228
5/22/69

807
AI-AEC-12823

MASTER

unclass
fahn 5/26/69

LARGE RADIOISOTOPE
HEAT SOURCE CAPSULE (LRHSC)
SEVENTH QUARTERLY PROGRESS REPORT
JANUARY-MARCH 1969

AEC Research and Development Report

ATOMICS INTERNATIONAL

A DIVISION OF NORTH AMERICAN ROCKWELL CORPORATION

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

P1399

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency Thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

DISCLAIMER

Portions of this document may be illegible in electronic image products. Images are produced from the best available original document.

LEGAL NOTICE

This report was prepared as an account of Government sponsored work. Neither the United States, nor the Commission, nor any person acting on behalf of the Commission:

A. Makes any warranty or representation, express or implied, with respect to the accuracy, completeness, or usefulness of the information contained in this report, or that the use of any information, apparatus, method, or process disclosed in this report may not infringe privately owned rights; or

B. Assumes any liabilities with respect to the use of, or for damages resulting from the use of information, apparatus, method, or process disclosed in this report.

As used in the above, "person acting on behalf of the Commission" includes any employee or contractor of the Commission, or employee of such contractor, to the extent that such employee or contractor of the Commission, or employee of such contractor prepares, disseminates, or provides access to, any information pursuant to his employment or contract with the Commission, or his employment with such contractor.

Printed in the United States of America
Available from

Clearinghouse for Federal Scientific and Technical Information
National Bureau of Standards, U.S. Department of Commerce
Springfield, Virginia 22151

Price: Printed Copy \$3.00; Microfiche \$0.65

LARGE RADIOISOTOPE
HEAT SOURCE CAPSULE (LRHSC)
SEVENTH QUARTERLY PROGRESS REPORT
JANUARY-MARCH 1969

This report has been prepared under
Contract AT(29-2)-2338 with the
U.S. Atomic Energy Commission

LEGAL NOTICE

This report was prepared as an account of Government sponsored work. Neither the United States, nor the Commission, nor any person acting on behalf of the Commission

A. Makes any warranty or representation, expressed or implied, with respect to the accuracy, completeness, or usefulness of the information contained in this report, or that the use of any information, apparatus, method, or process disclosed in this report may not infringe privately owned rights, or

B. Assumes any liabilities with respect to the use of, or for damages resulting from the use of any information, apparatus, method, or process disclosed in this report.

As used in the above, "person acting on behalf of the Commission" includes any employee or contractor of the Commission, or employee of such contractor, to the extent that such employee or contractor of the Commission, or employee of such contractor prepares, disseminates, or provides access to, any information pursuant to his employment or contract with the Commission, or his employment with such contractor.

ATOMICS INTERNATIONAL

A DIVISION OF NORTH AMERICAN ROCKWELL CORPORATION

CONTRACT: AT(29-2)-2338
ISSUED: MAY 1, 1969

P1399

DISTRIBUTION

This report has been distributed according to the category "Propulsion Systems and Energy Conversion," as given in the Standard Distribution for Unclassified Scientific and Technical Reports, TID-4500.

FOREWORD

This is the seventh quarterly progress report, describing the technical status of the Large Radioisotope Heat Source Capsule (LRHSC) Program. It covers the work accomplished by Atomics International during the period from January 1, 1969 through March 31, 1969 under contract AT(29-2)-2338 for the U.S. Atomic Energy Commission.

CONTENTS

	Page
Foreword	3
I. Introduction	9
II. Program Management	11
A. Task Objectives	11
B. Summary of Task Status	11
C. Accomplishments During the Quarter	11
III. Capsule Design	13
A. Task Objectives	13
B. Summary of Task Status	13
C. Accomplishments During the Quarter	13
IV. Process Development	15
A. Task Objectives	15
B. Summary of Task Status	15
C. Accomplishments During the Quarter	15
V. Fabrication and Assembly.....	17
A. Task Objectives	17
B. Summary of Task Status	17
C. Accomplishments During the Quarter	17
VI. Capsule Creep Testing	23
A. Task Objectives	23
B. Summary of Task Status	23
C. Accomplishments During the Quarter	24
1. Creep Capsule B5*	24
2. Creep Capsule B7	26
3. Creep Capsule B6	26
4. Creep Capsule B4	29
5. Test Equipment	30
6. Data Evaluation	34

CONTENTS

	Page
VII. Impact Testing	37
A. Task Objectives	37
B. Summary of Task Status	37
C. Accomplishments During the Quarter.....	37
VIII. Capsule Fire Test	51
A. Task Objectives	51
B. Summary of Task Status	51
C. Accomplishments During the Quarter	51
1. Fire Test Capsule Assembly and Installation	51
2. LRHS Fire Test	60

TABLES

II-1 Official Milestone Summary	12
VIII-1 Thermal Location Data	58

FIGURES

V-1 Creep Capsule "C-STD" Final Assembly	18
V-2 Assembled Creep Capsules	20
V-3 Creep Capsule A-2a After Final Assembly	21
VI-1 Creep Capsule B-5*.....	25
VI-2 Creep Rupture Test Results.....	27
VI-3 Creep Capsule B7.....	28
VI-4 Creep Capsule B-4a Stress vs Strain Relationship	31
VI-5 Stress-Strain Rate Relationship of T-111 Pressure Vessels.....	32
VI-6 Tantalum Heater Utilized for the Burst Test Capsule	33
VI-7 Stress vs Strain Rate Relationship LRHSC Pressure Vessel 2000°F 10 ⁻⁸ torr	35

FIGURES

	Page
VII-1 Barrel Assembly-Impact Tester 1.750	39
VII-2 Impact Capsule A-7a with Al ₂ O ₃ Coating Applied.....	41
VII-3 Impact Capsule A-7a Inserted in the Pt-Rh Barrier Shell and Cap	41
VII-4 Test Graph for Calibration and Testing of Impact A-7a.....	42
VII-5 Impact Capsule A-7a After Impact Testing at 1200°F at 346 ft/sec	43
VII-6 Impact Capsule A-7a with the Pt-Rh Removed	44
VII-7 Impact Capsule A-7a T-111 Structure After Testing at 1200°F at 345 ft/sec	44
VII-8 Nose Portion of T-111 Capsule After Testing	45
VII-9 Impact Capsule A-7a After Being Half-Sectioned (Note Fuel Annulus Intact After Impact at 1200°F at 346 ft/sec).....	45
VII-10 Mechanical Test Analysis of Impact Capsules A-1a Through A-7a	46
VII-11 Impact Capsule A-1a After Testing at 1200°F at 250 ft/sec	47
VII-12 Impact Capsule A-2a After Testing at 1200°F at 250 ft/sec.	47
VII-13 Impact Capsule A-3a After Testing at 1200°F at 260 ft/sec.	48
VII-14 Impact Capsule A-4a After Testing at 1200°F at 230 ft/sec. (Pt-Rh Nose Cap Hit Stripper)	48
VII-15 Impact Capsule A-5a After Testing at 1200°F at 240 ft/sec (T-111 Shell .100-in Thick)	49
VII-16 Impact Capsule A-6a After Testing at 1200°F at 260 ft/sec (T-111 Shell .100-in Thick)	49
VIII-1 LRHS Fire Test Capsule During Assembly Showing the Ta-10W Outer Liner with T/C #1 Penetrating the Fuel Retainer Ring...	53
VIII-2 LRHS Fire Test Capsule Assembly Sequence Showing the T-111 Structural Shell with T/C #2 in Place	53

