

Q: 210.51

Test Report No. 14331-2

No. of Pages 8

REVISION 1 - 3/13/79

Report of Test on

SEISMIC VIBRATION TESTING
OF ONE (1) LIMITORQUE SMB-000/HOBC ACTUATOR
FOR LIMITORQUE CORPORATION
UNDER PURCHASE ORDER NO. TL-413



Date January 31, 1979

| | Prepared | Checked | Approved |
|--------|-----------------------|--------------------|-------------------|
| By | B. Esposito | M. Casaubon | M. L. Tolf |
| Signed | <i>Bruce Esposito</i> | <i>M. Casaubon</i> | <i>M. L. Tolf</i> |
| Date | <i>Jan 31, 1979</i> | <i>1-31-79</i> | <i>1/31/79</i> |

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SEISMIC TEST SMB-000/HOBC

Test Report #B0045

Subject: Seismic testing of Limitorque SMB-000-5/HOBC

Reference: A) Seismic testing procedure for Limitorque SMB-000-5/
HOBC - Research & Development Project #678023

B) Acton Environmental Testing Corporation Test
Reports #14331-2 and #14331-3

UNIT DESCRIPTION:

Unit Identification:

Type: SMB
Size: 000
Order No. 678023
Serial No.

Motor Identification:

Start: 5
Run: 1
Frame: R48
RPM: 850
Volts: 460
Amb. C: 40
Duty: 15 Min.
Horsepower: 17
Type: P
Phase: 3
Hz: 60
Amps: .9
Ins. Class: RH

Manual Unit Identification:

Type: H
Size: OBC
Order No. 3B8785A
Serial No. 273183
273180



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PROCEDURE:

Prior to seismic exposure, the SMB-000/H0BC was equipped with a 5' # XP motor, four train - four gear limit switch and an integral limit switch cover. The torque switch was pre-set such that the H0BC manual unit delivered 450' # output torque.

The unit combination was mounted to a special seismic plate with provisions for a stem with a torque arm and seat which simulated loading of the valve operator during valve closing. The unit delivered 450' # output.

The limit and torque switch were wired into a control unit which contained a reversing starter, a pushbutton control station, and indicating lights for open, close and mid-stroke positions. The limit switch was set for a ten-second stroke in each direction.

The "open" side of the torque switch, normally closed, and one of the furthest contacts from the intermittent gearing of the limit switch, set for normally closed, were connected to chatter circuits calibrated to detect one milli-second switch chatter. (NOTE: While connecting the chatter circuit, it was noted the torque switch was defective and could not be corrected before start of test. The defect created the torque switch chatter noted during testing. Prior developmental tests performed by Limitorque have shown the SMB-000 torque switch to be capable of withstanding up to 8g seismic acceleration without switch chatter.) The unit combination was then subjected to seismic testing per referenced test procedure.

SEQUENCE OF TESTING:

The following table lists the type test, in chronological order, as performed:

| <u>Test No.</u> | <u>Axis of Excitation</u> | <u>Frequency (Hz)</u> | <u>Test Level (G)</u> | <u>Excitation Rate</u> | <u>Seismic Support Bracket & Adapter</u> |
|-----------------|-------------------------------|---------------------------|---------------------------|------------------------|--|
| 1A | H ₁ | 1-50-1 | .5 | 6 sec/freq. | No |
| 2A | H ₂ | 1-50-1 | .5 | 6 sec/freq. | No |
| 3A | V | 1-60-1 | .5 | 6 sec/freq. | No |
| 1B | V | 1-60-1 | .5 | 6 sec/freq. | Yes |
| 2B | H ₁ | 1-50-1 | .5 | 6 sec/freq. | Yes |
| 3B | H ₂ | 1-50-1 | .5 | 6 sec/freq. | Yes |
| 4B | V | 33 | 3,4,5,6 | 30 sec/level | Yes |
| 5B | V | 5-36 | .5 | 1 oct/min | Yes |
| 6B | H ₁ | 5-36 | .5 | 1 oct/min | Yes |
| 7B | H ₁ | 33 | 3,4,5,6 | 30 sec/level | Yes |
| 8B | H ₂ | 5-36 | .5 | 1 oct/min | Yes |
| 9B | H ₂ | 33 | 3,4,5,6 | 30 sec/level | Yes |
| 4A | H ₂ | 33 | 3,4,5,5.5 | 30 sec/level | No |
| 5A | H ₁ | 33 | 3,4,5,6 | 30 sec/level | No |
| 6A | V | 33 | 3,4,5,6 | 30 sec/level | No |
| 7A | V | 33 | 7,8,9,10,11,12 | 30 sec/level | No |
| 10B | V | 33 | 7,8,9,10,11,12 | 30 sec/level | Yes |
| 11B | H ₁ | 33 | 7,8,9,10,11,12 | 30 sec/level | Yes |
| 12B | H ₂ | 33 | 7,8,9 | 30 sec/level | Yes |
| 13B | H ₂ | 10-24 24-10 | .025 DA .75 | 2 oct/min (90 min) | Yes |
| 14B | H ₁ | " | " | " | " |
| 15B | V | " | " | " | " |

