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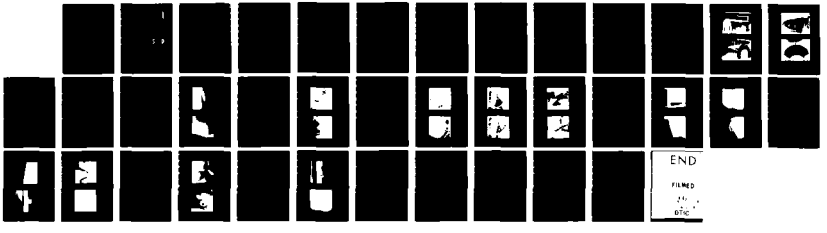

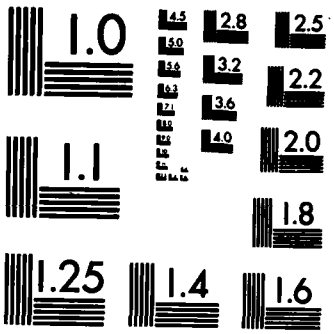

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REPLICA FUEL TANK BLADDERS

RLANDO TECHNOLOGY, INC.
237 Edgewater Drive
Orlando, Florida 32810

JANUARY 1981

FINAL REPORT FOR PERIOD JUNE 1980 - JANUARY 1981

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20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*

Replica fuel tank bladders, parts of fuel tanks that were built as replicas of the tanks of potential air targets, were designed, manufactured and installed in existing replica fuselage sections. Two bladder geometric configurations were required for each section.

A prototype bladder in each geometric configuration was manufactured and subjected to demonstration tests prior to manufacture of the total lot of bladders. Modifications to the replica fuselage sections were also required to accommodate the bladders.

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20. ABSTRACT (CONCLUDED)

The modifications were designed and then evaluated during the demonstration tests.

The design and fabrication of the bladders as well as the replica fuselage tank preparation was proven adequate during the demonstration tests. During the demonstration, tank bottoms were identified as a structural element limiting internal overpressure. As a consequence internal overpressure were limited to 2.5 psig during the demonstration tests.

PREFACE

This report summarizes an analysis conducted from June 1980 to January 1981 by Orlando Technology, Incorporated, 6237 Edgewater Drive, Orlando, Florida 32810, under Contract No. FO8635-80-C-0230 with the Air Force Armament Laboratory, Armament Development and Test Center, Eglin Air Force Base, Florida 32542. Capt Patrick H. Crotty (DLYV) served as program manager for the Armament Laboratory.

This report summarizes the design and manufacture of replica fuel tank bladders, the modification of existing replica fuel tanks to accept the bladders and the installation of the bladders in the tanks. Orlando Technology, Inc. program manager was Mr. Paul W. Morgan.

Warhead effectiveness analyses require detailed knowledge of the warhead's capabilities. Against jet aircraft, the ability of a warhead to rupture or perforate a fuel cell causing fuel to be ingested into the engines is of primary importance. To determine the warhead's ability to cause fuel ingestion requires testing on sufficiently accurate models of threat aircraft. Under a previous contract, 9 fuselage sections were constructed, which represented threat aircraft fuel tanks. This contract obtained replica bladders for those tanks.

This report has been reviewed and is approved for publication.

FOR THE COMMANDER

JAMES L. THOREEN
Chief, Analysis Division

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LIST OF FIGURES

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SECTION I

INTRODUCTION

1.1 PROGRAM OBJECTIVES

The program objective was to design and manufacture replica fuel bladders to be used in existing replica fuselage sections which accurately represent threat aircraft fuel tanks. The desired bladder material properties were specified from previous investigations.

The existing replica fuselage sections consisted of nine identical units each requiring two independent fuel bladders having different geometries.

1.2 PROGRAM APPROACH

The program was divided into three main efforts; the design and manufacture of the bladders, the design and incorporation of modifications to the replica fuselage sections and the installation and test of the bladders in the fuselage sections. The program elements are provided in more detail in Table I.

(A) BLADDER MANUFACTURE
- Material Analysis
- Design
- Prototype Manufacture
- Prototype Demo Test
- Lot Manufacture

(B) REPLICA FUSELAGE PREPARATION
- Design
- Accessory Fabrication
- Fuselage Preparation

