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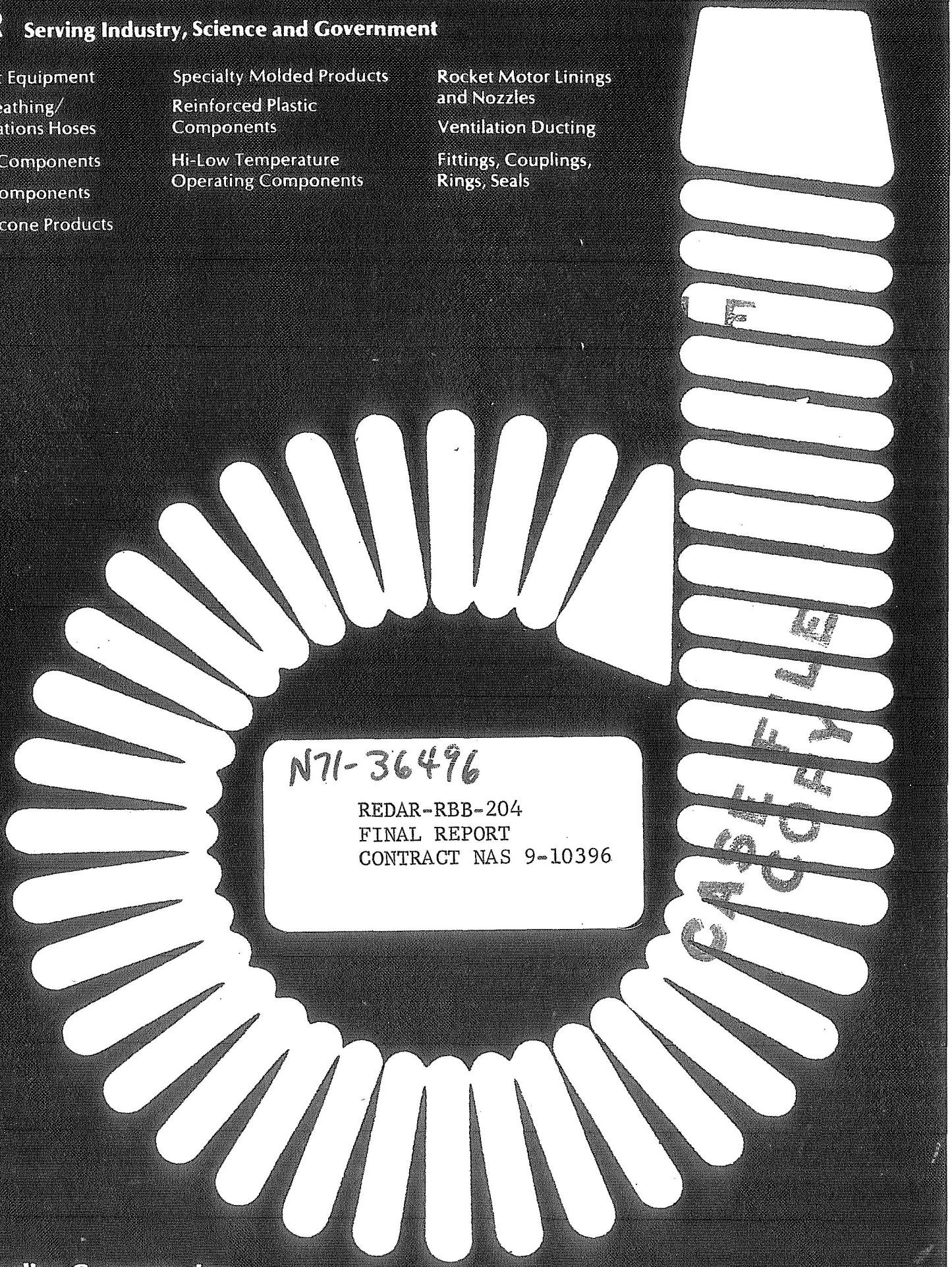
Life Support Equipment
Oxygen-Breathing/ Communications Hoses
Aerospace Components
Undersea Components
Medical Silicone Products

Specialty Molded Products
Reinforced Plastic Components
Hi-Low Temperature Operating Components

Rocket Motor Linings and Nozzles
Ventilation Ducting
Fittings, Couplings, Rings, Seals



R. E. Darling Company, Inc.
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CR-115157

R. E. DARLING CO., INC.

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REDAR- RBB-204
date July 30, 1971

R. E. DARLING CO. TECHNICAL DOCUMENT

FINAL REPORT
CONTRACT NAS9-10396

RESEARCH AND DEVELOPMENT
OF
UMBILICAL HOSE ASSEMBLY CONCEPTS
FOR
MANNED SPACE FLIGHT

INCLUDING
DESIGN VERIFICATION TEST REPORT REDAR-RTR-351

PREPARED BY: W. A. SYLVESTER

R. C. DOUGHERTY

R. E. DARLING, JR.

no.	*date*	*by*	*REVISIONS*	*pages affected*

ABSTRACT

Several construction approaches using a variety of materials were evaluated to obtain a substantially improved umbilical hose assembly and PLSS oxygen and water hose. Flexibility and prevention of delamination were overriding design criteria. The final configuration for the umbilical hose and the PLSS hose was subjected to a Design Verification Test program. Results are contained in the accompanying report, REDAR-RTR-351.

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INTRODUCTION

In October of 1969, the R. E. Darling Company submitted a proposal in response to NASA-MSC request NAS-BG721-54-0-48P for the development and verification testing of new concepts for hose assemblies to be used for ventilation of crewmen in spacecraft. On December 29, 1969, the R. E. Darling Company received a firm fixed-price contract number NAS9-10396 for this effort. In November, 1970, the contract was amended to include a similar effort for oxygen and water hose used in conjunction with the Portable Life Support System (PLSS).

Monthly progress reports have been submitted to the cognizant offices at the Manned Spacecraft Center. This final report summarizes the efforts and presents the final configurations generated. Included with this document but presented as a separate entity is the Design Verification Test Report No. REDAR-RTR-351.

TECHNICAL APPROACH

Prior to the time of submission of our proposal to NASA, R. E. Darling Company, Inc. (REDAR) production, engineering and quality control personnel had jointly spent many hours generating a total of twelve different hose design concepts. These ideas incorporated several different materials, different internal bore configurations and different construction techniques. Many were significant departures from the standard hose REDAR has been manufacturing for aircraft and spacecraft applications for many years. However, constraints placed on the spacecraft hose by procurement specifications had dictated the end item.

The specification in the statement of work presented many of these same constraints. However, in the preparation and evaluation of each unit developed, the NASA technical monitor was informed of the deviations. In instances where the concept was worthy of further consideration, the specification was relaxed. These trade-offs were found necessary to obtain the optimum in design.

Although the R. E. Darling Company is primarily a manufacturer of rubber products, our material evaluation did not overlook metal and plastic materials. Our search for optimum materials also included fibers and several exotic elastomers. The permeability of oxygen through elastomers necessitated our

evaluation of the metal and plastic materials. However, our final analysis, as discussed later in this report, showed these materials to possess more rigidity than was deemed acceptable in order to provide optimum astronaut mobility.

Although REDAR material engineers have continually evaluated newly presented materials in the fiber and elastomer field, this program concentrated their efforts toward a specific end item. In a previous program under contract NAS9-7764, Viton® materials from Dupont, Fluorel® materials from Raybestos-Manhattan and Mosites Rubber Company and silicone compounds developed by REDAR as well as Dexsil® from Olin Mathieson, Kel-F® from 3M and CNR from Thiokol were examined quite extensively for their application in spacecraft hardware. Since that time, additional Viton and silicone based materials have been generated. It was these latter materials which were examined by REDAR material engineering with back up data from the Crew Systems Division at MSC.

