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JPL Contract 951709

# STERILIZABLE LIQUID PROPULSION SYSTEM

## Eighth Quarterly Progress Report


Author
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January 1969




MARTIN MARIETTA DENVER DIVISION

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Denver, Colorado 80201



This work was performed for the Jet Propulsion Laboratory, California Institute of Technology, sponsored by the National Aeronautics and Space Administration under Contract NAS7-100.

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Program Manager

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DENVER DIVISION
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## FOREWORD

This document is the eighth issue of the Quarterly Progress Report and is submitted in accordance with Article 1(a)(1)(v)(H) and 2(c)(3) of modification No. 1 to JPL Contract 951709.

CONTENTS

## I. INTRODUCTION

This is the eighth quarterly progress report submitted in accordance with JPL contract 951709. This report covers the period from 1 October through 31 December 1968.

The program involved the design, assembly and exposure of the fueled bipropellant liquid propulsion system to the ethylene oxide (ETO) and heat sterilization environments specified by JPL specification VOL50503 ETS. After exposure, the system was successfully fired for 280 seconds. The program was supported by a materials compatibility test program and component verification program wherein suitability of all selected components was demonstrated prior to the system assembly.

Under an extension to the contract the system will be refurbished, submitted to additional heat sterilization and fired again. Design changes will be made to the oxidizer tank and expulsion diaphragm during the rebuild period. In addition the fuel tank screen trap will be modified to eliminate two-phase flow from the tank when expelling in a negative 1-g regime.

During the report period negative -one g (-1g) single phase outflow tests of the feed tank were successfully completed. The material test program was initiated with 25 specimens starting a 600 hour exposure in $N_2O_4$ at 275$^\circ$F on December 20th 1968.

The oxidizer tanks due for delivery in late December were not delivered as scheduled. During the assembly of the tanks the Teflon diaphragms were found to be small and in an attempt to fit them to the tank wall by modest stretching the diaphragms ruptured. See section IV for the complete history.

## II. CONCLUSIONS

As a result of the work performed during this period the following conclusions can be made.

1. The inflation pressure normally used to establish membrane stability for dimensional checks of the diaphragms causes approximately 1.5% stretch

2. Providing an additional stretch from this reference of 2% lead to the failure of both diaphragms

3. The application of heat enabled the diaphragm to stretch. Continued application of the pressure differential after removal of the heat caused diaphragm S/N 101 to rupture

4. The design of the girth seal has been adequately demonstrated

5. Some degradation of the Teflon membrane was evident in the area of membrane to girth flange ring heat seal

6. Fabrication of Teflon shapes involves estimates of shrinkage resulting from the repeated curing of laminates which must be more understood

7. The trap device installed in the fuel tank successfully provides single phase liquid outflow in a negative 1g regime. Trap devices are a proven method for propellant control and may be incorporated in future vehicle designs.

## III. RECOMMENDATIONS

1. Future designs of Teflon of diaphragms, bladders and other devices should provide for line to line wall contact with less then 1 percent inflation.

2. An indepth program should be initiated to understand the behavior of Teflon when exposed to heat and propellants. Immediate attention should be directed to degradation of physical properties such as elasticity, yield strength and shrinkage after exposure to heat and pressure.

3. Screen traps devices for propellant management may be employed in future vehicle designs.

# IV. GENERAL REPORT

## A. FUEL TANK

The modified fuel tank was received at the Martin Marietta Corporation in November 1968. The modifications included increasing the outflow area beneath the propellant trap so that the calculated flow pressure drop was reduced from 1.5" $H_2O$ to 0.13" $H_2O$; improved design to eliminate a riveted closure plate; and sealing of the riveted ring plate with sodium silicate.

The propellant tank was mounted in the component test fixture for testing according to procedures developed during phase II of the program. Seventy-four (74) pounds of monomethyl hydrazine were loaded into the tank through successive filters of 5 and 2 microns. The tank was inverted to overfill the trap eliminating any possible bubble resident below the trap in its normal positive 1g orientation. Off-loading the tank in a normal 1g regime to provide the normal fuel load of the tank was accomplished resulting in a net load of 49 pounds. This assured the trap was not submerged when inverted and was indeed retaining the trapped volume of propellant in -1g condition. Minus 1g outflow was completed showing a single phase liquid outflow at a flow-rate of 0.13 pounds per second. A fuel volume of 520 cc was discharged as determined by collection in a 1000 ml graduate cylinder.

The computed volume of the trap to the level of the window sectors was 347 cc. The total volume within the tank and outflow system below the trap weld attachment point is 607 cc. Allowing for 5 cubic inches of trap volume results in a net volume of 530 cc., Fig. 1. This would indicate the fuel located outside the trap was swept out in the discharge. The events were recorded on film for future presentations.

The tank was then purged with nitrogen and baked at 150°F for eight hours. Following this procedure the unit was capped and put into storage until the module is reassembled.

## B. OXIDIZER TANKS AND DIAPHRAGMS

### 1) Diaphragm Failures

During the final tank assembly activities a major problem was encountered. The Teflon diaphragm to be installed inside the oxidizer tank was purposely designed 2% undersize to provide for a modest stretch in the actual tank useage at the sterilization temperature of 275°F with $N_2O_4$ loaded in the tank. The 2% stretch was implemented as a result of the earlier component tank testing. In that test some wrinkling of the membrane was evident after the sterilization when the slightly oversize diaphragm was subjected to the $N_2O_4$ vapor pressure of 800 psia at 275°F. The 2% stretch was implemented at the suggestion of Bell Aerosystems and the vendor experience.

When the final steps were taken to seat the diaphragm inside the hemisphere wall the diaphragm took a permanent set such that the

