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REINFORCED CARBON CARBON (RCC) OXIDATION RESISTANT MATERIAL SAMPLES - BASELINE COATED, AND BASELINE COATED WITH TETRAETHYL ORTHOSILICATE (TEOS) IMPREGNATION

Final Report (Vought Corp., Dallas, Tex.)

Dated

7 January 1977

 Submitted To

The National Aeronautics and Space Administration
Johnson Spacecraft Center
Houston, Texas
FINAL REPORT
FOR
Reinforced Carbon Carbon (RCC) Oxidation Resistant Material Samples - Baseline Coated, And Baseline Coated With Tetraethyl Orthosilicate (TEOS) Impregnation

Dated
7 January 1977

Submitted To
The National Aeronautics and Space Administration
Johnson Spacecraft Center
Houston, Texas

Written By: E. E. Gantz
E. E. Gantz
Test Project Engineer - LESS

Approved By: G. B. Whisenhunt
G. B. Whisenhunt
Program Manager - LESS

VOUGHT CORPORATION
P. O. Box 5907
Dallas, Texas 75222
ABSTRACT

This report presents a description of the program for: (1) the fabrication of Reinforced Carbon Carbon (RCC) oxidation resistant plasma arc, combined environment and mechanical properties specimens for evaluation by the NASA, and (2) the silicon carbide coating of six NASA heater elements. The specimens provided included both baseline coated specimens as well as baseline coated/Tetraethyl Orthosilicate (TEOS) impregnated specimens.

All of the specimens were fabricated and processed in accordance with specification procedures accepted by the prime Shuttle Contractor for the fabrication and processing of the Leading Edge Structural Subsystem (LESS) elements for the Space Shuttle Orbiter.
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Enclosure (2) TEST SPECIMEN SHIPPING PAPERS AND CERTIFICATION DOCUMENTS - BASELINE COATED AND INSTRUMENTED PLASMA ARC TEST SPECIMENS CONTRACT NAS9-14476

Enclosure (3) SHIPPING PAPERS - SILICON CARBIDE COATED NASA HEATER ELEMENTS CONTRACT NAS9-14476

Enclosure (4) SHIPPING PAPERS AND CERTIFICATION DOCUMENTS - RCC BASELINE COATED AND TEOS IMPREGNATED SPECIMENS CONTRACT NAS9-14476

Enclosure (5) SHIPPING PAPERS AND CERTIFICATION DOCUMENT - NASA MASS LOSS SPECIMENS, RCC BASELINE COATED AND TEOS IMPREGNATED CONTRACT NAS9-14476
1.0 INTRODUCTION

This program was initiated by Vought Corporation on 2 December 1974 under Contract NAS9-14476. The program objective was twofold: (1) to provide Reinforced Carbon Carbon (RCC) material samples both baseline coated and baseline coated, Tetraethyl Orthosilicate (TEOS) impregnated for evaluation by the NASA Lyndon B. Johnson Space Center, and (2) to silicon carbide coat six NASA heater elements for evaluation by the Lyndon B. Johnson Space Center.

The (RCC) specimens were machined from 19 and 33 ply flat panels which were fabricated and processed in accordance with the specifications and procedures accepted by the prime Shuttle Contractor for the fabrication and processing of the Leading Edge Structural Subsystem (LESS) elements for the Space Shuttle Orbiter. The specimens were then baseline coated and TEOS impregnated, as applicable, in accordance with the procedures and requirements of the appropriate LESS production specifications.

Three heater bars were ATJ graphite silicon carbide coated with the Vought "pack cementation" coating process, and three were Stackpole Grade 2020 graphite silicon carbide coated with the chemical vapor deposition process (CVD) utilized by Vought in coating the LESS shell development program entry heater elements.
2.0 PROGRAM MATERIAL SUMMARY

The end items of this contract are the test samples and materials as specified in Paragraph 3.0 of the contract statement of work. A summary discussion of the items delivered with regard to the appropriate statement of work requirement follows:

2.1 RCC Baseline Coated Test Specimens

By Paragraph 3.1 of Reference (a), "a minimum of 130 RCC baseline coated specimens shall be supplied in a configuration mix of 1.0 in. to 3.0 in. diameter discs, and 0.8 in. x 2.8 in. to 1.4 in. x 6.5 in. bars. The specimens are to be fabricated from thin ply (19 ply) and thick ply (38 ply) panels. Approximately 10 of the 3.0 in. diameter discs are to be instrumented with three thermocouples each."

A total of 130 specimens were fabricated and shipped to the NASA in the configuration mix as outlined in Table 1.0, page 7. Table 1.0 also presents the specimen serial numbers and identifies the NASA center to which the various specimens were shipped.

As will be noted, additional specimen configurations were included and the specimen configuration mix varied somewhat from the requirements specified in Paragraph 3.1 of Reference (a). These adjustments were discussed with the NASA Technical Monitor on 13 May 1975 in a telephone conversation with Mr. E. E. Gantz of Vought.

Copies of the shipping papers for these specimens are the Certification Reports are presented in Enclosures (1) and (2).

2.2 Coated Graphite Heater Elements

Paragraph 3.2 of Reference (a) states, "The Contractor shall apply the 0.020 in. thick oxidation inhibited coating to the following (GFE) graphite heater elements: (a) six carbon strips, 29.875 in. x 1.850 in. x 0.136 in., (b) six carbon blocks, 1.375 in. x 1.75 in. x 0.875 in., and (c) six carbon pins, 5/16 in. diameter x 0.25 in."

