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LARGE RADIOISOTOPE
HEAT SOURCE CAPSULE (LRHSC)
NINTH QUARTERLY PROGRESS REPORT
JULY-SEPTEMBER 1969

MASTER

AEC Research and Development Report

Atomics International
North American Rockwell

P3618

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FOREWORD

This is the ninth 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 July 1, 1969 through September 30, 1969 under contract AT(29-2)-2338 for the U.S. Atomic Energy Commission.

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I. INTRODUCTION

The Large Radioisotope Heat Source Capsule (LRHSC) Program was 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 (5) years or more. The program has included the design, fabrication, test and evaluation of a tantalum alloy capsule whose design takes into account the operating requirements of a typical heat source. During the past quarter, the tantalum alloy capsule technology developed under the LRHSC Program was selected for use in the Transit Program. At that time the LRHSC Program was reconfigured into two (2) series of tasks. The first series of tasks is a continuation of the high temperature isotope fuel capsule technology program. The second series of tasks provide direct support to the development of the isotope fuel capsule for the Transit RTG. Section II of this report contains a description of and a progress report on each of the tasks in the high temperature capsule technology program. Section III contains the same information for the tasks in the Transit Support Program.

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II. HIGH TEMPERATURE CAPSULE TECHNOLOGY PROGRAM

The objective of this program continues to be the development of the technology for an isotope fuel capsule capable of operation in a space environment at a surface temperature of 2000°F or more for five (5) years or more. 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 survival in potential abort environments. The data generated in this program will be used to validate design approaches and define design margins that would exist for high temperature capsules intended for flight systems.

The high temperature capsule technology program is being accomplished under the following tasks:

- A1 - Technology Program Management
- A2 - Analytical Evaluation
- A3 - Hardware Design, Fabrication and Assembly
- A4 - Capsule Creep Testing
- A5 - Capsule Impact Testing
- A6 - Material Compatibility Testing
- A8 - Transit-Sized Capsule Fabrication and Testing

While Task A8 is in support of the Transit Program, it was in the LRHSC Program prior to the program redirection and will continue to be reported as Task 8 to avoid confusion. The objectives and progress during the quarter for each of the above tasks follow.

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TASK NO. A1 - TECHNOLOGY PROGRAM MANAGEMENT

Task Objectives

The objectives of this task are to provide management, direction and planning for all aspects of the High Temperature Capsule Technology Program. This includes technical direction, reporting, detailed plans and procedures.

Summary of Task Status

The program plan for GFY 1970 has been completed. The technology program milestones are shown in Table A1-1. The program is on schedule with respect to these milestones.

Accomplishments During the Quarter

The GFY 1970 program plan was negotiated with the AEC. On the basis of this program plan, detailed task plans, including technical approach, budgets and milestones, have been generated and provided to the performing departments.

All materials required for this year's test programs have been ordered. Detailed test plans for each task are being prepared by the functional departments.

TABLE A1-1

TECHNOLOGY PROGRAM MILESTONES	DATES
1. Complete Transit-Sized Capsule Impact Tests	Nov. 1969
2. Complete Reference Capsule Impact Test Series	Nov. 1969
3. Release Reference Capsule Impact Test Topical (Topical Report No. 8)	Jan. 1970
4. Complete Compatibility Testing (Out to 1,000 hours and up to 2500°F)	March 1970
5. Release Preliminary Creep Test Topical (Topical Report No. 9)	June 1970
6. Release Compatibility Test Topical (Topical Report No. 10)	June 1970

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TASK NO. A2 - ANALYTICAL EVALUATIONS

Task Objectives

The analytical task contains two (2) specific areas of analysis. These are impact correlations and creep correlations. During GFY 1970 the impact program on the LRHSC design will be completed and all impact results will be analyzed and correlated. The creep analysis effort will use the accumulated experimental data and attempt to correlate this data against the assumed mathematical creep model. Only a first cut at correlation at accumulated data is to be made.

Summary of Task Status

Analysis of the impact and creep data will occur in the January-March 1970 time period.

