VEHICLE AND CONTROL SYSTEMS DIVISION
INTERNAL REVIEW
12 MARCH 1991

BOND SURFACE EVALUATION BY OSEE INSTRUMENT
TITAN IV PAYLOAD FAIRING

PRESENTED BY

R. P. DATE

MANUFACTURING ENGINEERING DEPARTMENT
DESIGN ENGINEERING SUBDIVISION
AGENDA

- BACKGROUND
- PLF MANUFACTURING AT MDSSC
- SURFACE PREPARATION AND COATING AT LAUNCH SITE
- TEST PROCEDURE
- TEST RESULTS
- OBSERVATIONS AND COMMENTS
- CONCLUSIONS
- RECOMMENDATIONS
BACKGROUND

- **TITAN IV PAYLOAD FAIRINGS:**
  - MANUFACTURED BY MDSSC
  - ASSEMBLED AT LAUNCH SITE (CCAFS & VAFB)

- **BASE MATERIAL:**
  - 7075-T73 ALUMINUM

- **APPROXIMATE DIMENSIONS:**
  - DIAMETER: 17 FT
  - LENGTH: 56-86 FT.

- **SECTIONS OF PLF:**
  - NOSE CONE SECTION
  - CYLINDRICAL SECTION
  - BOATTAIL SECTION
BACKGROUND (CONTINUED)

- THERMAL COATING:
  - PRIMER (DC 1200)
  - THERMAL COATING (DYNATHERM)

- FAILURE HISTORY:
  FEW COATING FAILURES DURING FLIGHT
  SEVERAL IN-PROCESS TEST FAILURES
  - DUE TO INABILITY TO MEET SPECIFIED BOND STRENGTH

- DESIGN REQUIREMENT:
  PLUG PULL ADHESION STRENGTH 40 PSI MINIMUM
CROSS SECTIONAL VIEW OF THERMAL COATING

TITAN IV PAYLOAD FAIRING FORWARD SECTION

THERMAL COATING (DYNATHERM)

ALUMINUM ISOGGRID (7075-T73)

PRIMER (DC1200)

SECTION AT A
PLF MANUFACTURING AT MDSSC

- 7075-T73 ALUMINUM PLATE
- MILL ISOGRID POCKETS
- BRAKE-FORM ISOGRID PANELS
- CHEMICAL CONVERSION COAT
- ASSEMBLE PLF TRISECTORS
- PACKAGE AND SHIP TRISECTORS
- STORAGE AT LAUNCH SITE
THERMAL COATING APPLICATION AT LAUNCH SITE

1. TRISECTORS IN STORAGE
2. SURFACE PREPARATION
3. APPLY PRIMER
4. APPLY THERMAL COATING
5. PLUG PULL TEST
6. PAINT
7. ASSEMBLE PAYLOAD FAIRING
PRELIMINARY ASSESSMENT

- PRIMARY AREAS OF CONCERN:
  - CHEMICAL CONVERSION COATING
  - SURFACE PREPARATION
  - THERMAL COATING APPLICATION

- MOST PROBABLE CAUSE:
  - SURFACE CONTAMINATION
  - SURFACE PREPARATION METHOD

- SOURCES OF CONTAMINATION:
  - GREASE
  - OXIDATION
  - MOISTURE
  - OIL
  - CORROSION
  - FINGERPRINTS
  - DIRT

- OSEE INSTRUMENT USED TO DETECT CONTAMINATION LEVELS
**OSEE TECHNIQUE**

- **OSEE:**
  - OPTICALLY STIMULATED ELECTRON EMISSION

- **OSEE PRINCIPLE:**
  - SURFACE ILLUMINATED WITH ULTRAVIOLET LIGHT
  - UV PROTONS REACT WITH SURFACE TO PRODUCE ELECTRONS
  - EMITTED ELECTRONS ARE COLLECTED AND MEASURED
  - CHANGE IN EMITTED ELECTRONS IS A MEASURE OF CONTAMINATION

- **ADVANTAGES OF OSEE:**
  - NONCONTACT, NONDESTRUCTIVE METHOD
  - DOES NOT NEED VACUUM OR CONTROLLED ATMOSPHERE
  - CAN MEASURE VERY THIN FILMS (FEW A THICKNESS)
  - CAN BE USED ON METALS AND NONMETALS AND WITH ORGANIC OR INORGANIC CONTAMINANTS
SCHEMATIC DIAGRAM OF OSEE INSTRUMENT

