MANUFACTURE AND DELIVERY OF COMPOSITE MOTOR CASES. VOLUME I

Roger J. Dale

Hercules, Incorporated

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April 1973
HERCULES INCORPORATED
ALLEGAN BALLISTICS LABORATORY
CUMBERLAND, MARYLAND

AO-255-135-01-012

MANUFACTURE AND DELIVERY OF
COMPOSITE MOTOR CASES

VOLUME I

FINAL TECHNICAL REPORT

ROGER J. DALE

SPONSORED BY

U.S. ARMY MISSILE COMMAND
RESEARCH, DEVELOPMENT, ENGINEERING AND
MISSILE SYSTEMS LABORATORY
PROPULSION DIRECTORATE
REDSTONE ARSENAL, ALABAMA

CONTRACT DAAH01-72-C-0829

APRIL 1973

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THE FINDINGS IN THIS REPORT ARE NOT TO BE CONSTRUED AS AN OFFICIAL DEPARTMENT OF THE ARMY POSITION.

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This report covers the design, fabrication, experimental design verification, manufacture and delivery of 20 fiberglass and 20 PRD-49 Type III three-inch diameter composite rocket motor cases for application to SMAWT (Short Range Man Portable Anti-Tank Weapons Technology). Both motor case designs had open aft ends to permit propellant to be cast and case bonded to the case wall or the insertion and bonding of a cartridge-loaded grain.
**Composite rocket motor cases**

Filament winding

PRD-49 fiber

S904 fiberglass

SMAWT (Short Range Man Portable Anti-Tank Weapons Technology)
FOREWORD

The work described in this report was performed at Hercules Incorporated, Allegany Ballistics Laboratory (ABL) in compliance with U. S. Army Missile Command Contract DAAH01-72-C-0829, ABL Authorization Order 255. The final program report covers a work period from May 8, 1972 through April 30, 1973. Project Technical Director was Mr. William S. Crownover, Propulsion Directorate, RDE and MSL, AMSMI-RK, Redstone Arsenal, Alabama. At ABL, technical design was by Mr. T. C. White and the program was conducted and controlled by Mr. Roger J. Dale.
ABSTRACT

The program goal entailed the design, fabrication, experimental design verification, manufacture and delivery of twenty each fiberglass and PRD-49 Type III three-inch diameter composite rocket motor cases, and the engineering documentation developed to support the program. The rocket motor case is for SMART (Short Range Man Portable Anti-Tank Weapons Technology), which includes a short burning time, tube launched high acceleration (high pressure) weapon. High specific strength of composites (e.g., compared to maraging steel) provides high performance in the form of light weight. Each unit is encased in its own combination storage/launcher container for the tactical environment.

The program thrust was to design optimum (i.e., minimum weight) cases within the material, dimensional and performance restrictions of MICOM Technical Requirement No. 1617, dated 15 February 1972. Task I materials were S904 fiberglass filament wound composite (FWC) in an ERL 2256/Tonox 6040 matrix. Task II materials were an advanced organic filament PRD-49 Type III and a compatible matrix to be selected by the contractor. ERL 2256/Tonox 6040 was chosen. Both motor cases were required to have full-open aft ends to permit propellant to be cast and case bonded to the case wall, or the insertion and bonding of a cartridge loaded grain. This provides the propellant with structural support in high acceleration applications.

The fiberglass design consisted of an inner and outer case. The full-open aft end inner case consists of an aluminum pole piece and helical FWC to provide forward dome integrity. A nozzle is integrally wound into each outer case using helical windings to form the throat and exit cone. The two slip-fit cases are bonded together using Epon 946.
The advanced material design features a PRD-49-III case reinforced with directional fiberglass cloth in the skirt and aft attach regions. An S904 fiberglass FWC/cloth nozzle is attached to the case with 36 dowel pins in a two-row staggered rivet pattern. There is no forward pole piece, threads are wound into the FWC and provide sufficient strength to effect closure with a threaded plug.

All program objectives were met and the program was successfully concluded within the time span of the contract.
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<td>S/N 004 Hydrotest</td>
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SECTION I

INTRODUCTION

The purpose of this program was to design, verify, and manufacture twenty each fiberglass and FRD 49-III filament wound composite (FMC) three-inch diameter rocket motor cases for delivery to the COM. This is in support of the Short Range Man Portable Anti-Tank Weapon Technology (SNAMT) Program.

Program objectives included:

(1) Pull-open aft end to accept a case bonded propellant grain.

(2) Optimize design for minimum weight.

(3) Verify designs by hydrobursting cases.

(4) Prepare and issue a Final Technical Report describing the designs, raw materials acceptance procedure, material preparation, cooling, and inspection results including dimensional and weight data.

The above objectives are successfully completed with this report.
SECTION II
FIBERGLASS CASE

A. DESIGN

Figures 1, 2, and 3 show the fiberglass case-in-case (CIC) chamber assembly which meets the design requirements listed in Table I. The inner shell has a full-open aft end in which a propellant grain may be cast in place. The outer shell features an integrally wound aft dome, throat and divergent exit cone reinforced with high angle helix and hoop windings. The long, unsupported forward skirt is reinforced with 2:1 directional weave glass cloth (S901-34) to prevent bearing failure during static hydroburst.

Design disclosure consisting of all pertinent design calculations, material specifications, drawings, etc., are provided in the appendices.

1. Inner Case

The inner case design progression was based upon hydrotest results to provide adequate forward dome strength. Design philosophy centered around the lightest weight structure which would achieve a hydroburst pressure above 11,400 psi. The initial design (Design A, Table II) used four helicals and one hoop for compaction during cure and the hoop layer was machined after cure to the proper diameter. Most of the hoop layer was removed.

Hydrotest of the initial inner case design showed hoop failure of the inner case at the forward dome/pole-piece area. Helical windings were increased from four to six, eliminating the failure mode. Two cases were made
Figure 2. Case-in-Case Components

Figure 3. Case-in-Case Partially Assembled
TABLE I
DESIGN REQUIREMENTS
(technical Requirement No. 1617, 15 Feb. 1972)

A. ROVING MATERIAL

1. Cas-in-Case
   Owens Corning Fiberglass HTS-904 finish, continuous 12-end roving.

2. Advanced Material
   DuPont TED-49 Type III - 380 denier, 12-end roving

B. RESIN MATRIX

1. Case-in-Case
   Union Carbide ERL 2256 resin
   Uniroyal Tonox 6040 crosslinking agent

2. Advanced Material
   Contractor to select for compatibility with roving. ERL 2256/Tonox 6040 chosen.

C. DESIGN PARAMETERS

Payload Weight: 2.95 lbs.
Design Pressure: 11,400 psi (a)
Design Acceleration: 48,500 lbf/burnout wt. (a)
Static Thrust: 32,300 lbf

D. DESIGN DIMENSIONS

<table>
<thead>
<tr>
<th></th>
<th>CIC</th>
<th>Adv.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inside Diameter (in.)</td>
<td>2.734</td>
<td>2.734</td>
</tr>
<tr>
<td>Maximum O.D. (in.)</td>
<td>3.150</td>
<td>3.150</td>
</tr>
<tr>
<td>Throat Diameter (in.)</td>
<td>1.922</td>
<td>1.922</td>
</tr>
<tr>
<td>Tangent-to-tangent (in.)</td>
<td>5.650</td>
<td>5.650 (b)</td>
</tr>
<tr>
<td>Skirt-to-tangent (in.)</td>
<td>5.200</td>
<td>---</td>
</tr>
</tbody>
</table>

(a) Includes 1.5 factor of safety over maximum expected values.
(b) Forward tangent arc to interior usable cylindrical length.
on one teflon coated aluminum mandrel and the fiberglass was machined on the mandrel after cure. The cases were separated at the centerline and stripped from the mandrel using an arbor press and tooling designed for this application.

2. Outer Case

Hydrotest results were also used to effect design progression for the outer case. Several problem areas were rectified including bearing and compression failure of the skirt, and failure of the aft dome at the tangent. Design philosophy was to achieve maximum fiber strength within the design constraints by approaching the design burst pressure from below rather than overdesigning initially and producing a heavyweight non-optimum configuration.

Table II contains the outer case design progression with the designated failure modes. Table III contains the final design parameters.

Manufacturing procedure is similar to the inner case. The only manufacturing problem encountered was roving slippage due to the small radius over the nozzle exit plane return block. Roving slippage was eliminated by using small pins at the circumference, a proven manufacturing method developed for the Poseidon igniter.
<table>
<thead>
<tr>
<th>Design</th>
<th>Inner Case (IC) Winding Pattern</th>
<th>Outer Case (OC) Winding Pattern</th>
<th>Failure Mode</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>XXXX0</td>
<td>XOXOMO•XO•DD</td>
<td>Skirt Bearing</td>
</tr>
<tr>
<td>B</td>
<td>XXXX0</td>
<td>XOXOMO•XO•DDDC•CDDCC</td>
<td>Skirt compression (cloth &amp; hoops added)</td>
</tr>
<tr>
<td>C</td>
<td>XXXX0</td>
<td>XOXOXOC•XO•CO•DDD</td>
<td>IC forward dome hoop @ pole piece</td>
</tr>
<tr>
<td>D</td>
<td>XXXXXXX0</td>
<td>XOXOXOC•XO•CO•DDD</td>
<td>OC aft tangent &lt;11,400 psig</td>
</tr>
<tr>
<td>E</td>
<td>XXXXXXX0</td>
<td>XXOXOCOXO•CO•DDD</td>
<td>OC aft tangent &gt;11,400 psig</td>
</tr>
</tbody>
</table>

where:

- $X = 27^\circ$ helical for IC
- $X = 42^\circ$ helical for OC
- C = full hoop winding
- $\bullet = 1/2$ hoop winding
- M = helical mat over aft dome and exit cone only
- C = glass cloth
- D = high angle helical reinforcement over nozzle exit plane
### TABLE III

**CASE-IN-CASE FINAL DESIGN PARAMETERS**

**Inner Case**

6 - 27° helical layers  
1 - 90° hoop layer  
(The hoop and part of 2 helicals are machined off the cylindrical section)  
t = 0.047 in.  

**Helical stress level**  
Design @ 11,400 psi  245,500 psi  
Achieved @ 12,380 psi (max.)  266,600 psi

**Outer Case**

6 - 42° helical layers  
6 - 90° hoop layers  
3 - glass cloth layers in skirt region  

**Stress levels (Hydrotest)**

<table>
<thead>
<tr>
<th>Stress Level</th>
<th>Design @ 11,400 psi (psi)</th>
<th>Achieved @ 12,380 psi (psi)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forward Skirt</td>
<td>23,520</td>
<td>25,540</td>
</tr>
<tr>
<td>Cylinder Hoop</td>
<td>250,800</td>
<td>360,970</td>
</tr>
<tr>
<td>Aft Dome</td>
<td>213,620</td>
<td>232,000*</td>
</tr>
</tbody>
</table>

**Unit**

Total Weight: 1.41 lbs.

*Failure
B. HYDROTEST

Appendix A-6 presents the hydrotest fixture sketches. Table IV presents the hydrotest summary for the CIC portion of the program, including the burst pressures and failure modes. In general, case hydrotest preparation involved providing a sealing mechanism for the case to prevent weeping of the thin fiberglass at the extremely high pressures necessary for hydroburst. Spraylat latex rubber (Spraylat Corp., 1 Park Avenue, New York, N.Y.), seam sealing compound and Epon 946 were unsuccessful in preventing weeping. Silica rubber bladders were made using green rubber and a case mandrel and were successful in preventing weeping in subsequent tests.

The hydrotest procedure involved set-up of the case in the fixture, attaching high pressure lines, bleeding all air from the system and leak testing at 100 psig. Two techniques were used to achieve high pressure, the Sprague pump and Miller Ram. The Sprague is a small diameter low capacity air-driven booster pump which has a slow reaction time. The Miller Ram is a series of fluid coupled multiplying pistons which has a fast reaction time when compared to the Sprague pump. Fast reaction time is necessary for valid testing of a motor whose burning time is measured in milliseconds. Composite strength degrades with time under stress as shown in Figure 4. (1,2)


<table>
<thead>
<tr>
<th>Case S/N</th>
<th>Design &amp; Test No.</th>
<th>Date</th>
<th>Pump</th>
<th>Coating</th>
<th>Max. Press. (psi)</th>
<th>Time Under Press. (sec)</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>001</td>
<td>A-1</td>
<td>8/14/72</td>
<td>Miller</td>
<td>Spraylat 8</td>
<td>4810</td>
<td>30</td>
<td>General leakage, weeping</td>
</tr>
<tr>
<td></td>
<td>A-2</td>
<td>8/14/72</td>
<td>Miller</td>
<td>Spraylat 8</td>
<td>4890</td>
<td>10</td>
<td>General leakage, weeping</td>
</tr>
<tr>
<td></td>
<td>A-3</td>
<td>8/14/72</td>
<td>Miller</td>
<td>Spraylat 8</td>
<td>6060</td>
<td>0.95</td>
<td>Skirt failed in bearing against fwd plate</td>
</tr>
<tr>
<td></td>
<td>B-4</td>
<td>8/24/72</td>
<td>Sprague</td>
<td>Spraylat 8 + SSC</td>
<td>5594</td>
<td>18</td>
<td>Skirt failed in compression at forward tangent</td>
</tr>
<tr>
<td>002</td>
<td>A-1</td>
<td>8/14/72</td>
<td>Miller</td>
<td>Spraylat 8</td>
<td>4934</td>
<td>4</td>
<td>General leakage, weeping</td>
</tr>
<tr>
<td></td>
<td>A-2</td>
<td>8/14/72</td>
<td>Sprague</td>
<td>Spraylat 8</td>
<td>5170</td>
<td>30</td>
<td>General leakage, weeping</td>
</tr>
<tr>
<td></td>
<td>A-3</td>
<td>8/26/72</td>
<td>Sprague</td>
<td>Spraylat 8</td>
<td>5770</td>
<td>39</td>
<td>General leakage, weeping</td>
</tr>
<tr>
<td></td>
<td>B-4</td>
<td>8/25/72</td>
<td>Sprague</td>
<td>Spraylat 8 + SSC</td>
<td>6225</td>
<td>6</td>
<td>Skirt failed in compression at forward tangent</td>
</tr>
<tr>
<td>003</td>
<td>C-1</td>
<td>9/8/72</td>
<td>Sprague</td>
<td>Spraylat 3 coats Epon 946</td>
<td>7770</td>
<td>47</td>
<td>Weep aft cyl. section &amp; aft dome</td>
</tr>
<tr>
<td></td>
<td>C-3</td>
<td>9/27/72</td>
<td>Miller</td>
<td>Epon 946 Bladder</td>
<td>4970</td>
<td>0.74</td>
<td>Forward dome failed in hoop around pole piece, pole piece ejected</td>
</tr>
<tr>
<td></td>
<td>C-4</td>
<td>10/17/72</td>
<td>Miller</td>
<td>Epon 946 Bladder</td>
<td>8090</td>
<td>1.4</td>
<td>Forward dome failed in hoop around pole piece, pole piece ejected</td>
</tr>
<tr>
<td>004</td>
<td>C-1</td>
<td>9/27/72</td>
<td>Miller</td>
<td>Epon 946 + Spraylat + Bladder</td>
<td>9150</td>
<td>1.7</td>
<td>Forward dome failed in hoop around pole piece, pole piece ejected</td>
</tr>
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<td>005</td>
<td>D-1</td>
<td>10/11/72</td>
<td>Miller</td>
<td>Bladder</td>
<td>8410</td>
<td>2.27</td>
<td>Failed in hoop at aft tangent. Slight leak</td>
</tr>
<tr>
<td></td>
<td>D-1</td>
<td>10/11/72</td>
<td>Miller</td>
<td>Bladder</td>
<td>9422</td>
<td>1.09</td>
<td>Failed in hoop at aft tangent. No leak</td>
</tr>
<tr>
<td>006</td>
<td>E-1</td>
<td>11/8/72</td>
<td>Miller</td>
<td>Bladder</td>
<td>9257</td>
<td>3.8</td>
<td>Bladder punctured and leaked</td>
</tr>
<tr>
<td></td>
<td>E-2</td>
<td>11/8/72</td>
<td>Miller</td>
<td>Bladder</td>
<td>10137</td>
<td>5.3</td>
<td>Seal ruptured in line.</td>
</tr>
<tr>
<td></td>
<td>E-3</td>
<td>11/8/72</td>
<td>Miller</td>
<td>Bladder</td>
<td>11692</td>
<td>11.6</td>
<td>Burst at aft tangent in hoop. Time to reach pressure 7.6 sec. Pressurization rate 4,440 psi/sec.</td>
</tr>
<tr>
<td>007</td>
<td>E-1</td>
<td>10/20/72</td>
<td>Miller</td>
<td>Bladder</td>
<td>9520</td>
<td>1.9</td>
<td>Bladder and nozzle O-ring failed, explosive decompression</td>
</tr>
<tr>
<td></td>
<td>E-2</td>
<td>10/20/72</td>
<td>Miller</td>
<td>Bladder</td>
<td>5716</td>
<td>0.72</td>
<td>Inner and outer cases separated, probably because of previous test. Forward dome slightly cracked 180° apart.</td>
</tr>
<tr>
<td></td>
<td>E-3</td>
<td>11/7/72</td>
<td>Miller</td>
<td>Bladder</td>
<td>5838</td>
<td>0.76</td>
<td>Reheated. Forward dome failed in area noticed after test #2.</td>
</tr>
<tr>
<td>008</td>
<td>E-1</td>
<td>11/10/72</td>
<td>Miller</td>
<td>Bladder</td>
<td>12380</td>
<td>2.61</td>
<td>Burst at aft tangent in hoop</td>
</tr>
</tbody>
</table>

| Notes: | Sealed Sealing Compound |
S/N 001 (Design A) failed in bearing at the forward plate at 6060 psig. The failed area was faced off and the skirt was reinforced for the forward 3 inches using three layers of S901-34 cloth and S904 roving (Design B). Epon 826 and ZL-0803 room temperature cure resin was used to prevent having to remove and reapply the Spraylat coating. S/N 002 was modified in the same manner. Upon rehydrotest, S/N 001 and 002 both failed in compression in the outer shell near the forward tangent of the inner shell at 5594 and 6225 psig, respectively (Figure 5). After failure, the skirt was sectioned and tested in compression in a Baldwin testing machine. The unreinforced section failed at 15,750 lbs and the reinforced section failed at 37,900 lbs, a safety factor of 1.17 over the required 32,300 lbs.

S/N 003 and 004 (Design C) burst at 8090 psig and 9190 psig, respectively. Failure was characterized by a probable hoop failure of the fibers around the pole pieces, causing them to be ejected (Figure 6). Design ultimate helical stress of 420,000 psi for S-904 was reduced 90% (380,000 psi) as used in larger vessels. Stress achieved during the test was about 290,700 psi probably due to pole piece wedging. Examination of the skirts and aft domes showed no evidence of incipient failure.

S/N 005 and 006 were manufactured with two additional helicals over the inner case forward dome (Design D), to reduce the stress level to about 245,500 psi at ultimate pressure. The helicals as wound extend the full length of the case but are machined off the cylindrical section for fitting in the outer case. Hydroburst occurred in hoop at the outer case aft tangent/dome area for both units (Figure 7). S/N 005 burst at 8400 psig and 006 at 8400 psig.
Figure 5. S/N 001 and 002 Hydrotest

Figure 6. S/N 004 Hydrotest
S/N 007 and 008 incorporated two additional helicals for the full length of the unit and extends a skirt hoop winding to the aft tangent (Design E). Calculated stress level at the aft dome is 213,600 psi at burst. S/N 008 was hydrotest to 9520 psig before the bladder and nozzle o-ring failed and the unit explosively decompressed. The unit was retested to 3716 psig where the inner and outer cases separated and the inner case moved rapidly forward, impacting the skirt support ring with considerable force.

Upon disassembly and inspection, it was discerned that the bond line did not fail. About 50% of the inner layer of helicals from the outer case stayed with the inner case (Figure 5), and some of the outer helicals from the inner case remained with the outer case. These helicals were removed by sanding and the cases were rebonded. Inspection also revealed two small cracks in the inner case forward dome, 180° apart, probably caused by the dome impact against the skirt support. Failure is attributed to the damage caused by explosive decompression on the first test.

The unit was instrumented with linear potentiometers to determine unit shrinkage as a function of pressure to ensure the nozzle o-ring seal is in position at pressure. The unit failed in the forward dome in the cracked area at 5838 psig.

The hydrotest bladder for unit S/N 007 passed a pressure leak test before being inserted into the pressure vessel. The assembly was positioned in the hydrotest fixture with 0.050 inch shims inserted between the aft plate and the floating piston to move the o-ring seal forward. The unit
Figure 7. S/N 005 and 006 Hydroburst

Figure 8. S/N 006 Inner Case After Separation
and fixture were instrumented with linear potentiometers to determine the unit shrinkage and the fixture extension under pressure. Pressure was applied and a leak was observed at 9357 psig. Pressure was gradually removed, the unit disassembled and the bladder was examined for possible leaks by pressure testing. A small slit was found in an area which appears to have been pinched.

The bladder was repaired and the unit assembled using seam sealing compound around the beveled edge of the floating piston and joint between the piston and nozzle approach section. Pressure reached 10,137 psig before a seal ruptured in the high pressure hydraulic line leading to the case. Pressure was gradually removed as the seal was replaced.

Pressure was applied and reached the equipment limitation in 2.6 seconds. Pressure remained on the unit for an additional 9 seconds when the unit burst in hoop at the outer case aft tangent, propagating into both the dome and cylindrical section (Figure 9). Minimum acceptable burst pressure is 11,400 psig. Pressure achieved was 11,692 psig without normalizing. Assuming no damage from the previous two tests and normalizing the 11.6 second to 0.007 second (Figure 4), the burst pressure is equivalent to about 14,000 psig.

Based upon the above results, production of the twenty delivery units was initiated.

S/N 023 was randomly selected from the second set of 10 cases to be manufactured as a quality check hydroburst. Burst occurred at 12,380 psig, over 8% above the minimum required burst pressure of 11,400 psig (Figure 10).
Figure 9. S/N 007 Hydroburst

Figure 10. S/N 023 Hydroburst
C. RESULTS, CONCLUSIONS AND RECOMMENDATIONS

1. Results and Conclusions

Hercules has successfully designed and manufactured a lightweight fiberglass three-inch diameter rocket motor which meets or exceeds all requirements of TR 1617. Total pressure vessel weight with a stub skirt is less than 0.8 pounds on the average, and includes inner case, outer case, pole piece and bonding resin. The extended length skirt weighs about 0.6 pounds for a total average unit weight of about 1.4 lbs. Manufacturing and inspection records are provided as appendix A-7, with the weights of the unassembled inner and outer cases, and pertinent inspected dimensions.

2. Recommendations

Further reduction in unit weight may be accomplished by judicious selection of materials for certain design requirements. For example, glass must be used for the inner case because of the difficulty in machining PRD to a smooth surface which will slip-fit with the outer case. The weight difference between the two materials in this small application is insignificant, and the probable expense in developing a machining method is not justified.

The external case weight, however, is significantly reduced by using PRD and a light-weight resin. Minimum machining is required and is in areas where surface finish is not critical. Shear appears to be a problem with PRD thus it is recommended that directional glass cloth be used as the lateral skirt reinforcement rather than PRD on the outer case.
A calculated weight breakdown of the combined PRD/glass design is compared to the average weights from the all fiberglass design in Table V.

It is recommended that a program be conducted to design and verify a fiberglass/PRD case-in-case unit for a 40% savings in weight.

A second recommendation is to conduct a manufacturing methods study to determine the most effective and efficient methods of high volume manufacturing rates for the design.
### TABLE V
COMPOSITE CASE-IN-CASE WEIGHT COMPARISON

<table>
<thead>
<tr>
<th></th>
<th>All Fiberglass (lb)</th>
<th>Combined Fiberglass and PRD (lb)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Pressure Vessel</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Inner Case</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Polar Adapter</td>
<td>0.0456</td>
<td>--</td>
</tr>
<tr>
<td>Fiberglass</td>
<td>0.1731</td>
<td>0.170</td>
</tr>
<tr>
<td>Centerport Plug</td>
<td>--</td>
<td>0.005</td>
</tr>
<tr>
<td>Resin</td>
<td>0.0547</td>
<td>0.049</td>
</tr>
<tr>
<td></td>
<td>0.2734</td>
<td>0.224</td>
</tr>
<tr>
<td><strong>Outer Case</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fiber</td>
<td>0.3117</td>
<td>0.182</td>
</tr>
<tr>
<td>Resin</td>
<td>0.0985</td>
<td>0.094</td>
</tr>
<tr>
<td></td>
<td>0.4101</td>
<td>0.276</td>
</tr>
<tr>
<td><strong>Bonding Resin</strong></td>
<td>0.013</td>
<td>0.013</td>
</tr>
<tr>
<td>Total Pressure Vessel</td>
<td>0.6965</td>
<td>0.513</td>
</tr>
<tr>
<td><strong>Skirt</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fiber</td>
<td>0.4913</td>
<td>0.282</td>
</tr>
<tr>
<td>Cloth</td>
<td>0.0680</td>
<td>0.068</td>
</tr>
<tr>
<td>Resin</td>
<td>0.3551</td>
<td>0.146</td>
</tr>
<tr>
<td>Total Skirt Weight</td>
<td>0.7144</td>
<td>0.496</td>
</tr>
<tr>
<td><strong>Total Unit Weight</strong></td>
<td>1.4109</td>
<td>1.009</td>
</tr>
</tbody>
</table>
A. DESIGN

Figures 11 and 12 show the PRD 49-III chamber/nozzle assembly which meets the design requirements listed in Table I. The case has a full-open aft end in which a propellant grain may be cast in place. The case features a glass cloth reinforced stub skirt, wound-in threads in the forward dome, no polar adapter and a glass cloth reinforced aft case/nozzle joint. The S904 fiberglass/S901-34 direction glass cloth nozzles are wound separately, line drilled with the case and are assembled to the case using thirty-six 1/8 inch dia. by 7/16 long dowel pins in a two row staggered pattern.

Design disclosure for the unit and all pertinent specifications and procedures are provided in the appendices.

1. Case

The unit design progression was based upon hydrotest results to provide the lightest weight system consistent with design requirements, Table VI. Table VII contains the PRD case final design parameters.

Two nozzles and doubler sections representing the nozzle/case joint were assembled and tested in shear on a Baldwin testing machine. Average failure load was 22,000 lbs at a cross head speed of 0.05 in/min. Anticipated bearing load on the PRD/glass doubler by the pins at 11,400 psig hydrotest pressure is 33,500 psi, and 23,500 psi (70%) was reached before movement occurred. Failure (movement) was characterized by rotation of the dowel pins and slight
Figure 12. PRD Cases S/N 001 and 002
## TABLE VI

### FRD UNIT DESIGN PROGRESSION

<table>
<thead>
<tr>
<th>Design</th>
<th>Case Winding Pattern</th>
<th>Failure Mode</th>
</tr>
</thead>
<tbody>
<tr>
<td>A - Aft Ped</td>
<td></td>
<td>Tension at forward nozzle pin ring.</td>
</tr>
<tr>
<td>B - Pressure Vessel Forward Skirt Aft Doubler</td>
<td>XO XO XO XO 0 0 0 CH₄COCOCOCH</td>
<td>CH</td>
</tr>
<tr>
<td>C - Pressure Vessel Forward Skirt Aft Doubler</td>
<td>XO XO XO XO 0 0 0 CH₄COCOCOCH</td>
<td>CH</td>
</tr>
<tr>
<td>Nozzle</td>
<td>XXXXX00000 CCO</td>
<td>Repeat 7 times</td>
</tr>
</tbody>
</table>

Where:  
X = 1 15° helical layer (case) 42° layer (nozzle)  
0 = 1 hoop layer over entire length  
H = 1 hoop layer over skirt or doubler only  
C = 1 layer of S901-34 glass cloth  
R₉ = hoop fill-in for forward skirt/dome junction

*Design A used type 181 FRD cloth  
**Repeated to assure 3.150 minimum diameter after machining
**TABLE VII**

**PRD FINAL DESIGN PARAMETERS**

**Nozzle**

4 - 42° helical layers  
13 - 90° hoop layers  
14 - glass cloth reinforcement.

**Case**

4 - 15° helical layers  
Refer to Table VI, Design B.

**Stress levels (hydrotest)**

<table>
<thead>
<tr>
<th></th>
<th>Design @ 11,400 psi</th>
<th>Achieved @ 12,250 psi</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forward Dome</td>
<td>304,560</td>
<td>327,250</td>
</tr>
<tr>
<td>Fwd Opening (shear)</td>
<td>12,630</td>
<td>13,570</td>
</tr>
<tr>
<td>Hoop</td>
<td>320,000</td>
<td>343,840</td>
</tr>
<tr>
<td>Nozzle tension</td>
<td>41,450</td>
<td>44,520</td>
</tr>
<tr>
<td>Nozzle bearing</td>
<td>37,640</td>
<td>40,440</td>
</tr>
<tr>
<td>Static Skirt Compression</td>
<td>19,714</td>
<td>21,180</td>
</tr>
<tr>
<td>Static Skirt Shear Stress</td>
<td>2.563</td>
<td>2.750</td>
</tr>
</tbody>
</table>

**Unit**

<table>
<thead>
<tr>
<th>Case</th>
<th>0.66 lb</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nozzle and Pins</td>
<td>0.39 lb</td>
</tr>
<tr>
<td><strong>Total Wt:</strong></td>
<td>1.05 lb</td>
</tr>
</tbody>
</table>
bearing failure of the doubler. The pins did not bend. It was anticipated that the material behavior would be somewhat viscoelastic/plastic, permitting movement at the slower loading rate which may not occur until later at higher loading rates.

Problems anticipated in the advanced material design centered around the following:

a. No pole piece, wound in 1/4 NPT threaded opening.

b. Shear strength of the FRD at the forward opening, forward skirt/chamber interface and in the aft doubler.

c. Failure mechanism of the case/nozzle pin joint.

These problems and potential failure modes were resolved during hydroburst design verification and are discussed in Section III-C.

2. Nozzle

The nozzle is shown in Figures 11 and 12. Because of the unfamiliarity of the effect of propellant exhaust gases on the FRD, were it to be used for making the nozzle, 8904 fiberglass and 8907-34 glass cloth were used. FRD may be substituted for the glass at a later date.

