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Generic Ordnance Ramjet Engine (GORJE)

Fuel Tank, Final Report

T. C. Warren
Chemical Systems Division—United Technologies
for the

Propulsion Development Department

OCTOBER 1976



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FOREWORD

This report describes work conducted during the period July 1974 to January 1976 on the design, analysis, fabrication, testing and delivery of positive expulsion fuel tank assemblies for the generic ordnance ramjet engine (GORJE). This effort was sponsored by the Naval Weapons Center (NWC), China Lake, California, under Navy Contract N00123-74-1357 and supported by the Naval Air Systems Command under AirTask A3303300/008B/4F31334300.

B. Waldon was the Navy Technical Coordinator and has reviewed this report for technical accuracy.

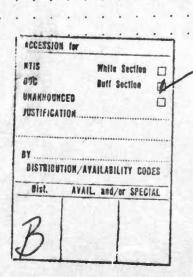
This report is released for information at the working level and does not necessarily reflect the views of NWC.

Released by G. W. LEONARD, Head Propulsion Development Department 1 October 1976 Under authority of G. L. HOLLINGSWORTH Technical Director

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- (U) Generic Ordnance Ramjet Engine (GORJE) Fuel Tank, Final Report, by T. C. Warren, Chemical Systems Division. China Lake, Calif., NWC, October 1976. 210 pp. (NWC TP 5835, publication UNCLASSIFIED.)
- (U) This report discusses the design, analysis, fabrication, testing, and delivery of positive expulsion fuel tank assemblies for the generic ordnance ramjet engine (GORJE). The program was conducted in two phases: Phase I Task I encompassed the design and analysis of a tank assembly satisfying the basic GORJE requirements. This assembly consisted of a 4130 steel tank with a reinforced elastometic positive expulsion bladder that contains the ramjet fuel and collapses around a central collector pipe that houses the fuel delivery gas generator and flow control valve. Phase I Task II involved the fabrication and test of one ground test tank with a spare collector pipe and six expulsion bladders. This ground test tank was delivered to NWC for testing purposes.
- (U) Phase II involved the fabrication, checkout, and delivery of four flight test units to NWC for use in the GORJE flight test program.
- (U) This program was concluded with a detailed manufacturing cost analysis of the tank assembly in quantities up to 2,000 units.

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ACRONYMS

ASTM CRES CSD GTA MPI NASA NASTRAN NWC SS STAGS TDC	American Society for Testing Materials Corrosion resistant steel Chemical Systems Division Gas tungsten arc Magnetic particle inspection National Aeronautics and Space Administration National Aeronautics and Space Administration Structural Analysis Code (computer program) Naval Weapons Center Stainless steel Static Shell Analysis Code (computer program) Top dead center
	NOMENCLATURE
$C_{L_{\alpha}}$ f f f H ℓ_B M q S_{o} S_{x} x x_{m} x_{o} V_{B} σ_A σ_H σ_R	Lift curve slope for forebody (radians) -1 Diameter of body (feet) Force (pounds) Ratio of &E/d Altitude (feet) Length of body (feet) Mach number Maximum dynamic pressure (pounds/square feet) Forebody cross-sectional area at station 0 Forebody cross-sectional area (square feet) Forebody length (feet) Location of moment center (feet) Forebody length at station 0 (feet) Volume of body (cubic inches) Axial stress (psi) Hoop stress (psi) Radial stress (psi)
Subscripts	
su tu ty	Ultimate compression Tensile ultimate Tensile yield

1 INTRODUCTION

This program was conducted to analyze, design, manufacture, test, document, and deliver five Generic Ordnance Ramjet Engine (GORJE) fuel tank assemblies including fuel tank, containment and expulsion device (bladder), and collector pipe assembly.

The program was divided into two phases. Phase I included as concurrent tasks: (1) analysis and design of fuel tank assemblies; and (2) design, manufacture, test, and delivery of one ground test unit. Phase II consisted of manufacture, test, and delivery of four flight test assemblies.

The program began on 10 July 1974 and was completed on 31 December 1975. This report describes the program design activities during that period.

The 47.5-pound ground test unit design described in this report, which was fabricated and delivered under Phase I, Task 2, is identical to the flight test unit design that was fabricated and delivered during Phase II of this program.

This final report covers the design, analysis, and manufacturing of the tanks, testing conditions and results, and the final manufacturing cost analysis.

2 FUEL TANK DESIGN OBJECTIVES

The primary design objective was to design and analyze CORJE fuel tank assemblies which satisfied requirements and constraints specified in the Appendix A data package.

This report contains a design description, a structural analysis, and a manufacturing cost analysis. The complete preferred design description includes engineering drawings, method of manufacture, rationale for the design of all components, materials, weight estimates, fuel volume estimates, and expulsion efficiency estimates.

A detailed structural analysis of the fuel tank was conducted. A detailed manufacturing cost analysis (up to 2,000 units) includes the following cost comparisons used to arrive at the preferred design: (1) bladder cost versus expulsion efficiency (2) tank internal volume versus tank cost and (3) tank weight versus cost. The cost analysis employed design-to-cost information.

GORJE FUEL TANK ASSEMBLY DESIGN DESCRIPTION

TANK ASSEMBLY

The GORJE fuel tank assembly (CSD drawing No. C11225) consists of four major subassemblies: (1) tank pressure case and structure, (2) removable suspension lug assembly, (3) reinforced elastomeric expulsion bladder, and (4) fuel collector pipe.

The same tank assembly design was used for both the ground test unit and the four flight test units. This configuration, excluding bladder and collector pipe, weighs 47.5 pounds compared to a ground test unit maximum allowable weight of 51 pounds and a flightweight design goal of 44 pounds. The proposed methods of reducing the current 47.5-pound tank to the 44-pound flightweight production configuration are discussed in this section.

Figure 3-1 is a complete block diagram for the tank assembly. Assembly and component drawings are presented in Appendix B.

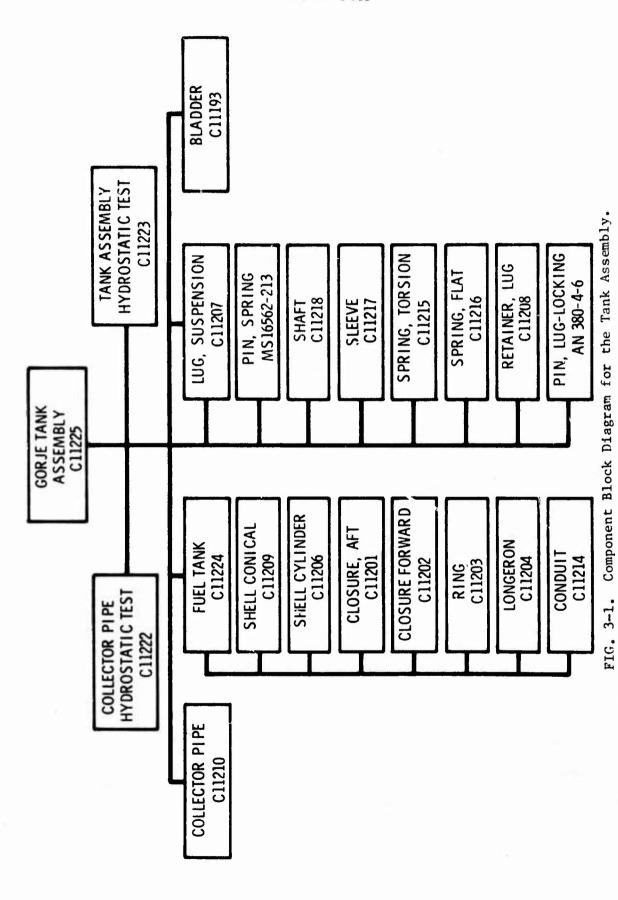
Photographs of the ground test unit tank are shown in Figs. 3-2 through 3-5.

Tank Structure (Design Approach)

Detailed trade studies were conducted which resulted in selection of a baseline design that meets all NWC requirements and constraints specified in the GORJE Fuel Tank Assembly Data Package (Appendix A). The design-to-cost disciplines were implemented by appointing a component cost targeting board which established baseline component cost estimates in coordination with the cost engineering team. These estimates were used during the integrated trade studies of candidate designs.

Two basic design approaches were investigated. The first approach allowed the pressure tank to share the captive flight and ejection loads with the suspension lug attach support structure. The second approach was to separate the fuel tank into two structural elements: (1) a pressure vessel to provide the required volume and support for the bladder, and (2) a suspension lug attach structure to react captive and ejection loads.

The latter approach resulted in a lower weight and lower cost design. Further weight reductions that were investigated are possible at increased costs. The key design features of the fuel tank structure include: (1) low cost 4130 steel components, (2) roll and weld construction, (3) separate structural components for reacting concentrated loads, and (4) removable suspension lug assemblies.



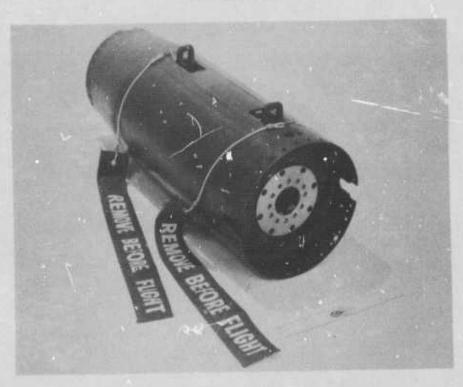


FIG. 3-2. Fuel Tank Assembly with Bladder and Collector Pipe Installed.



FIG. 3-3. Fuel Tank Assembly Showing Forward Closure.

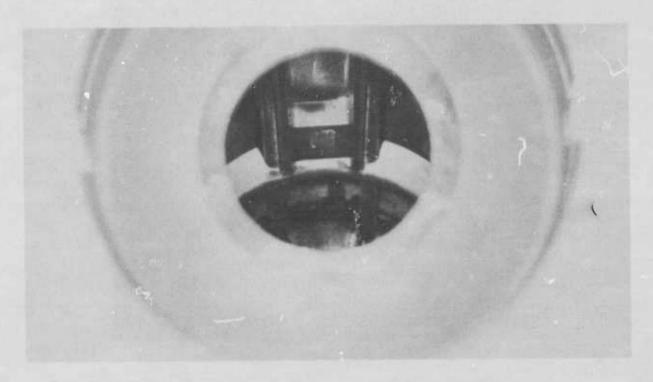


FIG. 3-4. Fuel Tank Showing Internal Sway Brace Ring and Longeron.

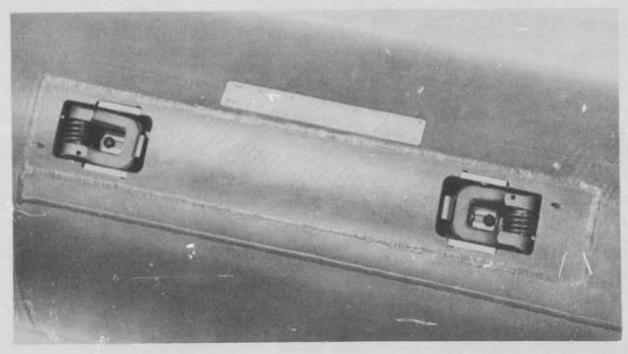


FIG. 3-5. Fuel Tank Assembly Showing Suspension Lugs in Retracted Position.

Design Description

The GORJE fuel tank assembly is shown in Appendix B, Fig. B-1. This configuration meets all requirements shown in Table 3-1.

FUEL TANK CASE

The tank is a five-component weldment consisting of forward and aft closures, two-piece cylindrical center section, and a conical fore-body. The tank case functions to provide the required internal volume and to support the fuel bladder. In addition, both closures have skirt flanges which include provisions for all specified attachments. Two 0.63-inch-diameter raceway tubes penetrate the closures and pass through the tank interior to connect the skirt areas. The forward closure has an internal boss which provides lateral support for the forward end of the collector pipe assembly and contains vent holes through which the expulsion gas is admitted to the space between the tank interior and bladder to initiate bladder collapse. The forward closure also has seven externally mounted bosses which provide attachment for flight instrumentation. The closure also has three ports in the center for the gas generator igniter, pressure relief valve, and instrumentation.

TABLE 3-1. Requirements and Constraints.

Envelope constraints NWC Drawing No. SK45760004
Fuel volume, 1b 75 (minimum)
Weight, 1b 44 (maximum) flight production design
51 (maximum) ground test design
External loads Fig. A-3 of Appendix A
Vibration Fig. A-3 of Appendix A
Factor of safety
All point loads 1.5 on ultimate
1.15 on yield
Pressure, psi
Proof 450
Yield 475
Ultimate 550
Temperature, °F
Storage45 to 140
Flight 550 (internal)

The conical forebody is a 0.062-inch-thick roll and welded frustum of a right circular cone. It provides the necessary transition between the 10-inch-OD forward closure attach skirt and the 12-inch-OD tank cylindrical centerbody.

The centerbody is a two-piece cylinder consisting of a 0.062-inch-thick roll-formed cylindrical section 315 degrees in arc length into which a thickened (0.093-inch) roll-formed section with an arc length of 45 degrees has been inserted. Two longitudinal welds attach the two pieces to form the complete cylinder. The thickened skin section was added to provide the required stress distribution in the cylinder in the area of attachment to the longeron assembly. The thickened skin has a cutout into which the longeron is welded at final assembly.

The aft closure is welded to the cylindrical centerbody to complete the tank. The closure includes an integral skirt with attachment provision and an opening and attachment bolt hole pattern for securing the aft end of the collector pipe/bladder assembly. The Y joint of the closure acts as a part of the structure which reacts the concentrated loads introduced by the aft sway brace units. The closure has slots and holes in the skirt for tank fill, vent valves, and fuel transfer lines.

All components of the tank case are fabricated from 4130A steel per MIL-S-18729. The forward closure is annealed, the contral and cylindrical shells are normalized, and the aft closure is heat treated to 140,000 to 160,000 psi minimum ultimate tensile strength.

To minimize overall costs, the suspension lug, sway brace, and ejection concentrated loads on the tank are carried by a reinforcement structure which acts independently from the basic case wall. The structure includes a forward sway brace stiffener ring, longeron, and an aft sway brace stiffener ring, which consists of the thickened area of the aft closure Y joint.

The support ring and longeron include webs at load application points to react concentrated loads. The longeron also includes integral suspension lug housings. U-shaped cross sections are selected for both units to give structural efficiency in bending while minimizing fabrication cost and weight.

SUSPENSION LUGS

Replaceable retracting suspension lugs are housed in the longeron. (See Fig. 3-6.) The lugs are forged of 4340 stee. and machined. The force required to restore each of the vehicle attachment lugs to its recessed position during vehicle flight is provided by a high-strength steel torsion spring. Each spring exerts a torque of 28 inch-pounds when the lug is rotated for attachment of the vehicle to the aircraft. This torque is sufficient to overcome frictional drag and inertial forces acting on the lug and will rotate the lug into the recess provided in the longeron. Once down, the lug is secured in position by a flat

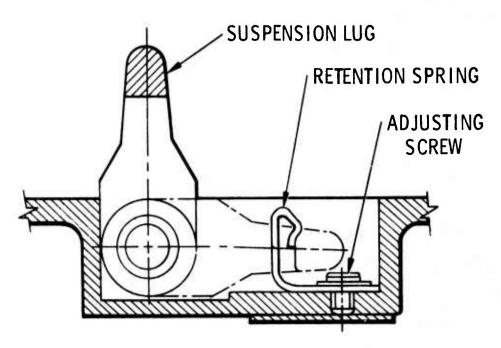


FIG. 3-6. Suspension Lug Retention System.

steel spring which engages the lug crossbar. This prevents rerotation of the lug back into the airstream.

The adjustment of the flat spring is performed by loosening the adjustment screw and shifting the flat spring until contact is made with the lug with interference of 0.03 to 0.06 inch. This approach (low-torque torsion spring, securing spring) was selected because it was found to be impractical to design a spring to meet the alternative requirement (250 inch-pounds of torque).

A pullpin is also provided which passes through the strongback wall and into the lug to hold the lug in the upright position during mounting on the aircraft. This pin is removed following mounting.

The suspension lug subassembly, consisting of lug, shaft, sleeve, and spring, can easily be removed for maintenance and/or replacement. The two retainer plates are unbolted and the lug assembly is slid out of the slots in the pocket sidewall.

The lug shaft has flats which interface with the top lip on the slot. This feature provides added bearing area on the shaft and increased shear area to the slot lip.

The shaft sleeve stabilizes the torsion spring in the loaded position.

FUEL EXPULSION BLADDER ASSEMBLY

The tank requires a bladder to ensure positive fuel expulsion for all attitudes and operational environments and to separate the expulsion gas from the fuel. A reinforced elastomeric bladder which collapses around the fuel collector pipe is the baseline design for this application.

Bladder Design

Design considerations for the positive expulsion bladder were as follows: (1) low cost, (2) reliability, (3) expulsion efficiency, (4) weight and volume, (5) compatibility with the propellant (long term storage), (6) permeability, (7) low temperature and high temperature operating characteristics, (8) multiple cycle life, and (9) ease of installation in tank assembly.

Design Approach

The baseline bladder design is shown in Appendix B, Fig. B-2, and a photograph of the expanded bladder attached to the collector pipe is shown in Fig. 3-7. The bladder provides multiple cycle capability to permit expulsion testing for acceptance and for demonstration of reliability for single cycle use.

Evaluation of the design requirements led to the selection of a nylon fabric reinforced nitrile laminate elastomer bladder (Goodyear BTC 17-4). The propellant is contained within the bladder and discharged through the collector pipe as the bladder collapses around the pipe during expulsion. The bladder is attached at each end of the collector pipe by metallic rings vulcanized to the ends of the bladder. The bladder is contoured to assume the internal shape of the pressure vessel. Depressions are incorporated in the structure to accommodate the strongback, electrical raceways and sway brace stiffener ring which protrude into the tank. This geometry minimizes membrane bridging and reduces bladder stresses. Basic thickness of the bladder is 0.020 inch. External strips are located at 60-degree intervals on the bladder exterior so that the bladder can be fully expanded in the pressure case without air entrapment between case and bladder. Reinforcement is added at the attach rings located at the bladder poles to accommodate the higher stress loads.

The aft end bladder flange consists of the bladder vulcanized between two stainless steel compression rings. This flange is bolted to the aft flange of the fuel collector pipe assembly with 12 4-40 screws, as shown in Fig. B-1 in Appendix B. The attach bolts are installed from outside of the tank, pass through the collector pipe flange, and screw into the outer compression collar. Leakage from either the bladder interior to exterior or through the flange bolt holes is prevented by O-ring seals on both the inner edge of the bladder flange and under the flange bolt heads. The nonuniform spacing of the bolt hole pattern keeps the bladder in position so its shape conforms with the tank interior configuration.

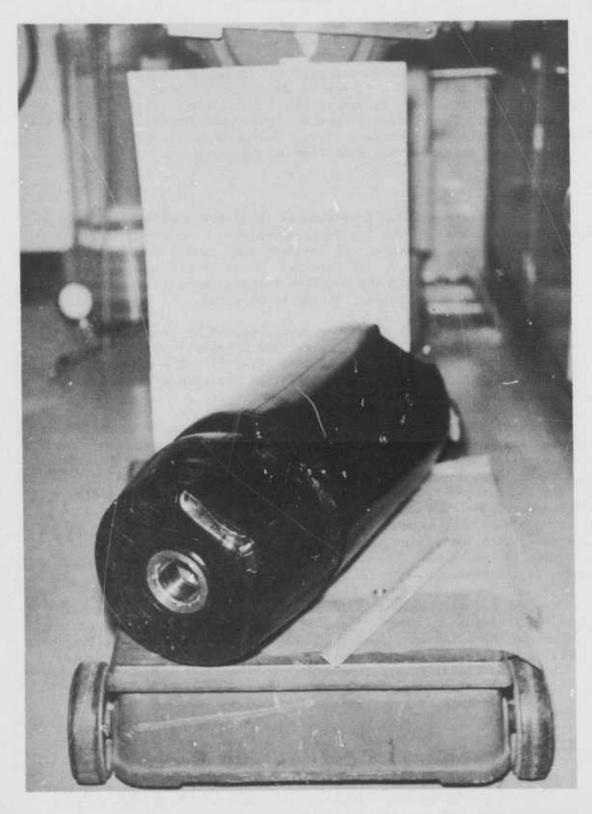


FIG. 3-7. Expanded Bladder Assembly as Attached to Collector Pipe.

The bladder forward end flange consists of the bladder vulcanized between two stainless steel compression rings using the same technique applied to the aft flange. The outer compression ring slides over the forward end of the fuel collector pipe and is sealed by an O-ring compressed between the bladder flange ID and collector pipe OD (Fig. B-1, Appendix B). The bladder flange is attached to the collector pipe with 12 4-40 screws. The bladder flange also fits over the collar inside the tank forward closure to prevent lateral movement of the bladder/collector pipe assembly when installed in the tank.

Bladder Analysis

The stresses resulting from bladder operation with the baseline design can be placed in the following categories: (1) internal load caused by propellant vapor pressure, (2) internal load caused by axial and lateral acceleration and vibration, (3) stresses caused by bridging when the bladder is partially empty and sloshing occurs, and (4) stresses caused by small radius bladder folding at low temperature.

The maximum internal bladder pressure caused by propellant vapor pressure at 140°F is less than 1 psia. The bladder is designed to be supported by the pressure case including areas of cable raceways, stiffener ring, and strongback. Therefore, negligible stresses will be induced during storage.

Vibration is not expected to cause appreciable loads in the bladder because frequencies are above 20 Hz and high frequencies will not cause damaging propellant sloshing. Captive flight may induce accelerations as high as 15 g, resulting in sloshing pressures as high as 15 psi axially and 6.5 psi radially. These pressures are not excessive even if the bladder fails to match the contour of the tank interior and localized bridging occurs. (Subsequent testing of bladders pressurized to 50 psi internally with the cavity between bladder and case vented resulted in no damage to the bladder, even when the bladder was incorrectly positioned in the case.)

Maximum bladder membrane bending occurs in the folds during hard collapse expulsion (maximum ΔP) and at the poles where the bladder is attached to the collector pipes. The bladder material selected precludes a folding problem and reinforcement is used at the polar bosses where failures were initially experienced during bladder development on other programs. The polar compression collars are contoured to prevent a sharp fold at points of attachment.

Bladder Material Selection

The requirements of the GORJE bladder present an extension of current technology with TH-Dimer fuel and elastomer bladders with respect to expulsion gas temperatures, operational pressures, and configuration. A review of available data supported the initial selection of Goodyear BTC 17-4, a nitrile/nylon laminate, as the bladder material. It is a

composite construction consisting of an 0.003-inch film of nylon sand-wiched between single layers of nitrile coated, 2-ounce nylon fabric. The nylon is the impermeable barrier to the fuel and the fabric contributes to the structural, handling, and bonding characteristics of the bladder.

COLLECTOR PIPE ASSEMBLY

The GORJE fuel tank collector pipe assembly contains the tank pressurization gas generator and fuel controller. It also serves as the attachment point for the positive expulsion bladder, collects the fuel through radial holes, and delivers it to the fuel controller.

Design

The collector pipe assembly was designed to meet the requirements of Appendix A. The corresponding CSD design is shown in Fig. B-11 of Appendix B. The assembly, including bladder flanges, was fabricated of CRES 304. The aft flange was designed to fit a 5-inch-diameter opening in the end of the fuel tank. This opening is controlled by the space required for bladder installation. (The bladder attachment was described earlier in this section). Internal geometry of the collector pipe will accept the gas generator and fuel controller valve assemblies. The ground test unit collector pipe is shown in Fig. 3-8.

Structural Analysis

The structural analysis of the collector pipe is an integral part of the analysis of the tank as a whole. The loads and failure modes considered for the collector pipe are stress and buckling forces due to inertial forces, and sloshing and bending stresses at the bolted flange. The modeling of the collector pipe in the general models of the assembled tank is in sufficient detail to give accurate solutions for stresses and displacements. The solutions for stresses and displacements, therefore, come from the solutions for the assembled tank.

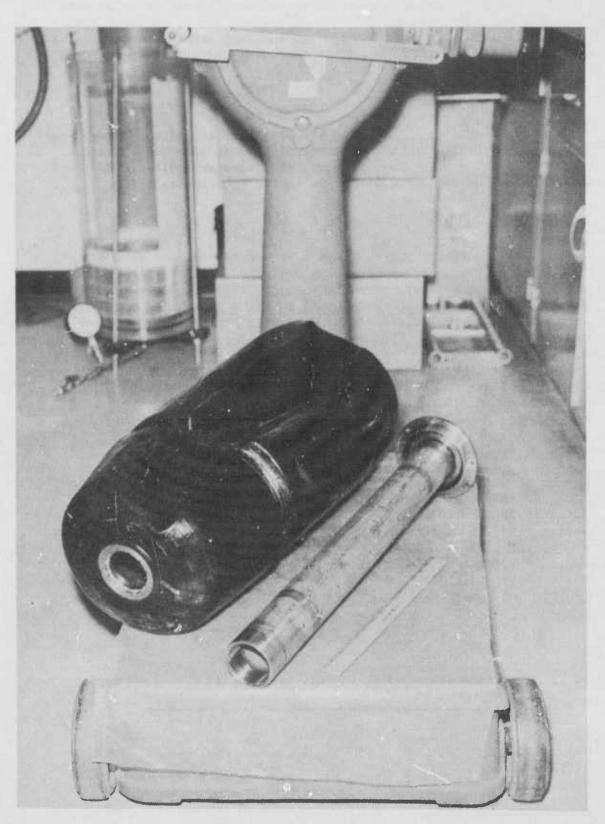


FIG. 3-8. Fuel Collector Pipe.

4 STRUCTURAL ANALYSIS

The structural analysis of the GORJE fuel tank is divided in three parts: (1) the static analysis of the flight test (47.5-pound) tank for inertial loads, flight loads, and internal pressure; (2) a dynamic analysis of the flight test tank to predict the response of the tank to the transient eject load and to predict the factor of safety of the tank when vibration tested as part of the assembled vehicle; and (3) an analysis of the design changes required to result in a flightweight production tank.

This report summarizes the analysis of the flight test tank and that portion of the dynamic analysis pertaining to the response of the tank to the eject load. As part of the structural analysis, extensive calculation was done of air loads and all the possible inertial loads contained in specification MIL-A-8591D were investigated. This report also contains a summary of the load calculations.

The flightweight tank is a design by modification of the flight test tank. The computer models were modified accordingly and the stresses evaluated. Also, the NASTRAN model of the tank used for dynamic analysis was used to determine the response of the tank to the power spectral density curve given in the tank specification.

The configuration of the tank used in the structural analysis models is shown in Fig. B-1 of Appendix B.

STATIC ANALYSIS (FLIGHT TEST TANK)

The computer analyses and the manual calculations show that after the required safety factor has been applied to the loads, all parts of the fuel tank and support lugs have positive margins of safety. A summary of the critical failure modes and the associated margins of safety is given in Table 4-1.

The critical load on the fuel tank is generally the ultimate internal pressure of 550 psi, but both the eject load and a captive flight load, which result in a 16,500-pound ultimate lug load, produce high bending stresses in the strongback adjacent to the shell.

Axial forces in the bottom of the tank shell which might cause buckling have been calculated to be low enough to give high margins of safety for this potential failure mode.

Skin buckling in the vicinity of the strongback because of internal heating by the pressurizing gas is absent because the internal pressure will result in a net tensile stress field in this area.

TABLE 4-1. Summary of Flight Test Model Margins of Safety

Load	Area	Mode	Stress, psi	Allowable Stress, psi	Margin of Safety
P _c = 550 psi	Basic case wall	Ноор	62,500	90,000	0.44
T = 550°F	Forward dome	Plate bending	61,000	90,000	0.47
	Aft dome Longitudinal weld	Ноор Ноор	62,000 62,500	90,000 83,000	0.45 0.32
Lug load = 16,500 lb	Lug pin Lug pin Longeron	Shear Bearing Shear	71,700 82,500 33,400	109,000 287,000 95,000	0.53 2.4 1.7
Ejection load = 15,000 lb	Strongback Shell	Bending Axial stress	134,000	140,000 95,000	0.07 2.1
	Shell	Hoop bending	157,000	See case subsection] -
	Forward ring	Bending	83,000	140,000	0.7
Two forward brace loads = 16,500 lb	Forward ring Cone	Bending Axial stress	83,000 73,000	140,000 95,000	0.7
	Cylinder	Axial stress	86,000	95,000	0.44
	Cylinder	Ноор	80,000	95,000	0.19
Point 2 loads x 1.5 safety factor	Strongback Shell	Bending Hoop bending	130,000 79,000	140,000 95,000	0.08
	Shell Forward ring	Axial Bending	45,000 70,000	95,000 140,000	1.1

One of the principal benefits obtained from the use of the three-dimensional structural analysis program, STAGS, was that the tank shell augments the stiffness of the strength of the strongback, thereby permitting design of a minimum weight structure.

The calculated margins of safety for the support lugs have already been verified by component ultimate loads tests.

DYNAMIC ANALYSIS

The NASTRAN analysis for the dynamic ejection load indicated there was no dynamic amplification of the load over application as a static load. The natural frequencies of the tank are larger than the frequency of the (one-cycle) dynamic load so that the structure is able to follow the load in time. This allowed the stress analysis to be performed by the static shell analysis code (STAGS). The NASTRAN dynamic results for displacement under point of application of the load with corresponding static (NASTRAN) results are:

 $\delta_{140} = -0.0355$ inch (dynamic result)

 $\delta_{140} = -0.0374$ inch (static result).

STATIC ANALYSIS

Loads

A summary of the structural loads as defined in the GORJE statement of work in Appendix A can be seen in Fig. 4-1 and 4-2.

Since these requirements did not specify the end reaction or how the lug and brace loads were to be reacted, the inertial and air loads were evaluated in accordance with MIL-A-8591D. The various load combinations are presented in Table 4-2 and air loads used and methods of calculations are presented in Appendix C. The two points indicated by arrows on Table 4-2 were considered worst case and the two combined load conditions applied to the analysis model.

The material degradation because of the free flight temperature will only affect the pressurized loading condition. The reduced allowable strengths for the material were used for this condition.

Materials

The material used for the structural members was 4130 steel heat treated to various levels in accordance with the drawing requirements. The free flight internal temperature of 550°F will reduce the allowable strength to 95% of room temperature values in accordance with MIL-HNBK-5B. The following room temperature strength levels were used:

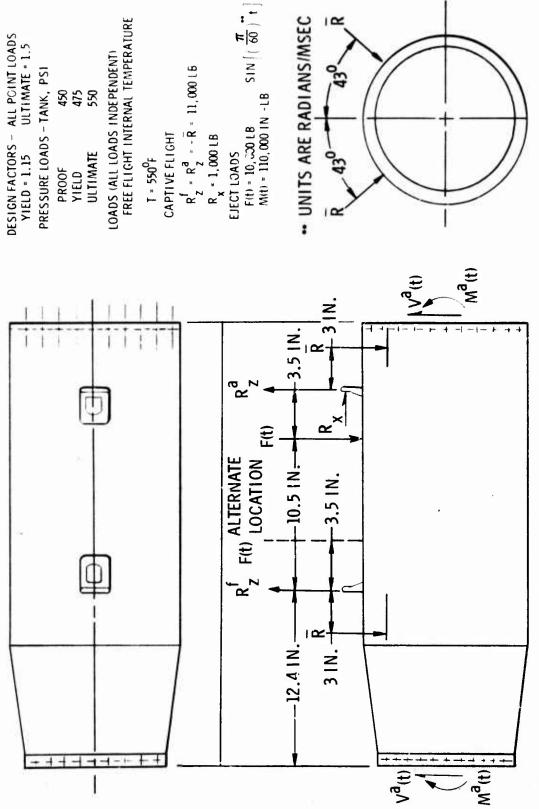
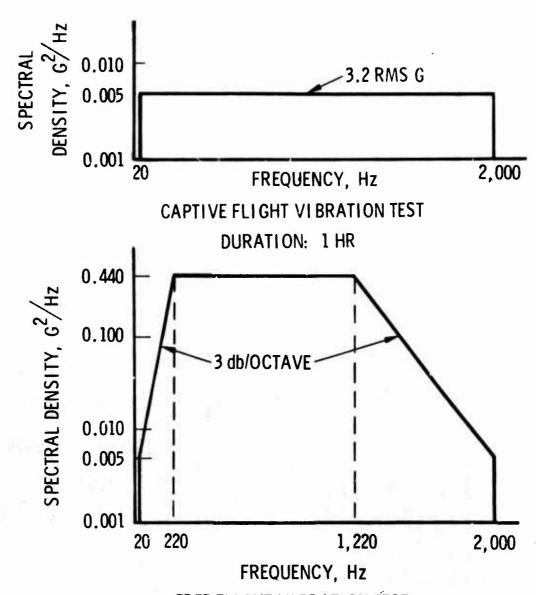


FIG. 4-1. Fuel Management System Structural Criteria.



PULSE: F (t) = (10,000 LB) SIN $\left[\left(\frac{\pi}{60} \right) t \right]$ t IN MSEC

 $0 \le t \le 60 \text{ MSEC}$

FIG. 4-2. Captive Flight and Free Flight Vibration Tests.

TABLE 4-2. GORJE Fuel Tank Loads Analysis.