ULTRAVIOLET LIGHT SOURCE

COLLECTOR

EMITTED PHOTOELECTRONS

AMMETER

BIASED VOLTAGE

SURFACE UNDER TEST
TEST PROCEDURE

- 3 IN. X 5 IN. SAMPLES FROM PLF PANEL
- FOUR TYPES OF SURFACE CONDITION EVALUATED:

<table>
<thead>
<tr>
<th>(1)</th>
<th>SOLVENT CLEANED (MEK)</th>
<th>HEAVY WIPE, 2 LIGHT WIPE, 1 LIGHT WIPE</th>
</tr>
</thead>
<tbody>
<tr>
<td>(2)</td>
<td>ABRASIVE APPLIED (SCOTCHBRITE)</td>
<td>HEAVY, LIGHT</td>
</tr>
<tr>
<td>(3)</td>
<td>CONTAMINANT APPLIED (BOELUBE)</td>
<td>10, 25, 20 &amp; 100 MG/FT²</td>
</tr>
<tr>
<td>(4)</td>
<td>CONTAMINANT APPLIED (RUSTLCIK OIL)</td>
<td>10, 25, 20 &amp; 100 MG/FT²</td>
</tr>
</tbody>
</table>

- CONTAMINANT LEVELS MEASURED WITH OSEE INSTRUMENT

- ALL SAMPLES COATED WITH:
  PRIMER (DC 1200)
  THERMAL COATING (DYNATHERM)

- ALL SAMPLES PLUG PULL TESTED USING:
  ALUMINUM PLUGS (0.798 IN. DIA)
  SEALENT (RTV)
  3 PLUGS FOR EACH SAMPLE
# TABLE I
## TEST RESULTS

<table>
<thead>
<tr>
<th>SPECIMEN TYPE</th>
<th>OSEE READING</th>
<th>NUMBER OF PLUG PULL SAMPLES</th>
<th>LOAD (LBS.)</th>
<th>BOND STRENGTH (PSI)</th>
<th>MODE OF FAILURE **</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) HEAVY MEK WIPE</td>
<td>227.0</td>
<td>6</td>
<td>85.2</td>
<td>170.4</td>
<td>2 ADHESION/ 4 TEST SET UP</td>
</tr>
<tr>
<td>2) 2 LIGHT MEK WIPES</td>
<td>122.3</td>
<td>3</td>
<td>56.0</td>
<td>112.0</td>
<td>3 ADHESION/ 4 TEST SET UP</td>
</tr>
<tr>
<td>3) 1 LIGHT MEK WIPE</td>
<td>46.3</td>
<td>3</td>
<td>48.0</td>
<td>96.0</td>
<td>3 ADHESION/ 4 TEST SET UP</td>
</tr>
<tr>
<td>4) BOELUBE, 10 MG /FT²</td>
<td>97.0</td>
<td>3</td>
<td>62.3</td>
<td>124.6</td>
<td>1 ADHESION/ 2 TEST SET UP</td>
</tr>
<tr>
<td>5) BOELUBE, 25 MG /FT²</td>
<td>73.0</td>
<td>3</td>
<td>30.0</td>
<td>60.0</td>
<td>2 ADHESION/ 1 TEST SET UP</td>
</tr>
<tr>
<td>6) BOELUBE, 50 MG /FT²</td>
<td>54.8</td>
<td>3</td>
<td>18.3</td>
<td>36.6</td>
<td>3 ADHESION/ 1 TEST SET UP</td>
</tr>
<tr>
<td>7) BOELUBE, 100 MG /FT²</td>
<td>45.6</td>
<td>3</td>
<td>21.0</td>
<td>42.0</td>
<td>3 ADHESION/ 1 TEST SET UP</td>
</tr>
<tr>
<td>8) RUSTLICK, 10 MG /FT²</td>
<td>95.6</td>
<td>3</td>
<td>77.3</td>
<td>154.6</td>
<td>3 ADHESION/ 1 TEST SET UP</td>
</tr>
<tr>
<td>9) RUSTLICK, 25 MG /FT²</td>
<td>57.4</td>
<td>3</td>
<td>76.7</td>
<td>153.4</td>
<td>3 ADHESION/ 1 TEST SET UP</td>
</tr>
<tr>
<td>10) RUSTLICK, 50 MG /FT²</td>
<td>46.6</td>
<td>3</td>
<td>63.0</td>
<td>126.0</td>
<td>3 ADHESION/ 1 TEST SET UP</td>
</tr>
<tr>
<td>11) RUSTLICK, 100 MG /FT²</td>
<td>20.0</td>
<td>3</td>
<td>28.0</td>
<td>56.0</td>
<td>3 ADHESION/ 1 TEST SET UP</td>
</tr>
<tr>
<td>12) LIGHT SCOTCHBRITE</td>
<td>317.0</td>
<td>3</td>
<td>79.0</td>
<td>158.0</td>
<td>3 ADHESION/ 3 TEST SET UP</td>
</tr>
<tr>
<td>13) HEAVY SCOTCHBRITE</td>
<td>2620.0*</td>
<td>3</td>
<td>104.3</td>
<td>208.6</td>
<td>3 ADHESION/ 3 TEST SET UP</td>
</tr>
</tbody>
</table>

