Rev.	ECO	Description	Author	Approved	Date
A	32-229	Initial Release	M. Smith		

Flight Unit
Vibration Test Procedure

Dwg. No. 32-06004.03

Assembly Part Number 32-10000
Serial Number: _____

Revision A
August 13, 2007

Table of Contents

1 Introduction

1.1 Activity Description

The procedure defined herein verifies the workmanship of the CRaTER Instrument and its ability to satisfy the launch conditions of the LRO.

1.2 Test Item Description

The Unit Under Test (UUT) is CRaTER Flight Unit, 32-10000. The UUT has all the necessary Blanket support posts installed but the Blanket is excluded from this test.

The overall weight of the assembly is approximately 9.4 lbs, excluding weight of the accelerometers and thermal blanket.

1.3 Environment Assumptions

The test levels are based on the assumption that LRO will launch on an Atlas V 401.

1.4 Support Documents

1.4.1 Applicable Documents

431-SPEC-000012	Lunar Reconnaissance Orbiter Mechanical System Specification, Rev D.
32-06003.01	Crater Long Form Functional Test Procedure.
32-06003.02	Crater Short Form Functional Test Procedure
99-01003	ESD Procedure
32-02003.03	CRaTER Mechanical Interface Drawing(MID)

1.4.2 Reference Documents

NASA-HDBK-7005	Dynamic Environmental Criteria
NASA-STD-5001	Structural Design and Test Factors of Safety for Spacecraft Hardware
NASA-STD-7001	Payload Vibroacoustic Test Criteria
NASA-STD-7003	Pyroshock Test Criteria
RP-1403	Force Limited Vibroacoustic Testing Monograph, NASA Reference Publication
GSFC-STD-7000	General Environmental Verification Standards (GEVS) for Flight Programs and Projects

2 Requirements.

This section contains information for all steady-state and dynamic handling, launch, and on-orbit environments. This document assumes that the LRO will launch on an Atlas V 401. All other configurations may differ and need to be evaluated.

The LRO hardware structures 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

All vibration testing shall be preceded by lower levels of -12 db and -6 db to ramp up to the desired levels to ensure no anomalies are evident.

2.2.1 Low-Level Resonance Search(Sine Sweep)

This test determines the baseline for verifying that no significant changes occur during each vibration test. Low-Level resonance search shall be at 1/2g. Rate is 2 Octaves per minute.

2.2.2 Sine Vibration Environment

The CRaTER instrument sine vibration environments are shown below. The input is defined in the LRO coordinate system. Duration is 4 Oct/Min/Axis.

Table 2-1. CRaTER Instrument X-Axis Sine Vibration Environnent

Protoflight/Qualification		**Acceptance**	
Frequency (Hz)	**Level**	**Frequency** (Hz)	**Level**
5 – 9.9	1.27 cm D.A.	5 - 8.8	1.27 cm D.A.
9.9 - 50	2.5 g's	8.8 – 50	2.0 g's

Table 2-2. CRaTER Instrument Y-Axis Sine Vibration Environnent

Protoflight/Qualification		**Acceptance**	
Frequency (Hz)	**Level**	**Frequency** (Hz)	**Level**
5 - 15.6	1.27 cm D.A.	5 - 14.0	1.27 cm D.A.
15.6 - 25	6.25 g's	14.0 – 25	5.0 g's
25 - 50	3.125 g's	25 – 50	2.5 g's

Table 2-3. CRaTER Instrument Z-Axis Sine Vibration Environment

Protoflight/Qualification		Acceptance	
Frequency (Hz)	**Level**	**Frequency** (Hz)	**Level**
5 - 17.1	1.27 cm D.A.	5 - 15.3	1.27 cm D.A.
17.1 - 25	7.5 g's	15.3 - 25	6.0 g's
25 - 50	3.125 g's	25 - 50	2.5 g's

2.2.3 Structural Loads, Sine Burst

Crater shall be subjected to a Sine Burst for 5 cycles Full Level at 1.25 x limit load. The limit load for Crater is 8.0g's in any direction. The frequency shall be 35Hz.

2.2.4 Random Vibration

Crater shall be subjected to the following Random Vibration levels in each axis. Rates are 1 minute per axis.

Table 2-4. Random Vibration Levels

Frequency (Hz)	Level
20	0.26 g^2/Hz
20-50	+6dB/Octave
50-800	0.160 g^2/Hz
800-2000	-6dB/Octave
2000	0.026 g^2/Hz
Overall	14.1 grms

2.2.5 Post Low-Level Resonance Search (Sine Sweep)

This test verifies that the natural frequencies of the assembly have not changed more than 5% from the pre-shake sine sweep. Low-Level resonance search shall be at 1/2g. Rate is 2 Octaves per minute.