(C) BLADDER INSTALLATION
- Installation
- Assembly Test

TABLE I. PROGRAM ELEMENTS

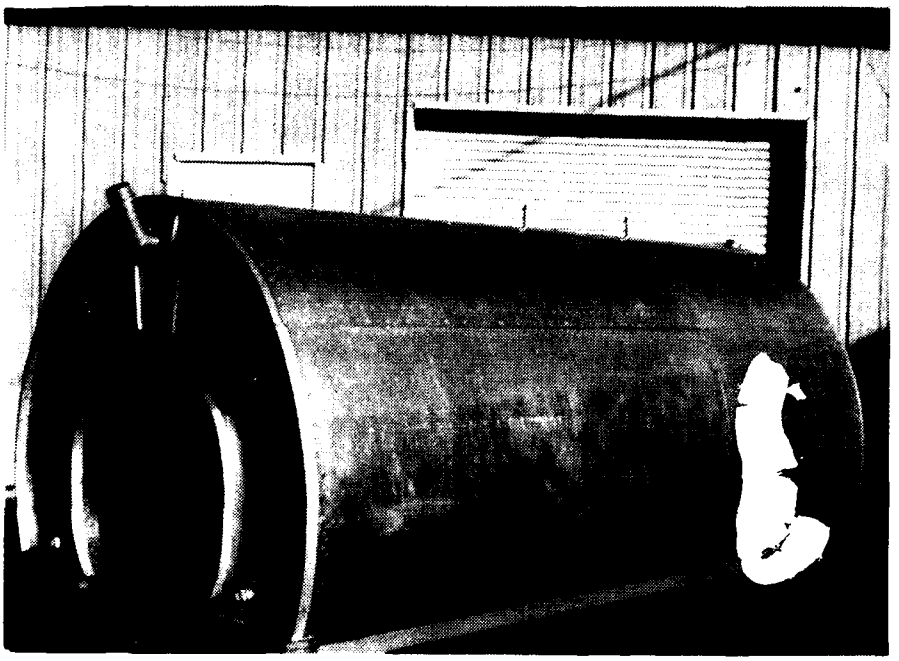
SECTION II

REPLICA TANK GENERAL ARRANGEMENT

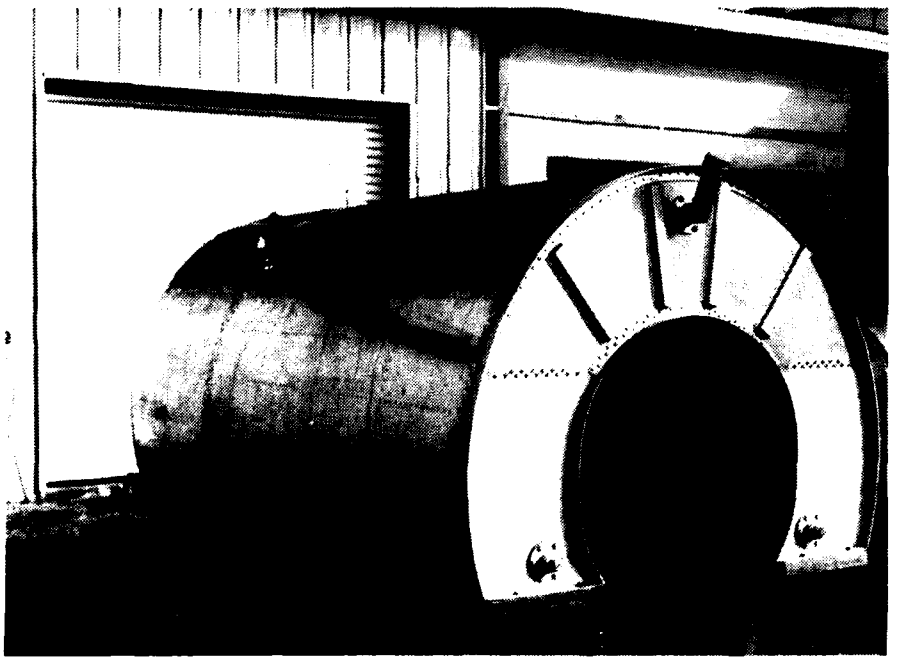
The replica fuselage section, Figure 1, consists of an aircraft type structure constructed from the drawings of Appendix A. Two independent tanks are longitudinally arranged within the fuselage section. They are bounded on the outer ends by the fuselage section forward and aft bulkheads, and separated by an interior bulkhead located about two-thirds of the way aft from the forward end. The forward tank is of a horseshoe shaped cross section and occupies the forward two-thirds of the fuselage section. The aft tank is composed of the upper portion of the horseshoe only and occupies the aft one-third of the section.

Each of the tanks is completely independent. The forward tank is serviced by a filler and two drains located in the forward bulkhead. The aft tank is serviced by a filler located in the aft bulkhead and a drain located in the tank bottom. Both tanks are serviced by vents extending upward through the fuselage section dorsal stiffeners.

The fuel tanks are lined with fuel bladders constructed of a urethane impregnated nylon fabric, Figure 2.

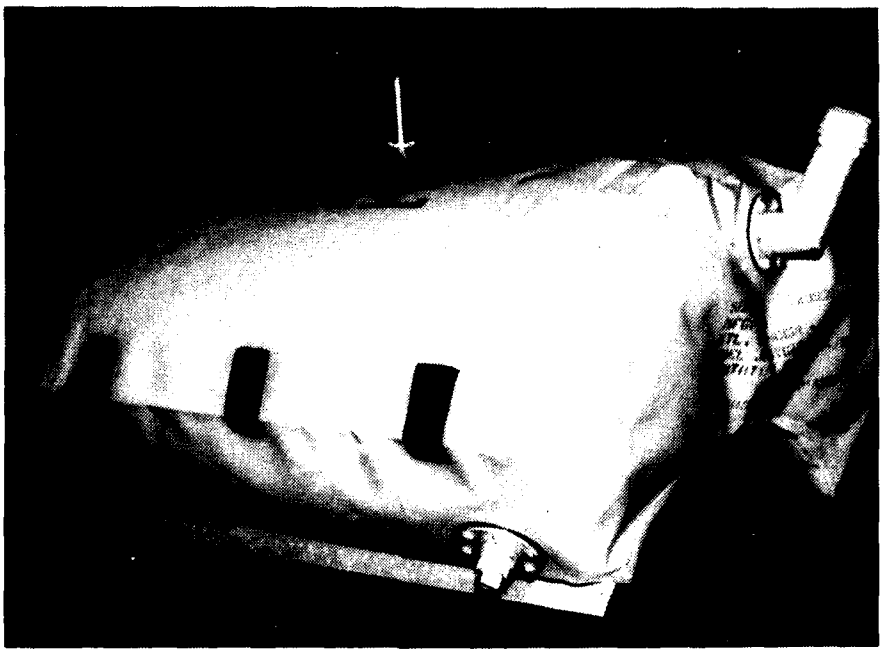


(A) Access Panels Installed



(B) Access Panels Removed

FIGURE 1. GENERAL ARRANGEMENT OF THE REPLICA TANKS



(A)

(B)

FIGURE 2. BLADDER GENERAL ARRANGEMENT

SECTION III

FUEL BLADDER MANUFACTURE

The manufacture of the fuel bladders required a materials selection study, a definition of bladder geometry and a development of detailed fabrication techniques.

3.1 MATERIAL

The design requirements for the bladder material are shown in Table 2.

	Properties
Weight	35-40 oz yd^2
Tensile Strength	85-95 psi Warp
	85-95 psi Fill
Adhesion	10 psi (Minimum)
Thickness	.03 to .06 in.

TABLE 2. Material Requirements

The replica bladders are made of coated fabric. The material is composed of a nylon fabric impregnated from each side with a polyurethane compound. The coated fabric is compatible with JP fuels, aviation gasoline, aeromatic gasolines and diesel fuel. A specification sheet from the manufacturer is presented in Table 3.

