Flight Unit S/N 002
Workmanship
Vibration Test Report

Dwg. No. 32-06050.0103

Revision 01
December 10, 2007
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1 Introduction

1.1 Activity Description

This report summarizes the results for the Workmanship Vibration testing of the CRaTER Instrument, S/N 002 as performed per the Workmanship Vibration Procedure 32-06004.04.

1.2 Test Item Description

The Unit Under Test (UUT) is CRaTER Flight Unit, 32-10000, S/N 002. The Thermal Blanket was not installed for this test.

After successful completion of the vibration testing previously, the UUT had to be reworked per an eeo that was generated to fix problems found during EMI/EMC testing. Also, during a subsequent meeting, with the Thermal Blanket personnel, an additional blanket support post was requested to be added to the top cover and thus added. During the fit check of the thermal blanket, one post had been dislodged from the top cover. The unit was reworked and retested to workmanship vibration levels in the Z direction per 32-06004.04.

The overall weight of the UUT was 11.5 lbs (excludes the weight of the Thermal Blanket System.)

1.3 Support Documents

1.3.1 Applicable Documents

<table>
<thead>
<tr>
<th>Document ID</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>431-SPEC-000012</td>
<td>Lunar Reconnaissance Orbiter Mechanical System</td>
</tr>
<tr>
<td></td>
<td>Specification, Rev D.</td>
</tr>
<tr>
<td>32-06003.01</td>
<td>Crater Long Form Functional Test Procedure</td>
</tr>
<tr>
<td>32-06003.02</td>
<td>Crater Short Form Functional Test Procedure</td>
</tr>
<tr>
<td>32-06004.04</td>
<td>Workmanship Vibration Procedure</td>
</tr>
</tbody>
</table>
2 Requirements.

CRaTER shall demonstrate the ability to “survive” the ground, launch, and operational environments. The survival criteria are listed below.

2.1 Acceptance criteria, applicable to CRaTER

- Complete testing to limit levels with the appropriate test factor.
- No structural degradation after test.
- No unexplained frequency shifts more than 5% between pre and post test.
- No visible damage that is a result of the test environment.
- Pass all functional performance testing performed during and upon completion of the test.

2.2 Vibration Testing Levels

The Random vibration test was preceded by a low level, -20 db, then was ramped up to the desired levels to ensure no anomalies are evident.

2.2.1 Low-Level Resonance Search (Sine Sweep)

This test determined the baseline for verifying that no significant changes occur during the vibration test. Low-Level resonance search was performed at 1/2g at a rate is 2 Octaves per minute.

2.2.2 Random Vibration

Crater was subjected to the following Random Vibration levels in the Z axis. The duration was 1 minute.

<table>
<thead>
<tr>
<th>Frequency (Hz)</th>
<th>Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>0.013 g²/Hz</td>
</tr>
<tr>
<td>20-50</td>
<td>+6dB/Octave</td>
</tr>
<tr>
<td>50-800</td>
<td>0.080 g²/Hz</td>
</tr>
<tr>
<td>800-2000</td>
<td>-6dB/Octave</td>
</tr>
<tr>
<td>2000</td>
<td>0.013 g²/Hz</td>
</tr>
<tr>
<td>Overall</td>
<td>10.1 grms</td>
</tr>
</tbody>
</table>

2.2.3 Post Low-Level Resonance Search (Sine Sweep)

Low-Level Resonance search was tested at 1/2g at a rate of 2 Octaves per minute. This test was used to verify that the natural frequencies of the assembly did not change more than 5% from the pre-shake sine sweep.

2.3 Electrical Testing

Before vibration testing started, the UUT was electrically tested per the CRaTER Long From Functional Test Procedure. After Final Vibration testing and inspection, the UUT was tested per the CRaTER Long Form Functional Test Procedure.

CRaTER passed all electrical testing before and after the vibration test.
3 Facilities and Configuration

3.1 Facility
   The facility and shaker used for this test is provided by Charles Stark Draper Labs, Cambridge MA.

3.2 Test Configuration
   The CRaTER Assembly is attached to the vibration test fixture at the mounting flange by a total of five (5), #10-32UNC x 1” SHCS, High Strength, and one (1) #10-32UNC x ¾” SHCS, high strength, and six (6) washers.

3.3 Accelerometers
   Two triax accelerometers were located per Figures 1 and 2. These were adhered by first placing Kapton tape on the surface and then the accelerometers were bonded to the Kapton tape with a fast drying adhesive.

Figure 1. Accelerometer 01 Location: Telescope.
Figure 2.
Accelerometer 02 location: E-Box.
3.4 Coordinate System

The Axis for vibration testing as defined by the LRO coordinate system. The LRO Coordinate system is shown in Figure 3.

Figure 3. LRO Coordinate System.
4 Preparation

4.1 Identification

4.1.1 Equipment

Document model and serial number of the accelerometers used.

<table>
<thead>
<tr>
<th>Description</th>
<th>Acc Model number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Telescope @1</td>
<td>40900</td>
</tr>
<tr>
<td>E-Box @2</td>
<td>40899</td>
</tr>
<tr>
<td>Control #1</td>
<td>Not recorded</td>
</tr>
<tr>
<td>Control #2</td>
<td>Not recorded</td>
</tr>
</tbody>
</table>

4.1.2 Installation

The shaker plate was attached to the shaker head. The bolts were torque to 45 ft lbs.

Two control accelerometers at opposing ends of the plate during the Z direction.

A 1/2g sine sweep was run on the interface plate to verify no loose connections and to see the profile of the shaker plate.