Fibers used for reinforcing of the elastomer member in the hose construction have in the past been confined to nylon, Nomex® and beta fiberglass. Our efforts in this area were directed toward Fypro® by Travis Mills, Durette® from Monsanto, Kynol® from Carborundum, and commercial grades of fiberglass. Our conclusion in this area was that beta fiberglass offers the

best strength, flexibility and flame resistance characteristics when used in the hose constructions we considered.

Immediately upon receipt of the contract from NASA we commenced a systematic review of the twelve concepts presented in our proposal. Most concepts were prototyped and evaluated; a few were critically reviewed without actually making a sample unit. When obvious shortcomings were noted either the design was modified or eliminated. When the final design had been reached, a total of nineteen different concepts had been evaluated.

The following pages show the various designs which were evaluated. Following each sketch is the conclusion reached about the concept.

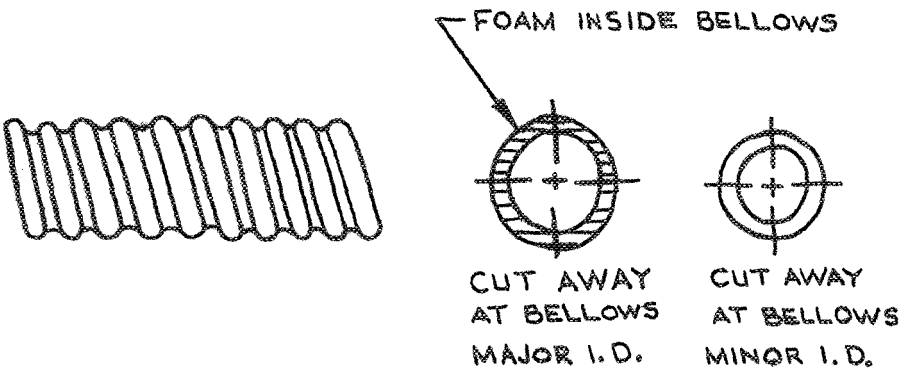
R. E. DARLING CO., INC.

DESIGN CONCEPTS
CONTRACT
NAS 9-10396

REDAR

I HOSE, OXYGEN METAL BELLOWS SPIRAL FOAM LINED

R. E. DARLING CO., INC.



REDAR-SK-444

CONSTRUCTION:

Light weight metal spiral bellows, with internal convolutions, lined with a foam to provide a smooth bore.

ADVANTAGES:

1. No leakage
2. Foam lined bore gives lower pressure drop than corrugated I.D.
3. Foam improves temperature increase over bare metal.
4. Metallic exterior provides excellent fire resistance.

TO BE DETERMINED:

1. Comparative weight
2. Flexibility
3. Heat loss
4. Compressive and longitudinal strength

ALTERNATE CONSTRUCTION POSSIBILITIES:

1. Internal restraint line for longitudinal strength and to curtail elongation.
2. Reinforcing the bellows with an internal helix prior to foam lining to provide additional compressive load strength.

COMMENTS

REDAR-SK-444

1. The metallic bellows proved to be too stiff when compared to existing hardware.

2. A concern was felt for the use of a foam or sponge rubber in the inner bore.

   a) The foam might break up causing particle contamination.

   b) The foam would absorb liquids either used in cleaning or from breathing gases.

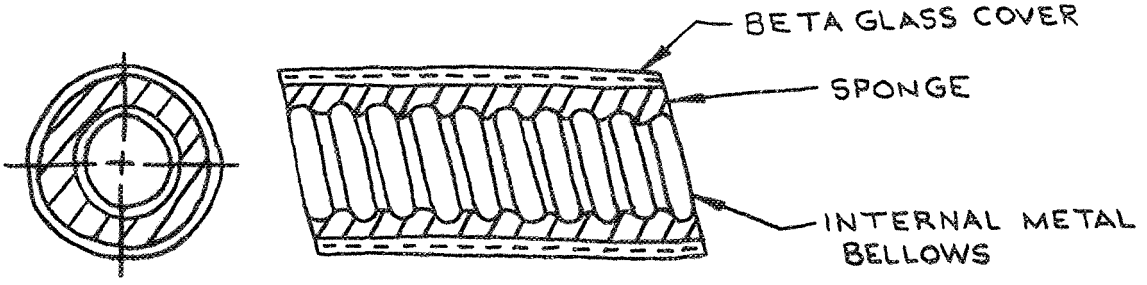
   c) The construction could not be used to convey liquids thus limiting its usefulness.

3. This concept was rejected.

REDAR

II SPIRAL METAL BELLOWS
FOAM COVERED

R. E. DARLING CO., INC.



REDAR-SK-445

CONSTRUCTION:

Light weight metallic spiral bellows, external foam layer, with tubular coated or impregnated Beta glass cover secured at end cuffs.

ADVANTAGES:

1. No leakage
2. External foam provides improved temperature increase
3. No internal delamination
4. Improved flexibility
5. Adequate longitudinal strength provided by Beta cover
6. No elongation due to restraint provided by Beta glass cover.
7. Excellent fire resistance.

TO BE DETERMINED:

1. Comparative weight
2. Pressure Drop
3. Compressive strength

ALTERNATE CONSTRUCTION POSSIBILITIES:

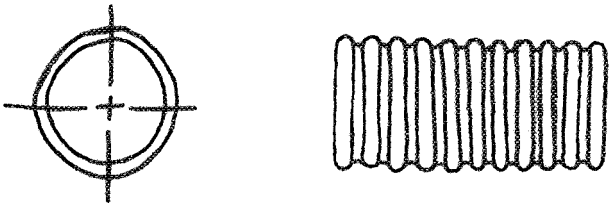
1. Reinforce bellows internally with a helix to provide additional compressive load strength.

COMMENTS

REDAR-SK-445

1. The metal bellows, even when made of the thinnest gauge metal available, did not provide the flexibility needed in this application. Each bellows flex was approximately 20 degrees instead of the 45 degrees desired to meet reasonable bend radii requirements.

2. This concept was rejected.



REDAR-SK-446

CONSTRUCTION:

Standard light weight bellows

ADVANTAGES:

1. Maximum flexibility
2. Fire resistance
3. Good compressive strength to weight ratio
4. No leakage
5. No delamination

TO BE DETERMINED:

1. Temperature increase
2. Elongation under load
3. Pressure drop

ALTERNATE CONSTRUCTION POSSIBILITIES:

1. Foamed in place liner for smooth bore, to improve Pressure drop and Temperature increase. (SEE PROPOSED CONSTRUCTION #1)
2. Foamed external thermal insulation, with tubular Beta glass cover, for improved Temperature increase and glass cover to proved longitudinal load strength without elongation.
3. Reinforcing rings added internally in the circular convolutes for increased compressive load strength.