Column	Column Heading	MIL-A-8591D Nomenclature	Column Heading	Heading	MIL-A-8591D Nomenclature
Point	Point	Ref. figure 4-3	VBF	< < <	Vertical component of forward sway brace
X	×	Longitudinal load factor	VBA		Vertical component of aft sway brace
Z	د ک	Lateral load factor		py,mz	
N	, _c	Vertical load factor	RTF	of 1	Forward lug reaction
∢	່ ຮ	Angle of attack		2 4	
8	, g	Yaw angle of attack	RTA	60	Aft lug reaction
Ϋ́	۵,	Total longitudinal load		2 .	
γ	۲ _۵ :	Total lateral load	R.	π,	Forward lug
PZ	۰۵,	Total vertical load	RA	, a R	Aft lug
Α	'∑	Total pitching moment	RBF	2	Forward sway brace
MZ	N N	Total yawing moment	884	C 10	Aft twan brace

¥ 8 A	•	0	0	0	0	0	0	0	1616	1103	2743	5555	2473	1960	3600	3087	9	0	0	0	o	0	0	0	o
	3 2 5	1371	344	1371	1371	344	1371	344	1960	2473	3087	3600	1103	1616	2229	2743	0087	3773	4900	3773	4800	3173	4800	3773	645
RBF	э	0	0	9	0	P	0	0	1449	1963	322	836	2225	2736	1094	1611	2	0	9	0	0	0	9	>	5
	1289	262	1289	262	292	1289	292	1289	2738	2225	1611	1098	1963	1449	836	322	3364	4391	3364	4391	3364	1957	3364	1057	473
RA	5118	0619	3118	4190	6190	5118	4190	3118	0	0	0	9	c	0	0	0	3779	2707	1779	707	6562	5489	4562	3489	1010
RF	6097	3536	6099	5536	3536	4609	5536	6099	0	0	0	0	0	0	0	0	1447	2519	3447	4519	3858	4930	5858	6930	6730
RTA	5116	0619	3118	4190	6190	5118	4190	3110	-2037	-965	4037	-2965	-965	-2037	-2965	-4037	3779	2707	1779	707	6562	5489	4562	3489	1010
RIF	6098	3536	6099	5536	3536	4609	5536	6099	1592	2665	408	-665	-2665	1592	-665	408	1447	2519	3447	4519	3858	4930	5858	6930	6736
VBA	251	1002	251	1002	1002	-251	1002	-251	251	1002	251	1002	1005	-251	1005	-251	3508	-2758	.3508	-2758	. \$508	2758	3508	2758	-691
VBF	596	192	942	192	-192	206-	-192	-942	942	192	276	192	-192	-942	-192	-942	. 5459	.3210	. 5459	3210	5459	3210	2459	3210	-346
HZ	7000	1000	7000	7000	7000	1000	7000	7000	7000	7000	7000	7000	7000	7000	7000	7000	7000	. 2000	7000	. 0007	7000	1000	7000	1000	2731
H 7	14000	14000	14000	14000	14000	14000	14000	14000	14000	14000	14000	14000	14000	14000	14000	14000	0007	14000	14000	14000	14000	14000	14000	14000	39094
2 d	8533	8533	8533 -	8533 -	1258	8533	8533 .	8533 -	4823	4823	4823 -	4823 -	4823	4823	4823 -	4823 -	742	742	742 -	742 -	4452	4452	- 6577	4 6577	- 0119
q	•	•	•	•	•	•	•	•													•	•	•	•	- 996-
χd	١														•	•		•	1		•				1113
60	0.0	0					9																		. 0
<	0													2				0	0		•	•	•		19.9
NZ	11.5		•	•	•	•	•	•	•	•	•	•	•		•						•				11.5
N.	. 5																	2.2	2 .	2 2	1	7			-1.5
NT NX	5																								. 5
104	-					u a				۱ ۳	٠,	۱ ا	1 4	4	7 4		ט ז	·			٠.	•		0 4	~

4152 4637 3026 3510 3932 4354 4354 2805 5025 RBF E. N. 7753 9559 9559 9555 9555 9555 9555 RIA VBA (Contd.) ¥8F 7 14000 7000 1 14000 1 14000 1 14000 1 14000 1 16000 1 1 4-2. ¥ TABLE 24 • N ž ž POINT

KB A

NWC TP 5835

Part	Drawing Number	F _{tu} , psi x 10 ³	$^{ m F}$ ty, psi x 10 3	F _{su} , psi x 10 ³	F _{tu} at 550°F, psi x 10 ³
Lug	C11207	180	163	108	171
Longeron	C11204	150	132	90	142
Forward closure Tank shell	C11202 C11206	95 95	75 75	57 57	90 90
Aft closure	C11201	150	132	90	142
Ring	C11203	150	132	90	142
Cone	C11027	95	75	57	90

Method of Analysis and Results

The production model was checked for: (1) internal pressure of 550 psi; (2) ejection load of 10,000 pounds in either location; (3) both forward brace loads being 11,000 pounds; and (4) Point 2 captive flight inertia and air load from Table 4-2.

These are the worst case loading conditions and the margins from these runs are large enough so that the other load conditions need only be checked on the flight model. For a summary of the safety margins see Table 4-1.

The STAGS analysis used two models, a 180-degree model for symmetric loads and a 360-degree model for the nonsymmetric Point 2 loading. The models are otherwise identical. The axial profile is shown in Fig. 4-3 and a typical cross section is shown in Figs. 4-4 and 4-5.

Three preliminary sizing and model checkout runs were made which varied the model density, method of modeling the strongback and shell buildup, and strongback inertia. These runs substantiated the model's adequacy. The results of these preliminary runs are on file but have not been presented because they are not directly comparable and there is no substantial difference from the final results which are presented here (e.g., maximum strongback radial deflection under ejection load of 0.083, 0.074, and 0.087 inch as compared to a final design value of 0.084 inch).

Closure and Case Pressurized. The end closures were analyzed using the CSD finite element computer program LI65ZZZ. The model, boundary condition, and results are shown in Figs. 4-6 and 4-7. The loading used was the ultimate internal pressure of 550 psi. The closure stress for the captive flight loading conditions was verified by the STAGS analysis to be appreciably less.

The aft closure-to-collector pipe flange joint was analyzed using the LI65ZZZ finite element program. The finite element model is presented in Fig. 4-8. Both the hydrotest and the flight loading conditions were used. The hydrotest condition provided the most severe loading condition. The interface on the model between the two flanges contained a thin row of

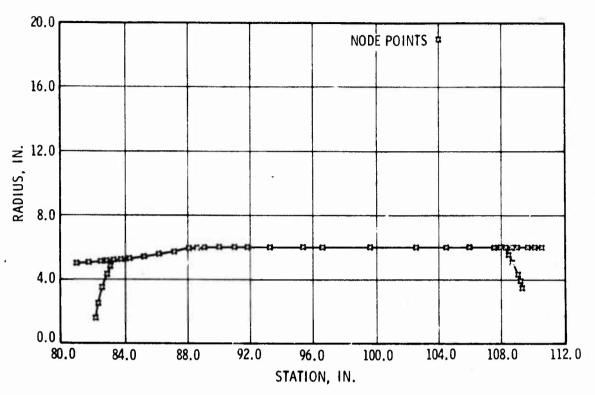


FIG. 4-3. STAGS Model.

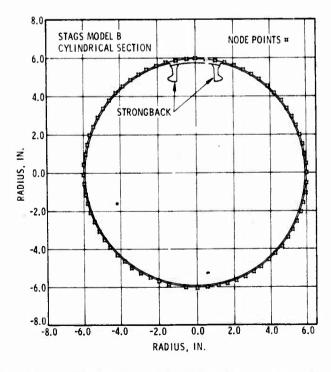


FIG. 4-4. STAGS Model B Cylindrical Section.

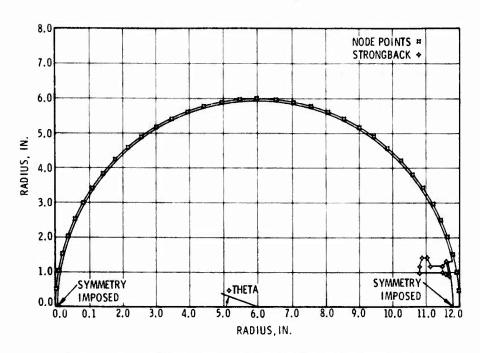


FIG. 4-5. STAGS Model A Cylindrical Section.

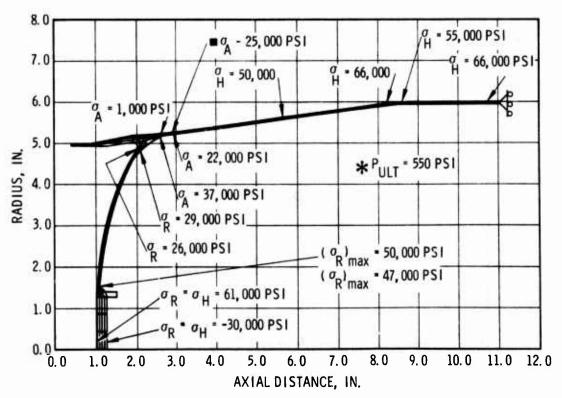


FIG. 4-6. Forward Closure.

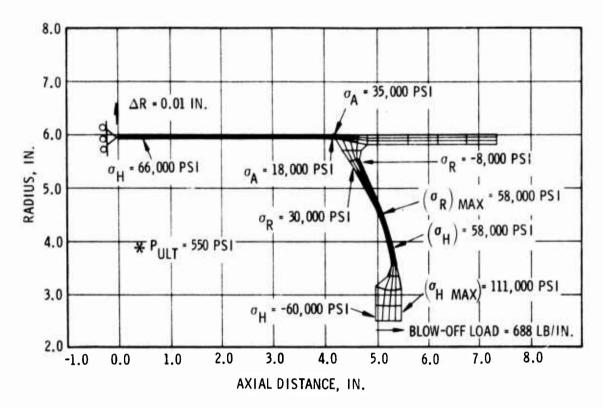


FIG. 4-7. Aft Closure.

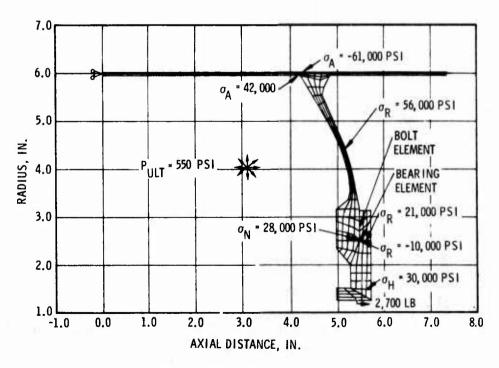


FIG. 4-8. Aft Closure.

elements. The bolt element was given a modulus which gives it the same spring rate as the bolts. The bearing element was hydrostatic to eliminate any shear restraint. The other interface elements were given a very low modulus (10). Although an early run used a bearing element at the outside diameter of the flange, the results were tension in the bearing element and compression in the bolt element. Thus, the model was changed to a bearing element at the inside diameter of the flange. The aft closure flange tended to rotate and the collector pipe flange restrained the rotation of the closure, resulting in a bolt load which was three times the blowout load.

Main Ring. The main ring was preliminary-sized using NASA TN 929* for a circular shell supported frame. The uncertainty in this method is estimating the relative stiffness (term d) of the shell. A best guess for d of 500 gave a ring stress of 54,000 psi because of an 11,000-pound brace load. However, a d of 10 would give a stress of 120,000 psi. A STAGS run was made applying a forward brace load of 11,000 pounds. Because of symmetry specified at the boundary of 0 and 180 degrees, these results are for worst case loading of both forward brace loads, or 11,000 pounds. The ring deflection and stress are shown in Figs. 4-9 and 4-10. The maximum stress in the ring as a result of the ejection load was also 54,000 psi, as shown by Fig. 4-11.

^{*} Analysis of Circular Shell Supported Frames, NASA Technical Note No. 929, May 1944.

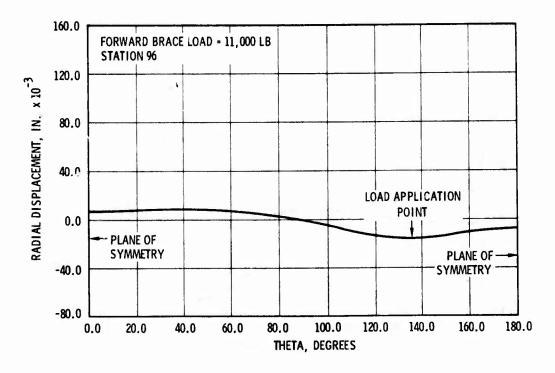


FIG. 4-9. Ring Displacement.

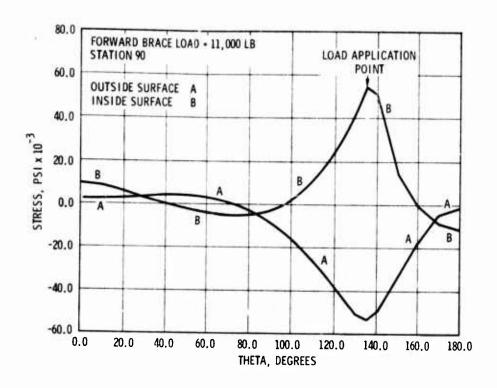


FIG. 4-10. Ring Stress.

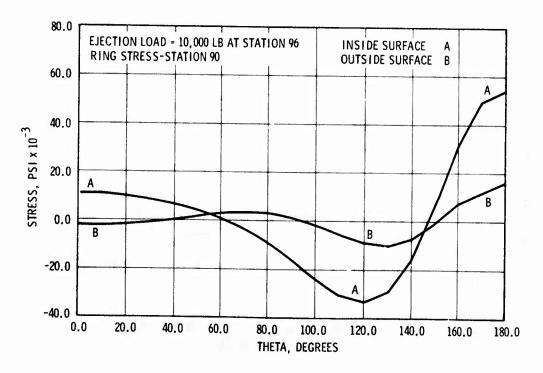


FIG. 4-11. Ring Stress Station 90.

Longeron. The longeron was checked by STAGS analysis for the ejection load in its allowable location and the forward lug load.

Preliminary manual calculations for a simple beam showed the worst case loading for moment in the longeron to be an ejection load of 10,000 pounds at Station 96. The STAGS results have shown that the support provided by the skin makes the stress and deflection relatively independent of the load location. A comparison of longeron radial deformation for the ejection load at Stations 96 and 103 is shown in Fig. 4-12. The stress and deformation patterns for the loading at Station 103 are similar and only slightly less than those for loading at Station 96.

Since completion of the analysis, the Station 96 location has been dropped and the ejection load will only be applied at Station 103. The tables of safety reflect the values for Station 103.

The maximum stress for the ejection load of 10,000 pounds was 90,000 psi. The Point 2 flight loading gave a maximum longeron stress of 87,000 psi. These are all elastic stresses at the surface; plastic capabilities would provide greater margins.

Case. For the captive flight load, the membrane stress levels in the basic shell wall are all very low (i.e., 25,000 psi or less). There is no problem with the ultimate safety factor. However, there are small localized areas with high bending stress which cannot theoretically meet the required safety factor upon yield. Under the ejection load, at the junction of the shell to the strongback, the STAGS program predicts a large moment in the shell because the strongback does not rotate. Compatibility of rotation causes a high bending stress in the shell as shown by Fig. 4-13. Examination of the displacements, as shown in Fig. 4-14, indicates there is no great discontinuity in replacements. Minor plastic redistribution would allow rotation at the juncture, thus removing the moment. This is not a moment that must be carried by the shell but one that results because of the compatibility of rotation requirement that has been imposed by the computer program.

The lug loading was in the opposite direction and the maximum stress was only 53,000 psi at the juncture for the Point 2 loading condition.

These stress levels are not realistic for design of the structure and have been presented only for completeness of the report.

The critical load on the attachment flanges is the requirement of a moment of 110,000 in-lb that results from the ejection load. The captive flight loads give smaller end moments. A moment of 165,000 in-lb ultimate distributed as a cosine variation results in a maximum axial line load of 1,460 pounds/inch ultimate. This gives a maximum bolt load of 1,955 pounds and shell stress of 29,000 psi. Conformation has been made with the STAGS analysis, which applied end moments of 72,000 in-lb and there were no unexpected stresses.

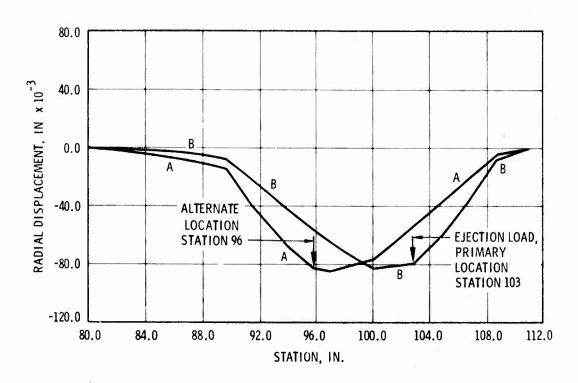


FIG. 4-12. Strongback Radial Displacement.

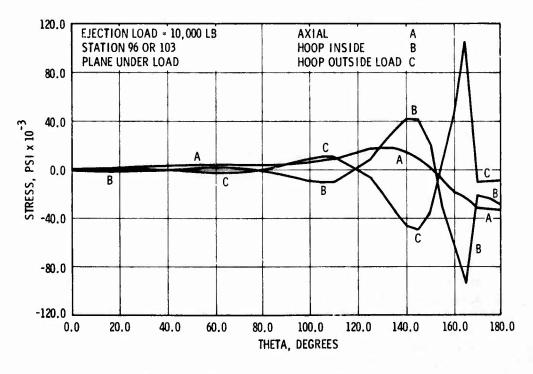


FIG. 4-13. Plane Under Load.

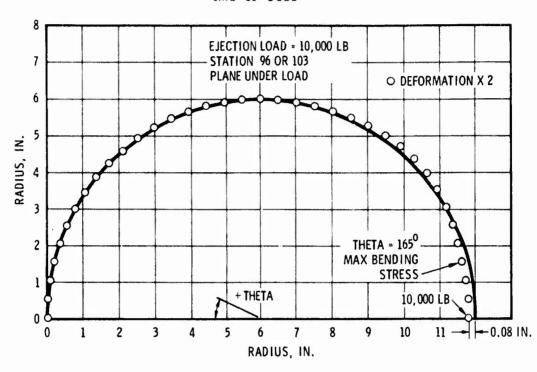


FIG. 4-14. Plane Under Load.

Lugs

The lugs were analyzed by manual calculation and the critical margin was a 0.5 margin on pin shear. A lug and retention system model has since been tested to an ultimate loading of 16,500 pounds with no visible yielding.

DYNAMIC ANALYSIS

NASTRAN Dynamic Model

A NASTRAN model of the GORJE tank was constructed mainly to study the natural modes of vibration and dynamic response of the tank. The problem was run on a CDC 6600 using a MacNeal Schwendler version of NASTRAN (MSC-20). As the tank is symmetrical about a vertical plane through the center, the cyclic symmetry option was used.

The various model elements are described as follows:

- 1. The end sections of the tank were modeled with rectangular and triangular plate sections.
- 2. The longitudinal sections of the tank were modeled with rectangular plates.
- 3. The fluid was modeled by use of solids having a high bulk modulus (simulating incompressibility).
- 4. The longitudinal stiffeners (longeron) and the forward ring were modeled with offset beams. These beams are not shown in the computer drawings.

A number of NASTRAN drawings of various sections of the structural model were drawn primarily to check for errors in the model. However, these drawings provide a vivid picture of the structural model of the (half) tank. Figs. 4-15 through 4-17 show the front, side, and rear elevations, respectively, of the outer shell of the tank. Figs. 4-18 through 4-25 show the sections comprised of solid elements used to model the fluid of the half-filled tank. These sections are shown as orthographic views. In some studies, these fluid sections were omitted from the model. A listing of the NASTRAN bulk data (Table 4-3) identifies the elements and the nodal points of the drawings and the structural model.

This model was used for two types of studies: (1) dynamic response of the tank to an ejection load and (2) frequency-modal analysis of the tank structure. In both of these studies, the fluid elements were removed from the tank so that the results pertain to an empty tank. The inertial effect of the missile sections forward and aft of the tank was incorporated into this model.

Dynamic Analysis of the Ejection Load

The NASTRAN model was primarily used to study dynamic loads. The direct integration method (APP DISP 9) was used to study the response to the dynamic ejection load. This load is characterized in the specifications:

F (t) =
$$(10,000 \text{ lb})/\sin (\pi t/60)/$$
 0 F (t) = 0 t > 60
where the time (t) is in msec.

With reference to Fig. 4-16 of the structural model, the ejection load was applied as a vertical load on point 140 of the model. The tank was supported on very soft springs at two points (5 and 185) in the vertical direction only.

The radial displacement of the shell centerline is given under point of application of the load. The maximum value shown on this plot is slightly less than that obtained from a shell static analysis.

It should be noted that the displacements and stress distribution followed the applied load in form. As could be shown by a frequency-modal analysis of the tank, the frequencies are in such a range that excitation of the tank would not be expected.

In Fig. 4-26, the radial displacement of the point under the load is plotted versus time. In Fig. 4-27, a plot of the maximum (and minimum) stress in the beam reinforcement (strongback) section of the tank is plotted versus time. These stresses occur in extreme fibers of the beams.

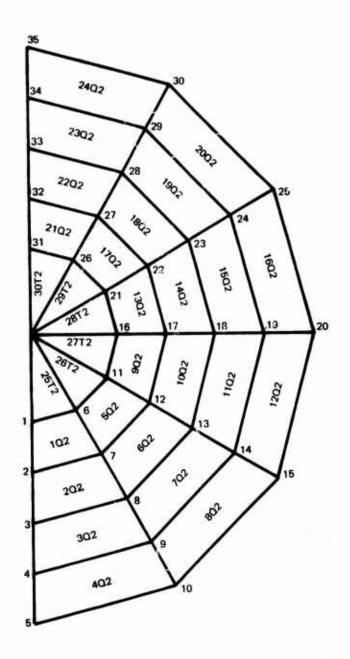


FIG. 4-15. Vibration Study of GORJE Tank - Modes of Half-Filled Tank, Undeformed Shape (Forward Dome).

315		310		305			300			295		290		285
	24802		24702			24602		24502			24402		24302	
280		275		270			265			260		255		250
245	24202	240	24102	235		24002	230	23902		225	23802	220	23702	215
210	23602	205	23502	200		23402	195	23302		190	23202	185	23102	180
175	23002	170	22902	165		22802	160	22702		155	22602	150	22502	145
140	22402	135	22302	130		22202	125	22102	1	120	22002	115	21902	110 14
105	21802	100	21702	95		21602	90	21502	700.7	85	21402	80	21302	75
	70	21202	21102	60		21002	55	20000		30 1	20802	- 1	20702	2
		20602	1	20502		20402			20302		20202	20102		# I T
		35	8		28		5	¥		15	10	_		

FIG. 4-16. Vibration Study of GORJE Tank - Modes of Half-Filled Tank, Undeformed Shape (Side Elevation).

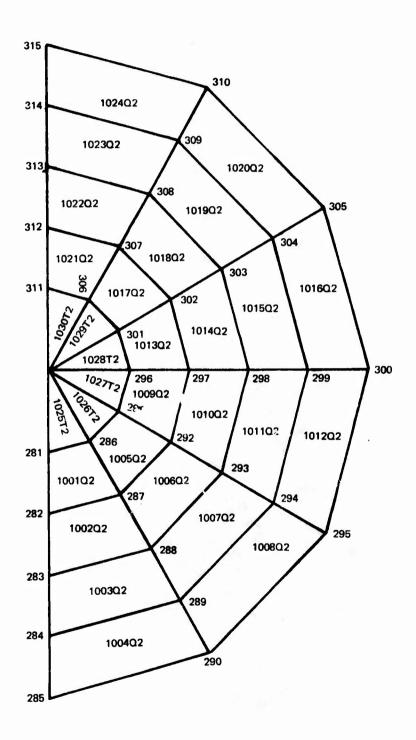


FIG. 4-17. Vibration Study of GORJE Tank - Modes of Half-Filled Tank, Undeformed Shape (Aft Dome).



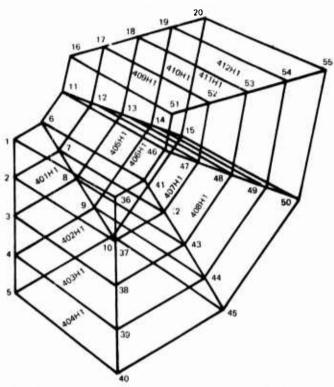


FIG. 4-18. Vibration Study of GORJE Tank - Modes of Half-Filled Tank, Undeformed Shape (First Fluid Section).

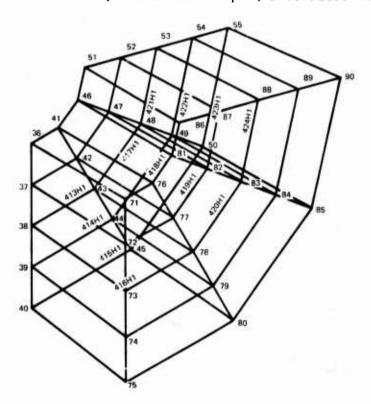


FIG. 4-19. Vibration Study of GORJE Tank - Modes of Half-Filled Tank, Undeformed Shape (Second Fluid Section).

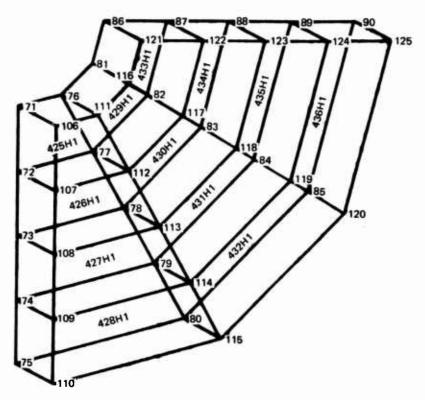


FIG. 4-20. Vibration Study of GORJE Tank - Modes of Half-Filled Tank, Undeformed Shape (Third Fluid Section).

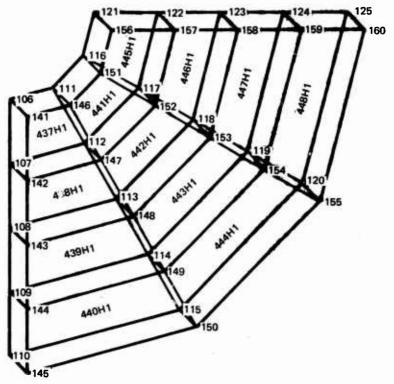


FIG. 4-21. Vibration Study of GORJE Tank - Modes of Half-Filled Tank, Undeformed Shape (Fourth Fluid Section).

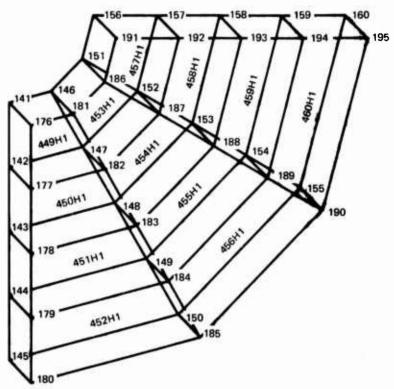


FIG. 4-22. Vibration Study of GORJE Tank - Modes of Half-Filled Tank, Undeformed Shape (Fifth Fluid Section).

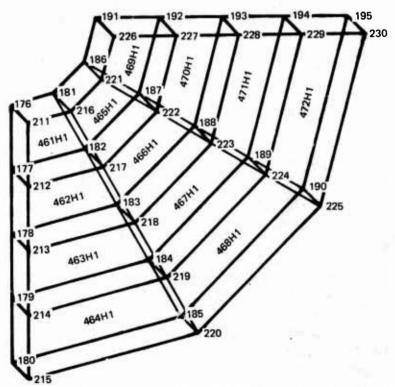


FIG. 4-23. Vibration Study of GORJE Tank - Modes of Half-Filled Tank, Undeformed Shape (Sixth Fluid Section).

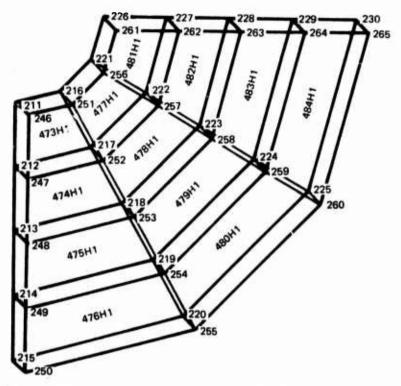


FIG. 4-24. Vibration Study of GORJE Tank - Modes of Half-Filled Tank, Undeformed Shape (Seventh Fluid Section).

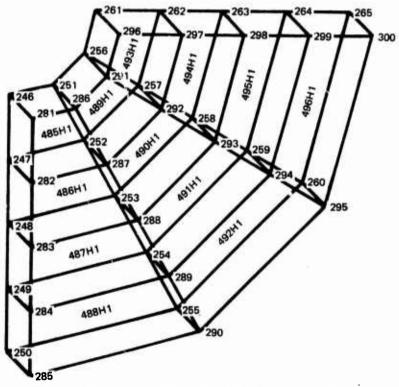


FIG. 4-25. Vibration Study of GORJE Tank - Modes of Half-Filled Tank, Undeformed Shape (Eighth Fluid Section).

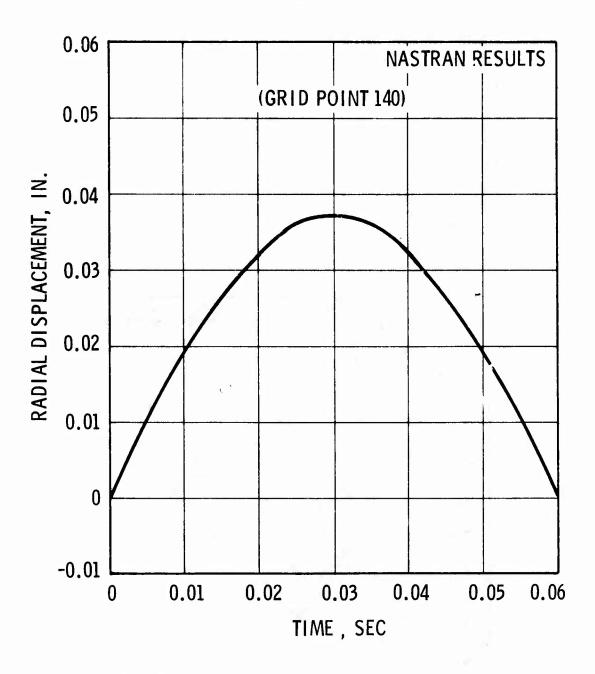


FIG. 4-26. Dynamic Ejection Load, Displacement Under Point of Load.

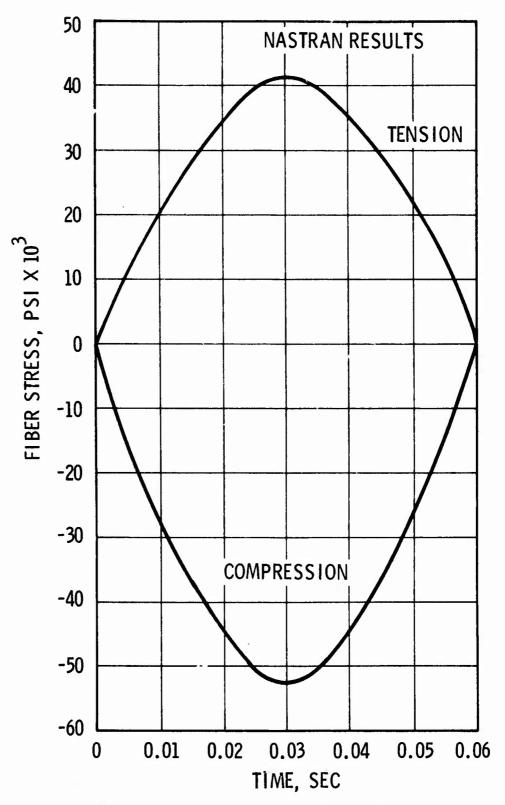


FIG. 4-27. Dynamic Ejection Load, Maximum Stress in Beam Strongback.

FLIGHTWEIGHT TANK ANALYSIS

The 44-pound flightweight design has been checked for the captive flight loads using the same STAGS computer program model as that used on the flight test design. The captive flight loads were the critical loads on the hardware. The reduced basic case wall thickness and reduced strong-back cross section increased the strongback deflections and stresses by 25%. Specifically, the maximum radial deflection of the strongback under the 10,000-pound ejection load increased from 0.083 inch for the production design to 0.102 inch for the flight design. The maximum strongback axial stress of 90,000 psi for the production model increased to 114,000 psi. These results still give the required 1.15 safety factor on yield and there is a minimum margin of safety on ultimate load of 0.16. The basic case wall stresses were increased by approximately 9% and the minimum margin of safety remained positive.

The pressurized loading condition was analyzed for the flight design thickness on a final finite element computer run as shown by Fig. 4-8. A STAGS run was made to check the stress developed at the strongback-to-aft closure attachment weld because of pressure loading. The resulting maximum stress in the case wall was 31,000 psi, giving a high margin of safety.

Hence, this analysis shows that the weight reductions for the flight-weight design did not make a significant reduction in structural capability from the production model.

5 TANK MANUFACTURING

The GORJE fuel tank assembly manufacturing plan used for fabrication of the ground test and flight test units is described in this section.

Fabrication materials and processes for the ground test and flight test tanks are described in Table 5-1. A flow chart of manufacturing and assembly operations is shown in Fig. 5-1. Photographs of the tank structure during fabrication are presented in Figs. 5-2 and 5-3. A further description is detailed below.

GROUND TEST UNIT AND FLIGHT TEST MANUFACTURING

Tank Structure

The ground test and flight test tanks were manufactured in-house using the CSD manufacturing facilities located at Coyote and Sunnyvale, California. Raw materials used for fabrication were procured from certified suppliers. The forward closure (C11202) and the aft closure (C11201) were machined from 4130 plate per MIL-S-6758 (condition A) because the schedule did not permit procurement of forgings for these components. The parts were rough machined on a tracer lathe, stress relieved, 100% magnetic particle inspected, and machined to final contour. The instrumentation mounting bosses were GTA fusion fillet welded to the forward closure using a locating jig. The aft closure was heat treated per MIL-H-6875 to 140,000/160,000 psi.

The forward conical shell (Cl1209) was roll formed from 0.060-inch thick 4130 sheet per MIL-S-18729 (normalized), GTA fusion seam welded, stress relieved, 100% magnetic particle inspected, and final machined to print.

The cylindrical shell (Cl1206) was manufactured using the same processes as the conical shell from 0.060 and 0.090-inch thick 4130 steel per MIL-S-18729 (normalized). The 0.090-inch sheet is used in the zone adjacent to the longeron to provide a transition between the nominal 0.060-inch shell and the thicker longeron.

The longeron (C11204) was rough machined from annealed 4130 steel plate per MIL-S-18729, heat treated per MIL-H-6875 to 140,000/160,000 psi, 100% magnetic particle inspected, and final machined. The forward sway brace ring (C11203) was rough machined from annealed 4130 steel plate per MIL-S-18729, heat treated to 140,000/160,000 psi per MIL-H-6875, magnetic particle inspected, and final machined to drawing requirements.

The remaining fuel tank components (excluding fuel collector pipe and suspension lug details) were the electrical raceway conduits (C11274).

TABLE 5-1. Materials and Processes, GORJE Fuel Tank.

Part No.	Item	Current Materials*	Current Fabrication Process*
C11207	Lug	4340 steel forging MIL-S-5000 (normalized)	Machine: heat treat per MIL-H-6875 to 180,000/200,000 psi ultimate; MPI; cadmium plate.
C11218	Shaft	4340 bar per MIL-S-5000 or 4130 bar, MIL-S-6758 (normalized)	Machine; heat treat per MIL-H-6875 to 180,000/200,000 psi ultimate; MPI; cadium plate QQ-P-416.
C11217	Sleeve	ASTM A-513 (type 5) (C1010/1020 mild steel tubing)	Machine to length, cadmium plate $QQ\!-\!P\!-\!416$.
C11215	Spring, torsion	ASTM A-228 steel wire phosphate coated	Outside procurement per print,
C11216	Spring, lock	17-7 PH sheet per MIL-S-25043 (annealed)	Outside procurement per print.
C11208	Retainer	4130 steel plate per ML-S-18729 (annealed or normalized)	Machine; heat treat per MIL-H-6875 to 140,000/160,000 psi ultimate; MPI; cadium plate QQ^+P-416 .
c11210	Collector pipe assembly (-11-01, -12-01, and -13-01 closures) (-14-01, -15-01 tubing)	304 stainless steel plate QQ-S-766 304 stainless steel tubing M1L-T-8506	Rough machine closure and tubing details; GTA fusion weld; fluorescent penetrant inspect welds/ final machine to print.
c11202	Closure, forward (-11-01) item 5 (-12-01, -13-01, -14-01, -15-01, items 6, 7,8, and 9)	4130 steel plate MIL-S-18729, annealed 4130 steel bar MIL-S-6758, annealed	Details machined to print, items 6,7,8, and 9; GTA fillet weld; MPI; final machined.
C11209	Shell conical (forward)	4130 steel sheet MIL-S-18729 (normalized)	Sheet blank trimmed to size; roll and weld conical section; GTA fusion weld; stress relieve; MPI 100%, final machine to print
c11206	Shell cylindrical -11-01 (0.060 sheet) -12-01 (0.090 sheet)	4130 steel sheet MIL-S-18729 (normalized)	Trim sheet blanks to size; roll-form -11-01 and -12-01 details; GTA fusion butt weld cylinder blanks, stress relieve, 100% MPI; final machine to print.
C11201	Closure, aft	4130 steel plate MIL-S-18729 (annealed)	Rough machine to approximate configuration; heat treat per ML-H-6875 to 140,000/150,000 psi ultimate; final machine to print, 100% MPI.