The nozzle approach, throat, exit cone and exit plane doubler are wound on the mandrel and cured. Machining of the mating surfaces, boring groove and doubler was accomplished on the mandrel before disassembly.
B. HYDROTEST

PRD case hydrotest fixtures and procedures were similar to those used for the fiberglass case except for a modified skirt support ring, due to the much shorter skirt on the PRD case. Forward closure was effected using a common 1/4 NPT pipe plug fitting and teflon tape. No leakage was ever observed through the dome or around the fitting.

S/N 001 and 002 both failed in tension at the nozzle/case forward pin ring. Both cases exhibited leakage between the case and nozzle, past the o-ring and back-up ring, and exiting between the two pieces or along the dome pins. The aft cylindrical section also weeped water while under pressure. S/N 002 burst at 7985 psig, 70% of design pressure. This unit had nearly 3.7 minutes under pressure in six hydrotests before failure, Table VIII. Slight compression failure at the skirt forward face and a similar failure just aft of the forward skirt in the cylindrical section, both at an included angle of 90°, was probably due to the uneven load and sharp energy release as the nozzle and portion of the case moved aft. Slight resin cracking was noted in the forward dome.

S/N 001 exhibited similar skirt compression failure at a pressure of 8535 psig, and no resin cracking in the forward dome.

S/N 003 and 004 winding configurations were altered, Table VI, and the following design changes were instituted to prevent failure as shown by S/N 001 and 002.
<table>
<thead>
<tr>
<th>Case S/N</th>
<th>Design/ Test No.</th>
<th>Date</th>
<th>Pump</th>
<th>Coating</th>
<th>Max. Press. (psig)</th>
<th>Time Under Press. (sec)</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>001</td>
<td>A-1</td>
<td>9/1/72</td>
<td>Sprague</td>
<td>8 Spraylat</td>
<td>6575</td>
<td>44</td>
<td>Weeped aft cyl. sect. &amp; between case &amp; nozzle</td>
</tr>
<tr>
<td></td>
<td>A-2</td>
<td>10/16/72</td>
<td>Miller</td>
<td>Epon 946 + Bladder</td>
<td>8535</td>
<td>1.4</td>
<td>Case failed in tension at forward nozzle pin ring</td>
</tr>
<tr>
<td>002</td>
<td>A-1</td>
<td>9/1/72</td>
<td>Sprague</td>
<td>8 Spraylat</td>
<td>4310</td>
<td>7</td>
<td>Aft Cyl. sect. weeped, leaked between case &amp; nozzle</td>
</tr>
<tr>
<td></td>
<td>A-2</td>
<td>9/1/72</td>
<td>Sprague</td>
<td>8 Spraylat</td>
<td>5920</td>
<td>15</td>
<td>&quot;</td>
</tr>
<tr>
<td></td>
<td>A-3</td>
<td>9/1/72</td>
<td>Sprague</td>
<td>6 Spraylat</td>
<td>5525</td>
<td>42</td>
<td>&quot;</td>
</tr>
<tr>
<td></td>
<td>A-4</td>
<td>9/3/72</td>
<td>Sprague</td>
<td>3 Coats Epon 946</td>
<td>7510</td>
<td>58</td>
<td>&quot;</td>
</tr>
<tr>
<td></td>
<td>A-5</td>
<td>9/8/72</td>
<td>Sprague</td>
<td>Epon 946 + SSC*</td>
<td>5270</td>
<td>92</td>
<td>&quot;</td>
</tr>
<tr>
<td></td>
<td>A-6</td>
<td>9/8/72</td>
<td>Sprague</td>
<td>&quot;</td>
<td>7985</td>
<td>7</td>
<td>Failed in tension at forward nozzle pin ring</td>
</tr>
<tr>
<td>003</td>
<td>B-1</td>
<td>1/19/73</td>
<td>Miller</td>
<td>Bladder</td>
<td>12,250</td>
<td>2.5</td>
<td>Aft end doubler failed, reaction caused interlaminar skirt failure</td>
</tr>
<tr>
<td>004</td>
<td>C-1</td>
<td>1/19/73</td>
<td>Miller</td>
<td>Bladder</td>
<td>5760</td>
<td>0.7</td>
<td>Skirt interlaminar shear</td>
</tr>
<tr>
<td>013</td>
<td>3/13/73</td>
<td>Miller</td>
<td>Bladder</td>
<td>10,540</td>
<td>4.8</td>
<td>Similar to S/N 003. Equipment malfunction reduced pressurization rate</td>
<td></td>
</tr>
</tbody>
</table>

*Seam Sealing Compound
(1) S34-501 glass cloth was used rather than PRD cloth to increase directional tensile and compressive strength in the aft case doubler and forward skirt, respectively.

(2) Nozzle retaining pin edge distance was increased from 0.23 inch to 0.62 inch to increase shear distance.

(3) Distribute helical layers more uniformly through the aft doubler.

An additional change was made to determine whether the doubling of cloth layers in the forward skirt and aft doubler would significantly affect tensile and compressive strength.

S/N 003 burst at 12,500 psig, 9.6% over the required minimum of 11,400 psig. Primary failure occurred at the aft chamber/skirt region of a combined hoop/bearing/winding code, Figure 13. The outer fibers appeared to fail in hoop/shear to fail in the nozzle and retaining pins was causing the fiberglass nozzle to break. The forward skirt to fail in bearing at the pins, causing the nozzle to shear. The inner helical fibers appear to have buckled either due to the test or due to the nozzle being ejected. The forward skirt failed in interlaminar shear between the pressure vessel and skirt doubler. The forward dome was also buckled slightly.

S/N 004 failed at 5,760 psig in interlaminar shear at the forward end between the pressure vessel and skirt windings as shown in Figure 14. Dome buckling also occurred. The unit moved forward, breaking the nozzle/hydro-test piston seal and the bladder ruptured. It is postulated that S/N 004 would have achieved a similar pressure had the skirt not sheared.
Figure 13. S/N 003 Hydroburst

Figure 14. S/N 004 Hydrotest
S/N 013 was removed from the production run and hydroburst. The Miller ram hydrotest equipment malfunctioned, decreasing the pressurization rate such that the unit achieved 10,540 psig. This hydroburst was accepted by the Technical Monitor. Failure was identical to S/N 003. The threads in the forward dome showed no evidence of incipient failure.

C. RESULTS, CONCLUSIONS AND RECOMMENDATIONS

1. Results and Conclusions

Hercules has successfully designed and manufactured a lightweight PRD-49 Type III three-inch diameter rocket motor which meets or exceeds all requirements of TR1617. Total weight of the unit is just over 1.0 lb. Manufacturing and inspection records are provided as Appendix B-4, with weights of the cases and nozzles, and pertinent inspected dimensions.

2. Recommendations

Alternate case/nozzle joint attachment techniques should be examined to decrease weight and increase effectiveness and simplicity. The skirt/case shear failure area should be examined to optimize the joint. The wound-in threads as the forward polar opening showed that this concept is viable and could be significant in reducing case costs by eliminating the conventional aluminum pole piece.

The nozzle, which weighs 0.3 lb as glass, could be manufactured using PRD to obtain nozzle throat erosion data and a weight reduction to about 0.2 lb.
APPENDIX A

FIBERGLASS CASE-IN-CASE DESIGN DISCLOSURE
APPENDIX A

FIBERGLASS CASE-IN-CASE DESIGN DISCLOSURE

A-1. Design Calculations
A-2. CIC Sketches
A-3. Tooling Sketches
A-4. Material Acceptance Specifications
A-5. Bonding Procedure
A-6. Hydrotest Tooling and Bladder Mfg.
A-7. Manufacturing and Inspection Records
APPENDIX A-1

DESIGN CALCULATIONS
Design Parameters

\[ P_{\text{design}} = 11,400 \text{ psi} \]
\[ P_{\text{design}} = \frac{7600}{1.5} \]

Max thrust = 35,300 lb.

\[ A_{\text{cyl}} = 1.367 \text{ in.} \]
\[ r_e = .961 \text{ in.} \]
\[ A_e = 2.9013 \text{ in}^2 \]

Assuming \( C_F = 1.465 \)

\[ F = 7600 \times 2.901 \times 1.465 \]
\[ F = 32,300 \text{ lb.} \]

Inner Shell

\[ N_F = \frac{11,400 \times (1.98)}{2} = 7,792 \text{ lb/in.} \]

Assume \( \theta = 90^\circ \)

\[ \cos^2 \theta = .7939 \]
\[ \sin \theta = \frac{.63}{1.39} = .45376 \]

\[ \sin^2 \theta = \frac{.20608}{.45376} \]

\( \theta = 27^\circ \)

\[ \omega = \frac{1.367 + .023}{.621} = 2.244 \text{ rad/s} \]

\[ \omega = 2.244 \times \sqrt{.7939} \]

\[ \omega = 2.244 \times \sqrt{.7939} \]

\[ \omega = 2.244 \times \sqrt{.7939} \]

\[ \omega = 2.244 \times \sqrt{.7939} \]

Assume \( \lambda = 4.0 \text{ in/hr} \)

\( \lambda = 374,433 \text{ psi} \).
\[ t_d = 4v(1.115) \]
\[ t_d = 0.46 \text{ in.} \]

Assume \( n_0 = 1 \) layer, \( \varphi_0 \)
\[ t_e = 0.065 \text{ in.} \]

Inner shell \( t_c = 0.056 \text{ in.} \)

Winding sequence: \( XX \cdot XX \cdot \)

Adhesive \( g \gamma = 0.015 \)

Outer shell \[ R_c^1 = 1.367 + 0.056 + 0.015 \]
\[ R_c = 1.438 \text{ in.} \]

Force on shell during hydro: \( F \)

\[ F = \rho \pi R_c^2 t_c^2 - \rho \pi R_c^2 t_e^2 \]

\[ \rho \pi (R_c^2 - R_e^2) \]

\[ = 114.339 \pi \left[ 2.098 - 0.689 \right] \]

\[ = 35.914 \times 1.14 \]

\[ = 41.037 \text{ lb} \]

\[ F_{min} = 41,037 \text{ lb} \]

\[ N_d = \frac{41,037}{9.035} = 4521.10 \text{ lb/in} \]

Best Available Copy
Aft dome winding angle

\[ R = 1.437 + 0.023 \]

\[ = 1.461 \]

\[ \overline{R}_{rev} = 0.961 + 0.040 \]

\[ = 1.000 \]

\[ \sin \alpha = \frac{1.000}{1.461} = 0.68446 \]

\[ \theta_{44} = 43^\circ 12' \]

\[ \cos^2 \alpha = 0.5214 \]

\[ \sin^2 \alpha = 0.4786 \]

\[ \tan \alpha = 0.8818 \]

\[ N_\theta = 45.57 = m_x (3.830 \times 8.79) (5.310) \]

\[ m_x = \frac{45.57}{1345.5} \]

\[ m_x = 3.373 \text{ layers} \] for \( f_2 = 384,000 \) @ 11,000

\[ \text{for } m_x = 4.0 \; f_2 = 320,735 \; @ 15,000 \]

Assume:

\[ @ \sigma = 2900 \; f_2 = 369,518 \text{ psi} \]

4 helical layers over aft cone \( t_2 = 0.046 \)

3 helical layers over cylinder \( t_2 = 0.034 \)
\[ t_{\text{dc}} = 0.46 \]
\[ t_{\text{oa}} = \text{var} \]
\[ t_{\text{op}} = 0.15 \]
\[ t_{\text{BP}} = 0.11 \]
\[ t_{\text{ba}} = \text{var} \]
\[ R = 1.327 \]

\[ N_\Phi = \frac{45 \times 10^{3}}{35.9 \times 10^{3}} = \frac{45}{35.9} \]

\[ T_\Phi = \frac{45.57}{11.93} = 3.83 \]

\[ \sum m_\alpha \times \Phi = 3 \times (0.15 \times 0.14 \times 0.35) = 3 \times 0.07 = 0.21 \]

\[ N_\Theta = 11.43 \times (1.937) = 16.39 \]

\[ m_\Theta \times T_\Theta = 16.39 \times 0.14 = 2.31 \]
for $F_0 = 420,000 \text{ psi}$,

$$T_0 = 7,717 \text{ in/rev}$$

$$m_0 = \frac{14,000}{2 \pi (9.117)} = \frac{14,000}{2,998.5}$$

$$m_0 = 5.003 \text{ layers}$$

Assume $m_{\text{total}} = 5.0 \text{ layers @ 90\degree}$

Winding Sequence:

Inner Shell $X \text{ MX XX}^2$

Outer Shell $X \text{ OM OXOXO X}$

$R_i = 1.367$

$R_{\text{rail}} = 1.473$

$R_{\text{outer}} = 1.426$

$R_{\text{inner}} = 1.520$
Forward Dome Contour

\[ R_c = 1.367 \text{ in.} \]
\[ t_d = 4(0.015) = 0.06 \text{ in.} \]
\[ \bar{R} = 1.367 + 0.06 = 1.393 \text{ in.} \]
\[ \bar{d} = 2.780 \]
\[ \alpha = 27^\circ \]

<table>
<thead>
<tr>
<th>x</th>
<th>y</th>
<th>t°</th>
<th>\bar{R}</th>
<th>\bar{y}</th>
<th>\bar{t}_{d/2}</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0</td>
<td>0</td>
<td>2.0</td>
<td>1.390</td>
<td>0</td>
<td>0.0230</td>
</tr>
<tr>
<td>.999</td>
<td>.0356</td>
<td>2.003</td>
<td>1.3834</td>
<td>.0466</td>
<td>.0230</td>
</tr>
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<td>1.3761</td>
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<td>.0236</td>
</tr>
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<td>.96</td>
<td>.2108</td>
<td>2.117</td>
<td>1.3594</td>
<td>.2927</td>
<td>.0242</td>
</tr>
<tr>
<td>.92</td>
<td>.2937</td>
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<td>1.3488</td>
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<td>.4930</td>
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<td>.84</td>
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<tr>
<td>.80</td>
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<td>.76</td>
<td>.4706</td>
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<td>1.0541</td>
<td>.6681</td>
<td>.0336</td>
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<tr>
<td>.72</td>
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<td>1.0008</td>
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<td>.0367</td>
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<td>.7500</td>
<td>.0405</td>
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<td>.64</td>
<td>.5645</td>
<td>3.95</td>
<td>0.8896</td>
<td>.7848</td>
<td>.0455</td>
</tr>
</tbody>
</table>
Nozzle and aft dome details

\[ d_{exit} = 2.946 \]
\[ r_{exit} = 1.473 \]
\[ A_{exit} = 6.818 \]
\[ \varepsilon = \frac{6.818}{2.9013} = 2.35 \]

Momentum Balance

\[ F_{c} = \rho_{c} A_{i} (1 + \gamma M_{c}^{2}) \]

Assume \( \gamma = 1.19 \)

\[ A \cdot 2.185 \]

Assume \( F_{c} = 7600 \text{ psi} \)

\[ \rho \]
\[ 290 \]
\[ 10 \]
\[ 2.188 \]

\[ \frac{P_{e}}{\rho} \]
\[ 1.051 \]
\[ \frac{P_{e}}{P_{c}} \]
\[ 1.767 \]
\[ 10.4633 \]

\[ C_{p, vac} \]
\[ -1.20497 \]
\[ 1.304108 \]

\[ \left( \frac{P_{e}}{\rho_{c}} \right) \]
\[ 0.56594 \]
\[ 0.285936 \]

\[ \rho \]
\[ 7.331 \]
\[ 4.301 \]
\[ 736 \]

\[ \rho A \]
\[ 44,781.6 \]
\[ 13,478.5 \]
\[ 49,999.9 \]
\[
\lambda \delta = 1.19 (93.4) \\
= 1.170
\]

<table>
<thead>
<tr>
<th>(\lambda \delta M^2)</th>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>M^2</td>
<td>.0841</td>
<td>1.0</td>
<td>4.7873</td>
</tr>
<tr>
<td>(\lambda \delta M^2)</td>
<td>.10008</td>
<td>1.170</td>
<td>5.6011</td>
</tr>
<tr>
<td>1 + (\lambda \delta M^2)</td>
<td>1.1</td>
<td>2.170</td>
<td>6.6011</td>
</tr>
<tr>
<td>(F_e)</td>
<td>47,260</td>
<td>37,078</td>
<td>32,675</td>
</tr>
</tbody>
</table>

![Graph](image)

**Calculation**

At point 3,

\[
\frac{cF_{vac}}{corr.} = \lambda \left[ \frac{cF_{vac} - \frac{c}{f_c}}{f_c} \right] + \frac{c}{f_c} \\
= 0.933 \left( \frac{1.279514}{2.57} \right) + \frac{2.35 (19.7)}{26.70} \\
= 1.25776 + 2.2459
\]

\[
\frac{cF_{vac}}{corr.} = 1.48235
\]

\[
\frac{cF_{corr}}{corr.} = 1.48235 - 0.000235 = 1.4778
\]

**Notes:**

- \(\lambda\): Acoustic factor
- \(\delta\): Frequency factor
- \(M\): Mass matrix
- \(F_e\): Force matrix
Thrust = \( C_f A \)

\[ = 1.4778 \times (7600)(2.9013) \]

Thrust = 32,585 lb. @ \( \rho = 7600 \text{ ps}^{\circ} \text{atm} \)

\text{at sea level}

\text{For Hydrotest}

\[ \rho = 1.4044, \quad \text{lb} = 1.427 \]

\[ F = \rho A = 11400(6.193) \]

\[ = 70,600 \]

\[ \Delta F = 37,529 \]

\[ N \Delta F = \frac{37529}{8.96} \approx 4146 \]
AST Union Contour

\( \alpha = 43^\circ \)

\( J = 0.468 \quad J_{c y} = 0.468 \)

\( t_d = 0.046 \)

\( P_{c} = 1.464 \)

\( R = 1.427 \)

\( \bar{D} = 2.854 \)

\[
Z = \frac{0.046}{2.854} = 0.01612
\]

For \( d = 40^\circ \)

\( J = 0.66 \)

\( Z = 0.015 \)

<table>
<thead>
<tr>
<th>( x )</th>
<th>( y )</th>
<th>( \bar{z} )</th>
<th>( R_{1} )</th>
<th>( \bar{R} )</th>
<th>( Y )</th>
<th>( \sqrt{2} )</th>
<th>( R_{1} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0</td>
<td>0</td>
<td>3.0</td>
<td>1.0972</td>
<td>1.427</td>
<td>0</td>
<td>0.023</td>
<td></td>
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<tr>
<td>0.977</td>
<td>0.0367</td>
<td>3.035</td>
<td>0.67094</td>
<td>1.4256</td>
<td>0.6527</td>
<td>0.5230</td>
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<tr>
<td>0.99</td>
<td>0.0647</td>
<td>3.052</td>
<td>0.48194</td>
<td>1.4127</td>
<td>0.1662</td>
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<tr>
<td>0.78</td>
<td>0.1458</td>
<td>3.107</td>
<td>0.69328</td>
<td>1.3985</td>
<td>0.2345</td>
<td>0.0238</td>
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<tr>
<td>0.74</td>
<td>0.2318</td>
<td>3.153</td>
<td>0.72083</td>
<td>1.3699</td>
<td>0.3553</td>
<td>0.0247</td>
<td></td>
</tr>
<tr>
<td>0.74</td>
<td>0.3236</td>
<td>3.351</td>
<td>0.76227</td>
<td>1.3414</td>
<td>0.4027</td>
<td>0.0257</td>
<td></td>
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<tr>
<td>0.90</td>
<td>0.3819</td>
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<td>1.3843</td>
<td>0.5163</td>
<td>0.0290</td>
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<tr>
<td>0.86</td>
<td>0.4704</td>
<td>4.022</td>
<td>1.0326</td>
<td>1.3272</td>
<td>0.6071</td>
<td>0.0308</td>
<td></td>
</tr>
<tr>
<td>0.82</td>
<td>0.4831</td>
<td>4.114</td>
<td>1.4855</td>
<td>1.1705</td>
<td>0.6853</td>
<td>0.0246</td>
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</tr>
<tr>
<td>0.78</td>
<td>0.5798</td>
<td>5.201</td>
<td>1.1131</td>
<td>0.7561</td>
<td>0.0399</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
# VESSEL STRESSES - LAW PROGRAM

**Inner Shell**

<table>
<thead>
<tr>
<th>Proposed Design</th>
<th>Demonstrated Values</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Forward Dome</strong></td>
<td><strong>LAW II</strong></td>
</tr>
<tr>
<td>6 layers @ 27°</td>
<td>Others</td>
</tr>
<tr>
<td>( F = 245,500 \text{psi} )</td>
<td>( F = 290,000 \text{psi} )</td>
</tr>
</tbody>
</table>

\( \sigma = \frac{F}{A} \)  
\( \sigma = \frac{245,500}{A} \)  
\( \sigma = \frac{290,000}{A} \)  
\( \sigma = \frac{353,275}{A} \)  

**Outer Shell**

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Aft Dome</strong></td>
<td><strong>LAW II</strong></td>
</tr>
<tr>
<td>6 layers @ 42°</td>
<td>Others</td>
</tr>
<tr>
<td>( F = 213,625 \text{psi} )</td>
<td>( F = 264,218 \text{psi} )</td>
</tr>
</tbody>
</table>

\( \sigma = \frac{F}{A} \)  
\( \sigma = \frac{213,625}{A} \)  
\( \sigma = \frac{264,218}{A} \)  

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cyl. Hoop</strong></td>
<td><strong>LAW II</strong></td>
</tr>
<tr>
<td>6 layers @ 90°</td>
<td>Others</td>
</tr>
<tr>
<td>( F = 350,801 \text{psi} )</td>
<td>( F = 346,316 \text{psi} )</td>
</tr>
</tbody>
</table>

\( \sigma = \frac{F}{A} \)  
\( \sigma = \frac{350,801}{A} \)  
\( \sigma = \frac{346,316}{A} \)  

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Forward Skirt</strong></td>
<td><strong>LAW II</strong></td>
</tr>
<tr>
<td>6 layers @ 42°</td>
<td>Others</td>
</tr>
<tr>
<td>( F = 235,212 \text{psi} )</td>
<td>( F = 248,726 \text{psi} )</td>
</tr>
</tbody>
</table>

\( \sigma = \frac{F}{A} \)  
\( \sigma = \frac{235,212}{A} \)  
\( \sigma = \frac{248,726}{A} \)  

**Probable Mode of Failure**

- **Forward Dome**: \( p = 13,420 \text{ psi} \)
- **Cyl. Hoops**: \( p = 14,870 \text{ psi} \) (based upon \( F = 459,000 \text{ psi} \))

\( F = 37,600 \text{ lb} \)
Outer Shell—Present Design:

4 layers @ 42°
6 layers @ 70°
4 layers cloth

Assume:
6 layers @ 42°
4 layers @ 27°

\[ N_0 = 4539 = 0.00666 \frac{f_d}{d} \left[ \frac{4(0.794) + 6(0.249)}{6} \right] \]

\[ = 0.00666 \frac{f_d}{d} (3.176 + 3.1884) \]

\[ = 0.00666 (6.3644) f_d \]

\[ = 0.429 f_d \]

\[ f_d = 117.052 \]

\[ N_0 = \pi_0 N T_0 + 713.0 \left[ \frac{4(0.204)}{6} + (0.468) \right] \]

\[ 11403(1.437) = + 7130 \left( 0.824 + 2.811c \right) \]

\[ + 7130 (3.635c) \]

\[ + 2592 \]

\[ N_0 = 16,610 = \pi_0 f_0 (0.00666) + 2592 \]

\[ 0.00666 \pi_0 f_0 = 1401 \]

\[ \pi_0 = \frac{2194.235}{4} \]
for \( n_0 \quad f_0 \)

| 4    | 350,501 |
| 5.5  | 382,692 |
| 5    | 420,961 |

Outer shell:

\[ R_c = 1.417 \]

6 layers @ 42°

5 layers @ 90° over entire cylindrical section

3 layers cloth over forward skirt

1 layer @ 90° over forward skirt

\[
\begin{array}{c}
XXOXXO C_{SK} O XXO C_{SK} O C_{SK} O
\end{array}
\]

in body:

\[
\begin{array}{c}
XXOXXOOXXOO
\end{array}
\]

Increased wt.

in cyl.

\[ l = 10.65 \]

\[ \bar{R} = 1.5 + 0.15 = 1.65 \]

\[ w^+ = 2\pi \bar{R} \ell p \]

\[ = 2\pi (1.5)(0.03)(10.65)(0.7) \]

\[ = 9.519 \times 0.224 \]

\[ = 2.13 \text{ lb.} \]
\[ L = 1.3(3.39) = 4.40 \]

\[ \omega t = \frac{4.4}{10.65} \times 0.32 \geq 2.19 = \frac{0.098(2.19)}{3.90} = 0.062 \]

\[ \omega t_{\text{increase}} = 0.275 \times 1.4, \quad 1.16 \times \frac{5}{1.4} = 1.41 \]

\[ L_{\text{shirt}} = 10.65 - 5.65 + 2.26 = 5.26 \text{ in.} \]

\[ \overline{R}_{\text{shirt}} = \frac{1.417 + 1.535}{2} = 1.476 + 0.011 = 1.487 \]

\[ t = 1.535 - 1.417 = 0.118 + 0.022 = 0.140 \]

\[ \omega t = 2\pi (14 \times 0.140)(5.26)(0.07) \]

\[ = 9.337(0.0515) \]

\[ \omega t_{\text{shirt}} = 0.486\text{ lb.} \]

Fold skirt: \[ R' = 1.417 \]

\[ R_0 = 1.535 + 0.032 = 1.567 \]

\[ t = 0.150 \]

\[ \overline{R} = 1.492 \]

\[ 2\pi \overline{R} = 9.3745 \quad 2\pi \overline{R} t = 1.461 \quad 2\pi \overline{R} t = 1.094 \]

\[ @ p = 11,000 \quad F = 33.071 \quad @ p = 9,800 \quad F = 27.269 \]

\[ \gamma = 23.521 \]
<table>
<thead>
<tr>
<th>Vessel</th>
<th>Stresses</th>
<th>Proposed Design</th>
<th>Demonstrated</th>
</tr>
</thead>
<tbody>
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<td></td>
<td></td>
<td>No. Layers</td>
<td>Stress @ 1500</td>
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<tr>
<td>Inner Shell</td>
<td></td>
<td>6</td>
<td>245,500</td>
</tr>
<tr>
<td>Fwd dome</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Outer Shell</td>
<td></td>
<td>6</td>
<td>213,625</td>
</tr>
<tr>
<td>Aft dome</td>
<td></td>
<td>6</td>
<td>350,801</td>
</tr>
<tr>
<td>Cyl hoop</td>
<td></td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>Fwd. Skirt</td>
<td>6@42</td>
<td>3 c1.</td>
<td>33,071 lb.</td>
</tr>
</tbody>
</table>
Forward Flow Analysis

$\alpha = 7^\circ$

$\theta = 15^\circ$

$F = 1.3$

$N_f = 7.72$

$\frac{11.2}{1.05} = 10.6$

$\frac{205}{130} = 1.57$

$\Delta T = \frac{177.2}{183} = 0.97$

$24.5 \times 10^7$

$\Delta x = \frac{14.6}{1.05} = 13.9$

$\Sigma F = 24.5 \times 10^7$

$\Sigma N = 10.6$

$\Sigma y = 1.57$

$\Sigma F = 24.5 \times 10^7$

Best Available Copy
LAW II Case Analysis

Strength improvement based upon pressureizing time

\[ K = 1.222 \]

\[ 1.222 \times 9082 = 11,080 \text{ psi} \]
1. MATERIAL: 7075-T6 ALUM. OR EQUAL

2. SYMBOL + INDICATES RESULTS TO BE REPORTED BY THE FABR. 7OR.

POLE PIECE 

SCALE

720531
**NOTES:**

1. **INNER SHELL FRAGMENT WIRING SEQUENCE**
   - A - INDICAL LAYER.
   - C - REPEAT A
   - E - REPEAT A
   - G - REPEAT A
   - FILL VOID WITH SAME MIXTURE T D00X & B00.
   - RESIN USED WITH FILAMENT WIRING.

2. **MATERIAL:** FIBERGLAS FILAMENT, G-924, B-143 PAVING,
   - OWENS-CORNING FIBERGLAS CORP., RESIN, CRI, 2856,
   - UNION CARBIDE CORP., TYPE 6344 D, EVERGLAS CO.

3. **SYMBOL** Indicates results to be reported by the fabricator.

**DOME COORDINATES**

<table>
<thead>
<tr>
<th>X</th>
<th>Y</th>
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</tr>
<tr>
<td>1.558</td>
<td>100</td>
</tr>
<tr>
<td>1.562</td>
<td>200</td>
</tr>
<tr>
<td>1.803</td>
<td>300</td>
</tr>
<tr>
<td>1.823</td>
<td>500</td>
</tr>
<tr>
<td>1.852</td>
<td>600</td>
</tr>
<tr>
<td>1.866</td>
<td>700</td>
</tr>
<tr>
<td>1.850</td>
<td>115</td>
</tr>
<tr>
<td>1.754</td>
<td>800</td>
</tr>
</tbody>
</table>

**INNER SHELL ASSEMBLY**

1: SCALE

720531-1
NOTES

1. EPON 946, PARTS A & B, USED IN ADHESIVE GAP IN THIS AREA BY BRUSHING ADHESIVE ON MATING SURFACES OF INNER & OUTER SHELLS.

GLASS FIBER MOTOR 1/4 SCALE
APPENDIX A-3

FIBERGLASS CASE-IN-CASE TOOLING SKETCHES
NOTES:

1. MATERIAL: 2024 T351 ALUMINUM OR EQUAL.
2. SURFACE FINISH ALL OVER.
3. REMOVE ALL BURRS AND SHARP EDGES, 0.005 MAX R.
4. ALL DIAMETERS TO BE 0.001 TIR WITH CENTERS.
5. DIMENSIONS TYPICAL FOR BOTH ENDS.
6. DIMENSIONS SHOWN ARE BEFORE TFELO N COATING.
7. GROUND AREA TO BE TFELO N COATED.
8. TFELO N COAT TO 0.001 MAX AS SHOWN.
9. SYMBOL INDICATES RESULTS TO BE REPORTED BY FABRICATOR.