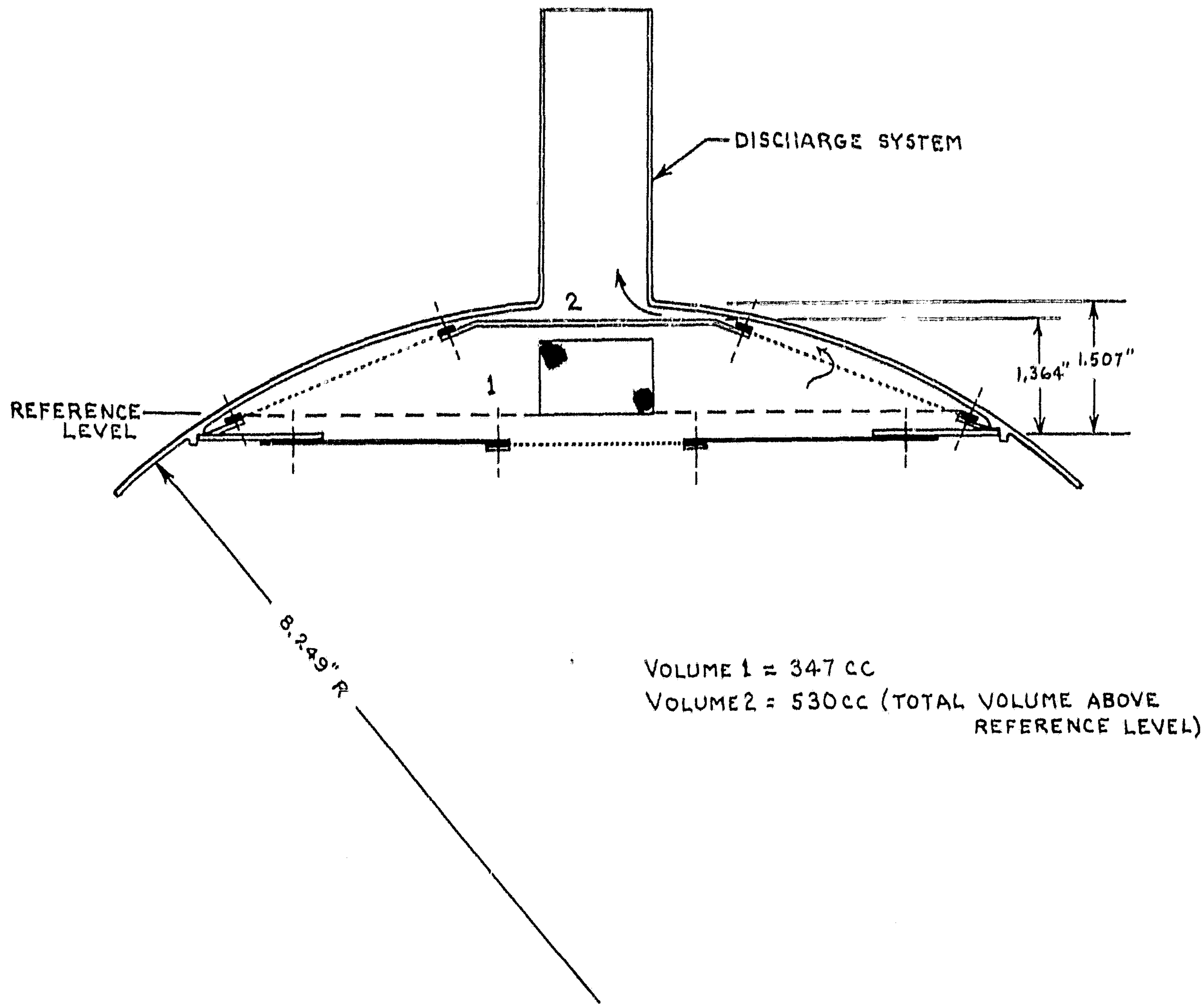



FIGURE 1. FUEL TANK TRAP VOLUMES

minimum section thickness was less than 1/3 its original value. When the remaining diaphragm was installed in the tank in a heated condition it survived the initial stretching operations and leak check; however, preliminary checks prior to formal acceptance testing indicated a se[illegible]re leak in the diaphragm. Subsequent tank disassembly showed the substituted unit had a small hole approximately 1/16" in its greatest dimension.

The failure was characterized by stretching of the diaphragm around approximately 75% of the circumference as indicated by a white streak. In the one case a small hole developed, while in the original unit a hole did not develop. Figure 2 shows the general arrangement of the propellant tank weld area, and the point of failure of the diaphragm. The photographs of the failures are shown in Figures 3 and 4.

2) Steps of Diaphragm Installation and Tank Welding

The program requires that two oxidizer tanks be fabricated each containing a Teflon hemispherical diaphragm. One tank was adapted with the peculiar fittings for assembly into a complete bipropellant propulsion system, the remaining tank was fitted with normal "AN" type tube ends to be used as a work horse component tank. The assembly steps leading to the failure of both diaphragms are described in the following paragraphs.

Diaphragm serial number 102 was selected for assembly into the system tank, or module tank because the flange to membrane seal appeared to be in a better conditon. The diaphragm was placed in the upper tank hemisphere and fitted with the retainer ring to hold it in