COMMENTS

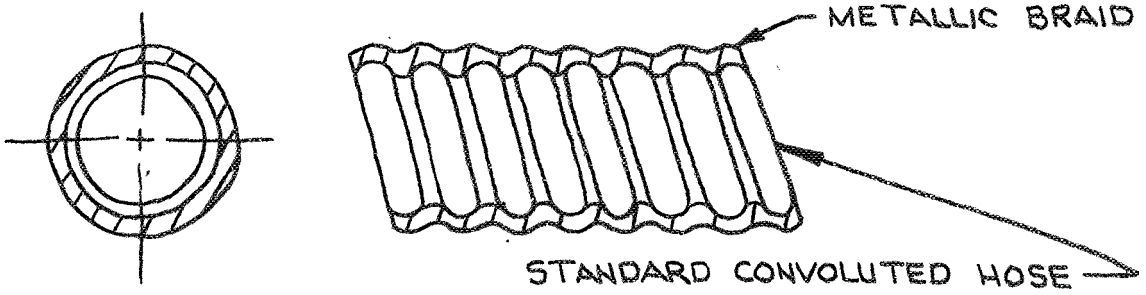
REDAR-SK-446

1. As in the previous two concepts, the metal bellows did not provide the flexibility desired. Weight was an added factor in this concept.

2. This concept was rejected.

REDAR

IV METALLIC BRAID COVER OVER
LIGHT WEIGHT POLYMER HOSE *R. E. DARLING CO., INC.*



REDAR-SK-447

CONSTRUCTION:

Gas carrying inner liner, helix reinforcement imbedded in tie-gum with metallic braid bonded to the polymer.

ADVANTAGES:

1. Fire resistant
2. Low pressure drop
3. Acceptable longitudinal and compressive load strength
4. No elongation
5. Excellent abrasion resistance

TO BE DETERMINED:

1. Temperature increase
2. Weight
3. Flexibility

ALTERNATE CONSTRUCTION POSSIBLITIES:

1. Limited elongation, corrugated bore construction for additional flexibility.

COMMENTS

REDAR-SK-447

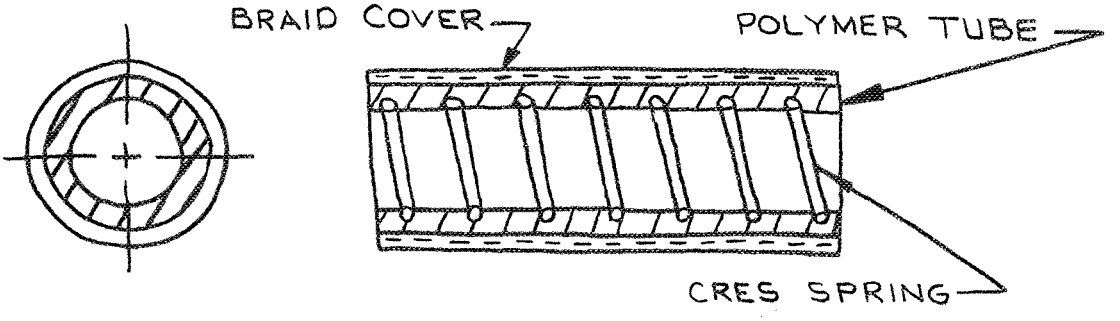
1. Braided metallic outer covering when compared to beta fiberglass restricted the flexibility of the hose.

2. The metallic braid added significantly to the overall weight of the unit.

3. After testing in our flame chamber we found no significant flame resistance over the beta fiberglass.

4. There is a trade-off possible between flexibility and fire resistance. The finer the metal filament the more flexible the braided outer covering. However, when the filament is drawn extremely fine, the flame resistance decreases significantly.

5. This concept was eliminated.



REDAR-SK-448

CONSTRUCTION:

Reinforcing helix coil I.D. flush with I.D. of polymer tube, with coated or impregnated Beta glass braid cover.

ADVANTAGES:

1. Light weight
2. Very flexible
3. Good Pressure drop in straight length
4. No delamination
5. Acceptable longitudinal and compressive load strength
6. No elongation

TO BE DETERMINED:

1. Retention of helix under flex and compressive load
2. Temperature increase
3. Pressure drop when bent or looped
4. Cleaning
5. Fire resistance

ALTERNATE CONSTRUCTION POSSIBILITIES:

Metallic braid cover for better fire resistance.

COMMENTS

REDAR-SK-448

1. The initial prototype, REDAR-SL-448A, showed the concept worthy of further development.

2. Two additional prototypes were generated, REDAR-SK-448B and REDAR-SK-448C.

3. a) REDAR-SK-448A had a smooth outer surface.

   b) REDAR-SK-448B had a fiberglass cord helically wrapped around the outer surface and left on after curing the hose.

   c) REDAR-SK-448C was the same as (b) except the fiberglass cord was removed leaving a slightly convoluted outer surface.

4. It was found that REDAR-SK-448C afforded the greatest flexibility of the three alternatives.

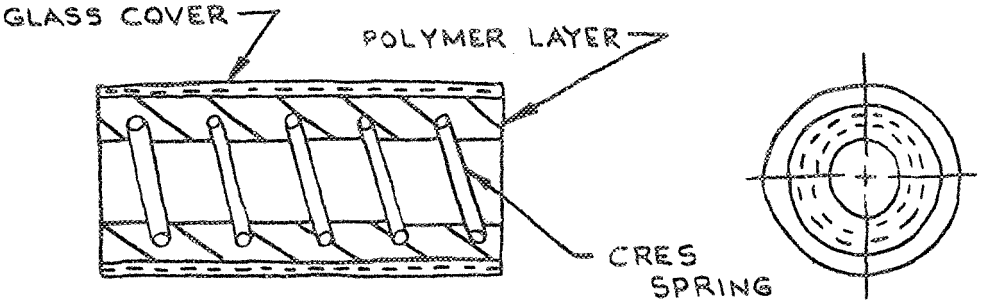
5. REDAR-SK-448A and REDAR-SK-448B were eliminated.

6. REDAR-SK-448C was retained as the concept used for the PLSS hoses. See further discussion and details concerning REDAR-A10921 and REDAR-A10922.

REDAR

VI SINGLE LAYER,
NON-METALLIC,
MOLDED

R. E. DARLING CO., INC.



REDAR-SK-449

CONSTRUCTION:

Reinforcing helix centered in the wall of the gas carrying innertube, impregnated or coated tubular glass cover.

ADVANTAGES:

1. Light weight
2. Excellent Pressure drop in straight length
3. No delamination
4. Acceptable longitudinal and compressive load strength
5. No elongation
6. Helix retained in position during flex and compressive loading.

TO BE DETERMINED:

1. Fire resistance
2. Pressure drop when bent or looped
3. Flexibility
4. Temperature increase

ALTERNATE CONSTRUCTION POSSIBILITIES:

1. Metallic braid cover for better fire resistance.

COMMENTS

REDAR-SK-449

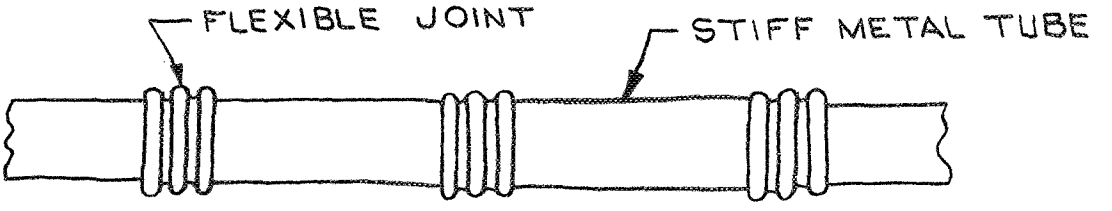
1. Due to the necessity to increase the polymer layer to imbed the spring, the flexibility of the prototype decreased substantially.

