DR 415

AI-AEC-12713

COPY

MASTER

LARGE RADIOISOTOPE
HEAT SOURCE CAPSULE (LRHSC)
FOURTH QUARTERLY PROGRESS REPORT
APRIL-JUNE 1968

AEC Research and Development Report

ATOMICS INTERNATIONAL

A DIVISION OF NORTH AMERICAN ROCKWELL CORPORATION

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)
FOURTH QUARTERLY PROGRESS REPORT
APRIL-JUNE 1968

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: AUGUST 15, 1968

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

fy

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 fourth 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 April 1, 1968 through June 30, 1968 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. Analytical Evaluation.....	13
A. Task Objectives	13
B. Summary of Task Status.....	13
C. Accomplishments During the Quarter	13
IV. Capsule Design	15
A. Task Objectives	15
B. Summary of Task Status.....	15
C. Accomplishments During the Quarter	15
V. Process Development.....	17
A. Task Objectives	17
B. Summary of Task Status.....	17
C. Accomplishments During the Quarter	18
1. Brazing.....	18
2. Welding.....	19
3. CVD Coating Development	20
4. Iron Titanate.....	21
5. Fuel Simulant	21
6. Documentation and Specifications	21
VI. Fabrication and Assembly	23
A. Task Objectives	23
B. Summary of Task Status.....	23

CONTENTS

	Page
C. Accomplishments During the Quarter.....	23
1. GFY 1969 Materials	23
a. Tantalum Alloys	23
b. Impact Absorbers	24
2. Capsule Piece Part Fabrication.....	24
a. T-111 Structural Shell	24
b. Piece Part Tooling	29
c. T-111 End Caps	29
d. Pt-Rh End Caps	32
e. Assembly Tooling Checkout	32
f. Creep Capsule B3a Assembly	32
VII. Capsule Creep Testing	35
A. Task Objectives	35
B. Summary of Task Status	35
C. Accomplishments During the Quarter.....	35
1. Capsule Creep Testing	35
a. Test B1a	36
b. Capsule B2a	41
c. Additional Creep System Construction	41
d. Pre- and Post-Diameter Measurements	42
VIII. Coupon Compatibility and Coating Development	49
A. Task Objectives	49
B. Summary of Task Status	49
C. Accomplishments During the Quarter.....	49
IX. Impact Testing	51
A. Task Objective	51
B. Summary of Task Status	51

CONTENTS

	Page
X. Soil Burial.....	53
A. Task Objective.....	53
B. Summary of Task Status	53
C. Accomplishments During the Quarter.....	53
XI. Creep Capsule Evaluation.....	55
A. Task Objective.....	55
B. Summary of Task Status	55

TABLES

II-1 Official Milestone Summary	12
VI-1 T-111 Structural Shell Fabrication History	25
VI-2 Piece Part Tooling	29
VII-1 Post Test Analysis (Bla)(Bulk Chemical)	40
VIII-1 Schedule of Coupon Compatibility Testing	50

FIGURES

V-1 Full Sized Stainless Steel Mockup	20
VI-1 Ta-10W Inner Liner End Cap Tooling	30
VI-2 Ta-10W Inner Liner Flanged Cap Tooling	30
VI-3 Ta-10W Outer Liner Stepped Cap and Outer Liner Closure End Cap Tooling	31
VI-4 Ta-10W Fuel Retainer Ring Tooling	31
VI-5 Pt-Rh Barrier Cap with Feed-Through Tooling	31
VI-6 Pt-Rh Barrier Caps without Feed-Through	33
VI-7 Pt-Rh Barrier Cap with Feed-Through.....	33
VII-1 Tangential Stress - Capsule Bla	37
VII-2 Mid-Point Diametral Strain - Capsule Bla	37

FIGURES

	Page
VII-3 Aging of T-111 Structure (B1a).....	39
VII-4 Capsule Profilometer	43
VII-5a Capsule and Standards Disassembled.....	44
VII-5b Capsule and Standards in Profilometer	44
VII-6 Diametral Scan of B5a	47

BLANK

I. INTRODUCTION

The LRHSC Program has been established to develop the technology of an isotope fuel capsule capable of operating 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. In addition to indicating the suitability of the reference capsule for ground test, the data generated in this study 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) Analytical Evaluation
- 3) Capsule Design
- 4) Process Development ✓
- 5) Fabrication and Assembly ✓
- 6) Capsule Creep Testing ✓
- 7) Coupon Compatibility and Coating Development ✓
- 8) Impact Testing
- 9) Soil Burial ✓
- 10) Creep Capsule Evaluation

BLANK

II. PROGRAM MANAGEMENT

A. TASK OBJECTIVES

The objectives of this task are to provide management, directions 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 1968 are shown in Table II-1. All milestones for the fiscal year have been successfully accomplished. The program completed the fiscal year on budget. An overall plan showing the requirements for completion of the program has been prepared and reviewed with the AEC. However, the detailed program planning for GFY 1969 awaits final budget allocations.

C. ACCOMPLISHMENTS DURING THE QUARTER

Long range planning has been accomplished during the quarter to define the requirements for completion of the LRHSC Program. The overall plan, including technical requirements, schedules and manpower, has been completed and reviewed with Sandia and AEC management. Detailed allocation of the required effort between GFY 1969 and GFY 1970 awaits final determination of the GFY 1969 budgetary limitations.

Two topical reports were issued during the quarter.

