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MANUFACTURE AND DELIVERY OF COMPOSITE MOTOR CASES. VOLUME I

Roger J. Dale

Hercules, Incorporated

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April 1973

AD

HERCULES INCORPORATED
ALLEGANY BALLISTICS LABORATORY
CUMBERLAND, MARYLAND

AO-255-135-01-012

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VOLUME I

FINAL TECHNICAL REPORT

ROGER J. DALE

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REDSTONE ARSENAL, ALABAMA

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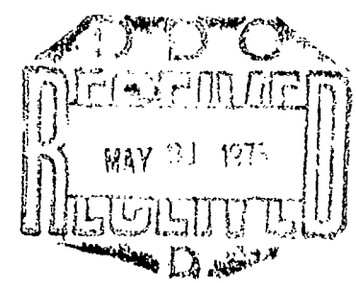

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13. ABSTRACT

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.

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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 SMAWT (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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SECTION I

INTRODUCTION

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

Program objectives included:

(1) Full-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, tooling, and inspection results including dimensional and weight data.

The above objectives are successfully completed with this report.

SECTION II

FIBERGLASS CASE

A. DESIGN

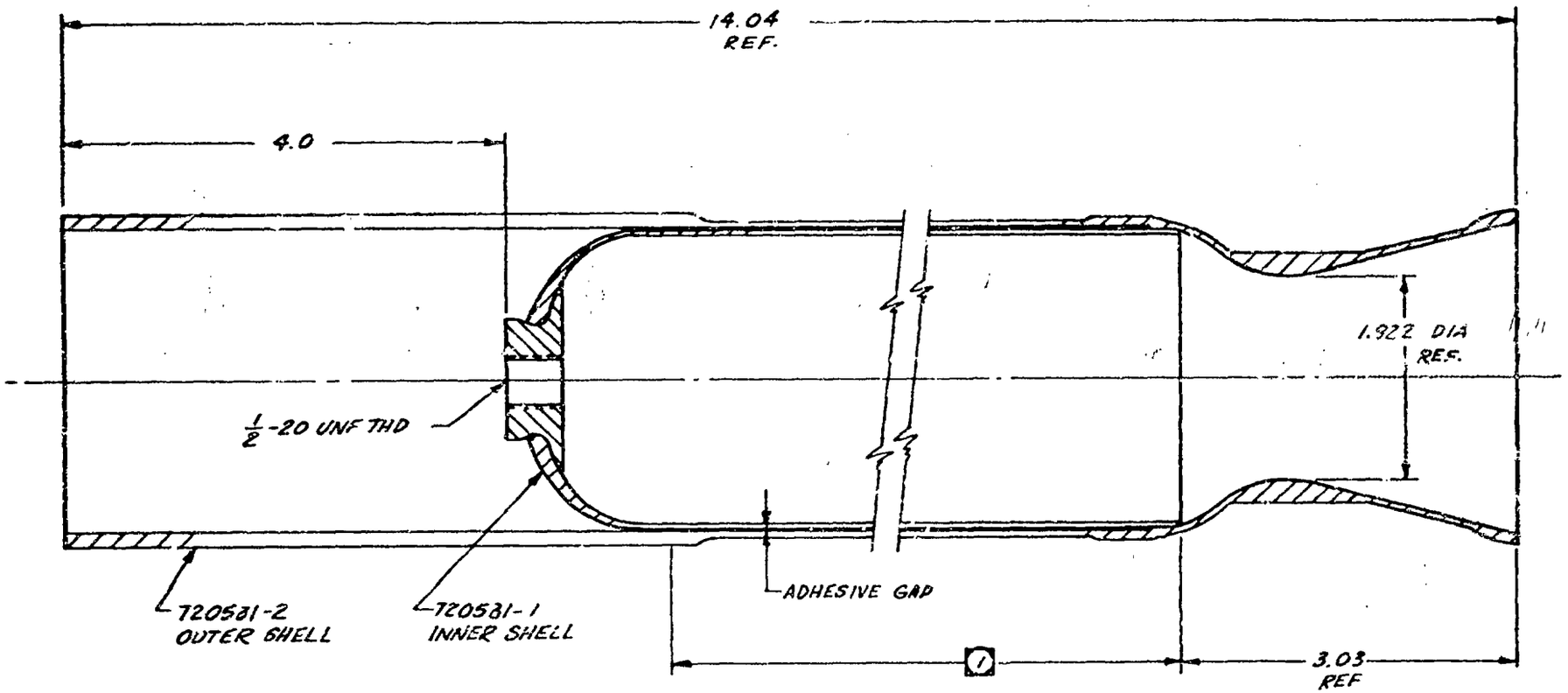
Figures 1, 2, and 3 show the fiberglass case-in-case (CIC) chamber assembly which meets the design requirements listed in Table I. The inner shell has a full-open aft end in which a propellant grain may be cast in place. The outer shell features an integrally wound aft dome, throat and divergent exit 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



NOTES

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

Figure 1. Case -in - Case Fiberglass Design Sketch

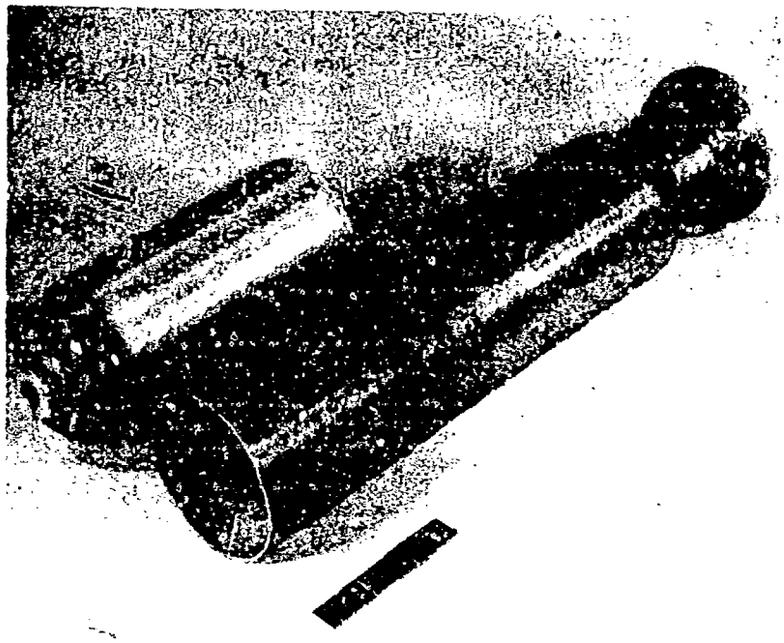


Figure 2. Case-in-Case Components

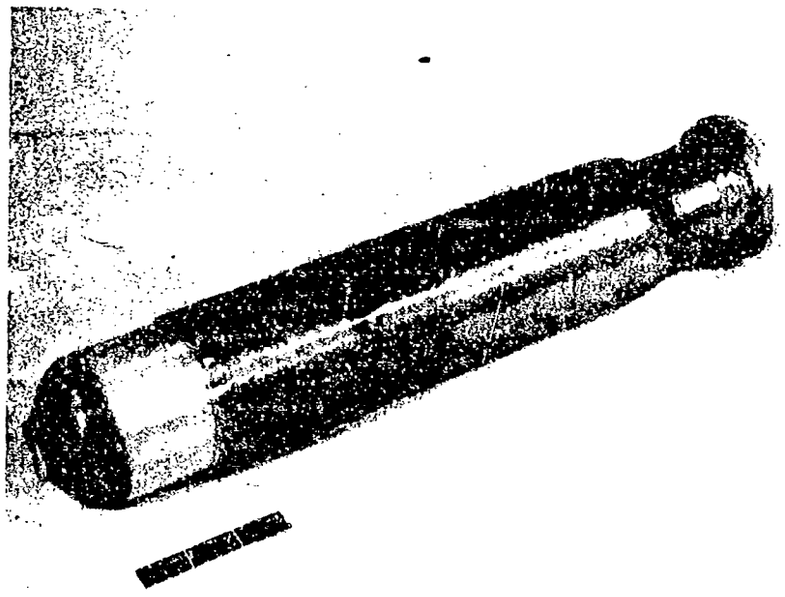


Figure 3. Case-in-Case Partially Assembled

TABLE I

DESIGN REQUIREMENTS

(Technical Requirement No. 1617, 15 Feb. 1972)

A. ROVING MATERIAL

1. Case-in-Case

Owens Corning Fiberglass HTS-904 finish, continuous 12-end roving.

2. Advanced Material

DuPont HSD-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

	CIC	Adv. Mat'ls
Inside Diameter (in.)	2.734	2.734
Maximum O.D. (in.)	3.150	3.150
Throat Diameter (in.)	1.922	1.922
Tangent-to-tangent (in.)	5.650	5.650(b)
Skirt-to-tangent (in.)	5.200	---

(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 II

FIBERGLASS CASE-IN-CASE DESIGN PROGRESSION

Design	Inner Case (IC) Winding Pattern	Outer Case (OC) Winding Pattern	Failure Mode
A	XXXXO	XOXOMO●XO●DD	Skirt Bearing
B	XXXXO	XOXOMO●XO●DDC●C●C●	Skirt compression (cloth & hoops added)
C	XXXXO	XOXOXOC●XOC●CODD	IC forward dome hoop @ pole piece
D	XXXXXXO	XOXOXOC●XOC●CODD	OC aft tangent <11,400 psig
E	XXXXXXO	XXOXXOCOXXOCOC●●DD	OC aft tangent >11,400 psig

where:

X = 27° helical for IC
X = 42° helical for OC
C = full hoop winding
● = 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 psig	245,500 psi
Achieved @ 12,380 psig (max.)	266,600 psi

Outer Case

6 - 42° helical layers

6 - 90° hoop layers

3 - glass cloth layers in skirt region

Stress levels (Hydrotest)

	Design @ 11,400 psig (psi)	Achieved @ 12,380 psig (psi)
Forward Skirt	23,520	25,540
Cylinder Hoop	250,800	380,970
Aft Dome	213,620	232,000*

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]

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(1) Outwater, J. O., Seibert, W. J., "On The Strength Degradation of Filament Wound Pressure Vessels Subjected to a History of Loading", Contract Nour-3219(01)(X), 22 April 1965.

(2) White, T. C., "Fabrication of Spiralloy Test Tubing, Flat Plates, and Development and Fabrication of Spiralloy Motor Cases", Contract No. N-6587, HI/ABL, ABL-TR-70-4, 20 December 1969.

TABLE IV

FIBERGLASS CIC HYDROTEST SUMMARY

Case S/N	Design & Test No.	Date	Pump	Coating	Max. Press. (psig)	Time Under Press. (sec)	Comments
001	A-1	8/14/72	Miller	8 Spraylat	4810	30	General leakage, weeping
	A-2	8/14/72	Miller	8 Spraylat	4890	10	General leakage, weeping
	A-3	8/14/72	Miller	8 Spraylat	6060	0.95	Skirt failed in bearing against fwd plate
	B-4	8/24/72	Sprague	8 Spraylat + SSC*	5594	18	Skirt failed in compression at forward tangent
002	A-1	8/14/72	Miller	8 Spraylat	4934	4	General leakage, weeping
	A-2	8/14/72	Sprague	8 Spraylat	5170	30	General leakage, weeping
	A-3	8/24/72	Sprague	8 Spraylat	5770	39	General leakage, weeping
	B-4	8/25/72	Sprague	8 Spraylat + SSC	6225	6	Skirt failed in compression at forward tangent
003	C-1	9/8/72	Sprague	3 coats Epon 946	7770	47	Weep aft cyl. section & aft dome
	C-2	9/8/72	Sprague	Epon 946 + SSC	7457	45	Weep aft cyl. section & aft piston. O-ring and back-up ring failed, damaging nozzle O-ring sealing surface.
	C-3	9/27/72	Miller	"	4970	0.74	"
	C-4	10/17/72	Miller	Epon 946 + Bladder	8090	1.4	Forward dome failed in hoop around pole piece, pole piece ejected
004	C-1	9/27/72	Miller	Epon 946 + Spraylat + Bladder	9190	1.7	Forward dome failed around pole piece, pole piece ejected
005	D-1	10/11/72	Miller	Bladder	8418	2.27	Failed in hoop at aft tangent. Slight leak
006	D-1	10/11/72	Miller	Bladder	9422	1.09	Failed in hoop at aft tangent. No leak.
007	E-1	11/8/72	Miller	Bladder	9357	3.8	Bladder punched and leaked.
	E-2	11/8/72	Miller	Bladder	10137	5.3	Seal ruptured in line.
	E-3	11/8/72	Miller	Bladder	11692	11.6	Burst at aft tangent in hoop. Time to reach pressure 7.6 sec. Pressurization rate 4,410 psi/sec.
008	E-1	10/20/72	Miller	Bladder	9520	1.9	Bladder and nozzle O-ring failed, explosive decompression.
	E-2	10/20/72	Miller	Bladder	5716	0.72	Inner and outer cases separated, probably because of previous test. Forward dome slightly cracked 180° apart.
	E-3	11/7/72	Miller	Bladder	5838	0.74	Rebonded. Forward dome failed in area noticed after test #2.
023	F-1	1/10/73	Miller	Bladder	12380	2.61	Burst at aft tangent in hoop

* Seam Sealing Compound

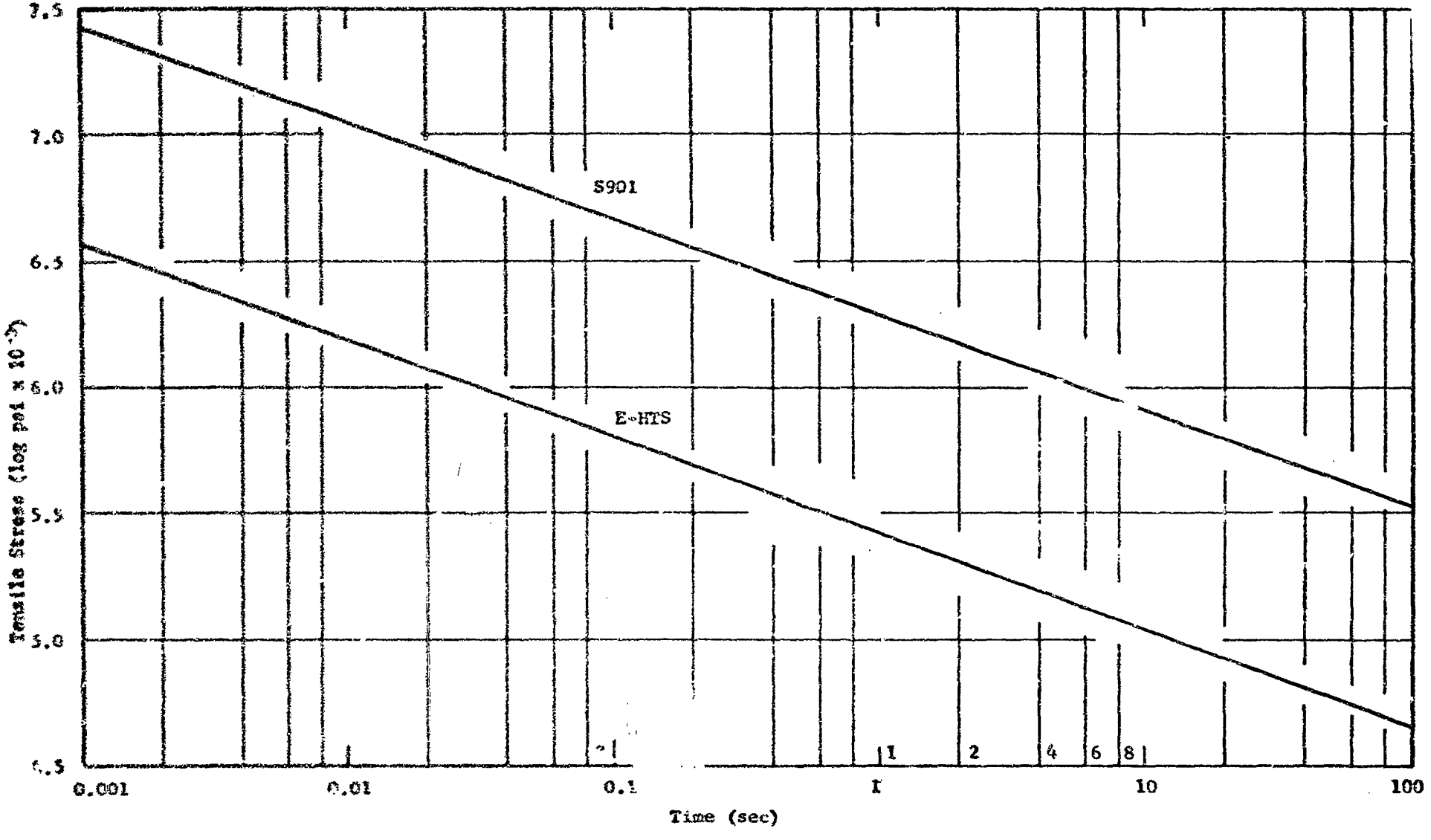


Figure 4. Glass - FWC Strength - Time Normalization Curve

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 ZZL-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 9400 psig.

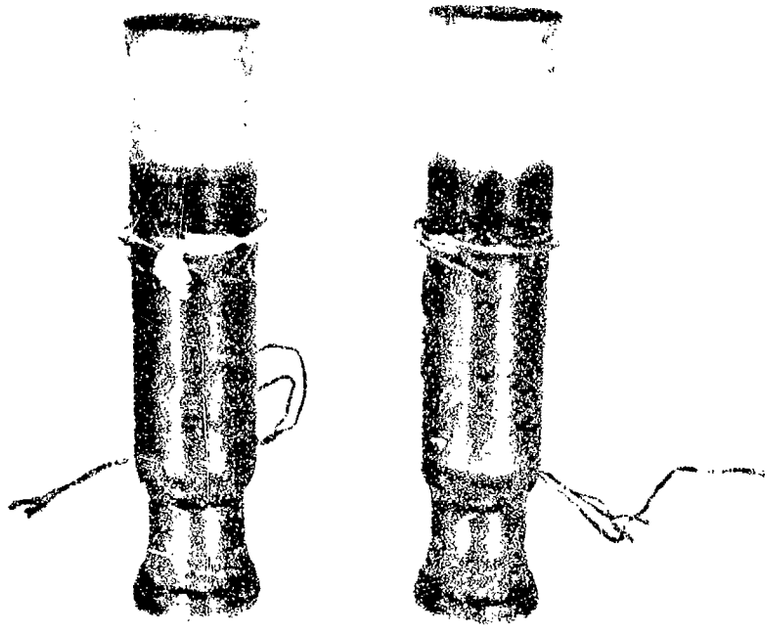


Figure 5. S/N 001 and 002 Hydrotest

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 5716 psig where the inner and couter 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 inmost layer of helicals from the outer case stayed with the inner case (Figure 8), 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 assure the nozzle o-ring seal is in position at pressure. The unit failed in the forward dome in the cracked area at 5836 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.[illegible] inch shims inserted between the aft platen and the floating piston to move the o-ring seal forward. The unit

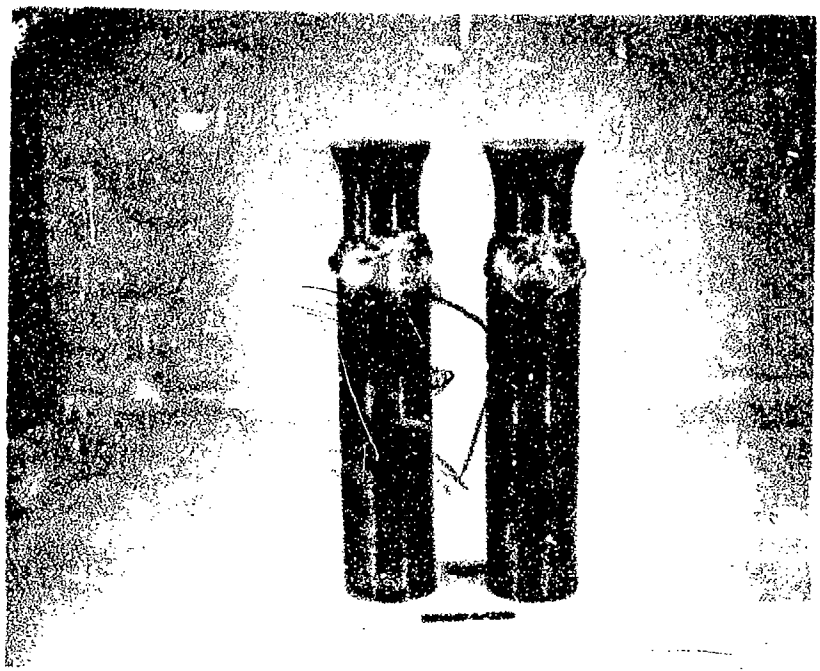


Figure 7. S/N 005 and 006 Hydroburst

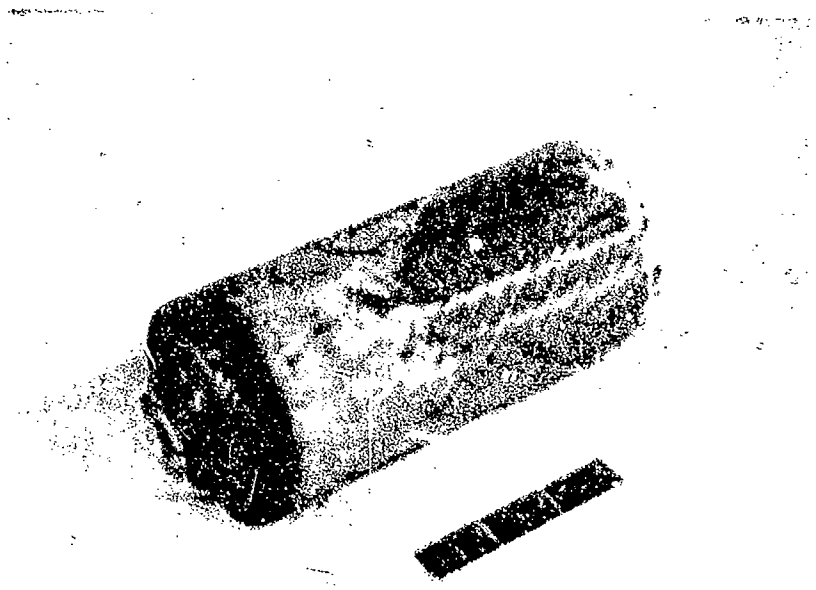


Figure 8. S/N 006 Inner Case After Separation

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 and 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

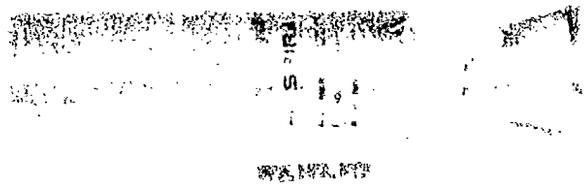


Figure 10. S/N 023 Hydroburst

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

	All Fiberglass (lb)	Combined Fiberglass and PRD (lb)
Pressure Vessel		
Inner Case		
Polar Adapter	0.0456	--
Fiberglass	0.1731	0.170
Centerport Plug	--	0.005
Resin	0.0547	0.049
	0.2734	0.224
Outer Case		
Fiber	0.3117	0.182
Resin	0.0984	0.094
	0.4101	0.276
Bonding Resin	0.013	0.013
Total Pressure Vessel	0.6965	0.513
Skirt		
Fiber	0.4913	0.282
Cloth	0.0680	0.068
Resin	0.1551	0.146
Total Skirt Weight	0.7144	0.496
Total Unit Weight	1.4109	1.009

SECTION III

PRD 49-III CASE

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.

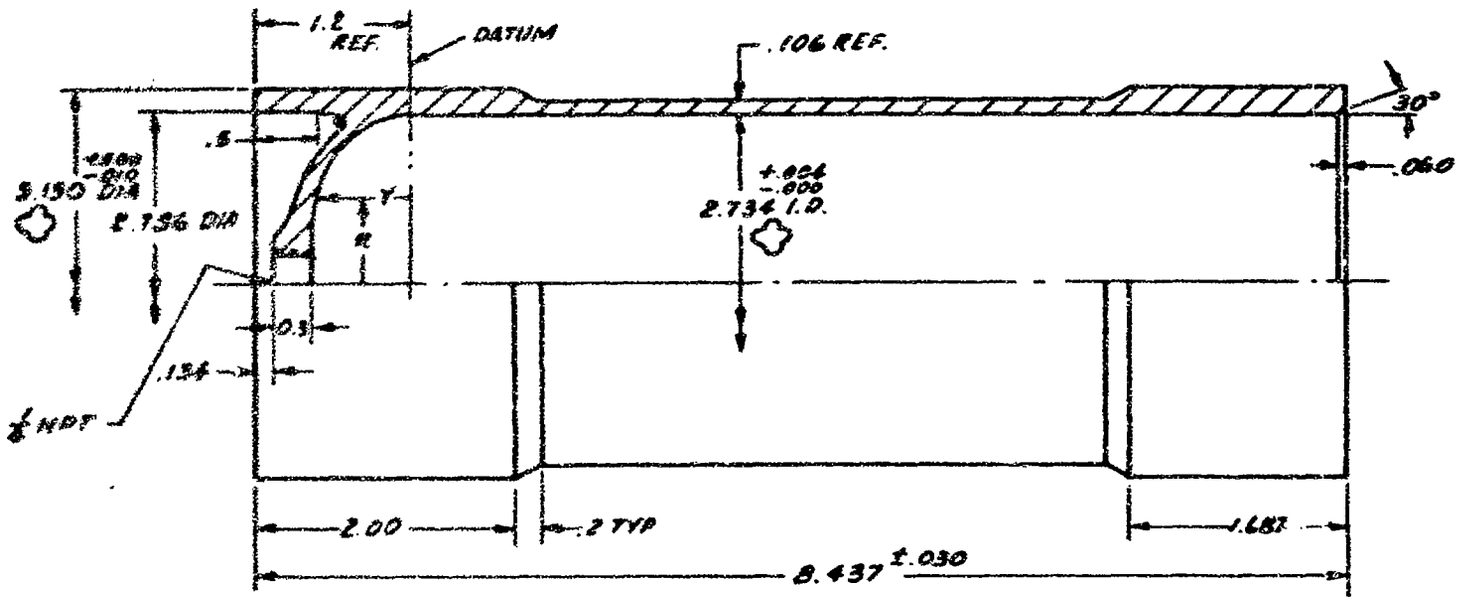
1. Case

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 33,300 psi, and 23,500 psi (70%) was reached before movement occurred. Failure (movement) was characterized by rotation of the dowel pins and slight

DOME COORDINATES

R	Y
1.367	0
1.360	.10
1.336	.20
1.259	.30
1.157	.40
1.058	.50
1.039	.60
.668	.70
.710	.76
.520	.76
.258	.764



NOTES :

1. SYMBOL ◇ INDICATES RESULTS TO BE REPORTED BY FABRICATOR.
2. (2) REPEAT TO ASSURE 3.150 MINIMUM DIAMETER AFTER MACHINING.
3. WINDING SEQUENCE

PRESSURE VESSEL	X O X O X X O O O O
FORWARD SKIRT	C H_4 C O C O C O C H (C H)
AFT DOUBLER	X O C X O C X O C X O C O C O C O C H (C H) (2)

X = HELICAL, 15°
O = HOOP
C = GLASS CLOTH
● = "O" RING
H_4 = FILL WITH HOOP AT O-RING, H = HOOP OVER SKIRT & DOUBLER
MATERIAL : DUPONT PRD-49 TYPE III, 12 END ROVING; ERL 2256 RESIN, UNION CARBIDE CORP, TONOX 6040, UNIROYAL CO.; FIBER GLASS CLOTH, S901-34, OWENS CORNING FIBERGLASS CORP.