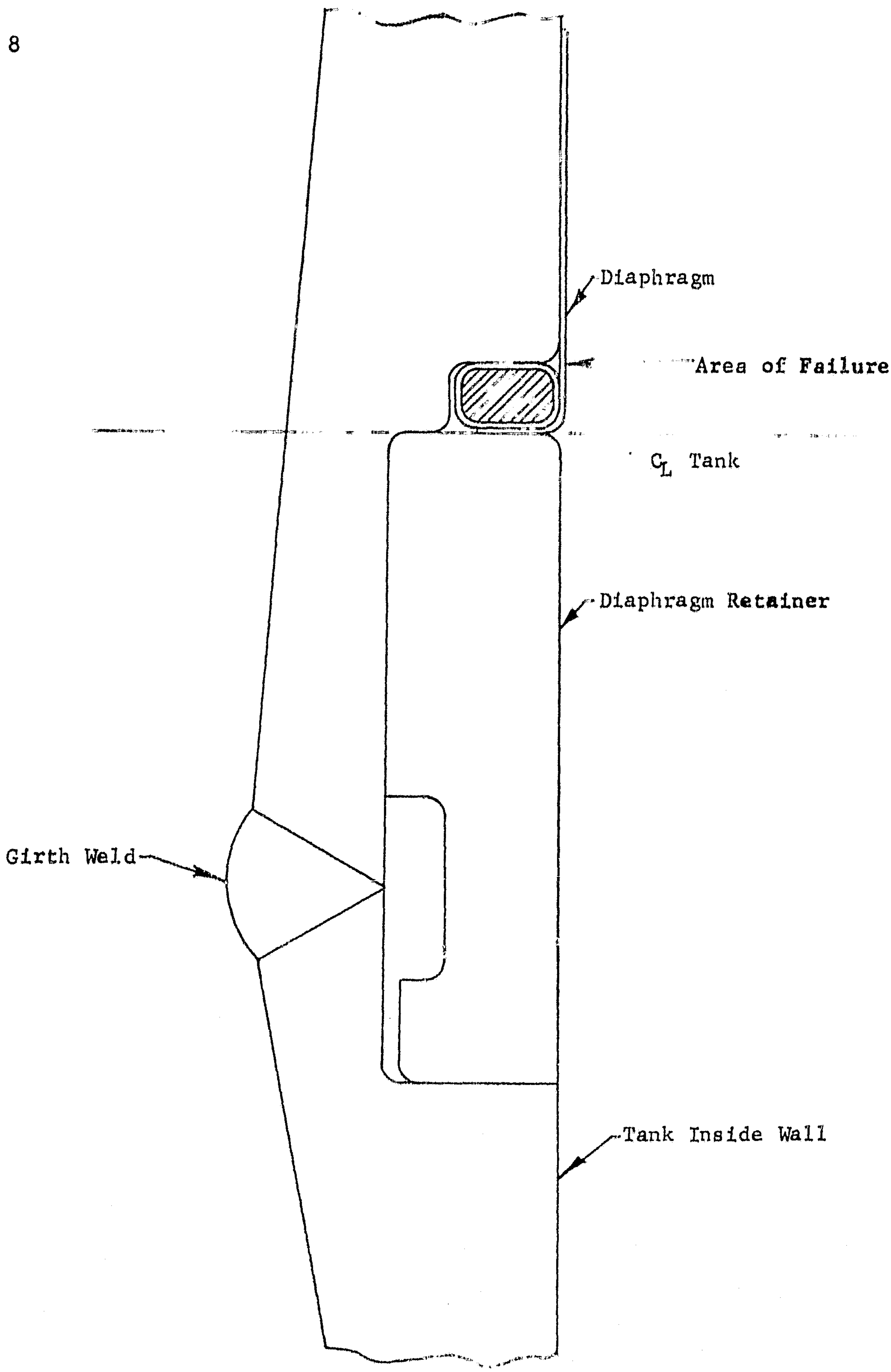



Figure 2. Oxidizer Tank Diaphragm Retainer Joint Design

place. This provided a vacuum tight seal. A vacuum was then drawn behind the diaphragm to stretch it into place. When a vacuum of 20 inches of mercury was reached the diaphragm began to stretch beyond the elastic limit around the girth area as indicated by a white coluration.

The assembly process was immediately stopped and the diaphragm removed. The wall thickness of the Teflon diaphragm was determined to be 0.003 inches as compared the nominal figure of 0.010 inches.

A conference was held with the vendor, Dilectrix Corp of Farmingdale, N. Y. During that conference it was suggested that the remaining diaphragm be heated in the upper dome area of the diaphragm to induce a uniform stretch into the tank hemisphere. The vendors experience with this type of a diaphragm configuration indicated that a stretch up to 4% at room temperature had been obtained. With this knowledge plus the application of heat to the tank wall we had every reason to believe the second diaphragm, S/N 101 would be satisfactory. The diaphragm and tank walls were heated with a hot air gun to approximately 160 to 180°F. The lower half was then assembled and clamped into position. Sufficient force was applied to draw the tank halves to a gap distance of 0.010" for welding.

Vacuum was then applied to the upper hemisphere that was at the elevated temperature. A pumping rate of 0.5" hg. per minute was obtained and the vacuum successfully reached 29.5" hg. The tank was then isolated by closing the in-line valves and the pump removed and the system capped. The tank isolation valve was then reopened and the pressure reading dropped from 29.5" to 6" hg. It was then observed for 10 minutes and the readings held steady indicating no leak in the tank either at the girth seal or through diaphragm membrane. The vacuum system was then reinstalled and 29.5" hg vacuum was re-established.

The tank was then installed in the small vacuum chamber and the girth area was tacked welded to assure no degradation of the seal. When this tack welding operation was complete a differential pressure had been on the diaphragm for 3 hours. The tank was then installed in the large automatic welding chamber with both ends uncapped. The pressure was reduced to a hard vacuum in approximately 1 hour. While it was observed by the operator that the outgassing of the lower half exceeded that of the upper half, the differential pressure was in the direction to seat the diaphragm and not cause it to fold through. Because of the large volume of the chamber and tank the differential pressure developed during pumpdown was not considered significant.

Normal weld procedures were then implemented. Weld X-ray were examined carefully and there was no evidence of any weld porosity and the weld was judged successful.

Preliminary leak checks were then attemped prior to delivery to Wyle Laboratories for formal acceptance tests. The leak check was performed with gaseous nitrogen and an unrestrained flow was developed indicating a severe leak.

When the leak was discovered the tank was filled with alcohol until the level of the leak was determined. Before and after weight determinations showed the leak was in the girth area. The tank was then cut open for examination and the condition of the failure is shown in Figures 3 and 4 shown in a 10 x magnification.

3) Dimensional Checks

A review of the various pertinent dimension was made following the failures of the diaphragms. Figure 5 shows the outline of the diaphragm and the applicable dimensions. The basic tank radius was checked and determined to be 8.250 inches and within the required tolerances. The diaphragms were measured with the results shown below in Table I.

TABLE I

DIAPHRAGM RADIUS, INCHES

| | Relaxed | Inflated | Required |
|---|---|---|---|
| S/N 101 | 7.985 | 8.080 | 8.080±.005 |
| S/N 102 | 7.950 | 8.078 | 8.080±.005 |