Topical Report # 2 - LRHSC Program Process Specifications

Topical Report # 4 - LRHSC Program Capsule Fabrication Processes

TABLE II-1

OFFICIAL MILESTONE SUMMARY

<u>Official Milestones</u>	<u>Target Date</u>	<u>Status</u>
1. Freeze design and release capsule piece-part drawings	August 1967	Complete
2. Complete and release all material specifications	August 1967	Complete
3. Complete and release all capsule assembly drawings	September 1967	Complete
4. Complete and release fixture drawings	September 1967	Complete
5. Complete Al ₂ O ₃ CVD vs Plasma Coating Evaluations	October 1967	Complete
6. Complete all assembly specifications	November 1967	Complete
7. Complete all processing and test	January 1968	Complete
8. Complete Topical Report # 1, LRHSC Program Material Specifications	January 1968	Complete
9. Initiate short term creep tests	January 1968	Complete (March 1968)
10. Complete coupon (except coupon stacks associated with creep capsules) tests	March 1968	Complete
11. Complete Topical Report # 2, LRHSC Program Process Specifications	March 1968	Complete (April 1968)
12. Complete Topical Report # 3, LRHSC Program Ceramic Coating Process Development and Evaluations	April 1968	Complete
13. Complete Topical Report # 4, LRHSC Program Capsule Fabrication Processes	May 1968	Complete (June 1968)
14. Complete GFY 1968 Capsule Fabrication and Assembly	June 1968	Complete

III. ANALYTICAL EVALUATION

A. TASK OBJECTIVES

The objectives of this task are to provide analytical support to the capsule design, fabrication, and test programs, and provide the analysis for verification of design approach, using the test data generated in the program. Further efforts will include definition of the design margins in the capsules by comparison of test program results with typical operational requirements.

B. SUMMARY OF TASK STATUS

Analyses have been accomplished in support of capsule design, assembly and test design. The verification of design approach and definition of design margin activities will not be initiated until substantial test data are available. Until that time, the first quarter of GFY 1969, no specific efforts are planned under this task.

C. ACCOMPLISHMENTS DURING THE QUARTER

No activity under this task during the quarter.

BLANK

IV. CAPSULE DESIGN

A. TASK OBJECTIVES

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

A major portion of this task is evaluation of the fabricability of the design and preparation of a complete tolerance study on all capsule configurations.

B. SUMMARY OF TASK STATUS

All capsule piece-part, assembly, tooling and fixture design has been completed and the drawings released. All compatibility and creep test fixture design is complete.

No further design effort is required this year except minor modifications to the tooling that may become necessary when the tooling is checked out.

C. ACCOMPLISHMENTS DURING THE QUARTER

No activity under this task during the quarter.

BLANK

V. PROCESS DEVELOPMENT

A. TASK OBJECTIVES

The objective of the Process Development Task is 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 will be performed as required.

B. SUMMARY OF TASK STATUS

An improved brazing procedure for the Ta-10W to stainless pressure feed-through joint has been successfully developed using 82Au-18Ni braze alloy. Ultrasonic shear wave testing was conducted on the sample braze joints to inspect the bond area. Also, weld parameters have been established on three electron beam welds during the reporting period: Weld procedure #1233 for the Ta-10W inner liner end cap to the Ta-10W inner liner tube, Weld Procedure #1234 for the Ta-10W inner liner tube to the Ta-10W inner liner flanged cap, and Weld Procedure # 1235 for the Ta-10W outer liner stepped cap to the Ta-10W outer liner sleeve.

Structural shell S/N 018 was ultrasonically tested successfully. This shell was assigned to creep capsule B3a. The process specification for deep drawing of the T-111 shells has been completed and issued.

The CVD Al_2O_3 coating scaleup has been initiated using two full size 304 stainless steel capsules.

A fuel simulant for the PuO_2 fuel has been established as the following:

Density of Vibrated W Powder - 10.3 g/cc

Density of Vibrated Mo Powder - 4.72 g/cc

Simulant Mixture - 35.5 vol. % W + 64.5 vol. % M $\rightarrow$ 6.7 g/cc

C. ACCOMPLISHMENTS DURING THE QUARTER

1. Brazing

During the quarter, the problems associated with making a reproducible braze joint between the stainless steel pressure tube and the Ta-10W pressure feed-through tube were investigated. The object remains to produce a lap joint braze which will be pressure tight (up to 10,000 psi) and will show a continuous bond when inspected ultrasonically. The basic parameter studies and a tentative brazing process were developed during the second quarter.

A specification, ST0107NA0026, "Brazing - LRHSC," has been written and released. The specification refers directly to a procedure document TI-734-20-005. Together the two documents completely characterize the brazing process including acceptance testing and quality assurance techniques.

Two process parameters were investigated. These were the braze alloy and the braze joint configuration. The first alloy used was Au-20Cu. This material did not reproducibly yield good joints due to poor molten flow on the tantalum alloy. Based on some previous wetting studies a gold-copper alloy with 20% Ag (Silcoro 60) was investigated. This alloy was certainly less viscous than the previous alloy at brazing temperature (1750°F), however, the joints produced were still unsatisfactory.

A literature search revealed some work which was done brazing stainless to tantalum using common alloys known as silver solders⁽¹⁾. The article also

(1) M. L. Torti and R. W. Douglass, "Refractory Metals and Alloys III: Applied Aspects," Brazing of Tantalum and its Alloys, V. 30, AIME Metallurgical Society Conferences 1963, P 171-182.

discussed tantalum and stainless cleaning operations prior to brazing. The adaptation of these alloys and cleaning processes to our process constitutes the current braze development effort. Some improvement in braze wetting of tantalum has been observed when the Ta-10W tube was electrochemically cleaned in a solution of HF, H₂O and NH₄F.

The original joint design had the Ta-10W surrounding 304 stainless steel. The gap between the two components would close at brazing temperature; however, upon cooling the alloy was put into tension. From the literature, we have found that the gold-copper alloy forms a brittle phase on the tantalum surface which would rupture when the joint is in tension. Some experiments are now being conducted with the joint circumferential sequence reversed. This will put the braze alloy in compression which would appear to be more reasonable. Another design concept employs the use of a double enclosure which, in essence, lengthens the braze joint length from one to three inches.