FIGURES

	Page
VIII-3 LRHS Fire Test Capsule Assembly Sequence After a 0.002-In Coating of Al_2O_3 was Plasma Sprayed over the T-111 Structural Shell. Pt-10Rh Oxidation Barrier Shell is Adjacent to the Capsule.....	53
VIII-4 LRHS Fire Test Capsule Prior to Plasma Spraying the Emittance Coating of Fe_2O_3 . TiO_2 over the Pt-10Rh Oxidation Barrier.....	53
VIII-5 Fire Test Capsule - LRHS	55
VIII-6 LRHS Fire Test Capsule Completely Instrumented and with Foamed Silica Protecting the Lead Tube. Visible Thermocouples are W5%Re vs W26%Re (Lower) and Pt vs Pt-10%Rh (Upper).....	59
VIII-7 Copper Slug Calorimeter	61
VIII-8 LRHS Fire Test Capsule Installed in the Burn Pit at Isotopes, Inc., Atop an 18" x 18" x 12" Block of Solid Propellant Prior to Ignition.....	62
VIII-9 Infra-Red Photograph Taken While the Fire Test was in Progress. Flame Inhibitor on the Front Face of the Burning Propellant is Obscuring the View of the Capsule	63
VIII-10 LRHS Fire Test Capsule Immediately Following the end of the Fire Test. The Capsule, as well as the Copper Calorimeter, is Coated with an Oxide Produced by the Burning Propellant. This Oxide has been Determined to be Primarily Al_2O_3 and Aluminum	64
VIII-11 Time vs Temperature Relationship of the LRHS Fire Test Capsule	65
VIII-12 External Appearance of the LRHS Fire Test Capsule as Viewed from the Top. Deposits are from the Solid Propellant and are Primarily Al_2O_3 and Aluminum	67
VIII-13 External Appearance of the LRHS Fire Test Capsule as Viewed from the Side. Deposits are from the Solid Propellant and are Primarily Al_2O_3 and Aluminum	68
VIII-14 External Appearance of the LRHS Fire Test Capsule as Viewed from the Bottom. Deposits are from the Solid Propellant and are Primarily Al_2O_3 and Aluminum	69

FIGURES

	Page
VIII-15 Gamma Radiograph's of the LRHS Fire Test Capsule Taken Before and After the Solid Propellant Fire Test. Orientation of the Capsule to the Solid Propellant in this View is 0°	70
VIII-16 Gamma Radiographs's of the LRHS Fire Test Capsule Taken Before and After the Solid Propellant Fire Test. Orientation of the Capsule to the Solid Propellant in this View is 90°.....	71
VIII-17 LRHS Fire Test Capsule After Being Dissected. The T-111 Structure was not Penetrated by the Fire. The Ta-10W Fuel Liner is Undamaged and the Fuel Simulant was Totally Contained. The Top Edge of the Capsule is Toward the Center of the Photograph.....	72

I. INTRODUCTION

The Large Radioisotope Heat Source Capsule (LRHSC) Program has been established to develop the technology of an isotope fuel capsule capable of operation in a space environment at a surface temperature of about 2000°F for five years or more. The objectives of the present phase are the design, fabrication, test and evaluation of a test capsule whose design takes into account the operating requirements of a typical heat source. The work includes process, fabrication and test activities. The process and fabrication includes the work required to define an acceptable manufacturing specification for the reference design capsule and to manufacture the test items required for the program. The test program involves various coupons and capsules with evaluation of chemical compatibility, thermal cycling and adherence of coatings, capsule creep, capsule impact and capsule earth burial. A new task (No. 8 - Capsule Fire Test) was added this quarter to subject the LRHS capsule to a launch abort accident fire and to determine the effect of the fire on the capsule. In addition to indicating the suitability of the reference capsule for ground test, the data generated in this program will be used to validate presently accepted design approaches and define design margins that would actually exist for high temperature capsules intended for flight systems.

The LRHSC Program is being accomplished under the following tasks:

- 1) Program Management
- 2) Capsule Design
- 3) Process Development
- 4) Fabrication and Assembly
- 5) Capsule Creep Testing
- 6) Impact Testing
- 7) Soil Burial Testing
- 8) Capsule Fire Test

BLANK

II. PROGRAM MANAGEMENT

A. TASK OBJECTIVES

The objectives of this task are to provide management, direction and planning for all aspects of the Large Radioisotope Heat Source Capsule Program. This includes technical direction, reporting, detailed plans and procedures.

B. SUMMARY OF TASK STATUS

The official milestones for GFY 1969 are shown in Table II-1. All milestones for the fiscal year have been successfully accomplished. An overall program plan for GFY 1970 has been submitted after review by AEC Headquarters personnel and the Sandia Technical Director.

C. ACCOMPLISHMENTS DURING THE QUARTER

The revised GFY 1970 Program Plan has been submitted after review of the initial plan with AEC Headquarters personnel and the Sandia Technical Director. The plan includes completion of the creep test program, completion of the capsule impact test program, materials compatibility studies, emittance coating studies, and analyses of the design implications of LRHSC Program test data.

A major review of the program was held with AEC, Sandia and TRW personnel with regard to the application of the LRHSC technology to the TRANSIT Program. In addition to a detailed summary of the program, recommendations for capsule modifications for TRANSIT were presented. A briefing book covering all material presented is available.

Mound is preparing to fuel a prototype LRHS capsule. During February details of the capsule fabrication and assembly were reviewed with AEC and Mound personnel. On the basis of Mound requirements for hardware and technical support a cost estimate was prepared and transmitted to the AEC.

