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Thiokol CHEMICAL CORPORATION

# PROPELLANT EXPULSION BLADDER FOR THE SATURN V/S-IVB

Report RMD 5125-Q4

Report Period: 13 August 1968 through 31 October 1968

Contract No. NAS8-21149





REACTION MOTORS DIVISION
DENVILLE, NEW JERSEY

SQ-50132

Thiokol
REACTION MOTORS DIVISION
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Control No.
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and SI (IF) S2(IF) and S3(IF)

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# FOREWORD

This report was prepared by Thiokol Chemical Corporation, Reaction Motors Division, Denville, New Jersey under Contract No. NAS8-21149, "Propellant Expulsion Bladder for the Saturn V/S-IVB" for the George C. Marshall Space Flight Center of the National Aeronautics and Space Administration. Mr. J. Schell is the Project Engineer.

This is the fourth quarterly report and covers the work conducted during the period 13 August 1968 through 31 October 1968 on RMD Project 5125.

The personnel of Thiokol Chemical Corporation, Reaction Motors Division assigned to the project were Mr. J. C. Dorfler, Mr. R. L. Heilman and Mr. D. Sinclair under the direction of Mr. H. C. Pickering, Jr. and Mr. N. Levine.

## ABSTRACT

Work has been resumed following a shutdown for program replanning. Development of a rubber-to-gold adhesive system is continued, using state-of-the-art adhesives and CNR liquid polymer. RMD drawings formalizing the RCS bladder design and a specification defining goldplating requirements have been submitted to NASA/MSFC for approval. A six-inch mandrel has been delivered to NASA/MSFC for plating. Additional development of the aluminum mandrel dissolving process was required to dispose of more resistant weld metal and a usable solution was found. Four RCS mandrels and all test rigs have been reworked as required.

CONTENTS

# ILLUSTRATIONS

## I. SUMMARY

The requirement for a nitrogen tetroxide resistant expulsion bladder with essentially zero permeability has led to the investigation of an electroformed gold/carboxy nitroso rubber laminate for this application.

All work was stopped for a three month period while the program was replanned and redefined.

Development of an adhesive system for bonding CNR to gold has continued, utilizing state-of-the-art adhesives and CNR liquid polymer to achieve better physical and functional uniformity.

Further development of the process for dissolving aluminum mandrels has yielded a solution effective for both the base metal and the weld metal.

RMD drawings formalizing the RCS bladder design and a specification defining goldplating requirements have been submitted to NASA/MSFC for approval.

One six inch diameter mandrel has been delivered to NASA/MSFC for goldplating. Four RCS mandrels have been reworked to prepare them for plating.

Rework has been completed on test rigs and the rotating spray rig.

## II. INTRODUCTION

Expulsion bladders are the most reliable and efficient device for metering propellants into a rocket engine thrust chamber under zero gravity conditions. Elastomers are ideally suited for this application; however, until recently their use was limited due to the unavailability of materials with the requisite resistance to propellants such as nitrogen tetroxide. The development of carboxy nitroso rubber (CNR) by Thiokol-RMD was a major milestone in this area. This material, which is resistant to $N_2O_4$, was characterized for expulsion bladder application in a company funded program and a subsequent USAF-AFML/NASA-MSFC jointly funded program. In the latter, CNR expulsion bladders closely approximating the Saturn V/S-IVB RCS configuration were successfully fabricated and tested.

The desirability of an impermeable bladder for the Saturn V/S-IVB RCS application prompted the study of metal foil/CNR laminates in the aforementioned program. Since all polymeric materials are permeable to liquids and gases, the use of a flexible metallic liner is necessary to prevent permeation. Thiokol-RMD demonstrated the suitability of electroformed gold/CNR laminates for zero permeability propellant storage although results were limited by poor adhesion between CNR and gold.

The objective of this program is the fabrication and demonstration testing of composite electroformed gold/CNR full scale Saturn V/S-IVB

RCS configuration bladders. In the execution of this goal, Thiokol-RMD will:

1. Characterize the material properties of CNR, electroformed gold and laminates thereof, for bladders for the Saturn V/S-IVB-LEM mission.