MANOREL - OUTER SHELL BODY

1/SCALE 720613
NOTES:
1. MATERIAL: 2024 T.351 ALUMINUM OR EQUAL
2. SURFACE FINISH V ALL OVER.
3. REMOVE ALL BURRS AND SHARP EDGES .005 MAX.
4. ALL DIAMETERS TO BE 0 .001 TIR.
5. DIMENSIONS SHOW ARE BEFORE TEFLOM BLEND COATING.
6. Grit blast area to be Teflon coated
7. Teflon coat to .001 max as shown
8. Symbol + INDICATES RESULTS TO BE REPORTED BY FABRICATOR.

NOZZLE FORMER
+ SCALE
    720613-1
Ilk

44

%A

I

ti

>161

\[ \frac{21}{32} \text{ DIA THRU} \]
(NO TEFLOM COATING)

1.000 DIA

.875 DIA

2.800 DIA

2.125 DIA

2.500 DIA

1.250

2.000

.118 ±.002

NOTES:
1. MATERIAL: 2024 T351 ALUM. OR EQUAL.
2. SURFACE FINISH \( \frac{6}{128} \) ALL OVER
3. REMOVE ALL BURRS AND SHARP EDGES
   .005 MAX R.
4. ALL DIAMETERS \( \pm .001 \) TIR
5. DIMENSIONS SHOWN ARE BEFORE TEFLOM COATING.
6. GRIT BLAST AREA TO BE TEFLOM COATED.
7. TEFLOM COAT TO .001 MAX.

END PLATE
\( \frac{1}{4} \) SCALE

720613-2
NOTES:
1. MATERIAL: ALUMINUM 2024-T351 OR EQUAL
2. GRIT BLAST PRIOR TO TFELOM COAT.
3. TFELOM COAT TO .001 THK. MAXIMUM
4. % INDICATES TOLERANCE PRIOR TO TFELOM COAT.
5. DIMENSIONS TYPICAL BOTH ENDS.
6. SYMBOL indicates results to be reported by the fabricator.
7. USE "O" RING AN6227 B-23
INNER SHELL MACHINING CENTER
SAW CUT AFTER BORING

\( \frac{1}{2} \)

BREAK TO .010 APPROX. (TYP).

COUNTERBORE TO \( \frac{1}{16} \) DEEP.

5.5 DIA.

2.910 DIA. BORE

3\( \frac{1}{2} \)

7

3\( \frac{1}{2} \)

7

STRIPPING PLATE

\( \frac{1}{2} \)" - 2024 T4 ALUM.
NOTES:

1. MATERIAL: 2024 T4 ALUMINUM, .125 THICK

2. METAL STAMP IN 1/4" CHARACTERS, BOTH PARTS AS SHOWN.

SHELL PARTING GAGES

1/2 SCALE

720616
* N.B. At present there is no specification for PRD 49 Type III filament or cloth.
1. MATERIAL. GLASS ROVING, 12-END, CONTINUOUS FILAMENT, NON-AGING

1.1 DESCRIPTION. The glass roving is a low-alkali, magnesia-alumina, silicate glass coated with a non-aging sizing of a type compatible with epoxy resins. The glass roving consists of 12 ends gathered together in a flat band without twist. The ends are made up of a parallel arrangement of 204 continuous high-strength filaments gathered together without twist.

1.2 CLASSIFICATION. NA

2. INFORMATION AFFECTING PROCUREMENT

2.1 SUPPLIER AND MATERIAL IDENTIFICATION. Supplier and material identification are provided below:

<table>
<thead>
<tr>
<th>Supplier</th>
<th>Trade Name</th>
<th>Program</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Owens Corning Fiberglas Corp.</td>
<td>S-904 Glass Roving</td>
<td>Poseidon S/S</td>
<td>WS 11895</td>
</tr>
</tbody>
</table>

2.2 PROBLEMS. (None identified)

3. ACCEPTANCE CRITERIA. (Attached)

4. TEST METHODS. (Attached)
HERCULES SPECIFICATION DATA SHEET

Glass Roving, 12-End, Continuous Filament, Non-Aging

The glass roving is a low-alkali, magnesia-alumina, silicate glass coated with a non-aging sizing of a type compatible with epoxy resins. The glass roving consists of 12 ends gathered together in a flat band without twist. The ends are made up of a parallel arrangement of 204 continuous high-strength filaments gathered together without twist.

3. ACCEPTANCE CRITERIA. Acceptance criteria shall conform to the following:

3.1 Material. The supplier shall certify that the glass roving conforms to 3.1.1, 3.1.2, and 3.1.3.

3.1.1 Construction. The glass roving shall be a low alkali, magnesia-alumina, silicate glass coated with a non-aging sizing of a type compatible with epoxy resins. The ends shall be made up of a parallel arrangement of continuous, high-strength filaments, formed simultaneously from a bushing having 204 openings and gathered together without twist.

3.1.2 Cure. After applying the sizing, the glass shall be cured at a temperature of 129°C ± 5°C for 22 to 26 3/4 hours, including warmup and cooldown periods.

3.1.3 End count. The roving shall consist of exactly 12 ends which have been gathered in a flat band without twist.

3.2 Ignition loss. The average ignition loss for the lot shall be not less than 1.30 nor greater than 1.80 percent by weight. The ignition loss for each sample unit (one roving ball) shall be not less than 1.0 nor greater than 2.25 percent by weight.

3.3 Extractable content. The extractable content for each sample unit shall be not less than 85 percent.

3.4 Weight. The average roving weight for the lot shall be not less than 0.360 nor greater than 0.370 grams (g) per yard (yd). The roving weight for each sample unit shall be not less than 0.345 nor greater than 0.385 g per yd.

3.5 Breaking load. The average breaking load (load at which fracture occurs) for each sample unit shall be not less than 120 pounds. The breaking load for any individual specimen shall be not less than 110 pounds.

3.6 Modulus of elasticity. The average modulus of elasticity (ratio of stress to corresponding strain below the proportional limit) for each sample unit shall be not less than 11.5 x 10⁶ pounds per square inch.

3.7 Sizing identification. The extract from the sizing shall be acidic to brom cresol green indicator when tested in accordance with 4.7.
3.8 Workmanship. The material shall be uniform in texture and free of impurities, excessive broken ends, and other defects that would prevent its use for the purpose intended.

4. Test Methods. Conformance to acceptance criteria shall be determined in accordance with the following procedures.

4.1 Visual examination. Visual examination of each sample unit shall be conducted to determine compliance with 3.8.

4.2 Ignition loss. The ignition loss shall be determined in accordance with the following:

   a. Weigh 60 ± 1/3 yd of roving to the nearest 0.1 milligram (mg) and record as weight A.

   b. Ignite the specimen at 815° ± 25° C for a minimum of 25 minutes.

   c. Cool specimen to room temperature in a desiccator, then weigh to the nearest 0.1 mg, and record as weight B.

   d. Calculate percent ignition loss as follows:

   \[
   \text{Percent ignition loss} = \frac{A - B \times 100}{A}
   \]

   Where:  
   \(A = \) original specimen weight, g
   \(B = \) specimen glass weight after ignition, g

   a. Report the percent ignition loss for each sample unit.

   b. Report the average for all sample units in the lot.

4.3 Extractable content. Extractable content shall be determined in accordance with the following:

   a. Weigh 30 ± 1/3 yd of roving to the nearest 0.1 mg. Record as weight \(W_h\).

   b. Place specimen in a Soxhlet extraction apparatus and, with technical grade methylene chloride, extract for a minimum of nine cycles.

   c. Remove specimen from extraction, allow to drip-dry at ambient conditions, then place in a preheated oven maintained at 75° ± 3° C for a minimum of 1 hour.

   d. Allow specimen to cool to room temperature in a desiccator, weigh to the nearest 0.1 mg, and record as weight \(W_s\).

   e. Ignite the specimen at 815° ± 25° C for a minimum of 25 minutes.
f. Cool specimen to room temperature in a desiccator, then weigh to the nearest 0.1 mg., and record as weight \( W_3 \).

g. Calculate percent extractable as follows:

\[
\text{Percent extractable content} = \frac{(W_1 - W_2) \times 100}{(W_1 - W_3)}
\]

Where: 
- \( W_1 \) = original weight of specimen, g
- \( W_2 \) = weight of specimen after extraction, g
- \( W_3 \) = weight of specimen after ignition, g

h. Report the percent extractable content for each sample unit.

4.4 Weight. Weight shall be determined in accordance with the following:

\[
\text{Weight, g/yd} = \frac{B}{L}
\]

Where:
- \( B \) = glass weight after ignition, g (from 4.2c)
- \( L \) = length of specimen, yd (from 4.2a)

4.5 Breaking load. Breaking load shall be determined in accordance with ASTM D 2343-67, procedure A, and the following:

a. Perform specimen conditioning and testing at 25\(^\circ\) ± 3\(^\circ\) C and 50 percent maximum relative humidity.

b. Impregnate the specimens with resin mixed in accordance with table II.

### Table II. Impregnating Resin

<table>
<thead>
<tr>
<th>Material</th>
<th>Specification</th>
<th>Parts by weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Epoxy resin</td>
<td>HS-CP-105</td>
<td>100 ± 1</td>
</tr>
<tr>
<td>Curing agent</td>
<td>HS-CP-164</td>
<td>29.5 ± 0.5</td>
</tr>
<tr>
<td>Toluene</td>
<td>Technical grade</td>
<td>22 ± 2</td>
</tr>
</tbody>
</table>

c. Cure specimens for 60 ± 5 minutes at 120\(^\circ\) ± 5\(^\circ\) C followed by 120 ± 5 minutes at 160\(^\circ\) ± 5\(^\circ\) C.
d. Discard any breaking load results outside specification limits where resin content calculated in accordance with ASTM D 2343-67, is less than 40 percent. Repeat test as necessary to provide five valid determinations. If an individual specimen within a sample unit yields a breaking load value less than 110 pounds, the results shall be checked for homogeneity as follows:

1. Subtract the lowest breaking load from the second lowest breaking load of the five specimens. Call this difference $R_1$.

2. Subtract the lowest breaking load from the highest breaking load of five specimens. Call this difference $R_2$.

3. Calculate the ratio $R_1/R_2$.

4. If $R_1/R_2$ is less than 0.500, the breaking loads are valid, and the sample unit is beyond specification limits. If $R_1/R_2$ is equal to or greater than 0.500, the low breaking load is an outlier and shall be discarded, and an additional specimen shall be broken. The values from the additional specimen and the remaining four original specimens shall be used to make the evaluation for that particular ball. No further tests for outliers shall be made on the ball.

4.6 Modulus of elasticity. Modulus of elasticity shall be determined in accordance with ASTM D 2343-67 using data from 4.5 and glass density provided by the supplier (2.485 grams per cubic centimeter for Owens-Corning 5-904 glass).

4.7 Sizing identification. The sizing shall be identified in accordance with the following:

a. Reagent solution -- dissolve 0.1 ± 0.01 g brom cresol green in 100 milliliters (ml) of 20 percent ethyl alcohol-water solution.

b. Measure 10 to 15 yd of glass roving to be tested, being careful to avoid contamination of glass surface. Insert the glass roving into a 250 ml Erlenmeyer flask, add 25 ml of ethylene chloride, stopper the flask, and allow to stand for 10 minutes with occasional swirling.

c. After 10 minutes, add 6 drops of the reagent solution, and record the color of extract.

NOTE

Basic or acidic contamination from glassware or other chemicals coming in contact with the sample could cause erroneous results.
<table>
<thead>
<tr>
<th>Property</th>
<th>Data Source</th>
<th>No. of lots tested</th>
<th>Average result</th>
<th>Range of Data</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Low</td>
</tr>
<tr>
<td>End count</td>
<td>Owens-Corning</td>
<td>1</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td>Ignition loss, % by wt</td>
<td>Owens-Corning</td>
<td>1</td>
<td>1.47</td>
<td>1.47</td>
</tr>
<tr>
<td>Lot ave.</td>
<td>Owens-Corning</td>
<td>1</td>
<td>1.47</td>
<td></td>
</tr>
<tr>
<td>Ball ave.</td>
<td>Owens-Corning</td>
<td>1</td>
<td>1.05</td>
<td>2.40</td>
</tr>
<tr>
<td>Extractable content, %</td>
<td>Owens-Corning</td>
<td>1</td>
<td>94</td>
<td></td>
</tr>
<tr>
<td>Weight, g/yd</td>
<td>Owens-Corning</td>
<td>1</td>
<td>0.368</td>
<td>0.368</td>
</tr>
<tr>
<td>Lot ave</td>
<td>Owens-Corning</td>
<td>1</td>
<td>0.364</td>
<td></td>
</tr>
<tr>
<td>Ball ave</td>
<td>Owens-Corning</td>
<td>1</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Breaking load, lbs</td>
<td>Owens-Corning</td>
<td>1</td>
<td>135</td>
<td></td>
</tr>
<tr>
<td>Ball ave</td>
<td>Owens-Corning</td>
<td>1</td>
<td>119</td>
<td></td>
</tr>
<tr>
<td>Individual specimen</td>
<td>Owens-Corning</td>
<td>1</td>
<td>119</td>
<td></td>
</tr>
<tr>
<td>Modulus of elasticity, psi</td>
<td>Owens-Corning</td>
<td>1</td>
<td>12.5</td>
<td>12.2</td>
</tr>
<tr>
<td>Sizing identification</td>
<td>Owens-Corning</td>
<td>1</td>
<td>-</td>
<td></td>
</tr>
</tbody>
</table>
1. MATERIAL. CLOTH, GLASS, FINISHED

1.1 DESCRIPTION.

Type I - Style 341 glass cloth is a reverse-weave fabric made from continuous-filament rovings made from type E glass (lime-alumina-borosilicate). The designation 341 indicates the fabric is the reverse weave pattern of normal 143 weave. The cloth is coated with a finish compatible with epoxy resins.

Type II - Style 181 glass cloth is a 5-counter, 8-harness warp flush satin weave fabric made from continuous-filament, type E glass. The cloth is coated with a finish compatible with epoxy resins.

1.2 CLASSIFICATION. NA

2. INFORMATION AFFECTING PROCUREMENT.

2.1 SUPPLIERS AND MATERIAL IDENTIFICATION. Suppliers and material identification are provided below:

<table>
<thead>
<tr>
<th>TYPE</th>
<th>SUPPLIER</th>
<th>TRADE NAME</th>
<th>PROGRAM</th>
<th>SPECIFICATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Hess Goldsmith</td>
<td>341 glass cloth</td>
<td>Poseidon</td>
<td>WS 8020</td>
</tr>
<tr>
<td>I</td>
<td>Clark Schwebel</td>
<td>(143 reversible</td>
<td>FS/SS</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>weave) I 550 finish</td>
<td></td>
<td></td>
</tr>
<tr>
<td>II</td>
<td>Hess Goldsmith</td>
<td>181 glass cloth</td>
<td>Poseidon</td>
<td>WS 8020</td>
</tr>
<tr>
<td>II</td>
<td>Clark Schwebel</td>
<td>CS 550 finish</td>
<td>FS/SS</td>
<td></td>
</tr>
<tr>
<td>II</td>
<td>Hess Goldsmith</td>
<td>181 glass cloth</td>
<td>Sprint</td>
<td></td>
</tr>
<tr>
<td></td>
<td>J. P. Stevens</td>
<td>Volan A finish</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

2.2 PROBLEM AREAS. (None identified)

3. ACCEPTANCE CRITERIA. (Attached)

4. TEST METHODS. (Attached)

NOTES:

A. Other Hercules prepared specifications covering material with similar characteristics are as follows:
<table>
<thead>
<tr>
<th>TYPE</th>
<th>SPECIFICATION</th>
<th>PROGRAM</th>
<th>SUPPLIER</th>
<th>TRADE NAME</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>WS 3342</td>
<td>Polaris</td>
<td>United Merchants Industrial Fabrics</td>
<td>341 Cloth</td>
</tr>
<tr>
<td>I</td>
<td>HPC-133-08-2-5</td>
<td>Minuteman</td>
<td>Hess Goldsmith</td>
<td>398 Cloth</td>
</tr>
<tr>
<td>I</td>
<td>HPC-253-02-2-3</td>
<td>BE3</td>
<td>Hess Goldsmith</td>
<td>398 Cloth Volan finish</td>
</tr>
<tr>
<td>I</td>
<td>HS-259-2-162</td>
<td>X259 (Goddard)</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>II</td>
<td>HPC-253-02-2-3</td>
<td>BE3</td>
<td>Hess Goldsmith</td>
<td>181 Cloth Volan finish</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Coast Mfg. &amp; Supply</td>
<td>181 Cloth Volan finish</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>J. P. Stevens</td>
<td>181 Reverse Weave Volan finish</td>
</tr>
</tbody>
</table>

B. This amendment has been issued solely to record differences contained in Sprint specification 11181420 for Type II Glass Cloth - Finished. The Sprint specification contains:

1. A requirement and test method for chrome finish.
2. A maximum thickness of 0.012 inches (in lieu of a 0.011-inch maximum).
3. An increased range in weight per square yard of 8.00 to 9.80 ounces (in lieu of a range of 8.50 to 9.50 ounces).
HERCULES SPECIFICATION DATA SHEET

1. MATERIAL. CLOTH, GLASS, FINISHED

1.1 DESCRIPTION.

Type I - Style 341 glass cloth is a reverse-weave fabric made from continuous-filament rovings made from type E glass (lime-alumina-borosilicate). The designation 341 indicates the fabric is the reverse weave pattern of normal 143 weave. The cloth is coated with a finish compatible with epoxy resins.

Type II - Style 181 glass cloth is a 5-counter, 8-harness warp flush satin weave fabric made from continuous-filament, type E glass. The cloth is coated with a finish compatible with epoxy resins.

1.2 CLASSIFICATION. NA

2. INFORMATION AFFECTING PROCUREMENT.

2.1 SUPPLIERS AND MATERIAL IDENTIFICATION. Suppliers and material identification are provided below:

<table>
<thead>
<tr>
<th>TYPE</th>
<th>SUPPLIER</th>
<th>TRADE NAME</th>
<th>PROGRAM</th>
<th>SPECIFICATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Hess Goldsmith</td>
<td>341 glass cloth</td>
<td>Poseidon</td>
<td>WS 8020</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(143 reversible</td>
<td>FS/SS</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>weave)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>I 550 finish</td>
<td></td>
<td></td>
</tr>
<tr>
<td>II</td>
<td>Hess Goldsmith</td>
<td>181 glass cloth</td>
<td>Poseidon</td>
<td>WS 8020</td>
</tr>
<tr>
<td></td>
<td></td>
<td>CS 550 finish</td>
<td>FS/SS</td>
<td></td>
</tr>
<tr>
<td></td>
<td>J. P. Stevens</td>
<td>181 glass cloth</td>
<td>Sprint</td>
<td>1181420</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Volan A finish</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

2.2 PROBLEM AREAS. (None identified)

3. ACCEPTANCE CRITERIA. (Attached)

4. TEST METHODS. (Attached)

NOTES:

A. Other Hercules prepared specifications covering material with similar characteristics are as follows:
HERCULES SPECIFICATION DATA SHEET

15 November 1968

CLOTH, GLASS, FINISHED

Type I - Style 341 glass cloth is a reverse-weave fabric made from continuous-filament, lime-alumina-borosilicate. The designation 341 indicates the fabric is the reverse weave pattern of normal 143 weave. The cloth is coated with a finish compatible with epoxy resins.

Type II - Style 18i glass cloth is a 5-counter, 8-harness warp flush satin weave fabric made from continuous-filament, type E glass. The cloth is coated with a finish compatible with epoxy resins.

3. ACCEPTANCE CRITERIA. Acceptance criteria shall conform to the following.

3.1 Materials. The supplier shall certify that the glass cloth was manufactured from continuous-filament, lime-alumina-borosilicate (type E) glass yarn; that the glass yarn construction is in accordance with table I; and that the glass cloth was cleaned to remove the oils and binders present on the yarn and then coated with a high-strength finish compatible with epoxy resins.

Table I. Yarn Construction

<table>
<thead>
<tr>
<th>Glass cloth</th>
<th>Yarn construction*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Warp</td>
</tr>
<tr>
<td>Type I</td>
<td>ECD 450 1/2</td>
</tr>
<tr>
<td>Type II</td>
<td>ECE 225 1/3</td>
</tr>
</tbody>
</table>

*Glass yarn construction shall be designated in accordance with ASTM D 578-61.

3.2 Construction and physical properties. Construction and physical properties shall be in accordance with table II.

3.3 Workmanship. The finished glass cloth shall have a uniform color. The cloth shall be clean, evenly woven, and free from any defect that would render the product unsuitable for the purpose intended.

4. TEST METHODS. Conformance to acceptance criteria shall be determined in accordance with the following procedures.

4.1 Visual examination. The finished glass cloth shall be examined visually to determine compliance with 3.3.

4.2 Warp and fill. The number of yarns per inch of the warp and fill shall be determined in accordance with ASTM D 1910-64.
### Table II. Construction and Physical Properties

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Unit</th>
<th>Type I (341)</th>
<th>Type II (181)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Minimum</td>
<td>Maximum</td>
</tr>
<tr>
<td>Warp</td>
<td>Yarns/in.</td>
<td>30</td>
<td>32</td>
</tr>
<tr>
<td>Fill</td>
<td>Yarns/in.</td>
<td>49</td>
<td>51</td>
</tr>
<tr>
<td>Thickness</td>
<td>In.</td>
<td>0.008</td>
<td>0.010</td>
</tr>
<tr>
<td>Weight</td>
<td>Oz/sq yd</td>
<td>8.08</td>
<td>9.12</td>
</tr>
<tr>
<td>Flexural strength, dry</td>
<td>Psi</td>
<td>---</td>
<td>55,000</td>
</tr>
<tr>
<td>Warp</td>
<td></td>
<td>---</td>
<td></td>
</tr>
<tr>
<td>Fill</td>
<td></td>
<td>120,000</td>
<td>---</td>
</tr>
<tr>
<td>Flexural strength, wet</td>
<td>Psi</td>
<td>---</td>
<td>45,000</td>
</tr>
<tr>
<td>Warp</td>
<td></td>
<td>---</td>
<td></td>
</tr>
<tr>
<td>Fill</td>
<td></td>
<td>100,000</td>
<td>---</td>
</tr>
<tr>
<td>Breaking strength</td>
<td>Lb/in. width</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Warp direction</td>
<td></td>
<td>35</td>
<td></td>
</tr>
<tr>
<td>Fill direction</td>
<td></td>
<td>370</td>
<td></td>
</tr>
</tbody>
</table>

4.3 **Thickness.** Thickness of the glass cloth shall be determined in accordance with ASTM D 579-66.

4.4 **Weight.** Weight of the glass cloth shall be determined in accordance with ASTM D 1910-64.

4.5 **Flexural strength test.** Flexural strength for both wet and dry conditions shall be determined by preparing and testing the laminate in accordance with ASTM D 2403-65 T and one of the following methods:

4.5.1 **Method A.**

a. Resin for the laminate shall be 100 parts by weight (pbw) resin, conforming to HS-CP-105, mixed with 29.5 ± 0.5 pbw curing agent, conforming to HS-CP-164.

b. Cure the laminate for 120 ± 5 minutes (min) at 200° ± 5° Fahrenheit (F) followed by 240 ± 5 min at 320° ± 5° F.
4:5.2 Method B.

a. Resin for the laminate shall be 100 pbw resin, conforming to HS-CP-105, mixed with 19.3 ± 0.5 pbw curing agent, conforming to HS-CP-106.

b. Cure the laminate for 60 ± 5 min at 250°F ± 10°F Fahrenheit (F) and 60 ± 5 min at 350°F ± 10°F.

4.6 Breaking strength test. Breaking strength shall be determined in accordance with ASTM D 579-66 except that method IR-E of ASTM D 1682-64 shall be used. The time to break shall be 20 ± 10 seconds.
<table>
<thead>
<tr>
<th>TYPE</th>
<th>SPECIFICATION</th>
<th>PROGRAM</th>
<th>SUPPLIER</th>
<th>TRADE ITEM</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>WS 3342</td>
<td>Polaris</td>
<td>United Merchants</td>
<td>341 cloth</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Industrial Fabrics</td>
<td></td>
</tr>
<tr>
<td></td>
<td>HPC-133-08-2-5</td>
<td>Minuteman</td>
<td>Hess Goldsmith</td>
<td>398 cloth</td>
</tr>
<tr>
<td>I</td>
<td>HPC-253-02-2-3</td>
<td>BE3</td>
<td>Hess Goldsmith</td>
<td>398 cloth</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I</td>
<td>HS-259-2-162</td>
<td>X259 (Goddard)</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>II</td>
<td>HUC-253-02-2-3</td>
<td>BE3</td>
<td>Hess Goldsmith</td>
<td>181 cloth</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Coast Manufacturing &amp; Supply</td>
<td>181 cloth</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>J. P. Stevens</td>
<td>181 cloth</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Volan finish</td>
</tr>
<tr>
<td>Property</td>
<td>Data source</td>
<td>No. of lots tested</td>
<td>Average Result</td>
<td>Range of data</td>
</tr>
<tr>
<td>------------------------------</td>
<td>-----------------</td>
<td>--------------------</td>
<td>----------------</td>
<td>---------------</td>
</tr>
<tr>
<td>Flexural strength, psi</td>
<td>Bacchus</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Method B (CL)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dry</td>
<td></td>
<td>2</td>
<td>137,600</td>
<td>122,100 - 153,100</td>
</tr>
<tr>
<td>Wet</td>
<td></td>
<td>2</td>
<td>136,800</td>
<td>130,700 - 142,900</td>
</tr>
<tr>
<td>Type II - 181 cloth</td>
<td>Hess Goldsmith</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Warp, yarn/in.</td>
<td></td>
<td></td>
<td>57</td>
<td>57 - 57</td>
</tr>
<tr>
<td>Fill, yarn/in.</td>
<td></td>
<td></td>
<td>54</td>
<td>54 - 54</td>
</tr>
<tr>
<td>Thickness, in.</td>
<td></td>
<td></td>
<td>0.0087</td>
<td>0.0087 - 0.0087</td>
</tr>
<tr>
<td>Weight, oz/sq yd</td>
<td></td>
<td></td>
<td>8.97</td>
<td>8.97 - 8.97</td>
</tr>
<tr>
<td>Flexural strength, psi</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dry</td>
<td></td>
<td></td>
<td>62,300</td>
<td>62,300 - 62,300</td>
</tr>
<tr>
<td>Wet</td>
<td></td>
<td></td>
<td>58,700</td>
<td>58,700 - 58,700</td>
</tr>
<tr>
<td>Breaking strength, lb/in.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Warp direction</td>
<td></td>
<td></td>
<td>229</td>
<td>229 - 229</td>
</tr>
<tr>
<td>Fill direction</td>
<td></td>
<td></td>
<td>197</td>
<td>197 - 197</td>
</tr>
</tbody>
</table>

HS-CF-110
15 November 1968
SUPPORTING DATA SUMMARY FOR
GLASS CLOTH FINISHED FOR EPOXY RESIN LAMINATES

Physical Properties Used in Establishing Specification Limits

<table>
<thead>
<tr>
<th>Property</th>
<th>Data source</th>
<th>No. of lots tested</th>
<th>Average Result</th>
<th>Range of data</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Low</td>
</tr>
<tr>
<td>Type I - 341 cloth</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Warp, yarns/in.</td>
<td>Clark Schwabel</td>
<td>5</td>
<td>30</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td>Hess Goldsmith</td>
<td>33</td>
<td>29</td>
<td>29</td>
</tr>
<tr>
<td>Fill, yarns/in.</td>
<td>Clark Schwabel</td>
<td>5</td>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td></td>
<td>Hess Goldsmith</td>
<td>33</td>
<td>48</td>
<td>48</td>
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<tr>
<td>Thickness, in.</td>
<td>Clark Schwabel</td>
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<td>0.0091</td>
<td>0.0085</td>
</tr>
<tr>
<td></td>
<td>Hess Goldsmith</td>
<td>33</td>
<td>0.0098</td>
<td>0.0092</td>
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<tr>
<td>Weight, oz/sq yd</td>
<td>Clark Schwabel</td>
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<td>8.83</td>
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<tr>
<td></td>
<td>Hess Goldsmith</td>
<td>33</td>
<td>8.86</td>
<td>8.12</td>
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<tr>
<td>Breaking strength, lb/in. width</td>
<td>Clark Schwabel</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Warp direction</td>
<td>6</td>
<td>60</td>
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<tr>
<td>Fill direction</td>
<td>6</td>
<td>554</td>
<td>406</td>
<td>815</td>
</tr>
<tr>
<td>Breaking strength, lb/in. width</td>
<td>Hess Goldsmith</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Warp direction</td>
<td>2</td>
<td>37</td>
<td>36</td>
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<tr>
<td>Fill direction</td>
<td>2</td>
<td>410</td>
<td>400</td>
<td>419</td>
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<tr>
<td>Flexural strength, psi</td>
<td>Bacchus</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Method A (Tonox)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dry</td>
<td></td>
<td></td>
<td>135,900</td>
<td>122,000</td>
</tr>
<tr>
<td>Wet</td>
<td></td>
<td></td>
<td>125,000</td>
<td>104,600</td>
</tr>
</tbody>
</table>
HERCULES SPECIFICATION DATA SHEET

1. MATERIAL  CLOTH, GLASS, UNFINISHED

1.1 DESCRIPTION. The material is a plain weave, unfinished glass cloth. The cloth is made from SCG 150 2/2 3.8S 4.0Z multi-filament yarn in the fill-direction and SCG 150 1/2 3.8S 4.0Z multi-filament yarn in the warp direction as defined in ASTM D 578-61. The yarn is made from high strength continuous glass filaments treated with an epoxy resin compatible sizing.