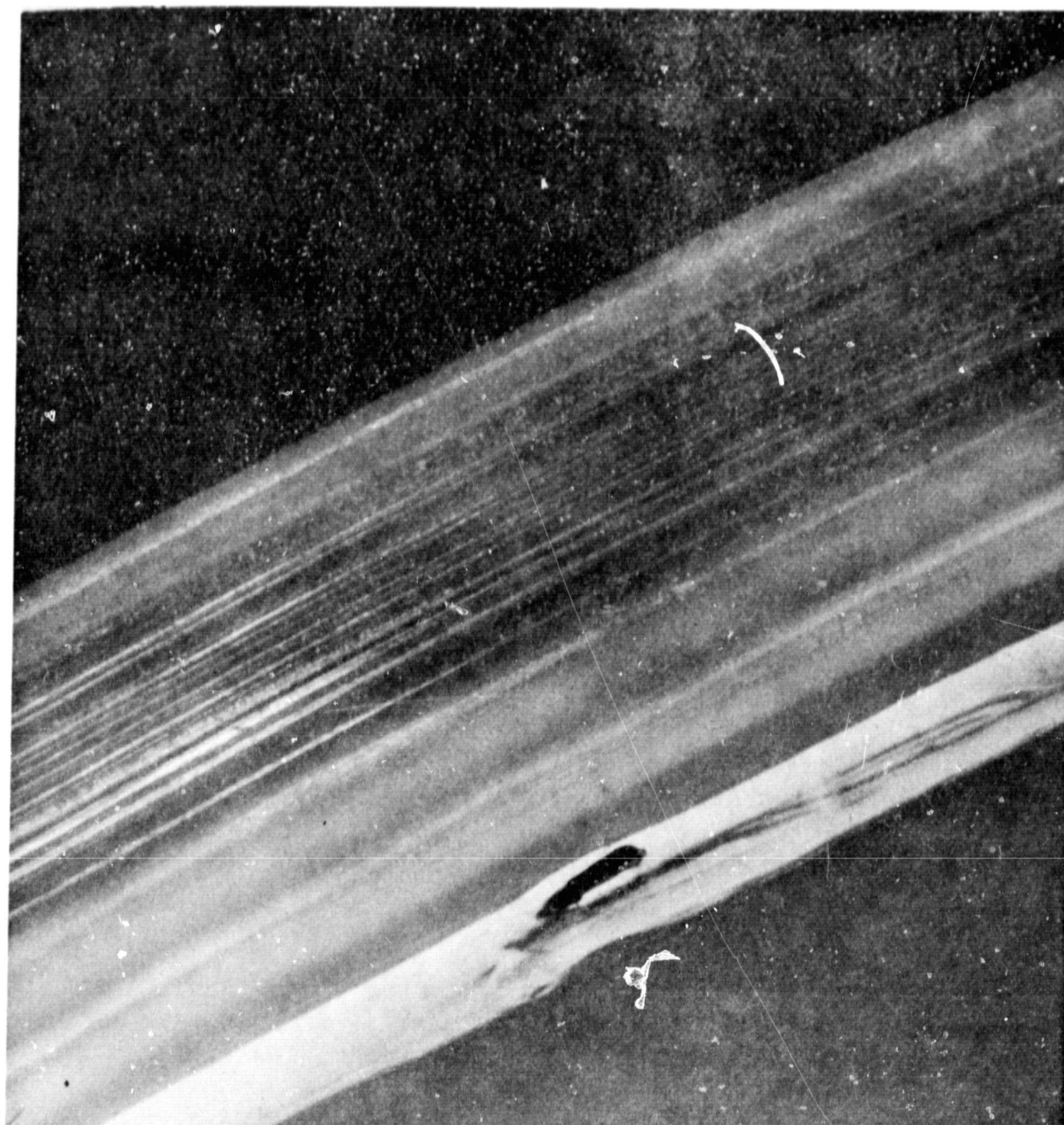


FIGURE 3. OXIDIZER DIAPHRAGM FAILURE AREA

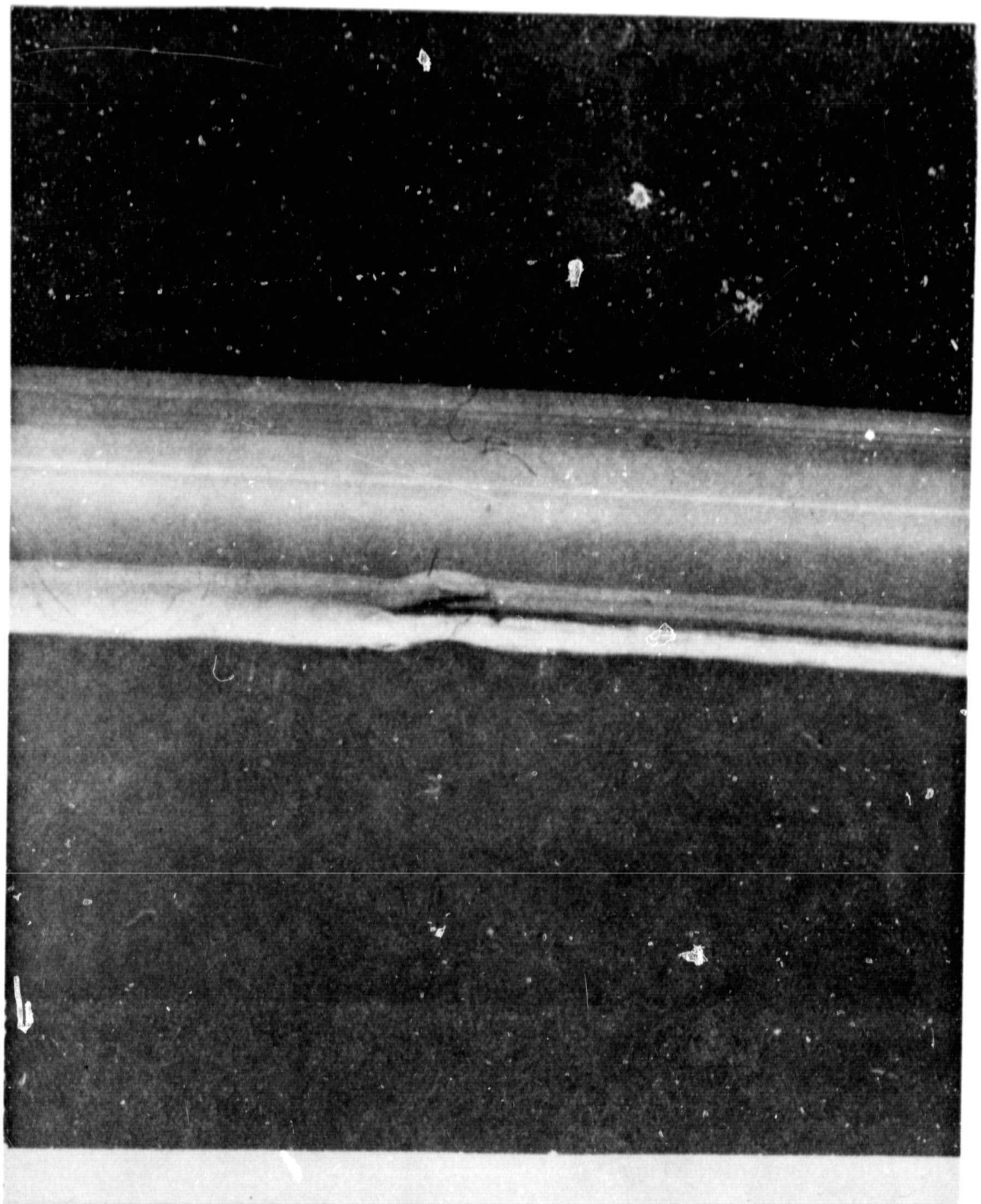
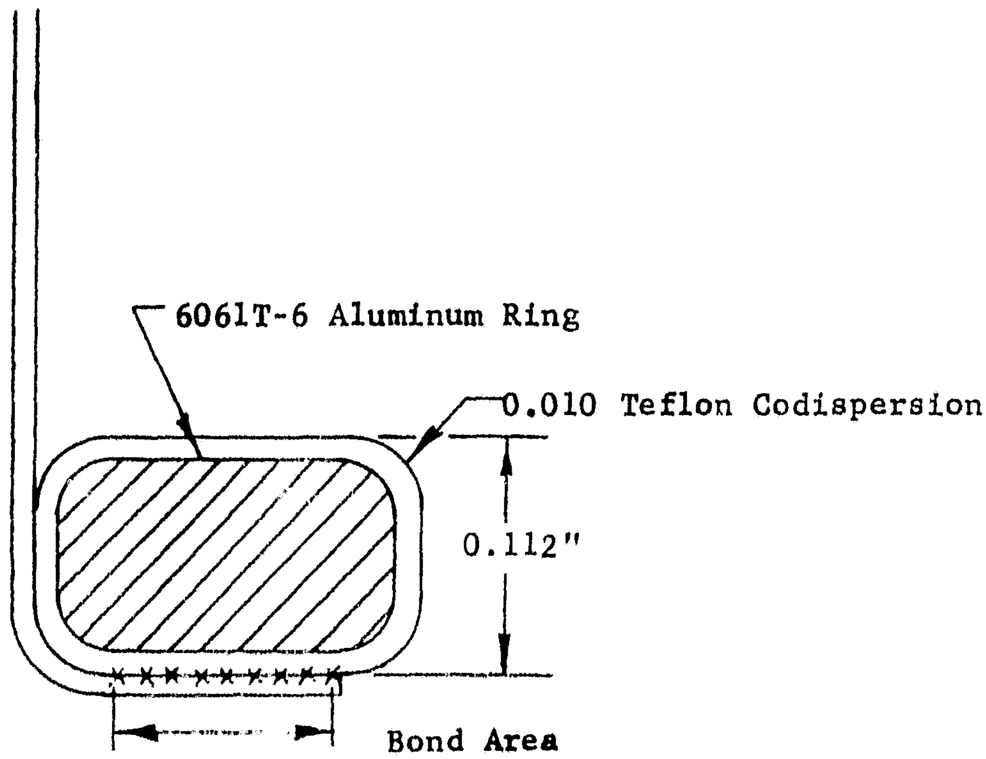