2. Classify bladder failure modes.

3. Determine design criteria for both vertically and horizontally oriented bladders by testing full scale bladders.

4. Determine bladder safety margins, as possible within the scope of the testing program.

5. Demonstrate full scale bladder characteristics when tested using $N_2O_4$.

Work on this program was stopped from mid-May 1968 until mid-August 1968. During this time the program status and scope was reviewed and revised. Reference A provides details of the revised program plan.

## III. TECHNICAL DISCUSSION

### A. Back-up Adhesive Study

During previous reports, we discussed the promising adhesion which was obtained with an epoxy adhesive (Shell 871 and 828 cured with Resin Z). Pulverized CNR, as a filler in this adhesive system, provided a CNR-to-gold bond yielding laminates which showed excellent $N_2O_4$ permeation resistance (a level too low for detection) when a pinhole was intentionally placed in the gold foil. Difficulty was encountered, however, in attempts to reproduce the promising bond strength (8 - 9 pli) when CNR was ground to the fineness desired for practical application.

Several other adhesive systems also appeared promising in previous studies and CNR liquid polymer is now readily available for adhesive evaluation. Therefore, a comprehensive investigation is currently underway, including the most promising state-of-the-art adhesives and liquid and gum CNR adhesive formulations. In addition, various surface priming techniques are being studied. The best CNR/gold foil adhesive and primer systems will be selected and optimized (by modification of techniques and formulation). Selection and data will be discussed in the next report and subsequently evaluated on the six inch prototype bladder.

### B. Specifications and Drawings

RMD Specification 7193 defining goldplating requirements for aluminum mandrels has been submitted to NASA/MSFC for approval. Approval will provide agreement on the adequacy of the definition and on NASA/MSFC ability to provide the required plating service as defined by contract. It is understood that approval will be contingent upon the successful plating of the six inch mandrel.

The following RCS mandrel and bladder drawings formalizing the bladder design have been submitted to NASA/MSFC for approval:

| | |
|---|---|
| SE-1032 | Mandrel |
| X427901 | Bladder |

C. Mandrel Dissolving Solution Development

Extensive work has been done during the program to establish an adequate procedure for dissolving the aluminum mandrel out of the completed bladder. This problem has been complicated by the chemical resistance of the mandrel weld alloy to the original solution selected, Oakite No. 30. Test data reported in RMD Report 5125-ML-9 showed that solutions of Oakite No. 130 at a concentration of 0.5 lb/gallon of water satisfactorily dissolved both mandrel base metal and weld metal, and therefore has been selected as the proper solution. An additional test will be made using a full size spare mandrel, prior to attempting dissolution of the mandrel from the first completed RCS bladder.

D. Fabrication and Tooling

A six inch diameter mandrel was polished to a mirror finish and submitted to NASA/MSFC for goldplating. A similar but unpolished mandrel is shown in Figure 1.

The RCS size mandrels were reworked to eliminate the flange holes, then sent out for pre-plating polishing by the original goldplating vendor. The first polished RCS mandrel is shown in Figure 2.

A fixture designed to securely hold an RCS mandrel and rotate it at a controlled rate while spraying with rubber has been completed and is shown in Figure 3.

The plexiglas test tank (PN X318429) has been assembled for the first time to demonstrate fit and function. It is shown in Figure 4.

Modification of the horizontal slosh rig (PN 318133) has been completed. The rig is shown in Figure 5.

Figure 6 illustrates the vertical twist rig (PN 318134). The same power cylinder will be used to actuate both the slosh rig and the twist rig.

## IV. PROGRAM STATUS

The operating schedule attached to the back of this report has been updated to illustrate program status in terms of technical accomplishments and also manhours expended as of October 31, 1968.

## V. ANTICIPATED WORK

Continue work on epoxy-liquid CNR candidate systems using latest batch of liquid CNR.

Complete polishing of RCS mandrels and ship to NASA/MSFC for plating.

Attempt bladder spraying using neoprene as a CNR simulant.

Continue fabrication of bladder handling fixtures. Initiate preparation of test plans for six inch and RCS bladders.

## VI. REFERENCES

Reference A - Letter Defense Contract Administration Services District, Newark, N. J., Attention Mr. W. Calabrese from Thiokol-RMD dated 7/15/68 (NASA/MSFC 6401A).

