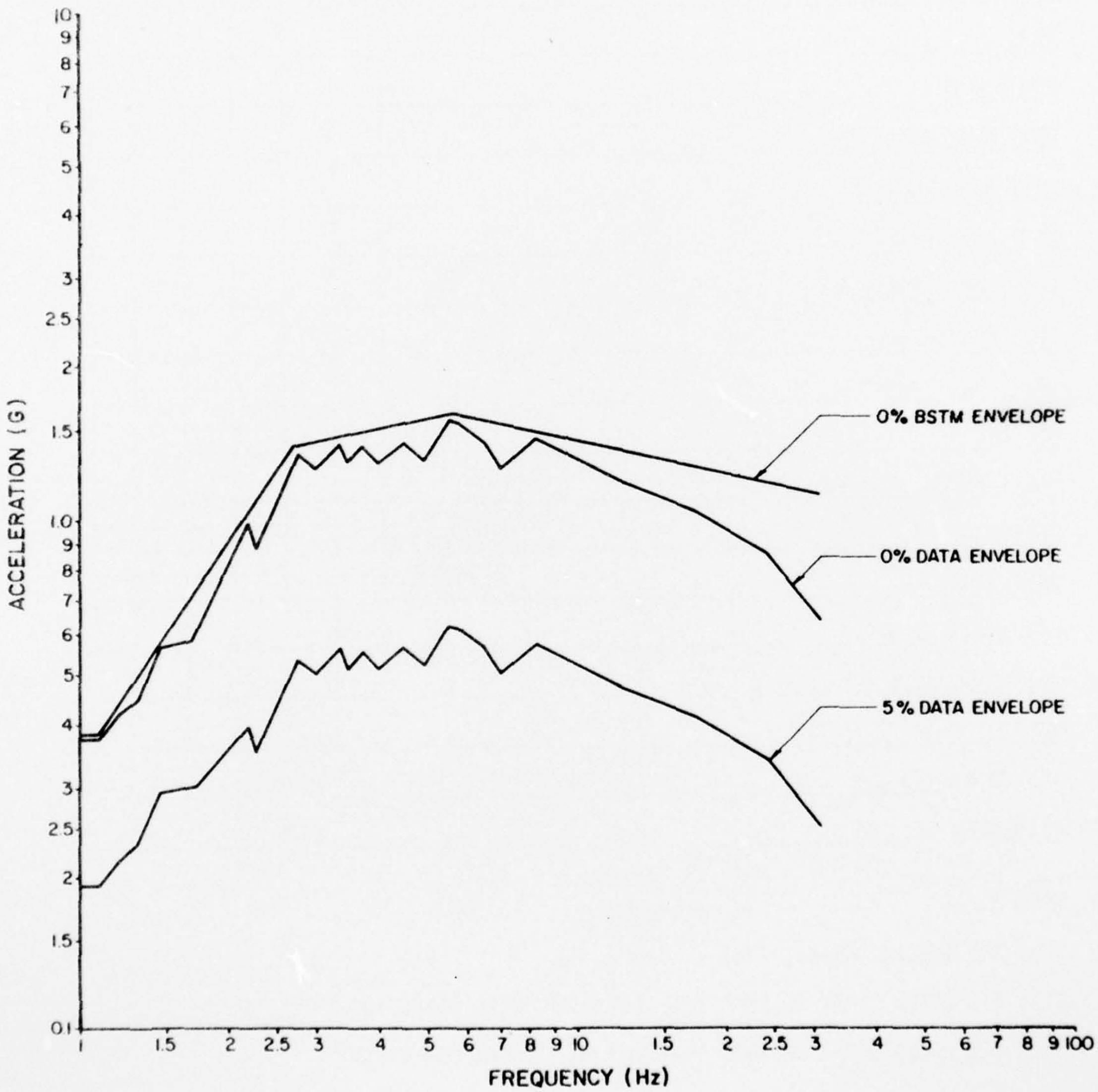


Figure E8. Vertical envelope spectra and proposed BSTM envelope for testing MOAC-2010 and MOAC-2500.

