

REFERENCE 10

HYDRODYNAMIC VIBRATION TESTING
(NEW LOADS)

REPORT NO. B-0115

AGREEMENT FOR TECHNICAL SERVICE NUMBER P-37

CONDUCTED AT

ACTON ENVIRONMENTAL LABS

UNDER DIRECT SUPERVISION

OF

LIMITORQUE CORPORATION AND BECHTEL POWER CORPORATION

Prepared by: J. B. Drab
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Date: June 24, 1982

TABLE OF CONTENTS

1.0 GENERAL	Page 1
2.0 DISCUSSION	Pages 1 and 2
3.0 RESONANCE SEARCH	Page 2
4.0 TEST PROCEDURE	Pages 2 and 3
5.0 CHOICE OF TEST UNITS	Pages 3 and 4
6.0 SUMMARY OF TEST LEVELS	Pages 4 and 5
7.0 CONCLUSION	Page 5

APPENDIX

Test Procedure	Appendix A
Hydrodynamic Test SMB-000-2/MOD. 10A Acton 16511-11	Appendix B
Hydrodynamic Test SMB-4-250 Acton 16511-11	Appendix B
Hydrodynamic Test SMB-1-60 Acton 16511-9	Appendix C
Hydrodynamic Test SMB-2-60 Acton 16511-9	Appendix C
Hydrodynamic Test SMB-00-15/H2BC Acton 16511-10	Appendix D

LIMITORQUE CORPORATION

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TEST REPORT

1.0 GENERAL

The following tests were conducted to determine the capability of Limitorque actuators to withstand high frequency vibrations up through 100 hz caused by hydrodynamic loadings in a boiling water reactor nuclear power plant.

2.0 DISCUSSION

It is generally agreed within the industry that random multi-frequency biaxial testing most closely duplicates the actual high frequency acceleration the actuator would see during hydrodynamic loading. Due to the complexity of the piping systems and the varied locations of the actuator, proper RRS curves could not be developed and it was decided to adopt the much more conservative mode of testing of sine-beat dwells at 1/3 octave intervals from 2 to 100 hz.

Actuator resonances would not be a consideration for random multi-frequency biaxial testing, but would have to be considered when choosing representative units for the more conservative sine beat testing at 1/3 octave intervals.

Due to this fact, it was decided to check the resonance points below 100 hz on all the actuator sizes in question.

Since it has been determined that the motor mounting flange is the most sensitive area in seismic testing, simplified stress static calculations were made.

The test units were chosen on the basis of considering the worst case combination of resonant frequencies and stress levels of each actuator.

3.0 RESONANCE SEARCH

Prior to start of actual testing, it was determined that resonance search by use of a shaker table might possibly create delays in the overall testing program. An alternate method of determining resonance by modal analysis could accelerate the schedule.

An SMB-0-25 was sent to the test lab to check resonant frequencies of the actuator by both modal analysis and a resonance survey by applying a .75 g input at a sweep rate of 2 octaves per minute from 5 to 200 hz to 5 hz. Since relatively close agreement was established between the two methods of determining resonances, modal analysis was considered valid and was used in determining resonances of the remainder of the actuators.

Due to the fact that resonance information was available on the SMB-3 from Report B0085, the SMB-3 was not subjected to a resonance search on this test.

4.0 TEST PROCEDURE

The test procedure used is included in Appendix A.

Due to lack of prior data in testing Limitorque actuators at high acceleration levels at frequencies in excess of 33 hz, it was decided to attach special supports to the limit switch finger base on two of the four trains. Should the finger base prove to be sensitive to high acceleration levels at higher frequencies due to resonance or

other reasons, this permits continuation of the testing with a potential design modification being tested. Testing proved the standard switch without the addition of the special supports passed the hydrodynamic test and therefore the actuators can be used as originally supplied.

5.0 CHOICE OF TEST UNITS

A joint engineering review by Limitorque and Bechtel lead to the following conclusions and choice of test actuators.

The most sensitive area to acceleration loading is the connection of the motor to the actuator. Since this area has a relatively complicated configuration and since this joint is the same in design concept on all size actuators varying only in physical size and metal thickness, a simple calculation was made. This calculation, although not providing actual stress levels, provided relative flange strengths which permitted selection of the "worst case units".

The SMB-2 actuator had the highest stress level, approximately 60% over the SMB-00 and SMB-0 actuators. Information at the time of evaluation showed the dominant resonances of actuators of the size SMB-3 and smaller were close to or in excess of 100 hz with resonances being detected on the SMB-4 below 100 hz, but well above 33 hz. Resonance was detected on the SMB-5 at 28 hz. On this basis, it was agreed that hydrodynamic testing should be conducted on the SMB-2 and SMB-4 actuators. The SMB-000 was also included, primarily to check the Modutronic 10A included in this unit. Decisions were then made to include an SMB-1 actuator in the test program to add another mid-size unit for additional confidence level.

A joint analysis (as shown below) was made by Bechtel and Limitorque, which showed the testing of the SMB-5 was not necessary.

- A. Acton's modal analysis detected a resonance in the SMB-5 at 28 hz.
- B. An earlier seismic test subjected an SMB-5 Limitorque actuator to 6 g acceleration at 28 hz with the actuator operating properly during the seismic dwell.
- C. The SMB-4, which was subjected to hydrodynamic testing had resonant frequencies slightly above the SMB-5 but below the 100 hz max test level and subsequently passed the hydrodynamic test without problem.
- D. Due to the generic family relationship of all Limitorque actuators, it is contended that the SMB-4 and SMB-5 actuators would react similarly to high frequency sine beat testing.
- E. On this basis, the SMB-5 is considered to have the capability of withstanding 6 g acceleration to frequency levels of up to 100 hz.

The SMB-000-2/H0BC and SMB-00-15/H2BC ninety degree actuators were also jointly reviewed. The most sensitive area to acceleration loading in this case is the adaptor that mounts the SMB actuator to the HBC ninety degree actuator. Since the SMB-00 is much heavier than the SMB-000 and the highest stressed area of the adaptors being of the same cross section, the SMB-00-15/H2BC was chosen as the test unit.

6.0 SUMMARY OF TEST LEVELS

<u>Actuator Size</u>	<u>Acceleration Level</u>
SMB-000-2/Mod. 10A	10 g
SMB-1-60	10 g

<u>Actuator Size</u>	<u>Acceleration Level</u>
SMB-2-60	10 g
SMB-4-250	7 g
SMB-00-15/H2BC	8 g

7.0 CONCLUSION

The actuators tested consisted of units which, in relation to high frequency acceleration load testing, included the most detrimental attributes of the generic family of actuators. Since the actuators performed all functions with no indication of malfunction during the acceleration load testing, the entire generic family of actuators, SMB/SB/SBD, is considered qualified for high frequency hydrodynamic loading (per test procedure) to 10 g in the size range of SMB-000 to 3, 7 g for the SMB-4 and 6 g for the SMB-5.

The SMB-00-15/H2BC was tested with limit switches that included special brackets. In reviewing the accelerometer strip charts, it was noted that comparing the acceleration readings of the SMB to the acceleration readings of the control accelerometer that there was no multiplication. Since the limit switches in all size actuator are of the same configuration and the maximum acceleration loading of the SMB-00 did not exceed 8 g, the standard limit switch would survive the vibration testing as proved in tests of the other units.

The SMB-00-15/H2BC envelopes the combinations of an SMB-00 mounted on an H1BC or H2BC or an SMB-000 mounted on these same ninety degree units and on an HOBC. These units are considered qualified for high frequency hydrodynamic loading of up to 8 g as defined in the test procedure.

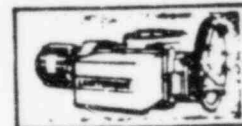
7.0 (Cont.)

It was determined the Modutronic 10A electronic board had to be modified by firmly securing one of the components by potting the board for additional rigidity. The Modutronic 10A, as modified, is also considered qualified for high frequency hydrodynamic loading as defined in the test procedure.

APPENDIX A
TEST PROCEDURE

LIMITORQUE CORPORATION

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TEST PROCEDURE

SINE BEAT SEISMIC DWELL TEST

BECHTEL P/O 8856-P-37, LIMITORQUE 681021

1. Use same test actuators listed

<u>Actuator Size</u>	<u>O/N</u>	<u>S/N</u>
SMB-000-2 (DC)	3A6083A	257332
SMB-00-25 (DC)	381264F	204579
SMB-0-25 (AC)	3812550	204081
SMB-1-60 (DC)	381264I	216441
SMB-2-60 (AC)	381264Z	213425
SMB-3-100 (AC)	381255T	217964
SMB-4-250 (AC)	381268G	210574
SMB-5-350 (AC)	381264BB	209264
SMB-000-2/HOBC	385285A	219170
SMB-00-15/H2BC	389499A	233835

2. Install the Navy Shock Bracket on the lower 2 RGLS so that one set of switches contains a bracket and the second set does not.
3. Install each of the above actuators on an aluminum fixture to check resonance (Fixture per Fig. 2 attached, except not arranged to accept load). Weight each actuator/fixture assembly and with this information, have the seismic lab advise the max. g level capability at each 1/3 octave interval from 2 to 100 hz and record. The external switch bracket and switches are to be retained on the actuators during resonance search only. Mount a triaxial accelerometer on the switch mounting plate. Extraneous conduit or fittings, etc. are to be removed before testing.
4. Install each actuator on shake table attaching triaxial accelerometers to the fixture at the actuator mounting face, top of the SMB, end cap of the motor and mini-triaxial accelerometers, one to the end of the

4. (cont)

limit switch finger base without the Navy Shock Bracket and one to the end of the limit switch finger base with the bracket. In the case of the SMB/HBC assemblies, mount the triaxial accelerometer to the top of the HBC with the remainder being mounted as indicated above. Also mount mini-triaxial accelerometers to the outboard face of the torque switch frame (do not connect to a movable part).

5. Conduct a resonance search on the SMB-0-25 by applying an acceleration of .75 g input (max table capacity at low frequencies) at a rate of 2 octaves per minute from 1-200 hz noting resonant frequencies (defined as a multiplication factor of 2 and a 90 degree phase shift) in each of the three axis. Also conduct a modal analysis on the same actuator for comparison to resonances established on the shake table.
6. If the resonant frequencies obtained by modal analysis agrees with the resonant frequencies established on the shake table, determine the resonant frequencies of the remainder of the actuators (with the exception of the SMB-3) by modal analysis. The resonant frequencies of the SMB-3 were known from prior tests. If the resonant frequencies disagree by a substantial amount, determine the resonant frequencies of the remainder of the units by use of the shake table as described in Step 5.
7. Calculate the stress level in the motor flange of each SMB actuator and the SMB-HBC adaptor of the two motor actuated manual units listed in Step 1 above. Coupling this with the resonance information and the shaker table g level capability established in Step 3 above, chose the actuators that would envelope the list of actuators. The information

7. (cont)

established is to be forwarded to Bechtel and the test units to be chosen to represent the generic family are to be to the mutual agreement of Bechtel and Limitorque.

8. Calibrate the chosen test units to the unit rating torque of the SMB actuators (choosing stem size and characteristics to provide nominal rated stem thrust) and to the rated output torque of the HBC for the motor operated 90 degree unit or units or to the maximum thrust and torque available from the test unit should it be below rating.
9. Mount each actuator on an aluminum seismic test fixture arranged to trip the actuator on torque switch in the seated position.
10. Install the actuator with test fixture on the seismic shake table and subject in each axis to a seismic excitation of a five beat-fifteen cycle sine beat test of 8 g (alternately 10 g) performed at 1/3 octave intervals from 2 to 100 hz and at each resonant point below 100 hz. (at lower frequencies, seismically excite to the limit of the shake table.) Also, in the cases where unit weight does not permit exciting to the stipulated g levels, excite the actuator to the capacity of the shake table as determined in Step 5 above. During each dwell, operate the actuator from limit switch open position to torque seated close position and at each alternate dwell, from torque seated close position to limit switch open position. This cycle (open or close) is to be initiated at the start of each sine beat series and completed before the start of the next sine beat series. During these seismic dwells, include heat aged inside containment and outside containment limit switches attached to the test fixture for comparison with non-aged switches. (Use of

Navy Shock Bracket to be evaluated during the study conducted in Step 6 above). Due to the severity and conservatism of the test, it is permissible to check and tighten bolting as necessary for successful test completion.

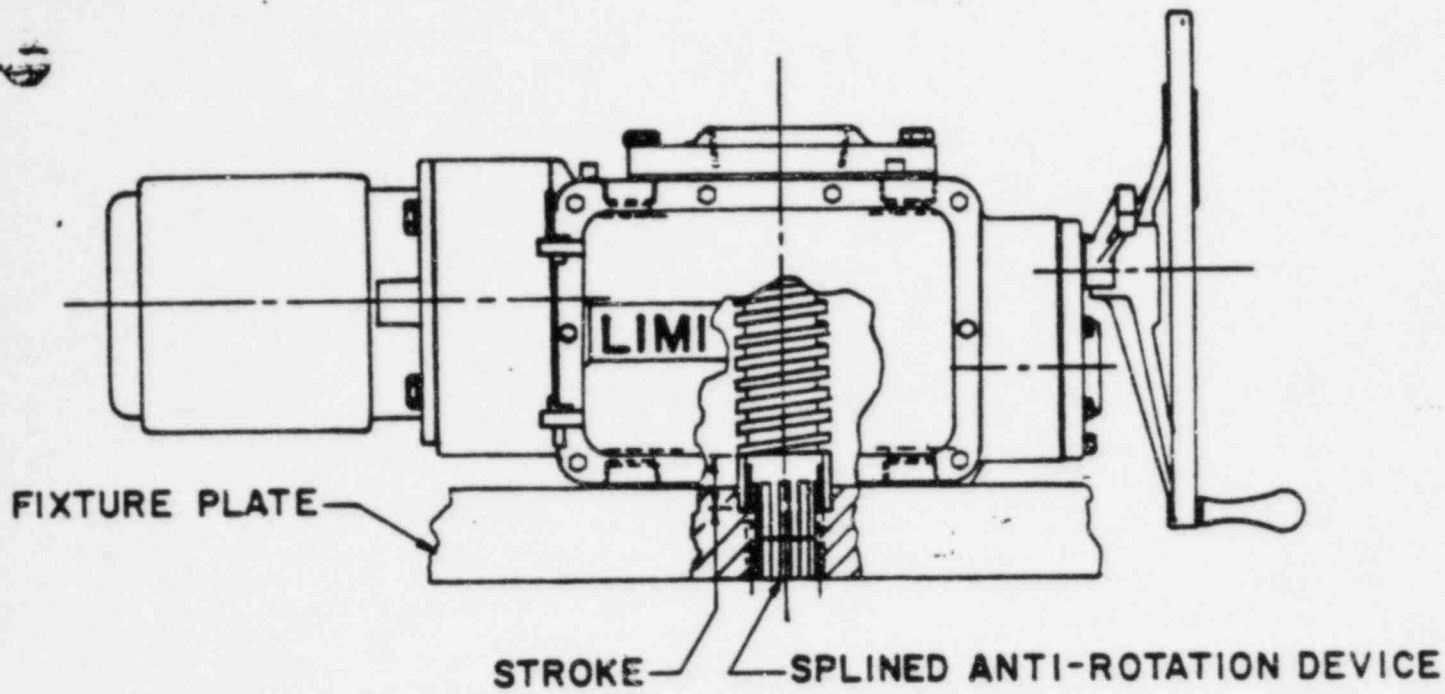
11. At the conclusion of testing, electrically operate the actuator from the open to close and back to open position and then clutch handwheel and operate actuator in both directions.
12. Visually inspect actuator for any damage noting observations.

J. B. Drab

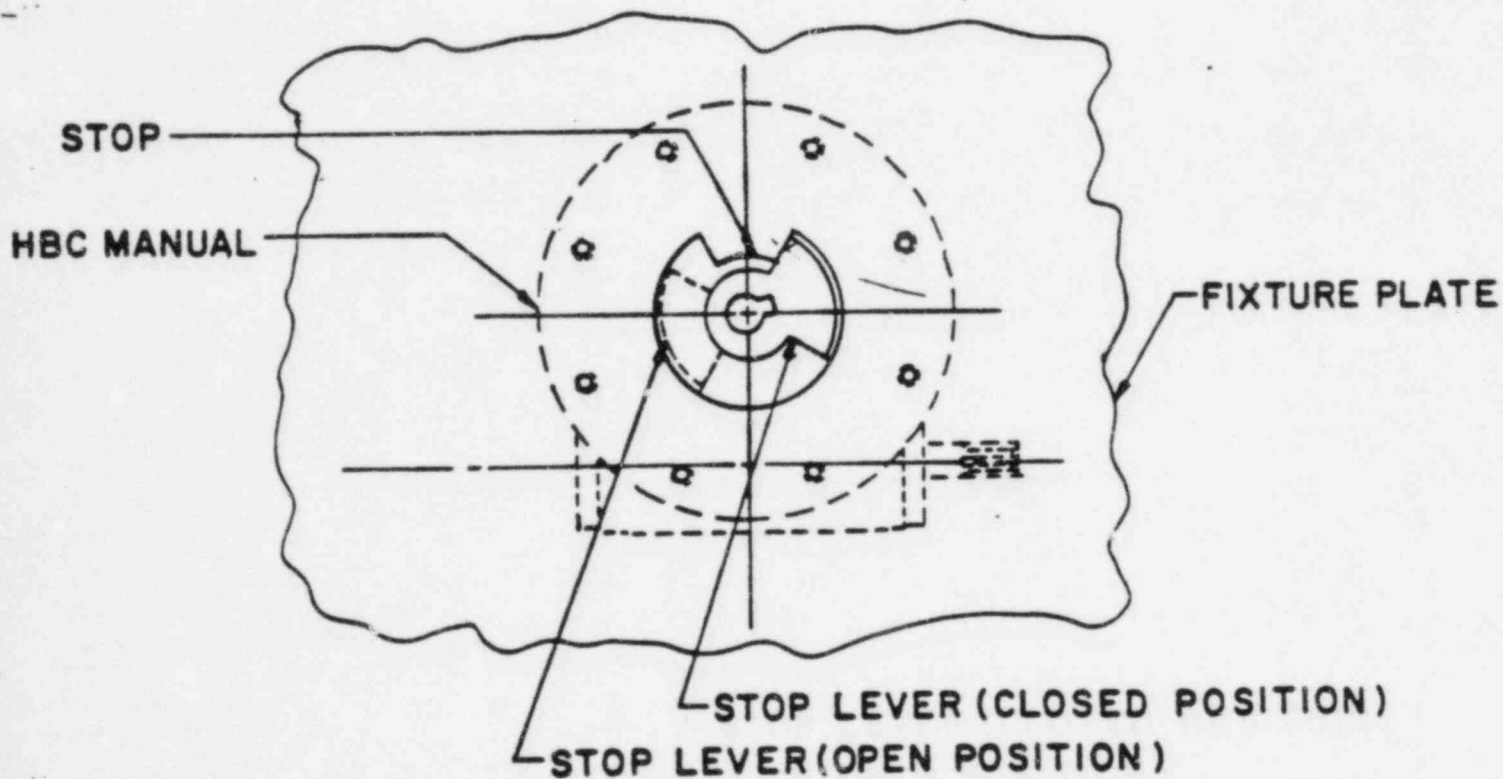
J. B. Drab
Special Projects

jhb

SEISMIC FIXTURING



LINEAR ACTUATORS - SMB/SB/SBD/SMC



ROTARY ACTUATORS - SMB/HBC & SMC-04/HBC

FIGURE-2

APPENDIX B

HYDRODYNAMIC TEST

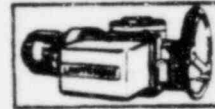
SMB-000-2/MOD 10A

SMB-4-250

ACTON TEST 16511-11

LIMITORQUE CORPORATION

Inter-Office Correspondence



DATE: May 19, 1982

FROM: C.H. Cox

TO: FILE

ATTENTION:

SUBJECT: Limitorque Research and Development Project
#681021 - High Frequency Hydrodynamic Loads
Testing

- Ref: 1) Bechtel Purchase Order 8856-P-37
2) Acton Environmental Testing Corporation
Reports # TR#16511-11 Rev. 1 and 16511-4
3) Test procedures for Limitorque valve actu-
ators - R&D Project #681021

Unit Identification and Description

Actuator Description

Type: SMB
Size: 000 (with Modutronic
10A DC controller)
Order #: 3A6083-A
Serial#: 257332

Motor Identification

Manufacturer: Reliance Motor Co.
I.D.#: 708431-ND
Start: 2 lb-ft
Type: TR
Frame: T56
H.P.: .355
RPM: 2100
Arm. volts: 75
Field volts: 100
Winding type: Shunt
Ins. Class: F
Duty: Valve
Max. Amb. Temp: 40°C
Form factor: 2.00

Amps: 5.6
Amps: 7.4

Background

Prior to any hydrodynamic loads testing the Limitorque SMB-000 w/Mod 10A was mounted on a test fixture to provide simulated valve seating loads during sine beat portions of the test.

Post test calibration checks indicated an average "closed" torque of 121.6 ft-lb and an average "open" torque of 44.8 lb-ft (both torque switch settings at "1").

The Modutronic 10A controller was epoxy treated to a depth of approximately 0.25 inches in order to prevent detachment of components during testing.

The test actuator was scanned for resonances (in each axis) before beginning sine beat tests. All test results from tests performed at Acton Labs can be found in the referenced reports accompanying this summary.

At the conclusion of hydrodynamic loads testing, the SMB-000 w/Mod 10A actuator was manually clutched and operated through a full open stroke-close stroke cycle. No apparent damage was detected.