*NOTE: Due to stiffness of vertical fixtures of the seismic test apparatus,
the sample was surveyed to 60Hz in the vertical plane without distortion.



EVALUATION OF TESTING:

The Limitorque actuator and seismic table were monitored, using eighteen (18) accelerometers in conjunction with recording visicorders. A video tape recording system was used to aid in field analysis of the dwell tests and an oscilloscope in determining true resonant frequencies. A stroboscopic light was used to detect relative movement between components of the Limitorque valve actuator assembly.

RESONANT SEARCH:

The following tables summarize the results of resonancy surveys of the referenced reports with respect to axis of vibration and unit configuration.

| <u>Test No.</u> | <u>Axis</u> | <u>Frequency of Resonance</u> | <u>Point of Indication</u> | <u>Survey Range (Hz)</u> | <u>Seismic Adapter</u> |
|-----------------|----------------|-------------------------------|--|--------------------------|------------------------|
| 1A | H ₁ | 37.5 | Motor end cap SMB-000 housing flange | 1-50-1 | No |
| 2A | H ₂ | 39.0 | End cap motor, SMB-000 mtg flange & hsg top corner | 1-50-1 | No |
| | | 44.0 | Gear frame of g.l.sw. | | |
| 3A | V | 58.5 | End cap of mtr, SMB-000 hsg top corner & mtg flange | 1-60-1 | No |
| 1B | V | 104* | Motor end cap | 1-60-1 | Yes |
| 2B | H ₁ | 70* | Motor end cap, SMB-000 hsg at top corner & mounting flange | 1-50-1 | Yes |
| 3B | H ₂ | 74* | Motor end cap and SMB-000 housing | 1-50-1 | Yes |
| 5B | V | None | None | 5-36 | Yes |
| 6B | H ₁ | None | None | 5-36 | Yes |
| 8B | H ₂ | None | None | 5-36 | Yes |

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SINUSOIDAL DWELL TEST:

Dwell tests consisted of 30-second continuous steady state sinusoidal inputs, at any resonant frequencies detected below 33 Hz. Since no resonances were found in this region, dwells were performed at 33Hz. The unit was operated during each dwell from the "open" position to "close" and back to "open". Manual operation was performed between each axis change.

Tests #4B, 7B and 9B were performed first to ensure a 6g minimum fragility level on the SMB-000-5/HOBC unit with the seismic support adapter and bracket before the unit became seismically abused. During Test #7B, the motor bolts



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yielded, due to loosening in previous test. After replacing bolts, no problems were detected. The unit operated correctly during these tests.

Tests 4A, 5A, 6A and 7A examined the fragility of the valve actuator assembly with the standard adapter. The following table lists the g level and excitation direction during failure.

| <u>Test No.</u> | <u>Axis</u> | <u>G Level</u> | <u>Test Frequency (Hz)</u> |
|-----------------|----------------|----------------|----------------------------|
| 4A | H ₂ | 5.5 | 33 |
| 5A | H ₁ | 6 | 33 |
| 6A & 7A | V | 12* | 33 |

During Test #4A, in the H₂ plane, at 5.5g, a phase change in the relative movement of the unit, as viewed on a video tape recording, led to the discovery of a hairline fracture in the flanged adapter on the SMB-000 side. The adapter was replaced and after the 6g dwell in the H₁ direction the same sort of fracture was found. In both cases, the fractures did not hinder the operation of the unit.