PHYSICAL PROPERTY	DESCRIPTION/SPECIFICATION
Construction:	Urethane/Nylon
Application:	Fuel and Oil Service to 50% Aromatics
Color:	Tan
Thickness:	.042" Average Per Federal Test Method 191B-5030.2
Weight:	36 oz/ sq yd Average Per Federal Test Method 191B-5041
Tensile:	350 x 250 Pounds Per Linear Inch Per Federal Test Method 191B-5012
Tear:	25 lbs. x 15 lbs. Per Federal Test Method 191B-5134
Coating Adhesion:	10 lbs/inch Maximum
Puncture:	110 lbs. Per Mil T 6396 ART.4.6.17
Permeation:	.010 fl. oz./sq.ft./24 hrs Per FAA TSO-C-80 Section 11.0

TABLE 3. PHYSICAL SPECIFICATIONS FOR REPLICA BLADDER COATED FABRIC

3.2 GEOMETRY

The fuel bladder cross sectional geometry very closely approximates that of the tank cavity. The geometry used is provided in the drawings of Appendix B and departures from the exact geometry of the tank interior are noted.

3.3 DETAIL DESIGN

The fuel tank bladders consist of one layer of the coated fabric described in Table 3. Areas requiring particular attention are the seams, the hanger loops and the fill, vent, and drain openings.

The bladder seam design for both longitudinal and corner seams is developed such that seams are overlapped a minimum of two inches and are radio frequency heat sealed or cemented. Reinforcing patches are located over all corner seams. All edges are covered with a bead to prevent wicking and the intrusion of fuel into the fabric interior, Reference 1.

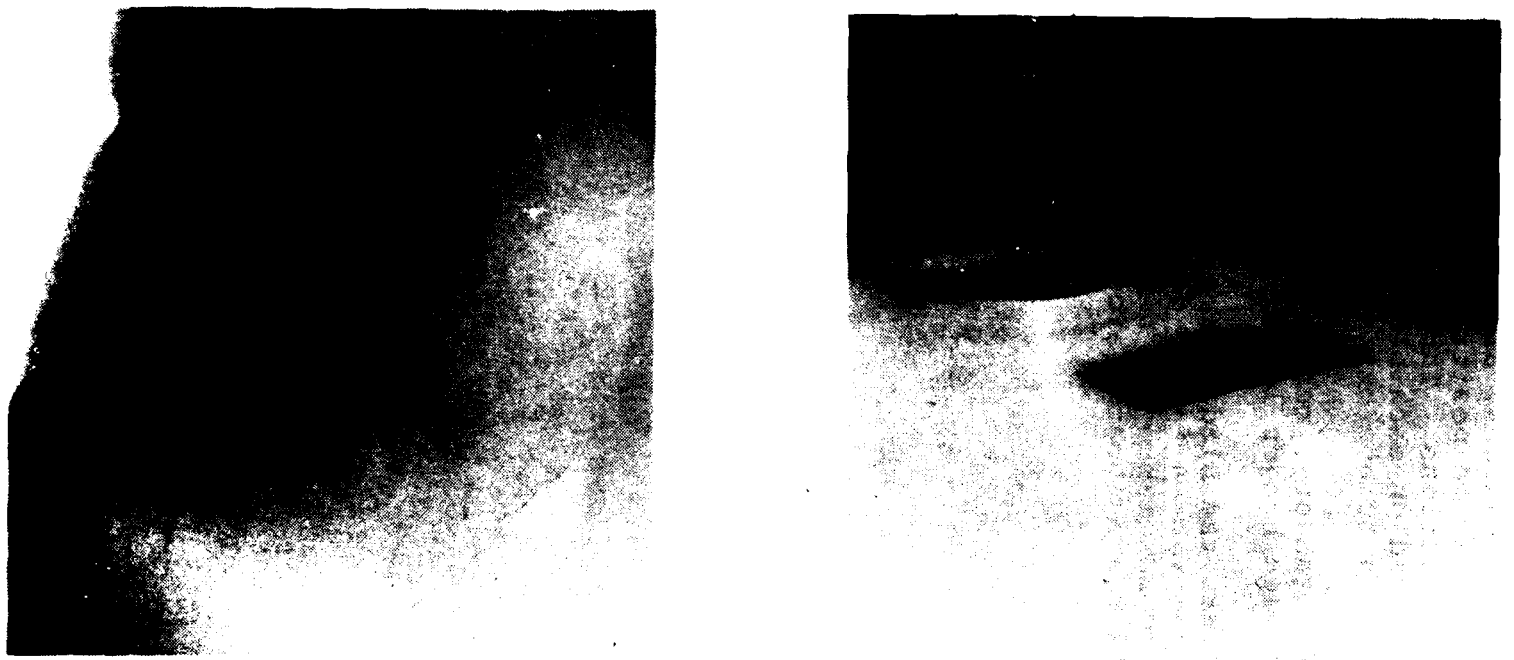
A typical series of quality control tests that are performed on each batch of material is shown in Table 4.

		Sample 1	Sample 2	Sample 3
Tensile Dry 1 inch	A. Warp (lbs.)	360	370	375
	B. Fill (lbs.)	250	250	270
Tensile Wet 1 inch	A. Warp (lbs.)	400	350	370
(Soak/24 hrs.)	B. Fill (lbs.)	220	230	240
Seam Tensile RF Sealed 1"OVLP.(lbs.)		230	250	210
Tear Dry	A. Warp (lbs.)	30	25	20
	B. Fill (lbs.)	35	40	45
Tear Wet	A. Warp (lbs.)	40	35	60
(Soak/24 hrs.)	B. Fill (lbs.)	60	55	70
Puncture Dry (lbs.)		100	135	130
Puncture Wet -(Soak/24 hrs.)(lbs.)		100	130	125
Avg. Thickness - (inches)		.043	.042	.042
Weight 1 Sq.Yd. (ounces)		35.1	35.9	36.0
Coating Integrity - Acetone - Surface Rub		OK	OK	OK
Soak in Gasoline 2 weeks		OK	OK	OK

TABLE 4. MATERIAL LABORATORY TESTS

Hanger loops, Figure 3, are incorporated into the bladders so that they may be positively positioned inside the replica fuselage sections. Three longitudinal rows of hanger loops are located on each bladder at circumferential positions corresponding to approximately 10, 12 and 2 o'clock. Five and three loops are contained in each longitudinal row on the forward and aft bladders, respectively. Nominal longitudinal spacing between hanger loops is twelve inches.

Openings into the bladder are reinforced on the interior of the bladder by a fabric doubler, Reference 1, that extends outward for twice the diameter of the access hole. These doublers are located around all fill, drain and vent holes.