1.2 CLASSIFICATION. Not applicable.

2. INFORMATION AFFECTING PROCUREMENT.

2.1 SUPPLIERS AND MATERIAL IDENTIFICATION. Suppliers and material identification are provided below.

<table>
<thead>
<tr>
<th>SUPPLIER</th>
<th>TRADE NAME</th>
<th>PROGRAM</th>
<th>SPECIFICATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Owens-Corning Fiberglas</td>
<td>Unfinished</td>
<td>Sprint</td>
<td>11181411X</td>
</tr>
<tr>
<td>Corp., 900 17th Street,</td>
<td>Glass Cloth</td>
<td>S/34-901</td>
<td></td>
</tr>
<tr>
<td>N. W. Washington, D. C.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20008</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

2.2 PROBLEMS. None identified.

3. ACCEPTANCE CRITERIA. (Attached)

4. TEST METHODS. (Attached)

NOTES:

A. The material shall be capable of meeting all the requirements of this specification for a minimum of 52 weeks from date of manufacture when stored below 32°F Fahrenheit (F) in the original unopened containers. The storage life may be extended to 2 years from date of manufacture when stored at 11°F to 32°F F or to 3 years from date of manufacture when stored at 0°F ± 10°F F in the original unopened containers.
B. A representative sample of each roll shall be selected for testing. The material shall be conditioned in an environment of 70° to 80° F and a maximum relative humidity of 60 percent for a minimum of 8 hours prior to opening the package for sampling.
The material is a plain weave, unfinished glass cloth. The cloth is made from SCG 150 2/2 3.8S 4.0Z multi-filament yarn in the fill direction and SCG 150 1/2 3.8S 4.0Z multi-filament yarn in the warp direction as defined in ASTM D 578-61. The yarn is made from high strength continuous glass filaments treated with an epoxy resin compatible sizing.

3. ACCEPTANCE CRITERIA

3.1 Chemical and physical properties. The chemical and physical properties shall conform to table I.

Table I. Chemical and physical properties

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thickness, inch</td>
<td>Min. 0.017 Max. 0.020</td>
</tr>
<tr>
<td>Weight, ounces per yard</td>
<td>8.4</td>
</tr>
<tr>
<td>Warp yarns per inch</td>
<td>15</td>
</tr>
<tr>
<td>Fill yarns per inch</td>
<td>45</td>
</tr>
<tr>
<td>Fill breaking strength, pounds per inch of width</td>
<td>1050</td>
</tr>
<tr>
<td>Extractable content of sizing, percent</td>
<td>75</td>
</tr>
<tr>
<td>Ignition loss, percent</td>
<td>1.00</td>
</tr>
</tbody>
</table>

3.2 Workmanship. The material shall be uniform in texture and free of impurities and other defects that would prevent its use for the purpose intended.
4. TEST METHODS shall be in accordance with the following procedures:

4.1 Thickness. Thickness shall be determined in accordance with the method for woven and knitted materials, felts, and nonwovens of method 5030 of CCC-T-191 except that a minimum of 10 determinations shall be made from each roll sampled. Report the average of all determinations for each sample.

4.2 Weight. Weight shall be determined in accordance with method 5041 of CCC-T-191 except that a minimum of 3 determinations shall be made on each sample. Report the average of all determinations for each sample.

4.3 Warp yarns per inch. Warp yarns per inch shall be determined in accordance with method 5050 of CCC-T-191 except that a minimum of 5 determinations shall be made on each sample. Report the average of all determinations for each sample.

4.4 Fill yarns per inch. Fill yarns per inch shall be determined in accordance with method 5050 of CCC-T-191 except that a minimum of 5 determinations shall be made on each sample. Report the average of all determinations for each sample.

4.5 Fill breaking strength. Fill breaking strength shall be determined in accordance with the following:

(a) Material and equipment:

(1) Cardboard: Approximately 1 1/2 inches square, one side unfinished.

(2) Adhesive: Epoxy resin (Epon 826) and diethylenetriamine.

(3) Testing machine: (Instron or equivalent) with minimum scale range of 0 to 1000 pounds, adjustable rate of cross head separation, and self aligning grips.
(b) Specimen preparation: Cut a minimum of 5 specimens from each sample, approximately 3/4 inch wide by 8 inches long, with the fill yarns parallel to the 8 inch dimension. Unravel sufficient fill yarns so that the resulting specimen is 25 fill yarns wide. Prepare sufficient adhesive, by mixing 10 ± 0.1 parts by weight of diethylenetriamine per 100 parts by weight of epoxy resin, until homogeneous. Place two cardboard squares for each specimen, with the unfinished surface facing upwards, 3 ± 1/16 inch apart and aligned. Place a specimen over the cardboard squares so that the specimen is centered. Place approximately 3 grams of the mixed adhesive on the cardboard. Place a second cardboard square with the unfinished surface facing downwards, directly over the adhesive on the specimen, align, and press down lightly. Place a suitable section of light gauge aluminum over the made up specimens. Cure at room temperature for a minimum of 24 hours taking precautions to protect the samples from distortion.

(c) Procedure: Set rate of cross head separation of test machine at 0.5 inch per minute. Set grips 3 inches apart. Secure specimens in the grips. Care shall be taken to align the fill yarns in the direction of the pull. Load specimen to failure.

(d) Calculation:

\[
\text{Fill breaking strength (pounds per inch of width)} = \frac{A}{25} \times B
\]

where:  
\[A = \text{Break load average, pounds}\]  
\[B = \text{number of fill yarns per inch width}\]  
\[25 = \text{number of fill yarns in specimen}\]

(e) Report the average of all determinations for each sample.

4.3 Extractable content of sizing. Extractable content of sizing shall be determined in accordance with the following:

(a) Procedure: Weigh approximately 10 grams of sample to the nearest 0.1 milligram (mg). Place specimen in a Soxhlet extraction apparatus and extract with 100 milliliters of methylene chloride for a minimum of 2 hours at approximately 5 cycles per hour. Remove specimen from the Soxhlet and dry in air (under a fume hood) for a minimum of 1/2 hour. Place in an oven and dry for a minimum
of 1/2 hour at $165^\circ \pm 5^\circ$ F. Remove specimen from the oven and cool in a desiccator to room temperature. Weigh specimen to nearest 0.1 mg. Place specimen in a furnace for a minimum of 1/2 hour at $1150^\circ$ to $1500^\circ$ F. Remove specimen from the furnace and cool in a desiccator to room temperature. Weigh specimen to nearest 0.1 mg.

(b) Calculation: Extractable content of sizing (percent) $= \frac{A-B}{A-C} \times 100$

where:
- $A =$ initial specimen weight, grams
- $B =$ specimen weight after removal from the oven, grams
- $C =$ specimen weight after ignition, grams

(c) Report the average of a minimum of 2 determinations for each sample.

4.7 Ignition loss. Ignition loss shall be determined in accordance with the following calculation:

(a) Calculation: Ignition loss (percent) $= \frac{(A-C)}{A} \times 100$

where:
- $A =$ initial specimen weight, grams (from 4.6)
- $C =$ specimen weight after ignition, grams (from 4.6)

(b) Report the average of a minimum of 2 determinations for each sample.
HERCULES SPECIFICATION DATA SHEET

1. MATERIAL. RESIN, EPOXY

1.1 DESCRIPTION. The material is a mixture of a diglycidyl ether of bisphenol A epichlorohydrin type epoxy resin and bis-(2, 3-epoxycyclopentyl)-ether in liquid form.

1.2 CLASSIFICATION. Not applicable.

2. INFORMATION AFFECTING PROCUREMENT.

2.1 SUPPLIERS AND MATERIAL IDENTIFICATION. Suppliers and material identification are provided below:

<table>
<thead>
<tr>
<th>SUPPLIER</th>
<th>TRADE NAME</th>
<th>PROGRAM</th>
<th>SPECIFICATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Union Carbide</td>
<td>ERL 2256</td>
<td>Sprint</td>
<td>11181401XB</td>
</tr>
<tr>
<td>Corporation</td>
<td></td>
<td>Poseidon</td>
<td>WS 8023</td>
</tr>
</tbody>
</table>

2.2 PROBLEMS. None identified.

3. ACCEPTANCE CRITERIA. (Attached)

4. TEST METHODS. (Attached)

NOTES:

A. Other specifications for ERL 2256 containing similar requirements are as follows:

<table>
<thead>
<tr>
<th>SUPPLIER</th>
<th>TRADE NAME</th>
<th>PROGRAM</th>
<th>SPECIFICATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Union Carbide</td>
<td>ERL 2256</td>
<td>Minuteman</td>
<td>HPC 133-08-2-3D</td>
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<tr>
<td>Corporation</td>
<td></td>
<td></td>
<td>HXS-2-17</td>
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<td></td>
<td></td>
<td></td>
<td>BE3</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>HPC 253-02-2-4A</td>
</tr>
</tbody>
</table>

B. Viscosity limits of 5.0 to 7.0 poises are necessary for the Poseidon program because of the long winding time for the Poseidon case.

C. Poseidon specification includes requirements and tests (performed by Bacchus) for working life, tensile strength, and elongation.
NOTES (cont)

D. Poseidon specification deletes requirement for specific gravity and determines viscosity by ASTM D 1084-63, Method B.
HERCULES SPECIFICATION DATA SHEET

RESIN, EPOXY

The material is a mixture of a diglycidyl ether of bisphenol A epichlorohydrin type epoxy resin and bis-(2,3-epoxycyclopentyl)-ether in liquid form.

3. ACCEPTANCE CRITERIA

3.1 Physical and chemical properties. The physical and chemical properties shall conform to Table I.

Table I. Physical and chemical properties

<table>
<thead>
<tr>
<th>Property</th>
<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Minimum</td>
</tr>
<tr>
<td>Specific gravity</td>
<td>1.155</td>
</tr>
<tr>
<td>Viscosity, centipoises</td>
<td>500</td>
</tr>
<tr>
<td>Weight per epoxy equivalent, grams per equivalent</td>
<td>135</td>
</tr>
<tr>
<td>Water content, percent</td>
<td>- - -</td>
</tr>
</tbody>
</table>

3.2 Workmanship. The material shall be uniform in texture and free of impurities or any other defect that would prevent its use for the purpose intended.

4. TEST METHODS shall be in accordance with the following procedures:

4.1 Specific gravity. Specific gravity shall be determined at 25°/25° centigrade (C) in accordance with method A of ASTM D 891-59. Report the average of a minimum of 2 determinations.

4.2 Viscosity. Viscosity shall be determined in accordance with ASTM D 1545-63 under the following conditions:

(a) Invert the tube until 3 consecutive readings agree within 0.1 second. This reading shall be reported as the result.
(b) Report the average of a minimum of 2 determinations in centipoises.

4.3 Weight per epoxy equivalent. Weight per epoxy equivalent shall be determined in accordance with the following:

(a) Equipment:

1. Pressure bottles, Fischer Scientific Catalogue number 3-100, or equivalent.

2. Canvas or cloth bags.

3. pH meter Beckman H2, or equivalent.

(b) Reagents and solutions:

1. Methanol-potassium hydroxide, 0.2 normal (N), standardized against standard hydrochloric acid or potassium acid phthalate to bromoresol purple indicator.

2. Pyridine hydrochloride solution, prepared by either of the two following methods:

   (a) Dissolve 27.0 grams of pyridine hydrochloride crystals in 3 to 5 milliliters (ml) of water. Add 500 ml of redistilled or chemically pure (CP) pyridine and shake to mix.

   (b) Carefully add 19.5 ml of reagent grade hydrochloric acid to 400 ml of redistilled or CP pyridine. Dilute to 500 ml with more pyridine and shake to mix.

3. Bromoresol purple indicator solution, prepared by dissolving 0.1 gram of bromoresol purple indicator in 100 ml of methanol.

4. Methanol, anhydrous.

5. Pyridine, redistilled or CP.
(c) Procedure: Weigh approximately one gram of sample to the nearest 0.1 milligram, transfer to a pressure bottle and add (pipette) 50 ml of pyridine hydrochloride solution. Stopper the bottle and swirl to effect solution of the sample. Prepare a blank by pipetting 50 ml of pyridine hydrochloride into a second pressure bottle. Place the two bottles in canvas bags or wrap in strong cloth and place in a steam or boiling water bath at 98° ± 2° C for a minimum of 4 hours. After heating remove the bottles from the steam bath and allow to cool to room temperature. (Do not remove the wrappers from the bottles while they are hot or attempt to hasten the cooling by immersing in cold water.) When the bottles have cooled to room temperature, loosen the wrappers, uncap the bottles slowly to release any pressure and then remove the wrappers. Rinse down the insides of the bottles with methanol and then quantitatively transfer the material from each flask into a clean dry beaker. Rinse each flask at least twice, transferring the rinsings to the beakers. Titrate the sample and the blank with 0.2 N potassium hydroxide solution to a pH of 8.2 ± 0.05 using a freshly standardized pH meter. Add the titrant at a moderate rate to pH 6.0, then dropwise to pH 7.0, and then dropwise to pH 8.3 ± 0.05 waiting approximately 5 seconds between each drop.

(d) Calculation: Weight per epoxy equivalent = \[ \frac{1000 \cdot W}{(B-A) \cdot N} \]

where:
- \( A \) = sample titration, ml
- \( B \) = average blank titration, ml
- \( W \) = sample weight, grams
- \( N \) = normality of the potassium hydroxide solution

(e) Report the average of a minimum of 2 determinations.

4.4 Water content. Water content shall be determined in accordance with ASTM E 203-64, except the end point shall be 10 seconds. Report the average of a minimum of 2 determinations.
HERCULES SPECIFICATION DATA SHEET

1. MATERIAL. CURING AGENT, AMINE BLEND
   
   1.1 DESCRIPTION. Tonox 6040 is an epoxy resin curing agent. The material is a liquid eutectic mixture of various aromatic amines, consisting of 40 percent meta-phenylenediamine and 44 percent of an isomeric mixture of methylenedianiline.

   1.2 CLASSIFICATION. NA

2. INFORMATION AFFECTING PROCUREMENT
   
   2.1 SUPPLIERS AND MATERIAL IDENTIFICATION. Suppliers and material identification are provided below:

<table>
<thead>
<tr>
<th>SUPPLIER</th>
<th>TRADE NAME</th>
<th>PROGRAM</th>
<th>SPECIFICATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Untroyal, Inc.</td>
<td>Tonox 6040</td>
<td>Poseidon F/S, F/S</td>
<td>WS 8026</td>
</tr>
</tbody>
</table>

   2.2 PROBLEM. (None identified)

3. ACCEPTANCE CRITERIA. (Attached)

4. TEST METHODS. (Attached)

NOTES:

A. Information regarding Tonox 6040 can also be found in Material Unit No. 2.3.5 (ERL 2256 filament winding resin).

B. Poseidon product-peculiar specification WS 8026 contains requirements and test methods for working life, tensile strength and elongation of mixed adhesive as used in that program.
Tonox 6040 is an epoxy resin curing agent. The material is a liquid eutectic mixture of various aromatic amines, consisting of 40 percent meta-phenylenediamine and 44 percent of an isomeric mixture of methylenedianiline.

3. **ACCEPTANCE CRITERIA.** Acceptance criteria shall conform to the following:

3.1 **Chemical composition.** The chemical composition of the curing agent, as determined by gas chromatographic analysis, shall be in accordance with Table I.

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>( m )-phenylenediamine</td>
<td>40 ± 4</td>
</tr>
<tr>
<td>( p,p' )-methylenedianiline</td>
<td>36 ± 4</td>
</tr>
<tr>
<td>( o,p' )-methylenedianiline</td>
<td>8 ± 2</td>
</tr>
<tr>
<td>Other chemicals</td>
<td>21 maximum</td>
</tr>
</tbody>
</table>

3.2 **Titretable nitrogen.** Titretable nitrogen content of the curing agent shall be not greater than 19.0 nor less than 18.0 percent.

3.3 **Moisture.** Moisture content of the curing agent shall be not greater than 0.4 percent.

3.4 **Workmanship.** The curing agent shall be in a liquid form, manufactured to assure a uniform product free from impurities and contamination that would prevent its use for the purpose intended.

4. **TEST METHODS.** Conformance to acceptance criteria shall be determined in accordance with the following procedures.

4.1 **Visual examination.** Samples shall be visually examined to determine compliance with 3.4.

4.2 **Chemical composition.** The chemical composition shall be determined in accordance with the following:

4.2.1 **Apparatus and reagents.** Dual column gas chromatograph with temperature programming and thermal conductivity detector (see figure 1).
Hamilton Micro Syringe 10 microliter (μl) capacity or equivalent.

Reagent Grade ethanol (MeOH) and Di-Butyl-Phthalate (DBP)

Metaphenylene diamine (NPDA) 99 + percent purity

4,4' Methylene-amine (4,4' MDA) 99 + percent purity

Chromatographic column (six feet of 1/4 inch stainless steel tubing packed with 15 percent Apiezon L on 80/90 Analarw ABS).

b. Operating conditions

| Column conditions | 220°-300° centigrade (C) and hold at 10° C/minute. |
| Detector block temperature | 300° C |
| Injection port temperature | 300° C |
| Carrier gas | Helium (He) |
| Flow rate | 70 milliliter (ml)/minute |
| Filament detector current | 150 milliamperes |
| Sample concentration | 1 gram (g) of sample/5 ml MeOH |
| Sample size | 5-μl |

c. Preparation of standard. Weigh into a 5 ml volumetric flask approximately 0.4 g of NPDA and 0.4 g of 4,4' MDA. Add sufficient DBP internal standard to give a final concentration of 40 milligram/milliter (mg/ml). Record the weight of these three components to the nearest milligram (mg) and dilute the flask to the mark with MeOH. Shake the flask until all of the solid material is completely in solution.

d. Preparation of sample. Weigh into a 5 ml volumetric flask approximately 1.0 g of curing agent. Add sufficient DBP to give a final concentration of 40 mg/ml, dilute to the mark with MeOH and shake until all the curing agent has gone into solution.

e. Column preparation. Make out a new column at 300° C for about 4 hours with the 70 ml/minute of He flowing through. Hold the column at 300° C inject five 5-μl portions of prepared sample one after the other. Wait until these have all come through the column. Then cool the column to 220° C and run a 5-μl sample from 220° to 300° C at 10° C/minute. Hold at 300° C and inject five more 5-μl samples and wait until all have come through. Cool to 220° C, inject a sample and program to 300° C at 10° C/minute and compare the A sample/A standard with the previous run for each of the three components (A = peak area). If the ratios are similar, the column is now ready to run the standard solution. If the second run has higher ratios, dope the column with five more 5-μl injections.
f. **Determination.** Inject a 5-μl portion of the standard. Follow this with a minimum of three 5-μl injections of prepared sample. A duplicate standard will be run after each group of sample injections.

g. **Calculations for standard.** Using the chromatogram obtained from the standard, calculate the area of the MPDA peak, the DBP peak and the 4,4' NDA peak. From the weighings of the standard find the weight of MPDA, weight of DBP and weight of 4,4' NDA. Knowing the above six weights and areas, calculate a factor for both MPDA and 4,4' NDA in the following manner:

\[
\text{Factor MPDA} = \frac{\text{Wt of MPDA}}{\text{Wt of internal standard}} \times \frac{\text{Area of MPDA}}{\text{Area of internal standard}}
\]

\[
\text{Factor 4,4' NDA} = \frac{\text{Wt of 4,4' NDA}}{\text{Wt of internal standard}} \times \frac{\text{Area of 4,4' NDA}}{\text{Area of internal standard}}
\]

h. **Calculations for sample.** Using triangulation calculate the areas of the following peaks in the sample chromatograph: MPDA, DBP, 2,4' NDA and 4,4' NDA. Calculate the following area ratios:

\[
\begin{array}{ccc}
\text{Area of MPDA} & \text{Area of 2,4' NDA} & \text{Area of 4,4' NDA} \\
\text{Area of DBP} & \text{Area of DBP} & \text{Area of DBP}
\end{array}
\]

Find the weight of DBP weighed into the sample and the weight of sample used. Calculate the percentages of each of the three components in the curing agent using the following formulas:

\[
\text{Percent MPDA} = \frac{\left(\frac{\text{Area of MPDA}}{\text{Area of DBP}}\right) \times \text{Wt of DBP} \times 100}{\text{Wt of curing agent sample}}
\]

\[
\text{Percent 2,4' NDA} = \frac{\left(\frac{\text{Area of 2,4' NDA}}{\text{Area of DBP}}\right) \times \text{Wt of DBP} \times 100}{\text{Wt of curing agent sample}}
\]

\[
\text{Percent 4,4' NDA} = \frac{\left(\frac{\text{Area of 4,4' NDA}}{\text{Area of DBP}}\right) \times \text{Wt of DBP} \times 100}{\text{Wt of curing agent sample}}
\]

A minimum of three sets shall be tested and the average of these tests will be reported to two significant figures.

4.3 **Titretable nitrogen.** Percent titretable nitrogen shall be determined in accordance with 4.3.1 through 4.3.5.

4.3.1 **Equipment.** The following equipment shall be used:

a. Calomel reference electrode.

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b. Glass electrode, all purpose.

c. Beckman Zeromatic pH meter.

4.3.2 Reagents. The following reagents shall be used:

a. Acetic acid, glacial, American Chemical Society (ACS) reagent grade.

b. Acetic anhydride, ACS reagent grade.

c. Potassium acid phthalate, primary standard.

d. Perchloric acid, ACS reagent grade.

4.3.3 Perchloric acid solution. Perchloric acid solution, 0.1 normal (N) shall be prepared as follows:

a. Place approximately 750 ml of glacial acetic acid in a 1000-ml volumetric flask.

b. Add 8 to 9 ml of 70 percent perchloric acid or 10 to 11 ml of 65 percent perchloric acid and mix.

c. Add 20 ml of acetic anhydride and mix.

d. Dilute to volume with glacial acetic acid and mix.

e. Stopper the flask and let stand for a minimum of 8 hours.

f. Weigh 0.45 to 0.50 g., to the nearest 0.1 mg., of dried potassium acid phthalate into a 250-ml beaker.

g. Add 50 to 100 ml of glacial acetic acid, stir and heat gently until all of the potassium acid phthalate has dissolved.

h. Cool to room temperature, immerse the electrodes in the sample, and titrate potentiometrically with the perchloric acid.

i. Run a blank determination.

j. Calculate normality of perchloric acid as follows:

\[
\text{Normality of perchloric acid } = \frac{W \times 6.597}{V_1 - V_2}
\]

where:  
- \(W\) = weight of potassium acid phthalate, g
- \(V_1\) = volume of perchloric acid required to titrate sample, ml
- \(V_2\) = volume of perchloric acid required to titrate blank, ml
- 6.597 = reciprocal of milliequivalent weight of potassium acid phthalate
k. Normality between duplicate standardization shall not differ more than 0.001.

4.3.4 Procedure. Titratable nitrogen shall be determined as follows:

a. Weigh a 2- to 4-milliequivalent sample, weighed to the nearest 0.1 mg, into a 250-ml beaker.

b. Add 50 to 100 ml glacial acetic acid and warm the solution, if necessary, to completely dissolve the sample.

c. After the sample has dissolved, let the solution cool to room temperature.

d. Place the electrodes in the solution and titrate potentiometrically with the standardized perchloric acid solution.

e. Perform a blank determination.

f. Calculate percent titratable nitrogen as follows:

\[
\text{Percent titratable nitrogen} = \frac{(V_1 - V_2)(N)(0.014)}{W} \times 100
\]

where:

- \(V_1\) = volume of perchloric acid solution required to titrate the sample, ml
- \(V_2\) = volume of perchloric acid solution required to titrate the blank, ml
- \(N\) = normality of the perchloric acid solution
- \(W\) = weight of sample, g
- 0.014 = milliequivalent weight of nitrogen

4.3.5 Alternate titration procedure. Alternatively, the standardization of the sample titration may be performed visually using crystal violet indicator providing that the sample coloration does not interfere with the observation of the blue-green endpoint. The same method shall be used for the standardization as for the sample titration. In case of dispute, the potentiometric titration procedure shall govern.

4.4 Moisture content. The moisture content shall be determined in accordance with ASTM E 203-64. A 15 percent salicylic acid in methanol solvent shall be used for this determination.
Figure 1. Dual Column Chromatograph
### SUPPORTING DATA SUMMARY FOR AMINE BLEND CURING AGENT

<table>
<thead>
<tr>
<th>Property</th>
<th>Data source</th>
<th>No. of lots tested</th>
<th>Average result</th>
<th>Range of data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chemical Composition</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>m-PDA, percent</td>
<td>Uniroyal</td>
<td>6</td>
<td>40.0</td>
<td>38.1 - 41.9</td>
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<tr>
<td></td>
<td>Hercules/Bacchus</td>
<td>6</td>
<td>41.1</td>
<td>39.3 - 42.7</td>
</tr>
<tr>
<td>p,p'-MDA, percent</td>
<td>Uniroyal</td>
<td>6</td>
<td>35.6</td>
<td>33.8 - 36.8</td>
</tr>
<tr>
<td></td>
<td>Hercules/Bacchus</td>
<td>6</td>
<td>35.1</td>
<td>33.6 - 36.8</td>
</tr>
<tr>
<td>o,p'-MDA, percent</td>
<td>Uniroyal</td>
<td>6</td>
<td>8.5</td>
<td>7.6 - 9.2</td>
</tr>
<tr>
<td></td>
<td>Hercules/Bacchus</td>
<td>6</td>
<td>8.1</td>
<td>7.8 - 8.6</td>
</tr>
<tr>
<td>Other, percent</td>
<td>Uniroyal</td>
<td>6</td>
<td>16.1</td>
<td>13.3 - 18.4</td>
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<tr>
<td></td>
<td>Hercules/Bacchus</td>
<td>6</td>
<td>15.8</td>
<td>14.9 - 16.3</td>
</tr>
<tr>
<td>Nitrogen, percent</td>
<td>Uniroyal</td>
<td>5</td>
<td>18.4</td>
<td>18.2 - 18.6</td>
</tr>
<tr>
<td></td>
<td>Hercules/Bacchus</td>
<td>7</td>
<td>18.4</td>
<td>18.0 - 18.7</td>
</tr>
<tr>
<td>Moisture, percent</td>
<td>Uniroyal</td>
<td>7</td>
<td>0.1</td>
<td>Nil - 0.2</td>
</tr>
<tr>
<td></td>
<td>Hercules/Bacchus</td>
<td>7</td>
<td>0.31</td>
<td>0.21 - 0.35</td>
</tr>
</tbody>
</table>
HERCULES SPECIFICATION DATA SHEET

1. MATERIAL. ADHESIVE, EPOXY RESIN BASE

1.1 DESCRIPTION. The adhesive consists of two parts; Part A is an epoxy resin containing a suspensoidal gelling agent (Bentone 27) and a polar agent (methanol). Part B is a liquid amine containing an accelerator.

2. INFORMATION AFFECTING PROCUREMENT

2.1 SUPPLIERS AND MATERIAL IDENTIFICATION. Suppliers and material identification are provided below:

<table>
<thead>
<tr>
<th>SUPPLIER</th>
<th>TRADE NAME</th>
<th>PROGRAM</th>
<th>SPECIFICATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hysol Division</td>
<td>EA 946</td>
<td>Sprint</td>
<td>11181310X</td>
</tr>
<tr>
<td>The Dexter Corporation</td>
<td>Poseidon</td>
<td>WS 8994</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Hibex</td>
<td>SDS</td>
<td></td>
</tr>
</tbody>
</table>

2.2 PROBLEMS. None identified

3. ACCEPTANCE CRITERIA. (Sections 3.3, 3.4, and 3.5 of attached specification HS-CP-102, (9/1/67))

4. TEST METHODS. (Section 4.4 of attached specification HS-CP-102, (9/1/67))

NOTES:

A. Poseidon specification WS 8994 deletes requirement and test for Flow of Part A; adds a requirement for viscosity of Part A tested in accordance with ASTM D 1084-63, Method B and identified exceptions; and adds acceptance criteria limiting the number of foreign particles in Part A and Part B.

B. Amendment I corrects supplier and trade name listed in paragraph 2.1 of cover page, identifies Poseidon criteria for foreign particles in note A, and adds note C.

C. In an effort to control foreign particles in the material, Dexter now screens both parts of all EA 946 produced through a 100 mesh screen prior to performing acceptance tests on the material.
HERCULES SPECIFICATION DATA SHEET

1. MATERIAL. Adhesive, Epoxy Resin Base

1.1 DESCRIPTION. The adhesive consists of two parts: Part A is an epoxy resin containing a suspensoidal gelling agent (Bentone 27) and a polar agent (methanol). Part B is a liquid amine containing an accelerator.

2. INFORMATION AFFECTING PROCUREMENT

2.1 SUPPLIERS AND MATERIAL IDENTIFICATION. Suppliers and material identification are provided below:

<table>
<thead>
<tr>
<th>SUPPLIER</th>
<th>TRADE NAME</th>
<th>PROGRAM</th>
<th>SPECIFICATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shell Chemical Co.</td>
<td>Epon 946</td>
<td>SPRINT</td>
<td>11181310X</td>
</tr>
<tr>
<td></td>
<td></td>
<td>POSEIDON</td>
<td>WS 8994</td>
</tr>
</tbody>
</table>

2.2 PROBLEMS. None identified

3. ACCEPTANCE CRITERIA. (Sections 3.3 and 3.4 of attached specification HS-CP-102, (9/1/67))

4. TEST METHODS (Section 4.4 of attached specification HS-CP-102, (9/1/67))

NOTES:

1. Coverpage prepared to provide Materials Manual Unit identification and to reflect exceptions contained in POSEIDON spec.

2. POSEIDON specification WS 8994 deletes requirement and test for Flow of Part A and adds a requirement for Viscosity of Part A tested in accordance with ASTM D 1064-63, Method B and identified exceptions.

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HERCULES SPECIFICATION

ADHESIVE, EPOXY RESIN BASE

HERCULES INCORPORATED

CHEMICAL PROPULSION DIVISION
WILMINGTON, DELAWARE

APPROVED BY
Manager, Quality Assurance

DATE 1 Sept 67

This specification consists of page 1 and 1 to 11 inclusive.
HERCULES INCORPORATED
CHEMICAL PROPULSION DIVISION
SPECIFICATION
ADHESIVE, EPOXY RESIN BASE

1. SCOPE

1.1 Scope. This specification covers one type of adhesive consisting of an epoxy resin base with an amine curing agent.

1.2 Classification. The material shall be of the following type:

Type I - Epoxy resin with filler

2. APPLICABLE DOCUMENTS

2.1 The following documents of the issue in effect on date of invitation for bids or request for proposal, form a part of this specification to the extent specified herein.

STANDARDS

Military

MIL-STD-129 Marking for Shipment and Storage

(Copies of specifications, standards, drawings, and publications required by suppliers in connection with specific procurement functions should be obtained from the procuring activity or as directed by the contracting officer.)