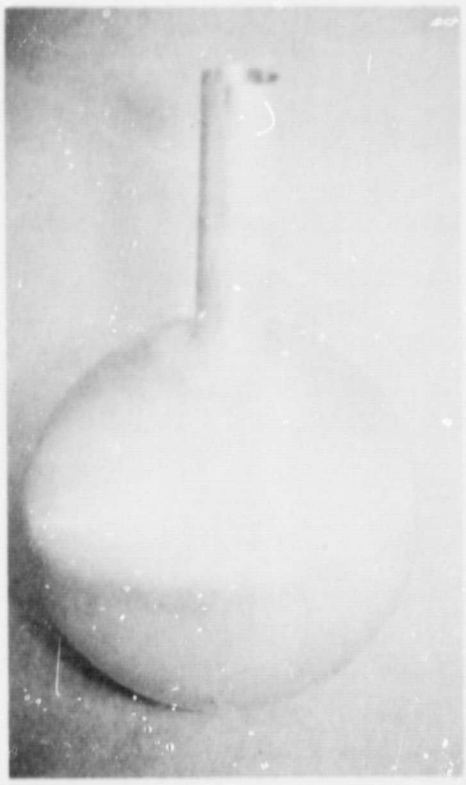

Figure 1 Six Inch Diameter Mandrel

Figure 2 RCS Size Mandrel, Polished for Plating
(P/N SE-1032)