2.3 Required Items

- Crater Assembly
- Shake fixture
- 2 Accelerometers, single axis
- 2 Triax accelerometers.
- Torque tools, in oz, in-lbs
- Ethyl Alcohol
- Alpha Clean room wipes
- #10-32 SHCS x 5/8"High Strength, and Heavy Duty #10 FW, qty 6 each.
- NMD clean bag material
- Kapton tape.

2.4 Order of Testing.

The order of testing is not specific for which order each axis is tested but testing within each AXIS shall be per this procedure.

2.5 Safety

All personnel involved in testing/operations shall have reviewed this procedure before beginning testing and will understand what hazards may be encountered during testing.

When unsafe conditions exist, the test conductor shall take whatever actions necessary to prevent injury to personnel and/ or equipment.

2.6 Data

The following shall be included as part of the CRaTER Acceptance Vibration Test Data Package:

- Control and response accelerometer PSD plots for all resonance searches.
- The as-run filled-in copy of this procedure.
- The as-run filled-in copies of the Short and Long Form Functional Test Procedures

2.7 Electrical Testing

Before vibration testing is started, the UUT shall be electrically tested per the CRaTER Long From Functional Test Procedure.

The UUT shall be tested in-between each axis per the CRaTER Short Form Functional Test Procedure.

After Final Vibration testing and inspection, the UUT shall be tested per the CRaTER Long Form Functional Test Procedure.

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 six (6) bolts, #10-32UNC x 5/8 High Strength, and six (6) washers. Two control single axis accelerometers are attached to the vibration fixture at opposing locations.

3.3 Accelerometers

Locate two triax accelerometers per Figures 1 and 2. Adhere to surfaces using acceptable adhesive.

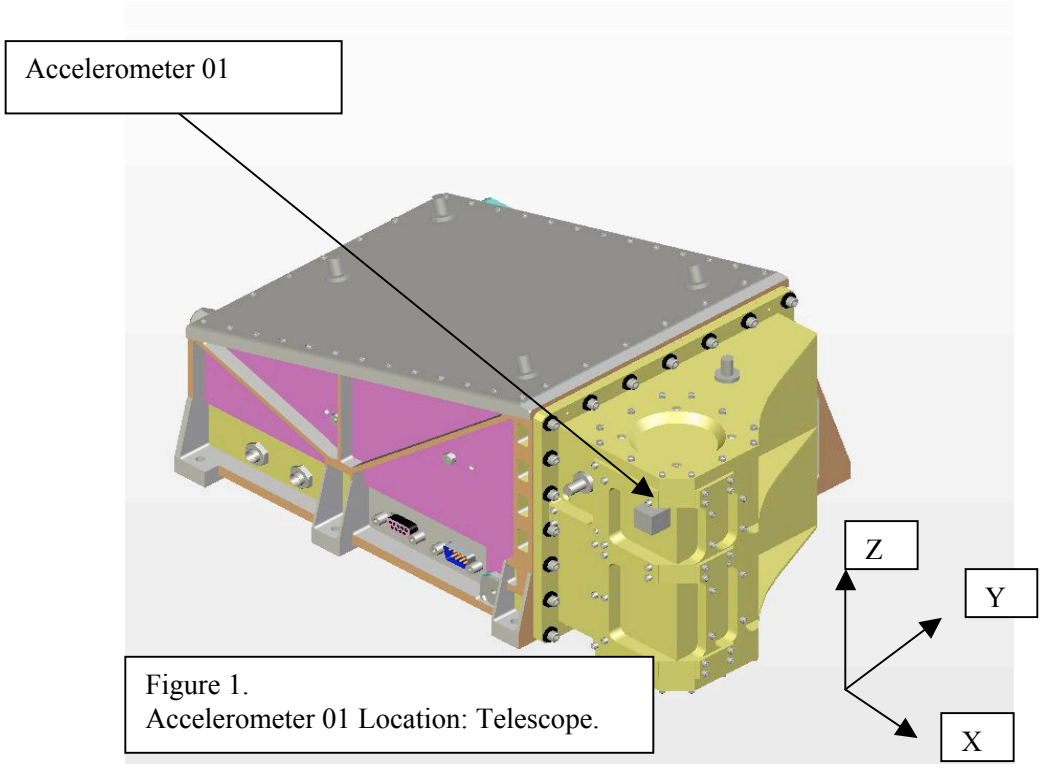

Figure 1.
Accelerometer 01 Location: Telescope.