(A) (B)

FIGURE 3. BLADDER HANGER LOOPS

SECTION IV

REPLICA FUSELAGE MODIFICATION

The modifications to the replica fuselage sections required by installation of the bladders fell into two major caterogies: (1)machining of bladder access and mounting holes into the tanks and (2)preparation of the tank interiors. Detail design of the modifications is provided in Appendix B.

4.1 ACCESS AND MOUNTING PROVISIONS

The provisions for the bladder access consist primarily of filler, drain and vent openings machined through the tank structure. Mounting provisions consist of holes drilled through the inner tank walls that allow attachment of the bladder to the tank wall.

Openings for the fillers, Figure 4, are located along the centerline near the top of the forward and aft bulkheads.

Two drains are provided for the forward tank, one in each side of the forward bulkhead just above the tank bottoms. The drain for the aft tank, Figure 4(B), is located in the port tank bottom near the aft bulkhead.

Vent openings are machined into the dorsal stiffener of both forward and aft tanks. The hole openings are located approximately ten inches forward and aft of the center bulkhead.

Pairs of holes were located in the tank inner walls to allow lacing the bladder into position inside the tank. Three longitudinal rows of holes were utlized, one row along each sidewall at approximately 10 and 2 o'clock, and one row along the tank top centerline. The hole spacing allows attachment to the bladder at intervals of approximately twelve inches.

(A) External View

(B) Internal View

FIGURE 4. FILL AND DRAIN OPENINGS

4.2 INTERIOR PREPARATION

Interior preparation of the fuselage sections fell into three major categories:

1) Fairing of steps and near discontinuities in the tank interiors.

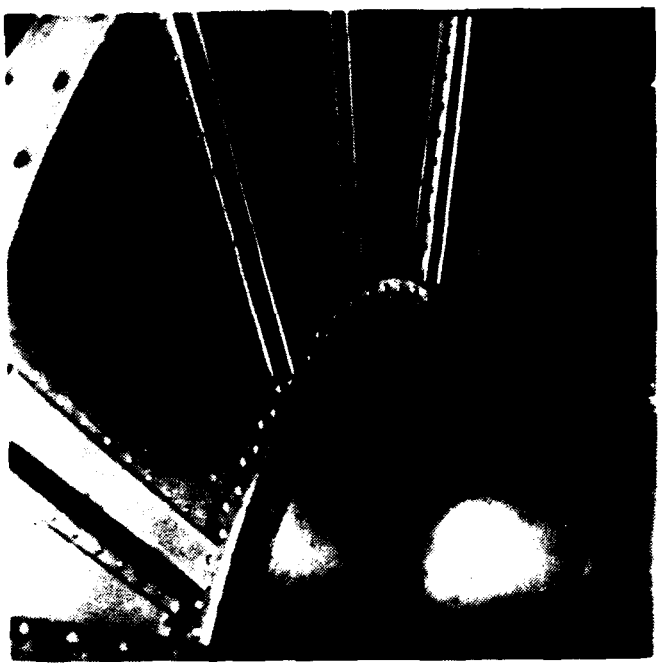
2) Filling and covering those areas of the tank where the bladders would lack proper support.

3) Covering protrusions, sharp edges, rivet heads, etc., which could possibly puncture the bladders.

Step fairings constructed of sheet aluminum were used to smooth the edges of the bulkhead weldments where they joined with the tank bottoms and upper bulkhead areas. Duct cap fairings of the same material were used to cover the rivet bucktails along the center of the airduct wall in the forward tank. Similar fairings were used to cover the rivet bucktails at the air duct wall joint with the bulkheads. Covers were also made for the bulkhead weldment stiffeners in the interior of the forward tank. In all instances, the aluminum sheet was contact cemented to the tank walls and then additionally secured and faired with fabric tape conforming to Spec PPP-T-60. Examples of the completed installation are shown in Figure 5 for the air duct wall rivets at the bulkhead and cap.

Cavities due to replica fuselage construction requirements existed in the intersection of the forward tank sidewall and bulkheads. These cavities were filled with closed cell ethafoam conforming to Mil-C-46842 and contact cemented in place. The filler then was additionally secured and faired with fabric tape.

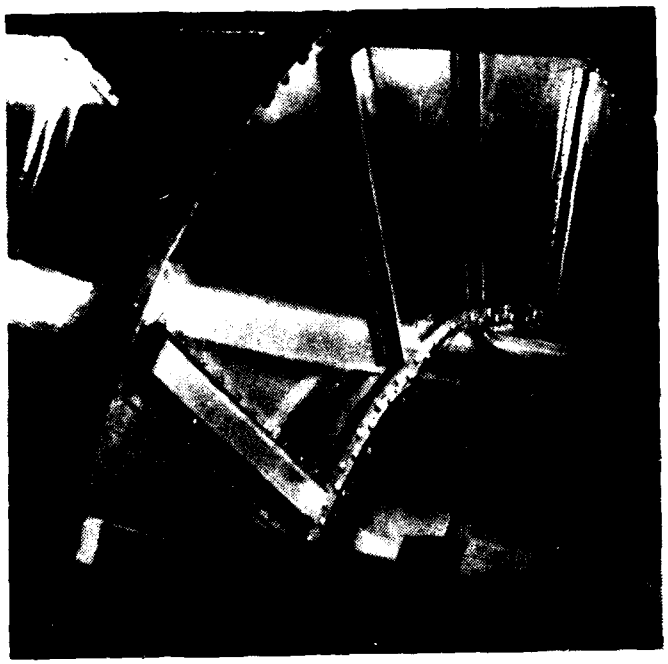
Protrusions, sharp edges and rivet heads were covered using a combination of .06 inch thick rubber sheet, foam filler and fabric tape. Bulkhead endwall stiffeners and access panel mounting anchor nuts, Figure 6, were covered with foam filler, cemented in place, then additionally secured and blended with fabric tape. Rivet heads on the tank side walls, dorsal and bulkheads were covered with tape.