Subsequent Vought experience in coating graphite indicated that Speer 890S graphite is not a suitable graphite for the Vought silicon carbide "pack cementation" coating process, and that ATJ graphite is the optimum graphite substrate for this process. Based on experience in coating the shell development program entry thermal heater bars, Vought strongly recommended that NASA coat their heater bars with the silicon carbide chemical vapor deposition coating.
<table>
<thead>
<tr>
<th>Specimen Quantity</th>
<th>Specimen Part No.</th>
<th>Specimen Configuration</th>
<th>Specimen Serial Numbers</th>
<th>Remarks</th>
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<tbody>
<tr>
<td>RCC Baseline Coated Specimens</td>
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<td>221GT4027</td>
<td>Log Specimen</td>
<td>9-7 and 9-8</td>
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<tr>
<td>18</td>
<td>221GT4027</td>
<td>1 in. Dia Disc</td>
<td>7-37, 7-38, 7-39, 7-40, 7-29, 7-30, 7-31, 7-32, 7-33, 7-35, 7-36, 7-41, 7-42, 7-43, 7-44, 7-45, 7-46, 7-52</td>
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<td>221GT4027</td>
<td>1 in. x 5 in. Flex Bar</td>
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<td>Shipped to NASA/JSC</td>
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<td>221GT4027</td>
<td>1-1/2 in. x 6 in. Flex Bar</td>
<td>2-11, 2-24, 2-31, 6-35, 6-36, 6-37, 6-38, 6-39</td>
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<td>23</td>
<td>221GT4027</td>
<td>2.8 in. Dia Disc</td>
<td>3-18-1, 3-19-1, 3-20-1, 3-21-1, 3-24-1, 3-25-1, 3-26-1, 3-27-1, 3-28-1, 3-29-1, 3-30-1, 3-31-1, 3-32-1, 3-33-1, 3-34-1, 3-35-1, 3-36-1, 3-37-1, 3-38-1, 3-39-1</td>
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<td>1 in. x 6 in. Flex Bar</td>
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<td>1.5 in. Dia Disc</td>
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<td>RCC Baseline Coated TEOS Impregnated Specimens</td>
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<td>2</td>
<td>-</td>
<td>1.5 in. x 6.5 in. x 33 Ply RCC Flexure</td>
<td>2-11 and 2-26</td>
<td>Shipped to NASA/JSC</td>
</tr>
<tr>
<td>10</td>
<td>-</td>
<td>1.5 in. x 6.5 in. x 19 Ply RCC Flexure Bar</td>
<td>2-1-1, 2-2-1, 2-7-1, 2-8-1, 2-9-1, 2-10-1, 2-13-1, 2-24-1, 2-35-1, 2-36</td>
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<tr>
<td>18</td>
<td>-</td>
<td>2.8 in. Dia x 19 Ply RCC Disc</td>
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<td>NASA Mass Loss Specimens-19 Ply</td>
<td>NO39P-1 thru NO39P-9</td>
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<td>NASA Mass Loss Specimens-33 Ply</td>
<td>NO40P-1 thru NO40P-9</td>
<td>Shipped to NASA/JSC</td>
</tr>
</tbody>
</table>

**ORIGINAL PAGE IS OF POOR QUALITY.**
To gather data with which to substantiate the predicted characteristics of the "pack cementation", a coating system on Speer 890S graphite, NASA delivered two heater elements to Vought which were cut into small specimens and coated. The coating thickness was very irregular - the coating disappearing completely at the corners of the specimens. The coating bond to the graphite was also extremely fragile and the graphite had eroded severely in the areas of coating discontinuity.

Based on these test data, it was agreed with the NASA Technical Monitor that the existing NASA heater bars would not be coated with the Vought silicon carbide "pack cementation" process as specified in the contract. Instead, three NASA (-5) configuration heater bars (Figure 1.0, Page 9), of ATJ graphite would be silicon carbide coated with the Vought "pack cementation" process, and three (-5) configuration bars of Stackpole Grade 2020 graphite would be silicon carbide coated with the chemical vapor deposition process by the Materials Technology Corporation of Garland, Texas. Vought would supply the graphite to NASA/JSC, NASA would machine the elements, and Vought would be responsible for coating the bars. The length of the bar would be limited to 28 in, maximum by the diameter of the Materials Technology Corporation coating reactor. The CVD applied coating thickness would be 0.010 in. applied in two 0.005 in. passes. The bar supports would be repositioned for the second pass to preclude pin holes through the coating at the support points.

NASA completed machining of the six bars to the NASA (-5) heater bar configuration and shipped them to Dallas on 4 December 1976. One bar was fractured at Materials Technology Corporation during coating. The failure was reported to the NASA technical monitor. He instructed Vought to ship the bar "as is".

The bars were coated and shipped to NASA/JSC on 27 January 1976. Copies of the shipping papers are presented in Enclosure (3).

On arrival of the six bars at NASA/JSC, all were broken. As replacements, Vought machined 2 additional bars of Stackpole graphite Grade 2020, had them CVD coated by Materials Technology Corporation, and "hand carried" them to NASA/JSC on 13 April 1976.
**FIGURE 1.0**

NASA/JSC HEATER ELEMENT CONFIGURATION

---

<table>
<thead>
<tr>
<th>DASH NO.</th>
<th>DIM A</th>
<th>DIM B</th>
<th>DIM C</th>
</tr>
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<tr>
<td>-1</td>
<td>72.000</td>
<td>73.000</td>
<td>420.004</td>
</tr>
<tr>
<td>-3</td>
<td>48.000</td>
<td>49.000</td>
<td>182.003</td>
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<tr>
<td>-5</td>
<td>17.000</td>
<td>19.200</td>
<td>4:75.059</td>
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2.3 NASA Mass Loss Specimens - RCC Baseline Coated and TEOS Impregnated

By Paragraph 3.1.6 of Reference (a), "18 specimens shall be supplied to the configuration shown in Figure 2.0, page 11. Nine shall be cut from one 12 in. x 16 in. x 33 ply panel, and 9 shall be cut from a 12 in. x 16 in. x 19 ply panel. The specimens shall be baseline coated and TEOS impregnated."

The specimens were shipped to NASA/JSC on 21 December 1976. Copies of the shipping papers, and the Certification Report are presented in Enclosure (5).

2.4 RCC BASELINE COATED AND TEOS IMPREGNATED TEST SPECIMENS

By Reference (b), the contract statement of work was revised with the addition of Paragraph 3.3 to the TEOS impregnation of 50 RCC baseline coated specimens. The specimens were to be government furnished in the following mix.

a. 20 - 3" diameter disc (33 ply)
b. 18 - 3" diameter disc (19 ply)
c. 10 - 1 1/2 in. x 6 1/2 in. bar (19 ply)
d. 2 - 1 1/2 in. x 6 1/2 in. bar (33 ply)

The TEOS was to be applied using the same processes defined in specifications accepted by the prime Shuttle Contractor.