2.2 Other publications. The following documents form a part of this specification to the extent specified herein. Unless otherwise indicated, the issue in effect on date of invitation for bids or request for proposal shall apply.

American Society for Testing and Materials

ASTM E 203-64 Water Using Karl Fischer Reagent
ASTM D 638-64T Tensile Properties of Plastics
ASTM D 1002-64 Strength Properties of Adhesives in Shear by Tension Loading (Metal to Metal)
ASTM D 1652-62T Epoxy Content of Epoxy Resins


Aeronautical Material Specifications

AMS 3366 Silicone Rubber Compound

(Application for copies should be addressed to the Society of Automotive Engineers, Inc., 485 Lexington Avenue, New York, New York, 10017.)
3. REQUIREMENTS

3.1 Material. The adhesive shall consist of two parts; an epoxy resin (part A) and a curing agent (part B) furnished in matched lots.

3.1.1 Part A. Part A shall be an epoxy resin containing a suspensoidal gelling agent (6.3) and a polar agent (6.4).

3.1.2 Part B. Part B shall be a liquid amine containing an accelerator.

3.2 Material modification. The supplier shall notify the procuring activity of any change to the material formulation or manufacturing processes, prior to shipping modified material in response to a contract or purchase order involving this specification.

3.3 Chemical and physical properties. The chemical and physical properties of the material shall conform to table I.

<table>
<thead>
<tr>
<th>Property</th>
<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Ingredients</td>
</tr>
<tr>
<td></td>
<td>Part A</td>
</tr>
<tr>
<td>Flow, inch</td>
<td>-- Min.</td>
</tr>
<tr>
<td>Titer content, percent</td>
<td>2.4 Min.</td>
</tr>
<tr>
<td>Weight per epoxy equivalent,</td>
<td>340 Min.</td>
</tr>
<tr>
<td>grams per equivalent</td>
<td></td>
</tr>
<tr>
<td>Titratable nitrogen, percent</td>
<td>-- Min.</td>
</tr>
<tr>
<td>Moisture content, percent</td>
<td>-- Min.</td>
</tr>
<tr>
<td>Bond shear strength, psi</td>
<td>-- Min.</td>
</tr>
<tr>
<td>Tensile strength, psi</td>
<td>-- Min.</td>
</tr>
<tr>
<td>Ultimate elongation, percent</td>
<td>-- Min.</td>
</tr>
<tr>
<td>Change in refractive index,</td>
<td>-- Min.</td>
</tr>
<tr>
<td>between 12 and 192 minutes after mixing</td>
<td>-- Min.</td>
</tr>
</tbody>
</table>

3.4 Workmanship. The material shall be uniform in quality, free of impurities or any defect that would prevent its use for the purpose intended.

4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for inspection. Unless otherwise specified in the contract or purchase order, the supplier is responsible for the performance of all inspection requirements as specified herein. Except as otherwise specified, the supplier may utilize his own or any other facilities or any commercial laboratory acceptable to the procuring activity. The procuring activity reserves the right to perform any of the inspections set forth in the specification where such inspections are deemed necessary to assure that the supplier and services conform to prescribed requirements.
4.2 Lot. A lot of adhesive shall consist of matched lots of part A and part B with each part compounded in a single batch without change in process or materials and offered for acceptance at one time.

4.3 Sampling. A representative sample of each part of each lot shall be selected for testing.

4.4 Acceptance tests. The following acceptance tests shall be performed on each lot. Failure of any sample to conform to any requirement of this specification shall be cause for rejection of the lot.

4.4.1 Flow. Flow shall be determined in accordance with the following:

(a) Equipment:

(1) Gardner film casting knife, or equivalent approved by the procuring activity.

(2) Glass plates conforming to figure 2. The test shall be conducted in an area free of vibration.

(3) A Nordson or Gardner film gage.

(b) Sample preparation: Thoroughly mix the ingredients in their original containers. Weigh the ingredients into a clean wax-free container in the ratio of 100 parts by weight (pbw) of part A to 15 ± 0.3 pbw of part B. Thoroughly mix the ingredients until a uniform blend is obtained.

(c) Procedure: Condition the sample (approximately 345 grams), glass plates, and Gardner film casting knife to 77 ± 2°F. Place the sample on the top line of the glass plate in the horizontal position. Make a rapid, even drawdown using the Gardner film casting knife, preset to give 0.070 ± 0.002 inch thickness of adhesive on the glass plate. Immediately after drawdown, measure the film thickness in 3 places using a Nordson or Gardner film gage. Remove excess adhesive above the top line and below the bottom line. Place 3 small pieces of black thread or brush bristles approximately 1/8 inch long on the glass plate as shown in figure 2. Raise the glass plate to the vertical position, (figure 2) 5 to 6 minutes after completing the drawdown and leave undisturbed for 20 ± 1 minute. Any downward movement of any of the 3 threads shall be measured and recorded as flow.
(d) Report each result from a minimum of 1 determination.

4.4.2 Filler content (part A). Filler content of part A shall be determined in accordance with the following:

(a) Procedure: All weighings shall be to the nearest 0.1 milligram (mg). Weigh 0.7 to 0.8 gram sample into a previously tared 50 milliliter (ml) glass beaker. Add 0.35 to 0.40 gram of filter aid (6.5) that has been previously dried for approximately 1 hour at 140 to 150°C Centigrade (°C). Add 10 ml of chlorobenzene and stir until all lumps are dissolved and any suspended matter is finely dispersed. Transfer the contents of the beaker into a previously tared medium porosity sintered glass crucible. Rinse the beaker twice with 5 ml portions of chlorobenzene each time and transfer the washings to the crucible. Vacuum filter the mixture. Wash the residue with 40 to 50 ml of chlorobenzene, catching the washings in the flask. Reserve the filtrate for 4.5.3. Dry the crucible and contents for 30 to 40 minutes at 150 ± 5°C. Cool in a desiccator and weigh.

(b) Calculation: Filler content (percent) = \( \frac{W_1 - (F + C)}{W} \times 100 \)

Where:
- \( W_1 \) = weight of crucible plus residue plus filter aid
- \( F \) = weight of crucible
- \( C \) = weight of filter aid
- \( W \) = weight of sample

(c) Report the average of a minimum of 2 determinations.

4.4.3 Weight per epoxy equivalent (part A). Weight per epoxy equivalent of part A shall be determined in accordance with ASTM D 1652-62T using the filtrate from the filler content test (4.4.2). Report the average of a minimum of 2 determinations.

4.4.4 Titratable nitrogen (part B). Titratable nitrogen of part B shall be determined in accordance with the following:

(a) Equipment: The following equipment, or its equivalent, shall be used:

(1) Calomel reference electrode.

(2) Glass electrode, all purpose.

(3) Beckman seromatic pH meter.
(b) Reagents:

(1) Acetic acid, glacial, American Chemical Society (ACS) reagent grade.

(2) Acetic anhydride, ACS reagent grade.

(3) Potassium acid phthalate, primary standard.

(4) Perchloric acid, ACS reagent grade.

(c) Perchloric acid solution, 0.1 Normal

(1) Preparation: Place approximately 250 ml of glacial acetic acid in a 1000 ml volumetric flask. Add 8 to 9 ml of 70 percent perchloric acid or 10 to 11 ml of 60 percent perchloric acid and mix. Add 20 ml of acetic anhydride and mix. Dilute to volume with glacial acetic acid and mix. Stopper the flask and let stand for a minimum of 6 hours. Weigh 0.45 to 0.50 gram of dried potassium acid phthalate into a 250 ml beaker. Add 50 to 100 ml of glacial acetic acid, stir and heat gently until all of the potassium acid phthalate has dissolved. Cool to room temperature, immerse the electrodes in the sample, and titrate potentiometrically with the perchloric acid. Run a blank determination.

(2) Calculation: Normality of perchloric acid = \( \frac{W \times 4.897}{V_1 - V_2} \)

Where: 
- \( W \) = weight of potassium acid phthalate, grams
- \( V_1 \) = volume of perchloric acid required to titrate sample, ml
- \( V_2 \) = volume of perchloric acid required to titrate blank, ml
- 4.897 = reciprocal of milliequivalent weight of potassium acid phthalate

(3) Normality: The normality between duplicate standardizations shall not differ more than 0.001.

(d) Procedure: Weigh to the nearest 0.1 mg a 2 to 4 milliequivalent sample into a 250 ml beaker. Add 50 to 100 ml glacial acetic acid and warm the solution, if necessary, to completely dissolve the sample. After the sample has dissolved, discontinue warming, and let the solution cool to room temperature. Place the electrodes in the solution and titrate potentiometrically with the standardized perchloric acid solution. Perform a blank determination.
(e) Titratable nitrogen (percent) = \( \frac{(V_1 - V_2) \times (N) \times 0.014}{W} \times 100 \)

Where: 
- \( V_1 \) = volume of perchloric acid solution required to titrate the sample, ml
- \( V_2 \) = volume of perchloric acid solution required to titrate the blank, ml
- \( N \) = normality of the perchloric acid solution
- \( W \) = weight of sample, grams
- 0.014 = milliequivalent weight of nitrogen

(f) Alternate titration procedure: Alternatively, the standardization and the sample titration may be performed visually using crystal violet indicator providing that the sample coloration does not interfere with the observation of the blue-green endpoint. In case of dispute, the potentiometric titration procedure shall govern.

(g) Report the average of a minimum of 2 determinations.

4.4.5 Moisture content (part A). Moisture content of part A shall be determined in accordance with ASTM E 203-64.

4.4.6 Bond shear strength. Bond shear strength shall be determined in accordance with ASTM D 1002-64 under the following conditions:

(a) The test panel material shall be 4 by 8 inch Alclad 2024-T3 aluminum alloy 0.064 ± 0.003 inch thick. The area to be bonded shall be free from surface imperfections, with the 6 inch edge milled and deburred.

(b) Vapor degrease the panels with trichloroethylene or methyl ethyl ketone; or degrease by wiping with a clean cloth saturated with trichloroethylene or methyl ethyl ketone until no discoloration appears on the cloth. Oven dry for a minimum of 10 minutes at 150 ± 5°F. Remove panels and cool to ambient temperature.

(c) Etch the area to be bonded (or the entire panel) for 10 to 12 minutes in a solution of 7 phr of concentrated sulfuric acid (95 to 98 percent), 2 phr of sodium dichromate, and 17 phr of distilled water. Remove panel from the solution and immediately rinse with running tap water and final rinse with distilled or deionized water. Inspect for water breaks during rinsing, and if water breaks are observed, repeat (b) and (c). Oven dry for 15 to 20 minutes at 150 ± 5°F or 30 to 35 minutes at 115 to 120°F. Remove panels and allow to cool to ambient temperature.
(d) Apply a thin coat of adhesive, prepared in accordance with 4.4.1 (b), on the bonding surface of each panel. Assemble the panels in pairs using an overlap of 0.5 ± 0.05 inch.

(e) Cure within 6 hours after assembly under 20 to 80 pounds of weight for 120 ± 5 minutes at 200 ± 50°F.

(f) The specimens shall be tested within 6 hours after cure.

(g) The specimens shall be conditioned for 2 to 4 hours at 75 ± 5°F and then tested at 75 ± 5°F.

(h) Report the average of a minimum of 5 determinations.

4.4.7 Tensile strength and ultimate elongation. Tensile strength and ultimate elongation shall be determined in accordance with ASTM D 638-64T under the following conditions:

(a) Test specimens shall be prepared in accordance with either method I or II (4.4.7.1 and 4.4.7.2). In case of dispute, method I shall govern.

(b) Testing of the specimens shall be within 24 hours after cure.

(c) The crosshead speed shall be 0.20 to 0.25 inch per minute.

(d) Compute ultimate elongation at the point of rupture of the specimens.

(e) Report the average of a minimum of 5 determinations.

4.4.7.1 Method I

(a) The mold (Figure 1) for the test specimens shall be silicone rubber conforming to MIL-S-3146 except the corrosion, dry heat resistance, compression set, and low temperature resistance requirements shall not apply.

(b) The test specimen dimensions shall be in accordance with type I of ASTM D 638-64T (1/4 inch or under). The specimen thickness shall be 0.125 ± 0.013 inch.

(c) Clean the mold by wiping with a dry rag.

(d) Brush a release agent (6.6) on the inside of the mold and then wipe it out with gauze.

(e) Prepare the adhesive in accordance with 4.4.1 (h) and centrifuge for 15 to 20 minutes at approximately 1800 revolutions per minute to remove entrapped air.
(f) Pour the adhesive into the mold carefully, holding the container as near to the mold as possible to avoid entrapment of air.

(g) Remove excess adhesive from top of mold by leveling with a straight edge.

(h) Cure at a temperature of 200 ± 5°F for 120 ± 5 minutes.

(i) Remove the mold and its contents from the oven and allow to cool at ambient temperature to approximately 150°F. Flex the mold until test specimens release and remove the test specimens from the mold. Allow the test specimens to cool to ambient temperature.

(j) Finish the specimen surfaces flat and parallel in accordance with the dimensions specified in (h).

4.4.7.2 Method II

(a) Prepare and centrifuge the adhesive in accordance with method I.

(b) Coat a sheet or plate 0.125 ± 0.015 inch in thickness and of sufficient length and width to provide a minimum of 5 specimens.

(c) Cure for 120 ± 5 minutes at a temperature of 200 ± 5°F.

(d) After cure, carefully stamp or machine the specimen from the sheet or plate.

(e) The specimen dimensions shall be in accordance with method I.

4.4.8 Change in refractive index. Change in refractive index of the mixed adhesive shall be determined in accordance with the following:

(a) Equipment:

(1) An Abbe type refractometer equipped for maintaining temperature control.

(2) A mold having inside dimensions of approximately 0.010 x 3 x 3 inches.

(b) Sample preparation: Prepare a sample of approximately 200 grams of adhesive in accordance with 4.4.1 (b) except that after the ingredients are combined the mixing shall be continued for a minimum of 5 minutes.
(c) Procedure: Fill the mold with the adhesive mixture and remove the excess by leveling with a straightedge. Maintain the temperature of the mold and adhesive mixture at 75 ± 3°F. Determine the refractive index at 25 ± 0.2°C of the adhesive mixture at 12 minutes from the end of the mix time and again at 192 minutes from the end of the mix time.

(d) Calculation: Change in refractive index = (refractive index at 192 minutes) - (refractive index at 12 minutes).

(e) Report the average of a minimum of 2 determinations.

4.5 Packaging and marking inspection. The inspector shall ascertain that the packaging and marking conform to the requirements of this specification.

5. PREPARATION FOR DELIVERY

5.1 Packaging and packing. Packaging and packing shall be Level C.

5.1.1 Level C. The adhesive shall be packaged and packed in containers complying with the rules and regulations applicable to the mode of transportation. As a minimum, protection shall be such as to prevent deterioration of the material during shipment and ensure safe delivery at destination.

5.2 Marking. Marking of containers shall be in accordance with MIL-STD-129, and shall include, but not be limited to, the following:

(a) Title, number, and revision letter of this specification.

(b) Manufacturer's name.

(c) Material: Part A or Part B.

(d) Lot number of Part A or Part B.

(e) Matched lot number.

(f) Date of manufacture.

(g) Contract or purchase order number.
6. NOTES

6.1 Intended use. The material is intended for use in the manufacture of rocket motors.

6.2 Ordering data. Procurement documents should specify, but not be limited to, the following:
   (a) Title, number, and revision letter of this specification.
   (b) Place of delivery.
   (c) Place of inspection.
   (d) Request for test results.

6.3 Gelling agent. The suggested gelling agent is Bentone 27 as supplied by the National Lead Company.

6.4 The polar agent. The suggested polar agent is methanol (nominal, 95 pbw methanol and 5 pbw water).

6.5 Filter aid. Filter aid found satisfactory for this test is Celite as manufactured by Johns-Manville.

6.6 Release agent. Release agent found satisfactory for this test is DC-33 silicone grease as manufactured by Dow Corning Company.

6.7 Suggested product. A suggested product capable of meeting this specification is Shell Epon 946 as manufactured by Shell Chemical Company.

6.8 Storage life and conditions. Storage life and conditions are shown in Table II.

<table>
<thead>
<tr>
<th>Material</th>
<th>Storage Life (from date of manufacture)</th>
<th>Storage Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resin (Part A)</td>
<td>12 months</td>
<td>0 ± 15°F in closed containers in a dry place.</td>
</tr>
<tr>
<td></td>
<td>6 months</td>
<td>60-85°F in closed containers in a dry place.</td>
</tr>
<tr>
<td>Curing agent</td>
<td>12 months</td>
<td>60-85°F in closed containers in a dry place.</td>
</tr>
</tbody>
</table>

Table II. Storage Life and Conditions
Except as otherwise specified below, this data is the exclusive property of Hercules Incorporated and may not be disclosed, duplicated or used by others without the specific authorization of Hercules Incorporated.

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Custodian: Hercules Incorporated
Ailegany Ballistics Laboratory
Cumberland, Maryland

Preparing activity: Hercules Incorporated
Ailegany Ballistics Laboratory
Cumberland, Maryland
NOTE: ALL DIMENSIONS ARE IN INCHES AND ARE APPROXIMATE

Figure 1. Mold for Tensile Specimens
This end up for test

Start adhesive

Place threads or bristles

This area shall be free of adhesive for test

-ADHESIVE-

Lines on plate

This area shall be free of adhesive for test

NOTE: ALL DIMENSIONS ARE IN INCHES AND ARE APPROXIMATE

Figure 2. Glass Plate for Flow Test Showing Relative Location of Threads for Test
## SUPPORTING DATA SUMMARY FOR EPOXY RESIN BASE ADHESIVE

<table>
<thead>
<tr>
<th>Property</th>
<th>Data source</th>
<th>No. of lots tested</th>
<th>Average result</th>
<th>Range of data Low</th>
<th>Range of data High</th>
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</thead>
<tbody>
<tr>
<td><strong>Part A</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Filler content, %</td>
<td>Dexter Corp.</td>
<td>12</td>
<td>2.99</td>
<td>2.51</td>
<td>3.41</td>
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<tr>
<td></td>
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<td>35</td>
<td>2.95</td>
<td>2.50</td>
<td>3.30</td>
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<tr>
<td></td>
<td>Hercules/Bacchus</td>
<td>14</td>
<td>3.08</td>
<td>2.80</td>
<td>3.30</td>
</tr>
<tr>
<td></td>
<td>Hercules/ABL</td>
<td>18</td>
<td>3.04</td>
<td>2.46</td>
<td>3.28</td>
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<tr>
<td>Weight per epoxy equiv., grams/</td>
<td>Dexter Corp.</td>
<td>12</td>
<td>355</td>
<td>346</td>
<td>367</td>
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<td>equiv.</td>
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<td>35</td>
<td>348</td>
<td>326*</td>
<td>368</td>
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<tr>
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<td>358</td>
<td>350</td>
<td>368</td>
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<tr>
<td></td>
<td>Hercules/ABL</td>
<td>19</td>
<td>353</td>
<td>330*</td>
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<td>Moisture content, %</td>
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<td>0.18</td>
<td>0.11</td>
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<td>0.10</td>
<td>0.22</td>
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<tr>
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<td>18</td>
<td>0.14</td>
<td>0.06</td>
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<tr>
<td><strong>Part B</strong></td>
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<td></td>
<td></td>
<td></td>
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<tr>
<td>Titratable nitrogen, %</td>
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<td>16.65</td>
<td>16.21</td>
<td>16.84</td>
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<td>34</td>
<td>16.62</td>
<td>16.30</td>
<td>16.90</td>
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<td></td>
<td>Hercules/Bacchus</td>
<td>14</td>
<td>16.36</td>
<td>16.10</td>
<td>16.70</td>
</tr>
<tr>
<td></td>
<td>Hercules/ABL</td>
<td>16</td>
<td>16.63</td>
<td>15.98</td>
<td>17.46</td>
</tr>
<tr>
<td>Mixed adhesive</td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flow, inch (see 3.3)</td>
<td>Dexter Corp.</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Shell Chemical</td>
<td>22</td>
<td>Conforms</td>
<td>Conforms</td>
<td>Conforms</td>
</tr>
<tr>
<td></td>
<td>Hercules/Bacchus</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Hercules/ABL</td>
<td>17</td>
<td>Conforms</td>
<td>Conforms</td>
<td>Conforms</td>
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<tr>
<td>Bond shear strength, psi</td>
<td>Dexter Corp.</td>
<td>12</td>
<td>2836</td>
<td>2120</td>
<td>3700</td>
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<tr>
<td></td>
<td>Shell Chemical</td>
<td>35</td>
<td>2544</td>
<td>1560</td>
<td>3750</td>
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<tr>
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<td>2155</td>
<td>1640</td>
<td>3380</td>
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<tr>
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<td>Hercules/ABL</td>
<td>16</td>
<td>2102</td>
<td>1165</td>
<td>2949</td>
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<tr>
<td>Tensile strength, psi</td>
<td>Dexter Corp.</td>
<td>12</td>
<td>1456</td>
<td>1160</td>
<td>1740</td>
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<tr>
<td></td>
<td>Shell Chemical</td>
<td>34</td>
<td>1233</td>
<td>812</td>
<td>1440</td>
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<tr>
<td></td>
<td>Hercules/Bacchus</td>
<td>14</td>
<td>1504</td>
<td>1078</td>
<td>2000</td>
</tr>
<tr>
<td></td>
<td>Hercules/ABL</td>
<td>17</td>
<td>1237</td>
<td>705</td>
<td>1762</td>
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<tr>
<td>Ultimate elongation, %</td>
<td>Dexter Corp.</td>
<td>12</td>
<td>67</td>
<td>51</td>
<td>75</td>
</tr>
<tr>
<td></td>
<td>Shell Chemical</td>
<td>35</td>
<td>69</td>
<td>51</td>
<td>99</td>
</tr>
<tr>
<td></td>
<td>Hercules/Bacchus</td>
<td>14</td>
<td>94</td>
<td>80</td>
<td>116</td>
</tr>
<tr>
<td></td>
<td>Hercules/ABL</td>
<td>17</td>
<td>66</td>
<td>50</td>
<td>89</td>
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</table>
SUPPORTING DATA SUMMARY FOR EPOXY RESIN BASE ADHESIVE (CONT’D)

<table>
<thead>
<tr>
<th>Property</th>
<th>Data source</th>
<th>No. of lots tested</th>
<th>Average result</th>
<th>Range of data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Change in refractive index,</td>
<td>Dexter Corp.</td>
<td>12</td>
<td>0.0055</td>
<td>0.0048 0.0060</td>
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<tr>
<td>between 12</td>
<td>Shell Chemical</td>
<td>13</td>
<td>0.0056</td>
<td>0.0050 0.0062</td>
</tr>
<tr>
<td>and 192 minutes</td>
<td>Hercules/Bacchus</td>
<td>15</td>
<td>0.0056</td>
<td>0.0047 0.0064</td>
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<tr>
<td>after mixing</td>
<td>Hercules/ABL</td>
<td>7</td>
<td>0.0054</td>
<td>0.0050 0.0058</td>
</tr>
</tbody>
</table>

*Early specifications for this material allowed a minimum weight per epoxy equivalent of 320 grams per equivalent. However, due to difficulties experienced at ABL in using the material, the minimum limit was subsequently raised to 340 grams per equivalent.
APPENDIX A-5

PROCEDURE FOR BONDING INNER AND OUTER CASES, CIC DESIGN

Bond one (1) matched inner and outer shell as follows:

1. Buff the inside diameter of the cylinder portion of the outer tube with emery cloth #150 until the shine is removed. Check by shining a flashlight through the nozzle end and observing through the forward end.

2. Clean surfaces to be bonded on both inner and outer shells with a trichloroethylene dampened clean rag. Wipe dry immediately. Weight Inner __________ 

Weight Outer __________

3. Slide the inner shell into the outer shell until it bottoms out and check the distance of 4.0 ± .10 from the pole face to the fwd face of the outer shell. Record. __________

4. Mix a batch of Epon 946 (100 PBW) and 946B (15 PBW). Use lot ___ (946A) and ___ (946B).

5. Paint a heavy coat of adhesive to the buffed surface of the outer shell I.D.

6. Paint a heavy coat of adhesive to the machined O.D. of the machined inner shell. Remove the temporary label prior to coating.

7. Paint the ¼ inch machined step at the aft end of the inner shell with a heavy coat of adhesive.

8. Slide the inner shell into the outer shell until it bottoms out and check the distance from the pole face to the fwd face of the outer shell. Compare with step 3 and record. __________

9. If there is no resin bead around the skirt cavity, place resin there to a width of 1/8 to 1/4 inch.

10. Use gauze swabs only (no thinners) to wipe away the excess adhesive on the exposed portion of the outer shell I.D. and in the aft dome I.D. area.

11. Wipe away all other adhesive contaminated surfaces.

12. Place a 5 lb. weight on the pole piece.

13. Place in an oven at 140 ± 15°F. and cure for 16 hours minimum while standing on the nozzle end.
NOTE: Check for adhesive drips every hour and wipe away as necessary in the nozzle-dome I.D. area.

14. Weigh unit
APPENDIX A-6

HYDROTEST TOOLING AND BLADDER MANUFACTURE

Buna-S silica rubber is manufactured into a hydrotest bladder using the following procedure:

1. Set up the Entec machine per MSU 10109.
2. Install the PRD case mandrel #720619-1 in the machine using a 3/16 hex drive.
3. Lay up 0.035 buna-S rubber per Figure 1.
4. Cover rubber with 0.003 nylon film and tape in place. Keep wrinkles to a minimum.
5. Install four (4) balls of scrap glass roving and set tension to 2 ± 1 lbs.
6. Wind two (2) dry helicals and two (2) dry 90°.
7. Cure for 8 hrs at 300 ± 15°F.
8. Strip off dry glass and film.
9. Remove liners from mandrel.
10. Assemble liners per composite dwg. and engineering instructions.
MATERIAL: 4130 STEEL
PLATES TO BE MATCH BORED

BEARING PLATE
2-REQ'D

SURFACES SHALL BE PARALLEL WITHIN .002 & FLAT WITHIN .001

5.500 ± .004
2.750 ± .002

1.25

8.00

5.000 ± .004
2.500 ± .001

1.250 ± .001

2.50

500

1.000 DIN THRU 5 PLACES
.05 x .45 CLEARANCE NEAR & FAR EDGES

.025 Diam thru 2 PLACES

2-REQ'D

690730-2
Material: 4130 Steel
All diameters to be concentric within 0.002 TIR

Tension Rod
2 - Req'd
MATERIAL: 4130 STEEL

ALL DIAMETERS TO BE CONCENTRIC WITHIN .002 TIR.

AFT PISTON ROD
1-REQ'D

690729-2 A
#10-32 UNF-2 THD X ½" DEEP
2 PLACES -180° APART
LOCATE ON 2.500 DIA

MATERIAL: ALUMINUM
ALL DIAMETERS TO BE CONCENTRIC WITHIN .002 TIR

SKIRT SUPPORT
1-REQ'D

690730 A
APPENDIX A-7

FIBERGLASS CASE-IN-CASE MANUFACTURING AND INSPECTION RECORDS
Manufacturing & Inspection Record

3.0 Dia. x 14.04 lg. Motor Case

Inner Shell Fabrication

Dwg. 720531-1

1. Winding Preparation

Machine set up installed. Level wind set to .083 lead.

Shaft extension T. I. R. 014.

Handrel cleaned properly.

Pole pieces and O-rings installed properly.

Roving (S904, 12-end) installed. Lot No. 2063.

Roving tension: 1. 2. 2.0 3. 1.7

2. Winding

Resin mixed correctly:

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Weight, lbs.</th>
<th>Lot No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resin</td>
<td>25.6</td>
<td>300</td>
</tr>
<tr>
<td>Catalyst</td>
<td>145</td>
<td>201</td>
</tr>
</tbody>
</table>

Sequence check off:

Excess resin removed without distorting dome area.

3. B-Stage and Cure

B-Stage: Time Started 9:30 Time Complete 8:00

Date 2/1/72 3929

Cure: Time Started 8:00 at 385°F

Time Complete 1:00 at 300°F

Date 7/11/72 293
### Machining and Stripping

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Actuals</th>
<th>Operator No.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>S/N 001</td>
<td>S/N 002</td>
</tr>
<tr>
<td>Units Identified</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.834 Dia. Nom.</td>
<td>2.852</td>
<td>2.842</td>
</tr>
<tr>
<td>2.828 + .002 - .002 Dia.</td>
<td>2.818</td>
<td>2.828</td>
</tr>
<tr>
<td>2.734 + .004 - .004 Dia.</td>
<td>2.734</td>
<td>2.734</td>
</tr>
<tr>
<td>.060 ± .010</td>
<td>.060</td>
<td>.060</td>
</tr>
<tr>
<td>.260 ± .010</td>
<td>.260</td>
<td>.260</td>
</tr>
<tr>
<td>6.85 ± .03</td>
<td>6.853</td>
<td>6.852</td>
</tr>
<tr>
<td>2.806 + .000 - .000 Dia.</td>
<td>2.806</td>
<td>2.805</td>
</tr>
</tbody>
</table>

### Finishing and Packing

Coating mixed correctly:

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Weight, gms.</th>
<th>Lot No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adhesive</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Catalyst</td>
<td></td>
<td>7-16-72</td>
</tr>
<tr>
<td>Thinner</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Cure: Time Started \(\text{NA}\) at \(0^\circ\) F.  
Time Completed \(\text{NA}\) at \(0^\circ\) F.

Final Weight (lbs.) \(\text{NA}\)  
\(\text{S/N 1 } 7.6 \)  
\(\text{S/N 2 } 7.5 \)  

137
5. **Finishing and Packing (cont.)**

Clean up work performed satisfactorily.

Signed: [signature]

Supervisor Review: [signature] Date: 2/12/72

Engineer Review: [signature] Date: 7/16/72
Manufacturing & Inspection Record

3.0 Dia. x 14.04 lg. Motor Case

Inner Shell Fabrication

Dwg. 720531-1

1. Winding Preparation

Machine set up installed. Level wind set to .083 lead.
Shaft extension T. I. R. 0.1 2
Mandrel cleaned properly.
Pole pieces and O-rings installed properly.
Roving (S904, 12-end) installed. Lot No. 253
Roving tension: 1. 2.5 2. 2 3. 2 5

2. Winding

Resin mixed correctly:

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Weight, ers.</th>
<th>Lot No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resin</td>
<td>2256</td>
<td>100</td>
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<td>Catalyst</td>
<td>29</td>
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</table>

Sequence check off:

| X | X | X | X | O |

Excess resin removed without distorting core area.