TABLE 5-1. (Contd.).

Part No.	Item	Current Materials	Current Fabrication Process
C11204	Longeron	4130 steel plate ML-S-18729 (annealed)	Rough machine to approximate configuration; heat treat per MIL-H-6875 to 140,000/160,000 psi ultimate; final machine to print, 100% MPI.
C11203	Ring, forward -15-01, 14-01, 13-01	4130 steel plate MIL-S-18729 (annealed)	Rough machine -15-01 to approximate configuration; GTA weld details, -14-01 and 13-01; heat treat per MIL-H-6875 to 140,000/160,000 psi ultimate; final machine to print, 100% MPI
C11214	Conduit, tube	4130 steel tubing per MIL-T-6736	Outside procurement; trim to length; form contour to print.
511224	Weldment, fuel tank (-01-01 assembly)	As described in part numbers below: C11204 longeron C11201 closure, aft C11203 ring, forward C11206 shell, cylindrical C11202 closure, forward C11207 shell, forward	GTA fusion weld (fillet) longeron to C11203 forward ring and GTA butt weld aft closure to longeron; 100% MPI; assemble two each C11214 conduits in cylindrical shell subassembly; fillet weld to aft closure.
		G11214 conduit, tube	GTA fusion girth weld Cll207 forward shell to Cll202 forward closure to make forward tank subassembly; 100% MPI.
			Assemble C11206 cylindrical shell over longeron assembly and CTA fusion weld longitudinal and girth seams; 100% MPI.
			GTA fusion girth weld forward tank subassembly to cylindrical shell subassembly; fillet weld conduit tubes.
X			GTA fusion weld -11-01, -12-01, -13-01, -14-01, and -15-01 of G11224 to G11202 forward closure; 100% MPI.
			Stress-relief C11224 fuel tank weldment; 100% MPI welds.
			Clean, degrease, machine final closure bolt hole details, hydrotest.

* Materials and processes used to fabricate ground test units and flight test units; not necessarily the final approach based on design-to-cost.

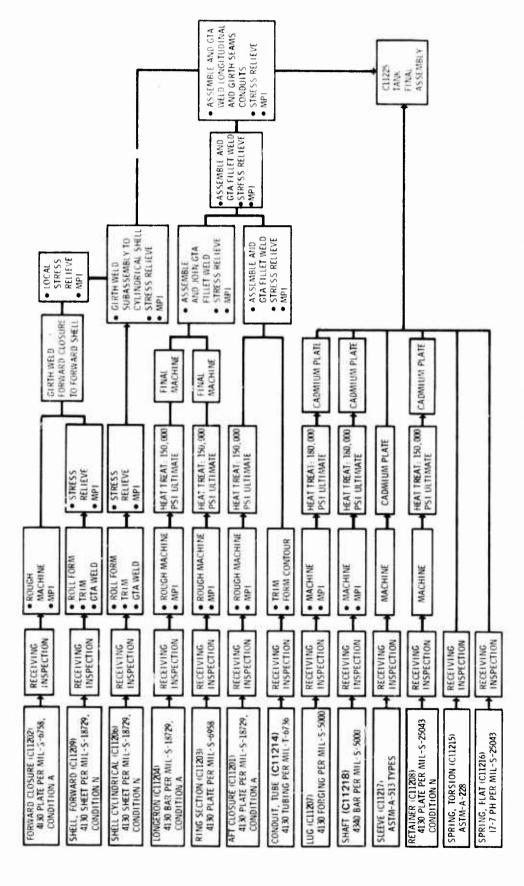


FIG. 5-1. GORJE Ground Test Unit/Flight Test Unit Manufacturing Process Flow Plan.

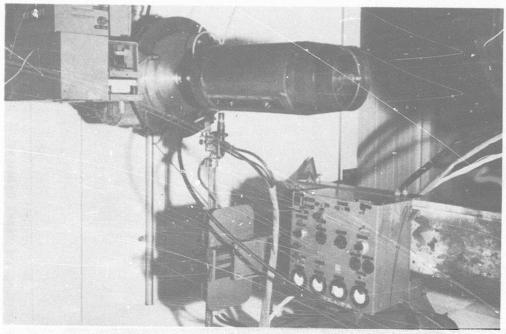


FIG. 5-2. Final Weldment in Semi-Automatic Welder.

These items, fabricated from 4130 steel tubing per MIL-T-6739, were trimmed to length and formed to print contour dimensions.

Fuel tank assembly of the components described above was accomplished by the following weldment procedures:

- 1. The C11214 conduits were GTA fillet welded to the aft closure, stress relieved, and magnetic particle inspected. Then the C11204 longeron was GTA fusion (fillet) welded to the C11203 forward ring and the C11201 aft closure (with conduits) was GTA fusion butt welded to the longeron using the weld tooling designed and fabricated for this purpose. This weldment subassembly, consisting of forward ring, longeron, aft closure, and conduits, is shown in Fig. 5-3(A).
- 2. The C11209 forward conical shell was GTA fusion girth welded to the C11202 forward closure, stress relieved, and 100% magnetic particle inspected after welding. The conical shell/forward closure subassembly was GTA fusion girth welded to the C11206 cylindrical shell, stress relieved after welding, and 100% magnetic particle inspected. This weldment subassembly, consisting of forward closure, conical shell, and cylindrical shell, is shown in Fig. 5-3(B).

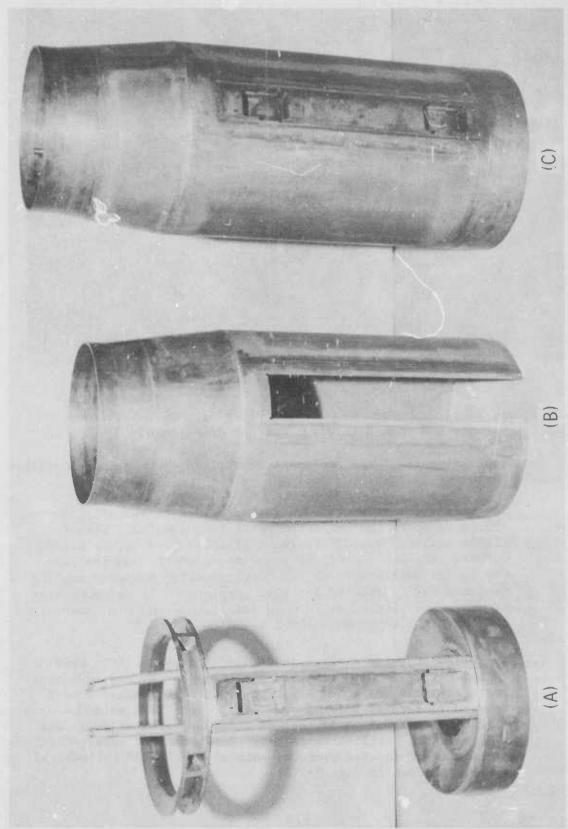


FIG. 5-3. Aft Subassembly, Forward Subassembly, and Final Weldment.

3. Subassembly A (above) was GTA fusion girth welded to subassembly B (above) at the cylindrical shell/aft closure interface, and between the cylindrical shell and the longeron. The conduit tubes were also fillet welded at the forward closure interface. These welding operations are shown in process in Fig. 5-2. Stress relief and 100% magnetic particle inspection of the completed tank weldment was conducted subsequent to completion of all welding operations. The completed weldment is shown in Fig. 5-3(C).

The tank weldment assembly was final machined to incorporate the bolt hole patterns on each closure, the aft closure flange interface for the collector pipe assembly, and the final details on the forward closure instrumentation mounting bosses. Final tank assembly operations consisted of degreasing, cleaning, hydrotest, and inspection.

The tank suspension lug assembly consists of lug, shaft, sleeve, torsion spring, lock spring, retainers, and attach bolts and washers. These components in the assembled configuration are shown in Fig. 3-5. The C11207 lug was machined from a standard 1,000-pound stores suspension lug, 4340 steel forging per MIL-S-5000 (normalized). After machining, the lug was heat treated per MIL-H-6875 to 180,000/200,000 psi ultimate, magnetic particle inspected, and cadmium plated. The suspension lug shaft (C11218) was machined from 4340 steel bar per MIL-S-5000 (normalized), heat treated per MIL-H-6875 to 180,000/200,000 psi ultimate, magnetic particle inspected, and cadmium plated. The sleeve (C11217) was machined from ASTM A-513 mild steel tubing and cadmium plated. The torsion spring was manufactured from ASTM A-228 phosphate coated steel wire by a spring subcontractor. The flat lock spring (C11216) was manufactured from 17-7 PH steel plate per MIL-S-25043 (annealed) and heat treated to condition C950 per MIL-H-6875 by a spring subcontractor. The lug retainers were machined from 4130 steel plate per MIL-S-18729 (normalized), heat treated per MIL-H-6875 to 140,000/160,000 psi ultimate, magnetic particle inspected, and cadmium plated per QQ-P-416.

Expulsion Bladder

Fabrication of the bladder is displayed in the flow diagram (Fig. 5-4). The mandrel washout plaster is prepared with a contour simulating the inside configuration of the bladder. Two plies of the nitrile-coated nylon fabric are vulcanized to the forward and aft bladder flanges between the main attach rings and compression ring. These bonded plies are separated during vulcanization so that the main body plies may be interlocked with them during layup of the bladder.

These forward and aft flanges with bonded flaps are fitted to each end of the washout mandrel and the mandrel surface (excluding flanges) is coated with a release agent. The fittings are prepared and cleaned to facilitate bonding to the bladder. Before being applied to the mandrel, the nylon fabric is swab coated with a thin film of uncured nitrile rubber. Patterns of the fabric are cut to shape from the sheet

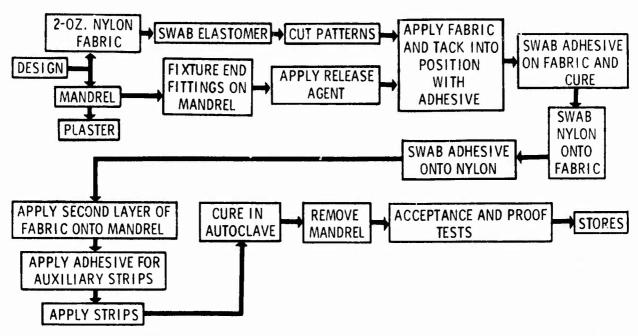


FIG. 5-4. Bladder Fabrication Flow Sheet.

stock, including the stiffener ring and strongback depressions in the mandrel and the main body of the bladder. The patterns at the dome areas are shaped to interlock for added strength. The cut patterns are overlapped a minimum of 1 inch and held in place with a nitrile conversion adhesive. The mandrel is fully covered with one ply of the coated fabric and coated with the adhesive conversion coating. After the adhesive sets, nylon is swabbed onto the entire surface to a minimum 3-mil thickness. Adhesive is again applied and a second layer of fabric applied in the same manner as was the first layer, except that the joint areas are staggered. The longitudinal strips and reinforcements are then applied to complete the assembly.

Curing is accomplished in a steam autoclave at about 60 psi, 290°F for 3 hours. The plaster mandrel is then washed out for removal from the bladder.

Collector Pipe

The collector pipe assembly was designed to use standard off-the-shelf materials and components to provide low cost processing and minimum lead time procurement. Fabrication and operations were coordinated among CSD Manufacturing, Quality Control, and Vendor Liaison departments to assure conformance to design requirements within required delivery schedules.

The collector pipe assembly (see Appendix B, Fig. B-11) consists of (1) the collector pipe, (2) gas generator housing, (3) mounting flange, and (4) forward annulus. The fabrication approach for these components for the ground test unit and flight test units is discussed below.

- 1. Outer Pipe. Standard weld drawn tubing of 304SS 3-inch OD by 0.065-inch wall, was procured in accordance with MIL-T-8506. The tubing was cut to length, the ends faced, drilled as necessary with 3/16-inch-diameter holes through the wall, cleaned, and stored for subsequent assembly.
- 2. <u>Gas Generator Housing.</u> Standard weld drawn tubing of 304SS 2-5/8-inch OD by 0.049-inch wall, was procured in accordance with MIL-T-8506. The tubing was cut to length, the ends faced, then cleaned, and stored for later assembly.
- 3. Mounting Flange. The mounting flange was machined to drawing configuration from 3/4-inch-thick 304SS plate stock. The mounting flange hole pattern was drilled using the same master pattern as for the aft closure of the fuel tank. The flange was then cleaned and stored for later assembly.
- 4. <u>Closures.</u> The annulus closure was machined from 3-1/8-inch OD by 2-3/8-inch ID 304SS tubing. The gas generator closure was machined from 3-inch-diameter bar stock parted in lengths of 1/2-inch. The standoff was integral with the closure.

The collector pipe assembly sequence is shown in the flow chart of Fig. 5-5. Basically, the assembly is a weldment of the previously described subcomponents. All welds were X-rayed, fluorescent penetrant inspected, and leak checked to ensure a 100% seal.

PRODUCTION TANK MANUFACTURING

Manufacturing options considered for the production tank configuration are listed in Table 5-2. Design changes to the ground test unit/ flight test unit configuration required to meet the flightweight production goal of 44 pounds are listed in Table 5-3.

Bladder

Expulsion bladder fabrication requires the same steps for development as for production; only the methods employed differ. Fabric patterns are hand cut for small quantities whereas automated die cutting is used in production lots. In production, the application of the nitrile to the nylon is automated. Multiple mandrels are processed for production. The hand layup is one constraint; however, it is required in production as well as in development, although jigs and fixtures are used extensively on production to reduce handling time.

Tank Structure

Fabrication materials and fabrication processes for the production tank are described in Fig. 5-6 and in Table 5-4. Some of the processes recommended for production were eliminated during fabrication of the ground test unit and the flight test unit because of the prohibitive

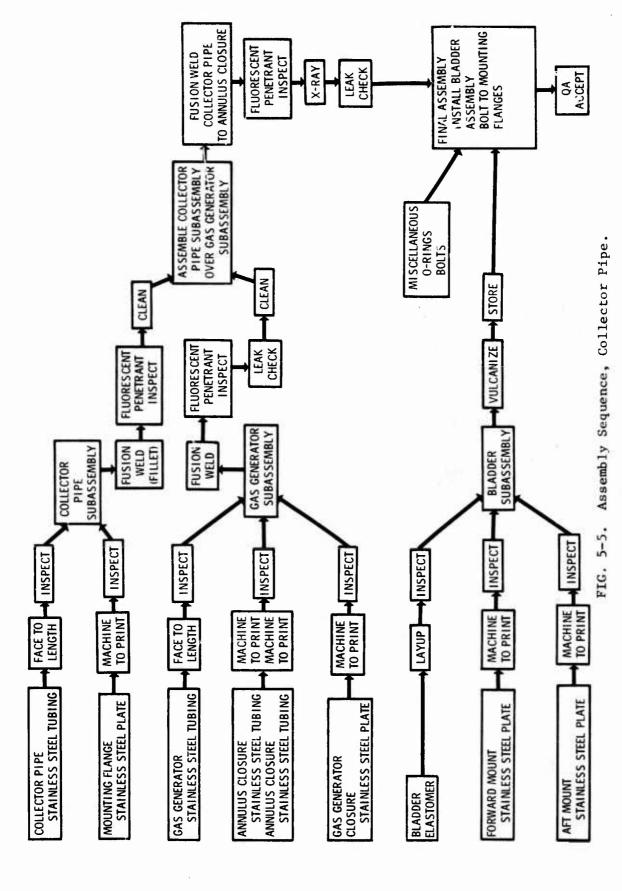


TABLE 5-2. Manufacturing Options for Production Tank Configuration.

Part Number	Manufacturing Options
C11206 Shell, cylindrical	Roll and weld sneet Power (shear)spin cylinder Machined seamless or mechanical tubing Machined forging
C11201 Closure, aft	Machined from forged bar (round) Closed die forged and machined Either the first option or the second with roll and weld skirt Casting
C11203 Ring, forward	Weldment (plate) Forging (die or ring) Extrusion (flash welded ring or doubler) Rolled bar (flash welded ring or doubler) Casting
C11204 Longeron	Weldment Forging (die) Casting Powder Metallurgy
C11202 Closure, forward C11209 Shell, conical	Forged head and skirt welded to roll and weld commanual spum head and come welded to skirt Head and skirt machined from plate welded to roll and weld come Hydroformed head and come welded to skirt Deep drawn head and come welded to skirt Power (shear) spum using die forged or machined preform (no welds) Casting

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TABLE 5-3. GORJE Weight Summary:

Component	Ground Test Unit/Flight Test Unit, 1b (Estimated)	Flight Production, 1b	Remarks
Longeron (C11204)	7.8	7.29	Add holes along neutral axis
Ring (C11203)	4.5	3.67	Asymmetrical casting
Closure, forward (C11202)	6.7	6.27	Reduce wall thickness
Closure, aft (C11201)	10.8	10.1	Reduce wall thickness
Cylinder (C11206) Conical (C11209)	14.7	12.8	Reduce thickness to 0.05 in.
Suspension lug components	2.0	2.0	Minimum weight design
Conduits (C11214)	1.0	1.0	Fixed by NWC requirement
Total (actual)	47.5	44.0	

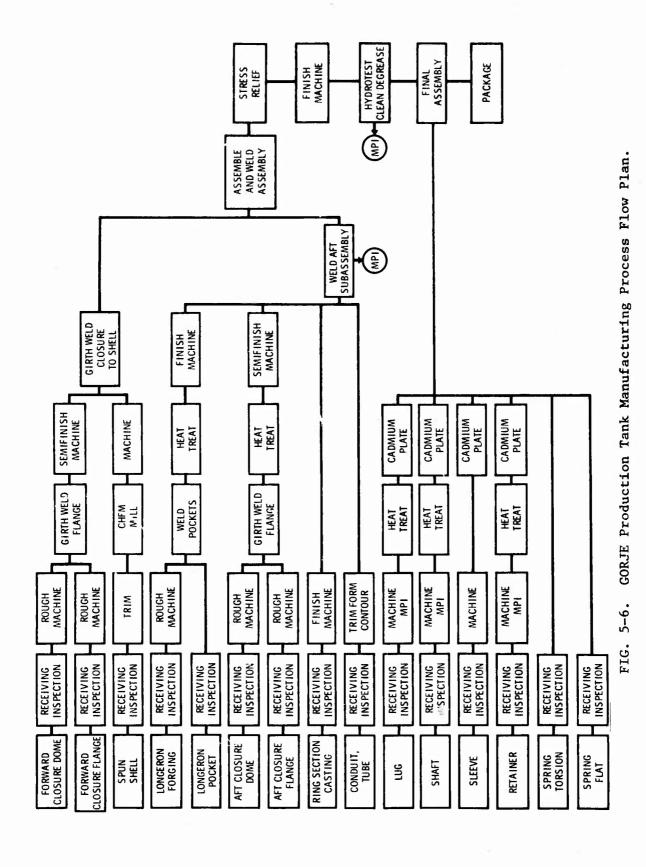


TABLE 5-4. Material and Processes, GORJE Fuel Tank Production Unit.

Part No.	Item	Material	Fabrication Process
C11207	Lug	4340 steel forging MIL-S-5000 (normalized)	Machine; heat treat per MTL- H-6875 to 180,000/200,000 psi ultimate; MPI, cadmium plate.
C11218	Shaft	4340 bar per MIL-S-5000 or 4130 bar, MIL-S-6758 (normalized)	Machine; heat treat per MIL- H-6875 to 180,000/200,000 psi ultimate; MPI; cadmium plate, QQ-P-416.
C11217	Sleeve	ASTM A-513 (type 5) (C1010/1020 mild steel tubing)	Machine length, cadmium plate, QQ-P-416.
C11215	Spring, torsion	ASTM A-228 steel wire phosphate coated	Outside procurement per print.
C11216	Spring, lock	17-7 PH sheet per HIL- D-25043 (annealed)	Outside procurement per print.
C11208	Retainer	4130 steel plate per MIL-S-18729 (annealed or normalized)	Machine; heat treat per MIL- E-6875 to 140,000/160,000 psi ultimate; MPI; cadmium plate, QQ-P-416.
C11210	Collector pipe assembly (-11-01, -12-01, snd -13-01 closures) (-14-01, -15-01 tubing)	304 stainless steel plate QQ-S-766 304 stainless steel tubing MIL-T-8506	Rough machine closure and tubing details; GTA fusion welds; fluor- escent penetrant inspect welds/ final machine to print.
C11202	Closure, forward	4130 steel plate MIL-S- 18729 (annealed) 4130 steel forging MIL- S-6758 (annealed)	Rough machine dome forging and flange; GTA fusion weld; final machine.

TABLE 5-4. (Contd.)

Part No.	It es	Material	Fabrication Process
C11209/ C11206	Shell conical/ cylindrical	4130 steel plate MIL-8-18729 (normalized)	Sheet blank trimmed to size; roll and weld; spin to shape; tris; chem mill; final machine to print.
C11201	Closure, aft	4130 steel plate MIL-S- 18729 (annealed) 4130 steel forging MIL- S-6758 (annealed)	Rough machine doma forgin, and flange; GTA funion weld; heat treat per MIL-H-6875 to 140,000/150,000.psi ultimate; final machine to print.
C11204	Longeron	4130 forging MIL (annealed) 4130 powder metallugy formed pocket	Rough machine longeron forging; CTA weld punch load webs; CTA weld pocket; heat treat per MIL- E-6875 to 140,000/160,000 pei ultimate; final machine to print
C11203	Ring, foward	4330 steel casting MIL-S-15083; heat treated per HIL-M-6875 to 140/150 ksi ulti-mate	Final machine to print.
C11214	Conduit, tube	4130 steel tubing per HIL-T-6736	Outside procurement to trim length; form contour to print.
C11224	Weldment, fuel tank (-01-01 assembly)	As described in part numbers below: C11204 longeron C11201 closure, aft C11203 ring, forward C11206 shell, conical C11207 shell, cylindrical	GTA fusion weld (fillet) C11204 longeron to C11203 forward ring and GTA butt weld aft closure to longeron; assemble two each C11214 conduits; fillet weld to aft closure to make aft tank subassembly; 100% MPI.

TABLE 5-4. (Contd.)

C11224, contd.	C11202 closure, forward C11214 conduit, tube	GTA fusion girth weld Cl1206/ Cl1207 shell, conical/cylind- rical, to Cl1202 forward closure to make forward tank subassembly. Assemble forward tank sub- assembly GTA fusion weld longi- tudinal and girth seams; fillet weld conduit tubes.
		Stress-relief C11224 fuel tank weldment; 100% MPI welds.
		Clean; degresse; machine final closure interface diameter and bolt hole details; hydrotest.

cost of tooling for these processes. The significant material changes recommended for production lots, nominally in excess of 500 units, are as follows: (1) closures fabricated from a net forged dome with a welded flange; (2) tank shell (conical and cylindrical section) shear spun as a single detail and chemically milled to achieve the 0.090 to 0.060 transition in the area of the longeron; (3) a cast variable cross-section sway brace ring; and (4) a forged or extruded longeron with welded load webs and welded powder metallurgy formed lug pockets. These processes, particularly the chemical milling and the powder metallurgy-formed lug pockets, will require some additional development.

The production collector pipe will be fabricated from 304 stainless steel tubing. The outer pipe will be machined from 3.0-inch OD by 0.035-inch wall tubing and the gas generator housing (inner pipe) from 2.625-inch OD by 0.049-inch wall tubing.

The collector pipe mounting flange (C11210-11-01) and gas generator forward clspure (C11210-12-01) will be machined from either casting or forging stock instead of plate to minimize machining requirements. The annulus closure (C11210-13-01) will be machined from 3 1/8-inch OD by 2 3/8-inch ID tubing. All other manufacturing operations will be the same as used for the flight test collector pipe fabrication.

PRODUCTION TANK MANUFACTURING COST ANALYSIS

A manufacturing cost analysis was conducted for the production tank configuration.

Expulsion Bladder

Subcontract manufacturing costs were acquired for manufacture of the nylon reinforced nitrile expulsion bladder. Cost tradeoffs were made for the following design deletions.

- 1. Removal of external strips that assist in bladder venting.

 The bladder can probably be used minus venting strips without causing a performance penalty.
- 2. Removal of the circumferential depression used to accommodate the sway brace ring and the longitudinal depression used to accommodate the longeron and raceway tubes. Development testing has indicated that the bladder will probably bridge these areas without failure during flight loads. However, a 3% to 5% decrease in volumetric efficiency can be expected.
- 3. Removal of metallic polar fittings. The metallic polar fittings could be replaced with fittings used to sandwich the bladder to the collector pipe during assembly; however, a decrease in reliability in regard to a potential leakage at the polar interface can be expected.

A cost summary for the baseline bladder and the three options is shown in Table 5-5.

Tank Metal Structure

The manufacturing cost analysis for the metal tank structure and collector pipe is presented in Tables 5-6 through 5-27.

Cost trades were made in the following areas:

Forward Closure. A comparison of Tables 5-6 and 5-7 shows that the forged closure with welded ring is a lower cost manufacturing approach than a one-piece forged ring closure.

TABLE 5-5. Bladder Cost Summary (Including Tooling).

Bladder	No. of	Units (Cost	/Unit) \$
Configuration	500	1,000	2,000
Baseline bladder	710	680	673
No venting strips	695	665	658
No depressions	682	652	645
No polar fitting	625	595	588
All deletions included	582	552	545

Aft Closure. A comparison of Tables 5-8 and 5-9 shows that a forged aft closure with welded flange is a lower cost manufacturing approach than a one-piece forged ring closure.

Longeron. A comparison of Tables 5-10 and 5-11 shows that a forged bar longeron with welded powder metallurgy pocket is a lower cost manufacturing approach than a longeron machined from bar stock, even though the initial tooling cost is much higher.

Sway Brace Ring. A comparison of Tables 5-12 and 5-13 shows that a cast and heat treated sway brace ring is a lower cost manufacturing approach than a forged ring.

Tank Skin. Four approaches were analyzed for the tank skin fabrication, as shown in Tables 5-14 through 5-17:

- 1. Spun section with chemical milled stiffener
- 2. Spun section with welded stiffener
- 3. Rolled and welded section with welded stiffener
- 4. Rolled and welded section with chemical mill stiffner

The spun section with chemical milled stiffener is the lowest cost manufacturing approach for 500 or more units. The spun section with welded stiffener section is less expensive for 50 or less units.

Miscellaneous Hardware. Costs per tank for miscellaneous hardware including suspension lugs are presented in Table 5-18.

Forward, Aft, and Final Assembly Weldments. Unit costs for forward, aft, and final assembly weldments are shown in Tables 5-19 through 5-21.

Final Machining. Final machining unit costs are shown in Table 5-22.

Collector Pipe. Manufacturing costs for the collector pipe are shown in Table 5-23.

Tooling. The unit tooling costs for the tank and collector pipe are summarized in Table 5-24. These costs are detailed in previous tables.

Tank Manufacturing Materials and Labor. A summary of tank unit material and labor requirements is presented in Table 5-25. The labor requirements, converted into dollars at \$25/hour for manufacturing and \$30/hour for engineering and quality support, are summarized in Table 5-26.

Total unit costs including labor, materials, and tooling are presented in Table 5-27.

Tank Assembly Cost. Total tank assembly unit costs including the baseline bladder configuration and collector pipe are as follows.

No. of Units	50	500	1,000	2,000
Assembly unit cost, \$	5,767	2,576	2,247	1,943

These costs represent a 44-pound tank with a 76-pound TH-Dimer fuel capacity.

The effect of tank weight on cost has been analyzed for the following conditions:

- 1. Use of 1020 mild steel for the tank shell
- 2. Use of 1020 mild steel for the complete tank assembly
- 3. Use of net forged closures and longeron with no contour finish machining
- 4. Use of constant cylindrical shell thickness in conjunction with 2 above.

All of these changes will result in a weight increase over the baseline design. Lighter tank configurations were not analyzed because the baseline design incorporates all practical approaches to weight reduction without the use of exotic materials or manufacturing processes with attendant large increase in manufacturing costs.

Use of the 1020 mild steel for the tank shell will result in a 10% increase in tank weight with a negligible decrease in materials and manufacturing costs.

Use of the 1020 mild steel for the complete tank assembly will increase tank weight over 100% with a reduction in manufacturing cost of less than 10%.

Use of 4130 steel forward and aft closures and longeron in the net forged condition will result in a tank weight increase of over 50% with less than a 10% reduction in manufacturing costs.

Use of a constant tank shell thickness (no chemical milling) will result in a tank weight increase of 15% to 20% with a manufacturing cost reduction of less than 2%.

Examination of these options shows that the possible methods of manufacturing cost reduction are not worth the weight penalty.

An increase in tank volume over the baseline design can be achieved by increasing the ellipse ratio of the closures. The maximum possible volume increase with flat closures will result in a volume increase of less than 3% with a negligible cost increase; however, a large increase in tank weight will result. The baseline design is considered optimum from the cost versus volume standpoint. The effect of bladder volume versus cost is discussed at the beginning of this section.

TABLE 5-6. Forged Forward Closure with Welded Flange.

			of Units	
	50	500	1,000	2,000
Tooling, \$ Lathe fixture, ring	006	006	006	006
Lathe fixture, dome	800	800	800	800
Weld fixture	1,500	1,500	1,500	1,500
Forging tooling	6,500	6,500	6,500	6,500
Drill fixture	700	700	700	700
Total	10,400	10,400	10,400	10,400
Unit cost	208	20.80	10.40	5.20
Material, \$				
Dome forging	. 42.56	38.59	36.75	35.00
Ring	5.00	2.00	5.00	2.00
Total	47.56	43.59	41.75	40.00
Labor, hr	166	1,166	2,100	3,779
Weld preparation, ring Weld preparation, dome				
Weld assembly Semi-finish machine				
Drill pilot holes	,	•	,	(
Total	991	1,166	2, 100	3,779
Unit cost				
Material and tooling, \$	255,56	64.39	52.15	45.20
Labor, hr	3.32	2.33	2.10	1.89
Total & Total &	338.56	122.69	104.65	92.44
TOLOTT	20000			

250 250 250 250 250 900 700 2,600 1.30 12,598 12,598 39.51 6.30 157.47 196.98 38.21 38.21 2,000 250 250 250 250 250 700 700 2,600 2,60 7,000 40.81 7.00 175.20 216.01 1,000 7,000 38.21 38.21 No. of Units Forward Closure with Forged Ring. 2,600 5.20 43.41 7.78 194.00 237.41 250 250 250 250 250 900 700 3,888 3,888 38.21 38.21 500 250 250 250 250 250 900 700 2,600 91.84 11.04 276.00 369.84 551 551 20 TABLE 5-7. Labor, hr Material and tooling, \$ ID template, rough . . ID template, finished OD template, finished OD template, rough. Labor, nr Labor at \$25/hr, \$ Forged ring . . . Total . . . Unit cost . . Total . . . Machine OD (20) Machine ID Lathe fixture Drill fixture Total . . Drill holes Total, \$ Labor, hr Material, \$ Tooling, \$ Unit cost

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		No of	F 1125 40	
	50		1	2,000
F				
TD template, rough	250	250	250	250
OD template, rough	250	250	250	250
	250	250	250	250
	250	250	250	250
a	006	006	006	006
Drill fixture	700	700	200	700
Total	2,600	2,600	2,600	2,600
Unit cost	52	5.20	2.60	1.30
material, 9	61 7.0	50 73	50 73	50 73
Forging	10	10	6	8
Total	71.40	69.73	68.73	67.73
Labor, hr Machine OD (20)	551	3,888	7,000	12,598
Machine ID				
Drill holes	551	3,888	7.000	12,598
IOCAL	1			
Unit cost	7 261	£6 7L	71, 33	69,03
Taker hr	11.04	7.78	7.00	6.30
Labor at \$25/hr. \$	276.00	194,00	175.00	157.47
Total, \$	399.4	268.93	246.33	226.5

TABLE 5-8. Aft Closure with Forged Ring.

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Tooling, \$ So	TABLE 5-9. Forged Aft Closure with Welded Flange.	with Weld	ed Flange.		
ring. 900 900 900 dome. 1,500 1,500 1,500 1,500 1,500 1,500 1,500 1,500 1,500 1,500 1,500 1,500 1,500 1,500 1,500 1,500 1,500 1,500 5,800 1,500 1,500 1,500 5,800 1,500 1,500 1,500 3,334 1,000 1,100 1,100 1,100 1,100 1,100 1,100 1,100 1,100 1,100 1,100 1,100 1,100 1,100 1,100 1,100 1,100 1,100 1,100 1,100 1,100 1,100 1,100 1,100 1,100 1,100 1,100 1,100 1,100 1,100 1,100 1,100 1,100 1,100 1,100 1,100 1,100 1,100 1,100 1,100 1,100 1,100 1,100 1,100 1,100 1,100 1,100 1,100 1,100 1,100 1,100 1,100 1,100 1,100 1,100 1,100 1,100 1,100			oĘ	Inits	
ring. 900 900 900 900 900 900 900 900 900 9		50	200	1,000	2,000
ring. 900 900 900 900 900 900 900 900 900 9	Tooling, \$				
dome		. 900	006	006	006
1,500 1,500 1,500 1,500 1,500 1,500 1,500 5,800 5,000 5,000 5,000 5,000 5,000 5,800 5,000 5,800 5,000 5,800 5,000 5,800		800	800	800	800
5,800 5,800 5,800 5,800 5,800 5,800 5,000 5,000 5,000 5,700		1,500	1,500	1,500	1,500
700 700 700 700 700 700 700 9,		, 800	5,800	5,800	5,800
9,700 9,700		700	200	200	200
194 19.40 9.70 57.89 55.14 53.34 5.00 5.00 5.00 5.00 5.00 62.89 60.14 58.34 6.1166 1,166 2,100 6.256.89 79.54 68.04 6.256.89 79.54 68.04 6.256.89 79.54 68.04 6.256.89 79.54 68.04 6.256.89 79.54 68.04 6.256.89 79.54 68.04 6.256.89 79.54 68.04 6.256.89 79.54 68.04 6.256.89 79.54 68.04 6.256.89 79.54 68.04 6.256.89 79.54 68.04 6.256.89 79.54 68.04 6.256.89 79.54 68.04 6.256.89 79.54 68.04 6.256.89 79.55		,700	9,700	9,700	9,700
ine es ine es oling, \$ \$ 57.89		194	19.40	9.70	4.85
57.89 55.14 53.34 5.00 5.00 5.00 5.00 5.00 5.00 5.00 5.00 5.00 5.00 5.00 5.00 n, ring (6) 1,166 2,100 ine 1,166 2,100 es 1,166 2,100 oling, \$ 3.32 2.33 2.10 \$ \$ 58.30 52.50 \$ \$ 137.84 120.54 1	Material, \$				
ine 166 1,166 2,100 oling, \$ 256.89 79.54 68.04 oling, \$ 332 2.33 2.10 ine 256.89 79.54 68.04 oling, \$ 332 2.33 2.10 ine 332 2.33 2.10 ine 1,166 2,100 2.10 ine 1,166 1,166 2,100 ine 1,166 1,100 ine 1,166 1,166 1,100 ine 1,166 1,100 1,100 ine 1,100 1,100 1,100 ine	oniz	1.89	55.14	53.34	50.00
ine ine es ine en ine e		5.00	5.00	5.00	2.00
ine ine es oling, \$ \(\text{ing } (6) \) \(\text{ine} \) oling, \$ \(\text{ine}					
ine ine es oling, \$ oling, \$ vistal and a serial content of the		12.89	60.14	58.34	55.00
ine ine es oling, \$		221	221.	001	077 6
aration, dome mbly h machine ot holes and tooling, \$	Labor, hr	700	00161	7,100	5,113
mbly h machine ot holes . 166 1,166 2,100 . 256.89 and tooling, \$ 256.89 3.32 2.33 2.10 \$25/hr, \$ 339.89 137.84 120.54	Weld preparation, dome				
h machine ot holes 1,166 2,100 2,56.89 79.54 68.04 3.32 2.33 2.10 52.50 \$\$25/hr, \$\$	Weld assembly				
ot holes 1,166 2,100 and tooling, \$ 256.89 79.54 68.04 \$25/hr, \$ 2.33 2.10 \$25/hr, \$ 339.89 137.84 120.54	Semifinish machine				
and tooling, \$	Drill pilot holes				
and tooling, \$	Total	166	1,166	2,100	3,779
and tooling, \$					
256.89 79.54 68.04 3.32 2.33 2.10 83.00 58.30 52.50 339.89 137.84 120.54	Unit cost				
25/hr, \$		68.99	79.54	68.04	59.85
;25/hr, \$		3.32	2.33	2.10	1.89
	25/hr, \$	33.00	58.30	52.50	47.24
		68.6	137.84	120.54	107.09

TABLE 5-10. Longeron, Powder Metallurgy Pocket/Forged Bar.