No failures were found in Tests #6A and 7A through 12g testing.

Tests 10B, 11B and 12B examined the fragility of SMB-000/HOBC system with the seismic support bracket and adapter. The following table lists axis excitation and level of failure.

| <u>Test No.</u> | <u>Axis</u> | <u>G Level</u> | <u>Test Frequency (Hz)</u> |
|-----------------|----------------|----------------|----------------------------|
| 10B | V | 12 | 33 |
| 11B | H ₁ | 12 | 33 |
| 12B | H ₂ | 9 | 33 |

No failures occurred during test #10B (V axis), the unit operated correctly.

After the 12g dwell in Test #11B (H₁ axis), a hairline fracture was discovered and was similar to the type as in previous fragility testing. Test 12B was suspended at 9g level, due to a time factor. During the first attempt at 9g's, a finger base of the limit switch fractured. It's attachment to the gear limit box had not been inspected before the 9g dwell test, due to accelerated testing. Accelerometers were relocated to the gear frame cover of the gear limit switch to prevent electrical shorting of the accelerometers. The coverplate is a thin metallic sheet; the response of the accelerometer mounted at this point was not indicative to that of the gear limit switch assembly.

VIBRATION AGING TEST:

The actuator system in Tests #13B, 14B and 15B was exposed to multifrequency cycling. Sinusoidal input consisted of a 10-100-10 Hz sweep at two (2) octaves/minute, with a double amplitude of 0.025 inches from 10-24Hz, and 0.75g 24-100Hz, for 90 minutes in each orthogonal axis. The actuator was cycled every fifteen (15) minutes.

No deterioration or malfunctions occurred in this test. Resonant frequencies corroborated those determined in Tests #1B, 2B and 3B.

At the end of testing, the unit was operated both electrically and manually with no problems apparent.

CONCLUSIONS:

Based on the results presented in Acton Report #14331-2, the SMB-000-5/HOBC is qualified to IEEE 344 (1975) to a level of 5g's. The unit performed all functions and torqued out at maximum torque with no malfunction or physical damage during and after all dwells.

Damage was not noted until g levels of 5.5 and higher were reached. The unit was subjected to several dwells at various g levels, constituting the equivalent 5 OBE dwells normally performed.

Based on the results presented in Acton Report #14331-3, the SMB-000-5/HOBC with seismic support bracket is qualified to 9 g's. The damaged finger base, noted during Test 12B, was considered a result of the excessive testing experienced during the prior fragility testing and a result of loose hardware. The second finger base installed on the four train gear limit switch functioned properly without physical damage.

Respectfully submitted,

Paul T. Young / W.L.S. 3/28/79
Paul Thomas Young
Assistant Chief Test Engineer

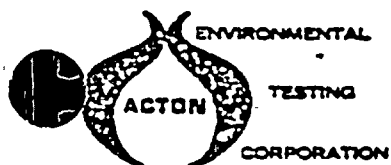
Attachments

cc: W.J. Denkowski
I.E. Wilkinson
W.L. Sykes
C.D. Formica
J.B. Drab
D.S. Warsing
D.A. DiPasquale

REVISION RECORD

| DATE | REVISION NUMBER | PAGE NUMBER | PARAGRAPH NUMBER | CHANGES OR ADDITIONS | APPROVED BY |
|---------|--------------------|-----------------------|---------------------|---|---|
| 1/31/79 | 0 | -----FIRST ISSUE----- | | | |
| 3/10/79 | 1 | 2 | 1.0 | Added last sentence | <i>Bevan Gynns 3/13/79</i> <i>Revised for 3/6/79 Indefinite</i> <i>Letter</i> |
| | | | 3.0 | Changed 67803 to 678023 | |
| | | 3 | 3.2 | Changed 440 to 460 | |
| | | 3 | Footnote | Typographical correction | |
| | | 4 | Footnote | Typographical correction | |
| | | 5 | 4.1(2A) | Corrected spelling of frame, added coma | |
| | | | 4.2(5A) | Changed valve to actuator | |
| | | | 4.2(6A) | Added switch | |
| | | 6 | 4.2 | Added last sentence | |

