CSD 5597-93-2

BSM DELTA QUALIFICATION 2
FINAL REPORT

Volume II

11 November 1994

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UNITED TECHNOLOGIES CHEMICAL SYSTEMS

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FOREWORD

This report, presented in three volumes, provides the results of a two-motor Delta Qualification 2 program conducted in 1993 to certify the following enhancements for incorporation into Booster Separation Motor (BSM) flight hardware:

- Vulcanized-in-place nozzle aft closure insulation
- New iso-static ATJ bulk graphite throat insert material
- Adhesive EA 9394 for bonding the nozzle throat, igniter grain rod/centering insert/igniter case
- Deletion of the igniter adapter insulator ring
- Deletion of the igniter adapter/igniter case interface RTV
- Deletion of Loctite from igniter retainer plate threads.

The enhancements above directly resulted from (1) the BSM Total Quality Management (TQM) Team initiatives to enhance the BSM producibility, and (2) the necessity to qualify new throat insert and adhesive systems to replace existing materials that will not be available.

Testing was completed at both the component and motor levels. Component testing was accomplished to screen candidate materials (e.g., throat materials, adhesive systems) and to optimize processes (e.g., aft closure insulator vulcanization approach) prior to their incorporation into the test motors. Motor testing — consisting of two motors, randomly selected by USBI's on-site quality personnel from production lot AAY, which were modified to accept the enhancements — were completed to provide the final qualification of the enhancements for incorporation into flight hardware.

This report addresses the motor level test results, with summary discussions of the component level testing where appropriate. Volume I discusses the results obtained from the Delta Qualification 2 testing. Volume II details the environmental testing (vibration and shock) conducted at Marshall Space Flight Center (MSFC) to which the motors were subjected prior to static testing. Volume III provides various supporting documentation to Volumes I and II, including the analyses and plans that governed the testing of the two Delta Qualification units.
BSM MOTOR S/N 1000734
PYROSHOCK TEST PROCEDURE
BSM Delta Qualification Test
Motor to Bracket Assembly / Pyro Shock Simulation Test Procedure

This Procedure Describes Safety Critical Operations
BSM Delta Qualification Test

Motor to Bracket Assembly / Pyro Shock Simulation Test Procedure

Prepared by:
Mat Bevill EP-12

08/16/93

Motor SN: 1000734
Test Date: 09/21/93
## Motor to Bracket Assembly/Fyro Shock Simulation

### Prepared by:

<table>
<thead>
<tr>
<th>Name</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>John Booth</td>
<td>9/15/93</td>
</tr>
</tbody>
</table>

### Approved by:

<table>
<thead>
<tr>
<th>Name</th>
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<tbody>
<tr>
<td>Jim Hocking</td>
<td>9/14/93</td>
</tr>
<tr>
<td>Jon Hocking/LMSC</td>
<td>9/14/93</td>
</tr>
<tr>
<td>Richard Leonardi</td>
<td>9/16/93</td>
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<tr>
<td>Rick Clements</td>
<td>9/16/93</td>
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<tr>
<td>Ben Goldberg</td>
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<tr>
<td>Chuck Wells/UTC/CSD TE</td>
<td>9/16/93</td>
</tr>
<tr>
<td>Don Wenel/USBI</td>
<td>9/16/93</td>
</tr>
<tr>
<td>Charlie Lovel/CWI Engineer/CN71</td>
<td>9/16/93</td>
</tr>
</tbody>
</table>
Motor to Bracket Assembly/Pyro Shock Simulation

Prepared by: 
Mat Bevill  
Mat Bevill/MSFC TE/EP12  
09/15/93  
Date

Approved by: 
Jim McGee/MSFC Vibration Lab TE  
09/14/93  
Date

Jim Herring/MSFC Pyro Shock Lab TE  
09/14/93  
Date

Richard Leonard/MSFC Safety/CS01  
09/16/93  
Date

Rick Clements/MSFC Quality/CQ06  
09/15/93  
Date

Ben Goldberg/Motor Systems Division/EP11  
09/14/93  
Date

Steve Brewster/Dynamic Test Branch/ED73  
09/14/93  
Date

Chuck Wells/UTC/CSD TE  
Don Wencil/USB1  
Charlie Lovell/PCH Engineer/CN71

Date
10 General Information

1.1 Scope

This test procedure addresses all the requirements to perform pyro shock testing on Booster Separation Motors (BSM). Included in this procedure are the steps to assemble the BSM to the aft skirt support brackets.

1.2 Objective

The objective of the pyro shock testing is to verify the physical and functional survivability of the Booster Separation Motors. Of particular interest for these tests are the components bonded using EA9394 adhesive. The components using this adhesive include the throat insert, the centering insert, and the igniter grain support rod.

20 Applicable Documents

<table>
<thead>
<tr>
<th>Document Code</th>
<th>Description</th>
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</thead>
<tbody>
<tr>
<td>MSFC-STD-513A</td>
<td>Certification of Equipment Operations and Materials Handling Personnel</td>
</tr>
<tr>
<td>EG5300.36A</td>
<td>Safety</td>
</tr>
<tr>
<td>29 CFR 1910</td>
<td>Occupational Safety and Health Administration (OSHA)</td>
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<tr>
<td>NSS/GO 1740.9</td>
<td>Safety Standard for Lifting Devices and Equipment</td>
</tr>
<tr>
<td>NHB 1700.1(V1)</td>
<td>Basic Safety Manual</td>
</tr>
<tr>
<td>AMC-R 385-100</td>
<td>Safety Manual</td>
</tr>
<tr>
<td>MM 1700.4</td>
<td>Safety and Environmental Health Hazards</td>
</tr>
<tr>
<td>MMI 1700.17</td>
<td>MSFC Procedures for Acquiring Shipping Permits for Rocket Motors and Igniters</td>
</tr>
<tr>
<td>MMI 1710.1</td>
<td>Safety Review and Approval of Hazardous and Potentially Hazardous Facilities and Activities at MSFC</td>
</tr>
<tr>
<td>MMI 1710.6</td>
<td>MSFC Program for Personnel Certification</td>
</tr>
<tr>
<td>MMI 1711.2</td>
<td>Mishap Reporting and Investigation</td>
</tr>
</tbody>
</table>
3.0 Safety

3.1 The following safety criteria are in accordance with ET01-SOP-01, Rev. A., "Standard Operation Procedures for Safety Critical Operations". If safety rules/regulations are not followed, injury to personnel and/or damage to test items could occur.

Emergency telephone numbers are as follows:

<table>
<thead>
<tr>
<th>Service</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Safety</td>
<td>4-0046</td>
</tr>
<tr>
<td>Ambulance</td>
<td>112</td>
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<tr>
<td>Fire</td>
<td>117</td>
</tr>
<tr>
<td>Security</td>
<td>4-4357</td>
</tr>
<tr>
<td>Utilities</td>
<td>4-3919</td>
</tr>
<tr>
<td>Medical Center</td>
<td>4-2390</td>
</tr>
<tr>
<td>Communication Repair</td>
<td>4-1771</td>
</tr>
</tbody>
</table>

3.1.1 In the event of serious personnel injury, do not move the injured person unless necessary to prevent further serious injury. Call 112 for ambulance.

3.2 Prior to starting work in 4619, a visual inspection of the work area shall be made for anomalies by the MSFC TE and MSFC SE.

MSFC TE  [Signature]  MSFC SE  [Signature]

Date / Time: 09/21/93  6:00 p.m.
3.3 Personnel shall not work or position themselves beneath suspended loads unless such loads are securely and adequately blocked up.

3.4 Objects handled by overhead hoist shall be lifted only high enough to clear fixed objects in the path of travel. Spreader bars and slings may be left on the hoist if desired when not in use, but must be raised so that the lowest part of the lifting equipment will be at least seven feet from the floor when not in use.

3.5 Crane, hoist, prime lift operators, and riggers shall be certified according to the latest revision of MMI 1710.6, and shall have in their possession a valid certification card.

Certifications checked by: [Signature]

Date / Time: 07/21/97 6:00

3.6 Personnel working around suspended loads shall be alert to the possibility of being crushed between the suspended load and a fixed object.

3.7 Loads shall be moved slowly so they will not accumulate more momentum than can be stopped with little or no swing.

3.8 Where handling slings are called out, a sling with more pickup points than required may be used if the weight capacity per point used is equal or greater than the weight capacity of each point of the noted sling and the free pickup point is (are) secured to prevent it (them) from swinging and causing damage to parts.

3.9 Only the area coordinator should direct the crane moves, however, any person determining an immediate danger or problem may request stoppage of activities.

3.10 The lifting or transportation operation shall be halted by the area coordinator at any time the control area cannot be maintained.

3.11 Steel toe shoes are required during lifting operations. Hardhats are required when the lift is at or above the shoulders.

3.12 Tag line operators are to wear leather gloves.
3.13 The primary safety hazards associated with this operation are:

3.13.1 Lift operations
3.13.2 Solvent Use (See NOTE)
3.13.3 Live (Loaded) Solid Rocket Motor (propellant handling)

NOTE: Grease and solvent use are only "if needed" as determined by the MSFC TE and CSD TE.

3.14 Any time a crane is being used, it must be dogged if:

3.14.1 The load will be suspended in a static condition for an extended amount of time.
3.14.2 A crane operator crew change or substitution must be made.

3.15 No electric power tools shall be used near the live test item. Use of pneumatic tools is acceptable.

3.16 All ground cables and ground straps end-to-end resistances shall be verified with a multimeter. These resistances must measure less than 1 ohm.

3.17 All personnel within touching distance of the BSM or ordnance shall wear a wrist strap that has been checked with a wrist strap checker.

3.18 All personnel within touching distance of open grain propellant (and ordnance) shall wear antistatic coveralls.

3.19 Wrist strap connections to facility ground must be verified. This step should be performed each time the wrist strap ground is broken.

3.20 In case of an accidental BSM ignition, the nearest fire alarm pull station shall be activated in order to evacuate building 4619. Personnel shall stay clear of the test site until the emergency response personnel have given the "all clear" to return to the building.

4.0 Test Items and Test Requirements

4.1 Test Items

The test item for the qualification pyro shock tests consists of a live BSM which will be tested in the aft motor configuration. The motor will be tested with an aero heat shield over the exit cone. The motor weighs approximately 154 pounds.
4.2 Test Requirements

4.2.1 Test Tolerances

Unless otherwise stated in this procedure, the tolerances applicable to the test conditions described shall be as specified in MIL-STD-810D. These tolerances are as follows:

Shock Response Spectrum: +6dB, -3dB
(when analyzed with a 1/3 octave shock spectrum analyzer and 5% damping)

4.2.2 Test Data

All data taken with non-recording instruments will be recorded in ink directly onto data sheets and/or log sheets. The log or data sheets will identify the test being performed, the test item, the item part number, and the applicable test procedure. Corrections or changes will be made by drawing a single line through the original entry. The new entry will be made directly above the old and initialed by the person making the entry. Each page will be signed and dated at the bottom of the page by the person making the entries, and counter signed by the test engineer after review.

4.3 Test Conditions

4.3.0 The pyrotechnic shock tests for both motors will be conducted at the test site's ambient temperature.

4.3.1 The MSFC TE shall check with the Army MET team to ensure that there is no lightning within 10 miles. (MET team phone number....876-2465).

4.3.1.1 If lightning is within 10 miles during any time that a live BSM is in building 4619, the MSFC TE shall make arrangements to disconnect the motor ground from the facility ground. The motor shall remain ungrounded until the lightning is out of range.

4.3.1.2 When reconnecting the ground after a lightning storm, a 100Kohm resistor should be connected to the ground wire from the motor before connecting to facility ground. This allows any charge on the motor to slowly dissipate to ground. The resistor should be left connected for no less than 30 seconds.

4.3.1.3 After the specified time, disconnect the ground wire from facility ground and remove the resistor. Reconnect the ground strap from the motor to facility ground.
4.3.2 The test site's relative humidity must be above 20%. If the humidity is below 20%, all test operations must cease until favorable weather conditions resume.

Test site's relative humidity 52% MSFC TE MB

4.4 Test Equipment

4.4.1 All measurements shall be made with instruments and equipment whose accuracy and/or calibration has been verified.

Calibration Acceptable (MFSC TE)

4.4.2 Proof Loading of Handling Equipment (required for PCH)

4.4.2.1 The heaviest lift during all of the delta qualification testing will be lifting the motor while in its shipping container. The motor and shipping container together weigh about 310 lbs. All forklifts and overhead hoists must be load (break) tested to at least 110% of this weight (i.e. 350 lbs.). This test must be performed prior to any handling of the BSM but does not need to be repeated until something other than the BSM is lifted by the same handling equipment. It is therefore recommended that the break tests be performed each evening before the BSM testing commences. The break tests shall be performed as follows:

a. The proof load must be at least 350 lbs.

b. Lift the dummy load clear of the ground (less than 1 foot) and lower to ground three times, holding for five minutes on the third lift. Lifting straps and spreader bar should be attached during the lift.

SEE APPENDIX E FOR THE PROOF TEST INSPECTION SHEETS.

4.5 Test Procedure

4.5.1 After review and documented approval, a redline change to this procedure may be performed. Approval shall be by a minimum of MSFC TE, MSFC SE, and the MSFC QA.

4.5.2 As soon as possible after a test failure, a deviation from the specified test environment, or any other incident which affects the test or test item, MSFC will notify the authorized UT/CSD representative of the event verbally and will then generate a Test Procedure Deviation (NASA form 3959). A copy of the Test
Procedure Deviation is presented in Appendix B. Photographs of any discrepancies shall also be taken.

5.0 Personnel Responsibilities

5.1 Test Witnessing

All tests will be witnessed by the authorized UT/CSD representative and USBI representative. The MSFC test engineer will also witness the testing. Notification of the start of each test shall be communicated to the authorized UT/CSD and USBI representatives and the MSFC safety representative and test engineer at least 2 hours in advance.

- MSFC Safety Notified
  - Yes

- UT/CSD Notified
  - No

5.2 The MSFC TE will serve as the area coordinator for the test. All handling of the BSM will be directed by the MSFC TE or cognizant test engineer.

5.3 Jim Herring (pyro shock) shall be responsible for photographic coverage of the pyro shock test activities.

5.4 The area around the outside of the pyro shock facility shall be secured before the live BSM is brought to the pyro shock test site.

- Area secured? Yes
  - NO
  - MSFC TE
  - MSFC SE

Comments:

- Doors locked, gates secured
- Area well off

5.5 The MSFC TE shall notify the fire department prior to delivery of the BSM. (Fire dept. phone #...117).

5.6 The MSFC TE shall make arrangements for the live BSM to be delivered from the NASA igloo to the pyro shock test site.

5.7 All involved lab directors and division chiefs shall be notified prior to testing.
6.0 Pyrotechnic Shock Test

6.1 Test Site Preparatory Activities

An inspection shall be made of the hardware to ensure it is all available. Should some hardware be missing the cognizant test engineer shall determine whether those components are required for the safe operation of the procedure. Should they not be required for safe operations, the test engineer shall determine whether an operations halt is required or whether the operations may proceed.

6.1.1 Verify the following components, tools and materials are available and certified (when applicable). All lifting equipment, cables, fixtures, etc... within one year stating the load limit and the date tested stencilled on the equipment.

Aft BSM Plate Mounting Hardware:

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Quantity</th>
<th>Nomenclature</th>
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</thead>
<tbody>
<tr>
<td>EWB0420-8-23</td>
<td>6</td>
<td>Bolts*</td>
</tr>
<tr>
<td>EWB0420 - 10-(20,-32)</td>
<td>2</td>
<td>Bolts*</td>
</tr>
<tr>
<td>TLN1021CPD2-8</td>
<td>6</td>
<td>Nut (SelfAligning)</td>
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<tr>
<td>TLN1023CD3-10</td>
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<td>Nut (SelfAligning)</td>
</tr>
<tr>
<td>NAS1587-8C</td>
<td>6</td>
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</tr>
<tr>
<td>NAS1587-10C</td>
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<td>Washer</td>
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* 10107-XX-XX series bolts are acceptable alternates (-20 for pyro, -32 for vibration)

Aft BSM Bracket Mounting Hardware:

<table>
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<tr>
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<th>Quantity</th>
<th>Nomenclature</th>
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<td>8</td>
<td>Bolts</td>
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<tr>
<td>NAS1957C13</td>
<td>12</td>
<td>Bolts</td>
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<tr>
<td>NAS1587-5C</td>
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<td>Washers</td>
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<td>NAS1587-7C</td>
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<tr>
<td>NAS1587-7</td>
<td>12</td>
<td>Washers</td>
</tr>
<tr>
<td>VN324BC070</td>
<td>12</td>
<td>Locknuts</td>
</tr>
<tr>
<td>NAS1101E08H10</td>
<td>14</td>
<td>Aero Heat Shield Fasteners</td>
</tr>
</tbody>
</table>

Fasteneners Accounted For: [MB] MSFC TE

Breakover brackets  2
Lifting D-rings
Spreader bar with associated lifting straps and D-rings

Custom wood supports to horizontally support the BSM

Tool Box with Assorted Wrenches Rm 170, Bldg. 4619
(See Appendix D for detailed tool list)

Pre-drilled Wood Pallet to fit aft skirt support bracket bolt holes

Lifting straps (3)

SN: 3240
SN: 3301
SN: 2203

Desiccant (12, 16 unit size bags)

Rubber mallet

Lead wire seal (for security bag)

Forklift (at least 500 lb. capacity)

ESD Scanner

Materials

1,1,1 Trichloroethane; 1 bottle (enough for cleaning)

MIL-G-4343 grease; 1 container (AHS seal)

MIL-T-83483 thread compound; 1 container (AHS)

Conoco HD-2 grease; 1 container (bolts, faying surfaces)

Other consumables, including rimple cloth, que-tips, tape, bags and towels are also to be supplied if needed.

Gloves (Latex)

Ground straps

Wrist stats (5 each)

Stat gun (1 each)

Ohm meter (1 each)

Wrist stat checker (1 each)

Chemical safety goggles (2 each)

100 Kohm resistor (1 each)
All hardware accounted for: MSFC TE

6.1.2 After the truck has arrived with the motor, the engine should be turned off and the emergency brake engaged. Chock at least one of the truck's wheels.

Truck braked and wheel chocked: MSFC TE

6.1.3 A sign with the word "LOADED" should be attached to the motor shipping container.

6.1.4 Attach a ground strap (long enough to reach the shipping container on the truck) to the pyro facility ground and verify the resistance. Resistance must be less than 1 ohm.

Resistance measured: MSFC QA

CAUTION: Make New Ground Before Braking Old Ground.

6.1.5 Touch the free end of the ground wire to the truck chassis to make sure the truck and the facility are at the same potential, then, connect the free end of the ground strap to motor shipping container (not to lid or lid bolts).

6.1.6 Check continuity of shipping container to ground strap using an ohm meter. Resistance should measure less than 1 ohm.

Resistance Measured MSFC QA

6.1.7 Disconnect shipping container-to-truck tie down apparatus. Move tie down out of the way.

6.1.8 Disconnect shipping container to truck chassis ground.

CAUTION: Do Not disconnect the motor's ground wire while removing from the truck.

6.1.9 Using the fork lift, remove shipping container from truck and set container on the floor in the test room where it may be easily accessed by personnel and the overhead crane. If deemed necessary by the MSFC TE, the overhead crane may be used to remove the shipping container from the truck.

Forklift used: yes no Crane used: yes no

6.1.10 The truck may exit the test area at this time.

NOTE: If the truck does not leave the site at this time, the driver will coordinate the exit with the MSFC TE.
6.1.11 The large pyro bay doors should be "closed in" but left "cracked" open during the assembly and pyro test operations.

6.1.12 Install the shock test control equipment on the pyro plate as illustrated in Figure 1 (see Appendix C).

   Equipment installed __ MSFC TE

6.1.13 The pyrotechnic shock test will be conducted in the aft motor configuration.

6.2 Pyro Test Setup

6.2.0 Record the test site's temperature and relative humidity. The relative humidity shall be above 20%. If the humidity is not above 20%, all test operations must halt until favorable weather conditions resume.

   Temperature: __ °F; Relative Humidity __  %

6.2.1 Remove Motor From Shipping Container

6.2.1.0 Verify wrist straps are being used by ALL personnel while working with the live motor. All wrist straps shall be checked with a wrist strap checker before being used. Continuity checks shall be performed on all main ground straps after making any new ground connection.

   MSFC SE __

6.2.1.1 Position shipping container so that the overhead crane can easily attach to the test item (this step necessary only if fork lift positioning was not adequate for crane attachment.)

   CAUTION: When using the ESD scanner and the electrostatic reading on the motor case surface exceeds 1.0 kilovolt, stop all activities on the case, initiate personnel fall back (a minimum of 4 feet) and notify safety.

   After initial reading over 1.0 kilovolt, repeat electrostatic reading at intervals not to exceed 5 minutes until the the voltage has dissipated below 1.0 kilovolt. When the reading is below 1.0 kilovolt, removal operations may continue.
If after 30 minutes the measured electrostatic charge is in excess of 1.0 kilovolt, verify facility ground. If connection to facility ground is open, reconnect through larger resistor (100 Kohm min.) to allow a slow discharge of the motor case.

If the electrostatic reading on the case surface exceeds 4.0 kilovolts, STOP all activities on the case, notify safety, and evacuate all personnel to safe locations as directed by safety.

WARNING: Do not remove the nozzle's security bag and weather seal. Removing the bag and seal will expose the propellant grain and increase the risk of motor ignition.

6.2.1.2 Open the shipping container and remove all the packing that interferes with the removal of the test item. Monitor static charge while removing packaging.

Record Stat Gun reading _[ ]_ [ ] streamlined

Record SN of Stat Gun C10459

CAUTION: Make New Ground Before Braking Old Ground.

6.2.1.3 Attach a ground wire to the pyro facility ground and verify its resistance. Resistance shall measure less than 1 ohm. This wire should be attached at a location close to the BSM.

Resistance measured 0.12 MSFC QA [ ]

6.2.1.4 Attach the ground wire in step 6.2.1.3 from the facility ground to the live BSM.

6.2.1.5 Disconnect the motor to shipping container ground wire.

6.2.1.6 Attach two lifting rings (along with lifting strap) to the BSM's aft section, 180° apart.

6.2.1.7 Certifications for all lifting fixtures shall be provided:

Lifting beam assembly certification provided MB

Lifting rings (D-rings) MB
CAUTION: When using the ESD scanner and the electrostatic reading on the motor case surface exceeds 1.0 kilovolt, stop all activities on the case, initiate personnel fall back (a minimum of 4 feet) and notify safety.

After initial reading over 1.0 kilovolt, repeat electrostatic reading at intervals not to exceed 5 minutes until the voltage has dissipated below 1.0 kilovolt. When the reading is below 1.0 kilovolt, removal operations may continue.

If after 30 minutes the measured electrostatic charge is in excess of 1.0 kilovolt, Verify facility ground. If connection to facility ground is open, reconnect through larger resistor (100 Kohm min.) to allow a slow discharge of the motor case.

If the electrostatic reading on the case surface exceeds 4.0 kilovolts, STOP all activities on the case, notify safety, and evacuate all personnel to safe locations as directed by safety.

CAUTION: The following step involves working with a suspended load. Keep hands and feet out from under the load.

6.2.1.8 Slowly, monitoring static charge, lift the motor out of the container using the overhead crane. Lower the test item so that the forward end of the motor is at waist height.

A detailed visual inspection shall be performed by the MSFC test engineer and the CSD test engineer on the live test items before testing. Record the motor’s serial number.

No Damage

Damage (detail in attachment)

Serial Number

CAUTION: The following step involves working with a suspended load. Keep hands and feet out from under the load.

6.2.1.9 Attach the "break-over" brackets and lifting strap on the forward end of the motor (see Figure 2, Appendix C).

CAUTION: Do Not disconnect the ground wire while breaking the motor to the horizontal position.
CAUTION: The following step involves working with a suspended load. Keep hands and feet out from under the load.

6.2.1.10 Lower the motor on its wood supports so that the motor rests horizontally. The MSFC TE will designate someone to hold the lifting strap on the forward end while placing the motor in the horizontal position (see Figure 3, Appendix C). The person holding the strap should be wearing a wrist strap.

6.2.1.11 Unhook the lifting straps and remove lifting hardware.

6.2.1.12 Re-attach the lifting hardware for bracket installation. Attach lifting straps in the saddle position (see Figure 4b, Appendix C).

6.2.2 Attach Motor to the Aft Skirt Support Brackets

Steps 6.2.2.1 and 6.2.2.2 may be skipped if deemed "not necessary" by the MSFC test engineer and the CSD test engineer. However, the fasteners should still be installed with grease applied. If time permits, all of the cleaning and surface preparation may be done before the test date.

CAUTION: When using trichloroethane, personnel shall wear chemical goggles and neoprene-Latex gloves. Contaminated materials shall be disposed of as hazardous waste.

CAUTION: When using grease, personnel shall wear Neoprene-Latex gloves. Contaminated materials shall be disposed of as hazardous waste.

6.2.2.1 Wipe faying surfaces clean with 1,1,1 trichloroethane and apply an unbroken film of HD-2 to each surface. After assembly remove excess grease with a lint-free cloth.

Surfaces wiped at this time: Yes No
Grease applied at this time: Yes No

CAUTION: When using trichloroethane, personnel shall wear chemical goggles and neoprene-Latex gloves. Contaminated materials shall be disposed of as hazardous waste.

CAUTION: When using grease, personnel shall wear Neoprene-Latex gloves. Contaminated materials shall be disposed of as hazardous waste.
6.2.2 Clean washers and bolts with 1,1,1 trichloroethane and install wet with HD-2 grease. After assembly remove excess grease with a lint-free cloth.

Washers cleaned at this time: Yes No

CAUTION: Make sure the motor remains properly grounded during the move to position the test item.

6.2.2.3 Position the motor on the wood supports so the forward and aft brackets can be easily attached. Leave lifting straps attached.

6.2.2.4 At forward end of BSM install NAS1955C10H bolts with NAS1587-5C washers (8 places) through supports and into threaded inserts of BSM and torque to 145 to 170 in-lbs (13 to 14 ft-lbs) above running torque.

Torque value: 140 in-lbs MSFC QA RC

Record SN of torque wrench: T-247-62 (4-671)

NOTE: The forward attach bracket has an alignment pin so there is only one way it can be installed.

NOTE: Be sure the aft attach bracket is in correct alignment with the forward bracket before installing the aft attach bolts.

6.2.2.5 At aft end of BSM install NAS1957C13 bolts with NAS1587-7C washers (under bolt head), NAS1587-7 washers (under nut) and VN324BC070 locknuts (12 places) and torque to 460 to 540 in-lbs (39 to 45 ft-lbs) above running torque. * Due to inaccessibility bolts were torqued in a "best effort" basis.

Torque value: 550 in-lbs MSFC QA RC

Record SN of torque wrench: T-267-62 (4-671) (in-lb)

6.2.3 Bracket Cover Installation

6.2.3.1 Bracket cover required? Yes No

If yes above, the 1/4 inch diameter bolts shall be torqued to 90-110 inch-pounds above running torque. The 5/16 inch diameter bolts shall be torqued to 185-200 inch-pounds (16 to 17 ft-lbs) above running torque.

Torque value: __________ MSFC QA __________

Record SN of torque wrench: ____________
Motor 90 Degrees for Pyro Plate Mounting

- torque and remove the bracket to inspection plate fasteners.
- face fasteners in a labeled bag.
- With the test item resting on the brackets, unhook the belly straps from the horizontal stabilizing bar (lifting straps should still be in the chocked position as shown in Figure 4a, Appendix C).
- Wrap the belly straps around the motor on each end as shown in Figure 4b (saddle configuration, Appendix C).

CAUTION: Personnel shall not work under or place any body part under a suspended load.

CAUTION: Be careful not to disconnect the motor's ground wire during the lifting and rotation operation.

1. Lift the motor and brackets to waist height using the overhead crane so that the motor can be rotated.
2. Holding the motor by the support brackets, rotate the motor 90 degrees so that the brackets can be mounted on the pyro plate.
3. Use the overhead crane to move the test item to the mounting area on the pyro plate.

Attach the Brackets and Shims to the Pyro Plate

REINDER: Be sure to put the custom shims in their correct positions and orientation before sliding bolts through the pyro plate.

CAUTION: When using grease, personnel shall wear Neoprene-Latex gloves. Contaminated materials shall be disposed of as hazardous waste.

Install wet with grease (HD-2) EWB0420-8-23 bolts (10107-8-23 alternate) with NAS1587-8C washers and TLN1021CPD2-8 self-aligning nuts at “A”, “B”, and “D” positions (as marked on supports, 6 places) and torque to 605 to 710 in-lbs above running torque. At the “C” position, install EWB0420-10-20 bolts (10107-10-20 alternate) with NAS1587-10C washers and TLN1023CD3-10 self-aligning nuts (2 places) and torque to 1175 to 1380 in-lbs above running torque.

Torque value: “C” 105 ft-lbs MSFC QA
A, B, D 55 ft-lbs
Redline:

Aero Heat shield holes on the motor exit cone had to be tapped for Aero Heat shield assembly. This step was performed before the grain inspection.
6.2.5.2 Record SN of torque wrench: EM56035-9 A, B, D BTW-2RCE

6.2.5.2 Release the tension from the lifting straps but do not disconnect the straps. These straps may be used to tape off accelerometer wires if necessary.

6.2.5.3 Place the pyrotechnic debris shield in front of the large bay doors on the north side of the pyro room.

6.2.6 Perform Grain Inspection

6.2.6.1 Clear area of all nonessential personnel for grain inspection. (Only the grain inspectors (2) and the MSFC TE shall remain.)

6.2.6.2 Verify grain inspector(s) is(are):

a. Wearing 100% cotton coveralls, shorts, and undershirts.

b. Wearing a wrist strap.

c. Wearing tethers and/or tape to keep eye glasses, rings, and watches from falling into the motor.

6.2.6.3 The grain inspector shall now remove the security bag and cover from the exit cone.

6.2.6.4 Perform grain inspection.

Cracked propellant? yes no

If yes, give approximate location and size of crack.

No propellant grain cracks or other defects noted. Small amount of TWA residue on igniter case and main grain. OK to proceed with pyrotech test.

Other comments on grain condition:

Grain inspector
Grain inspector

6.2.7 Install Aero Heat Shield

CAUTION: When using trichloroethane, personnel shall wear chemical goggles and Neoprene-Latex gloves. Contaminated materials shall be disposed of as hazardous waste.
6.2.7.1 CLEAN (if necessary) preservative or oil from the aeroheat shield using a lint-free cloth and 1,1,1 Trichloroethane. DO NOT clean over the identification.

Cleaning performed: Yes [✓] No

CAUTION: When using trichloroethane, personnel shall wear chemical goggles and neoprene-Latex gloves. Contaminated materials shall be disposed of as hazardous waste.

CAUTION: When using grease, personnel shall wear Neoprene-Latex gloves. Contaminated materials shall be disposed of as hazardous waste.

NOTE: Dow Corning Moly Kote 55M Silicone O-ring lubricant meets the MIL-G4343 specification.

6.2.7.2 Using a lint-free cloth and 1,1,1 Trichloroethane, an operator wearing a properly grounded wrist stat will CLEAN (if necessary) the sealing surface of the aeroheat shield cover and corresponding nozzle surfaces. LUBRICATE (if necessary) the surfaces with MIL-4343 grease.