3. B Stage and Cure

B-Stage: Time Started 1700 Time Complete 2045

Date 7/26/70 776

Cure: Time Started 2645 at 508 C 0r.

13% Time Complete 2330 at 300 0r.

Date 8-22-72 886
### Machining and Stripping

<table>
<thead>
<tr>
<th>Parameter</th>
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<tbody>
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<tr>
<td>2.828 ± .002 Dia.</td>
<td>2.830</td>
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<tr>
<td>2.734 ± .004 Dia.</td>
<td>2.736</td>
</tr>
<tr>
<td>0.056 ± .010</td>
<td>.065</td>
</tr>
<tr>
<td>0.260 ± .010</td>
<td>.256</td>
</tr>
<tr>
<td>2.806 ± .000 Dia.</td>
<td>2.804</td>
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### Finishing and Packing

Coating mixed correctly:

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Weight, gms.</th>
<th>Lot No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adhesive</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Catalyst</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thinner</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Cure: Time Started [Date] at [Temperature]°F.

Time Completed [Date] at [Temperature]°F.

Final Weight (gms.)

<table>
<thead>
<tr>
<th>S/N</th>
<th>S/N</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<table>
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<tr>
<th>Wt.</th>
<th>Wt.</th>
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5. **Finishing and Packing (cont.)**

Clean up work performed satisfactorily.

---

<table>
<thead>
<tr>
<th>Supervisor Review</th>
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<th>Engineer Review</th>
<th>Date</th>
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</thead>
<tbody>
<tr>
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</table>
Manufacturing & Inspection Record
3.0 Dia. x 15.04 12. Motor Case
Inner Shell Fabrication
Dwg. 720531-1

1. Winding Preparation
   Machine set up installed. Level wind set to .083 lead.
   Shaft extension T. I. R. 020
   Mandrel cleaned properly.
   Pole pieces and O-rings installed properly.
   Rowing (S904, 12-end) installed. Lot No. 9614
   Rowing tension: 1. 1.5 2. 1.5 3. 2

2. Winding
   Resin mixed correctly:
   Ingent Weight, c.c. Lot No.
   Resin 225C 100 96131
   Catalyst Tomex 2.9 9617
   Sequence check off:
   X X X X X X O

   Excess resin removed without distorting cone area.

3. B-Stage and Cure
   B-Stage: Time Started 2:130 Time Complete 2:30
   Date 2/30/72 232
   Cure: Time Started 1:30 2:30
   Time Elapsed 1100 360
   Date 2/1/73
### 4. Machining and Stripping

<table>
<thead>
<tr>
<th>Parameter</th>
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<th>S/N 096</th>
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<td>2.829</td>
<td>2.828</td>
<td>2.5285</td>
</tr>
<tr>
<td>2.736 + .004 - .000 Dia.</td>
<td>2.735</td>
<td>2.7344</td>
<td>2.735</td>
</tr>
<tr>
<td>.060 ± .010</td>
<td>.065</td>
<td>.060</td>
<td>.065</td>
</tr>
<tr>
<td>.260 ± .010</td>
<td>.255</td>
<td>.260</td>
<td>.255</td>
</tr>
<tr>
<td>2.806 + .000 - .002 Dia.</td>
<td>2.804</td>
<td>2.806</td>
<td>2.804</td>
</tr>
</tbody>
</table>

### 5. Finishing and Packing

Coating mixed correctly:

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Weight, oz.</th>
<th>Lot No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adhesive</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Catalyst</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thinner</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Cure:
- Time Started: ________ at ________ o'clock
- Time Completed: ________ at ________ o'clock

Final Weight (lbs.):
- 3/4 C. ________
- 3/4 C. ________
- 1/2 C. ________

Date: ________
5. Finishing and Packing (cont.)

Clean up work performed satisfactorily.

Supervisor Review

Engineer Review
Manufacturing & Inspection Record

3.0 Dia. x 14.04 In. Motor Case

Inner Shell Fabrication
Dwg. 720531-1

1. Winding Preparation

Operator No.

Machine set up installed. Level wind set to 0.083 lead.

Shaft extension T. I. R. 0.16

Handrel cleaned properly.

Pole pieces and O-rings installed properly.

Roving (8904, 12-end) installed. Lot No. A134 4

Roving tension: 1. 15 2. 15 3. 2

2. Winding

Resin mixed correctly:

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Weight, lbs.</th>
<th>Lot No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resin</td>
<td>2.25</td>
<td>100</td>
</tr>
<tr>
<td>Catalyst</td>
<td>0.42</td>
<td>29</td>
</tr>
</tbody>
</table>

Sequence check off:

Excess resin removed without distorting dome area.

3. B-Stage and Cure

B-Stage: Time Started 1530 Time Complete 205

Date 16-13 1/2 5.2

Cut: 0.09 1.04 2.01 3.00 4.00 5.00 6.00 7.00 8.00

Date 16-17 2 5.2
4. Machining and Stripping

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Actuals</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Units Identified</td>
<td>S/N 007</td>
<td>S/N 008</td>
<td></td>
</tr>
<tr>
<td>2.828 + .002 Dia.</td>
<td>2.829</td>
<td>2.829</td>
<td>2.828</td>
</tr>
<tr>
<td>2.735 ± .004 Dia.</td>
<td>2.7345</td>
<td>2.7335</td>
<td>2.7355</td>
</tr>
<tr>
<td>.060 ± .010</td>
<td>.066</td>
<td>.068</td>
<td></td>
</tr>
<tr>
<td>.260 ± .010</td>
<td>.267</td>
<td>.263</td>
<td></td>
</tr>
<tr>
<td>6.80 ± .03</td>
<td>6.855</td>
<td>6.850</td>
<td></td>
</tr>
<tr>
<td>2.806 ± .000 Dia.</td>
<td>2.806</td>
<td>2.8048</td>
<td></td>
</tr>
</tbody>
</table>

5. Finishing and Packing

Coating mixed correctly:

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Weight, lbs.</th>
<th>Lot No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adhesive</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Catalyst</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thinner</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Cure: Time Started at ___ °F.

Time Completed at ___ °F.

Date ___

Final Weight (lbs.)

S/N __________ S/N __________

wt. __________ wt. __________
5. Finishing and Packing (cont.)

Clean up work performed satisfactorily.

Supervisor Review ___________________ Date ____________

Engineer Review ___________________ Date 12-17-72
Manufacturing & Inspection Record
3.0 Dia. x 14.04 1g Motor Case

Inner Shell Fabrication
Dwg. 720531-1

1. Winding Preparation

- Machine set up installed. Level wind set to .083 lead.
- Shaft extension T. I. R. 015
- Mandrel cleaned properly.
- Pole pieces and O-rings installed properly.
- Roving (S904, 12-end) installed. Lot No. A0L 4
- Roving tension: 1. 2. 2. 3. 2

Operator No. 4158

2. Winding

- Resin mixed correctly:
  - Resin 8256, 500, A0L 24
  - Catalyst Torik, 145, A0L 7

Sequence check off:

```
X X X X X X X O
```

Excess resin removed without distorting dough area.

3. B-Stage and Cure

- B-Stage: Time Started 11.22.72 Time Complete 0.715
- Date 11.22.72

- Cure: Time: Started 07/25 2.85 0.
- Time: Plate: 1030 300 0.
- Date 11.22.72 890

143
### 4. Machining and Stripping

<table>
<thead>
<tr>
<th>Parameter</th>
<th>S/N 009</th>
<th>S/N 010</th>
</tr>
</thead>
<tbody>
<tr>
<td>Units Identified</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.828 + .002 - .002 Dia.</td>
<td>2.828</td>
<td>2.8275</td>
</tr>
<tr>
<td>2.734 + .004 - .000 Dia.</td>
<td>2.734</td>
<td>2.7357</td>
</tr>
<tr>
<td>.060 ± .010</td>
<td>.065</td>
<td>.058</td>
</tr>
<tr>
<td>.260 ± .010</td>
<td>.255</td>
<td>.264</td>
</tr>
<tr>
<td>6.85 ± .03</td>
<td>6.852</td>
<td>6.853</td>
</tr>
<tr>
<td>2.806 + .000 - .002 Dia.</td>
<td>2.804</td>
<td>2.805</td>
</tr>
</tbody>
</table>

### 5. Finishing and Packing

Coating mixed correctly:

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Weight, gms.</th>
<th>Lot No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adhesive</td>
<td>8.746 A</td>
<td>537</td>
</tr>
<tr>
<td>Catalyst</td>
<td>7.3 gms</td>
<td>537</td>
</tr>
<tr>
<td>Thinner</td>
<td>4.0 gms</td>
<td>537</td>
</tr>
</tbody>
</table>

Cure: Time Started 07/01 at 140 °F.
Time Completed 1500 at 140 °F.

Final Weight (gms.)

<table>
<thead>
<tr>
<th>S/N 009</th>
<th>S/N 010</th>
</tr>
</thead>
<tbody>
<tr>
<td>42.0</td>
<td>42.0</td>
</tr>
<tr>
<td>126.5</td>
<td>126.5</td>
</tr>
</tbody>
</table>

Date 11-25-72
3. Finishing and Packing (cont.)

Clean up work performed satisfactorily.

Supervisor Review: D.J. Date: 11/29/77

Engineer Review: F.E. Rivera Date: 11/30/77
Manufacturing & Inspection Record

3.0 Dia. x 14.04 in. Motor Case

Inner Shell Fabrication

Dwg. 720531-1

1. Winding Preparation

- Machine set up installed. Level wind set to .083 lead.
- Shaft extension T. I. R. .014.
- Mandrel cleaned properly.
- Pole pieces and O-rings installed properly.
- Roving (3904, 12-end) installed. Lot No. ABL-4.
- Roving tension: 1. 2. 3. 2.5

2. Winding

- Resin mixed correctly:
  
<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Weight, oz.</th>
<th>Lot No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resin</td>
<td>2250</td>
<td>ABL-4</td>
</tr>
<tr>
<td>Catalyst</td>
<td>29</td>
<td>ABL-8</td>
</tr>
</tbody>
</table>

- Sequence check off:

  ![](sequence_check.png)

- Excess resin removed without distorting core area.

3. B-Stage and Cure

- B-Stage: Time Started: 6:00 Time Complete: 16:00
- Date: 12/1/72
- Cure: Time: Start: 18:30; Time: End: 21:30; Temperature: 310°F
- Date: 12/1/72
### Machining and Stripping

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Units Identified</th>
<th>S/N 011</th>
<th>S/N 012</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.828 ± .002 Dia.</td>
<td>-0.002</td>
<td>2.729</td>
<td>2.727</td>
</tr>
<tr>
<td>2.734 ± .004 Dia.</td>
<td>-0.004</td>
<td>2.735</td>
<td>2.734</td>
</tr>
<tr>
<td>.050 ± .010</td>
<td></td>
<td>.063</td>
<td>.063</td>
</tr>
<tr>
<td>.250 ± .010</td>
<td></td>
<td>.255</td>
<td>.255</td>
</tr>
<tr>
<td>6.85 ± .03</td>
<td></td>
<td>6.854</td>
<td>6.854</td>
</tr>
<tr>
<td>2.806 ± .006 Dia.</td>
<td>-0.006</td>
<td>2.804</td>
<td>2.804</td>
</tr>
</tbody>
</table>

### Finishing and Packing

Coating mixed correctly:

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Weight, gms.</th>
<th>Lot No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adhesive E</td>
<td>946 A</td>
<td>50</td>
</tr>
<tr>
<td>Catalyst</td>
<td>946 B</td>
<td>75</td>
</tr>
<tr>
<td>Thinner</td>
<td>ACETONE</td>
<td>40</td>
</tr>
</tbody>
</table>

Cure: Time Started 1400 at 140°F.

Time Completed 2200 at 170°F.

Final Weight (gms.)

<table>
<thead>
<tr>
<th>S/N 15. 011</th>
<th>S/N 15. 012</th>
</tr>
</thead>
<tbody>
<tr>
<td>122 grams</td>
<td>124 grams</td>
</tr>
</tbody>
</table>

| Date | 
|------|------|
| 12-5-72 | 762 |

<table>
<thead>
<tr>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>880</td>
</tr>
</tbody>
</table>
3. Finishing and Packing (cont.)

Clean up work performed satisfactorily.

Supervisor Review: D. McCarthy  Date: 12-6-72

Engineer Review: Date: ___________
September 27, 1972

Manufacturing & Inspection Record

1. Winding Preparation

Operator No. 189

Machine set up installed. Level wind set to .083 lead.

Shaft extension 7. I. R. 020

Mandrel cleaned properly.

Pole pieces and O-rings installed properly.

Roving (S504, 12-end) installed. Lot No. 031 1

Roving tension: 1. 1.5 2. 2.5 3. 1.5

2. Winding

Resin mixed correctly:

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Weight, lbs.</th>
<th>Lot No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resin</td>
<td>22.50</td>
<td>500</td>
</tr>
<tr>
<td>Catalyst</td>
<td>1.006</td>
<td>145</td>
</tr>
</tbody>
</table>

Sequence check off:

Excess resin removed without distorting done area.

3. B-Stage and Cure

B-Stage: Time Started 2230 Time Complete 1430

Date 12-15-72 189

Cure:

Date 12-5-72 299
### Machining and Stripping

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Actuals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Units Identified</td>
<td>511 013</td>
</tr>
<tr>
<td>Dimensons Measured</td>
<td>Max.</td>
</tr>
<tr>
<td>2.823 ± .002 / .002 Dia.</td>
<td>2.828</td>
</tr>
<tr>
<td>2.734 ± .002 / .002 Dia.</td>
<td>2.735</td>
</tr>
<tr>
<td>.060 ± .010</td>
<td>.065</td>
</tr>
<tr>
<td>.260 ± .010</td>
<td>.255</td>
</tr>
<tr>
<td>6.85 ± .03</td>
<td>6.850</td>
</tr>
<tr>
<td>2.805 ± .000 / .002 Dia.</td>
<td>2.805</td>
</tr>
</tbody>
</table>

### Finishing and Packing

Coating mixed correctly:

- **Ingredient:**
  - Adhesive: 99% Li
  - Catalyst: 99% Li
  - Thinner: 2CETK E

- **Weight:**
  - 5 C
  - 7/2
  - 4 C

- **Lot No.:**
  - 130-60
  - 130-60
  - ARL-78

- **Cure: Time Started:**
  - Date: 12-19-72
  - Time: 1:30 PM at 140°F
  - Time Completed: 0100 12-19-72 at 140°F

- **Final Weight:**
  - 1147
  - 1147
  - 1147
  - 1147

---

*Reproduced from best available copy.*
5. Finishing and Packing (cont.)

Clean up work performed satisfactorily.

Supervisor Review: [Signature]  Date: 12-20-72

Engineer Review: [Signature]  Date: 12-27-72
Manufacturing & Inspection Record

3.0 Din. x 14.04 l. Motor Case

Inner Shell Fabrication

Dug. 720531-1

1. Winding Preparation

Machine set up installed. Level wind set to .083 lead.
Shaft extension T. I. R. 018
Handrol cleaned properly.
Pole pieces and O-rings installed properly.
Roving (5904, 12-end) installed. Lot No. AGLE
Roving tension: 1. 2 2. 2.5 3. 3

2. Winding

Resin mixed correctly:

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Weight, gms</th>
<th>Lot No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resin</td>
<td>2254</td>
<td>AGLE3Y</td>
</tr>
<tr>
<td>Catalyst</td>
<td>Toner 6040</td>
<td>AGLE1</td>
</tr>
</tbody>
</table>

Sequence check off:

```
X X X X X O
1/1/1/1/1/1
```

Excess resin removed without distorting done area.

3. D-Stage and Cure

D-Stage: Time Started 0700 Time Complete 1300

Cure:

\[ T : 15 \ldots 15 \ldots 200 \ldots 0^\circ \]  

Time Complete at 700 \( \circ \)

152
4. Machining and Stripping

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Units Identified</th>
<th>S/N 015</th>
<th>S/N 016</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.828 ± .002 Dia.</td>
<td>2.827</td>
<td>2.824</td>
<td>2.8265</td>
</tr>
<tr>
<td>2.734 ± .004 Dia.</td>
<td>2.734</td>
<td>2.733</td>
<td>2.735</td>
</tr>
<tr>
<td>.060 ± .010</td>
<td>.065</td>
<td>.060</td>
<td></td>
</tr>
<tr>
<td>.260 ± .010</td>
<td>.261</td>
<td>.263</td>
<td></td>
</tr>
<tr>
<td>6.85 ± .03</td>
<td>6.855</td>
<td>6.853</td>
<td></td>
</tr>
<tr>
<td>2.806 ± .000 Dia.</td>
<td>2.804</td>
<td>2.806</td>
<td></td>
</tr>
</tbody>
</table>

5. Finishing and Packing

Coating mixed correctly:

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Weight, grs.</th>
<th>Lot No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adhesive</td>
<td>50</td>
<td>7/13</td>
</tr>
<tr>
<td>Catalyst</td>
<td>742</td>
<td>4/128</td>
</tr>
<tr>
<td>Thinner</td>
<td>40</td>
<td>4/128</td>
</tr>
</tbody>
</table>

Cure: Time Started 09:30 at 140 °F.  
Time Completed 12:30 at 140 °F.  
Date 4/6.  
Final Weight (grs.)  
S15 419.5  S16 416.6  497  
R 118.7  R 118.7  497.
5. **Finishing and Packing (cont.)**

Clean up work performed satisfactorily.

---

Supervisor Review: [signature] Date: 12-20-72

Engineer Review: [signature] Date: 12-27-72

---
Manufacturing & Inspection Record

3.0 Dia. x 14.04 in. Motor Case

Inner Shell Fabrication

Dwg. 720531-1

1. Winding Preparation

Machine set up installed. Level wind set to .083 lead.  149
Shaft extension T. I. R.  .018.  669
Handrel cleaned properly.  669
Pole pieces and O-rings installed properly.  669
Roving (S904, 12-end) installed. Lot No. ABL-4.  669
Roving tension: 1. 2 2. 2 2 2 2.  669

2. Winding

Resin mixed correctly:

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Weight, cms.</th>
<th>Lot No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resin</td>
<td>2256</td>
<td>100</td>
</tr>
<tr>
<td>Catalyst</td>
<td>1560</td>
<td>29</td>
</tr>
</tbody>
</table>

Sequence check off:

```
X X X X X X O
- - - - - - 
```

Excess resin removed without distorting cone area.  669

3. B-Stage and Cure

B-Stage: Time Started 1630  Time Complete 1130

Date 12-21-72  1847

Cure: Time Started 1145  Time Complete 2145

Time Complete at 300°.  397

Date 12-21-72  397
4. Machining and Stripping

<table>
<thead>
<tr>
<th>Units Identified</th>
<th>Actuals</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>S/N 017</td>
</tr>
<tr>
<td>2.828 + .002 - .002 Dia.</td>
<td>2.827</td>
</tr>
<tr>
<td>2.734 + .004 - .000 Dia.</td>
<td>2.736</td>
</tr>
<tr>
<td>.060 ± .010</td>
<td>.060</td>
</tr>
<tr>
<td>.260 ± .010</td>
<td>.265</td>
</tr>
<tr>
<td>6.85 ± .03</td>
<td>6.850</td>
</tr>
<tr>
<td>2.806 ± .000 - .002 Dia.</td>
<td>2.806</td>
</tr>
</tbody>
</table>

5. Finishing and Packing

Coating mixed correctly:

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Weight, ozs.</th>
<th>Lot No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adhesive</td>
<td>946-A</td>
<td>50</td>
</tr>
<tr>
<td>Catalyst</td>
<td>946-B</td>
<td>7½</td>
</tr>
<tr>
<td>Thinner</td>
<td>ACOTON®</td>
<td>40</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Cure: Time Started **2115** at **140° F.**
Time Completed **6515** at **140° F.**

Final Weight (ozs.)

<table>
<thead>
<tr>
<th>S/N</th>
<th>wt.</th>
</tr>
</thead>
<tbody>
<tr>
<td>017</td>
<td>17V 90.</td>
</tr>
<tr>
<td>018</td>
<td>125 90.</td>
</tr>
</tbody>
</table>
5. **Finishing and Packing (cont.)**

Clean up work performed satisfactorily.

Supervisor Review  A. H. Bessell  Date  12/23/32

Engineer Review  F. E. Reeves  Date  1-4-33
Manufacturing & Inspection Record

3.0 Dia. x 14.04 Iz. Motor Case

Inner Shell Fabrication

Dwg. 720531-1

1. Winding Preparation

Machine set up installed. Level wind set to .083 lead.
Shaft extension T. I. R. 0.24
Handrel cleaned properly.
Pole pieces and O-rings installed properly.
Roving (S904, 12-end) installed. Lot No. AB4-4
Roving tension: 1. 2. 2. 2. 2. 2. 3. 134

2. Winding

Resin mixed correctly:

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Weight, 1bs</th>
<th>Lot No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resin</td>
<td>2256</td>
<td>AB4-4</td>
</tr>
<tr>
<td>Catalyst</td>
<td>Toyo X 6040</td>
<td>29</td>
</tr>
</tbody>
</table>

Sequence check off:

Excess resin removed without distorting done area.

3. B-Stage and Cure

B-Stage: Time Started 6.215 Time Complete 6.430
Date 12-30-72 6.69

Cure: Time Started 6.500 290° F

Time Complete 7.00 at 300° F

Date 12-30-72 6.69
4. Machining and Stripping

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Actuals</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Units Identified</td>
<td>S/N 019</td>
<td>S/N 020</td>
<td></td>
</tr>
<tr>
<td>2.828 ± .002 Dia.</td>
<td>2.729</td>
<td>2.727</td>
<td>2.828</td>
</tr>
<tr>
<td>2.734 ± .004 Dia.</td>
<td>2.7365</td>
<td>2.734</td>
<td>2.7365</td>
</tr>
<tr>
<td>.060 ± .010</td>
<td>.060</td>
<td>.063</td>
<td>.060</td>
</tr>
<tr>
<td>.260 ± .010</td>
<td>.265</td>
<td>.260</td>
<td>.265</td>
</tr>
<tr>
<td>2.806 ± .000 Dia.</td>
<td>2.805</td>
<td>2.804</td>
<td>2.805</td>
</tr>
</tbody>
</table>

Operator No: 1447

5. Finishing and Packing

Coating mixed correctly:

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Weight, gms.</th>
<th>Lot No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adhesive</td>
<td>.10</td>
<td>E10</td>
</tr>
<tr>
<td>Catalyst</td>
<td>.12</td>
<td>E60</td>
</tr>
<tr>
<td>Thinner</td>
<td>.40</td>
<td>E100</td>
</tr>
</tbody>
</table>

Cure: Time Started 11/26 at 126°F.
Time Completed CE30 at 130°F.

Final Weight (gms.)

<table>
<thead>
<tr>
<th>S/N</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>#19</td>
<td>421c</td>
<td>421c</td>
</tr>
<tr>
<td>#20</td>
<td>421c</td>
<td>421c</td>
</tr>
<tr>
<td>123</td>
<td>421c</td>
<td>421c</td>
</tr>
<tr>
<td>117</td>
<td>421c</td>
<td>421c</td>
</tr>
</tbody>
</table>

Date 1/2/3 3924
5. Finishing and Packing (cont.)

Clean up work performed satisfactorily.

Supervisor Review A.J. Barcelo Date 1-3-73
Engineer Review F.E. Faure Date 1-4-73
1. Winding Preparation

Machine set up installed. Level wind set to .083 lead.
Shaft extension T. I. R. .012
Mandrel cleaned properly.
Pole pieces and O-rings installed properly.
Roving (S904, 12-end) installed. Lot No. FBL4.
Roving tension: 1. 2465 2. 2685 3. 25125

2. Winding

Resin mixed correctly:

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Weight, ozs.</th>
<th>Lot No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resin</td>
<td>2556</td>
<td>ABL24</td>
</tr>
<tr>
<td>Catalyst</td>
<td>60x600</td>
<td>ABL7</td>
</tr>
</tbody>
</table>

Sequence check off:

<table>
<thead>
<tr>
<th>X</th>
<th>X</th>
<th>X</th>
<th>X</th>
<th>X</th>
<th>O</th>
</tr>
</thead>
</table>

Resin mixed correctly: OK

3. B-Stage and Cure

B-Stage: Time Started 19:15 Time Complete 23:25
Date 1-7-73

Cure: Time Started 23:30 at 190.07
Time Complete 02:20 at 300.07
Date 1-7-73
### 4. Machining and Stripping

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Units Identified</th>
<th>Actuals</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>S/N 021</td>
</tr>
<tr>
<td>2.828 ± .002</td>
<td>2.829</td>
<td>2.828</td>
</tr>
<tr>
<td>2.734 ± .004</td>
<td>2.735</td>
<td>2.734</td>
</tr>
<tr>
<td>.060 ± .010</td>
<td>.057</td>
<td>.065</td>
</tr>
<tr>
<td>.260 ± .010</td>
<td>.255</td>
<td>.260</td>
</tr>
<tr>
<td>2.806 ± .000</td>
<td>2.806</td>
<td>2.806</td>
</tr>
</tbody>
</table>

### 5. Finishing and Packing

Coating mixed correctly:

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Weight, oz.</th>
<th>Lot No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adhesive</td>
<td>50</td>
<td>5101 55</td>
</tr>
<tr>
<td>Catalyst</td>
<td>7½</td>
<td>502 50</td>
</tr>
<tr>
<td>Thinner</td>
<td>30</td>
<td>501 25</td>
</tr>
</tbody>
</table>

Cure: Time Started 11/30 at 75°F.

Time Completed 12/1 at 130°F.

Date 12/1/73 257
5. **Finishing and Packing (cont.)**

Clean up work performed satisfactorily.

<table>
<thead>
<tr>
<th>Supervisor Review</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>[Signature]</td>
<td>1/5/73</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Engineer Review</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>F. E. Review</td>
<td>1/6/73</td>
</tr>
</tbody>
</table>
Manufacturing & Inspection Record

3.0 Dia. x 14.04 Ig. Motor Case

Inner Shell Fabrication

Dwg. 720531-1

1. Winding Preparation

Machine set up installed. Level wind set to .083 lead.

Shaft extension T. I. R. 010

Mandrel cleaned properly.

Pole pieces and O-rings installed properly.

Roving (904, 12-end) installed. Lot No. ABL-4

Roving tension: 1. 2" 2. 2" 3. 2"

2. Winding

Resin mixed correctly:

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Weight, lbs</th>
<th>Lot No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resin</td>
<td>2.256</td>
<td>ABL-24</td>
</tr>
<tr>
<td>Catalyst</td>
<td>7.000</td>
<td>ABL-7</td>
</tr>
</tbody>
</table>

Sequence check off:

```
X X X X X O
/ / / / / /
```

Excess resin removed without distorting cone area.

3. B-Stage and Cure

B-Stage: Time Started 16:00 Time Complete 24:00

Date 04-07-72

Cure: Time Started 06:00 Time Complete 15:00

Date 04-07-72

164
### 4. Machining and Stripping

<table>
<thead>
<tr>
<th>Parameter</th>
<th>S/N 023</th>
<th>S/N 024</th>
</tr>
</thead>
<tbody>
<tr>
<td>Units Identified</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dimensions Measured</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Max.</td>
<td>Min.</td>
<td>Max.</td>
</tr>
<tr>
<td>2.828 ± .002</td>
<td>2.827</td>
<td>2.828</td>
</tr>
<tr>
<td>2.734 ± .004</td>
<td>2.735</td>
<td>2.734</td>
</tr>
<tr>
<td>0.060 ± .010</td>
<td>0.065</td>
<td>0.063</td>
</tr>
<tr>
<td>0.260 ± .010</td>
<td>0.265</td>
<td>0.260</td>
</tr>
<tr>
<td>6.85 ± .03</td>
<td>6.855</td>
<td>6.852</td>
</tr>
<tr>
<td>2.506 ± .002</td>
<td>2.5055</td>
<td>2.5055</td>
</tr>
</tbody>
</table>

### 5. Finishing and Packing

Coating mixed correctly:

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Weight, oz.</th>
<th>Lot No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adhesive</td>
<td>9.16</td>
<td>50</td>
</tr>
<tr>
<td>Catalyst</td>
<td>9.46</td>
<td>7.5</td>
</tr>
<tr>
<td>Thinner</td>
<td>A21 78 Active</td>
<td>40</td>
</tr>
</tbody>
</table>

Cure Data:

- Time Started: 11/26 at 73°F
- Time Completed: 11/26 at 73°F
- Date: 11/26

Final Weight (oz.):

<table>
<thead>
<tr>
<th>S/N 023</th>
<th>S/N 024</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.23</td>
<td>0.24</td>
</tr>
<tr>
<td>0.28</td>
<td>0.31</td>
</tr>
</tbody>
</table>

023 amber 1 oz. shell bonded together for oxidizer. 023 gpm are assembled wet.
5. **Finishing and Packing (cont.)**

Clean up work performed satisfactorily.

**Supervisor Review**

[Signature]

**Date** 11/22

**Engineer Review**

[Signature]

**Date** 1/2/73

 sept. 27, 1972
Manufacturing & Inspection Record
3.0 Dia. x 14.04 in. Motor Case
Inner Shell Fabrication
Dwg. 720531-1

1. Winding Preparation
Machine set up installed. Level wind set to .083 lead.
Shaft extension T. I. R. .011
Handrel cleaned properly.
Pole pieces and O-rings installed properly.
Roving (S904, 12-end) installed. Lot No. ABL-4
Roving tension: 1. 2" 2. 2" 3. 2"

2. Winding
Resin mixed correctly:

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Weight, oz.</th>
<th>Lot No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resin</td>
<td>2.256</td>
<td>ABL-4</td>
</tr>
<tr>
<td>Catalyst</td>
<td>7.0w0</td>
<td>ABL-8</td>
</tr>
</tbody>
</table>

Sequence check off:

| X | X | X | X | X | X | X | O |

Excess resin removed without distorting core area.