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Administrative Data

1.0 Purpose of Test: To subject one (1) actuator to seismic vibration testing.

2.0 Manufacturer: Limitorque Corporation
Lynchburg, Virginia

3.0 Manufacturer's Type or Model No: SMB-000/HOBC

4.0 Drawing, Specification or Exhibit: Limitorque Seismic Test of
Limitorque SMB-000/HOBC R&D
Project #678023, dated 8/24/78.

5.0 Quantity of Items Tested: One (1)

6.0 Security Classification of Items: Unclassified

7.0 Date Test Completed: September 11, 1978

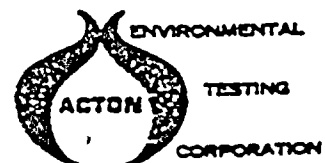
8.0 Test Conducted By: C.Pilotte

9.0 Disposition of Specimens: Returned to Limitorque Corporation.

10.0 Abstract: Refer to result section herein.

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1.0 TEST ITEM

One (1) Limitorque SMB-000/HOBC Actuator was submitted by Limitorque Corporation for seismic vibration testing at Acton Environmental Testing Corporation (AETC). Note: Actuator was also subjected to additional seismic excitation as documented in Acton Report 14331-3.

2.0 TEST REQUIREMENTS

The purpose of this test was to subject the actuator specified in section 1.0 above to the seismic vibration test specified in Limitorque Seismic Test of Limitorque SMB-000/HOBC Research & Development Project No. 678023, dated August 24, 1978, to determine its ability to withstand such vibration without evidence of mechanical damage, deterioration, loss of its ability to operate properly, or contact chatter in excess of one (1) millisecond.

3.0 TEST PROCEDURES

This test was performed under the direction of Mr. Paul Young of Limitorque Corporation and in accordance with Limitorque Seismic Test of Limitorque SMB-000/HOBC Research & Development Project No. 678023, dated August 24, 1978.

3.1 Test Mounting

The actuator was bolted to a test fixture supplied by Limitorque. The test fixture was then securely attached to the single-axis table of the AETC seismic test facility.

3.2 Test Conditions

All tests were performed at room temperature and pressure.

During the resonance survey specified in section 3.4 below, the actuator was not operated.

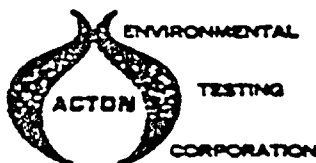
During the sinusoidal dwell test specified in section 3.5 below, the actuator was cycled open and closed at least once per dwell. 460 VAC 3Ø power was supplied to the actuator.

3.3 Test Monitoring

The actuator was visually monitored for any evidence of

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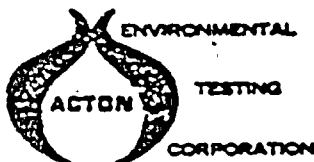
mechanical damage, deterioration or loss of its ability to operate properly.

The actuator was monitored with triaxial groups of accelerometers by AETC personnel to determine its mechanical response during the resonance survey and sinusoidal dwell test specified in sections 3.4 and 3.5 below. Data from these accelerometers through appropriate signal conditioning was recorded on visicorder recording paper included with this report. The eighteen (18) monitoring accelerometers and one (1) control accelerometer were mounted as follows:

| ACCELEROMETER NO. | AXIS SENSING ORIENTATION* | LOCATION |
|-------------------|---------------------------|---|
| 1 | H ₁ | Triaxial on end of motor |
| 2 | H ₂ | |
| 3 | V | |
| 4 | H ₁ | Triaxial on SMB-000 Housing at mounting flange |
| 5 | H ₂ | |
| 6 | V | |
| 7 | H ₁ | Triaxial on HOBC mounting adaptor |
| 8 | H ₂ | |
| 9 | V | |
| 10 | H ₁ | Triaxial on base of test. fixture, control is #12 |
| 11 | H ₂ | |
| 12 | V | |
| 13 | H ₁ | Triaxial on top corner of actuator housing |
| 14 | H ₂ | |
| 15 | V | |
| 16 | H ₁ | Triaxial on gear frame of geared switch |
| 17 | H ₂ | |
| 18 | V | |

