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SUBJECT: Technical Highlights of Space and Terrestrial Systems Programs at Oak Ridge National Laboratory for April 1980

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FROM: A. C. Schaffhauser

This monthly report is intended to inform the Division of Advanced Nuclear Systems and Projects, DOE, and their contractors of significant technical highlights of technology and systems support programs in progress at Oak Ridge National Laboratory. A detailed technical presentation of information will be published in topical reports and open literature publications.

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SOLAR-POLAR MISSION MATERIALS SUPPORT

(Activity AE 15 15 20 0, WPAS 02313)

R. L. Heestand

The purpose of this task is to provide direct materials support on work specific to the General Purpose Heat Source (GPHS) design. The scope of this work includes (1) determining the impact properties and optimum weld parameters for the DOP-26 iridium alloy fuel cladding material, (2) thermal conductivity and emissivity data on cladding and thermal insulation materials, (3) fabrication and characterization of test samples of carbon-bonded carbon-fiber (CBCF) insulation developed by ORNL and Y-12 which may be used for GPHS, and (4) determination of creep properties of the 2219 aluminum alloy housing. Data on the impact properties and welding of iridium are integrated with complementary work reported in the Materials Technology section of this report.

CBCF-3 Insulation Fabrication (G. W. Brassell and R. L. Heestand)

Five sets (a set refers to one sleeve and two end caps) of CBCF-3 insulation parts were shipped to LASL for use in GPHS vibration testing. Eight additional sets were machined, however, inspection results indicated the wrong inspection procedures were used and the sets were returned for reinspection.

The equipment for fabrication of CBCF-3 at ORNL has been installed and tested by conducting several preliminary fabrication runs. The nine mandrel deposition assembly is being used, however, the length has been increased to 152.4 mm. This length is 50.8 mm longer than those used previously in order to allow sufficient material to trim off end deposition effects and machining of test samples. The samples fabricated in preliminary runs are being carbonized and will be evaluated for density, uniformity, and materials properties.

CBCF-3 Characterization (G. C. Wei)

Test samples of CBCF-3 cups fabricated from the multimandrel molding facility were outgassed (1500°C/36 h/6.7 E-3 Pa) and submitted for spark source mass spectroscopic chemical analysis. The higher temperature of 1500°C will be used rather than the 1350°C used previously in order that additional shrinkage will be minimized after machining from the final 1500°C offgassing.

A subcontract with TPRL (Thermophysical Properties Research Lab) of Purdue University on thermal conductivity measurements was initiated. The objective of this effort is to establish that the thermal conductivity of CBCF-3 parts can be sufficiently and necessarily controlled by the bulk density. A statistical data base of the thermal conductivity of CBCF-3 parts will also be established. This subcontract is presently in the process of internal approval.

In this period, two problems in the bulk density of CBCF-3 parts and test samples were encountered. The first problem was the test samples (12.7 mm diam by 2.0 mm thick) machined from CBCF-3 cups were of unusually high densities (0.25 E3 kg/m^3) whereas the CBCF-3 sleeve parts machined from the same billets had the specified densities (0.20 ± 0.02 E3 kg/m^3). The second problem was that the density (0.24 E3 to 0.28 E3 kg/m^3) of CBCF-3 disk parts machined from CBCF-3 plates (203 mm diam by 25.4 mm thick) No. 2 and 3 which were sent to LASL on April 15, 1980, for GPHS safety related testings was higher than the density (0.21 ± 0.002 E3 kg/m^3) of test samples machined from CBCF-3 plates No. 1 and 4. Investigative analyses of these two problems were performed. Possible causes were identified and solutions proposed. The results are summarized below.

Several factors could contribute to the high density observed in the test samples from CBCF-3 cups. These include compression and damage of billets in the area where parts are held for machining, infiltration of loosened fibers into the bulk of test samples due to the vacuum fixture used in machining, and the fact that edge areas where a two dimensional vacuum molding might exist during billet casting to result in high density materials were used in the machining of test samples. The latter two were ruled out because (1) the vacuum fixture was also used in previous machining of disk parts which showed the specified density and (2) test samples from the very edge of a multimandrel CBCF-3 cup had the right density. Microstructural examinations with the aid of an SEM of the high density test specimens showed a microstructure consisting of unusually densely-packed fibers and bonds along with numerous short, broken fibers. This indicated excessive compression and damage in the high density test samples. Thus, we tentatively concluded that excessive pressure while holding the parts for machining was the reason for the observed high density in test samples. The machining facility was notified and corrective actions were taken.