Surface cleaned: Yes [✓] No
Surface lubricated: Yes [✓] No

CAUTION: When using grease, personnel shall wear neoprene-Latex gloves. Contaminated materials shall be disposed of as hazardous waste.

6.2.7.3 EXAMINE seal, P/N B12879-02-01 for damage that could effect the results of the pyro shock or vibration tests. APPLY MIL-G-4343 grease.

Seal damaged? yes [✗]
Description of damage: ______________________________

NOTE: Extreme care must be taken when installing the seal. Notice there is a small and large lip on the seal (see Fig. 5, Appendix C). The larger lip is the seal aft face, and the smaller lip is the seal outside diameter.

6.2.7.4 INSTALL seal, P/N B12879-02-01 on the exit cone of the motor. Reference drawing B14036.
CAUTION: When using thread compound, personnel shall wear neoprene-Latex gloves. Contaminated materials shall be disposed of as hazardous waste.

6.2.7.5 COAT fourteen (14) screws (NAS1101E08H10) with MIL-T-83483 thread compound.

CAUTION: When installing the Aero Heat Shield, personnel shall be extremely careful not to drop any foreign object into the rocket motor (watches, rings, and other jewelry shall be removed; eye glasses shall be tethered if worn).

6.2.7.6 With the nozzle cant vertically up, a properly grounded operator will INSTALL the aeroheat shield cover with the hinge on the left or right side when aft looking forward as specified by USBI/CSD. Proper alignment in either position is provided by a positioning pin and mating hole.

(NOTE: DO NOT lockwire the screws.)

6.2.7.7 INSTALL the 14 screws and TORQUE the fasteners using a standard cross pattern. Record the torque values.

<table>
<thead>
<tr>
<th>Pass</th>
<th>Torque (in-lbs)</th>
<th>Value</th>
<th>MSFC QA</th>
</tr>
</thead>
<tbody>
<tr>
<td>First</td>
<td>Finger Tight</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Second</td>
<td>10-15</td>
<td>10-15</td>
<td></td>
</tr>
<tr>
<td>Third</td>
<td>20-25</td>
<td>20-25</td>
<td></td>
</tr>
<tr>
<td>Fourth</td>
<td>20-25</td>
<td>20-25</td>
<td></td>
</tr>
</tbody>
</table>

Record SN of torque wrench: 5492304

6.2.8 Make Sure the Pyro Facility Bay Doors are Open

6.2.9 Clear Area for Test

The only personnel allowed in the control room are the pyro shock test conductor, a pyro technician, the MSFC TE, and the MSFC SE (total of four (4) people). All other personnel should move to a clear area. The clear areas are defined as the NORTH hallway of building 4619 and the area outside the pyro control room on the WEST side. Other areas must be cleared with the MSFC TE and the MSFC SE.
6.2.9.0 Conduct Pyro Shock Test to the Following Parameters:

Test Parameters:

<table>
<thead>
<tr>
<th>Frequency (Hz)</th>
<th>Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>50</td>
<td>24 g peak</td>
</tr>
<tr>
<td>50 to 100</td>
<td>+12 db/octave</td>
</tr>
<tr>
<td>100</td>
<td>94 g peak</td>
</tr>
<tr>
<td>100 to 4000</td>
<td>+6 db/octave</td>
</tr>
<tr>
<td>4000 to 10,000</td>
<td>3750 g peak</td>
</tr>
</tbody>
</table>

6.2.9.1 Turn on the flashing light outside room 170A.

6.2.9.2 For each measurement location select an accelerometer of a type suitable for the amplitude expected.

6.2.9.3 Calibrate each accelerometer per ED73-SHK-FOP-008.

6.2.9.4 Verify test, checkout, and assembly hardware are connected to the facility ground system.

6.2.9.5 Verify that no leads are connected to the junction box terminals.

6.2.9.6 Move junction box switch to "BULB" position.

6.2.9.7 Connect 12 volts to the firing panel.

6.2.9.8 Insert the firing key and verify panel meter indicates the correct voltage.

6.2.9.9 Switch key to "ARMED" position and verify power indicator light is illuminated.

6.2.9.10 Open red cover and flip firing switch, verify bulb on junction box lights.

6.2.9.11 Close red cover.

6.2.9.12 Switch key to "SAFE" position.

6.2.9.13 Move junction box switch to "METER" position.

6.2.9.14 Switch key to "ARMED" position and verify power indicator light is illuminated.

6.2.9.15 Open red cover and flip the firing switch, verify that the meter on junction box indicates 12 volts.
6.2.9.16 Close red cover.

6.2.9.17 Switch key to "SAFE" position and disconnect voltage source.

6.2.9.18 Remove firing key.

6.2.9.19 Verify that no severe weather or electrical storms are within 10 miles of the immediate vicinity (Army Met. Team 876-2465).

6.2.9.20 Verify that no flammable solvents, paints, gases, etc., are in the hazardous area.

6.2.9.21 Verify all non-essential personnel are clear of the test area.

6.2.9.22 Verify pyro technician is:
   a. Wearing 100% cotton coveralls, shorts, and undershirts.
   b. Wearing safety goggles, hearing protection, and a wrist strap when installing explosive items.
   c. In possession of the arming key and that the firing panel is in the safe position.

6.2.9.23 The pyro technician shall remove all matches, lighters, jewelry, and all battery-powered devices such as electrical wrist watches, calculators, portable radios, etc.

6.2.9.24 During periods of connecting blasting caps, MDF, and FLSC, a maximum of two people (to be designated by the MSFC TE) will be permitted to remain in the shock area.

6.2.9.25 Install required MDF or FLSC on exciter plate. (Total of 26" of ~25 grains per foot) (See Fig. 6 and Fig. 7, Appendix C)

6.2.9.26 Verify switch on junction box is in "BULB" position.

**WARNING:** If bulb glows, there is sufficient radio frequency in the area to possibly cause detonation of the blasting cap. The cap should be left shorted and returned to room 170B storage cabinet. All blasting activities will be curtailed until the RF source is removed.

6.2.9.27 Verify that bulb on junction box is not illuminated.

6.2.9.28 In room 170B, verify that blasting cap shorting coil is in place and is undamaged before removing from storage container.

6.2.9.29 Remove blasting cap from container and transport to room 170.
6.2.9.30 In room 170, verify that wrist straps are in place.

6.2.9.31 Install blasting cap on exciter plate.

6.2.9.32 Press blasting cap shorting coil firmly against facility ground for 1 second. In order to short the leads, remove enough shorting coil from the blasting cap to attach alligator clip.

6.2.9.34 Remove shorting coil.

6.2.9.35 Move switch on junction box to "METER" position.

6.2.9.36 Verify 0 (zero) volts on meter.

**WARNING:** If voltage is indicated, the lines to the firing panel are either connected to a voltage source or are picking up voltage from radiation caused by a nearby source. The cap should be left shorted and returned to room 170B storage cabinet. All blasting activities will be curtailed until the voltage source is removed.

6.2.9.37 Move junction box switch to "BULB" position.

6.2.9.38 Install blasting cap leads in junction box, move switch to "FIRE" position, and remove alligator clip.

6.2.9.39 The pyro technician shall now leave the area, close the door, and inform the MSFC TE of the status.

6.3 **Detonation of Pyrotechnics**

6.3.1 The lead pyro engineer shall now prepare the data acquisition system to acquire data.

6.3.2 Start the tape recorder.

6.3.3 Connect firing lines to the pyro control room junction box.

6.3.4 The lead pyro engineer, the pyro technician, the MSFC TE, and the MSFC SE shall now leave the pyro control room and move to the clear area outside.

6.3.5 Connect firing panel voltage supply and insert firing key, verify that the meter indicates the appropriate voltage.

6.3.6 Begin countdown.
6.3.7 On the count of "3", the pyro technician shall put the switch in the "ARMED" position and verify that the power indicator is illuminated.

6.3.8 On the FIRE command, the pyro technician will open the red cover and flip the firing switch.

6.3.9 After firing, turn the firing panel key to the "UNARMED" position.

**WARNING:** If blasting cap does not fire, refer to Section 10.4 in ED73-SHK-FOP-004 (see Appendix A).

Blasting Cap Fired: yes [✓] no

6.3.10 Remove the arming key and disconnect the voltage supply.

6.3.11 Test personnel may now return to the control room.

6.3.12 Wait a minimum of 5 minutes after firing before opening the door to room 170.

6.3.13 The lead pyro engineer shall now begin to reduce the data.

6.4 Post Test Inspection

6.4.1 Inform the MSFC TF that the door to room 170 from the control room is to be opened.

6.4.2 The pyro technician shall enter room 170 and move the junction box switch to the "BULB" position.

6.4.3 Remove blasting cap leads from junction box.

6.4.4 Inspect the shock plate to insure all explosive devices fired properly.

**WARNING:** If all explosive items did not fire, refer to Section 10.5 in ED73-SHK-FOP-004 (see Appendix A).

6.4.5 The BSM shall be visually inspected for damage resulting from the pyro shock test. Any anomalies will be recorded. All other personnel shall remain in the control room or in the clear area until the "ALL CLEAR" is given by the MSFC TE. _No Damage_

6.4.6 MSFC TE indicates all clear for appropriate personnel.

6.5 Post Test Removal from the Pyro Plate
6.5.1 Have a certified fork lift (500 pound minimum) ready to load the BSM and pallet onto the transport truck.

CAUTION: Exercise care not to entangle or tug on the motor grounding strap during the following lifting operations.

6.5.2 Tighten the lifting straps using the overhead crane so that the bolts can be loosened.

6.5.3 De-torque and remove the bolts that attach the brackets to the pyro plate.

CAUTION: The following steps involve working with a suspended load. Keep hands and feet out from under the load.

6.5.4 Remove custom shims and place in labeled bag for use in the vibration tests.

6.5.5 Lower the motor to waist height.

6.5.6 Rotate the motor 90 degrees so that the brackets can be mounted on the pallet.

6.5.7 Using the overhead crane, place the motor on the pallet so that it rests on the aft skirt support brackets and is aligned with the pre-drilled bolt holes.

6.5.8 With the test item resting on the brackets, unhook the belly straps from the horizontal stabilizing bar.

6.5.9 Bolt the test item to the pallet using the provided fasteners for transport to vibration.

Motor secured to pallet MSFC TE

6.6 Test Report and Data Requirements

A final test report will be submitted to UT/CSD within 30 working days after testing is completed. Three copies plus one reproducible copy of this report will be submitted containing shock response spectrum (SRS) plots (with Q=10 value) and the time history plots. The test tolerances shall be overplotted on the control spectrum.

Model numbers and serial numbers for all instrumentation and test equipment shall be included in the report. Test setup photos should also be included in the report.
7.0 **Post Test Verification**

The procedure delineated in the above document has been satisfactorily completed and:

a. All sequences in the procedure have been completed (or deleted by approved deviation)

b. All Procedure changes have been recorded and approved.

Submitted Verified by:  

Test Engineer

Date: 09/21/93

Motor Serial Number: 1000734
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BSM MOTOR S/N 1000734
VIBRATION TEST PROCEDURE
BSM Delta Qualification Test

Vibration Tests and Packaging Procedure

This Procedure Describes Safety Critical Operations
BSM Delta Qualification Test

Vibration Tests and Packaging Procedure

Prepared by:
Mat Bevill EP-12

08/16/93

Motor SN:
Test Date:
Vibration Tests and Packaging Procedure

Prepared by: 

Mat Bevill
Mat Bevill/MSFC TE/EP18
09/15/93

Approved by: 

Jim McGee
Jim McGee/MSFC Vibration Lab TE
9-14-93

Jim Herring
Jim Herring/MSFC Vibration Lab TE
9-14-93

Richard Leonard
Richard Leonard/MSFC Safety/CS01
9-16-93

Rick Clements
Rick Clements/MSFC Quality/CQ06
9-15-93

Ben Goldberg
Ben Goldberg/Motor Systems Division/EP11
9-14-93

Steve Brayster
Steve Brayster/Dynamic Test Branch/ED73
9-14-93

Charles E. Wells
Chuck Wells/UTC/CSD TE
9-16-93

Don Wendell
Don Wendell/USBI
9-14-93

Charlie Lovell
Charlie Lovell/FCH Engineering/CN71
9-16-93
Vibration Tests and Packaging Procedure

Prepared by: Mat Bevill
Mat Bevill/MSFC TE/EP12

Approved by: Jim McGee
Jim McGee/MSFC Vibration Lab TE

Jim Herring
Jim Herring/MSFC Pyro Shock Lab TE

Richard Leonard
Richard Leonard/MSFC Safety/CS01

Rick Clements
Rick Clements/MSFC Quality/CQ06

Ben Goldberg
Ben Goldberg/Motor Systems Division/EP11

Steve Brese
Steve Brese/Dynamic Test Branch/ED73

Chuck Wells
Chuck Wells/UTC/CSD TE

Don Wenciu
Don Wenciu/USBI

Charlie Lovell
Charlie Lovell/PCH Engineer/CN71

Date: 09/15/93
Date: 09/14/93
Date: 09/15/93
Date: 09/14/93
Date: 09/14/93
Date: 09/14/93
Date: 09/16/93

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10 General Information

1.1 Scope

This test procedure addresses all the requirements to perform vibration testing on Booster Separation Motors (BSM). The test program consists of lift-off vibration, boost vibration, and vehicle dynamics vibration.

1.2 Objective

The objective of the dynamic testing is to verify the physical and functional survivability of the Booster Separation Motors. Of particular interest for these tests are the components bonded using EA9394 adhesive. The components using this adhesive include the throat insert, the centering insert, and the igniter grain support rod.

20 Applicable Documents

<table>
<thead>
<tr>
<th>Document ID</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>MSFC-STD-513A</td>
<td>Certification of Equipment Operations and Materials Handling Personnel</td>
</tr>
<tr>
<td>EG5300.36A</td>
<td>Safety</td>
</tr>
<tr>
<td>29 CFR 1910</td>
<td>Occupational Safety and Health Administration (OSHA)</td>
</tr>
<tr>
<td>NSS/GO 1740.9</td>
<td>Safety Standard for Lifting Devices and Equipment</td>
</tr>
<tr>
<td>NHB 1700.1(V1)</td>
<td>Basic Safety Manual</td>
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<tr>
<td>AMC-R 385-100</td>
<td>Safety Manual</td>
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<tr>
<td>MM 1700.4</td>
<td>Safety and Environmental Health Hazards</td>
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<tr>
<td>MMI 1700.17</td>
<td>MSFC Procedures for Acquiring Shipping Permits for Rocket Motors and Igniters</td>
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<td>MMI 1710.1</td>
<td>Safety Review and Approval of Hazardous and Potentially Hazardous Facilities and Activities at MSFC</td>
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<tr>
<td>MMI 1710.6</td>
<td>MSFC Program for Personnel Certification</td>
</tr>
<tr>
<td>MMI 1711.2</td>
<td>Mishap Reporting and Investigation</td>
</tr>
</tbody>
</table>
3.1 The following safety criteria are in accordance with ET01-SOP-01, Rev. A., Standard Operation Procedures for Safety Critical Operations. If safety rules/regulations are not followed, injury to personnel and/or damage to test items could occur. Emergency telephone numbers are as follows:

<table>
<thead>
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<th>Service</th>
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<tr>
<td>Safety</td>
<td>4-0046</td>
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<tr>
<td>Ambulance</td>
<td>112</td>
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<tr>
<td>Fire</td>
<td>117</td>
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<td>Security</td>
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<td>Utilities</td>
<td>4-3919</td>
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<td>4-2390</td>
</tr>
<tr>
<td>Communication Repair</td>
<td>4-1771</td>
</tr>
</tbody>
</table>

3.2 Prior to starting work in 4619, a visual inspection of work area shall be made for anomalies by task supervisor and safety personnel.

MSFC TE [Signature] MSFC SE [Signature]

Date/Time: 09/25/93 11:15 a.m.

3.3 Personnel shall not work or position themselves beneath suspended loads unless such loads are securely and adequately blocked up.
3.4 Objects handled by overhead hoist shall be lifted only high enough to clear fixed objects in the path of travel. Spreader bars and slings may be left on the hoist if desired when not in use, but must be raised so that the lowest part of the lifting equipment will be at least seven feet from the floor when not in use.

3.5 Crane, hoist, lift prime operators, and riggers shall be certified according to the latest revision of MMI 1710.6, and shall have in their possession a valid certification card.

Certifications checked by: ___________________________

Date / Time: 2/15/93 / I. N. C. A.

3.6 Personnel working around suspended loads shall be alert to the possibility of being crushed between the suspended load and a fixed object.

3.7 Loads shall be moved slowly so they will not accumulate more momentum than can be stopped with little or no swing.

3.8 Where handling slings are called out, a sling with more pickup points than required may be used if the weight capacity per point used is equal or greater than the weight capacity of each point of the noted sling and the free pickup point is (are) secured to prevent it (them) from swinging and causing damage to parts.

3.9 Only the area coordinator should direct the crane moves, however, any person determining an immediate danger or problem may request stoppage of activities.

3.10 The lifting or transportation operation shall be halted by the area coordinator at any time the control area cannot be maintained.

3.11 Steel toe shoes are required during lifting operations. Hardhats are required when the lift is at or above the shoulders.

3.12 Tag line operators are to wear leather gloves.

3.13 The primary safety hazards associated with this operation are:

3.13.1 Lift operations
3.13.2 Solvent Use (See NOTE)
3.13.3 Live (Loaded) Solid Rocket Motor
NOTE: Grease and solvent use are only "if needed" as determined by the MSFC TE and CSD TE.

3.14 Any time a crane is being used, it must be dogged if:

3.14.1 The load will be suspended in a static condition for an extended amount of time.

3.14.2 A crane operator crew change or substitution must be made.

3.15 No electric power tools shall be used near the live test item. Use of pneumatic tools is acceptable.

3.16 All ground cables and ground straps end-to-end resistances shall be verified with a multimeter. These resistances must measure less than 1 ohm.

3.17 All personnel within touching distance shall wear a wrist strap that has been checked with a wrist strap checker. This step should be performed each time the wrist strap ground is broken.

3.18 All personnel within touching distance of open grain propellant (and ordnance) shall wear antistatic coveralls.

**Test Items and Test Requirements**

4.1 Test Items

The test item for the vibration tests consist of a BSM which will be tested in the aft motor configuration. The motor will be tested with an aero heat shield over the exit cone. The motor weighs approximately 154 pounds.

Motor Serial Number 1000734 Conditioning Temp. 25°F ±5°F

4.2 Test Requirements

4.2.1 Test Tolerances

The tolerances applicable to the test conditions are as follows:

(Unless otherwise stated in the procedure)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Tolerance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vibration Frequency</td>
<td>± 5%</td>
</tr>
<tr>
<td>Test Duration</td>
<td>+10%, -0%</td>
</tr>
<tr>
<td>Temperature</td>
<td>± 5°F</td>
</tr>
<tr>
<td>Sinusoidal Control Signal</td>
<td>±10%</td>
</tr>
<tr>
<td>Maximum Harmonic Distortion</td>
<td></td>
</tr>
<tr>
<td>Sinusoidal Peak Acceleration</td>
<td>+20%, -10%</td>
</tr>
</tbody>
</table>
Composite Root Mean Square Acceleration

±10%

Acceleration Spectral Density

+100%, -25%

(+3dB, -1.5dB)

4.2.2 Test Data

All data taken with non-recording instruments will be recorded in ink directly onto data sheets and/or log sheets. The log or data sheets will identify the test being performed, the test item, the item part number, and the applicable test procedure. Corrections or changes will be made by drawing a single line through the original entry. The new entry will be made directly above the old and initialed by the person making the entry. Each page will be signed and dated at the bottom of the page by the person making the entries, and counter signed by the test engineer after review.

4.3 Test Conditions

The live delta qualification motor will be vibration tested at a specific temperature. The motor will either be tested at 25°F (+0, -5 °F) or at 125°F (+5, -0 °F) depending on which qualification motor this procedure controls.

4.3.1 The MSFC TE shall check with the Army MET team to ensure that there is no lighting within 10 miles. (MET team phone number....876-2465).

4.3.1.1 If lightning is within 10 miles during any time that a live BSM is in building 4619, the MSFC TE shall make arrangements to disconnect the motor ground from the facility ground. The motor shall remain ungrounded until the lightning is out of range.

4.3.1.2 When reconnecting the ground after a lightning storm, a 100Kohm resistor should be connected to the ground wire from the motor before connecting to facility ground. This allows any charge on the motor to slowly dissipate to ground. The resistor should be left connected for no less than 30 seconds.

4.3.1.3 After the specified time, disconnect the ground wire from facility ground and remove the resistor. Reconnect the ground strap from the motor to facility ground.
4.3.2 The test site's relative humidity must be above 20%. If the humidity is below 20%, all test operations must cease until favorable weather conditions resume.

Test site's relative humidity 76% MSFC TE \( UB \) 81°F

4.4 Test Equipment

4.4.1 All measurements shall be made with instruments and equipment whose accuracy and/or calibration has been verified.

Calibration Acceptable \( UB \) MSFC TE

4.4.2 Proof Loading of Handling Equipment (required for PCH)

4.4.2.1 The heaviest lift during all of the delta qualification testing will be lifting the motor while in its shipping container. The motor and shipping container together weigh about 310 lbs. All forklifts and overhead hoists must be load (break) tested to at least 110% of this weight (i.e. 350 lbs.). This test must be performed prior to any handling of the BSM but does not need to be repeated until something other than the BSM is lifted by the same handling equipment. It is therefore recommended that the break tests be performed each evening before the BSM testing commences. The break tests shall be performed as follows:

a. The proof load must be at least 350 lbs.

b. Lift the dummy load clear of the ground (less than 1 foot) and lower to ground three times, holding for five minutes on the third lift. Lifting straps and spreader bar should be attached during the lift.

SEE APPENDIX C FOR THE PROOF TEST INSPECTION SHEETS.

4.5 Test Procedure

4.5.1 After review and documented approval, a redline change to this procedure may be performed. Approval shall be by a minimum of the MSFC TE, MSFC QA, and MSFC SE.

4.5.2 As soon as possible after a test failure, a deviation from the specified test environment, or any other incident which affects the test or test item, MSFC will notify the authorized UT/CSD representative of the event verbally and will then generate a Test Procedure Deviation (NASA form 3959). A copy of the Test
Procedure Deviation is presented in Appendix A. Photographs of any discrepancies shall also be taken.

5.0 **Personnel Responsibilities**

5.1 **Test Witnessing**

All tests will be witnessed by the authorized UT/CSD representative and USBI representative. The MSFC test engineer will also witness the testing. Notification of the start of each test shall be communicated to the authorized UT/CSD and USBI representatives and the MSFC safety representative and test engineer at least 2 hours in advance.

<table>
<thead>
<tr>
<th>MSFC Safety Notified</th>
<th>MSF</th>
</tr>
</thead>
<tbody>
<tr>
<td>UT/CSD Notified</td>
<td>MSF</td>
</tr>
</tbody>
</table>

5.2 The MSFC TE will serve as the area coordinator for the test. All handling of the BSM will be directed by the MSFC TE or cognizant test engineer.

5.3 Jim McGee (vibration) shall be responsible for photographic coverage of the vibration test activities.

5.4 All involved lab directors and division chiefs shall be notified prior to testing.

5.5 The area around the outside of the vibration facility shall be secured before the live BSM is brought to the pyro shock test site.

<table>
<thead>
<tr>
<th>Area secured?</th>
<th>YES</th>
<th>NO</th>
<th>MSF</th>
</tr>
</thead>
<tbody>
<tr>
<td>MSFC TE</td>
<td></td>
<td></td>
<td>MSF</td>
</tr>
<tr>
<td>MSFC SE</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Comments: Doors locked, security tape up

6.0 **Vibration Tests**

6.0.1 Make sure the CSD TE has reviewed the calibrations for the vibration tests.

6.0.2 Open the doors that enter the vibration test room from the high bay of bldg. 4619.

6.1 Re-check system setup. Verify chamber temperature.
6.2 Radial Axis Tests

6.2.1 Assemble the leg supports on the conditioning chamber. [✓]

6.2.2 Lift Off Vibration

6.2.2.1 The following levels and conditions apply for the lift off vibration tests. Vibrate the motor only as follows for a duration of 60 seconds:

<table>
<thead>
<tr>
<th>Frequency (Hz)</th>
<th>Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>0.017 g²/Hz</td>
</tr>
<tr>
<td>20 to 55</td>
<td>+6 db/octave</td>
</tr>
<tr>
<td>55 to 200</td>
<td>0.077 g²/Hz</td>
</tr>
<tr>
<td>200 to 280</td>
<td>-11 db/octave</td>
</tr>
<tr>
<td>280 to 1200</td>
<td>0.022 g²/Hz</td>
</tr>
<tr>
<td>1200 to 2000</td>
<td>-4.5 db/octave</td>
</tr>
<tr>
<td>2000</td>
<td>0.010 g²/Hz</td>
</tr>
</tbody>
</table>

Composite: 6.9 grms

6.2.3 Boost Vibration

6.2.3.1 The following levels and conditions apply for the boost vibration tests. Vibrate the motor only as follows for a duration of 120 seconds:

<table>
<thead>
<tr>
<th>Frequency (Hz)</th>
<th>Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>20 to 200</td>
<td>0.54 g²/Hz</td>
</tr>
<tr>
<td>200 to 350</td>
<td>-12 db/octave</td>
</tr>
<tr>
<td>350 to 1000</td>
<td>0.060 g²/Hz</td>
</tr>
<tr>
<td>1000 to 2000</td>
<td>-6 db/octave</td>
</tr>
<tr>
<td>2000</td>
<td>0.015 g²/Hz</td>
</tr>
</tbody>
</table>

Composite: 14.0 grms

6.2.4 Vehicle Dynamics Vibration

6.2.4.1 The following levels and conditions apply for the vehicle dynamics tests. Vibrate the motor only as follows:

<table>
<thead>
<tr>
<th>Frequency (Hz)</th>
<th>Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 to 10</td>
<td>0.7 g peak</td>
</tr>
<tr>
<td>10 to 40</td>
<td>3.7 g peak</td>
</tr>
</tbody>
</table>

Sweep Rate: 3 octaves per minute
6.3 Transport Motor From Room 156 to Room 158/ Setup for Tang. Axis

6.3.1 Remove leg supports from conditioning chamber.

6.3.2 Disconnect the conditioning unit from the conditioning chamber.

6.3.3 Inspection certifications shall be provided for the overhead cranes in 4619.

Crane #1, Bldg. 4619 rm. 156 certification provided

Crane #2, Bldg. 4619 rm. 158 certification provided

6.3.4 Certifications for all lifting fixtures shall be provided:

Lifting beam assembly certification provided

Lifting rings (D-rings)

CAUTION: Be careful not to disconnect the motor ground while lifting.

CAUTION: The following step involves working with a suspended load. Keep feet and hands out from under the load.

6.3.5 Using the overhead crane, lift the conditioning chamber off of the vibration table and place it on the floor.

Record time when chamber was removed 12:06 p.m. 09/25/43

6.3.6 Verify motor ground connection on the motor and at the facility ground contact point.

6.3.7 Disconnect the instrumentation wires. Remove any other instrumentation that is no longer needed or that might interfere with motor transport.

6.3.8 Attach the lifting straps (as shown in Fig. 1a) to the motor and spreader bar and hook to the overhead crane.

6.3.9 Remove adapter plate to vibration table fasteners.

CAUTION: Be careful not to disconnect the motor ground while lifting.

CAUTION: The following step involves working with a suspended load. Keep feet and hands out from under the load.
6.3.10 Slowly lift the motor off of the table and place it on the facility's roll cart.

6.3.11 Unhook spreader bar from lifting straps. Leave straps wrapped around the motor.

6.3.12 Open the doors that enter the high bay in room 158.

CAUTION: Make sure that the ground strap is long enough to reach to room 158 during the transport from one room to the other.

6.3.13 Slowly pull the motor using the roll cart from room 156 to room 158. Be sure to place the cart directly beneath the overhead crane.

6.3.14 Attach spreader bar to lifting straps and the overhead crane.

CAUTION: Be careful not to disconnect the motor ground while lifting.

CAUTION: The following step involves working with a suspended load. Keep feet and hands out from under the load.

6.3.15 Using the overhead crane, lift the motor from the pull cart and place it on the vibration table.

6.3.16 Align the adapter plates with the holes on the table.

6.3.17 Fasten the adapter plates to the table using the facility supplied fasteners. Torque these fasteners to 65 ft-lbs.

Record torque value: 65 ft-lbs  MSFC QA

Torque wrench SN: BTW - 2RCF

6.3.18 Remove all lifting hardware.

6.3.19 Attach accelerometers to the motor (see Fig. 2)

6.3.20 Reconnect accelerometer wires.

6.4 Thermal Conditioning Setup for Tangential and Longitudinal Axis

6.4.1 Use the overhead crane to place the conditioning chamber over the motor.

6.4.2 Once the chamber is in place, attach the necessary hoses and instrumentation from the conditioning unit to the chamber.
6.4.3 Make sure the chamber thermocouple is in the correct position for measuring the air temperature around the motor.

6.4.4 Make sure the motor ground strap is secured.

6.4.5 Activate conditioning unit and monitor the temperature until it has stabilized to the desired temperature.

Record time/ temperature when stabilized: \(12.28 \text{ C}, 25 \text{ F temp lowered to } 21.9 \text{ F}\). Record total time out of conditioning: 22.5 min.

6.4.6 Recondition motor for twice the time out of conditioning if out more than 30 minutes.

Reconditioning necessary: Yes (No).
If yes, how long does motor need reconditioned? N/A

6.5 Tangential Axis Tests

6.5.1 Lift Off Vibration

6.5.1.1 The following levels and conditions apply for the lift off vibration tests. Vibrate the motor only as follows for a duration of 60 seconds:

<table>
<thead>
<tr>
<th>Frequency (Hz)</th>
<th>Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>0.016 g²/Hz</td>
</tr>
<tr>
<td>20 to 75</td>
<td>+3 db/octave</td>
</tr>
<tr>
<td>75 to 1000</td>
<td>0.060 g²/Hz</td>
</tr>
<tr>
<td>1000 to 2000</td>
<td>-3 db/octave</td>
</tr>
<tr>
<td>2000</td>
<td>0.030 g²/Hz</td>
</tr>
</tbody>
</table>

Composite: 10.0 grms

6.5.2 Boost Vibration

6.5.2.1 The following levels and conditions apply for the boost vibration tests. Vibrate the motor only as follows for a duration of 120 seconds.

<table>
<thead>
<tr>
<th>Frequency (Hz)</th>
<th>Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>20 to 800</td>
<td>0.24 g²/Hz</td>
</tr>
<tr>
<td>800 to 2000</td>
<td>-4 db/octave</td>
</tr>
<tr>
<td>2000</td>
<td>0.071 g²/Hz</td>
</tr>
</tbody>
</table>

Composite: 18.4 grms
6.5.3 Vehicle Dynamics

6.5.3.1 The following levels and conditions apply for the vehicle dynamics tests. Vibrate the motor only as follows:

<table>
<thead>
<tr>
<th>Frequency (Hz)</th>
<th>Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 to 10</td>
<td>0.7 g peak</td>
</tr>
<tr>
<td>10 to 40</td>
<td>4.3 g peak</td>
</tr>
</tbody>
</table>

Sweep Rate: 3 octaves per minute

6.6 Axis Change From Tangential to Longitudinal

6.6.1 Disconnect conditioning unit from conditioning chamber.

6.6.2 Attach overhead crane to the conditioning chamber.

6.6.3 Slowly lift the conditioning box off of the test item and move it away and move it away from the vibration table and place on the floor. Disconnect lifting hardware.