Figure 11. PRD 49-III Assembly Sketch

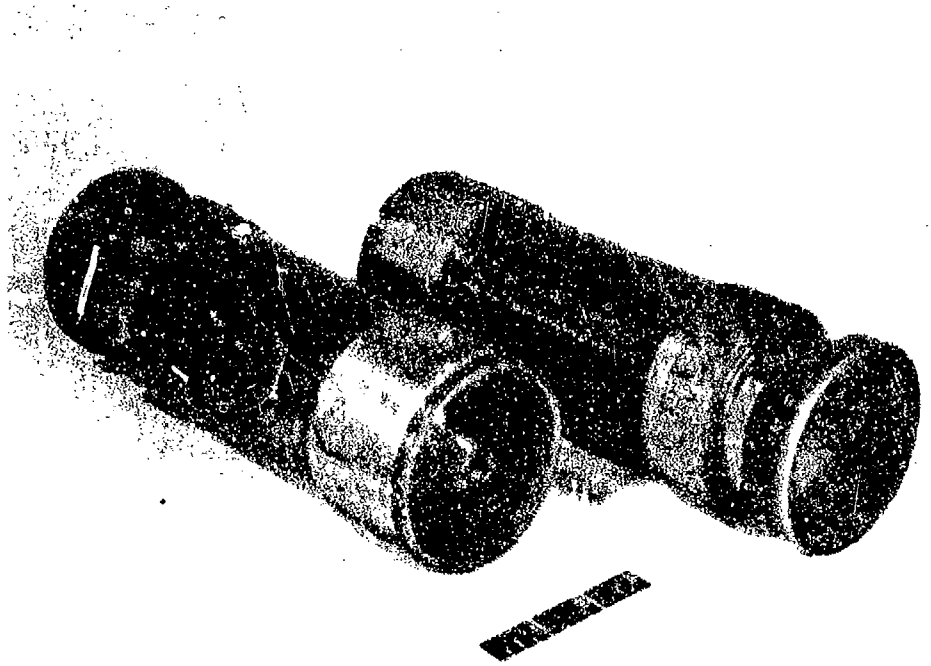


Figure 12. PRD Cases S/N 001 and 002

TABLE VI

PRD UNIT DESIGN PROGRESSION

<table>
<tr><th>Design</th><th>Case Winding Pattern</th><th>Failure Mode</th></tr>
<tr><td>A - Aft
Fwd</td><td>XOHOXOOXOC*OCOCOCOCO
XOHOXOOX*CHCHCHCOCOCOCOCOCO</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   O O O
CH_4COCOCOCH | CH | **
XOCXOCXOCXO   COCOCOCH | CH |</td><td>Combined hoop/bearing/buckling at nozzle pin joint, skirt/case interlaminar shear</td></tr>
<tr><td>C - Pressure Vessel
Forward Skirt
Aft Doubler</td><td>XO XO XO XO   O O O
CH_4CCOCCOCCOC | CH | **
XOCXOCXOCXO   CCOCCOCCOC | CH |</td><td>Skirt/case interlaminar shear</td></tr>
<tr><td>Nozzle</td><td>XXXXOOOOOO | CCO | Repeat 7 times</td><td></td></tr>
</table>

Where: X = 1 15° helical layer (case) 42° layer (nozzle)
O = 1 hoop layer over entire length
H = 1 hoop layer over skirt or doubler only
C = 1 layer of S901-34 glass cloth
H_4 = hoop fill-in for forward skirt/dome junction

*Design A used type 181 PRD 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)

	Design @ 11,400 psig (psi)	Achieved @ 12,250 psig (psi)
Forward Dome	304,560	327,250
Fwd Opening (shear)	12,630	13,570
Hoop	320,000	343,840
Nozzle tension	41,430	44,520
Nozzle bearing	37,640	40,440
Static Skirt Compression	19,714	21,180
Static Skirt Shear Stress	2,563	2,750

Unit

Case	0.66 lb
Nozzle and Pins	0.39 lb
Total Wt:	1.05 lb

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 PRD 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 PRD, were it to be used for making the nozzle, S904 fiberglass and S901-14 glass cloth were used. PRD 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, o-ring 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 VIII

PRD CASE HYDROTEST SUMMARY

Case S/N	Design/ Test No.	Date	Pump	Coating	Max. Press. (psig)	Time Under Press. (sec)	Comment
001	A-1	9/1/72	Sprague	8 Spraylat	6575	44	Weeped aft cyl. sect. & between case & nozzle
	A-2	10/16/72	Miller	Epon 946 + Bladder	8535	1.4	Case failed in tension at forward nozzle pin ring
002	A-1	9/1/72	Sprague	8 Spraylat	4310	7	Aft Cyl. sect. weeped, leaked between case & nozzle
	A-2	9/1/72	Sprague	8 Spraylat	5920	15	"
	A-3	9/1/72	Sprague	6 Spraylat	5525	42	"
	A-4	9/8/72	Sprague	3 Coats Epon 946	7510	58	"
	A-5	9/8/72	Sprague	Epon 946 + SSC*	5270	92	"
	A-6	9/8/72	Sprague	"	7985	7	Failed in tension at forward nozzle pin ring
003	B-1	1/19/73	Miller	Bladder	12,250	2.5	Aft end doubler failed, reaction caused inter-laminar skirt failure
004	C-1	1/19/73	Miller	Bladder	5760	0.7	Skirt interlaminar shear
013	B-1	3/19/73	Miller	Bladder	10,540	4.8	Similar to S/N 003. Equip-ment malfunction reduced pressurization rate

*Seam Sealing Compound

(1) S34-901 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/[illegible] mode, Figure 13. The outer fibers appeared to fail in hoop while due to load on the nozzle and retaining pins was causing the fiberglass nozzle and [illegible] skirt to fail in bearing at the pins, causing the nozzle to [illegible]. The inner helical fibers appear to have buckled either during burst or due to the nozzle being ejected. The forward skirt failed in [illegible] 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/hydrotest piston seal and the bladder ruptured. It is postulated that S/N 004 would have achieved a similar pressure had the skirt not sheared.

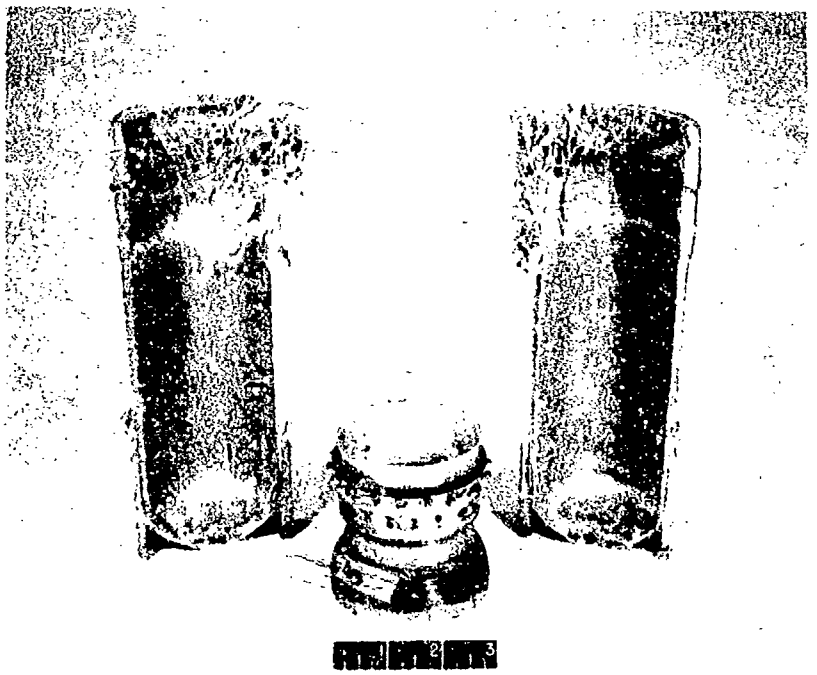


Figure 13. S/N 003 Hydroburst

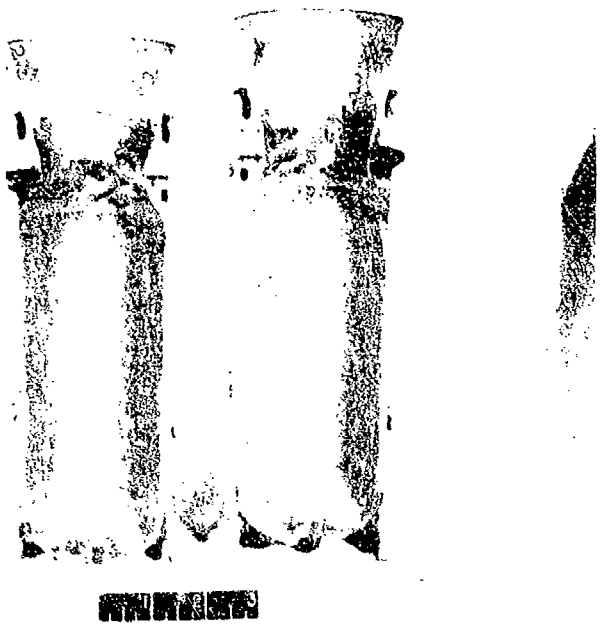


Figure 14. S/N 004 Hydrotest

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

TITLE: Composite Case Design - Fiberglass Configuration

Design Parameters

$P_{design} = 11,400$ psi $\frac{P_{design}}{1.5} = 7600$

Max thrust = 32,300 lb.

$R_{i\,cyl.} = 1.367$ in.

$r_t = .961$ in.

$A_t = 2.9013$ in^2

Assume $C_F = 1.465$

$F = 7600(2.901)C_F = 22,048(1.465)$

$F = 32,300$ lb.

Inner Shell

$N_\phi = \frac{11,400(1.390)}{2} = 7,792$ lb/in

$\bar{R} = 1.367 + .023$

$= 1.390$

Assume $\alpha = 27°$

$\cos^2\alpha = .7939$

$\sin^2\alpha = .2061$

$\tan^2\alpha = .2596$

$\bar{r} = .631$

$\sin\alpha = \frac{.631}{1.390} = .45396$

$\sin^2\alpha = .20608$

$\alpha = 27°$

$\cos^2\alpha = .7939$

$\tan^2\alpha = .2596$

$N_\phi = n_\alpha N A_{end} f_\alpha \cos^2\alpha$

$= n_\alpha (341)(2.3176 \times 10^{-4})(3.8 \times 10^5)(.7939)$

$= n_\alpha (22869)(8.792)$

$= 2010.2\, n_\alpha$

$n_\alpha = \frac{7923}{2010.2} = 3.94$

Assume $n_\alpha = 4.0$ layers $f_\alpha = 374,433$ psi.

$t_\alpha = 40(.00115)$

$t_\alpha = .046$ in

Assume $n_\theta = 1$ layer @ 90°

$t_\theta = .0095$

inner shell $t_c = .056$ in.

Winding Sequence XX•XX•

Adhesive gap = 0.015

Outer shell

$R_i' = 1.367 + .056 + .015$

$R_i = 1.438$ in.

Force on Aft end during hydrotest

$F = p\pi R_i^2 - p\pi r_t^2$

$p\pi (R_i^2 - r_t^2)$

$= 11{,}400\pi [2.068 - .923]$

$= 35{,}814 (1.14$

$F_{axial} = 41{,}037$ lb.

$N_\phi \approx \frac{41{,}037}{9.035} = 4539$ lb/in

Assume ...

$r_t = .961$

$R_i = 1.404$

$R_i^2 = 1.971$

$35814(1.048) = 37{,}533$

Aft dome winding angle

$\bar{R} \cong 1.437 + .023$

$= 1.461$

$\bar{r}_{rev.} \cong .961 + .040$

$= 1.000$

$\sin\alpha = \frac{1.000}{1.461} = .68446$

$\alpha_{calc} = 43°12'$

$\cos^2\alpha = .5514$

$\sin^2\alpha = .4626$

$\tan^2\alpha = .8818$

$N_\phi = 4539 = m_\alpha (381)(8.792)(.5514)$

$m_\alpha = \frac{4539}{1845.5}$

$m_\alpha = 3.373$ layers. for $t_\alpha = 324{,}000$ @ 11,000

for $m_\alpha = 4.0$ $t_\alpha = 320{,}435$ @ 11,000

Assume: @ 9900 $t_\alpha = 344{,}318$ psi.

4 helical layers over dome $t_\alpha = .046$

3 helical layers over cylinder $t_\alpha = .034$

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In the cylindrical section

$t_{w_1} = .046$

$t_{w_2} =$ [illegible]

$t_{pp} =$ [illegible]

$t_{b_1} =$ [illegible]

t_{b_2}

$t_T = .046 + .034 + .047$

$= .127$

$R_i = 1.367$

$N_\phi = 45\,59 = 3(\quad) T_\phi (.7726) + 3(\quad) T_\phi (.5514)$

$\frac{4559}{3(\quad)} = T_\phi (.7726 + \quad)$

$T_\phi = \frac{4559}{2.4(1.311)} = \frac{4559}{1133}$

$T_\phi = 4.02$

$\Sigma m_i T_i \sin\alpha = 3(\quad)(\quad)(.\quad + .4614)$

$= 3456(.6\quad)$

$= 2321$ #/in

$N_\theta = 11,400(1.432)$

$= 16,328$

$m_\theta \pi T_\theta = 16,3\quad \quad 2121$

$=$ [illegible]

HKR 18581 REV. 1-71 100 PADS			A 6018 (8-65)
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for $S_\theta = 420{,}000\ psi$

$T_\theta = 9.717\ lb/end$

$$n_\theta = \frac{14{,}000}{288\,(9.717)} = \frac{14{,}000}{2{,}798.5}$$

$n_\theta = 5.003$ layers

Assume $n_{\theta_{Total}} = 5.0$ layers @ 90°

Winding Sequence

		t_c ends	t_c cyl.
Inner Shell	X M • X X •	.056	.044
	adhesive		.015
Outer Shell	X O M O X O X O	.084	.072
		.143	.131
	R_i	1.367	1.367
	$R_{o\ inner}$	1.423	
	$R_{i\ outer}$	1.426	1.426
	$R_{o\ outer}$	1.510	1.498

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Forward Dome Contour

$R_i = 1.367$ in.

$t_\alpha = 4(.0115) = .046$ in.

$\bar{R} = 1.367 + .023 = 1.390$ in.

$\bar{D} = 2.780$

$\alpha = 27°$

$Z \frac{t}{D} \cdot \frac{.046}{2.78}$

$Z = .016547$

x	y	$t°$	$\bar{R}$	$\bar{Y}$	$t_\alpha/2$
1.0	0	2.0	1.390	0	.0230
.999	.03351	2.003	1.3886	.0466	.0230
.99	.10624	2.026	1.3761	.1477	.0233
.98	.14984	2.052	1.3652	.2083	.0236
.96	.21054	2.107	1.3344	.2927	.0242
.92	.29371	2.227	1.2788	.4083	.0256
.88	.35471	2.364	1.2232	.4930	.0272
.84	.40382	2.521	1.1676	.5613	.0290
.80	.44509	2.705	1.112	.6187	.0311
.76	.48066	2.924	1.0564	.6681	.0336
.72	.51186	3.197	1.0008	.7115	.0367
.68	.53957	3.52	.9452	.7500	.0405
.64	.56457	3.95	.8896	.7848	.0455

Nozzle and aft dome details

$d_{exit} = 2.946$

$Y_{exit} = 1.473$

$A_{exit} = 6.818$

$d_{case} = 2.801$

$Y_{case} = 1.404$

$A_{case} = 6.193$

$$\epsilon = \frac{6.818}{2.9013} = 2.35$$

for $\epsilon = 2.35$

$A_{exit} = 6.818055$

$r^2 = 2.170325$

$r = 1.473$

Momentum Balance

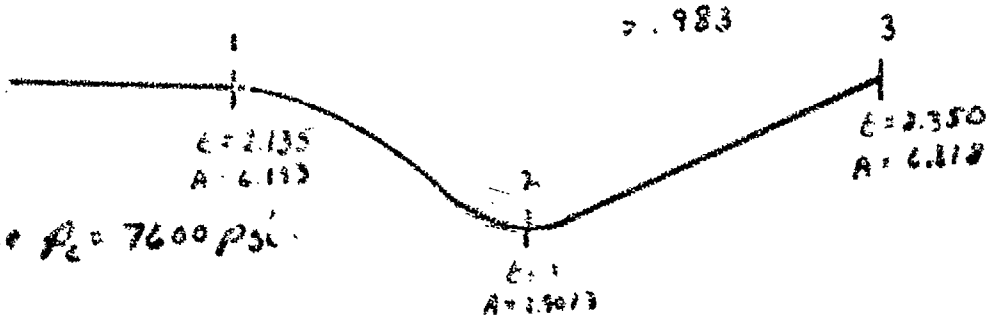
$$F_i = P_i A_i (1 + \lambda \gamma M_i^2)$$

Assume $\gamma = 1.19$

$\lambda = .5 + .5 \cos 15°$

$= .5 + .5(.9659)$

$= .983$



Assume $P_c = 7600$ psi

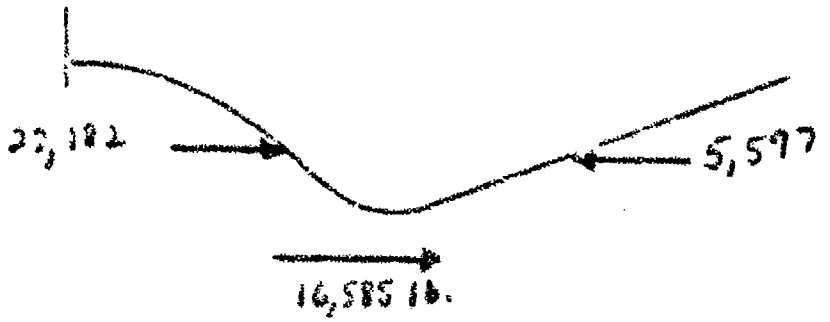
P_{exit}

	1	2	3 (ε = 2.35)
M	2.90	1.0	2.188
$\frac{P_0}{P}$	1.051	$\frac{P_0}{P_c}$ 1.767	10.4633
$C_{F_{mc}}$		1.8[illegible]97	1.504108
$\epsilon\left(\frac{P_0}{P_c}\right)$		.565594	.2285736
P	7231	4301	726
PA	44,751.6	13,478.5	4999.9

$\lambda\gamma = 1.19(.95)$
$= 1.170$

Point

	1	2	3
M^2	.0841	1.0	4.7873
$\lambda\gamma M^2$	.10008	1.170	5.6011
$1+\lambda\gamma M^2$	1.1	2.170	6.6011
F_i	49,260	37,078	32,675



C_F Computation

At point 3.

$$C_{F\ vac\ cov.} = \lambda\left[C_{F\ vac} - \epsilon\frac{A_e}{A_t}\right] + \epsilon\frac{A_e}{A_t}$$

$$= .95\left(1.379514\right) + \frac{2.35\,(14.7)}{76.10}$$

$$= 1.25776 + .22459$$

$$C_{F\ vac\ cov.} = 1.48235$$

$C_{F\ cov}$ = 1.48235 − .00035 = 1.4778
Sea level

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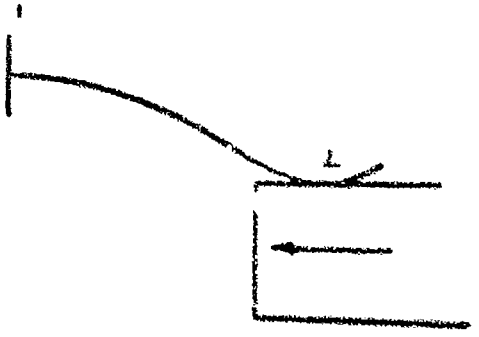
Thrust = $C_F p_c A_t$

= 1.4778(7600)(2.9013)

Thrust = 32,585 lb. @ p = 7600 psi
sea level

For Hydrotest



@ 1

$F = pA = 11{,}900(2.193)$

$= 70{,}600$

$\bar{R} = 1.904 + .033 = 1.937$

$2\pi \bar{R}_{cos\theta} = 8.966$

@ 2

$F = -11900(2.901)$

$= -33{,}071$

$J = \frac{33071}{70{,}600} = .4684$

$\Delta F = 37{,}529$

$N_\phi = \frac{37529}{8.966} = 4186$

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Aft Dome Contour

$\alpha = 43^\circ$

$J = .468 \quad J_{cr} = .462$

$t_d = .046$

$R_{ic} = 1.404$

$\bar{R} = 1.427$

$\bar{D} = 2.854$

$Z = \frac{.046}{2.854} = .01612$

For $\alpha = 40^\circ$

$J = .06$

$z = .015$

X	y	z'	R_1	$\bar{R}$	Y	W/2	R_1
1.0	0	3.0	.66972	1.427	0	.023"	
.997	.0369	3.005	.67094	1.4256	.0527	.0230	
.99	.11647	3.052	.68214	1.4127	.1662	.0234	
.98	.16436	3.107	.69385	1.3985	.2345	.0238	
.96	.23118	3.203	.72628	1.3699	.3303	.0247	
.94	.28236	3.351	.76237	1.3414	.4029	.0257	
.90	.36184	3.648	.86163	1.2843	.5163	.0280	
.86	.42346	4.022	1.0268	1.2272	.6071	.0308	
.82	.48321	4.444	1.2023	1.1701	.6853	.0346	
.78	.53987	5.201	1.3462	1.1131	.7561	.0399	

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VESSEL STRESSES - LAW PROGRAM

	Proposed Design @ p = 11,400 psi	Demonstrated Values. LAW II	Others.
Inner Shell			
Forward Dome	6 layers @ 27°	4 layers @ 27°	Sprint I, II
	f = 245,500 psi	f = 290,000 psi	f = 291,580 psi 353,975 psi
Outer Shell			
Aft Dome	6 layers @ 42°	4 layers @ 42°	Sprint
	f = 213,625 psi	f = 264,218 psi	f = 292,000 psi
Cyl. Hoop	6 layers @ 90°	5 layers @ 90°	MICOM 3"
	f = 350,801 psi	f = 346,316 psi	f = 458,000 psi
			LAW II
Forward Skirt	6 layers @ 42° 6 layers @ 90° 3 layers cloth	4 layers @ 42° 5 layers @ 90° 3 layers cloth	3 layers @ 42° 5 layers @ 90° 3 layers cloth
	T = 23,521 psi	T = 24,926 psi	
	F = 33,071 lb.		F = 37,000 lb.

Probable Mode of Failure: Forward Dome - p = 13,460 psi
Cyl. Hoops p = 14,870 (based upon f = 458,000 psi)

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TITLE:		

Outer Shell - Present Design.

4 layers @ 42° t_2 =

6 layers @ 90°

4 layers cloth

Assume:

6 layers @ 42°

4 layers @ 270°

$$N_\phi = 4539 = .00666\, f_2 \left[4(.794) + 6(.5314)\right]$$

$$= .00666\, f_2 \,(3.176 + 3.1884)$$

$$= .00666\,(6.3644)\, f_2$$

$$= .0424\, f_2$$

$$f_2 = 107,052$$

$$N_\theta = m_\theta N T_\theta + 713.0 \left[4(.206) + 6(.4681)\right]$$

$$11400(1.157) = +7130\,(.824 + 2.8116) + 713.0\,(3.6356) + 2592.$$

$$N_\theta = 16,610 = m_\theta f_\theta (.00666) + 2572$$

$$.00666\, m_\theta f_\theta = 14,038$$

$$m_\theta f_\theta = 2,109,205$$

for n_B f_B

6 350,801

5.5 382,692

5 420,961

Outer Shell:

$R_i = 1.417$

6 layers @ 42°

5 layers @ 90° over entire cylindrical section

3 layers cloth over forward skirt

1 layer @ 90° over forward skirt

X X O X X O C_{SK} O X X O C_{SK} O C_{SK} O

in body: X X O X X O O X X O O O

Increased wt.

in cyl. 2 @ 42° 1 @ 90°

$\ell = 10.65$

$\bar{R} = 1.5 + .015 = 1.515$

$wt = 2\pi \bar{R} \gamma \ell \rho$

$= 2\pi (1.515)(.03)(10.65)(.07)$

$= 9.519 (.0224)$

$= .213$ lb.

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CHECKED BY:	PLANT:	
TITLE:		

$\ell = 1.3(3.39) = 4.40$

$wt = \frac{4.4}{10.65} \times \frac{.022}{.031} \times .213 = \frac{.0918(.213)}{.390} = .062$

$wt_{increase} = .275$ lb.

$1.16 + .25 = 1.41$

$\ell_{skirt} = 10.65 - 5.65 + .260$

$= 5.26$ in.

$\bar{R}_{skirt} = \frac{1.417 + 1.535}{2} = 1.476 + .011 = 1.486$

$t = 1.535 - 1.417 = .118 + .022 = .140$

$wt = 2\pi(1.486)(.140)(5.26)(.07)$

$= 9.337(.0515)$

$wt_{skt.} = .481$ lb.

Prev.

Fwd skirt: $R_i = 1.417$

$R_o = 1.535 + .032 = 1.567$

$t = .150$ $\quad t = .118$

$\bar{R} = 1.492$ $\quad \bar{R} = 1.476$

$2\pi\bar{R} = 9.3745$ $\quad 2\pi\bar{R}t = 1.406$ $\quad 2\pi\bar{R}t = 1.094$

@ $p = 11,900$ $\quad F = 33,071$ $\quad$ @ $p = 9100$ $\quad F = 27,269$

$F = 23,521$

HER 1658 REV 1-71 100 PAGE

A 6018 (5-68)

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TITLE:		

Vessel Stresses.

	Proposed Design		Demonstrated	
Inner Shell	No. Layers	Stress @ 11,500	LAW II	MICOM
Fwd dome	6	245,500	290,724	225,000
Outer Shell				
Aft dome	6	213,625	264,218	225,000
Cyl. hoop	6	350,801	346,316	458,000
Fwd. Skirt	6@42 6@90 3 cl.	T = 23,521 psi F = 33,071 lb.	T = 24,926 psi F = 37,600 lb (comp. test)	

PREPARED BY: T. White	HERCULES INCORPORATED	PAGE NO 1 OF
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CHECKED BY:	PLANT:	
TITLE: LAW II		

Forward Time Analysis

$\alpha = .27$

Found [illegible]

$\bar{E} = 1.3 \times$

$N_\phi = 7712$ [illegible]

[illegible] $= .00527 n_\alpha \bar{\epsilon}_\alpha$

for $N_\phi = 7712$:

$n_\alpha \bar{\epsilon}_\alpha = \frac{7712}{.0352 \times 1.} = 14.73 \times$

n_α - layer	$\bar{\epsilon}_\alpha$ - psi	Found - [illegible]
4	362,500	11,4
[illegible]	= 14,600	"
6	245,500	"

If

n_α	Found - psi	$\bar{\epsilon}_\alpha$ - [illegible]
[illegible]	7,000	240,724
5	11,250	"
6	13,500	"

PREPARED BY:	HERCULES INCORPORATED	PAGE NO OF
DATE:	SYSTEMS GROUP	REF NO
CHECKED BY:	PLANT:	
TITLE:		

LAW II Case Analysis.

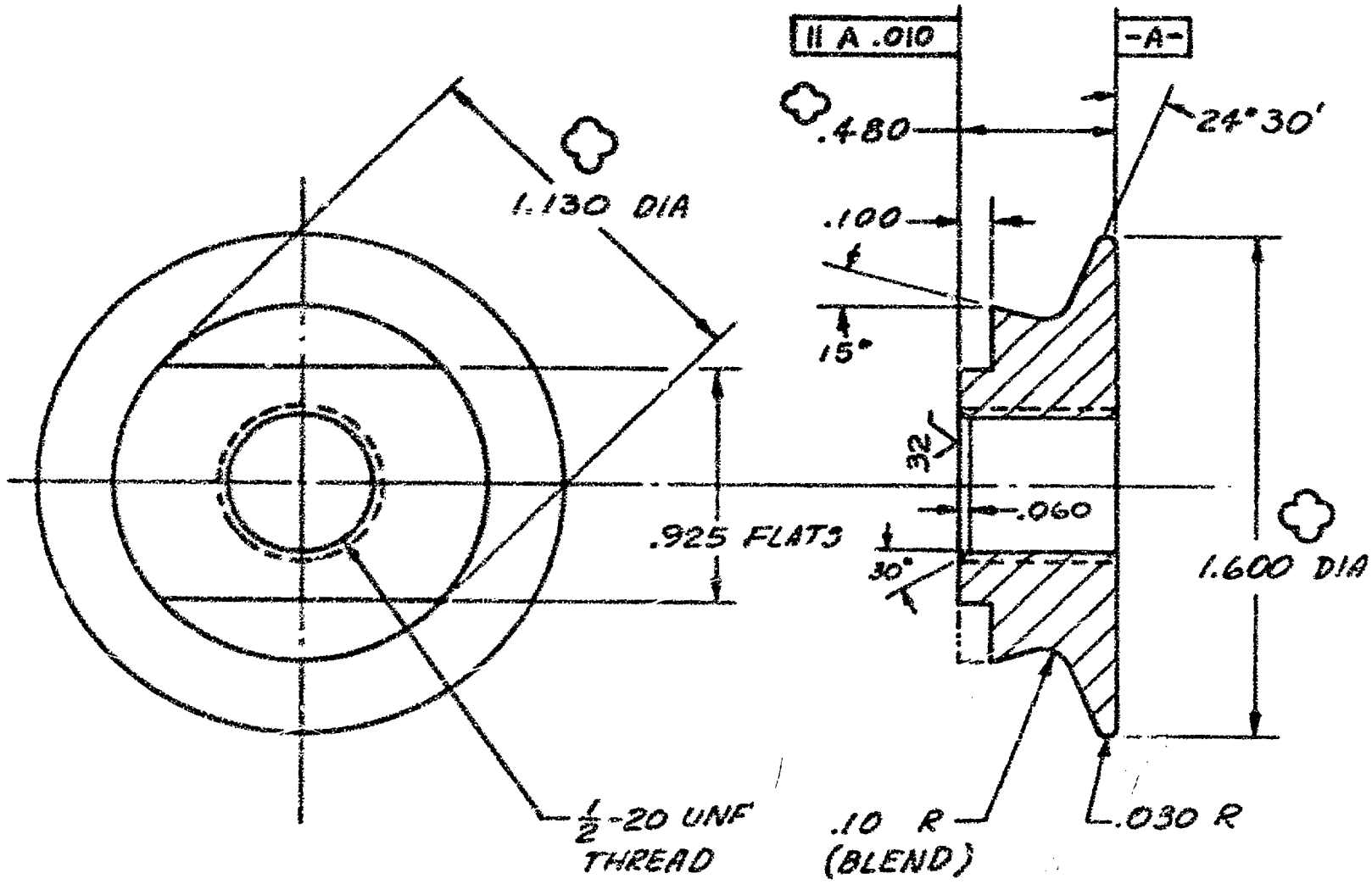
Strength improvement Based upon Prestressing time

$K = 1.222$

$1.222(9080) = 11,100$ psi

APPENDIX A-2

FIBERGLASS CASE-IN-CASE CHAMBER SKETCHES



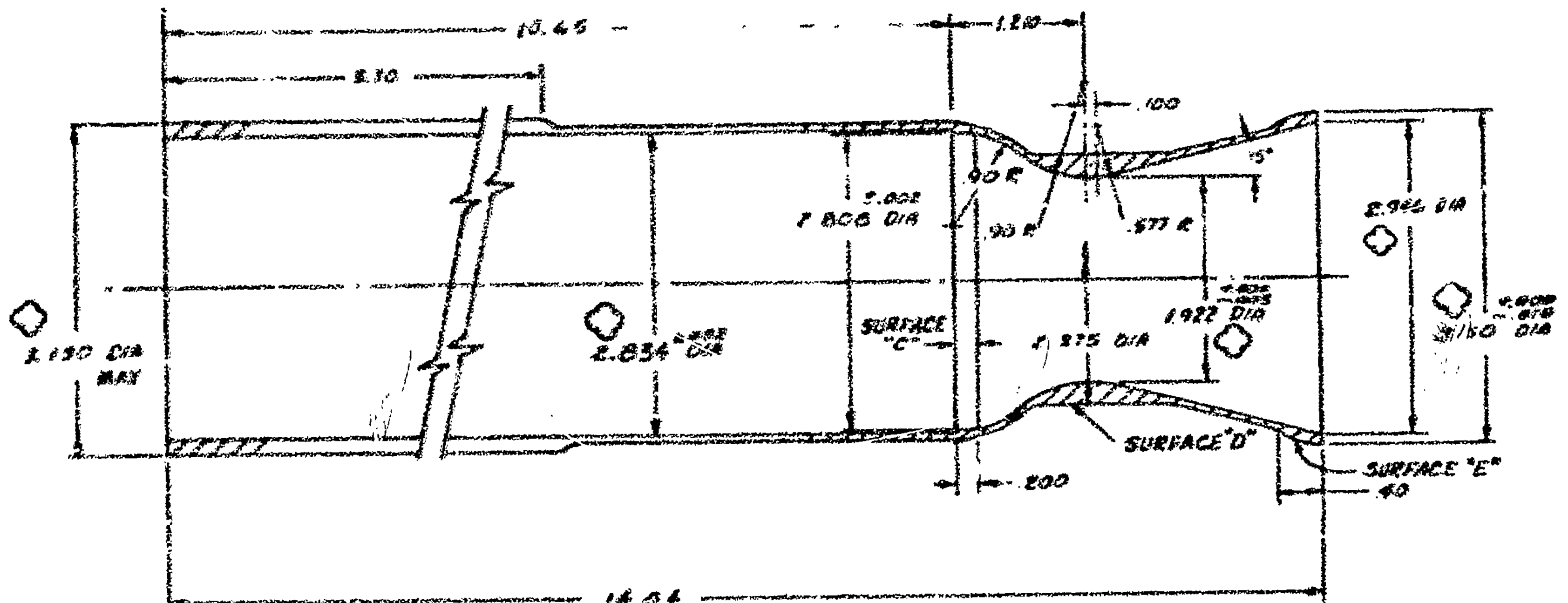
1. MATERIAL: 7075-T6 ALUM. OR EQUAL
2. SYMBOL ⌖ INDICATES RESULTS TO BE REPORTED BY THE FABRICATOR.