FIGURE 4. OXIDIZER DIAPHRAGM FAILURE AREA




A Cross Section

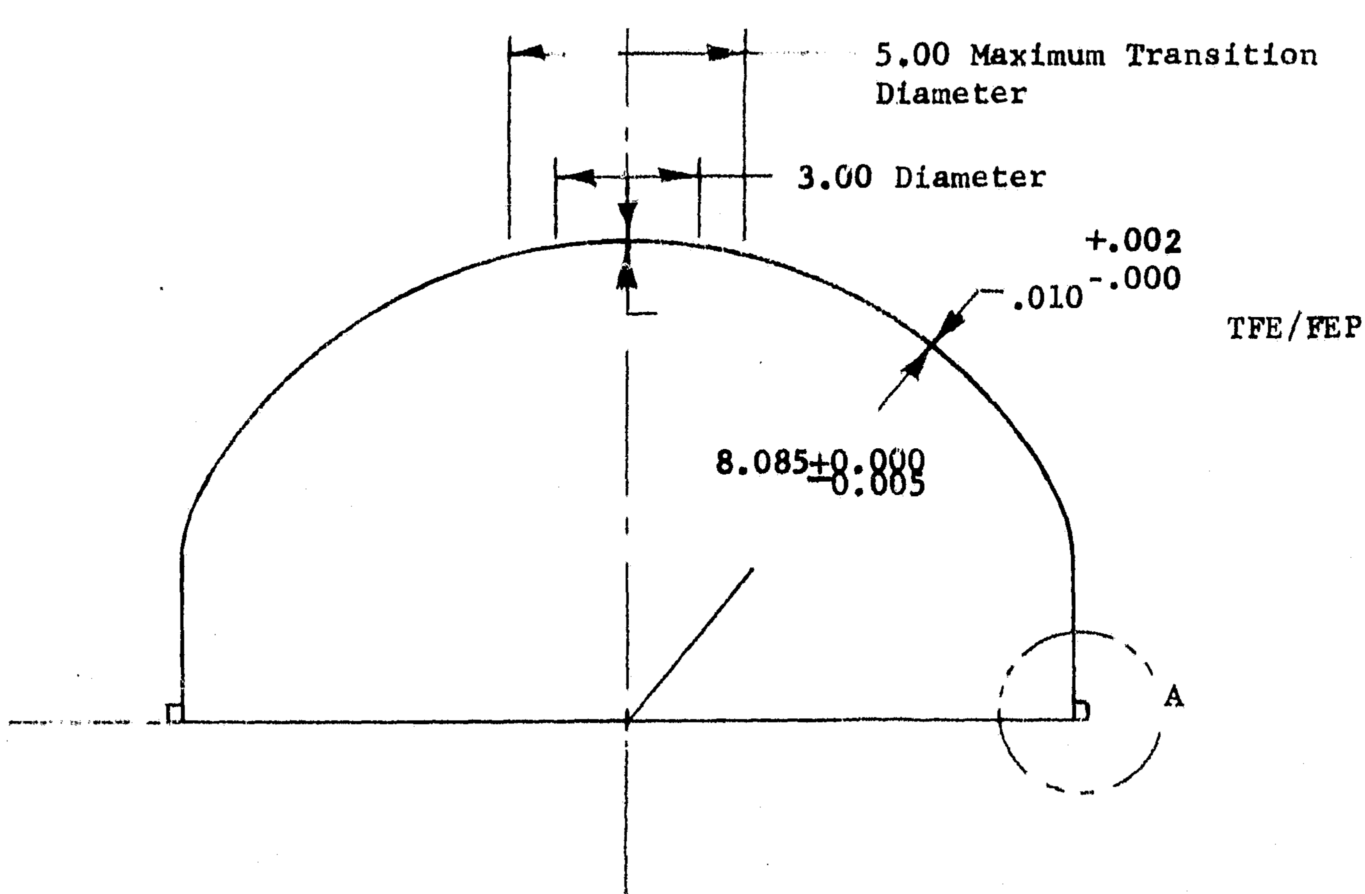



Figure 5. Oxidizer Tank Diaphragm Design

The acceptance test plan allows an inflation pressure of 0.4±0.1 psi to provide a stable membrane for the dimensional checks.

The S/N 101 diaphragm was sectioned for further examination. Figure 6 shows the condition of the seal area. Close examination and measurement show the membrane thickness to be within drawing tolerance except for the local failure area.

Before the failure Table I above shows that an inflation pressure of 0.4 psi causes an increase in radius of 0.128 inches or approximately 1.5%. After the failure a similar check was made which indicated 0.4 psi inflation increased the radius 0.162 inches reflecting some degradation due to the failure and approaching 2% of the basic dimension.

4) Seal Performance

During the fabrication of the diaphragms some difficulty was experienced in obtaining a heat fusion of the membrane to the flange ring. The ring was coated with codispersion Teflon with a thin coating of FEP applied as the final spray on the bottom of the ring. This was to provide a positive heat seal between the codispersion ring and the laminated membrane. The sealing of the first diaphragm was extremely difficult and the heat sealing operation was repeated several times before a leak tight seal was obtained. Some blistering of the seal area was evident. Table 2 shows the seal thickness measurements before and after rework.