TABLE II-1
OFFICIAL MILESTONE SUMMARY

<u>Official Milestones</u>	<u>Target Date</u>	<u>Status</u>
1. Startup Creep Rig # 2	July 1968	Complete
2. Startup Creep Rig # 3	August 1968	Complete
3. Distribute Topical Report # 5	September 1968	Complete
4. Complete First "A" Capsule	October 1968	Complete
5. Startup Creep Rig # 4	October 1968	Complete
6. Complete First "C" Capsule	November 1968	Complete
7. Conduct Preliminary Impact Tests	November 1968	Complete
8. Complete First Creep Rupture Test	January 1969	Complete
9. Distribute Topical Report # 6	March 1969	Complete
10. Complete "C" Capsule Short Term Tests	May 1969	May 1969
11. Distribute Topical Report # 7	June 1969	June 1969

A major review was held with NASA Lewis and Sandia personnel with regard to the application of the LRHSC technology to the large heat source system.

Discussions were completed with Isotopes, Inc. on the requirements for testing an LRHS capsule in a solid propellant fire. A single "C" type capsule laying on top of the propellant block was tested during the reporting period.

III. CAPSULE DESIGN

A. TASK OBJECTIVES

The objectives of this task are to define the capsule and the test fixture requirements of the Large Radioisotope Heat Source Capsule Program. This encompasses capsule piece-part drawings, capsule assembly drawings, burial heater design and assembly drawings, and welding and test fixture design and drawings.

B. SUMMARY OF TASK STATUS

No additional design changes occurred during the reporting period.

C. ACCOMPLISHMENTS DURING THE QUARTER

No additional design changes occurred during the reporting period. However special design modification for assembly of the instrumented fire test capsule were completed.

BLANK

IV. PROCESS DEVELOPMENT

A. TASK OBJECTIVES

The objectives of the process development task are to provide the necessary technical guidance and control to all phases of the capsule fabrication in applications considered laboratory practice, to qualify fabrication, assembly and weld procedures, to perform the required experimental work in processes extending present technology, and to provide material and process specifications for the capsule fabrication program. The processes of interest include raw material and piece-part fabrication, cleaning, annealing, joining, and non-destructive testing. Studies of alternate materials fabrication and assembly techniques are performed as required.

B. SUMMARY OF TASK STATUS

Weld development of the .090-in. wall and the .100-in. wall T-111 structural shell to the T-111 structural end cap was completed during the reporting period.

With receipt of the GFY 1969 supplemental funding the planned met work on heat treating, creep, rupture, coupon and miscellaneous samples previously deferred was reinitiated.

C. ACCOMPLISHMENTS DURING THE QUARTER

Weld development of the .090-in. and .100-in. T-111 structural shell to the T-111 structural end cap was completed during the reporting period. These new weld parameters were utilized in the assembly of creep capsule B-4a (.090-in. wall) and impact capsules A-5a and A-6a (.100-in. wall).

With receipt of the GFY 1969 supplemental funding this task has been re-opened for conducting all of the planned met work on heat treating, creep, rupture, coupon and miscellaneous samples.

Following is a list of the work presently being conducted/planned:

- 1) Coupon Stack 14 - Met and Microprobe
 - 2) Welded Sections of Impact Capsule A7 - Met
 - 3) T-111 Oxidation Samples - Met
 - 4) Fire Test of LRHS Capsule - Met and Microprobe
 - 5) Creep Capsule B5* - Met and Microprobe
 - 6) Various Platinum Fabrication and Weld Samples - Met
 - 7) Various T-111 Weld Samples - Met
 - 8) Various Ta-10W Weld and Fabrication Samples - Met
 - 9) Eight Compatibility Coupon Samples - Met and Microprobe
 - 10) Five Creep Tests - Met and Limited Microprobe
 - 11) Some Number of Seven Impact Tests - Met
 - 12) More T-111 Oxidation Samples - Met .
 - 13) Failure Analysis of Seven T-111 Fabrication Defects - Met and Some Microprobe
 - 14) Brazements of Pt to Fe to Ta Base Alloys - Met and Microprobe
- Evaluation of this Work will be Reported as it Progresses.

V. FABRICATION AND ASSEMBLY

A. TASK OBJECTIVES

The objectives of this task are to obtain all raw materials, to fabricate all capsule, coupon piece-parts and assembly tooling, and to assemble all capsules and coupon stacks.

B. SUMMARY OF TASK STATUS

Fabrication of all piece parts was completed for GFY 1969 with the successful fabrication of seven Pt-Rh barrier caps.

Assembly of one impact capsule, three creep test capsules, creep capsule "C" Standard, and the LRHSC fire test capsule was completed during the reporting period.

Assembly of two creep "C" capsules was initiated.

Fabrication of a new barrel for the Impact Test Facility was completed.

C. ACCOMPLISHMENTS DURING THE QUARTER

Assembly of one impact test capsule; three creep test capsules; creep capsule "C-STD," and the LRHSC fire test capsule was completed during the reporting period.

Impact capsule A-7a liner assembly was completed and inserted in the T-111 structural shell. The final closure weld was made and the capsule coated with Al_2O_3 and delivered to test.

Creep capsule "C" Standard was completed during the reporting period. The T-111 shell was coated with Al_2O_3 and the capsule was inserted in a Pt-Rh barrier shell, which was in turn welded to the Pt-Rh barrier cap. The assembly was then coated with iron titanate. Figure V-1 shows the final assembly steps for the "C-STD" capsule.

"C-STD" After Coating of Al_2O_3 Applied to
the T-111 Structure

"C-STD" With Pt-Rh Barrier Shell and Cap

"C-STD" Coated with Iron Titanate

Figure V-1. Creep Capsule "C-STD" Final Assembly

Creep capsules B-3a and B-4a were assembled, the pressure feed-through lines brazed, and the capsules delivered to test (Figure V-2).

Creep capsule A-2a outer liner assembly was completed and coated with Al_2O_3 . An attempt was then made to insert the Al_2O_3 coated outer liner assembly into the T-111 structural shell using the E.B. weld and assembly fixture. As experienced in previous attempts to insert with a basic line to line fit-up, the coated outer liner assembly started to gall the inside of the T-111 shell after being inserted approximately 1-3/4 inch. This capsule was taken apart and the Al_2O_3 coating removed from the outer liner assembly. The structural shell from creep capsule A-2a was diverted to the Fire Test. A new structural shell was assigned to creep capsule A-2a and assembled with a slip fit between the outer liner assembly and the T-111 shell. The structural closure weld was made and the capsule delivered to test. Figure V-3 shows creep capsule A-2a after final assembly.

Assembly of creep capsules C-1a and C-4a was initiated during the reporting period.