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TASK NO. A3 - HARDWARE DESIGN, FABRICATION, AND ASSEMBLY

Task Objectives

This task contains all efforts related to hardware design, fabrication, and assembly in support of the other program tasks. The principal effort will be the fabrication and assembly of four (4) capsules for the impact test task and one capsule which contains an internal heater to simulate capsule operation when fueled. All supporting test fixtures for the coating and coupon test tasks will be built under this task.

Summary of Task Status

Drawings of the LRHSC capsule configuration are being updated. New drawings are being prepared for the internal capsule heater and for assembly of the internally heated capsule. Six (6) structural shells have been fabricated. Two (2) of these shells were assembled into impact capsules A-9 and A-24. Another shell is being used in the assembly of the internally heated capsule. The final parameters for arc-plasma spraying Al_2O_3 on T-111 have been developed and the plasma spraying specification prepared.

Accomplishments During the Quarter

New drawings are being prepared for GFY 1970 fabrication effort. The basic LRHSC design includes 18 drawings which are 60% complete. The drawings will be tabulated to allow fabrication of the various impact capsule configurations. The major design modifications contemplated are to eliminate the outer liner stepped cap to tube weld and incorporate a single weld joint over the forward fuel ring. This will eliminate a critical weld joint. Also the outer liner cap will be fabricated with a .060 straight section to ease assembly, and the general tolerances will be loosened up.

Six (6) structure shells have been completed and are available capsule assemblies.

The coupon and coupon holder drawings for the GFY 1970 compatibility program are approximately 70% complete.

During the reporting period the fabrication of the impact barrel for testing of LRHS capsules with 0.060 and 0.090-inch walls was completed. The barrel was installed and checked-out in the impact test facility. Also, a large diameter impact test barrel has been designed, fabricated, and delivered. This barrel will be used for impact tests on Transit-sized capsules.

Impact capsules A-9 and A-24 were assembled. Capsule A-9 is a 0.060-inch wall reference capsule without oxidation clad (i.e., the standard "A" configuration). W-Mo fuel simulant was loaded in the fuel annulus. Capsule A-24 has no inner fuel liner. Retainer discs were used instead of retainer rings and the whole cylindrical section of the capsule was fully packed with W-Mo fuel simulant. The T-111 wall thickness on A-24 is 0.082-inch. No Pt-Rh clad was used on the capsule. Impact of these capsules is described under Task A-5.

The basic design of the internally heated LRHS capsule has been completed and heater parts are being fabricated. The design of the internal capsule heater is shown in Figure A3-1. The heater is composed of a double wrap of Ta wire on an Al_2O_3 mandrel. An Al_2O_3 sleeve is used over the heater wire to restrain it. Al_2O_3 end plugs center the heater in the capsule. The final layout for the internally heated capsule test includes the Ta-10W outer fuel liner and the internal thermocouples which are not shown on Figure A3-1. The heater assembly has been fabricated and acceptance tested, and the capsule assembly initiated.

The final parameters for arc plasma spraying Al_2O_3 on the LRHSC T-111 structural shell were developed and a series of tests were run to determine the acceptability of the coating. A process specification was written covering this procedure. In determining the final parameters, the coating was applied to a T-111 tube which had been prepared as follows. The tube was cleaned per

Figure A3-1. LRHS Internally Heated Capsule Design

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ST0610NA0005 and masked with tape to expose four separate areas as shown in Figure A3-2. Each area was grit blasted at different pressures with 24-48 grit alumina, to determine the resulting surface roughness. The area grit blasted at 20 psi was determined to have a finish of ~60 rms. The surface grit blasted at 40, 60 and 80 psi had finishes of 80 to 90 rms. Each area was measured with a micrometer prior to grit blasting and again prior to applying the coating. The coating was applied using the parameters given in Table A3-1. The plasma spray gun was held perpendicular to the substrate surface and ~4 to 5 in. away. The test piece was aligned so the gun nozzle was directed at the center of an area. The test piece was rotated at 7-1/2 rpm for five revolutions while the coating was applied. This process was repeated for each area. The individual areas were analyzed by X-ray diffraction after being coated. There was no distinguishable difference in the coatings. All areas were ~75% γ - Al_2O_3 and 25% α - Al_2O_3 .