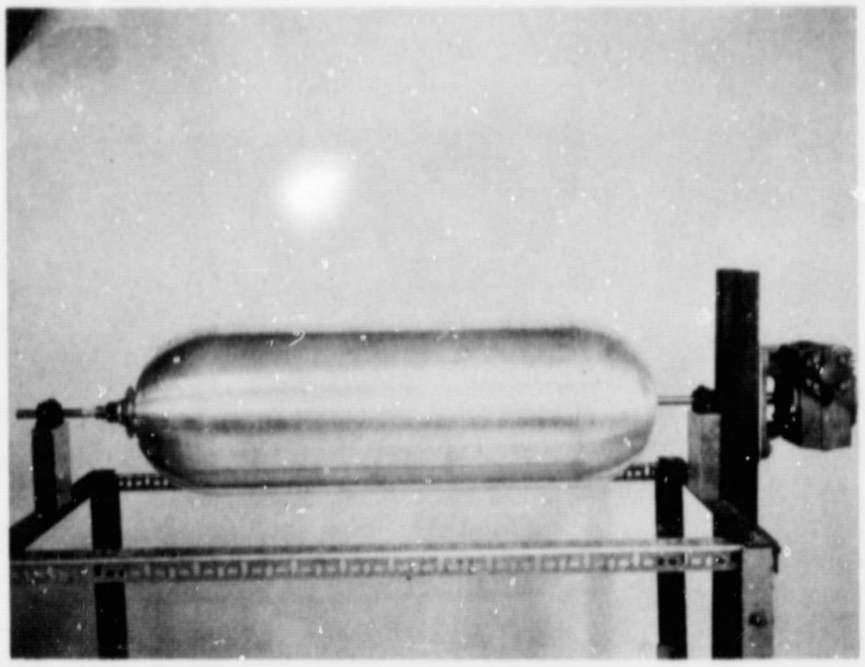

Figure 3 Rotating Fixture for Spraying

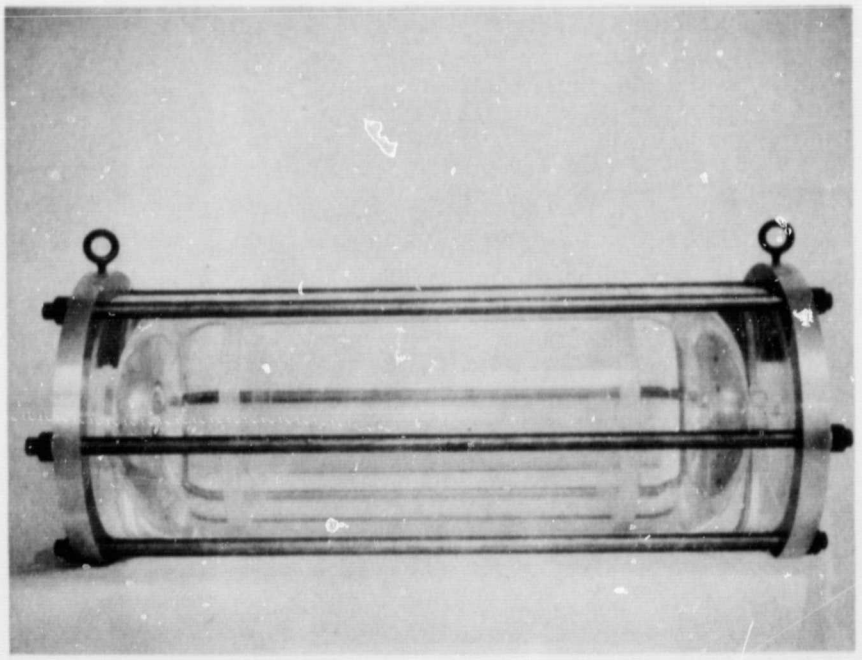

Figure 4 Test Tank Assembly (P/N X318429)

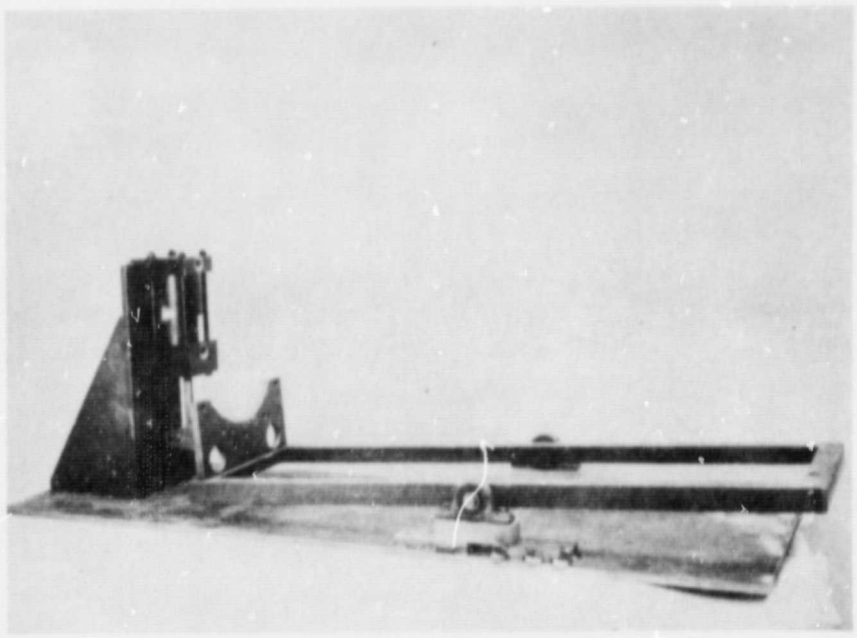

Figure 5 Horizontal Slosh Rig (P/N X318133)

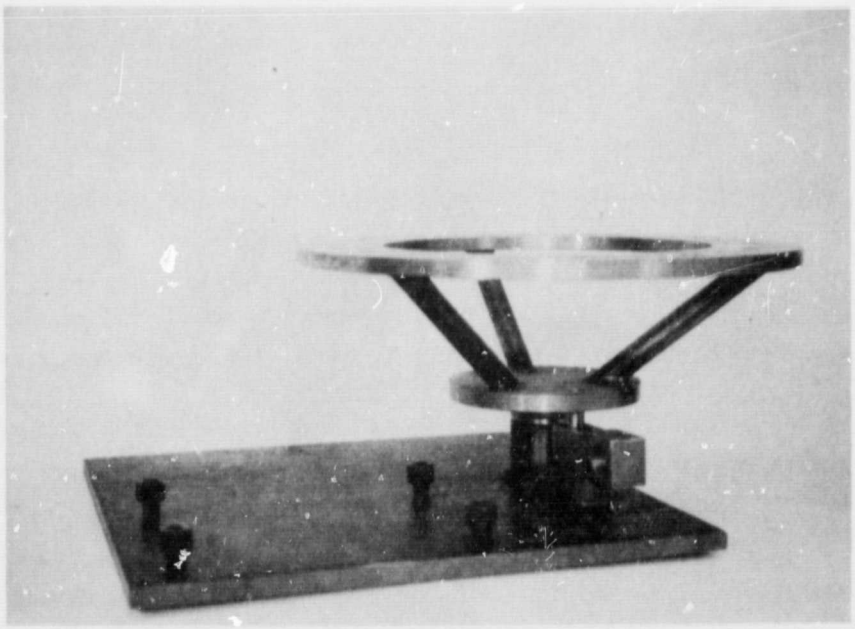

Figure 6 Vertical Twist Rig (P/N X318134)
Note: This rig will utilize the power cylinder shown in Figure 5.