A LRHS fire test capsule was assembled during the reporting period. For details of this assembly see Task No. 8 of this report.

Fabrication of a new barrel for the Impact Test Facility was completed.

Fabrication of seven Pt-Rh barrier end caps was completed.

Figure V-2. Assembled Creep Capsules

Figure V-3. Creep Capsule A-2a
After Final Assembly

BLANK

VI. CAPSULE CREEP TESTING

A. TASK OBJECTIVES

The LRHSC Program fuel capsule design utilizes a first generation tantalum alloy (Ta-10W) for primary containment of the fuel, a second generation tantalum alloy (T-111) for secondary containment, and Pt-10%Rh for oxidation protection of the reactive refractory metal containers. The objective of this task is to provide and test a design approach that accounts for creep deformation at elevated temperatures.

To achieve this end a test series has been established to evaluate heat-to-heat variations on the creep of the T-111 structural shell, determine the effects of variable stress on creep of the shell, relate uniaxial and biaxial stress states to creep of T-111 and finally to determine the interacting effects of capsule components on the creep of the structural member.

During the first year of the program three biaxial creep rigs were operated to observe the creep of capsule components at 2000°F in high vacuum. At the end of the first year preliminary creep data for test times less than 2000 hours had been obtained. During the second year additional creep rigs are being utilized and longer term creep data is being obtained.

B. SUMMARY OF TASK STATUS

Capsule B5* which was originally scheduled to be a 5% strain test was redesignated as a rupture capsule. During the quarter rupture did occur at a pressure of about 5000 psid. The rupture occurred after 3500 hours of test. During the last few days of the test the creep rate was in the range of 1% per day which is very high for a creep type test. A significant point in this test was the very high strain achieved prior to failure. It was expected that the strain to rupture would be in the range of 5 to 7% and definitely less than 10%.

However, the total diametral strain at the time of rupture was nearly 15%. The rupture was very ductile in nature with approximately 50% wall thickness reduction in the area of the rupture.

Capsule B7 completed testing during the quarter after achieving 5% total strain. The stress-time relationship up to 5% strain was identical to that of the B5* capsule. The strain rates at various times for equal stress in both of these capsules were almost identical.

Capsule B6 is continuing test aimed at reaching 0.1% strain at 2600 hours and 1% strain in the following 6200 hours.

Creep capsule B-4a was tested during the quarter. It was a short term test to 5% strain. The test was operated at a constant pressure of 3345 psia for 48 hours at which time the capsule reached 0.1% strain. The capsule was then pressurized at a constant rate of 9.07 psia/hour. The target 1% apparent strain was achieved after 150 hours of total test time operation, 102 hours after the ramp was begun. The test was continued on until the 5% total apparent strain was reached in 195 hours.

C. ACCOMPLISHMENTS DURING THE QUARTER

1. Creep Capsule B5*

Creep capsule B5* was designed to be an intermediate strain rate test to rupture. The test was pressurized initially at a constant pressure to induce 0.1% strain in 480 hours, thereafter at a constant hoop stress rate to produce 1% apparent strain in the following 1000 hours. The test was to continue at this rate until rupture. Figure VI-1 shows the operation of this test. The strain at one of two mid plane diameters measured is plotted on the curve. It can be seen that the stress rate selected for the test produced a strain rate somewhat lower than intended. This has been the case with all previous tests. It is only now that enough data are becoming available from this program that

a preliminary biaxial stress-strain rate relationship is being developed. Future test behavior will be better predicted.

Figure VI-1. Creep Capsule B5*
Test Results

There are two additional aspects of the test which were different than predicted. These are the strain at rupture, and the very ductile high energy rupture. It was initially expected that the strain at rupture after 3000 hours under stress might be in the range of 5 to 10%. Probably more than 5% but certainly less than 10%. The strain at rupture was approximately 15%. It should be noted, however, that the strain rate during the latter portions of test was very high, in the range of 1%/day. Because of the stress-strain rate relationship remained essentially the same for the higher stresses and strains compared to the lower regime, this high strain rate portion of the test is not considered to be an exhibition of third stage creep.

Figure VI-2 shows the ruptured capsule. The thickness of the wall near the rupture was reduced by approximately 50%. It is not expected that this high strain during rupture would have occurred if there had been a smaller void volume, as in the case of a radioisotope capsule where much of the interior is liner and fuel. This would have resulted in a smaller gas inventory in the capsule and less energy would have been released during the rupture. The pressure in the capsule prior to rupture was almost 5000 psid. The resultant pressure in the test chamber was still well below atmospheric (3 psia); however, the energy released during the rupture was sufficient to cause severe damage to the furnace and support fixtures.

2. Creep Capsule B7

Capsule B7 was to undergo the same stress schedule as B5* but be terminated at 5% total strain. Figure VI-3 summarizes the operation of this test. The test has been terminated, but has not been removed from the test chamber for evaluation.

3. Creep Capsule B6

The new rig housing capsule B6 was modified significantly to improve a vibration problem which made measuring the strain in the capsule difficult.

RESULTS

- TEST TIME—3500 HOURS AT 2000°F
- STRAIN PRIOR TO FAILURE—15%
- DUCTILE FAILURE
- INCIPIENT FAILURE POINTS FOUND ELSEWHERE IN CAPSULE

CONCLUSIONS

- STRAIN PRIOR TO FAILURE OVER DOUBLE EXPECTED VALUE
- DUCTILITY REMAINED HIGH AFTER 3500 HOURS

9-F13-022-1

Figure VI-2. Creep Rupture Test Results

Figure VI-3. Creep Capsule B7
Test Results

Normal floor vibrations produced an oscillation in the capsule which has as great as 0.005-in. amplitude. This problem has been reduced significantly by shock mounting and strengthening members in the support stand. This test is pressurized at a constant stress to produce 0.1% strain in 2600 hours. The test will then be pressurized at a constant stress rate to produce 1% total strain in the following 6200 hours. This test will continue until 5% total strain is achieved.

4. Creep Capsule B4

Creep capsule B4 was installed in the test rig and tested during the month of March. It was a short term test to 5% strain. This was the first test to be operated on the basis of creep data generated on the test program. All prior test independent variables (pressure and pressure rate) were selected based on calculations and assumptions made on uniaxial constant load data. The model used for the previous tests produced pressure and pressure rates which caused significantly lower creep rates than calculated. While the initial correlation of the data from the test program is preliminary this creep test operated reasonably close to predicted strain rates.

The test was intended to operate at a constant pressure to achieve 0.1% apparent diametral strain in 58 hours. Thereafter it was to be pressurized at a constant rate to achieve 1% total strain in the following 100 hours. The test was to continue at that rate until test termination at 5% total apparent strain.