Record time of chamber removal: 1:29 pm, 03/25/33

6.6.4 Verify motor ground connection on the motor and at the facility ground contact point.

6.6.5 Remove adapter plate to vibration table fasteners.

6.6.6 Unhook control accelerometer.

CAUTION: Be careful not to disconnect the ground when changing the axis on the table.

CAUTION: The following step involves working with a suspended load. Keep feet and hands out from under the load.

6.6.7 Rotate the motor and bracket assembly 90° using the overhead crane. Disconnect lifting hardware.

6.6.8 Re-attach adapter plate to vibration table fasteners. Torque to 65 ft-lbs.

Record torque value: 65 ft-lb MSFC QA [Signature]

Torque wrench SN: [Signature]

6.6.9 Reconnect control accelerometer.
6.6.10 Reconnect lifting hardware to the conditioning chamber and place it over the motor. Reconnect chamber legs as necessary.

6.6.11 If necessary, re-attach hoses, instrumentation, etc., before starting conditioning unit.

6.6.12 Start conditioning unit. Monitor until it has stabilized to the desired temperature.

Record time/temperature when stabilized: 1:35 p.m., 62.5°F

Record total time out of tolerance: 24 min

6.6.13 Recondition motor for twice the time out of tolerance if the time out was greater than 30 minutes.

Reconditioning necessary: Yes
If Yes, how long does the motor need reconditioning? N/A

6.7 Longitudinal Axis Test

6.7.1 Lift Off Vibration

6.7.1.1 The following levels and conditions apply for the lift off vibration test. Vibrate the motor only as follows for a duration of 60 seconds.

<table>
<thead>
<tr>
<th>Frequency (Hz)</th>
<th>Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>0.016 g^2/Hz</td>
</tr>
<tr>
<td>20 to 75</td>
<td>+3 dB/octave</td>
</tr>
<tr>
<td>75 to 1000</td>
<td>0.060 g^2/Hz</td>
</tr>
<tr>
<td>1000 to 2000</td>
<td>-3 dB/octave</td>
</tr>
<tr>
<td>2000</td>
<td>0.030 g^2/Hz</td>
</tr>
</tbody>
</table>

Composite: 10.0 grms

6.7.2 Boost Vibration

6.7.2.1 The following levels and conditions apply for the boost vibration test. Vibrate the motor only as follows for a duration of 120 seconds.

<table>
<thead>
<tr>
<th>Frequency (Hz)</th>
<th>Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>20 to 800</td>
<td>0.24 g^2/Hz</td>
</tr>
<tr>
<td>800 to 2000</td>
<td>-4 dB/octave</td>
</tr>
<tr>
<td>2000</td>
<td>0.071 g^2/Hz</td>
</tr>
</tbody>
</table>

Composite: 18.4 grms
6.7.3 Vehicle Dynamics

6.7.3.1 The following levels and conditions apply for the vehicle dynamics test. Vibrate the motor only as follows.

<table>
<thead>
<tr>
<th>Frequency (Hz)</th>
<th>Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 to 10</td>
<td>0.7 g peak</td>
</tr>
<tr>
<td>10 to 40</td>
<td>4.3 g peak</td>
</tr>
</tbody>
</table>

Sweep Rate: 3 octaves per minute

6.8 Post Test Inspection

6.8.1 The BSM test item shall be visually inspected by the MSFC QA, MSFC TE, and the CSD TE for exterior damage resulting from vibration testing.

6.8.2 Remove all instrumentation.

6.9 Data Requirements

Power Spectral Density (PSD) plots for all control and response accelerometers for lift off and boost tests shall be recorded. The test tolerances shall be overplotted on the control accelerometers plots. Acceleration versus frequency plots shall be recorded for all accelerometers used during vehicle dynamics tests.

7.0 Post Test Disassembly/Prepare for Shipment

7.1 Conditioning Chamber Removal

7.1.1 Disconnect any hoses and instrumentation that hinders the removal of the chamber.

7.1.2 Using the overhead crane, slowly lift the conditioning chamber off of the vibration table and place on the floor.

7.1.3 Move chamber out of the way.

7.1.4 Move the conditioning unit out of the way if necessary.

7.1.5 Verify motor ground connection on the motor and at the facility ground contact point.

7.1.6 Remove vibration table insulation.
7.2 Aero Heat Shield Removal

WARNING: Removing the Aero Heat Shield exposes the motor's propellant grain. Personnel should use caution during any operations with and exposed grain. Tools, watches, eye glasses, etc., should be tethered (if necessary) to prevent dropping anything into the motor.

7.2.1 Make sure the motor ground is secured. [✓]

7.2.2 Make sure verified wrist straps are being worn by the personnel removing the aero heat shield. [✓]

7.2.3 Remove the fasteners from the Aero Heat Shield. Place the fasteners in a marked bag. [✓]

7.2.3 SLOWLY remove the Aero Heat Shield. [✓]

7.2.5 Remove the heat shield seal. Do not drop the seal into the motor. [✓]

7.3 Post Test Inspection of Motor Propellant Grain

7.3.1 Make sure motor ground wire is secured. [✓]

7.3.2 Clear area of all non-essential personnel. Only the grain inspectors (2) and the MSFC TE shall remain. [✓]

7.3.3 Verify grain inspector(s) is(are):

a. Wearing 100% cotton coveralls, shorts, and undershirts.

b. Wearing a wrist strap.

c. Wearing tethers and/or tape to keep eye glasses, rings, and watches from falling into the motor. [✓]

7.3.4 Perform grain inspection.

Cracked propellant yes

If yes, give approximate location and size of crack:

_________________________________________________________________

53
Other comments on grain condition:

No cracks or other internal defects noted. No motor external damage attributable to pressure shock or vibration testing.

Grain inspector(s) T. G. McLeod 9-25-93

7.3.5 A draw-wire, fabric, security bag shall be installed over the nozzle exit cone. The bag shall be closed around the exit cone and secured by inserting the bag wire ends through a standard security lead-seal (i.e. cover the exit cone the same way that it was received).

7.4 Adapter Plate Removal

7.4.1 Remove the adapter plate to vibration table fasteners.

7.4.2 Attach lifting straps as shown in Fig. 1b (Appendix B).

CAUTION: Be careful not to disconnect the ground while lifting the motor.

CAUTION: The following step involves working with a suspended load. Keep hands and feet out from under the load.

7.4.3 Lift the motor off of the vibration table and move to an area near the wood supports.

7.4.4 Lower the motor so that it rests on the wood supports.

7.4.5 Rotate the motor 180° so that the adapter plates face up.

7.4.6 Remove the bracket to adapter plate fasteners. Place fasteners in a marked bag.

CAUTION: Be careful not to disconnect the ground while lifting the motor.

CAUTION: The following step involves working with a suspended load. Keep hands and feet out from under the load.

7.5 Aft Skirt Bracket Removal

7.5.1 Remove the aft end motor to bracket fasteners (12 places). Place fasteners in a marked bag.
CAUTION: Be careful not to disconnect the ground while lifting the motor.

CAUTION: The following step involves working with a suspended load. Keep hands and feet out from under the load.

7.5.2 Lift the motor to waist height using the overhead crane.

7.5.3 Rotate the motor 180° so that the bracket to adapter plate fastener holes face the floor.

7.5.4 Lower the motor so that it rests on the wood supports.

7.5.5 Remove forward end motor to bracket fasteners (8 places). Place fasteners in a marked bag.

8.0 Return Motor to the Vertical Position

8.1 Attach 2 D-rings, 180 degrees apart, and one lifting strap to the aft end holes of the motor.

8.2 Attach the "break-over" brackets (and lifting strap) to the appropriate bolt holes on the forward face of the motor case.

8.3 Attach the aft lifting strap to the overhead crane hook.

CAUTION: The following steps involve working with a suspended load. Keep hands and feet out from under the load.

CAUTION: Be careful not to disconnect the ground while lifting the motor.

8.4 One person (as chosen by the MSFC TE) shall hold the lifting strap on the forward end to keep the motor from swinging when lifted from the aft end. Slowly lift the aft end of the motor to bring it to a vertical position.

8.5 Raise the motor so that the aft end is at waist height.

CAUTION: The following steps involve working with a suspended load. Keep hands and feet out from under the load.

8.6 Disconnect the "break-over" brackets. Place brackets in a marked bag.
Place Motor In Shipping Container

9.1 Remove lid from shipping container by removing the lock-ring bolt and nut, lockring, and cover. (See Fig. 3 for an overall view of the shipping container).

9.2 Remove top cushion insert. Make sure that the top bearing plate is properly oriented to the relative location of the drum humidity indicator/pressure relief valve (see Fig. 4). If not as shown (the two 1-inch dia. clearance holes must straddle the (imaginary) horizontal center line) the center cushion insert, as a unit (do not lift center insert...it's keyed to the bottom insert) must be rotated to bring the top plate into proper position as shown.

9.3 Remove the bearing plate from the tie rods. DO NOT remove the tie rod nuts.

9.4 Remove and discard any old bags of desiccant.

9.5 Drape the loose end of the container ground strap over the edge of the container.

9.6 Visually inspect the container interior to assure it is free of any foreign matter. Vacuum interior if required.

9.7 Attach a ground wire to facility ground and verify its resistance. Resistance shall measure less than one (1) ohm.

Resistance measured: \( \text{MSFC QA} \text{ EC} \)

9.8 Connect this ground wire to the motor shipping container and verify the resistance (<1 ohm)

Resistance measured: \( \text{MSFC QA} \)

9.9 Install the antistatic foamed plastic liner tightly around the motor case, and secure in place by taping the liner’s vertical butt joint (trim as required) using 2" wide tape.

9.10 Install the antistatic plastic film bag, up and over the motor.

9.11 Visually orientate the motor nozzle cant to the side of the container indicated by the marking, "POSITION NOZZLE CANT THIS SIDE" on the cushion insert.

CAUTION: Be careful not to disconnect the motor ground while lowering the motor into the container.
CAUTION: The following steps involve working with a suspended load. Keep hands and feet out from under the load.

CAUTION: When using the ESD scanner and the electrostatic reading on the motor case surface exceeds 1.0 kilovolt, stop all activities on the case, initiate personnel fall back (a minimum of 4 feet) and notify safety.

After initial reading over 1.0 kilovolt, repeat electrostatic reading at intervals not to exceed 5 minutes until the the voltage has dissipated below 1.0 kilovolt. When the reading is below 1.0 kilovolt, removal operations may continue.

If after 30 minutes the measured electrostatic charge is in excess of 1.0 kilovolt, Verify facility ground. If connection to facility ground is open, reconnect through larger resistor (100 Kohm min.) to allow a slow discharge of the motor case.

If the electrostatic reading on the case surface exceeds 4.0 kilovolts, STOP all activities on the case, notify safety, and evacuate all personnel to safe locations.

9.12 Slowly lower the motor into the container while monitoring static charge.

Record Stat Gun SN: __________

CAUTION: Make new ground before breaking old ground.

9.13 Attach the container ground wire to the motor using the 1/4-20 UNC x 3/4 long bolt and nut provided. Torque to 50 in-lbs ±5 in-lbs. Measure resistance to verify ground (should be <1 ohm).

Record torque value: 50±5 MSFC QA __________

Torque wrench SN: 68180

Resistance Measured 0.1-2 MSFC QA __________

9.14 Disconnect ground wire connecting the motor and facility ground.

9.15 Remove lifting hardware.
9.16 Visually orientate the top bearing plate to the nozzle cant, indicated by the marking on the plate "POSITION THIS SIDE TO THE NOZZLE CANT", and place it over the nozzle and three tie rods and bring it to rest on the motor flange. Tighten and torque tie rod nuts to 20 in-lbs ±2 in-lbs.

Record torque value: \(20\) in-lbs  MSFC QA

Torque wrench SN: \(G8180\)

CAUTION: Make sure that the top bearing plate is indexed to the motor case O.D. and is resting flat on the top of the flange.

Also, make sure that the grounding strap terminal and attach nut and bolt head is positioned in the clearance hole in the plate.

9.17 Place twelve (12) 16 unit size bags of fresh desiccant into the container in the cavity around the top bearing plate.

CAUTION: Once the bagged desiccant has been put into the container, the remaining packaging steps must be completed immediately and the container closed to prevent the desiccant from over exposure to free air circulation.

If, after the desiccant has been placed into the container, the packaging cannot be completed, close the container until packaging can be resumed.

9.18 Install the top cushion insert. Make sure that its index slot, on the bottom face, matches with the index block on the top bearing plate.

9.19 Place the motor log book and any other required documentation into a suitable size electrostatic free plastic bag (3M velostat or Richmond Pink Poly) and place into the stowage slot provided in the top cushion insert.

9.20 Place the container lid onto the container, making sure that there is no foreign matter on the lid gasket or container rim.

9.21 Install the lockring, with its bolt flanges positioned (centered) between the container humidity indicator and lifting grip. Install the bolt and nut and torque to 6 ft-lbs ± 1/2 ft-lbs (72 in-lbs).

Record torque value: \(6\) ft-lbs  MSFC QA
NOTE: The lockring shall be tapped, using a rubber mallet, at various points around the ring during bolt tightening.

Install a standard wire and lead seal through the provided holes in the lockring bolt flanges. Secure using a QC press die engraved with UTC & No. 10 01/25/83

NOTE: Before shipping, USBI personnel shall make sure the shipping container is properly labeled. Reference CSD's Material Handling Card, Rev. C, dated 5-23-89 sections 10 and subsequent.

10.0 Test Report

A final test report will be submitted to UT/CSD within 30 working days after testing is completed. Three copies plus one reproducible copy of this report will be submitted containing the following information as a minimum:

A. A description of test mounting and setup and location of instrumentation with two sets of color still photographs (8-1/2 by 11 inches) of setups and instrumentation close-ups.
B. A list of all instrumentation and equipment with ranges and plot accuracy of all acquired data with objective evidence of calibration status at the time of tests.
C. Sketches of test setups.
D. Power spectral density (PSD) plots of all acceleration data.
E. The results of all inspections and tests performed i.e., data tapes, data plots, and completed data summary sheets.
F. Any alteration or deviation from this procedure will be described in detail by a Notice of Deviation and included in the final report.
G. Model numbers and serial numbers for all instrumentation and test equipment shall be included in the report.
11.0 Post Test Verification

The procedure delineated in the above document has been satisfactorily completed and:

a. All sequences in the procedure have been completed (or deleted by approved deviation)

b. All Procedure changes have been recorded and approved.

Submitted Verified by: [Signature]  Test Engineer

Date: 09/25/93

Motor Serial Number: 1000734

9-25-93
Appendix A

Test Procedure Deviation
Fastener Lockwire / Upper temp. Limit violation

1. Feed fasteners (motor to bracket) and AHS fasteners were lockwired for the aft motor (1000734).

2. Chamber temp. rose above upper tolerance during testing. Max temp during testing was 28\(^\circ\)F. Tolerance states 25\(^\circ\)F +5\(^\circ\)F. Testing proceeded as planned. CSD and USBT notified before proceeding. Motor chamber temp was stabilized at 22.5\(^\circ\)F before testing on radial axis table.
<table>
<thead>
<tr>
<th>TEST ENGINEER</th>
<th>QUALITY</th>
<th>DATE</th>
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<td>PAGE</td>
<td>SEQ</td>
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Figure 1

TEST PROCEDURE DEVIATION

TP No.

RIGINATOR: ORGANIZATION: ABOVE DEVIATION(S) INCREASE HAZARD LEVEL: SAFETY: ABOVE DEVIATION(S) AFFECT TEST REQUIREMENTS: 63
<table>
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<tr>
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<th>PAGE</th>
<th>SEQ</th>
<th>CHANGE/REASON</th>
<th>PERM. TEMP.</th>
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</table>

**Figure 1**

**TEST PROCEDURE DEVIATION**

<table>
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<th>QUALITY</th>
<th>DATE</th>
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</thead>
<tbody>
<tr>
<td>REQUIREMENTS ENGINEER:</td>
<td>OTHER</td>
<td></td>
</tr>
</tbody>
</table>

**TITLE:**

**ORGANIZATION:**

**ABOVE DEVIATION(S) INCREASE HAZARD LEVEL:**

**SAFETY:**

**ABOVE DEVIATION(S) AFFECT TEST REQUIREMENTS:**

64
<table>
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<tr>
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<tr>
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</tr>
<tr>
<td>1</td>
</tr>
<tr>
<td>2</td>
</tr>
</tbody>
</table>
Appendix B

Figures
FIGURE 1. LIFTING STRAP ATTACHMENTS
NOTE: If forward monitoring accelerometer cannot be mounted to the bracket assembly at fixture 180° location, it may be mounted on the bracket at fixture TDC (forward).

FIGURE 2. VIBRATION TEST SETUP
* LOCKING RING, STYLE - 1
MS27683 - 83

NUT & BOLT W/ LOCKWIRE HOLE

* COVER STYLE - 1, MS27683 - 63
GASKET, MS27683 - 93

TOP CUSHION INSERT - MOLDED
RUBBERIZED CURLED HAIR, 6-LB/FT²
PPP-C-1120

TOP BEARING PLATE

LOCK NUT & WASHER (TIE-ROD)

GROUNDING STRAP ASSY.
8909-326 (CSD)

ANTI - ROTATING BLOCK

SECURITY BAG

ROCKET MOTOR ASSEMBLY (BSM)
B12000 (SHIPPING CONFIGURATION)

HUMIDITY INDICATOR, MS25860
PRESSURE EQUALIZER DISC (COMM’L)
(BLOWN IN BUT NOT ACTUAL SIZED)

TIE - ROD
(SECURED TO BOTTOM PLATE)

BODY, MS27683 - 52

BOTTOM BEARING PLATE

THIS VOID AREA USED TO STOW (12) 1-
LB SIZED BAGGED DESCANT

BOTTOM CUSHION INSERT
MOLDED RUBBERIZED CURLED HAIR
6-LB/FT², PPP-C-1120

CENTER CUSHION INSERT

SKID

* DRUM, METAL - SHIPPING STORAGE MS -
27683 (80 GAL CAPACITY)

FIGURE 3. OVERALL VIEW OF SHIPPING CONTAINER
FIGURE 4. Top View of Shipping Container
BSM MOTOR S/N 1000738
PYROSHOCK TEST PROCEDURE
BSM Delta Qualification Test
Motor to Bracket Assembly / Pyro Shock Simulation Test Procedure

This Procedure Describes Safety Critical Operations
BSM Delta Qualification Test

Motor to Bracket Assembly / Pyro Shock Simulation
Test Procedure

Prepared by:
Mat Bevill EP-12
08/16/93

Motor SN: 1000738
Test Date: 09/20/95
Motor to Bracket Assembly/Pyro Shock Simulation

Prepared by:  
Maf Bevill  
Maf Bevill/MSFC TP/EP11  
09/15/93  
Date

Approved by:  
Jim McGee  
Jim McGee/MSFC Vibration Lab TE  
09/14/93  
Date

Jim Herring  
Jim Herring/MSFC Pyro Shock Lab TE  
09/14/93  
Date

Richard Leonard  
Richard Leonard/MSFC Safety/C301  
09/16/93  
Date

Rick Clements  
Rick Clements/MSFC Quality/CQ06  
09/15/93  
Date

Ben Goldberg  
Ben Goldberg/Motor Systems Division/EP11  
09/16/93  
Date

Stan Braisted  
Stan Braisted/Dynamic Test Branch/ED73  
09/16/93  
Date

Chuck Wells  
Chuck Wells/UTC/CSD TE  
09/16/93  
Date

Don Wendel  
Don Wendel/USBi  
09/16/93  
Date

Charlie Lovell  
Charlie Lovell/PCH Engineer/CN71  
09/16/93  
Date
Table of Contents

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   4.2 Test Requirements
   4.3 Test Conditions
   4.4 Test Equipment
   4.5 Test Procedure

5.0 Personnel Responsibilities

6.0 Pyro Shock Test
   6.1 Test Site Preparatory Activities
   6.2 Pyro Test Setup
   6.3 Detonation of Pyrotechnics
   6.4 Post Test Inspection
   6.5 Post Test Removal from Pyro Plate
   6.6 Test Report and Data Requirements

7.0 Post Test Verification

Appendix A - ED73-SHK-FOP-004
Appendix B - Test Procedure Deviations
Appendix C - Figures
Appendix D - Tool List
Appendix E - Proof Test Inspection Sheet (lifting equipment)
General Information

1.1 Scope

This test procedure addresses all the requirements to perform pyro shock testing on Booster Separation Motors (BSM). Included in this procedure are the steps to assemble the BSM to the aft skirt support brackets.

1.2 Objective

The objective of the pyro shock testing is to verify the physical and functional survivability of the Booster Separation Motors. Of particular interest for these tests are the components bonded using EA9394 adhesive. The components using this adhesive include the throat insert, the centering insert, and the igniter grain support rod.

2.0 Applicable Documents

- EG5300.36A Safety
- 29 CFR 1910 Occupational Safety and Health Administration (OSHA)
- NSS/GO 1740.9 Safety Standard for Lifting Devices and Equipment
- NHB 1700.1(V1) Basic Safety Manual
- AMC-R 385-100 Safety Manual
- MM 1700.4 Safety and Environmental Health Hazards
- MMI 1700.17 MSFC Procedures for Acquiring Shipping Permits for Rocket Motors and Igniters
- MMI 1710.1 Safety Review and Approval of Hazardous and Potentially Hazardous Facilities and Activities at MSFC
- MMI 1710.6 MSFC Program for Personnel Certification
- MMI 1711.2 Mishap Reporting and Investigation
3.0 Safety

3.1 The following safety criteria are in accordance with ET01-SOP-01, Rev. A, "Standard Operation Procedures for Safety Critical Operations". If safety rules/regulations are not followed, injury to personnel and/or damage to test items could occur.

Emergency telephone numbers are as follows:

<table>
<thead>
<tr>
<th>Service</th>
<th>Number</th>
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</thead>
<tbody>
<tr>
<td>Safety</td>
<td>4-0046</td>
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<tr>
<td>Ambulance</td>
<td>112</td>
</tr>
<tr>
<td>Fire</td>
<td>117</td>
</tr>
<tr>
<td>Security</td>
<td>4-4357</td>
</tr>
<tr>
<td>Utilities</td>
<td>4-3919</td>
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<tr>
<td>Medical Center</td>
<td>4-2390</td>
</tr>
<tr>
<td>Communication Repair</td>
<td>4-1771</td>
</tr>
</tbody>
</table>

3.1.1 In the event of serious personnel injury, do not move the injured person unless necessary to prevent further serious injury. Call 112 for ambulance.

3.2 Prior to starting work in 4619, a visual inspection of the work area shall be made for anomalies by the MSFC TE and MSFC SE.

MSFC TE  [Signature]  MSFC SE  [Signature]

Date / Time: 09/20/93
3.3 Personnel shall not work or position themselves beneath suspended loads unless such loads are securely and adequately blocked up.

3.4 Objects handled by overhead hoist shall be lifted only high enough to clear fixed objects in the path of travel. Spreader bars and slings may be left on the hoist if desired when not in use, but must be raised so that the lowest part of the lifting equipment will be at least seven feet from the floor when not in use.

3.5 Crane, hoist, prime lift operators, and riggers shall be certified according to the latest revision of MMI 1710.6, and shall have in their possession a valid certification card.

Certifications checked by: [Signature]

Date / Time: 7/21/93 6:00 p.m.

3.6 Personnel working around suspended loads shall be alert to the possibility of being crushed between the suspended load and a fixed object.

3.7 Loads shall be moved slowly so they will not accumulate more momentum than can be stopped with little or no swing.

3.8 Where handling slings are called out, a sling with more pickup points than required may be used if the weight capacity per point used is equal or greater than the weight capacity of each point of the noted sling and the free pickup point is (are) secured to prevent it (them) from swinging and causing damage to parts.

3.9 Only the area coordinator should direct the crane moves, however, any person determining an immediate danger or problem may request stoppage of activities.

3.10 The lifting or transportation operation shall be halted by the area coordinator at any time the control area cannot be maintained.

3.11 Steel toe shoes are required during lifting operations. Hardhats are required when the lift is at or above the shoulders.

3.12 Tag line operators are to wear leather gloves.
3.13 The primary safety hazards associated with this operation are:

3.13.1 Lift operations
3.13.2 Solvent Use (See NOTE)
3.13.3 Live (Loaded) Solid Rocket Motor (propellant handling)

NOTE: Grease and solvent use are only "if needed" as determined by the MSFC TE and CSD TE.

3.14 Any time a crane is being used, it must be dogged if:

3.14.1 The load will be suspended in a static condition for an extended amount of time.

3.14.2 A crane operator crew change or substitution must be made.

3.15 No electric power tools shall be used near the live test item. Use of pneumatic tools is acceptable.

3.16 All ground cables and ground straps end-to-end resistances shall be verified with a multimeter. These resistances must measure less than 1 ohm.

3.17 All personnel within touching distance of the BSM or ordnance shall wear a wrist strap that has been checked with a wrist strap checker.

3.18 All personnel within touching distance of open grain propellant (and ordnance) shall wear antistatic coveralls.

3.19 Wrist strap connections to facility ground must be verified. This step should be performed each time the wrist strap ground is broken.

3.20 In case of an accidental BSM ignition, the nearest fire alarm pull station shall be activated in order to evacuate building 4619. Personnel shall stay clear of the test site until the emergency response personnel have given the "all clear" to return to the building.

4.0 Test Items and Test Requirements

4.1 Test Items

The test item for the qualification pyro shock tests consists of a live BSM which will be tested in the aft motor configuration. The motor will be tested with an aero heat shield over the exit cone. The motor weighs approximately 154 pounds.
4.2 Test Requirements

4.2.1 Test Tolerances

Unless otherwise stated in this procedure, the tolerances applicable to the test conditions described shall be as specified in MIL-STD-810D. These tolerances are as follows:

Shock Response Spectrum: +6dB, -3dB
(when analyzed with a 1/3 octave shock spectrum analyzer and 5% damping)

4.2.2 Test Data

All data taken with non-recording instruments will be recorded in ink directly onto data sheets and/or log sheets. The log or data sheets will identify the test being performed, the test item, the item part number, and the applicable test procedure. Corrections or changes will be made by drawing a single line through the original entry. The new entry will be made directly above the old and initialed by the person making the entry. Each page will be signed and dated at the bottom of the page by the person making the entries, and counter signed by the test engineer after review.

4.3 Test Conditions

4.3.0 The pyrotechnic shock tests for both motors will be conducted at the test site's ambient temperature.

4.3.1 The MSFC TE shall check with the Army MET team to ensure that there is no lightning within 10 miles.
(MET team phone number....876-2465).

4.3.1.1 If lightning is within 10 miles during any time that a live BSM is in building 4619, the MSFC TE shall make arrangements to disconnect the motor ground from the facility ground. The motor shall remain ungrounded until the lightning is out of range.

4.3.1.2 When reconnecting the ground after a lightning storm, a 100Kohm resistor should be connected to the ground wire from the motor before connecting to facility ground. This allows any charge on the motor to slowly dissipate to ground. The resistor should be left connected for no less than 30 seconds.

4.3.1.3 After the specified time, disconnect the ground wire from facility ground and remove the resistor. Reconnect the ground strap from the motor to facility ground.

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4.3.2 The test site's relative humidity must be above 20%. If the humidity is below 20%, all test operations must cease until favorable weather conditions resume.

Test site's relative humidity __97%__ MSFC TE __✓__

4.4 Test Equipment

4.4.1 All measurements shall be made with instruments and equipment whose accuracy and/or calibration has been verified.

Calibration Acceptable __✓__ (MFSC TE)

4.4.2 Proof Loading of Handling Equipment (required for PCH)

4.4.2.1 The heaviest lift during all of the delta qualification testing will be lifting the motor while in its shipping container. The motor and shipping container together weigh about 310 lbs. All forklifts and overhead hoists must be load (break) tested to at least 110% of this weight (i.e. 350 lbs.). This test must be performed prior to any handling of the BSM but does not need to be repeated until something other than the BSM is lifted by the same handling equipment. It is therefore recommended that the break tests be performed each evening before the BSM testing commences. The break tests shall be performed as follows:

a. The proof load must be at least 350 lbs.

b. Lift the dummy load clear of the ground (less than 1 foot) and lower to ground three times, holding for five minutes on the third lift. Lifting straps and spreader bar should be attached during the lift.

SEE APPENDIX E FOR THE PROOF TEST INSPECTION SHEETS.

4.5 Test Procedure

4.5.1 After review and documented approval, a redline change to this procedure may be performed. Approval shall be by a minimum of MSFC TE, MSFC SE, and the MSFC QA.

4.5.2 As soon as possible after a test failure, a deviation from the specified test environment, or any other incident which affects the test or test item, MSFC will notify the authorized UT/CSD representative of the event verbally and will then generate a Test Procedure Deviation (NASA form 3959). A copy of the Test
Procedure Deviation is presented in Appendix B. Photographs of any discrepancies shall also be taken.

5.0 **Personnel Responsibilities**

5.1 **Test Witnessing**

All tests will be witnessed by the authorized UT/CSD representative and USBI representative. The MSFC test engineer will also witness the testing. Notification of the start of each test shall be communicated to the authorized UT/CSD and USBI representatives and the MSFC safety representative and test engineer at least 2 hours in advance.

<table>
<thead>
<tr>
<th>MSFC Safety Notified</th>
<th>MB</th>
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</thead>
<tbody>
<tr>
<td>UT/CSD Notified</td>
<td>MB</td>
</tr>
</tbody>
</table>

5.2 The MSFC TE will serve as the area coordinator for the test. All handling of the BSM will be directed by the MSFC TE or cognizant test engineer.

5.3 Jim Herring (pyro shock) shall be responsible for photographic coverage of the pyro shock test activities.

5.4 The area around the outside of the pyro shock facility shall be secured before the live BSM is brought to the pyro shock test site.

<table>
<thead>
<tr>
<th>Area secured?</th>
<th>YES</th>
<th>NO</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
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</tbody>
</table>

Comments: ____________________________________________

5.5 The MSFC TE shall notify the fire department prior to delivery of the BSM. (Fire dept. phone #...117).

5.6 The MSFC TE shall make arrangements for the live BSM to be delivered from the NASA igloo to the pyro shock test site.

5.7 All involved lab directors and division chiefs shall be notified prior to testing.
6.0 Pyrotechnic Shock Test

6.1 Test Site Preparatory Activities

An inspection shall be made of the hardware to ensure it is all available. Should some hardware be missing the cognizant test engineer shall determine whether those components are required for the safe operation of the procedure. Should they not be required for safe operations, the test engineer shall determine whether an operations halt is required or whether the operations may proceed.

6.1.1 Verify the following components, tools and materials are available and certified (when applicable). All lifting equipment, cables, fixtures, etc... within one year stating the load limit and the date tested stencilled on the equipment.