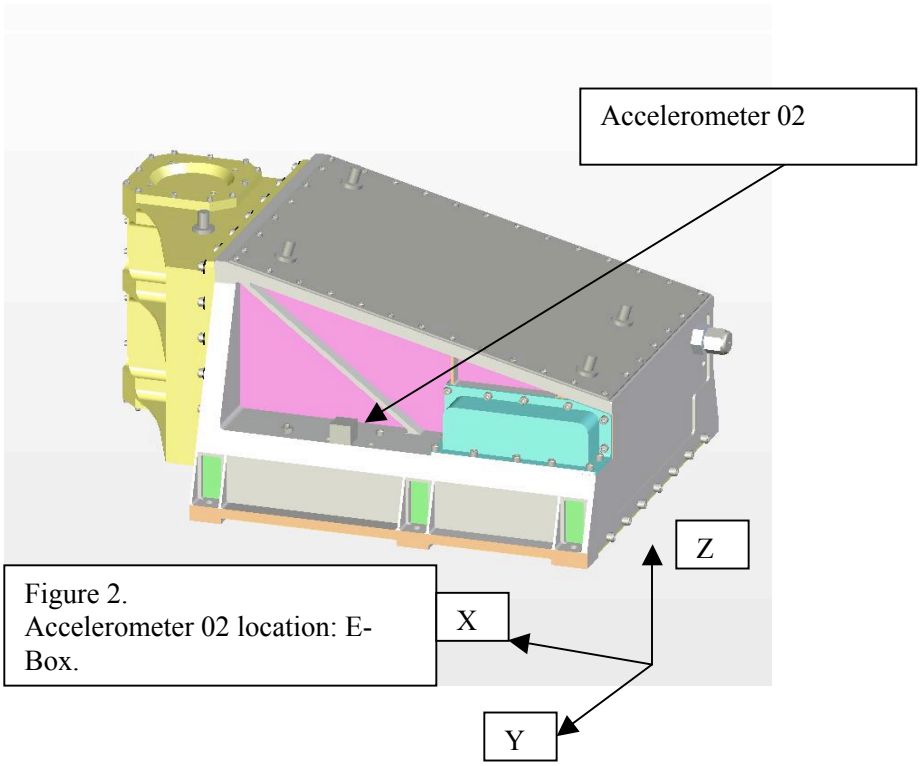

Figure 2.
Accelerometer 02 location: E-Box.

3.4 Control Accelerometers

Install two (2) single axis control accelerometers in the threaded holes in the shake plate. The two locations should be on opposing sides of the UUT.

3.5 Coordinate System

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

3.6 Clean-up

After the last vibration test is completed, remove the accelerometers and clean the CRaTER surfaces where the accelerometers were mounted with ethyl alcohol.