Conclusion

The Limitorque SMB-000 w/Mod 10A performed its function (as specified in test procedures for Project #681021) with no apparent malfunctions or physical damage.

C. M. Cox W. L. S.

Chas. H. Cox

Asst. Chief Test Engineer

/eab

LIMITORQUE CORPORATION

Inter-Office Correspondence



DATE: May 19, 1982

FROM: C.H. Cox

TO: FILE

ATTENTION:

SUBJECT: Limitorque Research and Development Project
#681021 - High Frequency Hydrodynamic Loads
Testing

- Ref: 1) Bechtel Purchase Order 8856-P-37
2) Acton Environmental Testing Corporation
Reports #16511 and TR# 16511-11
3) Test procedures for Limitorque valve actuators
- R&D Project #681021

Unit Identification and Description

Actuator Description

Type: SMB
Size: 4
Order #: 381268G
Serial #: 210575

Motor Identification

Manufacturer: Reliance Motor Co.
I.D.#: 744-21130-01
Start: 250 lb-ft
Run: 50 lb-ft
Volts: 230/460
Amps: 82/41
Frame: C256Y
RPM: 3460
Type: DAT
Phase: 3
Hz: 60
Code: J
°C Rise: 75
Duty: 15 min
Class B Insulation
45 BC03JPP

Background

Prior to any hydrodynamic loads testing, the Limitorque SMB-4-250 was mounted on a test fixture to provide simulated valve seating loads during sine beat portions of the tests.

Post test torque calibration checks indicated an average torque in the "closed" direction (setting 3-3/4) of 7,240 lb-ft and an average torque in the "open" direction (setting of 3-3/4) of 6,640 lb-ft.

The bottom two train geared limit switch was replaced prior to testing with a standard nuclear switch incorporating a Navy shock bracket. The top switch was replaced with a standard nuclear geared limit switch.

Maximum attainable accelerations in any axis was 7.0g (due to actuator mass and table limitations).

The SMB-4-250 was scanned for resonances (in each axis) before beginning sine beat tests. All test results from tests performed at Acton Labs can be found in reports accompanying this summary.

At the conclusion of hydrodynamic loads testing the SMB-4-250 actuator was manually clutched and operated through a full open stroke-close stroke cycle. No apparent damage was detected.

Conclusion

The Limitorque SMB-4-250 successfully performed its function (as specified in test procedures for Project #681021) with no apparent malfunction or physical damage. Both geared limit switches passed all tests.

C.M. Cox
W.L.S.

Chas. H. Cox
Asst. Chief Test Engineer

/eab



Test Report No. 16511-11

No. of Pages 31

Revision 1 - 5/3/82

Revision 2 - 6/9/82

Report of Test

FOR

HYDRODYNAMIC LOADING QUALIFICATION OF
TWO ACTUATORS SMB-000 WITH MOD 10A
AND SMB-4-250

FOR LIMITORQUE CORPORATION

Purchase Order No. RD-288

Prepared by: Timothy W. Fofonoff Date 6/17/82

Timothy W. Fofonoff, Project Engineer
Acton Environmental Testing Corporation
533 Main Street, Acton, MA 01720

Reviewed & Approved by: William C. McGinnis Date June 18, 1982

William C. McGinnis, Chief Dynamics Test Engineer
Acton Environmental Testing Corporation

TWE/mlr

REVISION RECORD

DATE	REVISION NUMBER	PAGE NUMBER	PARAGRAPH NUMBER	CHANGES OR ADDITIONS	APPROVED BY
0 -----FIRST ISSUE-----					
5/3/82	1	2,3,5 to the end.		Report Edited in its entirety to include Resonance Survey Test for Actuator SMB-000.	58
6/9/82	2	Cover		Added Rev. 2, 6/9/82. *Replaced 'Seismic' with 'Hydrodynamic Loading'	58
		1,2		*Replaced 'Seismic' with 'Hydrodynamic Loading'	
		3	2.1	Change section to read 'The purpose of the Resonance Survey Test was for information only.'	
		4	3.1	Add 'for Actuator SMB-000 with MOD 10A' to end of paragraph	
		6	3.3	Add 'for Actuator SMB-4-250, and in the frequency bandwidth of 5 to 100 Hz for Actuator SMB-000 w/MOD 10A' to end of paragraph	
		10	4.1	Add Motor, Handwheel, Undefined, and Motor Cap to table. *Changed per Linitorque letter of 5/19/82.	



Report No. 16511-11

ADMINISTRATIVE DATA

- 1.0 PURPOSE OF TEST: Hydrodynamic Loading Qualification of two (2) actuators for Limitorque Corporation
- 2.0 MANUFACTURER: Limitorque Corporation
P.O. Box 11318
Lynchburg, VA 24506
- 3.0 MANUFACTURER'S TYPE OR MODEL NO: SMB-000 w/ MOD 10A
SMB-4-250
- 4.0 DRAWING, SPECIFICATION OR EXHIBIT: Limitorque Test Procedure
Project No. 681021
- 5.0 QUANTITY OF ITEMS TESTED: Two (2)
- 6.0 SECURITY CLASSIFICATION OF ITEMS: Unclassified
- 7.0 DATE TEST COMPLETED: March 9, 1982
- 8.0 TEST CONDUCTED BY: E. Martin, D. Gosselin, M. Cormier,
C. Forbes, and P. McDermott
- 9.0 DISPOSITION OF SPECIMENS: Returned to Limitorque Corporation
- 10.0 ABSTRACT: Refer to Section 4.0

Report No. 16511-11
Rev. 2



1.0 TEST ITEM

Two (2) Actuators, SMB-000 w/ MOD 10A, S/N 257332, and SMB-4-250, S/N 210575 were submitted by Limitorque Corporation for hydrodynamic loading qualification testing at Acton Environmental Testing Corporation. Each actuator was subjected to a resonance survey test and to a sine beat test.

Report No. 16511-11
Rev. 2



2.0 TEST REQUIREMENTS

2.1 Resonance Survey Test

The purpose of the Resonance Survey Test was for information only.

2.2 Sine Beat Test

The purpose of the Sine Beat Test was to subject each actuator to the required sine beat excitation, in order to determine the actuators' functional integrity and ability to withstand such excitation without evidence of mechanical damage or deterioration.

Report No. 16511-11
Rev. 2



3.0 TEST PROCEDURE

3.1 Test Mounting

Each actuator was submitted by Limitorque Corporation bolted to an aluminum plate. The aluminum plate had a predrilled bolt pattern in order to adapt it to the head of an AETC A-249 electrodynamic shaker. The actuator/fixture plate assembly was attached to the A-249 for sine beat testing in the frequency range 20 to 100 Hz. The actuator/fixture plate assembly was rigidly clamped to the single axis hydraulic shaker for sine beat testing in the frequency range of 2 to 16 Hz for Actuator SMB-000 with MOD 10A.

3.2 Test Monitoring

Each actuator was visually monitored for any evidence of mechanical damage or deterioration by Limitorque personnel.

The actuators were instrumented with four (4) triaxial groups of accelerometers. The accelerometers were located on each actuator as follows:

<u>ACCELEROMETER</u>	<u>SENSE</u>	<u>LOCATION</u>
1	V	Base of Fixture
2	H ₁	
3	H ₂	

Report No. 16511-11
Rev. 2



3.2 Test Monitoring (continued)

<u>ACCELEROMETER</u>	<u>SENSE</u>	<u>LOCATION</u>
4	V	Motor Cap
5	H ₁	
6	H ₂	
7	V	Gear Box
8	H ₁	
9	H ₂	
10	V	Switch Case
11	H ₁	
12	H ₂	

ACCELEROMETER LOCATIONS FOR RESONANCE SURVEY TEST ON
ACTUATOR SMB-000 W/MOD 10A

<u>ACCELEROMETER</u>	<u>SENSE</u>	<u>LOCATION</u>
1	H ₂	Motor Cap
2	H ₁	
3	V	
4	H ₂	SMB Housing
5	H ₁	
6	V	
7	H ₂	Gear Box
8	H ₁	
9	V	
10	H ₂	Base of Fixture
11	H ₁	
12	V	

H₁ - Parallel to the Motor
H₂ - Perpendicular to the Motor
V - Vertical

Report No. 16511-11
Rev. 1



3.2 Test Monitoring (continued)

Outputs from all accelerometers, through appropriate signal conditioning, were recorded on visicorder recording paper which is included with this report.

Limatorque personnel operated the actuators during the test to determine functional integrity.

3.3 Resonance Survey Test

The resonance survey was performed on each actuator in the three (3) mutually orthogonal axes of excitation, one (1) vertical and two (2) horizontal axes. The resonance survey consisted of a sinusoidal input with peak accelerations of 0.75 performed at a sweep rate of 2 octaves/min. in the frequency bandwidth of 5 to 200 Hz for Actuator SMB-4-250, and in the frequency bandwidth of 5 to 100 Hz for Actuator SMB-000 with MOD 10A.

3.4 Sine Beat Test

The Sine Beat Test was performed in three (3) mutually orthogonal axes of excitation, two (2) horizontal and one (1) vertical. The test consisted of amplitude modulated sinusoids with peak horizontal and vertical accelerations of 10g's for Actuator SMB-000 w/ MOD 10A, and 7g's for Actuator SMB-4-250 (except when limited by AETC shaker capabilities as

Report No. _____
16511-11
Rev. 2



3.4 Sine Beat Test

listed below). The beat for a given frequency was 5 beats, 15 cycles/beat with a sufficient pause between beats to preclude any superposition of motion. The sine beats were performed at the following frequencies:

SMB-000 w/ MOD 10A

<u>FREQUENCY (Hz)</u>	<u>TEST No.</u>	<u>SENSE</u>	<u>ACCELERATION (g's)</u>
2	10, 11, 12	H ₁ , H ₂ , V	4, 4, 4
2.5	10, 11, 12	H ₁ , H ₂ , V	5, 5, 5
3.2	10, 11, 12	H ₁ , H ₂ , V	6, 6, 6
4.0	10, 11, 12	H ₁ , H ₂ , V	9, 9, 9
5	10, 11, 12	H ₁ , H ₂ , V	10, 10, 10
6	10, 11, 12	H ₁ , H ₂ , V	10, 10, 10
8	10, 11, 12	H ₁ , H ₂ , V	10, 10, 10
10	10, 11, 12	H ₁ , H ₂ , V	10, 10, 10
12.5	10, 11, 12	H ₁ , H ₂ , V	10, 10, 10
16	1, 2, 3	V, H ₂ , H ₁	10, 10, 10
20	1, 2, 3	V, H ₂ , H ₁	10, 10, 10
25	1, 2, 3	V, H ₂ , H ₁	10, 10, 10
32	1, 2, 3	V, H ₂ , H ₁	10, 10, 10
36	2	H ₂	10
40	1, 2, 3	V, H ₂ , H ₁	10, 10, 10
47	1, 2, 3	V, H ₂ , H ₁	10, 10, 10
50	1, 2, 3	V, H ₂ , H ₁	10, 10, 10
60	1, 2, 3	V, H ₂ , H ₁	10, 10, 10
66	1	V	10
68	2, 3	H ₂ , H ₁	10, 10
75	2	H ₂	10
80	1, 2, 3	V, H ₂ , H ₁	10, 10, 10
95	1	V	10
100	1, 2, 3	V, H ₂ , H ₁	10, 10, 10

H₁ - Parallel to the Motor
H₂ - Perpendicular to the Motor
V - Vertical

Report No. 16511-11
Rev. 1



3.4 Sine Beat Test (continued)

SMB-4-250

<u>FREQUENCY (Hz)</u>	<u>TEST No.</u>	<u>SENSE</u>	<u>ACCELERATION (g's)</u>
16	5, 7, 9	H ₂ , H ₁ , V	7, 6, 3.5*
20	5, 7, 9	H ₂ , H ₁ , V	7, 6, 7
25	5, 7, 9	H ₂ , H ₁ , V	7, 7, 7
29	7	H ₁	7
32	5, 7, 9	H ₂ , H ₁ , V	7, 7, 7
34	7	H ₁	7
40	5, 7, 9	H ₂ , H ₁ , V	7, 7, 7
43	7, 9	H ₁ , V	7, 7
50	5, 7, 9	H ₂ , H ₁ , V	7, 7, 7
56	9	V	7
58	5, 7, 9	H ₂ , H ₁ , V	7, 7, 7
60	5, 7, 9	H ₂ , H ₁ , V	7, 7, 7
71	5, 9	H ₂ , V	7, 7
74	9	V	7
75	5	H ₂	7
80	5, 7, 9	H ₂ , H ₁ , V	7, 7, 7
86	5	H ₂	7
94	7	H ₁	7
100	5, 7, 9	H ₂ , H ₁ , V	7, 7, 7

*Low g level due to a 16 Hz trunnion resonance on Test No. 9.

H₁ - Parallel to the Motor
 H₂ - Perpendicular to the Motor
 V - Vertical

During each beat, the acuator was operated by Limitorque personnel from limit switch-open position to torque-seated close position, and at each alternate beat, from torque seated-close position to limit switch-open position. During the Sine

Report No. _____
 16511-11



3.4 Sine Beat Test (continued)

Beat Test all visual monitoring of the inside containment and outside containment limit switches was done by Limitorque personnel.

Report No. 16511-11



Page 9

4.0 TEST RESULTS

4.1 Resonance Survey Test Results

Resonant frequencies for each Actuator were measured as follows:

<u>AXIS</u>	<u>SMB-4-250 FREQUENCY (Hz)</u>	<u>ACTUATOR POSITION</u>
Horizontal (H ₂)	Between 70-75 Motor Between 90-95 Motor	Open
Horizontal (H ₁)	28.8 Handwheel 33.6 Handwheel 98.7 Handwheel	Open
Horizontal (H ₁)	None between 20 and 40	Closed
Vertical (V)	58 Undefined 74 Motor End Cap	Open

<u>AXIS</u>	<u>SMB-000 w/MOD 10A FREQUENCY (Hz)</u>
Vertical (V)	66 Motor
Horizontal (H ₁)	47, 60 Motor
Horizontal (H ₂)	36, 75 Motor

The frequency response spectra for the above tests are included in this report.

4.2 Sine Beat Test Results

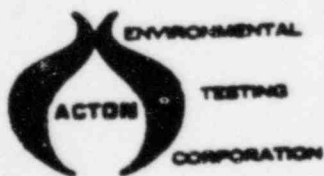
No anomalies were encountered during the sine beat testing of the two actuators in either of the horizontal directions or the vertical direction. All testing was witnessed and approved by Limitorque personnel.

Report No. 16511-11
Rev. 2



5.0 TEST EQUIPMENT LIST

Report No. 16511-11



TEST EQUIPMENT LIST

NAME	MFGR.	MODEL	SER. NO.	RANGE	ACCURACY	INV.#	CAL. FREQ.
Power Supply	PCB	483A02	396	6 Channel Gain: X1	+2%	PE305	6 months
Function Generator	KH	1000A	894	.2 Hz-3MHz 10V P-P @ 50 Ohm	+5% LP +2% HF	SG504	6 months
Exciter control	B & K	1047	919542			SG510	6 months
Scope, Storage	TEK	T912	T912 B015169	DC-10MHz Dual Trace	+3%	OS305	6 months
Sweep Function Generator	KH	1600	241	0.2 Hz to 3 MHz	+5%	SG349	6 months
Spectral Density Volt Meter	Ballantine	N122	8572		AC	ML534	6 months
Visicorder	HON	906B	9-8687	DC to 2 KHz 12 Channel 6" paper	+1db	RE301	6 months
Exciter Amplifier	LING	A249 PP120/150	70 56	30,000 lbs force 1" P/P disp. 5 - 5 KHz	+5% +2%	PE317	6 months
Power Supply	PCB	483A	273	12 Channel Gain: X1	+2%	PE374	6 months
Amplifier DC	HON	117-06	1000-54	Gain: 0.01/.02/.05/.1/.2/.5/ 1/2/5/10	+2% DC	PE394	6 months
Accelerometer	PCB	302A	1772	1 Hz - 5 KHz	+5%	AC415	6 months
Accelerometer	PCB	302A	1777	1 Hz - 5 KHz	+5%	AC420	6 months
Accelerometer	P-R	302A	1807	1 Hz - 5 KHz	+5%	AC426	6 months
Accelerometer	PCB	302A	1809	1 Hz - 5 KHz	+5%	AC428	6 months

TEST EQUIPMENT LIST

NAME	MFGR.	MODEL	SER. NO.	RANGE	ACCURACY	INV.#	CAL. FREQ.
Accelerometer	PCB	302A	1821	1 Hz - 5 KHz	+5%	AC437	6 months
Accelerometer	PCB	302A	1983	1 Hz - 5 KHz	+5%	AC440	6 months
Accelerometer	PCB	302A	1815	1 Hz - 5 KHz	+5%	AC433	6 months
Accelerometer	PCB	302A	1811	1 Hz - 5 KHz	+5%	AC429	6 months
Accelerometer	PCB	302A	4440	1 Hz - 5 KHz	+5%	AC340	6 months
Accelerometer	PCB	302A	1776	1 Hz - 5 KHz	+5%	AC419	6 months
Accelerometer	PCB	302A	4430	1 Hz - 5 KHz	+5%	AC342	6 months
Accelerometer	PCB	302A	670	1 Hz - 5 KHz	+5%	AC379	6 months

Electro-Rent Number 77314

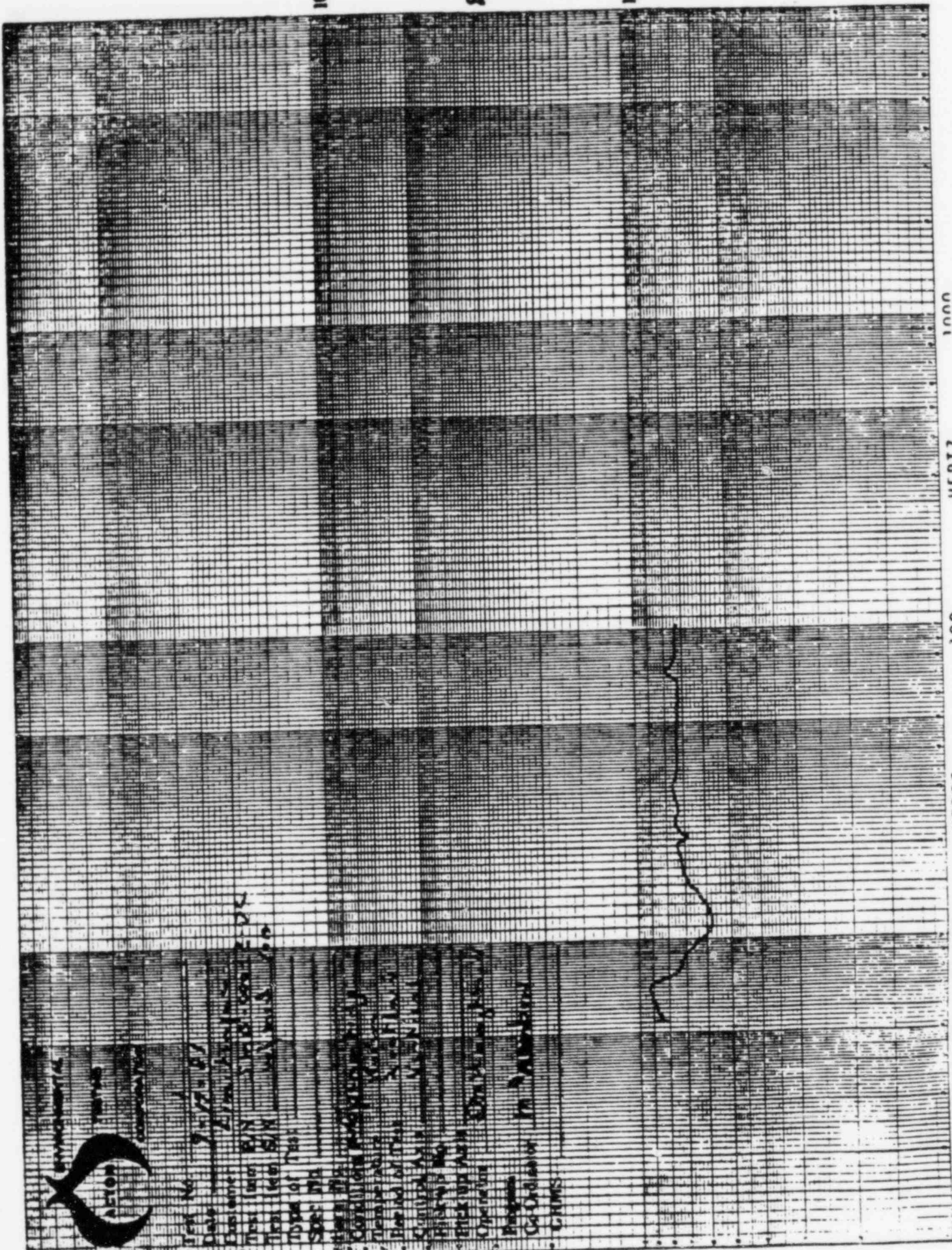
6.0 GRAPHS AND PHOTOGRAPHS

Report No. 16511-11





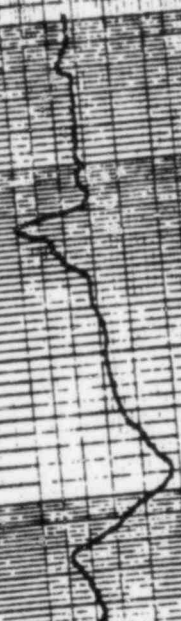
Test No. 9-11-67
 Date 9-11-67
 Customer Zim
 Test Item BN
 Test Lot 500
 Type of Test Wet
 Size of Test 100
 Station 100
 Conditional Pass OK
 Temperature 25
 Period of Test 10
 Sample No. 1
 Run No. 1
 Operator DM
 Program 10
 Co-ordinator 10
 C-11115



1000
 100
 10
 HERTZ
 UCOT7



Trans No: 9272-67
 Date: 12/18/67
 Customer: Washburn
 Most letter P/N
 Most item S/N
 Name of Tech
 S/Sgt No
 Name of
 Conclude
 Telephone
 Period of
 Control No
 Pict No
 Pict of
 Operator
 Program
 Co-Ordinator
 CHMS



1000
 100
 10
 1000
 100
 10

10. 10.



