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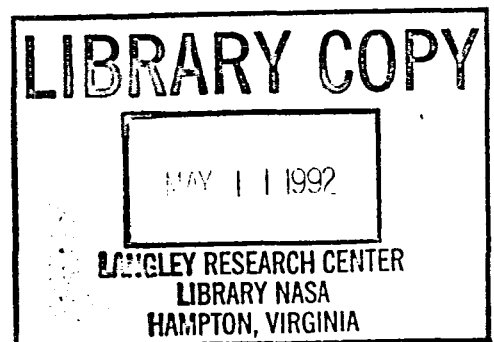
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Raven Report No. R0184-002

SPACE SHUTTLE INFLATABLE
TRAINING ARTICLES

Final Report
for
Contract NAS 9-16854

Submitted to:

National Aeronautics and Space Administration
Lyndon B. Johnson Space Center
Houston, Texas

20 February 1984

Prepared by: Approved by:

Mark L. West   Q. A. Winker
Project Engineer   Vice President
Applied Technology Division   Applied Technology Division

Raven Report No. R0184-002

NASA FINAL REPORT

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Final Report for NASA Contract 9-16854

SPACE SHUTTLE INFLATABLE TRAINING ARTICLES

This report concludes contract NAS 9-16854 which included the
design, development, construction and testing of the Long
Duration Experimental Facility Inflatable (LDEFI) and the Space
Telescope Training Article (STTA). Both articles are similar in
nature, materials and construction techniques but vary widely in
shape and have unique problems affecting size, shape, gross/net
lift and balancing.

1.0 DESIGN SUMMARY

1.1 Long Duration Experimental Facility Inflatable

The final design of the LDEFI varied little from the
design submitted in the original proposal (Appendix A). The
basic variations were in the following areas: Material, end
fittings and inflation port construction.

The material used was a 70-denier polyester with a count of
103 x 103 and a weight of 2.0 oz. per yard. This material
was coated with .15 oz. of adhesive followed by .25 oz. of
aluminized urethane on the outer surface and .25 oz. of
adhesive followed by 2.0 oz. of white urethane which served
as a helium barrier. This material was designed to meet the
specifications set forth in RBADS 1161 (Appendix B). The
test reports (Appendix C) show the results as tested to this
specification.

The skirts and end panels were made of a nylon material
similar in weight and strength to Dacron. The outer surface
had .15 oz. of adhesive covered with .35 oz. of silver. No
coating was placed on the reverse side.

The end fittings were redesigned to a larger diameter to
allow the material to be tucked less as it was secured to
the spool. The actual end fitting can be seen in drawing
C-51621 in Appendix D.

The torus was originally to be connected to the main
envelope by a series of three inch tabs glued to the torus
and the main envelope where they intersected. This proved
impossible, and a system of Velcro straps was devised
instead. Details of this may be found in drawing
D-51642 in Appendix D.

To define size, several prototypes were constructed to
determine elongation under biaxial pressure. Uniaxial
stress/strain and creep proved invalid due to the mechanics
of elongation of the woven fabric. The torus lay-flats were

not reduced in size in the warp direction but were reduced by 6.5% in the fill direction. The envelope size was increased in the warp direction by 2.0% and decreased in the fill direction by 3.7%.

The apparatus was constructed in accordance with the drawings in Appendix D. Very few problems occurred during the construction, and most were remedied by adjusting the assembly method or technique. The technique for fabricating the tori is detailed in Appendix E.

1.2 Space Telescope Training Article

The final design of the STTA varied greatly from the original design submitted in the proposal (Appendix F). There were several reasons for this.

First, the original weight distribution in the RFP called for two pounds at each hard mount. As a result, 39 pounds were placed within 41 inches of the forward end of the aft section. A study was conducted to determine whether other shapes could compensate or whether the dimensions of the forward and aft section should be changed (Appendix G).

It was determined that, by shortening the forward section by 5.5 feet and adding that amount to the aft section, the hard mounts were shifted closer to the center of buoyancy of the aft section. The object now could be balanced and buoyant.

Second, several potential problems were discovered in the fabrication of the LDEFI, and it was decided that the unsupported outer skin was not practical for reasons of appearance and sealability. Also, weight distribution for the actual configuration NASA would use varied significantly from the original requirement, increasing from 50 to 78 pounds. To accommodate NASA's needs and optimize our design, the configuration was changed to one of several shown in Appendix H.

Third, the method of attaching the forward and aft sections to each other was changed from the original angles and latching devices. Instead, a hasp latch was mounted to each torus and the two were hooked together using turn-buckles. This allows a limited degree of adjustment to ensure that the centerlines of the two halves line up.

The materials used were identical to those in the LDEFI. The end fittings were like the original design because less material was present with the 10-foot diameter for the inverted end. The changes in torus connection described for the LDEFI were also incorporated into this design.

Sizing of the tori was identical to that of the LDEFI, but minor problems were encountered which required removal of a five- to eight-inch section from the two larger tori.

Expected but unusual changes in elongation resulted when
sizing the main envelope. With conical sections to increase
and reduce diameter, the biaxial stress was not uniform
throughout the body, and each section acted independently.
The large diameter section was 14 feet in diameter and about
14 feet from end to end of the conical sections (see
Figure 1 below). This meant the torus circumferences had to
be corrected for proper skirt fit. Sizing in the fill
direction remained the same, and elongation in the warp
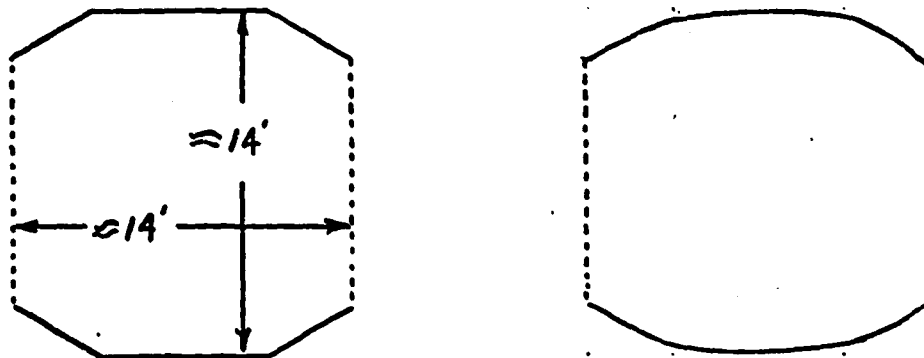direction was compensated for by shortening the center cable
slightly.

Figure 1

The apparatus was constructed according to the drawings in
Appendix I. One fabricating difficulty occurred while
manufacturing the two large tori that was not encountered on
the LDEFI. The tube diameter of these tori was large enough
that two widths of material were required to form the tube.
Thus, a butt seam now ran down the middle of the tucks,
making heat sealing very difficult. To resolve this, the
area had to be glued, activated and then heat sealed to
provide sufficient adhesion.

2.0 OBJECT UTILIZATION

Appendix J, LDEFI and STTA Service Manual, contains information
on assembly, inflation, servicing, maintenance, leak detection,
repair and storage.

The articles were designed with gross ballast points located to
compensate for the hardware weights as specified in the RFP or by
NASA. These gross ballast points bring the objects into
approximate balance about the three axes. Small lead weights
should be placed in pockets located on the tori to neutralize any
remaining rotational forces. Weights should then be evenly
distributed in these pockets to bring the inflatable to neutral
buoyancy.

APPENDIX A

LDEFI Proposal

RAVEN INDUSTRIES, INC.
PROPOSAL NO. ATD1182111
TECHNICAL SECTION

DESIGN AND FABRICATION
OF
LONG DURATION EXPOSURE
FACILITY INFLATABLE

Submitted to:

National Aeronautics and Space Administration
Lyndon B. Johnson Space Center
Houston, Texas

R.F.P. No. 9BB6-10-2-055P
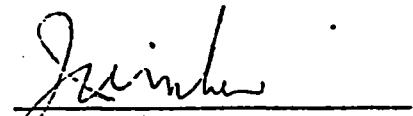
15 November, 1982

Prepared By: Approved By:

R. M. Enderson   J. A. Winker
Sales Engineer   Vice-President
Applied Technology Div.   Applied Technology Div.

Mark West
Project Engineer
Applied Technology Div.

1.1 INTRODUCTION

Raven Industries, Inc. is pleased to submit this proposal in response to NASA's Request For Proposal No. 9-BB6-10-2-055P.

The proposed basic configuration is a cylinder with inverted and restrained ends. Tori are utilized at the ends to facilitate generating flat ends. The fifteen hard mounting points will be attached to the skin at the required locations. The proposed configuration will be capable of being made neutrally buoyant with and without all government furnished hardware attached.

The proposed material is a polyurethane coated polyester fabric. The polyester base fabric is selected for its dimensional stability and the polyurethane coating for its abrasion resistance, helium retention and durability. The outer surface will incorporate an aluminized coating. The nominal material weight is 7.2 ounces per square yard.

Raven is a leading manufacturer of inflatables involving a wide range of materials. The proposed configuration will involve established and standard fabrication techniques. As a previous supplier of inflatable simulated payloads to NASA, Raven has a solid understanding of the requirement and is completely confident of our ability to meet the requirements for the LDEFI.

2.0 TECHNICAL DISCUSSION

The following detailed discussion of Raven's proposed design and fabrication objectives is presented with a plan for task accomplishment.

2.1 INFLATABLE CONFIGURATION

The proposed configuration of the LDEF1 and associated sub-assemblies are shown in Figures 1 through 10.

2.1.1 MAIN ENVELOPE

The primary structure, shown in Figure 1, is a 13.7 ft. diameter cylinder with inverted and restrained ends with an over all length of 29 ft. A critical feature of the LDEFI is the limited volume for bouyancy to support required hardware. The inverted end design optimizes available volume while continuing to provide sufficient skin tension for stiffness and hardware support.

Additionally, the inverted end configuration is more compatible than a hemispherical end in generating a flat
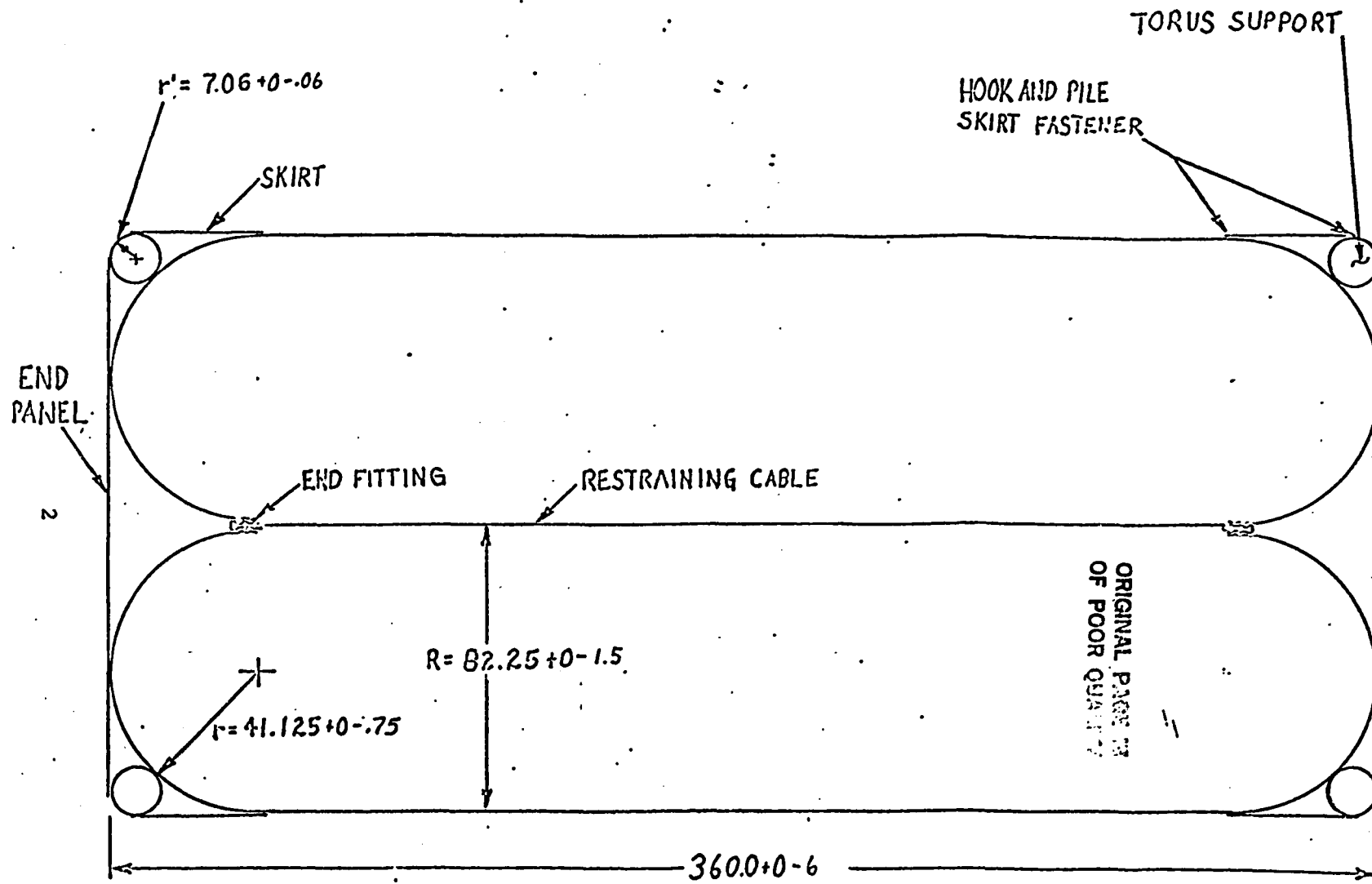
FIGURE 1 : CROSS-SECTION SIDE VIEW

TORUS SUPPORT

HOOK AND PILE
SKIRT FASTENER

r'= 7.06 +0 -.06

SKIRT

END
PANEL

2

END FITTING

RESTRAINING CABLE

R= 82.25 +0 -1.5

r= 41.125 +0 -.75

ORIGINAL PAGE IS
OF POOR QUALITY

360.0 +0 -6

ORIGINAL PAGE IS
OF POOR QUALITY

FABRIC

CLAMPING BANDS

PROTECTIVE WRAP

EYEBOLT   SEALANT

RESTRAINING CABLE

SPOOL

END FITTING

FIGURE 2

3.

SKIRT

END PANEL

HOOK AND
PILE FASTENER

TORUS SUPPORT

MAIN ENVELOPE
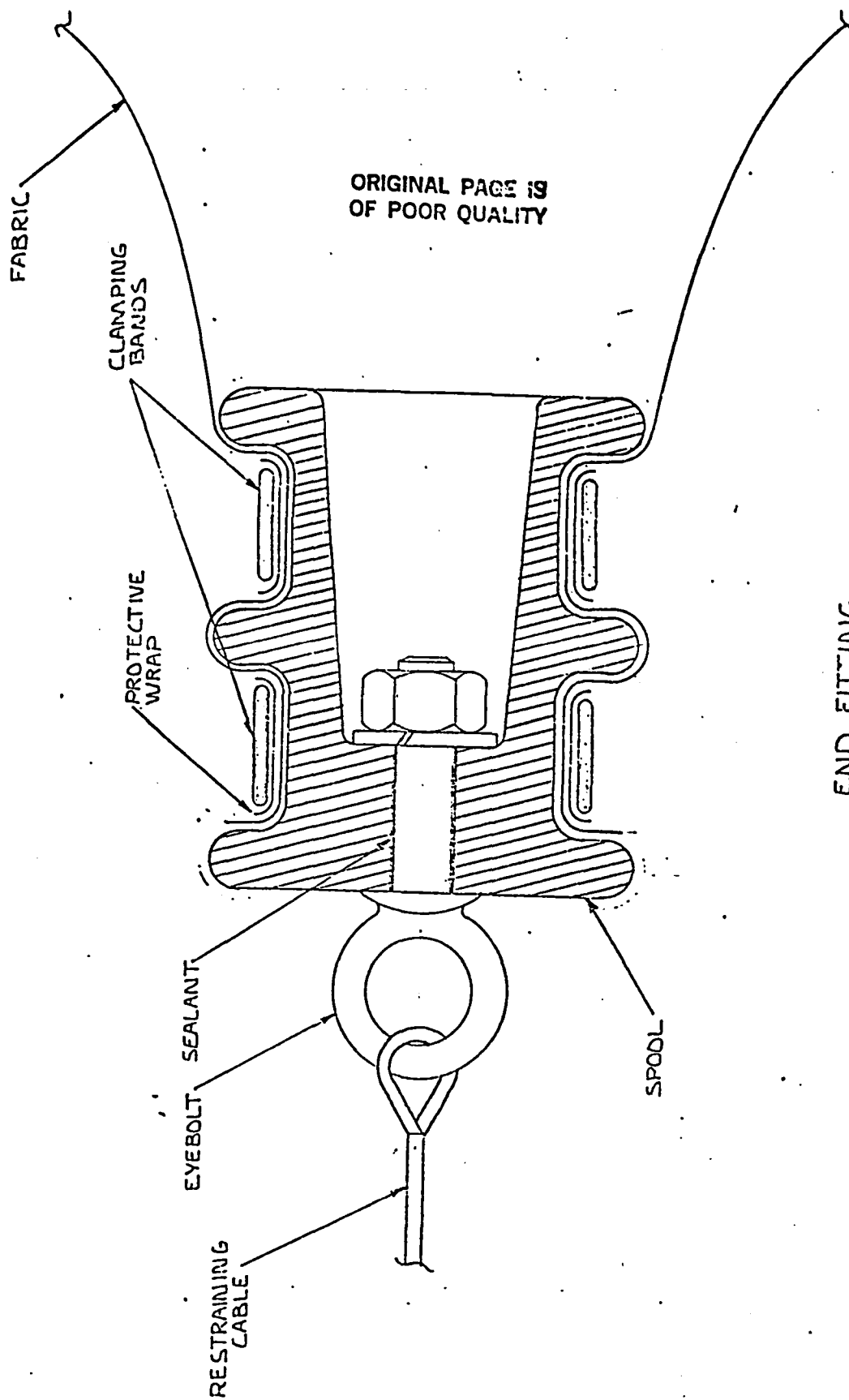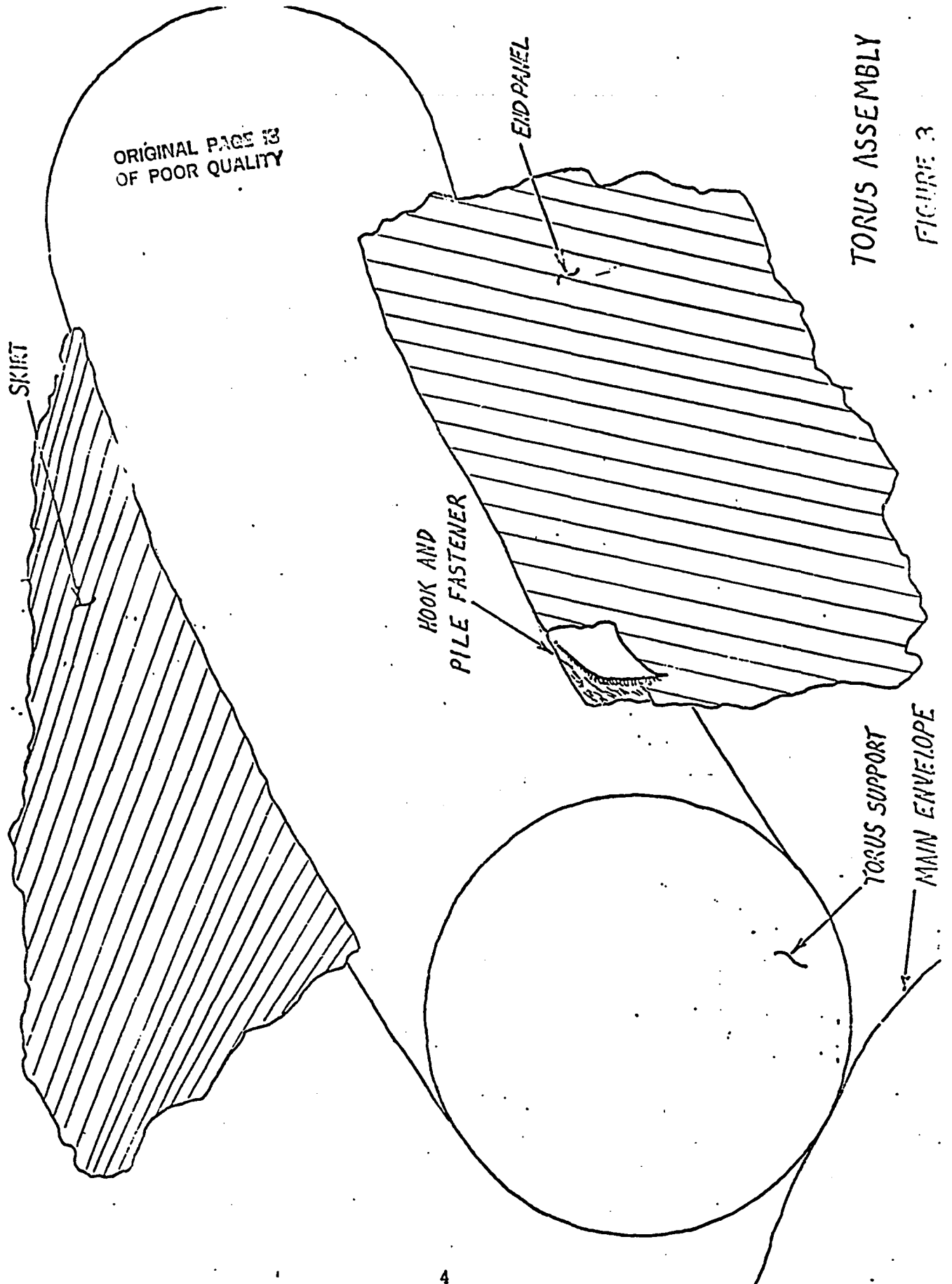
TORUS ASSEMBLY