2. This concept was eliminated.

REDAR

VII METAL TUBE WITH
FLEXIBLE METALLIC HINGE JOINTS

R. E. DARLING CO., INC.



REDAR-SK-450

CONSTRUCTION:

Circular metal tube with flexible metal bellows joining tube sections together at predetermined locations.

ADVANTAGES:

1. Fire proof
2. Less Pressure drop than all bellows construction
3. No leakage
4. Little or no elongation

TO BE DETERMINED:

1. Temperature increase
2. Flexibility - bend radius
3. Comparative weight

ALTERNATE CONSTRUCTION POSSIBILITIES:

1. Foamed external thermal insulation with tubular Beta glass cover for improved Temperature increase.

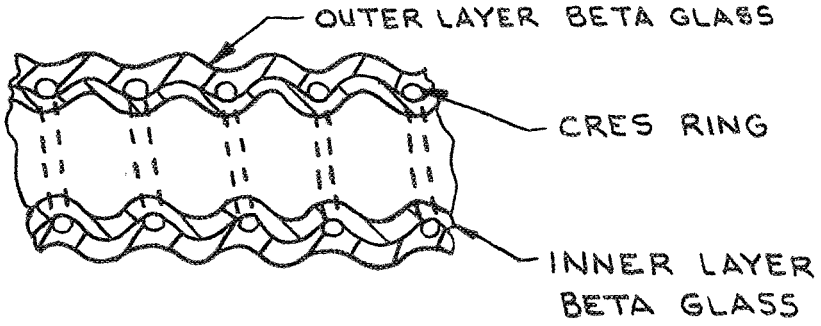
COMMENTS

REDAR-SK-450

1. After evaluating metallic bellows it became readily apparent that rigid segments would only increase the bend radius where there was too great a radius already.
2. Poor flexibility and high cost factors were also considered.
3. This concept was rejected.

VIII CORRUGATED LAMINATED BETA GLASS

R. E. DARLING CO., INC.



REDAR-SK-451

CONSTRUCTION:

Corrugated layers of Beta glass, impregnated with Teflon and heat fused to form a laminate with metal rings between the layers.

ADVANTAGES:

1. Very light weight
2. High fire resistance
3. Cannot delaminate
4. Low Temperature increase
5. Low leakage

TO BE DETERMINED:

1. Pressure drop
2. Flexibility
3. Elongation

ALTERNATE CONSTRUCTION POSSIBILITIES:

1. Same as above except use thin layer of VITON as laminating materials

COMMENTS

REDAR-SK-451

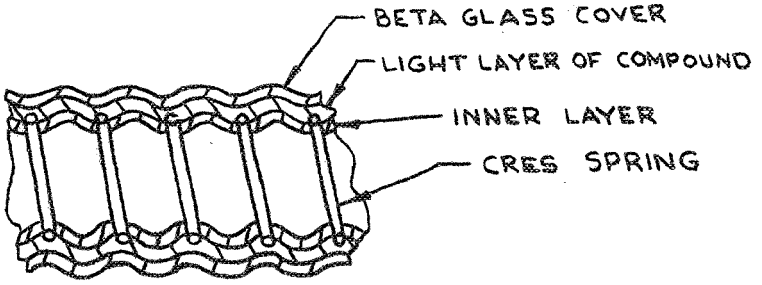
1. During prototyping it was noted that when two layers of fiberglass are laminated, the result is a very rigid structure such as seen in plywood.

2. The concern over delamination of the two layers was difficult to still.

3. This concept was rejected.

IX CORRUGATED ELASTOMER HOSE
WITH BETA GLASS COVER

R. E. DARLING CO., INC.



REDAR-SK-452

CONSTRUCTION:

Inner elastomer liner, reinforcing helix, light bonding layer, Beta glass coated with Viton

ADVANTAGES:

1. Very Flexible
2. High Fire Resistance
3. Relatively light weight
4. Low Temperature increase

TO BE DETERMINED:

1. Pressure drop
2. Elongation

ALTERNATE CONSTRUCTION POSSIBILITIES:

1. Same basic construction as above except add a second helix at minor diameter. This controls elongation.

NOTE:

We have built prototypes of this hose and it is very promising. Samples sent to NASA, GAEC and NAR with favorable reaction.

COMMENTS

REDAR-SK-452

1. The construction and materials used in this concept have received considerable attention in the Apollo program. This design was originally developed by the R. E. Darling Company under company funding. Prototypes were submitted to NASA-MSC, North American Rockwell and Grumman Aerospace Corporation. It affords considerable increase in flexibility over present crew umbilical hose assemblies although a slight increase in pressure drop must be accommodated. Astronaut reaction at Critical Design Reviews (CDR) both at Downey, California (NAR) and Bethpage, New York (GAC) was most complimentary. However, a decision was made by the Change Control Board (CCB) meeting in Houston that retrofit costs did not warrant changing the Command module and Lunar module configurations this late in the Apollo program.

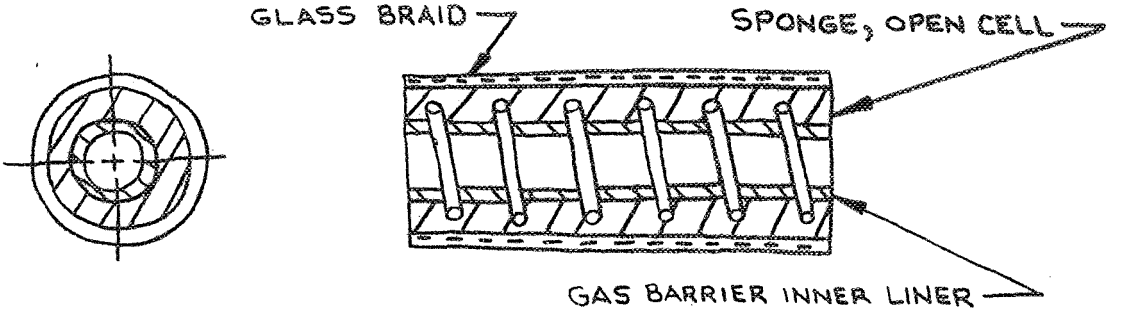
2. Only minor trade-offs in existing industry control specifications are required to afford a hose which would easily be qualified.

3. In as much as this concept was the state-of-the-art at the time of contract initiation, it was used as a base line. However, in an effort to advance the state-of-the-art, other concepts were furthered in deference to this one.

REDAR

X SPONGE IMBEDDED HELIX
WITH ELASTOMER LINER

R. E. DARLING CO., INC.



REDAR-SK-453

CONSTRUCTION:

Reinforcing helix surrounded by open cell sponge with a gas barrier inner liner and a Beta glass cover.

ADVANTAGES:

1. Very flexible
2. Light weight
3. No elongation
4. Low Temperature increase
5. Low Pressure drop

TO BE DETERMINED:

1. Fire resistance
2. Compressive load characteristics

ALTERNATE CONSTRUCTION POSSIBILITIES:

1. Same basic construction as above, but built in external convolutions.

NOTE:

We have built one prototype of this hose and it performs very satisfactory.

COMMENTS

REDAR-SK-453

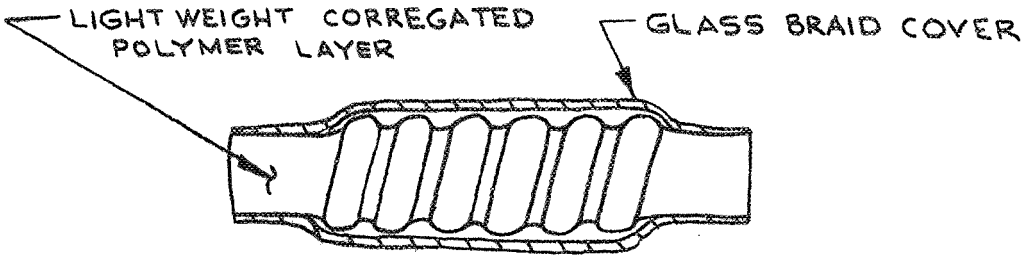
1. The bond between the inner liner and the open cell sponge proved too weak to prevent delamination when subjected to an internal vacuum.