Test No. 103
 Date 9-22-56
 Customer Autumn Laboratory
 Test Item P/N 2-02
 Test Item S/N 10101
 Type of Test
 Spec. No.
 Part No.
 Conditions
 Test Method
 Period of Test
 Control No.
 Flicker No.
 Flicker Assm.
 Operator
 Program
 Co-Ordinator
 U.R.M.S.



1000

UCDT7

100

UCDT7

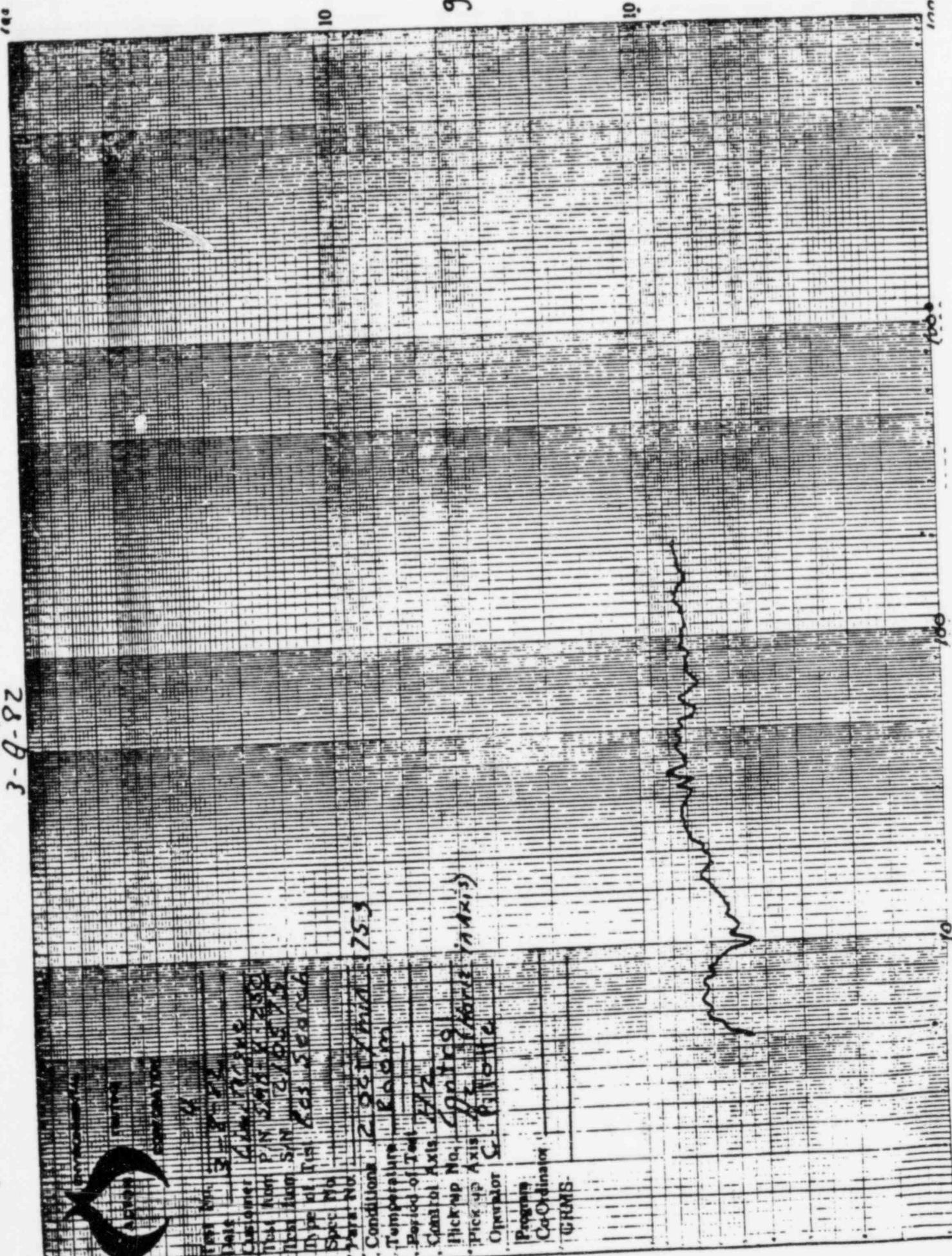
10

Job #16511
3-A-82



Test No. 4
 Date 3-8-75
 Customer CALIFORNIA
 Test Item P/N 2101-1-230
 Test Item S/N 2101-1-230
 Type of Test Res Search
 Spec No.
 Test No.
 Conditions 200Y/MIN 753
 Temperature Room
 Period of Test 172
 Control Axis 172
 Flick-up No. 172
 Pick-up Axis 172
 Operator S. P. Wolfe

Program
 Co-ordinator
 GRMS



Job # 13511



Item No. 6
 Date 3 Feb 8
 Location WINDFORD
 Test Item PIN SW-48-250
 Test Item Size 250

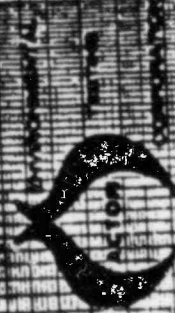
Type of Test SOURCE SURVEY
 Spec No.
 Item No.

Conditions 2000psi
 Temperature Room
 Method of Test
 Grind No. M. (Number of motor)
 Mesh No. 60 mesh
 Pickup Axis 45°

Operator G. F. HOGG
 Program
 Co-Ordinator
 LMS



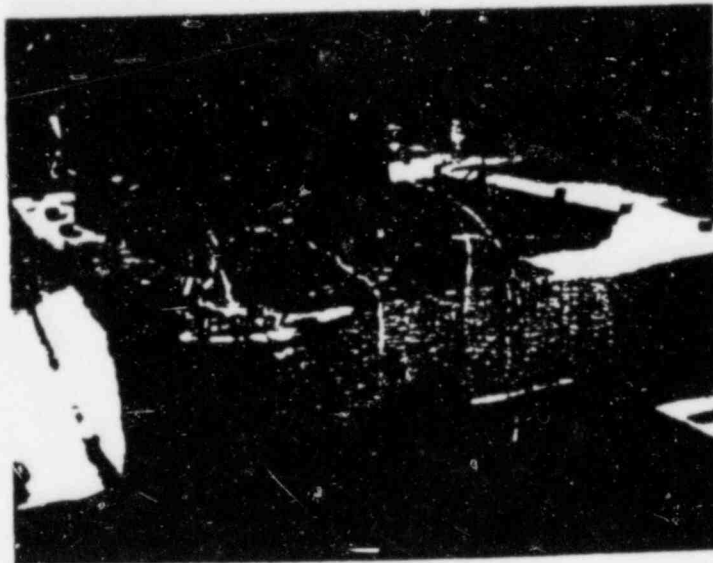
Job # 16511



Form No: 3-9-28
 Date: 3-9-28
 Customer: Union Pacific
 Test Item: FN 54610-250
 Test Item: SN 210575
 Type of Test: RES. Search
 Spec. No.
 Make No.
 Conditions: Res. Search, 15 min per PPT
 Member No.
 File No. of Test: 100-10000
 Control: W. H. [unclear]
 Machine No.
 Printer: [unclear]
 Operator: E. [unclear]
 Program:
 Backfiller:
 GAMS

Mr

10 5 10

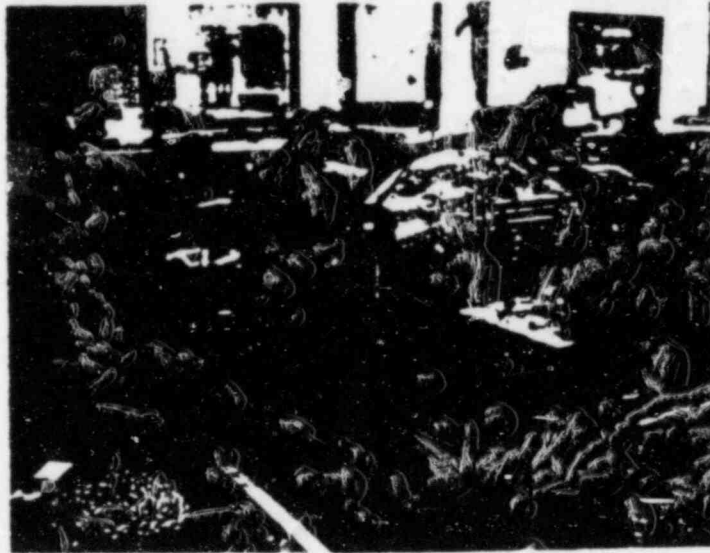


PHOTOGRAPH 1

SMB-4-250

LOCATION OF CONTROL ACCELEROMETER
AND ACCELEROMETERS 1, 2 and 3

Report No. 16511-11

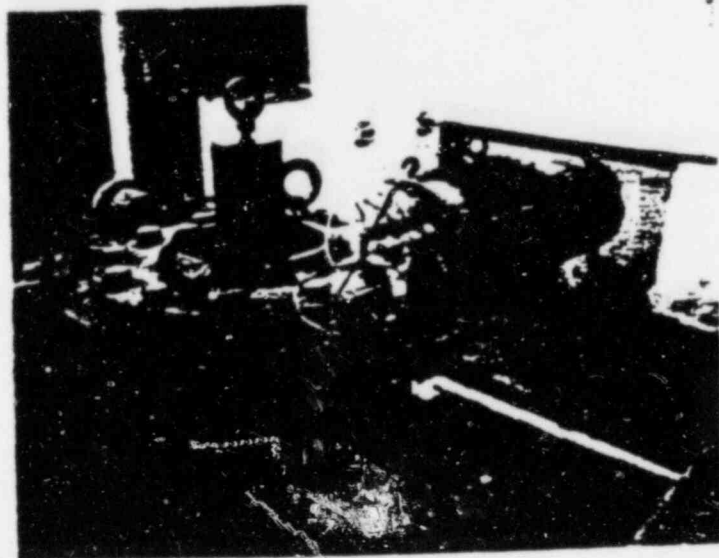


PHOTOGRAPH 2

SMB-4-250

LOCATION OF ACCELEROMETERS 4, 5 AND 6

Report No. 16511-11

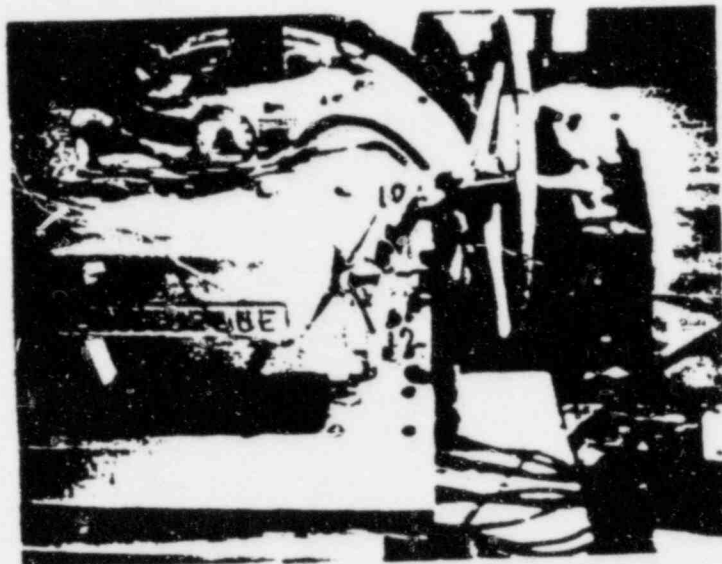


PHOTOGRAPH 3

SMB-4-250

LOCATION OF ACCELEROMETERS 7, 8, AND 9

Report No. 16511-11

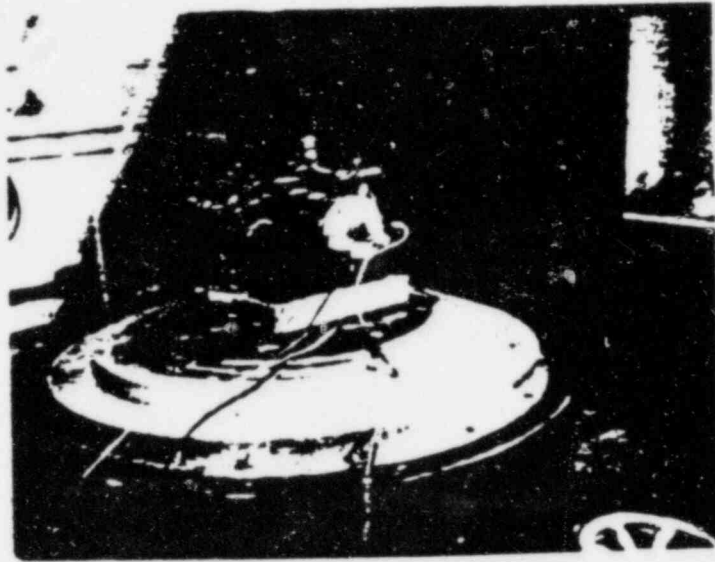


PHOTOGRAPH 4

SMB-4-250

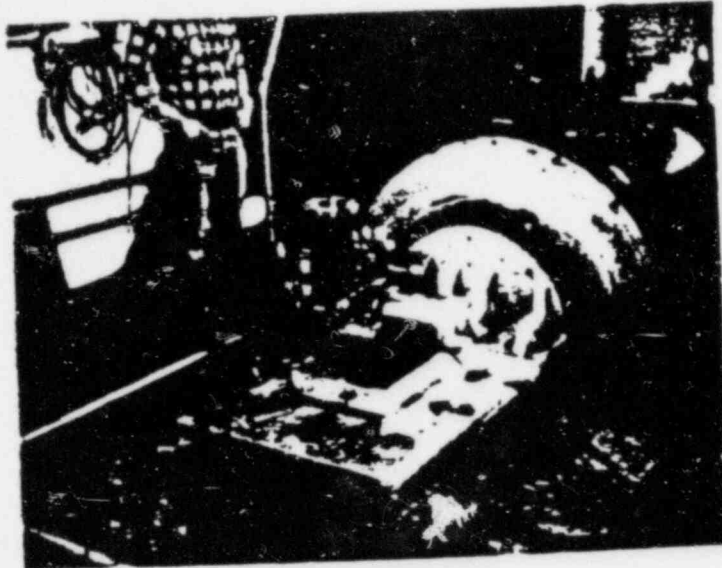
LOCATION OF ACCELEROMETERS 10, 11, AND 12

Report No. 16511-11



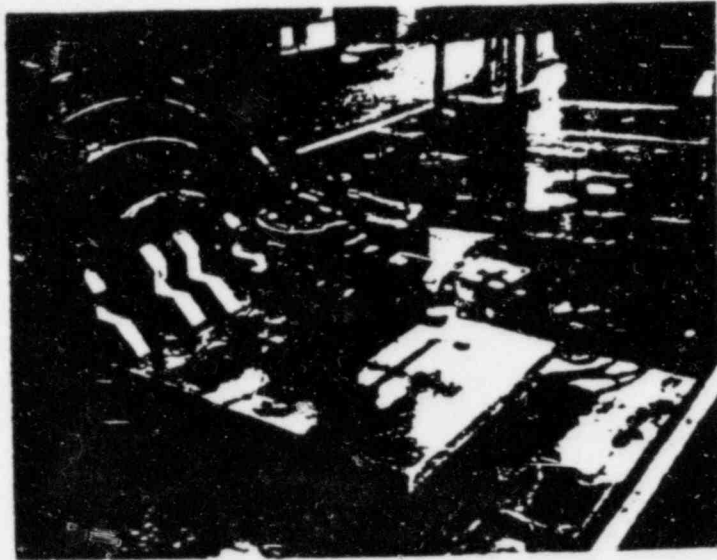
PHOTOGRAPH 5
SMB-000 w/MOD 10A
VERTICAL (V) AXIS OF EXCITATION
TEST NO. 1

Report No. 16511-11



PHOTOGRAPH 6
SMB-000 w/MOD 10A
HORIZONTAL (H₂) AXIS OF EXCITATION
PERPENDICULAR TO MOTOR AXIS
TEST NO. 2

Report No. 16511-11



PHOTOGRAPH 7
SMB-000 w/MOD 10A
HORIZONTAL (H_1) AXIS OF EXCITATION
PARALLEL TO MOTOR AXIS
TEST NO. 3

Report No. 16511-11



PHOTOGRAPH 8

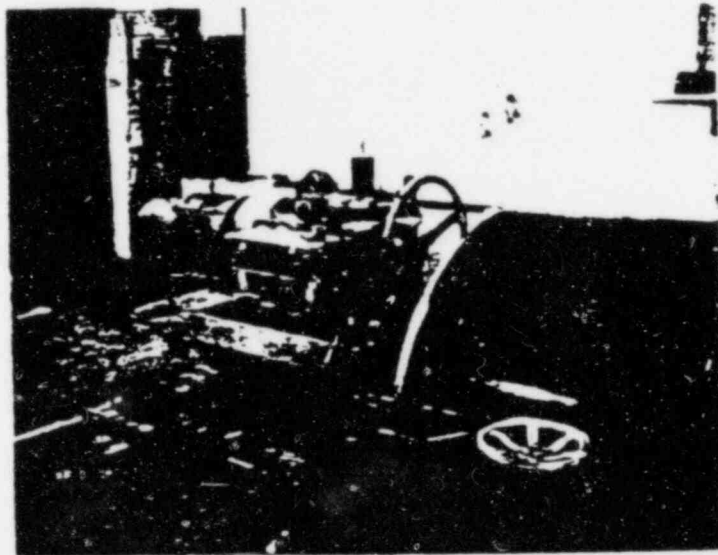
SMB-4-250

HORIZONTAL (H_2) AXIS OF EXCITATION

PERPENDICULAR TO MOTOR AXIS

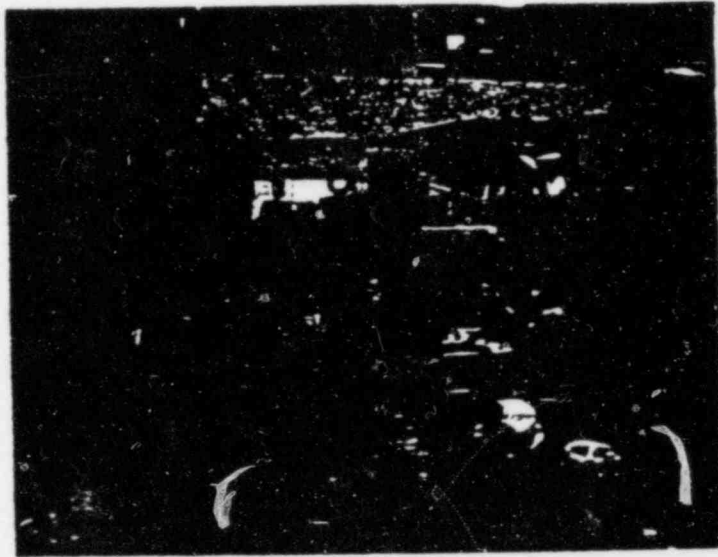
TEST NO. 4 & 5

Report No. 16511-11



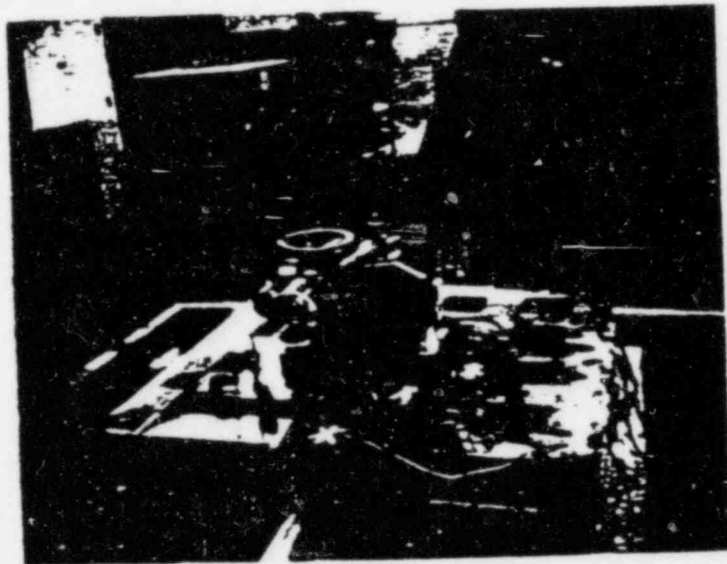
PHOTOGRAPH 9
SMB-4-250
HORIZONTAL (H_1) AXIS OF EXCITATION
PARALLEL TO MOTOR AXIS
TEST NO. 6, 6A, & 7