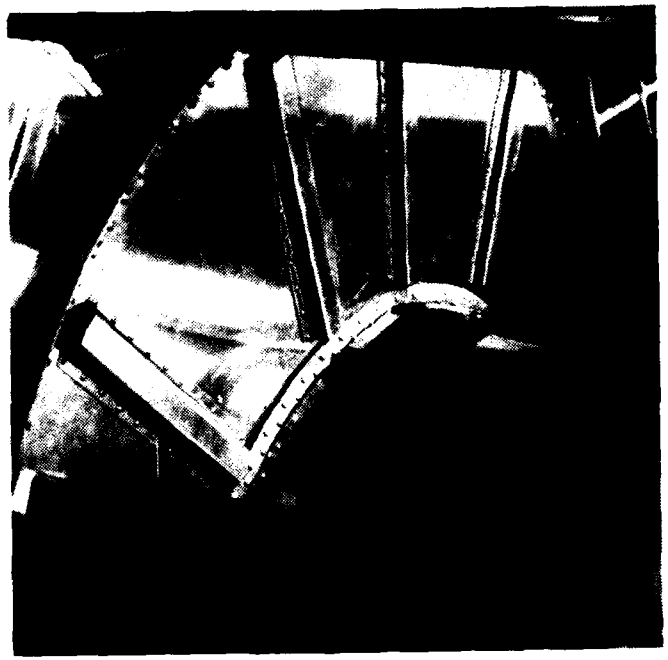
(A) Exposed Rivets

(B) Bulkhead Rivets Covered

FIGURE 5. AIR DUCT RIVET FAIRING



(C) Duct Cap Rivets Covered



(D) Completed Fairing

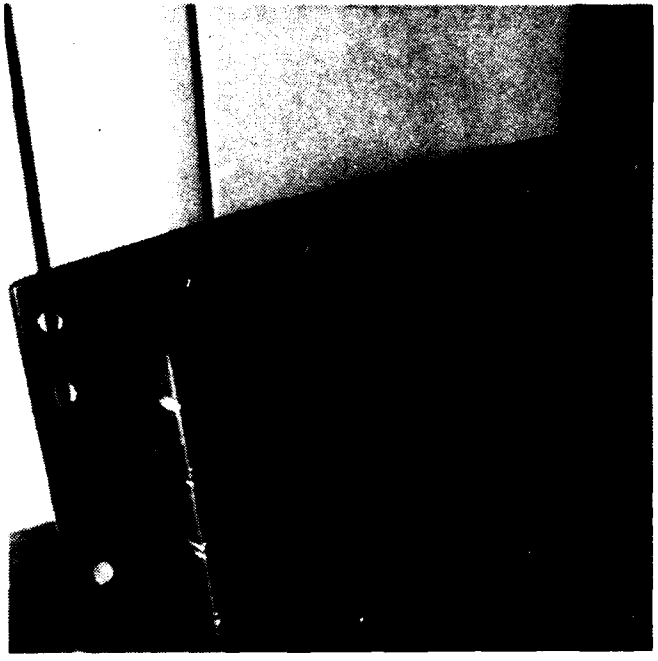
FIGURE 5. AIR DUCT RIVET FAIRING (CONTINUED)

(A) Anchor Nuts

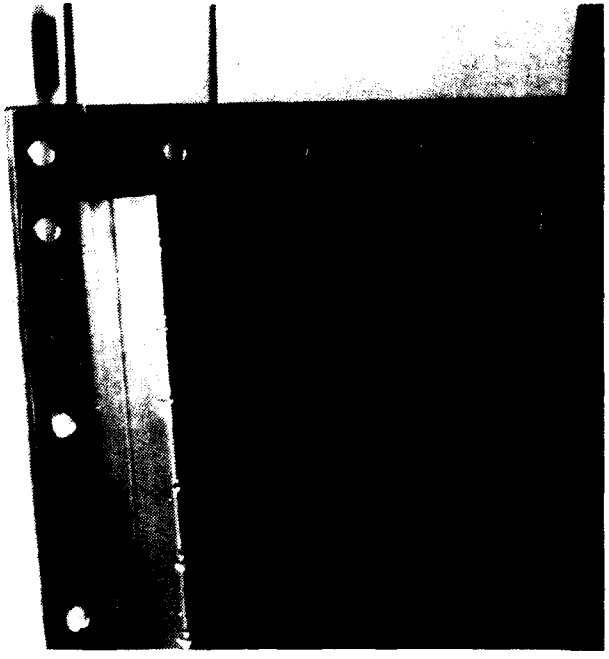
(B) Anchor Nut Covering

FIGURE 6. ANCHOR NUT COVERING

Blind rivet heads on the interior of the access panels were covered with .06 inch thick rubber sheet, contact cemented in place, then additionally secured and faired with fabric tape, Figure 7. Tank access panel openings were fitted with rubber and tape flaps, Figure 8, to provide an internally smooth contour following installation of the panels.



(A) Elements of Covering



(B) Completed Covering

FIGURE 7. ACCESS PANEL RIVET COVERING

(A) Panel/Dorsal

(B) Panel/Sidewall

FIGURE 8. ACCESS PANEL/TANK FAIRING

SECTION V

FUEL CELL INSTALLATION

The installation of the fuel bladders into the replica fuselage sections required attachment of the retention devices and connection of all bladder access provisions.