The capsule was pressurized initially at 3345 psia which would correspond to a calculated hoop stress of 29,500 psi. For this hoop stress it is assumed that the stressed member is a long, thin, right circular cylinder; no corrections have been made for effects of structure induced stress modes. It is only for the test program that these are not used. After 48 hours at the initial stress the capsule reached 0.1% strain. This strain is the ratio of the apparent change in diameter to the initial diameter. Correction strain models will be applied as part of the test interpretation, not operation.

After the 0.1% strain was achieved the capsule was pressurized at a constant rate of 9.07 psia/hour, which would correspond to hoop stress rate of 80 psi/hour. The target 1% apparent strain was achieved after 150 hours of total operation, 102 hours after the ramp was begun. The test continued on at that pressure rate until the 5% total apparent strain was reached in 195 hours. The behavior of this test is shown in Figure VI-4. As can be seen from Figure VI-5, a hand fit of the strain slope of the curve fits well with the same relationships for other tests in the program. It is this relationship that is being used to select the independent variables for the test program.

5. Test Equipment

During the quarter two furnaces were rendered inoperable. These were for Rig # 2 and # 3. The furnace in Rig # 2 was severely deformed when test capsule B5* ruptured. The furnace is shown in Figure VI-6. While many of the parts can be salvaged, the furnace must be reconstructed. Fabrication of this furnace is now in progress. During startup of a test in Rig # 3 there was an intermittent short, which caused the power limiters on the control circuit to trip. Examination of the furnace revealed that some of the alumina stand-offs were of an early design which allowed the heater wire to come very close to the heat shields when the coils relaxed. These were replaced with a new design standoff which holds the wire 1/8-in. further away from the heat shields. When the test was restarted, it was noted that the resistance to ground was still not adequate for proper temperature control. This was traced to some spillover of the tungsten coating on the heater support section of the standoff onto the insulation portion. The tungsten was removed from the insulator by grit blasting, the insulators reinstalled in the furnace, and the furnace is now operating properly.

Figure VI-4. Creep Capsule B-4a Stress vs Strain Relationship

4-11-69

00-102712

Figure VI-5. Stress-Strain Rate Relationship of T-111 Pressure Vessels

AI-AEC-12823

Figure VI-6. Tantalum Heater Utilized for the Burst Test Capsule

6. Data Evaluation

A preliminary stress-strain rate relationship has been developed to better predict the operation of the test capsules in the creep program. This is shown in Figure VI-7. It is noted that the stress is hoop stress calculated for a thin walled cylinder, and strain rate is the hand fitted slope of the apparent strain time curve. It can be seen that the relationship appears to have a minimum amount of scatter even though it covers a large range of stresses, strain rates, and total strains. Tests B-1a and B-2a cover the range up to 1% total strain, B-1a in a few hundred hours and B-2a in a few thousand hours. B5* is also a few thousand hour test but the strain ranges up to 10%. This relationship is being used to develop the stress and stress rates for the remaining tests in the program.

9-F17-022-43

Figure VI-7. Stress vs Strain Rate Relationship LRHSC Pressure Vessel
 2000°F 10^{-8} torr

BLANK

VII. IMPACT TESTING

A. TASK OBJECTIVES

The objective of this task is to determine, by testing, the capability of the reference capsule design to survive impact. The developmental impact tests will also allow insight into the actual capsule deformation phenomena, determine the capsule failure modes and ascertain the relative influence of various capsule design and impact parameters on capsule survival. A total of 24 capsules will be impacted on a granite target at various velocities, impact angles, and temperatures. During GFY 1969 only seven of these will be impacted.

B. SUMMARY OF TASK STATUS

Fabrication of a new barrel for the Impact Facility to allow hot breech loading and testing without the graphite sabots and stripper previously employed was completed and the barrel installed.

Upon completion of installation and checkout of the new barrel, impact capsule A-7a with a complete Pt-Rh oxidation barrier was tested at 1200°F at a velocity of 346 ft/sec. The results of this test are very good. Although the aft dome of the Pt0Rh barrier shell was punched out, the 0.127 in wall T-111 structural shell was leak tight.

Mechanical test analysis was completed on all seven impact capsules during the reporting period.

C. ACCOMPLISHMENTS DURING THE QUARTER

Impact Capsules A-1a through A-6a were impact tested at 1200°F at velocities ranging from ~230 ft/sec to ~260 ft/sec. Visual inspection of all six capsules after testing indicated that all were leak tight.

To facilitate testing of these six capsules minor modifications were made to the facility to allow hot breech loading of the capsules. Also, the existing barrel ID is 2-in. while the capsule OD is 1.680-in. To support, insulate, and center the small capsules in the barrel, graphite sabots were manufactured. Because the sabot's weight was approximately 5% of the capsule weight, it was desirable to strip the sabot from the capsule before impact. Stripping was accomplished by reducing the muzzle ID of the barrel. The stripper was threaded onto the end of the barrel and captured the sabot while allowing the capsule to continue on to impact.

Because of the uncertainty of friction and compressive forces being applied on the capsule at the instant of stripping the sabot from the capsule, it was difficult to calibrate and test to an exact velocity. Also angle of impact was affected by the stripping action. Therefore, during the reporting period, a new barrel 1.750-in. diameter by 10-ft. long was fabricated and installed in the Impact Facility. This new barrel is shown in Figure VII-1.

Upon completion of installation and checkout of the new barrel, impact capsule A-7a with a complete Pt-Rh oxidation barrier was tested at 1200°F at a velocity of 346 ft/sec. Although the aft dome of the Pt-Rh barrier shell was punched out, the T-111 structural shell was leak tight. Figure VII-2 shows the capsule in the impact "A" configuration, while Figure VII-3 shows the capsule in the test configuration with the Pt-Rh barrier shell and cap. Fe_2TiO_3 emissivity coating was not applied to allow a better visual examination of the Pt-Rh after testing. Figure VII-4 is the test graph showing the three calibration tests using a 5.1 lb dummy slug and the test of the capsule at 346 ft/sec. The calibration curve shown was calculated for a 5.1 lb capsule using the new barrel. It is hypothesized that gas blow-by resulted in the actual test curve falling on the low side of the efficiency band. However, photoelectric velocity measurements indicated a velocity of 346 ft/sec; so a good correlation exists.