POLE PIECE
2/1 SCALE

720531

NOTES

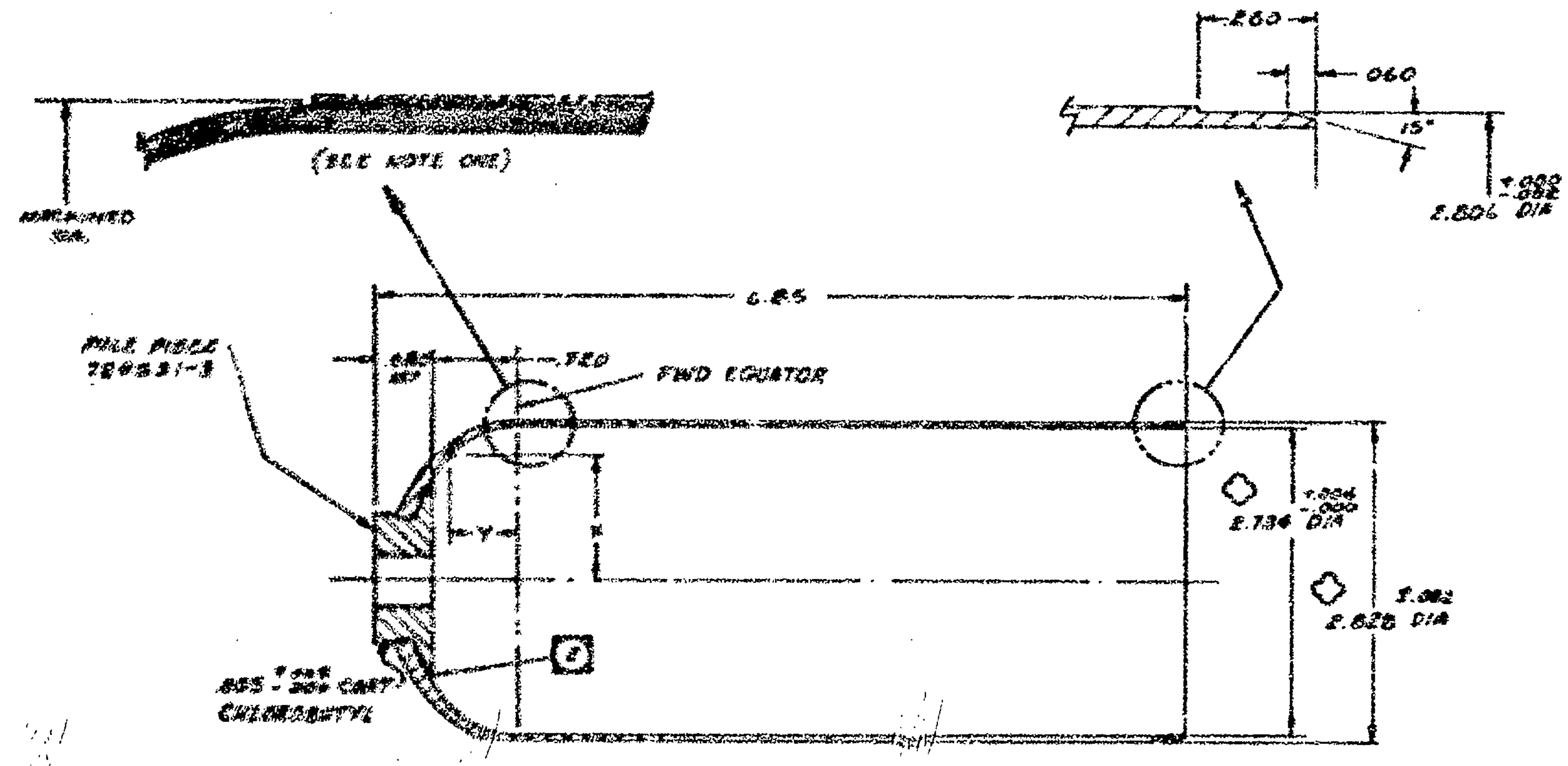
1. FILAMENT WINDING SEQUENCE
   - A. SINGLE ROVING HOOP WINDINGS OVER SURFACE "C" UNTIL SMOOTH TRANSITION BETWEEN AFT DOME AND CYLINDRICAL SECTION EXISTS.
   - B. ONE 42° HELICAL LAYER OVER NOZZLE, DOME, AND CYLINDRICAL AREA
   - C. REPEAT B
   - D. ONE HOOP LAYER OVER CYLINDRICAL SECTION
   - E. REPEAT B, F. REPEAT B, G. REPEAT D
   - H. ONE LAYER OF CLOTH IN SKIRT REGION
   - I. REPEAT B, J. REPEAT B, K. REPEAT B, L. REPEAT D, M. REPEAT H,
   - N. REPEAT D, O. REPEAT H, P. REPEAT B, Q. SINGLE ROVING HOOP WINDINGS OVER SURFACE "C", R. HIGH ANGLE HELICAL WINDINGS OVER SURFACE "E".
2. SYMBOL ◇ INDICATES RESULTS TO BE REPORTED BY FABRICATOR.



3. MATERIAL: FIBERGLASS FILAMENT, E-801, 12 END ROVING, OWENS-CORNING FIBERGLAS CORP, RESIN, ERL 2256, UNION CARBIDE CORP, TONOX 6040, UNIROYAL CO

OUTER SHELL
1/1 SCALE

720531-2



NOTES

1 INNER SHELL FILAMENT WINDING SEQUENCE
  A - 1 HELICAL LAYER - 27°
  B - REPEAT A
  C - REPEAT A
  D - REPEAT A
  E - REPEAT A
  F - REPEAT A
  G - 1 HOOP LAYER

2 FILL VOID WITH SAME MIXTURE TONOX & ERL RESIN USED WITH FILAMENT WINDING.

3. MATERIAL: FIBERGLAS FILAMENT, S 994, 12-END ROVING, OWENS - CORNING FIBERGLAS CORP; RESIN, ERL 2256, UNION CARBIDE CORP; TONOX 6040, UNIROYAL CO.

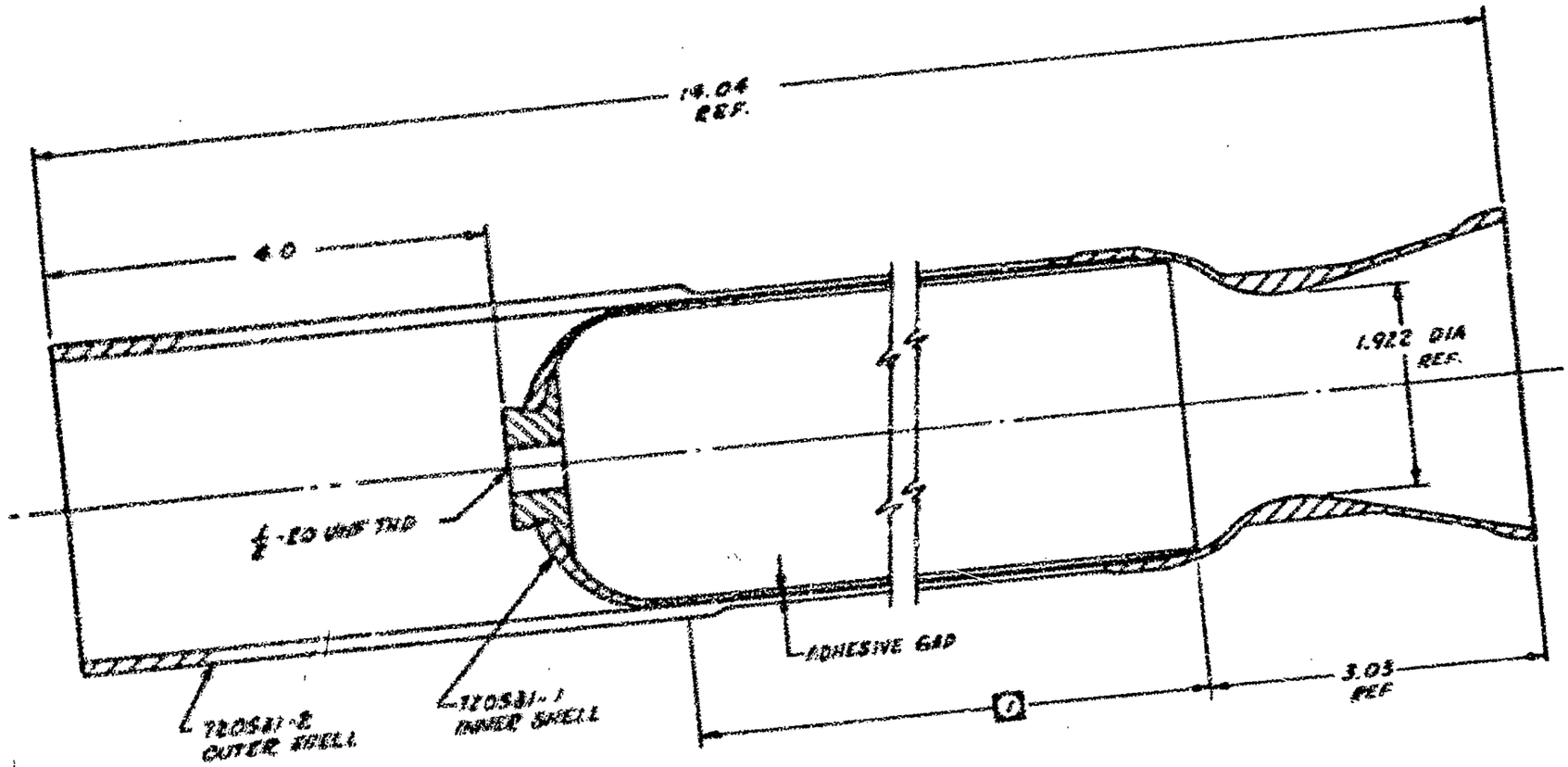
4. SYMBOL ◇ INDICATES RESULTS TO BE REPORTED BY THE FABRICATOR.

DOME COORDINATES

X	Y
1.367	0
1.358	.100
1.342	.200
1.303	.300
1.255	.400
1.182	.500
1.086	.600
.930	.700
.800	.778
.754	.800

INNER SHELL ASSEMBLY
1/1 SCALE

720531-1



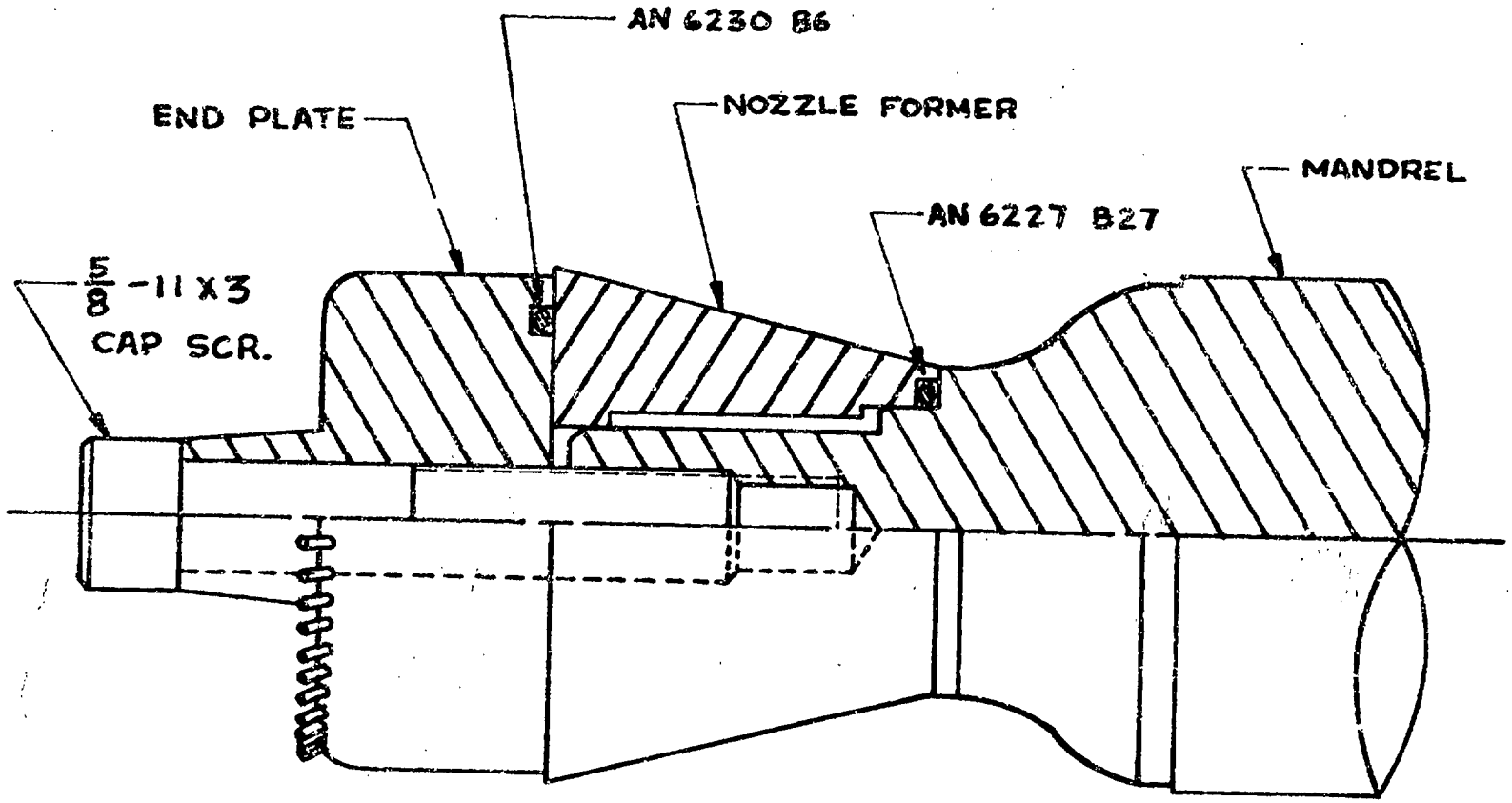
NOTES
1. CPON 946, PARTS A & B, USED IN ADHESIVE GAP IN THIS AREA BY BRUSHING ADHESIVE ON MATING SURFACES OF INNER & OUTER SHELLS.

GLASS FIBER MOTOR
¼ SCALE

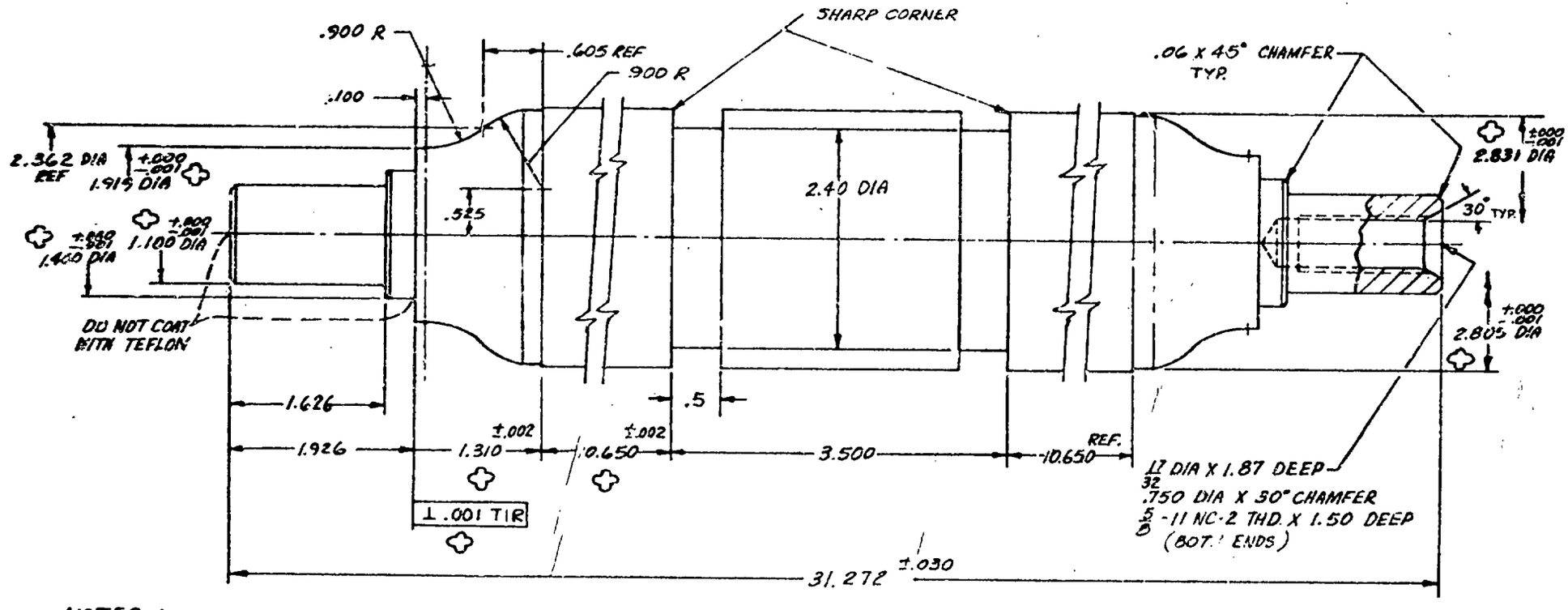
120531

APPENDIX A-3

FIBERGLASS CASE-IN-CASE TOOLING SKETCHES



OUTER SHELL ASS'Y



NOTES :

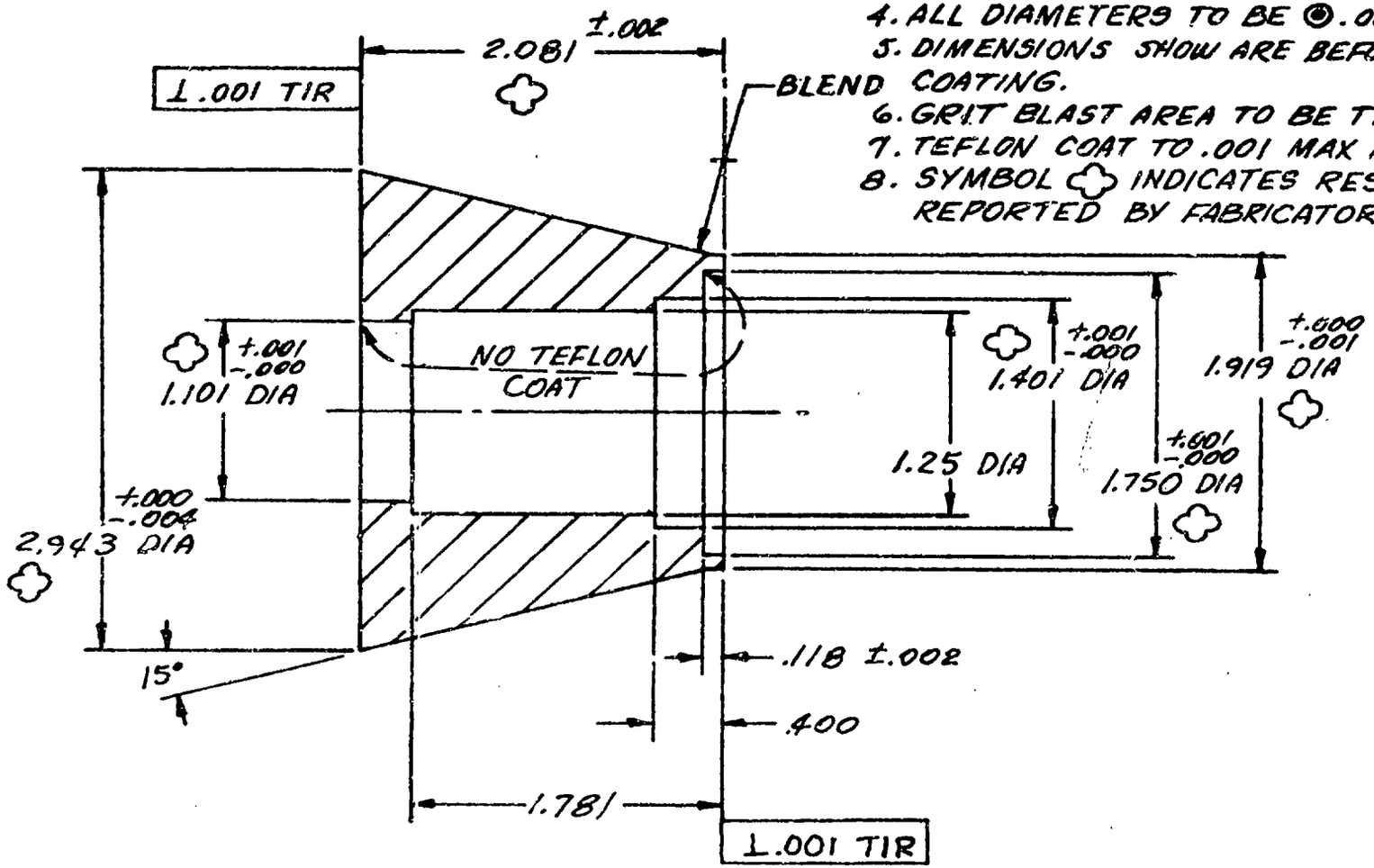
1. MATERIAL : 2024 T351 ALUMINUM OR EQUAL.
2. SURFACE FINISH 63 ALL OVER.
3. REMOVE ALL BURRS AND SHARP EDGES, .005 MAX R.
4. ALL DIAMETERS TO BE Ⓜ .001 TIR WITH CENTERS.
5. DIMENSIONS TYPICAL FOR BOTH ENDS.
6. DIMENSIONS SHOWN ARE BEFORE TEFLON COATING.
7. GRIT BLAST AREA TO BE TEFLON COATED.
8. TEFLON COAT TO .001 MAX AS SHOWN.
9. SYMBOL ✣ INDICATES RESULTS TO BE REPORTED BY FABRICATOR.

MANDREL – OUTER SHELL BODY

1/SCALE 720613

NOTES :

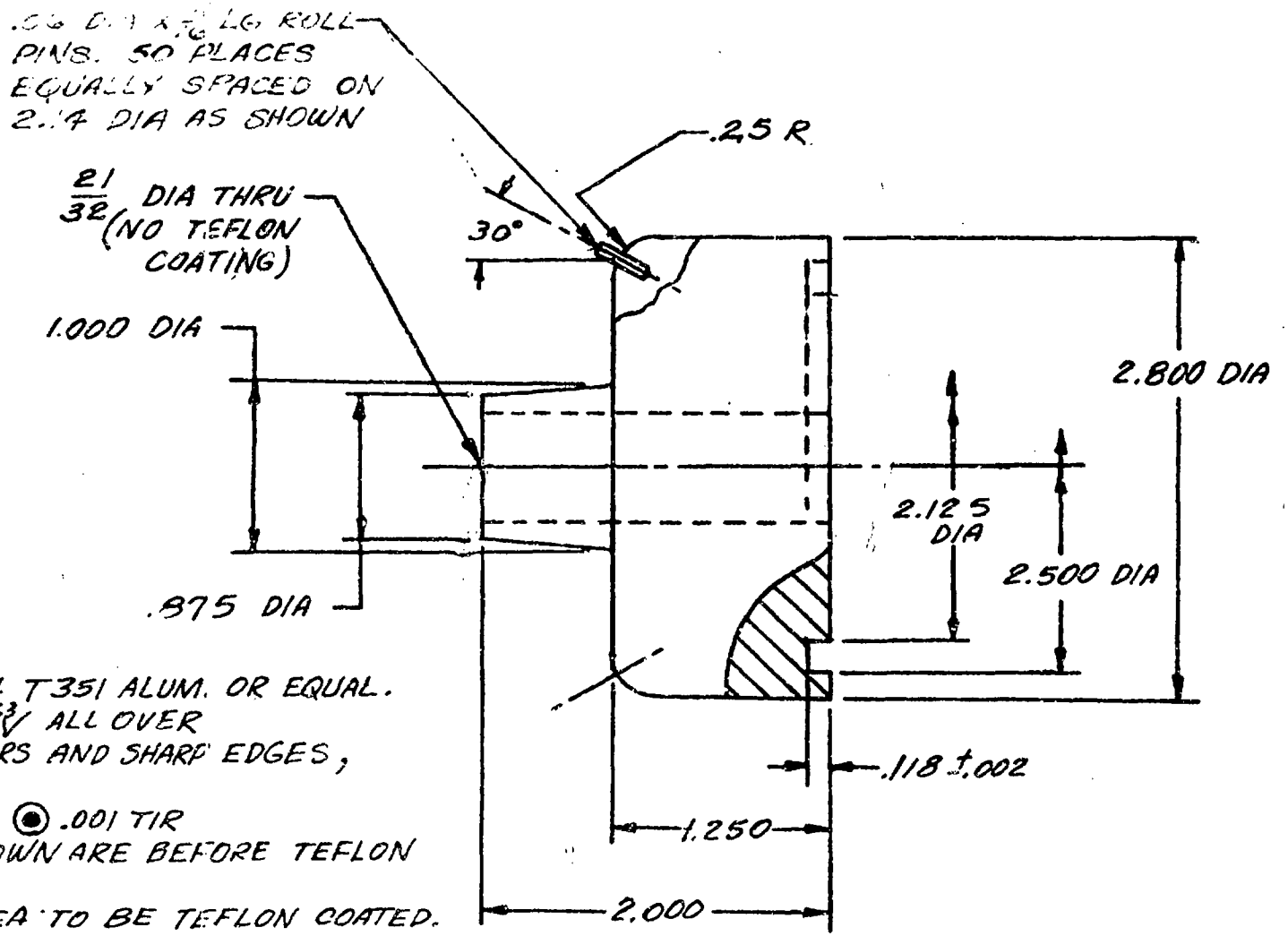
1. MATERIAL : 2024 T 351 ALUMINUM OR EQUAL
2. SURFACE FINISH $\sqrt{}$ ALL OVER.
3. REMOVE ALL BURRS AND SHARP EDGES, .005 MAX.
4. ALL DIAMETERS TO BE ⌀ .001 TIR.
5. DIMENSIONS SHOW ARE BEFORE TEFLON COATING.
6. GRIT BLAST AREA TO BE TEFLON COATED
7. TEFLON COAT TO .001 MAX AS SHOWN
8. SYMBOL ✣ INDICATES RESULTS TO BE REPORTED BY FABRICATOR.



NOZZLE FORMER

1/1 SCALE

720613-1



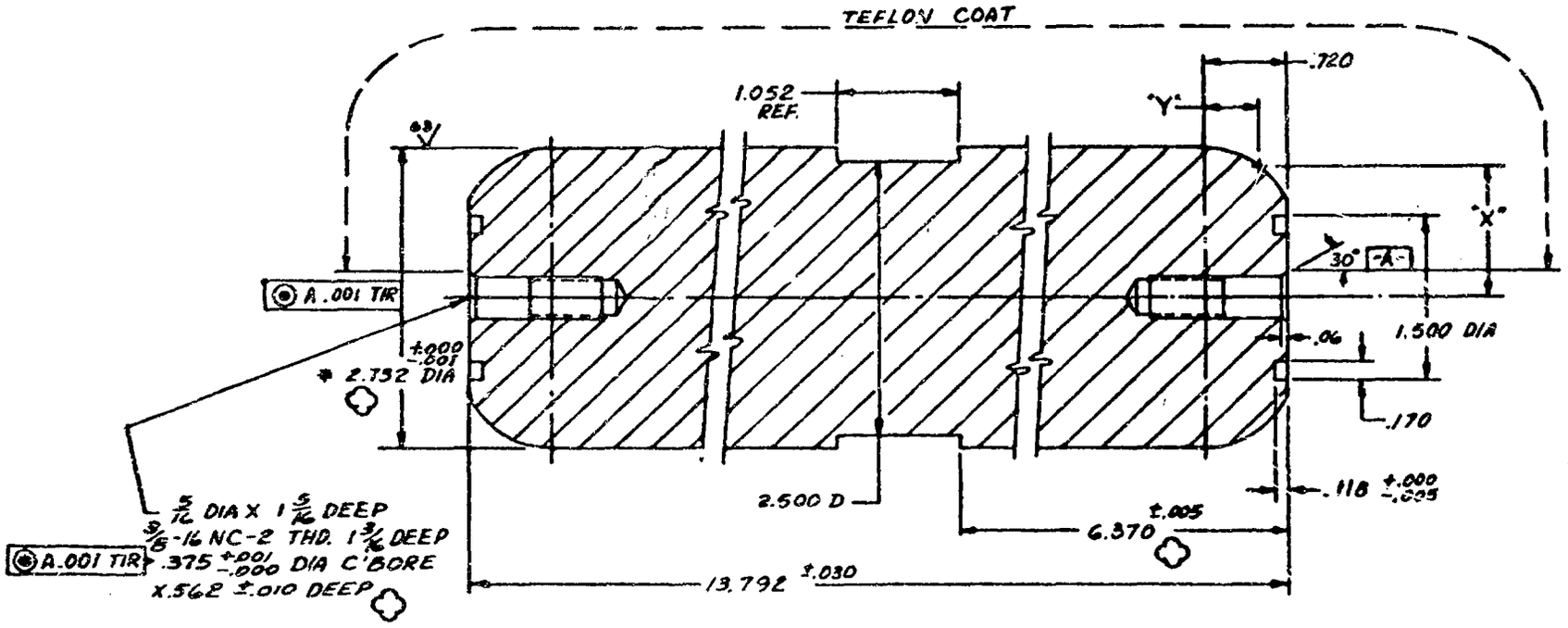
NOTES:

1. MATERIAL: 2024 T351 ALUM. OR EQUAL.
2. SURFACE FINISH 63 ALL OVER
3. REMOVE ALL BURRS AND SHARP EDGES, .005 MAX R.
4. ALL DIAMETERS Ⓜ .001 TIR
5. DIMENSIONS SHOWN ARE BEFORE TEFLON COATING.
6. GRIT BLAST AREA TO BE TEFLON COATED.
7. TEFLON COAT TO .001 MAX.