2. Pressure drop increased substantially when the hose was bent, due to crinkling of the inner lining.

3. This concept was eliminated.

XI CORRUGATED LIGHT WEIGHT TUBE
WITH BETA GLASS COVER

R. E. DARLING CO., INC.



REDAR-SK-454

CONSTRUCTION:

Ultra light weight flexible corrugated elastomer liner with Beta glass braid cover attached only at the ends. Internal helix in convolutions.

ADVANTAGES:

1. Very light weight
2. Very flexible
3. Cannot delaminate
4. No elongation

TO BE DETERMINED:

1. Pressure dorp
2. Temperature increase
3. Fire resistance
4. Leakage
5. Compressive load characteristics

NOTE:

We have built a prototype of this hose and it is very promising. It is light, flexible, and has almost no elongation.

COMMENTS

REDAR-SK-454

1. Basically, this concept from the onset looked quite promising.

2. Three configurations were generated out of this concept.

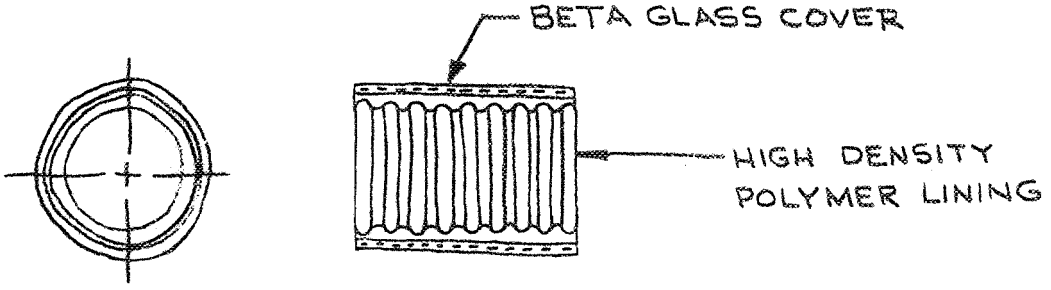
3. REDAR-SK-454A, the original concept, was abandoned because the reinforcing spring had a tendency to tilt sideways and close off the inner bore.

4. REDAR-SK-454B placed the reinforcing helix external to inner tubing but under the braid cover. This also had a like tendency to have the spring to tilt and block off the gas passage. Another problem was the delamination of the inner tubing. This configuration was also abandoned.

5. REDAR-SK-454C combined the two reinforcing springs of the previous two configurations. This approach proved to be very promising although the hose when subjected to an internal vacuum, decreased in length approximately 50 per cent. This situation was found to be acceptable to the NASA technical monitor, and the hose construction was used to make the oxygen umbilical for submission under this contract. See further discussion and details concerning REDAR-A10920.

XII HIGH DENSITY POLYMER LINER
WITH BETA GLASS COVER

R. E. DARLING CO., INC.



REDAR-SK-455

CONSTRUCTION:

Molded thin wall, light weight, convoluted or ringed high density polymer with a Beta Glass cover.

ADVANTAGES:

1. Very light weight
2. No leakage
3. No delamination
4. No elongation
5. Good flexibility

TO BE DETERMINED:

1. Pressure drop
2. Temperature increase
3. Fire resistance
4. Compressive load characteristics

ALTERNATE CONSTRUCTION POSSIBILITIES:

1. Same as above except add a reinforcing helix on the inside of the convolutions.

NOTE:

We have built one short piece of this type hose and it is worth further investigation.

COMMENTS

REDAR-SK-455

1. This concept was developed into three configurations.

2. REDAR-SK-455A, without reinforcing wire, was eliminated due to its lack of compressive load resistance.

3. REDAR-SK-455B carried a reinforcing helix external to the inner liner but under the outer cover. Delamination eliminated this approach.

4. REDAR-SK-455C placed the spring inside the inner liner. The approach showed great promise - lightweight, flexible, no possibility of collapse. However, when we attempted to procure the high density polymer liner material in the diameter to wall thickness ratio deemed optimum, we found it unavailable. Since other approaches were equally attractive, this concept was abandoned.

PRELIMINARY SCREENING TESTS

Each concept which was prototyped went through a screening test program if subjective evaluation showed it to warrant further study.

The results of the screening tests are shown on the chart which follows. Flexibility figures are determined by using a scale to pull the hose around a 4-inch diameter mandrel to a point either 90 degrees or 180 degrees from the tangent of the hose to the mandrel. Compressive load figures represent the per cent of deflection of the outside diameter both under the given load and two minutes after the load was removed. The stated load was placed over a 4-inch section parallel to the centerline of the hose.

PRELIMINARY SCREENING TEST RESULTS

REDAR-SK NUMBER	NOM I.D.	ELONGATION Relaxed Length	ELONGATION at 4.0 PSIG	ELONGATION at 6.4 PSIG	90° FLEXIBILITY Unpressurized	90° FLEXIBILITY at 4.0 PSIG	90° FLEXIBILITY at 6.4 PSIG	180° FLEXIBILITY Unpressurized	180° FLEXIBILITY at 4.0 PSIG	180° FLEXIBILITY at 6.4 PSIG	Wt. Per Ft.	100 lb. COMPRESSIVE LOAD % Deflection Under Load	100 lb. COMPRESSIVE LOAD % Permanent Set	150 lb. COMPRESSIVE LOAD % Deflection Under Load	150 lb. COMPRESSIVE LOAD % Permanent Set	175 lb. COMPRESSIVE LOAD % Deflection Under Load	175 lb. COMPRESSIVE LOAD % Permanent Set	DELAMINATION POTENTIAL
448A	1.25	23	23 1/2	23 3/4	1 lb.	2 lb.	2 lb.	4 lb.	5 lb.	6 lb.	131 gm	12	1.0	18	1.5	23	3	No
448B	1.25	23	23 1/4	23 1/2	2 lb.	2 lb.	2 lb.	5 lb.	5 lb.	5 lb.	140 gm	15	1.5	19	2.2	22	3	No
448C	1.25	23	23 1/4	23 1/2	1.5 lb.	1.5 lb.	2 lb.	4 lb.	4 lb.	4.5 lb.	140 gm	15	1.5	19	2.2	22	3	No
449A	1.25	22	22	22 1/16	6 lb.	7 lb.	8 lb.	10 lb.	11 lb.	12 lb.	176 gm	12.8	1.0	15.1	2.0	15.6	1.5	Yes
449B	1.25	20	20 1/16	20 1/4	5 lb.	7 lb.	8 lb.	7 lb.	11 lb.	12 lb.	180 gm	9.6	.9	14.0	1.3	16.0	1.7	Yes
454A	1.25	24 1/2	25 3/8	25 1/2	0 lb.	.5 lb.	.5 lb.	0 lb.	1 lb.	1.5 lb.	112 gm	Spring	Flips	Causing	Collapse	→	→	→
454C	1.25	15 1/2	17	17 1/4	0 lb.	0 lb.	0 lb.	1 lb.	1.5 lb.	2.5 lb.	168 gm	10	2.0	Spring	Flips	→	→	No - Unless Restrained
455B	1.0	13			.5 lb.			2 lb.			50 gm							No
455C	.75	18	18	18 1/16	.5 lb.	1 lb.	1 lb.	1 lb.	2.5 lb.	2.5 lb.	66 gm	32	6.4	37.5	7.2	42	8.4	No