The coated test piece was visually inspected for cracks, spalling and general coating condition. The coating appeared to be excellent. A second sample was coated with Al_2O_3 using the same parameters used to coat the test piece. This sample will be considered an archive specimen and will be subjected to the same nondestructive tests as the test piece. The coating on the archive specimen appears identical in condition to that of the test specimen.

Each area of the sample was measured with a micrometer to determine the coating thickness. These measurements are shown in Figure A3-3.

The test piece was placed in a vacuum furnace and thermal cycled three times: the first cycle was from ambient temperature to 2500°F and back to 1000°F. The second cycle was from 1000°F to 2500°F and back to 1000°F. The third cycle was from 1000°F to 2500°F and back to ambient temperature. The furnace vacuum was maintained at $< 5 \times 10^{-5}$ torr throughout the test.

Figure A3-2. Al_2O_3 Coating Test Specimen

	E.B. Welded ↓			
Original Diameter	1.5559	1.5559	1.5560	1.5559
Grit Blasting Pressure	80 psi	60 psi	40 psi	20 psi
Surface Roughness	80-90 RMS	80-90 RMS	80-90 RMS	60-70 RMS
Precoating Diameter	1.5568	1.5569	1.5570	1.5568
Coating Thickness	0.0035	0.0026	0.0032	0.0038
	Area #1	Area #2	Area #3	Area #4

Figure A3-3. Sketch of Test Specimen Showing Data Pertaining to Each Area.

The coatings were again analyzed by X-ray diffraction, and all areas were determined to be α - Al_2O_3 . There was no detectable trace of γ - Al_2O_3 remaining.

The test piece was subjected to several types of adherence tests: (1) it was exposed to several sharply struck blows from a hammer without evidence of coating damage; (2) it was tested for adherence by impressing scotch tape against the coated surface and the tape was inspected for evidence of coating material; and (3), it was scraped with a sharp knife. The only test which removed coating from the T-111 substrate was the third test, and even then, the coating proved difficult to remove.

The area identified in Figure A3-3 as area No. 4 was grit blasted clean using 80 psi pressure. This area was resprayed with Al_2O_3 . The coating was analyzed by X-ray diffraction and determined to be $\sim 75\%$ γ - Al_2O_3 and 25%

α - Al_2O_3 . The test piece was set up in the electron beam welder and a weld bead was placed between areas No. 3 and 4. The coatings were again analyzed by X-ray diffraction and found to be unaffected by the weld pass, i.e., area No. 3 was still all α - Al_2O_3 and area No. 4 was still $\sim 75\%$ γ - Al_2O_3 and 25% α - Al_2O_3 .

TABLE A3-1
 Al_2O_3 COATING PARAMETERS

<u>Power Requirements:</u>	<u>Arc Gas Argon:</u>
30-31 volts	50 ft ³ /hr
550 amps	50 psig regulator pressure
<u>Roto-Feed Hopper Settings:</u>	<u>Powder Injection:</u> Internal
15% hopper speed	<u>Stand Off Distance:</u> 3 in.
"A" gear set	<u>Angle of Application:</u> ± 10 degrees
8 ft ³ /hr flow rate	from normal to the substrate
50 psig regulator pressure	surface

TASK NO. A4 - CAPSULE CREEP TESTING

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 refractory metal container. The objective of this 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.

Creep testing activities during GFY 1970 will be related to completing on-going tests, post test evaluations and documentation of results. No new tests will be initiated during GFY 1970. Post test analysis and documentation will be completed on capsules tested in GFY 1969 and those completed in GFY 1970. A topical report summarizing this work will be released during the year.