Report No. 16511-11



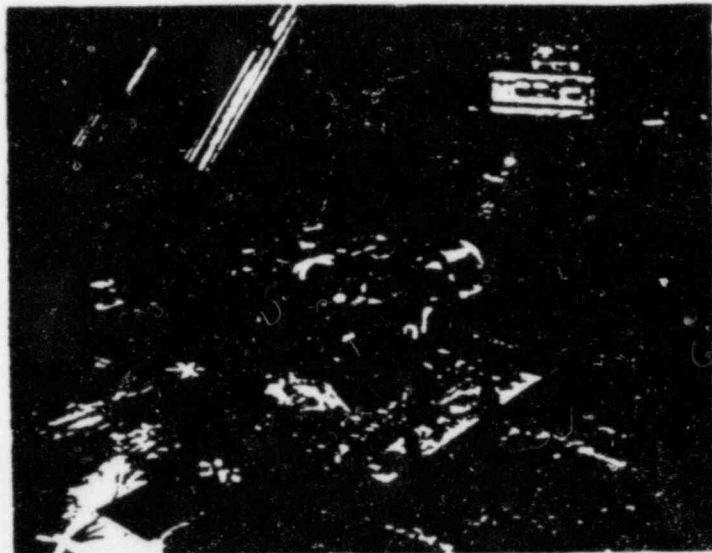
PHOTOGRAPH 10
SMB-4-250
VERTICAL (V) AXIS OF EXCITATION
TEST NO. 8 & 9

Report No. 16511-11



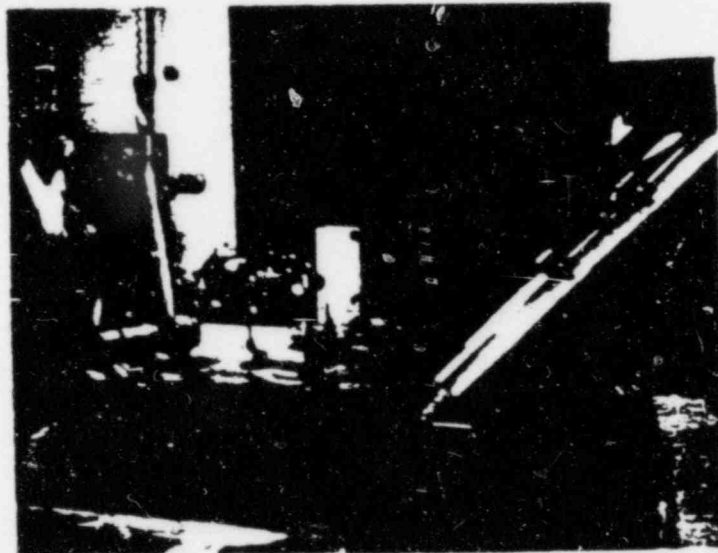
PHOTOGRAPH 11
SMB-000 w/MOD 10A
HORIZONTAL (H_1) AXIS OF EXCITATION
PARALLEL TO MOTOR AXIS
TEST NO. 10

Report No. 16511-11



PHOTOGRAPH 12
SMB-000 w/MOD 10A
HORIZONTAL (H₂) AXIS OF EXCITATION
PERPENDICULAR TO MOTOR AXIS
TEST NO. 11

Report No. 16511-11



PHOTOGRAPH 13
SMB-000 w/MOD 10A
VERTICAL (V) AXIS OF EXCITATION
TEST NO. 12

Report No. 16511-11

APPENDIX C
HYDRODYNAMIC TEST
SMB-1-60
SMB-2-60
ACTON TEST 16511-9

LIMITORQUE CORPORATION

Inter-Office Correspondence



DATE: May 19, 1982

FROM: C.H. Cox

TO: FILE

ATTENTION:

SUBJECT: Limitorque Research and Development Project
#681021 - High Frequency Hydrodynamic Loads
Testing

- Ref: 1) Bechtel Purchase Order 8856-P-37
2) Acton Environmental Testing Corporation
Reports 16511-9 and 16511-6
3) Test procedures for Limitorque valve
actuators - R&D Project #681021

Unit Identification and Description

Actuator Description

Type: SMB
Size: 1
Order No.: 381264-I
Serial No.: 216441

Motor Identification

I.D.#: L27513TZ TA
Frame: L187A
H.P: Spcl
Form: T
Volts: 250
Amps: 16.5
RPM: 1900
Duty: Special
Rise: 75°C
Field volts: 250
Field max amps: .329
Winding: Spcl. comp.
60lb-ft @ st
1 sec-12lb-ft
Run: 5 min.

Background

Prior to any hydrodynamic loads test, the Limitorque SMB-1-60-DC valve actuator was mounted on a test fixture to provide simulated valve seating loads during sine beat portions of the tests.

A check of output torque after all testing was completed indicated an average "closed" value of 1140lb-ft and an "open" value of 1080lb-ft (average).

The lower geared limit switch (of the 4-train assembly) was replaced prior to any testing with a geared limit switch assembled with a Navy shock bracket.

The actuator assembly was scanned for resonances (in each axis) before beginning sine beat tests. All test results from tests performed at Acton Labs can be found in the referenced reports accompanying this summary.

At the conclusion of hydrodynamic loads testing, the SMB-1-60-DC actuator was manually clutched and operated through a full open stroke-close stroke cycle. No apparent damage was detected.

Conclusion

The Limitorque valve actuator SMB-1-60-DC performed its function (as specified in test procedures for Project #681021) with no apparent malfunctions or physical damage. Both limit switches performed without failure.

Limit switch "drop-out" witnessed during portions of the sine beat test is due directly to improper contact made between the rotor and finger assembly. (Normal gap between the finger and the "L" bracket of the finger assembly, with measurement made at the finger assembly spring, should be .020/.040 inches.) Any lessening of spring tension would result in contact switch chatter.

C.M. Cox W.L.S.
Chas. H. Cox
Asst. Chief Test Engineer

/eab

LIMITORQUE CORPORATION

Inter-Office Correspondence



DATE: May 19, 1982

FROM: C.H. Cox

TO: FILE

ATTENTION:

SUBJECT: Limitorque Research and Development Project
#681021 - High Frequency Hydrodynamic Loads
Testing

- Ref: 1) Bechtel Purchase Order 8856-P-37
2) Acton Environmental Testing Corporation
Reports No. 16511-9 and 16511-7
3) Test procedures for Limitorque Valve
Actuators - R&D Project #681021

Unit Identification and Description

Actuator Description

Type: SMB
Size: 2
Order No.: 381264-A
Serial No.: 213425

Motor Identification

Manufacturer: Reliance Motor Co.
I.D.#: Y275111A3 RA
Frame: 215R2
Type: P
Ins. Class: B
H.P.: 7.9
RPM: 3390
Volts: 230/460
Amps: 21.4/10.7
Hz: 60
S.F.: 1.0

Amb: 40°C
Code: K
Phase: 3
Duty: 15min
Start: 60lb-ft
Run: 12lb-ft
75° Rise

Background

Prior to any hydrodynamic loads testing the Limitorque SMB-2-60-DC valve actuator was mounted on a test fixture to provide simulated valve seating loads during sine beat portions of the tests.

The unit was received with a "closed side" torque switch setting of "3", yielding a measured torque (average) of 1,556lb-ft. The setting on the "open side" of the torque switch was "2-3/4" yielding an average torque of 1,445lb-ft.

A modified two-rotor geared limit switch (Navy shock bracket with face plate) was installed, replacing the lower switch of the 4-rotor assembly.

The test actuator (with motor) was scanned for resonances (in each axis) before beginning sine beat tests. All test results from tests performed at Acton Labs can be found in the referenced reports accompanying this summary.

At the conclusion of hydrodynamic loads testing, the SMB-2-60 actuator was manually clutched and operated through a full open stroke-close stroke cycle. No apparent damage was detected.

NOTE: A heat aged (138°C - 300 hours), irradiated, Fiberite geared limit switch was attached to the test fixture during hydrodynamic loads testing. At the completion of testing the switch was manually operated and inspected showing no apparent physical damage or malfunction.

Conclusion

The Limitorque valve actuator SMB-2-60 performed its function (as specified in test procedures for Project #681021) with no apparent malfunctions or physical damage. Both limit switches functioned properly.

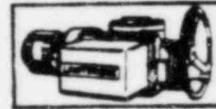
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C M Cox W.P.S.
Chas H. Cox
Asst. Chief Test Engineer

/eab

LIMITORQUE CORPORATION

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Reports 16511-9 and 16511-6
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Actuator Description

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Serial No.: 216441

Motor Identification

I.D.#: L27513TZ TA
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H.P: Spcl
Form: T
Volts: 250
Amps: 16.5
RPM: 1900
Duty: Special
Rise: 75°C
Field volts: 250
Field max amps: .329
Winding: Spcl. comp.
60lb-ft @ st
1 sec-12lb-ft
Run: 5 min.

Background

Prior to any hydrodynamic loads test, the Limitorque SMB-1-60-DC valve actuator was mounted on a test fixture to provide simulated valve seating loads during sine beat portions of the tests.

A check of output torque after all testing was completed indicated an average "closed" value of 1140lb-ft and an "open" value of 1080lb-ft (average).

The lower geared limit switch (of the 4-train assembly) was replaced prior to any testing with a geared limit switch assembled with a Navy shock bracket.

The actuator assembly was scanned for resonances (in each axis) before beginning sine beat tests. All test results from tests performed at Acton Labs can be found in the referenced reports accompanying this summary.

At the conclusion of hydrodynamic loads testing, the SMB-1-60-DC actuator was manually clutched and operated through a full open stroke-close stroke cycle. No apparent damage was detected.

Conclusion

The Limitorque valve actuator SMB-1-60-DC performed its function (as specified in test procedures for Project #681021) with no apparent malfunctions or physical damage. Both limit switches performed without failure.

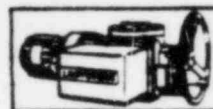
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Chas. H. Cox *W.L.S.*
Asst. Chief Test Engineer

/eab

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Actuator Description

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Size: 2
Order No.: 381264-A
Serial No.: 213425

Motor Identification

Manufacturer: Reliance Motor Co.
I.D.#: Y275111A3 RA
Frame: 215R2
Type: P
Ins. Class: B
H.P.: 7.9
RPM: 3390
Volts: 230/460
Amps: 21.4/10.7
Hz: 60
S.F.: 1.0

Amb: 40°C
Code: K
Phase: 3
Duty: 15min
Start: 60lb-ft
Run: 121lb-ft
75° Rise

Background

Prior to any hydrodynamic loads testing the Limitorque SMB-2-60-DC valve actuator was mounted on a test fixture to provide simulated valve seating loads during sine beat portions of the tests.

The unit was received with a "closed side" torque switch setting of "3", yielding a measured torque (average) of 1,556lb-ft. The setting on the "open side" of the torque switch was "2-3/4" yielding an average torque of 1,445lb-ft.

A modified two-rotor geared limit switch (Navy shock bracket with face plate) was installed, replacing the lower switch of the 4-rotor assembly.

The test actuator (with motor) was scanned for resonances (in each axis) before beginning sine beat tests. All test results from tests performed at Acton Labs can be found in the referenced reports accompanying this summary.

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Conclusion

The Limitorque valve actuator SMB-2-60 performed its function (as specified in test procedures for Project #681021) with no apparent malfunctions or physical damage. Both limit switches functioned properly.

Limit switch "drop-out" witnessed during portions of the sine beat test is a result of abnormal spring tension caused by an incorrect gap between the finger and "L" bracket of the finger assembly. (Correct gap is .020/.040 inches).

C M Cox W.F.S.
Chas H. Cox
Asst. Chief Test Engineer

/eab



Test Report No. 16511-9

No. of Pages 28

Revision 1 - 6/9/82

Report of Test

FOR

HYDRODYNAMIC LOADING QUALIFICATION OF TWO
ACTUATORS SMB-1-60 (DC) AND SMB-2-60 (AC)
FOR LIMITORQUE CORPORATION

RD-288

Purchase Order No. _____

Prepared by:

William C. McGinnis
William C. McGinnis, Project Engineer
Acton Environmental Testing Corporation
533 Main Street, Acton, MA 01720

Date June 18, 1982

Reviewed &
Approved by:

Richard S. Gilfoy Jr.
Richard S. Gilfoy, Jr. Chief Dynamics Engineer
Acton Environmental Testing Corporation

Date June 19, 1982

WCM/laf

REVISION RECORD

DATE	REVISION NUMBER	PAGE NUMBER	PARAGRAPH NUMBER	CHANGES OR ADDITIONS	APPROVED BY
0 -----FIRST ISSUE-----					
6/9/82	1	Cover		Added Rev. 1, 6/9/82 *Replaced 'Seismic' with 'Hydrodynamic Loading'	SB
		1,2		*Replaced 'Seismic' with Hydrodynamic Loading'	
		3	2.1	Changed Section 2.1 to read 'The purpose of the Resonance Survey Test was for information only'	
		4	3.2	Delete 'of' from 'Top of Limit Switch'	
		5	3.2	Delete 'of the' from 'On the Bottom of the Limit Switch'	
		9	4.1.1	Delete '5-6Hz Stem Rapping' and '18-22 Hz Handle Rapping' change to '100 Hz Undefined' and '125 Hz Undefined'	
		9	4.1.2	Add Motor and Bottom Limit Switch to table *Changed per Limitorque letter dated 5/19/82.	
7/15/82	2	11	4.2.1.1	Added Paragraph 4.2.1.1	ACM



Report No. 16511-9

ADMINISTRATIVE DATA

- 1.0 PURPOSE OF TEST: Hydrodynamic Loading Qualification of two (2) actuators for Limitorque Corporation
- 2.0 MANUFACTURER: Limitorque Corporation
P.O. Box 11318
Lynchburg, VA 24506
- 3.0 MANUFACTURER'S TYPE OR MODEL NO: SMB-1-60 (DC)
SMB-2-60 (AC)
- 4.0 DRAWING, SPECIFICATION OR EXHIBIT: Limitorque Test Procedure
Project No. 681021
- 5.0 QUANTITY OF ITEMS TESTED: Two (2)
- 6.0 SECURITY CLASSIFICATION OF ITEMS: Unclassified
- 7.0 DATE TEST COMPLETED: November 17, 1981
- 8.0 TEST CONDUCTED BY: D. McLaughlin, C. Forbes
- 9.0 DISPOSITION OF SPECIMENS: Returned to Limitorque Corporation
- 10.0 ABSTRACT: Refer to Section 4.0

Report No. 16511-9
Rev. 1



1.0 TEST ITEM

Two (2) Actuators, SMB-1-60 (DC) and SMB-2-60 (AC), were submitted by Limitorque Corporation for hydrodynamic loading qualification testing at the Acton Environmental Testing Corporation. Each actuator was subjected to a Resonance Survey and a Sine Beat Test.

Report No. 16511-9
Rev. 1



2.0 TEST REQUIREMENTS

2.1 Resonance Survey Test

The purpose of the Resonance Survey Test was for information only.

2.2 Sine Beat Test

The purpose of the Sine Beat Test was to subject each actuator to the required sine beat excitation, in order to determine the actuators' functional integrity and ability to withstand such excitation without evidence of mechanical damage or deterioration.

Report No. 16511-9
Rev. 1



Page 3

3.0 TEST PROCEDURE

3.1 Test Mounting

Each actuator was submitted by Limitorque Corporation bolted to an aluminum plate. The aluminum plate had a pre-drilled bolt pattern in order to adapt it to the head of an AETC A-249 electrodynamic shaker. The actuator/fixture plate assembly was attached to the A-249 for sine beat testing in the frequency range 20 to 100 Hz. The actuator/fixture plate assembly was rigidly clamped to the single axis hydraulic shaker for sine beat testing in the frequency range of 2 to 16 Hz.

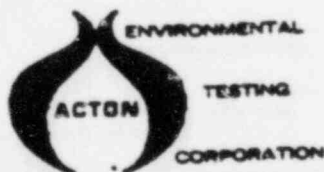
3.2 Test Monitoring

Each actuator was visually monitored for any evidence of mechanical damage or deterioration by Limitorque personnel.

The actuators were instrumented with five (5) triaxial groups of accelerometers. The accelerometers were located on each actuator as follows:

<u>ACCELEROMETER</u>	<u>SENSE</u>	<u>LOCATION</u>
1	H ₂	Top Limit
2	H ₁	Switch
3	V	

Report No. 16511-9
Rev. 1



3.2 Test Monitoring (continued)

<u>ACCELEROMETER</u>	<u>SENSE</u>	<u>LOCATION</u>
4	H ₁	Base of Fixture
5	H ₂	
6	V	
7	H ₁	On the Motor
8	H ₂	
9	V	
10	H ₁	SMB
11	H ₂	
12	V	
13	H ₁	On the Bottom Limit Switch
14	H ₂	
15	V	

H₁ - Parallel to the Motor
H₂ - Perpendicular to the Motor
V - Vertical

Outputs from all accelerometers through appropriate signal conditioning were recorded on visicorder recording paper which is included with this report.

Limitorque personnel operated the actuators during the test to determine functional integrity.

3.3 Resonance Survey Test

The resonance survey was performed in the three (3) mutually orthogonal axes of excitation, one (1) vertical and

Report No. 16511-9
Rev. 1



3.3 Resonance Survey Test (continued)

two (2) horizontal axes. The resonance survey consisted of a sinusoidal input with peak accelerations of 0.75g's performed at a sweep rate of 2 octaves/min. in the frequency bandwidth of 5 to 200 Hz.

3.4 Sine Beat Test

The Sine Beat Test was performed in three (3) mutually orthogonal axes of excitation, two (2) horizontal and one (1) vertical. The test consisted of amplitude modulated sinusoids with peak horizontal and vertical accelerations of 10g's (except when limited by AETC shaker capabilities as listed below). The beat for a given frequency was 5 beats, 15 cycles/beat with a sufficient pause between beats to preclude any superposition of motion. The Sine Beats were performed at the following frequencies and acceleration levels:

SMB-2-60 (AC)

<u>FREQUENCY (Hz)</u>	<u>ACCELERATION (g's)</u>
2	3
2.6	4
3.3	7.5
4	6.5

16511-9

Report No. _____



3.4 Sine Beat Test (continued)

SMB-2-60 (AC)

<u>FREQUENCY (Hz)</u>	<u>ACCELERATION (g's)</u>
5.3	8
6.6	10 Horiz., 8 Vert
8	10 Horiz., 8 Vert
10.6	10
13.2	10
16	10
20	10
26.6	10
32	10
42.6	10
53.2	10
64	10
85.3	10
100	10

SMB-1-60 (AC)

<u>FREQUENCY (Hz)</u>	<u>ACCELERATION (g's)</u>
2	3
2.6	4
3.3	7.5
4	9
5.3	10
6.6	10
8	10
10.6	10
13.2	10
16	10
20	10
26.6	10
32	10
42.6	10
53.2	10

Report No. 16511-9

3.4 Sine Beat Test (continued)

SMB-1-60 (AC)

<u>FREQUENCY Hz</u>	<u>ACCELERATION (g's)</u>
64	10
91	Performed only in the Vertical Axis
85.3	10
100	10

During each beat, the actuator was operated by Limitorque personnel from limit switch-open position to torque seated-close position, and at each alternate beats, from torque seated-close position to limit switch-open position. During the Sine Beat Test on the SMB-2-60 (AC), a set of heat-aged inside containment and outside containment limit switches were attached to the test fixture for visual monitoring by Limitorque personnel.

Report No. 15511-9

4.0 TEST RESULTS

4.1 Resonance Survey Test Results

4.1.1 SMB-2-60 (DC)

Resonant frequencies were measured as follows:

<u>AXIS</u>	<u>FREQUENCY</u>
Horizontal (H ₁)	None
Horizontal (H ₂)	100 Hz Undefined 125 Hz Undefined
Vertical	160 Hz Limit Switch 155 Hz Motor

4.1.2 SMB-1-60 (DC)

Resonant frequencies were defined as follows:

<u>AXIS</u>	<u>FREQUENCY</u>
Horizontal (H ₁)	190 Hz Motor
Horizontal (H ₂)	135 Hz Bottom Limit Switch
Vertical	140 Hz Motor 180 Hz Motor

4.2 Sine Beat Test Results

4.2.1 SMB-2-60 (DC)

The Sine Beat Test in the horizontal (H₁) axis at 100 Hz, 10g's caused the unit to shut down. The

Report No. 16511-9
Rev. 1



4.2.1 SMB-2-60 (DC) (continued)

acceleration was lowered to 5g's at 100 Hz and the unit still shut down. The frequency was lowered to 95 Hz at 10g's and the unit shut down again. The frequency was lowered to 90 Hz at 10g's and then functioned properly. It appeared the limit switches or torque switches were sensitive to frequency in the 95 to 100 Hz range. No other anomalies were encountered in the axis.

The Sine Beat Test in the horizontal (H₂) axis at 85.3 Hz, 10g's caused the unit to shut down. The acceleration level was lowered to 7g's, 8g's, and 9g's and the unit functioned properly at these levels. At 100 Hz, 10g level the unit shut down 1 out of 3 times. No other anomalies were encountered in this axis of excitation.

No anomalies were encountered for the Sine Beat Test in the vertical axis. After testing in all three axes, Limitorque personnel replaced the lower-limit switch set with a lower-standard-limit switch set. Sine

Report No. 16511-9



4.2.1 SMB-2-60 (DC) (continued)

beat excitation was performed as described in Section 3.4 in only the vertical axis of excitation. This test was performed to visually monitor structural integrity of the lower limit switch.

4.2.1.1 SRV Fatigue Test

A sine sweep in the vertical axis from 10 to 70 Hz to 10 Hz at a level of 3g at a sweep rate of 1 octave/minute was performed. This test was performed following the completion of all sine beat tests in accordance with customer request. (Refer to Pages 23 and 24.) The unit was non-operating during sweep.

4.2.2 SMB-1-60 (AC)

The Sine Beat Test in the horizontal (H₁) axis produced no anomalies. The unit operated properly during all excitation in this axis.