FINAL SELECTIONS

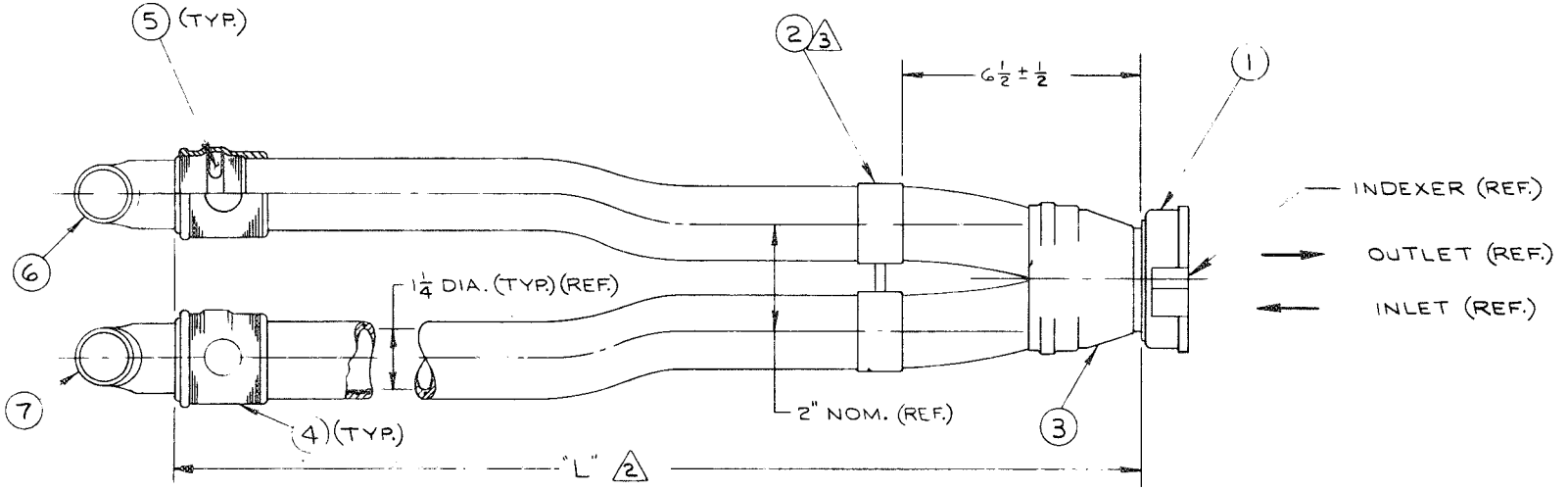
The concepts which were carried to the final design phase were REDAR-SK-448B and REDAR-SK-454C. The selection was based on a number of objective and subjective tests. However, the two overriding considerations were flexibility and protection from delamination (or blockage of the gas or liquid flow). These two items were clearly indicated both by NASA personnel and the "Statement of Work" as being critically important in this program.

Both concepts which became the final configurations submitted under this contract possess increased flexibility over existing hardware and protection from delamination. However, in the crew umbilical design requirements for pressure drop, strength and other considerations varied from those requirements placed on the PLSS hardware. Thus, the REDAR-SK-454C became the concept for use in the REDAR-A10920-1 crew umbilical assembly. Instructions on fabricating the hose portion of this assembly is detailed in our document REDAR-A90323. The PLSS oxygen hose, REDAR-A10921-1 and REDAR-A10921-2, and the PLSS water hose, REDAR-A10922-1, were generated from the REDAR-SK-448B concept. The details for preparation of the REDAR-A10921 hose are carried in our REDAR-A90025 Build Print Data. REDAR-A80633 details the fabrication procedures for REDAR-A10922-1. The foregoing drawings and instructions appear on the following pages.

Materials selected for the final configurations are the same throughout. The elastomer used is REDAR-FL-308-01. During the execution of this contract, samples were submitted to NASA-MSC for testing to MSC-PA-D-67-13, Category B. We are advised that White Sands Testing Facility report no. 70-1606 (MSC S/N 3069) indicates the material is acceptable for this application. The wire reinforcing member is stainless steel, type 302. Fabric reinforcement is provided by tubular braided beta fiberglass with a very thin coating of REDAR-FL-903-01 to provide abrasion resistance. REDAR-FL-903-01 coating material is REDAR-FL-308-01 Viton broken down with MEK solvent.

PART NO		"L" (2)
REDAR-A1092	1	72 ± 2

REVISIONS			
SYM	DESCRIPTION	DATE	APPROVAL



NOTES:

1. MATERIAL:
   HOSE – VITON, CRES WIRE REINFORCED
   OUTER COVER- BETA FIBERGLAS
   INPREGNATED WITH VITON
   PREMOLDED CUFFS – VITON
2. DIFFERENTIAL LENGTH BETWEEN LEGS OF HOSE NOT TO EXCEED ½ INCH. SEE TABULATION FOR OVERALL LENGTH TOLERANCE.
3. ITEM 2 (KEEPERS) SPACED AT APPROXIMATELY 12 INCHES ON CENTER.
4. PART MARKING PER MIL-STD-130 PLUS MFD (QTR & YEAR)

QTY. REQD	PART OR IDENTIFYING NO	ITEM	NOMENCLATURE OR DESCRIPTION	MATERIAL OR NOTE
1	COML	7	CONNECTOR (BLUE)	AIRLOCK PN 4247B
1	COML	6	CONNECTOR (RED)	AIRLOCK PN 4247R
4	NAS 397-28	5	CLAMP, HOSE	TINNERMAN PROD., CLEVELAND, OHIO
2	REDAR-S10215-4	4	COVER, CLAMP	
1	REDAR-S10221-1	3	COVER	
5	REDAR-S10210-1	2	KEEPER	
1	REDAR-C10974-1	1	CONNECTOR	

LIST OF MATERIALS OR PARTS LIST

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
Tolerances on Fractions Decimals Angles
√
MATERIAL
(1)
SURFACE TREATMENT

SIGNATURE		DATE
DR	BR	6/22/71
CHK		
CARD		6/22/71
APPROVED		11/3/71

REF

CAGE No.	NEXT ASSY	USED ON
APPLICATION		

R. E. DARLING CO., INC.
GAITHERSBURG, MARYLAND
TUCSON, ARIZONA

HOSE ASSEMBLY-UMBILICAL

SIZE C | REDAR-A10920 | —

SHEET 1

REDAR-A10920

REVISIONS

REV	DESCRIPTION	DATE	APP'D

BILL OF MATERIALS

ITEM	MATERIAL	PART NUMBER	SIZE	REMARKS
1	MANDREL	———	1¼ O.D.	CLEAN
2	TUBE	REDAR-C11208-1	.040 X 1.250	
3	SPRING	REDAR-C10163-44	.040 X 1.450	
4	WIRE-CRES	———	.020 DIA.	
5	COMPOUND	REDAR-FL-308-01	.015	
6	BRAID	-RTS-203-01	———	TREAT WITH BP-15
7	CEMENT	-FL-903-01	———	
8	CUFF	REDAR-S10293-1	———	ONE END ONLY

USED ON

REDAR-A10920		

SPECIFICATION CONTROL

DESCRIPTION

1¼ I.D. VITON WITH BETA GLASS COVER & VITON WASH

NASA PROJECT

DR. BR DATE 7/12/71 APP'D. FSC DATE 7/13/71

R. E. DARLING CO., INC.

BUILD PRINT DATA

REDAR-A90323 REV —

SHEET 1 OF 2

STEP 1: A. Blow tube onto mandrel.
B. Cello tube and cure in steam at 60 psi for 20 minutes.
C. Remove cello and remove tube from mandrel.