The second problem involving high density disk parts was also investigated through microstructural analysis. The SEM analysis of the high density disk parts machined from plate No. 2 and 3 showed a normal packing of fibers without short, broken fibers, but also a unusually high binder content. The high binder content was probably due to a wrong fiber to binder ratio in the formulation of the CBCF-3 plates No. 2 and 3. Incomplete carbonization was thought to be one of the possible causes but was ruled out because the SEM analysis did not reveal any space charge accumulation due to non-carbonized binders. Thus, we tentatively concluded that wrong formulation of binder to fiber ratio lead to the high density observed in disk parts machined from plates No. 2 and 3. This problem was due to operator error at Y-12 and should not recur with current QA procedures at ORNL.

It was noted at LASL and confirmed at ORNL that a normal outgassing treatment (1500°C/36 h/6.7 E-3 Pa) reduces the weight of the recently fabricated cups and plates by about 2% which is somewhat higher than the 1% weight change[1] observed in the outgassing of CBCF-3 parts made earlier. The causes of this difference is presently under investigation.

[1]Monthly Highlights, December and November 1979

Contact Conductance in GPHS Module (G. C. Wei)

Battelle's measurements of h•A (contact conductance times area) of post-vibration Aeroshell-GIS contact were completed. The results at low temperatures were in agreement with the data obtained by Taylor (Purdue University) and Williams (ORNL). Wei summarized the data and outlined several options to reduce h•A via design modifications (letters, Wei to Schaffhauser, dated April 18 and 24). Williams analyzed and assessed all the data obtained by Purdue, ORNL, Battelle, and Fairchild (letter, Williams to Heestand, dated May 5). These letters were transmitted to DOE/HQ.

QA Program of CBCF-3 Fabrication and Testing (G. C. Wei)

A copy of the revised CBCF-3 specification prepared by Mound was received. Review of this revised specification is in process. Draft forms of standard operating procedures for slurry preparation, molding, carbonization, machining, and testing specification for inspection of CBCF-3 were prepared in this month.

CBCF-3 Insulation Fabrication for LWRHU (G. W. Brassell and R. L. Heestand)

No additional CBCF-3 fabrication was conducted pending selection of the density and receipt of a design.

Creep Properties of 2219 Aluminum Housing Materials (J. P. Hammond)

The purpose of this task is to develop creep design curves on the 2216 T6 aluminum forging and to aid GE, Valley Forge, in the design of the housing component of the RTG generator. The essential requirement of the shell will be to firmly retain the RTG generator under elastic stress during ground tests and storage in air (condition II), and subsequent flight in vacuum (condition I).

George Ambrose, Design Section, GE, Valley Forge, has requested additional mechanical property data to complete the design of the shell component. The main question concerned stress relaxation in the aluminum housing in regions that correspond to the long transverse orientation (hoop stress) in the annular forging. Also, in order for creep design curves to be useful they should define stresses that give 0.2% or even 0.1% plastic strain instead of 1.0%. Specifically, questions were raised as the magnitude of creep strain, if any, for the following stress-time (σ—t) situations in the bolt-up, condition II, and condition I phases of housing operation:

Situation	σ (psi)	t (h)	T (°F)	Environment
Bolt Up — 1	4000	600	510	Air
Condition II — 2	4000	5,000	350	Air
Condition II — 3	6000	5,000	350	Air
Condition II — 4	8000	10,000	350	Air
Condition I — 5	1000	5,000	510	Vacuum
Condition I — 6	3000	5,000	510	Vacuum
Condition I — 7	5000	10,000	510	Vacuum

Situations 1 through 4 refer to exposure in air on the ground whereas situations 5 through 7 are for vacuum in outer space. However, we have found the creep responses in air and vacuum to be approximately equivalent for aluminum and tests in air for the latter should be acceptable.

Examination of the foregoing stress-time situations in the light of tentative design curves for 0.2% ε_p developed from limited Alcoa creep data suggests that only two situations (Nos. 4 and 7), represented conditions where appreciable plastic strain may occur. The other points seem to fall considerably below where the design curve would lie.

As a consequence of the GE information, the present test program was altered to include proof tests to determine accumulated creep through the bolt-up, condition II, and condition I phases of operation for the most severe stress-time situations (Nos. 4 and 7). A conservative evaluation of this strain will be obtained by determining strain for conditions II and I simultaneously in separate creep frames and then adding the two. The test for situation 4 will be preceded by the bolt up exposure (situation 1) but not so for situation 7. This is because the prior history would appear to result in a lower strain rate in the case of situation 7 but in a faster rate in the case of situation 4.

The altered plan further calls for 0.2% creep design curves (instead of 1% curves) extending from 1000 to 10,000 h, both at 350 and 500°F. The 350°F curve will be for specimens having been preconditioned by the bolt up exposure. However, this will not be necessary for the 500°F curve. These curves will be useful for estimating safety margins in the design parameters. The test specimens of the altered plan for the most part will be of long transverse orientation.