		No. of Units	Units	
	20	500	1,000	2,000
Tooling, \$	1,000	1,000	1,000	1,000
Pocket mold dies	20,000	20,000	20,000	20,000
Total	21,600	21,600 43.20	21,600 21,60	21,600 10,80
Material, \$ Bar forging	07	40	40	40
Heat treat	10	10 51	10 51	10
Labor, hr Machine assembly	137	972	1,750	3,149
Weld pocket Finish mill pocket Drill holes Total	137	972	1,750	3,149
Unit cost Material and tooling, \$	483.00	94.2 1.94	72.60	62.80
Labor at \$25/hr, \$	68.50 551.5	48.60 142.80	43.75 116.35	39.36 102.16

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78.05 15.75 394.00 471.73 2,000 1,000 500 600 2,100 1.05 31,494 77 31,494 79.10 17.49 437.42 516.52 1,000 500 600 2,100 2.10 17,497 1,000 17,497 No. of Units 81.20 19.44 486.00 567.20 9,720 9,720 1,000 500 600 2,100 4.20 77 TABLE 5-11. Longeron, Machined Bar Stock. 500 27.58 27.58 689.50 808.50 1,379 1,000 500 600 2,100 42.00 1,379 77 20 Material and tooling, Labor at \$25/hr, Labor, hr Total, \$. . Lathe fixture Labor, hr . . . Drill jig . . Total . . Mill fixture Unit cost Weld Total. . Bar . . . Total Material, \$ Tooling, \$ Unit cost Turn Drill M111

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TABLE 5-12.	Ring Casting.			
		No. of	of Units	
	50	500	1,000	2,000
Tooling, \$ Lathe fivture	007	006	006	006
Casting tooling	5,490	5,490	5,490	5,490
Total	6,390 127.80	6,390 12.78	6,390 6,39	6,390 3,20
Material, \$ Casting (heat treated)	138.60 138.60	125.70 125.70	119.70	114.00
Labor, hr	14	6	175	314
Deburr Total	14	26	175	314
Unit cost Material and tooling, \$	266.40 0.28 7.00 273.40	138.48 0.194 4.85 143.33	126.09 0.175 4.38 100.47	117.20 0.157 3.93 121.13

40.55 5.20 129.91 170.46 2,000 900 1,200 2,100 1.05 30.50 39.50 10,080 314 10,394 1,000 900 1,200 2,100 2.10 39.50 39.50 5,600 5,775 41.60 5.77 144.35 185.95 No. of Units 39.50 39.50 3,110 97 43.70 6.42 160.39 204.09 900 1,200 2,100 4.20 3,207 500 Ring, Forged. 81.50 9.10 227.60 309.10 900 1,200 2,100 42 39.50 39.50 455 441 14 20 TABLE 5-13. Labor, hr Labor at \$25/hr, \$. . Material and tooling, Machine OD (16) . . Drill holes (5) . . Total Unit cost. . . Drill fixture . . Total. . . . Total . . . Lathe fixture. Material, \$ Forge ring Tooling, \$ Deburr Unit cost Labor, hr

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		No. of	of Units	
	50	500	1,000	2,000
Tooling, \$ Spinning (fooling and setup)	1.200	1,200	1,200	1,200
Mask (5)	6,250	12,500	12,500	12,500
End plugs (5)	2,500	2,000	2,000	5,000
Baskets	500	19,000	1,000	000.1
Unit cost	203	39.40	19.70	9,85
Material, \$				
Sheet stock 0.090	30	30	30	30
Total	30	30	30	OS
Labor, hr		C	Ç	,
Mask	çç	388	00/	1,260
Chem mill				
Cut slot Total	55	388	200	1,260
Unit cost Material and tooling, \$	239	04.69	49.70	39,85
Labor, hr	1.10	0.78	0.70	0.63
Labor at \$25/hr, \$	27.59	19.44	17.50	15.75
Total, \$	266.59	88.84	67.20	55.60

TABLE 5-14. Skin-Spun Section, Chem Mill Stiffener.

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1.10 27.56 96.41 1,200 2,500 3,700 1.85 2,205 68.85 2,000 70.70 1.23 30.75 101.45 1,000 1,200 2,500 3,700 3.70 1,225 1,225 47 17 3 67 No. of Units 500 1, TABLE 5-15. Skin-Spun Section, Welded Stiffener. 75.40 1.36 34.00 109.90 1,200 2,500 3,700 7.40 48 17 3 58 680 680 146 1.94 48.50 194.50 52 17 3 1,200 2,500 3,700 74.00 97 97 50 Spinning (tooling and setup) Material and tooling, \$ Unit cost Total Sheet stock 0.060 Sheet stock 0.090 Labor, hr Cut slot Weld fixture . . Total Labor, hr ... Labor at \$25/hr, Spun cylinder Total, \$ Total . Material, \$ Tooling, \$ Unit Cost

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		2,000	200	009	1,200	2,000		20	3	23	6,299				***************************************		6,299	`	36	0 1	3.T5	10.74	104./4
	Units	1,000	200	009	1,200	2,000 2.00		20	æ	23	3,499						3,499		25		3.50	07.01	112.48
1 Stiffener.	No. of		200	009	1,200	2,000		20	က	23	1,940						1,940		7.6	100	3.88	10.76	124.05
Skin-Roll and Weld, Welded Stiffener.		50	200	009	1,200	2,000 40		20	3	23	276						276		63) (C	5.52	201.00	201.00
TABLE 5-16. Skin-Roll an			Tooling, \$	Weld fixture, circumferential	Weld Fixture, longitudinal	Total	Material	Sheet stock 0.063	Sheet stock 0.090	Total	Labor, hr	Shear Stock (IU) Trim Stock	Weld cone	Weld cylinder	Weld cone/cylinder	Cut Slot Weld atiffener	Total		Material and tooling S	0	Tahor at 625/hr 6		10tal, \$

TABLE 5-17. Skin-Roll and Weld, Chem Mill Stiffener.

		No. of U	Units	
	50	500	1,000	2,000
Tooling, \$				
template	200	200	200	200
fixture,	900	900	000	1 200
Weld fixture, longitudinal	1,200	12,500	12,500	12,500
End plugs	2,500	5,000	5,000	5,000
Daskets	11,250 225	20,500 41.00	20,500 20,500 20,50	20,500 20,500 10.25
Material, \$				
Sheet stock 0.090	30	9 9	30 30	30
Labor, hr				
Shear stock (12)	331	2,333	4,199	7,559
Weld cone				
Weld cylinder				
Trim Chem: mill				
Cut slot		c	000. 7	7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7
IOCAL	TCC	6,555	667.4	60061
Unit cost				
Material and cooling, \$	255.00	71.00	50.50	40.25
Labor, nr	165 50	10.4	70.70	0 / · / 0
Labor at \$25/hr, \$	420.50	187.75	155.50	134.73

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		No. o	of Units	
	100	J		4,000
S out Lock				
Conduit bending, apply fixture	750	750	750	750
Log holding fixture (mill)	500	200	200	200
Retainer holding fixture (mill)	200	200	200	200
Shaft holding fixture (mill)	500	2.250	2.250	2,250
Total	22.50	2,25	1,13	0.57
Conduit (2):4130 steel tubing per MIL-T-6736	3,75	3.75	3,75	3.75
L-S-5000	3.00	3.00	3,00	3.00
Retainer (4) per tank; 4130 steel per MIL-S-18729 · · ·	0.50	0.50	0.50	0.30
Torsion spring (2): subcontract spring manufacturer · · ·	0.40	07.0	0.40	0.40
Flat spring (2); subcontract spring manufacturer · · ·	0.40	0.40	0.40	0.40
Total	8.15	8.15	8.15	8.15
Labor, hr	332	2,096	3,779	7,560
Drill/mill lug (6) Form conduit				
Face and mill shaft				
Mill retainers				
Face sleeve	337	900 6	3 779	7 560
Total	300	20067	•	
Unit cost Material and fooling \$	30.65	10.40	9.28	8.72
Labor, hr	3,32	2,33	2.10	1.89
Labor at \$25/hr, \$	83.00	58,30	52.50	47.24
Total, \$	113.65	68.70	61.78	55.96

TABLE 5-18. Miscellaneous Hardware.

TABLE 5-19. Forward Assembly Weldment.

		No. of Units	S	
	50	500	1,000	2,000
Tooling, \$				
Weld fixture (addition to basic)	250	250	250	250
Lathe fixture	200	200	200	200
Total	750	750	750	750
Unit cost	15	1.50	0.75	0.38
Material, \$				
Total	1	ļ	1	!
Labor, hr.	75	290	520	076
Circumferential weld				
Total	42	290	520	076
Unit cost				
Material and tooling, \$!	1	1	1
	0.83	0.58	0.52	0.47
Labor at \$25/hr, \$	20.75	14.50	13.00	11.75
	35.75	16.00	13.75	12.13

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		2,000	800 800 05.40	!	1,260 1,260	0.63	15.75
	Units	1,000	800 800 0,80		700	0.70	17.49
ment.	No. of Units	500	800 800 1,60		390 390	0.78	19.44 21.04
Aft Assembly Weldment.		50	800	}	55 55	1.10	27.50 43.50
TABLE 5-20. Aft			Tooling, \$ Weld fixture	Material, \$ Total	Labor, hr Weld aft closure, longeron, and tubes	Unit cost Material and tooling, \$	Labor at \$25/hr, \$

TABLE 5-21. Final Assembly Weldment.

		No. of Units	ts	
	95	500	1,000	2,000
Tooling, \$				
Weld fixture	800	800	800	800
Total	800	800	800	800
Unit cost	16	1.60	08.0	0.40
Material, \$				
Total	•			
Labor, hr				
Final closing welds	69	485	870	1,580
Total	69	482	0/0	1,300
Unit cost				
Material and tooling. S	1	1	-	1
Labor, hr	1.38	0.97	0.87	0.79
Labor at \$25/hr. \$	34.49	24.26	21.87	19.68
Total, \$	50.49	25.86	22.67	20.08

TABLE 5-22. Final Machine.

		No	of Units		
	50	200		2,000	
				+3,650 for	٠
Tooling 6				additional set of	
1 - 1 - 1 - 1 - 1 - 1 - 1 - 1 - 1 - 1 -				tooling*	
Lathe lixture	006	006	006	006	
Drill jig, forward	006	006	006	006	
Drill jig, art	1,250	1,250	1,250	1,250	
orress reliei lixture	009	009	υ09	009	
Acceptance gage	2,000	5,000	5,000	5,000	
Total	8,650	8,650	8,650	12,300	
Unit cost	173.00	17.30	8.65	6.15	
Material, \$					
Stress relief	10	10	10	01	
Total	10	10	10	10	- •
Labor, hr	552	3,590	7,000	12,600	-
Drill forward flange					
Total	552	3,590	7,000	12,600	
Unit cost			. 13		
Material and tooling, \$	183.00	27,30	18,65	16.15	
Labor, hr	11.04	7.78	7.00	6,30	
mater 6	275.88	194.41	174.97	157,47	
Total, \$	458.88	221.91	193.62	173.62	

* Additional set of tooling required to increase production rate and reduce labor requirements

TABLE 5-23. Collector Pipe.

		No. of Units	Units	
	50	200	1,000	2,000
Tooling. \$				
Drill fig. tube preparation	625	625	625	625
Drill ito forward flampe	200	200	200	200
Drill tip, aft flance	200	200	200	200
Weld fixture, inner tube	006	006	006	006
Weld fixture, outer assembly	006	006	006	006
Total	3,425	3,425	3,425	3,425
Unit Cost	68.48	6.85	3.42	1.71
Material				
Aft flance, 6-1/4 in, diameter by 1 in	10.00	10.00	10.00	10.00
Disc, 3 in. diameter by 0.75 in.	1.50	1.50	1.50	1.50
Forward flange, 3 in, 0D by 2.51 in, ID by				
1.5 in.	1.00	1.00	1.00	1.00
Tube, 30.0 in by 0.035 in. wall by 26 in	1.80	1.80	1.80	1.80
Tube, 2-5/8 in OD by 0.049-in. wall by				
20 in ,	1.60	1.60	1.60	1.60
Total	15.90	15.90	15.90	15.90
	20%	3076	037 3	020
Machine flances, machine end (19)	420	760 60	0000	77,700
Detail, trim tube inner and outer				
Weld inner weldment assembly,				
and weld final weldment				
Finish machine				
Total	524	3,695	6,650	11,960

TABLE 5-23. (Contd.)

		No. of	Units	
	50	200	1,000	2,000
Unit cost				
Material and tooling, \$	84.38	22.75	19.32	17.61
Labor, hr	10.48	7.39	6.65	5.98
Labor at \$25/hr, \$	262.09	184.69	166.22	149.60
Total, \$	346.47	207.44	185.54	167.21

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TABLE 5-24. Tooling Costs.

abricated Tooling Cost, hr 156 156 64 36 370 740 90 30 32 32
156 156 64 36 370 740 90 30 32 52
156 156 64 36 370 740 90 30 32 52
156 64 36 370 740 90 30 32 52
156 64 36 370 740 90 30 32 52
64 36 370 740 90 30 32 52
36 370 740 90 30 32 52
370 740 90 30 32 52
74C 90 30 32 52
90 30 32 52
30 32 5?
32 5?
5?
21.6
346
492
137
23.
,449
,819
,819
,965
,,,,,,
,000
786
700
,965
393
373
4.56
1.79
9.48
5.90
1.73
+ + / J

TABLE 5-25. Fabrication Labor and Materials.

	No. of Units				
	1	50	500	1,000	2,000
Fabrication labor, hr					
Forward closure	2	3.32 3.32 2.74 0.28 1.10 3.32 0.83 1.10 1.38 11.04	2.33 2.33 1.94 0.19 0.78 2.38 0.58 0.78 0.97 7.78 7.39	2.10 2.10 1.75 0.18 0.70 2.90 0.52 0.70 0.87 7.00 6.65	1.89 1.89 1.57 0.16 0.63 1.89 0.47 0.63 0.79 6.30 5.98
Totals		38.91	27.40	24.67	22.20
Manufacturing support, \$ at 40% fabrication hours. QC at 20% fabrication hours		15.56 7.78	10.96 5.48	9.87 4 . 93	8.88 4.44
Forward closure		47.56 62.89 51.00 138.60 30.00 8.15 10.00 15.90 364.1	43.59 60.14 51.00 125.70 30.00 8.15 10.00 15.90 344.48	41.75 58.34 51.00 119.70 30.00 8.15 10.00 15.90 334.84	40.00 55.00 51.00 114.00 30.90 8.15 10.00 15.90 324.05

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TABLE 5-26. Fabrication Costs.

	No. of Units			
	50	500	1,000	2,000
Fabrication cost at \$25/hr, \$				
Forward closure	83.00	58.30	52.50	47.24
Aft closure	83.00	58.30	52.50	47.24
Longeron	68.50	48.60	43.75	39.3
Ring	7.00	4.85	4.38	3.93
Skin	27.59	19.44	17.50	15.7
Miscellaneous hardware	83.00	58.30	52.50	47.2
Forward assembly	20.75	14.50	13.00	11.7
Aft assembly	27.50	19.44	17.49	15.7
Final assembly	34.49	24.26	21.87	19.6
Final machining	275.88	194.41	174.97	157.4
Collector pipe	346.47	184.69	166.22	149.6
Total	1057.18	685.09	616.68	555.0
Fabrication support, \$		П		i
Manufacturing support at \$30/hr	466.80	328.80	296.10	266.4
QC at \$30/hr	233.40	164.40	148.05	133.2

TABLE 5-27. Fabrication Summary.

		N	C 31 - 1	
			f Units	
	50	500	1,000	2,000
				**
Fabrication unit labor, hr		,	_1	
Tooling fabrication	28.98	3.64	1.82	0.98
Tooling support	11.60	1.46	0.73	0.39
Tool design	28.98			
Tooling QC	5.80	1		
Fabrication	38.91			
Fabrication support · · ·	15.56			
Fabrication QC	7.78			
Totals	137.61	53.31	44.21	38.07
Fabrication unit cost, \$				
Tooling fabrication	724.50	90.95	45.46	24.56
Tooling purification	779.80	77.98	38.99	19.50
Tool design	869.40	109.14	54.57	29.48
Tool QC	. 174.00	21.84		
Material	364,10	344.48	334.84	324.05
	1,057.18	685.09	616.68	555.01
Fabrication support	466.80	328.80	296.10	266,40
Fabrication QC	233.40	164.40	148.05	133.20
Tool fabrication support	348.00		21.84	
Totals		1,866.36		
100010	3,017.10	1,000.30	1,507.45	1,309.09

6 TESTING AND RESULTS

This section presents the testing conditions and results for the GORJE tank ground test and flight test units, including bladder development expulsion tests.

The bladder expulsion test procedures and data sheets, and the fuel tank assembly, test, and packing procedures and information are presented as Appendices D and E.

The test logs for the ground test tank (S/N 001), flight test tanks (S/N 002 through 005), the spare collector pipe (S/N 002S) bladder (S/N 007S), and the test bladders are shown in Appendix F.

BLADDER EVALUATION TESTS

The bladder design verification tests were conducted with two tank assemblies. A plexiglass tank was used for the functional fit, expulsion efficiency, life cycle expulsion, and leak tests. The ground test tank was used for high pressure expulsion efficiency tests and verification of fuel capacity requirements.

The bladder assemblies successfully achieved the test objectives and satisfied the requirements.

Test Conditions

Each bladder assembly was processed per the leak test and installation procedure (Table 6-1) and recorded on the data sheet in Appendix F. Two bladder assemblies were also processed per the bladder expulsion test procedure (Table 6-2) and recorded on the data sheet shown below.

BLADDER EXPULSION TEST DATA SHEET

Test data	
Bladder S/N	
Bladder expulsion cycle	
Bladder expulsion pressure	
Bladder expulsion time	
Pretest expulsion tank empty weight	
Expulsion tank loaded weight	
Fuel weight	
Expelled tank weight	
Expelled fuel weight	
Expulsion efficienty	
Bladder post-test leakage rate	
Bladder visual condition	
Remarks regarding test procedure	

The bladder assembly was visually examined to assure that there were no cracks, delaminations, punctures, or discrepancies before leak check testing.

Fig. 6-1 shows the bladder, with collector pipe, prior to installation into the tank. The basic bladder configuration, as installed in the transparent plexiglass tank before expulsion, is shown in Fig. 6-2. The folding characteristics of the 'ledder are shown in Fig. 6-3.

Test Equipment

Plexiglass test tank/ground test tank

GN, bottle

Vacuum pump

Valves and gages

TABLE 6-1. Bladder Assembly Leak Test and Installation Procedure.

Leak Cneck Bladder Assembly, P/N C11193-01-01

- 1. Clean O-rings (4) and O-ring surfaces with a lint-free cloth. Lubricate with greese per MIL-G-4343.
- 2. Install O-rings P/N 2-037, 2-042, 2-248 to collector pipe and O-ring 2-151 to bladder assembly.
- 3. Install bladder assembly to collector pipe assembly P/N C11210-01-01. (Note: On bolt hole pattern of collector pipe aft flange, one hole is offset for alignment of bladder to collector pipe.)
- 4. Install No. 4-30 screws with lock-o-seal P/N 800-530-2, Parker Seal Co., on aft flange. (Lock-o-seal will self-center under screw head with gentle pressure.) Torque to 10 to 12 inch-pounds.
- 5. Install hydrostatic test fill plug P/N Cll223-11-01 (or NWC supplied fuel controller) in aft flange. Secure with retaining ring, P/N N5000-250, Waldes Truarc.
- 6. Collapse the bladder by hand for ease of installation into the fuel tank. Avoid sharp objects to prevent puncture.
- 7. Before installation, visually inspect the inside of the fuel tank for cleanliness.
- 8. Caution: Align the longitudinal indentation of the bladder to IDC of the fuel tank. Slowly insert the collapsed bladder into the fuel tank and secure with 1/4-28 flat head screws through collector pipe flange into tank flange. Torque screws to 70 to 90 inch-pounds.
- Install a pressure gage and a flow control valve on the hydrotest fill port and a pressure-vacuum gage and a flow control valve on forward dome for backside pressure and vacuum.
- 10. Pressurize backside of bladder with GN₂ to 40 psig for 2 to 4 minutes to bleed excess air. Close valves on fill port; hold for 5 minutes; check gage for pressure change. When pressure gage on fill port shows zero pressure, bladder shows no leaks and is satisfactory.
- 11. Alternate leak test method: after pressurizing backside, connect a line on fill port and put line in a beaker of water and check for gas bubble. No bubbles indicate satisfactory bladder.

TABLE 6-1. (Contd.)

Positioning of Bladder in the Fuel Tank

- 1. With bladder in the collapsed state, fill the bladder with 20 to 30 pounds of fluid and cap off end.
- 2. with aft end up, slosh fluid around for 30 seconds, then invert (forward end up) and slosh fluid around for another 30 seconds.
- 3. Place fuel tank in the horizontal position and expel traid by pressurizing the backside to 40 psig with GN2. Hold until air is expelled. Disconnect GN2 line.
- 4. Connect vacuum line to backside and evacuate to 26 to 30 inches of mercury and close valve. Bladder positioning is complete.

TABLE 6-2. Bladder Expulsion Test Procedure.

- 1. Install, leak check and position bladder.
- 2. For plexiglass tank, inspect bladder for proper setting on longeron and forward ring.
- 3. Fill bladder as follows:
 - A. Vertical test position (Fig. 6-4).
 - 1. Pull vacuum from backside of bladder. Check for proper contact with case.
 - 2. Fill with H₂O (approximately 90-3/4 pounds); pull vacuum while filling to eliminate folds.
 - B. Horizontal test position (Fig. 6-5.).
 - 1. All valves in OFF position.
 - 2. Open valves No. 2 and 3.
 - 3. Start vacuum pump and evacuate backside to 28 inches of Hg.
 - 4. Open valve No. 4 and equalize the vacuum on both sides of bladder.
 - 5. Close valve No. 4.
 - 6. Open valve No. 5 and fill with fluid.
- 4. Expel H₂O with GN₂ at 25 to 40 psig.
- 5. Weigh for weight expulsion and record on data sheet.
- 6. For recycle of test, add 20 to 25 pounds ${\rm H}_2{\rm O}$ and pull a vacuum.
- 7. Cap H₂O port and invert case, slosh H₂O to reposition bladder in case.
- 8. Set upright again, pull vacuum, and fill bladder with H₂O (repeat steps 3 through 5).
- 9. Perform leak test on bladder after every third expulsion test: pressurize backside and check H₂O inlet for air leak or pressurize bladder with gage and check for pressure drop.

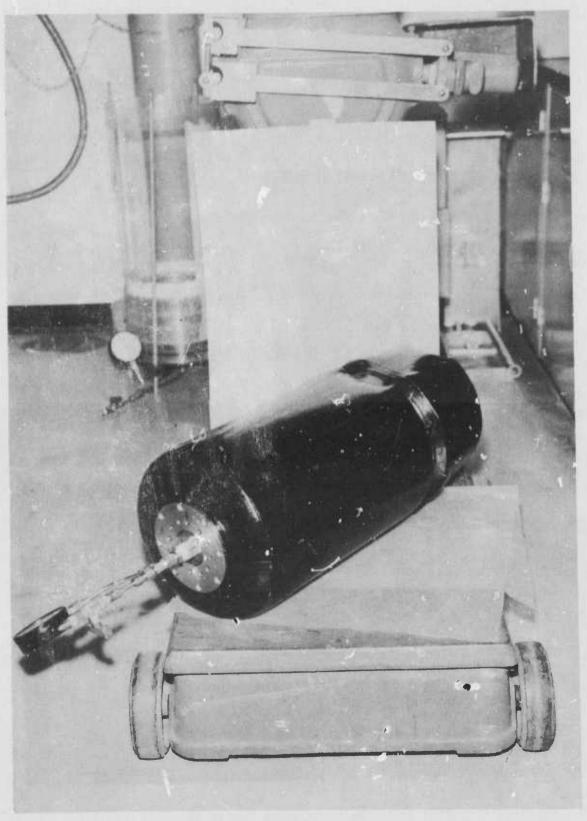


FIG. 6-1. Bladder with Collector Pipe Installed.

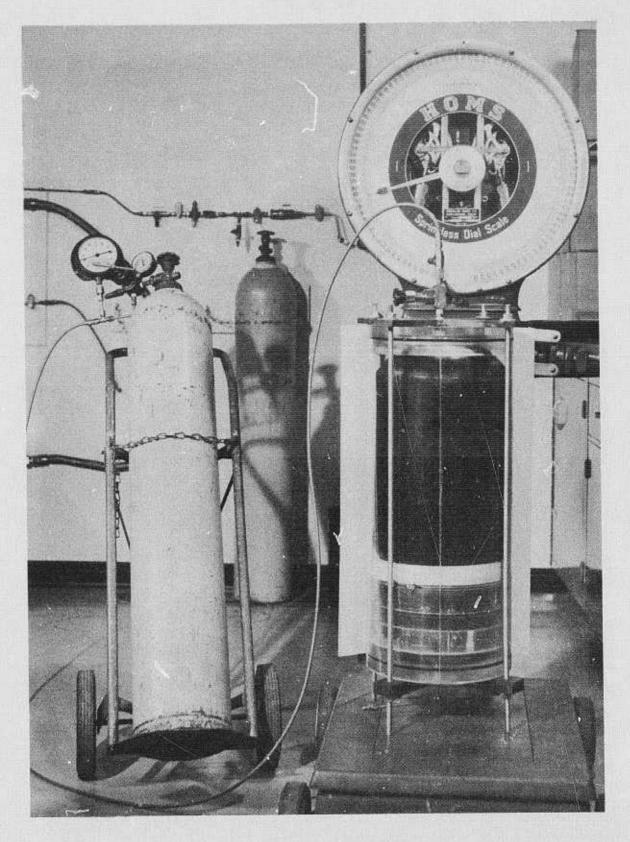


FIG. 6-2. Basic Bladder Configuration.

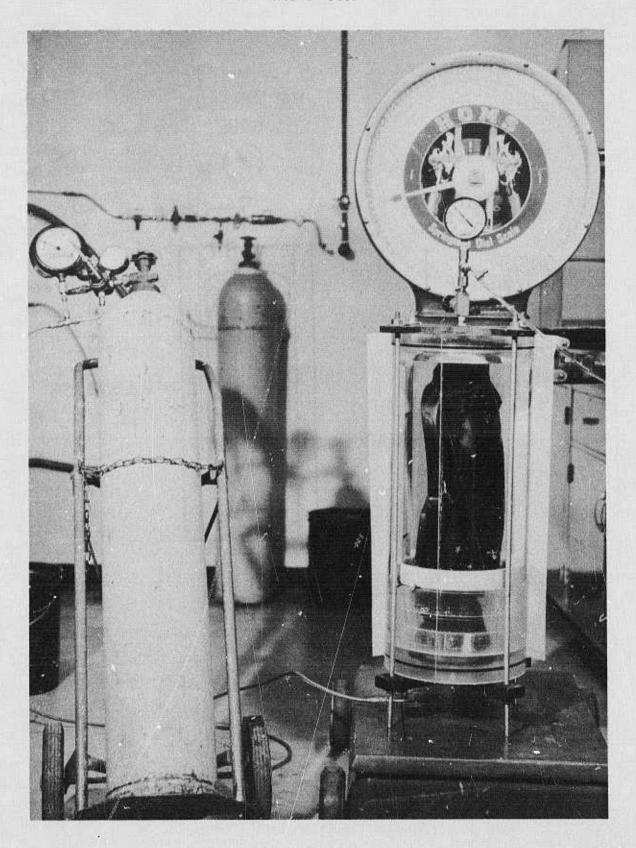


FIG. 6-3. Bladder Folding Characteristics.

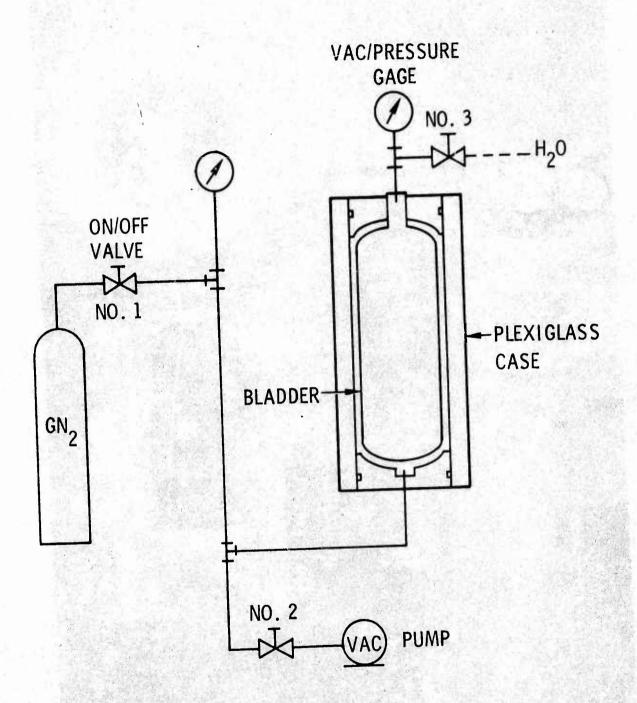
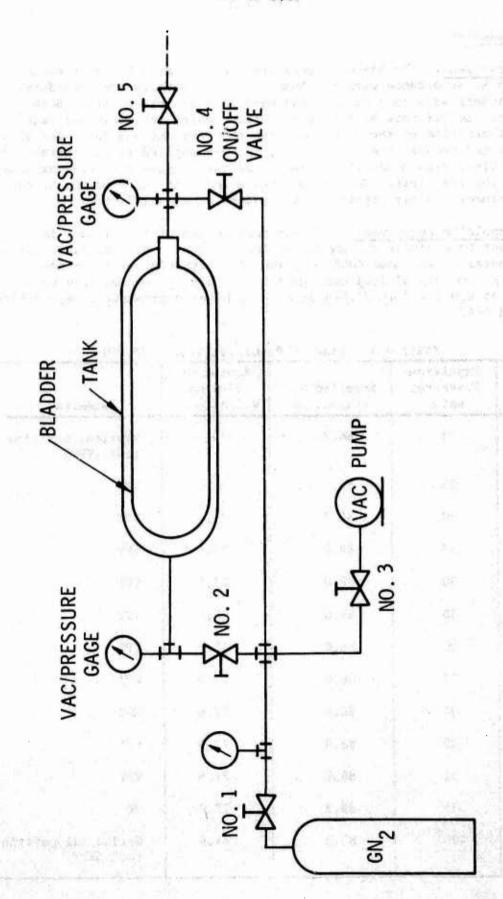


FIG. 6-4. Bladder Expulsion Test (Vertical).



1

FIG. 6-5. Bladder Expulsion Test (Horizontal).

Test Results

Leak Test. The bladders were leak checked with GN₂ at a minimum of 15 psig in accordance with the leak test and installation procedure. Two bladders were sent back to the manufacturer for repairs. Both bladders had blisters on the outer surface which were only noticeable after evacuation of the volume between the tank and bladder. The blisters were formed because the cosmetic coating was applied to the surface after it was wiped with a volatile cleaner and the trapped volatiles expanded during the leak test. One bladder had a leak; it was repaired by the manufacturer. After repairs, all bladders were satisfactory.

Expulsion Performance. Proper positioning of the bladder is important to maximize the amount of fuel it can hold. The expulsion of fuel contained was near 100%, but due to positioning of the bladder in the tank, amounts of fuel contained in the bladder varied from 85 to 88 pounds of H_2O (74.9 to 77.6 pounds of TH-Dimer equivalent). See Tables 6-3 and 6-4.

TABLE 6-3. Bladder Expulsion Test, S/N 001.

Cycle No.	Expulsion Pressure, psig	Expelled H ₂ O Weight, 1b	Equipment TH-Dimer Weight, 1b	Rem arks
1	25	86.2	76	Vertical position test (VPT)
2	25	86.5	76.2	VPT ·
3	30	88.0	77.6	VPT
4	35	88.0	77.6	VPT
5	30	88.0	77.6	VPT
6	30	88.0	77.6	VPT
7	30	88.0	77.6	VPT
8	27	88.0	77.6	VPT
9	37	88.0	77.6	VPT
10	35	88.0	77.6	VPT
11	35	88.0	77.6	VPT
12	35	88.2	77.7	VPT
13	400 ^a	85.0	74.9	Horizontal position test (HPT)

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TABLE 6-4. Bladder Expulsion Test, S/N 004.