REVISIONS			
SYM	ZONE	DESCRIPTION	DATE

Figure VII-1
AI-AEC-12823
39

QTY	PART OR IDENTIFYING NO	NOMENCLATURE OR DESCRIPTION	CODE IDENT	MATERIAL	DATA SPECIFICATIONS SIZES, NOTES, VENDORS	ZONE	LINE NO
1	05	BUMPER		ALUM. PLATE	4061-T6		010
1	04	SADDLE		304 SS TUBE	2.500 O.D. x .375 W		009
1	03	BREECH TUBE		304 SS TUBE	3.450 O.D. x .375 W		008
1	02	BARREL		304 SS TUBE	2.900 O.D. x .375 W		007
1	01	FLANGE		304 SS BAR	6.0 x 7.63		006
1	SK6090-88041	ASSY					005
1	000	TESTER					004
1	000	TESTER					003
1	000	TESTER					002
1	000	TESTER					001

UNLESS OTHERWISE SPECIFIED, DIMENSIONS ARE IN INCHES. TOLERANCES ON DECIMALS: .010, .020, .030, .040, .050, .060, .070, .080, .090, .100, .125, .150, .175, .200, .250, .300, .375, .400, .500, .625, .750, .875, 1.000, 1.250, 1.500, 1.750, 2.000, 2.500, 3.000, 3.500, 4.000, 4.500, 5.000, 5.500, 6.000, 6.500, 7.000, 7.500, 8.000, 8.500, 9.000, 9.500, 10.000.

APPROVED BY: V. Melillo 3/24/67

ATONICS INTERNATIONAL
4000 N. 10th Street, Suite 100
CANDLER PARK, CALIFORNIA

BARREL ASSY-IMPACT
TESTER-1.750 IN DIA.

CODE IDENT NO: 09974
SCALE: 1/1

NOTES: UNLESS OTHERWISE SPECIFIED

BLANK

Figure VII-2. Impact Capsule with Al_2O_3 Coating Applied

Figure VII-3. Impact Capsule A-7a Inserted in the Pt-Rh Barrier Shell and Cap

FIRING ORDER	FIRING PRESSURE (psig)	CAPSULE TEMP (°F)	COUNT (msec)	VELOCITY (ft/sec)	CAMERA DURING TEST
①	700	-	3.44	364	NO
②	600	-	3.71	338	YES
③	450	-	4.18	295	YES
LRHSC A-7a	630	1200	3.62	346	YES

4-11-69

00-102713

Figure VII-4. Test Graph for Calibration and Testing of Impact A-7a

Figure VII-5 shows the capsule after impact at 1200°F at 346 ft/sec. Note that the aft dome of the Pt-Rh shell has been punched out. Figure VII-6 shows the capsule with the Pt-Rh shell removed.

Figure VII-7 shows the T-111 structure while Figure VII-8 shows the T-111 nose section after testing. Figure VII-9 shows the capsule after being half sectioned. Metallurgical evaluation of this capsule is progressing.

Mechanical test analysis of all seven impact capsules was also completed during the reporting period and is shown in Figure VII-10. Note that in all cases that the T-111 was leak tight. Figures VII-11 through VII-16 show impact capsules A-1a through A-6a respectively, after testing. Capsules A-1a through A-4a were tested with .127-in T-111 shells while A-5 and A-6 were tested with .100-in T-111 shells. Impact capsule A-7a had a .127-in T-111 shell structure. Metallurgical analysis of all seven capsules is proceeding.

Figure VII-5. Impact Capsule A-7a After Impact Testing at 1200°F at 346 ft/sec.

Figure VII-6. Impact Capsule A-7a
With the Pt-Rh Removed

Figure VII-7. Impact Capsule A-7a T-111
Structure After Testing at 1200°F at 345 ft/sec.

Figure VII-8. Nose Portion of T-111 Capsule
After Testing

7734-4059

Figure VII-9. Impact Capsule A-7a After Being
Half-Sectioned (Note Fuel Annulus Intact
After Impact at 1200°F at 346 ft/sec)

AI-AEC-12823

S/N	Impact Velocity ft/sec	Angle	Impact Temp. °F	Ini. Length (in)	Dia. (in)	Final Length (in)	Final Dia. (in)	Dia. Strain %	Axial Strain %	Mass LB	Impact Energy ft/lbs	Wall (in)	Post-Test Wall		With Pt Rh	Summary
													Max.	Min.		
A-1a	250	30°	1200	7.375	1.676	6.836	1.926	14.8%	21.2%	4.8	4,680	.127	.165	.127	Yes (Cap)	T-111 and Pt-Rh Leak Tight
A-2a	250	10°	1200	7.376	1.677	6.750	1.928	15.0%	28.7%	4.7	4,720	.127	.160	.127	Yes (Cap)	T-111 Leak Tight
A-3a	260	End On	1200	7.372	1.676	6.610	1.972	17.4%	26.4%	4.7	4,940	.127	--	--	Yes (Cap)	Leak Tight
A-4a	230	10°	1200	7.348	1.676	6.616	2.030	21.5%	26.8%	4.8	3,950	.127	-	--	Yes (Cap)	Leak Tight
A-5a	240	End On	1200	7.325	1.624	6.624	1.919	18.2%	29.0%	4.0	3,600	.100	--	--	No	Leak Tight
A-6a	260	43°	1200	7.323	1.625	6.525	1.932	18.9%	33.8%	4.0	4,200	.100	.140	.100	No	Leak Tight
A-7a	346	End On	1200	7.419	1.718	6.100	2.115	26.5%	42.2%	5.2	9,700	.127	--	--	Yes (Comp)	Leak Tight

Figure VII-10. Mechanical Test Analysis of Impact Capsules A-1a Through A-7a

Figure VII-11. Impact Capsule A-1a After Testing at 1200°F at 250 ft/sec.

Figure VII-12. Impact Capsule A-2a After Testing at 1200°F at 250 ft/sec.

Figure VII-13. Impact Capsule A-3a After Testing at 1200°F at 260 ft/sec.

Figure VII-14. Impact Capsule A-4a After Testing at 1200°F at 230 ft/sec.
(Pt-Rh Nose Cap Hit Stripper)

Figure VII-15. Impact Capsule A-5a After Testing at 1200°F at 240 ft/sec.
(T-111 Shell .100-in Thick)

Figure VII-16. Impact Capsule A-6a After Testing at 1200°F at 260 ft/sec.
(T-111 Shell .100-in Thick)

BLANK

VIII. CAPSULE FIRE TEST

A. TASK OBJECTIVES

The objectives of this task are to subject the LRHS Capsule to a launch pad accident fire environment and to determine the effect of the fire on the capsule. The intent of the test is to simulate an event where a fueled heat source capsule comes in contact with burning solid propellant. The desired result is that the fuel loading be contained within the fuel annulus of the capsule.