The specimens were received on 5 October 1976, TEOS Impregnated, and shipped to NASA/JSC on 7 December 1976. Copies of the shipping papers and certification documentation are presented in Enclosure (4). The specimens are identified by configuration and serial number in Table 1.0, page 7.
NASA RCC MASS LOSS SPECIMEN CONFIGURATION

NOTE: WIDTH (b) AND LAMINATE THICKNESS (t) TO BE MEASURED IN CENTER TEST AREA.

FIGURE 2.6
REFERENCES


**LIST OF TABLES**

<table>
<thead>
<tr>
<th>1.0</th>
<th>RCC SPECIMEN SUMMARY</th>
<th>7</th>
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<th>Description</th>
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<tr>
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<td>NASA/JSC HEATER ELEMENT CONFIGURATION</td>
<td>9</td>
</tr>
<tr>
<td>2.0</td>
<td>NASA RCC MASS LOSS SPECIMEN CONFIGURATION</td>
<td>11</td>
</tr>
</tbody>
</table>
ENCLOSURE (1)

TEST SPECIMEN SHIPPING PAPERS
AND CERTIFICATION DOCUMENTS - RCC
BASELINE COATED TEST SPECIMENS

CONTRACT NAS9-14476
<table>
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<th>PART NO.</th>
<th>DESCRIPTION</th>
<th>UN．</th>
<th>AMOUNT</th>
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<tr>
<td>1</td>
<td>2 ea.</td>
<td>221GT4027</td>
<td>Lug Specimens - Serial Nos.: 9-7 &amp; 9-8</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>2</td>
<td>18 ea.</td>
<td>221GT4027</td>
<td>1 In. Dia. Discs - Serial Nos.: 7-29, 7-30, 7-31, 7-32, 7-33, 7-35</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>3</td>
<td>23 ea.</td>
<td>221GT4027</td>
<td>2.8 In. Dia. Discs - Serial Nos.: 3-18-1, 3-19-1, 3-20-1, 3-21-1, 3-48, 3-50, 3-51, 3-54</td>
<td>N/A</td>
<td>N/A</td>
</tr>
</tbody>
</table>

**INSPECTION REQUIRED:** ☑ LTV  ☑ GOVT.  ☑ CUST.

**MATERIAL CLASS:** □ HAZARDOUS  □ NON-HAZARDOUS

**REFER TO:**

Paragraph 3.1 of S.C.W.

**CONTRACT ITEM NO.**

**QUANTITY**

**PART NO.**

**DESCRIPTION**

**UNIT PRICE**

**TOTAL AMOUNT**

**SIGNATURE**

G. B. Whisenhunt  2-16000  (214)266-7722
<table>
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<th>PART NO.</th>
<th>DESCRIPTION</th>
<th>UNIT PRICE</th>
<th>TOTAL AMOUNT</th>
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<td>1\times 6 Flex Bars - Serial Nos.:</td>
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**Quality Control NDE and Test Logs and Certification Report**

- Material Class: Non-Hazardous
- Delivery Date: ASAP
- Contract: GOVT. CONTRACT ORDER NO. 2655 AAAA
- Inspection: LTV

**G. B. Whisenhunt**

Signature

Date: 2-16000 (214) 266-7722

**Box No.**: 0-00000

**Type in Division Name**: Report No. 221, RPN6053

**Enclosure (1)**

**Page No.**: 2 of 20
NASA COATED CARBON TEST SAMPLES

DOCUMENTATION PACKAGE

CONTRACT NASA-14476
VOUGHT SYSTEMS DIVISION
LTV AEROSPACE CORPORATION
P. O. BOX 5907
DALLAS, TEXAS 75222

This certifies that the RCC test specimens listed herein conform to the requirements of Contract NAS 9-14476 with the exceptions noted in the Deviation Summary.

Test reports and acceptance data are on file and are subject to examination on request.

G. F. Bentinck 4/11/75
Quality Program Manager
Leading Edge Structural Subsystem
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<th>PAGE</th>
<th>Title</th>
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<td>Certificate of Compliance</td>
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<td>3</td>
<td>Statement of Nondestructive Test Results</td>
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<td>4</td>
<td>Test Data Summary</td>
</tr>
<tr>
<td>5</td>
<td>Deviation Summary</td>
</tr>
<tr>
<td>6</td>
<td>Serial Number Listing</td>
</tr>
</tbody>
</table>
NONDESTRUCTIVE TEST RESULTS

RCC specimens included in this shipment have been subjected to radiographic examination and ultrasonic inspection per Process Specifications 208-7-40 and 208-7-41 and accepted.

Coating thickness has been verified by eddy current technique and has been accepted with deviations noted in Deviation Summary.
TEST DATA SUMMARY

- **FLEX TEST**
  - As coated 14,247 - 14,731 psi
  - Furnace cycled 13,100 - 15,705 psi

- **FURNACE CYCLE % WEIGHT CHANGE**
  - .06 to +.30 percent
  - -1% max.

- **PLASMA TEST MASS LOSS**
  - .78 to 1.61 x 10^-5 lbs. ft. sq.
  - 4.0 x 10^-5 max.
**DEVIATION SUMMARY**

1. Specimens 014-2-26, 014-4-6-1, and 026-6-36 do not have .03 radius on edges (LDS 65063).

2. Specimens have spots in coating and/or discoloration of coating (LDS 63837, 63842, 63840).

<table>
<thead>
<tr>
<th>S/N</th>
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<td>7-37</td>
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</table>

3. Ink markings came through coating (LSD 63837).

4. Temperature lagging time requirements of specification during coating cycle (LDS 63833).

5. Specimens 015-9-7 and 015-9-8 have coating thickness to .044 in. Exceeds spec. max. of .040 in. (MRA 043694).
<table>
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</table>
**Security Classification**