Cycle No.	Expulsion Pressure, psig	Expelled H ₂ O Weight, lb ²	Equivalent TH-Dimer Weight, lb	Remarks
1	30	88.0	77.6	Vertical test position (VTP); positioned bladder
2	30	87.9	77.5	VPT
3	40	88.0	77.6	VPT
4	39	87.9	77.5	VPT
5	39	88.0	77.6	VPT
6	38	88.0	77.6	VPT; positioned bladder
			,	Not positioned end-to-end
7	40	86.2	76	VPT
8	40	84.5	74.5	VPT; not positioned no vacuum pulled prior to filling
9	39	85.5	75.4	VPT; not positioned
10	38 **;	84.8	74.7	VPT; not positioned
11	37	84.6	74.6	VPT; not positioned
12	30	87.6	77.2	HPT; positioned bladder
13	60 ^a	84.7	74.7	HPT leaked at 50 psig; water trapped between tank and bladder

a Expulsion test conducted with ground test fuel tank.
Upon examination of the bladder, a metal chip was found which had punctured the bladder. The tank was recleaned and bladder S/N 001 was tested with success. Bladder S/N 004 was patched and re-leak tested with satisfactory results.

The multiple cycle tests were conducted on the two bladders used for expulsion testing. The maximum theoretical internal capacity of the tank (excluding bladder) was 80.59 pounds of TH-Dimer. Therefore, the internal volumetric efficiency based on Tables 6-3 and 6-4 data was estimated at 96.3% with no ullage. Ullage requirements for the vehicle mission have not been specified.

During the first test in the ground test unit, the bladder was damaged by a metal chip, causing a leak. The bladder was patched and tested again with satisfactory results.

Expulsion Life Cycle. Two bladders were expelled a total of 18 times each with no apparent deleterious effects. Life expectancy with cold gas should be at least 25 cycles.

Bladder Expulsion Pressure Logs. No measurable pressure drop was observed during expulsion testing. A 3- to 5-psi drop was measured between GN₂ inlet pressure and fuel outlet line pressure; however, this loss was primarily caused by the 1/4-inch discharge line.

TANK TESTS

The fuel tank and collector pipe were subjected to structural testing and successfully achieved test objectives and satisfied requirements. The ground test tank and collector pipe were used in the bladder expulsion test and the fuel expulsion efficiency test. The collector pipe and bladder, as assembled in the tank, are shown in Fig. 6-6.

Proof Pressure Test

The fuel tank was tested to the requirements of hydrostatic test assembly D/N C11223 and Operations and Quality Record Procedure 1002 (Appendix D). See Fig. 6-7 for the hydrotest schematic. The tank was filled with water and water soluble oil and pressurized with ${\rm GN}_2$.

The collector pipe was tested to the requirements of hydrostatic test assembly C11222 and Operations and Quality Record Procedure 1003 (Appendix D). See Fig. 6-8 for the hydrotest schematic. The collector pipe was filled with water and water soluble oil and pressurized with ${\rm GN}_2$.

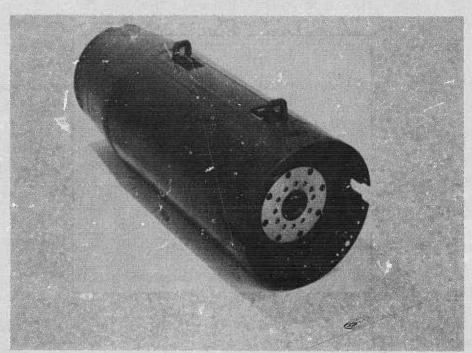


FIG. 6-6. Collector Pipe and Bladder Assembled in Ground Test Tank.

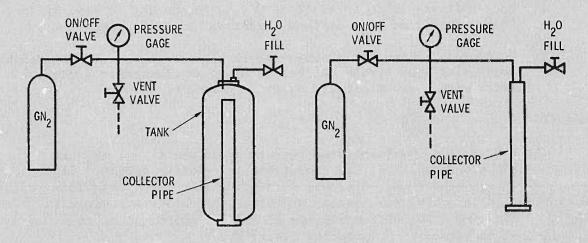


FIG. 6-7. Fuel Tank Test.

FIG. 6-8. Collector Pipe Test.

GORJE FUEL TANK SUSPENSION LUG STRUCTURE TEST

SCOPE

The test report covers testing of the proposed GORJE tank suspension lug and shaft to the ultimate load conditions for captive flight.

OBJECTIVE

The objective of the test was to verify the structural adequacy of the proposed design.

PROCEDURE

Two test units were fabricated as follows:

The suspension lug was machined from a standard 1,000-pound store lug forging (P/N 1252628).

The machined lug was heat treated to 180,000 psi minimum ultimate tensile strength.

The shaft was fabricated from 4340 steel per MIL-S-5000 and heat treated to 180,000 psi minimum ultimate tensile strength.

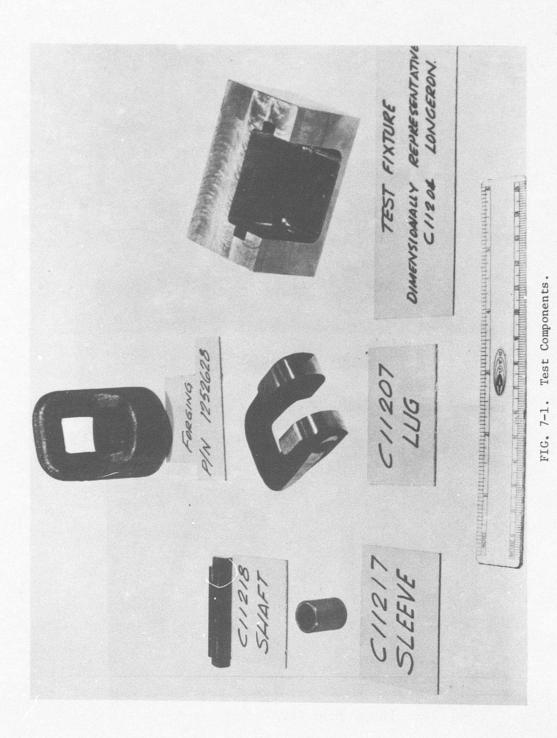
A test fixture was fabricated from 140,000 psi minimum ultimate tensile strength material. The test fixture was designed to simulate the side wall configuration of the GORJE tank longeron in the area of the lug recess.

All components used are shown in Fig. 7-1. The assembled test unit is shown in Fig. 7-2. The unit was tested in CSD's Tinius-Olsen 300,000-pound tensile test fixture (Fig. 7-3) as follows:

- Each unit was taken to limit load (11,000 pounds) for two cycles.
 Load was relaxed to a no-load condition between cycles.
- 2. Units were subsequently subjected to ultimate load (16,500 pounds) monitoring load versus deflection using an electronic deflectometer with readout printed by an XY recorder.

RESULTS

The test results confirmed the structural capability of the two units to withstand ultimate load conditions for captive flight. Figure 7-4 shows the load versus deflection curves for both units. (NOTE: Deflection is for total test setup; therefore, no deflection scale is shown on Fig. 7-4.) Visual examination of all components after test confirmed that no permanent deformation occurred.



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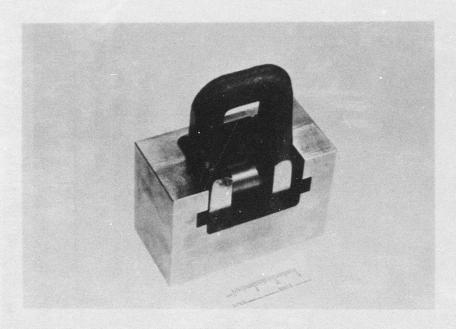


FIG. 7-2. Test Unit.

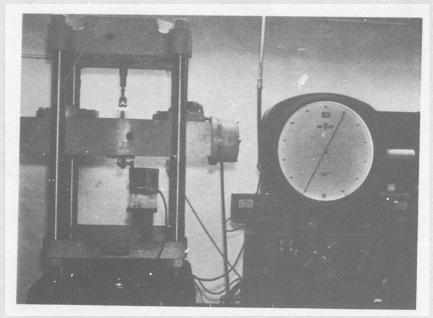


FIG. 7-3. Tinius Olsen Tensile Test Fixture.

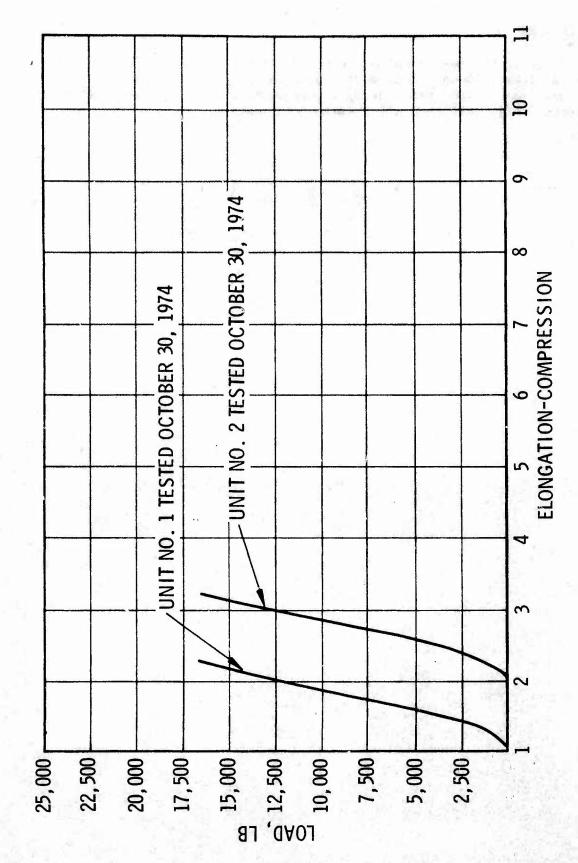


FIG. 7-4. Load Versus Deflection Curve.

NWC TF 5835

CONCLUSIONS

Based on the test results of the two units which had been randomly selected from a 20-unit lot, machined to the proposed design configuration and heat treated per drawing requirement, it is concluded that the proposed design will meet all program requirements.

Appendix A

GORJE FUEL TANK ASSEMBLY DATA PACKAGE

GORJE FUEL MANAGEMENT SYSTEM

Baseline Design

See Fig. A-1.

Theory of Operation

Pressurization Subsystem. The pressurization subsystem is a nozzleless cool gas generator noused in the centrally mounted collector pipe assembly. The gas exhausts through holes in the collector pipe assembly mounting boss at the forward end of the fuel tank. Pressure is regulated by a relief valve.

Expulsion Device. The expulsion device is nominally an elastomeric bladder attached to the collector pipe assembly at the tank ends. Gases from the gas generator collapse the bladder forcing fuel through holes in the collector pipe and down the annular gap between the collector pipe and gas generator housing to the fuel controller.

Fuel Controller. The fuel controller is an altitude scheduled, bellows activated, cavitating venturi valve. Fuel from the collector pipe enters the fuel controller through radial holes and exits through the aft tank closure to a normally closed explosive valve. As the fuel controller is normally open, the tank is filled back through the fuel controller. A fill vent is also provided in the fuel controller.

GORJE FUEL TANK ASSEMBLY BASELINE DESIGN AND REQUIREMENTS

Fuel Tank

See Fig. A-2. Structural design criteria are shown on Fig. A-3.

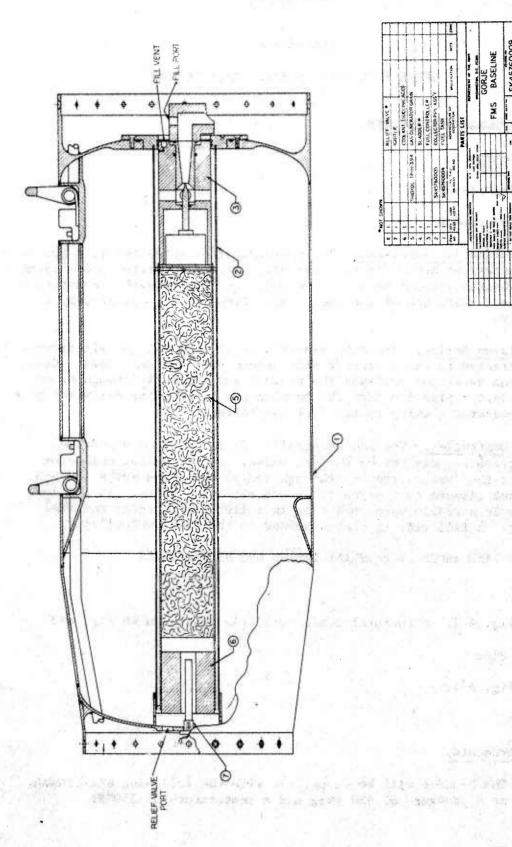
Collector Pipe

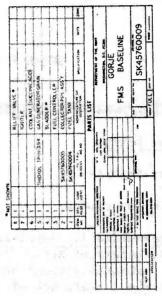
See Fig. A-4.

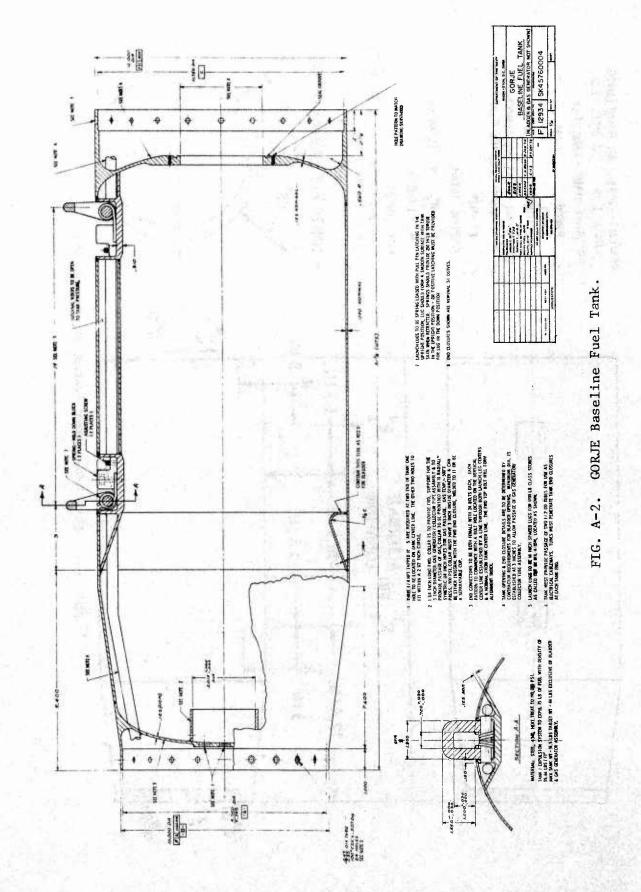
Bladder

Requirements.

1. The bladder will be compatible with the following environment at a pressure of 450 psig and a temperature of 550°F:







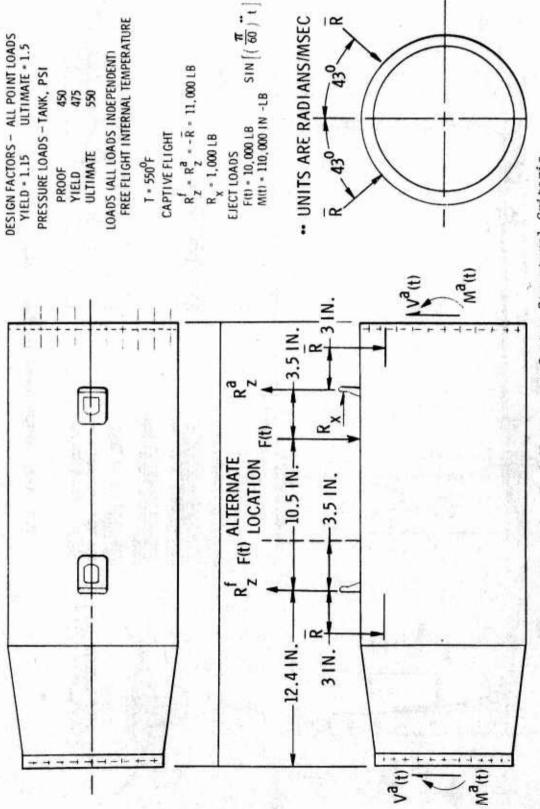
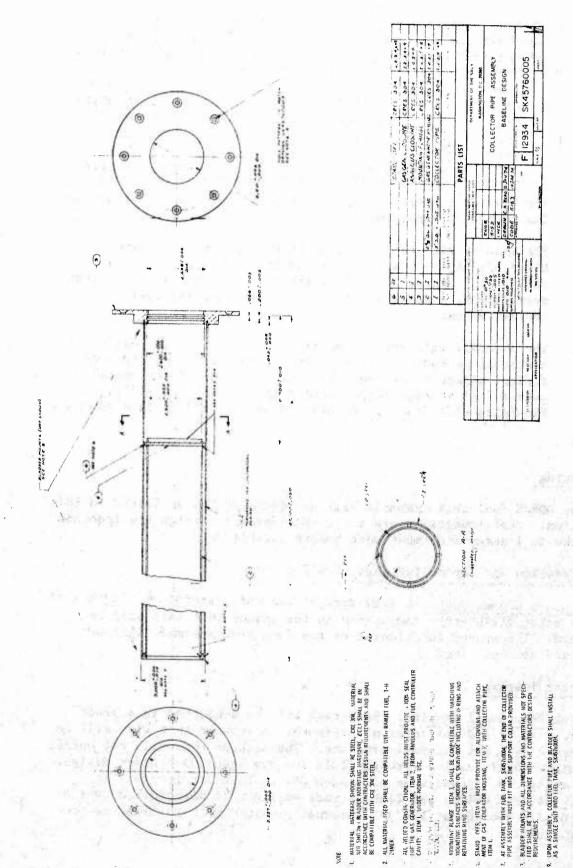


FIG. A-3. Fuel Management System Structural Criteria.



A-4. Collector Pipe Assembly Baseline Design.

\$.527-.005 0.4

Gas Generator Exhaust Products	Mole Fraction	Gas Generator Exhaust Products	Mole Fraction
Fe0	0.00020	С	0.06364
H ₂ 0	0.11542	N ₂	0.06140
Н2	0.30088	FeC12	0.00040
CO	0.21137	CH4	0.03306
CO 2	0.11358	cos	0.00023
HC1	0.07883	H ₂ S	0.02094

The bladder functions properly in this environment for 120 sec (maximum fuel expulsion cycle).

- 2. The bladder will be compatible with ramjet fuel TH Dimer, MIL-F-82522A, to ensure proper functioning after a storage period of 5 years. Compatibility includes minimal structural degradation, bladder swell, fuel permeation, and fuel contamination.
- 3. The assembly will expel a minimum of 1.3475 ft of fuel after a storage period of 5 years. The bladder will contain sufficient ullage to prevent structural failure of the assembly over a fuel storage temperature range of -40°F to 140°F. Expulsion efficiency is determined as outlined in this appendix.

TESTING

NWC Testing

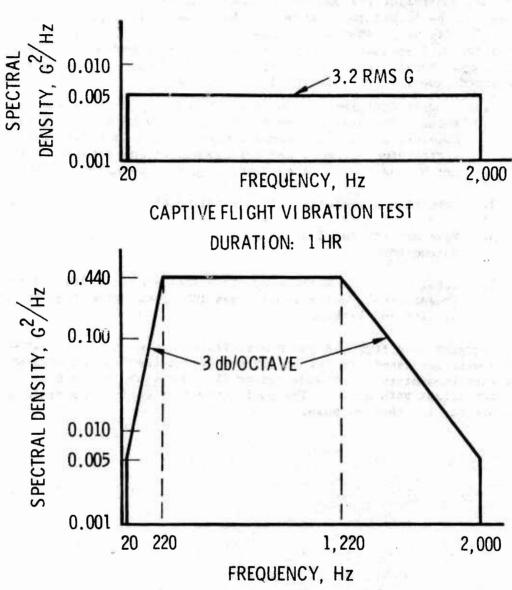
The GORJE fuel tank assembly will be tested at NWC as listed in this subsection. Test conditions are to be considered as design requirements which the full assemblies must meet before acceptance.

Vibration and Impact Testing. See Fig. A-5.

Vehicle Ground Test. A semi-freejet test of a prototype flight test vehicle using flight-type components in the ground test unit will be conducted. The proper functioning of the fuel tank assembly will be determined at that time.

Contractor Testing

Tank Structural Testing. Each tank will be subjected to a proof pressure test at 450 psi internal pressure. A leakage test also will be conducted at 450 psi internal pressure. The leakage rate will not exceed 2 psi/min with air as the working fluid for the baseline bladder design. If the contractor proposes an expulsion device that permits fuel to contact the tank walls, the leakage rate will not be discernible over a period of 120 seconds at 450 psi internal pressure with TH Dimer as the working fluid.



FREE FLIGHT VIBRATION TEST DURATION: 1 MIN

NOTE: EJECT LAUNCH TEST DURATION: I PULSE: F (t) = (10,000 LB) SIN $\left[\left(\frac{\pi}{60}\right) t\right]$ t IN MSEC $0 \le t \le 60$ MSEC

FIG. A-5. Captive and Free Flight Vibration Tests.

Expulsion Testing. NWC will supply the contractor with a flight-type fuel controller for use in the expulsion testing. The bladder design will be tested to confirm structural integrity, proper functioning, and cycle life at pressurization gas conditions of 450 psi, 550°F. The contractor will estimate the cycle life of the bladder under flight conditions. Total expulsion efficiency of the flight design will be determined experimentally on the following basis:

- 1. Loading Efficiency theoretical fuel volume less inerts and voids. The bladder and bladder mounts will be considered inerts. However, the volume occupied within the 3-inch-diameter collector pipe assembly and corresponding tank mounting cup will not be considered as theoretically available fuel volume.
- Expulsion Efficiency fuel expelled divided by fuel loaded.
- Permeability and leakage loss for 5 year storage need only be documented.
- 4. Total Expulsion Efficiency (%) fuel expelled divided by (theoretical fuel volume) times 100 minus percentage of permeability and leakage.

Pressure loss from the gas pressurization inlet to fuel controller cavity will not exceed 40 psi at 400 psi pressurization and maximum fuel flow rate (nominally 3.2 pounds/second TH Dimer with the tank at a 0-degree flight path angle. The fuel controller will incorporate a pressure tap for this purpose.

Appendix B

GORJE FUEL TANK DRAWING LIST

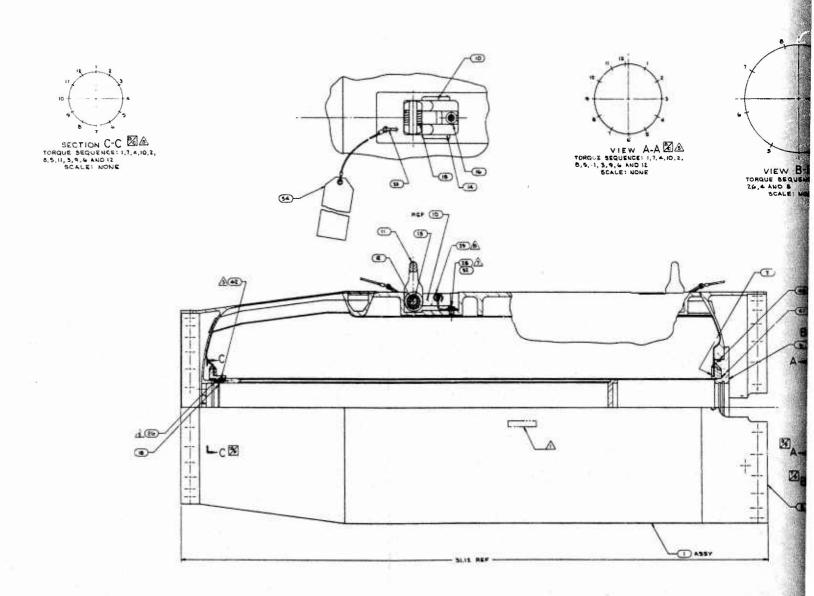
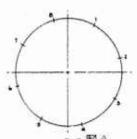
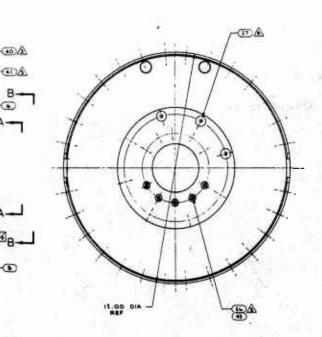


FIG. B-1. Fuel Tank Assembly, GORJE.



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26, 4 AND 8
SCALE: NONE



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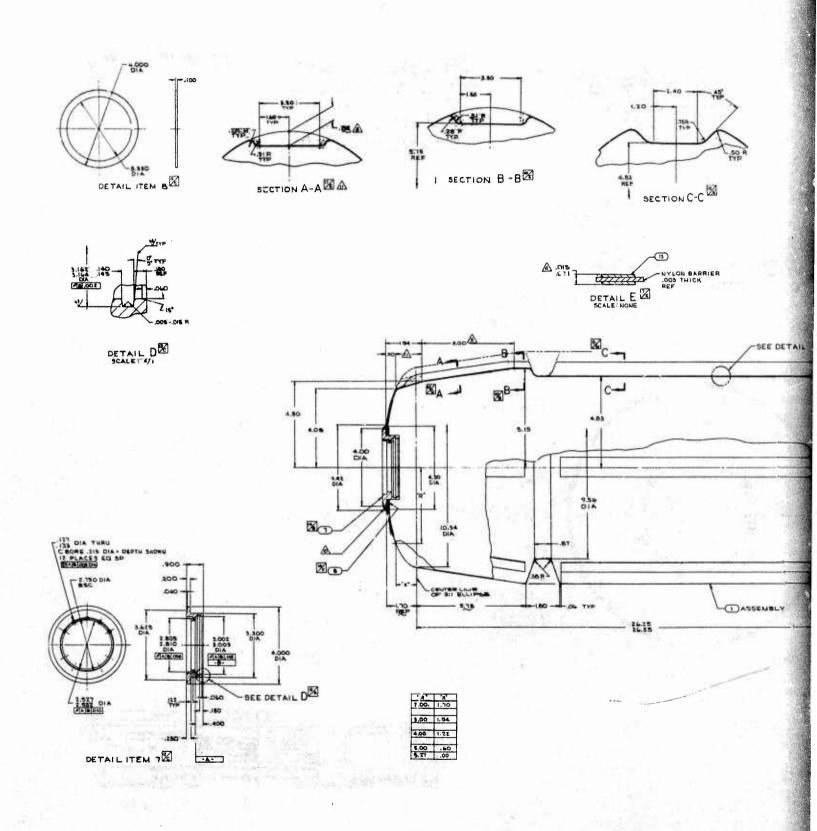
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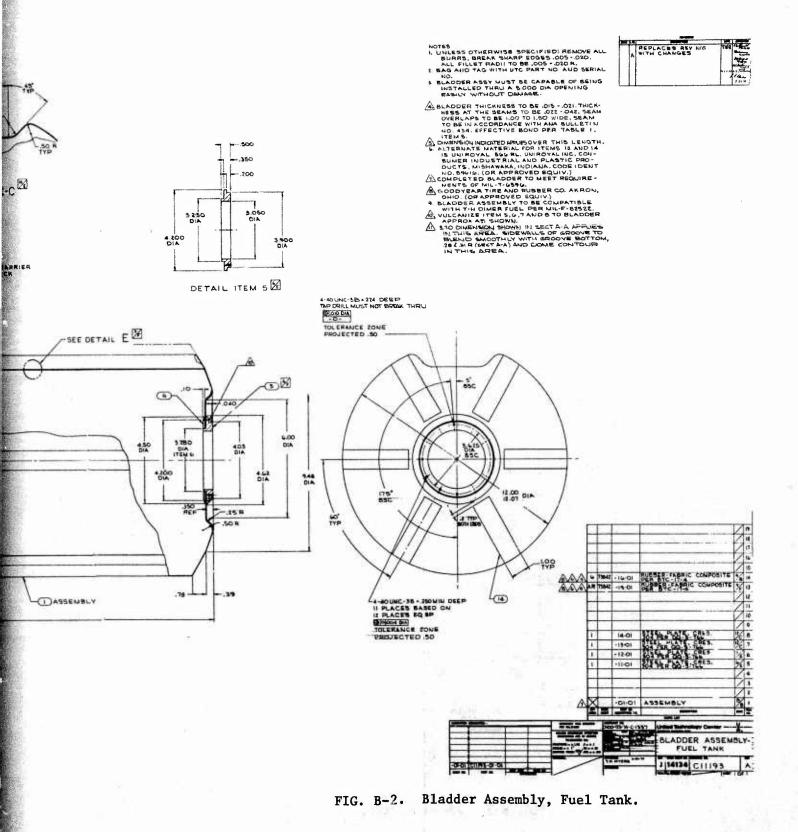
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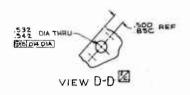
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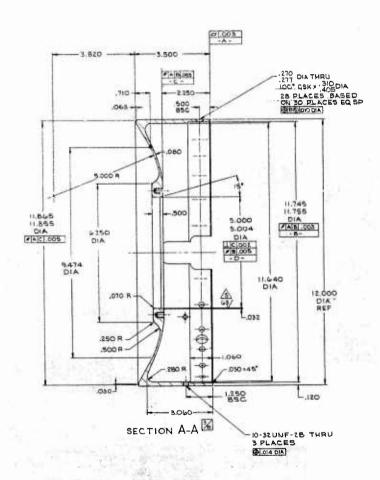
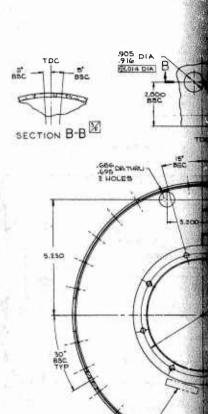


FIG. B-3. Closure, Aft.



CON'T.

OF MAGNETIZATION OPTIONAL, NO CRACKS OR DISCONTINUITIES ALLOWED.

SINDICATED SURFACE TO BE FREE OF NICKS, PITS, RUST, TOOL CHATTER MARKS AND SCRATCHES.

HEAT TREAT PRIOR TO FINAL MACHINING TO MO.OOD 150,000 ULTIMATE TENSILE STRENSTH PER MIL-H-GSTS, HARDNESS TO BE ROCKWELL C 34-29.

NOTES

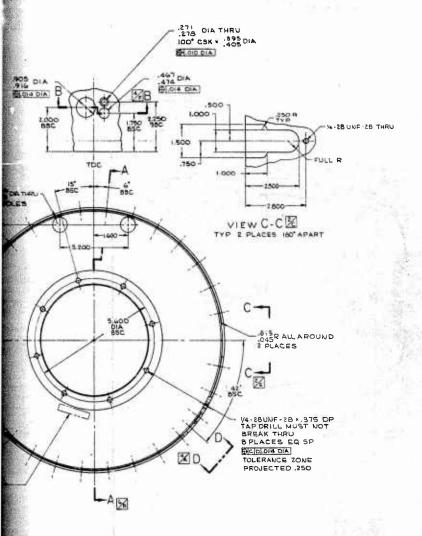
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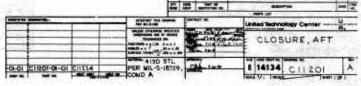
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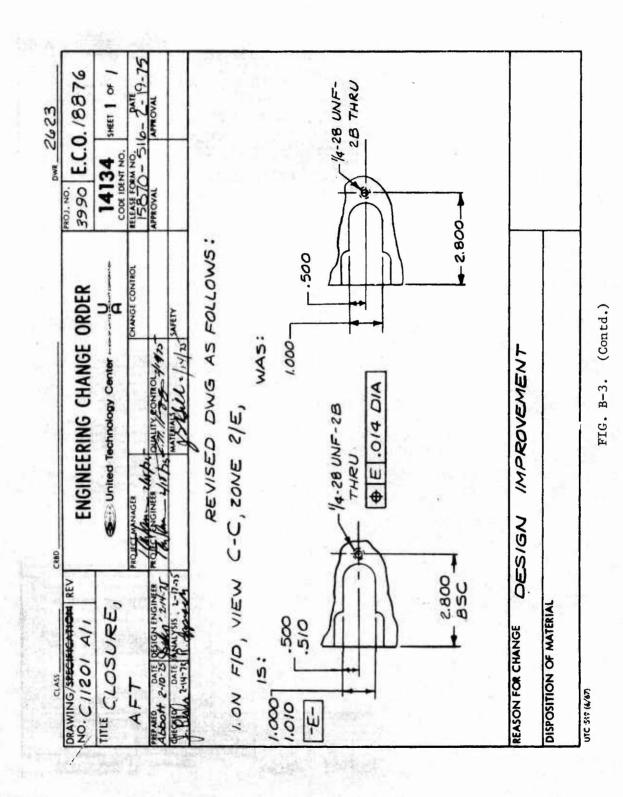
2. DIMENSIONS APPLY IN THE RESTRAINED CONDITION.

4. FLUDRESCENT WET CONTINUOUS MAGNETIC PARTICLE INSPECT PER MIL.T-68-68 ALL SURFACE 100%. CONCENTRATION AND VISCOSITY OF SUSPENSION SHALL BE WITHIN THE LIMITS OF PARA 5.1.2.METHOD









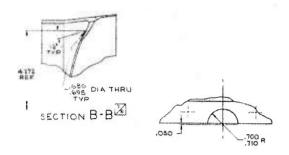
119

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500 -BSC -

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WELDMENT (



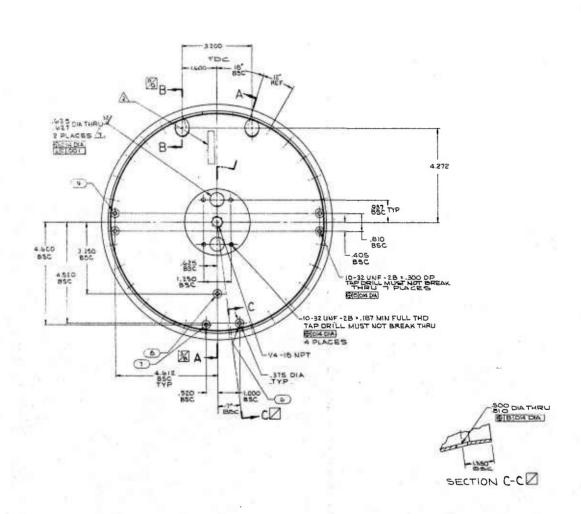


FIG. B-4. Closure, Forward.

NOTES:

1. UNLESS OTHERWISE SPECIFIED: REMOVE
ALL BURRS; BREAK ALL SHARP EDGES

.OOS-.O2O; ALL FILLET RADII.OOS-.O2O.

2. RUSBER STAMP PART NO. WITH 1/4 HIGH
CHARACTERS APPROX AS SHOWN.

MAX RATE OF CHANGE FOR THE ENTIRE CONTOUR OF DOME IS.O.40 INCL/INCH.

4. DIMENSIONS APPLY IN THE RESTRAINED
CONDITION.

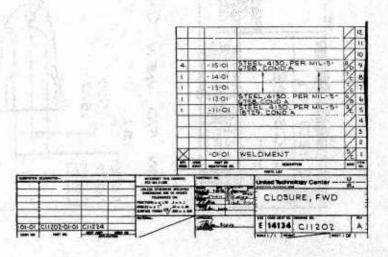
5. FLUORESCENT WET CONTINUOUS MAGNETIC
PARTICLE INSPECT PER MILT-6668, ALL
SURFACES 100%.
CONCENTRATION AND VISCOSITY OF SUSPENSION SHALL BE WITHIN THE LIMITS OF PARA.
5.1.2. METHOD OF MAGNETIZATION OPTIONAL.
NO CRACKS OR DISCONTINUITIES **LLOWED.