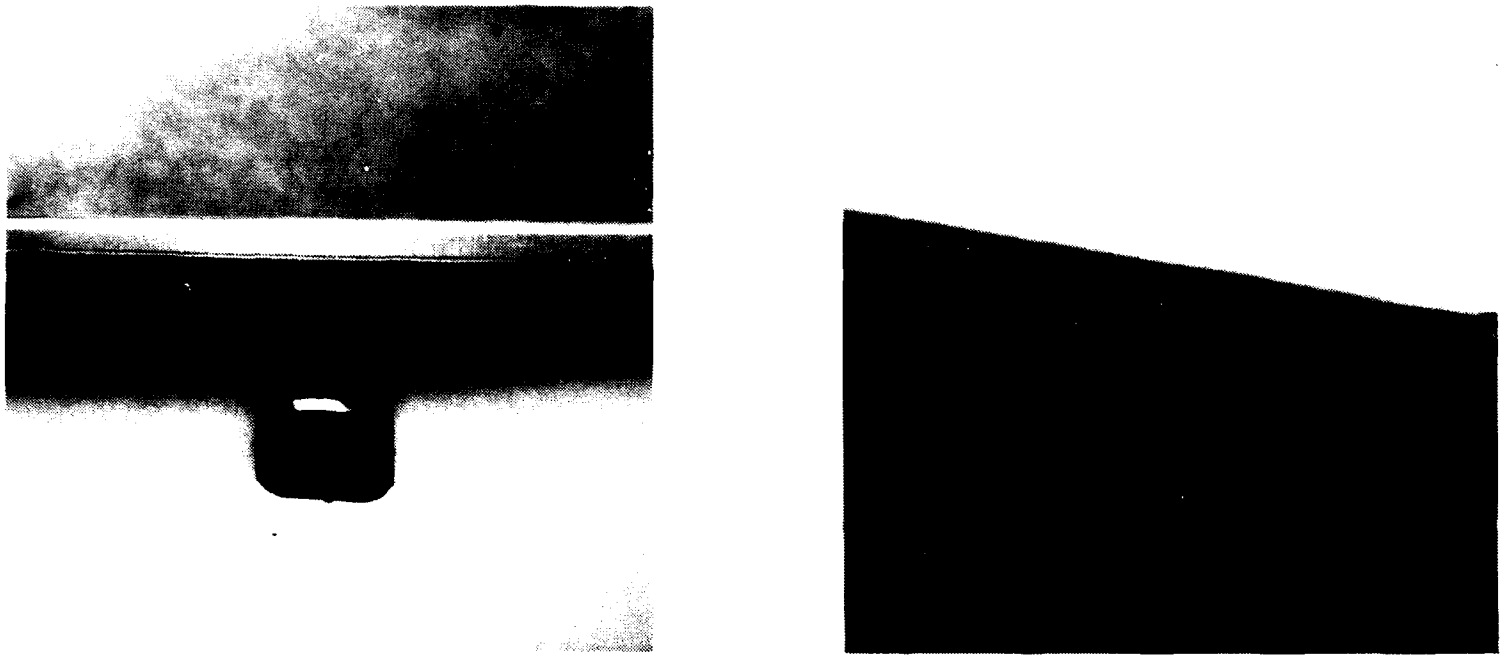
5.1 RETENTION

The bladders are maintained in position in the tanks through a combination of locating devices. The fills, drains, and vents positively attach the bladder to the tanks where they penetrate the tank structure. In addition to those restraints, the bladders are located by tie loops which are laced to the tank walls with nylon straps, Figure 9. The nylon lacing acts as a general locating device for the bladders while allowing the bladder some freedom of movement. Each point of attachment allows a bladder movement of approximately two inches about the nominal position. The bladders are laced to the tank along three longitudinal rows located at ten, twelve and two o'clock. The longitudinal rows contain five and three attachment points for the forward and aft tanks, respectively.

5.2 ACCESS PROVISIONS

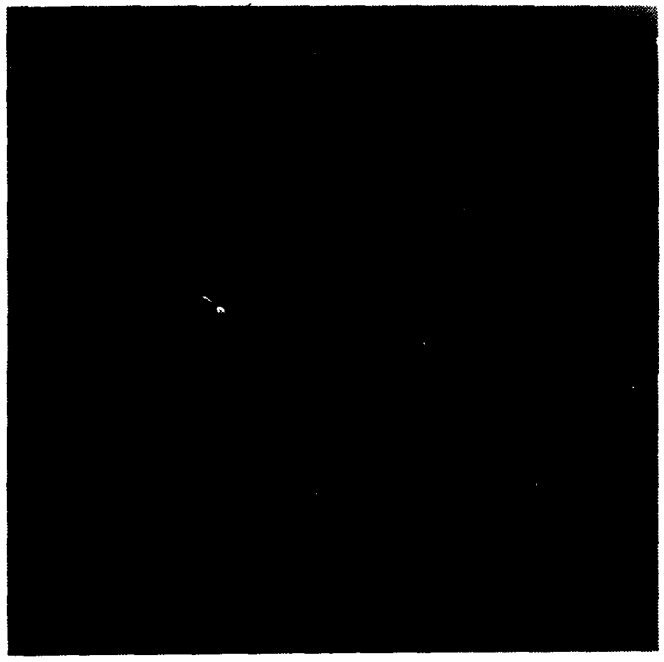
Installation of the fill provisions for each tank is shown in Figures 10 and 11. The external filler pipe flange is attached to the tank and bladder by bolts extending into the interior of the bladder and engaging a nut plate. Gaskets that are compressed by the bolts seal the pipe flange to the bulkhead and the bulkhead to the bladder.

Installation of the drain provisions for each tank is shown in Figure 12. The forward tank utilizes two drains, one to the left and one to the right side of the forward bulkhead. A single aft tank drain is located in the tank bottom.

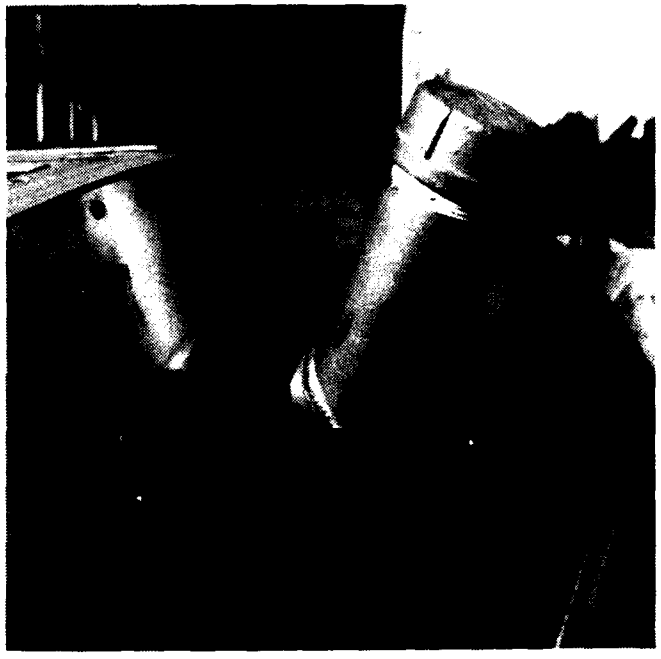


(A) (B)