FIGURE 3

end shape. The resulting torus radius at the end is only approximately 7 inches as shown on Figure 1.

The cylinder will be formed from longitudinal gores with shaped ends to yield the inverted end shape. The material at each end will be banded to a standard spool type balloon end filling. An adequate minimum gore width will be maintained to provide the necessary strength. The fittings at either end will be connected with a steel restraining cable. Details of the end fitting are shown on Figure 2.

2.1.2 TORUS END SECTIONS

Flat ends are generated by using a torus with a 7 inch radius around each end of the cylinder (see Figure 1). Each torus will be constructed independently and attached to the cylinder.

The skirts and end panels will be attached to the inflatable with hook and pile fastener (see Figure 3). The primary function of both sections is the generation of the desired shape and will carry no structural loads. Hard mounting points on the ends will be, as discussed in a following section, attached to the main inflatable surface. These will be available through holes in the end panels. The ability to remove the end panels facilitates the location of inflation servicing hardware and will be a distinct advantage in case of leak checking or repairs.

2.1.3 DIMENSIONAL PARAMETERS

The following tabularized information lists the final dimensions and resulting surface area and volume of the LDEFI. The structure is subdivided as shown in Figure 4 for ease of understanding.
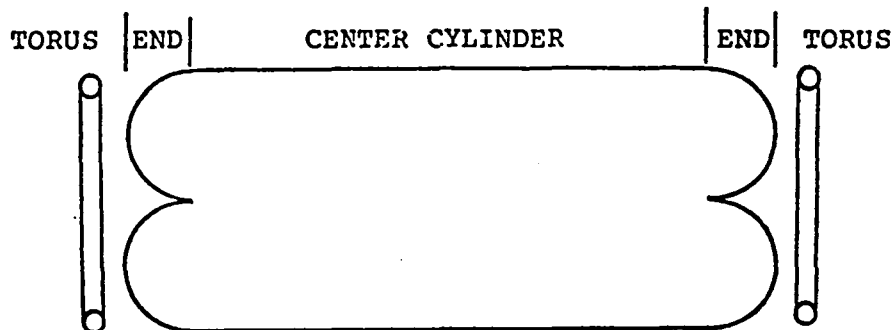
TORUS |END| CENTER CYLINDER |END| TORUS

FIGURE 4

5

SECTION		LENGTH	RADIUS	SURFACE AREA	VOLUME	GROSS LIFT	
Center	Cylinder	277.75"	82.25"	996.8^2 ft	3416.1^3 ft	225.1 lbs	
2 Ends		---	41.125"	463.7^2 ft	794.0^3 ft	52.3 lbs	
2 Tori		---	7.06"	290.0^2 ft	83.6^3 ft	5.5 lbs	
Totals		---	---	1750.5^2 ft	4293.7^3 ft	282.9 lbs	

The tabulated lift is based on standard conditions (ISA) at sea level with a free lift of helium of .06589 pounds per cubic feet. The total gross lift would be reduced to 269.4 lbs with an increased ambient temperature of 85^0 F (helium free lift of .06275). This gross lift value will be used for all subsequent bouyancy calculations.

2.2   MATERIAL

The proposed material is a polyurethane coated polyester fabric.

The base fabric is a 220 denier polyester with a thread count of 52 x 52. The nominal weight is 3.2 ounces per square yard. The tensile strength is 198 lbs x 215 lbs, tongue tear strength is 15.2 lbs.

The total nominal weight of the coating will be 4.0 ounces per square yard. The coating will be distributed with 3.0 ounces per square yard on the inside surface and 1.0 ounce per square yard on the outer surface. The outer coating will be pigmented to give the appearance of aluminum.

The measured helium permeability of a similar material is less than one liter per square meter per 24 hours. The only difference in this material and that proposed for the LDEF1 is that the base fabric weighs 4.2 ounces per square yard. The helium permeability of the proposed material, based on this comparison and Raven's extensive experience with coated fabrics, will also be less than one liter per square meter per 24 hours, well within the requirement of the statement of work.

A polyester base fabric is proposed because of its low elongation characteristics at low stress as compared to that of nylon. The polyurethane coating provides good abrasion resistance, helium retention and over all durability. The coating is compatible with both adhesive bonding and heat sealing techniques.

A sample of material representative of that proposed except for weight is enclosed.

6
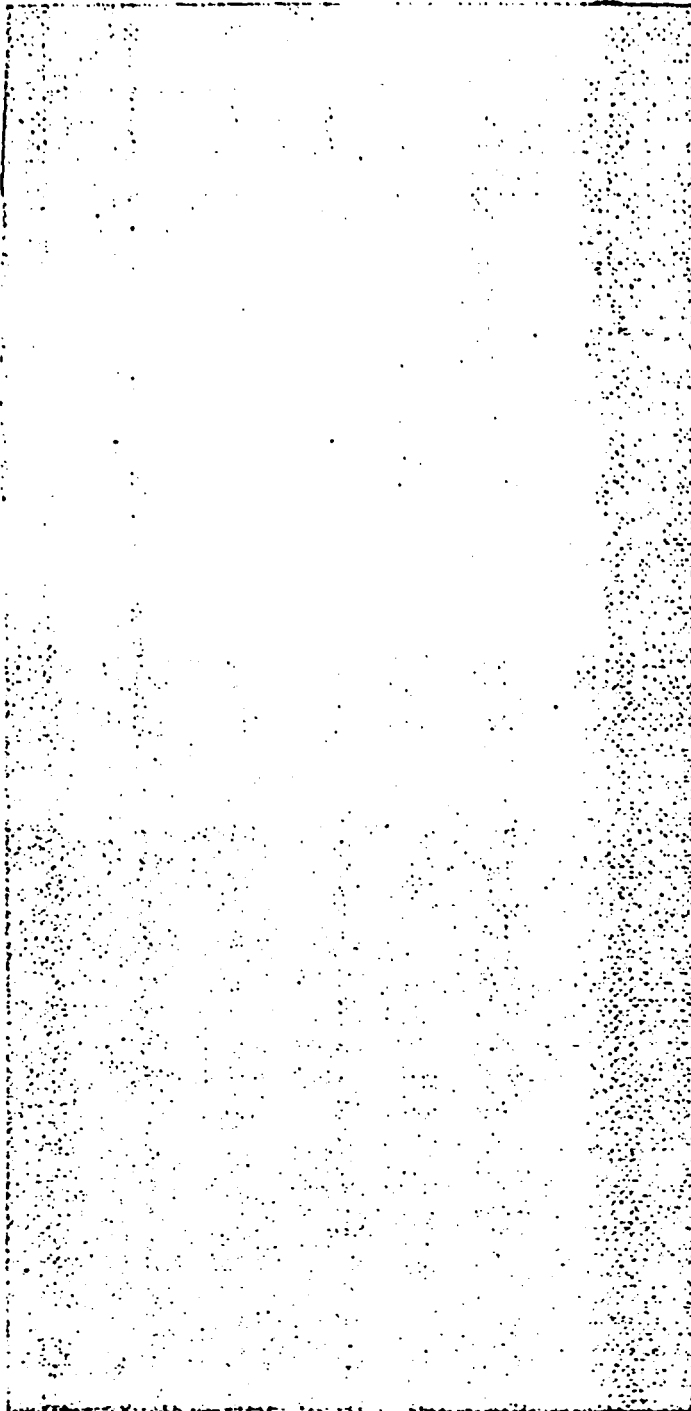
POLYURETHANE COATED POLYESTER

2.3 STIFFNESS

Three types of stiffness must be considered for the LDEFI;
skin, bending, and torsional. The following paragraphs
will discuss each.

2.3.1 SKIN STIFFNESS
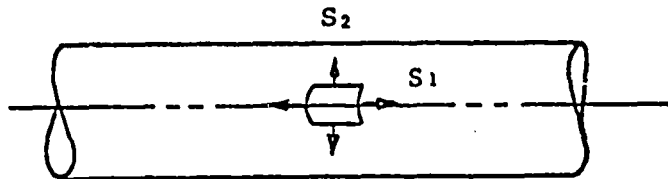
FIGURE 5

Skin stiffness is a factor of skin stress in an
inflatable. Longitudinal stress for a cylinder with
hemispherical ends is given by:

$$S_1 = \frac{\Delta PR}{2}$$

In the proposed configuration with inverted ends, the
above relationship must be modified to the following:

$$S_1 = \frac{\Delta P(R^2 - r^2)}{2R}$$

From Figure 1 R=82.25", r=41.125 and for an operating
pressure of 3 inches of water:

$$S_1 = \frac{(.108)(82.25^2 - 41.125^2)}{2(82.25)}$$

$$= 3.33 \text{ lbs/in}$$

Lateral skin stress is represented by the following
equation:

$$S_2 = \Delta PR$$

For an operating pressure of 3 inches of water and radius
of 82.25 inches:

$$S_2 = (.108 \text{ lb/in}^2)(82.25 \text{ in})$$
$$= 8.88 \text{ lbs/in}$$

8

The skin stress tangential to the end plane of the inverted ends of the main envelope will be governed by the following equations:

$$S_1 = \Delta Pr \qquad S_2 = \frac{\Delta Pr}{2}$$
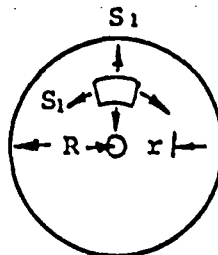
FIGURE 6

Again, for three inches of water pressure:

$$S_1 = .108(41.125) \qquad S_2 = .108(41.125)/2$$
$$= 4.44 \text{ lbs/in} \qquad = 2.22 \text{ lbs/in}$$

The end tori will be inflated to the same operating pressure as the main envelope. To determine the maximum skin stresses in each direction, the following equations apply:

$$S_1 = \frac{\Delta Pr'(2R-3r')}{2R - 4r'}$$

$$S_2 = \frac{\Delta Pr'}{2}$$
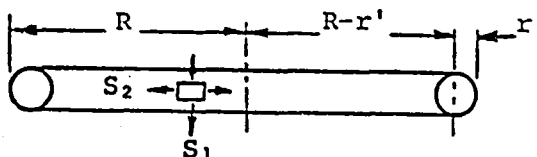
FIGURE 7

Where R = 8?.25 and r' = 7.06;

$$S_1 = \frac{.108(7.06)(164.5-21.18)}{(164.5-28.24)} \qquad S_2 = \frac{.108\ (7.06)}{2}$$

$$= .80 \text{ lbs/in} \qquad\qquad = .38 \text{ lbs/in}$$

2.3.2 BENDING STIFFNESS

Bending stress is related directly to longitudinal stress for a cylinder. The first wrinkle in the skin of the cylinder will occur when bending stress equals longitudinal stress. For the proposed configuration, this can be represented as follows:

$$M = S \pi R^2$$

9

For the stress determined in 2.1.4.1 of 3.33 lbs/in for the 82.25 inch radius:

$$M = (3.33 \text{ lbs/in}) \times \pi \times (82.25 \text{ inches})^2$$
$$= 70,773 \text{ in lbs}$$
$$= 5898 \text{ ft lbs force}$$

Increasing internal pressure yielding higher longitudinal skin stress will increase the bending force required to cause wrinkling.

2.3.3 TORSIONAL STIFFNESS

Thin, flexible fabrics vary wide in their reaction to shear in the plane of the material with thread denier, weave and coating material. Torsional loading also causes a reduction in lateral stress in the material and thus reduces skin tension. As the fabric is displaced in torsion and lateral stress is reduced, the material becomes susceptable to flexural displacement where lateral loads rapidly diminish.

Torsional stiffness of a rigid cylinder is proportional to the shear modulus of the material and is usually represented by the following equation:

$$\text{Torsional Stiffness} \qquad \frac{M_T}{\sigma} = \frac{\pi(D^4-d^4)G}{32L}$$

Where θ = angular displacement, M = torsional moment applied, G = shear modulus, D = outer diameter, d = inner diameter, L = length.

RFP 055P requires a torsional stiffness of:

$$\frac{M_T}{\theta} = 3000 \text{ ft lb/radian}$$

Assuming a material thickness of 10 mils and shear modulus G = 3000 PSI*

$$\frac{M_T}{\theta} = \frac{\pi[(164.5)^4-(164.48)^4]3,000}{32\,(360)} = \frac{[(in)^4-(in)^4]lb/in^2}{(in)} = \frac{in/lbs}{rad}$$

$$= 291,290 \text{ in lbs/RAD}$$
$$= 24,274 \text{ ft lbs/RAD}$$

*The shear modulus of 3000 PSI was derived from test data determined from model testing of pressurized cylinders under torsion constructed of coated fabric (NASA TN D-755 Aug 61). This material is somewhat heavier than the proposed LDEFI material but should yield a shear modulus on the same order of magnitude.

The shear modulus required by the statement of work would be 30.9 PSI. Synthetic rubber has a shear modulus of 5-20 PSI and when combined with a fabric, this modulus increases by two orders of magnitude or more.

The actual value for torsional stiffness of the LDEFI structure would fall well above the requirement set in the statement of work, but precise determination would only be possible through the collection of empirical data.
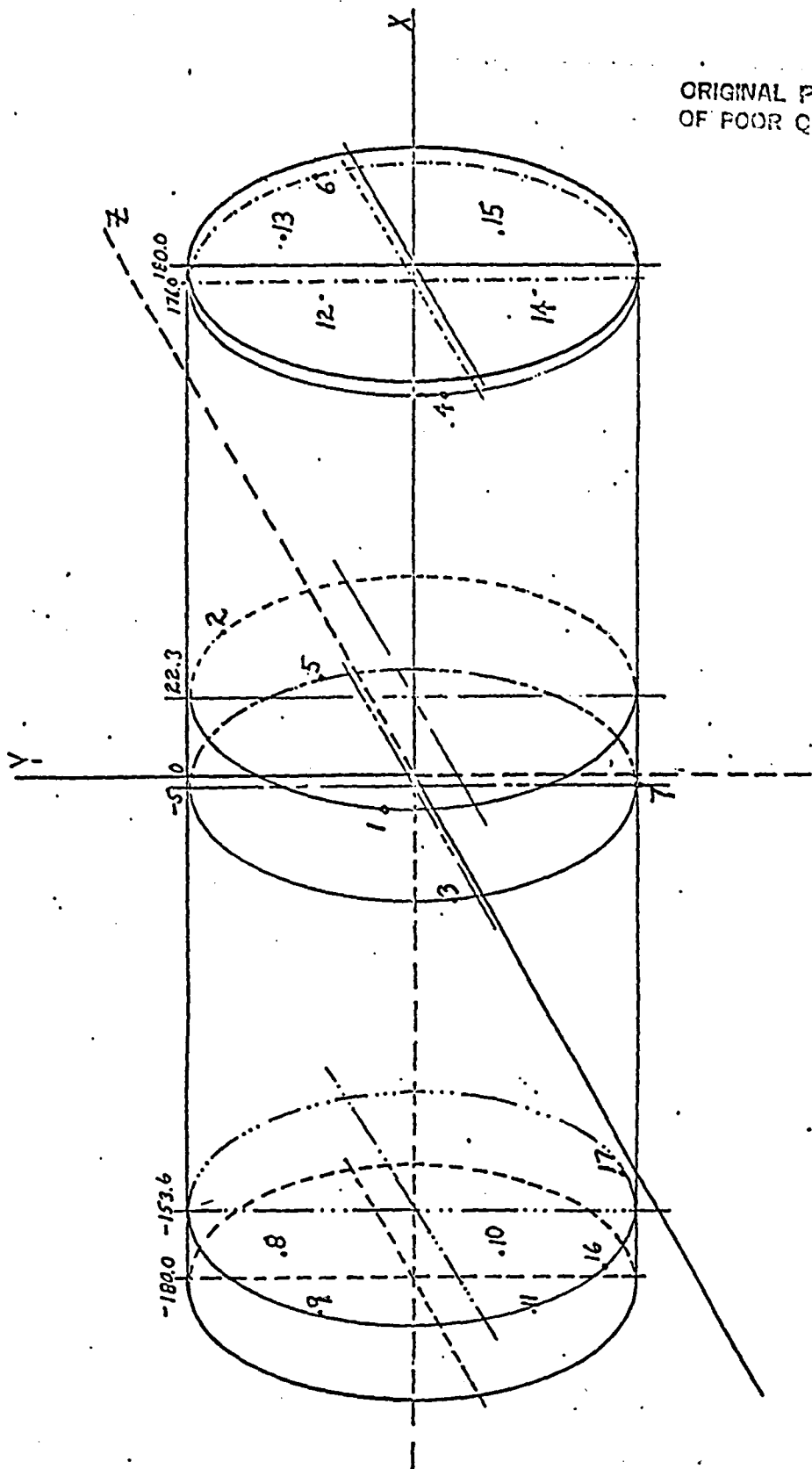
2.4 BOUYANCY

The bouyancy of the LDEFI as determined in section 2.1.3 is a gross lift of 269.4 lbs. A gross loading computation must first be made to place the center of gravity at the volumetric center of the LDEFI. The following table shows 17 required hardware mounts, their respective weights, and their x, y, and z locations (see Figure 8) with respect to the volumetric center. Points 1-15 are the required 15 nard points. Point 16 is the main inflation port and point 17 is the gross ballast point. The summation of moments in each axis is equal to zero.