END PLATE

1/1 SCALE

720613-2



DOME COORDINATES

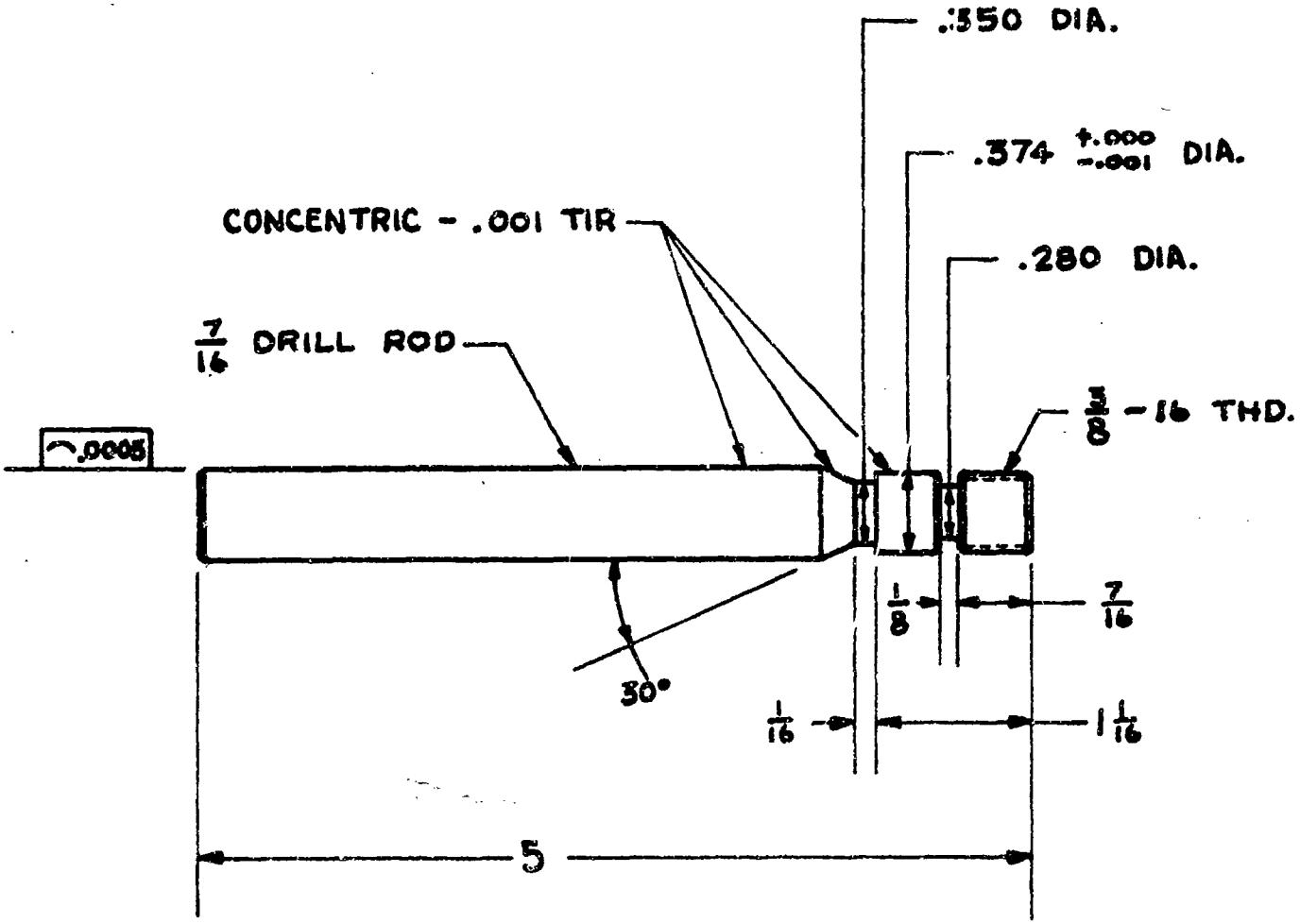
X	Y
1.366	0
1.358	.100
1.342	.200
1.303	.300
1.253	.400
1.182	.500
1.086	.600
.915	.720

NOTES:

1. MATERIAL : ALUMINUM 2024 T351 OR EQUAL.
2. GRIT BLAST PRIOR TO TEFLON COAT.
3. TEFLON COAT TO .001 THK. MAXIMUM
4. * INDICATES TOLERANCE PRIOR TO TEFLON COAT.
5. DIMENSIONS TYPICAL BOTH ENDS.
6. SYMBOL ⌖ INDICATES RESULTS TO BE REPORTED BY THE FABRICATOR.
7. USE "O" RING AN6227 B-23

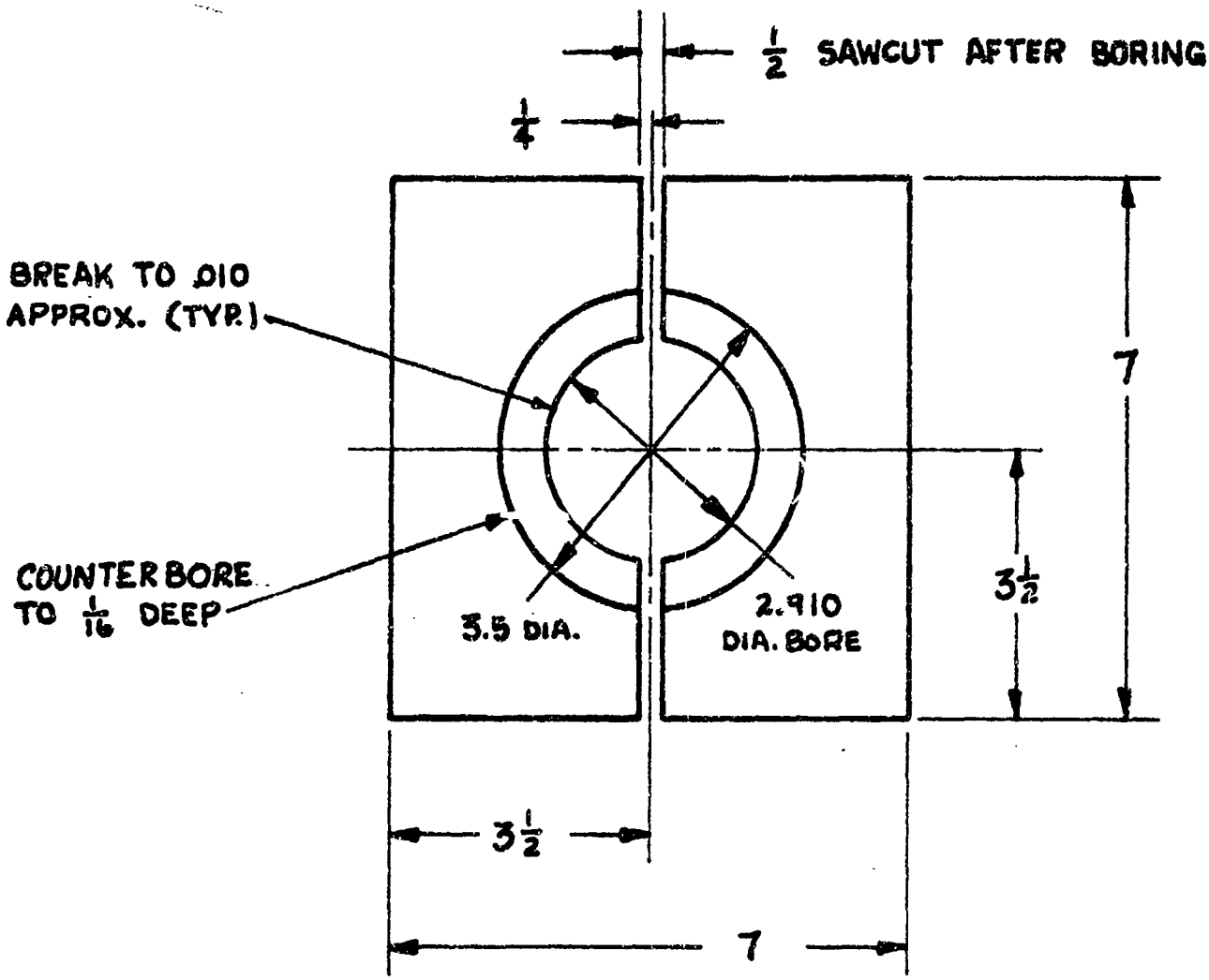
INNER SHELL MANDREL
4 SCALE

7206 08



INNER SHELL MACHINING CENTER

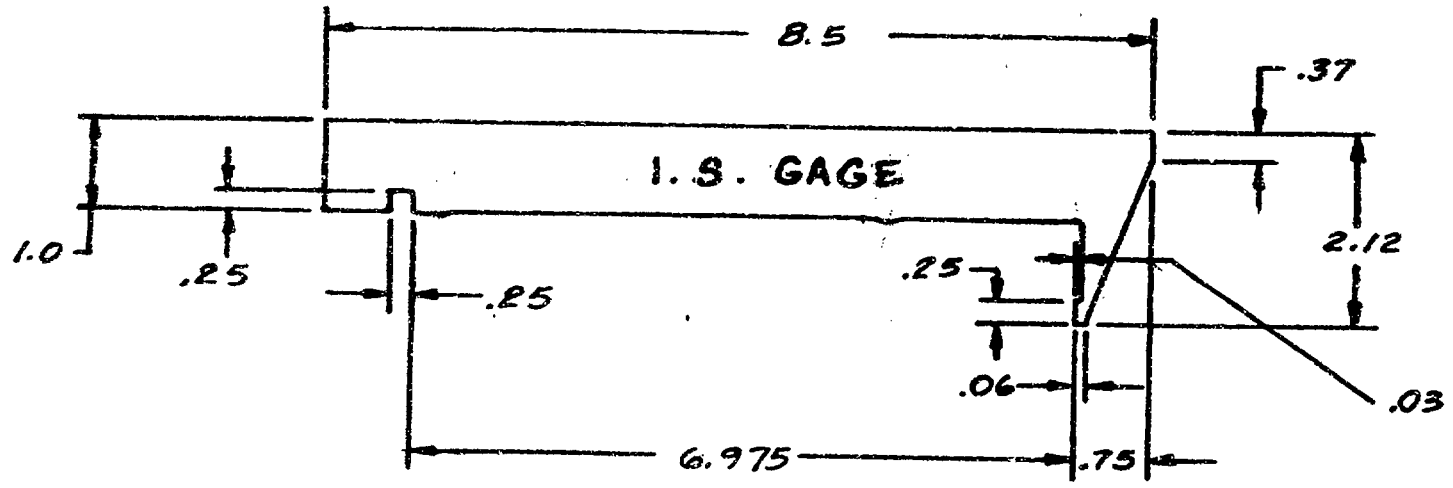
720606-1

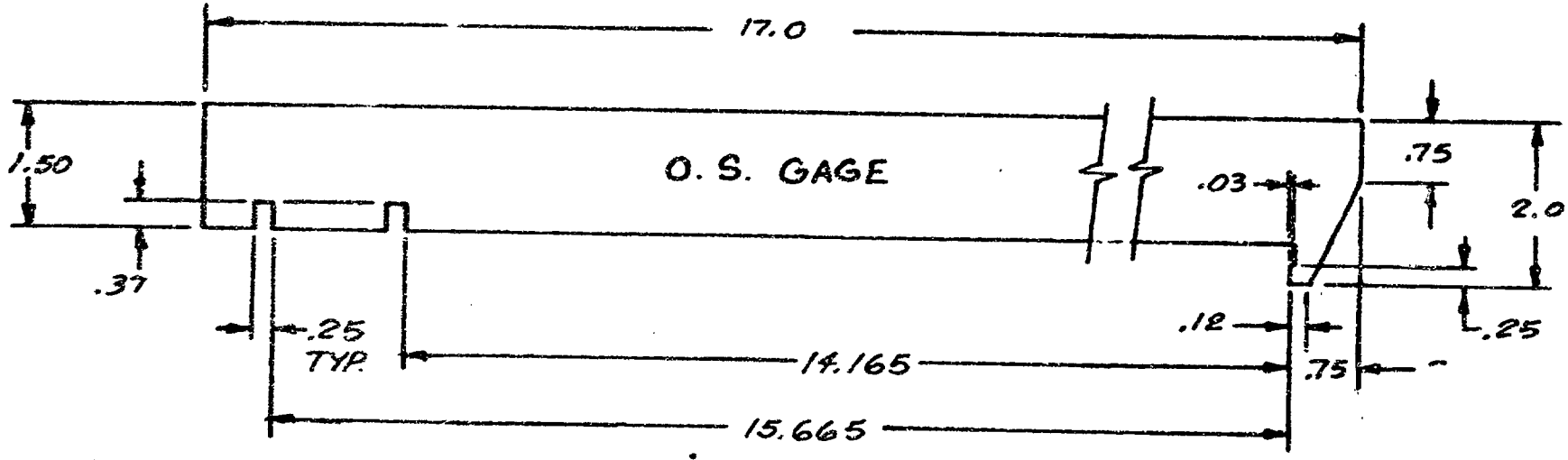


STRIPPING PLATE

1/2" - 2024 T4 ALUM.

720613-3





NOTES:

1. MATERIAL : 2024 T4 ALUMINUM, .125 THICK
2. METAL STAMP IN $\frac{1}{4}$" CHARACTERS, BOTH PARTS AS SHOWN.

SHELL PARTING GAGES

$\frac{1}{2}$ SCALE

720616

APPENDIX A-4

MATERIAL ACCEPTANCE SPECIFICATIONS *

* N.B. At present there is no specification for PRD 49 Type III filament or cloth.

Approved:
R. Steinberger (signature)
CPD/ME
4-9-71

HS-CP-264
Reinforced Plastics - Glass Filament
Glass Roving, 12-End, Continuous Filament, Non-Aging (S-904)
Materials Manual Unit 4.2.7

HERCULES SPECIFICATION DATA SHEET

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:

Supplier	Trade Name	Program	Specification
Owens Corning Fiberglas Corp.	S-904 Glass Roving	Poseidon S/S	WS 11895

   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 $129^{\circ} \pm 5^{\circ}$ centigrade (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 11.5×10^6 pounds per square inch.

3.7 Sizing identification. The extract from the sizing shall be acidic to bromcresol 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

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

f. 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_1.

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_2.

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:

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

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 4.2e)

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° ± 3° C and 50 percent maximum relative humidity.

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

Table II. Impregnating Resin

Material	Specification	Parts by weight
Epoxy resin	HS-CP-163	100 ± 1
Curing agent	HS-CP-164	29.5 ± 0.5
Toluene	Technical grade	22 ± 2

c. Cure specimens for 60 ± 5 minutes at 120° ± 5° C followed by 120 ± 5 minutes at 160° ± 5° 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 S-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 bromcresol 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 methylene 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.

SUPPORTING DATA SUMMARY FOR NON-AGING GLASS ROVING

Property	Data Source	No. of lots tested	Average result	Range of Data	
				Low	High
End count	Owens-Corning	1	12	12	12
Ignition loss, % by wt					
Lot ave.	Owens-Corning	1	1.47	1.47	1.47
Ball ave.	Owens-Corning	1	-	1.05	2.40
Extractable content, %	Owens-Corning	1	94	94	94
Weight, g/yd					
Lot ave	Owens-Corning	1	0.368	0.368	0.368
Ball ave.	Owens-Corning	1	-	0.364	0.372
Breaking load, lbs					
Ball ave	Owens-Corning	1	135	135	135
Individual specimen	Owens-Corning	1	119	119	119
Modulus of elasticity, psi	Owens-Corning	1	12.5	12.2	12.8
Sizing identification	Owens-Corning	1	-	Conforms	

APPROVED:	HS-CP-110, Am. 1
R Steinberger	Fibrous Reinforced Composites
CPD/ME 1-24-69	Glass Cloth, Finished (Type I-341 Cloth, 143 Reversible Weave; Type II-181 Cloth)
	Materials Manual Units 4.1.1 & 4.1.2

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:

TYPE	SUPPLIER	TRADE NAME	PROGRAM	SPECIFICATION
I	Hess Goldsmith Clark Schwebel	341 glass cloth (143 reversible weave) I 550 finish	Poseidon FS/SS	WS 8020
II	Hess Goldsmith Clark Schwebel	181 glass cloth CS 550 finish	Poseidon FS/SS	WS 8020
II	Hess Goldsmith J. P. Stevens	181 glass cloth Volan A finish	Sprint	11181420

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:

TYPE	SPECIFICATION	PROGRAM	SUPPLIER	TRADE NAME
I	WS 3342	Polaris	United Merchants Industrial Fabrics	341 Cloth
			Hess Goldsmith	398 Cloth
			J. P. Stevens	341 Cloth
I	HPC-133-08-2-5	Minuteman	Hess Goldsmith	398 Cloth
I	HPC-253-02-2-3	BE3	Hess Goldsmith	398 Cloth Volen finish
			Coast Mfg. & Supply	341 Cloth Volan finish
			J. P. Stevens	143 Reverse Weave Volan finish
I	MS-259-2-162	X259 (Goddard)	---	---
II	HPC-253-02-2-3	BE3	Hess Goldsmith	181 Cloth Volan finish
			Coast Mfg. & Supply	181 Cloth Volan finish
			J. P. Stevens	181 Cloth Volan finish

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).

APPROVED:
R Steinberger
CPD/ME 11-15-65

HS-3P-110
Fibrous Reinforced Composities
Glass Cloth, Finished (Type I-341 Cloth, 143 Reversible Weave; Type II-181 Cloth)
Materials Manual Units 4.1.1 & 4.1.2

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:

TYPE	SUPPLIER	TRADE NAME	PROGRAM	SPECIFICATION
I	Hess Goldsmith Clark Schwebel	341 glass cloth (143 reversible weave) I 550 finish	Poseidon FS/SS	WS 8020
II	Hess Goldsmith Clark Schwebel	181 glass cloth CS 550 finish	Poseidon FS/SS	WS 8020
II	Hess Goldsmith J. P. Stevens	181 glass cloth Volan A finish	Sprint	1181420

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

Cloth, Glass, Finished

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.

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

Glass cloth	Yarn construction*	
	Warp	Fill
Type I	ECD 450 1/2	ECE 225 3/2
Type II	ECE 225 1/3	ECE 225 1/3
*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

Characteristic	Unit	Type I (341)		Type II (181)	
		Minimum	Maximum	Minimum	Maximum
Warp	Yarns/in.	30	32	55	59
Fill	Yarns/in.	49	51	52	56
Thickness	In.	0.008	0.010	0.008	0.011
Weight	Oz/sq yd	8.08	9.12	8.50	9.50
Flexural strength, dry	Psi				
Warp		---	---	55,000	---
Fill		120,000	---	---	---
Flexural strength, wet	Psi				
Warp		---	---	45,000	---
Fill		100,000	---	---	---
Breaking strength	Lb/in. width				
Warp direction		35	---	210	---
Fill direction		370	---	195	---

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 2408-65 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° ± 10° Fahrenheit (F) and 60 ± 5 min at 350° ± 10° F.

4.6 Breaking strength test. Breaking strength shall be determined in accordance with ASTM D 579-66 except that method 1R-E of ASTM D 1682-64 shall be used. The time to break shall be 20 ± 10 seconds.

TYPE	SPECIFICATION	PROGRAM	SUPPLIER	TRADE NAME
I	WS 3342	Polaris	United Merchants Industrial Fabrics	341 cloth
			Hess Goldsmith	398 cloth
			J. P. Stevens	341 cloth
I	HPC-133-08-2-5	Minuteman	Hess Goldsmith	398 cloth
I	HPC-253-02-2-3	BE3	Hess Goldsmith	398 cloth Volan finish
			Coast Manufacturing & Supply	341 cloth Volan finish
			J. P. Stevens	143 Reverse Weave Volan finish
I	HS-259-2-162	X259 (Goddard)	---	---
II	HPC-253-02-2-3	BE3	Hess Goldsmith	181 cloth Volan finish
			Coast Manufacturing & Supply	181 cloth Volan finish
			J. P. Stevens	181 cloth Volan finish

Physical Properties Used in Establishing Specification Limits (Cont)

Property	Data source	No. of lots tested	Average Result	Range of data	
				Low	High
Flexural strength, psi	Bacchus				
Method B (CL)					
Dry		2	137,600	122,100	153,100
Wet		2	136,800	130,700	142,900
Type II - 181 cloth	Hess Goldsmith	1			
Warp, yarn/in.			57	57	57
Fill, yarn/in.			54	54	54
Thickness, in.			0.0087	0.0087	0.0087
Weight, oz/sq yd			8.97	8.97	8.97
Flexural strength, psi					
Dry			62,300	62,300	62,300
Wet			58,700	58,700	58,700
Breaking strength, lb/in. width					
Warp direction			229	229	229
Fill direction			197	197	197

SUPPORTING DATA SUMMARY FOR

GLASS CLOTH FINISHED FOR EPOXY RESIN LAMINATES

Physical Properties Used in Establishing Specification Limits

Property	Data source	No. of lots tested	Average Result	Range of data	
				Low	High
Type I - 341 cloth					
Warp, yarns/in.	Clark Schwabel	5	30	30	30
	Hess Goldsmith	33	29	29	29
Fill, yarns/in.	Clark Schwabel	5	50	50	50
	Hess Goldsmith	33	50	48	51
Thickness, in.	Clark Schwabel	7	0.0091	0.0085	0.0098
	Hess Goldsmith	33	0.0098	0.0092	0.0107
Weight, oz/sq yd	Clark Schwabel	3	8.83	8.71	8.89
	Hess Goldsmith	33	8.86	8.12	9.74
Breaking strength, lb/in. width	Clark Schwabel				
Warp direction		6	60	37	81
Fill direction		6	554	406	815
Breaking strength, lb/in. width	Hess Goldsmith				
Warp direction		2	37	36	38
Fill direction		2	410	400	419
Flexural strength, psi	Bacchus				
Method A (Tonox)					
Dry			135,900	122,000	154,000
Wet			125,000	104,600	144,100

APPROVED:
R Steinberger
CPD/ME 3-14-69

HS-CP-139
Reinforced Plastics - Woven Glass Cloth
Cloth, Glass, Unfinished (S/34-901)
Materials Manual Unit 4.1.3

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.

SUPPLIER	TRADE NAME	PROGRAM	SPECIFICATION
Owens-Corning Fiberglas Corp., 900 17th Street, N. W. Washington, D. C. 20006	Unfinished Glass Cloth S/34-901	Sprint	111814111X

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° Fahrenheit (F) in the original unopened containers. The storage life may be extended to 2 years from date of manufacture when stored at 11° to 32° F or to 3 years from date of manufacture when stored at 0° ± 10° 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.

HS-CP-139
March 14, 1969

HERCULES SPECIFICATION DATA SHEET

CLOTH, GLASS, UNFINISHED

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

Property	Value	
	Min.	Max.
Thickness, inch	0.017	0.020
Weight, ounces per yard	8.4	8.9
Warp yarns per inch	15	15
Fill yarns per inch	45	49
Fill breaking strength, pounds per inch of width	1050	--
Extractable content of sizing, percent	75	--
Ignition loss, percent	1.00	2.00

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, $3 \pm 1/16$ 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 specimens, 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 = Break load average, pounds
B = number of fill yarns per inch width
25 = number of fill yarns in specimen

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

4.6 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° ± 5° 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° to 1500° 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.

APPROVED:
R. Steinbacher
CPD/ME 2-20-69

HS-CP-105
Adhesive, Case Winding Resin
Resin, Epoxy (ERL 2256)
Materials Manual Unit 2.3.5

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:

SUPPLIER	TRADE NAME	PROGRAM	SPECIFICATION
Union Carbide Corporation	ERL 2256	Sprint Poseidon	11181401XB WS 8023

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:

SUPPLIER	TRADE NAME	PROGRAM	SPECIFICATION
Union Carbide Corporation	ERL 2256	Minuteman	HPC 133-08-2-3D HXS-2-17
		BE3	HPC 253-02-2-4A

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.

HS-CP-105
February 20, 1969

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

Property	Values	
	Minimum	Maximum
Specific gravity	1.155	1.175
Viscosity, centipoises	500	900
Weight per epoxy equivalent, grams per equivalent	135	145
Water content, percent	- - -	0.1

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 bromcresol 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) Bromcresol purple indicator solution, prepared by dissolving 0.1 gram of bromcresol 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 8.2 ± 0.05 waiting approximately 5 seconds between each drop.

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

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.

APPROVED:	HS-CP-164A
E F [illegible]	Adhesive, Curing Agent
CPD/ME 7/24/80	Amine Blend Curing Agent (Tonox 6040)
	Materials Manual Unit 2.4.3*

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 metaphenylenediamine 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:

SUPPLIER	TRADE NAME	PROGRAM	SPECIFICATION
Uniroyal, Inc.	Tonox 6040	Poseidon F/S, S/S	WS 8026

2.2 PROBLEMS. (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.

HERCULES SPECIFICATION DATA SHEET

Curing Agent, Amine Blend

Tonox 6040 is an epoxy resin curing agent. The material is a liquid eutectic mixture of various aromatic amines, consisting of 40 percent metaphenylenediamine 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 I. Chemical Composition

Ingredient	Percent
m - phenylenediamine	40 ± 4
p,p' - methylenedianiline	36 ± 4
o,p' - methylenedianiline	8 ± 2
Other chemicals	21 maximum

3.2 Titratable nitrogen. Titratable 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:

a. Apparatus and reagents

Dual column gas chromatograph with temperature programming and thermal conductivity detector (see figure 1).

Hamiliton Micro Syringe 10 microliter (µl) capacity or equivalent.

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

Metaphenylenediamine (MPDA) 99 + percent purity

4,4' Methylenedianiline (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 Anakrom 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 MPDA 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 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. Bake out a new column at 300° C for about 4 hours with the 70 ml/minute of He flowing through. Heating 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' MDA peak. From the weighings of the standard find the weight of MPDA, weight of DBP and weight of 4,4' MDA. Knowing the above six weights and areas, calculate a factor for both MPDA and 4,4' MDA in the following manner:

$$\text{Factor MPDA} = \frac{\dfrac{\text{Wt of MPDA}}{\text{Wt of internal standard}}}{\dfrac{\text{Area of MPDA}}{\text{Area of internal standard}}}$$

$$\text{Factor 4,4' MDA} = \frac{\dfrac{\text{Wt of 4,4' MDA}}{\text{Wt of internal standard}}}{\dfrac{\text{Area of 4,4' MDA}}{\text{Area of internal standard}}}$$

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

$$\frac{\text{Area of MPDA}}{\text{Area of DBP}} \qquad \frac{\text{Area of 2,4' MDA}}{\text{Area of DBP}} \qquad \frac{\text{Area of 4,4' MDA}}{\text{Area of DBP}}$$

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:

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

$$\text{Percent 2,4' MDA} = \frac{(\text{4,4' MDA factor})\left(\dfrac{\text{Area of 2,4' MDA}}{\text{Area of DBP}}\right)\text{Wt of DBP} \times 100}{\text{Wt of curing agent sample}}$$

$$\text{Percent 4,4' MDA} = \frac{(\text{4,4' MDA factor})\left(\dfrac{\text{Area of 4,4' MDA}}{\text{Area of DBP}}\right)\text{Wt of DBP} \times 100}{\text{Wt of curing agent sample}}$$

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

4.3 Titratable nitrogen. Percent titratable 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.

b. Glass electrode, all purpose.

c. Beckman Zeromatic p. 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 60 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 0.65 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:

$$\text{Normality of perchloric acid} = \frac{W \times 4.89}{V_1 - V_2}$$

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

4.89 = 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.

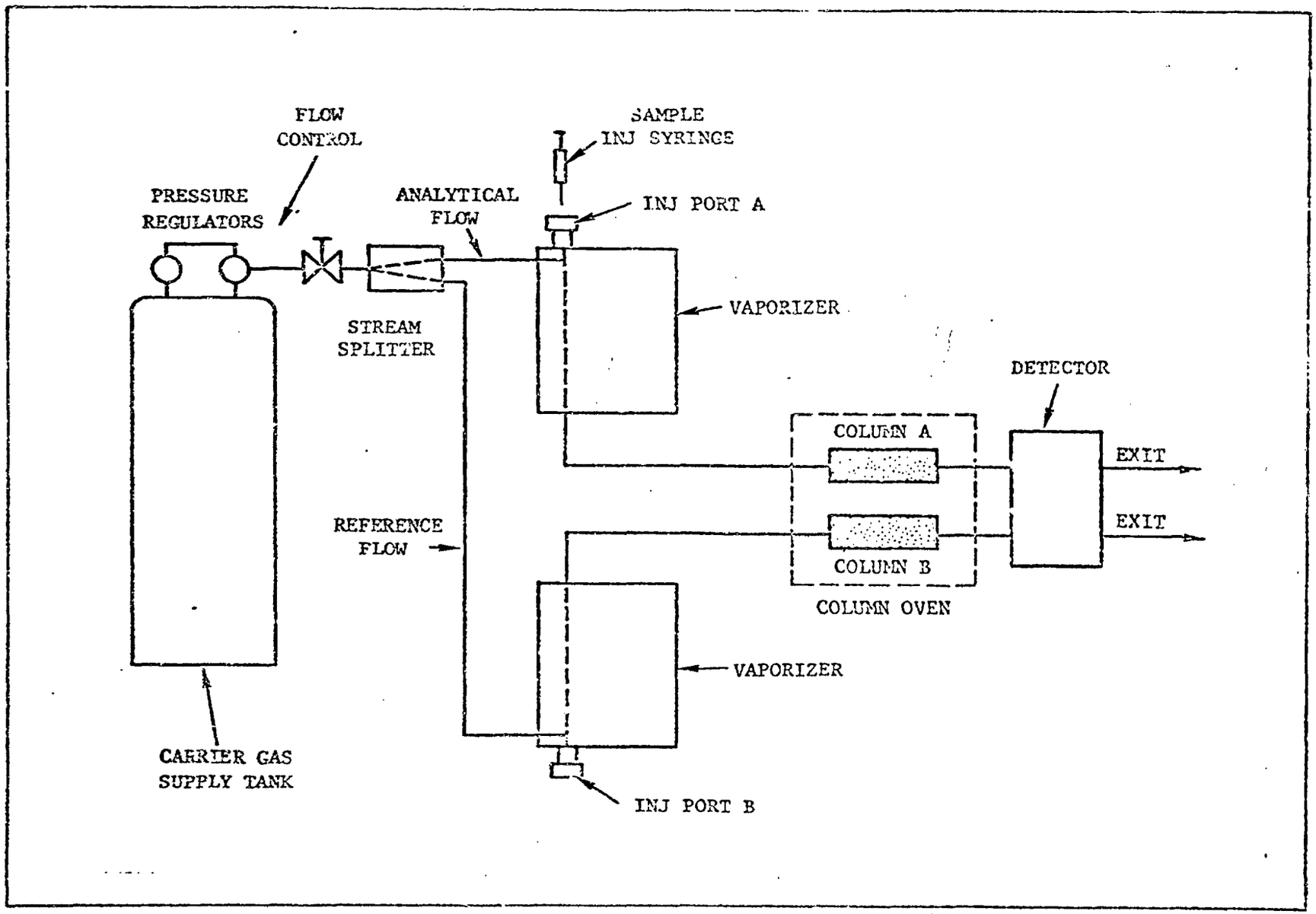


Figure 1. Dual Column Chromatograph

HS-GP-164A
7-21-70

SUPPORTING DATA SUMMARY FOR AMINE BLEND CURING AGENT

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

APPROVED:
CPD/ME 2/1/71

HS-CP-102, Amendment 1
General Purpose Adhesive
Adhesive, Epoxy Resin Base
Materials Manual Unit 2.1.20

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:

SUPPLIER	TRADE NAME	PROGRAM	SPECIFICATION
Hysol Division The Dexter Corporation	EA 946	Sprint Poseidon Hibex	11181310X WS 8994 SDS

   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 1 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.