STEP 2: A. Pull vacuum on tube to expand it.
B. Place spring opened to 3 coils per inch inside of tube.
C. Release vacuum and place spring and tube on a 1¼ mandrel.

STEP 3: A. Wrap .020 cres wire on tube between spring convolutions.
B. Tie wire ends down and protect tube from ends.

STEP 4: A. Apply .015 thick layer of compound on hose ends outside of spring section.
B. Apply braid full length of hose.
C. Cello ends of hose over compound and braid.

STEP 5: A. Cure in hot air at 330°F for 30 minutes.
B. Remove cello and allow hose to cool.

STEP 6: When cool apply uniform coat of cement full length of hose and dry.

STEP 7: A. When dry remove from mandrel.
B. Post cure hose 24 hours at 400°F.

STEP 8: A. Cement cuff on one end of hose
B. Post cure 4 hours at 400°F.

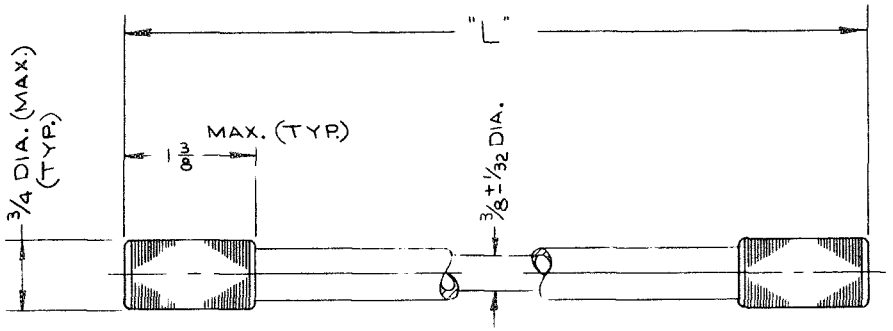
DESCRIPTION

1¼ I.D. VITON WITH BETA GLASS COVER

R. E. DARLING CO., INC.
BUILD PRINT DATA
REDAR-A90323 REV —
SHEET 2 OF 2

PART NO.	"L" DIM.
REDAR-A10922-1	26 1/8 ± 15/32

REVISIONS			
SYM	DESCRIPTION	DATE	APPROVAL



NOTES:

1. MATERIAL:
   HOSE - VITON, CRES WIRE REINFORCED
   OUTER COVER - BETA FIBERGLAS INPREGNATED WITH VITON
   PREMOLDED CUFFS - VITON
2. PART MARKING PER MIL-STD-130 PLUS MFD (QTR & YEAR)

REDAR-A10922

QTY. REQD	PART OR IDENTIFYING NO	ITEM	NOMENCLATURE OR DESCRIPTION	MATERIAL OR NOTE

LIST OF MATERIALS OR PARTS LIST

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
Tolerances on Fractions Decimals Angles

√

MATERIAL 1

SURFACE TREATMENT

DASH NO	NEXT ASSY	USED ON
APPLICATION		

SIGNATURE		DATE
DR	BR	6/21/71
CHK		
CARD		6/21/71
APPROVED		

REF NASA

R. E. DARLING CO., INC.
GAITHERSBURG, MARYLAND
TUCSON, ARIZONA

HOSE

CODE IDENT NO. | SIZE C | REDAR-A10922 | REV —

SCALE 1/1 | SHEET 1

REVISIONS

REV	DESCRIPTION	DATE	APP'D

BILL OF MATERIALS

ITEM	MATERIAL	PART NUMBER	SIZE	REMARKS
1	MANDREL	———	3/4 O.D.	CLEAN
2	SPRING	REDAR-C10163-43	.035 X .780	
3	TUBING	-C11208-2	.060 X .780	
4	CEMENT	-FL-903-01	———	
5	BRAID	-RTS-203-04	———	TREAT WITH BP-15
6	CEMENT	REDAR-FL-903-01	———	

USED ON

REDAR-A10921

SPECIFICATION CONTROL

DESCRIPTION

3/4 I.D. VITON WITH BETA GLASS COVER & VITON WASH
NASA PROJECT

DR. BR DATE 7/12/71 APP'D. FSC DATE 7/13/71

R. E. DARLING CO., INC.

BUILD PRINT DATA

REDAR® A90025 REV —

SHEET 1 OF 2

STEP 1: A. Thoroughly clean the building mandrel.
B. Spray mandrel with Releasa Gen H-15-1 and dry thoroughly.
C. After drying coat mandrel with soapstone dust.

STEP 2: A. Prestretch spring to 7 or 8 coils per inch.
B. Put spring on mandrel and tie down ends with strand of nomex.

STEP 3. A. Reverse tube onto mandrel over spring.
B. Wipe tube clean with clean dry rag, cello and remove cello.
C. Paint tube with uniform coating of cement full length.

STEP 4: A. Reverse glass braid over tube and cello down.

STEP 5: Cure in steam at 10 psi for 5 minutes then increase to 65 psi for 30 minutes.

STEP 6: A. When cool remove cello.
B. Apply uniform coating of cement full length of hose and let dry.

STEP 7: A. When thoroughly dry remove hose from mandrel.
B. Post cure 24 hours in hot air at 400°F.

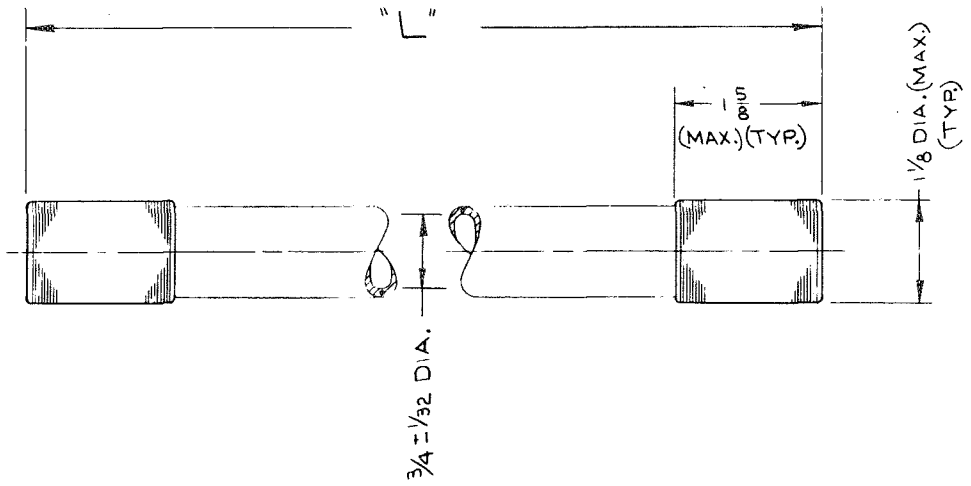
DESCRIPTION

3/4 I.D. VITON WITH BETA GLASS COVER & VITON WASH

H. F. DARLING [illegible], INC.
BUILD PRINT DATA
REDAR® A90025 REV —
SHEET 2 OF 2

PART NO.	"L" DIM.
REDAR-A10921-1	$43\frac{5}{16} \pm \frac{15}{32}$
" " -2	$23\frac{1}{8} \pm \frac{15}{32}$

REVISIONS			
SYM	DESCRIPTION	DATE	APPROVAL



NOTES:

1. MATERIAL:
   HOSE - VITON, CRES WIRE REINFORCED
   OUTER COVER - BETA FIBERGLAS INPREGNATED WITH VITON
   PREMOLDED CUFFS - VITON
2. PART MARKING PER MIL-STD-130 PLUS MFD (QTR & YEAR).