POINT	WT	X	Y	Z	X_m	Y_m	Z_m
1	18.15	22.3	41.125	71.23	406.975	750.53	1299.95
2	18.25	22.3	71.23	-41.125	406.975	1299.95	-750.53
3	8.25	- 5.0	14.0	81.05	- 41.25	115.5	668.66
4	8.25	176.0	14.0	81.05	1452.0	115.5	668.66
5	8.25	- 5.0	14.0	-81.05	- 41.25	115.5	-668.66
6	8.25	176.0	14.0	-81.05	1452.0	115.5	-668.66
7	8.25	- 5.0	-82.25	0	- 41.25	- 678.56	0
8	8.25	-180.0	37.2	-20.2	-1485.0	306.9	-166.65
9	8.25	-180.0	37.2	20.2	-1485.0	306.9	166.65
10	8.25	-180.0	-37.2	-20.2	-1485.0	- 306.9	-166.65
11	8.25	-180.0	-37.2	20.2	-1485.0	- 306.9	166.65
12	8.25	180.0	37.2	20.2	1485.0	306.9	166.65
13	8.25	180.0	37.2	-20.2	1485.0	306.9	-166.65
14	8.25	180.0	-37.2	20.2	1485.0	- 306.9	166.65
15	8.25	180.0	37.2	-20.2	1485.0	- 306.9	166.65
16	1.0	-153.6	-58.16	58.16	- 153.6	- 58.16	- 58.16
17	22.4	-153.6	-79.275	-21.931	-2330.6	-1775.76	-491.16
	167.15				0	0	0

Cable and Spools   6.5   lbs
Total Hardware Wt.   167.15 lbs
Trim Weights   10.00 lbs
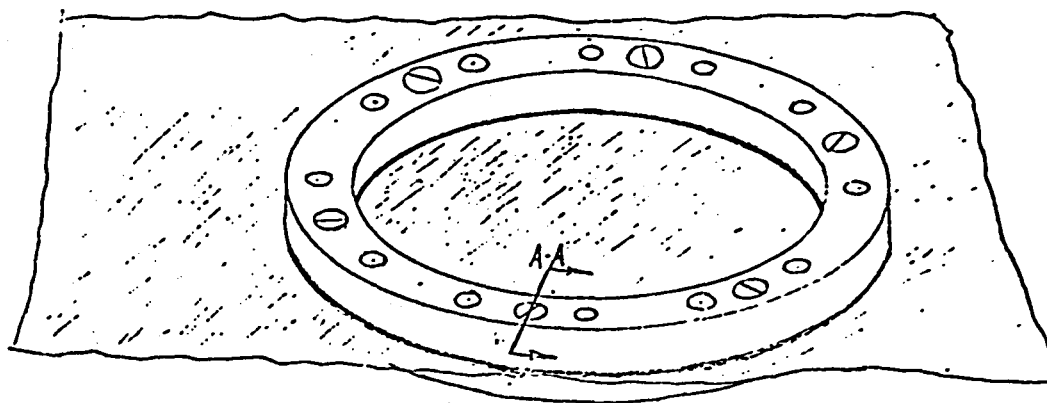Fabric Weight   85.75 lbs
                 269.4 lbs
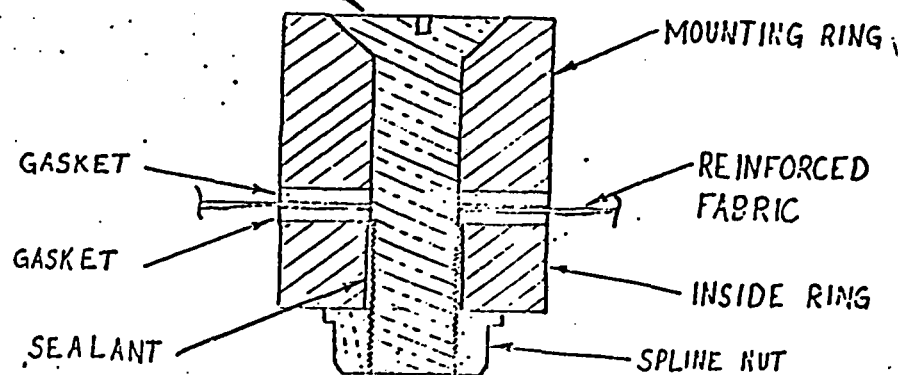
FIGURE 8

A-A

FLATHEAD SCREW

MOUNTING RING

GASKET

GASKET

SEALANT

REINFORCED
FABRIC

INSIDE RING

SPLINE NUT

SECTION A-A

2.5 FABRICATION AND CONSTRUCTION

The techniques which will be used to fabricate and construct the LDEFI are well proven and reliable. Quality control is built into each step of the process, i.e.; random samples of the materials will be tested to ensure the material meets desired specifications, seam samples will be tested for strength.

2.5.1 MAIN CYLINDER CONSTRUCTION

The main cylinder will be constructed of twelve gores. The end of each gore will split to form two gores for a more uniform construction of the inverted end (see engineering drawing C-51510). The seams will be bonded using high strength adhesives final assembly and checkout will be accomplished for the LDEFI with helium.

2.5.2 TORUS CONSTRUCTION

Several methods exist for the fabrication and construction of a torus. With the large difference between the outside torus radius 81.5 ± .75 inches and the tubular torus radius 7.0 ± .06 inches, the torus may be formed of gores, tucked tubular, or a modified gore tubular method. The latitude provided by these options allows for the selection of the design which would afford best distribution of skin stresses with other considerations of porosity, esthetics, maintainability and repairability.

2.6 ATTACHMENTS

Along with the fifteen required hard point attachments, several other types of attachments are required. Each will be discussed in the following sections.

2.6.1 HARD POINT ATTACHMENTS

The fifteen hardware attachment mounting points will be mounted on the skin of the LDEFI in the manner shown in Figure 9. The mounting ring will be constructed of 1/2" 60-64 aluminum with a matting inside ring constructed of 1/4" aluminum. Gaskets will be placed between each ring and the fabric which will be reinforced in the area of the interface.

2.6.2 BALLAST AND TRIM WEIGHTS

Ballast and trim weights will be contained in four pockets at each end of the LDEFI construction.

2.6.5 INFLATION SYSTEM

The LDEFI will consist of three distinct air chambers. The two tori will require only a single Schrader valve for both filling and top off due to the relatively low volume of helium contained in each. A second Schrader valve will be installed in each air chamber to allow pressure monitoring during servicing.

The main cylinder will have a rapid fill inflation tube (shown in Figure 10) which will be used for initial servicing. The inflatable will be taken up to just prior to skin stretch using this inflation port. The cover plate will then be installed and either of two Schrader valves located in the ends of the LDEFI main envelope will be used to reach operating pressure.

The rapid inflation port will be located as shown on Figure 8 so as to reduce the total amount of weight required to reach the coarse balance of the LDEFI.

2.6.4 TIE DOWN LINES

Tie down lines will be attached to each end of the main envelope on a "D" ring at the crossing point of three load webbings which will be adhered to the inverted end. The "D" ring will protrude through the end panel.

2.7 SAFETY

Safety is paramount in the design of any pressurized structure. Even with the low operating pressures of the LDEFI, an examination of the most serious failure must be made.

The restraining cable and end fittings have been determined as representing the greatest safety hazard if a failure were to occur. The restraining cable supporting the inverted ends will be constructed of steel aircraft cable. The tension is governed by the following relationship:

$$\sigma_t = \Delta P \pi r^2$$

For a working pressure of 3 inches of water pressure and a radius of 41.125 inches:

$$\sigma_t = .108 \ (\pi) \ (41.125)^2$$
$$= 574 \ lbs$$

Using a safety factor of 10, 7/32 inch 7x19 aircraft cable will be used. A proportionally larger cable will be used if it is determined that higher operating pressures are required.

15

FLANGED DEFUSER SLEEVE

SPLINED NUT

INNER AND OUTER RINGS

GASKETS

ENVELOPE WALL

FLANGED INFLATION TUBE

COVER PLATE

SCREWS (6)
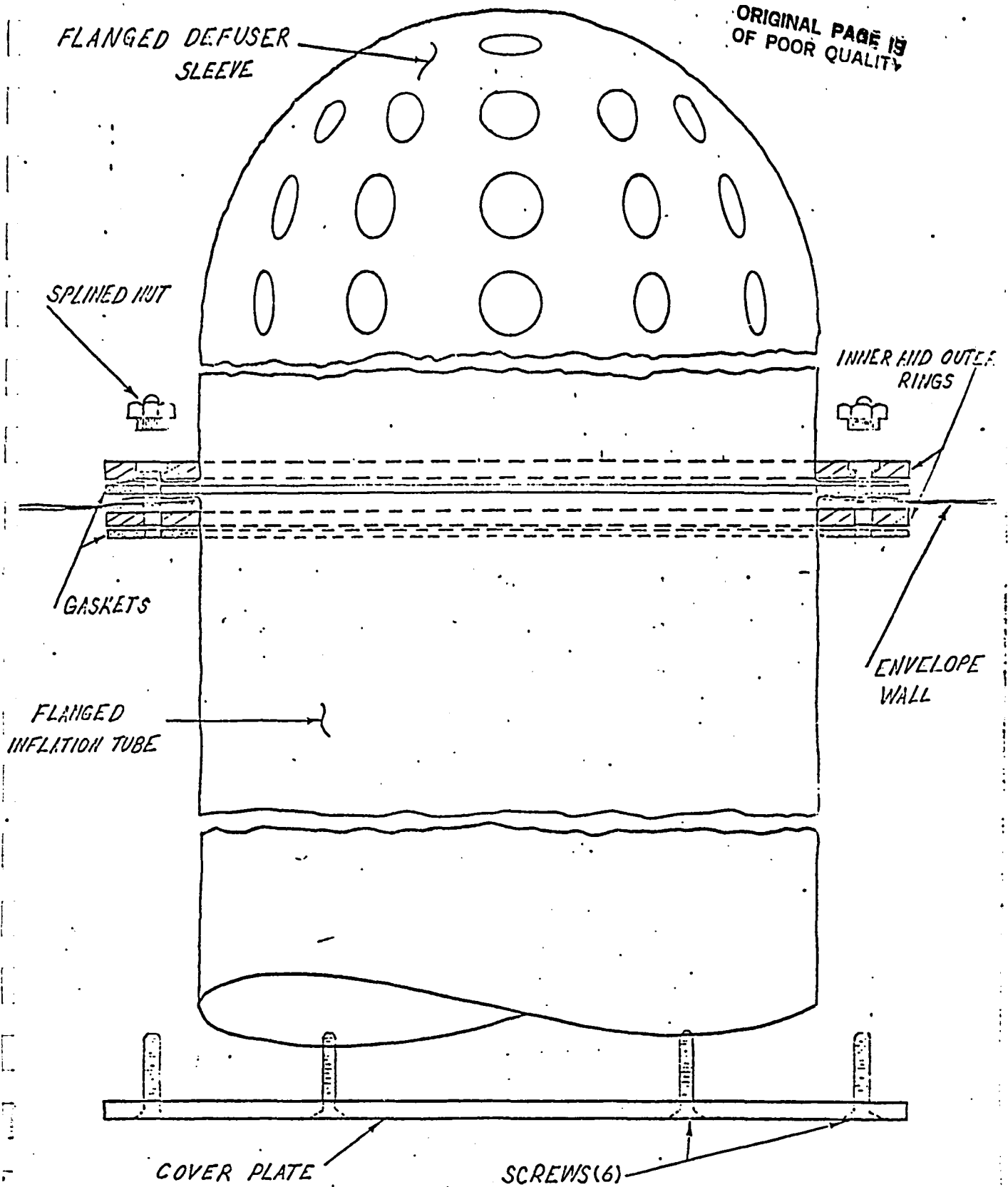
2.8 MAINTENANCE

Maintenance and servicing are minimal as the LDEFI will only require helium servicing periodically. It is recommended that prior to beginning an operational day the internal pressure be checked and brought up to working pressure. This will insure a minimum of 8 hours service free operation.

Tears, holes or leaks must be repaired with adhesive patches. A detailed discussion of this procedure will be accompanying the LDEFI with a field repair kit.

3.0 MANAGEMENT

3.1 GENERAL

The proposed program will be conducted within the Applied Technology Division of Raven Industries. Mr. James A. Winker is a Vice-President of Raven Industries and manager of the Applied Technology Division.

3.2 PROGRAM MANAGEMENT

The primary program management will be assigned to the engineering group. Mr. Patrick J. Cannon is the Engineering Group Manager. The program will be conducted on a project basis with an assigned project engineer from within the engineering group. Assignment of the project engineer will be made at the time of contract award and would be dependent upon existing requirements at that time. The engineering group will have the total technical responsibility as well as data management, documentation and conference requirements.

Fabrication will be coordinated with Mr. K. L. Tekrony, Production Manager for the Applied Technology Division.

3.3 PROGRAM SCHEDULE/PLAN

A program schedule outlining the major tasks with manpower loading is enclosed as Figure 11.

PROGRAM PLAN
TASKS AND MANPOWER LOADING

MILESTONES/MONTHS FROM GO-AHEAD	1	2	3	4	5	6	7	8	9	10	11	12
TASKS												
INITIAL INTERFACE MTN'G.												
SYSTEM DEFINITION												
MATERIAL PROCUREMENT												
DETAILED DESIGN												
FABRICATION												
FINAL ASS'M & CHECKOUT												
INSTALLATION												
PROGRAM MANAGEMENT & REPORTS												

LABOR CATAGORIES & HOURS	1	2	3	4	5	6	7	8	9	10	11	12
ENGINEER	64	64	64	32	64	96	120					504
DESIGNER/DRAFTSMAN	40	80	80	20	20							240
TECHNICIAN		40	40	40	60	80						260
ASSEMBLY				80	160							240
MACHINE SHOP			40	40								80
MONTHLY TOTALS	104	184	224	212	304	176	120					1324

ORIGINAL PAGE 19 OF POOR QUALITY

FIGURE 11

PROPOSAL CLARIFICATION

RAVEN PROPOSAL NO. ATD1182111

1.0 SKIRTS AND END PANELS

Question being addressed: Calculate and state surface area
and material of the skirts and end panels.

The end panels and skirts will be constructed of a 2.16
ounce dacron polyester base fabric with either a .5 ounce
pigmented polyurethane coating or a .5 mil aluminized mylar
laminate on the outer surface. The end panels will be
circular in shape with a diameter of 152.5". The skirt will
fit circumferentially around the main envelope and end
torus. The flat panel will have approximate dimensions of
516.8" x 36". The total surface area of the skirts (129.2
ft² each) and end panels (126.8 ft² each) is 512 ft.² or 56.9
yds?

2.0 GROSS BALLAST POINT

Question being addressed: What is meant by "gross ballast
point?"

The gross ballast point is the position (point 17 on Figure
8 of Ref. B) at which the absolute minimum amount of ballast
can be placed to bring the center of mass concentric with
the volumetric center of the LDEFI. This point is not
intended to be used to reach neutral buoyancy. Only to
balance out rotational moments about each axis. Some fine
trimming with weights 'n the end pockets may be required to
"fine tune" the rotational moments. A tubular 1.25"
diameter webbing filled with lead shot in one foot sections
will be used to comprise the weights for the oss ballast
as well as trim weights. Each one foot section will weigh
approximately 3.25 lbs. and will require seven such bags for
gross ballast.

An area of reinforced material will be located about the
gross ballast point to which the weights will be attached by
means of elastic straps (see Figure 1). The skirt will
cover the mounting area of the gross ballast point and is
easily removable by means of the hook and pile fastener.
This will allow some or all of the weights to be removed to
compensate for any government provided equipment which may
be removed and maintain rotational balance.

ELASTIC STRAPPING

REINFORCING MAT'L

SHOT FILLED
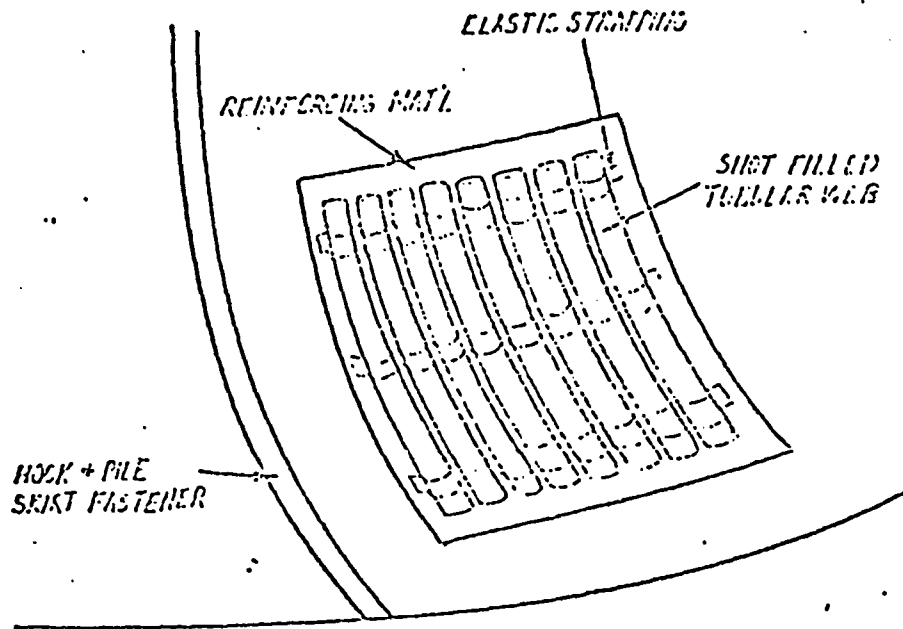TUBULAR WEB

HOOK + PILE
SKIRT FASTENER

FIGURE 1

3.0 TRIM POCKETS

Question being addressed: . Specify the location and orientation of weight pockets and total weight each can hold.