3. B-Stage and Cure
B-Stage: Time Started 1:00 Time Complete 12:10 Date 1-6-73 2025
Cure: Time Started 1915... 300 °F
Time Complete 2015 at 300 °F.
Date 1-6-73 2025
4. Machining and Stripping

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Units Identified</th>
<th>S/N 025</th>
<th>S/N 026</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>2.828 ± .002</td>
<td>2.825</td>
<td>2.827</td>
<td>2.829</td>
<td>2.827</td>
</tr>
<tr>
<td>2.734 ± .004</td>
<td>2.735</td>
<td>2.734</td>
<td>2.735</td>
<td>2.734</td>
</tr>
<tr>
<td>.060 ± .010</td>
<td>.060</td>
<td>.060</td>
<td>.060</td>
<td>.060</td>
</tr>
<tr>
<td>.260 ± .03</td>
<td>.260</td>
<td>.260</td>
<td>.260</td>
<td>.260</td>
</tr>
<tr>
<td>6.85 ± .03</td>
<td>6.840</td>
<td>6.850</td>
<td>6.850</td>
<td>6.850</td>
</tr>
<tr>
<td>2.806 ± .002</td>
<td>2.8055</td>
<td>2.8055</td>
<td>2.806</td>
<td>2.806</td>
</tr>
</tbody>
</table>

5. Finishing and Packing

Coating mixed correctly:

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Weight, lbs.</th>
<th>Lot No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adhesive</td>
<td>649 A</td>
<td>E1656</td>
</tr>
<tr>
<td>Catalyst</td>
<td>649 B</td>
<td>E1671</td>
</tr>
<tr>
<td>Thinner</td>
<td>649 C</td>
<td>E1672</td>
</tr>
</tbody>
</table>

Cure: Time Started **2200** at **140** °F.
Time Completed **1600** at **140** °F.

Date **2/25/72**

Final Weight (gms.)

<table>
<thead>
<tr>
<th>S/N</th>
<th>25</th>
<th>S/N</th>
<th>26</th>
</tr>
</thead>
<tbody>
<tr>
<td>wt.</td>
<td>121.80</td>
<td>wt.</td>
<td>121.90</td>
</tr>
</tbody>
</table>

Operator No. 1147
5. **Finishing and Packing (cont.)**

Clean up work performed satisfactorily.

---

Supervisor Review: [Signature] Date 11/10/72

Engineer Review: [Signature] Date 11/10/72

---

Sept. 27, 1972
Manufacturing & Inspection Record

3.0 Dia. x 14.04 in. Motor Case

Inner Shell Fabrication

Dwg. 720531-1

1. Winding Preparation

Operator No. 826

Machine set up installed. Level wind set to .083 lead.

Shaft extension T. I. R. 712

Handrel cleaned properly.

Pole pieces and O-rings installed properly.

Roving (S904, 12-end) installed. Lot No. 412

Roving tension: 1. 2. 3. 4. 5.

2. Winding

Resin mixed correctly:

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Weight, grs.</th>
<th>Lot No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resin</td>
<td>2.56</td>
<td>2.56</td>
</tr>
<tr>
<td>Catalyst</td>
<td>78.9</td>
<td>78.9</td>
</tr>
</tbody>
</table>

Sequence check off:

```
X X X X X X O
- - - - -
```

Excess resin removed without distorting dome area.

3. B-Stage and Cure

B-Stage: Time Started 12:20 Time Complete 2:30

Date 11/17/72

Cure: Time Started 5:00 at 300°F

Time Complete 170° at 300°F

Date 1/15/72
### Machining and Stripping

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Units Identified</th>
<th>Actuals</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>S/N I.S. 027</td>
<td>S/N I.S. 028</td>
</tr>
<tr>
<td>2.828 ± .002 - .002 Dia.</td>
<td>2.829</td>
<td>2.825</td>
</tr>
<tr>
<td>2.734 ± .004 - .000 Dia.</td>
<td>2.730</td>
<td>2.733</td>
</tr>
<tr>
<td>.060 ± .010</td>
<td>.060</td>
<td>.060</td>
</tr>
<tr>
<td>.260 ± .010</td>
<td>.260</td>
<td>.260</td>
</tr>
<tr>
<td>6.85 ± .03</td>
<td>6.851</td>
<td>6.850</td>
</tr>
<tr>
<td>2.806 ± .000 - .002 Dia.</td>
<td>2.8055</td>
<td>2.8055</td>
</tr>
</tbody>
</table>

### Finishing and Packing

Coating mixed correctly:

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Weight, lbs.</th>
<th>Lot No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adhesive</td>
<td>446A</td>
<td>106</td>
</tr>
<tr>
<td>Catalyst</td>
<td>446B</td>
<td>13</td>
</tr>
<tr>
<td>Thinner</td>
<td>None</td>
<td>83</td>
</tr>
</tbody>
</table>

Cure: Time Started at 90°F. 1/1/73

Time Completed at 75°F. 1/5/73

Final Weight (lbs.)

<table>
<thead>
<tr>
<th>S/N</th>
<th>027</th>
<th>S/N</th>
<th>028</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wt.</td>
<td>119.76</td>
<td>Wt.</td>
<td>119.415</td>
</tr>
</tbody>
</table>

Date 1/5/73

Reproduced from best available copy.
5. **Finishing and Packing (cont.)**

Clean up work performed satisfactorily.

Supervisor Review: [Signature], Date: 9/17/73

Engineer Review: [Signature], Date: 1-15-75
Manufacturing & Inspection Record

3.0 Dia. x 14.04 in. Motor Case

Inner Shell Fabrication

Dwg. 720531-1

1. Winding Preparation

Machine set up installed. Level wind set to .083 lead.

Shaft extension T. I. R. 0.03

Mandrel cleaned properly.

Pole pieces and O-rings installed properly.

Roving (S904, 12-end) installed. Lot No. A132

Roving tension: 1. 2 2. 1 3. 2

2. Winding

Resin mixed correctly:

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Weight, ozs.</th>
<th>Lot No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resin</td>
<td>2256</td>
<td>A13224</td>
</tr>
<tr>
<td>Catalyst</td>
<td>29</td>
<td>A1328</td>
</tr>
</tbody>
</table>

Sequence check off:

+----------------+----------------+----------------+----------------+----------------+
| X              | X              | X              | X              | X              |
| ¬               | ¬               | ¬               | ¬               | ¬               |

Excess resin removed without distorting dome area.

3. B-Stage and Cure

B-Stage: Time Started 1700 Time Complete 1730

Date 1/6/73

Cure: Time Started 2000 at 245 °F

Time Complete 2700 at 360 °F

Date 1/17/73
4. Machining and Stripping

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Actuals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Units Identified</td>
<td>S/N 029</td>
</tr>
<tr>
<td>2.828 + .002 - .002 Dia.</td>
<td>2.830</td>
</tr>
<tr>
<td>2.734 + .004 - .000 Dia.</td>
<td>2.735</td>
</tr>
<tr>
<td>.060 ± .010</td>
<td>.065</td>
</tr>
<tr>
<td>.260 ± .010</td>
<td>.260</td>
</tr>
<tr>
<td>6.85 ± .03</td>
<td>6.857</td>
</tr>
<tr>
<td>2.806 + .000 - .002 Dia.</td>
<td>2.806</td>
</tr>
</tbody>
</table>

5. Finishing and Packing

Coating mixed correctly:

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Weight, gms.</th>
<th>Lot No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adhesive</td>
<td>446A</td>
<td>100</td>
</tr>
<tr>
<td>Catalyst</td>
<td>446C</td>
<td>15</td>
</tr>
<tr>
<td>Thinner</td>
<td>80</td>
<td>60</td>
</tr>
</tbody>
</table>

Cure: Time Started 11/20 at 130 °F.
Time Completed 2/15 at 130 °F.

Final Weight (lbs.)
S/N 123 S/N 029 S/N 123 S/N 030
ct. 121 mm cc. 121 mmp
5. **Finishing and Packing (cont.)**

Clean up work performed satisfactorily.

Supervisor Review: [Signature]
Date: 1/24/73

Engineer Review: [Signature]
Date: 2/2/73
Manufacturing & Inspection Record

3.0 Dia. x 14.04 lg. Motor Case

Outer Shell Fabrication

Dwg. 720531-2

1. Winding Preparation

Machine set up installed. Level wind set to .250 lead.

Shaft extension T. I. R. .019

O-rings waxed only.

Mandrel cleaned properly.

(4) O-rings and mandrel assembled properly.

Roving (S904, 12-end) installed. Lot No. 2053

Roving tension: 1. 2.0 2. 2.0 3. 1.75

2. Winding

Resin mixed correctly:

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Weight, gms.</th>
<th>Lot No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resin</td>
<td>205.4</td>
<td>RBL17</td>
</tr>
<tr>
<td>Catalyst</td>
<td>145</td>
<td>RBL17</td>
</tr>
</tbody>
</table>

Fill place in 0.200 wide area at both ends.

Sequence check off:

<table>
<thead>
<tr>
<th>X</th>
<th>0</th>
<th>X</th>
<th>C</th>
<th>N</th>
<th>O</th>
<th>O</th>
<th>X</th>
<th>O</th>
<th>L</th>
<th>L</th>
<th>D</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
</tr>
</tbody>
</table>

Level wind reset to .083 lead.

NOTE: L designates Label
     D designates Doubler
Throat dia. measurements:

<table>
<thead>
<tr>
<th>Unit serial No.</th>
<th>S/N 05.001</th>
<th>S/N 05.002</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before winding</td>
<td>2.128</td>
<td>2.130</td>
</tr>
<tr>
<td>After winding</td>
<td>2.330</td>
<td>2.318</td>
</tr>
</tbody>
</table>

Excess resin removed without distorting winding
Doubles wound correctly at each end

3. B-Stage and Cure

B-Stage: Time Started 1645. Time Completed 2130. Date 7-10-72

Cure: Time Started 2000. Time Completed 2100. Date 7-11-72

4. Machining and Stripping

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit Identification</th>
<th>Actuvals</th>
<th>Actuvals</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>S/N 05.001</td>
<td>S/N 05.002</td>
<td></td>
</tr>
<tr>
<td>3.150 + .000 - .010 dia.</td>
<td>3.150</td>
<td>3.149</td>
<td>3.149</td>
</tr>
<tr>
<td>3.000 + .010 dia.</td>
<td>3.020</td>
<td>2.982</td>
<td></td>
</tr>
<tr>
<td>1.922 + .000 - .003 dia.</td>
<td>1.921</td>
<td>1.920</td>
<td>1.920</td>
</tr>
<tr>
<td>7.31 + .005 - .002 dia.</td>
<td>7.335</td>
<td>7.33</td>
<td>7.335</td>
</tr>
<tr>
<td>2.966 + .010 dia.</td>
<td>2.946</td>
<td>2.946</td>
<td></td>
</tr>
</tbody>
</table>

3.020: high at Torque, Body 0.04, Nozzle Angle.
5. **Finishing**

Coating mixed correctly:

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Weight, gms</th>
<th>Lot No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adhesive</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Catalyst</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thinner</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Cure: Time Started</th>
<th>NA</th>
<th>at</th>
<th>°F.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time Complete</td>
<td>NA</td>
<td>at</td>
<td>°F.</td>
</tr>
</tbody>
</table>

Clean up work performed satisfactorily.

Final Weight (gms.)

<table>
<thead>
<tr>
<th>S/N</th>
<th>1</th>
<th>S/N</th>
<th>2</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Wt.</td>
<td>42.6</td>
<td>Wt.</td>
<td>441.5</td>
<td>3970</td>
</tr>
</tbody>
</table>

---

**Supervisor Review**

**Engineer Review**

---

**Operator No.**

---

---
Manufacturing & Inspection Record

3.0 Dia. x 14.04 in. Motor Case

Outer Shell Fabrication

Dwg. 720531-2

1. Winding Preparation

Machine set up installed. Level wind set to .250 lead.

Shaft extension T. I. R. 0.26

O-rings waxed only.

Handrel cleaned properly.

(4) O-rings and handrel assembled properly.

Roving (S904, 12-end) installed. Lot No. 2053.

Roving tension: 1. 1 3 2. 2 4 3. 2 5

2. Blending

Resin mixed correctly:

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Weight, ozs.</th>
<th>Lot No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resin</td>
<td>2250</td>
<td>100</td>
</tr>
<tr>
<td>Catalyst</td>
<td>29</td>
<td>4046</td>
</tr>
</tbody>
</table>

Fill place in 0.200 wide area at both ends.

Sequence check off:

[Table with checkmarks]

Level wind reset to .083 lead.

NOTE: L designates Label
D designates Doubler
C designates Glass Cloth
Throat dia. measurements:

<table>
<thead>
<tr>
<th>Unit serial No.</th>
<th>S/N 05003</th>
<th>S/N 05004</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before winding</td>
<td>2.136</td>
<td>2.147</td>
</tr>
<tr>
<td>After winding</td>
<td>2.376</td>
<td>2.372</td>
</tr>
</tbody>
</table>

Excess resin removed without distorting winding

Doubler wound correctly at each end

3. B-Stage and Cure

B-Stage: Time Started 0600 Time Completed 1230

Date 9-1-72

Cure: Time Started 1345 at 300°F

Time Completed 1645 at 210°F

Date 9-1-72

4. Machining and Stripping

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Actuals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unit Identification</td>
<td>S/N CC0</td>
</tr>
<tr>
<td>Dimension Measured</td>
<td>Max.</td>
</tr>
<tr>
<td>3.150 ± .000 - .010 dia.</td>
<td>3.147</td>
</tr>
<tr>
<td>3.000 ± .010 dia.</td>
<td>3.004</td>
</tr>
<tr>
<td>1.922 ± .000 - .003 dia.</td>
<td>1.9218</td>
</tr>
<tr>
<td>2.834 ± .005 - .002 dia.</td>
<td>2.8368</td>
</tr>
<tr>
<td>2.946 ± .010 dia.</td>
<td>2.945</td>
</tr>
</tbody>
</table>

1147
5. **Finishing**

Coating mixed correctly:

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Weight, gms.</th>
<th>Lot No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adhesive</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Catalyst</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thinner</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Cure: Time Started ________ at ________ °F.

Time Complete ________ at ________ °F.

Date __________________________

Clean up work performed satisfactorily.

Final Weight (gms.)

<table>
<thead>
<tr>
<th>S/N</th>
<th>S/N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wt.</td>
<td>Wt.</td>
</tr>
</tbody>
</table>

Supervisor Review __________________________ Date __________

Engineer Review __________________________ Date __________
Manufacturing & Inspection Record

3.0 Dia. x 12.04 In. Motor Case

Outer Shell Fabrication

Date 720531-2

1. Winding Preparation

- Machine set up installed. Level wind set to .250 lead.
- Shaft extension T. I. R. 20
- O-rings waxed only.
- Handrel cleaned properly.
- (4) O-rings and mandrel assembled properly.

2. Winding

- Resin mixed correctly:
  - Resin: 5.22
  - Catalyst: 74.48
- Fill place in 0.200 wide area at both ends.
- Sequence check off:

<table>
<thead>
<tr>
<th>X</th>
<th>X</th>
<th>X</th>
<th>X</th>
<th>X</th>
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<td>1</td>
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<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

- Level wind reset to .083 lead.

NOTE: L designates Label
D designates Doubler
G designates Glass Cloth
Throat dia. measurements:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Actuals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unit serial No.</td>
<td>S/N 005</td>
</tr>
<tr>
<td></td>
<td>S/N 006</td>
</tr>
<tr>
<td>Before winding</td>
<td>2.149</td>
</tr>
<tr>
<td>After winding</td>
<td>2.392</td>
</tr>
<tr>
<td></td>
<td>2.385</td>
</tr>
</tbody>
</table>

Excess resin removed without distorting winding

Doubler wound correctly at each end

3. B-Stage and Cure

B-Stage: Time Started **0800** Time Completed **1100**

Date **9-78-72**

Cure: Time Started **1130** at **285° F.**

Time Completed **1430** at **300° F.**

Date **9/30/72**

4. Machining and Stripping

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Actuals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unit Identification</td>
<td>S/N 005</td>
</tr>
<tr>
<td></td>
<td>S/N 006</td>
</tr>
<tr>
<td>Dimension Measured</td>
<td>Max.</td>
</tr>
<tr>
<td></td>
<td>Min.</td>
</tr>
<tr>
<td></td>
<td>Max.</td>
</tr>
<tr>
<td></td>
<td>Min.</td>
</tr>
<tr>
<td>3.150 ± .003</td>
<td>3.147</td>
</tr>
<tr>
<td></td>
<td>3.117</td>
</tr>
<tr>
<td>3.000 ± .010</td>
<td>3.074</td>
</tr>
<tr>
<td></td>
<td>3.077</td>
</tr>
<tr>
<td>1.922 ± .003</td>
<td>1.921</td>
</tr>
<tr>
<td></td>
<td>1.921</td>
</tr>
<tr>
<td>2.834 ± .005</td>
<td>2.834</td>
</tr>
<tr>
<td></td>
<td>2.835</td>
</tr>
<tr>
<td>2.946 ± .010</td>
<td>2.948</td>
</tr>
<tr>
<td></td>
<td>2.950</td>
</tr>
</tbody>
</table>
5. Finishing

Coating mixed correctly:

- Adhesive
- Catalyst
- Thinner

Cure: Time Started at [ ] hours [ ] minutes
Time Complete at [ ] hours [ ] minutes

Date: [ ]

Clean up work performed satisfactorily.

Final Weight (gms.)

<table>
<thead>
<tr>
<th>S/N</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>005</td>
<td>606</td>
</tr>
<tr>
<td>408</td>
<td>408</td>
</tr>
<tr>
<td>598</td>
<td>598</td>
</tr>
</tbody>
</table>

Supervisor Review: [Signature] Date: [ ]
Engineer Review: [Signature] Date: [ ]
October 13, 1972

Manufacturing & Inspection Record

3.0 Dia. x 14.04 in. Motor Case

Outer Shell Fabrication

Dwg. 720531-2

1. Winding Preparation

Machine set up installed. Level wind set to .250 lead.

Shaft extension T. I. R. __0/4__

O-rings waxed only.

Mandrel cleaned properly.

(4) O-rings and mandrel assembled properly.

Roving (S904, 12-end) installed. Lot No. __1131__

Roving tension: 1. __1.5__, 2. __2__, 3. __1.5__

2. Winding

Resin mixed correctly:

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Weight, ozs</th>
<th>Lot No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resin</td>
<td>2.254</td>
<td>100</td>
</tr>
<tr>
<td>Catalyst</td>
<td>0.006</td>
<td>2.9</td>
</tr>
</tbody>
</table>

Fill place in 0.200 wide area at both ends.

Sequence check off:

<table>
<thead>
<tr>
<th></th>
<th>Y</th>
<th>X</th>
<th>O</th>
<th>X</th>
<th>X</th>
<th>O</th>
<th>G</th>
<th>O</th>
<th>C</th>
<th>O</th>
<th>O</th>
<th>L</th>
<th>L</th>
<th>O</th>
<th>D</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Level wind reset to .083 lead.

Operator No.

___

187

NOTE: L designates Label
D designates Doubler
C designates Glass Cloth

185
Throat dia. measurements:

<table>
<thead>
<tr>
<th>Unit serial No.</th>
<th>S/N 007</th>
<th>S/N 008</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dia. Before winding Step 6.1.17</td>
<td>2.230</td>
<td>2.235</td>
</tr>
<tr>
<td>Dia. After winding</td>
<td>2.380</td>
<td>2.382</td>
</tr>
</tbody>
</table>

Excess resin removed without distorting winding
Doubler s wound correctly at each end

3. B-Stage and Cure

B-Stage: Time Started 1/45, Time Completed 1/15
Date 10/14/72

Cure: Time Started 1500 10/4/72 at 285°F,
Time Completed 10/9 10/72 at 298°F,
Date 10/16/72

4. Machining and Stripping

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Actuals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unit Identification</td>
<td>S/N 007</td>
</tr>
<tr>
<td>Dimension Measured</td>
<td>Max.</td>
</tr>
<tr>
<td>3.150 ± .000</td>
<td>3.147</td>
</tr>
<tr>
<td>3.000 ± .010 dia.</td>
<td>3.124</td>
</tr>
<tr>
<td>1.922 ± .000</td>
<td>1.9207</td>
</tr>
<tr>
<td>2.034 ± .005</td>
<td>2.034</td>
</tr>
<tr>
<td>2.946 ± .010 dia.</td>
<td>2.937</td>
</tr>
</tbody>
</table>
5. Finishing

Coating mixed correctly:

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Weight, gms.</th>
<th>Lot No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adhesive</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Catalyst</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thinner</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Cure: Time Started at [___ °F.]
      Time Complete at [___ °F.]
      Date [___]

Clean up work performed satisfactorily.

Final Weight (gms.)

<table>
<thead>
<tr>
<th>S/N</th>
<th>S/N</th>
<th>Wt.</th>
<th>Wt.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Supervisor Review [___] - Date [___]
Engineer Review [___] Date [___]
Manufacturing & Inspection Record

3.0 in. x 14.0 in. Motor Case

Outer Shell Fabrication

Dwg. 720531-2

October 13, 1972

Operator No.

1. Winding Preparation

Machine set up installed. Level wind set to .250 lead.

Shaft extension T. I. R. 0.017.

O-rings waxed only.

Mandrel cleaned properly.

(4) O-rings and mandrel assembled properly.

Roving (S904, 12-end) installed. Lot No. RBL 4.

Roving tension: 1. 2 2 3 2.

2. Winding

Resin mixed correctly:

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Weight, oz.</th>
<th>Lot No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resin</td>
<td>2256</td>
<td>RBL 24</td>
</tr>
<tr>
<td>Catalyst</td>
<td>TONOX</td>
<td>RBL 7</td>
</tr>
</tbody>
</table>

Fill place in 0.200 wide area at both ends.

Sequence check off:

<table>
<thead>
<tr>
<th>X</th>
<th>X</th>
<th>X</th>
<th>X</th>
<th>X</th>
<th>C</th>
<th>C</th>
<th>C</th>
<th>C</th>
<th>C</th>
<th>C</th>
<th>C</th>
<th>C</th>
<th>T</th>
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<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
</tr>
</tbody>
</table>

Level wind reset to .083 lead.

NOTE: L designates Label
D designates Doubler
C designates Clean Cloth

188

Reproduced from best available copy.
Throat dia. measurements:

Unit serial No. S/N: 05009  S/N: 05010
Dia. Before winding: Step 3.1.17 2.190  2.190
Dia. After winding 1.375  1.375
Excess resin removed without distorting winding
Doubler wound correctly at each end

3. B-Stage and Cure

B-Stage: Time Started 22.45 Time Completed 04.45
Date 11-22-72

Cure: Time Started 07.30 at 285°F.
Time Completed 10.30 at 300°F.
Date 11-22-72

4. Machining and Stripping

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Actuals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unit Identification</td>
<td>S/N: 05009  S/N: 05010</td>
</tr>
<tr>
<td>Dimension Measured</td>
<td>Max.  Min.  Max.  Min.</td>
</tr>
<tr>
<td>3.150 ± .002 - .010 dir.</td>
<td>3.145  3.147</td>
</tr>
<tr>
<td>3.003 ± .010 dir.</td>
<td>3.128  3.060  3.131  3.061</td>
</tr>
<tr>
<td>1.927 ± .050 - .003 dir.</td>
<td>1.823  1.823  1.921  1.923  2.0</td>
</tr>
<tr>
<td>2.611 ± .003 - .002 dir.</td>
<td>2.633  2.634  2.637  2.638  2.744</td>
</tr>
<tr>
<td>2.946 ± .010 dir.</td>
<td>2.949  2.947  2.951  2.949</td>
</tr>
</tbody>
</table>
5. Finishing

Coating mixed correctly:

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Weight, oz.</th>
<th>Lot No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adhesive</td>
<td>50</td>
<td>44-55</td>
</tr>
<tr>
<td>Catalyst</td>
<td>14</td>
<td>44-55</td>
</tr>
<tr>
<td>Thinner</td>
<td>40</td>
<td>44-67</td>
</tr>
</tbody>
</table>

Cure: Time Started 0700 at 450°F.
Time Complete 1500 at 140°F.

Date 11.28.72 832

Clean up work performed satisfactorily.

Final Weight (ozs.)

<table>
<thead>
<tr>
<th>S/N</th>
<th>Wt.</th>
<th>S/N</th>
<th>Wt.</th>
</tr>
</thead>
<tbody>
<tr>
<td>169</td>
<td>535</td>
<td>160</td>
<td>528</td>
</tr>
</tbody>
</table>

Supervisor Review

Engineer Review 11.24.72
October 13, 1972

Manufacturing & Inspection Record
3.0 Dia. x 14.04 lg. Motor Case
Outer Shell Fabrication
Dog. 720531-2

1. Winding Preparation

Machine set up installed. Level wind set to .250 lead.

Shaft extension T. I. R. ______ 0.28 ______

O-rings waxed only.

Mandrel cleaned properly.

(4) O-rings and mandrel assembled properly.

Roving (S904, 12-end) installed. Lot No. A84-7 ______

Roving tension: 1. ______ 2. ______ 3. ______

2. Winding

Resin mixed correctly:

Ingredient
Resin
Catalyst

Weight, cgs.
22.56
14.4

Lot No.
A043v
AB08

Fill place in 0.200 wide area at both ends.

Sequence check off:

Level wind reset to .083 lead.

NOTE: L designates Label
D designates Doubler
C designates Cloth
October 13, 1972

Throat dia. measurements:

<table>
<thead>
<tr>
<th>Unit serial No.</th>
<th>S/N 011</th>
<th>S/N 012</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dia. Before winding Step 6.1.17</td>
<td>2.223</td>
<td>2.233</td>
</tr>
<tr>
<td>Dia. After winding</td>
<td>2.330</td>
<td>2.377</td>
</tr>
</tbody>
</table>

Excess resin removed without distorting winding
Doubler wound correctly at each end

3. B-Stage and Cure

B-Stage: Time Started 1500 Time Completed 1815

Date 12-1-72

Cure: Time Started 1830 at 245°F.
Time Completed 2100 at 310°F.

Date 12-1-72

4. Machining and Stripping

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit Identification</th>
<th>Actuals</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>S/N 011</td>
<td>S/N 012</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Dimension Measured</th>
<th>Max.</th>
<th>Min.</th>
<th>Max.</th>
<th>Min.</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.150 ± .000</td>
<td>3.145</td>
<td>3.145</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.000 ± .010</td>
<td>2.933</td>
<td>2.947</td>
<td>3.135</td>
<td>3.140</td>
</tr>
<tr>
<td>1.922 ± .000</td>
<td>1.923</td>
<td>1.925</td>
<td>1.925</td>
<td>1.920</td>
</tr>
<tr>
<td>2.830 ± .005</td>
<td>2.830</td>
<td>2.835</td>
<td>2.835</td>
<td>2.834</td>
</tr>
<tr>
<td>2.946 ± .010</td>
<td>2.939</td>
<td>2.939</td>
<td>2.937</td>
<td>2.936</td>
</tr>
</tbody>
</table>
October 13, 1972

5. Finishing

Coating mixed correctly:

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Weight, gms.</th>
<th>Lot No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adhesive</td>
<td>946 A</td>
<td>572</td>
</tr>
<tr>
<td>Catalyst</td>
<td>946 B</td>
<td>75</td>
</tr>
<tr>
<td>Thinner</td>
<td>ACE 1615</td>
<td>40</td>
</tr>
</tbody>
</table>

Cure: Time Started 12/05 at 140 °F.
Time Complete 2200 at 140 °F.

Date 12-5-72

Clean up work performed satisfactorily.

Final Weight (gms.)

<table>
<thead>
<tr>
<th>S/N</th>
<th>Wt.</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.5 011</td>
<td>512 660.00</td>
</tr>
<tr>
<td>0.5 012</td>
<td>512 660.00</td>
</tr>
</tbody>
</table>

880 880

Supervisor Review: A. S. M. Date 11-20-72

Engineer Review: Date
Manufacturing & Inspection Record  
3.0 Dia. x 14.04 in. Motor Case  
Outer Shell Fabrication  
Dwg. 720531-2

1. Winding Preparation
   Machine set up installed. Level wind set to .250 lead.  
   Shaft extension T. & R. 0.250
   O-rings waxed only.  
   Mandrel cleared properly.  
   (4) O-rings and mandrel assembled properly.
   Roving (S904, 12-end) installed. Lot No. 9.194.  
   Roving tension: 1. 2. 3. 4.

2. Winding
   Resin mixed correctly:
   
<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Weight, oz.</th>
<th>Lot No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resin</td>
<td>0.250</td>
<td>9.194</td>
</tr>
<tr>
<td>Catalyst</td>
<td>2.00</td>
<td>9.194</td>
</tr>
</tbody>
</table>

   Fill place in 0.200 wide area at both ends.
   Sequence check off:

   Level wind reset to .083 lead.

   NOTE: L designates Label  
   D designates Doubler  
   C designates Glass Cloth
Throat dia. measurement:

<table>
<thead>
<tr>
<th>Unit serial No.</th>
<th>S/N 05.013</th>
<th>S/N 05.014</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dia. Before winding Step 6.1.17</td>
<td>2.245</td>
<td>2.250</td>
</tr>
<tr>
<td>Dia. After winding</td>
<td>2.380</td>
<td>2.383</td>
</tr>
</tbody>
</table>

Excess resin removed without distorting winding. Double lays wound correctly at each end.