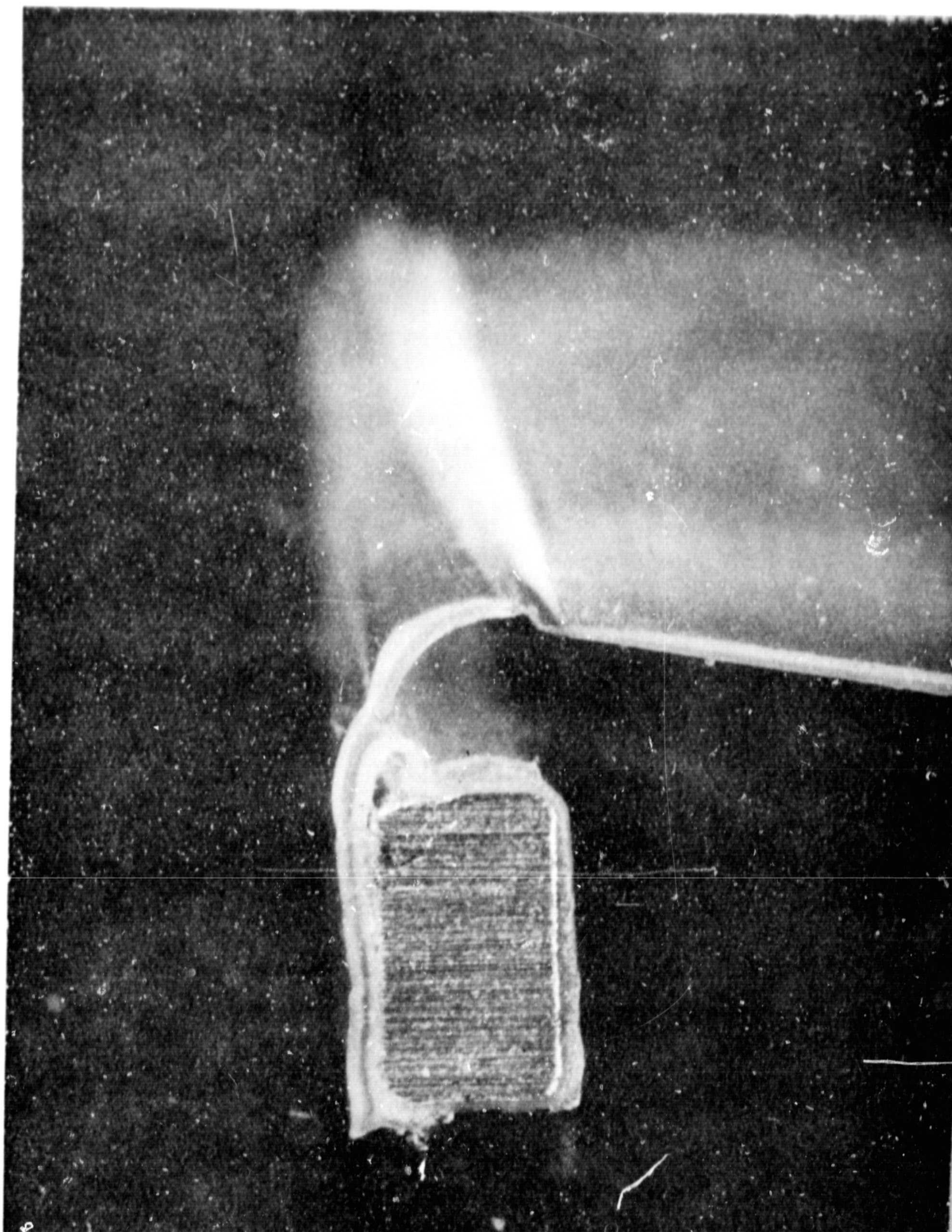


FIGURE 6. OXIDIZER GIRTH SEAL-SECTIONED VIEW

When the units were assembled into the tank hemispheres and retainer ring installed no problems were encounted with the girth seal. When the tank was cut open to examine the ruptured diaphragm there was no leakage through the serrated girth seal. This demonstrated the fundamental adequacy of the seal design.

TABLE II

DIAPHRAGM RIM THICKNESS

| Station | S/N 101 As Received | S/N 101 After Rework | S/N 102 As Received | S/N 102 After Rework |
|---|---|---|---|---|
| 1 | 0.1145 | 0.1145 | 0.115 | 0.114 |
| 2 | 0.116 | 0.115 | 0.114 | 0.113 |
| 3 | 0.116 | 0.115 | 0.1145 | 0.114 |
| 4 | 0.1155 | 0.115 | 0.115 | 0.114 |
| 5 | 0.117 | 0.1155 | 0.114 | 0.114 |
| 6 | 0.1152 | 0.115 | 0.115 | 0.114 |
| 7 | 0.115 | 0.115 | 0.115 | 0.114 |
| 8 | 0.1145 | 0.1145 | 0.1155 | 0.114 |
| 9 | 0.1155 | 0.115 | 0.1165 | 0.114 |
| 10 | 0.1148 | 0.1148 | 0.1163 | 0.114 |
| 11 | 0.114 | 0.114 | 0.1163 | 0.114 |
| 12 | 0.1145 | 0.1145 | 0.115 | 0.114 |
| 13 | 0.1142 | 0.1142 | 0.112 | 0.112 |
| 14 | 0.1152 | 0.115 | 0.113 | 0.113 |
| 15 | 0.1155 | 0.115 | 0.1138 | 0.1135 |
| 16 | 0.116 | 0.1155 | 0.114 | 0.114 |
| 17 | 0.1155 | 0.115 | 0.115 | 0.114 |
| 18 | 0.117 | 0.1155 | 0.116 | 0.114 |
| 19 | 0.1162 | 0.1155 | 0.116 | 0.114 |
| 20 | 0.1152 | 0.1152 | 0.116 | 0.114 |
| 21 | 0.115 | 0.115 | 0.115 | 0.114 |
| Max. | 0.117 | 0.1155 | 0.1165 | 0.114 |
| Min. | 0.114 | 0.114 | 0.112 | 0.112 |

5) Conclusion

The following conclusions can be made regarding the diaphragms.

a) The inflation pressure for reference dimensional checks imposes a stretch of 1.5% upon the membrane radius

b) Providing an additional stretch from this reference of 2% lead to the failure of both diaphragms

c) While the application of heat allowed diaphragm S/N 101 to stretch continued application of the driving pressure force after removal of the heat caused the diaphragm to rupture

d) A design approach that provides line to line contact of the diaphragm and the tank wall within the 1.5% stretch of the 0.4 psi inflation pressure should be adopted

e) The design of the girth seal has been adequately demonstrated as a practical girth seal.

6) Corrective Action

The following corrective action is being initiated. Two new diaphragms have been ordered incorporating the design approach described above. Final tank dimensional adjustments will be made when a complete assessment of the effect of cutting apart the tank is made.

New fixturing will be provided so that installation and leak checks of the diaphragm and seal can be made prior to welding the tank.

Assembly procedures will be revised to eliminate the need to apply excessive differential pressure on the diaphragm.

Further investigations will be made in conjunction with the vendor to more clearly understand the deleterious effect, if any, of the heat fusion of the membrane to girth seal.

7) Program Effect

The above corrective actions require reordering two diaphragms and subsequent refurbishment of the module tank. It is anticipated that the module firing date will be delayed twelve weeks. This will result in a four week schedule impact on the contract end date.

## C. MATERIALS TEST PROGRAM

1) Background

A new series of materials compatibility tests were initiated in order to supplement those tests conducted during the initial phase of the contract. The original study was accomplished to aid in selection of materials which would be compatible with monomethyl hydrazine or nitrogen tetroxide at 275°F for 600 hours. The resultant information was used in the final design of the sterilizable propulsion module.

Most materials tested were generally found to be compatible with the fuel providing adequate cleaning processes were applied; however, nitrogen tetroxide proved to be a greater challenge. For example, 300 series stainless steel were found to be completely unacceptable under this unique environmental condition. This test result came as somewhat of a surprise since these alloys are used extensively in $N_2O_4$ systems, operated at temperature up to 160°F, with no apparent problems. Of all structural alloys tested, only 6 Al-4V titanium and the aluminum alloys were found to be acceptable. This severe limitation in design selection created a need for a broader study of compatibility of materials with the oxidizer.