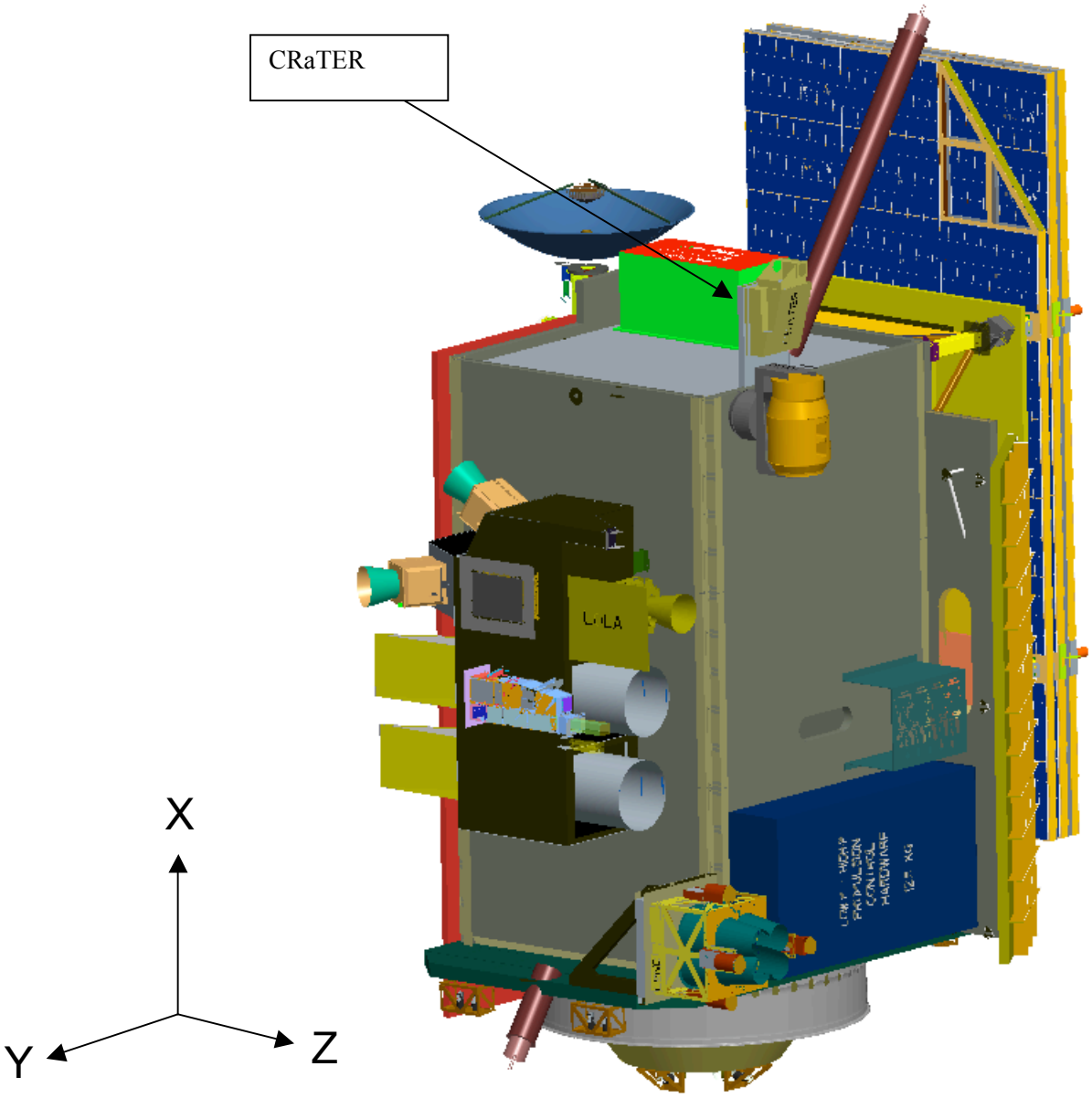

Figure 3. LRO Coordinate System.

4 Procedures

Space is provided to record information of particular significance pertaining to this test by the test conductor. In addition, the test conductor may redline the procedure to document the actual flow of events, both routine and anomalous. The following pages plus the facility data will be attached to the test report filed at the conclusion of these activities. The order of test axes is not significant. The order of the testing within each axis should be as specified.

4.1 Test Anomaly

Deviation from any expected result or observation of any anomalous behavior of the test article during vibration testing shall require the testing to be stopped and shall be noted in the test log. The test conductor will determine the proper course of action to be taken and when to continue with the remainder of the test procedure.

4.2 Identification

4.2.1 Equipment

Document model and serial number of the accelerometers used.

Description	Acc Model number	accel S/N	Calibration Date
Telescope @1			
E-Box @ 2			
Control #1			
Control #2			

4.2.2 Personnel

Quality Rep.	Test conductor	Date

4.3 Expected Frequencies

Table 4-1. Expected Resonance Frequencies

Axis	Frequency (Hz)	Location
X		
	435	Top Cover
	710	Analog board*
	880	Digital Board*
	980	Crater Assembly
	1400	Telescope
Z	260, 320	Bottom cover
	408	Top Cover
	620, 880	Digital Board*
	435, 710	Analog Board*
	1024, 1400, 1700	Crater, Telescope
Y	1024, 1400	Crater/ Telescope

* Analog and Digital Board frequencies will be lower than the specified frequencies. The frequencies listed are based on the Engineering Unit vibration test which had unpopulated circuit boards.

4.4 Pre-Vibration Long Form Functional Test

Perform Long From Functional test per 32-06003.01

Pass?	Operator	Date

4.5 X-Axis

4.5.1 Preparation

Attach shake plate to shaker head.
Torque bolts to facility specified torque values.
Specify torque values here _____ft lbs.

Install 2 control accelerometers at opposing ends of the plate.

Run sine sweep to verify control of shake plate.

Follow ESD Precautions.
Clean ESD safe gloves must be worn. Work surface shall be ESD safe and ESD wrist straps and coats shall be worn.