Summary of Task Status

During the previous fiscal year eight creep capsules were put on test. Of these, three have carried over to this fiscal year. The three capsules have achieved between 1800 and 4050 hours of 2000°F operation. The creep capsules that were completed last year have not yet undergone complete post-test evaluation. There was no attempt to determine the origin of transformations, deformation modes or the effect of creep and thermal soaking on other properties. These phenomena will be investigated through this year's post test evaluations.

Figure A4-1. Creep Capsule B-3a Test Behavior

The post test examination will consist of complete metallographic analysis, electron microscopy, wet chemistry, bend tests and analysis by X-ray diffraction. The intent is to separate the test induced variables in order to devise a model which will describe the creep of tantalum alloy radioisotope capsules.

Accomplishments During the Quarter

Capsule B-3a for the long term creep test of the T-111 structure shell has accumulated 3800 hours at 16,500 psi hoop stress. The capsule was scheduled to reach 0.1% diametral strain in 2800 hours while under a constant stress of 16,500 psi. Thereafter, it was to be increased at a rate to produce a total of 1% strain in the following 6000 hours. The apparent diametral strain is now .20% and the ramp portion of the test has been started. The behavior of this capsule is shown in Figure A4-1.

Capsule B-6a is also a long term test of the T-111 structure shell and has accumulated 4050 hours at 16,500 psi hoop stress. The creep schedule for this test is the same as B-3a except the stress rate will continue until the capsule has achieved 5% total strain. Creep capsule B-6a has a diametral strain of .253% after 4050 hours. The behavior of this capsule is shown in Figure A4-2.

After 1839 hours on test, a short occurred in the test rig containing creep capsule A-2a. The capsule is being held at ambient temperature, under pressure, while an investigation of the cause of the short is made. Creep capsule A-2a had a diametral strain of 0.373% after 1824 hours. This behavior of the test is shown in Figure A4-3.

Figure A4-2. Creep Capsule B-6a Test Behavior

Figure A4-3. Creep Capsule A-2a Test Behavior

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TASK NO. A5 - IMPACT TESTING

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 impact parameters on capsule failure. During GFY 1970 a total of 4 capsules will be impacted on a granite target at various velocities, impact angles, and temperatures. Post-test analysis and documentation will be completed on all GFY 1969 and GFY 1970 capsules and a topical report summarizing this work will be released during the year.

Summary of Task Status

Two (2) LRHSC capsules were impacted during the quarter. A 0.060-inch wall capsule with annular fuel loading and a 0.082-inch wall fully packed capsule survived, leak tight, 355 ft/sec impacts on granite.

Accomplishments During the Quarter

During the quarter two impact capsules, A-9 and A-24, were tested at 350 ft/sec. Impact capsule A-9, shown in Figure A5-1, is an 0.060-inch wall capsule and impact capsule A-24, shown in Figure A5-2, is an 0.082-inch wall capsule. Both capsules were impacted at 1200°F. Impact capsule A-24 was the large volume, fully packed capsule described in Task A3.

The post-test results are given in Table A5-1 and photographs of the exterior of as-tested capsules are shown in Figure A5-3 through A5-6. The capsules were leak tight.

Figure A5-1. Impact Capsule A-9 Prior to Test

Figure A5-2. Impact Capsule A-24 Prior to Test

**IMPACT CAPSULE
A-9**

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IMPACT CAPSULE A-9

Figure A5-4. Impact Capsule A-9 After Test

IMPACT CAPSULE A-24

Figure A5-5. Impact Capsule A-24 After Test

Figure A5-6. Impact Capsule A-24 After Test

Figure A5-7. Half Section of Impact Capsule A-9

Figure A5-8. Half Section of Impact Capsule A-24

TABLE A5-1
POST-IMPACT TEST RESULTS

S/N	Impact Velocity (ft/sec)	Impact Angle	Temperature (°F)	Initial Length (in.)	Initial Diam (in.)	Final Length (in.)
A-9	357	43°	1200	7.049	1.5404	6.000
A-24	353	24°	1200	7.060	1.5836	6.000

S/N	Final Diam (in.)	Diametral Strain (%)	Axial Strain (%)	Mass (lb)	Impact Energy (ft/lb)	Wall (in.)	Leak Tight
A-9	2.052	24.9	53.2	3.23	7,650	0.060	Yes
A-24	1.986	20.3	60.3	4.44	8,600	0.082	Yes

The high speed movie films of the impact tests have been reviewed. The capsule impact velocities were determined, from the film, to be the same as indicated by the calibration curve. Impact capsule A-9 had an impact velocity of 357 ft/sec and A-24 a velocity of 353 ft/sec.

