This report is an addendum to the ALSEP Boyd bolt Fastener Design Verification Test Program Final Report, ATM 807. This report summarizes the Preliminary Dynamic Tests of the Boyd bolt Fastener.

Prepared by R. Foster

Approved by M. Katz

Group Engineer
Structural/Thermal Design
### TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0 SUMMARY</td>
<td>3</td>
</tr>
<tr>
<td>2.0 INTRODUCTION</td>
<td>4</td>
</tr>
<tr>
<td>3.0 DESCRIPTION AND RESULTS OF DYNAMIC TESTS</td>
<td>5</td>
</tr>
<tr>
<td>4.0 CONCLUSION</td>
<td>13</td>
</tr>
</tbody>
</table>
1.0 SUMMARY

The preliminary dynamic tests were run to:

a) checkout the revised installation procedure

b) dynamically compare the two types of Boyd bolts (regular and hardened spindles)

c) further test the effect of Mylar insulation material.

Five tests were conducted: a sine sweep series test and four random test sequences. The details are explained in section 3.0.

The test results indicate the following:

a) Mylar insulation material does not contribute to loss of bolt preload.

b) Hardened spindled bolts release within the specified limits after dynamic tests.

c) Bolts installed properly by the new procedure should experience no loss of preload after environmental testing.
2.0 INTRODUCTION

These preliminary dynamic tests were run subsequent to the Boyd bolt static tests. The purpose was to (1) check out the revised installation technique (procedure 2335975, Revision C), (2) examine the Boyd bolt with the hardened spindles (CA 2773-14-1) as compared with the regular bolt (CA 2773-14), and (3) further test the effect of Mylar insulation material on bolt preload.
3.0 DESCRIPTION AND RESULTS OF THE DYNAMIC TESTS.

These preliminary dynamic tests were run on the test set-up shown in Figures 1 and 4. All testing was done in the vertical (X) axis. The Boyd bolt Test Fixture (BSX 8259) was used to simulate the ALSEP fastener interface.

As can be seen in Figure 1, six Boydbolts were used in this test series. Three of these bolts were of the old design (CA 2773-14), and three were of the new hardened spindle design (CA 2773-14-1).

As stated previously, the purpose of these preliminary dynamic tests was to determine the effect of Boydbolt installation procedure and hardware changes by comparison testing.

Five different test sequences were conducted. The description and results of these tests are covered in the following paragraphs.

3.1 Sine Test

All bolts were installed per the new procedure (2335975, Rev. C), which calls for ESNA nut preload torque of 44 ± 2 in-lbs. The test was run three times from 5 to 100 to 5 cps at 3/4 octave minute, with the shaker input level of:

- 0.25 inch double amplitude, 5-9 cps
- 1.0g-peak, 9-35 cps
- 0.25g-peak, 35 to 45 cps (critical frequency zone)
- 1.0g-peak, 45 to 100 cps

The Sine test output levels are shown in Figure 2. The test was not nearly as severe as the subsequent random tests. The Boydbolt preload torque level (per new procedure) did not change during the test.
Figure 1 Test Set-Up for Sine Test and Random Test Nos. 1 and 2

Figure 4 Test Set-Up for Random Test Nos. 3 and 4
VIBRATION LEVELS

Test Item: 1300 VD BOLTS
Test Date: 4 OCT 68
Serial Number:
Axis: X

Frequency - cps

Acceleration - g peak

100 10 1 1
3.2 Random Test No. 1

With the bolts as installed in 3.1 (per the new installation procedure), the following six random level tests were run. Each test level time duration was five minutes.

\[ H_i \text{ is the input at the test fixture.} \]

<table>
<thead>
<tr>
<th>Test</th>
<th>( A )</th>
<th>( G_{\text{RMS}} ) (calculated)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.02 ( g^2 / \text{cps} )</td>
<td>6.3</td>
</tr>
<tr>
<td>2</td>
<td>0.04</td>
<td>8.9 *Root-means-square acceleration</td>
</tr>
<tr>
<td>3</td>
<td>0.08</td>
<td>12.6</td>
</tr>
<tr>
<td>4</td>
<td>0.16</td>
<td>17.8</td>
</tr>
<tr>
<td>5</td>
<td>0.32</td>
<td>25.2</td>
</tr>
<tr>
<td>6</td>
<td>0.64</td>
<td>35.5</td>
</tr>
</tbody>
</table>

The bolt preload and spindle release force were checked after each individual five minute test.
The actual test inputs for the six test levels are shown in Figure 3. The test data is shown in Table 1.