Install Accelerometers at positions shown in figures 1 and 2. Orientate the accelerometers in the proper orientation so as to simplify the readouts.

Install accelerometer cables and test accelerometers. Keep the clean NMD bag draped over the instrument while testing cables.

Verify Serial Number matches the serial number listed on front page of this Document.
CRaTER Assembly 32-10000 S/N_____

Mount Crater assembly to shake table in X Direction:
Operator:_____Date:_____

Install high strength SHCS, #10-32 x 1" with Heavy Duty Flat washers.

Torque #10-32 screws to 35 in-lbs.

Secure NMB bag over unit with Kapton tape.

Operator	Date

Mission Assurance	Date

4.5.2 Low-level Resonance Search, Pre-Vibe, X-Axis.

Perform Low-Level Resonance vibration sine sweep at 1/2g for a minimum of 2 Oct/min.

Axis	Frequency	Response	Date	Initial
X				

4.5.3 Sinusoidal Vibration, X-Axis.

Perform Sinusoidal Vibration per Table 2.1, X-Axis,

Axis	Date	Initial
X		

4.5.4 Sine Burst, X-Axis

Perform 5 cycles of Sine Burst per 2.2.3

Axis	Frequency	Load Level	Date	Initial
X	35 Hz			

4.5.5 Random Vibration, X-Axis.

Perform Random Vibration per Table 2.4, X-Axis,

Axis	Date	Initial
X		

4.5.6 Low-level Resonance Search, Post-Vibe, X-Axis.

Perform Low-Level Resonance vibration sine sweep at 1/2g for a minimum of 2 Oct/min.

Axis	Frequency	Response	Date	Initial
X				

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4.5.7 Resonance Comparison, X-Axis.

Compare the results of the pre and post Low-level resonance searches for differences in recorded resonances.

Freq. Pre Shake (Hz)	Freq. Post Shake (Hz)	Difference (Hz)	Difference (%)	Date	Initial

Comments on any discrepancies:

Comparison comments	Date	Initial

4.5.8 Post X-Axis Inspection

Visually inspect the outside part of the unit for any loose screws or damage. Gently shake the Unit and listen for loose components inside the unit. Turn Unit upside down and gently shake again and listen for loose components inside the Unit.

Inspection comments	Date	Initial

4.5.9 Post X-Axis Functional Performance Test.

Perform Short Form Function test per 36-06003.02

Test Pass?	Date	Initial

4.6 Y-Axis

4.6.1 Preparation

Attach shake plate to shaker head.
Torque bolts to facility specified torque values.
Specify torque values here _____ft lbs.

Install 2 control accelerometers at opposing ends of the plate.

Run sine sweep to verify control of shake plate.

Follow ESD Precautions.
Clean ESD safe gloves must be worn. Work surface shall be ESD safe and ESD wrist straps and coats shall be worn.

Install accelerometers at positions shown in figures 1 and 2. Orientate the accelerometers in the proper orientation so as to simplify the readouts.

Install accelerometer cables and test accelerometers. Keep the clean NMD bag draped over the instrument while testing cables.

Verify Serial Number matches the serial number listed on front page of this Document.
CRaTER Assembly 32-10000 S/N_____

Mount Crater assembly to shake table in Y Direction:
Operator:_____Date:_____

Install high strength SHCS, #10-32 x 1" with Heavy Duty Flat washers.

Torque #10-32 screws to 35 in-lbs.

Secure NMB bag over unit with Kapton tape.

Operator	Date

Mission Assurance	Date

Accelerometer Identification if different than 4.2.1

Description	Acc Model number	accel S/N	Calibration Date
Telescope @01			
E-Box @02			
Control #1			
Control #2			

4.6.2 Low-Level Resonance Search, Pre-Vibe, Y-Axis.

Perform Low-Level Resonance vibration sine sweep at 1/2g for a minimum of 2 Oct/min.

Axis	Frequency	Response	Date	Initial
Y				

4.6.3 Sinusoidal Vibration, Y-Axis

Perform Sinusoidal Vibration per Table 2-2.

Axis	Date	Initial
Y		

4.6.4 Sine Burst, Y-Axis

Perform 5 cycles of Sine Burst per 2.2.3

Axis	Date	Initial
Y		

4.6.5 Random Vibration, Y-Axis.

Perform Y-Axis Random Vibration per Table 2-4

Axis	Date	Initial
Y		

4.6.6 Low-Level Resonance Search, Post Vibe, Y-Axis.

Perform Low-Level Resonance vibration sine sweep at 1/2g for a minimum of 2 Oct/min.