The Sine Beat Test in the horizontal (H₂) axis at 85.3 Hz and 100 Hz caused the limit switches to drop out. There were no other anomalies in this axis of excitation.

The Sine Beat Test in the vertical axis of excitation produced no anomalies. The unit operated properly during all vibration in this axis.

Report No. 16511-9
Rev. 2



TEST EQUIPMENT LIST

NAME	MFG.	MODEL	SER. NO.	RANGE	ACCURACY	INV. #	CAL. FREQ.
Accelerometer	PCB	302A	2845	1 Hz - 5 KHz	±5%	AC383	6 months
Accelerometer	PCB	302A	1983	1 Hz - 5 KHz	±5%	AC440	6 months
Accelerometer	PCB	302A	672	1 Hz - 5 KHz	±5%	AC381	6 months
Accelerometer	PCB	302A	695	1 Hz - 5 KHz	±5%	AC385	6 months
Accelerometer	PCB	302A	1779	1 Hz - 5 KHz	±5%	AC422	6 months
Accelerometer	PCB	302A	1808	1 Hz - 5 KHz	±5%	AC427	6 months
Accelerometer	PCB	302A	1780	1 Hz - 5 KHz	±5%	AC423	6 months
Accelerometer	PCB	302A	1809	1 Hz - 5 KHz	±5%	AC428	6 months
Accelerometer	PCB	302A	2853	1 Hz - 5 KHz	±5%	AC395	6 months
W/B Decade Amplifier	ALI	500A	858	5 to 1 MHz ±1dB Output 20V/20k Ohm	±1%	AM302	OFS
Digital Function Gener.	MTS	410.31	894	0.00001 Hz to 990 Hz Output: 0 to ±10V		PE311	6 months
Earthquake Simulator Hydraulic Actuator	MTS	908.34-01 204.63S		24" DA max. DC-200 Hz, 22K force lbs.	±5 amp	PE367	6 months
Controller	MTS	443.115		DC to 2000 Hz	±1%		
Power Supply	Dennison	Mod. 63		120 GPM Max. 3K-5K psi max 250 HP	NA	PE367	
Power Supply	PCB	483M23	288	12 Channel X1 & X5 gain filter Freq. 50 Hz	±2%	PE384	6 months
Scope, Storage	TEK	T912	T912 B015169	DC-10 MHz Dual Trace	±3%	OS305	6 months
Sweep Oscillator	SDY	SD-104-5	21A	0.005 Hz - 50 KHz	±1%	SG315	6 months
Visicorder	HON	1508	15-419	12 Channels, 8" Paper	±1 db	RE349	6 months

Electro Rent #43560 Visi 3-1-82

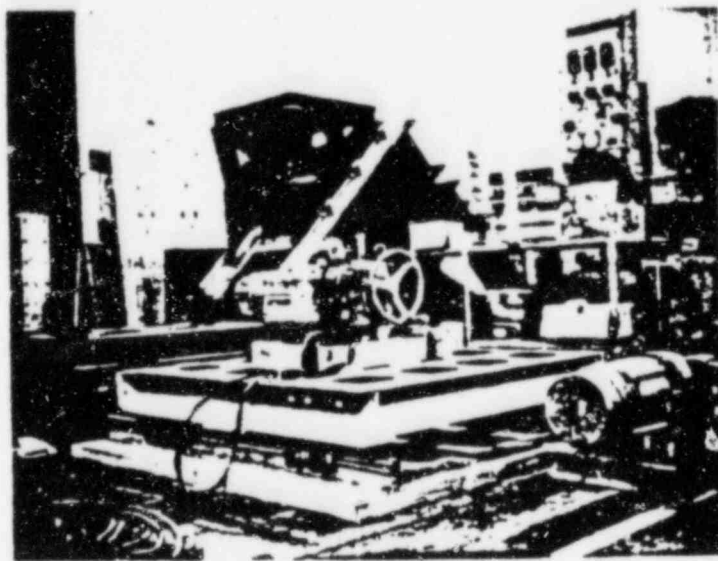


PHOTO 1

SMB-1-60
HORIZONTAL (H_1) AXIS OF EXCITATION
PARALLEL TO MOTOR

Report No. 16E11-9

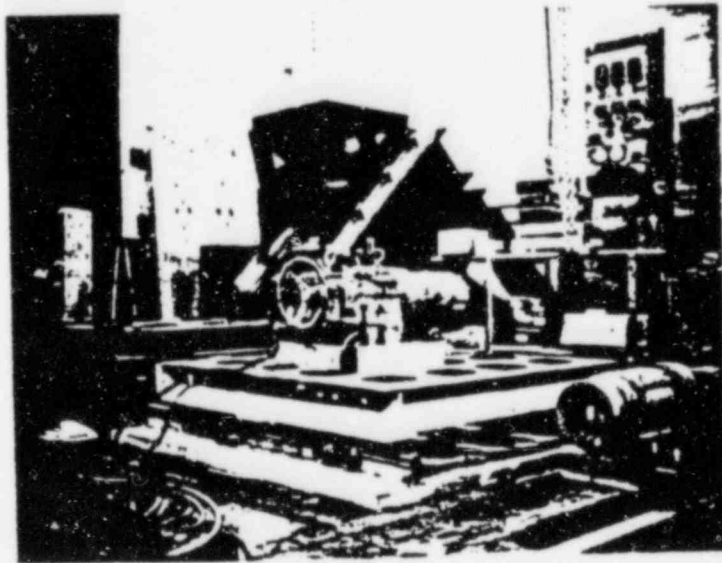


PHOTO 2

SMB-1-60
HORIZONTAL (H_2) AXIS OF EXCITATION
PERPENDICULAR TO MOTOR AXIS

Report No. 16511-9

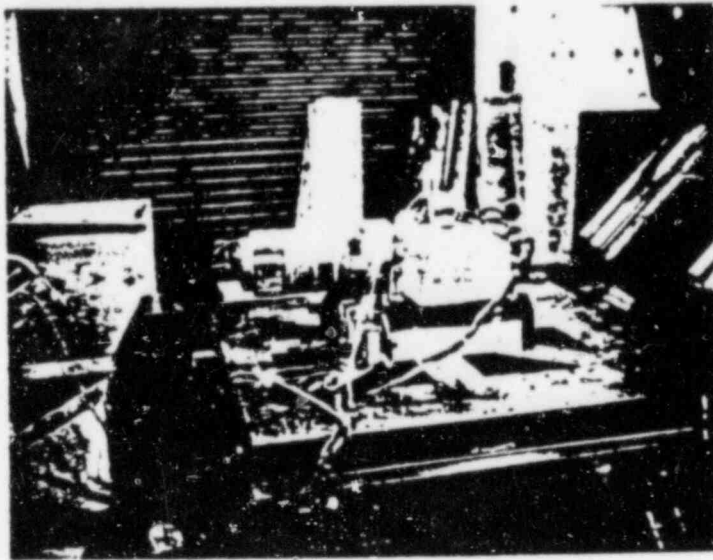


PHOTO 3

SMB-1-60

VERTICAL AXIS OF EXCITATION

Report No. 16511-9

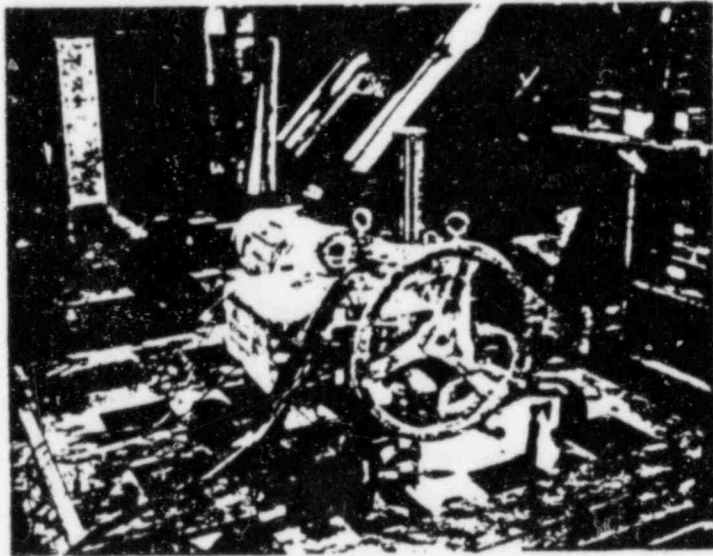


PHOTO 4

SMB-2-60

HORIZONTAL (H_1) AXIS OF EXCITATION
PARALLEL TO MOTOR AXIS

Report No. 16511-9

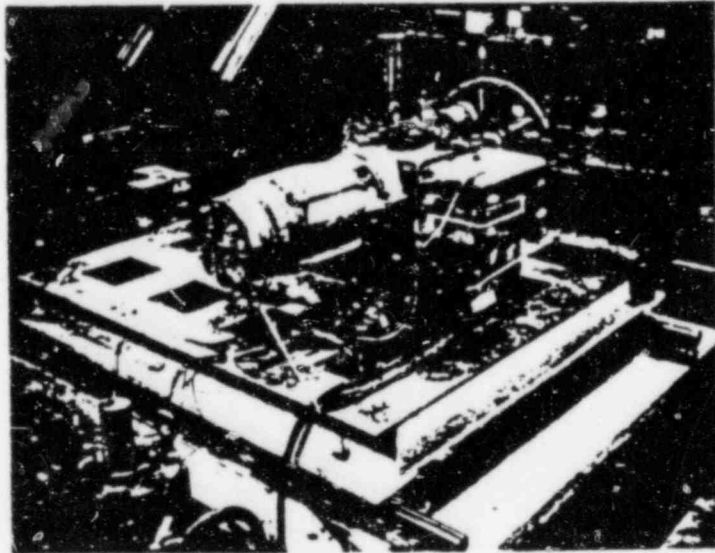


PHOTO 5

SMB-2-60

HORIZONTAL (H_2) AXIS OF EXCITATION
PERPENDICULAR TO MOTOR AXIS

Report No. 16511-9

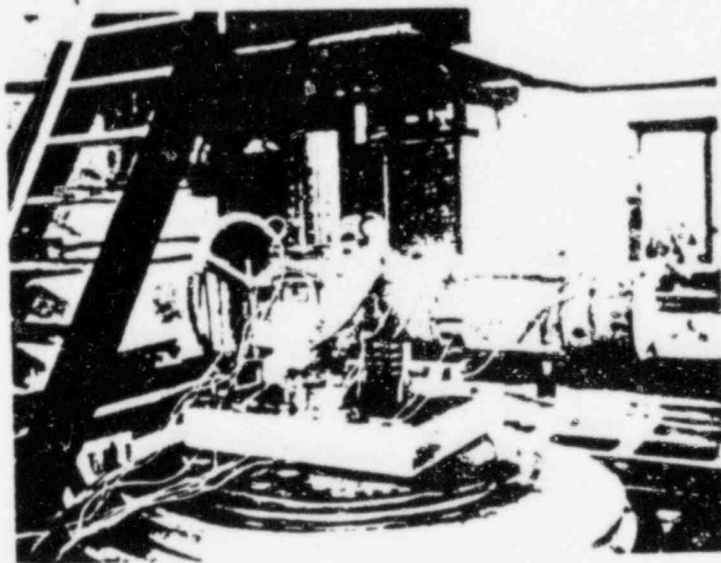


PHOTO 6
SMB-2-60
VERTICAL AXIS OF EXCITATION

Report No. 16511-9

PLOTS OF RESONANCE SURVEY
ACCELERATION LEVELS 5-200 HZ

Report No. 16511-9



Page 19



Test No. 14 16511-9
 Date 11/11/81
 Customer Limbsong
 Test Item P/N _____
 Test Item S/N _____
 Type of Test _____
 Spec No _____
 Para. No. _____
 Conditions Normal operation
 Temperature Room
 Period of Test 2 test runs
 Control Axis Hz
 Pick-up No. _____
 Pick-up Axis _____
 Operator Don Slough
 Program _____
 Co-Ordinator M. C. ...
 CRMS _____





Test No. 12-16511-9
Date 11/11/81
Customer Libertina
Test Item P/N SMB1-60
Test Item S/N _____
Type of Test _____
Spec No. _____
Part No. _____
Conditions Misc. operating
Temperature Room
Period of Test 2000
Control Axis He
Pick-up No. _____
Pick-up Axis _____
Operator D. M. Steyble
Program _____
Co-Ordinator M. C. ...
GRMS _____

10.0

8-

10





Test No. 10-16511-9

Date 11/1/81

Customer Limiting

Test Item P/N Smb2-c4

Test Item S/N

Type of Test

Spec No.

Para. No.

Conditions Very agitating

Temperature Room

Period of Test 20cfm

Control Axis Vertical

Pick-up No.

Pick-up Axis

Operator D. M. Long Jr.

Program

Co-Ordinator M. S. ...

GRMS



10 100 1000 HERTZ



Test No. 89-16511-9

Date 11-12-81

Customer Lincoln

Test Item P/N SM82-50

Test Item S/N

Type of Test

Spec No.

Para No.

Conditions Non operational

Temperature Room

Period of Test Test limit

Control Axis Vertical

Pick-up No.

Pick-up Axis

Operator Dr. C. L. H.

Program

Co-Ordinator in Control box

GRMS



1000
HERTZ
100
HERTZ
10



Test No. 89-16511-9

Date 11-2-81

Customer Lima Tank

Test Item P/N SM3-50

Test Item S/N

Type of Test

Spec. No.

Para. No.

Conditions New operating

Temperature 8000

Period of Test 1000

Control Axis Vertical

Pick-up No.

Pick-up Axis

Operator S. McLaughlin

Program

Co Ordinator M. Casanova

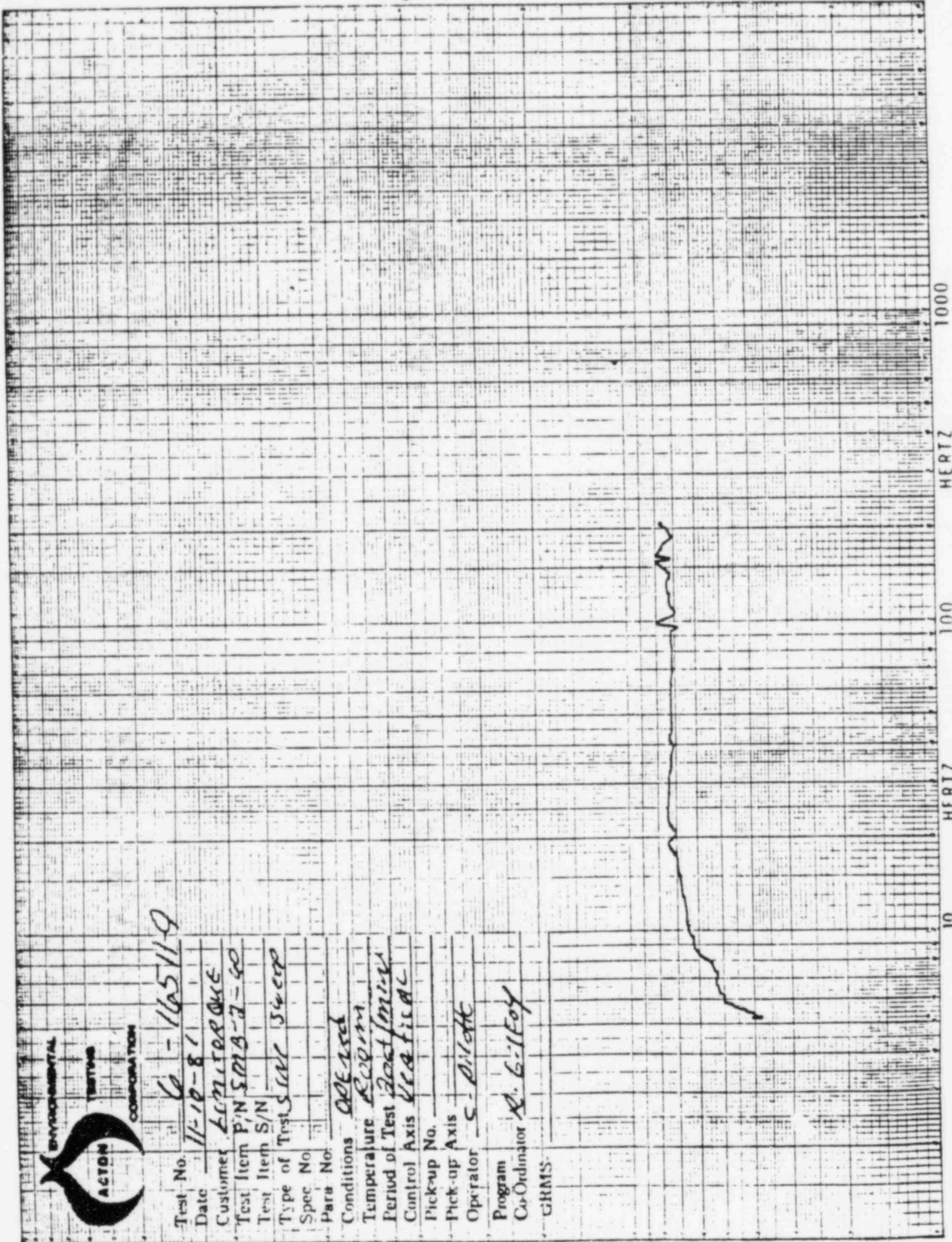
GRMS



1000 HERTZ 100 HERTZ 10 HERTZ



Test No. 6-165119
Date 11-10-81
Customer COMMERQUE
Test Item P/N 5018-2-50
Test Item S/N _____
Type of Test SIN SWEEP
Spec No. _____
Para No. _____
Conditions OPERATED
Temperature ROOM
Period of Test 200 MIN
Control Axis VIBRATIONAL
Pick-up No. _____
Pick-up Axis _____
Operator S. PILATE
Program _____
Co-Ordinator A. GILFOY
GRMS _____



10,
2

10

1000
HERTZ
100
HERTZ
10



Test No. 4-145119
 Date 11-10-81
 Customer LIMITOR 246
 Test Item P/N SMB-2-60
 Test Item S/N _____
 Type of Test SINE SWEEP
 Spec No. _____
 Para No. _____
 Conditions OPENED
 Temperature Room
 Period of Test 202 min
 Control Axis H_z
 Pickup No. _____
 Pickup Axis _____
 Operator C. PILATE
 Program _____
 Co-Ordinator R. Gilfoy
 GRMS _____



1000
 HERTZ
 100
 HERTZ
 10



Test No. 2-165119
 Date 11-14-81
 Customer Lim. Toyota
 Test Item P/N SMB-3-60
 Test Item S/N _____
 Type of Test _____
 Spec No _____
 Para No _____
 Conditions Control
 Temperature Room
 Period of Test 2.5 sec/1 min
 Control Axis H
 Pick-up No. _____
 Pick-up Axis _____
 Operator Dr. S. Long
 Program _____
 Co-Ordinator M. C. ...
 GRMS _____

1000
HERTZ
100
HERTZ
10

APPENDIX D
HYDRODYNAMIC TEST
SMB-00-15/H2BC
ACTON TEST 16511-10

LIMITORQUE CORPORATION

Inter-Office Correspondence



DATE: June 2, 1982

FROM: C.H. Cox

TO: FILE

ATTENTION:

SUBJECT: Limitorque Research and Development
Project #681021 - High Frequency
Hydrodynamic Loads Testing

Ref: 1) Bechtel Purchase Order 8856-P-37
2) Acton Environmental Testing Corporation
Reports #16511-3 and #16511-10
3) Test procedures for Limitorque valve
actuators - R&D Project #681021

Unit Identification and Description

Actuator Description

Type: SMB
Size: 00
Order #: 389499A
Serial#: 233835

Manual Unit

Type: H
Size: 2BC
Order #: 389499A
Serial #: 233845
Position B

Motor Identification

Manufacturer: Reliance Motor Company
I.D.#: 447026-WA
H.P: 1
Start: 15lb-ft
Run: 3ft-lb
Frame: M56
Type: P
Phase: 3
RPM: 1700
Volts: 230/460
Amps: 5.6/218
Ambient °C: 40
Ins. Class: B
Duty: 15 min.

Background

Prior to any hydrodynamic loads testing, the Limitorque SMB-00-15/H2BC was mounted on a test fixture to provide simulated valve seating loads during sine beat portions of the tests.

Post test torque calibration checks indicated an average torque in the "closed" direction of 810lb-ft and an average torque in the "open" direction of 860lb-ft.

The top geared limit switch (rotors 1 & 2) were replaced with a switch modified with Navy shock bracket and micarta end plate. The bottom switch contained the standard Navy shock bracket only.

The assembly was scanned for resonance (in each axis) before beginning sine beat tests. All results from tests performed at Acton Labs can be found in reports accompanying this summary.

At the conclusion of hydrodynamic loads testing, the SMB-00-15/H2BC actuator was manually clutched and operated through a full open stroke-close stroke cycle. No apparent damage was detected.

Conclusion

The Limitorque SMB-00-15/H2BC successfully performed its function (as specified in test procedures for Project #681021) with no apparent malfunction or physical damage.