Since this test was quite severe, six new nut plates (CA2774) and three new bolts (CA 2773-14) were secured for the subsequent tests.

3.3 Random Test No. 2

The bolts for this random test were installed as shown below:

<table>
<thead>
<tr>
<th>Old bolts</th>
<th>New bolts</th>
</tr>
</thead>
<tbody>
<tr>
<td>CA 2773-14</td>
<td>CA 2773-14-1</td>
</tr>
</tbody>
</table>

Old Procedure (Test Fixture) 55±2 in-lb
New Procedure 44±2 in-lb

The test level inputs were 0.08g²/cps and 0.16g²/cps. Time duration was five minutes each. The bolt preload and spindle release force were checked after each test level.

The results were:

a. No change in preload torque was experienced after five minutes at 11.5 G_RMS.

b. After five minutes at 16.5 G_RMS, no change in preload torque was noted in the new bolts, but the regular bolts had dropped from 55 in-lb to 30, 45 and 45 in-lb respectively.

3.4 Random Test No. 3

The bolt installation was the same as Random test no. 2 except:
Test: RANDOM VIBRATION
Test Item: BOLT SLITS
Test Date: 7 OCT 68

Power Spectral Density - g²/cps

Frequency - cpg
<table>
<thead>
<tr>
<th>Test No.</th>
<th>A</th>
<th>GRMS (Calculated)</th>
<th>GRMS (test)</th>
<th>Bolts loosened</th>
<th>Hardened Spindle</th>
<th>Regular Spindle</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.02 g²/cps</td>
<td>6.3</td>
<td>7.4</td>
<td>none</td>
<td>7 to 12</td>
<td>25 to 30</td>
</tr>
<tr>
<td>2</td>
<td>0.04</td>
<td>8.9</td>
<td>8.3</td>
<td>none</td>
<td>7 to 10</td>
<td>26 to 30</td>
</tr>
<tr>
<td>3</td>
<td>0.08</td>
<td>12.6</td>
<td>11.5</td>
<td>none</td>
<td>12 to 17</td>
<td>24 to 30</td>
</tr>
<tr>
<td>4</td>
<td>0.16</td>
<td>17.8</td>
<td>16.5</td>
<td>18 to 20</td>
<td>22 to 30</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>0.32</td>
<td>25.2</td>
<td>23.5</td>
<td>none</td>
<td>18 to 20</td>
<td>24 to 30</td>
</tr>
<tr>
<td>6</td>
<td>0.64</td>
<td>35.5</td>
<td>41.0</td>
<td>none</td>
<td>12 to 18</td>
<td>24 to 30</td>
</tr>
</tbody>
</table>

\[\text{one regular bolt loosened at 20 in-lb. No other bolts were loose.}\]

Table 1. Random Test No. 1 Data
1) 40 layers of .00025 inch thick Mylar insulation material was placed between the structural members of the test fixture being clamped by each bolt. (Ref: Figure 4).

2) The test level input was $16g^2/cps$ for five minutes. Two tests were run at this level.

The bolt preload and spindle release force were checked after each five minute test run.

The test results were as follows:

a. After five minutes at $16 Grms$, there was no loss of preload torque in the new bolts. The regular bolts dropped to 25, 35 and 40 in-lbs respectively.

b. After an additional five minutes at $16 Grms$, there was still no change in the new bolt preload torque, but the regular bolt torque had dropped further to 20, 25 and 30 in-lbs respectively.

3.5 Random Test No. 4

This test was to check the effect of insulation on Boydbolt preload.

The test hardware set up was the same as Random Test No. 3. However, for this test all the bolts were installed per the new procedure (2335975, Rev. C), with the ESNA nut torqued to $44 \pm 2$ in-lb. Two test sequences at $16g^2/cps$ were run. As in the above tests, the bolt preload and spindle release force were checked after each five minute test.

The test results were:

a. After five minutes at $16 Grms$, no change in preload torque of any bolt was noted.

b. After an additional five minutes at $16 Grms$, no change in bolt preload torque was noted.
4.0 CONCLUSIONS

The results from this dynamic test sequence leads to the following conclusions:

a. The Mylar insulation material does not cause a loss in bolt preload.

b. The revised bolt design using hardened spindles permits the spindle release force criteria to be met after dynamic testing.

c. When bolts are installed properly by the revised procedure (2335975, Rev. C) no loss of bolt preload should be experienced after environmental testing.

d. The technique of installing the Boydbolt is a very specialized task. When it is accomplished according to 2335975C, the Boydbolt can be expected to function as specified.