Aft BSM Plate Mounting Hardware:

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Quantity</th>
<th>Nomenclature</th>
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<tr>
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<td>6</td>
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</tr>
<tr>
<td>EWB0420 - 10-(20,-32)</td>
<td>2</td>
<td>Bolts*</td>
</tr>
<tr>
<td>TLN1021CPD2-8</td>
<td>6</td>
<td>Nut (SelfAligning)</td>
</tr>
<tr>
<td>TLN1023CD3-10</td>
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</tr>
<tr>
<td>NAS1587-8C</td>
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<tr>
<td>NAS1587-10C</td>
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<td>Washer</td>
</tr>
</tbody>
</table>

* 10107-XX-XX series bolts are acceptable alternates (-20 for pyro, -32 for vibration)

Aft BSM Bracket Mounting Hardware:

<table>
<thead>
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<td>Bolts</td>
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<tr>
<td>NAS1587-5C</td>
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<td>Washers</td>
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<tr>
<td>NAS1587-7C</td>
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<td>Washers</td>
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<tr>
<td>NAS1587-7</td>
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<td>Washers</td>
</tr>
<tr>
<td>VN324BC070</td>
<td>12</td>
<td>Locknuts</td>
</tr>
<tr>
<td>NAS1101E08H10</td>
<td>14</td>
<td>Aero Heat Shield</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Fasteners</td>
</tr>
</tbody>
</table>

Fasteners Accounted For: MSFC TE

Breakover brackets 2
Lifting D-rings
Spreader bar with associated lifting straps and D-rings
Custom wood supports to horizontally support the BSM
Tool Box with Assorted Wrenches Rm 170, Bldg. 4619
(See Appendix D for detailed tool list)
Pre-drilled Wood Pallet to fit aft skirt support bracket bolt holes

Lifting straps (3)

SN: 3298
SN: 3701
SN: 3808

Desiccant (12, 16 unit size bags)
Rubber mallet
Lead wire seal (for security bag)
Forklift (at least 500 lb. capacity)
ESD Scanner

Materials
1,1,1 Trichloroethane; 1 bottle (enough for cleaning)
MIL-G-4343 grease; 1 container (AHS seal)
MIL-T-83483 thread compound; 1 container (AHS)
Conoco HD-2 grease; 1 container (bolts, faying surfaces)

Other consumables, including rimple cloth, que-tips, tape, bags and towels are also to be supplied if needed.

Gloves (Latex)
Ground straps
Wrist stats (5 each)
Stat gun (1 each)
Ohm meter (1 each)
Wrist stat checker (1 each)
Chemical safety goggles (2 each)
100 Kohm resistor (1 each)
All hardware accounted for: \( \checkmark \) all needed for this test

6.1.2 After the truck has arrived with the motor, the engine should be turned off and the emergency brake engaged. Chock at least one of the truck's wheels.

Truck braked and wheel chocked: \( \checkmark \) MSFC TE

6.1.3 A sign with the word "LOADED" should be attached to the motor shipping container.

6.1.4 Attach a ground strap (long enough to reach the shipping container on the truck) to the pyro facility ground and verify the resistance. Resistance must be less than 1 ohm.

Resistance measured: / MSFC QA \( \checkmark \)

**CAUTION:** Make New Ground Before Braking Old Ground.

6.1.5 Touch the free end of the ground wire to the truck chassis to make sure the truck and the facility are at the same potential, then, connect the free end of the ground strap to motor shipping container (not to lid or lid bolts).

6.1.6 Check continuity of shipping container to ground strap using an ohm meter. Resistance should measure less than 1 ohm.

Resistance Measured / MSFC QA \( \checkmark \)

6.1.7 Disconnect shipping container-to-truck tie down apparatus. Move tie down out of the way.

6.1.8 Disconnect shipping container to truck chassis ground.

**CAUTION:** Do Not disconnect the motor's ground wire while removing from the truck.

6.1.9 Using the fork lift, remove shipping container from truck and set container on the floor in the test room where it may be easily accessed by personnel and the overhead crane. If deemed necessary by the MSFC TE, the overhead crane may be used to remove the shipping container from the truck.

Forklift used: \( \text{yes} \) no Crane used: yes \( \checkmark \) no

6.1.10 The truck may exit the test area at this time.

**NOTE:** If the truck does not leave the site at this time, the driver will coordinate the exit with the MSFC TE.
6.1.11 The large pyro bay doors should be "closed in" but left "cracked" open during the assembly and pyro test operations.

6.1.12 Install the shock test control equipment on the pyro plate as illustrated in Figure 1 (see Appendix C).

   Equipment installed __MSFC TE

6.1.13 The pyrotechnic shock test will be conducted in the aft motor configuration.

6.2 Pyro Test Setup

6.2.0 Record the test site's temperature and relative humidity. The relative humidity shall be above 20%. If the humidity is not above 20%, all test operations must halt until favorable weather conditions resume.

   Temperature: __°F; Relative Humidity __%

6.2.1 Remove Motor From Shipping Container

6.2.1.0 Verify wrist straps are being used by ALL personnel while working with the live motor. All wrist straps shall be checked with a wrist strap checker before being used. Continuity checks shall be performed on all main ground straps after making any new ground connection.

   MSFC SE __

6.2.1.1 Position shipping container so that the overhead crane can easily attach to the test item (this step necessary only if forklift positioning was not adequate for crane attachment.)

   CAUTION: When using the ESD scanner and the electrostatic reading on the motor case surface exceeds 1.0 kilovolt, stop all activities on the case, initiate personnel fall back (a minimum of 4 feet) and notify safety.

   After initial reading over 1.0 kilovolt, repeat electrostatic reading at intervals not to exceed 5 minutes until the voltage has dissipated below 1.0 kilovolt. When the reading is below 1.0 kilovolt, removal operations may continue.

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If after 30 minutes the measured electrostatic charge is in excess of 1.0 kilovolt, Verify facility ground. If connection to facility ground is open, reconnect through larger resistor (100 Kohm min.) to allow a slow discharge of the motor case.

If the electrostatic reading on the case surface exceeds 4.0 kilovolts, STOP all activities on the case, notify safety, and evacuate all personnel to safe locations as directed by safety.

WARNING: Do not remove the nozzle's security bag and weather seal. Removing the bag and seal will expose the propellant grain and increase the risk of motor ignition.

6.2.1.2 Open the shipping container and remove all the packing that interferes with the removal of the test item. Monitor static charge while removing packaging.

Record Stat Gun reading ~700 V±15

Record SN of Stat Gun C10653

CAUTION: Make New Ground Before Braking Old Ground.

6.2.1.3 Attach a ground wire to the pyro facility ground and verify its resistance. Resistance shall measure less than 1 ohm. This wire should be attached at a location close to the BSM.

Resistance measured / MSFC QA / 

6.2.1.4 Attach the ground wire in step 6.2.1.3 from the facility ground to the live BSM.

6.2.1.5 Disconnect the motor to shipping container ground wire. See damage on next page

6.2.1.6 Attach two lifting rings (along with lifting strap) to the BSM's aft section, 180° apart.

6.2.1.7 Certifications for all lifting fixtures shall be provided:

Lifting beam assembly certification provided

Lifting rings (D-rings)
CAUTION: When using the ESD scanner and the electrostatic reading on the motor case surface exceeds 1.0 kilovolt, stop all activities on the case, initiate personnel fall back (a minimum of 4 feet) and notify safety.

After initial reading over 1.0 kilovolt, repeat electrostatic reading at intervals not to exceed 5 minutes until the the voltage has dissipated below 1.0 kilovolt. When the reading is below 1.0 kilovolt, removal operations may continue.

If after 30 minutes the measured electrostatic charge is in excess of 1.0 kilovolt, Verify facility ground. If connection to facility ground is open, reconnect through larger resistor (100 Kohm min.) to allow a slow discharge of the motor case.

If the electrostatic reading on the case surface exceeds 4.0 kilovolts, STOP all activities on the case, notify safety, and evacuate all personnel to safe locations as directed by safety.

CAUTION: The following step involves working with a suspended load. Keep hands and feet out from under the load.

6.2.1.8 Slowly, monitoring static charge, lift the motor out of the container using the overhead crane. Lower the test item so that the forward end of the motor is at waist height.

A detailed visual inspection shall be performed by the MSFC test engineer and the CSD test engineer on the live test items before testing. Record the motor's serial number.

No Damage

Damage (detail in attachment): Yes, motor to shipping container ground wire broken. Also, small dent/scratch on near rear end.

Serial Number: 1000738

CAUTION: The following step involves working with a suspended load. Keep hands and feet out from under the load.

6.2.1.9 Attach the "break-over" brackets and lifting strap on the forward end of the motor (see Figure 2, Appendix C).

CAUTION: Do Not disconnect the ground wire while breaking the motor to the horizontal position.
CAUTION: The following step involves working with a suspended load. Keep hands and feet out from under the load.

6.2.1.10 Lower the motor on its wood supports so that the motor rests horizontally. The MSFC TE will designate someone to hold the lifting strap on the forward end while placing the motor in the horizontal position (see Figure 3, Appendix C). The person holding the strap should be wearing a wrist strap.

6.2.1.11 Unhook the lifting straps and remove lifting hardware.

6.2.1.12 Re-attach the lifting hardware for bracket installation. Attach lifting straps in the saddle position (see Figure 4b, Appendix C).

6.2.2 Attach Motor to the Aft Skirt Support Brackets

Steps 6.2.2.1 and 6.2.2.2 may be skipped if deemed "not necessary" by the MSFC test engineer and the CSD test engineer. However, the fasteners should still be installed with grease applied. If time permits, all of the cleaning and surface preparation may be done before the test date.

CAUTION: When using trichloroethane, personnel shall wear chemical goggles and neoprene-Latex gloves. Contaminated materials shall be disposed of as hazardous waste.

CAUTION: When using grease, personnel shall wear Neoprene-Latex gloves. Contaminated materials shall be disposed of as hazardous waste.

6.2.2.1 Wipe faying surfaces clean with 1,1,1 trichloroethane and apply an unbroken film of HD-2 to each surface. After assembly remove excess grease with lint-free cloth.

Surfaces wiped at this time: Yes No
Grease applied at this time: Yes No

CAUTION: When using trichloroethane personnel shall wear chemical goggles and neoprene-Latex gloves. Contaminated materials shall be disposed of as hazardous waste.

CAUTION: When using grease personnel shall wear Neoprene-Latex gloves. Contaminated materials shall be disposed of as hazardous waste.
6.2.2 Clean washers and bolts with 1,1,1 trichloroethane and install wet with HD-2 grease. After assembly remove excess grease with a lint-free cloth.

Washers cleaned at this time: Yes \[\checkmark\] No

CAUTION: Make sure the motor remains properly grounded during the move to position the test item.

6.2.2.3 Position the motor on the wood supports so the forward and aft brackets can be easily attached. Leave lifting straps attached.

6.2.2.4 At forward end of BSM install NAS1955C10H bolts with NAS1587-5C washers (8 places) through supports and into threaded inserts of BSM and torque to 145 to 170 in-lbs (13 to 14 ft-lbs) above running torque.

Torque value: \(150 \text{ in-lbs}\) MSFC QA \(\checkmark\)

Record SN of torque wrench: \(T-267-62\) (4621)

NOTE: The forward attach bracket has an alignment pin so there is only one way it can be installed.

NOTE: Be sure the aft attach bracket is in correct alignment with the forward bracket before installing the aft attach bracket bolts.

6.2.2.5 At aft end of BSM install NAS1957C13 bolts with NAS1587-7C washers (under bolt head), NAS1587-7 washers (under nut) and VN324BC07 locknuts (12 places) and torque to 460 to 540 in-lbs (39 to 45 ft-lbs) above running torque. *Due to inaccessibility bolts were torqued on a "best effort" basis.

Torque value: \(570\text{ in-lbs}\) MSFC QA \(\checkmark\)

Record SN of torque wrench: \(T-267-62\) (4621)

6.2.3 Bracket Cover Installation

6.2.3.1 Bracket cover required? Yes \(\checkmark\) No

If yes above, the 1/4 inch diameter bolts shall be torqued to 90-110 inch-pounds above running torque. The 5/16 inch diameter bolts shall be torqued to 185-200 inch-pounds (16 to 17 ft-lbs) above running torque.

Torque value: \(\text{N/\text{A}}\) MSFC QA \(\text{N/\text{A}}\)

Record SN of torque wrench: \(\text{N/\text{A}}\)
6.2.4 Rotate Motor 90 Degrees for Pyro Plate Mounting

6.2.4.0 De-torque and remove the bracket to inspection plate fasteners. Place fasteners in a labeled bag.

6.2.4.1 With the test item resting on the brackets, unhook the belly straps from the horizontal stabilizing bar (lifting straps should still be in the choked position as shown in Figure 4a, Appendix C).

6.2.4.2 Wrap the belly straps around the motor on each end as shown in Figure 4b (saddle configuration, Appendix C).

CAUTION: Personnel shall not work under or place any body part under a suspended load.

CAUTION: Be careful not to disconnect the motor's ground wire during the lifting and rotation operation.

6.2.4.3 Lift the motor and brackets to waist height using the overhead crane so that the motor can be rotated.

6.2.4.4 Holding the motor by the support brackets, rotate the motor 90 degrees so that the brackets can be mounted on the pyro plate.

6.2.4.5 Use the overhead crane to move the test item to the mounting area on the pyro plate.

6.2.5 Attach the Brackets and Shims to the Pyro Plate

REMINDER: Be sure to put the custom shims in their correct positions and orientation before sliding bolts through the pyro plate.

CAUTION: When using grease, personnel shall wear Neoprene-Latex gloves. Contaminated materials shall be disposed of as hazardous waste.

6.2.5.1 Install wet with grease (HD-2) EWB0420-8-23 bolts (10107-8-23 alternate) with NAS1587-8C washers and TLN1021CPD2-8 self-aligning nuts at "A", "B", and "D" positions (as marked on supports, 6 places) and torque to 605 to 710 in-lbs above running torque. At the "C" position, install EWB0420-10-20 bolts (10107-10-20 alternate) with NAS1587-10C washers and TLN1023CD3-10 self-aligning nuts (2 places) and torque to 1175 to 1380 in-lbs above running torque.

Torque value: "C" 105+1 lbs MSFC QA 8C
A, B, D 650 in-lbs

ORIGINAL PAGE IS OF POOR QUALITY
Record SN of torque wrench: "EMJ00359 A.A.D T-261.6C (4611)"

6.2.5.2 Release the tension from the lifting straps but do not disconnect the straps. These straps may be used to tape off accelerometer wires if necessary.

6.2.5.3 Place the pyrotechnic debris shield in front of the large bay doors on the north side of the pyro room.

6.2.6 Perform Grain Inspection

6.2.6.1 Clear area of all nonessential personnel for grain inspection. (Only the grain inspectors (2) and the MSFC TE shall remain.)

6.2.6.2 Verify grain inspector(s) is(are):
   a. Wearing 100% cotton coveralls, shorts, and undershirts.
   b. Wearing a wrist strap.
   c. Wearing tethers and/or tape to keep eye glasses, rings, and watches from falling into the motor.

6.2.6.3 The grain inspector shall now remove the security bag and cover from the exit cone.

6.2.6.4 Perform grain inspection.

   Cracked propellant? yes  no

   If yes, give approximate location and size of crack.

   Other comments on grain condition: No cracks or other defects noted on propellant grain. Small amount of lint and red stain on grain surface. OK to perform pyro shock test.

   Grain inspector B.J. Kelly 5-20-93

6.2.7 Install Aero Heat Shield

CAUTION: When using trichloroethane, personnel shall wear chemical goggles and Neoprene-Latex gloves. Contaminated materials shall be disposed of as hazardous waste.
6.2.7.1 CLEAN (if necessary) preservative or oil from the aeroheat shield using a lint-free cloth and 1,1,1 Trichloroethane. DO NOT clean over the identification.

Cleaning performed: Yes ☑ No ___

CAUTION: When using trichloroethane, personnel shall wear chemical goggles and neoprene-Latex gloves. Contaminated materials shall be disposed of as hazardous waste.

CAUTION: When using grease, personnel shall wear Neoprene-Latex gloves. Contaminated materials shall be disposed of as hazardous waste.

NOTE: Dow Corning Moly Kote 55M Silicone O-ring lubricant meets the MIL-G4343 specification.

6.2.7.2 Using a lint-free cloth and 1,1,1 Trichloroethane, an operator wearing a properly grounded wrist stat will CLEAN (if necessary) the sealing surface of the aeroheat shield cover and corresponding nozzle surfaces. LUBRICATE (if necessary) the surfaces with MIL-4343 grease.

Surface cleaned: Yes ☑ No ___
Surface lubricated: Yes ☑ No ___

CAUTION: When using grease, personnel shall wear neoprene-Latex gloves. Contaminated materials shall be disposed of as hazardous waste.

6.2.7.3 EXAMINE seal, P/N B12879-02-01 for damage that could effect the results of the pyro shock or vibration tests. APPLY MIL-G-4343 grease.

Seal damaged? yes ☑ no ___
Description of damage: ____________________________________________

NOTE: Extreme care must be taken when installing the seal. Notice there is a small and large lip on the seal (see Fig. 5, Appendix C). The larger lip is the seal aft face, and the smaller lip is the seal outside diameter.

6.2.7.4 INSTALL seal, P/N B12879-02-01 on the exit cone of the motor. Reference drawing B14036.
CAUTION: When using thread compound, personnel shall wear neoprene-Latex gloves. Contaminated materials shall be disposed of as hazardous waste.

6.2.7.5 COAT fourteen (14) screws (NAS1101E08H10) with MIL-T-83483 thread compound.

CAUTION: When installing the Aero Heat Shield, personnel shall be extremely careful not to drop any foreign object into the rocket motor (watches, rings, and other jewelry shall be removed; eye glasses shall be tethered if worn).

6.2.7.6 With the nozzle cant vertically up, a properly grounded operator will INSTALL the aeroheat shield cover with the hinge on the left or right side when aft looking forward as specified by USBI/CSD. Proper alignment in either position is provided by a positioning pin and mating hole.

(NOTE: DO NOT lockwire the screws.)

6.2.7.7 INSTALL the 14 screws and TORQUE the fasteners using a standard cross pattern. Record the torque values.

<table>
<thead>
<tr>
<th>Pass</th>
<th>Torque</th>
<th>Value</th>
<th>MSFC QA</th>
</tr>
</thead>
<tbody>
<tr>
<td>First Pass</td>
<td>Finger Tight</td>
<td>0-15</td>
<td></td>
</tr>
<tr>
<td>Second Pass</td>
<td>10-15 in-lbs</td>
<td>20-25</td>
<td>MSFC QA</td>
</tr>
<tr>
<td>Third Pass</td>
<td>20-25 in-lbs</td>
<td>20-25</td>
<td>MSFC QA</td>
</tr>
<tr>
<td>Fourth Pass</td>
<td>20-25 in-lbs</td>
<td>20-25</td>
<td>MSFC QA</td>
</tr>
</tbody>
</table>

Record SN of torque wrench:

6.2.8 Make Sure the Pyro Facility Bay Doors are Open

6.2.9 Clear Area for Test

The only personnel allowed in the control room are the pyro shock test conductor, a pyro technician, the MSFC TE, and the MSFC SE (total of four (4) people). All other personnel should move to a clear area. The clear areas are defined as the NORTH hallway of building 4619 and the area outside the pyro control room on the WEST side. Other areas must be cleared with the MSFC TE and the MSFC SE.
6.2.9.0 Conduct Pyro Shock Test to the Following Parameters:

**Test Parameters:**

<table>
<thead>
<tr>
<th>Frequency (Hz)</th>
<th>Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>50</td>
<td>24 g peak</td>
</tr>
<tr>
<td>50 to 100</td>
<td>+12 db/octave</td>
</tr>
<tr>
<td>100</td>
<td>94 g peak</td>
</tr>
<tr>
<td>100 to 4000</td>
<td>+6 db/octave</td>
</tr>
<tr>
<td>4000 to 10,000</td>
<td>3750 g peak</td>
</tr>
</tbody>
</table>

6.2.9.1 Turn on the flashing light outside room 170A.

6.2.9.2 For each measurement location select an accelerometer of a type suitable for the amplitude expected.

6.2.9.3 Calibrate each accelerometer per ED73-SHK-FOP-008.

6.2.9.4 Verify test, checkout, and assembly hardware are connected to the facility ground system.

6.2.9.5 Verify that no leads are connected to the junction box terminals.

6.2.9.6 Move junction box switch to "BULB" position.

6.2.9.7 Connect 12 volts to the firing panel.

6.2.9.8 Insert the firing key and verify panel meter indicates the correct voltage.

6.2.9.9 Switch key to "ARMED" position and verify power indicator light is illuminated.

6.2.9.10 Open red cover and flip firing switch, verify bulb on junction box lights.

6.2.9.11 Close red cover.

6.2.9.12 Switch key to "SAFE" position.

6.2.9.13 Move junction box switch to "METER" position.

6.2.9.14 Switch key to "ARMED" position and verify power indicator light is illuminated.

6.2.9.15 Open red cover and flip the firing switch, verify that the meter on junction box indicates 12 volts.
6.2.9.16 Close red cover.

6.2.9.17 Switch key to "SAFE" position and disconnect voltage source.

6.2.9.18 Remove firing key.

6.2.9.19 Verify that no severe weather or electrical storms are within 10 miles of the immediate vicinity (Army Met. Team 876-2465).

6.2.9.20 Verify that no flammable solvents, paints, gases, etc., are in the hazardous area.

6.2.9.21 Verify all non-essential personnel are clear of the test area.

6.2.9.22 Verify pyro technician is:
   a. Wearing 100% cotton coveralls, shorts, and undershirts.
   b. Wearing safety goggles, hearing protection, and a wrist strap when installing explosive items.
   c. In possession of the arming key and that the firing panel is in the safe position.

6.2.9.23 The pyro technician shall remove all matches, lighters, jewelry, and all battery-powered devices such as electrical wrist watches, calculators, portable radios, etc.

6.2.9.24 During periods of connecting blasting caps, MDF, and FLSC, a maximum of two people (to be designated by the MSFC TE) will be permitted to remain in the shock area.

6.2.9.25 Install required MDF or FLSC on exciter plate. (Total of 26" of ~25 grains per foot) (See Fig. 6 and Fig. 7, Appendix C)

6.2.9.26 Verify switch on junction box is in "BULB" position.

**WARNING:** If bulb glows, there is sufficient radio frequency in the area to possibly cause detonation of the blasting cap. The cap should be left shorted and returned to room 170B storage cabinet. All blasting activities will be curtailed until the RF source is removed.

6.2.9.27 Verify that bulb on junction box is not illuminated.

6.2.9.28 In room 170B, verify that blasting cap shorting coil is in place and is undamaged before removing from storage container.

6.2.9.29 Remove blasting cap from container and transport to room 170.
6.2.9.30 In room 170, verify that wrist straps are in place.
6.2.9.31 Install blasting cap on exciter plate.
6.2.9.32 Press blasting cap shorting coil firmly against facility ground for 1 second. In order to short the leads, remove enough shorting coil from the blasting cap to attach alligator clip.
6.2.9.34 Remove shorting coil.
6.2.9.35 Move switch on junction box to "METER" position.
6.2.9.36 Verify 0 (zero) volts on meter.

**WARNING:** If voltage is indicated, the lines to the firing panel are either connected to a voltage source or are picking up voltage from radiation caused by a nearby source. The cap should be left shorted and returned to room 170B storage cabinet. All blasting activities will be curtailed until the voltage source is removed.

6.2.9.37 Move junction box switch to "BULB" position.
6.2.9.38 Install blasting cap leads in junction box, move switch to "FIRE" position, and remove alligator clip.
6.2.9.39 The pyro technician shall now leave the area, close the door, and inform the MSFC TE of the status.

6.3 Detonation of Pyrotechnics

6.3.1 The lead pyro engineer shall now prepare the data acquisition system to acquire data.
6.3.2 Start the tape recorder.
6.3.3 Connect firing lines to the pyro control room junction box.
6.3.4 The lead pyro engineer, the pyro technician, the MSFC TE, and the MSFC SE shall now leave the pyro control room and move to the clear area outside.
6.3.5 Connect firing panel voltage supply and insert firing key, verify that the meter indicates the appropriate voltage.
6.3.6 Begin countdown.
On the count of "3", the pyro technician shall put the switch in the "ARMED" position and verify that the power indicator is illuminated.

On the FIRE command, the pyro technician will open the red cover and flip the firing switch.

After firing, turn the firing panel key to the "UNARMED" position.

**WARNING:** If blasting cap does not fire, refer to Section 10.4 in ED73-SHK-FOP-004 (see Appendix A).

Blasting Cap Fired: yes ✓ no

Remove the arming key and disconnect the voltage supply.

Test personnel may now return to the control room.

Wait a minimum of 5 minutes after firing before opening the door to room 170.

The lead pyro engineer shall now begin to reduce the data.

**Post Test Inspection**

Inform the MSFC TE that the door to room 170 from the control room is to be opened.

The pyro technician shall enter room 170 and move the junction box switch to the "BULB" position.

Remove blasting cap leads from junction box.

Inspect the shock plate to insure all explosive devices fired properly.

**WARNING:** If all explosive items did not fire, refer to Section 10.5 in ED73-SHK-FOP-004 (see Appendix A).

The BSM shall be visually inspected for damage resulting from the pyro shock test. Any anomalies will be recorded. All other personnel shall remain in the control room or in the clear area until the "ALL CLEAR" is given by the MSFC TE.

MSFC TE indicates all clear for appropriate personnel.

**Post Test Removal from the Pyro Plate**
6.5.1 Have a certified fork lift (500 pound minimum) ready to load the BSM and pallet onto the transport truck.

CAUTION: Exercise care not to entangle or tug on the motor grounding strap during the following lifting operations.

6.5.2 Tighten the lifting straps using the overhead crane so that the bolts can be loosened.

6.5.3 De-torque and remove the bolts that attach the brackets to the pyro plate.

CAUTION: The following steps involve working with a suspended load. Keep hands and feet out from under the load.

6.5.4 Remove custom shims and place in labeled bag for use in the vibration tests.

6.5.5 Lower the motor to waist height.

6.5.6 Rotate the motor 90 degrees so that the brackets can be mounted on the pallet.

6.5.7 Using the overhead crane, place the motor on the pallet so that it rests on the aft skirt support brackets and is aligned with the pre-drilled bolt holes.

6.5.8 With the test item resting on the brackets, unhook the belly straps from the horizontal stabilizing bar.

6.5.9 Bolt the test item to the pallet using the provided fasteners for transport to vibration.

Motor secured to pallet MSFC TE

6.6 Test Report and Data Requirements

A final test report will be submitted to UT/CSD within 30 working days after testing is completed. Three copies plus one reproducible copy of this report will be submitted containing shock response spectrum (SRS) plots (with Q=10 value) and the time history plots. The test tolerances shall be overplotted on the control spectrum.

Model numbers and serial numbers for all instrumentation and test equipment shall be included in the report. Test setup photos should also be included in the report.
7.0 Post Test Verification

The procedure delineated in the above document has been satisfactorily completed and:

a. All sequences in the procedure have been completed (or deleted by approved deviation)

b. All Procedure changes have been recorded and approved.

Submitted Verified by: [signature]

Test Engineer

Date: 09/21/93

Motor Serial Number: 1000738

[Signature]

9-21-93
BSM MOTOR S/N 1000738
VIBRATION TEST PROCEDURE
BSM Delta Qualification Test

Vibration Tests and Packaging Procedure

This Procedure Describes Safety Critical Operations
BSM Delta Qualification Test

Vibration Tests and Packaging Procedure

Prepared by:
Mat Bevill  EP-12

08/16/93

Motor SN: 1000758
Test Date: 09/22/93
Vibration Tests and Packaging Procedure

Prepared by:  
Mat Beville  
Mat Beville/MSFC TE/EP12  
9/15/93  
Date

Approved by:  
Jim Mcgee  
Jim Mcgee/MSFC Vibration Lab TE  
9/14/93  
Date

Jim Herring  
Jim Herring/MSFC Hyro Shock Lab TE  
9/14/93  
Date

Richard Leonard  
Richard Leonard/MSFC Safety/CS01  
9/16/93  
Date

Rick Clements  
Rick Clements/MSFC Quality/CQ06  
9/15/93  
Date

Ben Goldberg  
Ben Goldberg/Motor Systems Division/EP11  
9/14/93  
Date

Steve Brouwer  
Steve Brouwer/Dynamic Test Branch/ED73  
9/14/93  
Date

Chuck Wells  
Chuck Wells/UTC/CSD TE  
9/15/93  
Date

Donald Reif  
Donald Reif/USBI  
9/15/93  
Date

Charlie Lovell  
Charlie Lovell/PCH Engineer/CN71  
9/16/93  
Date
Vibration Tests and Packaging Procedure

Prepared by:  
Mat Bevill/MSFC TE/EP12  

Approved by:  
Jim McGee/MSFC Vibration Lab TE  
Jim Herring/MSFC Pyro Shock Lab TE  
Richard Leonard/MSFC Safety/CS01  
Rick Clements/MSFC Quality/CQ06  
Ben Goldberg/Motor Systems Division/EP11  
Steve Brawner/Dynamic Test Branch/ED73  
Chuck Wells/UTC/CSD TE  
Don Wencil/USBI  
Charlie Lovell/PCH Engineer/CN71  

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1.0 **General Information**

1.1 **Scope**

This test procedure addresses all the requirements to perform vibration testing on Booster Separation Motors (BSM). The test program consists of lift-off vibration, boost vibration, and vehicle dynamics vibration.

1.2 **Objective**

The objective of the dynamic testing is to verify the physical and functional survivability of the Booster Separation Motors. Of particular interest for these tests are the components bonded using EA9394 adhesive. The components using this adhesive include the throat insert, the centering insert, and the igniter grain support rod.

2.0 **Applicable Documents**

<table>
<thead>
<tr>
<th>Document</th>
<th>Title</th>
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</thead>
<tbody>
<tr>
<td>MSFC-STD-513A</td>
<td>Certification of Equipment Operations and Materials Handling Personnel</td>
</tr>
<tr>
<td>EG5300.36A</td>
<td>Safety</td>
</tr>
<tr>
<td>29 CFR 1910</td>
<td>Occupational Safety and Health Administration (OSHA)</td>
</tr>
<tr>
<td>NSS/GO 1740.9</td>
<td>Safety Standard for Lifting Devices and Equipment</td>
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<tr>
<td>NHB 1700.1(V1)</td>
<td>Basic Safety Manual</td>
</tr>
<tr>
<td>AMC-R 385-100</td>
<td>Safety Manual</td>
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<tr>
<td>MM 1700.4</td>
<td>Safety and Environmental Health Hazards</td>
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<td>MMI 1700.17</td>
<td>MSFC Procedures for Acquiring Shipping Permits for Rocket Motors and Igniters</td>
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<td>MMI 1710.1</td>
<td>Safety Review and Approval of Hazardous and Potentially Hazardous Facilities and Activities at MSFC</td>
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<td>MMI 1710.6</td>
<td>MSFC Program for Personnel Certification</td>
</tr>
<tr>
<td>MMI 1711.2</td>
<td>Mishap Reporting and Investigation</td>
</tr>
</tbody>
</table>
3.0 **Safety**

3.1 The following safety criteria are in accordance with ET01-SOP-01, Rev. A., *Standard Operation Procedures for Safety Critical Operations*. If safety rules/regulations are not followed, injury to personnel and/or damage to test items could occur.