APPROVED:
R Steinberger
CPD/ME 11-15-68

HS-CP-102
General Purpose Adhesive
Adhesive, Epoxy Resin Base
Materials Manual Unit 2.1.20

Winter

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:

SUPPLIER	TRADE NAME	PROGRAM	SPECIFICATION
Shell Chemical Co.	Epon 946	SPRINT	11181310X
		POSEIDON	WS 8994

   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 1084-63, Method B and identified exceptions.

HS-CP-102
1 September 1967

HERCULES SPECIFICATION

ADHESIVE, EPOXY RESIN BASE

HERCULES INCORPORATED

CHEMICAL PROPULSION DIVISION
WILMINGTON, DELAWARE

APPROVED BY _____ DATE 1 Sept 67
Manager, Quality Assurance

This specification consists of page 1 and 1 to 11 inclusive.

1 September 1967

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

(Copies of ASTM publications may be obtained from the American Society for Testing and Materials, 1916 Race Street, Philadelphia, Pennsylvania, 19103.)

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 I. Chemical and Physical Properties

Property	Values					
	Ingredients					
	Part A		Part B		Mixed Material	
	Min.	Max.	Min.	Max.	Min.	Max.
Flow, inch	--	--	--	--	--	1/16
Filler content, percent	2.4	3.4	--	--	--	--
Weight per epoxy equivalent, grams per equivalent	340	370	--	--	--	--
Titratable nitrogen, percent	--	--	15.7	18.0	--	--
Moisture content, percent	--	0.4	--	--	--	--
Bond shear strength, psi	--	--	--	--	1500	--
Tensile strength, psi	--	--	--	--	800	--
Ultimate elongation, percent	--	--	--	--	50	--
Change in refractive index, between 12 and 192 minutes after mixing	--	--	--	--	0.0045	0.0065

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 supplies 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 0.020 ± 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 a 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° 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 $\pm$ 5°C. Cool in a desiccator and weigh.

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

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 8 hours. Weigh 0.45 to 0.50 gram, to the nearest 0.1 mg, 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) = $\frac{(V_1 - V_2)\ (N)\ (0.014)}{W} \times 100$

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, 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 8 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 pbw of concentrated sulfuric acid (95 to 98 percent), 1 pbw of sodium dichromate, and 17 pbw of distilled water. Remove panels 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 ± 5°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 AMS 3166 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 (b) 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 (b).

4.4.7.2 Method II

(a) Prepare and centrifuge the adhesive in accordance with method 1

(b) Cast 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 scrape 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 0.020 x 3 x 3 inches.

(b) Sample preparation: Prepare a sample of approximately 210 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 II. Storage Life and Conditions

Material	Storage Life (from date of manufacture)	Storage Conditions
Resin (Part A)	12 months	0 ± 15°F in closed containers in a dry place.
	6 months	60-85°F in closed containers in a dry place.
Curing agent (Part B)	12 months	60-85°F in closed containers in a dry place.

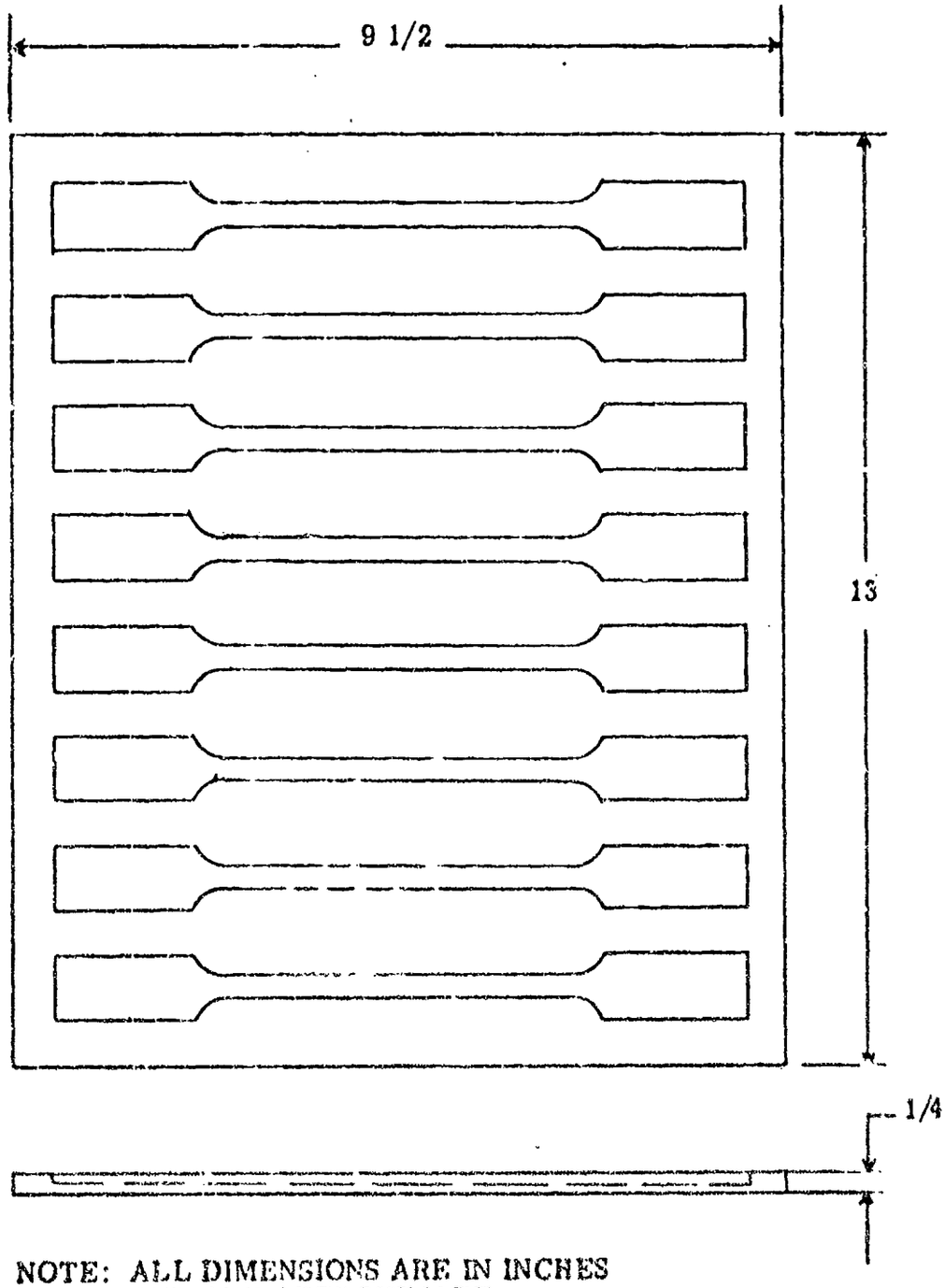
Custodian:

Hercules Incorporated
Allegany Ballistics Laboratory
Cumberland, Maryland

Preparing activity:

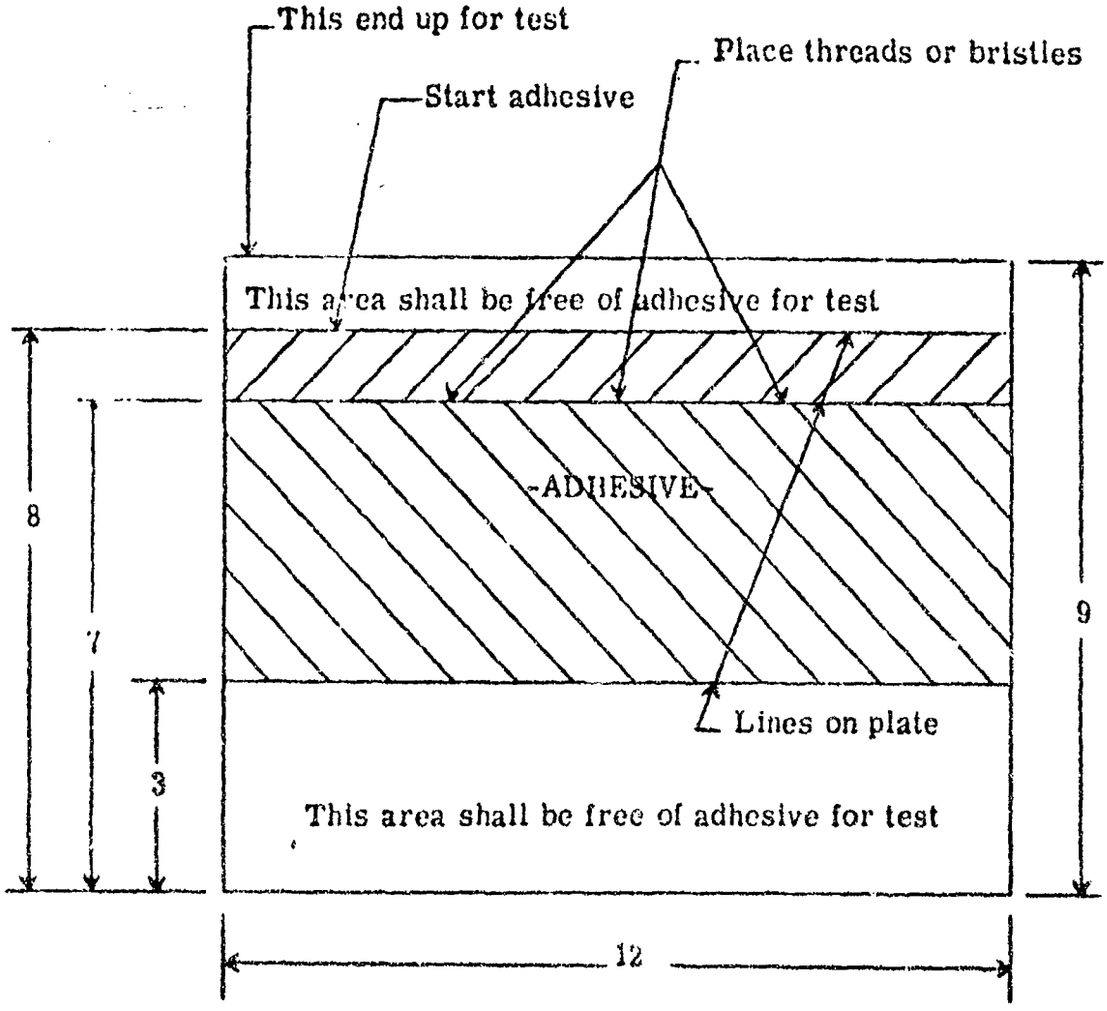
Hercules Incorporated
Allegany Ballistics Laboratory
Cumberland, Maryland

SILICONE RUBBER MOLD



NOTE: ALL DIMENSIONS ARE IN INCHES
AND ARE APPROXIMATE

Figure 1. Mold for Tensile Specimens



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

Property	Data source	No. of lots tested	Average result	Range of data	
				Low	High
Part A					
Filler content, %	Dexter Corp.	12	2.99	2.51	3.41
	Shell Chemical	35	2.95	2.50	3.30
	Hercules/Bacchus	14	3.08	2.80	3.30
	Hercules/ABL	18	3.04	2.46	3.28
Weight per epoxy equiv., grams/ equiv.	Dexter Corp.	12	355	346	367
	Shell Chemical	35	348	326*	368
	Hercules/Bacchus	14	358	350	368
	Hercules/ABL	19	353	330*	369
Moisture content, %	Dexter Corp.	12	0.18	0.11	0.31
	Shell Chemical	33	0.19	0.02	0.39
	Hercules/Bacchus	14	0.18	0.10	0.22
	Hercules/ABL	18	0.14	0.06	0.30
Part B					
Titratable nitrogen, %	Dexter Corp.	12	16.65	16.21	16.84
	Shell Chemical	34	16.62	16.30	16.90
	Hercules/Bacchus	14	16.36	16.10	16.70
	Hercules/ABL	16	16.63	15.98	17.46
Mixed adhesive					
Flow, inch (see 3.3)	Dexter Corp.	-	-	-	-
	Shell Chemical	22	Conforms	Conforms	Conforms
	Hercules/Bacchus	-	-	-	-
	Hercules/ABL	17	Conforms	Conforms	Conforms
Bond shear strength, psi	Dexter Corp.	12	2836	2120	3700
	Shell Chemical	35	2544	1560	3750
	Hercules/Bacchus	14	2165	1640	3380
	Hercules/ABL	16	2102	1156	2949
Tensile strength, psi	Dexter Corp.	12	1456	1160	1740
	Shell Chemical	34	1233	812	1740
	Hercules/Bacchus	14	1504	1078	2000
	Hercules/ABL	17	1237	705	1762
Ultimate elongation, %	Dexter Corp.	12	67	51	75
	Shell Chemical	35	69	51	99
	Hercules/Bacchus	14	94	80	110
	Hercules/ABL	17	66	50	89

SUPPORTING DATA SUMMARY FOR EPOXY RESIN BASE ADHESIVE (CONT'D)

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

*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. Chec 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 _____

   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 matchin inner shell. Remove the temporary label prior to coating.

7. Paint the ½ 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 ot 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 $300 \pm 15^{\circ}F$.
8. Strip off dry glass and film.
9. Remove liners from mandrel.
10. Assemble liners per composite dwg. and engineering instructions.

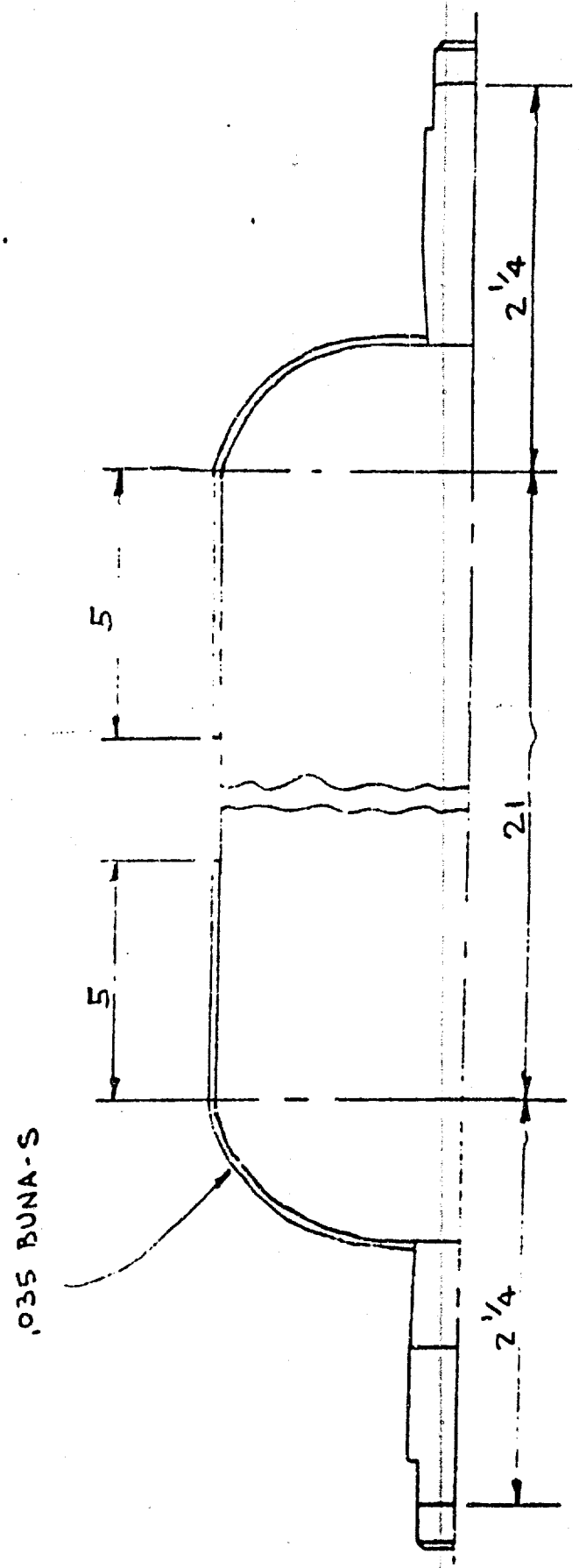


Figure 1

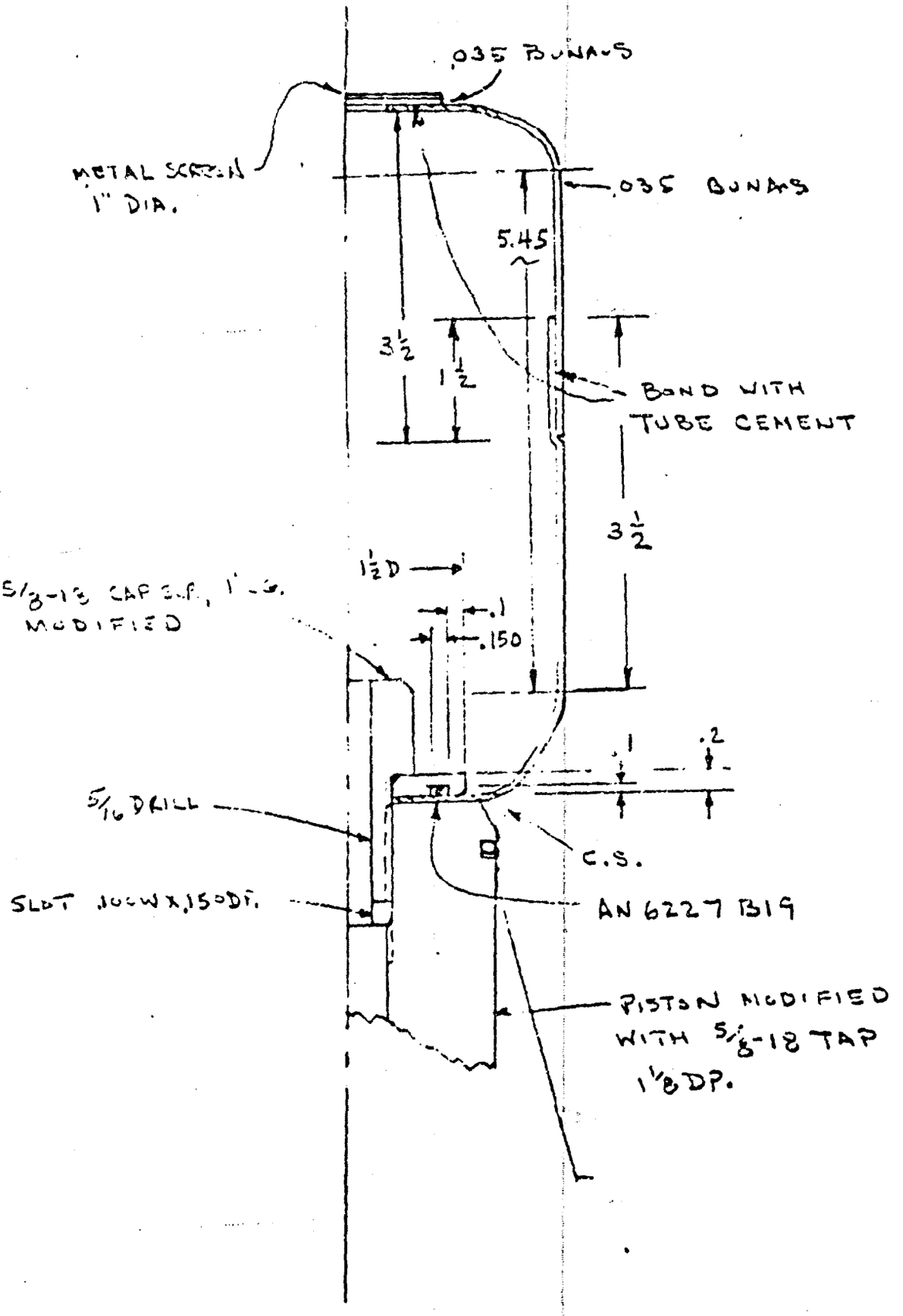
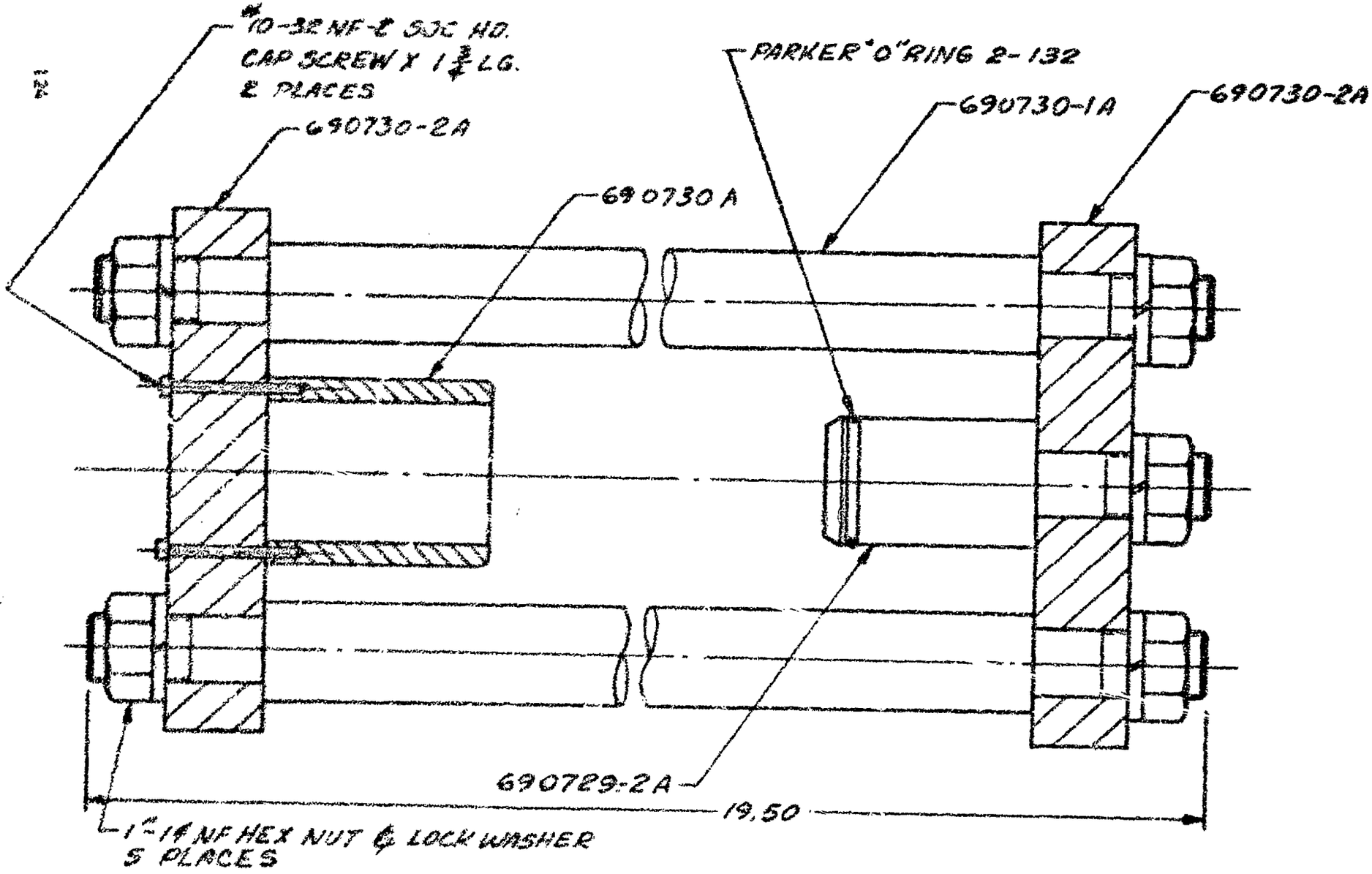
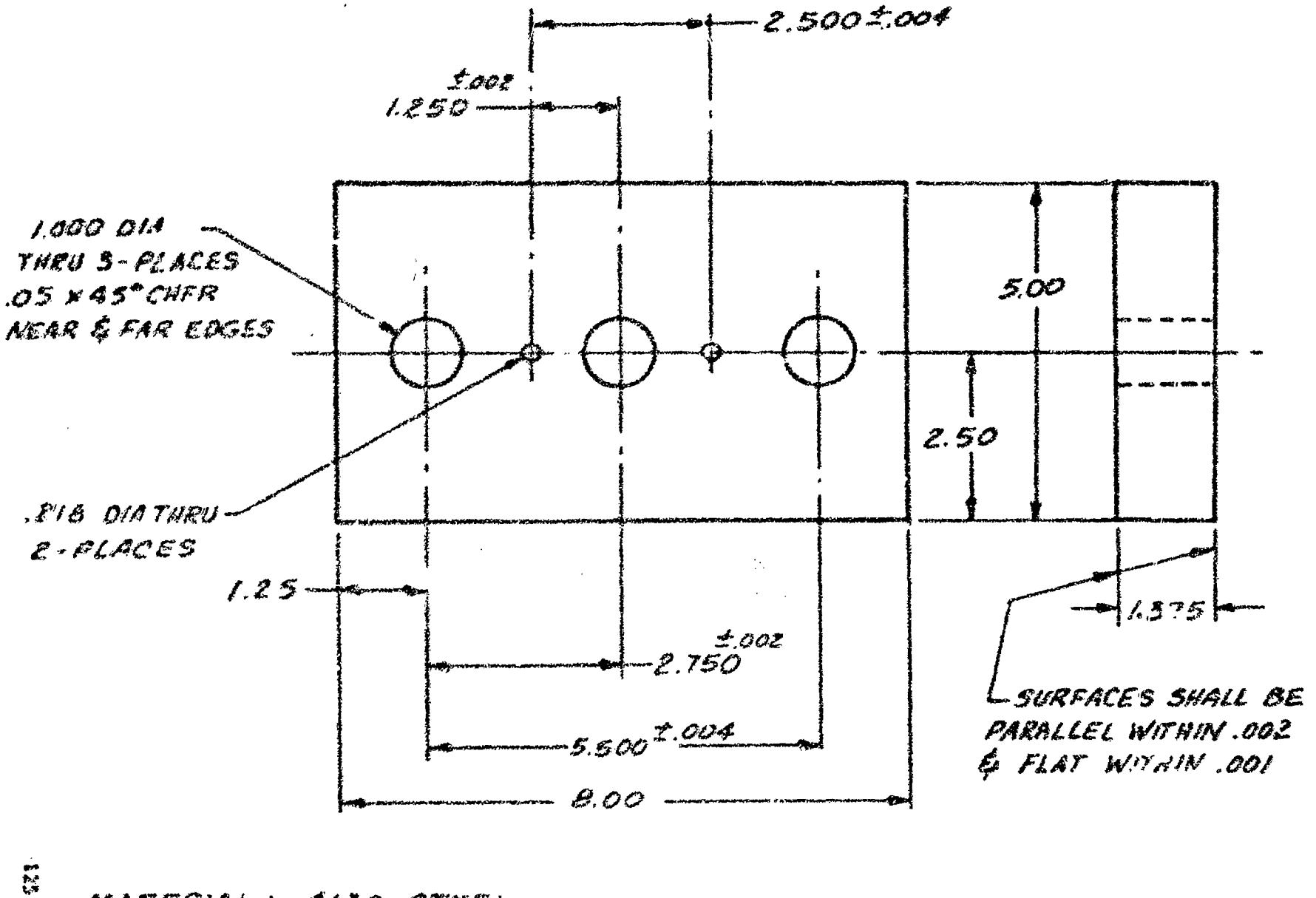

.035 BUNAS
METAL SCREEN
1" DIA.
.035 BUNAS
5.45
3½
1½
BOND WITH
TUBE CEMENT
3½
1½D
5/8-18 CAP S.F., 1" LG.
MODIFIED
.1
.150
.1
.2
5/16 DRILL
C.S.
SLOT .062W X .150DP.
AN 6227 B19
PISTON MODIFIED
WITH 5/8-18 TAP
1⅛ DP.