2. Welding

Ta-10W to Ta-10W tube weld tests simulating the pressure feed-through tube weld joint were completed. These tests were made to eliminate the marginal weld penetration and weld concavity observed in earlier welds. Also, weld development of the Ta-10W welds required for the inner and outer liner assemblies was initiated during the quarter.

Weld parameters for WP 1233, (Ta-10W Inner Liner End Cap to the Ta-10W Inner Liner Sleeve); WP 1234, (Ta-10W Inner Liner Sleeve to the Ta-10W Inner Liner Flanged Cap); and WP 1235, (Ta-10W Outer Liner End Cap to the Ta-10W Outer Liner Sleeve) were established using E. B. Weld Fixture T-6001638. The result of weld development of the Ta-10W Inner Liner End Cap to the Ta-10W Inner Liner Sleeve (WP 1233) was a smooth, full penetration weld zone of the 0.020" Ta-10W. Review of the stitch weld (WP 1234) indicated that the fused areas possess full penetration. A small concave pock mark exists at the point where the beam reappears after passing over the screening barrier; however,

this condition will not affect the performance of the weld. The unfused length of joint on the surface is in the 0.040 - 0.060 inch range. The unfused length of joint on the ID of the liner is estimated to be 0.250 inches. An improved method of interrupting the beam is being devised to obtain better uniformity of the unfused areas.

3. CVD Coating Development

Scale up of the CVD Al_2O_3 coating process was initiated. Two full-size mock-up capsules of 304 stainless steel were fabricated (Figure V-1) and delivered to San Fernando Laboratories for studies on equipment sizing and on heat and flow management. The 304 stainless steel capsules will be followed by five full-size T-111 capsules for coating with one to two mils of α Al_2O_3 . The two stainless steel capsules are equipped with 6-inch long feed through tubes, which must also be coated with α Al_2O_3 . This requirement is expected to constitute the major difficulty in the coating development program. Serious perturbations in inductive coupling, fluid flow rates, heat radiation and conduction, and other process parameters must be expected in the transition zone between the 1.67-inch diameter capsules and the 0.34-inch diameter stems.

Figure V-1. Full Sized Stainless Steel Mockup

4. Iron Titanate

An iron titanate application specification (ST0609NA0032) for the LRHSC program was written and released. The document covers the parameters to be used in arc plasma spraying iron titanate powder (per ST0115NB0018). It also defines the quality assurance of the coating including the required bonding and emissivity tests.

5. Fuel Simulant

A fuel simulant for the PuO_2 in the LRHSC was created. The mixture approximates the bulk packed density of PuO_2 microspheres at 6.7 g/cc. The simulant is composed of W and Mo powders with -80 to +250 mesh particle sizes. The following data apply to the simulant:

Density of Vibrated W Powder - 10.3 g/cc

Density of Vibrated Mo Powder - 4.72 g/cc

Target Density = 6.7 g/cc

Therefore:

Simulant Mixture = 35.5 vol. % W + 64.5 vol. % M

The LRHSC fuel annulus volume was calculated from the latest assembly and piece-part drawings. The volume is 79.21 cm^3 . This results in a fuel or fuel simulant weight of about 530 grams per capsule. The requirements, therefore, to fuel 17 impact test capsules are 11 pounds W, and 9 pounds Mo.

6. Documentation and Specifications

The following specifications were started and/or completed:

ST0170NB0053, Low Density Porous Metal, Tantalum-10 Percent Tungsten

ST0170NB0055, Metal Powder, Tungsten

ST0170NB0056, Metal Powder, Molybdenum

ST0602NA0003, Deep Drawing T-111 Plate, LRHSC

ST0170NB0053 is 95% complete. Completion of the rough draft is pending receipt of information from Astro Met for determining the apparent density of the material.

The rough drafts for ST0170NB0055 and ST0170NB0056 are each 25% complete. A selection of a range of particle sizes, which effects the density, is now in the process of being made. Four suppliers of metal powders, Fansteel, Plasmadyne, Climax Molybdenum, and Metallurgical International Incorporated have been contacted for technical information. Contact with Sandia indicates that a mesh size range of -80 to +250 is currently being used by their sub-contractors to simulate PuO₂.

Specification ST0602NA0003, Deep Drawing T-111 Plate, LRHSC, has been completed. Sketches have been made for all the structural shell deep draw tooling and AI tool numbers have been assigned. The tools are as follows:

Draw Ring Support Ring - LRHSC Structural Shell, T-6001687

Draw Tool No. 1 - LRHSC Structural Shell, T-6001688

Draw Tool No. 2 - LRHSC Structural Shell, T-6001689

Draw Tool No. 3 - LRHSC Structural Shell, T-6001690

Draw Tool No. 4 - LRHSC Structural Shell, T-6001691

Draw Tool No. 5 - LRHSC Structural Shell, T-6001692

Draw Tool No. 6 - LRHSC Structural Shell, T-6001693

Draw Tool No. 7 - LRHSC Structural Shell, T-6001694

Draw Tool No. 8 - LRHSC Structural Shell, T-6001695

VI. FABRICATION AND ASSEMBLY

A. TASK OBJECTIVES

The objectives of this task are to obtain all tantalum and platinum alloy semi-stock required for the LRHSC Development Program, to fabricate all capsule and coupon piece parts, to develop, fabricate, and check out all capsule piece part and assembly tooling, and to assemble all capsules and compatibility coupon stacks.

B. SUMMARY OF TASK STATUS

The second heat (Heat "B") of T-111 material for GFY 1969 structural shell and structural end cap fabrication was ordered from National Research Corporation. Also, sixty Ta-10W impact absorbers were ordered from Astro Met Associates.