Emergency telephone numbers are as follows:

<table>
<thead>
<tr>
<th>Service</th>
<th>Number</th>
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</thead>
<tbody>
<tr>
<td>Safety</td>
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<td>Ambulance</td>
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<td>Fire</td>
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<td>4-2390</td>
</tr>
<tr>
<td>Communication Repair</td>
<td>4-1771</td>
</tr>
</tbody>
</table>

3.2 Prior to starting work in 4619 a visual inspection of work area shall be made for anomalies by task supervisor and safety personnel.

MSFC TE [Signature] MSFC SE [Signature]

Date / Time: 09/29/93 5:00 p.m.

3.3 Personnel shall not work or position themselves beneath suspended loads unless such loads are securely and adequately blocked up.
3.4 Objects handled by overhead hoist shall be lifted only high enough to clear fixed objects in the path of travel. Spreader bars and slings may be left on the hoist if desired when not in use, but must be raised so that the lowest part of the lifting equipment will be at least seven feet from the floor when not in use.

3.5 Crane, hoist, lift prime operators, and riggers shall be certified according to the latest revision of MMI 1710.6, and shall have in their possession a valid certification card.

Certifications checked by: MS

Date / Time: 01/24/97 5:00 PM

3.6 Personnel working around suspended loads shall be alert to the possibility of being crushed between the suspended load and a fixed object.

3.7 Loads shall be moved slowly so they will not accumulate more momentum than can be stopped with little or no swing.

3.8 Where handling slings are called out, a sling with more pickup points than required may be used if the weight capacity per point used is equal or greater than the weight capacity of each point of the noted sling and the free pickup point is (are) secured to prevent it (them) from swinging and causing damage to parts.

3.9 Only the area coordinator should direct the crane moves, however, any person determining an immediate danger or problem may request stoppage of activities.

3.10 The lifting or transportation operation shall be halted by the area coordinator at any time the control area cannot be maintained.

3.11 Steel toe shoes are required during lifting operations. Hardhats are required when the lift is at or above the shoulders.

3.12 Tag line operators are to wear leather gloves.

3.13 The primary safety hazards associated with this operation are:

3.13.1 Lift operations
3.13.2 Solvent Use (See NOTE)
3.13.3 Live (Loaded) Solid Rocket Motor
NOTE: Grease and solvent use are only "if needed" as determined by the MSFC TE and CSD TE.

3.14 Any time a crane is being used, it must be dogged if:
3.14.1 The load will be suspended in a static condition for an extended amount of time.
3.14.2 A crane operator crew change or substitution must be made.
3.15 No electric power tools shall be used near the live test item. Use of pneumatic tools is acceptable.
3.16 All ground cables and ground straps end-to-end resistances shall be verified with a multimeter. These resistances must measure less than 1 ohm.
3.17 All personnel within touching distance shall wear a wrist strap that has been checked with a wrist strap checker. This step should be performed each time the wrist strap ground is broken.
3.18 All personnel within touching distance of open grain propellant (and ordnance) shall wear antistatic coveralls.

Test Items and Test Requirements

4.1 Test Items
The test item for the vibration tests consist of a BSM which will be tested in the aft motor configuration. The motor will be tested with an aero heat shield over the exit cone. The motor weighs approximately 154 pounds.

Motor Serial Number 1005738 Conditioning Temp. 125.0 ± 5°F

4.2 Test Requirements

4.2.1 Test Tolerances
The tolerances applicable to the test conditions are as follows: (Unless otherwise stated in the procedure)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Tolerance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vibration Frequency</td>
<td>± 5%</td>
</tr>
<tr>
<td>Test Duration</td>
<td>+10%, -0%</td>
</tr>
<tr>
<td>Temperature</td>
<td>± 5°F</td>
</tr>
<tr>
<td>Sinusoidal Control Signal</td>
<td>±10%</td>
</tr>
<tr>
<td>Maximum Harmonic Distortion</td>
<td>+20%, -10%</td>
</tr>
<tr>
<td>Sinusoidal Peak Acceleration</td>
<td></td>
</tr>
</tbody>
</table>
Composite Root Mean Square Acceleration

\[ \pm 10\% \]

Acceleration Spectral Density

\[ +100\%, -25\% \]
\[ (+3dB, -1.5dB) \]

4.2.2 Test Data

All data taken with non-recording instruments will be recorded in ink directly onto data sheets and/or log sheets. The log or data sheets will identify the test being performed, the test item, the item part number, and the applicable test procedure. Corrections or changes will be made by drawing a single line through the original entry. The new entry will be made directly above the old and initialed by the person making the entry. Each page will be signed and dated at the bottom of the page by the person making the entries, and counter signed by the test engineer after review.

4.3 Test Conditions

The live delta qualification motor will be vibration tested at a specific temperature. The motor will either be tested at 25°F (+0, -5°F) or at 125°F (+5, -0°F) depending on which qualification motor this procedure controls.

4.3.1 The MSFC TE shall check with the Army MET team to ensure that there is no lighting within 10 miles. (MET team phone number....876-2465).

4.3.1.1 If lightning is within 10 miles during any time that a live BSM is in building 4619, the MSFC TE shall make arrangements to disconnect the motor ground from the facility ground. The motor shall remain ungrounded until the lightning is out of range.

4.3.1.2 When reconnecting the ground after a lightning storm, a 100Kohm resistor should be connected to the ground wire from the motor before connecting to facility ground. This allows any charge on the motor to slowly dissipate to ground. The resistor should be left connected for no less than 30 seconds.

4.3.1.3 After the specified time, disconnect the ground wire from facility ground and remove the resistor. Reconnect the ground strap from the motor to facility ground.
4.3.2 The test site's relative humidity must be above 20%. If the humidity is below 20%, all test operations must cease until favorable weather conditions resume.

Test site's relative humidity 37% at 5:00 PM - 4/12/84 MSFC TE

4.4 Test Equipment

4.4.1 All measurements shall be made with instruments and equipment whose accuracy and/or calibration has been verified.

Calibration Acceptable MSFC TE CSD TE

4.4.2 Proof Loading of Handling Equipment (required for PCH)

4.4.2.1 The heaviest lift during all of the delta qualification testing will be lifting the motor while in its shipping container. The motor and shipping container together weigh about 310 lbs. All forklifts and overhead hoists must be load (break) tested to at least 110% of this weight (i.e. 350 lbs.). This test must be performed prior to any handling of the BSM but does not need to be repeated until something other than the BSM is lifted by the same handling equipment. It is therefore recommended that the break tests be performed each evening before the BSM testing commences. The break tests shall be performed as follows:

a. The proof load must be at least 350 lbs.

b. Lift the dummy load clear of the ground (less than 1 foot) and lower to ground three times, holding for five minutes on the third lift. Lifting straps and spreader bar should be attached during the lift.

SEE APPENDIX C FOR THE PROOF TEST INSPECTION SHEETS.

4.5 Test Procedure

4.5.1 After review and documented approval, a redline change to this procedure may be performed. Approval shall be by a minimum of the MSFC TE, MSFC QA, and MSFC SE.

4.5.2 As soon as possible after a test failure, a deviation from the specified test environment, or any other incident which affects the test or test item, MSFC will notify the authorized UT/CSD representative of the event verbally and will then generate a Test Procedure Deviation (NASA form 3959). A copy of the Test
Procedure Deviation is presented in Appendix A. Photographs of any discrepancies shall also be taken.

5.0 Personnel Responsibilities

5.1 Test Witnessing

All tests will be witnessed by the authorized UT/CSD representative and USBI representative. The MSFC test engineer will also witness the testing. Notification of the start of each test shall be communicated to the authorized UT/CSD and USBI representatives and the MSFC safety representative and test engineer at least 2 hours in advance.

MSFC Safety Notified

UT/CSD Notified

5.2 The MSFC TE will serve as the area coordinator for the test. All handling of the BSM will be directed by the MSFC TE or cognizant test engineer.

5.3 Jim McGee (vibration) shall be responsible for photographic coverage of the vibration test activities.

5.4 All involved lab directors and division chiefs shall be notified prior to testing.

5.5 The area around the outside of the vibration facility shall be secured before the live BSM is brought to the pyro shock test site.

Area secured? YES NO

Comments: doors bolted, security tape up.

6.0 Vibration Tests

6.0.1 Make sure the CSD TE has reviewed the calibrations for the vibration tests.

6.0.2 Open the doors that enter the vibration test room from the high bay of bldg. 4619.

6.1 Re-check system setup. Verify chamber temperature.
6.2 Radial Axis Tests

6.2.1 Assemble the leg supports on the conditioning chamber.

6.2.2 Lift Off Vibration

6.2.2.1 The following levels and conditions apply for the lift off vibration tests. Vibrate the motor only as follows for a duration of 60 seconds:

<table>
<thead>
<tr>
<th>Frequency (Hz)</th>
<th>Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>0.017 g²/Hz</td>
</tr>
<tr>
<td>20 to 55</td>
<td>+6 dB/octave</td>
</tr>
<tr>
<td>55 to 200</td>
<td>0.077 g²/Hz</td>
</tr>
<tr>
<td>200 to 280</td>
<td>-11 dB/octave</td>
</tr>
<tr>
<td>280 to 1200</td>
<td>0.022 g²/Hz</td>
</tr>
<tr>
<td>1200 to 2000</td>
<td>-4.5 dB/octave</td>
</tr>
<tr>
<td>2000</td>
<td>0.010 g²/Hz</td>
</tr>
</tbody>
</table>

Composite: 6.9 grms

6.2.3 Boost Vibration

6.2.3.1 The following levels and conditions apply for the boost vibration tests. Vibrate the motor only as follows for a duration of 120 seconds:

<table>
<thead>
<tr>
<th>Frequency (Hz)</th>
<th>Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>20 to 200</td>
<td>0.54 g²/Hz</td>
</tr>
<tr>
<td>200 to 350</td>
<td>-12 dB/octave</td>
</tr>
<tr>
<td>350 to 1000</td>
<td>0.060 g²/Hz</td>
</tr>
<tr>
<td>1000 to 2000</td>
<td>-6 dB/octave</td>
</tr>
<tr>
<td>2000</td>
<td>0.015 g²/Hz</td>
</tr>
</tbody>
</table>

Composite: 14.0 grms

6.2.4 Vehicle Dynamics Vibration

6.2.4.1 The following levels and conditions apply for the vehicle dynamics tests. Vibrate the motor only as follows:

<table>
<thead>
<tr>
<th>Frequency (Hz)</th>
<th>Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 to 10</td>
<td>0.7 g peak</td>
</tr>
<tr>
<td>10 to 40</td>
<td>3.7 g peak</td>
</tr>
</tbody>
</table>

Sweep Rate: 3 octaves per minute
6.3 Transport Motor From Room 156 to Room 158/Setup for Tang. Axis

6.3.1 Remove leg supports from conditioning chamber.

6.3.2 Disconnect the conditioning unit from the conditioning chamber.

6.3.3 Inspection certifications shall be provided for the overhead cranes in 4619.

Crane #1, Bldg. 4619 rm. 156 certification provided

Crane #2, Bldg. 4619 rm. 158 certification provided

6.3.4 Certifications for all lifting fixtures shall be provided:

Lifting beam assembly certification provided

Lifting rings (D-rings)

CAUTION: Be careful not to disconnect the motor ground while lifting.

CAUTION: The following step involves working with a suspended load. Keep feet and hands out from under the load.

6.3.5 Using the overhead crane, lift the conditioning chamber off of the vibration table and place it on the floor.

Record time when chamber was removed 6:42 p.m. 7:30 p.m.

6.3.6 Verify motor ground connection on the motor and at the facility ground contact point.

6.3.7 Disconnect the instrumentation wires. Remove any other instrumentation that is no longer needed or that might interfere with motor transport.

6.3.8 Attach the lifting straps (as shown in Fig. 1a) to the motor and spreader bar and hook to the overhead crane.

6.3.9 Remove adapter plate to vibration table fasteners.

CAUTION: Be careful not to disconnect the motor ground while lifting.

CAUTION: The following step involves working with a suspended load. Keep feet and hands out from under the load.
6.3.10 Slowly lift the motor off of the table and place it on the facility's roll cart.

6.3.11 Unhook spreader bar from lifting straps. Leave straps wrapped around the motor.

6.3.12 Open the doors that enter the high bay in room 158.

CAUTION: Make sure that the ground strap is long enough to reach to room 158 during the transport from one room to the other.

6.3.13 Slowly pull the motor using the roll cart from room 156 to room 158. Be sure to place the cart directly beneath the overhead crane.

6.3.14 Attach spreader bar to lifting straps and the overhead crane.

CAUTION: Be careful not to disconnect the motor ground while lifting.

CAUTION: The following step involves working with a suspended load. Keep feet and hands out from under the load.

6.3.15 Using the overhead crane, lift the motor from the pull cart and place it on the vibration table.

6.3.16 Align the adapter plates with the holes on the table.

6.3.17 Fasten the adapter plates to the table using the facility supplied fasteners. Torque these fasteners to 65 ft-lbs.

Record torque value: 65 f-lb MSFC QA [✓]

Torque wrench SN: BTV-22C6 [✓]

6.3.18 Remove all lifting hardware.

6.3.19 Attach accelerometers to the motor (see Fig. 2)

6.3.20 Reconnect accelerometer wires.

6.4 Thermal Conditioning Setup for Tangential and Longitudinal Axis

6.4.1 Use the overhead crane to place the conditioning chamber over the motor.

6.4.2 Once the chamber is in place, attach the necessary hoses and instrumentation from the conditioning unit to the chamber.
6.4.3 Make sure the chamber thermocouple is in the correct position for measuring the air temperature around the motor.

6.4.4 Make sure the motor ground strap is secured.

6.4.5 Activate conditioning unit and monitor the temperature until it has stabilized to the desired temperature.

Record time/ temp. when stabilized: 8:30 p.m.
Record total time out of conditioning: 1 hr

6.4.6 Recondition motor for twice the time out of conditioning if out more than 30 minutes.

Reconditioning necessary: Yes/ No
If yes, how long does motor need reconditioned? 2 hr

6.5 Tangential Axis Tests

6.5.1 Lift Off Vibration

6.5.1.1 The following levels and conditions apply for the lift off vibration tests. Vibrate the motor only as follows for a duration of 60 seconds:

<table>
<thead>
<tr>
<th>Frequency (Hz)</th>
<th>Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>0.016 g^2/Hz</td>
</tr>
<tr>
<td>20 to 75</td>
<td>+3 db/octave</td>
</tr>
<tr>
<td>75 to 1000</td>
<td>0.060 g^2/Hz</td>
</tr>
<tr>
<td>1000 to 2000</td>
<td>-3 db/octave</td>
</tr>
<tr>
<td>2000</td>
<td>0.030 g^2/Hz</td>
</tr>
</tbody>
</table>

Composite: 10.0 grms

6.5.2 Boost Vibration

6.5.2.1 The following levels and conditions apply for the boost vibration tests. Vibrate the motor only as follows for a duration of 120 seconds.

<table>
<thead>
<tr>
<th>Frequency (Hz)</th>
<th>Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>20 to 800</td>
<td>0.24 g^2/Hz</td>
</tr>
<tr>
<td>800 to 2000</td>
<td>-4 db/octave</td>
</tr>
<tr>
<td>2000</td>
<td>0.071 g^2/Hz</td>
</tr>
</tbody>
</table>

Composite: 18.4 grms
6.5.3 Vehicle Dynamics

6.5.3.1 The following levels and conditions apply for the vehicle dynamics tests. Vibrate the motor only as follows:

<table>
<thead>
<tr>
<th>Frequency (Hz)</th>
<th>Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 to 10</td>
<td>0.7 g peak</td>
</tr>
<tr>
<td>10 to 40</td>
<td>4.3 g peak</td>
</tr>
</tbody>
</table>

Sweep Rate: 3 octaves per minute

6.6 Axis Change From Tangential to Longitudinal

6.6.1 Disconnect conditioning unit from conditioning chamber.

6.6.2 Attach overhead crane to the conditioning chamber.

6.6.3 Slowly lift the conditioning box off of the test item and move it away and move it away from the vibration table and place on the floor. Disconnect lifting hardware.

6.6.4 Verify motor ground connection on the motor and at the facility ground contact point.

6.6.5 Remove adapter plate to vibration table fasteners.

6.6.6 Unhook control accelerometer.

CAUTION: Be careful not to disconnect the ground when changing the axis on the table.

CAUTION: The following step involves working with a suspended load. Keep feet and hands out from under the load.

6.6.7 Rotate the motor and bracket assembly 90° using the overhead crane. Disconnect lifting hardware.

6.6.8 Re-attach adapter plate to vibration table fasteners. Torque to 65 ft-lbs.

Record torque value: 65 ft-lbs. MSFC QA

Torque wrench SN: NS-W-2RCF

6.6.9 Reconnect control accelerometer.
6.6.10 Reconnect lifting hardware to the conditioning chamber and place it over the motor. Reconnect chamber legs as necessary.

6.6.11 If necessary, re-attach hoses, instrumentation, etc., before starting conditioning unit.

6.6.12 Start conditioning unit. Monitor until it has stabilized to the desired temperature.

Record time/temp. when stabilized: 11:26
Record total time out of tolerance: 26 min

6.6.13 Recondition motor for twice the time out of tolerance if the time out was greater than 30 minutes.

Reconditioning necessary: Yes / No
If Yes, how long does the motor need reconditioning? N/A

6.7 Longitudinal Axis Test

6.7.1 Lift Off Vibration

6.7.1.1 The following levels and conditions apply for the lift off vibration test. Vibrate the motor only as follows for a duration of 60 seconds.

<table>
<thead>
<tr>
<th>Frequency (Hz)</th>
<th>Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>0.016 g²/Hz</td>
</tr>
<tr>
<td>20 to 75</td>
<td>+3 dB/octave</td>
</tr>
<tr>
<td>75 to 1000</td>
<td>0.060 g²/Hz</td>
</tr>
<tr>
<td>1000 to 2000</td>
<td>-3 dB/octave</td>
</tr>
<tr>
<td>2000</td>
<td>0.030 g²/Hz</td>
</tr>
</tbody>
</table>

Composite: 10.0 grms

6.7.2 Boost Vibration

6.7.2.1 The following levels and conditions apply for the boost vibration test. Vibrate the motor only as follows for a duration of 120 seconds.

<table>
<thead>
<tr>
<th>Frequency (Hz)</th>
<th>Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>20 to 800</td>
<td>0.24 g²/Hz</td>
</tr>
<tr>
<td>800 to 2000</td>
<td>-4 dB/octave</td>
</tr>
<tr>
<td>2000</td>
<td>0.071 g²/Hz</td>
</tr>
</tbody>
</table>

Composite: 18.4 grms
CONDITIONS & POST TEST INSPECTION (C.8)

LOOSE AERO HEAT SHIELD BOLTS

- Missing Belts (QTY 1)
- Loose Bolts (QTY 3)
Q - Okay
6.7.3 **Vehicle Dynamics**

6.7.3.1 The following levels and conditions apply for the vehicle dynamics test. Vibrate the motor only as follows.

<table>
<thead>
<tr>
<th>Frequency (Hz)</th>
<th>Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 to 10</td>
<td>0.7 g peak</td>
</tr>
<tr>
<td>10 to 40</td>
<td>4.3 g peak</td>
</tr>
</tbody>
</table>

Sweep Rate: 3 octaves per minute

6.8 **Post Test Inspection**

6.8.1 The BSM test item shall be visually inspected by the MSFC QA, MSFC TE, and the CSD TE for exterior damage resulting from vibration testing.

6.8.2 Remove all instrumentation.

6.9 **Data Requirements**

Power Spectral Density (PSD) plots for all control and response accelerometers for lift off and boost tests shall be recorded. The test tolerances shall be overplotted on the control accelerometers plots. Acceleration versus frequency plots shall be recorded for all accelerometers used during vehicle dynamics tests.

7.0 **Post Test Disassembly/Prepare for Shipment**

7.1 **Conditioning Chamber Removal**

7.1.1 Disconnect any hoses and instrumentation that hinders the removal of the chamber.

7.1.2 Using the overhead crane, slowly lift the conditioning chamber off of the vibration table and place on the floor.

7.1.3 Move chamber out of the way.

7.1.4 Move the conditioning unit out of the way if necessary.

7.1.5 Verify motor ground connection on the motor and at the facility ground contact point.

7.1.6 Remove vibration table insulation.
7.2 Aero Heat Shield Removal

WARNING: Removing the Aero Heat Shield exposes the motor's propellant grain. Personnel should use caution during any operations with and exposed grain. Tools, watches, eye glasses, etc., should be tethered (if necessary) to prevent dropping anything into the motor.

7.2.1 Make sure the motor ground is secured.

7.2.2 Make sure verified wrist straps are being worn by the personnel removing the aero heat shield.

7.2.3 Remove the fasteners from the Aero Heat Shield. Place the fasteners in a marked bag.

7.2.3 SLOWLY remove the Aero Heat Shield.

7.2.5 Remove the heat shield seal. Do not drop the seal into the motor.

7.3 Post Test Inspection of Motor Propellant Grain

7.3.1 Make sure motor ground wire is secured.

7.3.2 Clear area of all non-essential personnel. Only the grain inspectors (2) and the MSFC TE shall remain.

7.3.3 Verify grain inspector(s) is(are):

   a. Wearing 100% cotton coveralls, shorts, and undershirts.

   b. Wearing a wrist strap.

   c. Wearing tethers and/or tape to keep eye glasses, rings, and watches from falling into the motor.

7.3.4 Perform grain inspection.

Cracked propellant yes no

If yes, give approximate location and size of crack:

________________________________________________________________________
Other comments on grain condition:

No differences noted from performance.

Grain inspector(s) 

MSFC QA

7.3.5 A draw-wire, fabric, security bag shall be installed over the nozzle exit cone. The bag shall be closed around the exit cone and secured by inserting the bag wire ends through a standard security lock-seal (i.e. cover the exit cone the same way that it was received).

7.4 Adapter Plate Removal

7.4.1 Remove the adapter plate to vibration table fasteners.

7.4.2 Attach lifting straps as shown in Fig. 1b (Appendix B).

CAUTION: Be careful not to disconnect the ground while lifting the motor.

CAUTION: The following step involves working with a suspended load. Keep hands and feet out from under the load.

7.4.3 Lift the motor off of the vibration table and move to an area near the wood supports.

7.4.4 Lower the motor so that it rests on the wood supports.

7.4.5 Rotate the motor 180° so that the adapter plates face up.

7.4.6 Remove the bracket to adapter plate fasteners. Place fasteners in a marked bag.

CAUTION: Be careful not to disconnect the ground while lifting the motor.

CAUTION: The following step involves working with a suspended load. Keep hands and feet out from under the load.

7.5 Aft Skirt Bracket Removal

7.5.1 Remove the aft end motor to bracket fasteners (12 places). Place fasteners in a marked bag. *

* LIGHT SCORING OF SURFACE AT THE AFT BRACKET ATTACHMENTS.
Chatter marks evident on 41311
Forward face of the motor

Drawn

RC 9-23-93
RyS 9-27-93
CAUTION: Be careful not to disconnect the ground while lifting the motor.

CAUTION: The following step involves working with a suspended load. Keep hands and feet out from under the load.

7.5.2 Lift the motor to waist height using the overhead crane.
7.5.3 Rotate the motor 180° so that the bracket to adapter plate fastener holes face the floor.
7.5.4 Lower the motor so that it rests on the wood supports.
7.5.5 Remove forward end motor to bracket fasteners (8 places). Place fasteners in a marked bag.

8.0 Return Motor to the Vertical Position

8.1 Attach 2 D-rings, 180 degrees apart, and one lifting strap to the aft end holes of the motor.
8.2 Attach the "break-over" brackets (and lifting strap) to the appropriate bolt holes on the forward face of the motor case.
8.3 Attach the aft lifting strap to the overhead crane hook.

CAUTION: The following steps involve working with a suspended load. Keep hands and feet out from under the load.

CAUTION: Be careful not to disconnect the ground while lifting the motor.

8.4 One person (as chosen by the MSFC TE) shall hold the lifting strap on the forward end to keep the motor from swinging when lifted from the aft end. Slowly lift the aft end of the motor to bring it to a vertical position.
8.5 Raise the motor so that the aft end is at waist height.

CAUTION: The following steps involve working with a suspended load. Keep hands and feet out from under the load.

8.6 Disconnect the "break-over" brackets. Place brackets in a marked bag.
**Place Motor In Shipping Container**

9.1 Remove lid from shipping container by removing the lock-ring bolt and nut, lockring, and cover. (See Fig. 3 for an overall view of the shipping container).

9.2 Remove top cushion insert. Make sure that the top bearing plate is properly oriented to the relative location of the drum humidity indicator/pressure relief valve (see Fig. 4). If not as shown (the two 1-inch dia. clearance holes must straddle the (imaginary) horizontal center line) the center cushion insert, as a unit (do not lift center insert... it's keyed to the bottom insert) must be rotated to bring the top plate into proper position as shown.

9.3 Remove the bearing plate from the tie rods. DO NOT remove the tie rod nuts.

9.4 Remove and discard any old bags of desiccant.

9.5 Drape the loose end of the container ground strap over the edge of the container.

9.6 Visually inspect the container interior to assure it is free of any foreign matter. Vacuum interior if required.

9.7 Attach a ground wire to facility ground and verify its resistance. Resistance shall measure less than one (1) ohm.

   Resistance measured: ___________ MSFC QA ___________

9.8 Connect this ground wire to the motor shipping container and verify the resistance (<1 ohm)

   Resistance measured: ___________ MSFC QA ___________

9.9 Install the antistatic foamed plastic liner tightly around the motor case, and secure in place by taping the liner's vertical butt joint (trim as required) using 2" wide tape.

9.10 Install the antistatic plastic film bag, up and over the motor.

9.11 Visually orientate the motor nozzle cant to the side of the container indicated by the marking, "POSITION NOZZLE CANT THIS SIDE" on the cushion insert.

**CAUTION:** Be careful not to disconnect the motor ground while lowering the motor into the container.
CAUTION: The following steps involve working with a suspended load. Keep hands and feet out from under the load.

CAUTION: When using the ESD scanner and the electrostatic reading on the motor case surface exceeds 1.0 kilovolt, stop all activities on the case, initiate personnel fall back (a minimum of 4 feet) and notify safety.

After initial reading over 1.0 kilovolt, repeat electrostatic reading at intervals not to exceed 5 minutes until the voltage has dissipated below 1.0 kilovolt. When the reading is below 1.0 kilovolt, removal operations may continue.

If after 30 minutes the measured electrostatic charge is in excess of 1.0 kilovolt, Verify facility ground. If connection to facility ground is open, reconnect through larger resistor (100 Kohm min.) to allow a slow discharge of the motor case.

If the electrostatic reading on the case surface exceeds 4.0 kilovolts, STOP all activities on the case, notify safety, and evacuate all personnel to safe locations.

9.12 Slowly lower the motor into the container while monitoring static charge.

Record Stat Gun SN: C10459

CAUTION: Make new ground before breaking old ground.

9.13 Attach the container ground wire to the motor using the 1/4-20 UNC x 3/4 long bolt and nut provided. Torque to 50 in-lbs ±5 in-lbs. Measure resistance to verify ground (should be <1 ohm).

Record torque value: 50 in-lb MSFC QA

Torque wrench SN: 52117

Resistance Measured MSFC QA

9.14 Disconnect ground wire connecting the motor and facility ground.

9.15 Remove lifting hardware.
9.16 Visually orientate the top bearing plate to the nozzle cant, indicated by the marking on the plate "POSITION THIS SIDE TO THE NOZZLE CANT", and place it over the nozzle and three tie rods and bring it to rest on the motor flange. Tighten and torque tie rod nuts to 20 in-lbs ±2 in-lbs.

Record torque value: \( 20 \text{ in-lbs} \)

Torque wrench SN: 5492304

CAUTION: Make sure that the top bearing plate is indexed to the motor case O.D. and is resting flat on the top of the flange.

Also, make sure that the grounding strap terminal and attach nut and bolt head is positioned in the clearance hole in the plate.

9.17 Place twelve (12) 16 unit size bags of fresh desiccant into the container in the cavity around the top bearing plate.

CAUTION: Once the bagged desiccant has been put into the container, the remaining packaging steps must be completed immediately and the container closed to prevent the desiccant from over exposure to free air circulation.

If, after the desiccant has been placed into the container, the packaging cannot be completed, close the container until packaging can be resumed.

9.18 Install the top cushion insert. Make sure that its index slot, on the bottom face, matches with the index block on the top bearing plate.

9.19 Place the motor log book and any other required documentation into a suitable size electrostatic free plastic bag (3M velostat or Richmond Pink Poly) and place into the stowage slot provided in the top cushion insert.

9.20 Place the container lid onto the container, making sure that there is no foreign matter on the lid gasket or container rim.

9.21 Install the lockring, with its bolt flanges positioned (centered) between the container humidity indicator and lifting grip. Install the bolt and nut and torque to 6 ft-lbs ± 1/2 ft-lbs (72 in-lbs).

Record torque value: \( 6 \text{ ft-lbs} \)

MSFC QA AC
NOTE: The lockring shall be tapped, using a rubber mallet, at various points around the ring during bolt tightening.

9.22 Install a standard wire and lead seal through the provided holes in the lockring bolt flanges. Secure using a QC press die engraved with UTC & No. [1]

NOTE: Before shipping, USBI personnel shall make sure the shipping container is properly labeled. Reference CSD's Material Handling Card, Rev. C, dated 5-23-89 sections 10 and subsequent.

10.0 Test Report

A final test report will be submitted to UT/CSD within 30 working days after testing is completed. Three copies plus one reproducible copy of this report will be submitted containing the following information as a minimum:

A. A description of test mounting and setup and location of instrumentation with two sets of color still photographs (8-1/2 by 11 inches) of setups and instrumentation close-ups.
B. A list of all instrumentation and equipment with ranges and plot accuracy of all acquired data with objective evidence of calibration status at the time of tests.
C. Sketches of test setups.
D. Power spectral density (PSD) plots of all acceleration data.
E. The results of all inspections and tests performed i.e., data tapes, data plots, and completed data summary sheets.
F. Any alteration or deviation from this procedure will be described in detail by a Notice of Deviation and included in the final report.
G. Model numbers and serial numbers for all instrumentation and test equipment shall be included in the report.
11.0 **Post Test Verification**

The procedure delineated in the above document has been satisfactorily completed and:

a. All sequences in the procedure have been completed (or deleted by approved deviation)

b. All Procedure changes have been recorded and approved.

Submitted Verified by: 

Test Engineer

Date: 8/23/93

Motor Serial Number: 100735

9-23-93
Appendix B

Figures
FIGURE 1. LIFTING STRAP ATTACHMENTS

(A) CHOKED

(B) SADDLED

(C) 3-D IN SADDLED POSITION
NOTE: If forward monitoring accelerometer cannot be mounted to the bracket assembly at fixture 180° location, it may be mounted on the bracket at fixture TDC (forward).