*
H₁ is the horizontal axis parallel to the motor axis.
H₂ is the horizontal axis perpendicular to the motor axis
V is the vertical axis

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One (1) normally closed (N/C) set of contacts of the limit switch and one (1) N/C set of contacts of the torque switch were monitored for contact chatter in excess of one (1) millisecond.

3.4 Resonance Survey

The resonance survey consisted of a sinusoidal input with peak horizontal or vertical accelerations of 0.5g. The resonance survey was conducted at a sweep rate of 6 seconds/Hz. The resonance surveys were performed as follows:

| TEST NO. | AXIS OF EXCITATION* | FREQUENCY RANGE(Hz) |
|----------|---------------------|---------------------|
| 1A | H ₁ | 1-50-1 |
| 2A | H ₂ | 1-50-1 |
| 3A | V | 1-60-1 |

3.5 Sinusoidal Dwell Test

The sinusoidal dwell test consisted of a continuous steady state sinusoidal input. The sinusoidal dwell test was to be performed at the resonant frequencies found during the resonance survey (only those below 33 Hz) specified in section 3.4 above. If no resonances were detected, then testing was to be performed at 33 Hz.

Each input at each test level was for a duration of thirty (30) seconds. The input was applied as follows:

| TEST NO. | AXIS OF EXCITATION* | TEST LEVEL(G) | TEST FREQ.(Hz) |
|----------|---------------------|----------------|----------------|
| 4A | H ₂ | 3,4,5,5.5 | 33 |
| 5A | H ₁ | 3,4,5,6 | 33 |
| 6A | V | 3,4,5,6 | 33 |
| 7A | V | 7,8,9,10,11,12 | 33 |

*
H₁ is the horizontal axis parallel to the motor axis
H₂ is the horizontal axis perpendicular to the motor axis
V is the vertical axis

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4.0 TEST RESULTS

4.1 Resonance Survey Test Results

TEST 1A:

Resonance was detected at 37.5 Hz on the gear limit housing, end cap of the motor and housing flange. The torque switch chattered. This switch was defective before the start of the test.

TEST 2A:

Resonance was detected at 44 Hz on the gear frame of gear limit switch, at 39 Hz, on the end cap of motor and top corner of actuator housing, as well as the SMB-000 mounting flange.

TEST 3A:

Resonance was detected at 46.3 Hz on the gear box housing of the gear limit switch at 58.5 Hz on the end cap of the motor, top corner of actuator housing and the SMB-000 housing mounting flange.

4.2 Sinusoidal Dwell Test Results

TEST 4A:

The actuator was operated at each test level. On the 5.5g level the coupling adaptor fractured. The adaptor was removed and replaced with another one.

TEST 5A:

The actuator was operated at each test level and the torque switch chattered at each level. At the completion of the 6g run during TEST 5A, the coupling adaptor was found to have a hair-line fracture. The coupling was replaced.

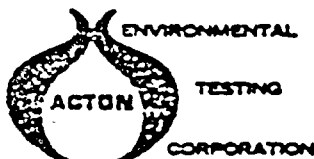
TEST 6A:

The actuator was operated at each test level. No switch chatter occurred and no mechanical damage occurred.

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TEST 7A:

The actuator was operated at each test level.
The torque switch chattered at 7g's, 8g's, 9g's,
10g's, 11g's & 12g's. Following completion of
the 8g run, the gear limit housing was retightened.

The actuator was operated manually by the representative
from Limitorque after testing in each axis was completed.