* EXTRAPOLATED READING ** ADHESION FAILURES: FAILED AT ISOGRID-PRIMER INTERFACE TEST SET UP FAILURES: FAILED AT PLUG-SEALENT INTERFACE
OSEE READING VS CONTAMINATION

OSEE

200

100

0

HEAVY MEK WIPE

BOELUBE/RUSTLICK (MG/SQ-FT)

10

25

50

100

BOELUBE

RUSTLICK
Manufacturing Engineering Department
Vehicle and Control Systems Division
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Graph showing comparisons between OSEE and SCOTCHBRITE for different cleaning methods:
- Heavy MEK Wipe: 227
- Heavy SCOTCHBRITE: 2620
- Light SCOTCHBRITE: 317
The graph shows the relationship between the strength (in PSI) and contamination levels of BOELUBE and RUSTLICK. The x-axis represents the concentration of BOELUBE/RUSTLICK in mg/sq-ft, ranging from 0 to 100. The y-axis represents the strength in PSI, ranging from 0 to 200. The contamination levels are as follows: Heavy MEK Wipe, 10, 25, 50, and 100. The results indicate that both BOELUBE and RUSTLICK decrease in effectiveness as the contamination level increases.
The graph shows the strength (in PSI) of different MEK wipe conditions.

- **Heavy MEK Wipe**: 170 PSI
- **2 MEK Wipes**: 112 PSI
- **1 MEK Wipe**: 96 PSI
THE AEROSPACE CORPORATION

Manufacturing Engineering Department
Vehicle and Control Systems Division

STRENGTH VS SCOTCHBRITE

<table>
<thead>
<tr>
<th></th>
<th>Strength (Psi)</th>
</tr>
</thead>
<tbody>
<tr>
<td>HEAVY MEK WIPE</td>
<td>170</td>
</tr>
<tr>
<td>HEAVY SCOTCHBRITE</td>
<td>209</td>
</tr>
<tr>
<td>LIGHT SCOTCHBRITE</td>
<td>158</td>
</tr>
<tr>
<td>SPECIMEN NUMBER</td>
<td>DESCRIPTION</td>
</tr>
<tr>
<td>-----------------</td>
<td>-----------------</td>
</tr>
<tr>
<td>1</td>
<td>HEAVY MEK</td>
</tr>
<tr>
<td>2</td>
<td>2X LIGHT MEK</td>
</tr>
<tr>
<td>3</td>
<td>LIGHT MEK</td>
</tr>
<tr>
<td>4</td>
<td>BOELUBE - 10</td>
</tr>
<tr>
<td>5</td>
<td>BOELUBE - 25</td>
</tr>
<tr>
<td>6</td>
<td>BOELUBE - 50</td>
</tr>
<tr>
<td>7</td>
<td>BOELUBE - 100</td>
</tr>
<tr>
<td>8</td>
<td>RUSTLICK - 10</td>
</tr>
<tr>
<td>9</td>
<td>RUSTLICK - 25</td>
</tr>
<tr>
<td>10</td>
<td>RUSTLICK - 50</td>
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<td>LIGHT SCOTCHBRITE</td>
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<td>13</td>
<td>HEAVY SCOTCHBRITE</td>
</tr>
</tbody>
</table>