FIGURE 2. VIBRATION TEST SETUP
FIGURE 3. OVERALL VIEW OF SHIPPING CONTAINER
FIGURE 4. Top View of Shipping Container
BSM MOTORS S/N 1000734 AND S/N 1000738 PYROSHOCK TEST DATA
October 6, 1993

TO: EE11/Mr. Smith
FROM: ED73/Mr. Brewster
SUBJECT: SRB Booster Separation Motor (BSM) Pyrotechnic Shock Qualification Test TCP# SRB-QUAL-ED93-062

Pyrotechnic Shock Qualification tests were completed on two BSM flight units on September 20-21, 1993 at the MSFC Pyrotechnic Shock Test Facility in building 4619. The tests were necessary to flight qualify various BSM hardware modifications. Test 1 was completed on BSM Unit SN 1000738 and test 2 was completed on BSM Unit SN 1000734. The tests were conducted according to BSM Delta Qualification Test Procedure #BSM-TCP-EP54001, dated August 16, 1993.

The test setup consisted of hanging a 4' X 8' X 1/2" steel plate from the ceiling of the blast room and mounting the BSM horizontally approximately in the middle of the plate with the thrust direction pointed to the blast room away from the door. The test setup is shown in enclosure 1 and the photographs in appendix A.

The pyrotechnic shock was generated by two #8 blasting caps and 20 inches of Flexible Linear Shape Charge (FLSC) (25 grains/foot) configured in two parts around each end of a two 3/8" X 13" X 2" thick steel bar and another #8 blasting cap and 6 inches of FLSC mounted to a second steel bar. The pyrotechnics were installed on the opposite side of the plate from the BSM. The pyrotechnic setup is shown in enclosure 2.

The instrumentation consisted of four 4 triaxial accelerometer configurations located in close proximity to the 4 BSM mounting feet. Each triaxial cluster was sensitive to the 3 orthogonal axes, horizontal, vertical, and normal to the panel. The accelerometers were calibrated according to Document #ED73-SHK-FOP-008, entitled "Facility Operating Procedure for calibration of Accelerometers used in Shock Tests," dated August 1992. The hardware list of accelerometers, data acquisition and analysis equipment is shown in enclosure 3.
The calibration dates of pertinent hardware is shown in enclosure 4. At least one measurement point in the horizontal, vertical, and normal direction from the four accelerometer locations was required to meet the shock specification test criteria.

The test data is enclosed in appendix B. The first plot is a time history of the real time shock recorded over a 25 millisecond interval and the units are G peak versus time. The second plot is a Shock Response Spectrum (SRS) analysis computed over the frequency band from 50 to 10,000 Hertz and its units are G's versus frequency. The SRS analysis is completed on both positive and negative data points and both curves are on the plot. The specification and tolerances have been added to the plots.

A deviation was issued against the response data being higher than the allowed +6db tolerance level for all axes. These exceedances were in most cases not significantly higher than the allowable tolerance and occurred in narrow bandwidths. Nevertheless, these exceedances were impossible to eliminate. The deviation is enclosed in appendix C.

Steve R. Brewster
Chief, Dynamics Test Branch

Enclosure

cc:
CS01/Richard Leonard
ED13/Roy Winkle
ED23/Robin Ferebee
ED71/Gerald Waggoner - w/o encl.
ED73/Jim Herring
ED73/File Copy
EP54/Jim Niblett
EP54/Matt Bevill (3 copies)
USBI/Don Wencil
BSM Pyroshock Test Setup
Front View

☐ Denotes accelerometer location
BSM Pyroshock Test Setup
Back View

Dimensions in inches
Not to scale
x - Denotes accelerometer location

Linear shape charge
Blasting cap •
## Data Acquisition / Analysis System

<table>
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<td>2225M5A</td>
<td>12</td>
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<tr>
<td>Shock amplifier</td>
<td>Endevco</td>
<td>2740B</td>
<td>12</td>
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<tr>
<td>FM Tape Recorder</td>
<td>DataTape</td>
<td>3700J</td>
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<tr>
<td>Shock Analyzer</td>
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### Shock Amplifier Calibration, Model 2740B

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### Shock Accelerometer Calibration, Model 2225M5A

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### Standard Accelerometer Calibration, Model 2270

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Appendix A

Photographs
Appendix B

Test Data
Appendix C

Specification Exceedance Deviation
Section 4.2.1 in BSM-TCP-EP54-001 states that the test tolerances for shock response spectrum are +6 dB and -3 dB when analyzed with a 1/8 octave shock spectrum analyzer and 5% damping.

The worst case over test for each axis is shown in the attached graphs.

- **X-axis**: accelerometers #10 and #4
- **Y-axis**: accelerometer #11
- **Z-axis**: accelerometers #12 and #9

Motor SN: 1000734

Jim Heising  
Lead Test Engineer
FIGURE 1. PYRO SHOCK CONTROL EQUIPMENT
## Test Procedure Deviation

<table>
<thead>
<tr>
<th>Test Engineer</th>
<th>Quality Engineer</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mat Bevill</td>
<td>Rick Clements</td>
<td>09/29/93</td>
</tr>
</tbody>
</table>

### Title:
Upper Limit Tolerance Violation for Pyro Shock Simulation Test (SN: 1000738)

<table>
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<th>SEQ</th>
<th>Change/Reason</th>
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<td></td>
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</table>

Section 4.2.1 in BSM-TCP-EP54-001 states that the test tolerances for Shock Response Spectrum are +6dB and -3dB when analyzed with a 1/3 octave shock spectrum analyzer and 5% damping.

The worst case overtest for each axis is shown in the attached graphs.

- X-axis: accelerometer #10
- Y-axis: accelerometer #11
- Z-axis: accelerometers #12 and #13

Motor SN: 1000738

Jim Heiring

---

NASA MSFC EP12

<table>
<thead>
<tr>
<th>Originator</th>
<th>Organization</th>
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</thead>
<tbody>
<tr>
<td>Mat Bevill</td>
<td></td>
</tr>
</tbody>
</table>

Above deviation(s) affect test requirements: N/A
FIGURE 1. PYRO SHOCK CONTROL EQUIPMENT
BSM MOTORS S/N 1000734 AND 1000738 VIBRATION TEST DATA
TO: EE11/Mr. Smith
FROM: ED73/Mr. Brewster
SUBJECT: SRB Booster Separation Motor (BSM) Vibration Qualification Test - SRB-QUAL-ED93-061

The Booster Separation vibration qualification tests were completed on two BSM motors SN 100034 and SN 100038 on September 20, 1993. Vehicle dynamics, random liftoff and random boost tests were performed on each motor in all three axes. The tests were run as specified in Document BSM-TCP-EP54-001, Title "BSM Delta Qualification Test," dated August 16, 1993.

Two control accelerometers and two axial response accelerometers were used for each test. The accelerometer locations and test axes are shown in figure 1. All instrumentation used for the test are shown in table 1.

This report contains all of the required data. Any questions concerning this report should be directed to Mr. J. McGee at 544-1136.

Steve R. Brewster
Chief, Dynamics Test Branch

Enclosure

cc: ED23/Mr. Ferebee
    ED73/Mr. Hofmann (4 copies)
    EP54/Mr. Bevill (3 copies)
    ED73/File Copy
    USBI/Mr. Tieman
TEST AND CHECKOUT PROCEDURE
FOR

VIBRATION QUALIFICATION TEST OF BOOSTER SEPARATION MOTOR (BSM)
SN 1000734 + SN 1000738 - SIRB-QUAL-ED93-061

Date of Test: 9-20-93
Test Article Serial Number: SN 1000734 + 1000738
Test Requirements Documents: BSM-TCP-EP54-001
FOP’s Attached: 

Type of Test: VIBRATION QUALIFICATION

PREPARED BY: J. P. Velage
Test Engineer/ED73 7-20-93 Date

Engineering Technician/ED73 Date

APPROVED BY: Steve R. Brewster
Steve R. Brewster/ED73
Chief, Dynamics Test Branch 11-1-93 Date

APPROVED BY: Rick Clements
Quality Assurance 7-20-93 Date
1.0 PURPOSE

This procedure defines the steps necessary to assure the proper check-out for and the execution of vibration and shock tests.

2.0 SCOPE

This procedure includes test levels, instrumentation and documentation necessary for the Test Engineer to conduct vibration and shock tests.

3.0 APPLICABLE DOCUMENTS

DST-POP-75-003 FACILITY OPERATION PROCEDURE (MARCH 21, 1981)

4.0 GENERAL REQUIREMENTS

The Test Engineer will be in charge of all preparations and activities during the vibration test phase.

5.0 SAFETY

When safety critical test conditions require personnel access, the Test Engineer will assure that the operation procedures and policies set forth in ET01-SOP-01, "Standard Operating Procedure for Safety Critical Operations" will be adhered to.

The Test Engineer will be responsible for the safety of personnel involved in the test activities; and will be notified immediately of any personnel injury.
TEST CONTROL PROGRAMS
1. IDENT
ERROR, LIFT-OFF RADIAL
2. TRUE RANDOM MODE? YES; NO
   YES
3. AVERAGING WEIGHTING FACTOR?
   16
   AVG/LOOP?
   5
4. 3 SIGMA CLIPPING? YES; NO
   YES
5. MEASUREMENT MODE? YES; NO
   YES
   # OF AVGs?
   20
   AVG/LOOP?
   5
6. # CONTROL CHANNELS?
   2
   EXTREMAL CONTROL? YES; NO
   NO
7. CALIBRATION? MV/G
   CHANNEL A
   100.00
   CHANNEL B
   100.00
   CHANNEL C
   100.00
8. SYSTEM GAIN? G/VOLT @ INPUT
   14.00
9. SELF CHECK LEVEL? -DB
   -6.00
10. LEVEL SCHEDULE
    LEVEL(-DB), TIME(SEC)?
    1. -9.00 20
    2. -6.00 10
    3. -3.00 5
    4. 0.00 62
11. LINE ABORTS ENABLED? -DB
    -3.00
12. ABORT TIME? 10 SEC MAX
    1.00
13. MANUAL MODE ENABLED? YES; NO
    YES
14. RMS ABORT LIMIT? DB
    3.00
15. # LINES?
    512
16. LOWEST FREQ?
    20.00
17. HIGHEST FREQ?
    2000.00
    MAX FREQ= 2500.00 HZ
    RESOLUTION= 4.88 HZ
    LOG HORIZ= 3 DECADES
18. INPUT MODE?
    1=MAC, FREQ; LIMIT, LIMIT-(DB); 2=SL, FREQ, LIMIT, LIMIT-(DB); 3=DIC
    1
19. MAGNITUDE? G/SQR/HZ, FI 20 HZ
    .017000
20. MAC, FREQ, LIMIT+,-?
    .077000 55.00 3.00 1.50
21. MAC, FREQ, LIMIT+,-?
    .077000 200.00 3.00 1.50
22. MAC, FREQ, LIMIT+,-?
    .022000 200.00 3.00 1.50
23. MAC, FREQ, LIMIT+,-?
    .022000 1200.00 3.00 1.50
24. MAC, FREQ, LIMIT+,-?
    .010000 2000.00 3.00 1.50
    RMS VALUE= 6.944 G/S
1. IDENT: ISM, BOOST RADIAL

3. TRUE RANDOM MODE? YES; NO
   YES

3. AVERAGING WEIGHTING FACTOR?
   16
   M/S-LOOP
   5

4. 3 SIGMA CLIPPING? YES; NO
   YES

5. MEASUREMENT MODE? YES; NO
   YES
   # OF AUSG?
   20
   AUSG/LOOP
   5

5. CONTROL CHANNELS?
   2

5. EXTREMAL CONTROL? YES; NO
   NO

7. CALIBRATION? M/V/G
   CHANNEL A
   30.00
   CHANNEL B
   30.00
   CHANNEL C
   30.00

8. SYSTEM GAIN? G/VOLT & INPUT
   20.00

9. SET CHECK LEVEL? -DB
   1.00

10. INITIAL VALUE
    LIMIT: TIME (SEC)
    1. 0.00 20.
    2. 1.00 50.
    3. 1.00 125.

11. LINE ABORT: ENABLED? -DE
    3.00

ABORT TIME? 10 SEC MAX
1.00

12. MANUAL MODE ENABLED? YES; NO
    YES

13. LINE ALARM LIMIT? 9
    59.00

14. RMS ABORT LIMIT? 28
    3.00

15. # LINES?
    512

16. LOWEST FREQ?
    20.00

17. HIGHEST FREQ?
    2000.00

MAX FREQ. 2500.00 HZ
RESOLUTION 4.88 HZ
LOG HORIZ 3 DECADES

18. INPUT MODE?
1=MAG., FREQ.LIMIT, LIMIT-DB ;
2=SLOPE, FREQ.LIMIT, LIMIT-DB ;
3=DISC
1

19. MAGNITUDE? GSQR/HZ, F 20 HZ
   .540000

20. MAG., FREQ.LIMIT, LIMIT-?
    .540000 200.00 3.00 1.50

21. MAG., FREQ.LIMIT, LIMIT-?
    .060000 350.00 3.00 1.50

22. MAG., FREQ.LIMIT, LIMIT-?
    .060000 1000.00 3.00 1.50

23. MAG., FREQ.LIMIT, LIMIT-?
    .015000 2000.00 3.00 1.50

G'S VALUE 14.056 G'S
FUNCTION /C,/R/,/L, S, DL, M, U, E, 22
1. IDENT?

2. LOWER FREQ LIMIT? Hz
   5.0

3. UPPER FREQ LIMIT? Hz
   40.0

4. STARTING FREQ? (+UP, -DOWN)
   5.0

5. NUMBER OF SINGLE SWEEPS?
   1

6. SWEEP MODE? 1=LOG, 2=LIN
   1

7. SWEEP TIME OR RATE?
   1=TIME, 2=OCT/MIN, 3=DEC/MIN
   2
   OCT/MIN?
   3.00
   SWEEP TIME = 1.000 MIN

8. REFERENCE ENVELOPE SPECIFICATION

   UNITS? 1=IN, 2=CM
   1

   FORMAT:
   FREQ,AMPL,TYPE,LIMIT(DB)

   AMPLITUDE TYPES:
   1=G'S P, 2=IN/SEC, 3=IN P-P

   ENTER 0 TO TERMINATE

   POINT # 1?
   5.0, .7000 1.30
   .70 G'S, 8.601 IN/SEC, .5475 IN)

   POINT # 2?
   9.5, .7000 1.30
   .70 G'S, 4.527 IN/SEC, .1517 IN)

   POINT # 3?
   10.0, 3.7000 1.30
   3.70 G'S, 22.730 IN/SEC, .7235 IN)

   POINT # 4?
   40.0, 3.7000 1.30
   3.70 G'S, 5.683 IN/SEC, .0452 IN)

9. MUX?
   YES; NO
   NO

10. NUMBER OF CONTROL CHANNELS?
    2

   ACCELERATION CALIBRATIONS?
   CHANNEL 1, MU/G
   1 300.000
   CHANNEL 2, MU/G
   2 300.000

11. CONTROL MEAS METHOD?
    1=PEAK, 2=AUG, 3=RMS, 4=FILTER
    4

12. CONTROL STRATEGY?
    1=MAX, 2=MID, 3=AUG
    3

13. NUMBER OF LIMIT CHANNELS?
    0

14. NUMBER OF MEAS CHANNELS?
    4

   MEAS SPECIFICATIONS?
   CHANNEL #1, MU/UNIT
   1 300.000
   CHANNEL #2, MU/UNIT
   2 300.000
   CHANNEL #3, MU/UNIT
   3 100.000
   CHANNEL #4, MU/UNIT
   4 100.000

15. MEASUREMENT MEAS METHOD?
    1=PEAK, 2=AUG, 3=RMS, 4=FILTER
    4

17. START-UP TIME? SEC
    5.0

18. SHUT-DOWN TIME? SEC
    1.0

19. MANUAL MODE ENABLED? YES; NO
    YES

20. MAX DRIVE? MU PEAK
    5000.

21. SELF CHECK LEVEL? MU PEAK
    500

22. ALARM LEVEL? % ABORT
    99.0

   MAX DISP = .7235 IN P-P
   MAX VEL = 22.730 IN/SEC P
   MAX ACCEL = 3.70 G'S P
1. IDENT
ISM, LIFT-OFF TANG.
2. TRUE RANDOM MODE? YES; NO
YES
3. AVERAGING WEIGHTING FACTOR?
   16
   AVG/LOOP?
   5
4. 3 SIGMA CLIPPING? YES; NO
YES
5. MEASUREMENT MODE? YES; NO
YES
   0 OF AVG?
   20
   AVG/L-LOOP?
   5
6. 0 CONTROL CHANNELS?
2
   EXTREMAL CONTROL? YES; NO
   NO
7. CALIBRATION? MU/G
   CHANNEL A
   100.00
   CHANNEL B
   100.00
   CHANNEL C
   30.00
8. SYSTEM GAIN? MU/VOLTS @ INPUT
   20.00
9. SELF CHECK LEVEL? -DB
   -6.00
10. LEVEL SCHEDULE
   LEVEL(-DB), TIME (SEC)?
   1. -3.00  20.
   2. -5.00  10.
   3. -3.00  5.
   4. -5.00  62.
11. LINE ABORTS ENABLED? -DB
    -3.00
12. MANUAL MODE ENABLED? YES; NO
    YES
13. LINE ALARM LIMIT? %
    99.00
14. RMS ABORT LIMIT? DB
    3.00
15. 8 LINES?
    512
16. LOWEST FREQ?
    20.00
17. HIGHEST FREQ?
    2000.00
    MAX FREQ. = 2500.00 Hz
    RESOLUTION = 4.88 Hz
    LOG HORIZ. = 3 DECADES
18. INPUT MODE?
    1=MAG.,FREQ, LIMIT+, LIMIT-(DB),
    2= SLOPE, FREQ, LIMIT+, LIMIT-(DB),
    3=DIP
    1
19. MAGNITUDE? GSQR/Hz, F = 20 Hz
    .016000
20. MAG, FREQ, LIMIT+, -?
    .060000  75.00  3.00  1.50
21. MAG, FREQ, LIMIT+, -?
    .060000  1000.00  3.00  1.50
22. MAG, FREQ, LIMIT+, -?
    .030000  2000.00  3.00  1.50
    RMS VALUE= 9.969 G'S
2. TRUE RANDOM NO. = NO
   5
   1. ERASER GAIN FACTOR?
      16
   4. SIGMA IMP. = YES
      5
   5. MEASUREMENT MODE = YES
      5
   1 OF AVGs?
      20
   4. AVG/LOOP?
      5
   6. # CONTROL CHANNELS?
      2
   5. REMOTE CONTROL = NO
      5
   7. CALIBRATION ENTRY
      100
      100
      100
      0
   CHANNEL C
      100.00
   SYSTEM GAIN = G = # INPUT
      100
   SELF CHECK LEVEL? -6dB
      6.00
   LEVEL SCHEDULE
   1. -9.00 0.00
   2. -6.00
   3. -3.00
   4. .00 125.
   THE AUTO CENTER? -DB
      8.00

ABORT TIME? 10 SEC MAX
      30
   MAX. LEVEL ENAB = YES
      5
   YES
   7. AUTO NORM LIN
   14. RMS ABORT LIMIT?
      1.00
   5. S102
   16. LOWEST FREQ?
      .00
   1. HIGHEST FREQ?
      2000.00
   4. MAX FREQUENCY?
      250.00
   6. RESOLUTION
      4.88
   17. HORIZ. = 3 DECADES
   18. INPUT 
      1 = MAG., FREQ., LIMIT, LIMIT (DP)
      2 = SLOPE, FREQUENCY, LIMIT, LIMIT
      3 = POL
   19. MAG., FREQUENCY, LIMIT, LIMIT
      5 = MAG., FREQUENCY, 5 = .24000
   20. MAG., LIMIT
      .24
      200
   21. MAG., FREQUENCY, LIMIT
      .07
      2000.00
      3.00
   1. VAL
      18.4
   .5
   FUNCTION? X, /, R, /, S, DL, PR, E, ??
### Setup Parameters

1. **Ident:**
   - BSN, U.D., TANG.
2. **Lower Freq Limit? Hz:**
   - 5.0
3. **Upper Freq Limit? Hz:**
   - 40.0
4. **Starting Freq? (+Up, -Down):**
   - 5.0
5. **Number of Single Sweeps?**
   - 1
6. **Sweep Mode? 1=Log, 2=Lin**
   - 1
7. **Sweep Time or Rate?**
   - 1=Time, 2=Oct/Min, 3=Dec/Min
   - 2
   - Oct/Min?
   - 3.00
   - Sweep time = 1.000 Min
8. **Reference Envelope Specification**
   - Units? 1=IN, 2=CM
   - 1
   - Format:
     - FREQ,AMPL,TYPE, LIMIT (DB)
   - Amplitude Types:
     - 1=G'S, P, 2=IN/SEC, 3=IN-P-P
   - Enter 0 to terminate
9. **Number of Control Channels?**
   - 2
   - Acceleration Calibrations?
     - Channel 8, MU/G
     - 1 300.000
     - Channel 8, MU/G
     - 2 300.000
10. **Control Meas Method?**
    - 1=Peak, 2=Avg, 3=RMS, 4=Filter
    - 4
11. **Control Strategy?**
    - 1=Max, 2=Min, 3=Avg
    - 3
12. **Number of Limit Channels?**
    - 0
13. **Number of Meas Channels?**
    - 4
14. **Meas Specifications?**
    - Channel 8, MU/UNIT
      - 1 300.000
      - Channel 8, MU/UNIT
      - 2 300.000
      - Channel 8, MU/UNIT
      - 3 100.000
      - Channel 8, MU/UNIT
      - 4 100.000
15. **Measurement Meas Method?**
    - 1=Peak, 2=Avg, 3=RMS, 4=Filter
    - 4
16. **Start-Up Time? SEC**
    - 5.0
17. **Shut-Down Time? SEC**
    - 1.0
18. **Manual Mode Enabled? Yes; No**
    - Yes
19. **Max Drive? MU Peak**
    - 5000.
20. **Self Check Level? MU Peak**
    - 500
21. **Alarm Level? % Abort**
    - 99.0
    - Max Disp = .8409 IN-P-P
    - Max Vel = 26.416 IN/SEC P
    - Max Accel = 4.30 G'S P
22. **2**

### Data Points

- **Point 1**: 5.0, .7000 IN/SEC, .5475 IN
- **Point 2**: 9.5, .7000 IN/SEC, .1517 IN
- **Point 3**: 10.0, 4.3000 IN/SEC, .8409 IN
- **Point 4**: 40.0, 4.3000 IN/SEC, .0526 IN

9. **MUX? Yes/No**
   - No
1. IDENT: DSM, LIFT-OFF LONG.

2. TRUE RANDOM MODE? YES; NO
   YES

3. AVERAGING WEIGHTING FACTOR?
   16
   AUS=LOOP
   5

4. 3 SIGMA CLIPPING? YES; NO
   YES

5. MEASUREMENT MODE? YES; NO
   YES
   # OF AUS?
   20
   AUS=LOOP
   5

6. # CONTROL CHANNELS?
   2
   EXTREMAL CONTROL? YES; NO
   NO

7. CALIBRATION? MV/G
   CHANNEL A
   100.00
   CHANNEL B
   100.00
   CHANNEL C
   36.00

8. SYSTEM GAIN? G/VOLT @ INPUT
   20.00

9. SELF CHECK LEVEL? -DB
   -6.00

10. LEVEL SCHEDULE
    LEVEL(-DB), TIME(SEC)?
    2. -5.0, 10.
    3. -3.00, 5.
    4. .000, 62.

11. LINE ABORTS ENABLED? -DB
    1.00

12. ABORT TIME? 10 SEC MAX
    1.00

13. MANUAL MODE ENABLED? YES; NO
    YES

14. RMS ABORT LIMIT? DB
    3.00

15. # LINES?
    512

16. LOWEST FREQ?
    20.00

17. HIGHEST FREQ?
    2000.00

   MAX FREQ=? 2500.00 HZ
   RESOLUTION= 4.88 HZ
   LOG HORIZ. = 3 DECADES

18. INPUT MODE?

   1= MAG, FREQ, LIMIT, LIMIT-DB;
   2=SLOPE, FREQ, LIMIT, LIMIT-DB;
   3=DISC

19. MAGNITUDE? GSQR/Hz, F= 20 Hz
    0.0100

20. MAG, FREQ, LIMIT+; -
    0.06008 75.00 3.00 1.50

21. MAG, FREQ, LIMIT+; -
    0.66008 1000.00 3.00 1.50

22. MAG, FREQ, LIMIT+; -
    8.93008 2000.00 3.00 1.50

   RMS VALUE= 9.969 G/S

1. TITLE:  
   STYLE. INVERTED.  
2. TRUE RANDOM MODE? YES\,NO  
   YES  
3. AVERAGING WEIGHTING FACTOR?  
   16  
   AUGS/LOOP?  
   5  
4. 3 SIGMA CLIPPING? YES\,NO  
   YES  
5. MEASUREMENT MODE? YES\,NO  
   YES  
   # OF AUGS?  
   20  
   AUGS/LOOP?  
   5  
6. # CONTROL CHANNELS?  
   2  
   EXTREMA CONTROL? YES\,NO  
   NO  
7. CALIBRATION H\,MU/G  
   CHANNEL A  
   30.00  
   CHANNEL B  
   30.00  
   CHANNEL C  
   30.00  
8. SYSTEM GAIN? G/VOLT \& INPUT  
   37.00  
9. SELF CHECK LEVEL? -DB  
   -6.00  
10. LEVEL SCHEDULE  
   LEVEL-DB, TIME(SEC)?  
   1. -9.00  
   2. -6.00  
   3. -3.00  
   4. 0.00  
   125.  
11. LINE ABORTS ENABLED? -DB  
   -3.00  
   ABORT TIME? 10 SEC MAX  
   1.00  
12. MANUAL MODE ENABLED? YES\,NO  
   YES  
13. LINE ALARM LIMIT? X  
   99.00  
14. RMS ABORT LIMIT? DB  
   3.00  
15. # LINES?  
   512  
16. LOWEST FREQ?  
   20.00  
17. HIGHEST FREQ?  
   2000.00  
   MAX FREQ. = 2500.00 HZ  
   RESOLUTION= 4.88 HZ  
   LOG HORIZ. = 3 DECADES  
18. INPUT MODE?  
   1=MAG., FREQ, LIMIT+, LIMIT-(DB);  
   2=SLOPE, FREQ, LIMIT+, LIMIT-(DB);  
   3=DISC  
   1  
19. MAGNITUDE? GSQR/HZ, F+  
   20 HZ  
   .240000  
20. MAG., FREQ, LIMIT+, -?  
   .240000  
   800.00  
   3.00  
   1.50  
21. MAG., FREQ, LIMIT+, -?  
   .071000  
   2000.00  
   3.00  
   1.50  
   RMS VALUE= 18.442 G/S  
   FUNCTION? /C,/R,/L,/S,DL,PU,/E, ??
POST-TEST VERIFICATION

Test and Checkout Procedure  
SRB-QUAL-ED93-061

been satisfactorily completed and documented.

Submitted by: J. P. Mcgee  9-20-93
Test Engineer/DE75  Date

Verified by: [Signature]  9-20-93
Quality Assurance  Date
Monitor

198
* Control System - H.P. Model 5427A S/N 1848A00160

* Charge Amp - Endevco Model 2775A S/N 783844
  784074
  784070
  783846
  783850

* Power Amplifier - Ling Model PSE 335 S/N 108

* Shaker - Ling B 335 S/N 628191

* Voltmeter - Keithley 193A S/N 303426

* Counter - HP 5316A S/N 2120A01228

* Tape Recorder - Datatape 37000 S/N 533772

* Shaker - UD T4000 S/N 353906

* Power Amplifier - UD T360 S/N 731628

* Accelerometers - Endevco 2227 S/N CF31
  Endevco 2227 S/N PA73
  Endevco 2226 S/N HA89
  Endevco 2226 S/N AB37

---

Table 1

---

200
SN 100034

CHECK OFF LIST
TEST OPERATIONS SET-UP

1.1 Verify proper calibration of instruments to be used.
1.2 Verify proper calibration of accelerometers to be used.
1.3 Install test article on shaker and verify test axis.
1.4 Install accelerometer(s) on test article.
1.5 Verify continuity from accelerometer(s) to charge amplifier output(s)

Torque Values:

Test Fixture: 65 ft-lbs
Test Article: Per BSM Test Plan
Shaker Used: UD T-14000
Adapters Used: MRAA 48" expander - 2" plate (90M10063-1)
LIFTOFF RANDOM

RANDOM CHECK-OUT

1. Verify test program and record RMS abort limit below.
   RMS abort limit: 1 dB

2. Perform levels as defined below and verify with plot.

3. Record the following:
   Amplifier Gain: 60%
   Charge Amp. F.S.: 30 G

<table>
<thead>
<tr>
<th>Hz</th>
<th>20 Hz</th>
<th>55 Hz</th>
<th>280 Hz</th>
<th>1200 Hz</th>
<th>2000 Hz</th>
<th>5000 Hz</th>
<th>10000 Hz</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hz</td>
<td>0.017</td>
<td>0.077</td>
<td>0.022</td>
<td>0.010</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Limits: +3, -1.5 dB

Composite: 6.9 Gms
Test Time: 60 Sec.

Test Level Concurrence: Component Assessment Branch Date
**Boost Random SN 1000734**

**Random Check-out**

1. Verify test program and record RMS abort limit below.
   - RMS abort limit: 1 dB

2. Perform levels as defined below and verify with plot.

3. Record the following:
   - Amplifier Gain: 75 %
   - Charge Amp. F.S.: 100 G

<table>
<thead>
<tr>
<th>H z</th>
<th>( \xi )</th>
<th>( G^2/\xi )</th>
<th>Limits</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>200</td>
<td>0.54</td>
<td></td>
</tr>
<tr>
<td>350</td>
<td>1000</td>
<td>0.06</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2000</td>
<td>0.015</td>
<td></td>
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</tr>
</tbody>
</table>

Composite = 14 Arms

Test Time = 120 sec.

Test Level Concallence:  
Component Assessment Branch  
Date
1.1 Verify test program and record the abort level below.

Abort Level: ________ dB

1.2 Perform levels as defined below and verify with plot.

1.3 Record the following:

Amplifier Gain: ________
Charge Amp. F.S.: ________

5 - 10 Hz at .07 G, limit _______ dB
10 - 40 Hz at 3.7 G, limit _______ dB

Sweep Rate = ______ oct/min

Test level concurrence: __________________________________________

Component Assessment Branch Date
**LIFT OFF RANDOM SN 1000734**

**RANDOM CHECK-OUT**

| 1. Verify test program and record RMS abort limit below. |
| RMS abort limit | _____ | dB |
| 2. Perform levels as defined below and verify with plot. |
| 3. Record the following: |
| Amplifier Gain | 70% |
| Charge Amp. F.S. | 30 G |

<table>
<thead>
<tr>
<th>Frequency (Hz)</th>
<th>Amplifier Gain</th>
<th>Limits</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>0.016 G²/Hz,</td>
<td>+3,-1.5 dB</td>
</tr>
<tr>
<td>75</td>
<td>0.060</td>
<td></td>
</tr>
<tr>
<td>1000</td>
<td>0.030</td>
<td></td>
</tr>
<tr>
<td>2000</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Composite = 10 Gms
Test Time = 60 Sec.