Once the LDEFI has been brought into gross balance by means of the gross ballast point, trim weights may now be placed in eight locations as necessary to trim out imbalances and bring the LDEFI to neutral bouyancy. On each end, there will be four locations on the main envelope which weights may be attached as described in 2.0 and Figure 1. This will facilitate balancing out any large amount of buoyant force which must be overcome to reach neutral. Adjacent to each of these locations will be a pocket located on the end panel and will provide a secure location for small amount of trim weights. The pocket will be closed by a strip of hook and pile fastener on the open end flap.

Each inner location on the main envelope ends will be designed to accomodate 25 lbs. of weight while the trim pockets will hold up to 5 lbs. This will enable the LDEFI to be brought to equilibrium with all government equipment removed and a best lift condition of 282.9 lbs.

4.0 BOUYANCY

Question being addressed: Is the LDEFI capable of being neutrally buoyant as described in the proposal? Show calculations to that effect.

While answering the aforestated questions, it was realized that the weight of the end panels and skirts were left off of the buoyancy calculations. To compensate, a slightly lighter weight material is being proposed for use in the LDEFI.

The base material remains a dacron polyester fabric of 70 denier thread and a thread count of 107 x 105. The nominal weight of the fabric is 2.2 ounces per square yard with tensil strengths of 111 x 110.5 lbs. and trapezoidal tear strength of 20 lbs. This yields a minimum safety factor of 12.5.

The fabric will be coated on the inside with 2.5 ounces per square yeard of polyurethane. The outside will either be coated with a pigmented urethane to produce a polished aluminum appearance (see material sample in Ref. D) or a .5 mil layer of aluminized mylar will be laminated to the surface producing a highly polished appearance. The final nominal fabric weight is 5.2 ounces per square yard. Final material selection will be made during preliminary design reviews with NASA.
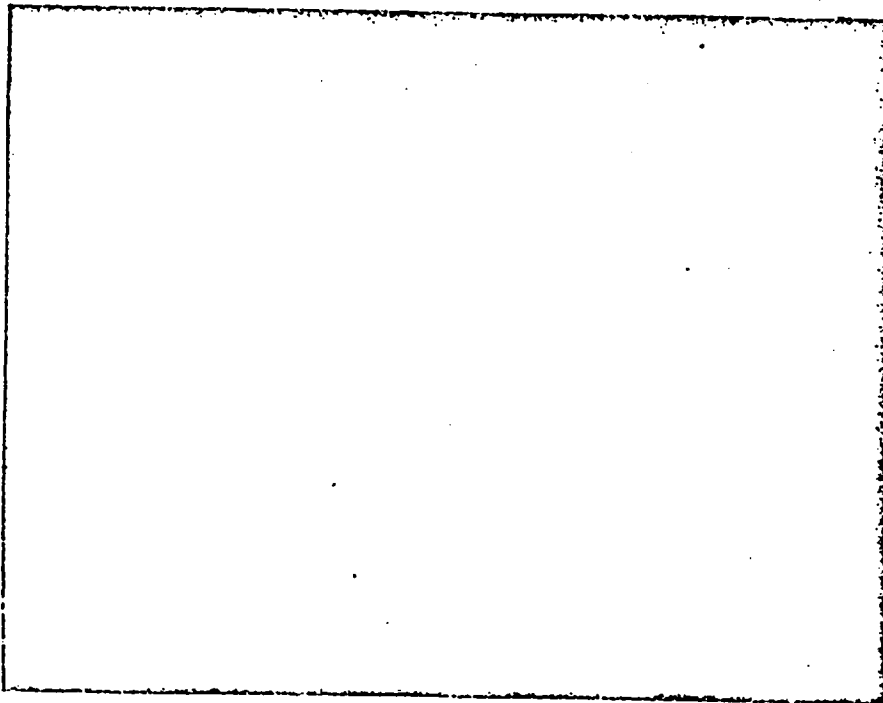
Enclosed is a stress-strain curve of the material showing a
linear elongation rate which would result in a 1.25%
elongation at a maximum operating load of 8.8 lbs./in. This
graph also shows a grab tensil strength of 235 lbs./in.

The following is a tabulation of buoyancy based on worst
case lift of 269.4 lbs. as would be generated at 85 F
(helium free lift of .06275):

Cable and Spools	6.5	lbs.
Government Hardware	125.0	lbs.
Mounting Hardware/Gross Ballast	42.15	lbs.
Trim Weights	14.84	lbs.
*Main Fabric + 10%	69.53	lbs.
**Skirts and End Panels	11.38	lbs.
Total Gross Life	269.4	lbs.

*194.5 square yards @ 5.2 oz./yd² plus 10%
** 56.9 square yards @ 3.2 oz./yd²

5.0 LIFETIME

Question being addressed: What is the service life of the
LDEFI?

The service life of the 5.2 ounce coated fabric used to
construct the main envelope and end tori is a minimum of 5
years. All other components have a virtually limitless life
expectancy if maintained within the design criteria. The
actual life of the LDEFI will be determined by the degree of
use, stress, and abuse which it undergoes. No means of
estimating these effects on the lifetime exists.

Cell

F

NASA

1.25 ?, ELONGATION   232

APPENDIX B

RBADS 1161

RAVEN
industries, inc.

COATED FABRIC, NASA INFLATABLES

Applied Technology Division

RBADS 1161

Prepared by:

M. L. West
Project Engineer
Applied Technology Division

Raven Industries, Inc.
P. O. Box 1007
Sioux Falls, SD 57117

COATED FABRIC, NASA INFLATABLES

RAVEN

industries, inc.

SPECIFICATION NO. RBADS 1161
DATE ISSUED: 15 July 1983
Page 2 of 2

1.0 Base Fabric

The base fabric shall be a Dacron polyester made of 70 denier yarns having a base weight of approximately 2.0 oz/yd^2.

2.0 Coating

Side one shall be a heat and solvent sealable polyurethane which will constitute a helium barrier with permeability rates as established in paragraph 5.3 of this specification. Side two shall have a base coating or adhesive with approximately .5 oz/yd^2 of a bright aluminized polyurethane.

3.0 Construction

The construction shall be as specified above with a total weight not to exceed 5.0 oz/yd^2.

4.0 Width

The minimum trimmed width shall be 43 inches.

5.0 Physical Properties

The finished fabric must meet the minimum values of the following listed physical properties.

5.1 Tensile Strength (one-inch strip method)

Machine direction - 50 lbs.   (minimum)
Transverse direction - 50 lbs.   (minimum)

5.2 Tear Strength (tongue tear)

Machine direction - 1.5 lbs.   (minimum)
Transverse direction - 1.5 lbs. (minimum)

5.3 Permeability (helium)

Maximum acceptable - 1 liter/meter^2/24 hours

5.4 Seam Strength

The peel strength of a one-inch heat sealed lap seam (side one to side one) shall be a minimum of 7 lbs. The peel strength of a one-inch heat sealed lap seam (side two to side two) shall be a minimum of 4 lbs. This test shall be accomplished on a sample prepared using the hot wheel sealing method.

5.5 Acceptance Tests

Failure of the fabric to meet the listed physical properties may constitute ground for rejection.

ITEM: _NASA- STTA/LDEFI_	CONTRACT/P.O.#:	/R.R.#
UNCOATED DACRON BASE FABRIC	W.O. #: _30071.03_	
LOT #: LOT SIZE:	MFG.	
	TEST FACILITIES: _RAVEN_	

TYPE OF TEST: _1" STRIP TENSILE_

TEST METHOD:

MATERIAL TESTED: ORIGINAL PAGE IS
                                          OF POOR QUALITY

COATED SALES MAT'L White STYLE 412

WARP	FILL
82.0	62.0
90.0	65.5
87.0	64.0
86.3 lbs. Avg.	63.8 lbs. Avg.

LAMA MAT'L

WARP	FILL
125.0	60.5
120.0	62.0
128.0	62.0
126.0	61.5 lbs. Avg.
125.3 lbs. Avg.	

TECHNICIAN: _____   SEE D.R. # _____

COPIES:

RS-238 _MARK WEST_   CUSTOMER _____

                                    GRAPH NO.: _1657_

APPENDIX C

Material Test Results

ITEM: NASA- STTA / LDEFI

CONTRACT/P.O.#: _____ / R.R.#

W.O. #: 3007-03

LOT #: _____ LOT SIZE: _____

MFG.

TEST FACILITIES: RAVEN

TYPE OF TEST: Weight - Tongue Tear

TEST METHOD:

MATERIAL TESTED:

COATED SALES MAT'L WHITE

Weight

ORIGINAL PAGE IS
OF POOR QUALITY

1.99
2.01
2.0 Oz/yd2

TONGUE TEAR

	WARP			FILL	
Initial 4.3	2.9		Initial 4.8	2.9
5.4	3.6		4.6	3.0
4.5	3.1		4.0	2.9
	3.2 lbs. Avg.			2.9 lbs. Avg.

TECHNICIAN: _____

SEE D.R. # _____

ITEM: NASA

CONTRACT/T.O.#: 873.3 / R.R.# I-21885

W.O. #: 30071-03

LOT #:   LOT SIZE:

MFG. REEVES BROS

Roll # 4376 182 yd Roll

TEST FACILITIES: RAVEN

TYPE OF TEST: Weight - Width

TEST METHOD: PER RBADS 1161

MATERIAL TESTED:

Coverlight White / Aluminize

4.6 OZ 43"

ORIGINAL PAGE IS OF POOR QUALITY

Weight - 5.0 OZ/yd² (Max)

4.63
4.60
5.04
4.76 OZ/yd²

Width - 43 inches (Min)

41½ inches

TECHNICIAN:

SEE D.R. # 1478

COPIES:

RS-238 Mark West

CUSTOMER

GRAPH NO.: 1882

ITEM: NASA

CONTRACT/P.O.#: 22313/R.R.# I-2185

W.O. #: 3C021.03

LOT #:   LOT SIZE:

MFG. REEVES BROS.

Roll# 4376   189 yd Roll

TEST FACILITIES: RAVEN

TYPE OF TEST: 1" STRIP TENSILE - TONGUE TEAR

TEST METHOD: PER RBADS 1184

MATERIAL TESTED:

Coverlight White / Aluminum
4.6 oz. 43"

1" STRIP TENSILE

**ORIGINAL PAGE IS
OF POOR QUALITY**

WARP	FILL
104.0	100.0
91.0	83.5
99.5	84.0
98.0	96.5
94.0	100.0
97.1 lbs. Avg	92.8 lbs. Avg

TONGUE TEAR

WARP	FILL
2.0	2.2
2.0	2.2
2.0	2.7
2.0	2.2
2.0	2.1
2.0 lbs. Avg	2.2 lbs. Avg

TECHNICIAN: _____

SEE D.R. # 1478

COPIES: MARK WEST

CUSTOMER _____

RS-238

GRAPH NO.: 1882

ITEM: NASA

CONTRACT/P.O.#: 27313 / R.R.#I.21885

W.O. #: 3007603

LOT #:

LOT SIZE:

MFG. REEVES BROS.

Roll #4376 180 yd Roll

TEST FACILITIES: RAVEN

TYPE OF TEST: Peel Tests

TEST METHOD: Per RGADS 1181

MATERIAL TESTED:

Coverlight White / Aluminum
4.6 oz. 43"

ORIGINAL PAGE IS
OF POOR QUALITY

White To White - Heat

Initial	12.6	Peel	11.5
	13.2		10.4
	14.2		11.4
	13.9		8.9
	11.2		6.7
	12.8 lbs Avg.		9.9 lbs. Avg.

White To White 7133+ Heat

Initial	12.0	Peel	6.7
	15.0		6.8
	13.5		15.6
	14.4		10.0
	14.2		11.2
	13.8 lbs Avg.		10.1 lbs. Avg.

TECHNICIAN:

SEE D.R. # 1478

COPIES:

CUSTOMER

RS-238 MARK WEST

BATCH NO. 1882

RAVEN INDUSTRIES, INC.

TESTING DATA SHEET

Date 9-20-83

ITEM: NASA

CONTRACT/P.O. #: 2713 / R.R.# I-21885

W.O. #: 300-71-03

LOT #:   LOT SIZE:

MFG. REEVES BROS.

Roll # 4326 182 3'd Roll

TEST FACILITIES: RAVEN

TYPE OF TEST: PEEL TESTS

TEST METHOD: PER RBADS 1104

MATERIAL TESTED:

Coverlight White / Aluminum

4.6 OZ. 43 inches (Min)

ORIGINAL PAGE IS
OF POOR QUALITY

White To Silver - HEAT

5.7
8.3
8.6
8.5
6.6
7.5 lbs. Avg.

White To Silver   7133 + HEAT

Initial	5.9	PEEL	5.3
	6.4		5.8
	6.0		6.0
	5.8		6.9
	6.7		5.5
	6.2 lbs Avg		5.9 lbs. Avg.

TECHNICIAN: ___

SEE D.R. # 1478

COPIES:

CUSTOMER _____

RS-238 MARK WEST

HELIUM PERMEABILITY TEST

DATE_____ TECHNICIAN_____

MATERIAL_____ ROLL # 4376 180 yd Roll

MANUFACTURER_____

JOB NO._____-03____ P.O.__2733____ R.R.__I-21885__

TEST NO. 1

Start MIC setting ___.7240____ Start pressure_____in

Finish MIC setting_____ X = _____

Time of test T = _____min

____11.75 (X) x 1.44/_____(T) = _____ L/m²day

TEST NO. 2

Start MIC setting ___.7240____ Start pressure_____in

Finish MIC setting_____ X = _____

Time of test T = _____min

____22.75 (X) x 1.44/_____(T) = _____./_____ L/m²day

TEST NO. 3

Start MIC setting ___.7240____ Start pressure_____in

Finish MIC setting_____ X = _____

Time of test T = _____min

____47 (X) x 1.44/_____(T) = _____ L/m²day

AVERAGE = ___1.92___ L/m²day

Copies to: ___MARK WEST___ Q.C. Chart No.__1882__

_____ 1478

TESTING DATA SHEET   Date: _10-1-83_

293 yds.

ITEM: _NASA - LDEF 1_   CONTRACT/P.O.#: _2733_ / R.R.# _400,037_

TRF Rec Insp.   W.O. #: _30071-13_

LOT #: _____ LOT SIZE: _____   MFG. _REEVES BROS._

2 Rolls / Roll Sampled   TEST FACILITIES: _RAVEN_

TYPE OF TEST: _Weight - Width_

TEST METHOD: _PER RBADS 1184_

MATERIAL TESTED:

Dacron Coated Sales Style 412

Weight - 5.2 oz/yd²

4.62
4.68
4.7?
4.67 oz/yd2

Width - 4.3" wide

42 inches

Rec for West
Mark 11-1-83

TECHNICIAN: _____   SEE D.R. # _____

COPIES:
RS-238 MARK WEST
Rog Wood

CUSTOMER _____

GRAPH NO.: _1920_

ITEM: NASA-LDEF!   CONTRACT/P.O.#: 2733 / R.R.# 400,037

W.O. #: Sco 71.13

LOT #:   LOT SIZE: MFG. Reeves Bros.

TEST FACILITIES: RAVEN

TYPE OF TEST: 1" STRIP TENSILE -- TONGUE TEAR

TEST METHOD:

MATERIAL TESTED:

Dacron Coated Sales Style 412

1" STRIP TENSILE   800 lbs warp 60.0 lbs. Fill

WARP	FILL
106.0	80.0
100.0	92.0
108.0	78.6
105.5	101.0
105.0	83.0
105.0 lbs. Avg.	86.8 lbs. Avg.

TONGUE TEAR   1.5 lbs. M.V WARP & FILL

WARP	FILL
1.83	2.2
2.1	2.2
2.04	1.9
2.0	2.2
2.0	2.2
2.0 lbs. Avg.	2.1 lbs. Avg.

TECHNICIAN: _____   SEE D.R. # _____

COPIES:

RS-238   MARK WEST

Rog Wood

CUSTOMER _____

GRAPH NO.: 1980

ITEM: NASA LDEF I	CONTRACT/I.C.#: 2.73.3/R.R.# 400,037
	W.O. #: 30071-13
LOT #: LOT SIZE:	MFG. REEVES BROS.
	TEST FACILITIES: RAVEN

TYPE OF TEST: PEEL TESTS

TEST METHOD:

MATERIAL TESTED:

DACRON Coated Sales Style 412

ORIGINAL PAGE IS OF POOR QUALITY

White To White HEAT ONLY 450°

Initial	14.8	PEEL	10.8
	16.0		12.3
	15.0		11.6
	16.8		10.4
	14.6		13.7
	15.4 lbs. Avg.		11.8 lbs. Avg.

White TO TRF White HEAT ONLY 450°

Initial	10.7	PEEL	8.3
	11.2		8.3
	10.8		8.6
	11.6		8.4
	12.0		8.2
	11.3 lbs. Avg.		8.4 lbs. Avg.

TECHNICIAN: _____   SEE D.R. # _____

COPIES: CUSTOMER _____

RS-238   MARK WEST
         Roy Wood   GRAPH NO.: 1720

ITEM: NASA LDEF

CONTRACT/P.O.#: 27313/R.R.# 400,037

W.O. #: 30071-13

LOT #: LOT SIZE:

MFG. REEVES BROS.

TEST FACILITIES: RAVEN

TYPE OF TEST: PEEL TESTS

TEST METHOD:

MATERIAL TESTED:

Dacron Coated Sales Style 412

White to White 7133 + HEAT 450°

Initial -	13.0		PEEL -	15.4
	14.7			11.9
	13.4			12.3
	15.6			7.9
	15.6			11.3
	14.5 lbs. Avg.			11.8 lbs. Avg.

Silver to White 7133 + HEAT 450°

Initial -	7.8		PEEL -	5.3
	9.6			6.2
	7.4			5.9
	7.6			5.5
	7.2			5.2
	7.9 lbs. Avg.			5.6 lbs. Avg.

TECHNICIAN:

SEE D.R. #

COPIES: CUSTOMER

RS-238 MARK WEST
Roy Wood

GRAPH NO.: 1920

ITEM: NASA-LDEF1

CONTRACT/P.O.#: 27313/R.R.#

W.O. #: 30071-13

LOT #: ___ LOT SIZE: ___

MFG. Reeves Bros.

TEST FACILITIES: Raven

TYPE OF TEST: Peel Tests

TEST METHOD:

MATERIAL TESTED:

Dacron Coated Sales Style 412

ORIGINAL PAGE IS OF POOR QUALITY

Silver to Silver 7133 + Heat 450°

10.6
13.5
10.6
6.9
10.2
10.4 lbs. Avg.

Silver to Silver 7133 + THF

18.2
21.3
20.6
15.3
15.4
18.2 lbs. Avg.

TECHNICIAN: ___

SEE D.R. # ___

TESTING DATA SHEET

ITEM: NASA - LDEF I

CONTRACT/I.O.#: 7313 / B.R.# 400,037

W.O. #: 3e8413

LOT #:   LOT SIZE: MFG. Reeves Bros.