As a result, the materials test program was extended to include a variety of new alloys and protective coatings which may enhance the resistance of common structural alloys to $N_2O_4$ at 275°F.

Selection of candidate materials was primarily influenced by four considerations 1) novelty of the material as related to initial testing, 2) availability of the material, 3) potential use for structural or special design applications, and 4) potentiality of improvement of the basic resistance through application protective coatings.

2) Test Set Up

Test specimens were placed in 19 mm diameter test tubes then inserted into a 1" diameter aluminum tube assembly. The tube was flared on each end and standard AN sleeves, nuts and plugs were used as closures. The propellant was first treated with nitric oxide (NO) then added to the test tube and allowed to flow into the bottom of the aluminum tube in order to assure that at least 1/2 of the test specimen would be immersed in the liquid after boil-off of sufficient liquid to satisfy the vapor pressure demand at 275°F. Pressure is not being measured during the test.

Candidate materials were exposed to the propellant with two types of specimens. 1) pre-stressed specimens using the stressed configuration devised by NASA - Langley and 2) unstressed. Stressed specimens were loaded to 75% of yield strength. Material not stressed were tested in this manner because their inherent physical properties or their available form was not conducive to the preparation of the Langley type of stressed specimen. Also, some of the non-stressed materials would be used, in airborne application, as bearing or sealing surfaces and never actually be stressed except with a minor shear load or in compression.

3) Selected Material

The following materials were in-test on December 20, 1968. This exposure to 275°F will be terminated on January 14, 1968. Where indicated the stressed and unstressed specimens were installed in the same tube container.

a) 2021-T6 Aluminum, chrome acid anodized-stressed & unstressed

b) 2014-T6 " " " " " " "

c) 6061-T6 " " " " " " "

d) 2021-T6 Aluminum, Sulfuric acid anodized,-stressed & unstressed

e) 2014-T6 " " " " " " "

f) 6061-T6 " " " " " " "

These alloys were tested during the early phases of this program. They were found to be acceptable for structural applications however, they were attacked and suffered a few mils of intergranular corrosion and produced a small quantity of abrasive corrosion products. Limited testing was conducted on specimens which had been anodized. The $Al_2O_3$ coating seemed to afford a certain degree of protection. This possibility is being pursued in the extension of the program. The alloys selected all possess good structural strength and are considered typical of those which would be selected by the designer. Both chromic acid and sulfuric acid anodizing processes were tested because of the chemical, physical and thickness differences of the coatings and the design restriction related to retaining residual sulfuric acid anodizing electrolyte in assemble units.

g) 2024-T3, Clad, not stressed

h) 2024-T3, Bare, not stressed

The primary purpose of this test is to ascertain the degree of protection afforded by the cladding of nearly pure aluminum on a high copper structural alloy. Previous tests with 1100-0 aluminum indicated that this type of material possessed greater corrosion resistance than the highly alloyed materials. The clad materials do not lend themselves to fusion welding, except when the cladding is removed in the weld zone. However if sufficient design margins are maintained in the major portion of tankage, the small amount of attack and resultant corrosion products in the weld area may be acceptable.

i) 430 Stainless Steel Alloy-Stressed & Unstressed

During the initial phase of testing, only 300 series alloys were tested because of their prominance in the construction of $N_2O_4$ propellant systems. Test results indicated that the high nickel content of these alloys was responsible for the creation of the amphorous, sticky substance as a corrosion product. It was initially suggested that 410 and 420 be tested in this phase of the program. These alloys were selected, at random, because they were typical 400 series alloys and contained a low nickel content. The 430 alloy was substituted because of unavailability of the previously suggested materials and it is considered a suitable substitute for the 410 or 420 alloys.

j) 321 Stainless Steel-Chromium Plated, stressed

This alloy exhibited properties of non-compatibility typical of all of the 300 series alloys. Since the presence of nickel in the alloy was considered the major cause of the corrosion product formation, a protective coating of two mils of chromium was applied. It is expected that a minor degree of attack will be sustained.

k) Titanium Alloy, 5 Al - 2.5 Sn - Stressed & Unstressed

l) Titanium Alloy, -1 Mo -8 Al - Stressed & Unstressed

These materials were included since only 6 Al-4V were tested during the initial phase. This selection is intended to give the designer and manufacturing engineer a greater latitude in material selection.

m) Tantalum Sheet - Not Stressed

Unalloyed tantalum is extremely ductile and does not lend itself to stressed specimens. One of its primary uses, in commercial chemical applications, is in heating systems which must be exposed to hot acids. This material is being tested as a possible source of screen material for a possitive displacement device for low gravity propulsion systems. Since it is extremely ductile, it could be easily drawn into wires and woven into screens.

n) Aluminum Oxide Ceramic

o) Beryllium Oxide Ceramic

It should be obvious that both of these materials will be completely unaffected by the $N_2O_4$ at 275°F. However, since no ceramics were tested earlier and since a number of surprises have occurred, these materials were selected for test. Their potential use would be in close tolerance hard seats, sliding unit guides or in drive mechanism subjected to compressive loading.

p) 6061 Aluminum Screen, Chromic Acid Anodized

q) 6061 Aluminum Screen, Sulfuric Acid Anodized

These materials are being given further consideration for application as a positive displacement device for zero gravity propulsion system starting. The purpose of the protective anodic coating was explained previously.

r) Beryllium - Not Stressed

Available samples of this material were such that the stressed specimen were not practical. The basic resistance to $N_2O_4$, at any temperature was questionable. Prior to loading it into a test vessel it was subjected to exposure to $N_2O_4$ at room temperature for 24 hours. No reaction was noted and it was accepted as a good test material. Although beryllium is difficult to fabricate, it possesses structural properties which must be of interest to the designer. It is lighter than aluminum, stronger than aluminum and has a modulus of elasticity of 40 million.

s) Tungsten, W-2 - Not Stressed

This material is extremely brittle and does not lend itself to the Langley type of stressed specimen.

It will withstand extremely high temperatures and possesses excellent resistance to wear by abrasion. It application to an engine module would be in areas where a high degree of abrasion would occur or when high temperatures are expected. Because of its brittleness, structural applications should be made where loading is primarily compressive.

t) L-605 Stainless Steel-Stressed & Unstressed

This alloy is a high chromic-nickel cobalt based alloy which contains 15% tungsten. Its primary aerospace use is in construction of hardware which will see exposure to high temperatures, for example, the engine compartment. This alloy could have application for use in engine components which would be exposed to the propellant during dry heat sterilization and which would be exposed to high temperatures during engine firing. If found compatible, it could also replace hardware for general propulsion tankage construction as a subsitiute for the 300 series stainless steels.

u) Columbium Alloy D-14

v) Columbium Alloy 752 - Stressed & Unstressed

These alloys are low strength, highly ductile materials which exhibit a high degree of resistance to nitric acid. They could be easily woven into screens for use in positive displacement assemblies for low gravity engine starting.

w) AMS 5538 - Cyclops - Stressed & Unstressed

This is a precipitation hardened stainless steel which exhibits high strength in the annealed condition, ie 65,000 YTS and 120,000 UTS. It could serve in a variety of structural applications for tankage, tubing and components. It also possesses good properties at high temperatures.

x) HY-140 Steel Plate - Not Stressed

This material was not stressed because its available form was plate and was not practical for use as a Langley type specimen. It is a low alloyed high strength steel which retains almost 100% of its strength at weld areas. It has a 140,000 psi YTS and excellent fracture toughness. HY-140 is currently being given consideration as a structural material for tankage for new USAF weapon system.

y) Austenitic Stainless Steel Alloy 21-6-0 - Stressed & Unstressed

This is a high chromium content (21%), high manganese (9%) stainless steel alloy. It has high strength in the annealed condition and can be strain hardened to 180,000 psi YTS.