**Test Level Concurrence:**

Component Assessment Branch

Date

206
**Boost Random SN 1000734**

**Random Check-Out**

1. Verify test program and record RMS abort limit below.
   
   RMS abort limit: 1 dB

2. Perform levels as defined below and verify with plot.

3. Record the following:
   
   Amplifier Gain: 80 %
   Charge Amp. F.S.: 100 G

<table>
<thead>
<tr>
<th>Hz</th>
<th>g^2/Hz, limits</th>
<th>Hz</th>
<th>g^2/Hz, limits</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>800</td>
<td>0.24</td>
<td>limits +3.1.5 dB</td>
</tr>
<tr>
<td>2000</td>
<td>0.017</td>
<td>1</td>
<td>limits 11</td>
</tr>
<tr>
<td>2000</td>
<td>0.017</td>
<td>limits</td>
<td></td>
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</tr>
<tr>
<td>2000</td>
<td>0.017</td>
<td>limits</td>
<td></td>
</tr>
</tbody>
</table>

Composite = 18.4 Gms

Test Time = 120 sec.

Test Level Concurrence:

Component Assessment Branch

Date

207
SAX DYNAMICS CHECK-OUT

1.1 Verify test program and record the abort level below.
   Abort Level: ___________ dB

1.2 Perform levels as defined below and verify with plot.

1.3 Record the following:
   Amplifier Gain: ___________ dB
   Charge Amp. F.S.: ___________ dB

5 - 10 Hz at 0.7, limit ±1.3 dB
10 - 40 Hz at 4.3, limit ___________ dB
   ___________ Hz at ___________, limit ___________ dB
   ___________ Hz at ___________, limit ___________ dB
   ___________ Hz at ___________, limit ___________ dB

Sweep Rate = 3 oct/min

Test level concurrence: ________________________________

Component Assessment Branch Date

SN 1000734
LIFTOFF RANDOM SN 100734

AXIS LONGITUDINAL

1. Verify test program and record RMS abort limit below.
   RMS abort limit

2. Perform levels as defined below and verify with plot.

3. Record the following:
   Amplifier Gain
   Charge Amp. F.S.

20 Hz e 0.16 g²/Hz², limits +3, -1.5 dB

75 Hz - 1000 Hz e 0.06 g²/Hz², limits

2000 Hz e 0.3 g²/Hz², limits

10000 Hz e

100000 Hz e

200000 Hz e

500000 Hz e

1000000 Hz e

2000000 Hz e

5000000 Hz e

10000000 Hz e

Composite = 10 Gms
Test Time = 60 Sec.

Test Level Concurrence: Component Assessment Branch Date

209
RANDOM CHECK-OUT

.1 Verify test program and record RMS abort limit below.

   RMS abort limit _______ L d3

.2 Perform levels as defined below and verify with plot.

.3 Record the following:

   Amplifier Gain 85
   Charge Amp. F.S. 100

   Hz  e  G^2/Hz,  limits  +3-1.5 db

   20 Hz - 800  Hz e .24  limits
   2000  Hz e .017  limits
   1000  Hz e
   5000  Hz e
   1000  Hz e
   15000 Hz e
   20000 Hz e
   30000 Hz e
   50000 Hz e

   Composite = 18.4 Gms
   Test Time = 120 Sec.

   Test Level Concurrence:
   Component Assessment Branch
   Date

210
CLE DYNAMICS CHECK-OUT

1.1 Verify test program and record the abort level below.

Abort Level: ___12B___

1.2 Perform levels as defined below and verify with plot.

1.3 Record the following:

Amplifier Gain: ___4072___
Charge Amp. F.S.: ___10.6___

5 - 10 Hz at 7, limit ±1.5 dB
10 - 40 Hz at 4.3, limit ±1 dB

Sweep Rate = ___3___ oct/min

Test level concurrence: ________________________________

Component Assessment Branch Date
Record a minimum of 30 seconds of calibration signal on tape recorder.

Set full scale ranges on instrumentation amplifiers and note on data sheet.

Set power amplifier gain to position noted during random test check-out.

Perform self check of control system.

Begin test sequence at \(-9\) dB from full level.

At \(-6\) dB, start tape recorder.

Note time when full level is reached. See Tape Log

At the completion of the test, set power amplifier gain to off.

Stop tape recorder.

Inspect test article for damage or degradation.

Remove test article from shaker.
Record a minimum of 30 seconds of calibration signal on tape recorder.

Set full scale ranges on instrumentation amplifiers and note on data sheet.

Set power amplifier gain to position noted during random test check-out.

Perform self check of control system.

Begin test sequence at -9 dB from full level.

At -6 dB, start tape recorder.

Note time when full level is reached. SEE TAPE LOG

At the completion of the test, set power amplifier gain to off.

Stop tape recorder.

Inspect test article for damage or degradation.

Remove test article from shaker.
CLE DYNAMICS TEST

1.1 Record a minimum of 30 seconds of calibration signal on tape recorder.

1.2 Set full scale ranges on instrumentation amplifiers and note on data sheet.

1.3 Set power amplifier gain to position noted during sine test check-out.

1.4 Perform self check of control system.

1.5 Start tape recorder.

1.6 Begin sine sweep.

1.7 Note time of DCS "SWEEP UP" or "SWEEP DOWN" indication light. SEE TAPE LOG

1.8 During first sweep, press the "SAVE" button on DCS.

1.9 If more than one sweep, note time of DCS "SWEEP UP" or "SWEEP DOWN" indication light.

1.10 At the completion of the sweep, set power amplifier gain to off.

1.11 Stop tape recorder.

1.12 Inspect test article for damage or degradation.

SN 1000734

page 1 of 1

214
SN 100034

Test Data
RANDOM, LIFT-OFF, RADIAL AXIS
CON.ROL L.O. RAD., PART 2
POST TEST
RMS LEVEL = 7.019 G's
G SQR/Hz

10

0

-1

-2

-3

-4

-5

19.5

10^11 HZ LOG

BSN, LIFT-OFF RADIAL S/N 1008734

ELAPSED TIME = 36 SECS AT 0.00 DB
DELTA F = 4.233
DOF = 546
AUF = 16
R3 TANG., RAD AXIS TEST
POWER SPECTRAL DENSITY
RMS LEVEL = 7.987
G SQRT/Hz

BSM L.O. RAD., S/N 1000734
CONTROL BOOST RAD., PART 1
POST TEST
RMS LEVEL = 14.57 G'S
G 50R/HZ

ELAPSED TIME = 22 SECS
DELTA F = 4.883
DOF = 505
AUF = 16

10 N

0

-1

-2

-3

-4

10 Hz LOG

BSM, BOOST RADIAL  S/N 1000734
CONTROL BOOST RAD., PART 5
POST TEST
RMS LEVEL = 14.03 G's
G SQR/Hz

ELAPSED TIME = 11 SECS AT .00 DB
DELTA F = 4.833
DOF = 464
AWF = 16

BSM, BOOST RADIAL YW 1000134
RE LONG., RAD AXIS TEST, BAD DATA, ACCEL CAM OFF

POWER SPECTRAL DENSITY

RMS LEVEL = 6.349

G 50R/HZ
RADIAL AXIS

VEHICLE DYNAMICS
CONTROL L.O., TANG., PART 1
POST TEST
RMS LEVEL = 9.979 G'S
G SQR/HZ

ELAPSED TIME = 50 SECS AT .00 DB
DELTA F = 4.833
DOF = 560
AUF = 16

10^10 Hz Log
RB TANG., TANG AXIS TEST
POWER SPECTRAL DENSITY
RMS LEVEL = 13.79
G SQR/HZ

BSM L.O. TANG., S/N 1000734
TANGENTIAL AXIS

RANDOM, BOOST
CONTROL BOOST, PART 1

POST TEST

RMS LEVEL = 18.56 G's

Q SQRT/Hz

ELAPSED TIME = 38 SECS AT .00 DB

DELTA F = 4.883

DOF = 546

AUF = 16

10^N Hz Log

BSM, BOOST TANG. SN 1000734

2002
RI TANG., TANG AXIS TEST
POWER SPECTRAL DENSITY
RMS LEVEL = 89.55
G SQR/Hz
LONGITUDINAL AXIS
RANDOM, LIFT-OFF
RB RAD., LONG AXIS TEST, BAD DATA, WIRE LOOSE
POWER SPECTRAL DENSITY
RMS LEVEL = 7.014
C: SQR/HZ

BSM L.O. LONG., S/N 1000734
LONGITUDINAL AXIS

RANDOM, BOOST
P1 LONG, LONG AXIS TEST
POWER SPECTRAL DENSITY
RMS LEVEL = 29.73
G SQR/HZ

10^N

0

-1

-2

-3

20.0 10^0 HZ LOG

2000

BSN BOOST LONG.. S/N 1000734
LONGITUDINAL AXIS

VEHICLE DYNAMICS
SN 1000738
CHECK OFF LIST
TEST OPERATIONS SET-UP

1.1 Verify proper calibration of instruments to be used.
1.2 Verify proper calibration of accelerometers to be used.
1.3 Install test article on shaker and verify test axis.
1.4 Install accelerometer(s) on test article.
1.5 Verify continuity from accelerometer(s) to charge amplifier output(s)

Torque Values:
Test Fixture: 65 ft lbs
Test Article: Per BSM TEST PLAN
Shaker Used: UD T-4000
Adapters Used: MRAD 48" EXPANDER - 2" PLATE (90110063-1)
TEST OPERATIONS SET-UP

1.1 Verify proper calibration of instruments to be used.
1.2 Verify proper calibration of accelerometers to be used.
1.3 Install test article on shaker and verify test axis.
1.4 Install accelerometer(s) on test article.
1.5 Verify continuity from accelerometer(s) to charge amplifier output(s)

Torque Values:
Test Fixture: 65°F
Test Article: Ceramsite Test Block
Shaker Used: VD T-4000
Adapters Used: 48 Expander - 2 Plate (901006-1)
LIFTOFF RANNUM SN 1020739

AXIS RADIAL

1. Verify test program and record RMS abort limit below.

   RMS abort limit __________ 1 dB

2. Perform levels as defined below and verify with plot.

3. Record the following:

   Amplifier Gain __________ 60%
   Charge Amp. F.S. __________ 300

<table>
<thead>
<tr>
<th>Hz</th>
<th>G²/Hz</th>
<th>Limits</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>0.017</td>
<td>+3.0,-1.5 dB</td>
</tr>
<tr>
<td>55</td>
<td>0.077</td>
<td></td>
</tr>
<tr>
<td>280</td>
<td>0.022</td>
<td></td>
</tr>
<tr>
<td>2000</td>
<td>0.010</td>
<td></td>
</tr>
</tbody>
</table>

Composite = 6.9 Gms
Test Time = 60 Sec.

Test Level Concurrence: Component Assessment Branch
BOOST RANDOM SW 1000738

RANDOM CHECK-OUT

1.1 Verify test program and record RMS short limit below.

RMS short limit _______ db

1.2 Perform levels as defined below and verify with plot.

1.3 Record the following:

Amplifier Gain _______ 75 %
Charge Amp. F.S. _______ 100 G

<table>
<thead>
<tr>
<th>Hz</th>
<th>Ez</th>
<th>G^2/Hz</th>
<th>Limits</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>200</td>
<td>0.54</td>
<td>______</td>
</tr>
<tr>
<td>350</td>
<td>1000</td>
<td>0.06</td>
<td>______</td>
</tr>
<tr>
<td></td>
<td>2000</td>
<td>0.015</td>
<td>______</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>______</td>
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<td>______</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>______</td>
</tr>
</tbody>
</table>

Composite = 14 Gms
Test Time = 120 Sec.

Test Level Concurrency: ___________________________ Component Assessment Branch Date
VEHICLE DYNAMICS CHECK-OUT

1.1 Verify test program and record the abort level below.

Abort Level: __________/dB

1.2 Perform levels as defined below and verify with plot.

1.3 Record the following:

- Amplifier Gain: __4.07%____
- Charge Amp. F.S.: __105____

<table>
<thead>
<tr>
<th>Sweep Rate</th>
<th>Hz at</th>
<th>Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 - 10</td>
<td>0.075</td>
<td>±1.5  dB</td>
</tr>
<tr>
<td>10 - 40</td>
<td>3.75</td>
<td>±1.5  dB</td>
</tr>
<tr>
<td></td>
<td></td>
<td>dB</td>
</tr>
<tr>
<td></td>
<td></td>
<td>dB</td>
</tr>
<tr>
<td></td>
<td></td>
<td>dB</td>
</tr>
</tbody>
</table>

Sweep Rate = __3__ oct/min

Test level concurrence: ________________________________

Component Assessment Branch  Date
LIFT OFF RANDOM

RANDOM CHECK-OUT

1. Verify test program and record RMS short limit below.  
   RMS short limit   1 d3

2. Perform levels as defined below and verify with plot.

3. Record the following:
   Amplifier Gain  70%
   Charge Amp. F.S.  30 G

20 Hz  0.016 g^2/Hz, limits +3-1.5d6

75 Hz - 1000 Hz  0.060 g^2/Hz, limits "

1000 Hz - 2000 Hz  0.030 g^2/Hz, limits "

2000 Hz - limits "

Composite = 10 Gms  
Test Time = 60 Sec.

Test Level Conformance: Component Assessment Branch Date
RANDOM CHECK-OUT

1. Verify test program and record RMS abort limit below.
   RMS abort limit

2. Perform levels as defined below and verify with plot.

3. Record the following:
   Amplifier Gain
   Charge Amp. F.S.

<table>
<thead>
<tr>
<th>Hz</th>
<th>G²/Hz</th>
<th>Limits</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>300</td>
<td>.24</td>
</tr>
<tr>
<td></td>
<td></td>
<td>11 limits</td>
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<tr>
<td>2000</td>
<td></td>
<td>.017</td>
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<td></td>
<td></td>
<td>16 limits</td>
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<td></td>
<td>limits</td>
</tr>
<tr>
<td></td>
<td></td>
<td>limits</td>
</tr>
</tbody>
</table>

Composite = 18.4 Gms
Test Time = 120 Sec.

Test Level Concurrence: Component Assessment Branch Date

305
1.1 Verify test program and record the abort level below.
   Abort Level: _____ dB

1.2 Perform levels as defined below and verify with plot.

1.3 Record the following:
   Amplifier Gain: 40.70 dB
   Charge Amp. F.S.: 10.5

5 - 10 Hz at 0.7, limit ±1.5 dB
10 - 40 Hz at 4.3, limit _____ dB

Sweep Rate = 3 oct/min

Test level concurrence: __________________________

Component Assessment Branch   Date
1.1 Verify test program and record RMS abort limit below.
   RMS abort limit  1 d3

1.2 Perform levels as defined below and verify with plot.

1.3 Record the following:
   Amplifier Gain  70%
   Charge Amp. F.S. 305

<table>
<thead>
<tr>
<th>Hz</th>
<th>g^2/Hz</th>
<th>Limits</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.0</td>
<td>0.016</td>
<td>+3, -1.5 dB</td>
</tr>
<tr>
<td>75</td>
<td>0.06</td>
<td></td>
</tr>
<tr>
<td>1000</td>
<td>0.06</td>
<td></td>
</tr>
<tr>
<td>2000</td>
<td>0.03</td>
<td></td>
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<tr>
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<tr>
<td>6000</td>
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<tr>
<td>7000</td>
<td>0.03</td>
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</tr>
<tr>
<td>8000</td>
<td>0.03</td>
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<tr>
<td>9000</td>
<td>0.03</td>
<td></td>
</tr>
<tr>
<td>10000</td>
<td>0.03</td>
<td></td>
</tr>
</tbody>
</table>

Composite = 10 Gms
Test Time = 60 Sec.

Test Level Concurrence: 

Component Assessment Branch  Date
RANDOM CHECK-OUT

Verify test program and record RMS short limit below.

RMS short limit 123

1.2 Perform levels as defined below and verify with plot.

1.3 Record the following:

Amplifier Gain 95
Charge Amp. F.S. 100

20 Hz - 800 Hz e 24
g^2/Hz^2, limits ±3-1.5 dB

2000 Hz e 017
limits

Hz - Hz e limits
limits

Hz - Hz e limits
limits

Hz - Hz e limits
limits

Hz - Hz e limits
limits

Hz - Hz e limits
limits

Hz - Hz e limits
limits

Composite = 18.4 Gms

Test Time = 120 Sec.

Test Level Concurrency:

Component Assessment Branch Date

308
**VEHICLE DYNAMICS CHECK-OUT**

1.1 Verify test program and record the abort level below.

Abort Level: _________ dB

1.2 Perform levels as defined below and verify with plot.

1.3 Record the following:

   Amplifier Gain: _________
   Charge Amp. F.S.: _________

<table>
<thead>
<tr>
<th>Frequency Range</th>
<th>dB Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 - 10 Hz</td>
<td>7, limit</td>
</tr>
<tr>
<td>10 - 40 Hz</td>
<td>4.3, limit</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Sweep Rate = _________ oct/min

Test level concurrence: __________________________

Component Assessment Branch Date
1. Record a minimum of 30 seconds of calibration signal on tape recorder.

2. Set full scale ranges on instrumentation amplifiers and note on data sheet.

3. Set power amplifier gain to position noted during random test check-out.

4. Perform self check of control system.

5. Begin test sequence at \(-9\) dB from full level.

6. At \(-6\) dB, start tape recorder.

7. Note time when full level is reached. See tape log.

8. At the completion of the test, set power amplifier gain to off.

9. Stop tape recorder.

10. Inspect test article for damage or degradation.

11. Remove test article from shaker.
Record a minimum of 30 seconds of calibration signal on tape recorder.

Set full scale ranges on instrumentation amplifiers and note on data sheet.

Set power amplifier gain to position noted during random test check-out.

Perform self check of control system.

Begin test sequence at -9 dB from full level.

At -6 dB, start tape recorder.

Note time when full level is reached.

At the completion of the test, set power amplifier gain to off.

Stop tape recorder.

Inspect test article for damage or degradation.

Remove test article from shaker.
VEHICLE DYNAMICS TEST

1.1 Record a minimum of 30 seconds of calibration signal on tape recorder.

1.2 Set full scale ranges on instrumentation amplifiers and note on data sheet.

1.3 Set power amplifier gain to position noted during sine test check-out.

1.4 Perform self check of control system.

1.5 Start tape recorder.

1.6 Begin sine sweep.

1.7 Note time of DCS "SWEEP UP" or "SWEEP DOWN" indication light.

1.8 During first sweep, press the "SAVE" button on DCS.

1.9 If more than one sweep, note time of DCS "SWEEP UP" or "SWEEP DOWN" indication light.

1.10 At the completion of the sweep, set power amplifier gain to off.

1.11 Stop tape recorder.

1.12 Inspect test article for damage or degradation.
SN 1000738
Test Data
R2 TANG., RAD AXIS TEST
POWER SPECTRAL DENSITY
PHS LEVEL = 3.184
G/SQR/Hz
RADIAL AXIS
RANDOM, BOOST
POST TEST

RMS LEVEL = 14.56 dB
0.00 lb

DELTA F = 4.883
DOF = 533

ELAPSED TIME = 61 SECS

MHz
PL LONG., RAD AXIS TEST
POWER SPECTRAL DENSITY
RMS LEVEL = 14.34
G SQR/Hz
P1 TANG., PAD AXIS TEST
POWER SPECTRAL DENSITY
RMS LEVEL = 8.318
G. SQR/HZ
R2 RAD., RAD AXIS TEST
POWER SPECTRAL DENSITY
RMS LEVEL = 17.73
G SQRT/Hz
RADIAL AXIS

VEHICLE DYNAMICS
RI PAD, PAX AXIS TEST, ACCEL CAME OFF
MEAS DATA: CH 4 POST TEST

UNITS

10^-2 HZ LOG

BSM, U.D., S/N 1008738
TANGENTIAL AXIS
RANDOM, LIFT-OFF
CONTROL L.O. TANG., PART 1
POST TEST
RMS LEVEL = 9.941 G'S
G SQR/Hz

ELAPSED TIME = 58 SECS AT .09 DB
DELTA F = 4.883
DOF = 57
NDF = 16

10^N
-5
-4
-3
-2
-1
0
19.5

10^6 HZ LOG

BEM, LIFT-OFF TANG. 5/21/1000 738
CONTROL L.O. TANG., PART 2
POST TEST
'.15 LEVEL = 9.959 G's
Q SQR/Hz

ELAPSED TIME = 3 SECS AT .00 DB
DELTA F = 4.883
DOF = 415
ALF = 16

BSM, LIFT-OFF TANG. S/N 1000 738
TANGENTIAL AXIS
RANDOM, BOOST
TANGENTIAL AXIS

VEHICLE DYNAMICS
R1 TANG. TANG AXIS TEST
MGRS DATA: CH 3 I POST TEST
UNITS

B5M, U.D., S/N 1000738

10^{-2} HZ LOG
LONGITUDINAL AXIS
RANDOM, LIFT-OFF
PI RAD., LONG AXIS TEST
POWER SPECTRAL DENSITY
RMS LEVEL = 12.71
G. SQ. R/Hz
P2 RAD., LONG AXIS TEST
POWER SPECTRAL DENSITY
PMS LEVEL = 8.943
G SQR/KZ

BSM L.O. LONG., S/N 1000738
LONGITUDINAL AXIS

VEHICLE DYNAMICS
LONGITUDINAL AXIS

RANDOM, BOOST
BSM MOTOR S/N 1000734
OBSERVATION AND DEVIATION SUMMARY
#1. Reference step 6.2.1.8 in BSM-TCP-EP54-001. No damage was noted. Motor and container in good shape.

#2. Reference step 6.2.6.4 in BSM-TCP-EP54-001. No propellant grain cracks or other defects noted. A small amount of RTV residue was observed on the igniter case and main propellant grain.

#3. Reference step 6.4.5 in BSM-TCP-EP54-001. No damage was observed due to the pyro shock test.

#4. Due to the loose fastener problem on SN 1000738, the forward bracket fasteners and the aero-heat shield fasteners were lockwired on SN 1000738. Torque stripes were also drawn on the bolt head so that any rotation during testing could be detected. Bolts torqued to 160 in-lbs.

#5. Reference Test Procedure Deviation item 1 for BSM-TCP-EP54-003. Conditioning chamber temperature for this motor is 25°F, +0°F, -5°F. During the radial axis testing, the chamber temperature exceeded the 25°F upper limit. The maximum temperature reached 28.2°F. The total time the chamber was out of tolerance was approximately ten minutes. After the radial axis testing was complete, the chamber temperature resumed to within tolerances. USBI, CSD, and MSFC agreed that the motor could not respond to the small change in temperature in that short amount of time. Testing was resumed.

#6. Reference step 6.8.1 in BSM-TCP-EP54-003. No damage was observed to the BSM due to vibration testing. This inspection was performed before bracket removal. It was noticed during this inspection that three of the forward bracket fasteners had de-torqued slightly (recall these were lockwired). The aero-heat shield fasteners remained torqued.

#7. Reference step 7.3.4 in BSM-TCP-EP54-003. No cracks or other internal defects noted on the propellant grain.

#8. Reference step 7.5.5 in BSM-TCP-EP54-003. Light burnishing marks were observed on the forward face of the BSM.
### Upper Limit Tolerance Violation for Pyro Shock Simulation Test (SN: 1000734)

**Section 4.2.1 in BSM-TC-EP54-001 states that the test tolerances for shock response Spectrum are +6 dB and -3 dB when analyzed with a 1/3 octave shock spectrum analyzer and 5% damping.**

The worst case over-test for each axis is shown in the attached graphs.

- **X-axis:** accelerometers #10 and #4
- **Y-axis:** accelerometer #11
- **Z-axis:** accelerometers #12 and #9

**Motor SN: 1000734**

**Jim Herring**  
**J.B. Herring**

**ED:** Lead Pyro Engineer
FIGURE 1. PYRO SHOCK CONTROL EQUIPMENT

PYRO PLATE
**Figure 1**

### TEST PROEDURE DEVIATION

<table>
<thead>
<tr>
<th>TEST ENGINEER:</th>
<th>QUALITY:</th>
<th>DATE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Matt Bevill</td>
<td>Rick Clements</td>
<td>09/29/93</td>
</tr>
<tr>
<td>REQUIREMENTS ENGINEER:</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Other:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Richard Leonard (Safety)</td>
<td>09/29/93</td>
</tr>
</tbody>
</table>

**Title:** Temperature Violation for Radial Axis Test (SN: 1000734)

<table>
<thead>
<tr>
<th>DEV. NO.</th>
<th>PAGE SEQ</th>
<th>CHANGE/REASON</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td>Section 8.0 in BSM-TCP-EP54-002 states the conditioning chamber temperatures for the delta qualification motors. The &quot;cold&quot; motor is to be conditioned at 25°F ± 0°F. At 11:38:42 a.m. on 09/28/93 the conditioning chamber temperature exceeded its 25°F upper limit. The chamber was out of temp. for 8 min, then out again at 11:58:42 and 12:04:42 for ~2 min, respectively. These violations occurred during the radial axis vibration test. USBT, CSD, and MSFC all agreed that the motor could not respond in the short amount of time at that low of temperature. SN: 1000734 Max temp. during testing was 28.2°F.</td>
</tr>
</tbody>
</table>

**Signatures:**
- Matt Bevill
- Richard Leonard

**Organization:**
N41A MSFC EP12

**Above Deviation(s) Affect Test Requirements:**
N/A
CAUTION: When using the ESD scanner and the electrostatic reading on the motor case surface exceeds 1.0 kilovolt, stop all activities on the case, initiate personnel fall back (a minimum of 4 feet) and notify safety.

After initial reading over 1.0 kilovolt, repeat electrostatic reading at intervals not to exceed 5 minutes until the voltage has dissipated below 1.0 kilovolt. When the reading is below 1.0 kilovolt, removal operations may continue.

If after 30 minutes the measured electrostatic charge is in excess of 1.0 kilovolt, Verify facility ground. If connection to facility ground is open, reconnect through larger resistor (100 Kohm min.) to allow a slow discharge of the motor case.

If the electrostatic reading on the case surface exceeds 4.0 kilovolts, STOP all activities on the case, notify safety, and evacuate all personnel to safe locations as directed by safety.

CAUTION: The following step involves working with a suspended load. Keep hands and feet out from under the load.

6.2.1.8 Slowly, monitoring static charge, lift the motor out of the container using the overhead crane. Lower the test item so that the forward end of the motor is at waist height.

A detailed visual inspection shall be performed by the MSFC test engineer and the CSD test engineer on the live test items before testing. Record the motor's serial number.

No Damage

Damage (detail in attachment)

Serial Number 1000734

CAUTION: The following step involves working with a suspended load. Keep hands and feet out from under the load.

6.2.1.9 Attach the "break-over" brackets and lifting strap on the forward end of the motor (see Figure 2, Appendix C).

CAUTION: Do Not disconnect the ground wire while breaking the motor to the horizontal position.
6.2.5.2 Record SN of torque wrench: EMT6030-9 A, B, D BTN-2RCE

6.2.5.2 Release the tension from the lifting straps but do not disconnect the straps. These straps may be used to tape off accelerometer wires if necessary.

6.2.5.3 Place the pyrotechnic debris shield in front of the large bay doors on the north side of the pyro room.

6.2.6 Perform Grain Inspection

6.2.6.1 Clear area of all nonessential personnel for grain inspection. (Only the grain inspectors (2) and the MSFC TE shall remain.)

6.2.6.2 Verify grain inspector(s) is(are):

a. Wearing 100% cotton coveralls, shorts, and undershirts.

b. Wearing a wrist strap.

c. Wearing tethers and/or tape to keep eye glasses, rings, and watches from falling into the motor.

6.2.6.3 The grain inspector shall now remove the security bag and cover from the exit cone.

6.2.6.4 Perform grain inspection.

Cracked propellant? yes no

If yes, give approximate location and size of crack.

No propellant grain cracks or other defects noted. Small amount of PIV residue on igniter case and main grain. OK to proceed with pyroshock test.

Other comments on grain condition:

Grain inspector:

Grain inspector:

6.2.7 Install Aero Heatshield

CAUTION: When using trichloroethane, personnel shall wear chemical goggles and Neoprene-Latex gloves. Contaminated materials shall be disposed of as hazardous waste.

403
6.3.7 On the count of "3", the pyro technician shall put the switch in the "ARMED" position and verify that the power indicator is illuminated.

6.3.8 On the FIRE command, the pyro technician will open the red cover and flip the firing switch.

6.3.9 After firing, turn the firing panel key to the "UNARMED" position.

WARNING: If blasting cap does not fire, refer to Section 10.4 in ED73-SHK-FOP-004 (see Appendix A).

Blasting Cap Fired: yes ✓ no

6.3.10 Remove the arming key and disconnect the voltage supply.

6.3.11 Test personnel may now return to the control room.

6.3.12 Wait a minimum of 5 minutes after firing before opening the door to room 170.

6.3.13 The lead pyro engineer shall now begin to reduce the data.

6.4 Post Test Inspection

6.4.1 Inform the MSFC TF that the door to room 170 from the control room is to be opened.

6.4.2 The pyro technician shall enter room 170 and move the junction box switch to the "BULB" position.

6.4.3 Remove blasting cap leads from junction box.

6.4.4 Inspect the shock plate to insure all explosive devices fired properly.

WARNING: If all explosive items did not fire, refer to Section 10.5 in ED73-SHK-FOP-004 (see Appendix A).

6.4.5 The BSM shall be visually inspected for damage resulting from the pyro shock test. Any anomalies will be recorded. All other personnel shall remain in the control room or in the clear area until the "ALL CLEAR" is given by the MSFC TE. No Damage

6.4.6 MSFC TE indicates all clear for appropriate personnel.

6.5 Post Test Removal from the Pyro Plate
6.7.3 **Vehicle Dynamics**

6.7.3.1 The following levels and conditions apply for the vehicle dynamics test. Vibrate the motor only as follows.

<table>
<thead>
<tr>
<th>Frequency (Hz)</th>
<th>Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 to 10</td>
<td>0.7 g peak</td>
</tr>
<tr>
<td>10 to 40</td>
<td>4.3 g peak</td>
</tr>
</tbody>
</table>

Sweep Rate: 3 octaves per minute

6.8 **Post Test Inspection**

6.8.1 The BSM test item shall be visually inspected by the MSFC QA, MSFC TE, and the CSD TE for exterior damage resulting from vibration testing.

6.8.2 Remove all instrumentation.

6.9 **Data Requirements**

Power Spectral Density (PSD) plots for all control and response accelerometers for lift off and boost tests shall be recorded. The test tolerances shall be overplotted on the control accelerometers plots. Acceleration versus frequency plots shall be recorded for all accelerometers used during vehicle dynamics tests.

7.0 **Post Test Disassembly/Prepare for Shipment**

7.1 **Conditioning Chamber Removal**

7.1.1 Disconnect any hoses and instrumentation that hinders the removal of the chamber.

7.1.2 Using the overhead crane, slowly lift the conditioning chamber off of the vibration table and place on the floor.

7.1.3 Move chamber out of the way.

7.1.4 Move the conditioning unit out of the way if necessary.

7.1.5 Verify motor ground connection on the motor and at the facility ground contact point.

7.1.6 Remove vibration table insulation.
7.2 Aero Heat Shield Removal

WARNING: Removing the Aero Heat Shield exposes the motor's propellant grain. Personnel should use caution during any operations with and exposed grain. Tools, watches, eye glasses, etc., should be tethered (if necessary) to prevent dropping anything into the motor.