Deep drawing of T-111 structural shells S/N 017 through 023 was completed. Some problems were encountered in the process control, particularly in regard to the in-process anneal. All LRHSC piece part tooling was completed with the exception of the Pt-Rh barrier shell tooling which is 80% completed.

E.B. Weld Fixture T-6001638 was installed in the E.B. Welder, checked out and used for the development of the three E.B. weld procedures discussed in Section V (Process Development).

Creep capsule B3a was assembled, inspected, and delivered to test.

C. ACCOMPLISHMENTS DURING THE QUARTER

1. GFY 1969 Materials

a. Tantalum Alloys

Thirty 6-1/2" diameter T-111 blanks were ordered from National Research Corporation for GFY 1969 "Heat B" shell fabrication. Sixty 2-1/2" diameter

T-111 blanks 0.250" thick were also ordered for GFY 1969 "Heat B" end cap fabrication. Delivery of the T-111 "Heat B" material for shells and end caps is scheduled for July 27, 1968. Fifteen Ta-10W pressure feed through tubes 20" long were ordered for GFY 1969 creep test capsules. The tubing is scheduled for delivery September 15, 1968.

b. Impact Absorbers

An order was placed with Astro Met Associates of Cincinnati, Ohio for sixty impact absorbers. These will be made of 15 to 25% dense Ta-10W porous metal. They will be machined to comply with AI Drawings N73420009 and N73420024. A specification covering the required chemical purity and material traceability is being written. The test plans for evaluation of these pieces are also being written.

2. Capsule Piece Part Fabrication

a. T-111 Structural Shell

The process developed to deep draw T-111 structural shells was reviewed after completion of shell S/N 016. Table VI-1 tabulates the continued fabrication of shells S/N 017 through S/N 023. To attempt to further simplify the fabrication process it was decided to draw a shell through the eight stage operation with only chemical cleaning being used after draw number 6 (when the shell is annealed). Chemical cleaning had previously been employed after each draw. It was also decided to verify the requirement for an in-process anneal by attempting to draw a shell through draw number 7 without it being annealed after draw No. 6.

S/N 017

This shell cracked after being drawn through Die number 7 without being annealed after draw number 6 confirming that the 2700°F/1 hour anneal after draw number 6 is required.

TABLE VI-1
T-111 STRUCTURAL SHELL FABRICATION HISTORY

S/N	Initial Blank Size	Lubricant Used	Die Material	Concen- tricity Fixture Used	Dies Used							Annealed After X Draw	Anneal Temp.	Anneal Time	Results Obtained (Insert Stage Number)										Press Loading (Tons)								Part Utilization	Remarks		
					0	1	1a	2	2a	3	4				5	Outside Surface Galling	Inside Surface Galling	Press Installed	Axial Cracks at Top	Axial Cracks at Bottom	Circum. Cracks at Top	Circum. Cracks at Bottom	Surface Checking	Bottom Punched Out	Other (Explain)	0	1	1a	2	2a	3	4			5	
001	10"	Paste	4130 Steel	No		X		X		X			None	None	None										Part pulled apart near top during 4									Develop.		
002	8-1/2"	Paste	4130	No		X		X		X	X	X	None	None	None	1,2,3,4,5	1,2,3,4,5	3,4,5																Develop.		
003	5-3/4"	Paste	4130	No		X		X					None	None	None			2			2		2	Part cocked during 2 draw		115			120					Develop.		
004	5-3/4"	Paste	4130	No		X		X					None	None	None						2			Pulled apart during 2 draw		115			120					Develop.		
005	5-3/4"	STP	4130	No		X		X		X			2	2700°F	1 Hr.	3							3					120		110			Develop.			
006	5-3/4"	Graphite & STP	4130	No		X		X		X			2	2700°F	1 Hr.								3					120		110			Develop.			
007	5-3/4"	Paste	4 & 5 Al Bronze	No		X		X	X	X	X	X	3	2700°F	1 Hr.	3	5											120	115	110	75	75	Develop.			
008	5-3/4"	Paste	4 & 5 Al	No		X		X	X	X	X	X	3	2700°F	1 Hr.	3	5											120	115	110	75	75	Develop.			
009	5-3/4"	Paste	Al Bronze	No		X	X	X	X	X	X	X	3	2550°F	1 Hr.				4	4			A	Uncleaned prior to anneal, also too short		115	110	105	75	75	70	60	Develop.			
010	5-3/4"	Paste	Al Bronze	No		X	X	X	X	X	X	X	3	2550°F	1 Hr.				4	4			A	" "		115	110	105	75	75	70	60	Develop.			
011	5-3/4"	Paste	Al Bronze	No		X	X	X	X	X	X	X	3	2550°F	1 Hr.				4	4			A	" "		115	110	105	75	75	70	60	Develop.			
012	5-3/4"	Paste	Al Bronze	No		X	X	X	X	X	X	X	3	2550°F	1 Hr.				4	4			A	" "		115	110	105	75	75	70	60	Develop.			
013	6-1/2"	Paste	Al Bronze	Yes	X	X	X	X	X	X	X	X	3	2700°F	1 Hr.		5		3		4			Used Concentricity Fixture	60	115	110	105	75	75	70	60	Develop.			
014	6-1/2"	Paste	Al Bronze	Yes	X	X	X	X	X	X	X	X	3	2700°F	1 Hr.									Used Concentricity Fixture	60	115	110	105	75	75	50	60	Develop.	Assigned to B-1a		
015	6-1/2"	Paste	Al Bronze	Yes	X	X	X	X	X	X	X	X	3	2700°F	1 Hr.									Used Concentricity Fixture	60	115	110	105	75	75	50	60	Qual.	Assigned to B-2a		
016	6-1/2"	Paste	Al Bronze	Yes	X	X	X	X	X	X	X	X	3	2700°F	1 Hr.									Used Concentricity Fixture	60	115	110	105	75	75	50	60	Qual.	Assigned to Weld Qual.		
017	6-1/2"	Paste	Al Bronze	Yes	X	X	X	X	X	X	X		None	None				4						Used Concentricity Fixture	60	115	110	105	75	75	50	60	Exp.	To certify annealing cycle		
018	6-1/2"	Paste	Al Bronze	Yes	X	X	X	X	X	X	X	X	3	2700°F	1 Hr.									Used Concentricity Fixture	60	115	110	105	75	75	50	60	Test	Assigned to B-3a		
019	6-1/2"	Paste	Al Bronze	Yes	X	X	X	X	X	X	X	X	3	2700°F	1 Hr.							2		Used Concentricity Fixture	60	115	110	105	75	75	50	60	Test	To be Assigned		
020	6-1/2"	Paste	Al Bronze	Yes	X	X	X	X	X	X	X	X	3	2700°F	1 Hr.						5		2	Used Concentricity Fixture	60	115	110	105	75	75	50	60	Test	Scrap		
021	6-1/2"	Paste	Al Bronze	Yes	X	X	X	X	X	X	X		3	2700°F	1 Hr.				5	5				Used Concentricity Fixture	60	115	110	105	75	75	50		Test	Scrap		
022	6-1/2"	Paste	Al Bronze	Yes	X	X	X	X	X	X	X	X	3	2700°F	1 Hr.				5	5				Used Concentricity Fixture	60	115	110	105	75	75	50	60	Test	To be Assigned		
023	6-1/2"	Paste	Al Bronze	Yes	X	X	X	X	X	X	X	X	3	2700°F	1 Hr.									Used Concentricity Fixture	60	115	110	105	75	75	50	60	Test	To be Assigned		
024																																				
025																																				