It would be an excellent structural material for propulsion tanks, liner, and fittings. It has good welding and forming characteristics.

z) TZM Titanium-Zirconium - Molybdenium Alloy

This material is a molybdenium base alloy containing titanium and zirconium. Its normal use is in high temperature structures.

# APPENDIX A

APPENDIX A

MONTHLY PROGRESS REPORT



PROGRESS REPORT FOR PERIOD 1 December through 31 December 1968

MILESTONE OR PROJECT TITLE Sterilizable Liquid Propulsion System

STATUS

Summary

The fuel tank which was used to demonstrate minus -1g single phase outflow very late in November was purged, dried and placed in storage in preparation for the module rebuild.

The materials compatibility test activity has been proceeding on schedule. Twenty-five material specimens exposed to the nitrogen tetroxide propellant at 275°F for 600 hours on 20 December 1968. At the close of the report period 280 hours had been accumulated. There have been no interruptions to that portion of the program. All controls are within normal limits.

The oxidizer tanks were not delivered on time. Illness at the vendors along with the holiday period prevented delivery on 20 December.

A major problem has been encountered in the assembly of the oxidizer tanks. During the installation of the diaphragms into the tank and subsequent planned stretching of the diaphragms to conform to the hemispherical radius, the diaphragms in one case showed extreme breakdown of the Teflon membrane and the second unit actually developed a small hole. Both diaphragms were rendered useless.

The proposed solution involves failure analysis of the diaphragm to explain the apparent undersize condition. This will be followed by a reorder of the diaphragms from the vendor. This activity and subsequent reorder and refurbishment of the propellant tanks causes an anticipated 12 week delay in the completion of the technical effort of the program according to the Martin Marietta internal schedules. This will be reflected in a 4 week schedule problem to the contract completion.

The planned action for the next period consists of evaluating the impact of this problem and arriving at a new program schedule. The diaphragm vendor will be authorized to proceed with fabrication of new units and Martin Marietta will fabricate the necessary metal flanges which are detail parts of the diaphragm assembly. The materials compatibility test exposure will be terminated on schedule on the 14th of January and the test results will be evaluated.

J C Lukens

AUTHORIZED REPRESENTATIVE

(To be typed on reverse side of MONTHLY PROGRESS REPORT - JPL 951709 )

INSTRUCTIONS FOR COMPLETING MONTHLY PROGRESS REPORT

This portion of the monthly status report shall include a brief concise account of the technical status of the Contract. The report shall include, but not necessarily be limited to, the following:

1. Name of project and milestone if reporting to that level.
2. Period covered if different from date of financial status reports.
3. Summary of status.
4. Progress made during reporting period.
5. Problems encountered during reporting period and solutions or proposed solutions.
6. Any situation or problem anticipated that might cause delays in schedule or expenditure changes.
7. Any requirements that must be handled by JPL in order to maintain schedule or contract requirements.
8. Planned effort for the next period.

# APPENDIX B

# MILESTONE PROGRESS REPORT

Appendix B.

**CONTRACTOR:** MARTIN MARIETTA CORP., DENVER DIVISION
Denver, Colorado 80201

**FOR PERIOD ENDING:** 31 December 1968

**CONTRACT NO.** 951[illegible]

| | MILESTONES (Key Task) (1) | MILESTONES WEIGHTED % (2) | MILESTONES ESTIMATED % OF COMPLETION (3) | TOTAL CONTRACT ESTIMATED % OF COMPLETION (4) | TECHNICAL EVALUATION (5) | 1968 M | J | J | A | S | O | N | 1969 D | J | F | M | A | M | J | J | A | S | O | N | D |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Basic Contract | 77.7 | 100.0 | 77.7 | | | | | | | | | | | | | | | | | | | | | |
| 2 | | | | | | | | | | | | | | | | | | | | | | | | | |
| 3 | Modification No. 1 | 22.3 | 33.0 | 7.4 | | | | | | | | | | | | | | | | | | | | | |
| 4 | | | | | | | | | | | | | | | | | | | | | | | | | |
| 5 | | | | | | | | | | | | | | | | | | | | | | | | | |
| 6 | | | | | | | | | | | | | | | | | | | | | | | | | |
| 7 | | | | | | | | | | | | | | | | | | | | | | | | | |
| 8 | | | | | | | | | | | | | | | | | | | | | | | | | |
| 9 | | | | | | | | | | | | | | | | | | | | | | | | | |
| 10 | | | | | | | | | | | | | | | | | | | | | | | | | |
| 11 | | | | | | | | | | | | | | | | | | | | | | | | | |
| 12 | | | | | | | | | | | | | | | | | | | | | | | | | |
| 13 | | | | | | | | | | | | | | | | | | | | | | | | | |
| 14 | | | | | | | | | | | | | | | | | | | | | | | | | |
| 15 | | | | | | | | | | | | | | | | | | | | | | | | | |
| 16 | | | | | | | | | | | | | | | | | | | | | | | | | |
| 17 | | | | | | | | | | | | | | | | | | | | | | | | | |
| 18 | | | | | | | | | | | | | | | | | | | | | | | | | |
| 19 | | | | | | | | | | | | | | | | | | | | | | | | | |
| 20 | | | | | | | | | | | | | | | | | | | | | | | | | |
| | TOTAL CONTRACT | 100% | | 85.1 | | | | | | | | | | | | | | | | | | | | | |

DELIVERIES DATE STATUS

SCHEDULE LEGEND:
SPAN TIME
STATUS
SCHEDULED
COMPLETED
RESCHEDULED
SLIPPAGE ANTICIPATED
ACTUAL SLIPPAGE

TECHNICAL EVALUATION SYMBOLS:
SATISFACTORY PROGRESS
SIGNIFICANT PROBLEM
SERIOUS PROBLEM

**REMARKS:** 1) Delay of approximately 12 weeks to internal schedule due to problems encountered in modification of Oxidizer Tanks may result in approximately a four week delay in completion of technical effort required by contract on 4/4/69. Formal request for contract modification will be submitted.

Approved: Samuel C. Lukens
Samuel C. Lukens
Program Manager

JPL 3174 R11.67