Figure 2



HYDROTEST FIXTURE ASSEMBLY

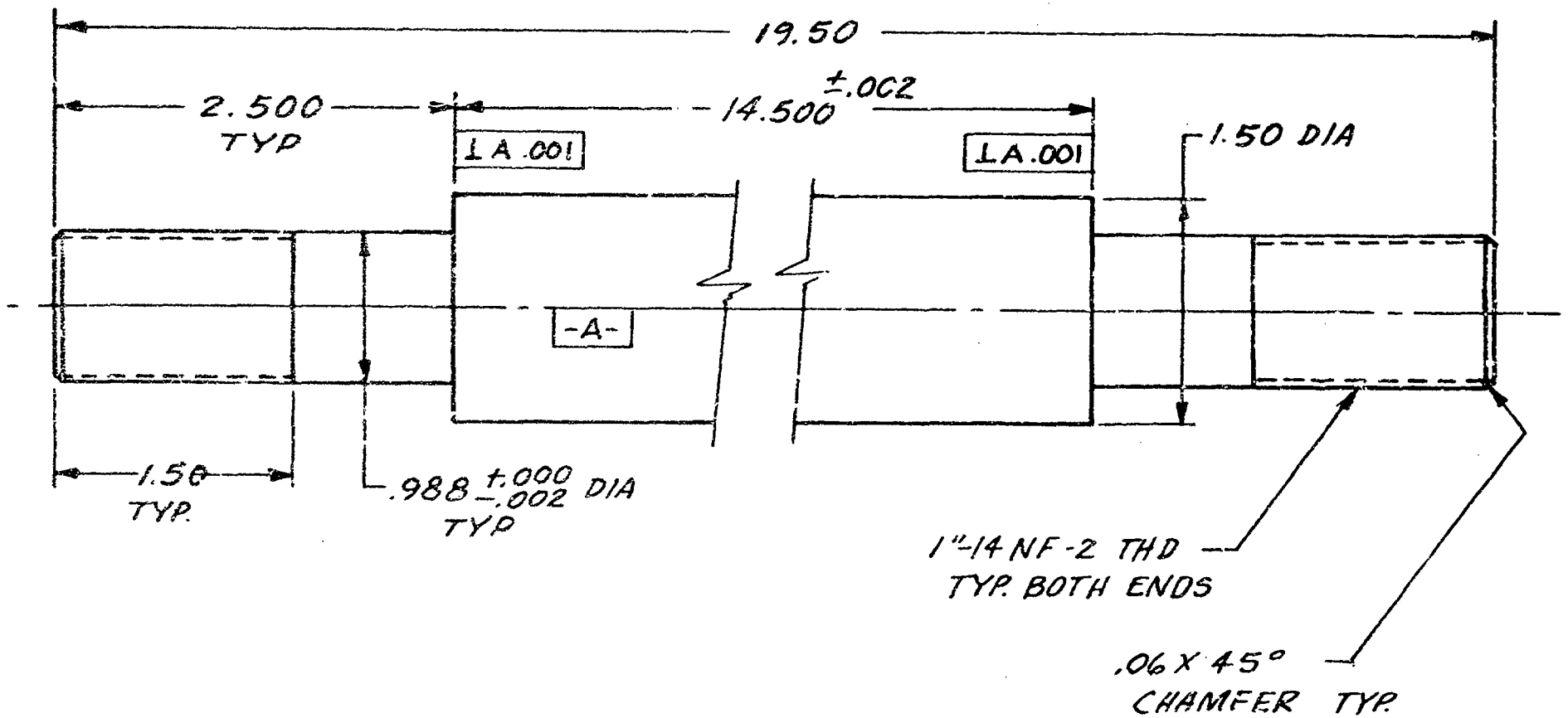


MATERIAL : 4130 STEEL

PLATES TO BE MATCH BORED

BEARING PLATE
2-REQ'D

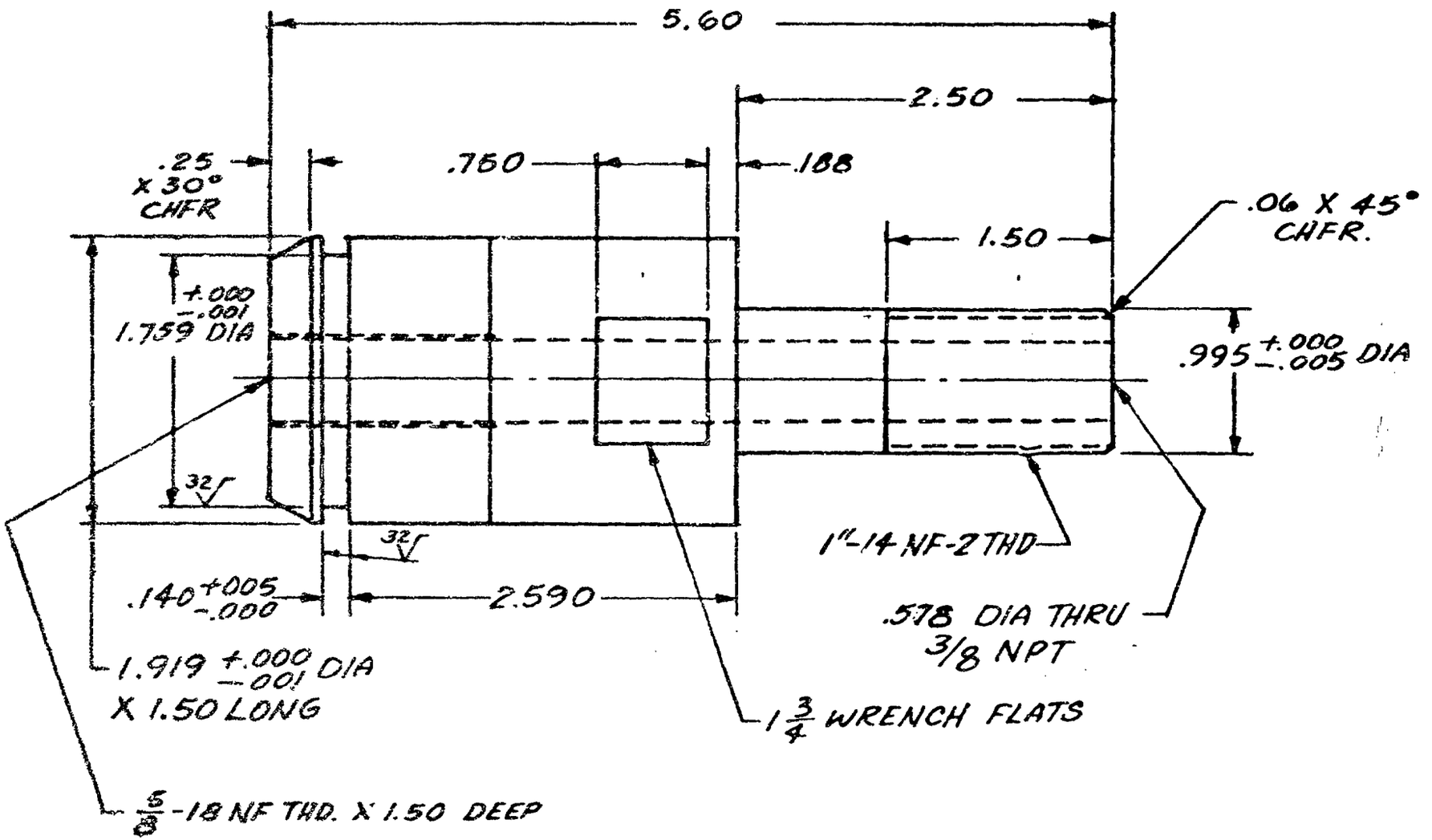
690730-2 A



MATERIAL : 4130 STEEL

ALL DIAMETERS TO BE CONCENTRIC WITHIN .002 TIR

TENSION ROD
2-REQ'D

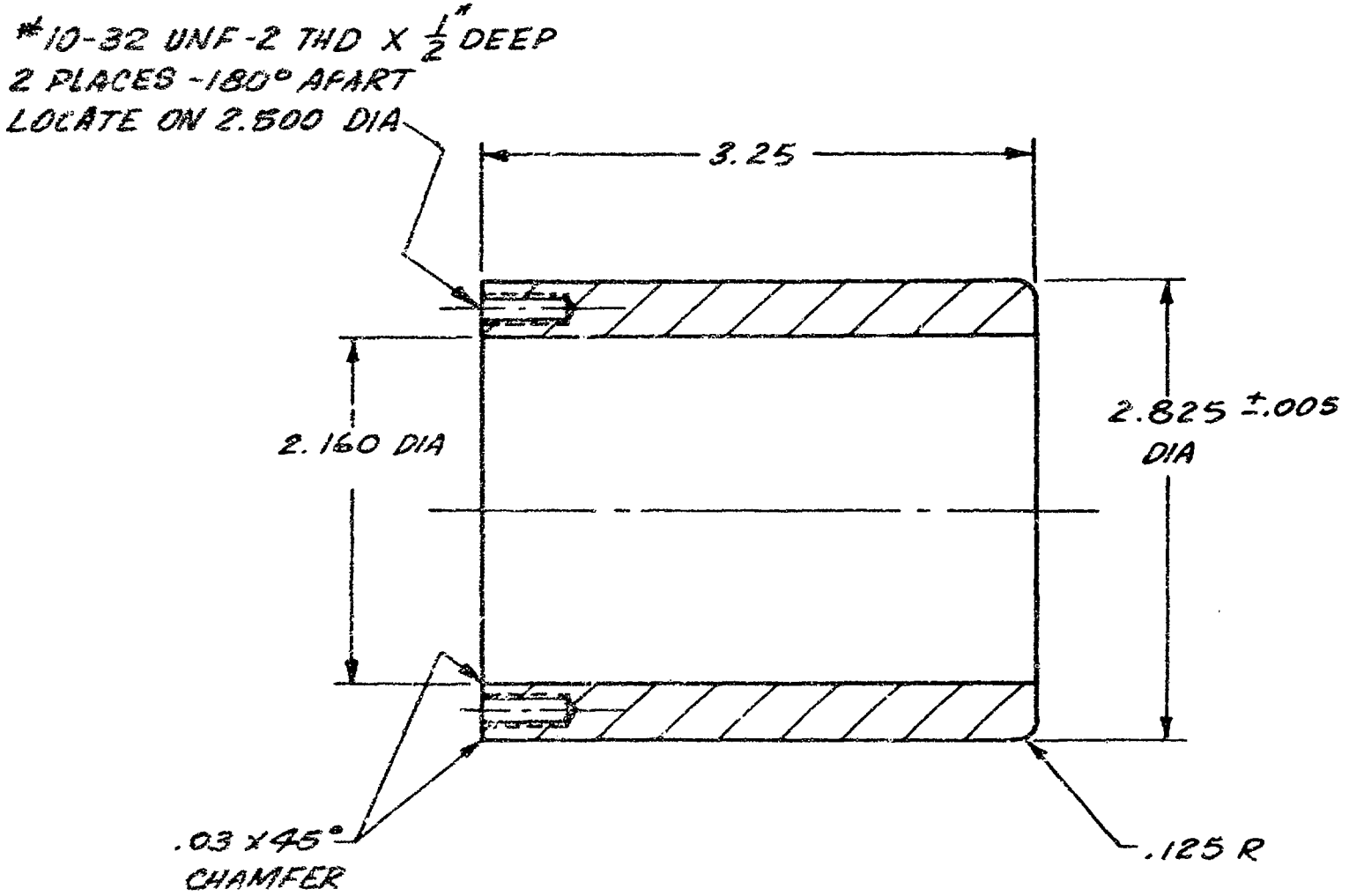


MATERIAL : 4130 STEEL

ALL DIAMETERS TO BE CONCENTRIC WITHIN .002 TIR.

AFT PISTON ROD
1-REQ'D

690729-2 A

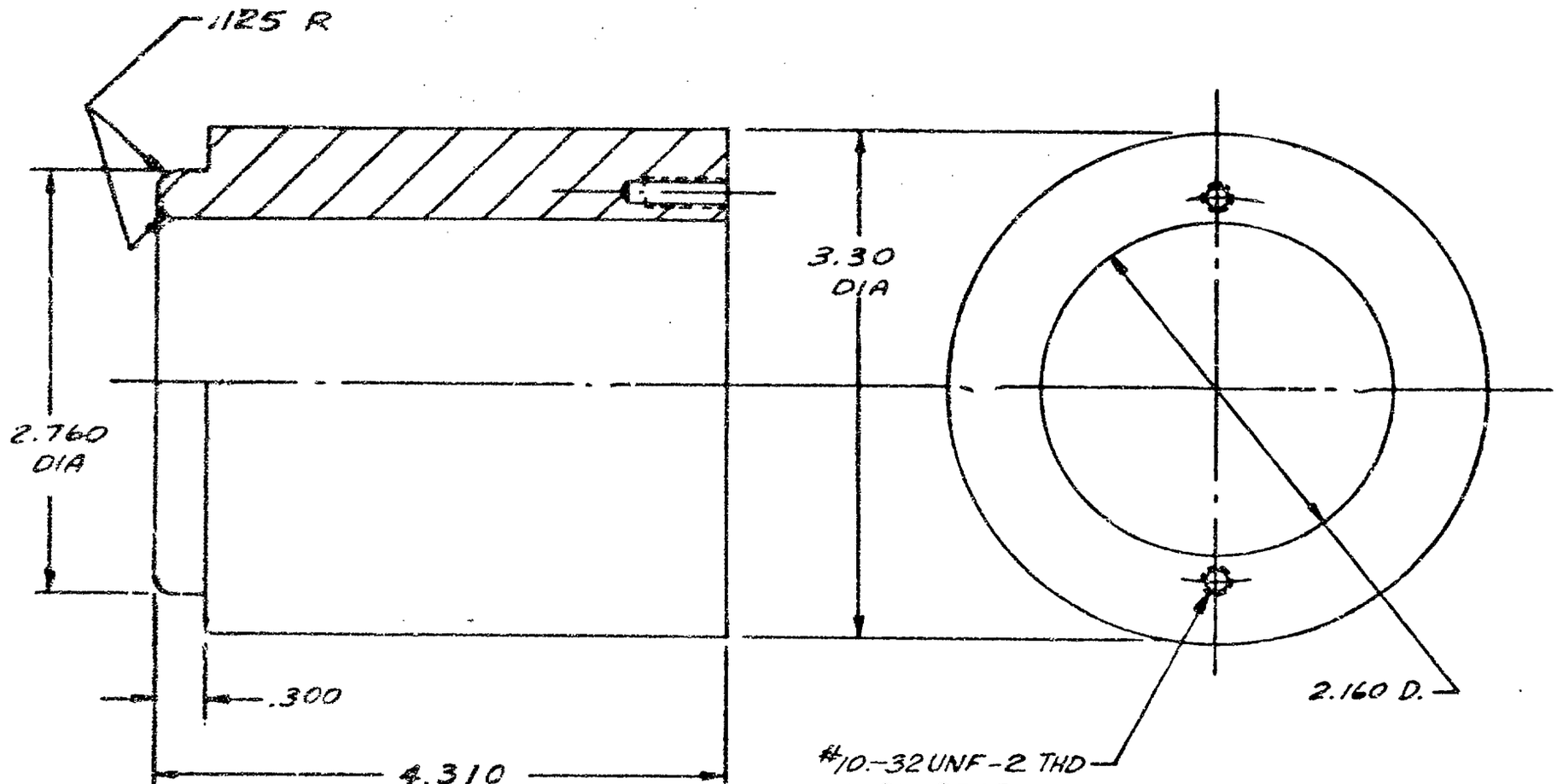


MATERIAL: ALUMINUM

ALL DIAMETERS TO BE CONCENTRIC WITHIN .002 TIR

SKIRT SUPPORT
1-REQ'D

690730 A



MATERIAL : ALUMINUM

ALL DIAMETERS TO BE CONCENTRIC WITHIN .002 TIR.

PRD SKIRT SUPPORT

1/1 SCALE 720720

APPENDIX A-7

FIBERGLASS CASE-IN-CASE MANUFACTURING AND INSPECTION RECORDS

C402.034 K.DALE

No 1, 2

Manufacturing & Inspection Record

3.0 Dia. x 14.04 lg. Motor Case

Inner Shell Fabrication

Dwg. 720531-1

	Operator No.
1. Winding Preparation	
Machine set up installed. Level wind set to .083 lead.	786
Shaft extension T. I. R. .014.	786
Mandrel cleaned properly.	
Pole pieces and O-rings installed properly.	786
Roving (S904, 12-end) installed. Lot No. 2053.	786
Roving tension: 1. 2.0 2. 2.0 3. 1¾.	786
2. Winding	
Resin mixed correctly:	

	Ingredient	Weight, gms.	Lot No.
Resin	2256	500	AAC 17
Catalyst	Tonox 60/40	145	AAC 7

Sequence check off:

X	X	X	X	O	O
✓	✓	✓	✓	✓	✓

Excess resin removed without distorting dome area. 786

3. B-Stage and Cure

B-Stage: Time Started 0330 Time Complete 0700

Date 2/10/72 3924

Cure: Time Started 0900 at 285 °F.

Time Complete 0100 at 300 °F.

Date 2-11-72 293

4. Machining and Stripping — Operator No.

Parameter	Actuals			
Units Identified	S/N .001		S/N .002	
Dimensions Measured	Max.	Min.	Max.	Min.
2.834 Dia. Nom.	2.850	2.842	2.848	2.842
2.828 + .002 - .002 Dia.	2.838	2.828	2.829	2.828
2.734 + .004 - .000 Dia.	2.735	2.734	2.735	2.734
.060 ± .010	.060	.060	.060	.060
.260 ± .010	.260	.260	.258	2.58
6.85 ± .03	6.853	6.852	2.860	2.859
2.806 + .000 - .002 Dia.	2.806	2.805	2.805	2.804

64

5. Finishing and Packing

Coating mixed correctly:

	Ingredient	Weight, gms.	Lot No.
Adhesive			
Catalyst	A	Epon 7-16-72	
Thinner			

Cure: Time Started NA at ____ °F.

Time Completed NA at ____ °F.

Date NA

Final Weight (gms.) (Assembled)

S/N 1 wt. 407.6 S/N 2 wt. 441.5

3970

3978

5. Finishing and Packing (cont.)

Clean up work performed satisfactorily. 3914

Supervisor Review A.A. Bacelli Date 2-17-72

Engineer Review F.B. Rivera Date 7-18-72

C402.088

Manufacturing & Inspection Record

3.0 Dia. x 14.04 lg. Motor Case

Inner Shell Fabrication

Dwg. 720531-1

Operator No.

1. Winding Preparation

Machine set up installed. Level wind set to .083 lead. 149

Shaft extension T. I. R. .012. 1897

Mandrel cleaned properly.

Pole pieces and O-rings installed properly. 1897

Roving (S904, 12-end) installed. Lot No. 2053. 832

Roving tension: 1. 2½ 2. 2 3. 2½. 832

2. Winding

Resin mixed correctly:

	Ingredient	Weight, grs.	Lot No.
Resin	2256	100	ABC-21
Catalyst	~~DNSA 6%~~ 20	29	ABC-6

Sequence check off:

X	X	X	X	O	

Excess resin removed without distorting dome area. 832

3. B-Stage and Cure

B-Stage: Time Started 1730 Time Complete 2045

Date 8-22-72 776

Cure: Time Started 2045 at 300 °F.

Time Complete 2330 at 300 °F.

Date 8-22-72 880

4. Machining and Stripping

Operator No. 1147

Parameter	Actuals			
Units Identified	S/N 003		S/N 004	
Dimensions Measured	Max.	Min.	Max.	Min.
2.834 Dia. Nom.	Tm		Tm	
2.828 + .002 - .002 Dia.	2.830	2.829	2.830	2.829
2.734 + .004 - .000 Dia.	2.736		2.7365	
.060 ± .010	.055		.060	
.260 ± .010	.256		.260	
6.85 ± .03	6.855		6.852	
2.806 + .000 - .002 Dia.	2.804		2.805	

5. Finishing and Packing

Coating mixed correctly:

	Ingredient	Weight, gms.	Lot No.
Adhesive			
Catalyst			
Thinner			

Cure. Time Started _____ at _____ °F.

Time Completed _____ at _____ °F.

Date _____

Final Weight (gms.)

S/N _____ S/N _____

Wt. _____ Wt. _____

5. Finishing and Packing (cont.)

Clean up work performed satisfactorily. _____

Supervisor Review _____ _____ Date _____

Engineer Review _____ Date _____

C402.178

Sh. 5, 6

Manufacturing & Inspection Record

3.0 Dia. x 14.04 Lg. Motor Case

Inner Shell Fabrication

Dwg. 720531-1

Operator No.

1. **Winding Preparation**

Machine set up installed. Level wind set to .083 lead. 1894

Shaft extension T. I. R. .020. 1894

Mandrel cleaned properly.

Pole pieces and O-rings installed properly. 1894

Roving (S904, 12-end) installed. Lot No. 9L4. 1894

Roving tension: 1. 1.5 2. 1.5 3. 2. 1894

2. **Winding**

Resin mixed correctly:

	Ingredient	Weight, lbs.	Lot No.
Resin	2256	100	9DL21
Catalyst	Tonox	2.9	HRL7

Sequence check off:

X	X	X	X	X	X	O
✓	✓	✓	✓	✓	✓	✓

Excess resin removed without distorting dome area. 1894

3. **B-Stage and Cure**

B-Stage: Time Started 2130 Time Complete 0300

Date 9/30/72 832

Cure: Time Started 1130 -- 325 °F.

Time Complete 1430 -- 350 °F.

Date 9/30/72 745

4. Machining and Stripping

Operator No.

Parameter	Actuals			
Units Identified	S/N 005		S/N 006	
Dimensions Measured	Max.	Min.	Max.	Min.
2.828 + .002 - .002 Dia.	2.829	2.828	2.8275	2.728
2.734 + .004 - .000 Dia.	2.735	2.7344	2.7355	2.7348
.060 ± .010	.065		.060	
.260 ± .010	.255		.266	
6.85 ± .03	6.853		6.854	
2.806 + .000 - .002 Dia.	2.804		2.806	

1147

5. Finishing and Packing

Coating mixed correctly:

	Ingredient	Weight, gms.	Lot No.
Adhesive			
Catalyst			
Thinner			

3924

Cure: Time Started ________ at ________ °F.

Time Completed ________ at ________ °F.

Date ________

3924

Final Weight (gms.)

S/N 0005 S/N 0006 4210

wt. 123 grams wt. 122 grams 4210

5. Finishing and Packing (cont.)

Clean up work performed satisfactorily. 3924

Supervisor Review O O Bowcutt Date 10-2-72

Engineer Review F.G. Pinion Date 10-3-72

Manufacturing & Inspection Record

3.0 Dia. x 14.04 Lg. Motor Case

Inner Shell Fabrication

Dwg. 720531-1

Operator No.

1. Winding Preparation

Machine set up installed. Level wind set to .083 lead. 149

Shaft extension T. I. R. .015. 1854

Mandrel cleaned properly.

Pole pieces and O-rings installed properly. 1854

Roving (S904, 12-end) installed. Lot No. AB21 4. 1854

Roving tension: 1. 1.5 2. 1.5 3. 2. 1854

2. Winding

Resin mixed correctly:

	Ingredient	Weight, grs.	Lot No.
Resin	2256	100	AB21
Catalyst	29	29	AB17

Sequence check off:

X	X	X	X	X	X	O
X	✓	✓	✓	✓	✓	✓

Excess resin removed without distorting dome area. 1854

3. B-Stage and Cure

B-Stage: Time Started 1530 Time Complete 2000

Date 10-13-72 1854

Cure: Time Started 2000 -- 300 Temp.

Time Stopped 2300 -- 300 Temp.

Date 10-13-72 1854

4. Machining and Stripping

Operator No. 1147

Parameter	Actuals			
Units Identified	S/N 007		S/N 008	
Dimensions Measured	Max.	Min.	Max.	Min.
2.828 + .002 - .002 Dia.	2.829	2.829	2.829	2.828
2.734 + .004 - .000 Dia.	2.7345	2.7335	2.7355	2.735
.060 ± .010	.065		.068	
.260 ± .010	.267		.265	
6.85 ± .03	6.855		6.850	
2.806 + .000 - .002 Dia.	2.805		2.8048	

5. Finishing and Packing

Coating mixed correctly:

	Ingredient	Weight, gms.	Lot No.
Adhesive			
Catalyst			
Thinner			

Cure: Time Started _____ at _____ °F.

Time Completed _____ at _____ °F.

Date _____

Final Weight (gms.)

S/N _____ S/N _____

wt. _____ wt. _____

5. Finishing and Packing (cont.)

Clean up work performed satisfactorily. _____

Supervisor Review _____ Date _____

Engineer Review T. A. Rivers Date 10-17-72

S/N 9, 10

Manufacturing & Inspection Record

3.0 Dia. x 14.04 lg. Motor Case

Inner Shell Fabrication

Dwg. 720531-1

	Operator No.
1. Winding Preparation	
Machine set up installed. Level wind set to .083 lead.	455
Shaft extension T. I. R. .015.	455
Mandrel cleaned properly.	
Pole pieces and O-rings installed properly.	786
Roving (S904, 12-end) installed. Lot No. ABL 4.	786
Roving tension: 1. 2# 2. 2# 3. 2#.	786
2. Winding	
Resin mixed correctly:	

	Ingredient	Weight, gms.	Lot No.
Resin	2256	500	ABL 24
Catalyst	TONOX	145	ABL 7

Sequence check off:

X	X	X	X	X	X	O
✓	✓	✓	✓	✓	✓	✓

Excess resin removed without distorting dome area. 786

3. B-Stage and Cure

B-Stage: Time Started 0515 11-22-72 Time Complete 0715

Date 11-22-72 786

Cure: Time Started 0730 — 285 °F.

Time to plus: 1030 — 300 °F.

Date 11-22-72 880

4. Machining and Stripping

Operator No.

Parameter	Actuals			
Units Identified	S/N 009		S/N 010	
Dimensions Measured	Max.	Min.	Max.	Min.
2.828 + .002 - .002 Dia.	2.829	2.8285	2.829	2.828
2.734 + .004 - .000 Dia.	2.736 ~~2.735~~	2.735 ~~2.734~~	2.736	2.735
.060 ± .010	.065		.058	
.260 ± .010	.255		.264	
6.85 ± .03	6.852		6.853	
2.806 + .000 - .002 Dia.	2.804		2.805	

1147

5. Finishing and Packing

Coating mixed correctly:

	Ingredient	Weight, gms.	Lot No.	
Adhesive	EP 946 A	60 gms	PO# 55	
Catalyst	EP 946 B	7½ gms	PO# 55	
Thinner	Acetone	40 gms	PO# 67	4210

Cure: Time Started 0700 at 140 °F.

Time Completed 1500 at 140 °F.

Date 11-28-72 832

Final Weight (gms.)

S/N 009 S/N 010 4210

wt. 126 gms. wt. 121 gms 4210

5. Finishing and Packing (cont.)

Clean up work performed satisfactorily. 3970

Supervisor Review _____ Date 11/29/72

Engineer Review F. A. Rivera Date 11/29/72

September 27, 1972

Manufacturing & Inspection Record

3.0 Dia. x 14.04 Lg. Motor Case

Inner Shell Fabrication

Dwg. 720531-1

Operator No.

1. Winding Preparation

Machine set up installed. Level wind set to .083 lead. 880

Shaft extension T. I. R. .014. 880

Mandrel cleaned properly.

Pole pieces and O-rings installed properly. 880

Roving (S904, 12-end) installed. Lot No. ABL-4. 880

Roving tension: 1. 2¼ 2. 2¼ 3. 2¼. 880

2. Winding

Resin mixed correctly:

	Ingredient	Weight, gms.	Lot No.
Resin	2256	100	ABL-24
Catalyst	TONOX	29	ABL-8

Sequence check off:

X	X	X	X	X	X	O
✓	✓	✓	✓	✓	✓	✓

Excess resin removed without distorting dome area. 880

3. B-Stage and Cure

B-Stage: Time Started 0600 Time Complete 1600

Date 12-1-72 716

Cure: Time started: 1830 :: 205 °F.

Time complete: 2130 :: 310 °F.

Date 12-1-72 765

4. Machining and Stripping

Operator No.

Parameter	Actuals			
Units Identified	S/N 011		S/N 012	
Dimensions Measured	Max.	Min.	Max.	Min.
2.828 + .002 - .002 Dia.	2.829	2.825	2.830	2.829
2.734 + .004 - .000 Dia.	2.735	2.734	2.7348	2.734
.060 ± .010	.063		.068	
.260 ± .010	.255		.264	
6.85 ± .03	6.854		6.852	
2.806 + .000 - .002 Dia.	2.804		2.805	

1147

5. Finishing and Packing

Coating mixed correctly:

	Ingredient	Weight, gms.	Lot No.	
Adhesive	946 A	50	98L-60	
Catalyst	946 B	25	98L-60	
Thinner	ACETONE	40	98L-69	532

Cure: Time Started 1400 at 140 °F.

Time Completed 2200 at 170 °F.

Date 12-5-72 785

Final Weight (gms.)

S/N I.S. 011 S/N I.S. 012 880

wt. 122 GRAMS wt. 124 GRAMS 880

5. Finishing and Packing (cont.)

Clean up work performed satisfactorily. 3924

Supervisor Review O A Bassett Date 12-6-72

Engineer Review _____ Date _____

September 27, 1972

S/N 13 4

Manufacturing & Inspection Record

3.0 Dia. x 14.04 Lg. Motor Case

Inner Shell Fabrication

Dwg. 720531-1

1. Winding Preparation — Operator No.

Machine set up installed. Level wind set to .083 lead. 149

Shaft extension T. I. R. .020. 184

Mandrel cleaned properly.

Pole pieces and O-rings installed properly. 184

Roving (S904, 12-end) installed. Lot No. ABL4. 184

Roving tension: 1. 1.5 2. 2.5 3. 1.5. 184

2. Winding

Resin mixed correctly:

	Ingredient	Weight, grs.	Lot No.
Resin	2256	500	ABL2
Catalyst	Lonzo	145	ABL7

Sequence check off:

X	X	X	X	X	X	O
✓	✓	✓	✓	✓	✓	✓

Excess resin removed without distorting dome area. 184

3. B-Stage and Cure

B-Stage: Time Started 2230 Time Complete 1630

Date 12-15-72 184

Cure: [illegible] 1645 to 300 F.

[illegible] 2145 to 200 F.

Date 12-5-72 299

4. Machining and Stripping

Operator No.

Parameter	Actuals			
Units Identified	S/N 013		S/N 014	
Dimensions Measured	Max.	Min.	Max.	Min.
2.828 + .002 - .002 Dia.	2.828	2.827	2.827	2.8265
2.734 + .004 - .000 Dia.	2.735	2.734	2.7345	2.734
.060 ± .010	.065		.070	
.260 ± .010	.255		.260	
6.85 ± .03	6.850		6.856	
2.806 + .000 - .002 Dia.	2.8055		2.805	

1147

5. Finishing and Packing

Coating mixed correctly:

	Ingredient	Weight, gms.	Lot No.	
Adhesive	946 A	50	2BL-60	
Catalyst	946 B	7½	2BL-60	
Thinner	ACETONE	40	ABL-78	399

Cure: Time Started 1200 at 140 °F.