Impact capsule A-9 and A-24 were submitted for metallography. The examination revealed that the outer liner of each capsule failed, transgranularly, at the impact end. All of the welds, however, were intact. Photographs of the two sectioned capsules are shown in Figures A5-7 and A5-8. Detailed microphotographs and a discussion of the metallographic results will be included in the impact test topical.

An impact barrel specifically designed to accommodate an 0.090-inch wall thickness capsule has been fabricated. The ID of this barrel is 1.675-inch. Also a 2.75-inch diameter barrel has been fabricated for Transit sized capsules.

A new timing light system has been procured for the impact facility. The system will consist of a pair of photoelectric chronograph screens and a chronograph counter. This type system is commonly used for measuring bullet velocities and has proven to be reliable as well as accurate ($< 1\%$ at 400 ft/sec). The facility is presently being modified on company funds to include the improved timing light trap, a convenient means of moving the granite target and a positive trap in which to catch rebounding impact capsules.

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TASK NO. A6 - MATERIAL COMPATIBILITY TESTING

Task Objectives

The LRHSC design requires that many dissimilar materials including noble metals, refractory metals and various ceramics be placed in close proximity or in contact with one another. The operating conditions for the capsule (2000°F for 5 years) are in a temperature range where the rates of solid state diffusion and vapor transport may be increased to levels which would cause significant degradation of the mechanical properties of capsule materials. To insure structural integrity of present and future capsules the compatibility task will determine the reactions that occur between the various materials proposed for capsule construction and evaluate what deleterious effect these reactions will produce during the lifetime of a capsule.

During GFY 1970 three types of compatibility tests will be conducted. These are structural and liner materials, emittance coating and hold-down materials, and reentry materials. Testing will be conducted at 2000°F, 2250°F, and 2500°F for times of 10, 100, and 1,000 hours.

Summary of Task Status

Planning, material procurement, and test specimen fabrication are underway for this year's compatibility test program. The first coupon stacks are scheduled to go on test in late October.

Accomplishments During the Quarter

During the reporting period the initial steps for the operation of the compatibility task were completed. The compatibility task plan was written and orders have been placed for the materials necessary for the task. These include Nb-1Zr, TZM, RPG (reinforced pyrolytic graphite), Mo-50Re, Pt-20Rh, and Ta-10W tubing. The other materials that will be tested and evaluated (T-111, Ta-10W, foamed silica, ZnO) are in-house.

Coupon Stack No. 5, which was tested for 100 hours at 2250°F in April 1968, was removed from the compatibility test facility and is being prepared for metallographic examination. The remaining coupon stacks from previous testing (CS3, CS4, CS6, CS7, CS8), have been repolished and are ready for analysis.

Fabrication of the coupon and coupon stack holders for the compatibility program is underway. Testing of four coupon stacks will commence in late October.

Table A6-1 summarizes the material status for this task.

TABLE A6-1
COUPON MATERIAL STATUS

Material	Total Coupons Needed for Testing Program	Shipping Data	Fabrication Progress
Ta-10W Tubing	32 Holders 64 Caps	10/14/69	Four holders have been fabricated from bar stock to compensate for the late delivery of tubing
Ta-10W	8	In-house	10 coupons have been fabricated
Ta-111	40	In-house	10 coupons have been fabricated
Nb-1Zr	48	10/1/69	
TZM	56	9/8/69	Arrived AI 9/24/69
Mo-50Re	8	9/15/69	Arrived Rocketdyne 10/2/69
Pt-20Rh	136	10/1/69	Shipping date now 10/15/69
ASTAR 811C	16	11/1/69	No Word
RPG	40	Received	40 coupons have been fabricated
Foamed SiO ₂	24	In-house	30 coupons have been fabricated
ZnO	24	In-house	Pressing and stacking of coupons is in progress