BLANK

S/N 018

This shell was satisfactorily drawn through all eight draws with chemical cleaning being employed after draw number 6 only. This shell has been assigned to creep capsule B3a.

S/N 019 and S/N 020

After being drawn through the fourth stage, these two parts were returned to AI for scarfing of surface defects developed during the fourth draw. These surface imperfections were removed and the parts returned to Claiborne for continuation of the fabrication sequence. They were drawn through number 5 and number 6 draws, returned to AI, annealed at 2700°F/1 hour and drawn through the final two dies. Examination of the shells after the final die (number 8) indicated surface checking on both parts.

Shell structure S/N 019 had no severe cracks visible on the surface while S/N 020 had one severe crack at the nose section. It was decided to machine the OD of shell S/N 019 to remove the surface cracks. The machining was completed with 0.122 inch wall thickness remaining (0.127 inch wall is the design thickness). S/N 020 was machined to 0.090 inch wall thickness without removal of the crack at the nose section. It is obvious that S/N 020 is scrap, however, S/N 019 may be usable for testing and was delivered to ultrasonic, helium leak, and dye penetrant inspection. Ultrasonic inspection revealed several material flaws which are currently being evaluated.

S/N 021, S/N 022 and S/N 023

After being drawn through the first six stages, parts S/N 021 and S/N 022 were annealed. S/N 021 was drawn through die number 7 successfully. However, examination of this shell after the final draw disclosed severe cracking of the part. S/N 022 was returned to AI without further fabrication.

Examination of S/N 022 revealed a grey film on its surface. Metallographic examination indicates that there was a thin case on the surface part, but no apparent change to the matrix.

An annealing study of two T-111 samples was performed in the vacuum furnace. Sample number 1 was placed inside a protective tantalum container while sample number 2 was left exposed to the chamber. The two parts were annealed at 2700°F for 1 hour, removed and examined. Sample number 1 (protected) showed no signs of surface contamination. Sample number 2 (exposed) revealed a grey film on its surface comparable to S/N 022. All further annealing will be performed with the parts inserted in a protective tantalum container to prevent potential contamination by back streaming.

Approximately 0.015" was removed from the surface of S/N 022 by chemical milling. The seventh and eighth draw were then successfully completed. These last two draws also used a 0.005 copper coating on the punch to eliminate internal galling of the shell when extracting the punch. The galling was eliminated; however, the 0.005 copper coating wrinkled when the punch was removed, causing a wrinkled surface on the ID of the shell. These wrinkles were polished out. To eliminate this wrinkling effect which is caused by too heavy of a copper coating, only a 0.001/0.002 mil copper flash will be used on the seventh and eighth punch in the future.

The Al-Bronze dies were reworked and shell S/N 023 fabricated. The T-111 blank was drawn through the first six draws, cleaned, annealed, and drawn through draws 7 and 8. This shell was then delivered to ultrasonic inspection along with S/N 022. The ultrasonic inspection again revealed some material flaws, 5 in 022 and 3 in 023. Detailed visual examination (30X) of the outside surfaces of the shells showed that some of the flaws were open at the surface (and were 0.020-0.060" in length). Approximately 0.002" material removal from the shell surfaces removed some but not all the flaws. Further evaluation of these two shells is in progress to determine the nature, cause and seriousness of the flaws.

b. Piece Part Tooling

All LRHSC piece part tooling has been completed with the exception of the Pt-Rh barrier shell tooling which is approximately 80% complete. A listing of all piece part tooling fabricated and the percent of the first three articles fabricated to certify the tooling is shown in Table VI-2.