Time Completed 0100 12-9-72 at 140 °F.

Date 12-9-72 776

Final Weight (gms.)

S/N 013 S/N 014 395

" 1259 " 1274 329

5. Finishing and Packing (cont.)

Clean up work performed satisfactorily. 955

Supervisor Review R D Brandt Date 12-20-72

Engineer Review F.G. Rivera Date 12-27-72

C402,128
Sept. 27, [illegible]

Manufacturing & Inspection Record

3.0 Dia. x 14.04 Lg. Motor Case

Inner Shell Fabrication

Dwg. 720531-1

	Operator No.
1. Winding Preparation	
Machine set up installed. Level wind set to .083 lead.	149
Shaft extension T. I. R. 018.	2125
Mandrel cleaned properly.	
Pole pieces and O-rings installed properly.	2125
Roving (S904, 12-end) installed. Lot No. 4064.	2125
Roving tension: 1. 2 2. 2.5 3. 3.	2125

2. Winding

Resin mixed correctly:

	Ingredient	Weight, gms.	Lot No.
Resin	2256	100	4064.3Y
Catalyst	Jeffamine T-403	29	4064.2

Sequence check off:

X	X	X	X	X	X	O
✓	✓	✓	✓	✓	✓	✓

Excess resin removed without distorting dome area. 2125

3. B-Stage and Cure

B-Stage: Time Started 0700 Time Complete 1300

Date 12/19/62. 2125

Cure: Time Started 1315 at 300 °F.

Time Complete 1615 at 300 °F.

Date 12/19/62 1514

4. Machining and Stripping — Operator No.

Parameter	Actuals			
Units Identified	S/N 015		S/N 016	
Dimensions Measured	Max.	Min.	Max.	Min.
2.828 + .002 - .002 Dia.	2.827	2.824	2.8265	2.826
2.734 + .004 - .000 Dia.	2.734	2.733	2.735	2.734
.060 ± .010	.065		.060	
.260 ± .010	.261		.265	
6.85 ± .03	6.855		6.853	
2.806 + .000 - .002 Dia.	2.804		2.806	

1147

5. Finishing and Packing

Coating mixed correctly:

	Ingredient	Weight, gms.	Lot No.
Adhesive	[illegible]	50	4/23
Catalyst	[illegible]	7½	4/23
Thinner	Acetone	40	4/28

4/28

Cure: Time Started 0930 at 140 °F.

Time Completed 1230 at 140 °F.

Date 12/[illegible] 235

Final Weight (grs.)

S/N 015 S/N 016 — 227

wt. 118 gr. wt. 118 gr. — 393

5. Finishing and Packing (cont.)

Clean up work performed satisfactorily. 399

Supervisor Review C.A. Bascelli Date 12-20-72

Engineer Review L.A. Rives Date 12-27-72

Sept. 27, 1972

SA-17 18

Manufacturing & Inspection Record

3.0 Dia. x 14.04 lg. Motor Case

Inner Shell Fabrication

Dwg. 720531-1

	Operator No.
1. Winding Preparation	
Machine set up installed. Level wind set to .083 lead.	149
Shaft extension T. I. R. .018".	669
Mandrel cleaned properly.	
Pole pieces and O-rings installed properly.	669
Roving (S904, 12-end) installed. Lot No. ABL-4.	669
Roving tension: 1. 2 2. 2 1/4 3. 2 1/4.	669

2. Winding

Resin mixed correctly:

	Ingredient	Weight, gms.	Lot No.
Resin	2256	100	ABL 24
Catalyst	Tonox 6640	29	ABL 7

Sequence check off:

X	X	X	X	X	X	O
✓	✓	✓	✓	✓	✓	✓

Excess resin removed without distorting dome area. 1894

3. B-Stage and Cure

B-Stage: Time Started 1630 Time Complete 1830

Date 12-21-72 1894

Cure: Time Started 1845 at 300 °F.

Time Complete 2145 at 300 °F.

Date 12-21-72 395

Operator No

4. Machining and Stripping

Parameter	Actuals			
Units Identified	S/N 017		S/N 018	
Dimensions Measured	Max.	Min.	Max.	Min.
2.828 + .002 - .002 Dia.	2.827	2.826	2.829	2.828
2.734 + .004 - .000 Dia.	2.736	2.735	2.7365	2.7355
.060 ± .010	.060		.068	
.260 ± .010	.265		.270	
6.85 ± .03	6.856		6.865	
2.806 + .000 - .002 Dia.	2.806	2.8055	2.8055	

1147

5. Finishing and Packing

Coating mixed correctly:

	Ingredient	Weight, gms.	Lot No.	
Adhesive	946 A	50	ABL55	
Catalyst	946 B	7½	ABL55	
Thinner	ACETONE	40	ABL69	2125

Cure: Time Started 2115 at 140 °F.

Time Completed 0515 at 140 °F.

Date 12/13/72 — 4145 3970

Final Weight (gms.)

S/N LS 017 S/N LS 018 — 4145 3970

wt. 122 gm. wt. 125 gm. — 4145 3970

5. Finishing and Packing (cont.)

Clean up work performed satisfactorily. 3924

Supervisor Review A.F. Bonelli Date 12/28/72

Engineer Review F.A. Rivera Date 1-4-73

C402.130
Sept. 27, 1972

Manufacturing & Inspection Record

3.0 Dia. x 14.04 Lg. Motor Case

Inner Shell Fabrication

Dwg. 720531-1

Operator No.

1. Winding Preparation

Machine set up installed. Level wind set to .083 lead. 669

Shaft extension T. I. R. .024. 669

Mandrel cleaned properly.

Pole pieces and O-rings installed properly. 669

Roving (S904, 12-end) installed. Lot No. ABL-4. 669

Roving tension: 1. 2 2. 2¼ 3. 13/4. 669

2. Winding

Resin mixed correctly:

	Ingredient	Weight, gms.	Lot No.
Resin	2256	100	ABL 24
Catalyst	TONOX 6040	29	ABL 7

Sequence check off:

X	X	X	X	X	X	O
✓	✓	✓	✓	✓	✓	✓

Excess resin removed without distorting dome area. 669

3. B-Stage and Cure

B-Stage: Time Started 0215 Time Complete 0430

Date 12-30-72 669

Cure: Time Started 0500 at 290 °F.

Time Complete 1700 at 300 °F.

Date 12-30-72 669

Sept. 27, 1972

4. Machining and Stripping

Operator No.

Parameter	Actuals			
Units Identified	S/N 019		S/N 020	
Dimensions Measured	Max.	Min.	Max.	Min.
2.828 + .002 - .002 Dia.	2.829	2.828	2.828	2.827
2.734 + .004 - .000 Dia.	2.7365	2.736	2.735	2.734
.060 ± .010	.060		.063	
.260 ± .010	.265		.260	
6.85 ± .03	6.859		6.853	
2.806 + .000 - .002 Dia.	2.805		2.804	

1147

5. Finishing and Packing

Coating mixed correctly:

	Ingredient	Weight, gms.	Lot No.	
Adhesive	[illegible]	[illegible]	[illegible]	
Catalyst	[illegible]	[illegible]	[illegible]	
Thinner	[illegible]	46	[illegible]	75C

Cure: Time Started [illegible] at [illegible] °F.

Time Completed 0830 at 130 °F.

Date 1/3/73 3924

Final Weight (gms.)

S/N [illegible] S/N [illegible] 421C

wt. 123 gms wt. 119 gms 421C

Sept. 27, 1972

5. Finishing and Packing (cont.)

Clean up work performed satisfactorily. 3924

Supervisor Review A A Bonelli Date 1-3-73

Engineer Review F.A. Rivera Date 1-4-73

C 22-131
Sept. 27, 1972
S/N 2[illegible]2

Manufacturing & Inspection Record

3.0 Dia. x 14.04 lg. Motor Case

Inner Shell Fabrication

Dwg. 720531-1

	Operator No.
1. Winding Preparation	
Machine set up installed. Level wind set to .083 lead.	926
Shaft extension T. I. R. .012.	980
Mandrel cleaned properly.	
Pole pieces and O-rings installed properly.	980
Roving (S904, 12-end) installed. Lot No. EBL 4.	1168
Roving tension: 1. 2.65 2. 2.85 3. 2.75.	1168
2. Winding	
Resin mixed correctly:	
Excess resin removed without distorting dome area.	1168
3. B-Stage and Cure	
B-Stage: Time Started 1915 Time Complete 2325 Date 1-2-73	1168
Cure: Time Started 2330 at 200 °F.	
Time Complete 0230 at 200 °F. Date 1-3-73	183

Ingredient		Weight, grs.	Lot No.
Resin	EPL 2256	100	ABL 24
Catalyst	TONOX 6040	29	ABL 7

Sequence check off:

X	X	X	X	X	X	○
✓	✓	✓	✓	✓	✓	✓

Sept. 27, 1972

4. Machining and Stripping

Operator No.

Parameter	Actuals			
Units Identified	S/N 021		S/N 022	
Dimensions Measured	Max.	Min.	Max.	Min.
2.828 + .002 - .002 Dia.	2.829	2.828	2.829	2.828
2.734 + .004 - .000 Dia.	2.7355	2.734	2.735	2.7335
.060 ± .010	.054		.068	
.260 ± .010	.265		.266	
6.85 ± .03	6.843		6.846	
2.806 + .000 - .002 Dia.	2.806		2.806	

1147

5. Finishing and Packing

Coating mixed correctly:

	Ingredient	Weight, gms.	Lot No.
Adhesive	946·A	50	[illegible] 55
Catalyst	946·B	7½	[illegible] 55
Thinner	Acetone	10·	[illegible]

1851

Cure: Time Started 1600 at ~~95~~ 130 °F. [illegible] 1/4/73

Time Completed 2300 at 130 °F.

Date 1-4-73 827

Final Weight (gms.)

S/N 021 S/N 022 827

wt. 124 [illegible] wt. 124 [illegible] 827

5. Finishing and Packing (cont.)

Clean up work performed satisfactorily. 397d

Supervisor Review _____ Date 11/5/73

Engineer Review _____ Date 1-6-73

C402.132
Sept. 27, 1972

Manufacturing & Inspection Record

3.0 Dia. x 14.04 lg. Motor Case

Inner Shell Fabrication

Dwg. 720531-1

	Operator No.
1. Winding Preparation	
Machine set up installed. Level wind set to .083 lead.	3970
Shaft extension T. I. R. .010.	880
Mandrel cleaned properly.	
Pole pieces and O-rings installed properly.	880
Roving (S904, 12-end) installed. Lot No. ABL-4.	880
Roving tension: 1. 2# 2. 2# 3. 2#.	880

2. Winding

Resin mixed correctly:

	Ingredient	Weight, grs.	Lot No.
Resin	2256	500	ABL-24
Catalyst	Jones	145	ABL-7

Sequence check off:

X	X	X	X	X	X	O
✓	✓	✓	✓	✓	✓	✓

Excess resin removed without distorting dome area. 932

3. B-Stage and Cure

B-Stage: Time Started 1600 Time Complete [illegible]

Date 1-4-73 256

Cure: Time Started [illegible] at [illegible] °F.

Time Complete [illegible] at [illegible] °F.

Date 1/5/73 256

Sept. 27, 1972

Operator No.

4. Machining and Stripping

Parameter	Actuals			
Units Identified	S/N 023		S/N 024	
Dimensions Measured	Max.	Min.	Max.	Min.
2.828 + .002 - .002 Dia.	2.828	2.827	2.828	2.826
2.734 + .004 - .000 Dia.	2.736	2.735	2.736	2.7345
.060 ± .010	.065		.063	
.260 ± .010	.265		.260	
6.85 ± .03	6.855		6.852	
2.806 + .000 - .002 Dia.	2.8055		2.8055	

1147

5. Finishing and Packing

Coating mixed correctly:

	Ingredient	Weight, gms.	Lot No.
Adhesive	946 Part A	50	ABL 60
Catalyst	946 Part B	7.5	ABL 60
Thinner	ABL 78 Acetone	40	ABL 78

3970

Cure. Time Started 1400 1/6/73 at 73 °F.

Time Completed 1100 at 73 °F.

Date 1/7/73 3970

Final Weight (gms.)

S/N 023 S/N 024

wt. 628 * wt. 119 gms

023 inner & outer shell bonded together for hydrotest. 628 gms is assembled wt.

5. Finishing and Packing (cont.)

Clean up work performed satisfactorily. 5970

Supervisor Review _____ Date 10/23

Engineer Review _____ Date 1/8/73

Sept. 27, 1972

Sht - 7, 24

Manufacturing & Inspection Record

3.0 Dia. x 14.04 Lg. Motor Case

Inner Shell Fabrication

Dwg. 720531-1

	Operator No.
1. Winding Preparation	
Machine set up installed. Level wind set to .083 lead.	3970
Shaft extension T. I. R. .011	880
Mandrel cleaned properly.	
Pole pieces and O-rings installed properly.	880
Roving (S904, 12-end) installed. Lot No. ABL-4.	880
Roving tension: 1. 2# 2. 2# 3. 2#.	880

2. Winding

Resin mixed correctly:

	Ingredient	Weight, grs.	Lot No.
Resin	2256	500	ABL-2Y
Catalyst	TONOX	145	ABL-8

Sequence check off:

X	X	X	X	X	X	O
✓	✓	✓	✓	✓	✓	✓

Excess resin removed without distorting dome area. 2125

3. B-Stage and Cure

B-Stage: Time Started 1600 Time Complete [illegible] 1-6-73

Date 1-6-73 2125

Cure: Time started 1915 1-6-73 at 300 °F.

Time Complete 2215 at 300 °F.

Date 1-6-73 2125

Operater No

4. Machining and Stripping

Parameter	Actuals			
Units Identified	S/N 025		S/N 02[illegible]	
Dimensions Measured	Max.	Min.	Max.	Min.
2.828 + .002 - .002 Dia.	2.828	2.827	2.829	2.827[illegible]
2.734 + .004 - .000 Dia.	2.735	2.734	2.7355	2.73[illegible]
.060 ± .010	.060		.062	
.260 ± .010	.270		2.265	
6.85 ± .03	6.849		6.856	
2.806 + .000 - .002 Dia.	2.8055		2.806	

1147

5. Finishing and Packing

Coating mixed correctly:

	Ingredient	Weight, gms.	Lot No.
Adhesive	946-A	100	[illegible]
Catalyst	946-B	15	[illegible]
Thinner	Coatanz	80	[illegible]

1894

Cure: Time Started 0200 at 125/140 °F.

Time Completed 1000 at ~~140~~ °F.

Date 1-[illegible]-72

2125

Final Weight (gms.)

S/N 25 S/N 26

wt. 121.60 wt. 121.60

4205

4205

5. Finishing and Packing (cont.)

Clean up work performed satisfactorily. 776

Supervisor Review M Lawrie Date 1/10/72

Engineer Review [illegible] Date 1/10/72

Date
Sept. 27, 1972
W.O. C402.35

Manufacturing & Inspection Record

3.0 Dia. x 14.04 lg. Motor Case

Inner Shell Fabrication

Dwg. 720531-1

Operator No.

1. Winding Preparation

Machine set up installed. Level wind set to .083 lead. 826

Shaft extension T. I. R. .012. 756

Mandrel cleaned properly.

Pole pieces and O-rings installed properly. 756

Roving (S904, 12-end) installed. Lot No. 402 #1. 756

Roving tension: 1. 5" 2. 5" 3. 5". 756

2. Winding

Resin mixed correctly:

	Ingredient	Weight, grs.	Lot No.
Resin	2256	100	402 #1
Catalyst	7044	24	402 3

Sequence check off:

X	X	X	X	X	X	O
✓	✓	✓	✓	✓	✓	✓

Excess resin removed without distorting dome area. 756

3. B-Stage and Cure

B-Stage: Time Started 1000 Time Complete 2200

Date 9-11-72 756

Cure: Time Started 2300 at 250° F.

Time Complete 0245 at 300° F.

Date 9/12/72 0216

Operator No.

4. Machining and Stripping

Parameter	Actuals			
Units Identified	S/N I.S. 027		S/N I.S. 028	
Dimensions Measured	Max.	Min.	Max.	Min.
2.828 + .002 - .002 Dia.	2.829	2.828	2.8285	2.828
2.734 + .004 - .000 Dia.	2.7350	2.735	2.7365	2.7355
.060 ± .010	.062		.060	
.260 ± .010	.255		.264	
6.85 ± .03	6.851		6.850	
2.806 + .000 - .002 Dia.	2.8055		2.8055	

1147

5. Finishing and Packing

Coating mixed correctly:

	Ingredient	Weight, gms.	Lot No.
Adhesive	946A	100	ABL64
Catalyst	946B	15	ABL64
Thinner	Acetone	80	ABL78

785

Cure: Time Started 1800 at 75 °F. 1/4/73

Time Completed 0830 at 75 °F.

Date 1/5/73

4210

Final Weight (gms.)

S/N 027 S/N 028

4310

wt. 119gms wt. 119gms

4210

5. Finishing and Packing (cont.)

Clean up work performed satisfactorily. 45 ID

Supervisor Review A.A. Bassetti Date 1/15/73

Engineer Review F.A. Rivera Date 1-15-73

C402.390
Sept. 27, 1972
S/N 29, 30

Manufacturing & Inspection Record

3.0 Dia. x 14.04 lg. Motor Case

Inner Shell Fabrication

Dwg. 720531-1

Operator No.

1. Winding Preparation

Machine set up installed. Level wind set to .083 lead. 149

Shaft extension T. I. R. .022". 2125

Mandrel cleaned properly.

Pole pieces and O-rings installed properly. 2125

Roving (S904, 12-end) installed. Lot No. ABL4. 2125

Roving tension: 1. 2 2. 1¾ 3. 2. 2125

2. Winding

Resin mixed correctly:

	Ingredient	Weight, grs.	Lot No.
Resin	2256	100	ABL24
Catalyst	Tonox	29	ABL8

Sequence check off:

X	X	X	X	X	X	O
✓	✓	✓	✓	✓	✓	✓

Excess resin removed without distorting dome area. 756

3. B-Stage and Cure

B-Stage: Time Started 1700 Time Complete 730

Date 11/6/73 756

Cure: Time Started 2000 at 295 °F.

Time Complete 2300 at 300 °F.

Date 1-16-73 756

Sept. 27, 1972

4. Machining and Stripping

Operater No

Parameter	Actuals			
Units Identified	S/N 029		S/N 030	
Dimensions Measured	Max.	Min.	Max.	Min.
2.828 + .002 - .002 Dia.	2.830	2.829	2.828	2.826
2.734 + .004 - .000 Dia.	2.735	2.734	2.7355	2.734
.060 ± .010	.065		.067	
.260 ± .010	.260		.268	
6.85 ± .03	6.857		6.859	
2.806 + .000 - .002 Dia.	2.806		2.806	

1147

5. Finishing and Packing

Coating mixed correctly:

	Ingredient	Weight, gms.	Lot No.	
Adhesive	946 A	100	AB 64	
Catalyst	1460	15	AA 60	
Thinner	methyl	80	AB 78	776

Cure: Time Started 1100 at 130 °F.

Time Completed 2145 at 130 °F.

Date 12/6/72 4210

Final Weight (gms.)

S/N TS 029 S/N TS 030 4210

wt. 121 gms wt. 120 gms 4210

5. Finishing and Packing (cont.)

Clean up work performed satisfactorily. 4210

Supervisor Review QA Bassett Date 1/24/73

Engineer Review F.G. Pinna Date 2-2-73

C402.035

S/N 1, 2

Manufacturing & Inspection Record

3.0 Dia. x 14.04 lg. Motor Case

Outer Shell Fabrication

Dwg. 720531-2

	Operator No
1. Winding Preparation	
Machine set up installed. Level wind set to .250 lead.	786
Shaft extension T. I. R. .014.	786
O-rings waxed only.	786
Mandrel cleaned properly.	786
(4) O-rings and mandrel assembled properly.	786
Roving (S904, 12-end) installed. Lot No. 2053.	786
Roving tension: 1. 2.0 2. 2.0 3. 1¾.	786
2. Winding	
Resin mixed correctly:	

	Ingredient	Weight, gms.	Lot No.	
Resin	2256	500	ABL 17	
Catalyst	Tonox 60/40	145	ABL 7	786

Fill place in 0.200 wide area at both ends.	786
Sequence check off:	

X	O	X	O	M	O	O	X	O	L	L	O	D	D	
✓	"	"	"	"	"	"	"	"	"	"	"	"	✓	1494

Level wind reset to .083 lead.	1494

NOTE: L designates Label
D designates Doubler

Operator No.

Throat dia. measurements:

Unit serial No.	S/N 05 001	S/N 05 002	
Before winding	2.128	2.130	
After winding	2.390	2.398	1894
Excess resin removed without distorting winding			1894
Doublers wound correctly at each end			1894

3. B-Stage and Cure

B-Stage: Time Started 1645 Time Completed 2130 776

Date 7-10-72 776

Cure: Time Started 2200 at 285 °F.

Time Completed 0100 at 300 °F.

Date 7-11-72 293

4. Machining and Stripping

Parameter	Actuals			
Unit Identification	S/N 05.001		S/N 05002	
Dimension Measured	Max.	Min.	Max.	Min.
3.150 + .000 - .010 dia.	3.150	3.149	3.149	3.148
3.000 ± .010 dia.	3.020	2.980	3.020	2982
1.922 + .000 - .003 dia.	1.921	1.920	1.920	1.920
2.[illegible] + .005 - .002 dia.	2.835	2.834	2.835	2.834
2.946 ± .010 dia.	2.946	2.945	2.947	2.946

3.020=high at Tangent Body O.D. & Nozzle Angle

64

127

5. **Finishing** — **Operator No.**

Coating mixed correctly:

	Ingredient	Weight, gms.	Lot No.	
Adhesive				
Catalyst	N/A	N/A	Thiokol 7-16-72	
Thinner				

Cure: Time Started N/A at ____ °F.

Time Complete N/A at ____ °F.

Date N.A.

Clean up work performed satisfactorily. 3924

Final Weight (gms.) Assembly

S/N 1 S/N 2 3970

Wt. 447.6 Wt. 441.5 3970

Supervisor Review [signature] Date 7/17/72

Engineer Review [signature] Date 7-20-72

C402.138
S/N: 3,4

Manufacturing & Inspection Record

3.0 Dia. x 14.04 In. Motor Case

Outer Shell Fabrication

Dwg. 720531-2

	Operator No.
1. Winding Preparation	
Machine set up installed. Level wind set to .250 lead.	786
Shaft extension T. I. R. .026.	786
O-rings waxed only.	880
Mandrel cleaned properly.	880
(4) O-rings and mandrel assembled properly.	880
Roving (S904, 12-end) installed. Lot No. 2053.	786
Roving tension: 1. 1 3/4 2. 2 1/4 3. 2 1/2.	786

2. Winding

Resin mixed correctly:

	Ingredient	Weight, gms.	Lot No.	
Resin	2256	100	45[illegible]2	
Catalyst	Tonox	29	406	786

Fill place in 0.200 wide area at both ends.	786

Sequence check off:

X	[illegible]	[illegible]	O	[illegible]	O	C	[illegible]	X	O	C	L	L	[illegible]	C	O	[illegible]	D	
✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	669

Level wind reset to .083 lead.	669

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

Operator

Throat dia. measurements:

Unit serial No.	S/N 05003	S/N 05004	
Before winding	2.134	2.147	
After winding	2.376	2.373	669
Excess resin removed without distorting winding			669
Doublers wound correctly at each end			669

3. B-Stage and Cure

B-Stage: Time Started 0800 Time Completed 1230 1884

Date 9-1-72 1897

Cure: Time Started 1345 at 300 °F.

Time Completed 1645 at 310 °F.

Date 9-1-72 880

4. Machining and Stripping

Parameter	Actuals			
Unit Identification	S/N 003		S/N 004	
Dimension Measured	Max.	Min.	Max.	Min.
3.150 +.000 -.010 dia.	3.147	3.145	3.148	3.146
3.000 ± .010 dia.	3.099	3.004	3.090	3.007
1.922 +.000 -.003 dia.	1.9218		1.9215	
2.834 +.005 -.002 dia.	2.8348		2.8352	
2.946 ± .010 dia.	2.945		2.946	

1147

5. **Finishing** — Operator No. _____

Coating mixed correctly:

	Ingredient	Weight, gms.	Lot No.	
Adhesive	_____	_____	_____	_____
Catalyst	_____	_____	_____	_____
Thinner	_____	_____	_____	_____

Cure: Time Started _____ at _____ °F.

Time Complete _____ at _____ °F.

Date _____ _____

Clean up work performed satisfactorily. _____

Final Weight (gms.)

S/N _____ S/N _____ _____

Wt. _____ Wt. _____ _____

Supervisor Review _____ Date _____

Engineer Review _____ Date _____

C4:2,176

Manufacturing & Inspection Record

3.0 Dia. x 14.04 In. Motor Case

Outer Shell Fabrication

Dwg. 720531-2

1. Winding Preparation — Operator No.

	Operator No.
Machine set up installed. Level wind set to .250 lead.	4168 / 832
Shaft extension T. I. R. 20.	4168 / 832
O-rings waxed only.	4168 / 832
Mandrel cleaned properly.	4168 / 832
(4) O-rings and mandrel assembled properly.	4168 / 832
Roving (S904, 12-end) installed. Lot No. PDL 4.	4168 / 832
Roving tension: 1. 1.5 2. 1.5 3. 2.	4168 / 832

2. Winding

Resin mixed correctly:

	Ingredient	Weight, gms.	Lot No.	Operator No.
Resin	2257	100	ABL21	
Catalyst	ZZ LOX	29	ADL7	4168 / 832

Fill place in 0.200 wide area at both ends. — 4168 / 832

Sequence check off:

X	0	X	0	X	0	C	[illegible]	[illegible]	[illegible]	C	[illegible]	[illegible]	[illegible]	[illegible]	C	[illegible]	[illegible]
✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

Operator No.: 4168 / 832

Level wind reset to .083 lead. — 4168 / 832

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

Operator No.

Throat dia. measurements:

Unit serial No.	S/N 005	S/N 006	
Before winding	2.149	2.140	
After winding	2.392	2.355	832
Excess resin removed without distorting winding			832
Doublers wound correctly at each end			832

3. B-Stage and Cure

B-Stage: Time Started 0800 Time Completed 1100 [illegible]

Date 9-30-72 [illegible]

Cure: Time Started 1130 at 285 °F.

Time Completed 1430 at 300 °F.

Date 9/30/72 786

4. Machining and Stripping

Parameter		Actuals			
Unit Identification		S/N 005		S/N 006	
Dimension Measured		Max.	Min.	Max.	Min.
3.150	+ .000 - .010 dia.	3.147		3.147	
3.000	± .010 dia.	3.074	2.993	3.077	2.991
1.922	+ .000 - .003 dia.	1.9228		1.921	
2.834	+ .005 - .002 dia.	2.8345	2.8335	2.834	2.8335
2.946	± .010 dia.	2.950	2.948	2.953	2.951

1147

5. Finishing

Operator No.

Coating mixed correctly:

Ingredient	Weight gms.	Lot No.	
Adhesive			
Catalyst			
Thinner			

Cure: Time Started _____ at _____ °F.

Time Complete _____ at _____ °F.

Date _____ 3524

Clean up work performed satisfactorily. 3524

Final Weight (gms.)

S/N 005 S/N 006 4410

Wt. 408 gms Wt. 405 gms. 4410

Supervisor Review A. Brandt Date 10/3/72

Engineer Review [illegible] Date 10/4/72

October 13, 1972

CW75

Manufacturing & Inspection Record

3.0 Dia. x 14.04 lg. Motor Case

Outer Shell Fabrication

Dwg. 720531-2

Operator No.

1. Winding Preparation

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

Shaft extension T. I. R. .014. 1891

O-rings waxed only. 1891

Mandrel cleaned properly. 1891

(4) O-rings and mandrel assembled properly. 1891

Roving (S904, 12-end) installed. Lot No. ABL H. 1891

Roving tension: 1. 1.5 2. 2 3. 1.5. 1891

2. Winding

Resin mixed correctly:

	Ingredient	Weight, gms.	Lot No.	
Resin	2256	100	ABL 21	
Catalyst	Tonox	29	MBL 7	1891

Fill place in 0.200 wide area at both ends. 1891

Sequence check off:

X	X	O	X	X	O	C	C	X	X	O	C	O	C	●	L	L	●	D	D
✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		

1891

Level wind reset to .083 lead. 1891

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

Operator No.

Throat dia. measurements:

Unit serial No.	S/N 007	S/N 008
Dia. Before winding Step 6.1.17	2.230	2.235
Dia. After winding	2.380	2.382

1894

Excess resin removed without distorting winding — 2125

Doublers wound correctly at each end — 2125

3. B-Stage and Cure

B-Stage: Time Started 1145 Time Completed 1415 — 2125

Date 10-16-72 — 2125

Cure: Time Started 1500 10/16/72 at 285 °F.

Time Completed 1800 10/16/72 at 298 °F.

Date 10/16/72 — 3970

4. Machining and Stripping

Parameter	Actuals			
Unit Identification	S/N .007		S/N .008	
Dimension Measured	Max.	Min.	Max.	Min.
3.150 + .000 - .010 dia.	3.147		3.150	
3.000 ± .010 dia.	3.124	3.051	3.127	3.052
1.922 + .000 - .003 dia.	1.9207	1.920	1.9232	1.9227
2.834 + .005 - .002 dia.	2.8344	2.834	2.8355	2.835
2.946 ± .010 dia.	2.938	2.937	2.939	2.937

1147

5. Finishing — Operator No.

Coating mixed correctly:

Ingredient	Weight, gms.	Lot No.	
Adhesive			
Catalyst			
Thinner			

Cure: Time Started _____ at _____ °F.

Time Complete _____ at _____ °F.

Date _____ _____

Clean up work performed satisfactorily. _____

Final Weight (gms.)