B. SUMMARY OF TASK STATUS

A launch abort fire test capsule of the LRHSC creep "C" configuration was assembled, instrumented, and successfully tested during the reporting period. The objective of this test was to subject the LRHS Capsule to a launch pad accident fire environment and to determine the effect of the fire on the capsule. Preliminary post test evaluation of the capsule shows that the capsule was leak tight and the fuel simulant was completely contained within the fuel annulus.

C. ACCOMPLISHMENTS DURING THE QUARTER

The LRHS Capsule Fire Test task was originated during the reporting period. Task objectives, capsule configuration, and thermocouple instrumentation requirements were determined and an instrumented capsule, with a tungsten-molybdenum fuel simulant, was fabricated. The capsule was delivered to Isotopes, Inc., Nuclear Systems Division, Middle River, Maryland, to be tested.

The test took place on March 27, 1969 with representatives of the AEC, TRW, Sandia, GGA, Weiner Associates, Isotopes, Inc., and Atomics International in attendance. The burn time was 4-1/2 minutes with a heat flux of approximately 49 Btu/ft²/sec. The temperature in the fuel annulus reached approximately 2800°F in 1 minute 45 seconds, at which time the lead tube

separated from the capsule and thermocouple data acquisition ceased. Preliminary post test evaluation of the capsule shows the fuel simulant was contained within the fuel annulus, although the platinum shell appears to have melted and oxidation of the structural shell has begun. A complete post test analysis will be completed during the next month.

1. Fire Test Capsule Assembly and Instrumentation

An LRHS capsule was assembled to comply with the requirements of Isotop Inc.'s "Solid Rocket Fire Test" Test Plan 466A3322084, dated February 14, 1961. The assembly sequence is shown in Figures VIII-1 through VIII-4. The assembly sequence was similar to that employed for the LRHSC creep "C" capsule except a Pt vs Pt-10Rh thermocouple (T/C # 1) was inserted through a penetration hole in the forward fuel retainer ring and attached to the inside of the Ta-10W outer liner (Figure VIII-5). The fuel simulant was a tungsten-40% molybdenum mixture with a total weight of 502.7 grams. The fuel simulant was loosely packed in the fuel annulus. The aft fuel retainer ring was put into place and electron beam welded to the Ta-10W outer liner cap and outer liner sleeve.

The T-111 structural shell was .127-in thick with a groove machined along the inside wall .040-in wide by .040-in deep by 3-in long (Figure VIII-5), to allow installation of a second Pt vs Pt-10Rh thermocouple (T/C # 2) which was placed into this groove. The T-111 structural shell was positioned over the inner capsule assembly so that T/C # 1 and T/C # 2 were in the same radial and axial plane. An outer liner end cap was put into place (not welded) to protect the thermocouple wires from the electron beam during final closure welding of the structural shell. Electron beam welding of the structural cap to the structural shell was then completed. The structural shell was coated with approximately .002-in Al_2O_3 and the coated capsule was slipped into the platinum-10% rhodium oxidation barrier shell. A 12-in Pt-10Rh lead tube was welded to the Pt-10Rh end cap which was in turn welded to the Pt-10Rh shell. Gamma radiographs of the capsule were taken for comparison with post test gamma radiographs.

Figure VIII-1. LRHS Fire Test Capsule During Assembly Showing the Ta-10W Outer Liner with T/C # 1 Penetrating the Fuel Retainer Ring

Figure VIII-2. LRHS Fire Test Capsule Assembly Sequence Showing the T-111 Structural Shell with T/C # 2 in Place

Figure VIII-3. LRHS Fire Test Capsule Assembly Sequence After a 0.002-in Coating of Al_2O_3 was Plasma Sprayed over the T-111 Structural Shell. Pt-10Rh Oxidation Barrier Shell is Adjacent to the Capsule

Figure VIII-4. LRHS Fire Test Capsule Prior to Plasma Spraying the Emittance Coating of $\text{Fe}_2\text{O}_3 \cdot \text{TiO}_2$ over the Pt-10Rh Oxidation Barrier

BLANK

- Notes:
1. ALL T/C ATTACHMENTS POINTS WILL BE IN THE SAME PLANE
 2. T/C #1 WILL BE BOND TO GRAPHITE & FEED-THRU TUBE
 3. T/C #2 WILL BE PT SHEATH WITH PH & PH RA LEADS W/O INSULATED RATED AT 3000°F.

FIRE TEST CAPSULE - LRHS

SK-N00114022

2/1/69 K. MELILLO

Figure VIII-5.

AI-AEC-12823

55

BLANK

The lead tube was formed 90° to the capsule to facilitate attachment of the completed capsule to the instrumentation column of the burn pit. The remaining thermocouples were then attached. All the thermocouples were on a plane 90° from the surface contact with the propellant. Table VIII-1 is a sketch showing the T/C locations and a table giving the pre-test thermocouple data.

A partial pressure of helium between the platinum shell and the structural shell was desirable, so the following procedure was devised. The capsule was held for 12 hours at a pressure of 1×10^{-5} mm Hg, and then backfilled with reactor grade helium to one atmosphere. Epon 956 potting compound was poured around the desired interface. The glove box was then evacuated and the helium was allowed to flow through the potting compound out of the capsule until a partial pressure of approximately 1 psia was achieved. The capsule remained at this pressure during the cure cycle of the Epon 956. An emittance coating of iron titanate ($\text{Fe}_2\text{O}_3 \cdot \text{TiO}_2$) was plasma sprayed over the Pt-10Rh shell and lead tube to a thickness of approximately .004 to .005-in.

Experiments to determine the appropriate material to protect the lead tube were performed leading to the selection of foamed silica. The test set-up was comprised of a Ta-10W tube with a chromel-alumel thermocouple attached. A 3/4-in thick piece of foamed silica was positioned between the flame of an oxy-acetylene torch and against the thermocouple. The temperature on the front face of the foamed silica was monitored by an optical pyrometer and determined to be 3600°F. The temperature on the back side of the foamed silica reached 200°F in 3 minutes. The amount of the protective covering was an arbitrary selection designed to afford maximum protection to the lead tube, where possible, without interfering with the performance of the fire test. Since the intent of the test was to have the capsule in contact with the solid propellant, only 3/4-in of foamed silica could be placed between the lead tube and the solid propellant.

The foamed silica was installed and the capsule was photographed (Figure VIII-6) prior to being packaged for delivery to Isotopes, Inc.