TEST FACILITIES: RAVEN

TYPE OF TEST: Peel Tests

TEST METHOD:

MATERIAL TESTED:

Dacron Coated Sales Style 412

Silver To White 7133 + THF

14.7
13.6
11.4
11.7
13.2
12.9 lbs. Avg

White To White 7133 + THF

18.4
19.6
17.7
15.9
14.6
17.2 lbs. Avg

TECHNICIAN: AP

SEE D.R. #

COPIES:

RS-238 Mark West
Rog Wood

CUSTOMER

GRAPH NO.: 1920

HELIUM PERMEABILITY TEST

DATE 10-31-83   TECHNICIAN JMG

MATERIAL NASA-LDEF 1   DACRON Coated SALES STYLE 4/2   ROLL #

MANUFACTURER Reeves Bros.

JOB NO. 30071-13   P.O. 27313   R.R. 400,031

TEST NO. 1

Start MIC setting .7240   Start pressure 5.39 in

Finish MIC setting .7170   X = 10.1

Time of test T = 10 min

  10.1 (X) x 1.44/ 10 (T) = 1.45 L/m²day

TEST NO. 2

Start MIC setting .7240   Start pressure 4.96 in

Finish MIC setting .7174   X = 9.6

Time of test T = 10 min

  9.6 (X) x 1.44/ 10 (T) = 1.38 L/m²day

TEST NO. 3

Start MIC setting .7240   Start pressure 5.14 in

Finish MIC setting .7160   X = 11.5

Time of test T = 10 min

  11.5 (X) x 1.44/ 10 (T) = 1.66 L/m²day

        AVERAGE = 1.497 L/m²day

Copies to: MARK WEST   Q.C. Chart No. 1920
           Rog West

APPENDIX D

LDEFI Drawing Package

NOTE: Because of its bulk, this drawing package is included as a separate package with this report.

APPENDIX E

Torus Construction

TORUS CONSTRUCTION

LDEPI and STTA

1.0 BASIC DESIGN

The tori were constructed using 36 gores to provide a smooth, non-lobed shape. Because the silver side of the material was difficult to seal, a butt seam would have been required with the sealing strip for each gore pattern. This would have produced three times the number of seams in the material compared to using only the radial seam. To prevent this, tucks were made in the material in the same gore shape as would have been cut.

2.0 FABRICATION

The torus lay-flat was marked with the 36 gore patterns, and glue was placed on the silver side of the material. After allowing the glue to dry, a hot iron was used to tack the tuck in place. The tuck was then run through a heat sealer to fuse the three layers of material. Several passes were required, depending on the width of the tuck.

The ends of the tucks tended to pull loose due to a concentration of stress. To eliminate this problem, a 1 x 2 inch patch was sealed over this point on the white side. This reinforcement removed any tendency to separate.

The two ends of the lay-flat were sealed together with a butt seam. A radial butt seam formed the tubular shape.

3.0 CONSTRUCTION DIFFICULTIES

The only major difficulties which occurred were in construction of the two large tori for the STTA. Two pieces of material were required to form the lay-flat. The material was sealed together with a glued butt seam to prevent heat shrinkage. The tuck now included six thicknesses of material, and heat would not adequately penetrate all layers. This problem was alleviated first by activating the glue with solvent and then running the material through the heat sealer. Test samples using this procedure produced extremely strong seals.

APPENDIX F

STTA Proposal

RAVEN INDUSTRIES, INC.
PROPOSAL NO. ATD0882092

TECHNICAL SECTION

DESIGN AND FABRICATION
OF
SPACE TELESCOPE TRAINING
ARTICLE

Submitted to:
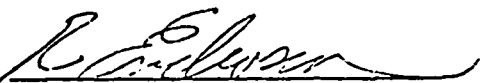
National Aeronautics and Space Administration
Lyndon B. Johnson Space Center
Houston, Texas
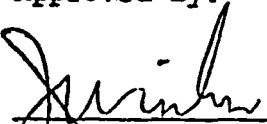
R.F.P. No. 9-BC72-93-2-66P

6 August, 1982

Prepared By: Approved By:

R. M. Enderson   J. A. Winker
Sales Engineer   Vice President
Applied Technology Div.   Applied Technology Div.

1.0 INTRODUCTION

Raven is pleased to submit this proposal in response to NASA's Request For Proposal No. 9-BC72-93-2-66P.

Raven's proposed basic configuration for meeting the requirements of the Space Telescope Training Article (STTA) is a 10 ft. diameter cylinder with inverted and restrained ends. Tori are used to generate flat ends on the 10 ft. diameter sections. Tori and/or a rigid structural ring are proposed for generating the 14 ft. diameter section of the AFT article.

Two different materials are being considered. One is a lamination of polyester film and polyester fabric. The other is a urethane coated polyester fabric. The polyester fabric is the same in both configurations.

The requirement presents an interesting challenge. Raven is completely confident, though, of its ability to successfully accomplish the requirements of the statement of work. Developed fabrication techniques will be utilized regardless of the material configuration selected.

A detailed discussion of Raven's proposed configuration is presented in the following sections as well as a plan for accomplishing the task.

2.0 PROPOSED DESIGN

2.1 STRUCTURAL CONFIGURATION

The proposed configurations for the Forward and Aft sections of the STTA are shown on figures 1 and 2.

2.1.1 FORWARD SECTION

The basic structure, as shown on figure 1, is a 10 ft. diameter cylinder with inverted and restrained end sections. The inverted end configuration was selected primarily because this shape is more compatible than hemispherical ends in constructing flat ends.

The cylinder will be formed from longitudinal gores with shaped ends to yield the inverted end shape. The material at each end will be banded to a standard spool type balloon end fitting. An adequate minimum gore width will be maintained to provide the necessary

strength. The fittings at either end will be connected with a steel restraining cable. Details of the end fitting are shown on figure 3.

The structure incorporates two tori which facilitate affecting flat ends and connecting the two sections together. This second factor will be discussed in detail in a following paragraph.

The exterior surface is completed with the two skirt sections and circular panels at either end.

The cylinder and two tori will be fabricated as separate items and then joined together with the skirts and end panels. Adhesive bonding techniques will be used in the fabrication. It is not determined at this time if the skirts will employ a laced section to establish skin tension or if this will be dependent upon stress developed by inflation.

Critical parameters of the Forward section as proposed are as follows:

        *Inflated Volume   1633 Ft.^{3}

        *Gross Lift   107 Lb.

        *Total Surface Area   140 Yd.^{2}

These parameters will be referenced and considered in the discussion on buoyancy.

2.1.2.   AFT SECTION

The proposed configuration is shown on figure 2.

The basic structure is the 10 ft. diameter cylinderical section as used in the Forward section. The 14 ft. diameter section will be formed by either two tori or one torus and a structural ring. The configuration of the end if the structural ring is used will be essentially the same as the ends of the simulated payloads previously supplied to NASA by Raven.

Fabrication and assembly of the Aft section will be similar to that of the Forward section.

Critical parameters of the Aft section are as follows:

        *Inflated Volume   3000 Ft.^{3}

        *Gross Lift   197 Lb.

        *Total Surface Area   260 Yd.^{2}

The surface area is based on using two tori in configuring the 14 ft. diameter section. The volume between the 10 ft. and 14 ft. diameter surfaces will be only slightly pressurized.

2.1.3.   STIFFNESS

The basic stiffness of a pressurized cylindrical shape is directly related to the longitudinal stress in the material. In a cylinder with hemispherical ends the longitudinal stress is given by:

$$S = \frac{\Delta PR}{2}$$

In the proposed configuration with inverted ends the above relationship has to be modified to the following:

$$S = \frac{\Delta P(R^2 - r^2)}{2R}$$

R and r are as shown on figure 1 and the values are 5 ft. and 2.5 ft. respectively.

The stress in a 10 ft. diameter cylinder with hemispherical ends and pressurized to 3 inches of water pressure is computed to be 3.25 lb./in. The longitudinal stress with the ends inverted is computed, at the same pressure, to be 2.43 lb./in. To generate a skin stress of 3.25 lb./in., the proposed configuration will have to be pressurized to 4.0 inches of water pressure.

The stress in the restraining cable is given by the following relationship:

$$S = \Delta p \, \Pi \, r^2$$

At 4.0 inches of water pressure this stress is computed to be 408 lb.

The first wrinkle will occur in a cylinder when the bending stress equals the longitudinal stress. For the proposed configuration this can be represented as follows:

$$M = 12 \, S \, \Pi \, R^2$$

With a skin stress of 3.25 lb./in., M computes to be 3063 ft./lb.

The basic stiffness of the STTA will be related to the minimum or 10 ft. diameter. If a maximum bending

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stress of 3063 ft./lb. is not adequate a higher degree of pressurization will have to be considered. The Computed material stresses are nominal and a higher degree of pressurization can be easily tolerated. The tori will be inflated to a pressure that will yield a skin stress equivalent to that of the cylinders.

The other factor that will directly effect the stiffness of the assembled STTA is the configuration of the interface connection. Raven's proposed method involves attaching rigid supports to the mating tori of the Aft and Forward sections and utilizing latching clamps to secure the connection. A sketch of a typical connection point is shown of figure 4.

The interface connection will impact directly also on the logitudinal alignment. A misalignment of one degree on the interface plane will cause an offset of approximately 4 inches at the end of the STTA. The rigid supports will provide a means of shimming as necessary to obtain proper alignment. The latches will be installed after correct permanent shimming has been accomplished. This task of final assembly and checkout will be done with the STTA inflated with helium.

The number of connection locations and the material for the rigid supports is to be determined. There is a significant degree of latitude in configuring the supports as well as available latch mechanisms. The latch protrusions will be limited to less than one inch from the surface of the STTA units.

2.1.4.   ATTACHMENT HARDWARE

2.1.4.1. HARD MOUNTING POINTS

The proposed method for attaching the hard mounting points vary depending upon location and are discussed accordingly.

    a. Aft Section – Station 3.0

       Rigid supports similar to the interface supports are proposed to be used since the radius of the torus tube is approximately six inches and the center of the hard mounting is only three inches from the end of the inflatable. The hard point will be bolted to the rigid support stations. See figure 5.

    b. Aft Section – Stations 28.0, 41.0, and 121.0
       Forward Section – Station 81.75
       Aft Section – 14 ft. Diameter End

At these locations the hard mounting points will be bolted to a clamp ring located on the inside surface, see figure 5. The surface at station 121.0 of Aft section is not a pressurized surface as such. Additional support at this stations, normal to the surface in direction, may have to be obtained with an auxiliary support attached to the pressurized 10 ft. diameter surface.

2.1.4.2. VELCRO PILE

The velcro pile patches will simply be adhesively bonded to the surface at the required locations. Rigid supports will again be utilized at station 6.00 of the Forward section and the end of the Aft section if the locations cannot be located on the curved surface of the tori.

2.1.5. MISCELLANEOUS ATTACHMENTS

2.1.5.1. BALLAST AND TRIM

A suitable number of pockets and weights will be provided to effect neutral and balanced buoyancy with or without the government furnished hardware attached.

2.1.5.2. TIE DOWN LINES

A fitting will be provided at the geometric center of both ends of both sections to which a tie down line can be attached.

2.1.6. INFLATION SYSTEM

Inflation ports will be provided in accordance with the statement of work. Two Shrader type valves will be provided at each end of a unit. This will provide a means of "topping off" the inflatable while monitoring pressure. Separate inflation means will be provided for inflating the tori. The large bore filling port for the cylindrical sections will be similar to those provided on previous SSSP's supplies by Raven.

2.1.7. FABRICATION & CONSTRUCTION

Adhesive bonding techniques will be utilized in fabricating the inflatable articles.

The tori will be fabricated from tubular elements. Each tori will consist of 24 elements. The elements are connected with a circumferential seam. The procedure is standard and used successfully numerous times in making gas tight structures.

The cylinders will be fabricated from straight longitudinal gores with shaped ends to form the inverted ends. Eighteen gores will be sued for each cylinder. The proposed procedures are, again, standard.

Final assembly and checkout will be accomplished with the STTA inflated with helium.

2.2   BUOYANCY

In analyzing the buoyancy of the STTA an estimate of material weight has to be made. This estimated material weight is initially selected as 4.0 oz. per square yard. The weight and buoyancy of each section of the STTA and the assembled system is estimated as follows:

Forward Section

1. Volume — 1633 Ft.^{3}
2. Gross Lift - 107 Lb.
3. Weight

a) Two hard mounting points at 1.5 lb. each	3.0 Lb.	
b) Attached government hardware	12.0 LB.	
c) Fitting and miscellaneous	15.0 LB.	
d) Material — 140 Yd.^{2} at 4.0 oz./yd.^{2} (includes 10% overage allowance)	35.0 Lb.	
Total Weight	65.0 LB.	

4. Net buoyancy (107-65)   42.0 LB.

Aft Section

1. Volume — 3000 Ft.^{3}
2. Gross Lift - 197 Lb.

3. Weight
   a) 18 hard mounting points   27.0 Lb.
      at 1.5 lb. each
   b) Attached government   38.0 Lb.
      hardware
   c) Fittings and miscellaneous   25.0 Lb.·
   d) Material – 260 Yd.^{2} 65.0 Lb.
      4.0 oz./yd.^{2} (includes
      10% overage allowance)

                    Total Weight   155.0 Lb.
4. Net Buoyancy (197-155)   42.0 Lb.

Obtaining balanced and neutral buoyancy, with the net buoyancy available for trim weights, will not be a problem for either the assembled or the individual sections. The existing net buoyancy will also allow consideration of alternate materials. Using a 5.2 oz./yd.^{2} would increase the weight of the Forward section approximately 10 lb., the Aft section 20 lb.· Sufficient buoyancy would remain for trimming.

The Aft section buoyancy and weight is based on using a torus to obtain a flat end on the 14 ft. diameter. This torus would weigh approximately 8 lb. The buoyancy is adequate if this torus is eliminated to consider the alternate configuration of using a structural ring to obtain a flat end as shown on figure 2.

2.3   MATERIAL

Two different material configurations, a lamination and a coated fabric, will be considered for fabricating the STTA. A description of each is as follows:

Lamination

This proposed material is a lamination of polyester film and a type 68 dacron polyester fabric. The film on the outer surface would be a 0.5 mil aluminized polyester film. The inner surface would be a 0.75 mil clear polyester film. The ultimate tensile strength is approximately 110 lb./in. The maximum weight will be 4.0 oz./yd.^{2}. A computed factor of safety at a pressure of 4.0 inches of water is 12.7.

Coated Fabric

This proposed material would consist of the same base fabric as used in the lamination. The fabric would be coated with 3 oz./yd.^{2} of polyurethane. The coating on the outer surface would have a polished aluminum

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appearance. The strength would, with the same base fabric being used, be the same as the lamination. Total weight would be approximately 5.2 oz./yd.^{2}.

Either of the proposed material configurations will meet all of the requirements of the statement of work. There are advantages and disadvantages to be considered with both with respect to ease of fabrication. Functionally they will be very similar. A Kevlar base fabric was considered but discounted on the basis of reported field experience.

Samples of similar material configurations are enclosed as figures 6 and 7.

The decision on the material will be made at the time of the preliminary design review. NASA's preference will be a factor in the decision.

3.0   MANAGEMENT

3.1   GENERAL

The proposed program will be conducted within the Applied Technology Division of Raven Industries. Mr. James A. Winker is a Vice-President of Raven Industries and manager of the Applied Technology Division. The latest annual report of Raven Industries is enclosed with this proposal.

3.2   PROGRAM MANAGEMENT

The primary program management will be assigned to the engineering group. Mr. Patrick J. Cannon is the Engineering Group Manager. The program will be conducted on a project basis with an assigned project engineer from within the engineering group. Assignment of the project engineer will be made at the time of contract award and would be dependent upon existing requirements at that time. The engineering group will have the total technical responsibility as well as data management, documentation and conference requirements.

Fabrication will be coordinated with Mr. K. L. Tekrony, Production Manager for the Applied Technology Division.

Resumes of key personnel that may be assigned to the program are enclosed in Appendix A.

3.3   PROGRAM SCHEDULE/PLAN

A program schedule outlining the major tasks to be accomplished is enclosed as figure 8. A discussion of the tasks is presented in the following paragraphs of this section.

3.3.1.   INITIAL INTERFACE MEETING

A primary objective of this meeting will be to critique Raven's proposed configuration with respect to the requirements of the statement of work and resolve any deficiencies or questions in the proposed program and/or interpretations of the statement of work. This meeting is proposed to be held at Raven's facility in Sioux Falls.

3.3.2.   SYSTEM DEFINITION

The proposed configuration will be modified in accordance with the determinations of the initial interface meeting. Detail design of components will be initiated.

3.3.3.   PRELIMINARY DESIGN REVIEW

The system as defined and design accomplished under task 3.3.2. will be reviewed. A major objective will be to finalize the material configuration.

3.3.4.   MATERIALS PROCUREMENT

The proposed polyester base fabric is a long lead time item. It is proposed that this material br ordered upon receipt of contract since it will be used regardless of the final material configuration. The decision as to whether the fabric will be coated or laminated will be made at the time of the preliminary design review.

3.3.5.   DETAILED DESIGN AND TESTING

The detailed design will be completed under this task. Tests will be accomplished as necessary to verify designed configurations are functional.

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3.3.6. CRITICAL DESIGN REVIEW

The final detailed design and results of tests will be
presented as well as the status of purchased material.

3.3.7. DESIGN MODIFICATION

Any design modifications that may result from 3.3.6.
will be accomplished.

3.3.8. FABRICATION

3.3.9. FINAL ASSEMBLY AND CHECKOUT

3.3.10. DELIVERY

3.3.11. INSTALLATION

3.3.12. SUBMIT FINAL REPORT & PROGRAM END

4.0 BACKGROUND

The Applied Technology Division of Raven is a major
designer and fabricator of inflatables. The products
range from polyethylene zero pressure balloons to heavy
lift balloons utilized in the logging industry.

More different configurations of materials are utilized
by Raven than probably any other one single balloon
manufacturer. The materials range from 0.5 mil
polyester films to coated fabrics weighing
approximately 16 oz./yd.^{2}.