The Crater assembly was mounted to the shaker plate using five(5) high strength SHCS, #10-32 x 1” with Heavy Duty Flat washers. And one (1) high strength SHCS, #10-32x ¾”L also with a Heavy Duty Flat washer. The #10-32 screws were torque to 35 in-lbs.

A piece of Kapton tape was placed at the locations where the accelerometers were to be placed on the unit. The accelerometers were then mounted to the Kapton tape with an adhesive, Loctite 455. After testing was completed the tape was removed and any residue was cleaned.
4.2 Test Results
All plots can be viewed in the Appendices.

4.2.1 Z-Axis

4.2.2 Low-Level Resonance Search, Pre Vibe, Z-Axis.

Performed Low-Level Resonance sine sweep at 1/2g for a minimum of 2 Oct/min. The peak frequencies and responses are listed below.

<table>
<thead>
<tr>
<th>Axis</th>
<th>Frequency</th>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>Z</td>
<td>725</td>
<td>1.6</td>
</tr>
<tr>
<td></td>
<td>959</td>
<td>4.1</td>
</tr>
<tr>
<td></td>
<td>1233</td>
<td>2.8</td>
</tr>
<tr>
<td></td>
<td>1738</td>
<td>4.2</td>
</tr>
</tbody>
</table>

The Pre-Vibe Low-Level Resonance sine sweep Test results can be viewed in Appendix A.

4.2.3 Random Vibration, Z-Axis.

Perform Random Vibration per Table 2, Z-Axis

Random Vibration Test results can be viewed in Appendix B.

4.2.4 Low-Level Resonance Search, Post Shake, Z-Axis.

Performed post vibe Low-Level Resonance sine sweep at 1/2g for a minimum of 2 Oct/min. The peak frequencies and responses are listed below.

<table>
<thead>
<tr>
<th>Axis</th>
<th>Frequency</th>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>Z</td>
<td>723</td>
<td>1.6</td>
</tr>
<tr>
<td></td>
<td>956</td>
<td>4.0</td>
</tr>
<tr>
<td></td>
<td>1232</td>
<td>2.8</td>
</tr>
<tr>
<td></td>
<td>1733</td>
<td>4.2</td>
</tr>
</tbody>
</table>

Low-Level Resonance vibration Test results can be viewed in Appendix C.
4.2.5 Resonance Comparison, Z-Axis.

Comparing the results of the 2 tests for differences in recorded resonances shows not change in frequency greater than 1%.

<table>
<thead>
<tr>
<th>Freq. Pre Shake (Hz)</th>
<th>Freq. Post Shake (Hz)</th>
<th>Difference (Hz)</th>
<th>Difference (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>725</td>
<td>723</td>
<td>2</td>
<td>&lt;1%</td>
</tr>
<tr>
<td>959</td>
<td>956</td>
<td>3</td>
<td>&lt;1%</td>
</tr>
<tr>
<td>1233</td>
<td>1232</td>
<td>1</td>
<td>&lt;1%</td>
</tr>
<tr>
<td>1738</td>
<td>1733</td>
<td>5</td>
<td>&lt;1%</td>
</tr>
</tbody>
</table>

4.3 Inspections

The UUT was inspected after the Z- axis vibration test for visible signs of damage. No signs of damage or loose external hardware were observed. The UUT was also gently rotated and shook to listen for loose items inside the unit and no sounds were noted.
5 Summary

The UUT, CRaTER s/n 002 meets all the acceptance criteria as specified in summary below:

- Complete testing to limit levels with the appropriate test factor.
- No structural degradation after test.
- No unexplained frequency shifts more than 5% between pre and post test.
- No visible damage that is a result of the test environment.
- Pass all functional performance testing performed during and upon completion of the test.
Level: 100 %  Control Peak: 0.462046 gn  Full Level Time: 00:03:19  Sweep
Frequency: 1998.061890 Hz  Demand Peak: 0.500000 gn  Time Remaining: 00:00:00  Sweep

Data saved at 01:14:08 PM, Thursday, November 08, 2007
Report created at 01:14:10 PM, Thursday, November 08, 2007
### Profile (S/N 002)

<table>
<thead>
<tr>
<th>Frequency (Hz)</th>
<th>(gn) / Hz</th>
</tr>
</thead>
<tbody>
<tr>
<td>20.00</td>
<td>20.0000</td>
</tr>
<tr>
<td>100.00</td>
<td>1.00E-07</td>
</tr>
<tr>
<td>1000.00</td>
<td>1.00E-06</td>
</tr>
<tr>
<td>2000.00</td>
<td>1.00E-05</td>
</tr>
<tr>
<td>20000.00</td>
<td>1.00E-04</td>
</tr>
<tr>
<td>200000.00</td>
<td>1.00E-03</td>
</tr>
</tbody>
</table>

### Levels:
- Level: 100%

### Control RMS:
- 9.994235 gn

### Demand RMS:
- 9.988903 gn

### Details:
- Full Level: 00:01:00
- Elapsed Time: 00:00:00
- Lines: 800
- Frame Time: 0.4000
- DOF: 200
- dF: 2.5000

Data saved at 01:40:14 PM, Thursday, November 08, 2007

Report created at 01:40:15 PM, Thursday, November 08, 2007

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**Graph:**

- Frequency (Hz) on the x-axis
- (gn) / Hz on the y-axis
- Various lines representing different measurements or conditions
08nov2007 CRaTER run03 z-axis post vibe sine sweep

Frequency (Hz)

Level: 100 % Control Peak: 0.489401 gn Full Level Time: 00:03:19 Sweep
Frequency: 1998.061890 Hz Demand Peak: 0.500000 gn Time Remaining: 00:00:00 Sweep

Data saved at 01:49:55 PM, Thursday, November 08, 2007
Report created at 01:49:57 PM, Thursday, November 08, 2007