TASK NO. A8 - TRANSIT-SIZED CAPSULE FABRICATION AND TESTING

Task Objectives

The objectives of this task are to provide limited process development, examination, fabrication and testing of a Transit-sized, vented capsule. The capsule will have a 0.020-inch Ta-10W liner, a 0.090-inch T-111 structural member, and a Pt-10Rh oxidation clad.

Fabrication process development will be done on 10 sets of blanks with the objective of obtaining at least enough piece-parts to assemble four (4) vented capsules. Extra piece-parts will be shipped to MRC. A preliminary manufacturing specification will be prepared.

Summary of Task Status

Ten (10) sets of material blanks have been used in the initial development of the Transit-sized capsule fabrication. From these blanks six (6) complete sets of Transit capsule parts have been obtained. Two (2) sets of parts have been sent to Mound Laboratory for their evaluation and for use in establishing their fueling and assembly requirements. The other four (4) sets of parts will be assembled into the impact capsules to be tested at Sandia in October. The success of this task in obtaining reference Transit piece-parts has demonstrated the feasibility of all the fabrication processes.

Accomplishments During the Quarter

Forming Development

Ta-10W Liner

Ten blanks have been used in the initial development of the liner drawing sequence. Nine of these blanks completed the six draws required for forming of the liner. These parts are being machined to the current TRW drawings. Two of the parts have been sent to Mound. Four of the parts will be used for the impact capsules. The remaining parts will be used for process evaluation and weld development.

Figure A8-1. Task 8 Liners

Figure A8-2. Task 8 Liner Caps

Critical problems in development of the liner drawing included elimination of wrinkling by die design, elimination of break-off of part tops by adjustment of the punch-die clearances to prevent excessive material gathering, and removal of the liner parts from the punches by air ejection or by the use of hardened split rings. The parts under Task A8 were drawn slightly over sized and final machined. The feasibility of drawing as-formed parts to print will be investigated under Task B2. Also deferred to Task B2 is the detailed evaluation of part response to heat treatment.

The liners sent to Mound are shown in Figure A8-1.

Ta-10W Liner End Cap

Ten (10) blanks have been used to check out the liner cap tooling. Two liner caps, machined to the TRW prints, have been sent to Mound. Four caps will be used for the impact capsules.

This part is easily made. The optimum blank size appears to be 3.5-inches in diameter. This size blank should minimize the machining time required for the final part. The problem of ejecting the parts from the closed die has been solved by use of a vent.

The liner caps sent to Mound are shown in Figure A8-2.

T-111 Structural Shells

Thirty (30) blanks from the LRHSC Program T-111 inventory have been taken through the first four (4) structural shell dies. From this point the shells can be drawn to final LRHSC, Transit, or any intermediate size. Ten (10) parts were carried through the final Transit dies. Two (2) of these parts, machined to final TRW print, have been shipped to Mound. Four (4) of the parts are being held for the Task 8 impact test.

A number of modifications to the draw tooling have been made to allow each draw to proceed with uniform pressure and to provide the desired final dimensions. However, the drawing of the structural shell has offered no

Figure A8-3. Task 8 Structural Shell

Figure A8-4. Task 8 Structural Caps

particular problems. The final heat treating studies for this component will be accomplished under Task B2.

The structural shells sent to Mound are shown in Figure A8-3.

T-111 Structural Cap

Ten (10) blanks have also been used for the T-111 structural cap development. Two (2) of the caps have been sent to Mound and four (4) are being held for the impact capsules. No difficulties have been encountered in forming this part. The dimensional data thus far obtained should allow selection of optimum blank size and proper blank tapering to minimize required final machining.

The structural caps sent to Mound are shown in Figure A8-4.