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TEST EQUIPMENT LIST

| NAME | MFGR | MODEL | SER. NO. | RANGE | ACCURACY | INV. # | CAL. FREQ. |
|--------------------------|--------------|-------------------|----------|---|--------------------------|--------|----------------|
| Exciter Amplifier | Ling Ling | A249 PP120/150 | 70 56 | 30,000 \pm force 1" P/P disp. 5 - 5 KHz | \pm 5% \pm 2% | | PE317 1 month |
| Hydraulic Actuator | MTS | 204.63S | | DC - 300 Hz, 25K force lbs. 25" DA max. | \pm 2% F \pm 5% A | | |
| Controller | MTS | 443.115 | | DC - 2000 Hz | \pm 1% | | PE367 6 months |
| Chatter Monitor | Matrix | 202D | 310 | Detection: 10 & 100 usec | \pm 2% | | PE370 6 months |
| Power Supply Rack | PCB | 483A | 299 | 22 VDC 12 MADC 12 channel | N/A | | PE379 6 months |
| Power Supply & Amplifier | PCB | 483M23 | 289 | 12 channel X1 & X5 gain filter freq. 50 Hz | N/A | | PE385 6 months |
| Power Supply | PCB | 483A02 | 364 | +22VDC, current 4 MA 6 channel | N/A | | PE397 6 months |
| Visicorder | Honeywell | 906B | 8687 | DC-2 KHz 12 channel | \pm 1db | | RE301 3 months |
| Visicorder | Honeywell | 906 | 9-5235 | DC-2 KHz 12 channel | \pm 1db | | RE332 3 months |
| Visicorder | Honeywell | 1508 | 161715R | 12 channel-metric | \pm 1db | | RE347 3 months |
| Timer Seconds | SE | S60 | | 0-60 seconds 1 rpm | \pm 0.1sec | | FM311 6 months |
| Strobotac | GRC | 1531A | 185 | 0-25K rpm | \pm 1% | | PP322 6 months |
| Sweep Oscillator | SDY | SD-104-5 | 21A | 0.005 Hz -50 KHz | \pm 1% | | SG315 6 months |
| Scope, Storage | Tektronix | 564- | 11582 | DC to 10 MHz | \pm 3% | | OS309 3 months |
| Power Supply | Trygon | HR60-5A | 27979 | 60 volts 5 amps | .01% | | PD328 6 months |
| Power Supply | Bubr | 506/16 | 322 | \pm 15 VDC, 1 ADC | 0.5% | | PD372 6 months |
| Decade Ampl. | Glen | F408 | 624 | 3 to 100 KHz 40db/x100 | \pm 1% | | AM315 6 months |

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TEST EQUIPMENT LIST

| NAME | MFGR. | MODEL | SER.NO. | RANGE | ACCURACY | INV.# | CAL.FREQ. |
|---------------|-------|-------|---------|-----------------|----------|-------|-----------|
| Accelerometer | PCB | 302A | 667 | 0.25 Hz - 5 KHz | +5% | AC376 | 3 months |
| " | " | " | 668 | " | " | AC377 | " " |
| " | " | " | 671 | " | " | AC380 | " " |
| " | " | " | 673 | " | " | AC382 | " " |
| " | " | " | 2845 | 1 Hz - 5 KHz | " | AC383 | " " |
| " | " | " | 694 | 0.25 Hz - 5 KHz | " | AC384 | " " |
| " | " | " | 696 | " | " | AC386 | " " |
| " | " | " | 697 | " | " | AC387 | " " |
| " | " | " | 2851 | 1 Hz - 5 KHz | " | AC392 | " " |
| " | " | " | 2852 | " | " | AC394 | " " |
| " | BK | 4344 | 447575 | 0.25 - 5 KHz | " | AC395 | " " |
| " | " | 302A | 2856 | 1 Hz - 5 KHz | " | AC414 | " " |
| " | " | " | 1772 | " | " | AC415 | " " |
| " | " | " | 1774 | " | " | AC417 | " " |
| " | " | " | 1780 | " | " | AC423 | " " |
| " | " | " | 1781 | " | " | AC424 | " " |
| " | " | " | 1805 | " | " | AC425 | " " |
| " | " | " | 1811 | " | " | AC429 | " " |