TABLE VIII-1
THERMAL LOCATION DATA

<u>T/C #</u>	<u>Type</u>	<u>Resistance</u>	<u>Method Of Attachment</u>	<u>Location</u>
1	Pt vs. Pt-10% Rh	21 Ω	Potted	Between Fuel Simulant and Inn Liner (See Dwg. Below)
2	Pt vs. Pt-10% Rh	21 Ω	Loose	Between Inner Liner and Outer Liner
3	Pt vs. Pt-10% Rh	21 Ω	Wire Tied	Exterior to Platinum Shell (See Dwg. Below)
4	Pt vs. Pt-10% Rh	21 Ω	Wire Tied	At Inner Face of Lead Tube to Capsule Exterior
5	Pt vs. Pt-10% Rh	21 Ω	Wire Tied	Next to Above
6	W5% Re vs. W26% Re	700 Ω	Wire Tied	Adjacent to T/C #3

Figure VIII-6. LRHS Fire Test Capsule Completely Instrumented and with Foamed Silica Protecting the Lead Tube. Visible Thermocouples are W5%Re vs W26%Re (Lower) and Pt vs Pt-10%Rh (Upper)

2. LRHS Fire Test

The capsule was delivered to Isotopes facility on March 24, 1969 at 9:00 AM. Inclement weather prevented the calibration run from taking place until March 26, 1969. The results of the calibration run, using a solid block calorimeter (Figure VIII-7), indicated the heat flux of the fire to be $49.3 \text{ Btu/ft}^2/\text{sec}$. The length of time of maximum intense burning determines the burn time. The burn time for the calibration run was timed at approximately 5 minutes.

On March 27, 1969 at 1:00 PM, the LRHS Fire Test Capsule was subjected to the solid propellant fire. Still photographs, movies, optical pyrometer measurements of the flame temperature, heat flux, and thermocouple data were taken during the test. Figures VIII-8, VIII-9, and VIII-10 are photographs taken before, during, and after the fire test.

The type of solid propellant used as Aerojet General's Algol IIB. It was in block form $18" \times 18" \times 12"$ with an inhibitor on all of the surfaces except the top.

The total burn time was 4.5 minutes with a maximum heat flux of approximately $49 \text{ Btu/ft}^2/\text{sec}$. The heat flux was measured with a solid copper block calorimeter, identical to the one used for the calibration (Figure VIII-7). It was placed on the block of solid propellant next to the test capsule and instrumented with a Type P30 (Pt/30%Rh vs Pt/6%Rh) thermocouple.

Thermocouple data are presented in Figure VIII-11 in a time vs temperature relationship.

Thermocouples 1, 4 and 5 ceased to operate simultaneously 1 minute 45 seconds into the test. Thermocouples 2, 3 and 6 had failed prior to this time. It was assumed that this is the same time in test that the lead tube separated from the capsule. The temperature in the fuel annulus was 2800°F and increasing (T/C # 1, Figure VIII-11), and it was estimated that this T/C would have reached its melt temperature of 3200°F at approximately 2 minutes into the

Total Exposed Surface Area 51.778 Sq. In.
 Weight 14 Pounds

Figure VIII-7. Copper Slug Calorimeter

Figure VIII-8. LRHS Fire Test Capsule Installed in the Burn Pit at Isotopes, Inc. atop an 18" x 18" x 12" Block of Solid Propellant Prior to Ignition

Figure VIII-9. Infra-Red Photograph Taken While the Fire Test was in Progress. Flame Inhibitor on the Front Face of the Burning Propellant is Obscuring the View of the Capsule

Figure VIII-10. LRHS Fire Test Capsule Immediately Following the End of the Fire Test. The Capsule, as Well as the Copper Calorimeter, is Coated with an Oxide Produced by the Burning Propellant. This Oxide has Been Determined to be Primarily Al_2O_3 and Aluminum.

Figure VIII-11. Time vs Temperature Relationship of the LRHS Fire Test Capsule

the test had the lead tube remained intact. All other useful thermocouple data had been generated at this time.

Preliminary post test evaluation of the capsule at Isotopes indicated that the capsule, although covered with large oxide deposits from the propellant, had survived the fire test with the fuel simulant contained within the fuel annulus. The platinum shell appeared to be intact along the surface that was in contact with the fuel, but due to the heavy oxide coatings surrounding the rest of the capsule, it could not be determined if the platinum shell was totally intact at that time (Figures VIII-12, VIII-13, and VIII-14). The capsule was weighed following the test and was found to have gained a net weight of 0.08 pounds from the pre-test weight of 5.14 pounds.

The capsule was returned to Atomics International on March 31, 1969 and a full post test analysis is presently under way. Gamma radiographs have been taken for comparison with the pre-test gamma radiographs (Figures VIII-15 and VIII-16). Interpretation of this data indicates that the Pt-10Rh shell melted and puddled along the center and lower half of the capsule structure, and the T-111 structural shell partially oxidized but was not penetrated. Areas of interest along the capsule surface were selected and samples were taken for chemical analysis.

The lead tube end of the capsule was removed to provide an adequate sealing surface for helium leak testing the T-111 structural shell. The capsule was leak tested with a Veeco MS9AB Helium Leak Detector and found to be leak tight. The capsule was then dissected to expose the surface in contact with the solid propellant and the surface most distant to the solid propellant. Figure VIII-17 shows the capsule interior. The Ta-10W fuel container is undamaged and the fuel simulant totally contained. The capsule is presently being sectioned for metallographic, as well as further visual examination.

Figure VIII-12. External Appearance of the LRHS Fire Test Capsule as Viewed from the Top.
Deposits are from the Solid Propellant and are Primarily Al_2O_3 and Aluminum.

Figure VIII-13. External Appearance of the LRHS Fire Test Capsule as Viewed from the Side. Deposits are from the Solid Propellant and are Primarily Al_2O_3 and Aluminum.

Figure VIII-14. External Appearance of the LRHS Fire Test Capsule as Viewed from the Bottom. Deposits are from the Solid Propellant and are Primarily Al_2O_3 and Aluminum.

Figure VIII-15. Gamma Radiograph's of the LRHS Fire Test Capsule Taken Before and After the Solid Propellant Fire Test. Orientation of the Capsule to the Solid Propellant in this View is 0°

Figure VIII-16. Gamma Radiograph's of the LRHS Fire Test Capsule Taken Before and After the Solid Propellant Fire Test. Orientation of the Capsule to the Solid Propellant in this View is 90°

7734-4058

Figure VIII-17. LRHS Fire Test Capsule After Being Dissected.
The T-111 Structure was not Penetrated by the Fire.
The Ta-10W Fuel Liner is Undamaged and the
Fuel Simulant was Totally Contained.