Platinum Barrier Shell

Preliminary work has been accomplished on the barrier shell tooling using copper and mild steel. However, no Pt-20Rh has been available this month. To meet the Task 8 schedules it has been decided to use Pt-10Rh from the LRHSC program. Checkout of the barrier tooling with the Pt-10Rh is in progress.

Platinum Barrier Cap

Pt-10Rh will also be used for the barrier cap. The status of this component is the same as for the barrier shell.

Assembly Development

Design of the weld fixtures required for the liner to liner cap weld, the structural shell to structural cap weld, the barrier shell to barrier cap weld, and the pressure relief device to the liner cap weld were completed. These weld fixtures have been fabricated, inspected and delivered for use. The fixtures are shown in Figure A8-5.

Figure A8-5. Transit Capsule Assembly Weld Fixtures

Development of the required welds has been initiated using the above weld fixtures and the piece-parts discussed above.

Impact Testing

Piece-parts produced under Task A8 will be used to assemble four impact capsules. Three of the capsules will be assembled using the new fuel form simulant. One capsule will be assembled using the tungsten-moly simulant. Two of the capsules will be encased in GFE graphite heat shields.

Current plans are to test all four capsules at Sandia in the latter part of October.

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III. TRANSIT CAPSULE SUPPORT PROGRAM

The tasks being accomplished in direct support of the Transit Capsule Development Program are as follows:

- B1 - Transit Support Program Management
- B2 - Transit Capsule Process Development and Qualification
- B3 - Transit Capsule Impact Tests
- B4 - Transit Capsule Fire Tests
- B5 - Transit Capsule Explosive Overpressure Tests
- B6 - Transit Capsule Oxidation Resistance
- B7 - Transit Capsule Thermal Verification
- B8 - Transit Capsule Fragmentation Tests

Task objectives, schedules and progress are detailed on the following pages.

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TASK NO. B1 - TRANSIT CAPSULE PROGRAM MANAGEMENT

Task Objectives

The objectives of this task are to provide management, direction and planning for all aspects of the Transit capsule support effort. This includes technical direction, reporting, detailed plans and procedures. Particular emphasis will be directed to maintaining a close liaison with TRW and MRC.

Summary of Task Status

The program plan for the Transit support effort has been prepared. The proposed program milestones are shown in Table B1-1.

TABLE B1-1	
PROPOSED TRANSIT SUPPORT MILESTONES	DATES
1. Complete Thermal Verification Testing	Feb. 1970
2. Complete Transit Capsule Impact Test Program	March 1970
3. Complete Transit Capsule Fire Test Program	March 1970
4. Complete Transit Capsule Overpressure Test Program	March 1970
5. Complete Transit Capsule Fragmentation Test Program	March 1970
6. Complete Transit Post-Impact Oxidation Testing	June 1970

Accomplishments During the Quarter

Internal work breakdown structures for the new Transit support tasks have been prepared and distributed to the functional organization. Task plans are being prepared for each of the new tasks.

A number of coordination meetings were held during the quarter with TRW and MRC. These meetings were primarily concerned with two major areas, the Transit capsule design drawings and the program schedule. It is anticipated that these detail coordination meetings will continue throughout the duration of the program.

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TASK NO. B2 - TRANSIT CAPSULE PROCESS DEVELOPMENT AND QUALIFICATION

Task Objectives

Using the experience of the LRHSC technology program and the results of Task 8, this task will provide the detailed development and qualification of the fabrication processes for the refractory and noble metal components in the specific Transit capsule configuration. The task involves the forming and finish manufacturing of all capsule piece parts but does not include development of weld parameters or assembly techniques. Manufacturing process descriptions and specifications, and quality assurance plans will be generated for each component.

Summary of Task Status

Assuming current delivery dates are met, all the required material for this task will be available by the scheduled start date of October 13.

A detailed task plan, preliminary process specification, and tooling drawings are currently being prepared for this task.