TOP SECRET CONFIDENTIAL UN-CLASSIFIED

(TYPE IN DIVISION NAME)

\[\text{Vought Systems Division}

\text{LTV Aerospace Corporation}

\text{P.O. Box 5907}

\text{Dallas, Texas 75222}

\]

\[\text{Transportation Officer}

\text{NASA Lyndon B. Johnson Space Center}

\text{Houston, Texas 77058}

\]

\[\text{Mark for: Accountability Property}

\text{Officer 807402}

\]

\[\text{Mark with: Purchase Req. No. 4-266-020}

\text{Contract \# NAS9-14476T}

\]

\[\text{For reissue to: D. J. Tillian, ESL, Bldg. 420}

\]

\[\text{DATE 11 July 1975}

\]

\[\text{NUMBER RFS-RCC-79}

\]

\[\text{INSPECTION REQUIRED: X LTV GOVT. CUST.}

\]

\[\text{MATERIAL CLASS: □ HAZARDOUS X NON-HAZARDOUS}

\]

\[\text{REFFER TO: Paragraph 3.1 of S.O.W.}

\]

\[\text{ACCOUNT NO.}

\]

\[\text{DELIVERY DATE DUE}

\]

\[\text{YOUR PO NUMBER}

\]

\[\text{F. O. B. VIA}

\]

\[\text{Houston, Texas}

\text{Air}

\]

\[\text{REJ. REPORT NO.}

\]

\[\text{OUR PO NUMBER}

\]

\[\text{STORES REQ.}

\]

\[\text{GOVT CONTRACT}

\text{NAS9-14476}

\]

\[\text{ORDER NO.}

\text{2636-AAAA}

\]

\[\text{CONTRACT ITEM NO.}

\]

\[\text{QUANTITY}

\]

\[\text{PART NO.}

\]

\[\text{DESCRIPTION}

\]

\[\text{UNIT PRICE}

\]

\[\text{TOTAL AMOUNT}

\]

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<tr>
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<th>DESCRIPTION</th>
<th>UNIT PRICE</th>
<th>TOTAL AMOUNT</th>
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</thead>
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<tr>
<td>1</td>
<td>6 ea.</td>
<td>221GT 4066</td>
<td>1 In. x 6 In. Flexure Bars - Ser. Nos.: 032-022 033-026</td>
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<td>N/A</td>
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<td></td>
<td></td>
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<td>032-023 033-027</td>
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<td>032-024 033-025</td>
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<td>2.8 In. Dia. Discs (Un-instrumented) Serial Nos.: 033-011 033-009</td>
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<td>031-002 031-008</td>
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<tr>
<td>4</td>
<td>11 ea.</td>
<td>221GT 4066</td>
<td>1.5 In Dia. Discs - Ser. Nos.: 033-029 033-030</td>
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<td>033-031 033-036</td>
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<td>033-032 033-037</td>
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<td>033-034</td>
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</table>

\[\text{INSPECTION LTV CUST LTV CUST LTV CUST LTV CUST}

\]

\[\text{LAYOUT CUST CUST CUST}

\]

\[\text{PRESERVATION PACKING}

\]

\[\text{AUTHORISED IN ACCORDANCE WITH AER. S.P. 441.1}

\]

\[\text{SIGNATURE}

\]

\[\text{G. R. Whisenhunt 2-16000 7722}

\]

\[\text{NAME(TYPE) UNIT EXT.}

\]

\[\text{FOR SHIPPING USE ONLY CHECK M.I.R. COMM. INV. SHIP. MEMO DATE SHIPPED}

\]

\[\text{REQUEST FOR SHIPMENT 0-87574 R2}

\]
Request for Shipment  RFS-RCC-79

Date  11 July 1975

(Continued)

<table>
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<th>Description</th>
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<th>Total Amount</th>
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<tr>
<td>5</td>
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<td>1 In. x 1 In. Squares - Ser. Nos.: 032-046 032-061 032-082 032-047 032-064 032-083 032-048 032-065 032-084 032-049 032-066 032-086 032-050 032-067 032-087 032-051 032-068 032-088 032-052 032-069 032-089 032-053 032-071 032-090 032-055 032-072 032-091 032-056 032-075 032-092 032-057 032-076 032-093 032-058 032-078 032-094 032-059 032-080 032-092 032-060 032-081</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>6</td>
<td>1 ea.</td>
<td>221GT 4066</td>
<td>6 In. x 12 In. Panel - Ser. No. 031-001</td>
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<td>N/A</td>
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<td>7</td>
<td>3 copies</td>
<td>221GT 4066</td>
<td>Quality Control NDE and Test Logs and Certification Report</td>
<td>N/A</td>
<td>N/A</td>
</tr>
</tbody>
</table>
This certifies that the RCC test specimens listed herein conform to the requirements of Contract NAS9-14476 with the exceptions noted in the Deviation Summary.

Test reports and acceptance data are on file and are subject to examination on request.

F. J. Patterson
Quality Program Manager
Leading Edge Structural Subsystem

Date 17 July 1976
TABLE OF CONTENTS

PAGE
1 Certification of Compliance
2 Table of Contents
3 Statement of Nondestructive Test Results
4 Test Data Summary
5 Deviation Summary
6 Serial Number Listing
NONDESTRUCTIVE TEST RESULTS

RCC specimens included in this shipment have been subjected to radiographic examination and ultrasonic inspection per Process Specification 208-7-40 and 208-7-41 and accepted.

Coating thickness has been verified by Eddy Current technique and has been accepted with deviations noted in Deviation Summary.
### TEST DATA SUMMARY

<table>
<thead>
<tr>
<th></th>
<th>ACTUAL</th>
<th>REQUIRED</th>
</tr>
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<tbody>
<tr>
<td><strong>FLEX TEST</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>As coated</td>
<td>12638 PSI</td>
<td>12042 PSI minimum</td>
</tr>
<tr>
<td>Furnace cycled</td>
<td>13147 PSI</td>
<td>11133 PSI minimum</td>
</tr>
<tr>
<td><strong>FURNACE CYCLED % WEIGHT CHANGE</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-0.39 to -0.90 Percent</td>
<td></td>
<td>-1% maximum</td>
</tr>
<tr>
<td><strong>PLASMA TEST MASS LOSS</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.62 to 2.39 x 10^-5 lbs. ft. sq.</td>
<td>4.0 x 10^-5 maximum</td>
<td></td>
</tr>
</tbody>
</table>
DEVIATION SUMMARY

1. All specimens have darker color, brownish, on mold side than normal (Ref. LDS #72977).

2. 1.5" dia. discs S/N #033-045 has white ditto mark on bag surface, 3" long (Ref. LDS #72965).