3. B-Stage and Cure

<table>
<thead>
<tr>
<th>B-Stage: Time Started</th>
<th>1300</th>
<th>Time Completed</th>
<th>1850</th>
</tr>
</thead>
<tbody>
<tr>
<td>Date</td>
<td>12-15-72</td>
<td></td>
<td>12-15-72</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Cure: Time Started</th>
<th>1845</th>
<th>at 300°F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time Completed</td>
<td>2145</td>
<td>at 300°F</td>
</tr>
<tr>
<td>Date</td>
<td>12-15-72</td>
<td></td>
</tr>
</tbody>
</table>

4. Machining and Stripping

<table>
<thead>
<tr>
<th>Dimension Measured</th>
<th>Max.</th>
<th>Min.</th>
<th>Max.</th>
<th>Min.</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.150 ± .000 dia.</td>
<td>3.150</td>
<td>3.145</td>
<td>3.000</td>
<td>2.920</td>
</tr>
<tr>
<td>3.000 ± .010 dia.</td>
<td>3.043</td>
<td>3.011</td>
<td>3.043</td>
<td>3.011</td>
</tr>
<tr>
<td>1.922 ± .003 dia.</td>
<td>1.925</td>
<td>1.919</td>
<td>1.925</td>
<td>1.919</td>
</tr>
<tr>
<td>2.834 ± .005</td>
<td>2.837</td>
<td>2.824</td>
<td>2.837</td>
<td>2.824</td>
</tr>
<tr>
<td>2.946 ± .010 dia.</td>
<td>2.948</td>
<td>2.929</td>
<td>2.948</td>
<td>2.929</td>
</tr>
</tbody>
</table>

1147

195
5. Finishing

Coating mixed correctly:

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Weight, gms.</th>
<th>Lot No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adhesive</td>
<td>30</td>
<td>4222-60</td>
</tr>
<tr>
<td>Catalyst</td>
<td>77</td>
<td>4231-60</td>
</tr>
<tr>
<td>Thinner</td>
<td>40</td>
<td>4281-78</td>
</tr>
</tbody>
</table>

Cure: Time Started 7:30 at 140°F.
Time Complete 8:00 at 140°F.

Date 12-19-72

Clean up work performed satisfactorily.

Final Weight (gms.)

<table>
<thead>
<tr>
<th>S/N 65 C12</th>
<th>S/N 65 C14</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wt. 476 gms</td>
<td>Wt. 565 gms</td>
</tr>
</tbody>
</table>

Supervisor Review 12-23-72
Engineer Review 12-27-72
December 1, 1972
S/N 12746

Manufacturing & Inspection Record

3.0 Dia. x 14.04 lg. Motor Case

Outer Shell Fabrication

Dwg. 720531-2

1. Winding Preparation

Machine set up installed. Level wind set to .250 lead.

Shaft extension T. I. R. O/B.

O-rings waxed only.

Mandrel cleaned properly.

(4) O-rings and mandrel assembled properly.

Roving (S904, 12-end) installed. Lot No. 131.

Roving tension: 1 2 2.5 3.3

2. Winding

Resin mixed correctly:

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Weight, oz.</th>
<th>Lot No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resin</td>
<td>2.5</td>
<td>F131.41</td>
</tr>
<tr>
<td>Catalyst</td>
<td>1.5</td>
<td>F131.9</td>
</tr>
</tbody>
</table>

Fill place in 0.700 wide area at both ends.

Sequence check off:

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th>!</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>!</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Level wind reset to .083 lead.

NOTES:
1. L designates Label
2. D designates Doubler
3. C designates Glass Cloth
Throat dia. measurements:

Unit serial No.  
S/N 05.013  
S/N 05.016

Dia. Before winding Step 6.1.17  
2.243  
2.241

Dia. After winding  
2.296  
2.378

Excess resin removed without distorting winding  

Doublers wound correctly at each end  

3. B-Stages and Cure:

B-Stages: Time Started  
0100  
Time Completed  
0345

Date  
11/19/72

Cure: Time Started  
1315  
at 300°F.  
Time Completed  
1615  
at 200°F.

Date  
12/19/72

4. Machining and Stripping

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Actuals</th>
<th>Actuals</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>S/N 013</td>
<td>S/N 016</td>
</tr>
<tr>
<td>Unit Identification</td>
<td>S/N 013</td>
<td>S/N 016</td>
</tr>
<tr>
<td>Dimension Measured</td>
<td>Max. Min.</td>
<td>Max. Min.</td>
</tr>
<tr>
<td>3.150 ± .000</td>
<td>3.148 3.149</td>
<td></td>
</tr>
<tr>
<td>3.000 ± .010</td>
<td>3.123 3.042</td>
<td></td>
</tr>
<tr>
<td>1.922 ± .000</td>
<td>1.9205 1.9195</td>
<td></td>
</tr>
<tr>
<td>2.834 ± .005</td>
<td>2.835 2.835</td>
<td></td>
</tr>
<tr>
<td>2.946 ± .010</td>
<td>2.937 2.936 2.936</td>
<td></td>
</tr>
</tbody>
</table>
5. Finishing

Coating mixed correctly:

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Weight, gms</th>
<th>Lot No.</th>
<th>Operator No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adhesive</td>
<td>50</td>
<td>ARI-60</td>
<td>4128</td>
</tr>
<tr>
<td>Catalyst</td>
<td>7/8</td>
<td>ARI-60</td>
<td>4128</td>
</tr>
<tr>
<td>Thinner</td>
<td>40</td>
<td>ARI-70</td>
<td>4128</td>
</tr>
</tbody>
</table>

Cure: Time Started **0930**, at 140 °F.
Time Complete **1230**, at 140 °F.

Date **12-07-72**

Clean up work performed satisfactorily.

Final Weight (gms.)

<table>
<thead>
<tr>
<th>S/N</th>
<th>Wt.</th>
<th>S/N</th>
<th>Wt.</th>
</tr>
</thead>
<tbody>
<tr>
<td>015</td>
<td>500</td>
<td>016</td>
<td>500</td>
</tr>
</tbody>
</table>

Supervisor Review **M. Desail** - Date **12-20-72**

Engineer Review **F. Ritz** - Date **12-27-72**
Manufacturing & Inspection Record

3.0 Dia. x 14.04 lg. Motor Case

Outer Shell Fabrication

Dwg. 720531-2

1. Winding Preparation

Machine set up installed. Level wind set to .250 lead.  
Shaft extension T. L. R.  .046.  
O-rings waxed only.  
Mandrel cleaned properly.  
(4) O-rings and mandrel assembled properly.  
Roving (S904, 12-end) installed. Lot No.  ABL-7.  
Roving tension:  1.  2.  2 1/16  3.  2 1/16  

Operator No.  

2. Winding

Resin mixed correctly:

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Weight, cts.</th>
<th>Lot No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resin</td>
<td>225°C</td>
<td>ABL-24</td>
</tr>
<tr>
<td>Catalyst</td>
<td>7% NOx 60%</td>
<td>ABL-7</td>
</tr>
</tbody>
</table>

Fill place in 0.200 wide area at both ends.  

Sequence check off:

<table>
<thead>
<tr>
<th>X</th>
<th>X</th>
<th>C</th>
<th>X</th>
<th>C</th>
<th>X</th>
<th>C</th>
<th>C</th>
<th>X</th>
<th>C</th>
<th>O</th>
<th>L</th>
<th>L</th>
<th>B</th>
<th>D</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
</tbody>
</table>

Level wind reset to .083 lead.  

NOTE:  L designates Label  
D designates Doubler  
C designates Glass Cloth
Throat dia. measurements:

<table>
<thead>
<tr>
<th>Unit serial No.</th>
<th>S/N 017</th>
<th>S/N 018</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dia. Before winding Step 6.1.17</td>
<td>2.237</td>
<td>2.234</td>
</tr>
<tr>
<td>Dia. After winding</td>
<td>2.351</td>
<td>2.376</td>
</tr>
</tbody>
</table>

Excess resin removed without distorting winding
Doubler's wound correctly at each end

3. B-Stage and Cure

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Actuals</th>
</tr>
</thead>
<tbody>
<tr>
<td>B-Stage: Time Started</td>
<td>2100</td>
</tr>
<tr>
<td>Time Completed</td>
<td>1030</td>
</tr>
<tr>
<td>Date</td>
<td>12-21-72</td>
</tr>
<tr>
<td>Cure: Time Started</td>
<td>0045</td>
</tr>
<tr>
<td>at 300 °F.</td>
<td>300</td>
</tr>
<tr>
<td>Time Completed</td>
<td>0345</td>
</tr>
<tr>
<td>at 300 °F.</td>
<td>300</td>
</tr>
<tr>
<td>Date</td>
<td>12-21-72</td>
</tr>
</tbody>
</table>

4. Machining and Stripping

<table>
<thead>
<tr>
<th>Parameter</th>
<th>S/N 017</th>
<th>S/N 018</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unit Identification</td>
<td>S/N 017</td>
<td>S/N 018</td>
</tr>
<tr>
<td>Dimension Measured</td>
<td>Max.</td>
<td>Min.</td>
</tr>
<tr>
<td>3.150 ± .010 dia.</td>
<td>3.1475</td>
<td>3.146</td>
</tr>
<tr>
<td>3.000 ± .010 dia.</td>
<td>3.131</td>
<td>3.053</td>
</tr>
<tr>
<td>1.922 ± .003 dia.</td>
<td>1.922</td>
<td>1.922</td>
</tr>
<tr>
<td>2.834 ± .005 dia.</td>
<td>2.8355</td>
<td>2.835</td>
</tr>
<tr>
<td>2.946 ± .010 dia.</td>
<td>2.938</td>
<td>2.938</td>
</tr>
</tbody>
</table>
5. **Finishing**

Coating mixed correctly:

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Weight, gms.</th>
<th>Lot No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adhesive</td>
<td>50 GMR.</td>
<td>AML-60</td>
</tr>
<tr>
<td>Catalyst</td>
<td>1/2 GMR.</td>
<td>AML-61</td>
</tr>
<tr>
<td>Thinner</td>
<td>40 GMR.</td>
<td>AML-77</td>
</tr>
</tbody>
</table>

Cure: Time Started **1230** at **25°C**. Time Complete **C** at **75°C**.

Date: 26 Dec 72

Clean up work performed satisfactorily.

Final Weight (gms.)

<table>
<thead>
<tr>
<th>S/N</th>
<th>Wt.</th>
</tr>
</thead>
<tbody>
<tr>
<td>CS 617</td>
<td>512 gms</td>
</tr>
<tr>
<td>CS 019</td>
<td>510 gms</td>
</tr>
</tbody>
</table>

Operator No. 399

---

Supervisor Review: [Signature] Date: 12-12-72

Engineer Review: [Signature] Date: 1-4-73
1. Winding Preparation

- Machine set up installed. Level wind set to .250 lead.
- O-rings waxed only.
- Mandrel cleaned properly.
- O-rings and mandrel assembled properly.
- Roving (5904, 12-end) installed. Lot No. ABL-4.
- Roving tension: 1. 3" 2. 2" 3. 2"

2. Winding

- Resin mixed correctly:
  - Ingredient: Resin
  - Weight, lbs.: 2256
  - Lot No.: ABL-24
  - Ingredient: Catalyst
  - Weight, lbs.: 145
  - Lot No.: ABL-7

Fill placed in 0.200 wide area at both ends.

Sequence check off:

- Level wind reset to .083 lead.

**NOTE:** L designates Label
D designates Doubler
C designates Glass Cloth
Thr~

D~a

4

Meteum6:

Unit: Serial

N~o.

8/31 0.5

CO N.

Di,. Before winding Step 6.1.17 2.331

Dia. After winding 2.980 1.76

2.260

2.575

3.865

2125

Excess resin removed without distorting winding

Doubler wound correctly at each end

3. B-Stage and Cure

B-Stage: Time Started 1800

Time Completed 2730

Date 12/21/72

Cure: Time Started 2145

at 300 °F.

Time Completed 0045

at 300 °F.

Date 12/27/72

4. Machining and Stripping

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Actuals</th>
<th>Actuals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unit Identification</td>
<td>S/N 019</td>
<td>S/N 020</td>
</tr>
<tr>
<td>Dimension Measured</td>
<td>Max. Min. Max. Min.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Max. Min.</td>
<td>Max. Min.</td>
</tr>
<tr>
<td>3.150 + 0.000 - 0.010 dia.</td>
<td>3.149</td>
<td>3.149</td>
</tr>
<tr>
<td>3.000 + 0.010 dia.</td>
<td>3.120 3.045</td>
<td>3.120 3.045</td>
</tr>
<tr>
<td>1.922 + 0.000 - 0.003 dia.</td>
<td>1.925 1.925</td>
<td>1.925 1.925</td>
</tr>
<tr>
<td>2.834 + 0.003 - 0.002 dia.</td>
<td>2.834 2.834</td>
<td>2.834 2.834</td>
</tr>
<tr>
<td>2.946 + 0.010 dia.</td>
<td>2.946 2.946</td>
<td>2.946 2.946</td>
</tr>
</tbody>
</table>

December 1, 1972
5. **Finishing**

Coating mixed correctly:

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Weight, gms.</th>
<th>Lot No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adhesive</td>
<td>946 A</td>
<td>AB155</td>
</tr>
<tr>
<td>Catalyst</td>
<td>946 B</td>
<td>AB155</td>
</tr>
<tr>
<td>Thinner</td>
<td>ACETONE</td>
<td>AB166</td>
</tr>
</tbody>
</table>

Cure: Time Started **2115** at **140°F**.
Time Complete **0515** at **140°F**.

Clean up work performed satisfactorily.

Final Weight (gms.)

<table>
<thead>
<tr>
<th>S/N</th>
<th>Wt.</th>
<th>S/N</th>
<th>Wt.</th>
</tr>
</thead>
<tbody>
<tr>
<td>019</td>
<td>310 gms</td>
<td>020</td>
<td>310 gms</td>
</tr>
</tbody>
</table>

Supervisor Review: C. Stenell, Date: 12-3-73

Engineer Review: J. A. Beatty, Date: 12-4-73
Manufacturing & Inspection Record

3.0 Dia. x 14.04 1/2 Motor Case

Outer Shell Fabrication

Dwg. 720531-2

1. Winding Preparation

Machine set up installed. Level wind set to .250 lead.  
Shaft extension T. I. R.:
O-rings waxed only.
Mandrel cleaned properly.
(4) O-rings and mandrel assembled properly.
Roving (S904, 12-end) installed. Lot No. 686-4.
Roving tension: 1. 27  2. 3  3. 27

2. Winding

Resin mixed correctly:

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Weight, oz.</th>
<th>Lot No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resin</td>
<td>2257</td>
<td>100</td>
</tr>
<tr>
<td>Catalyst</td>
<td></td>
<td>29</td>
</tr>
</tbody>
</table>

Fill place in 0.200 wide area at both ends.

Sequence check off:

```
X X 0 X X C O X X 0 C 0 C 0 L L L 0 D D
X X 0 X X C O X X 0 C 0 C 0 L L L 0 D D
```

Level wind reset to .083 lead.

Operator No.  
147  
832  
343  
399  
832  
832  
832  
832  
832  

NOTE:  
L designates Label  
D designates Doubler  
G designates Glass Cloth
Throat dia. measurements:

Unit serial No.
S/N 021
S/N 022

Dia. Before winding Step 6/1/72
2.232
2.238

Dia. After winding
2.381
2.377

Excess resin removed without distorting winding

Doubler wound correctly at each end

3. B-Stage and Cure

B-Stage: Time Started 2330 Time Completed 0400

Date 12-24-72

Cure: Time Started 0500 at 790°F

Time Completed 0800 at 2600°F

Date 12-24-72

4. Machining and Stripping

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Actuals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unit Identification</td>
<td></td>
</tr>
<tr>
<td>Dimension Measured</td>
<td>Max.</td>
</tr>
<tr>
<td>3.150 ± .000</td>
<td>3.157</td>
</tr>
<tr>
<td>3.000 ± .010 dia.</td>
<td>3.126 7.445° 3.123 3.044</td>
</tr>
<tr>
<td>2.922 ± .000</td>
<td>2.923 1.922 2.921 2.920</td>
</tr>
<tr>
<td>2.81 ± .001 dia.</td>
<td>2.815 2.814° 2.816 2.815</td>
</tr>
<tr>
<td>2.946 ± .010 dia.</td>
<td>2.941 2.939 2.945 2.936</td>
</tr>
</tbody>
</table>

Operator No.

669

669

669

1147
5. Finishing

Coating mixed correctly:

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Weight, gms</th>
<th>Lot No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adhesive</td>
<td>50</td>
<td>178.53</td>
</tr>
<tr>
<td>Catalyst</td>
<td>7%</td>
<td>181.53</td>
</tr>
<tr>
<td>Thinner</td>
<td>50</td>
<td>181.28</td>
</tr>
</tbody>
</table>

Cure: Time Started 1/400 at 75°F. 
Time Complete 22:00 at 130°F.

Date 1-4-73 4/68

Clean up work performed satisfactorily. 3970

Final Weight (gms.)

<table>
<thead>
<tr>
<th>S/N</th>
<th>S/N</th>
<th>8.25</th>
</tr>
</thead>
<tbody>
<tr>
<td>476</td>
<td>442</td>
<td></td>
</tr>
<tr>
<td>475</td>
<td>441</td>
<td>8.24</td>
</tr>
</tbody>
</table>

Supervisor Review

Engineer Review
Manufacturing & Inspection Record

3.0 Dia. x 4.04 lg. Motor Case

Outer Shell Fabrication

Dwg. 720531-2

1. Winding Preparation

Machine set up installed. Level wind set to .250 lead.

Shaft extension T. I. R. 0.020

O-rings waxed only.

Mandrel cleaned properly.

(4) O-rings and mandrel assembled properly.

Roving (804, 12-end) installed. Lot No. ABL-4.

Roving tension: 1. 2/4 2. 2/4 3. 2/4

Operator No. 832

2. Winding

Resin mixed correctly:

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Weight, lbs</th>
<th>Lot No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resin</td>
<td>27.56</td>
<td>ABL-24</td>
</tr>
<tr>
<td>Catalyst</td>
<td>10.0 x 60-40</td>
<td>29</td>
</tr>
</tbody>
</table>

Fill place in 0.200 wide area at both ends.

Sequence check off:

[Sequence chart]

Level wind reset to .083 lead.

Operator No. 832

NOTE: L designates Label
D designates Doubler
C designates Glass Cloth
December 1, 1972

Throat dia. measurements:

Operator No.

Unit serial No. | S/N 023 | S/N 024 |
--- | --- | --- |
Dia. Before winding Step 6.1.17 | 2.220 | 2.229 |
Dia. After winding | 2.382 | 2.380 |
Excess resin removed without distorting winding
Doubler wound correctly at each end

3. B-Stage and Cure

B-Stage: Time Started | 2315 | Time Completed | 2215 |
--- | --- | --- | --- |
Date | 1-4-73 | 1-5-73 |
Cure: Time Started | 200 | at | 235°F.
--- | --- | --- | --- |
Time Completed | 200 | at | 260°F.
--- | --- | --- | --- |
Date | 1-5-73 |

4. Machining and Stripping

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit Identification</th>
<th>Actuals</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>S/N C23</td>
</tr>
<tr>
<td>Dimension Measured</td>
<td>Max.</td>
<td>Min.</td>
</tr>
<tr>
<td>3.150 + .000 - .010 dia.</td>
<td>3.149</td>
<td>3.147</td>
</tr>
<tr>
<td>3.000 ± .010 dia.</td>
<td>3.134</td>
<td>3.044</td>
</tr>
<tr>
<td>1.922 + .000 - .003 dia.</td>
<td>1.928</td>
<td>1.928</td>
</tr>
<tr>
<td>2.834 + .005 - .002 dia.</td>
<td>2.835</td>
<td>2.835</td>
</tr>
<tr>
<td>2.946 ± .010 dia.</td>
<td>2.936</td>
<td>2.935</td>
</tr>
</tbody>
</table>

210
5. Finishing

Coating mixed correctly:

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Weight, gms.</th>
<th>Lot No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adhesive</td>
<td>946 A</td>
<td>50</td>
</tr>
<tr>
<td>Catalyst</td>
<td>946 B</td>
<td>7.5</td>
</tr>
<tr>
<td>Thinner</td>
<td>Acetone</td>
<td>46</td>
</tr>
</tbody>
</table>

Cure: Time Started 12:50 at 70 °F.
Time Complete 13:50 at 70 °F.

Date 1/5/70

Clean up work performed satisfactorily.

Final Weight (gms.)

- S/N 013: Wt. 4.9 gm.
- S/N 1374: Wt. 4.9 gm.

Supervisor Review

Engineer Review

Date 1/5/70

023. Juncranta shell located together

Rev. 1/70. 6/28 in assembled wt.
Manufacturing & Inspection Record

3.0 Dia. x 14.04 Lg. Motor Case

Outer Shell Fabrication

Dwg. 720531-2

1. Winding Preparation

Machine set up installed. Level wind set to .250 lead.

Shaft extension T. I. R. 6/15:

O-rings waxed only.

Mandrel cleaned properly.

(4) O-rings and mandrel assembled properly.

Roving (S904, 12-end) installed. Lot No. 7334.

Roving tension: 1. _ 2. _ 2.5 3. _

Operator No. 3970

1891

1894

1890

1891

1894

2. Winding

Resin mixed correctly:

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Weight, ccs.</th>
<th>Lot No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resin</td>
<td>2.75</td>
<td>106</td>
</tr>
<tr>
<td>Catalyst</td>
<td>29</td>
<td>103</td>
</tr>
</tbody>
</table>

Fill place in 0.200 wide area at both ends.

Operator No. 1894

Sequence check off:

[Check marks and numbers present]

Level wind reset to .083 lead.

Operator No. 1697

NOTE: L designates Label
      D designates Doubler
      C designates Glass Cloth
Throat dia. measurements:

Unit serial No. | S/N 022 | S/N 024
---|---|---
Dia. Before winding, Step 6.1.17 | 2.240 | 2.243
Dia. After winding | 2.374 | 2.382

Excess resin removed without distorting winding
Doublers wound correctly at each end

3. B-Stage and Cure

B-Stage: Time Started 08:00 | Time Completed 13:30 | 4/18

Date: 5-2-73

Cure: Time Started 12:30 at 300 °F.
Time Completed 16:30 at 300 °F.

Date: 5-2-73

4. Machining and Stripping

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Actuals</th>
<th>Actuals</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Unit Identification</td>
<td>S/N 022</td>
</tr>
<tr>
<td></td>
<td>Dimension Measured</td>
<td>Max.</td>
</tr>
<tr>
<td></td>
<td>3.150</td>
<td>3.149</td>
</tr>
<tr>
<td></td>
<td>3.000</td>
<td>3.049</td>
</tr>
<tr>
<td></td>
<td>1.922</td>
<td>1.922</td>
</tr>
<tr>
<td></td>
<td>2.834</td>
<td>2.833</td>
</tr>
<tr>
<td></td>
<td>2.945</td>
<td>2.946</td>
</tr>
</tbody>
</table>
### 5. Finishing

Coating mixed correctly:

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Weight, gms.</th>
<th>Lot No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adhesive</td>
<td>50</td>
<td>A8L4H</td>
</tr>
<tr>
<td>Catalyst</td>
<td>72</td>
<td>A5L4H</td>
</tr>
<tr>
<td>Thinner</td>
<td>40</td>
<td>A5L4H</td>
</tr>
</tbody>
</table>

Cure: Time Started **1045** at **140°F**.
Time Complete **1145** at **140°F**.

Date **1-9-73**

Clean up work performed satisfactorily.

Final Weight (gms.)

<table>
<thead>
<tr>
<th>S/N</th>
<th>25</th>
<th>S/N</th>
<th>26</th>
</tr>
</thead>
<tbody>
<tr>
<td>no.</td>
<td>504</td>
<td>Wt.</td>
<td>44.9</td>
</tr>
</tbody>
</table>

Supervisor Review **APR 16** - Date **1-10-73**

Engineer Review

Date **1-10-73**


Manufacturing & Inspection Record

3.0 Dia. x 14.04 l.g. Motor Case

Outer Shell Fabrication

Dwg. 720531-2

December 1, 1972
W.o.C402,355

Operator No.

1. Winding Preparation

Machine set up installed. Level wind set to .250 lead.

Shaft extension T. I. R. .020

O-rings waxed only.

Handrel cleaned properly.

(4) O-rings and mandrel assembled properly.

Roving (S904, 12-e) installed. Lot No. ARL-4

Roving tension: 1. 2** 2. 2** 3. 2**

2. Winding

Resin mixed correctly:

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Weight, ozs.</th>
<th>Lot No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resin</td>
<td>2.25%</td>
<td>ARL-20</td>
</tr>
<tr>
<td>Catalyst</td>
<td>0.014</td>
<td>ARL-8</td>
</tr>
</tbody>
</table>

Fill place in 0.200 wide area at both ends.

Sequence check off:

\[
\begin{array}{cccccccccc}
X & X & X & X & O & C & O & X & C & C
\end{array}
\]

Level wind reset to .093 lead.

NOTE: L designates Label
      D designates Doubler
      C designates Glass Cloth

215
December 1, 1973

Throat dia. measurements:

Unit serial No. | S/N 0.5.027 | S/N 0.8.028
--- | --- | ---
Diam. Before winding Step 6.1.17 | 2.243 | 2.250
Diam. After winding | 2.373 | 2.379

Excess resin removed without distorting winding

Doubler wound correctly at each end

3. B-Stage and Cure

B-Stage: Time Started | 2015 | Time Completed | 1900
--- | --- | --- | ---
Date | 1-1-73 |

Cure: Time Started | 2300 at 185°F. | Time Completed | 0200 at 300°F.
--- | --- | --- | ---
Date | 1/1/73 |

4. Machining and Stripping

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Actuals</th>
<th>Actuals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unit Identification</td>
<td>S/N 0.27</td>
<td>S/N 0.28</td>
</tr>
<tr>
<td>Dimension Measured</td>
<td>Max.</td>
<td>Min.</td>
</tr>
<tr>
<td>3.150 ± .000</td>
<td>7.149</td>
<td>7.149</td>
</tr>
<tr>
<td>3.000 ± .010</td>
<td>3.142</td>
<td>3.054</td>
</tr>
<tr>
<td>1.922 ± .003</td>
<td>1.922</td>
<td>1.922</td>
</tr>
<tr>
<td>2.834 ± .005</td>
<td>2.834</td>
<td>2.834</td>
</tr>
<tr>
<td>2.946 ± .010</td>
<td>2.946</td>
<td>2.946</td>
</tr>
</tbody>
</table>
### 5. Finishing

Coating mixed correctly:

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Weight, gms.</th>
<th>Lot No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adhesive</td>
<td>946A</td>
<td>100</td>
</tr>
<tr>
<td>Catalyst</td>
<td>946B</td>
<td>15</td>
</tr>
<tr>
<td>Thinner</td>
<td>80</td>
<td>ABL 78</td>
</tr>
</tbody>
</table>

Cure:
- Time Started: Dec 19 at 75°F. 14:10
- Time Complete: Dec 28 at 75°F.

Date: 11/5/73

Clean up work performed satisfactorily.

Final Weight (gms.)

<table>
<thead>
<tr>
<th>S/N</th>
<th>05 027</th>
<th>S/N</th>
<th>05 028</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wt.</td>
<td>50.5 lbs</td>
<td>Wt.</td>
<td>50.2 lbs</td>
</tr>
</tbody>
</table>

Operator No. 47.10

Supervisor Review: 11/24/73  Date: 11/24/73

Engineer Review: 11/15/73  Date: 11/15/73
Manufacturing & Inspection Record

3.0 Dia. x 14.04 in. Motor Case

Outer Shell Fabrication

Dwg. 720531-2

1. Winding Preparation

Machine set up installed. Level wind set to .250 Lead.

Shaft extension T. L. R. 12.5

O-rings waxed only.

Mandrel cleaned properly.

(4) O-rings and mandrel assembled properly.

Roving (S904, 12-end) installed. Lot No. A

Roving tension: 1. 2 2. 3 3. 2

2. Winding

Resin mixed correctly:

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Weight, lbs</th>
<th>Lot No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resin</td>
<td>1.25</td>
<td>A2621</td>
</tr>
<tr>
<td>Catalyst</td>
<td>2.9</td>
<td>A5167</td>
</tr>
</tbody>
</table>

Fill place in 0.200 wide area at both ends.

Sequence check off:

[Checkmarks and numbers]

Level wind reset to .063 lead.

NOTE: L designates Label
      D designates Doubler
      C designates Glass Cloth
December 1, 1972

Throat dia. measurements:

<table>
<thead>
<tr>
<th>Unit serial No.</th>
<th>S/N 0129</th>
<th>S/N 0130</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dia. Before winding Step 6.1.17</td>
<td>3.124</td>
<td>3.045</td>
</tr>
<tr>
<td>Dia. After winding</td>
<td>3.380</td>
<td>3.383</td>
</tr>
</tbody>
</table>

Excess resin removed without distorting winding

Doubles wound correctly at each end

3. B-Stage and Cure

<table>
<thead>
<tr>
<th>B-Stage: Time Started</th>
<th>1445</th>
<th>Time Completed</th>
<th>1700</th>
</tr>
</thead>
<tbody>
<tr>
<td>Date</td>
<td>1-16-73</td>
<td></td>
<td>1-17-73</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Cure: Time Started</th>
<th>2300</th>
<th>at 45°F</th>
<th>Time Completed</th>
<th>2600</th>
<th>at 340°F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Date</td>
<td>1-11-73</td>
<td></td>
<td>1-11-73</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

4. Machining and Stripping

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Actuals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unit Identification</td>
<td>S/N 0129</td>
</tr>
<tr>
<td>Dimension Measured</td>
<td>Max</td>
</tr>
<tr>
<td>3.150</td>
<td>+ .000 - .010 dia.</td>
</tr>
<tr>
<td>3.000</td>
<td>+ .010 dia.</td>
</tr>
<tr>
<td>1.922</td>
<td>+ .000 - .003 dia.</td>
</tr>
<tr>
<td>2.834</td>
<td>+ .005 - .002 dia.</td>
</tr>
<tr>
<td>2.946</td>
<td>+ .010 dia.</td>
</tr>
</tbody>
</table>
5. **Finishing**

Coating mixed correctly:

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Weight, gms.</th>
<th>Lot No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adhesive</td>
<td>40.2</td>
<td>102</td>
</tr>
<tr>
<td>Catalyst</td>
<td>40.1</td>
<td>101.64</td>
</tr>
<tr>
<td>Thinner</td>
<td>80.0</td>
<td>102.78</td>
</tr>
</tbody>
</table>

Cure: Time Started **14:00** at **170°F**.
Time Complete **21:45** at **130°F**.

Date **11/16/72**

Clean up work performed satisfactorily.

Final Weight (gms.)

<table>
<thead>
<tr>
<th>S/N</th>
<th>22.5</th>
<th>S/N CS 0.000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wt.</td>
<td>22.5</td>
<td>22.5</td>
</tr>
</tbody>
</table>

Supervisor Review **A.O.P., Nov.** - Date **11/16/72**

Engineer Review **E. P. Rice** - Date **2-2-73**