C.M. Cox
Chas. H. Cox *N.R.S.*
Asst. Chief Test Engineer

/eab

Attachments



Test Report No. 16511-10
Rev. 1, 6/7/82

No. of Pages 16

Report of Test

FOR

HYDRODYNAMIC LOADING VIBRATION TESTING
OF ONE (1) SMB-00/H2BC
LIMITORQUE ACTUATOR
FOR LIMITORQUE CORPORATION

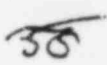
Purchase Order No. RD-288

Prepared by: Philip D. Hartz Date 12-3-81
Philip D. Hartz, Project Engineer
Acton Environmental Testing Corporation
533 Main Street, Acton, Massachusetts 01720

Reviewed & Approved by: Richard S. Gilfoy Date 3 Dec 81
Richard S. Gilfoy, Chief Dynamics Engineer
Acton Environmental Testing Corporation

PDH/tjw

REVISION RECORD

DATE	REVISION NUMBER	PAGE NUMBER	PARAGRAPH NUMBER	CHANGES OR ADDITIONS	APPROVED BY
0 -----FIRST ISSUE-----					
6/7/82	1	Cover		Added Rev. 1, 6/7/82 *Replaced 'Seismic' with Hydrodynamic Loading'	
		1	1.0	Deleted 'cover' on Administrative Data Sheet	
		1,2,9		*Replaced 'Seismic' with 'Hydrodynamic Loading'	
		9		Added 'Top of Actuator' to table	
				*Changed per Limitorque letter dated 5/19/82.	
		12		Added Rental Equipment specifications to Test Equipment List	



Report No. 15611-10

Administrative Data

- 1.0 Purpose of Test: Hydrodynamic Loading qualification testing of one (1) SMB-0015/H2BC Actuator.
- 2.0 Manufacturer: Limatorque Corporation
5114 Woodall Road/P.O. Box 11318
Lynchburg, VA 24506
- 3.0 Manufacturer's Type or Model No: SMB-0015/H2BC
- 4.0 Drawing, Specification or Exhibit: Test Procedure
Sine Beat Seismic Dwell Test
Bechtel P.O. 8856-P-37, Limatorque
681021
- 5.0 Quantity of Items Tested: One (1)
- 6.0 Security Classification of Items: Unclassified
- 7.0 Date Test Completed: October 27, 1981
- 8.0 Test Conducted By: D. McLaughlin
- 9.0 Disposition of Specimens: Returned to Limatorque Corporation
- 10.0 Abstract: Refer to Section 4.0

Report No. 16511-10

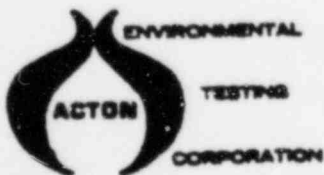
Page 1
Rev. 1



1.0 TEST ITEM

One (1) Limatorque SMB-00 15/H2BC actuator was submitted by Limatorque Corporation for hydrodynamic loading vibration testing at Acton Environmental Testing Corporation (AETC).

Report No. 16511-10
Rev. 1



Page 2

2.0 TEST REQUIREMENTS

2.1 Resonance Survey Test Requirements

The purpose of the resonance survey specified in Section 3.3 was to determine the resonant frequencies in the 5 to 100 Hz bandwidth for the actuator structure. The resonance survey was conducted in each of three (3) mutually perpendicular axes with a low-level sinusoidal input.

2.2 Sine Beat Test Requirements

The purpose of the sine beat test specified in Section 3.4 was to determine the actuator's ability to withstand the sine beat vibration without evidence of mechanical damage, deterioration, or interference with proper operation.

Report No. 16511-10



Page 3

3.0 TEST PROCEDURES

3.1 Test Mounting

The SMB-00 15/H2BC actuator was bolted to an aluminum plate test fixture such that the actuator would be limited by the torque switch in the seated position. The actuator/fixture assembly was mounted on the Acton Environmental Testing Corporation electrodynamic shaker for the resonance survey and for sine beat testing above 12.5 Hz. The actuator/fixture assembly was mounted on a single-axis seismic shaker table for sine beat testing from 2 to 12.5 Hz.

3.2 Test Monitoring

During all vibration testing, the SMB-00 15/H2BC actuator was monitored with accelerometers to determine its structural response. Three (3) triaxial groups of accelerometers monitored the actuator response and one (1) triaxial group of accelerometers was attached to the test fixture to monitor the test input. The accelerometers were located as seen in the chart on the following page.

Repr. No. 16511-10



3.2 Test Monitoring (continued)

ACCELEROMETER NUMBER	AXIS ORIENTATION*	LOCATION
1	H ₁	Fixture (Control)
2	H ₂	
3	Vertical	
4	H ₁	End cap of motor
5	H ₂	
6	Vertical	
7	H ₁	Top of the SMB
8	H ₂	
9	Vertical	
10	H ₁	Top of the HBC
11	H ₂	
12	Vertical	

* H₁ - Horizontal parallel to motor axis

H₂ - Horizontal perpendicular to motor axis

During the resonance survey and sine beat tests, the output from each accelerometer, through appropriate signal conditioning, was recorded on oscillographic recording paper included with this test report. During the resonance survey, the output from the control accelerometer was also recorded on X-Y plots of amplitude versus frequency, which are included with this test report.

Report No. 16511-10

3.3 Resonance Survey

The resonance survey was conducted in each of three (3) mutually perpendicular axes. In each axis, the resonance survey consisted of a 0.75g sinusoidal input at frequencies from 5 to 100 Hz and a sweep rate of two (2) octaves per minute. The actuator was not operated during the resonance survey.

3.4 Sine Beat Test

The sine beat test was conducted in each of three (3) mutually perpendicular axes. In each axis, the sine beat test consisted of an amplitude-modulated sinusoidal input with pauses between the beats applied at each test frequency. The sine beats at each test frequency included five (5) amplitude-modulated beats with fifteen (15) cycles per beat at the test frequency, with a sufficient pause between beats to preclude any superposition of motion.

The sine beat test was performed at each center frequency of the 1/3 octave bands from 2 to 100 Hz and at each resonant frequency below 100 Hz as determined by the resonance survey in each axis.

Report No. 16511-10



3.4 Sine Beat Test (continued)

The sine beats above 12.5 Hz were performed on an electrodynamic shaker table. The sine beats at frequencies from 2 to 12.5 Hz were performed on a hydraulic seismic vibration system. All sine beats were applied with 8g peak accelerations except where limited by hydraulic shaker capabilities at low frequencies. The shaker table limits for the horizontal and vertical directions, for sinusoidal inputs, are as follows:

HORIZONTAL DIRECTIONS

<u>Frequency</u>	<u>Table Limit</u>
2 Hz -----	4g
2.5 Hz -----	4g
3.2 Hz -----	5g
4.0 Hz -----	5g
5.0 Hz -----	5g
6.0 Hz -----	6g
8.0 Hz -----	8g

VERTICAL DIRECTION

<u>Frequency</u>	<u>Table Limit</u>
2 Hz -----	4g
2.5 Hz -----	4g
3.2 Hz -----	5g
4.0 Hz -----	5g
5.0 Hz -----	5g
6.0 Hz -----	6g
8.0 Hz -----	7g
10.0 Hz -----	7g
12.5 Hz -----	7g

Report No. 16511-10

3.4 Sine Beat Test (continued)

During the sine beats applied at each test frequency, the actuator was operated through a full cycle from the limit switch open position to the torque-seated closed position to the limit switch open position. At the conclusion of the sine beat testing, the actuator was operated through a full open-closed-open cycle both electrically and manually.

3.5 Test Sequence

The vibration testing of the SMB-00 15/H2BC actuator was conducted in the following order:

TEST NO.	INPUT AXIS	DESCRIPTION
#1	H ₂	Resonance survey 5-100 Hz
#2	H ₂	Sine beat test 16-100 Hz
#3	H ₁	Resonance survey 5-100 Hz
#4	H ₁	Sine beat test 16-100 Hz
#5	Vertical	Resonance survey 5-100 Hz
#6	Vertical	Sine beat test 16-100 Hz
#7	H ₂	Sine beat test 2-12.5 Hz
#8	H ₁	Sine beat test 2-12.5 Hz
#9	Vertical	Sine beat test 2-12.5 Hz

Report No. 16511-10



Page 8

4.0 TEST RESULTS

4.1 Resonance Survey Test Results

Resonant frequencies for the SMB-00 15/H2BC actuator were detected as follows:

INPUT AXIS	RESONANT FREQUENCY	
H ₁	90 Hz	Top of Actuator
H ₂	89 Hz	Top of Actuator
Vertical	87 Hz	Top of Actuator

4.2 Sine Beat Test Result

There was no evidence of any mechanical damage, deterioration, or interference with proper operation detected during or as a result of the sine beat testing of the SMB-00 15/H2BC actuator.

Report No. 16511-10
Rev. 1



5.0 TEST EQUIPMENT LIST

Report No. 16511-10



TEST EQUIPMENT LIST

NAME	MFGR.	MODEL	SER. NO.	RANGE	ACCURACY	INV. #	CAL. FREQ.
Accelerometer	PCB	302A	4438	1 Hz - 5 KHz	±5%	AC 342	6 months
Accelerometer	PCB	302A	2833	1 Hz - 5 KHz	±5%	AC 359	6 months
Accelerometer	PCB	302A	2844	1 Hz - 5 KHz	±5%	AC 374	6 months
Accelerometer	PCB	302A	667	1 Hz - 5 KHz	±5%	AC 376	6 months
Accelerometer	PCB	302A	673	1 Hz - 5 KHz	±5%	AC 382	6 months
Accelerometer	PCB	302A	2845	1 Hz - 5 KHz	±5%	AC 383	6 months
Accelerometer	PCB	302A	695	1 Hz - 5 KHz	±5%	AC 385	6 months
Accelerometer	PCB	302A	2853	1 Hz - 5 KHz	±5%	AC 395	6 months
Accelerometer	PCB	302A	1772	1 Hz - 5 KHz	±5%	AC 415	6 months
Accelerometer	PCB	302A	1809	1 Hz - 5 KHz	±5%	AC 428	6 months
Accelerometer	PCB	302A	1822	1 Hz - 5 KHz	±5%	AC 438	6 months
Accelerometer	PCB	302A	1983	1 Hz - 5 KHz	±5%	AC 440	6 months
Variable Filter	KH	3320	267	.001 Hz to 99.9 KHz High and Low Pass Cut Off	±2%	AM 348	6 months
Scope, Storage	TEK	T912	T912 B012114	DC - 10 MHz Dual Trace	±3%	OS 301	6 months
Power Supply	PCB	483A02	396	6 Channel Gain: X1	±2%	PE 305	6 months
Digital Function Gener.	MTS	410.31	894	0.00001 Hz to 990 Hz Output: 0 to ±10V		PE 311	6 months
Exciter Amplifier	Ling	A249 PP120/150	70 56	30,000 lbs force 1" P/P disp. 5 - 5 KHz	±5% ±2%	PE 317	6 months 6 months
Log Converter	MOS	60B	431	0 - 60db	±0.5db	PE 325	6 months
Exciter Control	B&K	1025	185876	Freq: 0 - 10 KHz Output: 10 volts	±1%	PE 336	6 months
Earthquake Simulator Hydraulic Actuator	MTS	908.34-01 204.63S		24" DA max. DC-200 Hz. 22K force lbs	±5% ampl	PE 367	6 months

TEST EQUIPMENT LIST

NAME	MFGR.	MODEL	SER.NO.	RANGE	ACCURACY	INV.#	CAL.FREQ.
Controller Power Supply	MTS Dennison	443.115 Mod. 63		DC to 2000 Hz 120 GPM Max. 3K - 5K psi max 250 HP	±1% NA	PE 367	
Earthquake Simulator Hydraulic Actuator	MTS MTS	806.39 204.64A-08		12 inch stroke DC-100 Hz, 35k for 1bs 12" DA max	±5% ±1%	PE 389	12 months 12 months
Recorder, X-Y	HP	7035B	1206A0 6843	Input: E=1, 10, 100 Mv/In 1, 10 V/In.	±0.2%	RE 336	6 months
Function Generator	HP	3312-A	1432A 01246	0.1 MHz - 13 MHz; 0.01 Hz - 10 KHz Sine, Sq & Triangle	±0.5% 10 Hz - 50 KHz	SG 347	6 months
Visicorder (rental)	HON	1858T79HG	3840ME79	18 Channel Main Frame .1 in/sec to 160 in/sec	0.5% F.S. to 1 KHz	48436	6 months
Visicorder (rental)	HON	1585T79HG	0423EH76	18 Channel Main Frame .1 in/sec to 160 in/sec	0.5% F.S. to 1 KHz	65267	6 months

6.0 GRAPHS

Report No. 16511-10





Test No. 1
 Date 10-20-51
 Customer Wingent
 Test Item P/N 308.00/H₂SC
 Test Item S/N
 Type of Test
 Speed No.
 Part No.
 Conditions NON operating
 Temperature Room
 Period of Test 200 min
 Control Axis
 Pick-up No.
 Pick-up Axis
 Operator D.H. F. A.
 Program
 Co-Ordinator M. C. S. M. B. S.
 GRMS

RESONANCE SURVEY TEST INPUT
 TEST # 1
 H₂ AXIS





Test No. 2
 Date 11/26-87
 Customer Lockheed
 Test Item P/N SHEL 001/R BC
 Test Item S/N
 Type of Test
 Speed: No
 Part No
 Conditions RT + Operator's
 Temperature 32.5 degrees C
 Period of Test 30 minutes
 Control Axis
 Pickup No
 Pickup Axis
 Operator S. M. ...
 Program
 Co-Ordinator M. C. ...
 CRMS

RESONANCE SURVEY TEST INPUT

TEST # 3
 H₁ AXIS





Test No. 10-26-81
 Date 10-26-81
 Customer Lin. Systems
 Test Item P/N 5281001A20C
 Test Item S/N _____
 Type of Test _____
 Spec No. _____
 Part No. _____
 Conditions Room Temp
 Temperature Room
 Period of Test Definite
 Control Axis _____
 Pickup No. _____
 Pickup Axis _____
 Operator _____
 Program _____
 Co-Ordinate Cal. 10/26/81
 vRMS 0.00000000

RESONANCE SURVEY TEST INPUT
 TEST # 5
 VERTICAL AXIS



REFERENCE II

ADDENDUM A
SEISMIC QUALIFICATION REPORT

PREPARED: J. B. Drab
J. B. Drab - Special Projects Engineer

Date : 10-6-78

APPROVED: *W. Denkowski*
W. Denkowski - Vice President Engineering

ACCEPTED: *C. Formica*
C. Formica - Quality Assurance Adminstr.

Revision A - January 4, 1979

Revision B - February 13, 1979

LIMITORQUE CORPORATION



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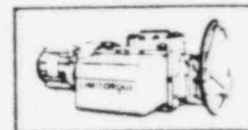
Telephone—804-528-4400 • Telex—82-9448

The below appendix table of contents replaces the table of contents currently in the document "Seismic Qualification."

APPENDIX

<u>Report No.</u>	<u>Unit Size</u>	<u>Test Date</u>
Aero Nav Report 5771	SMB-000-5	4/30/75
Aero Nav Report 5772	SMB-0-25 DC	7/28/75
Aero Nav Report 5773	SMB-3-100	7/22/75
Aero Nav Report 5774	SB-0-25	7/23/75
Wyle Report 43059-02	SMB-5 & Modutronic	10/30/75
Aero Nav Report 5770	SB-3-100	4/24/75
Aero Nav Report 5-6167-5	SMB-1-25/H4BC	11/18/75
Acton Report 13732	SMB-000-5 DC	12/1/77
Acton Report 13732-1	SMB-0-40 DC	12/1/77
Acton Report 14331	SMB-000-5/H0BC	9/11/78
Lockheed Report 2786-4786 Issue 2	SMB-0-25/H3BC	6/23/72
Lockheed Report 2786-3-4786	SMB-0/H3BC	12/15/72
Lockheed Report 2786-4-4786	SMB-3-100/H5BC	1/6/73
Lockheed Report 2773C-4773	SMB-000-2/H0BC	4/12/72
Aero Nav Report 5-6167-4	SMB-00-15/H3BC	11/17/75

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ADDENDUM A SEISMIC QUALIFICATION ENVELOPE SMB & SMB/HBC ACTUATORS

1.0 Introduction

The entire line of Valve Actuators, types SMB/SB/SBD/SMC/HBC is a generic family, all constructed of same materials and designed on same concepts, tolerance and stress levels with physical size varying as a function of rating. The same principle applies to the electric motors used with our Actuators. Past studies have shown that the Valve Actuator weight is a mathematical function of torque and further that the largest motor permissible on a specific Actuator is nominally a fixed percentage of the overall Actuator weight, further supporting the generic family concept.

This Seismic Qualification document was created to support our generic enveloping used in our various Environmental Qualifications. Primarily, seismic consideration directs itself to a weight distribution problem and resolves into the necessity of checking the adequacy of various connecting flanges. The Seismic Qualification document is a group of seismic tests conducted on units that are considered to contain the typical

1.0 Continued

and worst weight distribution that would provide the most severe loading on connecting flanges during seismic excitation, thereby providing a generic envelope for seismic qualification.

Based on the generic family concept, the following applies to Seismic Qualification:

- A. Since all Limitorque AC and DC equipment respond and are generically equivalent with regard to seismic excitation, the AC and DC seismic test data would be mutually supportive of each other.
- B. Seismic tests on SMB/HBC assemblies can be used to qualify the SMB Actuator to the seismic level obtained from accelerometers on the SMB mounting flange as well as qualify the SMC actuator and the HBC manual unit to the seismic test levels.
- C. In all environmental qualifications, 600376A, 600456, B0003, & B0009, a mid-size valve actuator was seismically aged prior to being subjected to environmental qualification. Based on the successful completion of additional seismic tests, which were done to verify the generic family concept, it has been demonstrated that the environmental testing qualification can be extended to all size units.

3.0 Type Test Procedure

3.0.4 In the seismic testing we have performed, we used several test facilities with these companies having both mechanical and hydraulic shake tables. Some of the test data from the mechanical table illustrate slight indication of cross-coupling, however, shows no sign of resonance. During our progress of this seismic testing, we evaluated the mechanical table and found that the slight signs of cross-coupling were in the table itself and not the Limatorque Actuator.

Both SMB and SMB/HBC Valve Operators show lack of resonance in frequency ranges of 2 hz to 34 hz. Results of the resonance searches are included in our seismic reports. As an example, refer to Aero Nav Report 5-6167-5 and compare input against column D on page 6, input against column C on page 8 and input against Column C on page 10. The "shake table" used for this test is unstable at 2 and 3 hz so a resonance search was not conducted at this frequency. However, the test data indicates lack of resonance below 4 hz, because of the lack of acceleration build-up in response as is normally experienced as resonance is approached.

3.0.4 Continued

Further, recent tests conducted on SMB and SMB/HBC Actuators using a hydraulic "shake table" show no resonances or cross coupling exists in the frequency of 1 to 33 hz. Acton Environmental testing Corporation reports No. 13732-1, 13732 and 14331 illustrates the lack of resonance and/or cross coupling within this frequency range. Accelerometer charts, that are light sensitive and not capable of being reproduced, are available for audit.

3.0.5 To provide reasonable fixturing (low silhouette) to insure dynamic stability of the seismic testing machine, the stroke of the valve actuator is substantially reduced (for seismic test only) maintaining the torque seat feature and reducing stroke time. The actual stroke time during seismic aging is unimportant since the intent is to age the unit by seismic vibration with operation merely proving the Valve Actuator capable of operating, providing the required torque and thrust, which has been demonstrated.

3.0.6 The acceptance criteria for seismic testing is proper operation of the unit during seismic dwell, torque tripping at close and limit switch tripping at open and also that there is no visible signs of overstress at the conclusion of the test. Signs of overstress means lack of any visible difference in equipment or performance compared to the unit prior to the seismic test, which would encompass cracks, bent shafting or other permanent deformation that could be noted by eye.

3.0.7 On the provision the assembly contains no resonance and the "shake table" is not imparting a rocking motion, there would be no additional acceleration that could cause contact chatter of an SMB/HBC over the seismic tests conducted on SMB units due to longer lever arms. The seismic tests we have conducted qualify our units seismically to g levels indicated when the seismic excitation is imparted to the mounting flange of our unit.

Contact chatter was not monitored on the Lockheed seismic tests. However, the same switches are used in all size units and therefore any seismic test checking switch chatter would define the action of the switches in any unit. Refer to seismic test 5-6167-5 which shows the switches retained their integrity to acceleration levels of up to 8g.

3.0.8 Limitorque actuators are designed with the motor leads passing through an internal conduit in the motor mounting flange and then connected in the limit switch compartment. The length of unsupported motor leads is small (inches) thereby minimizing undue loads during seismic excitation. Seismic tests conducted on actuators with either class B or class RH insulation would provide qualification for the other insulation system. The seismic dwell duration for the "RH" insulated motor, done during seismic aging for report 600376A, was actually longer than the generic envelope test data derived on class "B" insulation (540 secs. vs 360 secs.) This demonstrates the compatibility of the "RH" insulated motor leads to the combination seismic and environmental transient conditions.

- 3.0.9 From seismic test data available prior to report 600376A supplemented by seismic test data developed in the last 12 months, all Limitorque AC and DC equipment respond identically and are generically equivalent with regard to seismic excitation to an acceleration level of 6g over the frequency range of 1 to 33 Hz. Seismic testing on AC or DC actuators of the same configuration are mutually supportive, either one capable of qualifying the other.
- 3.1.4 For the Acton Reports, submitted as part of this Document, the test procedure is different than outlined in paragraph 3.1 of the cover document. Paragraph 3.1.4 should be supplemented as follows:
- 3.1.4.1 For the Acton tests, the resonance scan or survey, shall be conducted at frequencies from 1 Hz thru 33 Hz at a sweep rate of one (1) octave per minute. The test shall be run at a minimum of 0.2g in each of the three axis.
- 3.2.4 For the Acton Reports, submitted as part of this Document, the test procedure is different than outlined in paragraph 3.1 of the cover document. Paragraph 3.1.4 should be supplemented as follows:
- 3.2.4.1 For the Acton tests, the resonance scan, or survey, shall be conducted at frequencies from 1 Hz thru 33 Hz at a sweep rate of one (1) octave per minute. The test shall be run at a minimum of 0.2g in each of the three axis.