3. Specimens S/N's 033-35 and 033-36 have coating thickness below specification limit. Thickness should be .020 - .040. Specimens measure:
   
   033-35 .019 mold side .024 bag side
   033-36 .019 mold side .025 bag side

Reference MRA 0053542.
**SERIAL NUMBER LISTING**

1 In. x 6 In. Flecture Bars - Serial No.'s:
- 032-022
- 033-023
- 033-024
- 033-025

2.8 In. Dia. Discs (Uninstrumented) - Serial No.'s:
- 033-011
- 033-010
- 033-009

1.5 In. Dia. Discs - Serial No.'s:
- 033-029
- 033-030
- 033-031
- 033-032
- 033-033
- 033-034

1 In. x 1 In. Squares - Serial No.'s:
- 032-046 032-061 032-082
- 032-047 032-064 032-083
- 032-048 032-065 032-084
- 032-049 032-066 032-086
- 032-050 032-067 032-087
- 032-051 032-068 032-088
- 032-052 032-069 032-089
- 032-053 032-071 032-090
- 032-055 032-072 032-091
- 032-056 032-075 032-092
- 032-057 032-076 032-093
- 032-058 032-078 032-094
- 032-059 032-080 032-062
- 032-060 032-081

6 In. x 12 In. Panel - Serial No.:
- 031-001
<table>
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<tr>
<th>ITEM</th>
<th>QUANTITY</th>
<th>PART NO.</th>
<th>DESCRIPTION</th>
<th>UNIT PRICE</th>
<th>TOTAL AMOUNT</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>6 ea</td>
<td>221GT 4066</td>
<td>1 In. x 6 In. Flexure Bars - Ser. Nos.: 032-013, 032-014, 032-017, 032-018, 032-019, 032-021</td>
<td>N/A</td>
<td>N/A</td>
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</table>
ENCLOSURE (2)

TEST SPECIMEN SHIPPING PAPERS AND
CERTIFICATION DOCUMENTS - RCC BASELINE
COATED TEST SPECIMENS.

NAS 9 - 14476
**Transportation Officer**  
NASA Lyndon B. Johnson Space Center  
**DATE** 21 July 1975  
**NUMBER** RFS-RCC-81

**SHIP TO**  
Houston, Texas 77058

**Mark for:** Accountability Property Officer 807402  
**Mark With:** Purchase Req. No. 4-266-020  
**Contract #** NAS9-14476

**CHARGE**  
For Reissue To: D. J. Tillian, ES11, Bldg. 420

**INSPECTION REQUIRED:** LTV GOVT. CUST.  
**MATERIAL CLASS:** HAZARDOUS NON-HAZARDOUS

**REFER TO:** Paragraph 3.1 of S.O.W._  
**ACCOUNT NO.**  
**DELIVERY DATE DUE**  
**YOUR PO NUMBER**

**F. O. B.**  
Houston, Texas AIR

**VIA**  
**B/L NO.**  
**PREPAID**  
**COLLECT**  
**TERMS**

**SHIPMENT REQUEST**  
No: 221RPM0533

**RETURN FOR CREDIT**  
**RETURNED FOR CREDIT AND REPAIR**  
**REPAIR OR REWORK AT VENDOR'S EXPENSE**  
**REPAIR OR REWORK AT OUR EXPENSE**  
**REPAIR OR REPLACEMENT COVERED BY GUARANTEE**  
**MISCELLANEOUS (EXPLAIN)** Test Specimens

**REFERENCES TO ACCOUNT NO. DELIVERY DATE DUE- YOUR PO NUMBER**

<table>
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<th>CONTRACT ITEM NO.</th>
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<th>PART NO.</th>
<th>DESCRIPTION</th>
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<th>TOTAL AMOUNT</th>
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<td>221GT4066</td>
<td>2.8 In. Dia. Discs (Instrumented) Serial Nos:</td>
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<th>SERIAL NUMBERS:</th>
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<td>031-006</td>
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<td>031-007</td>
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<td>031-008</td>
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</table>

**INSPECTION:** LTV CUST  
**LAYOUT:** LTV CUST  
**PRESERVATION:** LTV CUST  
**PACKING:** LTV CUST

**AUTHORIZED IN ACCORDANCE WITH AER. S.P. 441.1**

**SIGNATURE**  
G. B. Whisenhunt 2-16000 7722

**NAME (TYPE):**

**UNIT:**  
**EXTR.:**

**FOR SHIPPING USE ONLY**  
CHECK M.I.R.R. COMM. INV. SHIP. MEMO DATE SHIPPED

**REQUEST FOR SHIPMENT** 0-87574 R2
This certifies that the RCC test specimens listed herein conform to the requirements of Contract NAS9-14476 with the exceptions noted in the Deviation Summary.

Test reports and acceptance data are on file and are subject to examination on request.

F. J. Patterson  
Quality Program Manager
Leading Edge Structural Subsystem  

26 August 1975

FINAL PAGE IS OF POOR QUALITY
TABLE OF CONTENTS

PAGE

1. Certification of Compliance
2. Table of Contents
3. Statement of Nondestructive Test Results
4. Test Data Summary
5. Deviation Summary
6. Serial Number Listing
RCC specimens included in this shipment have been subjected to radiographic examination and ultrasonic inspection per Process Specification 208-7-40 and 208-7-41 and accepted.

Coating thickness has been verified by Eddy Current technique and has been accepted.
<table>
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<th>FLEX TEST</th>
<th>ACTUAL</th>
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<tbody>
<tr>
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<tr>
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<tr>
<th>FURNACE CYCLED % WEIGHT CHANGE</th>
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<tr>
<td>-0.39 to -0.90 Percent</td>
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<td>-1% Maximum</td>
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<tr>
<th>PLASMA TEST MASS LOSS</th>
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<tr>
<td>1.62 to $2.39 \times 10^{-5}$ lbs. ft. sq.</td>
<td>$4.0 \times 10^{-5}$ Maximum</td>
</tr>
</tbody>
</table>
DEVIATION SUMMARY

1. All specimens have darker color, brownish, on mold side than normal (Ref. LDS #12977).
2.8 In. Dia. Discs (Instrumented)

031-002
031-003
031-004
031-005
031-006
031-007
031-008
ENCLOSURE (3)

SHIPPING PAPERS -
SILICON CARBIDE COATED NASA
HEAT ELEMENTS
CONTRACT NAS 9 - 14476
Enclosure (3) to Report
No: 221RPM0533

Page: 2 of 2

Transportation Officer
NASA Lyndon B. Johnson Space Center
Houston, Texas 77058

Mark for: Accountability Property Officer 807402

Mark with: Purchase Reg. No. 4-266-020
Contract No. NAS9-14476

For Reissue to: D. J. Tillian, ESII, Bldg. 420

(Ship in "as is" condition - No inspection required)

INSPECTION REQUIRED: [ ] LTV [ ] GOVT. [ ] CUST.