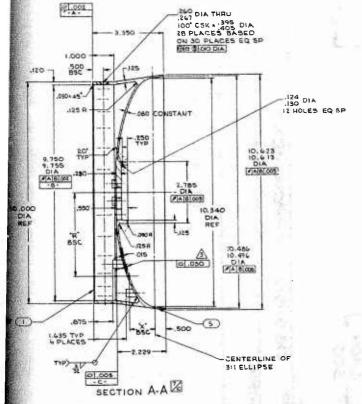
6. WELD PER MIL-**-6611.

NO TOOL CHATTER MARKS, PITS, RUST OR
SCHATCHES ALLOWED ON INDICATED SUR-FACES.

			AEVILONE		
	Lff		MENDARY TRAN	2416	MARONE
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sk.			UNF 28 + 375 D		130
0/4		ADDEC			

"R" BSC	*X * B5C
1.500	1,649
1.750	1.621
2.000	1,589
2.250	1.551
2,500	1.508
2.750	.1.459
3,000	1,403
3,250	1.340
3.500	1.268
3.750	1.186
4,000	1.092
4.250	. ,981
4,500	.848
4.750	.680
5,000	. 4 38
5.170	,000





DRAWING/TECHTON REV	ENGINEERING CHANGE ORDER	3992 E.C.0. / 9379
TITLE FWO	United Technology Center ————————————————————————————————————	14134 SHEET OF
	PROJECT MANAGER CONTROL	162 15-516-9-22-75
Sparker 9 675 High All A	TO SECURITIES GUALITY CONTROL 7/19/13	APPROVAL APPROVAL
(1) ON FID, ZONE.	OUF POSI	TION OIR DIA
(2) ON F/P, ZONE 8/D,	8/0,	
	WAS: (9)	
(3) ON F/O, ZONE 5/C, 15.	/c, /S: x .30 pp	
REASON FOR CHANGE TO R	TO REFLECT LATEST DIMENSION METHOD	
DISPOSITION OF MATERIAL		

177 ...

FIG. B-4. (Contd.)

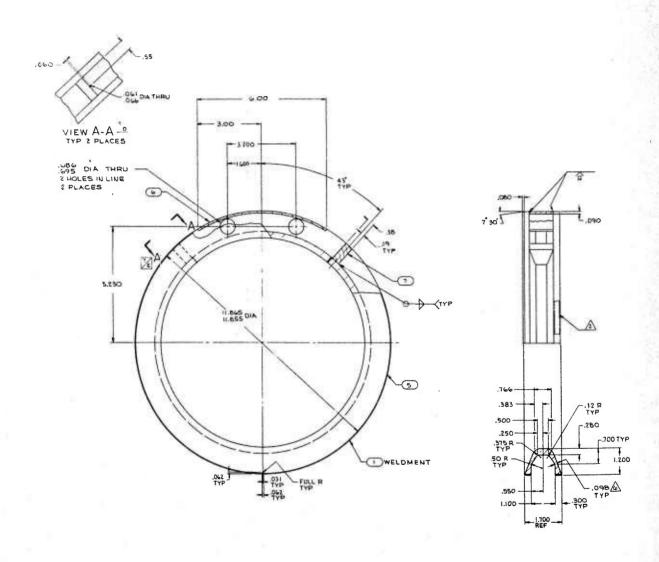
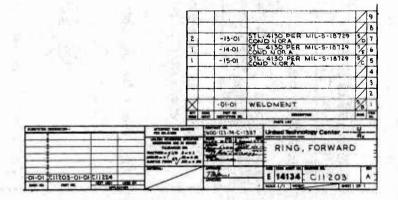


FIG. B-5. Ring, Forward.

r.280 r.700 TYP 1.200 .098 € TYP



OPTIONAL NO CRACKS OR DISCONTINUITIES ALLOWED.

5 HEAT TREAT PRIOR TO FINAL MACHINING TO 140,000 -140,000 MINIMUM TENSILE STRENGTH PER MIL-14-6875, HARDNESS TO BE ROCKWELL C 34-39.

FOR QUALITY CONTROL INSPECTION ONLY, DO NOT FABRICATE TO THIS DIMENSION.

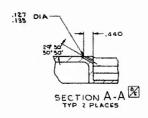
	WELDED.
A.	FLUORESCENT WET CONTINUOUS MAGNETIC
	PARTICLE INSPECT PER MIL-1-6868 ALL SUR-
	FACES 100%, CONCENTRATION AND VISCOSITY
	OF SUSPENSION SHALL BE WITHIN THE LIMITS
	OF PARA S.I.2 METHOD OF MAGNETIZATION
	OPTIONAL, NO CRACKS OR DISCONTINUIT-

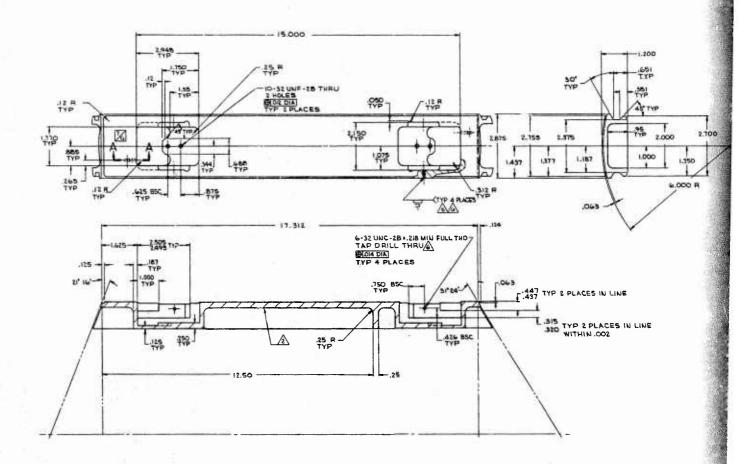
	CHARACTERS IN APPROX LOCATION SHOWN.
2	WELD PER MIL W- BGIL WELD DESIGN AND
æ.	
	WELD PROCEDURE TO BE APPROVED
	BY UTC BEFORE ACTUAL HARDWARE IS
	WELDED.

NOTES
I UNLESS OTHERWISE SPECIFIED: REMOVE ALL
A BURRS, BREAK SHARP EDGES .005020.
AUBBER STAMP PART NO WITH 1/4 INCH HIGH
CHARACTERS IN APPROX LOCATION SHOWN.
3. WELD PER MIL-W-BGH, WELD DESIGN AND
WELD PROCEDURE TO BE APPROVED

KIME L	TR EMESCRIPTION	BATE APPROVED
N/O	15 5 230 WAS: 5.170	UNION PASSES
wp !	REMOVED: 5 780	144 17.00
- 1	DIA	1 400
1	RC#	177
MP	REMOVED .040	1.07

10





NOTES

1. U'ILESS OTHERWISE SPECIFIED: REMOVE ALL BURRS, BREAK SHARP EDGES .005 -020.

FILLET RADII TO BE .020 R MAX.

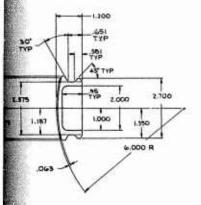
2. RUBBER STAMP PART NO. WITH 1/4 INCH HIGH CHARACTERS IN APPROX LOCATION SHOWN.

3. HEAT TREAT PRIOR TO FINAL MACHINING TO 140,000 -160,000 PSI TENSILE STRENGTH PER MIL 14 -6875.

4. FLUORES CENT WE CONTINUOUS MAGNETIC PARTICLE INSPECT PER MIL-1-6868 ALL SURFACES 100%. CONCENTRATION AND VISCOSITY OF SUSPENSION SHALL BE WITHIN THE LIMITS C. PARA 5.1.2, METHOD OF MAGNETICATION OPTIONAL, NO CRACKS OR DISCONTINUITIES ALLOWED.

WELD PER MIL-W-BGII.

A MINIMUM FULL THREAD OF .218 APPLIES AFTER WELDING.



E PLACES IN LINE

TYP 2 PLACES IN LINE WITHIN .002

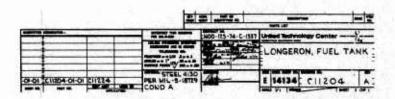
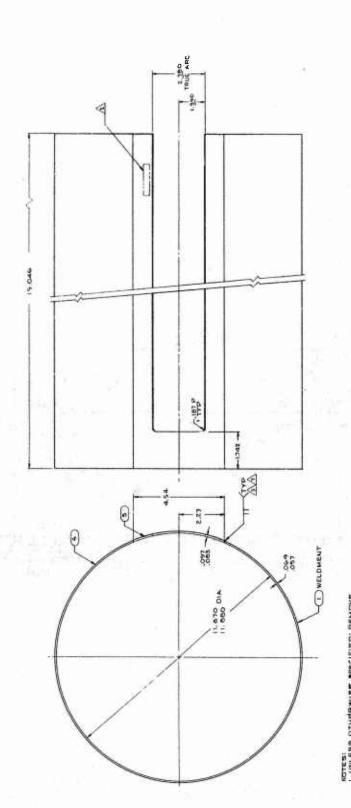


FIG. B-6. Longeron, Fuel Tank.





1 12	9 .		100		ď		è «	-04
EEL, 4130 PER MIL-5-16729.	7 3	WELD WELL CONSISTS OF	paccenter	an w	Unite Technology Center	HELL, TANK,	E 14134 C11206	10 Lane Lane 1/1 mm
	-11-DI COND		Mart Ca		NDO-123-74-C-1337			
2	= =	<u>.</u>	-	Deffect 46.	N00-123		1	
		×	1000	ľ			1	
					-	PACTOR OF THE PA		1
					T			9
							C11224	W 18
							CIT206-01-01 C11224	PACT AS
							10-10	1

FIG. B-7. Shell, Tank, Cylindrical.

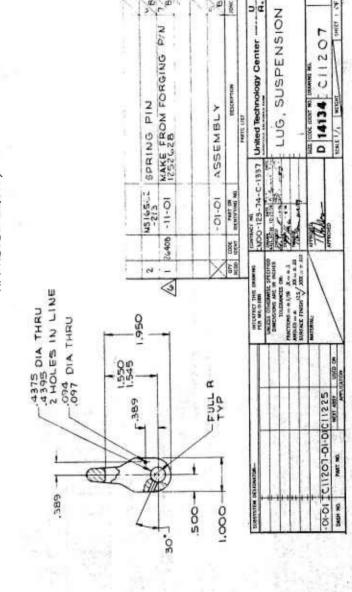
I. UNLESS OTHERWISE SPECIFIED: REMOVE ALL BURRS, BREAK SHARP EDGES, OOS -.020.

2. BAG AND TAG WITH PART NO.
3. HEAT TREAT PRIOR TO FINAL MACHINING
TO 180,000 -200,000 PSI TENSILE STRENGTH
ROCKWELL C 39-43, PER MIL-H-6815.
4. FLUORESCENT WET CONTINUOUS MAGNETIC
PARTICLE INSPECT PER MIL-T-6868 ALL
SURFACES 100%. CONCENTRATION AND
VISCOSITY OF SUSPENSION SHALL BE
WITHIN THE LIMITS OF PARA 51,2. METHOD
OF MAGNETIZATICN OPTIONAL. NO CRACKS
OR DISCONTINUITIES ALLOWED.

75 DIA

CLASS 3.

LAND-AIR INC. GRAND PRAIRIE, TEXAS. (OR APPROVED EQUIV.) CADMIUM PLATE PER QQ-P-416, TYPE 2,



Lug, Suspension. FIG. B-8.

125 R REF TYP

35 DIA

250

750 975

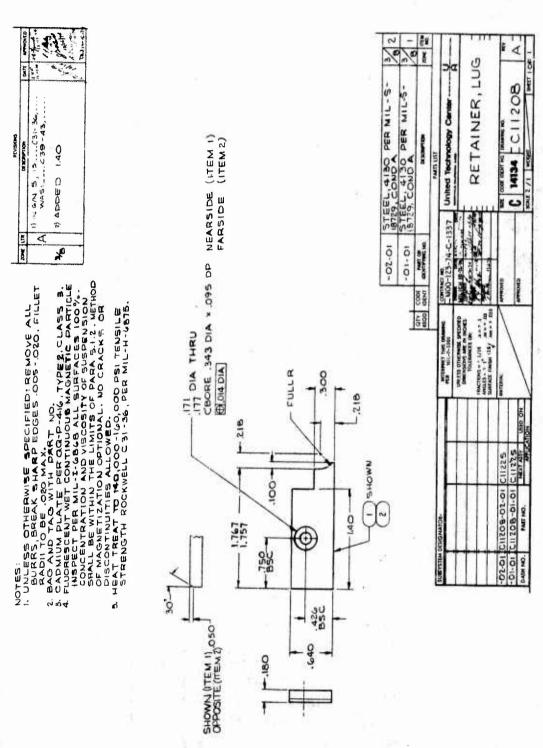
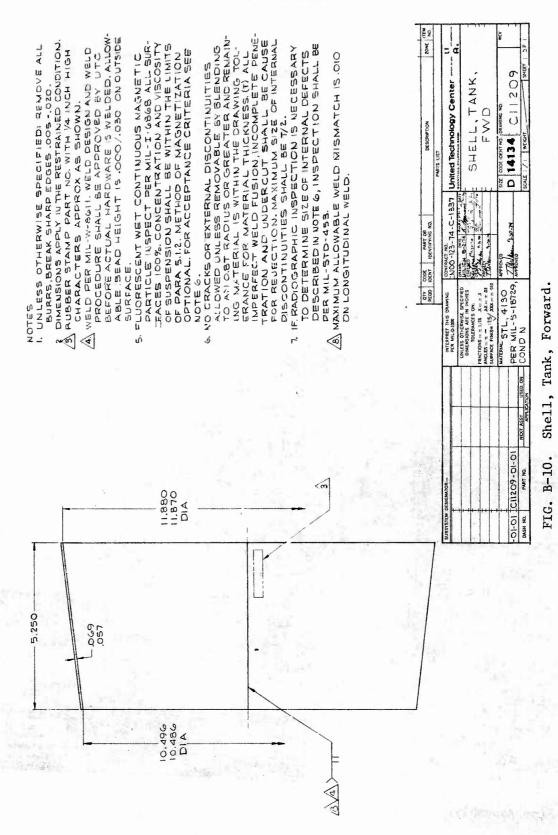


FIG. B-9. Retainer, Lug.



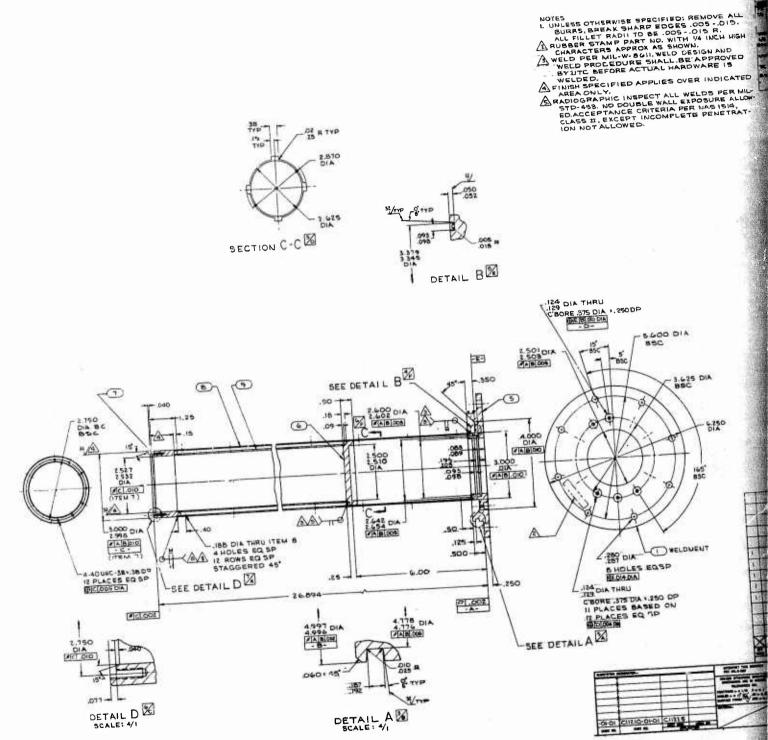
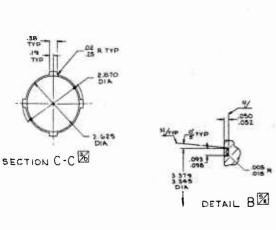


FIG. B-11. Collector Pipe Assembly.



NOTES
I. UNLESS OTHERWISE SPECIFIED: REMOVE ALL BURRS, BREAK SHARP EDGES .005 *.015 *.

ALL FILLET RADII TO BE .005 *.015 *.

ALL FILLET RADII TO BE .005 *.015 *.

CHARACTERS APPROX AS SHOWN,

WELD PER MIL-W-8011, WELD DESIGN AND

"WELD PROCEDURE SHALL BE APPROVED

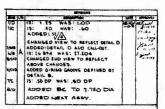
BY JITC BEFORE ACTUAL HARDWARE 13

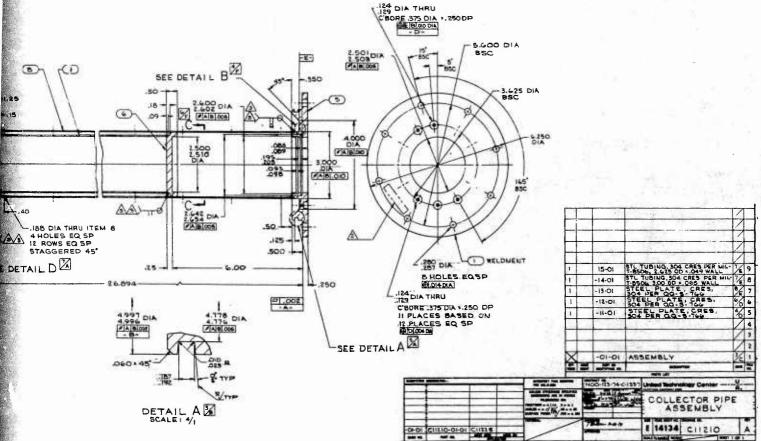
WELDED.

FINISH SPECIFIED APPLIES OVER INDICATED AREA ONLY.

AREA ONLY.

STADIOGRAPHIC INSPECT ALL WELDS PER MILSTO-453 NO DOUBLE WALL EXPOSURE ALLOWED.ACCEPTANCE CRITERIA PER NAS 1514,
CLASS II, EXCEPT INCOMPLETE PENETRATION NOT ALLOWED.





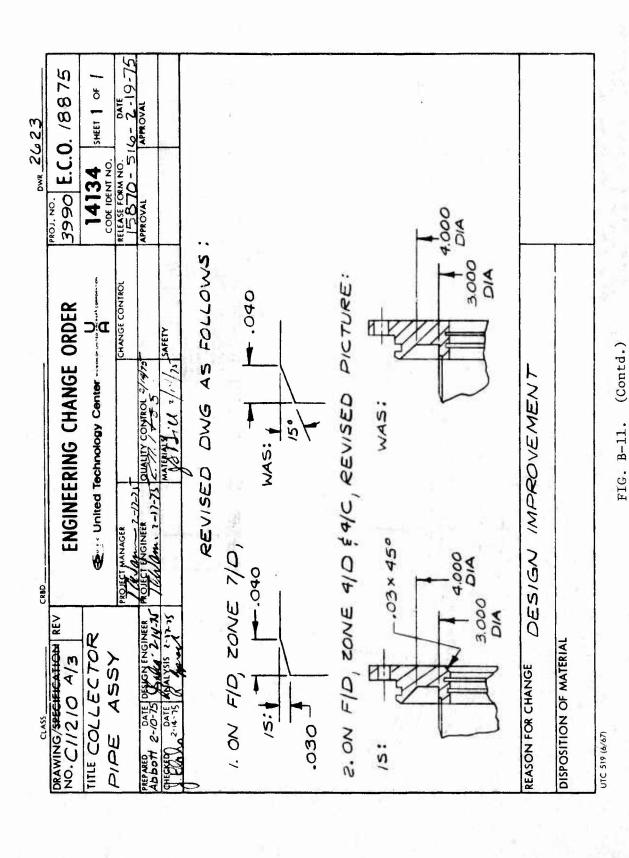
6. B-11. Collector Pipe Assembly.



NO.C/12/0 A/1	ENGINEERING CHANGE ORDER	INGE ORDER	3225 E.C.0	E.C.O. 1885
TITLE COLLECTOR PIPE	U United Technology Center	nter	14134 CODE IDENT NO.	SHEET OF
ASSEMBLY	TO SECTIONAL SER	CHANGE CONTROL	1	6- 11-25-74
FITT DATE DESIGN BUGINEER	No.	r wissing	APPROVAL	APPROVAL
ELLENED DATE ANALYSIS	William Warlow	Garling SARETY		
REVISED DY	DWG AS FOLLOWS:	1		
LIMI	LIMITED EFFECTIVITY: APPLIES TO PART NO CIT 210-01-01, SERIAL NO 001 THRU 008	TIVITY: A	PPLIES TO	90 90 80
1) ON FID ZOI	ZONE B/C			
15: 2.	2.998 D/A 2.996 D/A	WAS: 3.000 DIA	3 0/4	
C Transfer				
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	77 TO 14 TO 15 TO	しゅうじょう ス	570	
7 0 4	V			
PACH ENE CONTRACTOR		* 4		
REASON FOR CHANGE WATING	PART	WRONG (3.000/3.81)	8	
DISPOSITION OF MATERIAL			4 1 1	A African La

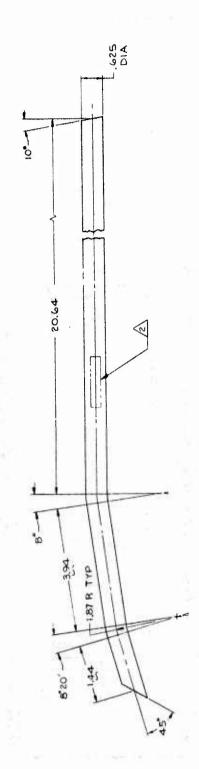
THE PROJECT MANAGER PROJECT OF THE PROJECT MANAGER PROJECT MAN	₩.	
WG AS FOLLOWS WAS: 280 DIA ES EQ SP DIA SFY INTERFACE REQUIREMENT TO SECURING THE SERVED TO	LECTOR PIPE	
WG AS FOLLOWS NG AS FOLLOWS NAS: 280 DIA 2 x.531 DIA ES EQ SP DIA SFY INTERFACE REQUIREMENT	PROJECT MANAGER CHANGE CONTROL 158 36 - 516	M
DWG AS FOLLOWS ZONE 3/B,C WAS: .280 DIA 82° x.531 DIA ACES EQ SP MISPY INTERFACE REQUIREMENT	77.10 1.175 271 /2 5 5 -17-15 SHETY 1-17-75	
WAS: 280 DIA SK 82 x.531 DIA PLACES EQ SP FLACES EQ SP JOI4 DIA SATISFY INTERFACE REQUIREMENT	OWG AS	
SK 82° x.531 DIA SK 82° x.531 DIA SLACES EQ SP DLACES EQ SP J.014 DIA SATISFY INTERFACE REQUIREMENT	F/D, 20NE	
SK 82° x.531 DIA SLACES EQ SP OI4 DIA SATISFY INTERFACE REQUIREMENT	.280 DIA THRU	
SATISEY INTERFACE	531 DIA B HOLES EQ EQ SP (H) 014 DIA	
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1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	S	T i
DISPOSITION OF MATERIAL	DISPOSITION OF MATERIAL	1

FIG. B-11. (Contd.)



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NOTES:
1 UNLESS OTHERWISE SPECIFIED: REMOVE
2 ALL BURRS, BREAK SHARP EDGES 005-020.
2 REMOVE
2 STAMP PART NO. WITH 14 HIGH
CHARACTERS APPROX AS SHOWN.



		AFT CODE PART OR BENT PRING NO.	DESCRIPTION 17EM NO.
			PARTS LIST
SUBSYSTEM DESIGNATOR-		INTERPRET THIS DRAWING CONTRACT NO.	NOO-174-C-1337 United Technology Center
			SUBBAVALL CALPTONNA SANCE
-		UNLESS OTHERWISE SPECIFIED DRAWN DATE	- J.M.F.
		DIMENSIONS ARE IN INCHES CHORDS	TITOLOG LOTT
		TO EBANCS ON	
114		ANGLES = 1 , XX = ± A3 DEDICT	
		SURFACE FINISH V XXX = # - 010	
+1-		MATERIAL: TUBING, STL., MATERIAL	
-01-01 TC11214-01-01 C11224	C11224	4130 PER MIL-T - APPROVED	D 14134 C 1 2 14
	NEXT ASSY LISED ON	1 1 WA WALL	SCALE 1/2 SPECHT SPECET 1 OF
DASH NO. PART NO.	APPLICATION		

FIG. B-12. Tube, Conduit.

NOTES:

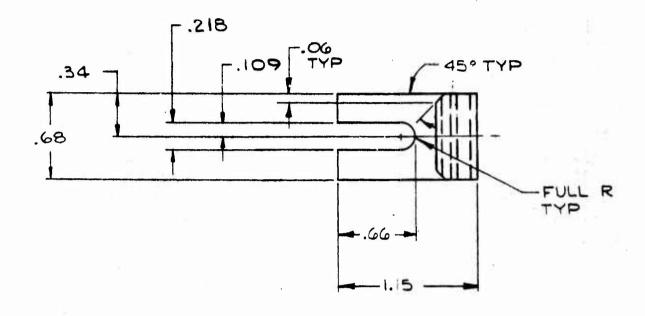
1. UNLESS OTHERWISE SPECIFIED: REMOVE ALL BURRS, BREAK SHARP EDGES. JOS -.020.

2. BAG AND TAG WITH PART NO.

3. MAX SPRING OD: 1.000 DIA
MIN SPRING OD: 1.000 DIA
MIN SPRING 1D: .687 DIA
SPRING WORKS OVER .630 DIA SHAFT.
TORQUE AT:
FINAL POSITION: 28±2 IN. LB.
INITIAL POSITION: 0 IN. LB.
DIRECTION OF HELIX: RIGHT HAND
TOTAL COILS: 4.62 REF - IIZ DIA FINAL POSITION LINITIAL POSITION ,550 R 105.

			1	1		DARY OR	ZONE HILLS
				PEOD IDENT		DENTIFYING NO.	
							PARTS LIST
				-	PAGETOR	PONTOACT NO	
SUBSYSTEM DESIGNATOR			INTERPRET THIS DRAWING	MING			United Technology Center
-			THE WALL AND ADDRESS OF THE PARTY OF THE PAR		_		EUROPEACE, CALIFORNIA, PROMIS
			THE ESS OTHERWISE SPECIFIED	COLFIED	DANKE	Die in	The state of the s
			DIMENSIONS ARE IN INCHES	CHES	100	J. 1. 2. 2. 1.	AND ADDING HELLCAL.
			TOLERANCES ON	4	*	The second	
			ANGLES = # DX = ± 00	SO # ==	Tales.	. he-14/	CYOCA
			SUPFACE FINISH 153 XXX	= ± 010			A38
			MATERIAL STEEL WIRE	WIRE	STOBIAL !	100	
10-10	61-01 C11215-01-01 C11225		PER ASTW-A-228,	228,	APPROVED	NED ON	014134 011213
	•	USED ON	PHOSPHATE COATED	TED		7	SCALE 2 /1 WEIGHT SHEET OF
PART NO.	APPLICATION	ATTON			-		

FIG. B-13. Spring, Helical, Torsion.



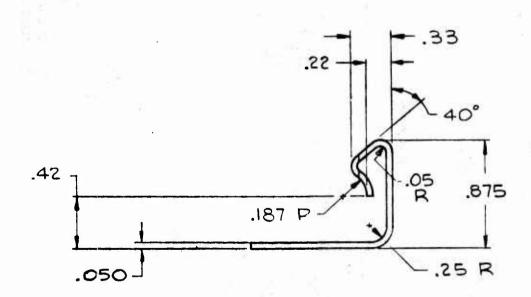


FIG. B-14. Spring, Flat.

NOTES:

1. UNLESS OTHERWISE SPECIFIED: REMOVE ALL
BURNS, BREAK SHARP EDGES.005 -.020.

2. BAG AND TAG WITH PART NO.

3. CADMIUM PLATE PER QQ-P-416, TYPE 2, CLASS 3.

SLEEVE-LUG, SUSPENSION C 14134 C C11217 United Technology Center PER ASTM-A-513 OI-OI-OI 630 DIA AIG \$54.

Sleeve, Lug, Suspension. FIG. B-15.

NOTES:

UNLESS OTHERWISE SPECIFIED: REMOVE ALL
BURHS, BREAK SHAPP EDGES.005-.020. FILLET
BURHS, BREAK SHAPP EDGES.005-.020. FILLET
BURHS, BROOK WELL
SAG AND TAG WITH PART NO.

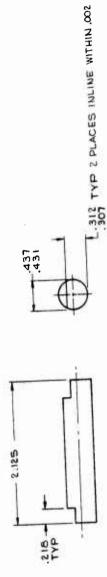
BAG AND TAG WITH PART NO.

STRENGTH, ROCKWELL C 39-49 PER MIL-4-68-75.

STRENGTH, ROCKWELL C 39-49 PER MIL-4-68-75.

STRENGTH, ROCKWELL C 39-49 PER MIL-4-68-75.

FLUORESCENT WET NAGNETICLE INSPECT
COSITY OF SUSPENSION SHALL BE WITHIN THE
SOUTH OF A SUSPENSION SHALL BE WITHIN THE
COSITY OF SUSPENSION SHALL BE WITHIN THE
SOUTH OF SUSPENSION SHALL BE SUSPENSION SHA





0	NOO-123-74-C-1337 United Technology Center A	SHAFT - LUG, SUSPENSION TATA CITIES ENERGY WOOTH	
	MITERINET THIS DRAWFING NOO-123-74-C-1337	ONUSS OPERMES SECURED WITH THE PROPERTY OF THE	
		OLOI CI1218-01-01 C11225 OLOI CI1218-01-01 C11225 SASH NO. PART NO.	

FIG. B-16. Shaft, Lug, Suspension.

2.25 DIA POLITION OF THE POLIT

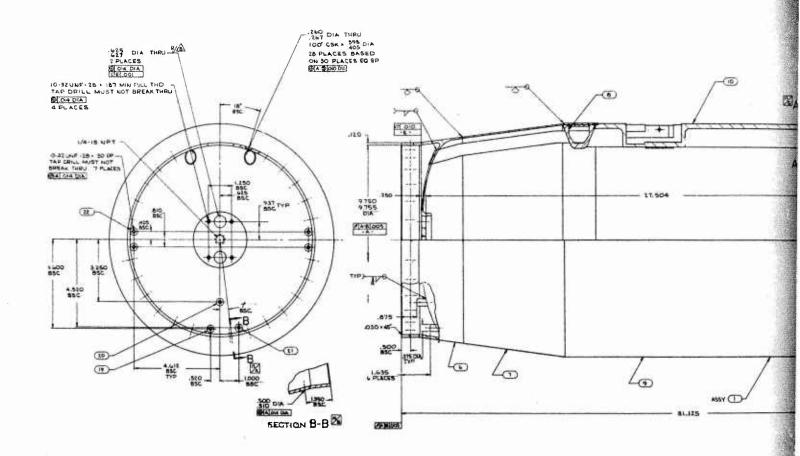
FIG. B-17. Ring, Retainer.

RING, RETAINER

TYP IS PLACES EQ SP

C 14134 CC11219

OI-01 CI1219-01-01



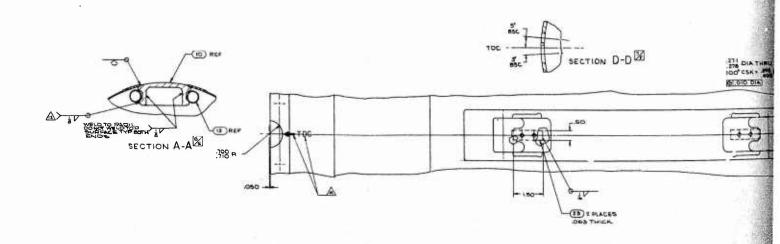
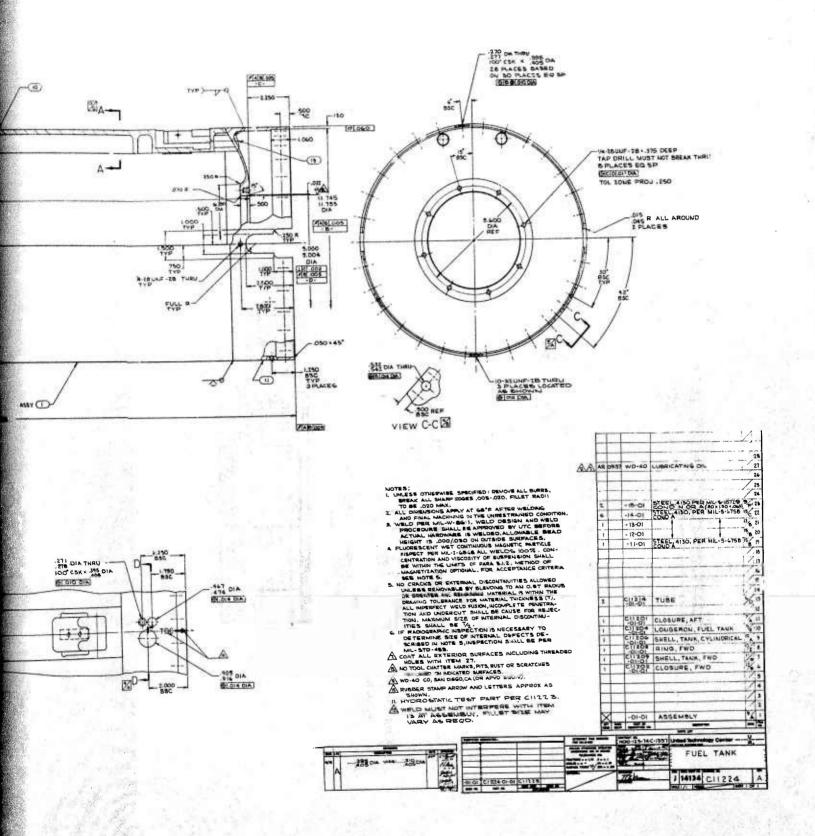


FIG. B-18. Fuel Tank.





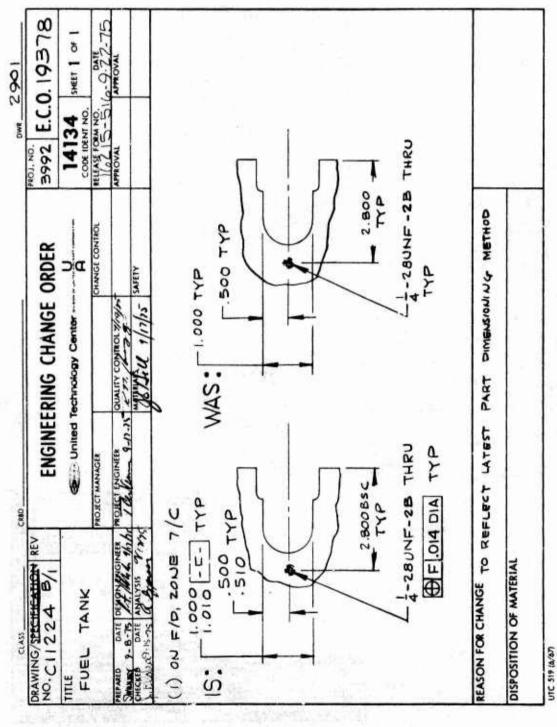
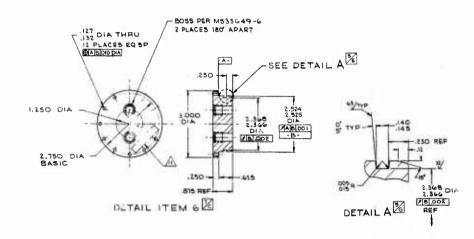


FIG. B-18.