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TASK NO. B3 - TRANSIT CAPSULE IMPACT TESTS

Task Objectives

This task will provide the impact test data and complete post-test evaluation of twelve (12) full-scale Transit capsules. Test parameters will vary angle, velocity, temperature, and fuel simulant, and will be determined through coordination with TRW and MRC.

Summary of Task Status

Test parameters for the twelve (12) impact capsules are to be provided by TRW by December 1, 1969. AI will provide detailed test plans by February 1, 1970. The breakdown of tests to be performed at AI and Sandia will be determined after review of the detailed test requirements. The impact tests will be conducted in March. Test reports are to be completed in April.

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TASK NO. B4 - TRANSIT CAPSULE FIRE TESTS

Task Objectives

This task will determine the response of the capsule to a solid propellant fire simulating a potential launch pad abort condition. Two (2) capsules will be exposed to the fire resulting from a burning block of propellant. Capsules will be instrumented to obtain the transient temperature response. The test configuration may be with or without reentry shield, or with or without oxidation clad, depending on results of overpressure and fragmentation tests. A comparison of fuel retention as well as complete post-test chemical and metallurgical examinations will be conducted.

Summary of Task Status

Test requirements for the two (2) fire test capsules are to be provided by TRW by December 1. AI will provide a test plan by February 1, assemble and instrument the capsules in February, conduct the tests in March and provide the post-test analysis and test reports in April.

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TASK NO. B5 - TRANSIT CAPSULE EXPLOSIVE OVERPRESSURE TEST

Task Objectives

This task will evaluate the capability of the heat source to withstand the shock wave which may result from a launch pad abort. Two (2) capsules will be used for this test, one of which may subsequently be used for sequential testing in Tasks B4 and B8.

Summary of Task Status

Test requirements are to be provided by TRW by January 1, 1970. AI will conduct the overpressure test in March. Reporting will be completed in April.

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TASK NO. B6 - TRANSIT CAPSULE POST-IMPACT OXIDATION RESISTANCE

Task Objective

This task will provide data with regard to the oxidation parameters of actual capsules. It will make use of two (2) impacted capsules from Task B3 and may include verification coupon testing as well as exposure of an internally heated capsule. Tests will vary the temperature and exposure due to cladding breech. Full or partial burial may be examined.

Summary of Task Status

Test requirements for the Transit capsule are to be provided by TRW by February 1, 1970. Capsules will be put on test in April and run through June. Post-test analysis and reporting will be accomplished in June.

To obtain initial parameters on the capsule oxidation, an impacted LRHSC capsule is being used in a preliminary test. A Pt-10Rh barrier was slip fitted on the end opposite the impact end of the capsule and the capsule placed in a pan of Ottawa sand. The capsule is instrumented with three (3) Chromel-Alumel thermocouples, and one in the sand one-inch away from the capsule. All thermocouples are approximately on a line intersecting the radial mid-point of the capsule. The capsule is in an air furnace at 1090°F. Results from this preliminary test will be used in the detailed test planning for this task.

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TASK NO. B7 - TRANSIT CAPSULE THERMAL VERIFICATION

Task Objectives

This task will provide the data necessary to verify and upgrade the thermal models which are being used to predict steady-state operating, reentry, and post-impact temperatures. A heat source will be assembled using an internal electrical heater and temperature instrumentation at each stage of assembly. The stabilized shell temperature as well as the temperature drops across the various gaps shall be determined.

Summary of Task Status

Test requirements are to be provided by TRW by November 1, 1969. AI will provide test plans and drawings by the end of November. Fabrication, assembly and test of the capsule will be in the December-January period.

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TASK NO. B8 - TRANSIT CAPSULE FRAGMENTATION TESTS

Task Objective

This task will test and evaluate the damage to the heat source resulting from fragments or shrapnel produced by a launch pad abort. The test will be performed under controlled conditions by using a sled facility and impacting the heat source into fragments representative of the shrapnel produced in an abort mold.

Summary of Task Status

Test requirements are to be provided by TRW by January 1, 1970. The tests will be accomplished at Sandia in March. AI will prepare the test plans, coordinate the tests and do the post-test analysis and reporting.