INSPECTION LAYOUT/PRESERVATION PACKING

Refer to: Paragraph 3.2 of S.O.W.

REQUEST FOR SHIPMENT

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<td>Silicone Carbide Coated Heater Bars:</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>3 Bars - Vought Corporation Silicon Carbide Pack Cementation Coating - .020 in. thick (LAVJ Graphite Bar &amp; 2 Stackpole 2020 Graphite Bars)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>3 Bars - CVD Silicon Carbide Coating - .010 in. thick (Stackpole 2020 Graphite Bars)</td>
</tr>
</tbody>
</table>

NOTE: These heater bars are "CRITICALLY FRAGILE" items - Class AA and should be packaged for shipment accordingly.
ENCLOSURE (4)

SHIPPING PAPERS AND CERTIFICATION DOCUMENTS - RCC BASELINE COATED AND TEOS IMPREGNATED TEST SPECIMENS
ENCLOSURE (4) TO REPORT
No: 221RPN0533
Page: 2 of 18

SHIPPING REQUEST
OFFICE

S. Urity Classification (Type in Division Name)

Enclosure

I - (4)

To Report

National Aeronautics & Space Administration

Johnson Space Center

1720 NASA Road 1

Houston, Texas 77058

Mark For: Accountability Property Officer 807402

Charge To

Dallas, Texas 75222

Check One

G. 0. 0. 4. 0.

B/L No.

PREPAID TERMS

COLLECT

For Reissue to: D. J. Tillian, ES11, Bldg. 420

Test Specimens - No Inspection Required

Material Class: [ ] Hazardous [ ] Non-Hazardous

Refer To:

Paragraph 3.3 of S. O. W.

Date 7 December 1976 Number RFS-RCC-119

YOUR INVOICE DATED AMOUNT REG. REPORT

Your Rej. Report No. 2636 AAAA

GOV'T. CONTRACT ORDER NO. NAS9-14476

F.O.B. VIA B/L NO. PREPAID TERMS

G. 0. NUMBER.

Houston, Texas Air Parcel Post

REJ. REPORT NO. OUR PO NUMBER STORES REQ. GOVT. CONTRACT ORDER NO. NAS9-14476

UNIT PRICE TOTAL AMOUNT

1. 20 ea 2.8 in. Dia x 33 ply RCC Disc - Baseline Coated & TEOS Impregnated.

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<td>3-59 3-66</td>
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<td>3-48</td>
<td>3-61 3-67</td>
</tr>
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2. 2 ea 1.5 in. x 6.5 x 33 ply RCC Flexure Bar Specimen, Baseline Coated & TEOS Impregnated.

<table>
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<td>2-11</td>
<td>2-26</td>
</tr>
</tbody>
</table>

Authorized in accordance with Aer. S.P. 441.1

Signature

G. R. Whisenhunt, 2-16000 7722

For shipping use only

Check M.I.H.R. COMM. INV. SHIP. MEMO DATE SHIPPED

REQUEST FOR SHIPMENT 0-87374 R2
**Request for Shipment**

**Date:** 7 December 1976

**Number:** RFS-RCC-119

**Your Invoice Dated:**

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<th>Reg. Report</th>
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**Charge To:**

- [ ] RETURNED FOR CREDIT
- [ ] RETURNED FOR CREDIT AND REPLACEMENT
- [ ] REPAIR OR REWORK AT VENDOR'S EXPENSE
- [ ] REPAIR OR REWORK AT OUR EXPENSE
- [ ] REPAIR OR REPLACEMENT COVERED BY GUARANTEE
- [ ] MISCELLANEOUS (EXPLAIN)

**Material Class:**

- [ ] HAZARDOUS
- [ ] NON-HAZARDOUS

**Inspection Required:**

- [ ] LTV
- [ ]Gov't
- [ ] Cust

<table>
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<tr>
<th>Your PO Number</th>
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<th>Part No.</th>
<th>Description</th>
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<tr>
<td></td>
<td>3. 4 ea</td>
<td>-</td>
<td>2.8 in. Dia x 19 ply RCC Disc - Baseline Coated and TEOS Impregnated, Serial Nos.: 3-14-1 3-19 009 011</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>4. 10 ea</td>
<td>-</td>
<td>1.5 in. x 6.5 in. x 19 Ply RCC Flexure Bar Specimen, Baseline Coated and TEOS Impregnated - Serial Nos.: 2-1-1 2-8 2-33 2-36 2-2-1 2-9 2-34 2-7 2-10 2-35</td>
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</table>

**Lot Price:** $5,904.00

**Signature:**

G. B. Whisenhunt 2-16000 7722

**Name (Type):**

**For Shipping Use Only:**

- [ ] Check
- [ ] M.I.R.
- [ ] COMM. INV.
- [ ] Ship. Memo
- [ ] Date Shipped

**Request for Shipment:**

0-87674 82

**Note:**

- [ ] CHECK
- [ ] M.I.R.
- [ ] COMM. INV.
- [ ] SHIP. MEMO
- [ ] DATE SHIPPED

**Enclosure (4) to Report No.: 221RPN0533**
Enclosure (4) to Report No: 221RFM0533
Page: 4 of 18

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<tr>
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<th>DATE 7 December 1976</th>
<th>NUMBER RFS-RCC-119</th>
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SHIP TO:

CHARGE TO:

INSPECTION REQUIRED: [ ] LTV [ ] GOV'T. [ ] CUST. MATERIAL CLASS: [ ] HAZARDOUS [ ] NON-HAZARDOUS

Refer to:

Account No.

Delivery Date Due

Your PO Number

F. O. S.

VIA

B/L No.

PREPAID

TERMS

REJ. Report No.

Our PO Number

Stores Req.

Gov't. Contract

Order No.