# H

◇ NASA Action/Approval

## OPERATING SCHEDULE

LEGEND
BASIC SCHED. ▭ REV. COMPL. △
REV. START ▽ ACT. START & COMPL. △

| PHASE I | 1968 AUGUST | SEPT |
|---|---|---|
| TASK I - MATERIALS AND FABRICATION | | |
| A. Back up Adhesive Study - Liq. Polymer/Epoxy Test Sample Fabrication and Test | ▽ | |
| B. Physical Properties - Complete | | |
| C. Specifications - Product and Process | ▽ | |
| D. Mandrel Dissolving Solution Dev. | ▽ | |
| E. CNR Coating Technique Evaluation | | |
| TASK II - BLADDER DESIGN AND TOOLING | | |
| A. Dwgs. - RCS Bladder; Mandrel | ▽ | |
| B. Mandrels: | | |
| 1. 6 Inch - Rwk. to Accom. Standpipe (1 pc) | | |
| 2. RCS - Inspect (6 pcs) and Rwk. (5 pcs) | | |
| C. Mandrel Dissolving Tooling Rwk. | | |
| D. Rotating Fixture (for Spray, Op. ) Design and Fab. | | |
| E. Bladder Handling Fixture - Design and Fab. (3 pcs) | | |
| F. Bladder Port Trimming Tools - Leak Test Fixture - Design and Fab. | | |
| G. Plastic Tank - Procure Small Parts - Fab. Wood Stand | | |
| H. Vertical Twist Rig Rework | | |
| I. Horizontal Slosh Rig Rework | | |
| TASK III - BLADDER FABRICATION | | |
| A. 6 Inch - Using Liq. Polymer Adh. (1 pc) | | |
| B. RCS - Neoprene; Partial Size (6 pcs) | | |
| C. RCS - Gold Plate/CNR (4 pcs) | | |
| TASK IV - BLADDER TESTING | | |
| A. Test Plan - RCS Bladders | | |
| B. 6 Inch - Permeation and Flexture (1 pc) | | |
| C. RCS - Gold Plate/CNR (Design Compliance Test) | | |
| 1. Non-Destr. Test (3 pcs) | | |
| 2. Destr. Tests (1 pc) | | |

| MPL. RT & MPL. | PROJECT | PHASE | TASK | OPER. | PAGE | DATE | COMPONENT |
|---|---|---|---|---|---|---|---|
| | | | | A.I. | | 10/31/6[illegible] | |

SEPTEMBER | OCTOBER | NOVEMBER | DECEMBER | JANUARY

GOLD PLATE

GOLD PLATE

A B C D

OPERATING SCHEDULE

LEGEND
BASIC SCHED. REV. COMPL.
REV. START ACT. START & COMPL.

PROJ

1968

| | AUGUST | SEPTEM |
|---|---|---|
| TASK IV - BLADDER TESTING (Cont.) | | |
| D. Functional Test - In Plastic Tank with Water - ~~1 RCS Bladder~~ | | |
| 1. Fill, Twist and Expulsion Tests - Vertical Attitude | | |
| 2. Slosh Tests - Horizontal Attitude | | |
| E. Functional Tests with $N_2O_4$ - In RCS Tank | | |
| TASK V - DESIGN REVIEW AT RMD | | |
| TASK VI - REPORTS | | |
| (Q - Quarterly; M-Monthly; F - Final) | | M |
| Planned Manhours | CUM 9/1/68 4131 | |
| Actual Manhours | | |
| | | 30 |

#B

| PL. & L. | PROJECT | PHASE | TASK | OPER. | PAGE | DATE | COMPONENT |
|---|---|---|---|---|---|---|---|
| | 1 | | | ALL | | 10/31/68 | |

SEPTEMBER | OCTOBER | NOVEMBER | DECEMBER | JANUARY

M M Q M M F DRAFT

608 4739 | 442 5181 | 415 5596 | 287 5883 | 39 5922

9/30 10/31