(Contd.)



NOTES

1. UNLESS OTHERWISE SPECIFIED: REMOVE A BURRS, BREAK SHARP EDGES.005-.020. FI RADII TO BE.020 MAY.

2. HYDROSTATIC TEST TO 100 PSIGES PSIGES & TO 3 MINUTES. LEAKAGE RATE SHALL NOT WORE THAN 2 PSIGE PER MINUTE.

APPLY A THIN COATING OF ITEM 14 TO ITE UNDER HEAD, SHANK AND THERADS, PRIOR TO RICATING, CLEAN THRANDS TO REMOVE FE PARTICLES.

11 INSPECT AND CLEAN C-RING, O-RING GOAND SEALING SURFACES WITH A LINT FELCIOTH.

5. ALL TESTING TO BE PERFORMED IN A VERTIFATIODE UNLESS AUTC APPROVED ME IS USED TO ELIMINATE ENTRAPPED AIR IN THE HORIZONTAL POSITION.

6. USE HYDROSTATIC TEST FLUID OF 20 PARTITAND ONE PART WATER SOLUBLE DIL. ALT TEST FLUIDS MAY BE USED IF PRIOR AFOOF UTC IS OBTAINED.

7. AFTER HYDROSTATIC TEST, ALL COMPONSHALL BE CLEANED, DEGREASED, INSPAND SHALL PAVE A THIN COATING OF IVE OIL APPLIED.

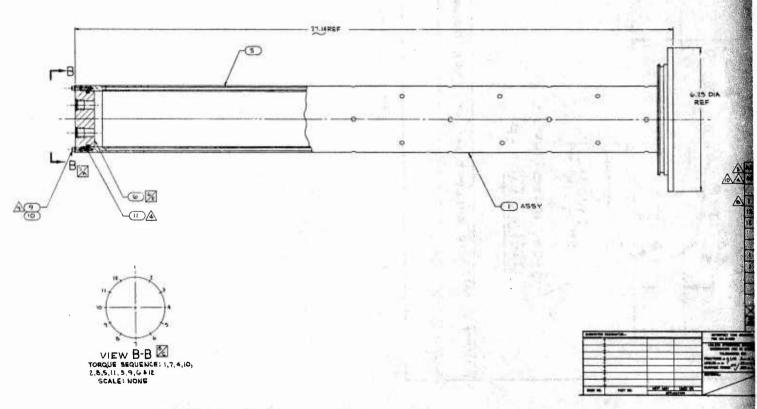
APPRICA SEAL CO, O-SEAL DIV. OF PARKER IFIN CORP. CULVER CITY, CALIF. (OR NOT EQUIV.)

1. TORQUE ITEM 9 TO 10-12 IN. LBS PER SECUIV.)

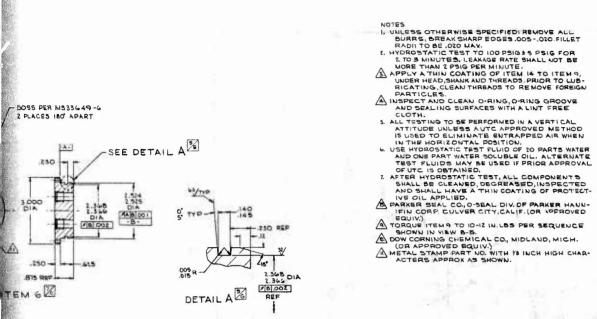
ADD WOON IN VIEW B.B.

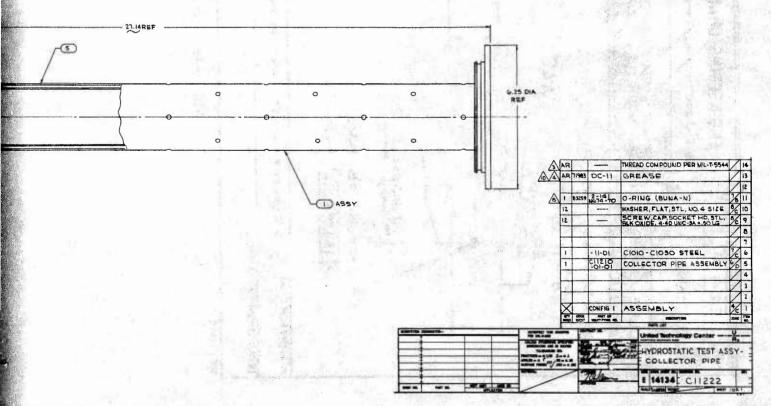
DOW CORNING CHEMICAL CO, MIDLAND, MCCRNING CHEMICAL CO, MIDLAND, ACTERS APPROVED BQUIV.)

METAL STAMP PART NO. WITH 18 INCH HID ACTERS APPROVED B HOWN.

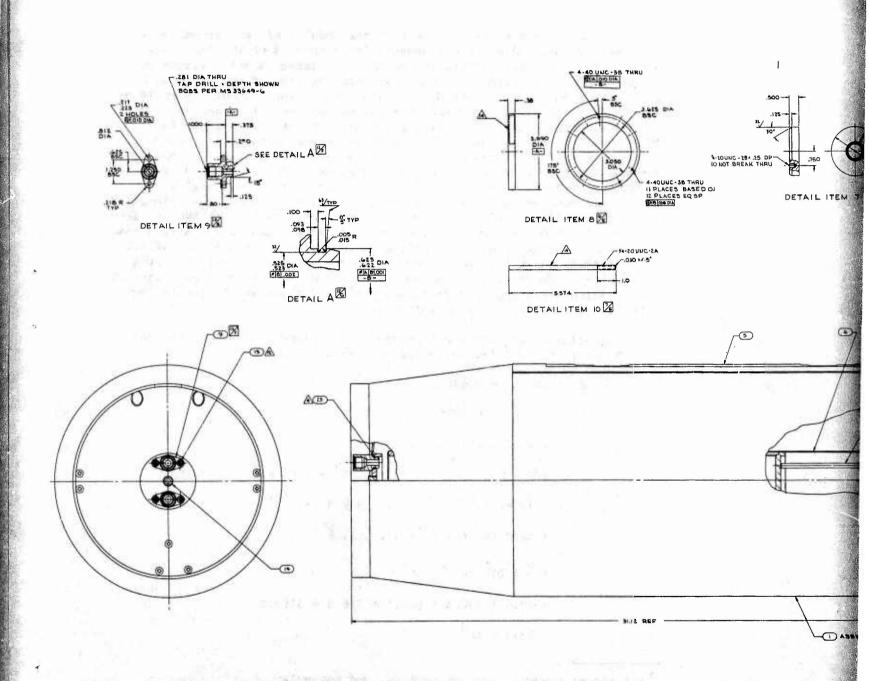


Hydrostatic Test Assembly, Collector Pipe. FIG. B-19.





B-19. Hydrostatic Test Assembly, Collector Pipe.



Triproduction (Electrical Manager Computer Compu

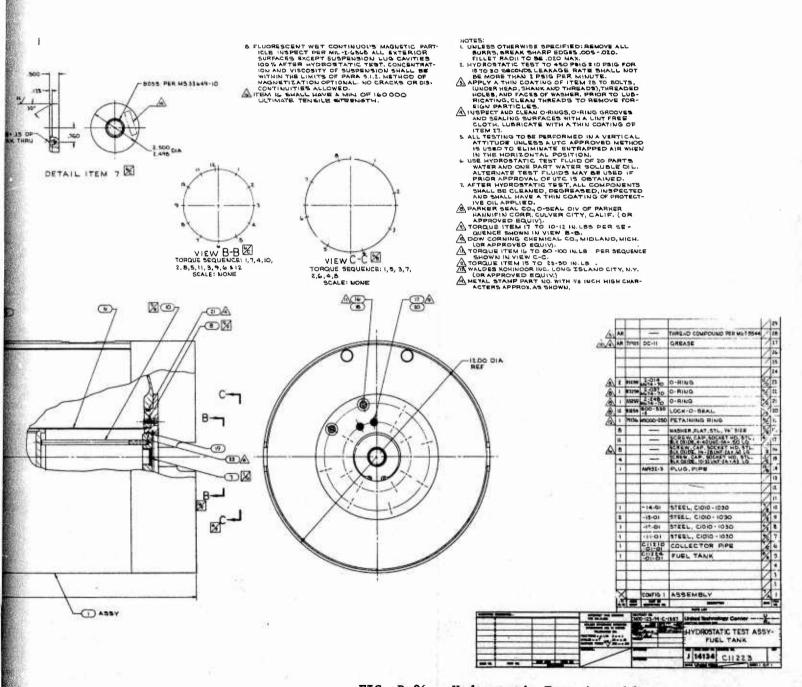


FIG. B-20. Hydrostatic Test Assembly, Fuel Tank.

Appendix C

AERODYNAMIC LOADS FOR GORJE

A complete structural analysis of the GORJE fuel tank assembly is necessary to determine the aerodynamic loads exerted on the fuel tank which result from aerodynamic forces on the forebody and the afterbody. In particular, the force and moment at both the forward and aft attach skirts is required. The aerodynamic loads are a function of the angle of attack which the venicle experiences during captive flight on the launch aircraft. A method for determining the angle of attack is given in MIL-A-8591D dated 2 January 1968. However, examination of the recommended formulas for Points 2 and 6 (see Fig. 11 of MIL-A8591D) reveals that effective angles of attack of 48.3 and 43.6 degrees could be expected at a flight condition of M = 0.8, H = 5,000 ft $(q = 788 \text{ lb/ft}^2)$. These angles of attack are considered to be unrealistically large and the loads calculated using these values would not be appropriate. Discussion with NWC confirmed that MIL-A-8591D gives unrealistic angles of attack and it was agreed that the angle of attack should be limited to 20 degrees. An angle of attack of 20 degrees is in the range where nonlinear aerodynamic effects could be expected. However, it is assumed that linear aerodynamics will predict forces which are slightly higher than would occur and are therefore conservative for structural load purposes.

The value of CL_{α} for the forebody is estimated using the method of DATCOM, section 4.2.1.1a, following the example shown:

d = 10 in. = 0.833 ft

$$\ell_B = 80$$
 in. = 6.67 ft
f = $\ell_B/d = 6.67/0.833 = 8.01$
 $V_B = 1/3\pi (2.5)^2 4.5 + 1/3\pi (3.25^2 + 2.5^2 + 3.25 \times 2.5) 5$
+ $1/3\pi (4.8^2 + 3.25^2 + 4.8 \times 3.25) 13$
+ $1/3\pi (5^2 + 4.8^2 + 5 \times 4.8) 9.5$
+ $\frac{\pi}{4} (10)^2 48$
= 29.4 + 130.5 + 669.5 + 716.3 + 3769.9
= 5315.6 in³

All figure numbers, section numbers, and nomenclature referenced in this appendix are taken from R. D. Finck, USAF Stability and Control DATCOM, October 1960 (Rev. January 1974), Flight Control Division, Air Force Flight Dynamics Laboratory, Wright-Patterson Air Force Base, Ohio.

Note that slender body theory would give $C_{L\alpha}=2/{\rm radian}$. The control surfaces (or wings) with the hinge point at Station 78 are allowed to deflect freely during captive flight and therefore will produce no lift. It is further assumed that, since these surfaces will align themselves with the local flow direction, there will be no downwash to affect the lift of the forebody or afterbody. Consequently, the value of $C_{L\alpha}$ for the forebody is:

 $\left(C_{L_{Q}}\right)_{f} = 1.82/\text{radian (based on S}_{o})$

The value of C_{L_Q} for the afterbody will be difficult to determine because no method is available for a body of noncircular cross section. The lift of the inlet ducts cannot be treated in any straightforward wanner. For lack of a precise method, it will be assumed that the inlet ducts produce the same lift as a low aspect ratio wing. However, it can be shown that the lift of the afterbody will be greater if the effect of the inlet ducts is neglected. This is because, by including the inlet ducts as an equivalent wing surface ahead of the fins, the aspect ratio of the combination is lower with a corresponding reduction in lift. Therefore, it will be assumed that the afterbody lift can be estimated by assuming the fin leading edge extends to the body. The method for calculating the lift of the wing-body combination follows the DATCOM method.

$$(c_{L_{\alpha}})_{WB} = \left[K_{N} + K_{W(B)} + K_{B(W)}\right] (c_{L_{\alpha}})_{e} \frac{s_{e}}{s_{W}}$$

Since the nose lift has been included as a forebody force, $K_N=0$. (The values of $K_{W(B)}$ and $K_{B(W)}$ are found in Fig. 4.3.1.2-10, Appendix II .)

$$\frac{d}{b} = \frac{12}{32} = 0.375$$

$$K_{W(B)} + K_{B(W)} = 1.33 + 0.57 = 1.90$$

The value for $\left(C_{L_{\alpha}}\right)_{e}$ is found in DATCOM.

$$A = \frac{20}{20.7} = 0.97$$

$$\Lambda_{\rm C/2} = 30^{\rm o}$$

$$(M_{fb})_{\Lambda=0} = 1.0$$
 from Fig. 4.1.3.2-43a

$$(M_{fb})_{\Lambda} = 1.0$$
 from Fig. 4.1.3.2-43b

$$K = \frac{C_{L_{\alpha}}}{2\pi} \approx 1.0$$

$$\frac{A}{K} \left[\left(\beta_{fb} \right)_{\Lambda}^{2} + \tan^{2} \Lambda_{c/2} \right]^{\frac{1}{2}} = \frac{0.97}{1.0} (.577^{2})^{\frac{1}{2}} = 0.560$$

$$\frac{c_{L_{\alpha}}}{A} = 1.55$$

$$(c_{L_{\alpha}})_{e} = 1.55 \times .97 = 1.50$$

$$S_e = 2 \times 10 \times 8 + 12.7 \times 10 = 287 \text{ in}^2 = 1.99 \text{ ft}^2$$

$$(c_{L_{\alpha}})_{WB} = [0 + 1.90] 1.50 \frac{1.99}{0.545} = 10.4/\text{radian (based on S}_{0})$$

$$(^{C_{L_{\alpha}}})_{a} = 10.4/\text{radian (based on S}_{o})$$

The value of $C_{m_{\rm Q}}$ for the forebody will be calculated using the method in section 4.2.2.1 of DATCOM. The local body cross sectional area is required.

NWC TP 5835

Station	Diameter, in.	s _x , ft ²	x, ft
0	0	0	0
4.5	5.0	0.136	0.375
9.5	6.5	0.230	0.792
22.5	9.6	0.503	1.875
32.0	10.0	0.545	2.667
80.0	10.0	0.545	6.667

This is plotted in Fig. C-1, from which dS/dx can be determined.

Station	dS_{x}/dx , ft
0 - 4.5	0.363
4.5 - 22.5	0.245
22.5 - 32.0	0.053
32.0 - 80.0	0.0

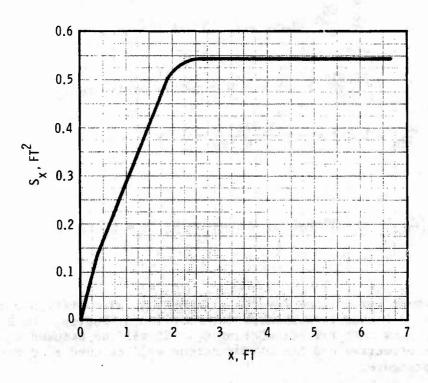


FIG. C-1. Forebody Cross Sectional Area Distribution.

The pitching moment curve slope, $C_{m_{\alpha}}$, is found from

$$C_{m_{\alpha}} = \frac{2 (K_2 - K_1)}{V_B} \int_0^{x_0} \frac{dS_x}{dx} (x_m - x) dx / radian$$

where $\mathbf{x}_{\mathbf{m}}$ is location of moment center.

Piecewise Integration of Equation For $C_{m_{\alpha}}$

Station	Δ×	(dS _x /dx)∆x	x	(x _m -x)	(dS _x /dx)(x _m -x)
0 - 4.5	0.375	0.136	0.187	6.48	0.881
4.5 - 22.5	1.500	0.368	1.125	5.54	2.039
22.5 - 32.0	0.792	0.042	2.667	4.00	0.168
32.0 - 80.0	4.000	0.0	-	-	0.0
	571				3.088

Note x_m at station 80.0

$$\Sigma \frac{dS_x}{dx} (x_m-x) \Delta x = 3.088 \text{ ft}^3$$
 $x=0$

$$C_{m_{\alpha}} = \frac{2(.91)}{3.076} 3.088 = 1.827/\text{radian (based on V}_B)$$

$$C_{m_{\alpha}} = 1.827 \times_{0.545} \frac{3.076}{x 6.667} = 1.55$$

$$(C_{m_{\alpha}})_{f}$$
 = 1.55/radian (based on S_{o} , ℓ = 6.667 ft)

The pitching moment curve slope for the afterbody is also difficult to determine since no method is available for noncircular bodies. In keeping with the assumptions made for calculating $C_{L\alpha}$, it will be assumed that only the fin is effective and the DATCOM method will be used to determine the center of pressure.

$$\frac{\mathbf{x_{a.c.}'}}{\mathbf{c_{r_e}}} = \frac{\left(\frac{\mathbf{x'}}{\mathbf{c_{r_e}}}\right)_{N} \mathbf{c_{L_{\alpha_N}}} + \left(\frac{\mathbf{x_{a.c.}'}}{\mathbf{c_{r_e}}}\right)_{W(B)} \mathbf{c_{L_{\alpha_W(B)}}} + \left(\frac{\mathbf{x_{a.c.}'}}{\mathbf{c_{r_e}}}\right)_{B(W)} \mathbf{c_{L_{\alpha_B(W)}}}}{\mathbf{c_{L_{\alpha_N}}} + \mathbf{c_{L_{\alpha_W(B)}}} + \mathbf{c_{L_{\alpha_B(W)}}}}$$

As before, the lift of the nose is included as a forebody force and $c_{L_{\alpha_N}} = 0$.

$$C_{L_{\alpha_{W}(B)}} = K_{W(B)} (C_{L_{\alpha}})_{e} \frac{S_{e}}{S_{o}}$$

$$C_{L_{\alpha_B(W)}} = K_{B(W)} (C_{L_{\alpha}})_e \frac{S_e}{S_o}$$

The values of $K_{W(B)}$ and $K_{B(W)}$ are found in Fig. 4.3.1.2-10 of Appendix II.

$$C_{L_{\alpha W(B)}} = 1.33 (1.50) \frac{1.99}{0.545} = 7.28$$

$$C_{L\alpha_B(W)} = 0.57 \ (1.50) \ \frac{1.99}{0.545} = 3.12$$

The value of $\left(\frac{X'_{a.c.}}{C_{r_e}}\right)_{W(B)}$ is found from Fig. 4.1.4.2-22:

$$\lambda = \frac{8}{20.7} = 0.386$$

$$\frac{\beta}{\tan \Lambda_{LE}} = \frac{\sqrt{1-.8^2}}{\tan 52^\circ} = \frac{.6}{1.2799} = 0.46$$

A
$$\tan \Lambda_{LE} = .97 \times 1.2799 = 1.24$$

$$\frac{X_{a.c.}}{C_r} = 0.3 = \left(\frac{X_{a.c.}^{i}}{C_{re}}\right)_{W(B)}$$

The value of
$$\left(\frac{X_{a.c.}^{1}}{C_{r_e}}\right)_{B(W)}$$
 is found as outlined in Step 6 of Appendix IV.

$$\beta A_e = \sqrt{1 - .8^2} \times 0.97 = 0.58$$

$$\frac{d}{b} = \frac{12}{20} = 0.6$$

$$\Lambda_{c/4} = 56^{\circ}$$

For $\beta A_e > 4.0$

$$\left(\frac{X_{a,c.}'}{C_{r_e}}\right)_{B(W)} = \frac{1}{4} + \frac{20 - 12}{2 \times 20.7} \tan 56^{\circ} \left[0.35\right] = 0.35$$

For $\beta A_e = 0$ and Figure 4.3.2.1-36b

$$\frac{1}{4} \left[A_{e} (1 + \lambda_{e}) \tan \Lambda_{LE} \right] = \frac{1}{4} \left[0.97(1.386) \tan 52^{\circ} \right] = 0.43$$

$$\left(\frac{X'_{a.c.}}{C_{r_{e}}} \right)_{B(W)} = 0.21$$

Interpolating gives

$$\left(\frac{X_{a,c.}^{i}}{C_{r_{e}}}\right)_{B(W)} = 0.23$$

The center of pressure can now be calculated

$$\frac{\overline{X}_{a.c.}'}{C_{r_a}} = \frac{0 + 0.3 \times 7.28 + 0.23 \times 3.12}{0 + 7.28 + 3.12} = 0.279$$

The pitching moment curve slope for a moment center located at station 111.125 is

$$C_{m_{\alpha}} = C_{L_{\alpha}} (Xm - X)_{/Q} = 10.4 \times \frac{33.5 + 0.279 \times 20.7}{6.667 \times 12} = 5.11$$

$$(C_{m_{\alpha}})_a = 5.11/\text{radian (based on } S_0, \ell = 6.667 \text{ ft})$$

The aerodynamic forces and moments can now be calculated. The maximum aerodynamic loads are given below:

Point	L _f , 1b	M _f , ft-1b	L _a , 1b	M _a , ft-1b
2 or 6	273	1549	1559	5106

NOTE: L is the lift in 1b normal to wind direction.

M is the moment in ft-1b.

f = forward.

a = aft.

It must be remembered that the aerodynamic loads given above are the maximum values. Since the values for α_S can be zero, it must be assumed that the aerodynamic loads can also be zero. The use of these loads in the structural analysis must consider the possibility of zero values and, therefore, selection of the worst case will be made during that analysis.

The values of $C_{L_{\rm Q}}$ and $C_{m_{\rm Q}}$ are applicable to all points on the load diagram. Should it be necessary to evaluate loads at points other than 2 or 6, it is only necessary to determine the new value of $\alpha_{\rm S}$ and evaluate the corresponding forces and moments.

Appendix D

GORJE FUEL TANK ASSEMBLY (O&QR No. 1001)

O&OR	S AND QUALITY RECORD CHANGE ORDER IDR PLAN OWR		1001	PAGE
T NO.	TITLE	QTY.	SERIAL NO.	PLAN DE
211225-	01-02 Fuel Tank Assembly GORJE	L NEXT ASS	Y-END ITEM	N/C
. Sakoi	T. C. Warren 11-11 R. Higgs 3/04/2	1		
FIGURATIO	N AUTHORITY CHANGE ORDER RECORD		WOR NO.	J
R.	OPERATIONS			COMP ST AM
GEI	NERAL INSTRUCTIONS			
Α.	This O&QR provides the documentation for the tank assembly (C11225-01-02) for delivery to		ly of a GORJE	
в.	Applicable Documents			
1	Required ECOs			
	Drawings ECOs			
	C11225 Rev A Fuel Tank Assembly	GORJE		
				- 110
	Information			- 1 E
H.	Drawings			
	C11222 N/C Hydrostatic Test Ass	sembly C	ollector Pipe	deser deser
	C11223 N/C Hydrostatic Test Ass	sembly F	uel Tank	W1 51
	UTC-567 Packaging Data Card	(PDC) F	orm 2518	
C.	All operations performed per this O&QR shall	be perfo	rmed within	
Ì	the scope of the UTC Safety Manual.		soft switch	
D.	All parts, components and materials shall have	re essiden	on of Onelière	
	Acceptance prior to issue.	e eviden	ce of Quality	
E.	Operator, Area Supervisor, or Quality Assur shall stamp those operations indicated in the OPS. VER. columns.	ance, as	applicable, STAMP or	
F.	Complete history sheet as applicable			
r.	Complete history sheet as applicable.			
G.	Upon completion of this O&QR, submit planning Acceptance Center.	ng packag	e to	1
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			Company Company	

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		ND QUALITY RECO	טאינ		1001	PAGE 4
IITMC	NOITAUN	SHEET		PART NO. C11225	1	PLAN REV
PER.			OPERATIONS .	011223		COMP
10	Obtain	parts and materia	als listed on configur	ed parts list from	n stores.	
20	corded has no	QA document num damaged parts.	l material received in taber (status tag No., Record all serial nu ponfigured parts list.	, log No., as rec	uired) an	d
30		t all expulsion tank g surfaces, tank I.	k parts for handling D.	damage; e.g., O	-ring	
40		ly inspect bladder ng damage.	assembly (C11193)	for any evidence	of	
50		ble two attach lugs , 15, 16, 28, 29 a	s per drawing C1122 nd 32.	5 using Items 10,	, 11, 12,	
60	Assem Item 2 finger	7 of drawing C1122	(C11210) to fuel tan 25, for shipping only	k (C11224) with s	crews, vs	3
70		y fuel tank assemb r per Note 1 of dra	oly P/N C11225-01-0 awing C11225.	2, and applicable	e serial	9
80		he following items ent to customer.	from stores and pa	ckage in kit form	for	
	Print (C11225			1997	
	Qty	Item No.	Description	- A		
	1 1	7 18	Bladder Assem Ring Retainer	ably	્ર ધ્	4
	24	26 33	Screws Cotter Pin		Harris State	
1	2 1 1	34 40 41	Streamer Asse O-ring O-ring	mbly		
	1 12	42 43	O-ring O-ring Lock-O-Seal	Total Grand Region	71,000	- 17
90	QC ve	rify identification	and accountability.			
100			o Shipping Departme	ent for packaging	in	
110	Forwa:	rd this O&QR to ac	cceptance center.		de Caracia	

ON	RATIONS AND QU FIGURED PARTS LIS	Ţ						1001	OF	3€ 3 3
ART C112	NO. !25 -01-0 2	Fue	El Tank Assembly GORJE		Q.	TY.	SERIAL	NO.	PLA	N REV
ìΤΥ.	PART NO.		PART NAME	DWG/SPEC. NO AND REVISIO		ENGINEER CHANGE		SERIAL NO		OPS. VER.
1	C11224-01-02		Tank, Fuel							
1	C11210-01-01		Collector Pipe Assy							
2	C11208-02-01		Retainer, Lug							
2	C11207-01-01		Lug, Suspension							
2	C11218-01-01		Shaft						-	
2	C11217-01-01		Sleeve					,		
2	C11208-01-01		Retainer, Lug							
2	C11215-01-01		Spring, Helical, Torsion					81		
2	C11216-01-02		Spring, Flat							
8	1		SCR, CAP, SCH, STL BLK Oxide, Flat 82° CSD, 1/4-28 UNF-2A x .50 Lg.	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1		of Art	.475			
2			SCR, CAP, Button Hd, STL BLK Oxide, 10-32 UNF-2A x .31 Lg.							
4			Screw Cap, Button Hd. STL, BLK Oxide 6-32 UNC-2A x 25 Lg.							
2	MS27183-8		Washer, Flat, Round, STL.		Į					
AR			Grease per MIL-G-4343 or equiva.			E		16.		
AR			Thread compound lubricant							
	4			-				(A)		, :
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	109D (7/72)			<u> </u>				+		

FUEL TANK HYDROSTATIC TEST ASSEMBLY (0&QR No. 1002)

UPERA		1003	PAGE 1
PART NO	O. TITLE QTY. SERIAL 6		PLAN REV-
J. Sa	A STALL DATE ENGINEER WILLIAM DATE DUALITY ASSERTED DATE NEXT ASSY-END ITEM		N/C
OPER.	OPERATIONS		COMPL. STAMP
	GENERAL INSTRUCTIONS A. This OSQR provides the documentation for the hydrostatic test of a collector pipe assembly (C11210-01-01).		-
	B. Applicable Documents		
	Required ECOs Drawings ECOs		=
	C11222 N/C Hydrostatic Test Assembly Collector Pipe	٠,٠	
	C. All operations performed per this OSQR shall be performed within t scope of the UTC Safety Manual.	he	
	D. All parts, components and materials shall have evidence of Quality Acceptance prior to issue.	16.6	1 4 37
	E. Operator, Area Supervisor, or Quality Assurance, as applicable, shall stamp those operations indicated in the COMPL. STAMP or OPS. VER. columns.	A SEC	10 10 10 10 10 10 10 10 10 10 10 10 10 1
	F. Complete history sheet as applicable.	-62 Hz	
	G. Upon completion of this O&QR, submit planning package to Acceptance Center.		
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	TIONS AND QUALITY RECORD	La calca comuni	1002	PAGE 2 OF 4
ONTI	NUATION SHEET	PART NO.		PLAN REV
OPER.	OPERATIONS	C11223		COMPL
NO.	GERATIONS.			STAME
10	Obtain parts and materials listed on configure	ed parts list fr	om stores.	
20	Verify that each part and material received is recorded QA document number (status tag. no., has no damaged parts. Record all serial number status tag numbers on configured parts list.	log no., as req	uired) and	
30	Visually inspect o-ring surfaces for signs of defects.	abrasion, cuts,	or other	ā
40	Visually inspect all o-ring mating surfaces. tool marks are not allowed.	Nicks, scratche		n e-
50	Clean and lubricant all o-rings and o-ring sur Perker o-ring lube or equivalent.	faces with a th	in coat of	
60	Clean all screws and bolts of foreign material lubricant.	and apply a th	nin coat of	
70	All items assembled per drawing C11223.		1.3%	1
80	Assemble item 10 to item 7 finger tight. Plus proof. Install into item 6 using items 19 and		7 to be leak	
90	Assemble item 8 to item 6 using items 17 and 2 10-12 in. 1b.		n 17 to .çds → 3	
.00	Assemble item 6 collector pipe C11210-01-01 to C11224-01-02 with items 16, 21. Torque item 1			
110	Install items 9 to fuel tank C11224-01-02 usin 23-30 in. 1b.	ng item 15 torq	ue to	
20	Fill tank with hydrostatic test fluid per Cll	223 note 6.		
130	Insert one AN-6 plug into on item 9 port.			
140	Connect pressure line to fuel tank to second to have manual cut-off valve).	item 9 port (pro	essure line	
150	Position valve in off position.			
160	Place fuel tank in proof testing box. Connect thru-bulkhead fitting in box.	t pressure line	to inside o	f
170	Connect GN2 bottle line to outside of testing	box thru bulkh	ead fitting.	
180	Turn cut-off valve to "on" position.			- 1
190	Increase pressure to 450 psig ± 10 psig for 1.	5 to 30 seconds		1

	ATIONS AND QUALITY REC	OND		PART NO.	1002	2 0	AGE 3 F 4 AN REV.
PER.				C11223			COMPL.
10.		OPERAT	IONS				STAMP
200	Leakage rate shall not be	more than 2	psig per mir	nute.			
210	QA verify						- erada
220	Shut off pressure.						15.
230	Reduce pressure.						1000
240	Disassemble.						1 1
250	Clean on dry components.						
		C					
260	Deliver to Development			N. J. Unic			,
270	MPI per Note 15 Dwg C0	1223.					
280	Return to Sunnyvale.			25			
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	FIGURED PARTS LIS							1002	OF	
ART (NO. 311223	Fue	1 Tank - HYDIWSTATIC T	ST ASSY	Q.	ry.	SERIAL	NO.	PLA	IN REV.
ìτν.	PART NO.		PART NAME	DWG/SPEC, NO	O. N	ENGINEE CHANGE	RING ORDERS	SERIAL NO. QC TRACE		OPS, VER.
1	C11224-01-02		Fuel Tank	-						
1	C11210-01-01		Collector Pipe	in a				100		
1	C11223-11-01	.]								
1	C11223-12-01						100	- A	-	
1	C11223-13-01	П					,			
1	C11223-14-01							14.194-152	*	- 1
1	AN 932-3		Pipe Plug				- 6	= 9	3	
8	1		Screw, Soc Hd Cap, 1/4-28 UNF-2A x .62 Lg.						X	
4		=	Screw, Soc Hd Cap, 10-32 UNF-2A x .43 Lg.					ALC (1 - 4)		
12			Screw, Soc Hd Cap, 4- 40 UNC-3A x .50 Lg.			54				
8	C ****		Washer, Flat, Stl., 1/4" Nom.							
1	N5000-250		Retaining Ring							
12	800-530-2		Lock-0-Seal							
1	2-248		O-Ring							n.
1	2-037		O-Ring					M		1
2	2-014	71	O-Ring	b .				—		
AR	DC-11		Grease or Equiv.							
AR	7		Thread Compound Lubricant							
			* 1.			Se T				120
	de i							lean-		40

COLLECTOR PIPE HYDROSTATIC TEST ASSEMBLY
(O&QR No. 1003)

RT NO.	}	S AND QUALITY RECORD CHANGE ORDER TIDE PLAN OWE			1002	PAGE 1
	23-01		97Y-	SERIAL	NO+	N/C
ANKE PLE	akoi	BATE ENGINEER TO DATE OUT THE DATE	NEXT ASSY.	END ITE	м	1
		N AUTHORITY CHANGE ORDER RECORD	FINAL	WOR NO		
ER.		- L		<u> </u>		COMPL
-		OPERATIONS				STAMP
	GENE	ERAL INSTRUCTIONS				
	A.	This O&QR provides the documentation for the hydrefuel tank (C11224-01-01).	ostatic t	est of	a	
	В.	Applicable Documents				
		Required ECOs				
		No. 18873				
		C11223 N/C Hydrostatic Test Assem	bly Fuel	Tank		
	c.	All operations performed per this O&QR shall be per the scope of the UTC Safety Manual.	erformed	within		4
	D.	All parts, components and materia? shall have ev Acceptance prior to issue.	idence of	Quali	ty	
	E.	Operator, Area Supervisor, or Quality Assurance, stamp those operations indicated in the COMPL. St columns.				
1	F.	Complete history sheet as applicable.				
	G.	Upon completion of this O&QR, submit planning pactenter.	kage to A	ccepta	nce	
1						
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ארבאא	TIONS AND QUALITY RECORD	2	1003	PAGE 3
ONTI	NUATION SHEET	PART NO.	1 1003	PLAN REV
OPER. NO.	OPERATIONS			COMP
10	Obtain parts and materials listed on configured	parts list fro	m stores.	
20	Verify that each part and material received is a recorded QA document number (status tag. no., lo has no damaged parts. Record all serial numbers status tag numbers on configured parts list.	og no., as requ	ired) and	
30	Visually inspect o-ring surfaces for signs of at defects.	orasion, cuts,	or other	
40	Visually inspect all o-ring mating surfaces. Not tool marks are not allowed.	icks, scratches	, pits and	100
50	Clean and lubricate all o-rings and o-ring surfa Parker o-ring lube or equivalent.	ices with a thi	n coat of	155
60	Clean all screws and bolts of foreign material a lubricant.	and apply a th	n coat of	
70	All items assembled per drawing C11222.		100	,
80	Assemble item 6 to item 5 using items 9, 10 and 10-12 in. 1b.	11. Torque is	em 9 to	
90	Fill item 5, collector pipe, thru port of item (per note 6.	6 with hydrosts	tic fluid	
100	Plug one port of item 6 with plug AN-6 and conne second port pressure line to have manual cut-of		ine to	
110	Position valve in off position.			
L20	Place collector pipe in proof testing box. Cominside of thru-bulkhead fitting in box.	nect pressure	line to	
130	Connect GN2 bottle line to outside of proof test	ting box thru-	oulkhead	
140	Turn cut-off valve to "on" position			1 -8
150	Increase pressure to 100 psig ± 5 psig for 2 to shall not be more than 2 psig per minute.	3 minutes. L	eakage rate	
160	QA verify			5
170	Shut off pressure.		1	
180	Reduce pressure.			
190	Disassemble, clean and dry components. Apply to oil.	hin coating of	protective	.