TABLE VI-2
PIECE PART TOOLING

<u>Title</u>	<u>% Tooling Completed</u>	<u>% First 3 Art.</u>	<u>Comment</u>
T-111 Structural Shell	100%	100%	Process Spec. Written
T-111 Structural End Cap	100%	100%	
T-111 Structural End Cap with Feed-Through	100%	100%	
Ta-10W Inner Liner End Cap (Figure VI-1)	100%	100%	
Ta-10W Inner Liner Flanged Cap (Figure VI-2)	100%	90%	
Ta-10W Outer Liner Stepped Cap (Figure VI-3)	100%	66%	
Ta-10W Fuel Retainer Ring (Figure VI-4)	100%	33%	
Ta-10W Outer Liner Closure End Cap (Figure VI-3)	100%	66%	
Pt-Rh Barrier Shell	80%		
Pt-Rh Barrier Cap	100%	33%	
Pt-Rh Barrier Cap with Feed-Through (Figure VI-5)	100%	33%	Two Stage Operation. First Stage Completed.

c. T-111 End Caps

Three end cap blanks were formed and the feed through attachment boss extended by "TIG" welding buildup. After welding, the caps were machined to "print" and have been designated for before/after samples and one cap for use on creep capsule B3a.

Figure VI-1. Ta-10W Inner Liner End Cap Tooling

Figure VI-2. Ta-10W Inner Liner Flanged Cap Tooling

Figure VI-3. Ta-10W Outer Liner Stepped Cap and Outer Liner Closure End Cap Tooling

Figure VI-4. Ta-10W Fuel Retainer Ring Tooling

Figure VI-5. Pt-Rh Barrier Cap with Feed-Through Tooling

Nine T-111 end caps were formed, cleaned and annealed. TIG buildup of the feed through boss is in work with three caps completed for creep capsule B4a. The six remaining caps will be used for creep capsules B5a and B6a.

d. Pt-Rh End Caps

Three Pt-Rh blanks for the barrier cap were formed (Figure VI-6). The first cap formed successfully but cracked at the radius on the weld lip. The second formed successfully and showed no signs of cracking. The third also cracked at the radius on the weld lip. Investigation of the cause for cracking indicated the blank size was too large resulting in the weld lip locking in the die and cracking the radius. Slightly reduced blank size should solve this problem.

Three additional Pt-Rh blanks were delivered for the barrier cap with the pressure feed through boss. Forming of these three parts resulted in tearing of the cap during final sizing (Figure VI-7). Investigation as to the cause of this tearing is presently underway.

e. Assembly Tooling Checkout

E.B. Weld Fixture T-6001638 has been checked out and used in weld development. The final E.B. Weld Fixture Tool T-6001654 has been wired into the E.B. weld system. A motor controller with a selector switch for driving three DC Globe motors individually has been installed.

f. Creep Capsule B3a Assembly

This capsule has been assembled, tested, and the capsule delivered to creep testing.

BLANK

BLANK

VII. CAPSULE CREEP TESTING

A. TASK OBJECTIVES

The LRHSC Program fuel capsule design utilizes a first generation tantalum alloy (Ta-10W) as primary containment for 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 the task is to provide and test a design approach that accounts for creep deformation at elevated temperatures for this capsule design.

To achieve this end a test series has been designed 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.

B. SUMMARY OF TASK STATUS

The first biaxial creep test has been completed. Analysis of this first test indicated that the creep strength was higher by as much as 30% from that uniaxial, constant load T-111 data in the literature. The second creep test is in progress. Early results indicates that the higher strength observed correlates with the first test. Two additional creep systems have been constructed and are undergoing checkout. A design has been formulated for nine additional creep systems. Chambers for these are now under construction. A profilometer for measuring the pre-and post-creep test diameters at a number of points along the capsule has been checked out and is operational.

C. ACCOMPLISHMENTS DURING THE QUARTER

1. Capsule Creep Testing

a. Test Bla

After 580 hours under pressure the first biaxial creep capsule for the program was terminated. This was prior to achieving 1% diametral strain. The test was dismantled to determine the cause of the low creep rate compared to that expected by calculations based on uniaxial constant load data from the literature. The stress schedule calculated vs. actual is shown in Figure VII-1. The resulting strain is shown in Figure VII-2.

At 2000°F the capsule was pressurized initially at 2840 psia for approximately 100 hours. Utilizing the right circular thin walled approximation this would correspond to 17,500 psi stress. Based on the constant load creep resistance of a median strength heat of sheet tested by Sawyer⁽¹⁾, this should have induced 0.1% strain in 60 hours. No strain was observed in 60 hours. The pressure was increased to 3230 psia which should produce 20,000 psi stress. This pressure remained for 50 hours, still no strain could be detected. The pressure was then increased to 3400 psia (approximately 21,000 stress) and remained there for approximately 150 hours until 0.1% diametral strain was achieved. A number of minor problems occurred with the pressure system during this period. These were remedied and the capsule was put on the pressure ramp of 11.4 psia/hour (71 psi stress/hour) after 320 hours of operation. When the capsule pressure reached 5,000 psia (30,000 psi stress) the strain was nominally 0.44%. This was much lower than had been anticipated even from the early results of the test. It was decided to terminate the test to examine the capsule and determine if the capsule was indeed that strong, or if the apparent creep resistance was due to a test variable such as contamination of the specimen by the test environment.

The 5,000 psia remained on the capsule for approximately another 100 hours until provisions could be made for the disassembly. At this time, the total strain was nominally 0.7%. Upon depressurizing the capsule contracted elastically a little less than 0.3%.

⁽¹⁾ Generation of Long Time Creep Data on Refractory Alloys at Elevated Temperature - TRW-ER-7203, Sawyer and Steigerwald.

8-J6-099-49

Figure VII-1. Tangential Stress - Capsule Bla

8-J6-099-50

Figure VII-2. Mid-Point Diametral Strain - Capsule Bla

Comparison of the pre- and post-test mechanical diameter measurements agrees well with the in-test optical measurements (approximately 0.4% plastic strain). The post test measurements also indicated that the end regions strained little (less than half of that observed in the mid regions).

Our calculations indicate that the domed end caps have a negligible affect on the creep resistance of the mid regions, the stress at the mid region being essentially unaffected by end constraints for this length capsule.