4.0 Conclusion

- 4.0.3 The seismic tests conducted to date on manual/motor SMC/HBC or SMB/HBC actuators envelope and qualify all standard assemblies to 3g as stipulated on our Nuclear Data Summary. The addition of the seismic support plate to the assembly has been tested and the modified assembly is qualified to 6g's (see Acton Environmental Testing Corporation Report 14331). The tested combination represents the most adverse weight distribution and the successful completion of the noted test can be used to qualify all modified assemblies to the 6g level.
- 4.0.4 The seismic test conducted to date on SMC-04 and SMB actuators qualify all standard units to 6g's.
- 4.0.5 The tested combinations of the above noted actuators included the most adverse weight distribution, allowing successful test completion to generically qualify seismically all tested and non-tested units to the noted acceleration levels.
- 4.0.6 Thrust tests conducted prior to and following seismic aging, permitted comparisons to determine the effect of seismic aging on the Actuator. Prior to the start of the environmental qualification, the Actuator's torque switch was calibrated to provide the unit's rated torque and thrust. Subsequent to seismic aging, the actuator was mounted on a thrust tube inside the environmental chamber and the unit was stroked measuring the output thrust. Since the pre-seismic test and post seismic test thrust values were in close agreement, it is concluded that seismic aging has no detrimental effect on the Limitorque Valve Actuators.

5.0 Supplementary Information

5.0.1 In addition to the reports used in the document "Seismic Qualification", Lockheed seismic reports 2786-4786 Issue 2, 2786-3-4786, 2786-4-4786, and 2773C-4773, and Aero Nav Report 5-6167-4 were provided in further support of seismic tests for SMB Actuators mounted on HBC manual units. The Lockheed Electronics seismic tests were conducted prior to current requirements of detail unit identification. These tests, however, were conducted with standard weatherproof units using 1800 RPM, 230/460 VAC, 3 phase, 60 cycle motors containing class B insulation.

5.0.2 Aero-Nav Report 5-6167-4

- A. The test was conducted with a 230/460 VAC, 3 phase, 60 cycle, 1800 RPM motor containing class B insulation.
- B. The maximum dropout time of the relay used to evaluate switch chatter was 8 milliseconds.
- C. The seismic support plate, although attached to the H3BC mounting flange, provided no support to the SMB-00/H3BC assembly since the bolts and spacer that would provide support to the SMB portion of the assembly were not installed. With the exception that the adapter between the SMB and HBC was of fabricated steel rather than normally used cast iron, this represents a seismic test of a standard SMB/HBC assembly. (The seismic support plate that was partially installed during this test is not of the type normally provided.)

5.0.2 Continued

D. A cast iron adapter is normally used in a standard SMB-HBC assembly. The use of a fabricated steel adapter would provide a more severe test for the SMB unit due to the fact the fabricated steel adapter would tend to amplify any input vibration and also due to its construction would tend to provide resonances in lower frequency ranges.

E. The designation "Position A" in the manufacture type entry is merely a description of the assembly location of the SMB unit on the HBC unit with the SMB mounted on one end of the housing or the other. Since the HBC housing is symmetrical, this would have no effect on the seismic test.

5.0.3 Aero-Nav Report 5-6167-5

A. The test was conducted with a 230/460 VAC, 3 phase, 60 hz, 1800 RPM, motor containing class B insulation.

B. The maximum dropout time of the relay used to evaluate switch chatter was 8 milliseconds.

C. The designation "Position A" in the manufacture type entry is merely a description of the assembly location of the SMB unit on the HBC unit with the SMB mounted on one end of the housing or the other. Since the HBC housing is symmetrical, this would have no effect on the seismic test.

D. The corrected resonance/cross coupling scan sheets (pages 7 and 8) have been added to the report and the report marked rev. 1.

5.0.4 Acton Reports 13732, 13732-1, 14331

For these reports axis H_1 , defined as side to side, is equivalent to original definition of horizontal-parallel to the motor axis; H_2 , defined as front-to-back, is equivalent to original definition of horizontal-perpendicular to the motor axis.

IMAGE EVALUATION
TEST TARGET (MT-3)

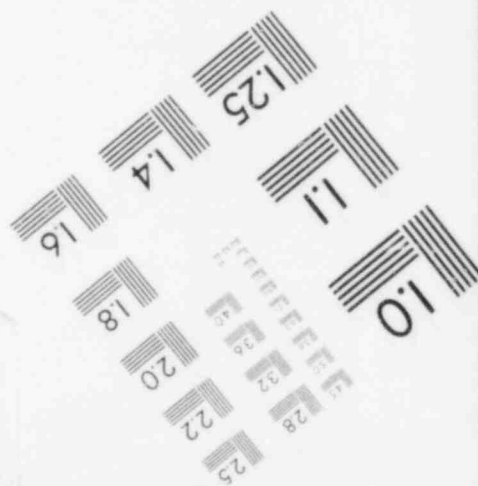
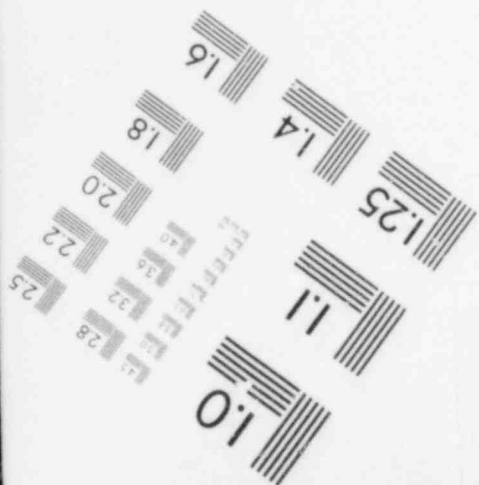
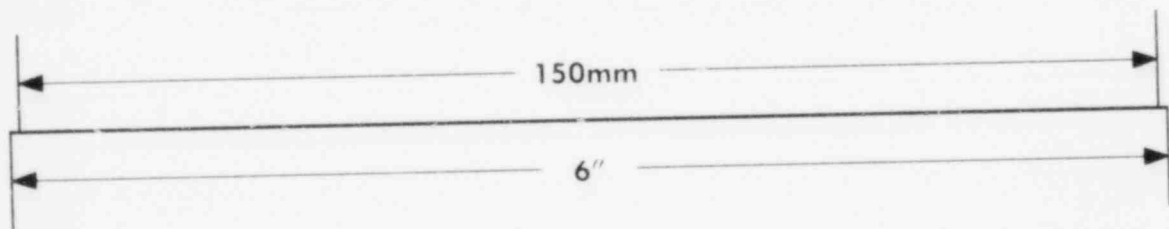
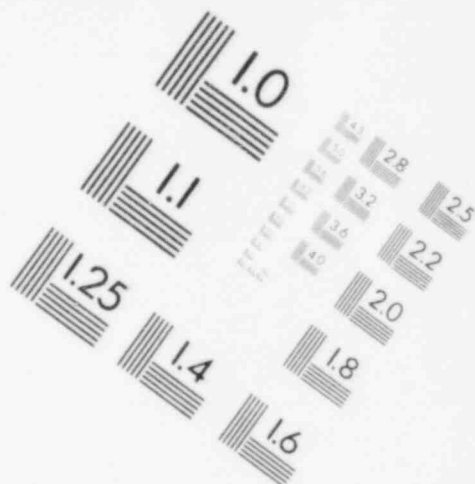
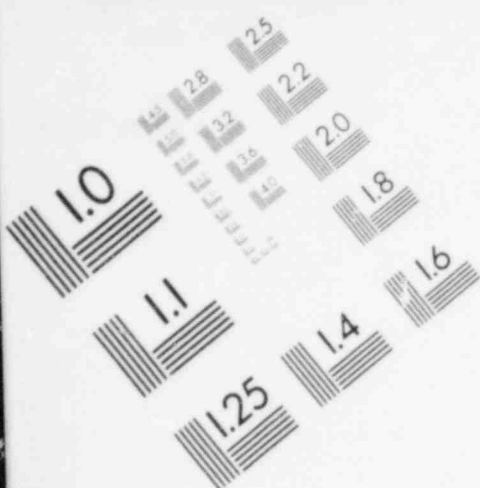
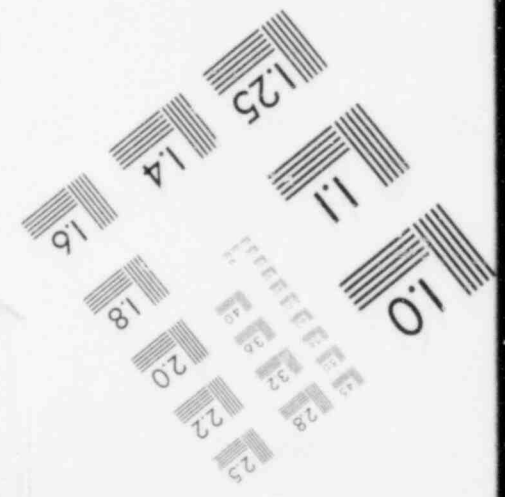
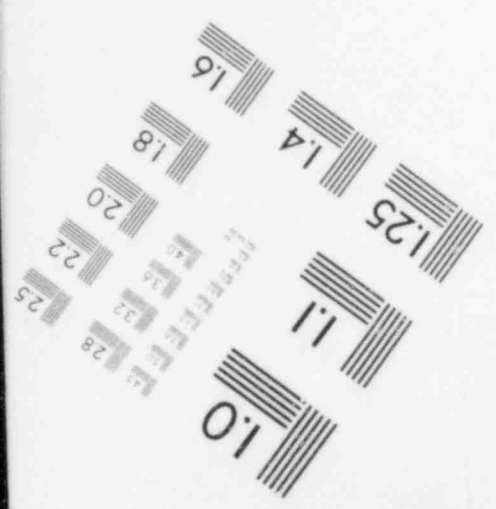
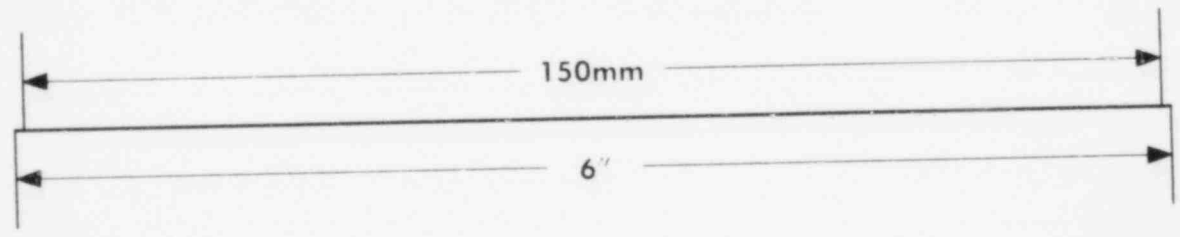
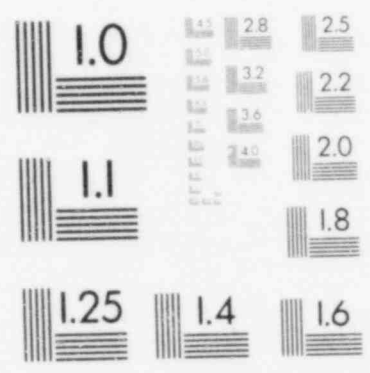
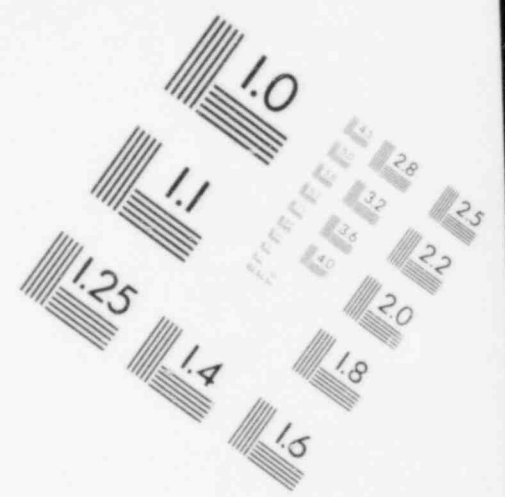
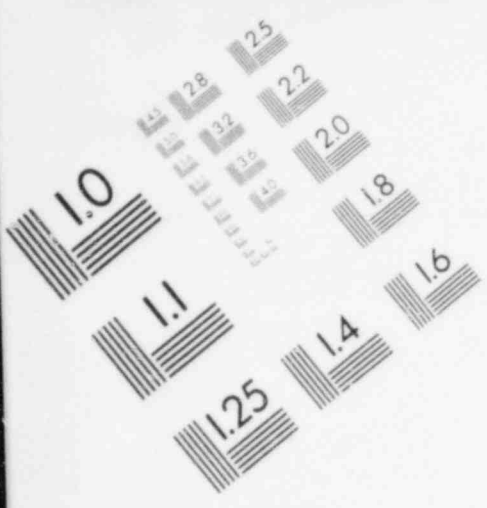


IMAGE EVALUATION
TEST TARGET (MT-3)



SECTION 1.1 SCOPE1.1.1 INTRODUCTION

This is the basic seismic qualification summary for all motor operated Limitorque Valve Actuators, those currently identified in Packages D-89 thru 96, 98 thru 123, 125 thru 127 and also wherever motor operated Limitorque Valve Actuators are used and are to be included in other packages, which have been subjected to environmental qualification.

Several dynamic tests were conducted on different sizes of motor operated actuators to encompass the entire family of Limitorque Actuators. The dynamic tests conducted include:

- i) Vibration aging to account for normal plant vibration.
- ii) Sine scan tests to determine resonant frequencies, in the frequency range of interest.
- iii) Sine beat (dwell) tests and random multifrequency biaxial tests to represent seismic aging simulating OBE and SSE situations and loads associated with 4900 SRV subsequent events, condensation and oscillation, high frequency SRV and LOCA loads to demonstrate that the design of Limitorque's safety related actuators are adequate to insure they will perform their safety related function during the postulated conditions in a nuclear power plant.

iv) Additional tests to establish the fragility limit acceleration for the actuators.

Section 1.2, Test Description, includes a brief description of the test details of the reports referenced in Section 4.0, and the test results.

Finally, in Section 1.3, the reasons supporting the conclusions, are delineated.

1.1.2 SUMMARY

The basic seismic qualification, documented in this generic binder, supports the conclusion that the motor operated Limatorque Valve Actuators perform their intended safety functions to the "G" level indicated for the enveloping generic actuator by the supplemental qualification by RIM test included with individual packages and thus satisfy Limerick qualification requirements.

The test reports and the actuators tested discussed in this package are listed below:

<u>Report No.</u>	<u>Unit Size</u>
Ogden Report 7192-9	SMB-0-25
Aero Nav Report 5720	SMB-0-25
Aero Nav Report 5722	SMB-1-40
AEL Report 75-149ET	SMB-0-25
Aero Nav Report 5771	SMB-000-5
Aero Nav Report 5772	SMB-0-25 DC
Aero Nav Report 5773	SMB-3-100
Aero Nav Report 5774	SB-0-25
Wyle Report 43059-02	SMB-5T & Modutronic 10A

<u>Report No.</u>	<u>Unit Size</u>
Aero Nav Report 5770	SB-3-100
Aero Nav Report 5-6167-5	SMB-1-25/H4BC
Acton Report 13732	SMB-000-5 DC
Acton Report 13732-1	SMB-0-40 DC
Acton Report 14331-2 and -3	SMB-000-5/H0BC
Acton Report 14801-1	SMB-1-60/H3BC
Acton Report 14801	SMB-3-150/H5BC
Acton Report 16573-81N (Niagara Mohawk NMP2)	(SMB-000-5) (SMB-0-25)
NTS Report 548-9291 (Niagara Mohawk NMP2)	(SMB-000-5) (SMB-0-25)

SECTION 1.2 TEST DESCRIPTION

A brief Description of the test details of the reports referenced in Section 4.0 and test results are included below.

1.2.1 Acton Test Report #16573-81N

Two Limitorque motor operated Velan valves 3 In-600LB with SMB-000-5 and 12 In-150LB with SMB-0-25 were subjected to a series of dynamic tests to determine the test specimen's ability to perform their intended safety functions.

- A) Operator Vibration Aging: Operators were subjected to sine scan in the frequency band from 5 to 200 to 5 Hz at an acceleration level of 0.75g not exceeding .025-inch double amplitude displacement. The sweep was performed at a rate of 2 octaves per minute. Ninety minutes of vibration was applied along each of three (3) orthogonal axes. The actuators were operated open or close every 7.5 minutes. This conforms to IEEE 382-1980.
- B) Sine Beat Testing Program: Single axis sine beat tests were performed in each of the three (3) orthogonal directions, except where limited by shaker table for peak responses of 7.1g, 6.4g and 5g at the operator base between 5 to 100 Hz frequency range. The valve was operated during testing. Interval between beats was 1.5 seconds or greater to preclude any superposition of motion.
- C) Additional Tests: Were performed to establish the fragility limit acceleration on the test specimens.

- C) The valves were stroked open against the differential and closed against the operating pressures during the tests.

The fragility limit determined by the tests were:

11g For 2MSI*MOV1A (3 In-600LB)/SMB-000-5

9.5g For 2CCP*MOV14B (12 In-150LB)/SMB-0-25

1.2.2 NTS Report #548-9291

Limiter Motor Operated Actuators SMB-000-5 and SMB-0-25 were subjected to the following test:

- A) Vibration Aging Test As per IEEE 382-1980 as in Section 1.2.1 (A) above.

- B) Random Multifrequency Biaxial Test

The actuators were subjected to a minimum of 105 seconds to several random multifrequency input motions applied biaxially along one principal horizontal axis and the vertical axis simultaneously, at the levels listed below.

Operator SMB-000-5 - Minimum ZPA of 6g

Operator SMB-0-25 - Minimum ZPA of 12g

Operators mounted on the test fixtures, were rotated 90° in the horizontal plane and tests repeated. Amplitudes of 1/12 octave frequency bands were adjusted to obtain the desired TRS of the horizontal and vertical input motions.

- C) Single Axis Sine Beat Test

The operators were subjected to a series of sine beats in the frequency range of 5Hz to 100Hz at input levels up to 6g. The operators were functional throughout the test and maintained a consistent stroke time.

D) Fragility Test

Both the operators were subjected to fragility tests in the frequency range from 5Hz to 100 Hz at input levels up to 14g, with operator performance consistent with baseline data.

1.2.3 Limitorque Report #B0058

This report summarizes the qualification program to demonstrate that the design of Limitorque's safety related actuators are adequate to insure they will perform their safety related function during a DBE condition in a nuclear power plant. The Limitorque environmental qualification conducted per IEEE 382-1972 and meeting the requirements of IEEE 323-1974 as they apply to valve actuators and seismic qualification as per IEEE 344-1975 which supports both the above documents, are discussed. Qualification conducted is aimed to encompass the entire family of Limitorque actuators - SMB, SB, SED and SMB/HBC in all available unit sizes (SMB-000 to SMB-5) by testing on a midsize unit (SMB-0), subjecting the actuator to simulated seating loads equivalent to actuator's published unit rating during the test procedure. The prime effort in qualification is directed toward type tests of complete actuators with experience and analysis being applied to establish the guidelines of the type test and extrapolate the results.

Vibration was not addressed in environmental qualifications, as it was considered to be generally of low intensity in power plants and not sufficient to cause actuator failure or malfunction.

1.2.3 (Continued)

Aging requirements include life aging, mechanical aging, thermal aging, radiation aging, and environmental transient profile tests in addition to seismic aging.

During the environmental qualifications, each of the actuators was seismically aged to insure that no physical weakness existed in the actuator that would effect the qualification. From the several environmental tests that were conducted, it was noted that preaging (thermal, mechanical, or irradiation up to 204 megarads) had no effect on the ability of the Limitorque valve actuator to qualify a seismic test.

To provide full qualification of Limitorque valve actuators, supporting seismic data tests in addition to qualifications for environmental conditions of interest such as, containment chamber of BWR (Ref. §4.3.1); outside containment (Ref. §4.3.2) and, specific BWR environmental conditions for a D.C. actuator (Ref. §4.3.3) are contained in Sections 1.2.3.1 thru 1.2.3.3 that follow.

Although all Limitorque actuators, type SMB/SB/SBD/SMC/HBC are a generic family, they do not all possess the same center of gravity. To insure that the actuator picked as "representative" of the actuator family truly represents the entire family, a seismic envelope was constructed as delineated in "Seismic Qualification Envelope" (Ref. §4.3.4) and is contained in Section 1.2.3.4.

1.2.3.1 BWR Containment Qualification Report #600376A

A Limitorque valve actuator SMB-0-25 was submitted for generic qualification to the type test specified by IEEE 382-1972 for service in a BWR containment.

In addition to thermal aging, mechanical aging and radiation aging, and before subjecting the actuator to accident simulation test profiles, the actuator was seismically qualified (Ref. §4.3.1.1) and the test is summarized in Section 1.2.3.1.1 below.

1.2.3.1.1 Ogden Technology Laboratories, Inc., Report #7192-9

The SMB-0-25 actuator was scanned for resonance in each of the three major axes, on an electro-hydraulic vibration machine, over a frequency range of 1 to 35Hz with a maximum acceleration of 1.0G's and no resonance was found. The actuator was then vibrated for 10 seconds (dwell) at each even integer frequency from 2 to 34Hz in each axis at an excitation of 3G's. The unit was operated during each dwell through one cycle from open limit to torque switch seated position and back to original point. The test sample was then vibrated for a minimum of 10 seconds at 35Hz in each axis at an excitation level of 5.3 to 5.8 G's with the unit being operated as indicated above.