EWC MODEL NO. ____________ DATE____________ SERIAL NO.________

TEST (NOTE 1)		A	B	C			
TIME							
FAN R.P.M.							
UNIT AMPS PHASE A							
UNIT AMPS PHASE B							
UNIT AMPS PHASE C							
UNIT VOLTS PHASE A							
UNIT VOLTS PHASE B							
UNIT VOLTS PHASE C							
AMBIENT °F							
FAN & MOTOR OPERATION							
RETURN AIR °F	Dry Bulb						
	Wet Bulb						
SUPPLY AIR °F	Dry Bulb						
	Wet Bulb						
STRUCTURAL DAMAGE							
DISCHARGE PSIG							
SUCTION PSIG							

TESTED BY:____________________ DATE__________

WITNESSED BY:____________________ DATE__________

NOTE 1:

TEST A - BEFORE SEISMIC TEST

TEST B - AFTER FIRST SEISMIC TEST 1ST HORIZONTAL DIRECTION

TEST C - AFTER FIRST SEISMIC TEST 2ND HORIZONTAL DIRECTION

ELLIS AND WATTS COMPANY CINCINNATI, OHIO 45244	TEST DATA SHEET NO. 1

Figure E9. Sample Functional Data Sheet.

NOTICE OF DEVIATION

Job no. ____________________

Nod. no. ____________________

Date ____________________

To ____

Attn: ____

Part name ____

Part no. ________________ S/N ____________________

Test ____

Specification ____________ Para. no. ________________

Notification made to ______________________________________

Date ________ By __________ VIA ________________

Specification requirements: ______________________________

____

____

Description of deviation: ______________________________

____

____

Specimen disposition: ______________________________

____

Comments/Recommendations: ______________________________

____

____

Test Monitor ______________________

Approved by ______________________
CERL FORM 80
25 Jan 74

Figure E10. Sample Notice of Deviation Data Sheet.

Table E3

Sequence of Test Events

1. Receive the two air-conditioner units and perform a receiving inspection.

2. Assemble and instrument the first air-conditioner unit.

3. Perform pre-test functional checks.

4. Mount the air-conditioner unit on the test platform.

5. Perform resonance search tests.

6. Perform pre-test functional checks.

7. Conduct a seismic multi-frequency test at 25 percent of the full-scale amplitude, using one of the 10 pulse repetitions.

8. Perform the post-test functional checks.

9. Repeat steps 6 through 8 for 50 percent and 75 percent of full-scale amplitude.

10. Repeat steps 6 through 8 for 100 percent of full-scale amplitude using 10 pulse repetitions.

11. Rotate the unit 90 degrees on the test platform and repeat steps 5 through 10.

12. Repeat steps 2 through 11 for the remaining air-conditioner unit.

13. Reduce all test data.

14. Analyze all test data.

15. Notify Ellis and Watts and TVA by letter of successful completion of testing.

16. Disassemble all test items and prepare for shipment.

(c) Acceleration response versus frequency for all resonance search tests.

(d) Shock spectrum plots from the test platform response acceleration data obtained during all multi-frequency tests.

Immediately after each test, copies of all test data shall be made available to the Ellis and Watts Company technical representatives.

16. Reports.

A formal test report shall be submitted in accordance with the sequence presented in Table E3. The test report shall include all shock spectrum plots, resonance search plots, and analog test records from selected accelerometers. The report shall also include copies of all inspection data sheets, functional data sheets, and Notice of Deviation sheets. Diagrams of test setups and transducer locations and photographs of the actual test setups and the test equipment used shall be included in this report.

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Shock resistance of air-conditioning units : test report for Ellis and Watts Co., Cincinnati, Ohio / by James B. Gambill, Walter E. Fisher. -- Champaign, IL : Construction Engineering Research Laboratory ; Springfield, VA : available from NTIS , 1979.
91 p. ; 27 cm. (Special report ; M-273)

1. Air conditioning -- equipment and supplies -- testing. 2. Earthquakes -- testing. I. Fisher, Walter E. II. Title. III. Series: U.S. Army Construction Engineering Research Laboratory. Special report ; M-273.