* REFERENCE MIL-HDBK-5
## STRENGTH / OSEE VS. CONFIDENCE

### "A" LEVEL (99%) 

<table>
<thead>
<tr>
<th>SPECIMEN NUMBER</th>
<th>DESCRIPTION</th>
<th>OSEE READING (AVERAGE)</th>
<th>STRENGTH (PSI)</th>
<th>&quot;A&quot; LEVEL (99%)</th>
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</thead>
<tbody>
<tr>
<td>1</td>
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<td>227</td>
<td>170</td>
<td>145</td>
</tr>
<tr>
<td>2</td>
<td>2 X LIGHT MEK</td>
<td>122</td>
<td>112</td>
<td>-62</td>
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<tr>
<td>3</td>
<td>LIGHT MEK</td>
<td>46</td>
<td>96</td>
<td>3</td>
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<tr>
<td>4</td>
<td>BOELUBE - 10</td>
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<tr>
<td>5</td>
<td>BOELUBE - 25</td>
<td>73</td>
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</tr>
<tr>
<td>6</td>
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<td>55</td>
<td>37</td>
<td>8</td>
</tr>
<tr>
<td>7</td>
<td>BOELUBE - 100</td>
<td>46</td>
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<td>17</td>
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<tr>
<td>8</td>
<td>RUSTLICK - 10</td>
<td>96</td>
<td>155</td>
<td>53</td>
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<tr>
<td>9</td>
<td>RUSTLICK - 25</td>
<td>57</td>
<td>153</td>
<td>-25</td>
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<tr>
<td>10</td>
<td>RUSTLICK - 50</td>
<td>47</td>
<td>126</td>
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<td>317</td>
<td>158</td>
<td>-360</td>
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<td>13</td>
<td>HEAVY SCOTCHBRITE</td>
<td>2620</td>
<td>209</td>
<td>2392</td>
</tr>
</tbody>
</table>

* Reference MIL-800K5
OBSERVATIONS AND COMMENTS

- BOND STRENGTHS MEASURED IN LABORATORY WERE CONSIDERABLY HIGHER THAN STRENGTHS OBSERVED AT LAUNCH SITE
- THE COATING PROCESS USED AT LAUNCH SITE IS NOT ROBUST
- NUMEROUS CONTAMINANTS MAY BE PRESENT AT THE POINT OF SURFACE PREPARATION
- TEST SET UP FAILURES GIVE SKewed RESULTS
- TEST METHOD USED AT LAUNCH SITE SHOULD BE ENHANCED TO ELIMINATE TEST SET UP FAILURES
## CONCLUSIONS

- EXCELLENT CORRELATION OF OSEE READINGS AND CONTAMINATION LEVEL
- VERY GOOD CORRELATION OF CONTAMINATION LEVEL (OSEEREADINGS) AND BOND STRENGTHS
- OSEE INSTRUMENT IS CAPABLE OF DETECTING VERY SMALL AMOUNTS OF CONTAMINATION
- LABORATORY TESTS APPEAR TO GIVE HIGHER BOND STRENGTHS
- MANUFACTURING MATERIALS AND PROCESSES USED FOR BONDING DYNATHERM ARE NOT ROBUST
- STATISTICAL ANALYSIS SHOWS THAT ONLY HEAVY SCOTCHBRITE IS A ROBUST METHOD OF SURFACE PREPARATION
RECOMMENDATIONS

- CONTROL TIME, TEMPERATURE, RELATIVE HUMIDITY, PRIMER THICKNESS ETC. TO MANUFACTURER’S RECOMMENDATIONS

- CONSIDER APPLICATION OF THERMAL INSULATION IN FACTORY

- CONSIDER PULL TEST ACCEPTABLE IF STRENGTH IS ABOVE 40 PSI. IF FAILURE OCCURS IN 40-79 PSI RANGE DO 4 MORE TESTS IN THE SAME AREA. ALL 4 TESTS MUST PASS 40 PSI MINIMUM.

- USE HEAVY SCOTCHBRITE TO PREPARE SURFACE FOR BONDING

- USE OSEE INSTRUMENT AS A TRAINING AID TO MANUFACTURING PERSONNEL