FIGURE 9. NYLON LACING



(A) Filler Pipe



(B) Installation

FIGURE 10. FILLER INSTALLATION

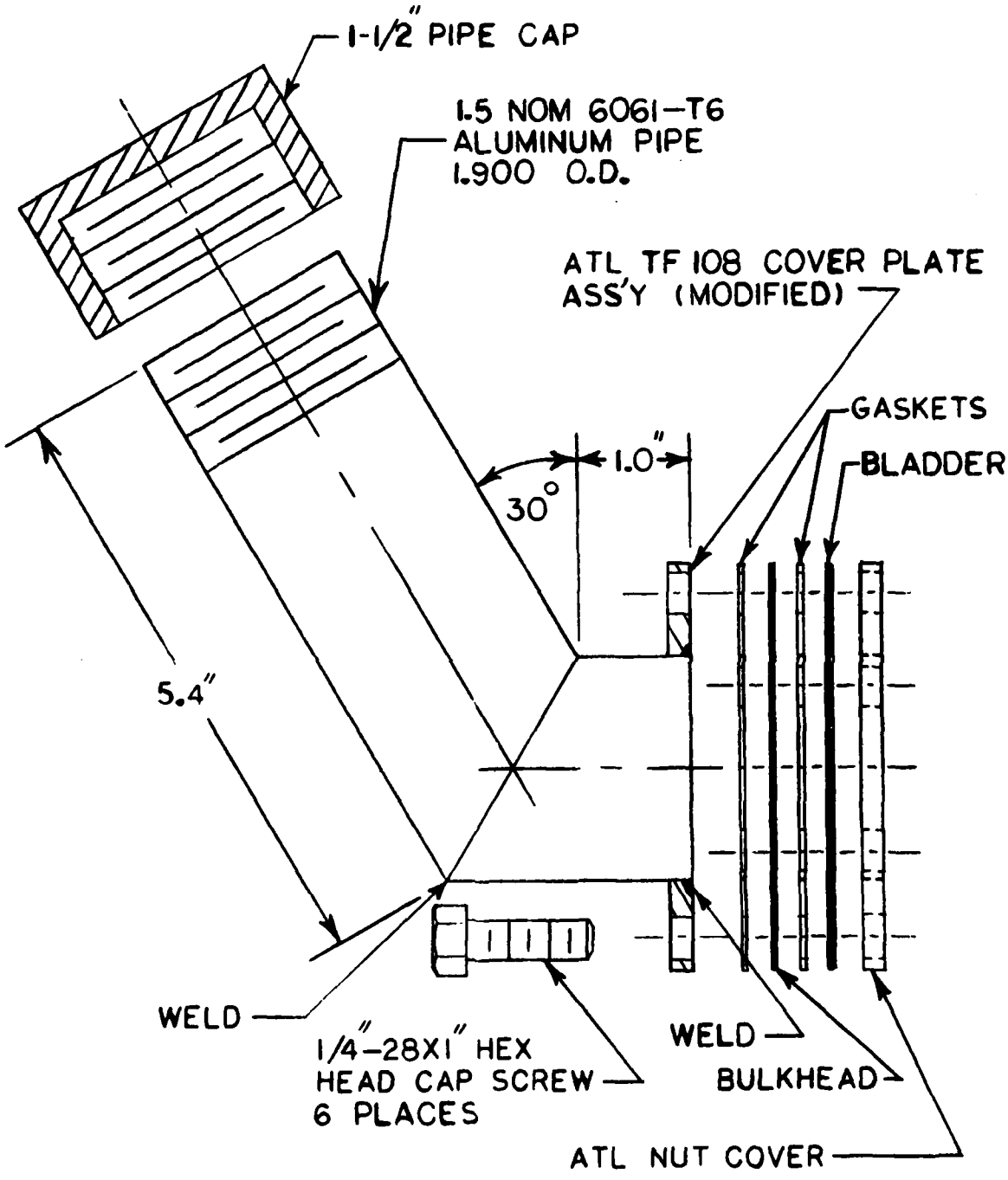


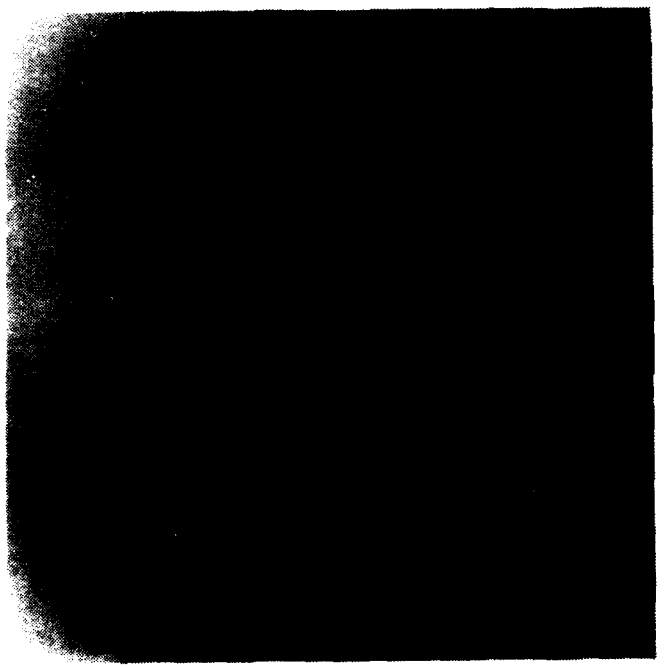
FIGURE 11: FILLER TUBE ASSEMBLY

(A) Forward Tank Drain

(B) Aft Tank Drain

FIGURE 12. DRAIN INSTALLATION

The vent installation is shown in Figures 13 and 14. A vent pipe extends from the top of each bladder through the tank dorsal. The vent pipe is not directly bolted to the tank dorsal but floats in a clearance hole and is prevented from falling into the tank interior by a washer and retaining ring. The vent pipe flange is attached to the bladder by bolts extending into the bladder interior and engaging a nut ring. A gasket, compressed by the bolts, seals the flange to the bladder.