1.2.3.2 Outside Containment Qualification Report #B0003

The purpose of this test was to determine the capabilities of a Limitorque valve actuator (Type SMB) equipped with an

1.2.3.2 (Continued)

electric motor with Class B insulation to satisfactorily operate during post-LOCA or Steam Line Break environmental condition.

After thermal aging, mechanical aging and radiation exposure and prior to environmental tests, the actuator was seismically aged (Ref. §4.3.2.1) and the test is summarized in Section 1.2.3.2.1 below.

1.2.3.2.1 (a) Aero Nav ETL Report #5720

Actuator SMB-0-25 was subjected to resonant frequency search from 5 to 33Hz at excitation levels from .1G to .75G, dwelling for 6 seconds at each frequency at discrete steps of 1Hz. Above tests were performed in each of the three (3) mutually perpendicular axes and no resonance was detected.

In addition seismic dwell tests were performed at 33Hz for a duration of 30 seconds for each run. In the vertical axis, five runs were performed at an input of 3.0G's and one run was performed at an input of 6.0G's. In the horizontal axis, parallel to motor axis, five runs were performed at an input of 4.9G's and one at 6.1G's. In the horizontal axis, perpendicular to the motor axis, five runs were performed at 3.2G's and one at 6.2G's. During the dwells the actuator was opened and closed. There was no evidence of external physical damage as a result of the stress from these tests.

(b) Aero Nav ETL Report #5722

Resonance scan and seismic dwell tests as described in Section 1.2.3.2.1(a) above was performed on SMB-1-40 Limitorque actuator. The seismic dwell consisted of five runs at 3G's in all directions and one run at 6.3G's in vertical and at 6.0G's in the horizontal directions. During the dwells the actuator was opened and closed. There was no evidence of external physical damage as a result of the stress from these tests.

1.2.3.3 DC Actuator Qualification Report #B0009

The purpose of this test was to determine the capabilities of a Limitorque valve operator (Type SMB) equipped with a Porter-Peerless DC electric motor to satisfactorily operate during a most severe post LOCA environment of a BWR. After unit aging for thermal, mechanical and radiation exposure and prior to environmental tests, the valve actuator was seismically aged (Ref. §4.3.3.1) and the test report is contained in Section 1.2.3.3.1 below.

1.2.3.3.1 American Electronic Laboratories, Inc. Report #75-149 ET

Resonance search from 5 to 33 to 5Hz was performed on the SMB-0-25 actuator in each of the 3 axes at an excitation of .3G's, dwelling for 6 seconds at each integer frequency and no resonance was found.

1.2.3.3.1 (Continued)

The operator was also subjected to five (5) sine dwells at 2G's for 30 seconds and one dwell at 4G's for 30 seconds in each of the 3 axes. The unit was operated electrically from open to close, during each dwell and there were no operational problems reported.

1.2.3.4 Seismic Qualification Envelope Report #B0037

A group of Limitorque valve actuators, chosen to envelope the entire generic family of available actuators type SMB/SB/SBD sizes 000 to 5 and SMC-04, were subjected to seismic qualification per IEEE 344-1975. Included were SMB,SB (which are Mod SMB units), as well as SMC actuators. SMB and SMC valve actuators mounted on secondary reducers (Type HBC) also were chosen to envelope worst possible unit assembly combinations and were also subjected to seismic qualifications per IEEE 344-1975. The generic family of valve actuators types SMB/SB/SBD/SMC/HBC are all constructed of similar materials and designed to same concepts, tolerance and stress levels with physical size varying as a function of rating. Valve actuator weight is a mathematical function of torque and further the largest motor permissible on a specific actuator is nominally a fixed percentage of the overall actuator weight, further supporting the generic family concept.

1.2.3.4 (Continued)

Primarily, seismic consideration directs itself to a weight distribution problem and resolves into the necessity of checking the adequacy of various connecting flanges. This document contains a group of seismic tests conducted on units that are considered to contain either typical or worst weight distribution (Most severe actuator configurations and unit combinations) that would provide the most severe loading on connecting flanges during seismic excitations, thereby providing a generic envelope for seismic qualification.

Since these seismic tests are to demonstrate the generic family concept, they were not subjected to aging or any other environmental qualification requirements. Even though it is intended that these tests not be used as qualification in and of itself, these tests, however, do qualify the equipment to IEEE 344-1975 because, as previously noted, preaging has no effect on Limitorque actuators.

The valve actuators tested are identified in each individual seismic report that is listed below.

1.2.3.4.1 Aero Nav Report #5771

Resonance scan and seismic dwell tests as described in Section 1.2.3.2.1(a) above was performed on SMB-000-5 Limitorque actuator.

1.2.3.4.1 (Continued)

Sine scan at excitation levels between .03 - 1.4G's did not indicate any resonance frequency below 35Hz. The sine dwell consisted of five runs at 3.05G's and one dwell at 6.1G's in the vertical and horizontal axis (H.) along the motor axis and five dwells at 3.15G's and one dwell at 6.3G's along horizontal axis perpendicular to motor axis. During the dwells the actuator was operated open to close seat to open. There was no evidence of external physical damage as a result of the stress of these tests.

1.2.3.4.2 Aero Nav Report #5773

Tests and results for SMB-3-100 are the same as in Section 1.2.3.4.1 except:

Resonance Scan: .1-1.5G; 5-33Hz; 6 seconds at each frequency

Seismic dwells at 33Hz for 30 seconds: V, H₁, H₂ - 2 at 5G; V-1 at 6.4G; H₁ - 1 at 6.34G, H₂ - 1 at 6.35G

1.2.3.4.3 Aero Nav Report #5774

Tests and results for SB-0-25 are the same as in Section 1.2.3.4.1, except:

Resonance scan: 0.11-1.45G, 5-33Hz, 6 seconds at each frequency

Seismic Dwells at 33Hz for 30 seconds each: V-2
at 5G and 1 at 6.25G

H₁ and H₂ - 5 at 5G and 1 at 6.25G

1.2.3.4.4 Aero Nav Report #5770

Tests and results for SB-3-100 are the same as
in Section 1.2.3.4.1, except:

Resonance scan: 0.036-1.55G; 5-33Hz, 6 seconds
at each frequency

Seismic dwells at 33Hz for 30 seconds each

V, H₁ & H₂ - 5 at 3.05G and 1 at 6.1G

1.2.3.4.5 Aero Nav Report #5772

Tests and results for SMB-0-25D.C. are the same
as in Section 1.2.3.4.1, except:

Resonance scan: 0.025-1.25G, 5-33Hz, 6 seconds
at each frequency

Seismic dwells at 33Hz for 30 seconds

V-2 at 5.1G and 1 at 6G

H₁-5 at 3.05G and 2 at 6G

H₂-2 at 5.0G and 1 at 6.2G

1.2.3.4.6 Acton Report #13732

Resonance survey consisting of sinusoidal input
with peak horizontal or vertical accelerations
of 0.2G's at a sweep rate of one(1)
octave/minute at frequencies from 1 thru 33Hz in
horizontal directions and 1 thru 35Hz in the
vertical direction of SMB-000-5D.C. did not
indicate any resonance.

1.2.3.4.6 (Continued)

Proof sinusoidal dwell tests consisted of 5 at 1.5G and 1 at 3G for 30 seconds at 33Hz in each axis. There was no visible evidence of mechanical damage, deterioration or loss of the actuator's ability to operate properly after the tests.

In addition, fragility sinusoidal dwell tests consisting of sinusoidal input with peak horizontal or vertical accelerations starting at 3.5G's and increasing in 0.5G steps at 33Hz and each input applied for 30 seconds were performed, until actuator failure occurred or until system limitations were reached. A 6.0G input level was reached in the two horizontal directions and an 8G input level was reached in the vertical testing direction.

1.2.3.4.7 Acton Report #13732-1

Resonance survey tests, proof sinusoidal dwell tests and fragility sinusoidal tests and results for SMB-0-40D.C. are the same as in Section 1.2.3.4.6, except:

Resonance scan from 1-35Hz in all directions

Fragility limits: Vertical (V) = 6.5G

Horizontal-Side/Side (H₁) =

5.0G

1.2.3.4.7 (Continued)

Horizontal-Front/Back (H₂) =
5.5G

1.2.3.4.8 Aero Nav Report #5-6167-5

The SMB-1-25 mounted on to the H4BC using a standard cast iron adapter did not show any resonance for the survey between 4 to 33Hz at an excitation level of 0.87 to 1.10G dwelling at least 6 seconds at each frequency.

The seismic dwell test was performed as fragility test at 33Hz in each of the three (3) mutually perpendicular axes. The acceleration levels for the dwell tests started at 3G's and was increased in 1'G', dwelling for a duration of thirty (30) seconds at each level until either the specimen failed or the maximum level of the vibration machine was reached. The fragility levels reached were

	Input	Unit Response
Vertical Axis (V along the H4BC Stem)	8.4G	9.6G
Horizontal Axis (H ₁ along the motor)	8.0G	8.9G
Horizontal Axis (H ₂ along the H4BC shaft)	7.9G	8.5G

The unit performed all functions and torqued out at minimum torque switch setting with no malfunctions or physical damage during all the dwells and at the end of the seismic qualification test.

1.2.3.4.8 (Continued)

The unit was considered qualified per the IEEE Standard 344 Specification for Seismic Levels up to 8G's.

1.2.3.4.9 Acton Report #14331-2 and 3

The SMB-000-5/HOBC was tested both with the standard adapter (Report #14331-2) and also with the seismic support bracket and adapter (Report #14331-3).

- A) The resonance survey of the actuator with the standard adapter consisting of sinusoidal input with peak horizontal or vertical accelerations of 0.5G at a sweep rate of 6 seconds/Hz in the frequency range of 1-50-Hz in the two horizontal directions and from 1-60-Hz in the vertical direction did not produce any resonance below 37.5Hz. The sinusoidal dwell fragility tests with thirty (30) seconds duration at each input test level from 3G at increments of 1G resulted in the following fragility limits

H₂-For horizontal axis perpendicular to motor axis - 5.5G

H₁-For horizontal axis parallel to the motor axis - 6G

V-Vertical axis - 12G

1.2.3.4.9 (Continued)

The actuator was operated manually at each test level after testing in each axis was completed.

- B) The actuator, with seismic support bracket and adapter, was subjected to a resonance search as in Section 1.2.3.4.9(A) above and no resonance below 70Hz was detected along any of the axes, on the single axis hydraulic table. On the ling A-249 magnetic table, no resonance was found when subjected to resonance survey from 5 to 36Hz with a peak excitation level of 0.5G at a sweep rate of 1 octave/min. Sine dwell tests, as in Section 1.2.3.4.9(A) above, to assure a 6G minimum fragility level, before the unit became seismically abused, was performed on the single axis hydraulic table.

The actuator was operated at each level from 3G to 6G at increments of 1G in each of the three (3) axes.

Next the actuators were retested on the ling A-249 magnetic table from 7G at increments of 1G resulting in the following levels:

V and H₁-12G and H₂-9G.

In addition, the test specimen was subjected to multifrequency cycling vibration aging by sine cycling tests. Sinusoidal input consisted of a 10-100-10Hz sweep at two (2) octaves/min. with a double amplitude of 0.025 inches from 10-24Hz, and a 0.75G peak from 24-100Hz, for 90 minutes in each orthogonal axis. The actuator was cycled every fifteen (15) minutes. No deterioration or malfunctions occurred in these tests. Resonant frequencies corroborated those determined in resonance survey earlier. At the end of testing, the unit was operated both electrically and manually with no problems apparent.

- C) Thus the test units were subjected to several dwells at various G levels, constituting the equivalent 5 OBE dwells normally performed. Hence the GMB-000-5/H0BC is considered qualified per IEEE 344-1975 to a level of 5G's with the standard adapter and to 9G's with seismic support bracket and adapter.

1.2.3.4.10 Acton Report #14801-1 (Limitorque Report #B0048)
and Acton Report #14801 (Limitorque Report
#B0047)

Two each SMB-1-60/H3BC and SMB-3-150/H5BC valve actuators were subjected to several seismic tests to complete the seismic qualification envelope. The principal reason for conducting the various seismic tests and test techniques was to permit evaluation of different tests and further permit extrapolation of the results of existing tests to testing requirements at a later date. This further permits analyzing sine dwell tests and predicting the units actions, if it were exposed to RRS type testing or vice versa.

The SMB-1-60/H3BC and SMB-3-150/H5BC were selected as they reflected the worst case conditions of all Limitorque actuator combinations per engineering evaluation of generic family of SMB/HBC type actuators. The largest motor available for the SMB actuators were used to provide conservatism in the seismic test.

The intent of these tests was to complete the generic envelope of all SMB/HBC or SMC/HBC actuator qualification to 3G seismic acceleration up to 33Hz in the "Standard" construction and to 6G seismic acceleration

1.2.3.4.10 (Continued)

up to 33Hz by the addition of a modification called the "Seismic Bracket".

The tests conducted include:

- A) Resonance search conducted, further to determine the effectiveness of various methods of resonance search by evaluating the results of a low impedance test or energy tickler method compared to a resonance survey on a shaker table at acceleration levels of 0.75G.
- B) Biaxial random multi frequency excitation to provide comparison with sine dwell testing as per IEEE 344-1975 and also seismic testing as per IEEE 382-1980 to compare with the same.
- C) Vibration testing at .75G acceleration in the frequency range of 10 to 100 to 10Hz for 30 minutes to evaluate the effect of possible plant vibration on an actuator.

1.2.3.4.10.1

Acton Report #14801

Two units of SMB-3-150/H5BC marked #1 and #2 were tested.

- i) Low impedance test consisting of a sinusoidal input with low level horizontal accelerations at frequencies 1-60-1Hz at a sweep rate of $1/2$

1.2.3.4.10.1 (Continued)

octave/minute was performed on actuator #1, both with and without the seismic support bracket. No resonances below 32.3Hz were found.

- ii) Next, a biaxial multiple frequency excitation was applied to the actuator. Qualification tests consisting of biaxial periodic pseudo random excitation were performed. The test duration for each input was thirty (30) seconds. The level was such that the test response spectra (TRS) at 5% damping would envelope the SSE required response spectra (RRS) with 3G ZPA and 9G peak accelerations. The test response spectra were also analyzed at 2.5% and 1.0% damping. The multifrequency test was performed with the seismic support bracket using actuator #1. The input was applied using AETC hydraulic seismic simulator in H_1 & V, H_2 & V, $-H_1$ & V and $-H_2$ & V directions. There was no evidence of mechanical damage or deterioration as a result of the above test.
- iii) In addition, resonance survey consisting of a sinusoidal input with peak acceleration of 0.75G at frequencies from 5-60-5Hz was performed at a sweep rate of $1/2$ octave/minute.

The resonance survey was performed both with and without the seismic support bracket using actuator #1, in both the horizontal and vertical directions, and no resonance below 35Hz was detected.

- iv) Next qualification test was performed on actuator #2 with the seismic support bracket. This qualification test consisted of a continuous steady state sinusoidal dwell input with peak horizontal or vertical accelerations of 6.0G except where limited by AETC shaker table capabilities. The sinusoidal dwell test was performed at $1/3$ octave intervals of frequency from 5 through 32Hz (5Hz at 0.75G; 6.3Hz at 1.0G; 8.0Hz at 1.2G; 10Hz-V at 2.2G, H₁ & H₂ at 4G; 12.5Hz-V at 2G, H₁ & H₂ at 5.5G; 16Hz-V at 3G, H₁ & H₂ at 6G; 20, 25, 32Hz at 6G's) as well as at 35Hz (6G). Each dwell was for a duration of fifteen (15) seconds. There was no evidence of mechanical damage or deterioration as a result of the above tests.
- v) In addition, actuator #2 was also subjected to qualification tests without seismic support bracket.

v) (Continued)

The tests consisted of continuous steady state sinusoidal dwells of thirty (30) seconds duration each, five (5) runs at 2.2G and one (1) at 4.4G in each axis.

vi) Next, the #2 actuator, with the seismic support bracket, was subjected to a plant vibrations aging test. This consisted of a sinusoidal input with peak acceleration of 0.75G at frequencies 10-100-10Hz, at a sweep rate of two (2) octaves/minute for 90 minutes along each axis. There was no evidence of mechanical damage, deterioration or contact chatter as a result of the above test.

1.2.3.4.10.2

Action Report #14801-1

Two units of SMB-1-60/H3BC marked #3 and #4 were tested.

- i) Resonance survey as in Section 1.2.3.4.10.1(iii) was conducted on actuator #4 with and without the seismic support bracket and no resonance was found below 34Hz.
- ii) Qualification tests as in Section 1.2.3.4.10.1(iv) above was performed with the seismic support bracket using

ii) (Continued)

actuator #4 in the horizontal axis parallel to the motor axis (H_1) and using actuator #3 along the other horizontal and vertical axis. The level of input applied was 5.0Hz at 1.0G; 6.3Hz at 1.5G; 8.0Hz at 3.0G; 10.0Hz at 5.0G; 12.5Hz at 5.5G and 16.0, 20.0, 25.0, 32.0 and 35.0Hz at 6.0G's. There was no evidence of mechanical damage, deterioration or contact chatter as a result of the qualification tests specified above.

iii) Biaxial multiple frequency test as in Section 1.2.3.4.10.1(ii) was performed on actuator #3 with the seismic support bracket. There was no evidence of mechanical damage, deterioration or contact chatter as a result of the multiple frequency test specified above.

iv) Plant vibration aging test as in Section 1.2.3.4.10.1(vi) was performed on actuator #3 with the seismic support bracket. There was no evidence of mechanical damage, deterioration, or contact chatter as

a result of the tests specified above.

1.2.3.4.10.3 Results

- i) The results of the low energy tickler method of resonance search agreed closely with the resonances discovered using a shaker table for high level input. It was therefore concluded that the tickler method of resonance search is suitable and will provide viable results.
- ii) Due to observation, analysis, and results of tests, it was concluded that the sine dwell testing is much more severe than random multi-frequency biaxial testing and is therefore the most conservative testing method below frequencies of 35Hz.
- iii) Since both SMB/HBC actuators without seismic bracket operated without problem during 3G excitation in each of the three axes and further since the two SMB/HBC actuators reflect the worst case conditions of all Limitorque actuator combinations, the entire generic family of SMB/HBC and SMC-04/HBC without seismic brackets

iii) (Continued)

are qualified to 3G's acceleration from 1 to 35Hz frequency per IEEE 344-1975.

iv) Both SMB/HBC actuators, with seismic bracket, operated properly during random multi-frequency biaxial testing and sine dwell testing with no resonances detected below 35Hz. Further, since the SMB/HBC operators tested reflect the worst case condition, the entire generic family of SMB/HBC and SMC-04/HBC, with seismic bracket and without gasket between the SMB adapter and HBC, is qualified to a seismic acceleration level of 6G's from 1 to 35Hz, both per IEEE 344-1975 and IEEE 382-1980.

1.2.3.4.11 Wyle Report #43059-02

The SMB-5T with modutronic 10A was first subjected to a low level single axis resonant search from 5Hz to 14Hz with 0.05 d.a. input and from 14Hz to 33Hz with 0.5G peak input in each of the three test axes. No resonant frequencies were detected below 33Hz in the vertical and longitudinal horizontal directions and below

1.2.3.4.11 (Continued)

28.8Hz in the lateral horizontal direction. In addition, resonant dwell tests at 6G's were performed at 33Hz in the vertical and longitudinal axes and at 28.8Hz in the lateral axes. The dwell duration was 30 seconds in each axis, with the unit operating. The specimen and modutronic unit withstood the specified environment without apparent structural degradation.

- 1.2.4 Addendum A, Seismic Qualification Report (V.P. 8031-E-24-7-1):
Summarizes the results and conclusions of testing reports referenced in Section 4.3.4 (§4.3.4.1 thru 4.3.4.9 & §4.3.4.11) and discussed in Section 1.2.3.4 (§1.2.3.4.1 thru §1.2.3.4.9 and §1.2.3.4.11) and validates the basic seismic qualification of the generic family of Limitorque motor operated valve actuators which have been environmentally qualified.

SECTION 1.3 CONCLUSIONS

The reports discussed in Section 1.2 qualify, the entire generic family of available actuators type SMB/SB/SED sizes 000 to 5, SMC-04, SMB/HBC and SMC/HBC, as per IEEE 344-1975 up to 33Hz.

However, in a boiling water reactor nuclear power plants, such as Limerick, the actuators are required to withstand high frequency vibrations up through 100Hz caused by hydrodynamic loadings.

In all environmental qualifications, Limitorque Reports #600376A, B0003 and B0009 (Ref. 4.3.1 thru 4.3.3) a midsize valve actuator was seismically aged prior to being subjected to environmental qualification. Based on successful completion of additional seismic tests (Limitorque Report #B0037, Ref. 4.3.4) which were done to verify the generic family concept, it has been demonstrated that the environmental testing qualification can be extended to all size units without any adverse effects.

The Acton Report #16573-8IN (Ref. 4.2.1) and NTS Report #548-9291 (Ref. 4.2.2) qualify the SMB-000 and SMB-0 actuators to 100Hz as required for hydrodynamic loads. However these two units by themselves do not envelope the generic family of Limitorque actuators considered.

Hence, the information on testing included in this generic binder will provide basic seismic qualification for Limitorque motor operated actuators which have been environmentally qualified. And, when used together with the supplemental qualification of hydrodynamic RIM test results for the enveloping actuator included with individual packages, will qualify completely the actuator under consideration to the required Limerick criteria.