The capsule was cut open for examination. Other than a minor discoloration near the weld (end of capsule), there was no visual evidence of contamination by either the pressurizing gas or the vacuum. Metallographic examination of the specimen indicated the microstructure of the T-111 contained a large number of fine precipitates. Their identity was not certain. If they were produced by contamination during testing, test procedures would have to be changed; however, if they are a naturally occurring phenomenon, then the test system or capsule needs to be redesigned. The creep rate of the capsule was less than expected. The system as it is presently designed, does not have the capacity to strain the "stronger" capsule the required amount for the shorter term tests.

While X-ray diffraction following extraction should result in phase identification, a heat treating study was undertaken to determine if the phases could be identified by other means. Samples of the tested capsule were heat treated 1 hour at 2700°F and 3909°F. Almost all of the precipitates went into solution after the 1 hour at 2700°F. The resulting structures are shown in Figure VII-3. It is not clear whether these were the HCP tantalum dimetal carbide or the FCC (H, f) (C, O, N). Bulk chemical analysis of the sample for interstitials indicated that there was no increase during testing. These results are shown in Table VII-1. The precipitates appear to be the normal reaction of T-111 to the thermal environment. The treatment at 3909°F took an additional portion of the precipitates into solution.

AGING OF T-111 STRUCTURE (B-1-a)

PRE-TEST

- CLEAN STRUCTURE
- UNIFORM GRAIN SIZE
- COMPLETE RECRYSTALLIZATION

POST-TEST
(600 HOURS)

- EXTENSIVE PRECIPITATES
- GRAINS UNCHANGED

POST TEST WITH 2700°F
FOR 1 HOUR ANNEAL

- 90% REDUCTION IN PRECIPITATES
- GRAINS UNCHANGED

8-J6-099-45

Figure VII-3. Aging of T-111 Structure (B1a)

TABLE VII-1
POST TEST ANALYSIS (B-1a) (BULK CHEMICAL)

<u>Element</u>	<u>As Received T-111 (ppm)</u>	<u>After Test (ppm)</u>
Carbon	38	40
Nitrogen	25	30
Hydrogen	5	10
Oxygen	65	45

Conclusion: Increased creep strength not due to interstitial
contamination

There does appear to be a second grain boundary phase on the inner surface of the capsule, and a second phase in the grains on the outer surface of the capsule. Neither exceeds 1/2 mm, and both were apparently unaffected by the heat treatments.

It was concluded that the strength observed during this first test will be typical of the remaining capsules. Therefore, some modifications will be required to perform the total test program. The test system was originally designed for a material approximately 30% lower in strength. The maximum clean gas pressure available (6,000 psia) will not be sufficient, for example, to strain a 0.127" wall capsule 1% in 100 hours although the longer term tests will be accumulated without change.

Evaluation of the test data does not indicate that the planned test program should be changed. The situation is being reviewed to determine the best method of changing the test vehicles so that the program can be carried out. It has been tentatively concluded that the wall thickness of the capsule should be reduced. The fabrication program is being reviewed to determine the best method of achieving this new capsule configuration. Until that time capsules which have been fabricated with the heavier wall will be tested. These tests will be long term, in the range of 1,000 hours or greater.

b. Capsule B2a

To verify the observed low creep rate of the first test a second capsule test was installed. This test was designed to achieve 0.1% strain in 480 hours, at a constant pressure, and 1% in the following 1000 under a constant pressure rate. This capsule is the same nominal configuration as the first.

Though the first test indicated as much as a 30% increase in strength from that expected from uniaxial data, a more conservative 15% increase in pressurization was used in the initial phase of the B2a test. After 500 hours of operation at 16,450 psi stress and 2000°F, the nominal strain was about 0.05%, compared to the 0.1% target. Review of these data indicated that the 30% increase over the baseline calculations was probably correct as the first test had indicated. The second portion of the test was then begun and the capsule pressurized at 0.928 psi per hour, which would correspond to 6.5 psi stress per hour. This stress rate should induce 1% total strain in the next 1,000 hours (1,500 hours total). The test has now logged 600 total hours, all sections of the test system appear to be operating satisfactorily.

c. Additional Creep System Construction

Construction of additional creep systems has proceeded during the quarter and procurement of nine additional chambers has been initiated. Two vacuum chambers, appendadage pumped by 1200 l/sec. ion pumps, were modified for use as biaxial creep systems. The modifications included installation of power, instrumentation, pressure, burst diaphragm, and ion gauge feed-throughs, and flanges for the two optically flat windows. Cooling coils have been brazed to the side walls and the support flanges of the chambers. The chambers were leak checked, installed on the pumps and have been evacuated to 10^{-9} torr for a final cold leak inspection, and checked out for system evacuation capability. Proportioning controller/silicon controlled rectifier systems have been constructed for control of the furnace temperature. The systems are the same as presently being used on the first chamber which maintains the temperature

swing to within 3°F at 2000°F. Construction of the furnace for the second chamber is complete and the furnace will be thermally profiled as soon as window shades and heat shields are constructed. The third furnace is about 50% assembled and is scheduled for final checkout early in the next quarter.