(A) Vent Tube

(B) Vent Installation

FIGURE 13. VENT INSTALLATION

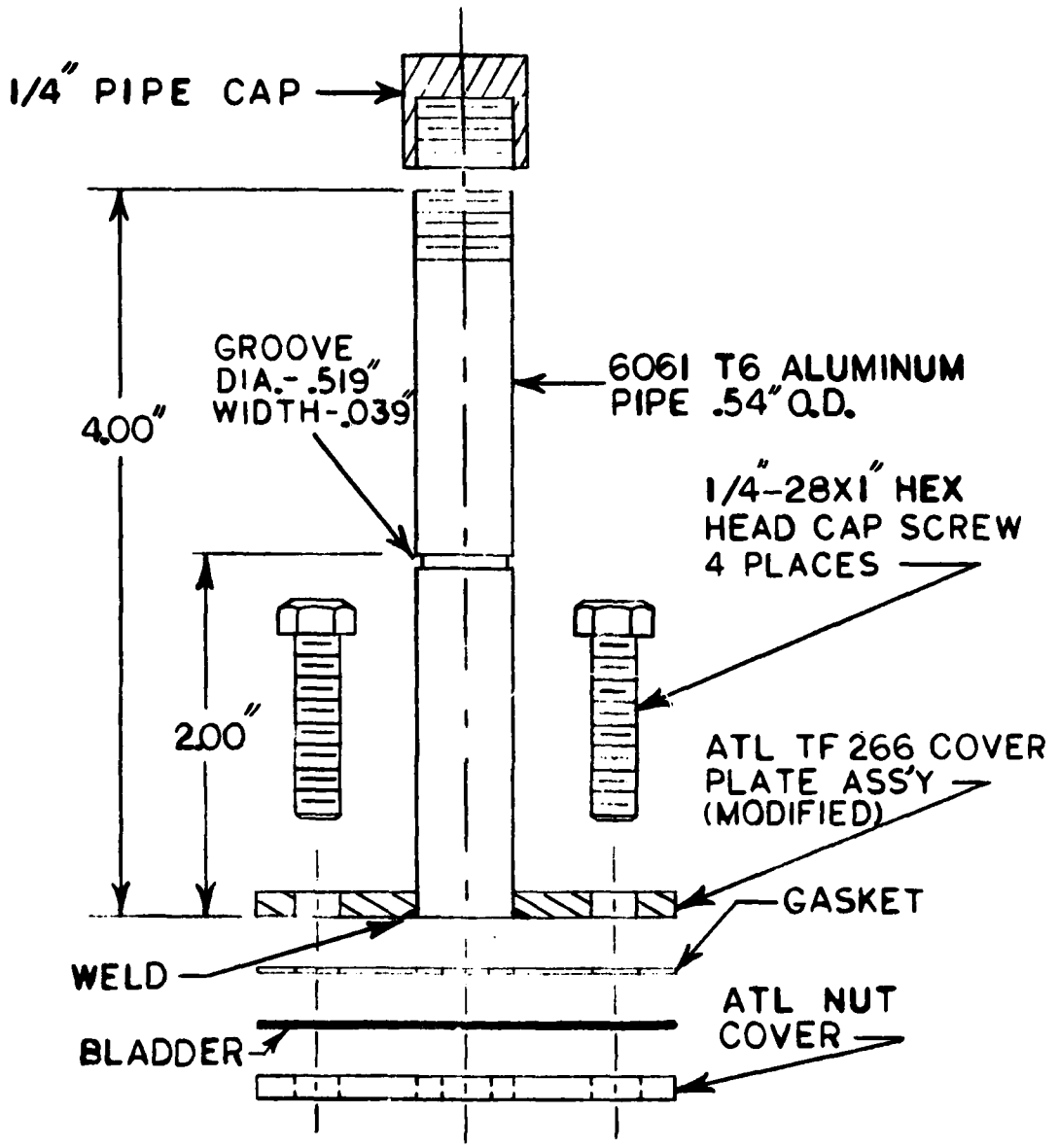


FIGURE 14 : VENT TUBE ASSEMBLY

SECTION VI

TESTING AND CHECKOUT

Tests were continuously conducted on the fuel bladders both during fabrication and installation. A summary of the major tests is as follows:

1. Initial Materials Test: The tests on the bladder material prior to fabrication is summarized in Table 4.

2. Bladder Leak Test: Following fabrication, all bladders were inflated in the unrestrained condition and leak tests were conducted. While the bladder was pressurized to .25 psig all seams and joints were tested with a leak detector solution.

3. Dimensional Test: All fabricated bladders were dimensionally inspected for fit and conformance with the replica fuselage sections.

4. Prototype Demonstration Test: The prototype bladders were installed, filled to 99% with JP-4 and subjected to an overpressure of 2.0-2.5 psig. The overpressure was maintained for 4.5 hours and the bladders were then drained and inspected for leaks or other evidence of unacceptability or deterioration. The test plan and test data may be found in Reference 2.

5. Assembly Checkout: All units were tested for leaks following assembly of the bladder with the replica fuselage sections. All assemblies were pressurized to 1.0 psig and observed for evidence of leakdown for a minimum of thirty minutes.

REFERENCES

1. "Replica Fuel Tank Bladder Materials and Fabrication Methods", Orlando Technology, Inc. Report dated June 1980.

2. "Progress Report - September 1 to October 10, 1980, Contract F08635-80-C-0230", Orlando Technology, Inc. Letter dated October 10, 1980.

APPENDIX A

DRAWINGS FOR REPLICA FUEL TANKS

DRAWING NO.	TITLE
SK1817SH1	Aircraft Fuel Tank Assembly
SK1817SH2	Aircraft Fuel Tank Assembly
SK1817SH3	Aircraft Fuel Tank Bulkhead Details
SK1817SH4	Endwell and Ring Support
SK1817SH5	Aircraft Fuel Tank Sidewall Subassembly
SK1817SH6	Aircraft Fuel Tank Details-Sidewall Subassembly
SK1817SH7	Aircraft Fuel Tank Access Panels and Dorsal Stiffeners
SK1817SH8	Aircraft Fuel Tank Airduct Subassembly Tank I
SK1817SH9	Aircraft Fuel Tank Airduct Subassembly Tank II

APPENDIX B

DRAWING LIST FOR BLADDER MANUFACTURE AND REPLICA FUSELAGE MODIFICATION

DRAWING NO.	TITLE
D019001	Bladder Envelope Cross Section
B019002	Filler Assembly
D019005	Fuel Tank Bladders
B019006	Step Covers
B019007	Duct Cap Cover
B019008	Stiffener Fairing
B019009	Vent Provisions Tanks I and II
B019010	Fill Provisions Tanks I and II
B019011	Drain Provisions Tank I
B019012	Drain Provisions Tank II
B019013	Anchor Nut Covering
B019014	Sidewall/Bulkhead Corner Filler
B019015	Dorsal Lacing Holes
B019016	Sidewall Lacing Holes
B019017	Vent Tube

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