UTC 3409E (7/72)

	FIGURED PA	ND QUALITY	NECOND				REL. NO.	PAG	E 3
ART		TITLE	Ē		gry.	SERIAL			3 N REV
TY.	PART	NO.	PART NAME	DWG/SPEC. NO AND REVISION		RING ORDERS	SERIAL NO.		OPS. VER.
1	C11210-0	1-01	Collector Pipe Assy			100	CAMO II	122 ,	(A)
1	C11222-1	1-01	Adapter	To John Miles				å	
12			Screw, Soc Hd. Cap, 40 UNC-3A x .50 Lg.			-	ne sale		
12		4850	Washer Flat, Nom. No. 4	r Petrit Service		care la	٥		
1	2-141	MIC THE SO	O-Ring	STR 30.3 53-0)					
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Appendix E

FUEL TANK ASSEMBLY PACKAGING DATA CARD (PDC 2518)

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1		2518
IANN, FUEL, ASSY (GORJE)		
BOX MARKING: THE FOLLOWING INFORMATION SHALL BE STENCILED ON THE SHIPPING BOX:		
P/N C11225		
1-EA.		
S/N (Add)		
-		
PROJ. NO. (Add) CONTR. NO. (Add)	P. 2. A.	
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Appendix F
TANK AND BLADDER TEST LOGS

TEST RESULTS

GORJE TANK ASSEMBLY

Part Number	Serial Number	Page Numbers
C11225-01-01	001	171 to 178
C11225-01-01	002	179 to 186
C11225-01-02	003	187 to 193
C11225-01-02	Ò04	194 to 200
C11225-01-02	005	201 to 213

CONFIGURATION SUMMARY / DETAILED PARTS LIST

Component	Part No.	Serial No.	Dwg Rev.	Applicable ECO'	5
GORJE Tank Assembly	C11225-01-01	001	N/C	None	
Fuel Tank	C11224-01-01	001	Α .	None	
Collector Pipe	C11210-01-01	001 .	A	18851, 18869	
Bladder Assembly	C11193-01-01	003	A	None	
Lug, Suspension	C11207-01-01	N/A	N/C	None	
Sleeve	C11217-01-01	N/A	N/C	None	
Shaft	C11218-01-01	N/A	N/C	None	
Retainer, Lug	C11208-01-01	N/A	A	None	\$1
Spring, Helical, Torsion	C11215-01-01	N/A	N/C	None	¢
Spring, Flat	C11216-01-01	N/A	N/C	None	
Ring, Retainer	C11219-01-01	N/A	N/C	None	

NNC TP 5835

1949 1991 31910

CHRONOLOGY OF MANUFACTURING HISTORY

Fuel Tank	Serial No
Event	Date
1. Completion Date of Fuel Tank	1/21/75
2. Acceptance Date of Fuel Bladder	1/18/75
3. Completion Date of Collector Pipe	1/15/75
4. Hydrotest Date of Collector Pipe	1/22/75
5. Hydrotest Date of Fuel Tank	1/22/75
	1/23/75
6. GORJE Tank Assembly Acceptance Date	Tonas A

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A STANT SHEET

GORJE FUEL TANK

ELADDER LEAK TEST & FUNCTIONAL FIT DATA SHEET

2516-003

Contract N00123-74-C-1337

UTC Project No. 2516

BLADDER ASSEMBLY P/N C11193-01-01

1.	Bladder S/N	003	
2.	Bladder Weight	3.56 LB	
3.	Bladder Test Date	1/23/75	
4.	Test Conductor	J. SAKOI	
5.	Bladder Test Tank	r4 (A	
6.	Bladder Fitup	✓ Acceptable Unacceptable	
7.	Leak Test Gas	(7L' 2.	
8.	Bladder Side Pressurized	Interior Exterior	
9.	Bladder Leak Test Pressure	15psi	L
ιο.	Bladder Leakage Rate	NONE psi	i/min
11.	Number of Bladder Expulsion Cycles	NONIE	
12.	Test Conductor Signature	Ciden'	
13.	Q.A. Observer Signature	Tildren For R. HIGS -	
4.	AFPRO Observer Signature	N/A Tow	

HYDROSTATIC TEST REPORT / WEIGHT SUMMARY

	<u>C11223-01-01</u>	AND AND	
Serial No.	. 001		
	Maria u St. T. at Mari		
Date 22J	Jan75	CALLED A DOM	
		No to the second	
		5	
		- 12 ⁻¹ - 1	
accordance	o certify that the above Fuel T e with the requirements of UTC o eptable to United Technology Cer	drawing C11223, and was found	
it yes note garat Aneso	(family in come to designed, and open	WELFARD SOLD SOUDIEDS	
	C 32 23		
The state of the s	Hedding plants 1 III - 1 CHI - MILLION	京都はむ 記録器に	
MANUAL SECTIONS IN	Tank Weight (without bladder a collector pipe - must be 51 1b		
vio _{w.}	maximum)		
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GORJE FUEL TANK COLLECTOR

PIPE HYDROTEST DATA SHEET

2516-001

Contract N00123-74-C-1337

UTC Project No. 2516

PROOF TEST COLLECTOR PIPE ASSEMBLY P/N C11210-01-01 Per UTC D/N C11222

1.	Collector Pipe S/N	001	
2.	Collector Pipe Weight	11,0	lbs
3.	Collector Pipe Capacity	:://+	in ³
4.	Test Date	1-22-75	. *
5.	Test Conductor	J. SAKOj	
6.	Test Location	RM 195 BLDG 5200	-60
7.	Test Fluid	1120	, ₄₈ .
8.	Test Pressurant	GUV	
9.	Proof Test Pressure	100	psi
0.	Proof Test Pressure Duration	37	min
1.	Leakage Rate	< 1.5 (FAX. 1174	psi/min
2.	Test Conductor Signature	Sold of	
.3.	NOT Inspection Results	-8.411-3 7 m	APTARIL THE
	Q.A. Observe Signature	P.72. 16550	122/15
.5.	AFFRO Observe Signature	N/A (For MIGHT	7.157 7.1465

GORJE FUEL TANK

HYDROTEST DATA SHEET

2516-002

Contract N00123-74-C-1337

UTC Project No. 2516

PROOF TEST FUEL TANK P/N C11224-01 01

per UTC Hydrostatic Test Assembly D/N C11223

1.	Tank S/N	001	
2.	Tank Weight (WITH LUGS & PANUT)	47,5	lbs
3.		1-22-75	end Warry
4.	Test Conductor	J. SAKUL S	*5
5.	Test Location	RN 195 BLDG 50	
6.	Test Fluid	H20 +56 Sous	and the second second
7.	Tank Capacity	2389	in 7693 lbs c
8.	Test Pressurant	_ CN	
9.	Proof Test Pressure	455	_ psi
10.	Proof Test Pressure Duration	30 SEC	-min-
11.	Leakage Rate	10 000000000000000000000000000000000000	_ psi/min
12.	MPI Inspection Results	Day Joseph	
13.	Q.A. Observe Signature / 23-75	12:11.11-55	
14.	AFPRO Observe Signature.	N/A (STAVE	-114c 71837)

NDT REPORT

GORJE Fuel Tank	
GORJE Fuel lank	s un erefest ord
Part No. <u>C11225-01-01</u>	_
Serial No. 001	The state of the s
\$25.17 C = 596	
Date 23Jan75	
	Right Brown
d - sor	There has been been been been been a stand
This Fuel Tank was magnetic	c particle inspected in accordance with

drawing note 4 of drawing C11224 before hydrostatic test, and per drawing note 15 of drawing C11223 after hydrostatic test, and was found to be acceptable to United Technology Center.

All other miscellaneous components which are part of the assembled Fuel Tank were examined by NDT in accordance with the applicable drawings, and were found to be acceptable to United Technology Center.

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(UTC Quality Assurance)

INTERFACE FEATURE REPORT

Inspection Points	Results
o Forward Skirt Inspection	Acceptable to drill jig
o Aft Skirt Inspection	Acceptable to drill jig
o Forward Dome Boss to Bladder Fitting	Functional fit opeable
o Aft Dome Boss to Collector Pipe	Functional fit acceptable
o Bladder to Tank Assembly	Functional fit acceptable
o Attach Lugs to Tank Longeron	Functional fit acceptable

CONFIGURATION SUMMARY / DETAILED PARTS LIST

Component	Part No.	Serial No.	Dwg.Rev.	Applicable ECO's
GORJE Tank Assembly	C11225-01-01	002	A	None -
Fuel Tank	C11224-01-02	002	В	18969, 18987
Collector Pipe	C11210-01-01	005	A	18851, 18869
Bladder Assembly	C11193-01-01	008	A	None
Lug, Suspension	C11207-01-01	N/A	N/C	None
Sleeve	C11217-01-01	N/A	N/C	None
Shaft	C11218-01-01	N/A	N/C	None
Retainer, Lug Retainer, Lug Spring, Helical, Torsion	C11208-01-01 C11208-02-01 C11215-01-01	N/A N/A N/A	A A N/C	None None None
Spring, Flat	C11216-01-C2	N/A	Α	None
Ring, Retainer	C11219-01-01	N/A	N/C	None ,

CHRONOLOGY OF MANUFACTURING HISTORY

and the region of a large walking .

	Fuel Tank Seria	1 No
	Event	Date
1.	Completion Date of Fuel Tank	1/21/75
2.	Acceptance Date of Fuel Bladder	4/16/75
3.	Completion Date of Collector Pipe	4/7/75
4.	Hydrotest Date of Collector Pipe	4/11/75
5.	Hydrotest Date of Fuel Tank	4/16/75
6.	GORJE Tank Assembly Acceptance Date (DD-250 Sign-off)	4/24/75

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GORJE FUEL TANK

BLADDER LEAK TEST & FUNCTIONAL FIT DATA SHEET

2516-003

Contract N00123-74-C-1337

UTC Project No. 2516

BLADDER ASSEMBLY P/N C11193-01-01

1.	Bladder S/N	- 00B	
2.	Bladder Weight	3,50 LBs.	. *
3.	Bladder Test Date	4-16-75	.*
4.	Test Conductor	200%	
5.	Bladder Test Tank	Pl€Y.	
6.	Bladder Fitup	Acceptable Unacceptable	
7.	Leak Test Gas	QN2	
8.	Bladder Side Pressurized	☐ Interior	
9.	Bladder Leak Test Pressure	30 - HOLD AT IS	psi
LO.	Bladder Leakage Rate	Nove.	psi/min
11.	Number of Bladder Expulsion Cycles		
12.	Test Conductor Signature	Le Demi	
13.	Q.A. Observer Signature	TR. n. //250	
L4.	AFPRO Observer Signature	CURIORO By EU. SINGLIO (TIME	sures arey
		277/1-53	-

HYDROSTATIC TEST REPORT / WEIGHT SUMMARY

Part No	o. <u>C1</u>	1223-01	l-01	
Serial	No	002		
Date	22 Ap	r 75	V 2-3	

This is to certify that the above Fuel Tank was hydrostatic tested in accordance with the requirements of UTC drawing Cll223, and was found to be acceptable to United Technology Center.

Tank Weight (without bladder and collector pipe - must be 51 lbs maximum)

47.8 lbs

(UTC Quality Assurance)

SS PART SEC. A STORE

GORJE FUEL TANK COLLECTOR

PIPE HYDROTEST DATA SHEET

2516-001

Contract N00123-74-C-1337

UTC Project No. 2516

PROOF TEST COLLECTOR PIPE ASSEMBLY

P/N C11210-01-01 Per UTC D/N C11222

1.	Collector Pipe S/N	005
2.	Collector Pipe Weight	10.50 lbs
3.	Collector Pipe Capacity	in ³
4.	Test Date	4-11-75
5.	Test Conductor	D. BONK
6.	Test Location	BUDG 5000 12-1 275
7.	Test Fluid	WATER
8.	Test Pressurant	GN 2
9.	Proof Test Pressure	
10.	Proof Test Pressure Duration	2,5 min
11.	Leakage Rate	C psi/min
12.	Test Conductor Signature	all South
13.	NDT Inspection Results	Accommon
14.	Q.A. Observe Signature	-R.m. 16-5-3-
15.	AFPRO Observe Signature	N/A - WALLO THIS COL-
		only. Tanifera

GORJE FUEL TANK

HYDROTEST DATA SHEET

2516-002

Contract N00123-74-C-1337

UTC Project No. 2516

PROOF TEST FUEL TANK P/N C11224-01-01 Per UTC Hydrostatic Test Assembly D/N C11223

l.	Tank	S/N	-
2.	Tank	Weight	-
3.	Test	Date	

- 4. Test Conductor
- 5. Test Location
- 6. Test Fluid
- 7. Tank Capacity
- 8. Test Pressurant
- 9. Proof Test Pressure
- 10. Proof Test Pressure Duration
- 11. Leakage Rate
- 12. MPI Inspection Results
- 13. Q.A. Observe Signature
- 14. AFPRO Observe Signature.

* WITHOUT ATTACH LUGS

* EQUIVALENT TO 75.82 Ibs OF TH DIMING @ 140°F

NDT REPORT

Part No.	011225-01-01
Serial No.	002

Date 4/18/75

GORJE Fuel Tank

This Fuel Tank was magnetic particle inspected in accordance with drawing note 4 of drawing C11224 before hydrostatic test, and per drawing note 15 of drawing C11223 after hydrostatic test, and was found to be acceptable to United Technology Center.

All other miscellaneous components which are part of the assembled Fuel Tank were examined by NDT in accordance with the applicable drawings, and were found to be acceptable to United Technology Center.

(UTC Quality Assurance)

INTERFACE FEATURE REPORT

Inspection Points

- o Forward Skirt Inspection
- o Aft Skirt Inspection
- o Forward Dome Boss to Bladder Fitting
- o Aft Dome Boss to Collector Pipe
- o Bladder to Tank Assembly
- o Attach Lugs to Tank Longeron

Results

Acceptable to drill jig

Acceptable to drill jig

Functional fit acceptable

Functional fit acceptable

Functional fit acceptable

Functional fit acceptable

NWC TP 5835

CONFIGURATION SUMMARY / DETAILED PARTS LIST

Component	Part No.	Serial No.	Dwg Rev.	Applicable ECO's
GORJE Tank Assembly	C11225-01-02	003	A	None
Fuel Tank	C11224-01-02	003	В	19378
Collector Pipe	C11210-01-01	003	Α.	18851, 18869, 18875
Bladder Assembly	C11193-01-01	010	A _	None
Lug, Suspension	C11207-01-01	N/A	и/с	None
Sleeve	C11217-01-01	N/A	N/C	None
Shaft	C11218-01-01	N/A	N/C	None
Retainer, Lug	C11208-01-01	n/A	Α .	None
Retainer, Lug	C11208-02-01	N/A	Ā	None
Spring, Helical, Torsion	C11215-01-01	N/A	N/C	None
Spring, Flat	C11216-01-02	N/A	A :	None
Ring, Retainer	C11219-01-01	N/A	N/C	None

CHRONOLOGY OF MANUFACTURING HISTORY

	Fuel	Tank	Serial	No.	003
Event					Date
1. Completion Date of Fuel Tank	•		•		8-8-75
2. Acceptance Date of Fuel Bladder					4-18-75
3. Completion Date of Collector Pipe					5-28-75
4. Hydrotest Date of Collector Pipe					9-5-75
5. Hydrotest Date of Fuel Tank					9-8-75
6. GORJE Tank Assembly Acceptance Date (DD-250 Sign-Off)					9-26-75

HYDROSTATIC TEST KEPORT / WEIGHT SUMMARY

Part No	C11223-01-0)1
Serial No.	003	
	4	
Date 9-8-	75	

This is to certify that the above Fuel Tank was hydrostatic tested in accordance with the requirements of CSD drawing C11223, and was found to be acceptable to Chemical Systems Division of United Technologies.

Tank Weight (without bladder and collector pipe - must be 51 lbs maximum)

44.5 lbs

(CSD Quality Assurance)

GORJE FUEL TANK COLLECTOR

PIPE HYDROTEST DATA SHEET

2516-001

Contract N00123-74-C-1337

UTC Project No. 2516

PROOF TEST COLLECTOR PIPE ASSEMBLY

P/N C11210-01-01 Per UTC D/N C11222

1.	Collector Pipe S/N	.3	
	Collector Pipe Weight	9.98	_ _ 1bs
3.	Collector Pipe Capacity	N/A	_in ³ .
4.	Test Date	9-5-75	-1
5.	Test Conductor	J.S. SAKOI	_ ==
6.	Test Location	SV	4
7.	Test Fluid	E-120/5	06.016
8.	Test Pressurant	FO GN2	- Fr
9.	Proof Test Pressure	104	_ psi
10.	Proof Test Pressure Duration	2	_ min
11.	Leakage Rate	NONE	_ psi/min
12.	Test Conductor Signature	Soly	14
13.	NDT Inspection Results	NOT APPLICABLE	b
14.	Q.A. Observe Signature	8.71.16.75	_
15.	AFPRO Observe Signature	~/A	jan .

GORJE FUEL TANK

HYDROTEST DATA SHEET

2516-002

Contract N00123-74-C-1337

UTC Project No. 2516

PROOF TEST FUEL TANK P/N C11224-01-01 Per UTC Hydrostatic Test Assembly D/N C11223

1.	Tank S/N	3
2.	Tank Weight	44,5 lbs
3.	Test Date	9-5-75
4.	Test Conductor	J. SAKOI STALLO
5.	Test Location	SV
6.	Test Fluid	H20/SOL. OIL
7.	Tank Capacity	2350 in ³
8.	Test Pressurant	GNV
9.	Proof Test Pressure	450 psi
10.	Proof Test Pressure Duration	1/2 min
11.	Leakage Rate	psi/min
12.	MPI Inspection Results	July 9-10-25
13.	Q.A. Observe Signature	x.77.11-57
	AFPRO Observe Signature	11/12

NOT REPORT

GORJE Fuel	Tank	
Part No	C11225-01-02	
Serial No.	003	_
Date 9-	18-75	

This Fuel Tank was magnetic particle inspected in accordance with drawing note 4 of drawing Cl1224 before hydrostatic test, and per drawing note 15 of drawing Cl1223 after hydrostatic test, and was found to be acceptable to Chemical Systems Division of United Technologies.

All other miscellaneous components which are part of the assembled Fuel Tank were examined by NDT in accordance with the applicable drawings, and were found to be acceptable to Chemical Systems Division of United Technologies.

(CSD Quality Assurance)

INTERFACE FEATURE REPORT

Inspection Points

- o Forward Skirt Inspection
- o Aft Skirt Inspection
- o Ferward Dome Boss to Bladder Fitting
- o Aft Dome Boss to Collector Pipe
- o Bladder to Tank Assembly
- o Attach Lugs to Tank Longeron

Results

Acceptable to drill jig

Acceptable to drill jig

Functional fit acceptable

Functional fit acceptable

Functional fit acceptable

Functional fit acceptable

NWC TP 5835

CONFIGURATION SUMMARY / DETAILED PARTS LIST

Component	Part No.	Serial No.	Dwg Rev.	Applicable ECO's
. GORJE Tank Assembly	C11225-01-02	004	A	None
Fuel Tank	C11224-01-02	004	В	19378
Collector Pipe	C11210-01-01	004	A	18851, 18869, 18875
Bladder Assembly	C11193-01-01	911	A	None
Lug, Suspension	C11207-01-01	N/A	N/C	None
Sleeve	C11217-01-01	N/A	N/C	None
Shaft	C11218-01-01	N/A	N/C	None
Retainer, Lug	C11208-01-01	N/A	er Arond	. None
Retainer, Lug	C11208-02-01	N/A	April April	None
Spring, Helical, Torsion	C112150101	N/A	N/C	None
Spring, Flat	C11216-01-02	N/A		None
Ring, Retainer	C11219-01-01	N/A	N/C	None

CHRONOLOGY OF MANUFACTURING HISTORY

	Fuel Tank Serial No. 004	
Event	Date	
1. Completion Date of Fuel Tank	8-8-75	10
2. Acceptance Date of Fuel Bladder	4-18-7	5
3. Completion Date of Collector Pipe	5-28-7	5
4. Hydrotest Date of Collector Pipe	9-5-75	
5. Hydrotest Date of Fuel Tank	9-8-75	
6. GORJE Tank Assembly Acceptance Date (DD-250 Sign-Off)	9-26-	25

HYDROSTATIC TEST REPORT / WEIGHT SUMMARY

Part No.	C11223-01-01	
Serial No.	. 004	
Date 9-	8-75	

This is to certify that the above Fuel Tank was hydrostatic tested in accordance with the requirements of CSD drawing C11223, and was found to be acceptable to Chemical Systems Division of United Technologies.

Tank Weight (without bladder and collector pipe - must be 51 lbs maximum) 44.7 1hs

(CSD Quality Assurance)

GORJE FUEL TANK COLLECTOR

PIPE HYDROTEST DATA SHEET

2516-001

Contract N00123-74-C-1337

UTC Project No. 2516

PROOF TEST COLLECTOR PIPE ASSEMBLY

P/N C11210-01-01 Per UTC D/N C11222

1.	Collector Pipe S/N	حح ا	
	Collector Pipe Weight	10.44	1bs
3.	Collector Pipe Capacity	N/A	in ³
4.	Test Date	9-5-75	
5.	Test Conductor	J. S. SAKOI	
6.	Test Location	5 V	
7.	Test Fluid	H20/506.01L	
8.	Test Pressurant	GNZ	
9.	Proof Test Pressure (100 Pil)	102	psi
10.	Proof Test Pressure Duration	21/2	min
11.	Leakage Rate	NONE	psi/min
12.	Test Conductor Signature	- Soler'	
13.	NDT Inspection Results	Not APRICABLE	, -
14.	Q.A. Observe Signature	P.11.16000	
15.	AFPRO Observe Signature	~/19	

NWC TP 5835 GORJE FUEL TANK

HYDROTEST DATA SHEET

2516-002

Contract N00123-74-C-1337

UTC Project No. 2516

PROOF TEST FUEL TANK P/N C11224-01-01 Per UTC Hydrostatic Test Assembly D/N C11223

	•	. //-
1.	Tank S/N	
2.	Tank Weight	44.7 lbs
3.	Test Date	9-8-75
4.	Test Conductor	J. SAKOI Faller
5.	Test Location	. <u> 5V</u>
6.	Test Fluid	H30 /SOL OIL
7.	Tank Capacity	2350 in ³
8.	Test Pressurant	GNV
9.	Proof Test Pressure	450 psi
0.	Proof Test Pressure Duration	//v min
1.	Leakage Rate	psi/min
2.	MPI Inspection Results	100/19-12-25
.3.	Q.A. Observe Signature	R.77.11-570
4.	AFPRO Observe Signature.	NA

NDT REPORT

Part No	C11225-01-02	_
Serial No.	004	

GORJE Fuel Tank

Date 9-18-75

This Fuel Tank was magnetic particle inspected in accordance with drawing note 4 of drawing C11224 before hydrostatic test, and per drawing note 15 of drawing C11223 after hydrostatic test, and was found to be acceptable to Chemical Systems Division of United Technologies.

All other miscellaneous components which are part of the assembled Fuel Tank were examined by NDT in accordance with the applicable drawings, and were found to be acceptable to Chemical Systems Division of United Technologies.

(CSD Quality Assurance)

INTERFACE FEATURE REPORT

In	spection Points	Results	
0	Forward Skirt Inspection	Acceptable	to drill jig
0	Aft Skirt Inspection	Acceptable	to drill jig
0	Forward Dome Boss to Bladder Fitting	Functional	fit acceptable
0	Aft Dome Boss to Collector Pipe	Functional	fit acceptable
0	Bladder to Tank Assembly	Functional	fit acceptable
0	Attach Lugs to Tank Longeron	Functional	fit accentable

CONFIGURATION SUMMARY / DETAILED PARTS LIST

Component	Part No.	Serial No.	Dwg Rev.	Applicable ECO's
GORJE Tank Assembly	C11225-01-02	005	A	None
Fuel Tank	C11224-01-02	005	3	19378
Collector Pipe	C11210-01-01	006	A	18851, 18869, 18875
Bladder Assembly	C11193-01-01	012	A	None
Lug. Suspension	C11207-01-01	N/A	N/C	None
Sleeve	C11217-01-01	N/A	N/C	None
Shaft	C11218-01-01	N/A	N/C	None
Retainer, Lug	C11208-01-01	N/A	A	None
Retainer, Lug	C11208-02-01	N/A	Α .	None
Spring, Helical,	C11215-01-01	n/A	N/C	None
Torsion	·			None
Spring, Flat	C11216-01-02	n/A	A	None
Ring, Retainer	C11219-01-01	N/A	N/C	None

CHRONOLOGY OF MANUFACTURING HISTORY

•	Fuel Tank Serial No. 005
Event	Date
1. Completion Date of Fuel Tank	8-8-75
2. Acceptance Date of Fuel Bladder	4-21-75
3. Completion Date of Collector Pi	pe <u>5-28-75</u>
4. Hydrotest Date of Collector Pip	e <u>9-5-75</u>
5. Hydrotest Date of Fuel Tank	9-8-75
6. GORJE Tank Assembly Acceptance (DD-250 Sign-Off)	Date 9-26-75

HYDROSTATIC TEST REPORT / WEIGHT SUMMARY

Part No.	C11223-01-01
Serial No.	005
Date 9-8-	75

This is to certify that the above Fuel Tank was hydrostatic tested in accordance with the requirements of CSD drawing C11223, and was found to be acceptable to Chemical Systems Division of United Technologies.

Tank Weight (without bladder and collector pipe - must be 51 lbs maximum) 44.7 1bs

(CSD Quality Assurance)

NWC TF 5835

GORJE FUEL TANK COLLECTOR

PIPE HYDROTEST DATA SHEET

2516-001

Contract: N00123-74-C-1337

UTC Project No. 2516

PROOF TEST CCLLECTOR PIPE ASSEMBLY

P/N C11210-01-01 Per UTC D/N C11222

1.	Collector Pipe S/N	6
2.	Collector Pipe Weight	
	Collector Pipe Capacity	N/Δ_{in}^3
4.	Test Date	9-5-75
•		J.S. SAKO1
	Test Conductor	Sil
6.	Test Location	1/ 2/5444
7.	Test Fluid	H20/SUL. 01L
8.	Test Pressurant	GN2 gn
9.	Proof Test Pressure	psi
10.	Proof Test Pressure Duration	Z/v min
11.	Leakage Rate	NONE psi/min
12.	Test Conductor Signature	Sales
13.	NDT Inspection Results	Not APIDLICABLE
14.	Q.A. Observe Signature	R.71.//-
15.	AFPRO Observe Signature	<u> </u>

GORJE FUEL TANK

HYDROTEST DATA SHEET

2516-002

Contract N00123-74-C-1337

UTC Project No. 2516

PROOF TEST FUEL TANK P/N C11224-01-01

per UTC Hydrostatic Test Assembly D/N C11223

1.	Tank S/N	5
2.		44.7 lbs
3.	Test Date	9-8-75
4.	Test Conductor	J. SAKOI Saleon
5.	Test Location	<u> 51</u>
6.	Test Fluid	Hap/ Soi. Oic
7.	Tank Capacity	2350 in ³
8.	Test Pressurant	GNZ
9.	Proof Test Pressure	750 psi
.0.	Proof Test Pressure Duration	
11.	Leakage Rate	2 psi/min
12.	MPI Inspection Results	1 9-18-25
13.	Q.A. Observe Signature	K.71/45 5
4.	AFPRO Observe Signature.	NA

NOT REPORT

Part No.	C11225-01-02
Serial No.	005
Data 0	10 75

GORJE Fuel Tank

This Fuel Tank was magnetic particle inspected in accordance with drawing note 4 of drawing Cl1224 before hydrostatic test, and per drawing note 15 of drawing Cl1223 after hydrostatic test, and was found to be acceptable to Chemical Systems Division of United Technologies.

All other miscellaneous components which are part of the assembled Fuel Tank were examined by NDT in accordance with the applicable drawings, and were found to be acceptable to Chemical Systems Division of United Technologies.

(CSD Quality Assurance)

INTERFACE FEATURE REPORT

Inspection Points

- o Forward Skirt Inspection
- o Aft Skirt Inspection
- o Forward Dome Boss to Bladder Fitting
- o Aft Dome Boss to Collector Pipe
- o Bladder to Tank Assembly
- o Attach Lugs to Tank Longeron

Results

Acceptable to drill jig

Acceptable to drill jig

Functional fit acceptable

Functional fit acceptable

Functional fit acceptable

Functional fit acceptable

GORJE FUEL TANK

BLADDER LEAK TEST & FUNCTIONAL FIT DATA SHEET

2516-003

Contract N00123-74-C-1337

UTC Project No. 2516

BLADDER ASSEMBLY P/N C11193-01-01

1.	Bladder S/N	000	
2.	Bladder Weight	3.7	
3.	Bladder Test Date	2-71-75	
4.	Test Conductor	The Course	
5.	Bladder Test Tank	Plantalises	
6.	Bladder Fitup	X Acceptable Unacceptable	
7.	Leak Test Gas	GUZ	
8,	Bladder Side Pressurized	Interior Exterior	
9.	Bladder Leak Test Pressure	psi	i
10.	Bladder Leakage Rate	<u> </u>	i/min
11.	Number of Bladder Expulsion Cycles		
12.	Test Conductor Signature	- Committee of the comm	
13.	Q.A. Observer Signature		
14.	AFPRO Observer Signature	e e e e e e e e e e e e e e e e e e e	

GORJE FUEL TANK

BLADDER LEAK TEST & FUNCTIONAL FIT DATA SHEET

2516-003

Contract N00123-74-C-1337

UTC Project No. 2516

BLADDER ASSEMBLY P/N C11193-01-01

1.	Bladder S/N	<u></u>
2.	Bladder Weight	3.22 KBS
3.	Bladder Test Date	4-18-75
4.	Test Conductor	7775: 12.
5.	Bladder Test Tank	Dirunians Touti
6.	Bladder Fitup	Acceptable Unacceptable
7.	Leak Test Gas	GNZ
8.	Bladder Side Pressurized	☐ Interior
9.	Bladder Leak Test Pressure	75-15 psi
10.	Bladder Leakage Rate	Viene psi/min
ıi.	Number of Bladder Expulsion Cycles	
12.	Test Conductor Signature	
13.	Q.A. Observer Signature	
1 4	AFPRO Observer Signature	

GORJE FUEL TANK

BLADDER LEAK TEST & FUNCTIONAL FIT DATA SHEET

2516-003

Contract N00123-74-C-1337

UTC Project No. 2516

BLAUDER ASSEMBLY P/N C11193-01-01

1.	Bladder S/N	0055	
2.	Bladder Weight		
3.	Bladder Test Date	30 JAN 75	
4.	Test Conductor	J.S. SAKOI	
5.	Bladder Test Tank	PLEXIGLASS TANK	
6.	Bladder Fitup	Acceptable Unacceptable	
7.	Leak Test Gas	GNZ	
8.	Bladder Side Pressurized	☐ Interior ☐ Exterior	
9.	Bladder Leak Test Pressure		p s i
10.	Bladder Leakage Rate	1/2 PS1	psi/ai
11.	Number of Bladder Expulsion Cycles	<u> </u>	
12.	Test Conductor Signature	S.G. Galio	
13.	Q.A. Observer Signature		
	AFPRO Observer Signature		

GORJE FUEL TANK

BLADDER LEAK TEST & FUNCTIONAL FIT DATA SHEET

2516-003

Contract N00123-74-C-1337

UTC Project No. 2516

BLADDER ASSEMBLY P/M C11193-01-01

1.	Bladder S/N	098	
2.	Bladder Weight	5.25	
3.	Bladder Test Date	4.21-71	
4.	Test Conductor	-15	
5.	Bladder Test Tank	Marine Some	
6.	Bladder Fitup	Acceptable Unacceptable	aubiki
7.	Leak Test Cas	(1)/21	
8.	Bladder Side Pressurized	Interior Exterior	
9.	Bladder Leak Test Pressure	25-15	psi
lo.	Bladder Leakage Rate	1/3115	psi/min
11.	Number of Bladder Expulsion Cycles		
12.	Test Conductor Signature	Charles with	
13.	Q.A. Observer Signature		
14.	AFPRO Observer Signature		

GORJE FUEL TANK

MADDER LEAK TEST & FUNCTIONAL FIT DATA SHEET

2516-003

Contract N00123-74-C-1337

UTC Project No. 2516

BLADDER ASSERBLY P/N C11193-01-01

	1.	. Bladder S/W	007 (ALSO 0075)
	2.	. Dladder Weight	3.31 LB.
	3.	. Bladder Test Date	5 FCB 75
	4.	. Test Conductor	J. S. SAKOI
	5.	. Bladder Test Tank Die	VIGLOSS TONK.
	ű.	. Bladder Fitup	ctable [Chacceptable
	7.	. Leak Test Cas	
	3.	. Clodder Side Pressurized	cior 🔯 Laterior
	9.	. Bladder Leak Test Pressure 17 PS1	40 30 psi
	10.	. Bladder Leakage Hate	ps1/ain
	11.	. Number of Bladder Expulsion Cycles	
	12.	. Test Conductor Signature	55/6
	13.	. Q.A. Cusarver Signature	
	14.	. AFPRO Observer Signature	
		+ 15-PSI @ 10:50 AM 6 FLB (A	un Hold - 14 leak wielle
-			remin approx size bidon

NWC TP 5835 GORJE FUEL TANK

BLADDER LEAK TEST & FUNCTIONAL FIT DATA SHEET

2516-003

Contract N00123-74-C-1337

UTC Project No. 2516

BLADDER ASSEMBLY P/N C11193-01-01

1.	Bladder S/N	000	
2.	Bladder Weight	3,43 LB3.	
3.	Bladder Test Date	4-18-75	
4.	Test Conductor	DO BONK.	
5.	Bladder Test Tank	PLEXIGHUSS . THOK.	
6.	Bladder Fitup	Acceptable Unacceptable	
7.	Leak Test Gas	<u> </u>	
8.	Bladder Side Pressurized	☐ Interior ☐ Exterior	
9.	Bladder Leak Test Pressure	<u>35 - 15</u> psi	
10.	Bladder Leakage Rate	<u>i) e 15 E</u> psi	/min
11.	Number of Bladder Expulsion Cycles		
12.	Test Conductor Signature	The same of the sa	
13.	Q.A. Observer Signature		
14.	AFPRO Observer Signature		

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