S/N _____ S/N _____ _____

Wt. _____ Wt. _____ _____

Supervisor Review _____ Date _____

Engineer Review J.G. Rivera Date 10-17-72

October 13, 1972

Manufacturing & Inspection Record

3.0 Dia. x 14.04 In. Motor Case

Outer Shell Fabrication

Dwg. 720531-2

	Operator No.
1. Winding Preperation	
Machine set up installed. Level wind set to .250 lead.	313
Shaft extension T. I. R. .017.	1894
O-rings waxed only.	1894
Mandrel cleaned properly.	1894
(4) O-rings and mandrel assembled properly.	1894
Roving (S904, 12-end) installed. Lot No. ABL 4.	1894
Roving tension: 1. 2 2. 2 3. 2.	1894
2. Winding	
Resin mixed correctly:	

	Ingredient	Weight, grs.	Lot No.	
Resin	2256	500	ABL 2 4	
Catalyst	TONOX	145	ABL 7	1894

Fill place in 0.200 wide area at both ends.	1894
Sequence check off:	

X	X	C	X	X	X	C	X	X	C	C	C	L	L	D	D
✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

	4168
Level wind reset to .083 lead.	4168

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

Operator No

Throat dia. measurements:

Unit serial No.	S/N 05009	S/N 05010	
Dia. Before winding Step 6.1.17	2.190	2.190	
Dia. After winding	2.275	2.375	4168
Excess resin removed without distorting winding			4168
Doublers wound correctly at each end			4168

3. B-Stage and Cure

B-Stage: Time Started 2345 Time Completed 0445 786

Date 11-22-72 786

Cure: Time Started 0730 at 285 °F.

Time Completed 1030 at 300 °F.

Date 11-22-72 860

4. Machining and Stripping

Parameter	Actuals			
Unit Identification	S/N 05009		S/N 05010	
Dimension Measured	Max.	Min.	Max.	Min.
3.150 + .000 - .010 dia.	3.145		3.147	
3.000 ± .010 dia.	3.128	3.060	3.131	3.061
1.922 + .000 - .003 dia.	1.9235	1.923	1.9213	1.922
2.634 + .005 - .002 dia.	2.8333 ~~2.8345~~	2.8338 ~~2.8344~~	2.8348	2.8344
2.946 ± .010 dia.	2.949	2.947	2.951	2.949

5. Finishing

Operator No.

Coating mixed correctly:

	Ingredient	Weight, gms.	Lot No.	4210
Adhesive	EPON 946A	50 gms	ABL-55	4210
Catalyst	EPON 946B	7½ gms	ABL-55	4210
Thinner	ACETONE	40 gms	ABL-67	4210

Cure: Time Started 0700 at 140 °F.

Time Complete 1500 at 140 °F.

Date 11-28-72 832

Clean up work performed satisfactorily. ____

Final Weight (gms.)

S/N 009 S/N 010 4210

Wt. 535.4 Wt. 536 gms 4210

Supervisor Review _____ Date 11/29/72

Engineer Review E.A. Pierce Date 11-29-72

October 13, 1972

Manufacturing & Inspection Record

3.0 Dia. x 14.04 lg. Motor Case

Outer Shell Fabrication

Dwg. 720531-2

	Operator No.
1. Winding Preparation	
Machine set up installed. Level wind set to .250 lead.	
Shaft extension T. I. R. .028.	550
O-rings waxed only.	890
Mandrel cleaned properly.	890
(4) O-rings and mandrel assembled properly.	880
Roving (S904, 12-end) installed. Lot No. ASL-4.	880
Roving tension: 1. 2 ½# 2. 2 ½# 3. 2 ½#.	550

2. Winding

Resin mixed correctly:

	Ingredient	Weight, gms.	Lot No.	
Resin	2256	500	ABC 34	
Catalyst	Tonox 6040	145	ABC 8	2125

Fill place in 0.200 wide area at both ends. 2125

Sequence check off:

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	C	[illegible]	C	[illegible]	L	L	[illegible]	D	D
✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓

2125

Level wind reset to .083 lead. 2125

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

October 13, 1972

Operator No.

Throat dia. measurements:

Unit serial No.	S/N 011	S/N 012	
Dia. Before winding Step 6.1.17	2.223	2.232	
Dia. After winding	2.380	2.377	2125
Excess resin removed without distorting winding			2125
Doublers wound correctly at each end			2125

3. B-Stage and Cure

B-Stage: Time Started 1500 Time Completed 1815 705

Date 12-1-72 756

Cure: Time Started 1830 at 285 °F.

Time Completed 2130 at 310 °F.

Date 12-1-72 956

4. Machining and Stripping

Parameter	Actuals			
Unit Identification	S/N 011		S/N 012	
Dimension Measured	Max.	Min.	Max.	Min.
3.150 + .000 - .010 dia.	3.145		3.145	
3.000 ± .010 dia.	3.123	3.007	3.135	3.016
1.922 + .000 - .003 dia.	1.923	1.9215	1.9205	1.920
2.834 + .005 - .002 dia.	2.8356	2.8345	2.835	2.834
2.946 ± .010 dia.	2.939	2.938	2.937	2.936

1147

October 13, 1972

5. Finishing

Operator No.

Coating mixed correctly:

	Ingredient	Weight, gms.	Lot No.	
Adhesive	946 A	30	[illegible]60	832
Catalyst	946 B	25	[illegible]6[illegible]	832
Thinner	ACETONE	40	ABC 69	832

Cure: Time Started 1400 at 140 °F.

Time Complete 2200 at 140 °F.

Date 12-5-72 786

Clean up work performed satisfactorily. 3924

Final Weight (gms.)

S/N O.S. 011 S/N OS 012 890

Wt. 512 GRAMS Wt. 503 GRAMS 890

Supervisor Review A.P. Stovall Date 12-6-72

Engineer Review _____ Date _____

December 1, 1972

Manufacturing & Inspection Record

3.0 Dia. x 14.04 lg. Motor Case

Outer Shell Fabrication

Dwg. 720531-2

	Operator No.
1. Winding Preperation	
Machine set up installed. Level wind set to .250 lead.	4168
Shaft extension T. I. R. .018 .	4168
O-rings waxed only.	4168
Mandrel cleaned properly.	4168
(4) O-rings and mandrel assembled properly.	4168
Roving (S904, 12-end) installed. Lot No. XJ1411 .	4168
Roving tension: 1. 2.165 2. 2.1/163. 2.165.	4168

2. Winding

Resin mixed correctly:

	Ingredient	Weight, gms.	Lot No.	
Resin	EL2256	100	AKC34	
Catalyst	TONOX 6040	22	AXL7	4168

Fill place in 0.200 wide area at both ends. 4168

Sequence check off:

X	X	O	X	X	C	C	C	X	X	C	C	C	L	L	L	D	D
✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

669

Level wind reset to .083 lead. 669

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

Operator No.

Throat dia. measurements:

Unit serial No.	S/N 05.013	S/N 05.014
Dia. Before winding Step 6.1.17	2.245	2.250
Dia. After winding	2.380	2.383

669

Excess resin removed without distorting winding 669

Doublers wound correctly at each end 669

3. B-Stage and Cure

B-Stage: Time Started 1300 -12-15-72 Time Completed 1830 1894

Date 12-15-72 1894

Cure: Time Started 1545 at 300 °F.

Time Completed 2145 at 300 °F.

Date 12-15-72 399

4. Machining and Stripping

Parameter	Actuals			
Unit Identification	S/N 013		S/N 014	
Dimension Measured	Max.	Min.	Max.	Min.
3.150 + .000 - .010 dia.	3.148		3.150	
3.000 ± .010 dia.	3.117 ~~3.117~~	3.041	3.123	3.043
1.922 + .000 - .003 dia.	1.919	1.9195	1.9215	1.9205
2.834 + .005 - .002 dia.	2.835	2.834	2.8341	2.8335
2.946 ± .010 dia.	2.940		2.939	

1147

5. **Finishing** — Operator No.

Coating mixed correctly:

	Ingredient	Weight, gms.	Lot No.	
Adhesive	FS 44446-M	50	2126-60	399
Catalyst	946-B	7 1/2	1131-60	399
Thinner	ACETONE	40	1181-78	399

Cure: Time Started 1700 at 140 °F.

Time Complete 0100 at 140 °F.

Date 12-19-72 776

Clean up work performed satisfactorily. 355

Final Weight (gms.)

S/N C.S. 013 S/N CS 014 399

Wt. 496 GRAMS Wt. 505 GRAMS 399

Supervisor Review [signature] Date 12-20-72

Engineer Review F.A. Rivera Date 12-27-72

C402.286

December 1, 1972

S/N 5, 16

Manufacturing & Inspection Record

3.0 Dia. x 14.04 lg. Motor Case

Outer Shell Fabrication

Dwg. 720531-2

Operator No.

1. Winding Preparation

Machine set up installed. Level wind set to .250 lead. 826

Shaft extension T. I. R. .018. 1894

O-rings waxed only. 1894

Mandrel cleaned properly. 1894

(4) O-rings and mandrel assembled properly. 1894

Roving (S904, 12-end) installed. Lot No. M3L 4. 1894

Roving tension: 1. 2 2. 2.5 3. 3. 1894

2. Winding

Resin mixed correctly:

	Ingredient	Weight, grs.	Lot No.	
Resin	826	500	M3L24	
Catalyst	Tonox	25	5312	1894

Fill place in 0.700 wide areas at both ends. 1894

Sequence check off:

X	X	O	X	X	O	C	O	X	X	O	C	O	C	O	L	L	O	D	D
✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

1894

Level wind reset to .083 lead.

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

Operator No.

Throat dia. measurements:

Unit serial No.	S/N 05 015	S/N 05 016	
Dia. Before winding Step 6.1.17	2.243	2 241	
Dia. After winding	2.276	2 378	1894
Excess resin removed without distorting winding			2125
Doublers wound correctly at each end			2125

3. B-Stage and Cure

B-Stage: Time Started 0100 Time Completed 0345 2125

Date 12/19/72 2125

Cure: Time Started 1315 at 300 °F.

Time Completed 1615 at 300 °F.

Date 12/19/72 3914

4. Machining and Stripping

Parameter	Actuals			
Unit Identification	S/N 015		S/N 016	
Dimension Measured	Max.	Min.	Max.	Min.
3.150 + .000 - .010 dia.	3.148		3.149	
3.000 ± .010 dia.	3.130	3.043	3.123	3.042
1.922 + .000 - .003 dia.	1.9205	1.9195	1.922	1.9215
2.834 + .005 - .002 dia.	2.8355	2.835	2.835	2.8345
2.946 ± .010 dia.	2.937	2.936	2.936	2.935

1147

December 1, 1972

5. **Finishing** — Operator No.

Coating mixed correctly:

	Ingredient	Weight, gms.	Lot No.	
Adhesive	EPON-946 PART A	50	ARL-60	4128
Catelyst	EPON-946 PART B	7½	ARL-60	4128
Thinner	ACETONE	40	ARL-28	4128

Cure: Time Started 0930 at 140 °F.

Time Complete 1230 at 140 °F.

Date 12-20-72 — 355

Clean up work performed satisfactorily. — 355

Final Weight (gms.)

S/N 015 S/N 016 — 355

Wt. 500 gr Wt. 500 gr — 355

Supervisor Review A.F. Bissell Date 12-20-72

Engineer Review F.G. Rivera Date 12-27-72

C402.287
December 1, 1972

Manufacturing & Inspection Record

3.0 Dia. x 14.04 lg. Motor Case

Outer Shell Fabrication

Dwg. 720531-2

	Operator No.
1. Winding Preparation	
Machine set up installed. Level wind set to .250 lead.	669
Shaft extension T. I. R. .026.	669
O-rings waxed only.	669
Mandrel cleaned properly.	669
(4) O-rings and mandrel assembled properly.	669
Roving (S904, 12-end) installed. Lot No. ABL-4.	669
Roving tension: 1. 2 2. 2¼ 3. 2¼.	669

2. Winding

Resin mixed correctly:

	Ingredient	Weight, gms.	Lot No.	
Resin	2255	100	ABL-24	
Catalyst	MNA 6640	29	ABL-7	669

Fill place in 0.200 wide area at both ends. 669

Sequence check off:

X	X	C	X	X	C	C	X	X	C	C	C	L	L	D	D
✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

Level wind reset to .083 lead. 1894

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

Operator No.

Throat dia. measurements:

Unit serial No.	S/N 017	S/N 018
Dia. Before winding Step 6.1.17	2.237	2.234
Dia. After winding	2.381	2.376

1894

Excess resin removed without distorting winding 1894

Doublers wound correctly at each end 1897

3. B-Stage and Cure

B-Stage: Time Started 2100 Time Completed 0030 827

Date 12-21-72 827

Cure: Time Started 0045 at 300 °F.

Time Completed 0345 at 300 °F.

Date 12-21-72 4223

4. Machining and Stripping

Parameter	Actuals			
Unit Identification	S/N 017		S/N 018	
Dimension Measured	Max.	Min.	Max.	Min.
3.150 + .000 - .010 dia.	3.1475		3.146	
3.000 ± .010 dia.	3.131	3.053	3.133	3.051
1.922 + .000 - .003 dia.	1.923	1.922	1.921	1.920
2.834 + .005 - .002 dia.	2.835	2.835	2.835	2.834
2.946 ± .010 dia.	2.939	2.936	2.935	2.936

1147

December 1, 1972

5. **Finishing** Operator No.

Coating mixed correctly:

	Ingredient	Weight, gms.	Lot No.	
Adhesive	946 A	50 GRAMS	ABL-60	399
Catalyst	946 B	7½ GRAMS	ABL-[illegible]	399
Thinner	ACETONE	40 GRAMS	ABL-78	399

Cure: Time Started 1230 at 75 °F. 21 Dec 72

Time Complete 0930 at 75 °F.

Date 26 Dec 72 4210

Clean up work performed satisfactorily. 4210

Final Weight (gms.)

S/N OS 017 S/N OS 019 4210

Wt. 512 gms Wt. 510 gms 4210

Supervisor Review [signature] Date 12-27-72

Engineer Review F.A. Rivers Date 1-4-73

December 1, 1972

S/N 19, 20

Manufacturing & Inspection Record

3.0 Dia. x 14.04 lg. Motor Case

Outer Shell Fabrication

Dwg. 720331-2

	Operator No.
1. Winding Preparation	
Machine set up installed. Level wind set to .250 lead.	
Shaft extension T. I. R. .023.	880
O-rings waxed only.	880
Mandrel cleaned properly.	880
(4) O-rings and mandrel assembled properly.	880
Roving (5904, 12-end) installed. Lot No. ABL-4.	880
Roving tension: 1. 2# 2. 2# 3. 2#.	880

2. Winding

Resin mixed correctly:

	Ingredient	Weight, grs.	Lot No.	
Resin	2256	500	ABL-24	
Catalyst	Tonox	145	ABL-7	580

Fill piece in 0.200 wide area at both ends. 880

Sequence check off:

X	X	C	X			C		X	R	C	C	C	L	L		D	D
✓	✓	✓	✓	✓	✓	•	•	•	✓	✓	✓	✓	✓	✓	✓	✓	✓	/	✓

2135

Level wind reset to .083 lead. 2135

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

Operator

Throat dia. measurements:

Unit serial No. S/N 05 019 S/N 05 020

Dia. Before winding Step 6.1.17 2.231 2.247

Dia. After winding ~~2.580~~ 3.260 ~~2.575~~ 3.265 2125

Excess resin removed without distorting winding 2125

Doublers wound correctly at each end 2125

3. B-Stage and Cure

B-Stage: Time Started ~~0700~~ 1800 Time Completed 2230 2125

Date 12/26/72 2120

Cure: Time Started 2145 at 300 °F.

Time Completed 0045 at 300 °F.

Date 12/27/72 4145

4. Machining and Stripping

Parameter	Actuals			
Unit Identification	S/N 019		S/N 020	
Dimension Measured	Max.	Min.	Max.	Min.
3.150 + .000 - .010 dia.	3.148		3.149	
3.000 ± .010 dia.	3.121	3.047	3.120	3.045
1.922 + .000 - .003 dia.	1.9235	1923	1.9215	1.9205
2.834 + .005 - .002 dia.	2.835	2.834	2.836	2.835
2.946 ± .010 dia.	2.941	2.940	2.938	2.937

1147

5. **Finishing** — Operator No.

Coating mixed correctly:

	Ingredient	Weight, gms.	Lot No.	
Adhesive	946 A	50	AB155	2126
Catalyst	946 B	7½	AB155	2126
Thinner	Acetone	40	AB169	2125

Cure: Time Started 2115 at 140 °F.

Time Complete 0515 at 140 °F.

Date 12/30/72 3920

Clean up work performed satisfactorily. 3920

Final Weight (gms.)

S/N 0.5 019 S/N 0 5 020 3920

Wt. 50 grams Wt. 500 grams 3920

Supervisor Review C C Sewell Date 1-3-73

Engineer Review F. A. Burns Date 1-3-73

C402.289
December 1, 1972

Manufacturing & Inspection Record

3.0 Dia. x 14.04 lg. Motor Case

Outer Shell Fabrication

Dwg. 720531-2

Operator No.

1. Winding Preperation

Machine set up installed. Level wind set to .250 lead. 149

Shaft extension T. I. R. .027 ; 832

O-rings waxed only. 399

Mandrel cleaned properly. 395

(4) O-rings and mandrel assembled properly. 395

Roving (S904, 12-end) installed. Lot No. CBL-4. 832

Roving tension: 1. 24 2. 2 3. 24. 832

2. Winding

Resin mixed correctly:

	Ingredient	Weight, gms.	Lot No.	
Resin	2256	100	CBL-24	
Catalyst	~~BDMA~~ NoX 60-40	29	ABL-7	832

Fill place in 0.200 wide area at both ends. 832

Sequence check off:

X	X	O	X	X	O	C	O	X	X	O	C	O	C	O	L	L	O	D	D
X	X	O	X	X	O	C	O	X	X	O	C	O	C	O	L	L	O	D	D

832

Level wind reset to .083 lead. 832

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

Operator No.

Throat dia. measurements:

Unit serial No.	S/N 021	S/N 022	
Dia. Before winding Step 6.1.17	2.232	2.238	
Dia. After winding	2.381	2.377	832
Excess resin removed without distorting winding			832
Doublers wound correctly at each end			832

3. B-Stage and Cure

B-Stage: Time Started 2330 Time Completed 0400 669

Date 12-29-72 669

Cure: Time Started 0500 at 290 °F.

Time Completed 0800 at 300 °F.

Date 12-30-72 669

4. Machining and Stripping

Parameter	Actuals			
Unit Identification	S/N 021		S/N 022	
Dimension Measured	Max.	Min.	Max.	Min.
3.150 + .000 - .010 dia.	3.147		3.145	
3.000 ± .010 dia.	3.120	3.045	3.123	3.044
1.927 + .000 - .003 dia.	1.923	1.922	1.921	1.920
2.815 + .000 - .002 dia.	2.815	2.814	2.816	2.815
2.940 ± .010 dia.	2.941	2.939	2.935	2.936

1147

December 1, 1972

5. Finishing

Operator No.

Coating mixed correctly:

	Ingredient	Weight, gms.	Lot No.	
Adhesive	946-A	50	ABL53	1894
Catalyst	946-B	9½	ABL53	1894
Thinner	Acetone	40	ABL78	1894

Cure: Time Started 1100 at ~~75~~ 130 °F. gm 1/4/73

Time Complete 2200 at 130 °F.

Date 1-4-73 4168

Clean up work performed satisfactorily. 3970

Final Weight (gms.)

S/N 021 S/N 022 8924

Wt. 470 [illegible] Wt. 493 [illegible] 8924

Supervisor Review [signature] - Date 1/5/73

Engineer Review F. A. Rivers Date 1-5-73

C902.270
December 1, 1973
SN 25 24

Manufacturing & Inspection Record

3.0 Dia. x 14.04 lg. Motor Case

Outer Shell Fabrication

Dwg. 720531-2

	Operator No.
1. Winding Preparation	
Machine set up installed. Level wind set to .250 lead.	826
Shaft extension T. I. R. .020 .	832
O-rings waxed only.	832
Mandrel cleaned properly.	832
(4) O-rings and mandrel assembled properly.	832
Roving (S904, 12-end) installed. Lot No. ABL-4.	832
Roving tension: 1. 2¼ 2. 2¼ 3. 2½.	832

2. Winding

Resin mixed correctly:

	Ingredient	Weight, gms.	Lot No.	
Resin	2256	100	ABL-24	
Catalyst	Tonox 60-40	29	ABL-7	832
Fill place in 0.200 wide area at both ends.				832

Sequence check off:

X	X	O	X	X	O	C	O	X	X	O	C	O	C	•	L	L	•	D	D
X	X	O	X	X	O	C	O	X	X	O	C	O	C	•	L	L	•	D	D

832

Level wind reset to .083 lead. 832

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

Operator N

Throat dia. measurements:

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

832

Excess resin removed without distorting winding — 832

Doublers wound correctly at each end — 832

3. B-Stage and Cure

B-Stage: Time Started 2315 Time Completed 2315 — 786

Date 1-4-73 1-5-73 — 786

Cure: Time Started 2300 at 275 °F.

Time Completed 0600 at 300 °F.

Date 1-5-73 — 786

4. Machining and Stripping

Parameter	Actuals			
Unit Identification	S/N 023		S/N 024	
Dimension Measured	Max.	Min.	Max.	Min.
3.150 + .000 - .010 dia.	3.149		3.147	
3.000 ± .010 dia.	3.134	3.044	3.124	3.042
1.922 + .000 - .003 dia.	1.920	1.919	1.9225	1.922
2.834 + .005 - .002 dia.	2.8355	2.835	2.8345	2.834
2.946 ± .010 dia.	2.936	2.935	2.937	2.936

1147

December 1, 1972

5. Finishing Operator No.

Coating mixed correctly:

	Ingredient	Weight, gms.	Lot No.	
Adhesive	946 A	50	ABL 60	3970
Catalyst	946 B	7.5	" "	3970
Thinner	Acetone	40	ABL 70	3970

Cure: Time Started 1350 at 72 °F.

Time Complete 1350 at 72 °F.

Date 1/3/72 3970

Clean up work performed satisfactorily. 3970

Final Weight (gms.)

S/N 023 S/N 024 9212

Wt. 628 gms* Wt. 49.3 gms 9212

Supervisor Review [signature] Date 1/4/73

Engineer Review [signature] Date 1/4/73

023 - Inner & outer shell bonded together
[illegible] Rydetect. 628 is assembled wt.

C402.291
December 1, 1972

Manufacturing & Inspection Record

3.0 Dia. x 14.04 lg. Motor Case

Outer Shell Fabrication

Dwg. 720531-2

	Operator No.
1. Winding Preparation	
Machine set up installed. Level wind set to .250 lead.	3970
Shaft extension T. I. R. .015 :	1894
O-rings waxed only.	1894
Mandrel cleaned properly.	1894
(4) O-rings and mandrel assembled properly.	1894
Roving (S904, 12-end) installed. Lot No. ABK4.	1894
Roving tension: 1. 2 2. 2.5 3. 3.	1894
2. Winding	
Resin mixed correctly:	

	Ingredient	Weight, cms.	Lot No.	
Resin	2256	100	ABK4	
Catalyst	Tonox	29	ABK F	1894

Fill place in 0.200 wide area at both ends.	1894
Sequence check off:	

X	X	O	X	X	J	C	O	X	X	C	C	C	C	L	L	L	D	D
✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	—	—	✓	—	—	✓	—	—

	1894
Level wind reset to .083 lead.	1894

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

Operator No.

Throat dia. measurements:

Unit serial No.	S/N 025	S/N 024
Dia. Before winding Step 6.1.17	2.240	2.243
Dia. After winding	2.374	2.382

1854

Excess resin removed without distorting winding — 4168

Doublers wound correctly at each end — 4168

3. B-Stage and Cure

B-Stage: Time Started 0700 Time Completed 1230 — 4168

Date 1-8-73 — 4168

Cure: Time Started 1225 at 300 °F.

Time Completed 1630 at 300 °F.

Date 1-8-73 — 993

4. Machining and Stripping

Parameter	Actuals			
Unit Identification	S/N 025		S/N 024	
Dimension Measured	Max.	Min.	Max.	Min.
3.150 + .000 - .010 dia.	3.149		3.149	
3.000 ± .010 dia.	3.126	3.049	3.124	3.041
1.922 + .000 - .003 dia.	1.9205	1.9195	1.922	1.921
2.834 + .000 - .002 dia.	2.835	2.834	2.836	2.835
2.946 ± .010 dia.	2.939	2.937	2.940	2.939

1147

December 1, 1972

5. **Finishing** Operator No.

Coating mixed correctly:

	Ingredient	Weight, gms.	Lot No.	
Adhesive	946 PART A	50	ABL64	226
Catalyst	946 PART B	7½	ABL64	226
Thinner	ACETONE	40	ABL78	226

Cure: Time Started 1045 at 140 °F.

Time Complete 1845 at 140 °F.

Date 1-9-73 F-293

Clean up work performed satisfactorily. 3524

Final Weight (gms.)

S/N 25 S/N 26 4505

Wt. 504 Wt. 449 4505

Supervisor Review A.A. Bartlett Date 1-10-73

Engineer Review [signature] Date 1/10/73

December 1, 1972

W.O. C402.355

- 2726

Manufacturing & Inspection Record

3.0 Dia. x 14.04 lg. Motor Case

Outer Shell Fabrication

Dwg. 720531-2

	Operator No.
1. Winding Preparation	
Machine set up installed. Level wind set to .250 lead.	826
Shaft extension T. I. R. .020.	880
O-rings waxed only.	880
Mandrel cleaned properly.	880
(4) O-rings and mandrel assembled properly.	880
Roving (S904, 12-end) installed. Lot No. ABL-4.	880
Roving tension: 1. 2# 2. 2# 3. 2#.	880

2. Winding

Resin mixed correctly:

	Ingredient	Weight, ems.	Lot No.	
Resin	2256	100	ABL-24	
Catalyst	touch cold	29	ABL-8	832

Fill place in 0.200 wide area at both ends. 832

Sequence check off:

X	X	O	X	X	O	C	O	X	X	O	C	O	C	●	L	L	●	D	D
X	X	O	X	X	O	C	O	X	X	O	C	O	C	●	L	L	●	D	D

832

Level wind reset to .083 lead. 832

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

Operator

Throat dia. measurements:

Unit serial No.	S/N O.S.027	S/N O.S.028
Dia. Before winding Step 6.1.17	2.243	2.250
Dia. After winding	2.373	2.379

832

Excess resin removed without distorting winding — 832

Doublers wound correctly at each end — 832

3. B-Stage and Cure

B-Stage: Time Started 1615 Time Completed 1900 — 293

Date 1-11-73 — 293

Cure: Time Started 2300 at 255 °F.

Time Completed 0200 at 300 °F.

Date 1/12/73 — 4210

4. Machining and Stripping

Parameter	Actuals			
Unit Identification	S/N 027		S/N 028	
Dimension Measured	Max.	Min.	Max.	Min.
3.150 +.000 -.010 dia.	3.149		3.149	
3.000 ± .010 dia.	3.142	3.054	3.139	3.053
1.922 +.000 -.003 dia.	1.923	1.921	1.921	1.920
2.834 +.005 -.002 dia.	2.837	2.834	2.837	2.836
2.946 ± .010 dia.	2.943	2.940	2.944	2.943

1147

December 1, 1972

5. Finishing — Operator No.

Coating mixed correctly:

	Ingredient	Weight, gms.	Lot No.	
Adhesive	946 A	100	ABL 64	786
Catalyst	946 B	15	ABL 64	786
Thinner	Acetone	80	ABL 78	786

Cure: Time Started 1900 at 75 °F. 1/12/73

Time Complete 0030 at 75 °F.

Date 1/15/73 42-10

Clean up work performed satisfactorily. 42-10

Final Weight (gms.)

S/N 05 027 S/N 05 029 42-C

Wt. 505 gms. Wt. 502 gms 42-C

Supervisor Review [signature] Date 1/15/73

Engineer Review [signature] Date 1-15-73

C402.391
December 1, 1972
1 29, 30

Manufacturing & Inspection Record

3.0 Dia. x 14.04 In. Motor Case

Outer Shell Fabrication

Dwg. 720531-2

	Operator No.
1. Winding Preparation	
Machine set up installed. Level wind set to .250 lead.	149
Shaft extension T. I. R. .015 .	2125
O-rings waxed only.	2125
Mandrel cleaned properly.	2125
(4) O-rings and mandrel assembled properly.	2125
Roving (S904, 12-end) installed. Lot No. ARL4.	2125
Roving tension: 1. 2 2. 1½ 3. 2 .	2125
2. Winding	
Resin mixed correctly:	

	Ingredient	Weight, cms.	Lot No.	
Resin	2256	100	ARC2V	
Catalyst	Tonox	29	ARC2	2125

Fill place in 0.200 wide area at both ends.	2125
Sequence check off:	

X	X	O	X	X	O	C	O	X	X	C	C	C	●	L	L	●	D	D
✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓			

2125

Level wind reset to .083 lead.	2125

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

Operator No.

Throat dia. measurements:

Unit serial No.	S/N 029	S/N 030	
Dia. Before winding Step 6.1.17	2.241	2.245	
Dia. After winding	2.380	2.383	9125
Excess resin removed without distorting winding			2125
Doublers wound correctly at each end			2125

3. B-Stage and Cure

B-Stage: Time Started 1445 Time Completed 1700 736

Date 1-16-73 736

Cure: Time Started 1700 at 245 °F.

Time Completed 2300 at 300 °F.

Date 1-17-73 756

4. Machining and Stripping

Parameter	Actuals			
Unit Identification	S/N 029		S/N 030	
Dimension Measured	Max.	Min.	Max.	Min.
3.150 + .000 - .010 dia.	3.149		3.145	
3.000 ± .010 dia.	3.000	3.047	3.121	3.045
1.922 + .000 - .003 dia.	1.921	1.920	1.922	1.921
2.834 + .005 - .002 dia.	2.835	2.833	2.836	2.835
2.946 ± .010 dia.	2.946	2.937	2.945	2.939

1147

December 1, 1972

5. **Finishing** — Operator No.

Coating mixed correctly:

	Ingredient	Weight, gms.	Lot No.	
Adhesive	946 A	100	ABL 64	746
Catalyst	946 B	15	ADL 64	746
Thinner	Acetic	80	ABL 78	746

Cure: Time Started 1400 at 130 °F.

Time Complete 2145 at 130 °F.

Date 1/4/73 — 4210

Clean up work performed satisfactorily. — 4210

Final Weight (gms.)

S/N 01 012 — S/N CS 630 — 4210

Wt. 50 gms. — Wt. 108 gms. — 4210

Supervisor Review A.A. Rivet — Date 1/4/73

Engineer Review E.A. Rivet — Date 1-4-73