The design for nine additional creep chambers was completed, released, bid and a contract awarded for their construction. The chambers are quite similar to the first three, except they will be appendage pumped by 400 l/sec. ion pumps since they are for longer term tests where the higher pumping capacity will not be required.

d. Pre- and Post-Diameter Measurements

During the quarter a profilometer was set up for pre- and post-creep test diameter traces. The system is designed to measure the diameter of the capsule at 12 radial locations along the capsule's complete length. The instrument is shown in Figure VII-4. In this particular view a longer, smaller diameter specimen is being examined. A closeup of the capsule and standards are shown in Figure VII-5. The diameter is measured by two opposing linear differential transformers, attached to the carriage of a precision lathe. Trip levers are placed in the head stock which actuate the recorders. For this test 12 levers were placed equally about the trip wheel. As a result the diameter of the capsule is measured in 12 equal radial planes. The precision of the transducer assembly is 50 μ -in. The sensors are advanced along the capsule by the carriage lead screw of the lathe. The pitch of the thread is 15, therefore, a complete radial scan of the capsule is made 15 times per inch. Positioning the capsule and providing the standardization required for each capsule scan are a set of cylindrical standards. Each set contain four known standard cylindrical surfaces. The trace is begun on one set, traverses out onto the capsule, and terminates on the second. The standards are secured to the head and tail stocks to assure alignment of the specimen. The data points are presented immediately on punched tape for direct computer input, numerical

BLANK

Figure VII-5a. Capsule and Standards Disassembled

Figure VII-5b. Capsule and Standards in Profilometer

printout from a digital recorder, and x-y plot. All three contain the same information, just in a different form. An example of the x-y plot of a capsule and standards is shown in Figure VII-6. The punched tape is saved until the post test profiles are taken, and then the values for each point are compared. Computer codes are available for this purpose.

BLANK

Figure VII-6. Diametral Scan of B5a

BLANK

VIII. COUPON COMPATIBILITY AND COATING DEVELOPMENT

A. TASK OBJECTIVES

The objectives of the Coupon Compatibility Task are to identify any interactions that occur between those capsule materials that will be in contact with each other, to measure the rates of interaction as functions of time and temperature, and to determine the chemical and structural effects the interactions have on the base material properties.

The design of the tests consists of smooth surfaces of the materials, in intimate contact with each other, exposed to high temperatures for fixed times in a vacuum. To reduce the effects of uncontrolled variables, strict material, fabrication, cleaning and annealing specifications will be adhered to for all coupon components. These specifications are identical to those for the fuel capsules.

B. SUMMARY OF TASK STATUS

To date all of the coupon stacks which were scheduled for testing this fiscal year have been tested. The new schedule and task status is shown in Table VIII-1. The investigation of these stacks has been suspended until FY 1969.

C. ACCOMPLISHMENTS DURING THE QUARTER

All compatibility tests scheduled for GFY 1968 have been completed. Throughout the test series the performance of the compatibility test rig (vacuum chamber and tantalum-wire furnace) has been excellent. Only two modifications were made to the system since the first start-up. This was the replacement of the unnecessary side window with a blank flange and the addition of several new shields to cool the bell-jar and window during operation at 2250°F.

TABLE VIII-1

SCHEDULE OF COUPON COMPATIBILITY TESTING

<u>Coupon Stack No.</u>	<u>Test Start Date</u>	<u>Temp. °F</u>	<u>Atm Torr</u>	<u>Time of Test (Hours)</u>	<u>Test Status</u>
CS2	11-06-67	2000	10^{-8}	100	Complete
CS4	11-21-67	2250	10^{-8}	10	Complete
CS3	12-14-67	2000	10^{-8}	1000	Complete
CS7*	1-03-68	2500	10^{-8}	10	Complete
CS8*	1-08-68	2500	10^{-8}	100	Complete
CS5	1-25-68	2250	10^{-8}	100	Complete
CS6	2-03-68	2250	10^{-8}	1000	Complete
CS1	2-03-68	RT	760	0	Complete
CS9**	3-02-68	2000	10^{-8}	2200	
CS10**	3-07-68	2000	10^{-8}	1800	
CS11**	5-15-68	2000	10^{-8}	1000	

* Tested in Creep Test Rig #1

** To be tested with creep capsule 25, 19 and 22 respectively

IX. IMPACT TESTING

A. TASK OBJECTIVE

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 impact parameters on capsule failure. A total of 15 capsules will be impacted hot ($\sim 1150^{\circ}\text{F}$) on a granite target at various velocities and impact angles.

B. SUMMARY OF TASK STATUS

The impact testing will be accomplished in FY 1969. No effort is planned for FY 1968.

BLANK

X. SOIL BURIAL

A. TASK OBJECTIVE

The objective of this task is to determine, by testing, the maximum surface temperature of a capsule buried in soil at a depth expected from earth impact of the capsule at terminal velocity. Additionally, a preliminary evaluation of the soil corrosion problem will be obtained under this task. Two internally heated, pressurized capsules will be used for the one year burial tests.

B. SUMMARY OF TASK STATUS

The burial tests will be accomplished in FY 1969. Test plans and experimental designs are being evaluated in late FY 1968.

C. ACCOMPLISHMENTS DURING THE QUARTER

A test laboratory has been acquired in Building 5 with adequate facilities to conduct the test. The test heaters are being designed to produce 204 watts of continuous power in a C type LRHS capsule. The instrumentation requirements are being evaluated, particularly the internal and external thermocouples.

Three large (6 foot diameter by 6 foot long) sections of corrugated pipe for soil bins have been ordered. Orders have also been placed for Ottawa sand and Western Bentonite. All of these materials are expected to arrive in early FY 1969.

BLANK

XI. CREEP CAPSULE EVALUATION

A. TASK OBJECTIVE

The objective of the Creep Capsule Evaluation Program is to obtain the maximum meaningful data from the creep testing program. To accomplish this, the creep capsules will be subjected to a wide range of pre- and post-test examinations and statistical correlation of the results of these examinations with the creep testing conditions will be attempted. The data gathered from this effort will be used for analytical evaluations of various creep models and if necessary development of a new varying-stress creep model. Precise measurements taken through the testing program and extreme care used in handling all capsules and test samples should greatly facilitate the correlation of the data.

B. SUMMARY OF TASK STATUS

A test plan has been prepared for creep capsule evaluation and the pre-test examination requirements have been defined.

No work will be accomplished under this test until GFY 1969.