Raven is very familar with the requirements of NASA for
simulated payloads. Raven has previously worked with
NASA in the design and fabrication of two previous
simulated payloads. We are confident of our proposed
approach to this requirement.
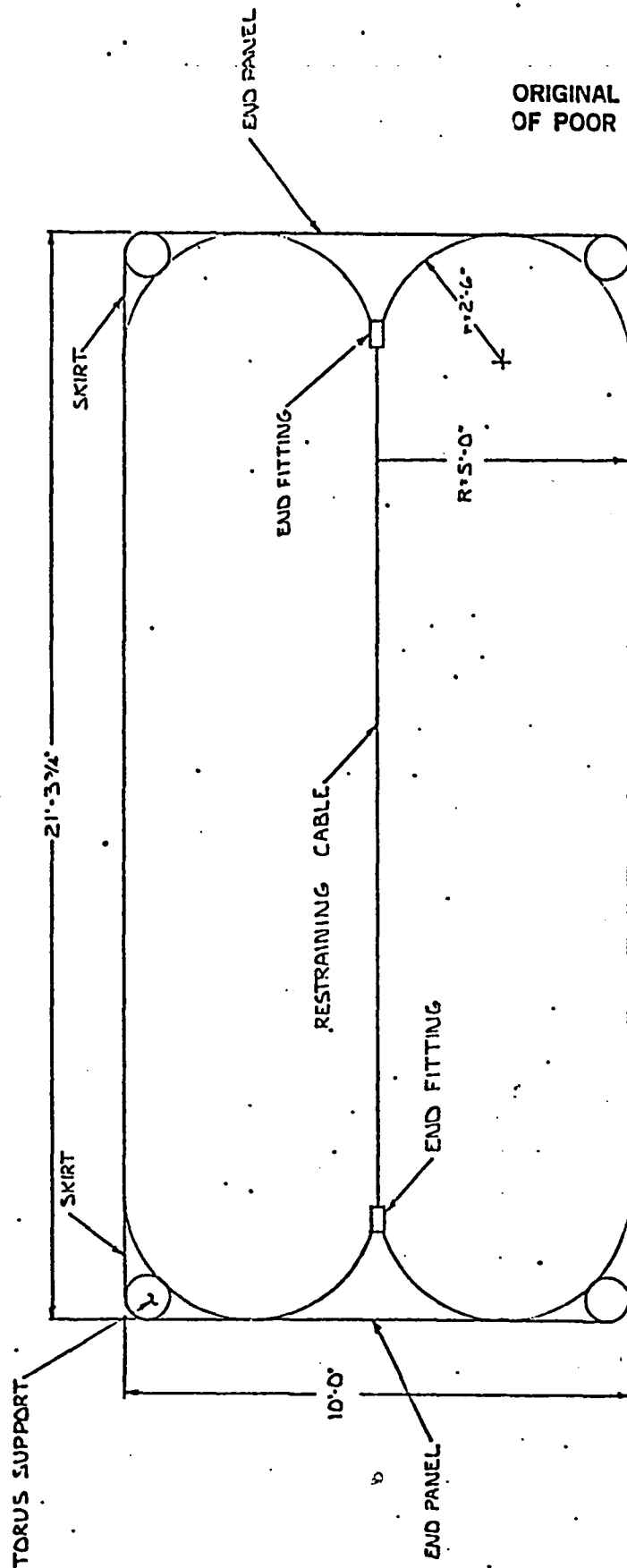
FORWARD SECTION
CROSS-SECTION

END PANEL

SKIRT

END FITTING

R·2·6·

R·5·0·

RESTRAINING CABLE

END FITTING

21'·3¾'

SKIRT

TORUS SUPPORT

END PANEL

10·0'

TORUS SUPPORT

END PANEL

14'-0"

END FITTING

RIGID STRUCTURAL RING OPTIONAL

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21'-9"

RESTRAINING CABLE

END FITTING

5'-1¾"

SKIRT

END FITTING

10'-0"

END PANEL

AFT SECTION
CROSS-SECTION

FABRIC

CLAMPING BANDS

PROTECTIVE WRAP

SEALANT

EYEBOLT

RESTRAINING CABLE

END FITTING

SPOOL

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FIGURE 3

RIGID MOUNTING

INTERFACE PLANE

TYPICAL LATCH
FORWARD/AFT INTERFACE

RIGID MOUNTING

END PANEL

10' DIA.
CYLINDER END

SKIRT

TORUS SUPPORT

RIGID MOUNTING

FIGURE 4

FABRIC
SPLINE NUT
INSIDE
NUT RING
SEALANT
MOUNTING RING
OTS
FLAT HEAD SCREW
GASKET

HARD MOUNTING POINT
THRU FABRIC WALL

HARD MOUNTING POINT
RIGID MOUNTING
END PANEL
SKIRT
ORUS SUPPORT

HARD MOUNTING POINT
ATTACHMENT: AFT SECTION
FORWARE EDGE
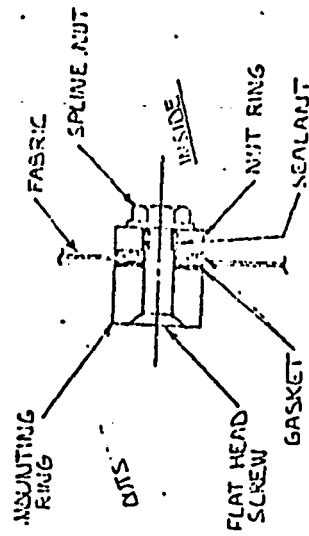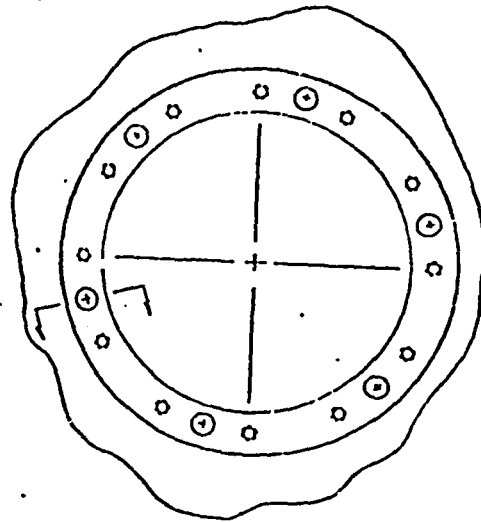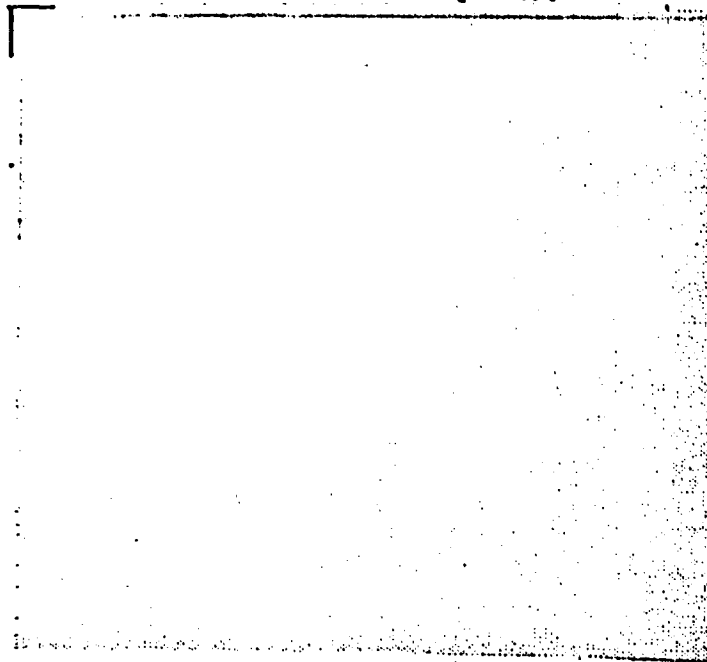
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URETHANE COATED
POLYESTER FABRIC

FIGURE 7

TASKS AND MANPOWER LOADING

MILESTONES/MONTHS FROM GO-AHEAD	1	2	3	4	5	6	7	8	9	10	11	12
TASKS												
1. INITIAL INTERFACE MTN'G.												
2. SYSTEM DEFINITION												
3. PDR												
4. MATERIAL PROCUREMENT												
5. DETAILED DESIGN												
6. CDR												
7. DESIGN MODIFICATION(S)												
8. FABRICATION												
9. FINAL ASS'M & CHECKOUT												
10. INSTALLATION												
11. PROGRAM MANAGEMENT & REPORTS												

LABOR CATAGORIES & HOURS	1	2	3	4	5	6	7	8	9	10	PROGRAM TOTALS	
1. ENGINEER	90	90	90	20	40	40	40	136	120		666	
2. DESIGNER/DRAFTSMAN	120	120	120	20							380	
3. TECHNICIAN		40	40		40	80	40	216			456	
4. ASSEMBLY					100	190	100				390	
5. MACHINE SHOP				80							80	
MONTHLY TOTALS	210	250	250	120	180	310	180	352	120		1972	

FIGURE 8

APPENDIX G

STTA Alternate Sizing Analysis

ORIGINAL FORWARD SECTION

SECTION	SURFACE AREA	VOLUME	C/L (FROM FREE END)	LIFT	MOMENT	DIMENSIONS
① END TORUS	77.44 Ft²	16.62 Ft³	5.15"	1.04	5.36	r = 5.15" R = 54.85"
① END ½ TORUS	123.37 Ft²	154.21 Ft³	17.28"	9.68	167.27	r = 30" R = 30"
10' DIA TUBE	512.47 Ft²	1281.18 Ft³	127.88"	80.37	10280.77	R = 60" L = 195.75"
② END ½ TORUS	123.37 Ft²	154.21 Ft³	238.47"	9.68	2308.31	r = 30" R = 30"
② END TORUS	77.44 Ft²	16.62 Ft³	250.60"	1.04	260.62	r = 5.15" R = 54.85"
① END PANEL	68.42 Ft²	—	—	—	—	R = 56"
① SKIRT	65.45 Ft²	—	—	—	—	R = 60" L = 25"
② SKIRT	65.45 Ft²	—	—	—	—	
② END PANEL	68.42 Ft²	—	—	—	—	
	1181.83 Ft²	1622.84 Ft³		101.83 lbs	13022.43 in·lbs	

+ 5% SEAMS...

1240.92 Ft²

C/L = moment/lift

= 127.88"

OBJECT WT

CABLE AND SPOOLS	6.4
TOTAL HARDWARE	23.25
TRIM WT	10.0
FABRIC WT @ 5.20z/yd²	44.81
	84.46 lbs

MOUNTING HARDWARE

12 × 12 VELCRO = .0625 lbs
HARD PT RINGS = 1.25 lbs

HELIUM LIFT

.06275 lbs/ft³
@ S.L, 85°F

ORIGINAL FORWARD SECTION

POINT	WEIGHT	X	Y	Z
1	1.0625	6	6C	0
2	1.0625	6	0	60
3	1.0625	6	-60	0
4	1.0625	6	0	-60
5	3.25	81.75	14	58.34
6	3.25	.81.75	14	-58.34
7	1.0625	123.93	60	0
8	1.0625	123.93	-60	0
9	1.0625	140.02	0	60
10	1.0625	140.02	0	-60

THE MOMENTS IN THE X AXIS EQUAL-800.432
THE MOMENTS IN THE Y AXIS EQUAL 91
THE MOMENTS IN THE Z AXIS EQUAL 0

ORIGINAL AFT SECTION

SECTION	SURFACE AREA (Ft²)	VOLUME (Ft³)	C/L (FROM SM END)	LIFT	MOMENT	DIMENS.
SM. END TOR.	78.80	17.24	5.25	1.08	5.67	R:54.5 r:5.2
10' SM. ½ TOR	123.37	154.21	17.28	9.68	167.27	R=r=30
10' TUBE	526.22	1320.45	130.50	82.86	10883.23	R=60 L=207.5
MID TORUS	236.87	118.43	73.25	7.43	544.25	R=72 r=12
14' OUTER CYL	641.41	981.12	161.12	61.56	9918.55	R:84 r:60 r:115
10' LG ½ TOR	123.37	154.21	243.72	9.68	2359.21	R=r=30
LG END TOR	268.67	156.73	247.0	9.83	2428.01	R=70 r=14
	1998.71	2902.39 Ft³		182.12	26236.19	

SM END SKIRT 65.44

SM END PANEL 65.19

MID END PAN 28.36

~~MID SKIRT~~ 108.9

~~LG END SKIRT~~ 2265.40

LG END PAN: 168.27

2378.67 Ft²

C/L = MOMENTS/LIFT

= 26236.19/182.12

= 144.06

OBJECT WT.

CABLE AND SPOOLS 6.4

TOTAL HARDWARE 106.06

TRIM WT 10.00

FABRIC WT @ 52°/₁₀² 85.90

208.36

MOUNTING HARDWARE

12×12 VELCRO = .0625 lbs

HARD PT RINGS = 1.25 lbs

INTERFACE MTS = 2.25 lbs

HELIUM LIFT

.06275 lbs/ft³

@ S.L 85°F

ORIGINAL AFT SECTION

POINT	WEIGHT	X	Y	Z
11	4.25	3	45.96	38.57
12	4.25	3	14	58.34
13	4.25	3	-25.36	54.38
14	4.25	3	45.96	-38.57
15	4.25	3	14	-58.34
16	4.25	3	-25.36	-54.38
17	3.25	28	14	38.57
18	3.25	28	14	-38.57
19	3.25	28	60	0
20	3.25	28	-60	0
21	3.25	41	0	60
22	3.25	41	0	-60
23	3.25	121	14	82.825
24	3.25	121	14	-82.825
25	3.25	121	-84	0
26	3.25	261	-36	0
27	3.25	261	18	31.18
28	3.25	261	18	-31.18
29	1.0625	261	78	0
30	1.0625	261	-78	0

THE MOMENTS IN THE X AXIS EQUAL-4611.87
THE MOMENTS IN THE Y AXIS EQUAL 203.1
THE MOMENTS IN THE Z AXIS EQUAL 6.10352E-05

ORIGINAL COMPOSITE

POINT	WEIGHT	X	Y	Z
1	1.0625	6	60	0
2	1.0625	6	0	60
3	1.0625	6	-60	0
4	1.0625	6	0	-60
5	3.25	81.75	14	58.34
6	3.25	81.75	14	-58.34
7	1.0625	123.93	60	0
8	1.0625	123.93	-60	0
9	1.0625	140.02	0	60
10	1.0625	140.02	0	-60
11	4.25	258.75	45.96	38.57
12	4.25	258.75	14	58.34
13	4.25	258.75	-25.36	54.38
14	4.25	258.75	45.96	-38.57
15	4.25	258.75	14	-58.34
16	4.25	258.75	-25.36	-54.38
17	3.25	283.75	14	38.57
18	3.25	283.75	14	-38.57
19	3.25	283.75	60	0
20	3.25	283.75	-60	0
21	3.25	296.75	0	60
22	3.25	296.75	0	-60
23	3.25	376.75	14	82.825
24	3.25	376.75	14	-82.825
25	3.25	376.75	-84	0
26	3.25	516.75	-36	0
27	3.25	516.75	18	31.18
28	3.25	516.75	18	-31.18
29	1.0625	516.75	78	0
30	1.0625	516.75	-78	0

THE MOMENTS IN THE X AXIS EQUAL-1531.18
THE MOMENTS IN THE Y AXIS EQUAL 294.1
THE MOMENTS IN THE Z AXIS EQUAL 6.10352E-05

$C/L = 302.29$

∴ GROSS BALANCE 7.14 lbs

FABRIC WT | CABLE+WIRES-LS / TRIM-10 / HARDWARE-62.625 / SKIRT / END PANELS+1108 | GROSS BALLAST | TOTAL WT

GROSS BALLAST

FOR AN ADDED LENGTH OF 0 FT:
SURFACE AREA = 1998.71 SQUARE FEET
VOLUME = 2902.39 CUBIC FEET
LIFT = 182.125 LBS
C/L IS LOCATED AT 144.062 INCHES FROM THE SMALL END

(handwritten: 22.18 lbs + 9639 LBS ; 50.66 = 219.18 ; LIFT + 182.13 ; NET BUOY -37.05)

FOR AN ADDED LENGTH OF .5 FT:
SURFACE AREA = 2014.41 SQUARE FEET
VOLUME = 2941.66 CUBIC FEET
LIFT = 184.589 LBS
C/L IS LOCATED AT 148.144 INCHES FROM THE SMALL END

(handwritten: 72.74 lbs + 9634 lbs + 49.1 = -218.19 ; +184.59 ; -33.59)

FOR AN ADDED LENGTH OF 1 FT:
SURFACE AREA = 2030.11 SQUARE FEET
VOLUME = 2980.93 CUBIC FEET
LIFT = 187.053 LBS
C/L IS LOCATED AT 152.198 INCHES FROM THE SMALL END

(handwritten: 73.31 lbs + 96.34 lbs + 47.57 = -217.22 ; +187.05 ; -30.17)

FOR AN ADDED LENGTH OF 1.5 FT:
SURFACE AREA = 2045.81 SQUARE FEET
VOLUME = 3020.2 CUBIC FEET
LIFT = 189.518 LBS
C/L IS LOCATED AT 156.225 INCHES FROM THE SMALL END

(handwritten: 73.89 lbs + 96.34 lbs + 46.06 = -216.29 ; +189.52 ; -26.76)

FOR AN ADDED LENGTH OF 2 FT:
SURFACE AREA = 2061.51 SQUARE FEET
VOLUME = 3059.47 CUBIC FEET
LIFT = 191.982 LBS
C/L IS LOCATED AT 160.225 INCHES FROM THE SMALL END

(handwritten: 74.44 lbs + 96.34 lbs + 44.57 = -215.35 ; +191.98 ; -23.31)

FOR AN ADDED LENGTH OF 2.5 FT:
SURFACE AREA = 2077.21 SQUARE FEET
VOLUME = 3098.74 CUBIC FEET
LIFT = 194.446 LBS
C/L IS LOCATED AT 164.2 INCHES FROM THE SMALL END

(handwritten: 75.01 lbs + 96.34 lbs + 43.11 = -214.46 ; +194.45 ; -20.01)

FOR AN ADDED LENGTH OF 3 FT:
SURFACE AREA = 2092.91 SQUARE FEET
VOLUME = 3138.01 CUBIC FEET
LIFT = 196.91 LBS
C/L IS LOCATED AT 168.151 INCHES FROM THE SMALL END

(handwritten: 75.58 lbs + 96.93 lbs + 41.68 = -213.6 ; +196.91 ; -16.69)

FOR AN ADDED LENGTH OF 3.5 FT:
SURFACE AREA = 2108.61 SQUARE FEET
VOLUME = 3177.28 CUBIC FEET
LIFT = 199.374 LBS
C/L IS LOCATED AT 172.078 INCHES FROM THE SMALL END

(handwritten: 76.14 lbs + 96.93 lbs + 40.27 = -212.75 ; +199.37 ; -13.38)

FOR AN ADDED LENGTH OF 4 FT:
SURFACE AREA = 2124.31 SQUARE FEET
VOLUME = 3216.55 CUBIC FEET
LIFT = 201.839 LBS
C/L IS LOCATED AT 175.982 INCHES FROM THE SMALL END

(handwritten: 76.71 lbs + 96.94 lbs + 38.89 = -211.94 ; +201.44 ; -10.1)

FOR AN ADDED LENGTH OF 4.5 FT:
SURFACE AREA = 2140.01 SQUARE FEET
VOLUME = 3255.82 CUBIC FEET
LIFT = 204.303 LBS
C/L IS LOCATED AT 179.865 INCHES FROM THE SMALL END

(handwritten: 77.28 lbs + 96.94 lbs + 37.53 = -211.24 ; +204.30 ; -6.99)

FOR AN ADDED LENGTH OF 5 FT:
SURFACE AREA = 2155.71 SQUARE FEET
VOLUME = 3295.09 CUBIC FEET
LIFT = 206.767 LBS
C/L IS LOCATED AT 183.726 INCHES FROM THE SMALL END

(handwritten: 77.85 lbs + 96.94 lbs + 36.02 = 210.81 ; +206.77 ; -3.44)

FOR A C/L LOCATED 144.062 INCHES FROM THE SMALL END:
THE MOMENTS IN THE X AXIS EQUAL-5923.88   *50.66 LBS*
THE MOMENTS IN THE Y AXIS EQUAL 471.5
THE MOMENTS IN THE Z AXIS EQUAL-1750.2