Axis	Frequency	Response	Date	Initial
Y				

4.6.7 Resonance Comparison, Y-Axis.

Compare the results of the pre and post Low-Level resonance searches for differences in recorded resonances.

Freq. Pre Shake (Hz)	Freq. Post Shake (Hz)	Difference (Hz)	Difference (%)	Date	Initial

Comments on any discrepancies:

Comparison comments	Date	Initial

4.6.8 Post Y-Axis Inspection

Visually inspect the outside of the unit for any loose screws or damage. Gently shake the Unit and listen for loose components inside the unit. Turn Unit upside down and gently shake again and listen for loose components inside the Unit.

Inspection comments	Date	Initial

4.6.9 Post Y Axis Functional Performance Test.

Perform Short Form Function test per 36-06003.02

Test.	Date	Initial

4.7 Z-Axis

4.7.1 Preparation

Attach shake plate to shaker head.
Torque bolts to facility specified torque values.
Specify torque values here _____ft lbs.

Install 2 control accelerometers at opposing ends of the plate.

Run sine sweep to verify control of shake plate.

Follow ESD Precautions.
Clean ESD safe gloves must be worn. Work surface shall be ESD safe and ESD wrist straps and coats shall be worn.

Install Accelerometers at positions shown in figures 1 and 2. Orientate the accelerometers in the proper orientation so as to simplify the readouts.

Install accelerometer cables and test accelerometers. Keep the clean NMD bag draped over the instrument while testing cables.

Verify Serial Number matches the serial number listed on front page of this Document.
CRATER Assembly 32-10000 S/N_____

Mount Crater assembly to shake table in Z Direction:

Install high strength SHCS, #10-32 x 1" with Heavy Duty Flat washers.

Torque #10-32 screws to 35 in-lbs.

Secure NMB bag over unit with Kapton tape.

Operator	Date

Mission Assurance	Date

Accelerometer Identification (if different than 4.2.1.)

Description	Acc Model number	accel S/N	Calibration Date
Telescope @01			
E-Box @02			
Control #1			
Control #2			

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

Perform Low-Level Resonance vibration sine sweep at 1/2g for a minimum of 2 Oct/min.

Axis	Frequency	Response	Date	Initial
Z				

4.7.3 Sinusoidal Vibration, Z-Axis,

Perform Sinusoidal Vibration per Table 1, Z-Axis,

Axis	Date	Initial
Z		

4.7.4 Sine Burst, Z-Axis.

Perform 5 cycles of Sine Burst per 2.2.3

Axis	Date	Initial
Z		

4.7.5 Random Vibration, Z-Axis.

Perform Random Vibration per Table 2, Z-Axis

Axis	Date	Initial
Z		

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

Perform Low-Level Resonance vibration sine sweep at 1/2g for a minimum of 2 Oct/min.

Frequency	Response	Date	Initial

4.7.7 Resonance Comparison, Z-Axis.

Compare the results of the 2 tests for differences in recorded resonances.

Freq. Pre Shake (Hz)	Freq. Post Shake (Hz)	Difference (Hz)	Difference (%)	Date	Initial

Comments on Discrepancies:

Comparison comments	Date	Initial

4.7.8 Post Z-Axis Inspection

Visually inspect outside part of the unit for any loose screws or damage. Gently shake the Unit to listen for loose components inside the unit. Turn Unit upside down and gently shake again and listen for loose components inside the Unit.

Inspection comments	Date	Initial

4.7.9 Post Z-Axis Functional Performance Test.

Perform Short Form Function test per 36-06003.02

Test Pass?	Date	Initial

4.8 Removal CRaTER Assembly from the Shaker Fixture.

Observe ESD precautions.

Remove the accelerometer cables on the accelerometers attached to the Unit. Loosen and remove the six 10-32 SHCS that hold the Unit to the shake plate. the CRaTER Assembly from the vibration plate. Remove accelerometers and clean off the surface on the Unit with alcohol where the accelerometers where mounted. Install CRaTER onto shipping plate. Secure NMD Bag. Place into shipping crate.

Operators Initial	Date

Mission Assurance	Date

4.9 Post Vibration Inspection

4.9.1 External/Internal

Visually inspect the exterior of the Sensor Base Assembly for structural damage, backed out screws or other anomalies. Gently shake the unit to listen for any parts that might have come loose during vibration testing.

Comments	Date	Initial

4.10 Functional Test, Post Vibration

Perform Long Form Functional Test Procedure.

Test Pass?	Date	Initial