G. O. Number

Material Class:

Emergency Class:

For Shipping Use Only

Notes:

1. Per Article VII of the contract, "Final inspection and acceptance shall be accomplished by the Contracting Officer or his duly authorized representative at NASA Lyndon B. Johnson Space Center".

2. Vought Corporation inspection required for packaging and shipping only.

3. Shipping to prepare a DD-250 shipping document for shipment of these items with copies distributed as follows:

<table>
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<tr>
<th>Quant.</th>
<th>Description</th>
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<th>Total Amount</th>
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<td>NASA-JSC Contracting Officer</td>
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<td>NASA-JSC Technical Monitor</td>
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<td>NASA-JSC Accountability Property Officer, Mail Code JF9</td>
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<td>NASA-JSC Cost &amp; Accounting Branch, Mail Code BR8</td>
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<td>2</td>
<td>Data Package</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Attached</td>
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Internal Distribution - Vought:

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<tr>
<td></td>
<td>J. M. Abbott - Unit 2/65000</td>
</tr>
<tr>
<td></td>
<td>G. B. Whisenhunt - Unit 2/16000</td>
</tr>
</tbody>
</table>

Authorized in accordance with SEC. 3, P. 441.1

Signature: G. B. Whisenhunt 2-16000 7722

Name (Type): Unit: Ext.
NASA TEST SPECIMENS
CERTIFICATION REPORT

CONTRACT NAS9-14476

REPORT NO. 221RPN0526

9 DECEMBER 1976
This document certifies that the GFE RCC specimens listed herein have been TEOS impregnated in accordance with Specification procedures accepted by the prime Shuttle Contractor as required by Contract NAS9-14476.

Test reports and acceptance data are on file and are subject to examination on request.

E. E. Gantz
Test Project Engineer
Leading Edge Structural Subsystem

Date 9 December 1976
<table>
<thead>
<tr>
<th>PAGE</th>
<th>Description</th>
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<tbody>
<tr>
<td>1.</td>
<td>Certification Of Compliance</td>
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<tr>
<td>2.</td>
<td>Table Of Contents</td>
</tr>
<tr>
<td>3.</td>
<td>Nondestructive Test Results</td>
</tr>
<tr>
<td>4.</td>
<td>Test Data Summary</td>
</tr>
<tr>
<td>5.</td>
<td>Specimen Serial Number Summary</td>
</tr>
</tbody>
</table>
NONDESTRUCTIVE TESTS RESULTS

The TEOS impregnated, baseline coated RCC specimens, covered by this document have been checked for conformance with the process controls, NDE test requirements, and coating performance requirements as defined in the TEOS Impregnation Process Specification, 208-7-42 and meet the appropriate requirements as stated.
<table>
<thead>
<tr>
<th>Paragraph of Spec 208-7-42</th>
<th>Item</th>
<th>Required</th>
<th>Actual</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.2.8(b)</td>
<td>Control Specimen Weight Gain - 19 Ply Flex Bar</td>
<td>4.7% to 8.0%</td>
<td>4.99% to 7.25%</td>
</tr>
<tr>
<td>5.6.1.3</td>
<td>Control Specimen Tube Furnace Mass Loss</td>
<td>&lt;0.041 lb/ft²</td>
<td>0.028 lb/ft² max.</td>
</tr>
</tbody>
</table>
### SPECIMEN SERIAL NUMBER SUMMARY

1. **20 ea - 2.8 in. Dia x 33 ply RCC Disc - Baseline Coated and TEOS Impregnated**
   
<table>
<thead>
<tr>
<th>3-18-1</th>
<th>3-19-1</th>
<th>3-20-1</th>
<th>3-21-1</th>
<th>3-40</th>
<th>3-48</th>
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<td>3-50</td>
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<td>3-58</td>
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<td>3-68</td>
<td>3-69</td>
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<td></td>
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<td></td>
</tr>
</tbody>
</table>

2. **2 ea - 1.5 in. x 6.5 in. x 33 ply RCC Flexure Bar - Baseline Coated and TEOS Impregnated**
   
   | 2-11 |
   | 2-26 |

3. **4 ea - 2.8 in. Dia x 19 ply RCC Disc - Baseline Coated and TEOS Impregnated**
   
   | 3-14-1 |
   | 3-19   |
   | 009    |
   | 011    |

4. **10 ea - 1.5 in. x 6.5 in. x 19 ply RCC Flexure Bar - Baseline Coated and TEOS Impregnated**
   
   | 2-1-1   | 2-2-1   | 2-7     |
   | 2-8     | 2-9     | 2-10    |
   | 2-33    | 2-34    | 2-35    |
**National Aeronautics & Space Administration**

**Johnson Space Center**

**1720 NASA Road 1**

**DATE** 14 December 1976

**NUMBER** RFS-RCC-120

---

**SECURITY CLASSIFICATION**
- [ ] TOP SECRET
- [ ] CONFIDENTIAL
- [ ] SECRET
- [X] UN-CLASSIFIED
- [ ] CONFIDENTIAL - MODIFIED HANDLING

**Check one**
- [ ] Enclosure
- [ ] SHIPPING REQUEST
- [ ] SHIPPING MEMO
- [ ] DEBIT MEMO

**Mark For:** Accountability Property Officer 807402

**Mark With:** Purchase Req. No. 4-266-020

**Contract No.** NAS9-14476

**To:**

**F. O. S.**

**VIA**

**Collected**

**PREPAID**

**Order No.**

**G. O. Number** 2636 AAAA

---

**INSTRUCTION**

**INSPECTION LAYOUT PRESERVATION PACKING**

**AUTHORISED IN ACCORDANCE WITH AER. S.P. 444.1**

**G. B. Whisenhunt** 2-16000 7722

**NAME (TYPE)** **SIGNATURE**

**UNIT** **EXT.**

**FOR SHIPPING USE ONLY**

**REQUEST FOR SHIPMENT** 0-47574 R2

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**DESCRIPTION**

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<th>PART NO.</th>
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<td>2.8 in. dia. x 19 ply RCC disc - baseline coated and TEOS impregnated. Serial Nos.:</td>
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<td>3-70</td>
<td>3-76</td>
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<td><strong>Lot Price</strong> $2,296.00</td>
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<tr>
<td>2.</td>
<td>3 cc</td>
<td></td>
<td>Certification Report No. 221RP N0528</td>
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**Lot Price** $2,296.00
**Notes:**