QTY. REQD	PART OR IDENTIFYING NO	ITEM	NOMENCLATURE OR DESCRIPTION	MATERIAL OR NOTE

LIST OF MATERIALS OR PARTS LIST

DASH NO.	NEXT ASSY	USED ON

APPLICATION

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
Tolerances on Fractions Decimals Angles
√

MATERIAL
1

SURFACE TREATMENT

REF.
NASA

	SIGNATURE	DATE
DR	BR	6/21/71
CHK	[illegible]	
CARD		6/21/71
APPROVED	[illegible]	7/[illegible]/71

R. E. DARLING CO., INC.
GAITHERSBURG, MARYLAND
TUCSON, ARIZONA

HOSE

CODE NO. 14452 | SIZE C | REDAR-A10921 | REV —

SCALE 1/1 | SHEET 1

REDAR-A10921

REVISIONS

REV	DESCRIPTION	DATE	APP'D

BILL OF MATERIALS

ITEM	MATERIAL	PART NUMBER	SIZE	REMARKS
1	MANDREL	———	3/8 O.D.	CLEAN
2	SPRING	REDAR-C10163-1	.032 X .375	
3	TUBING	-C11208-3	.060 X .380	
4	CEMENT	-FL-903-01	———	
5	BRAID	-RTS-203-05	———	TREAT WITH BP-15
6	CEMENT	REDAR-FL-903-01	———	

USED ON

REDAR-A10922

SPECIFICATION CONTROL

DESCRIPTION

3/8 I.D. VITON WITH BETA GLASS COVER & VITON WASH
NASA PROJECT

DR. BC DATE 7/12/71 APP'D. FSC DATE 7/13/71

R. E. DARLING CO., INC.

BUILD PRINT DATA

REDAR® A80633 REV —

SHEET 1 OF 2

STEP 1: A. Thoroughly clean the building mandrel.
B. Spray mandrel with Releasa Gen H-15-1 and dry thoroughly.
C. After drying coat mandrel with soapstone dust.

STEP 2: A. Prestretch spring to 7 or 8 coils per inch.
B. Put spring on mandrel and tie down ends with strand of nomex.

STEP 3. A. Reverse tube onto mandrel over spring.
B. Wipe tube clean with clean dry rag, cello and remove cello.
C. Paint tube with uniform coating of cement full length.

STEP 4: A. Reverse glass braid over tube and cello down.

STEP 5: Cure in steam at 10 psi for 5 minutes then increase to 65 psi for 30 minutes.

STEP 6: A. When cool remove cello.
B. Apply uniform coating of cement full length of hose and let dry.

STEP 7: A. When thoroughly dry remove hose from mandrel.
B. Post cure 24 hours in hot air at 400°F.

DESCRIPTION

3/8 I.D. VITON WITH BETA GLASS COVER & VITON WASH

R. E. DARLING CO., INC.
BUILD PRINT DATA
REDAR® A80633 REV —
SHEET 2 OF 2

R. E. DARLING CO., INC.
AERONAUTICAL SYSTEMS DIVISION
16021 INDUSTRIAL DRIVE, GAITHERSBURG, MARYLAND 20760, (301) 948-5920
AEROSPACE SYSTEMS DIVISION
3749 N. ROMERO ROAD, TUCSON, ARIZONA 85705, (602) 887-2400

COMPOUND DATA SHEET
REDAR®-FL-308

REDAR®-FL-308 is a nonflammable Viton® member of the fluoroelastomer family. The medium durometer of this material makes it more flexible than some other fluoroelastomers in the nonflammable field. The material also exhibits excellent resistance to many organic and inorganic fluids plus capabilities at high operating temperatures typical of most fluoroelastomers. It exhibits improved low temperature characteristics over REDAR®-FL-307 but it is not quite as flame resistant.

SPECIFICATIONS

Press Cure:	25 minutes at 320°F
Post Cure:	24 hours at 400°F

Unaged Physical Properties	Typical Values
Color	Brown
ASTM D-676 Durometer, Shore A	60 ± 5
ASTM D-412 Tensile Strength (psi)	1660
ASTM D-412 Elongation (%)	360
ASTM D-412 Specific Gravity	1.98
100% Modulus (psi)	275

DESIGN VERIFICATION TEST PROGRAM

After the screening tests had been concluded and the optimum fabrications had been selected, test hardware of the final configurations was manufactured. These parts were subjected to a complete Design Verification Test Procedure as specified in document REDAR-RQC-0148 submitted for approval on March 9, 1970 except a single test hose assembly was used. Following considerable discussion, this document was approved in January of 1971. A synopsis of the test program and required values follows. Additional characteristics and actual test results are contained in report REDAR-RTR-351.

I. A. Performance Characteristics (REDAR-A10920-1)

Leakage - 2.0 cc/hr/ft @ 4 psig

Flexibility endurance - 500 coils to 4" dia.
250 longitudinal twists

Compressive strength (175 lb.) - 30% max.
5% max. permanent set

Temperature increase - approx. $1^{\circ}F$/ft of length at
$25^{\circ}F$ temperature differential

Tensile loading - 60 lb. proof, 300 lb. ultimate

Delamination - 25 inches Hg.

Pressure - 8 psig proof

B. Environmental Conditions (REDAR-A10920-1)

Temperature range + 0°F to + 135°F

Pressure - 5 psi to 1 x 10^{-4} mm Hg.

II. A. Performance Characteristics (REDAR-A10921 and REDAR-A10922)

Leakage -

REDAR-A10921 - 2.0 cc/hr/ft @ 4.5 psig

REDAR-A10922 - 2.0 cc/hr/ft @ 53.0 psig

Flexibility endurance - same as REDAR-A10920

Compressive strength - same as REDAR-A10920

Pressure -

REDAR-A10921 - 9 psig proof

REDAR-A10922 - 106 psig proof

B. Environmental conditions for REDAR A10921 and REDAR-A10922 same as listed for REDAR-A10920.

CONCLUSIONS

The efforts expended under contract NAS9-10396 were quite fruitful. A number of concepts and materials deemed feasible at the outset of the program were found to be lacking when examined in the overall perspective of end item application. The final configurations are indeed more flexible and offer great assurance that delamination cannot occur. The designs are a significant departure from previous hose constructions although the techniques used were quite standard. The material selected for construction is new and offers considerably more protection from fire hazards than that presently in use.

SUBMISSIONS

This document and the accompanying Design Verification Test Report REDAR-RTR 351 comprise the final report required under contract NAS9-10396.

Under separate cover are prototype hoses of the three configurations which underwent the Design Verification Testing. One each part number REDAR-A10920-1, crew umbilical assembly, REDAR-A10921-1 and REDAR-A10921-2, PLSS oxygen hose and REDAR-A10922-1, PLSS water hose are being shipped on our packing slip number 1H-0002T. The REDAR-A10920-1 being submitted is the actual part which was subjected to the Design Verification Test procedure. This unit has been subjected to destructive testing and cannot be considered functional.