FOR A C/L LOCATED 148.144 INCHES FROM THE SMALL END:
THE MOMENTS IN THE X AXIS EQUAL-5835.93   *49.1 LBS*
THE MOMENTS IN THE Y AXIS EQUAL 471.5
THE MOMENTS IN THE Z AXIS EQUAL-1750.2

FOR A C/L LOCATED 152.198 INCHES FROM THE SMALL END:
THE MOMENTS IN THE X AXIS EQUAL-5746.17   *47.57 LBS*
THE MOMENTS IN THE Y AXIS EQUAL 471.5
THE MOMENTS IN THE Z AXIS EQUAL-1750.2

FOR A C/L LOCATED 156.225 INCHES FROM THE SMALL END:
THE MOMENTS IN THE X AXIS EQUAL-5654.67   *46.06 LBS*
THE MOMENTS IN THE Y AXIS EQUAL 471.5
THE MOMENTS IN THE Z AXIS EQUAL-1750.2

FOR A C/L LOCATED 160.225 INCHES FROM THE SMALL END:
THE MOMENTS IN THE X AXIS EQUAL-5561.42   *44.57 LBS*
THE MOMENTS IN THE Y AXIS EQUAL 471.5
THE MOMENTS IN THE Z AXIS EQUAL-1750.2

FOR A C/L LOCATED 164.2 INCHES FROM THE SMALL END:
THE MOMENTS IN THE X AXIS EQUAL-5466.55   *43.11 LBS*
THE MOMENTS IN THE Y AXIS EQUAL 471.5
THE MOMENTS IN THE Z AXIS EQUAL-1750.2

FOR A C/L LOCATED 168.151 INCHES FROM THE SMALL END:
THE MOMENTS IN THE X AXIS EQUAL-5370.14   *41.68 LBS*
THE MOMENTS IN THE Y AXIS EQUAL 471.5
THE MOMENTS IN THE Z AXIS EQUAL-1750.2

FOR A C/L LOCATED 172.078 INCHES FROM THE SMALL END:
THE MOMENTS IN THE X AXIS EQUAL-5272.17   *40.27 LBS*
THE MOMENTS IN THE Y AXIS EQUAL 471.5
THE MOMENTS IN THE Z AXIS EQUAL-1750.2

FOR A C/L LOCATED 175.982 INCHES FROM THE SMALL END:
THE MOMENTS IN THE X AXIS EQUAL-5172.71   *38.89 LBS*
THE MOMENTS IN THE Y AXIS EQUAL 471.5
THE MOMENTS IN THE Z AXIS EQUAL-1750.2

FOR A C/L LOCATED 179.865 INCHES FROM THE SMALL END:
THE MOMENTS IN THE X AXIS EQUAL-5071.9   *37.53 LBS*
THE MOMENTS IN THE Y AXIS EQUAL 471.5
THE MOMENTS IN THE Z AXIS EQUAL-1750.2

FOR A C/L LOCATED 183.726 INCHES FROM THE SMALL END:
THE MOMENTS IN THE X AXIS EQUAL-4969.67   *36.02 LBS*
THE MOMENTS IN THE Y AXIS EQUAL 471.5
THE MOMENTS IN THE Z AXIS EQUAL-1750.2

FOR AN ADDED LENGTH OF 5.5 FT:
SURFACE AREA = 2171.41 SQUARE FEET
VOLUME = 3334.36 CUBIC FEET
LIFT = 209.231 LBS
C/L IS LOCATED AT 187.568 INCHES FROM THE SMALL END

78.41 lbs + 96.34 lbs + 34.9 = -209.65
+209.23
-.42

FOR AN ADDED LENGTH OF 6 FT:
SURFACE AREA = 2187.11 SQUARE FEET
VOLUME = 3373.63 CUBIC FEET
LIFT = 211.695 LBS
C/L IS LOCATED AT 191.389 INCHES FROM THE SMALL END

79.79 lbs + 96.34 lbs + 33.66 = -208.98
+211.70
+2.72

FOR AN ADDED LENGTH OF 6.5 FT:
SURFACE AREA = 2202.81 SQUARE FEET
VOLUME = 3412.9 CUBIC FEET
LIFT = 214.159 LBS
C/L IS LOCATED AT 195.192 INCHES FROM THE SMALL END

77.55 lbs + 96.34 lbs + 32.37 = -208.26
+214.16
+5.9

FOR AN ADDED LENGTH OF 7 FT:
SURFACE AREA = 2218.51 SQUARE FEET
VOLUME = 3452.17 CUBIC FEET
LIFT = 216.624 LBS
C/L IS LOCATED AT 198.976 INCHES FROM THE SMALL END

80.11 lbs + 96.34 lbs + 31.1T = -207.6
+216.62
+9.02

FOR AN ADDED LENGTH OF 7.5 FT:
SURFACE AREA = 2234.21 SQUARE FEET
VOLUME = 3491.44 CUBIC FEET
LIFT = 219.088 LBS
C/L IS LOCATED AT 202.743 INCHES FROM THE SMALL END

80.69 lbs + 96.34 lbs + 29.94 = -206.96
+219.09
+12.13

FOR AN ADDED LENGTH OF 8 FT:
SURFACE AREA = 2249.91 SQUARE FEET
VOLUME = 3530.71 CUBIC FEET
LIFT = 221.552 LBS
C/L IS LOCATED AT 206.493 INCHES FROM THE SMALL END

91.75 lbs + 96.34 lbs + 28.77 = 206.36
+221.55
+15.19

FOR AN ADDED LENGTH OF 8.5 FT:
SURFACE AREA = 2265.61 SQUARE FEET
VOLUME = 3569.98 CUBIC FEET
LIFT = 224.016 LBS
C/L IS LOCATED AT 210.226 INCHES FROM THE SMALL END

91.81 lbs + 96.34 lbs + 27.62 = 205.77
+224.02
+13.25

FOR AN ADDED LENGTH OF 9 FT:
SURFACE AREA = 2281.31 SQUARE FEET
VOLUME = 3609.25 CUBIC FEET
LIFT = 226.48 LBS
C/L IS LOCATED AT 213.944 INCHES FROM THE SMALL END

82.29 lbs + 96.34 lbs + 26.5 = 205.22
+226.48
+21.26

FOR AN ADDED LENGTH OF 9.5 FT:
SURFACE AREA = 2297.01 SQUARE FEET
VOLUME = 3648.52 CUBIC FEET
LIFT = 228.945 LBS
C/L IS LOCATED AT 217.646 INCHES FROM THE SMALL END

82.75 lbs + 96.34 lbs + 25.34 = 204.63
+228.95
+24.32

FOR AN ADDED LENGTH OF 10 FT:
SURFACE AREA = 2312.71 SQUARE FEET
VOLUME = 3687.79 CUBIC FEET
LIFT = 231.409 LBS
C/L IS LOCATED AT 221.333 INCHES FROM THE SMALL END

83.57 lbs + 96.34 lbs + 24.32 = -204.17
+231.41
+27.24

FOR A C/L LOCATED 187.568 INCHES FROM THE SMALL END:
THE MOMENTS IN THE X AXIS EQUAL -4866.21 *34.9 lbs*
THE MOMENTS IN THE Y AXIS EQUAL 471.5
THE MOMENTS IN THE Z AXIS EQUAL -1750.2

GROSS BALLOT

FOR A C/L LOCATED 191.389 INCHES FROM THE SMALL END:
THE MOMENTS IN THE X AXIS EQUAL -4761.39 *33.66 lbs*
THE MOMENTS IN THE Y AXIS EQUAL 471.5
THE MOMENTS IN THE Z AXIS EQUAL -1750.2

FOR A C/L LOCATED 195.192 INCHES FROM THE SMALL END:
THE MOMENTS IN THE X AXIS EQUAL -4655.41 *32.37 lbs*
THE MOMENTS IN THE Y AXIS EQUAL 471.5
THE MOMENTS IN THE Z AXIS EQUAL -1750.2

FOR A C/L LOCATED 198.976 INCHES FROM THE SMALL END:
THE MOMENTS IN THE X AXIS EQUAL -4548.2 *31.15 lbs*
THE MOMENTS IN THE Y AXIS EQUAL 471.5
THE MOMENTS IN THE Z AXIS EQUAL -1750.2

FOR A C/L LOCATED 202.743 INCHES FROM THE SMALL END:
THE MOMENTS IN THE X AXIS EQUAL -4439.89 *29.94 lbs*
THE MOMENTS IN THE Y AXIS EQUAL 471.5
THE MOMENTS IN THE Z AXIS EQUAL -1750.2

FOR A C/L LOCATED 206.493 INCHES FROM THE SMALL END:
THE MOMENTS IN THE X AXIS EQUAL -4330.49 *28.77 lbs*
THE MOMENTS IN THE Y AXIS EQUAL 471.5
THE MOMENTS IN THE Z AXIS EQUAL -1750.2

FOR A C/L LOCATED 210.226 INCHES FROM THE SMALL END:
THE MOMENTS IN THE X AXIS EQUAL -4219.98 *27.62 lbs*
THE MOMENTS IN THE Y AXIS EQUAL 471.5
THE MOMENTS IN THE Z AXIS EQUAL -1750.2

FOR A C/L LOCATED 213.944 INCHES FROM THE SMALL END:
THE MOMENTS IN THE X AXIS EQUAL -4108.51 *26.5 lbs*
THE MOMENTS IN THE Y AXIS EQUAL 471.5
THE MOMENTS IN THE Z AXIS EQUAL -1750.2

FOR A C/L LOCATED 217.646 INCHES FROM THE SMALL END:
THE MOMENTS IN THE X AXIS EQUAL -3996 *25.34 lbs*
THE MOMENTS IN THE Y AXIS EQUAL 471.5
THE MOMENTS IN THE Z AXIS EQUAL -1750.2

FOR A C/L LOCATED 221.333 INCHES FROM THE SMALL END:
THE MOMENTS IN THE X AXIS EQUAL -3882.52 *24.32 lbs*
THE MOMENTS IN THE Y AXIS EQUAL 471.5
THE MOMENTS IN THE Z AXIS EQUAL -1750.2

FIGURE 2

AFT SECTION INCREASED BY 5.5 FEET

SECTION	SURFACE AREA	VOLUME	c/L (FROM SMALL END)	LIFT	MOMENT	DIMENSIONS
SM END TORUS	78.80 ft²	17.24 ft³	5.25"	1.08	5.67	R:5.97 r:5.25
SM END ½ TORUS	123.37 ft²	154.21 ft³	17.28"	9.68	167.27	R=30 r=30
10' TUBE	699.0 ft²	1747.51 ft³	163.5"	109.66	17928.80	R=60 L=267.
MID TORUS	236.87 ft²	118.43 ft³	139.25"	7.43	1034.63	R=72 r=12
14' OUTER CYL	641.41 ft²	981.12 ft³	227.12"	61.56	13981.51	R=84 r=60 L=175-
LG END ½ TORUS	123.37 ft²	154.21 ft³	309.72"	9.68	2998.09	R=30 r=30
LG END TORUS	269.67 ft²	156.73 ft³	313.0"	9.83	3076.79	R=70 r=14
	2171.49 ft²	3329.45 ft³		208.92	39192.76	

SM END SKIRT	65.45 ft²
SM END PAN	68.42 ft²
MID END PAN	28.36 ft²
LG END PAN	106.9 ft²
	269.13 ft²

c/L = moments/lift

= 39192.76/208.92

= 187.6"

__OBJECT WT__

CABLE AND SPOOLS	6.6 —
TOTAL HARDWARE	96.03
TRIM WT	10.0
MAIN FABRIC 110%@5.2	86.26
SKIRT/END PAN 110%@2.7	5.55
	204.44

EXCESS LIFT 4.48 lbs + 10 lbs trim wts

FORWARD SECTION DECREASED BY 5.5 FEET

SECTION	SURFACE AREA	VOLUME	C/L (FROM FACE END)	LIFT	MOMENT	DIMENSIONS
Ⓛ END TORUS	77.44 Fr²	16.62 Fr³	5.15"	1.04	5.36	r=5.15 R=54.15
Ⓛ END ½ TORUS	123.37 Fr²	154.21 Fr³	17.28"	9.68	167.27	r=30 R=30
10' DIA TUBE	339.68 Fr²	849.21 Fr³	94.815"	53.29	5055.69	R=60 L=121.75
Ⓡ END ½ TORUS	123.37 Fr²	154.21 Fr³	172.4"	9.68	1669.51	r=30 R=30
Ⓡ END TORUS	77.44 Fr²	16.62 Fr³	184.60"	1.04	191.98	r=5.15 R=54.15
	741.30 Fr²	1190.82 Fr³		74.73	7089.81	

Ⓛ END PANEL   68.42 Fr²
Ⓛ SKIRT   65.45 Fr²
Ⓡ SKIRT   65.45 Fr²
Ⓡ END PANEL   68.42 Fr²
      267.74 Fr²

$$C/L = moments/lift$$
$$= 7089.81/74.73$$
$$= 94.81"$$

OBJECT WT

CABLE AND SPOOL   ~~6.2~~ 10
TOTAL HARDWARE   20.8
TRIM WT   10.0
MAIN FABRIC +10.@5.2   29.45
SKIRT/END PANEL+10% @.2   5.52
     71.97

EXCESS LIFT 2.76 lbs + 10 lbs Trim wts

APPENDIX H

STTA Alternate Configuration Analysis

REVISED AFT SECTION

SECTION	SURFACE AREA	VOLUME	C/L (FROM SMALL END)	LIFT	MOMENT	DIMENSIONS
SM END TORUS	78.80 FT²	17.24 FT³	5.25"	1.08	5.67	R=54.75 r=5.25
SM END ½ TORUS	123.37 FT²	154.21 FT³	17.28"	9.68	167.27	R=30 r=30
10' DIA SECTION	255.91 FT²	639.77 FT³	78.88"	40.08	3161.19	R=60 L=97.75
SM END CONE	150.8 FT²	394.94 FT³	150.8"	24.74	3730.95	r=60 R=84 H=41 S=43
14' DIA SECTION	315.98 FT²	1105.92 FT³	212.38"	69.28	14713.76	R=84 L=86.21
LG END CONE	150.8 FT²	394.94 FT³	273.95"	24.74	6777.52	r=60 R=84 H=41 S=43
LG END ½ TORUS	123.37 FT²	154.21 FT³	309.72"	9.68	2998.09	R=30 r=30
LG END TORUS	268.67 FT²	156.73 FT³	313.0"	9.82	3073.14	R=70 r=14
MID TORUS	180.70 FT²	65.95 FT³	136.51"	4.13	563.98	R=75.24 r=8.76
	1648.40	3084.01		193.23	35191.56	

C/L = MOMENTS / LIFT = 182.12
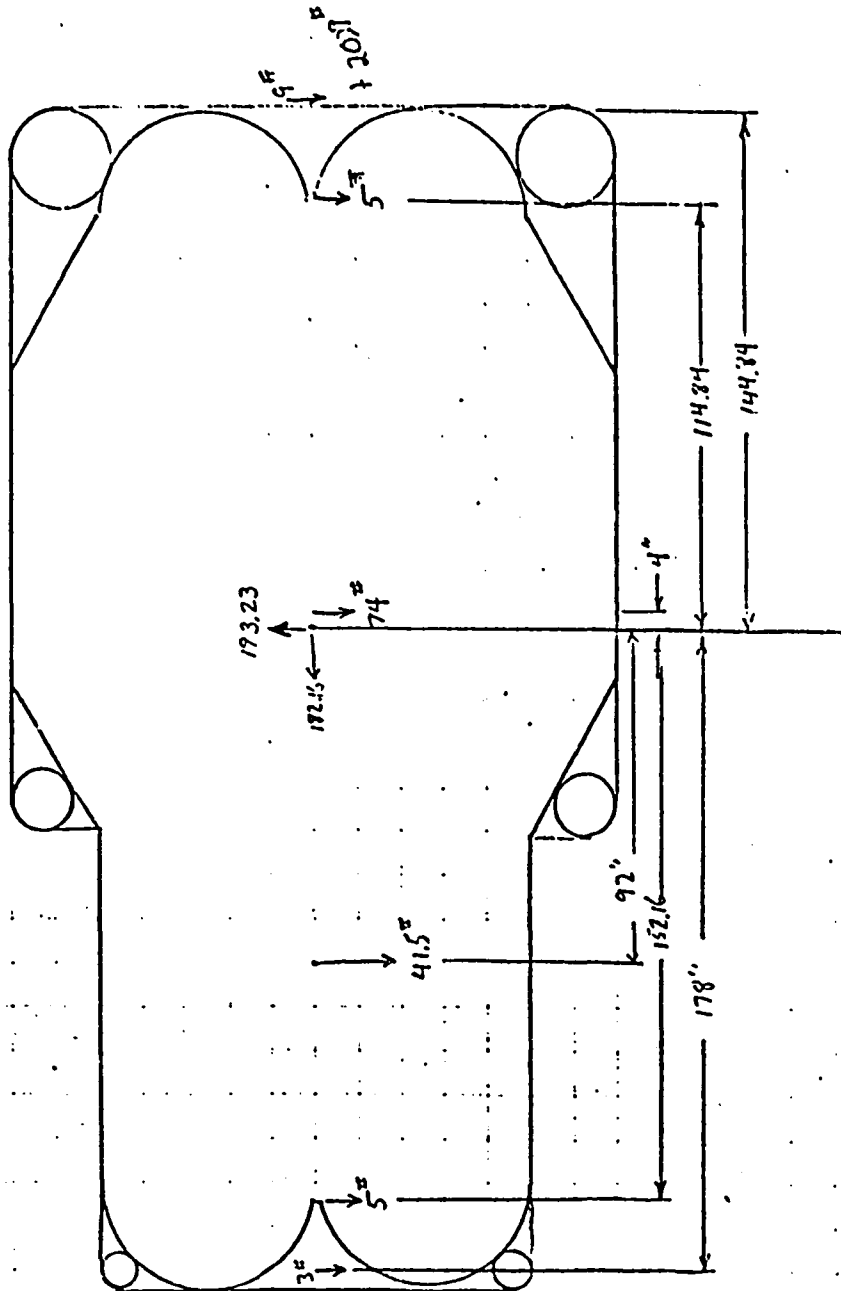
SM END SKIRT   65.45 FT²
SM END PAN   68.42 FT²
MID END PAN   24.61 FT²
MID SKIRT   120.07 FT²
LG END SKIRT   210.82 FT²
LG END PANEL   106.9 FT²
                596.27 FT²

OBJECT WEIGHT
CABLE AND SPOOLS   10.0
TOTAL HARDWARE   74.73
TRIM WT   10.0
MAIN FABRIC + 18% @ 5.2   65.48
SKIRT/ENDPAN + 18% @ 2.7 12.29
                      172.60