1. Per Article VII of the contract, "Final inspection and acceptance shall be accomplished by the Contracting Officer or his duly authorized representative at NASA Lyndon B. Johnson Space Center".
2. Vought Corporation inspection required for packaging and shipping only.
3. Shipping to prepare a DD-250 shipping document for shipment of these items with copies distributed as follows:

**Quan.**

- 2 NAVPRO Inspection Agency
- 2 NASA-JSC Contracting Officer
- 1 NASA-JSC Transportation Officer
- 1 NASA-JSC Technical Monitor
- 1 NASA-JSC Accountability Property Officer, Mail Code JF9
- 1 NASA-JSC Cost & Accounting Branch, Mail Code BR8
- 2 Data Package
- 4 Attached

**Internal Distribution - Vought**

- 1 J. M. Abbott - Unit 2/65000
- 1 G. B. Whisenhunt - Unit 2/16000

---

**Table:**

<table>
<thead>
<tr>
<th>ITEM</th>
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**REQUEST FOR SHIPMENT**
NASA TEST SPECIMENS

CERTIFICATION REPORT

CONTRACT NAS9-14476

REPORT NO. 221RPN0528

17 DECEMBER 1976
This document certifies that the GFE RCC specimens listed herein have been TEOS impregnated in accordance with specification procedures accepted by the prime Shuttle Contractor as required by Contract NAS9-14476.

Test reports and acceptance data are on file and are subject to examination on request.

E. E. Gantz  
Test Project Engineer  
Leading Edge Structural Subsystem  

17 December 1976  
Date
<table>
<thead>
<tr>
<th>Page</th>
<th>Title</th>
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<tr>
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<td>Certification Of Compliance</td>
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<td>Nondestructive Test Results</td>
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<tr>
<td>4</td>
<td>Test Summary</td>
</tr>
<tr>
<td>5</td>
<td>Specimen Serial Number Summary</td>
</tr>
</tbody>
</table>
NONDESTRUCTIVE TEST RESULTS

The TEOS impregnated, baseline coated RCC specimens covered by this document have been checked for conformance with the process controls, NDE test requirements, and coating performance requirements as defined in the TEOS Impregnation Process Specification, 208-7-42, and meet the appropriate requirements as stated except that the tube furnace mass loss of both control specimens exceeds the maximum allowable specification value of 0.041 lb/ft^2.

The excessive control specimen mass loss is not considered to be indicative of unacceptable TEOS impregnation, however, since the percentage weight gain of these 14 specimens during the TEOS processing agreed closely with the weight gains experience with the other 36 specimens in the impregnation run. The indicated excessive tube furnace mass loss is considered rather to reflect a deficiency in the control specimen substrate only. No specimens of the actual specimen substrate lot were available so the control specimens were selected from another substrate lot which was adjudged to be similar.

To confirm the acceptability of the specimen TEOS impregnation, one specimen (Serial No. 3-13) was subjected to the tube furnace check, and demonstrated mass loss well within specification requirements.
## TEST DATA SUMMARY

<table>
<thead>
<tr>
<th>Paragraph of Spec. 208-7-42</th>
<th>Item</th>
<th>Required</th>
<th>Actual</th>
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</thead>
<tbody>
<tr>
<td>4.2.8(b)</td>
<td>Control Specimen Weight</td>
<td>4.7% to 8.0%</td>
<td>6.64% to 6.69%</td>
</tr>
<tr>
<td></td>
<td>Gain - 19 Ply Flex Bar</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.6.1.3</td>
<td>Control Specimen Tube Furnace Mass Loss</td>
<td>0.041 lb/ft(^2)</td>
<td>0.056 lb/ft(^2) max</td>
</tr>
<tr>
<td>5.6.1.3</td>
<td>Specimen Number 3-13 Tube Furnace Mass Loss</td>
<td>0.041 lb/ft(^2)</td>
<td>0.029 lb/ft(^2)</td>
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</table>
SPECIMEN SERIAL NUMBER SUMMARY

1. 3-13
2. 3-14
3. 3-15
4. 3-17
5. 3-70
6. 3-71
7. 3-72
8. 3-73
9. 3-74
10. 3-76
11. 3-77
12. 3-78
13. 3-80
14. 3-81
SHIPPING PAPERS AND CERTIFICATION
DOCUMENT - NASA MASS LOSS SPECIMENS, RCC
BASELINE COATED AND TEGOS IMPREGNATED

CONTRACT NAS 9 - 14476
National Aeronautics & Space Administration

Johnson Space Center
1720 NASA Road 1
Houston, Texas 77058

Mark For: Accountability Property Officer 807402
Mark With: Purchase Req. No. 4-266-020
Contract No. NAS9-14476

For Reissue To: D. J. Tillian, ES11, Bldg. 420

INSPECTION REQUIRED: X LTV □ GOVT. □ CUST.
MATERIAL CLASS: □ HAZARDOUS X NON-HAZARDOUS

Paragraph 3.1.b of S. O. W.

Houston, Texas Insured Air Parcel Post

REJ. REPORT NO. OUR PO NUMBER STORES REQ. GOV'T CONTRACT ORDER NO. G. O. NUMBER
NAS9-14476 2636 AAAA

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INSPECTION LAYOUT PRESERVATION PACKING

Authorized in accordance with AER. S.P. 441.1

G. B. Whisenhunt 2-16000 7722

CHECK M.I.R.R. COMM. INV. SHIP. MEMO DATE SHIPPED

REQUEST FOR SHIPMENT 0-87574 R2
Shipping to prepare a DD-250 shipping document for shipment of these items with copies distributed as follows:

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<tr>
<td>4</td>
<td>Attached</td>
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</tr>
</tbody>
</table>

Internal Distribution - Vought

1. J. M. Abbott - Unit 2/65000
2. G. B. Whisenhunt - Unit 2/16000
VOUGHT CORPORATION  
P. O. BOX 5907  
DALLAS, TEXAS 75222

This certifies that the POC test specimens listed below have been manufactured, inspected and tested to the applicable Vought process specifications and requirements of contract NAS9-14476.

Test data for mechanical properties and non-destructive testing is on file.

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F. J. Patterson  
Quality Assurance Manager  
LESS Program  
22 December 1976