7.2.1 Make sure the motor ground is secured. [✓]
7.2.2 Make sure verified wrist straps are being worn by the personnel removing the aero heat shield. [✓]
7.2.3 Remove the fasteners from the Aero Heat Shield. Place the fasteners in a marked bag. [✓]
7.2.3 SLOWLY remove the Aero Heat Shield. [✓]
7.2.5 Remove the heat shield seal. Do not drop the seal into the motor. [✓]

7.3 Post Test Inspection of Motor Propellant Grain

7.3.1 Make sure motor ground wire is secured. [✓]
7.3.2 Clear area of all non-essential personnel. Only the grain inspectors (2) and the MSFC TE shall remain. [✓]
7.3.3 Verify grain inspector(s) is(are):
   a. Wearing 100% cotton coveralls, shorts, and undershirts. [✓]
   b. Wearing a wrist strap.
   c. Wearing tethers and/or tape to keep eye glasses, rings, and watches from falling into the motor.

7.3.4 Perform grain inspection. [✓]

Cracked propellant: yes [no]

If yes, give approximate location and size of crack:

__________________________________________________________________________
Other comments on grain condition:

No cracks or other internal defects noted. No motor external damage attributable to pyroshock or vibration testing.

Grain inspector(s)

MSFC QA

7.3.5 A draw-wire, fabric, security bag shall be installed over the nozzle exit cone. The bag shall be closed around the exit cone and secured by inserting the bag wire ends through a standard security load-seal (i.e. cover the exit cone the same way that it was received).

7.4 Adapter Plate Removal

7.4.1 Remove the adapter plate to vibration table fasteners.

7.4.2 Attach lifting straps as shown in Fig. 1b (Appendix B).

CAUTION: Be careful not to disconnect the ground while lifting the motor.

CAUTION: The following step involves working with a suspended load. Keep hands and feet out from under the load.

7.4.3 Lift the motor off of the vibration table and move to an area near the wood supports.

7.4.4 Lower the motor so that it rests on the wood supports.

7.4.5 Rotate the motor 180° so that the adapter plates face up.

7.4.6 Remove the bracket to adapter plate fasteners. Place fasteners in a marked bag.

CAUTION: Be careful not to disconnect the ground while lifting the motor.

CAUTION: The following step involves working with a suspended load. Keep hands and feet out from under the load.

7.5 Aft Skirt Bracket Removal

7.5.1 Remove the aft end motor to bracket fasteners (12 places). Place fasteners in a marked bag.
CAUTION: Be careful not to disconnect the ground while lifting the motor.

CAUTION: The following step involves working with a suspended load. Keep hands and feet out from under the load.

7.5.2 Lift the motor to waist height using the overhead crane.

7.5.3 Rotate the motor 180° so that the bracket to adapter plate fastener holes face the floor.

7.5.4 Lower the motor so that it rests on the wood supports.

7.5.5 Remove forward end motor to bracket fasteners (8 places). Place fasteners in a marked bag. Light burning on food face.

8.0 Return Motor to the Vertical Position

8.1 Attach 2 D-rings, 180 degrees apart, and one lifting strap to the aft end holes of the motor.

8.2 Attach the "break-over" brackets (and lifting strap) to the appropriate bolt holes on the forward face of the motor case.

8.3 Attach the aft lifting strap to the overhead crane hook.

CAUTION: The following steps involve working with a suspended load. Keep hands and feet out from under the load.

CAUTION: Be careful not to disconnect the ground while lifting the motor.

8.4 One person (as chosen by the MSFC TE) shall hold the lifting strap on the forward end to keep the motor from swinging when lifted from the aft end. Slowly lift the aft end of the motor to bring it to a vertical position.

8.5 Raise the motor so that the aft end is at waist height.

CAUTION: The following steps involve working with a suspended load. Keep hands and feet out from under the load.

8.6 Disconnect the "break-over" brackets. Place brackets in a marked bag.
BSM MOTOR S/N 1000738
OBSERVATION AND DEVIATION SUMMARY
BSM Observation and Deviation Summary
1993 Delta Qualification Tests at MSFC

Motor SN: 1000738

#1. Reference step 6.2.1.8 in BSM-TCP-EP54-001. It was noticed after opening the shipping container that the motor to shipping container ground strap was broken. The motor did not appear to have rotated much during shipment. The broken ground strap was placed in the "mass simulator" shipping container and shipped back to CSD.

#2. Reference step 6.2.1.8 in BSM-TCP-EP54-001. A small dent/scratch was observed on the motor case. This dent/scratch was located at approximately 30° from the forward indicator pin, 3 1/4" from forward end.

#3. Reference step 6.2.6.4 in BSM-TCP-EP54-001. No cracks or other defects were noted on the propellant grain. A small amount lint and liner particles were observed on the grain. A red stain was also noticed on the grain surface.

#4. Reference step 6.2.7.7 in BSM-TCP-EP54-001. The aero-heat shield fasteners were very difficult to torque due to the primer in the holes on the exit cone. The primer was removed with 1,1,1 trichloroethane and que-tips.

#5. Reference step 6.4.5 in BSM-TCP-EP54-001. No damage was observed to the BSM due to the pyro shock test.

#6. Reference step 6.8.1 in BSM-TCP-EP54-003. No damage was observed to the BSM due to vibration testing. This inspection was performed before any bracket disassembly.

#7. Reference step 7.3.4 in BSM-TCP-EP54-003. Post-test grain inspection revealed no differences from the pre-test inspection.

#8. Reference step 7.5.1 in BSM-TCP-EP54-003. Light burnishing marks were observed on the motor case after removal of the aft attach bracket.

#9. Reference Test Procedure Deviation item 3 for BSM-TCP-EP54-003. The forward bracket attach fasteners were torqued per step 6.2.2.4 in BSM-TCP-EP54-001 (150 in-lbs). These fasteners were not lockwired on this motor. After finishing the radial axis tests, the lead vibration engineer noticed two fasteners laying in the forward bracket. Further inspection showed that in addition to the two fasteners out, four were loose.
Photographs were taken. USBI, CSD, and MSFC agreed to re-torque the fasteners and proceed with the testing. The torques were verified with a different torque wrench after re-torquing with the same wrench used at assembly. The test team also decided to re-check these torques after each axis.

A deviation was also written for the test sequence of the radial axis tests (see Test Procedure Deviation items 1 and 2 for BSM-TCP-EP54-003). The boost vibration time duration should be 120 seconds as stated in BSM-TCP-EP54-003 step 6.2.3.1. However, a USBI representative noticed that the boost vibration test was only conducted for 60 seconds. He also noticed that the lift-off vibration test was one second short (test tolerance on test duration is +10%, -0%). This deviation was discovered after the motor had already been unfastened from the table. So, the motor was re-connected to the table and brought back to temperature. Conditioning chamber temperature was resumed 24.5 minutes after chamber removal so no re-conditioning time was necessary. The final 60 seconds of the boost test and the one second on lift-off were then completed. The response data indicated that the forward fasteners probably came loose at about 30 seconds into the boost sequence. This means that the forward fasteners were probably already loose before the chamber was re-connected to finish the last 60 seconds.

#10. Reference step 7.5.5 in BSM-TCP-EP54-003. Chatter marks were evident on the forward face of the motor case. These marks were caused by the forward fasteners coming loose during the radial axis test allowing the bracket and the motor to rub. Burnishing marks were also evident on the forward face of the motor.

#11. Reference step 6.8 in BSM-TCP-EP54-003. After all of the vibration testing was complete, the post-test inspection revealed four aero-heat shield fasteners were missing. Several other fasteners were loose. The aero-heat shield was still secured to the exit cone, however, and did not appear to move during testing.
Figure 1

TEST PROCEDURE DEVIATION

<table>
<thead>
<tr>
<th>TEST ENGINEER</th>
<th>QUALITY</th>
<th>DATE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mat Bevill</td>
<td>Rick Clements</td>
<td>09/29/93</td>
</tr>
</tbody>
</table>

REQUIREMENTS ENGINEER: Richard Leonard (safety) 09/29/93 SHEET 1 of 6

TITLE: Upper Limit Tolerance Violation for Pyro Shock Simulation Test (SN: 1000738)

<table>
<thead>
<tr>
<th>DEVI. NO.</th>
<th>PAGE</th>
<th>SEQ</th>
<th>CHANGE/REASON</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td></td>
<td>Section 4.2.1 in BSM-TCP-EP54-001 states that the test tolerances for Shock Response Spectrum are +6dB and -3dB when analyzed with a 1/3 octave shock spectrum analyzer and 5% damping.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>The worst case overtest for each axis is shown in the attached graphs.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>X-axis: accelerometer #10</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Y-axis: accelerometer #11</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Z-axis: accelerometers #12 and #3</td>
</tr>
</tbody>
</table>

Motor SN: 1000738

Jim Herring  
6173, Lead Pyro Engineer

ORIGINATOR: Mat Bevill

ABOVE DEVIATION IS INCREASE HAZARD LEVEL: N/A

NASA MSC EP12
Min Value: -4782
Max Value: 4848
Time (ms)
Acc (g)

20-Sep-93  T1 All SRB BSM QUAL. TEST
24:51:18

20-Sep-93  T1 All SRB BSM QUAL. TEST
24:52:22

5.0% Damp Abs Acc
1/6 Octave Pri Pos
FIGURE 1. PYRO SHOCK CONTROL EQUIPMENT
CAUTION: When using the ESD scanner and the electrostatic reading on the motor case surface exceeds 1.0 kilovolt, stop all activities on the case, initiate personnel fall back (a minimum of 4 feet) and notify safety.

After initial reading over 1.0 kilovolt, repeat electrostatic reading at intervals not to exceed 5 minutes until the the voltage has dissipated below 1.0 kilovolt. When the reading is below 1.0 kilovolt, removal operations may continue.

If after 30 minutes the measured electrostatic charge is in excess of 1.0 kilovolt, Verify facility ground. If connection to facility ground is open, reconnect through larger resistor (100 Kohm min.) to allow a slow discharge of the motor case.

If the electrostatic reading on the case surface exceeds 4.0 kilovolts, STOP all activities on the case, notify safety, and evacuate all personnel to safe locations as directed by safety.

CAUTION: The following step involves working with a suspended load. Keep hands and feet out from under the load.

6.2.1.8 Slowly, monitoring static charge, lift the motor out of the container using the overhead crane. Lower the test item so that the forward end of the motor is at waist height.

A detailed visual inspection shall be performed by the MSFC test engineer and the CSD test engineer on the live test items before testing. Record the motor's serial number.

No Damage

Damage (detail in attachment) Yes, motor to shipping container ground wire. Also, small dent in bracket 10 ft. from end. (also, small dent in bracket, 10 ft. from end.)

Serial Number 1000738

CAUTION: The following step involves working with a suspended load. Keep hands and feet out from under the load.

6.2.1.9 Attach the "break-over" brackets and lifting strap on the forward end of the motor (see Figure 2, Appendix C).

CAUTION: Do Not disconnect the ground wire while breaking the motor to the horizontal position.
Record SN of torque wrench: "E" EMJ00359 A.B. D 261.62 (417)

6.2.5.2 Release the tension from the lifting straps but do not disconnect the straps. These straps may be used to tape off accelerometer wires if necessary.

6.2.5.3 Place the pyrotechnic debris shield in front of the large bay doors on the north side of the pyro room.

6.2.6 Perform Grain Inspection

6.2.6.1 Clear area of all nonessential personnel for grain inspection. (Only the grain inspectors (2) and the MSFC TE shall remain.)

6.2.6.2 Verify grain inspector(s) is(are):

a. Wearing 100% cotton coveralls, shorts, and undershirts.

b. Wearing a wrist strap.

c. Wearing tethers and/or tape to keep eye glasses, rings, and watches from falling into the motor.

6.2.6.3 The grain inspector shall now remove the security bag and cover from the exit cone.

6.2.6.4 Perform grain inspection.

Cracked propellant? yes

If yes, give approximate location and size of crack.

____________________________
____________________________

Other comments on grain condition:

No cracks or other defects noted on propellant grain. Small amounts of lint, fiber particles, and red stain on grain surface. OK to perform pyro shock test.

Grain inspector

6.2.7 Install Aero Heat Shield

CAUTION: When using trichloroethane, personnel shall wear chemical goggles and Neoprene-Latex gloves. Contaminated materials shall be disposed of as hazardous waste.
6.3.7 On the count of "3", the pyro technician shall put the switch in the "ARMED" position and verify that the power indicator is illuminated.

6.3.8 On the FIRE command, the pyro technician will open the red cover and flip the firing switch.

6.3.9 After firing, turn the firing panel key to the "UNARMED" position.

WARNING: If blasting cap does not fire, refer to Section 10.4 in ED73-SHK-FOP-004 (see Appendix A).

Blasting Cap Fired: yes ✓ no ___

6.3.10 Remove the arming key and disconnect the voltage supply.

6.3.11 Test personnel may now return to the control room.

6.3.12 Wait a minimum of 5 minutes after firing before opening the door to room 170.

6.3.13 The lead pyro engineer shall now begin to reduce the data.

6.4 Post Test Inspection

6.4.1 Inform the MSFC TE that the door to room 170 from the control room is to be opened.

6.4.2 The pyro technician shall enter room 170 and move the junction box switch to the "BULB" position.

6.4.3 Remove blasting cap leads from junction box.

6.4.4 Inspect the shock plate to insure all explosive devices fired properly.

WARNING: If all explosive items did not fire, refer to Section 10.5 in ED73-SHK-FOP-004 (see Appendix A).

6.4.5 The BSM shall be visually inspected for damage resulting from the pyro shock test. Any anomalies will be recorded. All other personnel shall remain in the control room or in the clear area until the "ALL CLEAR" is given by the MSFC TE.

6.4.6 MSFC TE indicates all clear for appropriate personnel.

6.5 Post Test Removal from the Pyro Plate
6.7.3 **Vehicle Dynamics**

6.7.3.1 The following levels and conditions apply for the vehicle dynamics test. Vibrate the motor only as follows.

<table>
<thead>
<tr>
<th>Frequency (Hz)</th>
<th>Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 to 10</td>
<td>0.7 g peak</td>
</tr>
<tr>
<td>10 to 40</td>
<td>4.3 g peak</td>
</tr>
</tbody>
</table>

Sweep Rate: 3 octaves per minute

6.8 **Post Test Inspection**

6.8.1 The BSM test item shall be visually inspected by the MSFC QA, MSFC TE, and the CSD TE for exterior damage resulting from vibration testing.

6.8.2 Remove all instrumentation.

6.9 **Data Requirements**

Power Spectral Density (PSD) plots for all control and response accelerometers for lift off and boost tests shall be recorded. The test tolerances shall be overplotted on the control accelerometers plots. Acceleration versus frequency plots shall be recorded for all accelerometers used during vehicle dynamics tests.

7.0 **Post Test Disassembly/Prepare for Shipment**

7.1 **Conditioning Chamber Removal**

7.1.1 Disconnect any hoses and instrumentation that hinders the removal of the chamber.

7.1.2 Using the overhead crane, slowly lift the conditioning chamber off of the vibration table and place on the floor.

7.1.3 Move chamber out of the way.

7.1.4 Move the conditioning unit out of the way if necessary.

7.1.5 Verify motor ground connection on the motor and at the facility ground contact point.

7.1.6 Remove vibration table insulation.
7.2 Aero Heat Shield Removal

WARNING: Removing the Aero Heat Shield exposes the motor's propellant grain. Personnel should use caution during any operations with and exposed grain. Tools, watches, eye glasses, etc., should be tethered (if necessary) to prevent dropping anything into the motor.

7.2.1 Make sure the motor ground is secured. [✓]
7.2.2 Make sure verified wrist straps are being worn by the personnel removing the aero heat shield. [✓]
7.2.3 Remove the fasteners from the Aero Heat Shield. Place the fasteners in a marked bag. [✓]
7.2.5 SLOWLY remove the Aero Heat Shield. [✓]
7.2.6 Remove the heat shield seal. Do not drop the seal into the motor. [✓]

7.3 Post Test Inspection of Motor Propellant Grain

7.3.1 Make sure motor ground wire is secured. [✓]
7.3.2 Clear area of all non-essential personnel. Only the grain inspectors (2) and the MSFC TE shall remain. [✓]
7.3.3 Verify grain inspector(s) is(are):
   a. Wearing 100% cotton coveralls, shorts, and undershirts.
   b. Wearing a wrist strap.
   c. Wearing tethers and/or tape to keep eye glasses, rings, and watches from falling into the motor.

7.3.4 Perform grain inspection. [✗]

Cracked propellant yes

If yes, give approximate location and size of crack:

____________________________________________________________________

421
Other comments on grain condition:

Grain inspector(s)  
MSFC QA

7.3.5 A draw-wire, fabric, security bag shall be installed over the nozzle exit cone. The bag shall be closed around the exit cone and secured by inserting the bag wire ends through a standard security lead-seal (i.e. cover the exit cone the same way that it was received).

7.4 Adapter Plate Removal

7.4.1 Remove the adapter plate to vibration table fasteners.

7.4.2 Attach lifting straps as shown in Fig. 1b (Appendix B).

CAUTION: Be careful not to disconnect the ground while lifting the motor.

CAUTION: The following step involves working with a suspended load. Keep hands and feet out from under the load.

7.4.3 Lift the motor off of the vibration table and move to an area near the wood supports.

7.4.4 Lower the motor so that it rests on the wood supports.

7.4.5 Rotate the motor 180° so that the adapter plates face up.

7.4.6 Remove the bracket to adapter plate fasteners. Place fasteners in a marked bag.

CAUTION: Be careful not to disconnect the ground while lifting the motor.

CAUTION: The following step involves working with a suspended load. Keep hands and feet out from under the load.

7.5 Aft Skirt Bracket Removal

7.5.1 Remove the aft end motor to bracket fasteners (12 places). Place fasteners in a marked bag.

* LIGHT SCORING OF SURFACE AT THE AFT BRACKET ATTACHMENTS.

422
CHATTER MARKS EVIDENT ON MS (1/11)
FORWARD FACE OF THE MOTOR

RE: 9.23.93
RG 9.23.93
CONDITIONS & POST TEST INSPECTION (6.8)

Loose Aero Heat Shield Bolts
- Missing Bolts (QTY 4)
- Loose Bolts (QTY 3)
& - OKAY
<table>
<thead>
<tr>
<th>TEST ENGINEER</th>
<th>QUALITY AUDITOR</th>
<th>DATE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mat Bevill MB</td>
<td>Rick Clements PC</td>
<td>09/22/93</td>
</tr>
</tbody>
</table>

**Title:** Radial Axis, Boost Vibration time Limit (Motor 1000738)

<table>
<thead>
<tr>
<th>DEV. NO.</th>
<th>PAGE</th>
<th>SEQ</th>
<th>CHANGE/REASON</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td></td>
<td>Boost vibration time duration should be 120 sec as stated in BSM-TCP-EP54-003 step 6.2.3.1.</td>
</tr>
</tbody>
</table>

Boost vibration test was only conducted for 60 sec. Conditioning equipment and instrumentation were re-connected. Chamber temp was resumed 24.5 minutes after chamber removal.

Testing was resumed per NOTE in section 8.0 in BSM-TCP-EP54-002.

The final 60 secs. were finished after chamber resumed temp.

<table>
<thead>
<tr>
<th>DEV. NO.</th>
<th>PAGE</th>
<th>SEQ</th>
<th>CHANGE/REASON</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>2</td>
<td></td>
<td>Lift off vibration timed was short by 1 sec.</td>
</tr>
</tbody>
</table>

Once the chamber resumed temperature (see dev. 1above) the test was resumed. (i.e. Lift off vibration was performed for one more second.) Time tolerance as stated in 4.2.1 has time tolerance of +/-0%, -0%.
Figure 1

TEST PROCEDURE DEVIATION

<table>
<thead>
<tr>
<th>TEST ENGINEER</th>
<th>QUALITY</th>
<th>DATE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Matt Bevill</td>
<td>Rick Clements</td>
<td>09/22/93</td>
</tr>
</tbody>
</table>

REQUIREMENTS ENGINEER: 

OTHER:

Richard Leonard 1999-22-95 SHEET 2 OF 2

TITLE: FWD Bracket to motor attach fasteners loosened during vibration

<table>
<thead>
<tr>
<th>DEV. NO.</th>
<th>PAGE</th>
<th>SEQ</th>
<th>CHANGE/REASON</th>
<th>PERM TEMP</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>3</td>
<td>3</td>
<td>The fwd bracket to motor attach bolts were torqued per step 6.2.2.4 in BSM-TCP-EP54-001. (150 in-lbs.)</td>
<td>T</td>
</tr>
</tbody>
</table>

After finishing the radial axis boost vibration test (see dev. 1), it was noticed that 4 fasteners were loose, 2 were completely out, and 2 were tight. Photographs were taken.

Fasteners were re-torqued per 6.2.2.4 in BSM-TCP-EP54-001 (150 in-lbs with the same torque wrench). These torques were then verified with another torque wrench SW.BTW-2RCF.

* Retorquing the bolts per step 6.2.2.4 does not increase the hazard level. However, as stated above, the fact that they came loose during vibration testing did increase the hazard level, to avoid this happening...

ORIGINATOR: Matt Bevill

426

EP12

ABOVE DEVIATION(S) INCREASE HAZARD LEVEL. SAFETY: P II I I
VEHICLE DYNAMICS CHECK-OUT

1.1 Verify test program and record the abort level below.

Abort Level

1.2 Perform levels as defined below and verify with plot.

1.3 Record the following:

Amplifier Gain

Charge Amp. F.S.

Test level concurrence:

Component Assessment Branch  Date

---

Sweep Rate = 3 oct/min
LIFT-OFF RANDOM

RANDOM CHECK-OUT

1. Verify test program and record RMS abort limit below.
   RMS abort limit: 1 dB

2. Perform levels as defined below and verify with plot.

3. Record the following:
   Amplifier Gain: 70%
   Charge Amp. F.S.: 30 G

<table>
<thead>
<tr>
<th>Frequency (Hz)</th>
<th>Level (G^2/Hz)</th>
<th>Limits</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>0.016</td>
<td>±3 ±1.5 dB</td>
</tr>
<tr>
<td>75</td>
<td>0.060</td>
<td></td>
</tr>
<tr>
<td>1000</td>
<td>0.030</td>
<td></td>
</tr>
<tr>
<td>2000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Composite</td>
<td>10 Gms</td>
<td></td>
</tr>
<tr>
<td>Test Time</td>
<td>60 Sec.</td>
<td></td>
</tr>
</tbody>
</table>

Test Level Concordance:

Component Assessment Branch

Date

304
RANDOM CHECK-OUT

.1 Verify test program and record RMS abort limit below.

RMS abort limit _______ 1 dB

.2 Perform levels as defined below and verify with plot.

.3 Record the following:

Amplifier Gain 80 %
Charge Amp. F.S. 100 G

Hz / Hz / G^2 / Hz, limits +3 -1.5 dB

20 Hz - 200 Hz @ .24 1 limits 11

200 Hz - 2000 Hz @ .017 limits .16

limits .

limits .

limits .

limits .

limits .

limits .

limits .

limits .

limits .

Test Time = 120 Sec.

Test Level Concurrence: Component Assessment Branch

Data

305
VEHICLE DYNAMICS CHECK-OUT

1.1 Verify test program and record the abort level below.

Abort Level: 1 dB

1.2 Perform levels as defined below and verify with plot.

1.3 Record the following:

Amplifier Gain: 40.70
Charge Amp. F.S.: 10.6

5 - 10 Hz at 0.7, limit ± 1.5 dB
10 - 40 Hz at 4.3, limit ___ dB
--- --- Hz at --- , limit ___ dB
--- --- Hz at --- , limit ___ dB
--- --- Hz at --- , limit ___ dB

Sweep Rate = 3 oct/min

Test level concurrence: ____________________________

Component Assessment Branch Date

306
<table>
<thead>
<tr>
<th>Frequency (Hz)</th>
<th>Peak Value (g)</th>
<th>g²/Hz,</th>
<th>Limits</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>0.16</td>
<td></td>
<td>+3, -1.5 dB</td>
</tr>
<tr>
<td>75</td>
<td>0.06</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1000</td>
<td>0.06</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2000</td>
<td>0.03</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Composite = 10 Gms**

**Test Time = 60 Sec.**

Test Level Concurrence: [Component Assessment Branch]

Date
1. Verify test program and record RMS abort limit below.

   RMS abort limit _______ d3

1.2 Perform levels as defined below and verify with plot.

1.3 Record the following:

   Amplifier Gain _______ 85

   Charge Amp. P.S. _______ 100

<table>
<thead>
<tr>
<th>Hz</th>
<th>G^2/Hz</th>
<th>limits</th>
<th>G^2/Hz</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>800</td>
<td>.24</td>
<td>limits</td>
</tr>
<tr>
<td></td>
<td>2000</td>
<td>.017</td>
<td>limits</td>
</tr>
<tr>
<td>2000</td>
<td></td>
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<tr>
<td>2000</td>
<td>_______</td>
<td>_______</td>
<td>limits</td>
</tr>
</tbody>
</table>

Composite = 18.4 Gms

Test Time = 120 Sec.
VEHICLE DYNAMICS CHECK-OUT

1.1 Verify test program and record the abort level below. __________

Abort Level: __________

1.2 Perform levels as defined below and verify with plot. __________

1.3 Record the following:

Amplifier Gain: __________

Charge Amp. F.S.: __________

<table>
<thead>
<tr>
<th>Frequency (Hz)</th>
<th>Limit (dB)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>7</td>
</tr>
<tr>
<td>10</td>
<td>4.3</td>
</tr>
<tr>
<td>40</td>
<td>3</td>
</tr>
</tbody>
</table>

Sweep Rate: __________ oct/min

Test level concurrence: ____________________________

Component Assessment Branch Date
Record a minimum of 30 seconds of calibration signal on tape recorder.

Set full scale ranges on instrumentation amplifiers and note on data sheet.

Set power amplifier gain to position noted during random test check-out.

Perform self check of control system.

Begin test sequence at -9 dB from full level.

At -6 dB, start tape recorder.

Note time when full level is reached. See tape log.

At the completion of the test, set power amplifier gain to off.

Stop tape recorder.

Inspect test article for damage or degradation.

Remove test article from shaker.
1. Record a minimum of 30 seconds of calibration signal on tape recorder.

2. Set full scale ranges on instrumentation amplifiers and note on data sheet.

3. Set power amplifier gain to position noted during random test check-out.

4. Perform self check of control system.

5. Begin test sequence at \(-7\) dB from full level.

6. At \(-6\) dB, start tape recorder.

7. Note time when full level is reached.

8. At the completion of the test, set power amplifier gain to off.

9. Stop tape recorder.

10. Inspect test article for damage or degradation.

11. Remove test article from shaker.
1.1 Record a minimum of 30 seconds of calibration signal on tape recorder.

1.2 Set full scale ranges on instrumentation amplifiers and note on data sheet.

1.3 Set power amplifier gain to position noted during sine test check-out.

1.4 Perform self check of control system.

1.5 Start tape recorder.

1.6 Begin sine sweep.

1.7 Note time of DCS "SWEEP UP" or "SWEEP DOWN" indication light. SEE TAPE LOG

1.8 During first sweep, press the "SAVE" button on DCS.

1.9 If more than one sweep, note time of DCS "SWEEP UP" or "SWEEP DOWN" indication light.

1.10 At the completion of the sweep, set power amplifier gain to off.

1.11 Stop tape recorder.

1.12 Inspect test article for damage or degradation.
SN 1000738

Test Data
RADIAL AXIS
RANDOM, LIFT-OFF
R2 TANG., RAD AXIS TEST
POWER SPECTRAL DENSITY
PHS LEVEL = 3.104
G SOR/Hz

10^11
-1
-2
-3
-4
-5

20 Hz LOG
10^8 Hz LOG

BSS L.O. RAD, S/N 1000738
RADIAL AXIS
RANDOM, BOOST
R2 RAD, RAD AXIS TEST
POWER SPECTRAL DENSITY
RMS LEVEL = 17.73
G SQR/HZ
RADIAL AXIS

VEHICLE DYNAMICS
TANGENTIAL AXIS
RANDOM, LIFT-OFF
TANGENTIAL AXIS

RANDOM, BOOST
RI LONG, TANG AXIS TEST
POWER SPECTRAL DENSITY
RMS LEVEL = 16.55
G SQR/Hz

BSM BOOST TANG, S/N 10073B
PB RAD., TANG AXIS TEST
POWER SPECTRAL DENSITY
RMS LEVEL = 10.48
G SQRT/Hz

20.0 Hz LOG

BSM BOOST TANG, S/N 1000738
TANGENTIAL AXIS

VEHICLE DYNAMICS
LONGITUDINAL AXIS

RANDOM, LIFT-OFF
CONTROL L.O. LONG. AXIS
POST TEST
RMS LEVEL = 10.06 G'S
G SQR/Hz

ELAPSED TIME = 62 SECS AT .00 DB
DELTA F = 4.883
DOL = 583
AWF = 16

10 19.5 0 Hz Log

BSM, LIFT-OFF LONG. S/N 1000738
CAUTION: When using thread compound, personnel shall wear neoprene-Latex gloves. Contaminated materials shall be disposed of as hazardous waste.

6.2.7.5 COAT fourteen (14) screws (NAS1101E08H10) with MIL-T-83483 thread compound.

CAUTION: When installing the Aero Heat Shield, personnel shall be extremely careful not to drop any foreign object into the rocket motor (watches, rings, and other jewelry shall be removed; eye glasses shall be tethered if worn).

6.2.7.6 With the nozzle cant vertically up, a properly grounded operator will INSTALL the aeroheat shield cover with the hinge on the left or right side when aft looking forward as specified by USBI/CSD. Proper alignment in either position is provided by a positioning pin and mating hole.

(NOTE: DO NOT lockwire the screws.)

6.2.7.7 INSTALL the 14 screws and TORQUE the fasteners using a standard cross pattern. Record the torque values.

<table>
<thead>
<tr>
<th>Pass</th>
<th>Fastener</th>
<th>Value</th>
<th>MSFC QA</th>
</tr>
</thead>
<tbody>
<tr>
<td>First Pass</td>
<td>Finger Tight</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Second Pass</td>
<td>10-15 in-lbs</td>
<td>10-15</td>
<td></td>
</tr>
<tr>
<td>Third Pass</td>
<td>20-25 in-lbs</td>
<td>20-25</td>
<td></td>
</tr>
<tr>
<td>Fourth Pass</td>
<td>20-25 in-lbs</td>
<td>20-25</td>
<td></td>
</tr>
</tbody>
</table>

Record SN of torque wrench:

6.2.8 Make Sure the Pyro Facility Bay Doors are Open

6.2.9 Clear Area for Test

The only personnel allowed in the control room are the pyro shock test conductor, a pyro technician, the MSFC TE, and the MSFC SE (total of four (4) people). All other personnel should move to a clear area. The clear areas are defined as the NORTH hallway of building 4619 and the area outside the pyro control room on the WEST side. Other areas must be cleared with the MSFC TE and the MSFC SE.