ORIGINAL PAGE 19
OF POOR QUALITY

SINGLE WALL INVERTED END
ALTERNATE AFT SECTION

SECTION	SURFACE AREA (ft²)	VOLUME (ft³)	C/L (Fm sm. end) in	LIFT	MOMENT	DIMENS.
10' END TOR	78.8	17.23	5.25	1.08	5.67	R=54.75 r=5.2
10' SM END ½ TOR	123.37	784.23	17.28	9.68	167.27	R=r=30
10' DIA TUBE	83.12	207.8	45.87	13.04	598.12	R=60 L=31.75
MID TORUS	178.29	64.1	70.38	4.02	283.09	R=75.37 r=9.63
CONICAL SECT	150.8	395.42	83.69 —	24.81	2076.57	R=84 r=60 L=41.5
14' DIA TUBE	423.99	1483.96	161.16	93.12	15006.98	R=94 L=115.68
LARGE END ½ TOR	241.8	423.16	236.8	26.55	6287.82	R=42 r=42
LARGE END TOR	142.96	40.21	254.25	2.52	641.52	r=6.75 R=17.25
	1423.13	2786.09 ft³		174.82	25067.04	

SM END SKIRT	65.44
SM END PANEL	65.99
MID END PANEL	28.76
MID SKIRT	124.62
LG END SKIRT	128.28
LG END PANEL	132.73
	1968.55
+5% SEAM	98.43
	2066.98 ft²

C/L = mom cuts / LIFT

= 25067.04/174.82

= 143.38

ORIGINAL PAGE IS
OF POOR QUALITY

OBJECT WT
CABLE AND SPOOLS	6.4
TOTAL HARDWARE	105.45
TRIM WEIGHT	10.0
FABRIC WT @ 5.2 oz/yd²	74.64
	196.49

MOUNTING HARDWARE
12 x 12 VELCRO = .0625 lbs
HARD PT RINGS = 1.25 lbs
INTERFACE MTS = 2.25 lbs

HELIUM LIFT
.06275 lbs/ft³
@ S.L. 85°F

POINT	WEIGHT	X	Y	Z
11	4.25	3	45.96	38.57
12	4.25	3	14	58.34
13	4.25	3	-25.36	54.38
14	4.25	3	45.96	-38.57
15	4.25	3	14	-58.34
16	4.25	3	-25.36	-54.38
17	3.25	28	14	38.57
18	3.25	28	14	-38.57
19	3.25	28	60	0
20	3.25	28	-60	0
21	3.25	41	0	60
22	3.25	41	0	-60
23	3.25	121	14	82.825
24	3.25	121	14	-82.825
25	3.25	121	-84	0
26	3.25	261	-36	0
27	3.25	261	18	31.18
28	3.25	261	18	-31.18
29	1.0625	261	78	0
30	1.0625	261	-78	0

THE MOMENTS IN THE X AXIS EQUAL-4566.57
THE MOMENTS IN THE Y AXIS EQUAL 203.1
THE MOMENTS IN THE Z AXIS EQUAL 6.10352E-05

ALTERNATE AFT SECTION

SPHERICAL ENDED
ALTERNATE AFT SECTION

SECTION	SURFACE AREA(FT²)	VOLUME (FT³)	C/L (FROM FREE END)	LIFT	MOMENT	DIMENSIONS
10' TORUS	140.23	60.13	10.29	3.77	38.79	r=10.29 R=49.71
10' DIA ½ SPHERE	157.08	261.80	34.56	16.43	567.82	R=60
MID TORUS	178.29	64.1	70.38	4.02	282.93	r=8.63 R=75.37
14' END TORUS	274.92	165.56	246.59	10.36	2554.67	r=14.41 R=69.59
CONICAL	150.8	395.42	·83.69	24.81	2076.35	R=84 r=60 L=41.56
14' DIA CYL.	270.05	945.18	175.78	59.31	10425.51	R=84 L=73.68
14' DIA ½ SPHERE	307.88	718.38	212.62	45.08	9648.70	R=84
14' END PAN	106.90	2610.57 FT³		163.78	25594.77	
14' SKIRT	256.56					
MID SKIRT	152.33					
MID END PAN	47.42					
10' SKIRT	130.90					
10' END PANEL	54.54					
	2227.95 FT²					
+5% SEAMS	111.40					
	2339.35 FT²					

$C/L = moments/lift$
$= 25594.77/163.78$
$= 156.28$

OBJECT WT
TOTAL HARDWARE WT 118.44
TRIM WEIGHT 10.00
FABRIC WT @ 5.2 °²/qyₜ 84.48
212.92

MOUNTING HARDWARE
12 x 12 VELCRO = .0625 lbs
HARD PT RINGS = 1.25 lbs
INTERFACE MTS = 2.25 lbs

HELIUM LIFT
.06275 lbs/ft³
@ S.L. 85°F

POINT	WEIGHT	X	Y	Z
11	4.25	3	45.96	38.57
12	4.25	3	14	58.34
13	4.25	3	-25.36	54.38
14	4.25	3	45.96	-38.57
15	4.25	3	14	-58.34
16	4.25	3	-25.36	-54.38
17	3.25	28	14	38.57
18	3.25	28	14	-38.57
19	3.25	28	60	0
20	3.25	28	-60	0
21	3.25	41	0	60
22	3.25	41	0	-60
23	3.25	121	14	82.825
24	3.25	121	14	-82.825
25	3.25	121	-84	0
26	3.25	261	-36	0
27	3.25	261	18	31.18
28	3.25	261	18	-31.18
29	1.0625	261	78	0
30	1.0625	261	-78	0

THE MOMENTS IN THE X AXIS EQUAL-5426.03
THE MOMENTS IN THE Y AXIS EQUAL 203.1
THE MOMENTS IN THE Z AXIS EQUAL 6.10352E-05

SPHERICAL ENDED
ALTERNATE AFT SECTION

APPENDIX I

STTA Drawing Package

NOTE: Because of its bulk, this drawing package is included
as a separate package with this report.

APPENDIX J

LDEFI and STTA Service Manual

LDEFI and STTA

SERVICE MANUAL

Table of Contents

LDEFI and STTA

SERVICE MANUAL

1.0 LIST OF SPECIAL TOOLS AND EQUIPMENT REQUIRED

The following is a complete list of tools and equipment required to inflate, assemble, attach equipment, repair and maintain these inflatables.

Tools, Equipment

Main inflation port adaptor
Main inflation hose with regulator
Servicing hose with dill valve adaptor
Pressure gauge with range of 0 to 5 inches of H_2O
Pressure gauge with range of 0 to 3 psi
7/16 inch hex socket or open end (for 1/4 inch-20 attaching bolts)
Scissors
Acid brushes
Rubber gloves
Sponges and pail
Roller

Consumable Supplies

Bostik 7133 adhesive (patching adhesive)
Reeves B119-099 adhesive (Velcro adhesive)
THF activator
Patching material
Compressed helium

2.0 INFLATION AND ASSEMBLY OF THE LDEFI

2.1 The LDEFI is composed of the following pieces:

1 main envelope
2 tori
2 end skirts
2 round end panels
6 gross ballast shot bags

2.2 Inflation and assembly require a minimum of two (2) people. Begin by inflating the main envelope and two tori with helium. To inflate the main envelope, attach a large hose to the large port on the main servicing panel and fill to a pressure of three (3) inches of water pressure. Fill the tori by attaching a small hose with a dill valve adaptor to the dill valve on the torus. Service the tori to a pressure of one (1) psi.

1

NOTE

Prior to inflation, remove as much air as possible
from the envelopes to ensure maximum lift when
inflated.

WARNING

Use great caution. Helium is usually under
extremely high pressure, up to 3,000 psi.
Pressurized gases contain a great deal of
potential energy and can be dangerous.

2.3 Match the torus marked "Forward" with the end of the main
envelope marked "Forward." Find the Velcro strap on the
torus with the number that matches a convenient attaching
patch on the main envelope. Attach the Velcro strap so that
the black mark lines up with the end of the Velcro on the
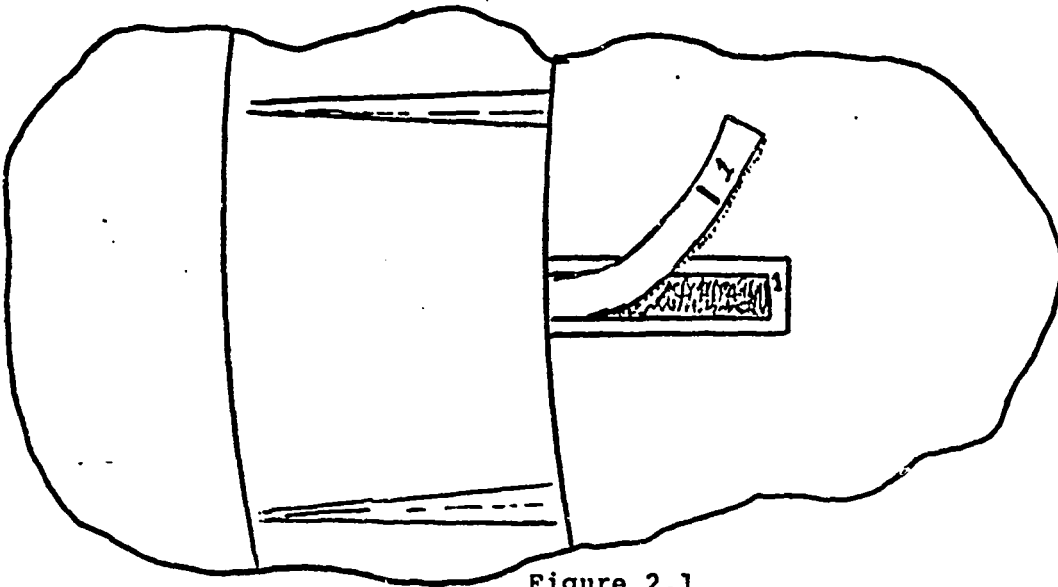main envelope (see Figure 2.1).

Figure 2.1

Move around the balloon attaching each strap in the same
manner. When complete, attach the remaining torus to the
opposite end in the same manner.

2.4 Identify the skirt marked "Forward." Locate the black marks
on the Velcro of the torus and main envelope of the forward
end. Attach approximately 24 inches to the envelope Velcro.
Then attach to the torus envelope. Continue around the
balloon in the same manner until the skirt is attached.

NOTE

Uneven pressure on the Velcro during installation
will cause wrinkling and uneven stretch.

If the ends of the skirt are uneven or do not meet, return to starting point and restretch Velcro on each edge around the balloon. Attach the remaining skirt in the same manner on the opposite end.

2.5 Identify the round end panel marked "Forward." Locate the black mark on the Velcro and the corresponding mark on the Velcro of the forward torus. Move around the circumference of the panel, attaching it to the Velcro. To verify proper orientation, check that access patches are directly in front of servicing ports. Attach remaining panel to opposite end in same manner.

3.0 INFLATION AND ASSEMBLY OF THE STTA

3.1 The STTA is composed of the following pieces:

1 forward end main envelope
1 aft end main envelope
5 tori
5 skirts
4 round end panels
1 mid panel
6 gross ballast shot bags

3.2 **Inflation and assembly require a minimum of three (3) people.** Begin by inflating the main envelopes and five tori with helium. The main envelopes may be filled by attaching a large hose to the large port on the main servicing panels. The tori may be filled by attaching a small hose with a dill valve adaptor to the dill valve on the torus. The envelopes should be inflated to the following pressures:

Forward main envelope	—	4" H_2O
Aft main envelope	—	3" H_2O
Large torus (1)	—	7" H_2O
Mid torus (1)	—	14" H_2O
Small tori (3)	—	35" H_2O

NOTE

Prior to inflation, remove as much air as possible from the envelopes to ensure maximum lift when inflated.

WARNING

Use great caution. Helium is usually under extremely high pressure, up to 3,000 psi. Pressurized gases contain a great deal of potential energy and can be dangerous.

3.3 To begin attaching the tori, select the large torus and match it up with the aft end of the aft envelope. Find the

corresponding mark on the Velcro of the aft end torus. Move around the circumference of the panel attaching it to the Velcro. Verify correct orientation by checking that access panels are directly over servicing ports. In the same manner, attach the remaining end panels and the mid panel. Both Velcro index marks on the mid panel must be matched to ensure that no twist has been induced in the material.

3.6 To hook forward and aft section together, match the two ends so the trunnion mounts are all in line. Then turn both balloons so the top attaching points are accessible. Attach a turn buckle to each point. The balloons are now connected at the **top point only** (1 of 6). Turn the balloons back to the normal orientation. Adjust the position so that the two halves line up. When a proper alignment is achieved, attach a turn buckle to each side simultaneously. Install the remaining three turn buckles and adjust as necessary to ensure that the center lines are nearly parallel.

4.0 DAILY SERVICING

4.1 The STTA and LDEFI should be serviced daily to prevent total loss of skin tension which could cause bending of the objects and possible misalignment of tori, skirts and end panels. If the objects are not in active use, they need only be serviced to one-half (1/2) of normal operating pressure. This reduces stress and lengthens fabric and coating life.

The following is a summary of operating pressures for each object: (See Figures 4.1 and 4.2 for servicing locations of the LDEFI and STTA, respectively.)

<div align="center">

LDEFI

Main envelope - 3" H_2O
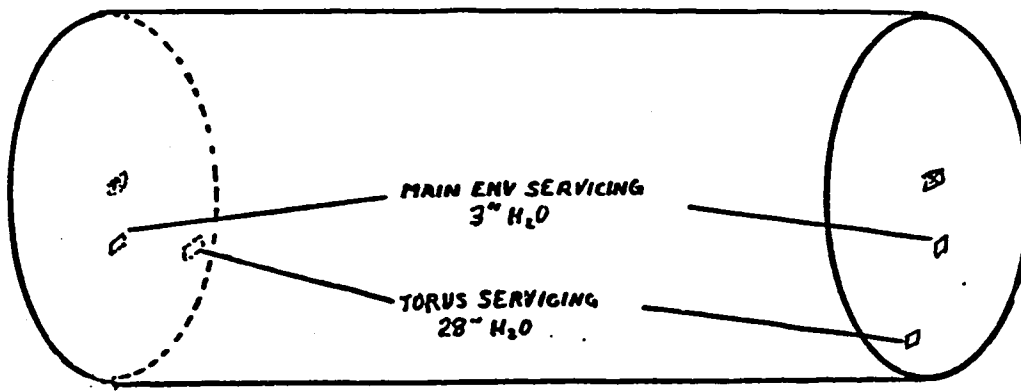Tori - 1 psi (28" H_2O)

</div>

MAIN ENV SERVICING 3" H_2O

TORUS SERVICING 28" H_2O

<div align="center">

Figure 4.1

</div>

STTA

Forward main envelope - 4" H_2O
Aft main envelope - 3" H_2O
Large torus - .25 psi (7" H_2O)
Mid torus - .5 psi (14" H_2O)
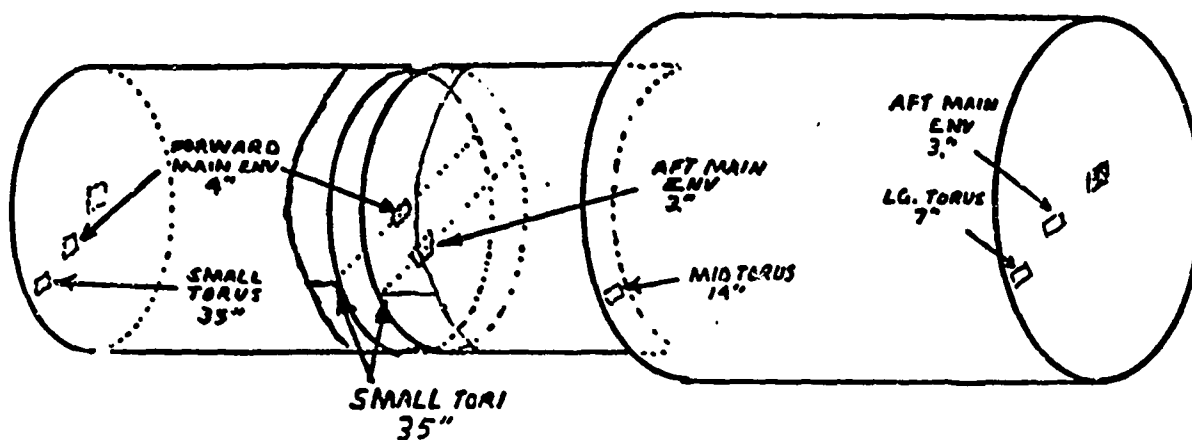3 small tori - 1.25 psi (35" H_2O)

Figure 4.2

No other servicing is required.

5.0 PERIODIC MAINTENANCE - None

6.0 LEAK DETECTION

Three types of leaks may be found in helium inflatables: Micro leaks, small pinhole leaks and large leaks.

6.1 Micro leaks are often caused by minute holes. They may not take a direct path through the material but rather find a series of channels by which to escape. It is very difficult to find these leaks. A special apparatus must be used to detect the presence of inner gases. Such leaks do not present a problem for articles such as the STTA and LDEFI because their operating time between servicing is short.

6.2 Higher than usual loss rates for a particular envelope are the first indication of pinhole leaks. Most small pinholes will not allow enough gas to escape to need servicing more often than the required eight-hour operational period, but they should be identified and repaired. If the proximity of the leak is known, Liquid Snoop (provided in the repair kit) may be used to identify its exact location. If the proximity is unknown, the envelope may be leak-checked by going over the balloon section-by-section with a soapy water solution and watching for bubbles.

6.3 Large leaks are those too large to be detected with soapy
water. High air flow blows away all the soap solution
before bubble films can form. Loss of gas in a relatively
short time is evidence of such leaks. The best way to
locate these leaks is by sound and touch. The face tends to
be more sensitive to the air flow than the hands.

7.0 LEAK AND DAMAGE REPAIR

7.1 Once a leak has been located, or if a tear has occurred,
lower the pressure of that envelope to below 0 psid.

CAUTION

If a repair is attempted while the balloon is
pressurized, the area to which glue is applied may
become completely porous.

CAUTION

The adhesive and activator are hazardous
materials. Read the labels on the cans and the
enclosed safety data sheet before using.

A hole or damaged area can be repaired by making a fabric
patch which, if possible, overlaps the damaged area on all
sides by three inches. Apply adhesive with a small
paintbrush to both the patch and damaged area. Allow the
adhesive to dry completely. Apply a second coat of glue.
When the second coat has dried, use a cloth to apply the
activator to the adhesive on both the patch and the balloon.
This seals the patch to the balloon.

When repairing a long tear, activate the glue on only a
portion of the balloon and the patch at one time. The
portion which has been activated should then be pressed to
the envelope and rolled in place with the roller provided.
Continue this process until the entire patch has been
secured to the balloon.

NOTE

The adhesive provided, Bostik 7133, has a shelf
life of six (6) months. Once the shelf life has
been passed, the adhesive may not dry properly,
and this may enlarge the damage area.

8.0 STORAGE

8.1 If the envelope is stored inflated or partially inflated,
the pressure should be kept near or below 0 psid to provide
longest service life.

CAUTION

Changes in atmospheric pressure may cause
overpressurization of some or all of the
envelopes.

8.2 If the balloon is deflated and packed in a crate, use
extreme care to ensure that hardware does not damage the
fabric. The envelope should be folded and stored in a low
or normal humidity area at temperatures between 50°F and
80°F.

END

DATE

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