Figure 1 illustrates the use of design creep curves for appraising strain of the various stress-time situations. Situations 2 through 7 accordingly are superimposed on the curves, which are only tentative. Because situations 5 and 6 fall far below the 500°F curve they are not expected to result in creep strain. Whereas this figure does not contain a 350°F curve, situations 2 and 3 probably would fall considerably below it also. Thus only situations 4 and 7 may pose significant questions.

Creep tests have been initiated at 500 and 350°F aimed at the 0.2% creep in 1000 h, using the earlier longitudinal specimens. The proof tests and additional tests for design curves will be initiated when we receive the long transverse specimens.

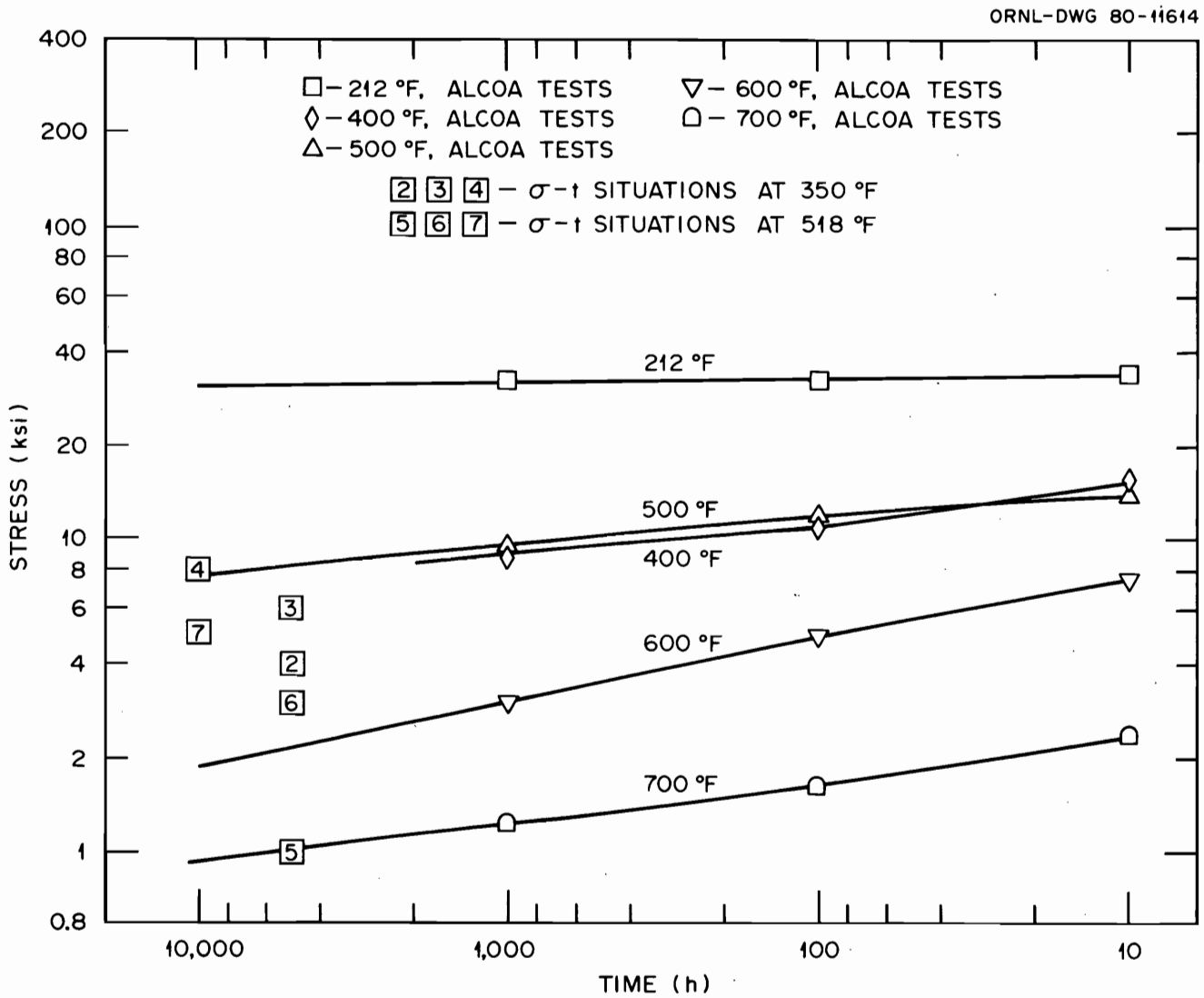

Fig. 1. Tentative design curves for 0.2% creep.

Meetings

R. L. Heestand and G. W. Brassell attended the GPHS and RHU Review meetings conducted April 1—2, at DOE, Germantown.

A. C. Schaffhauser, D. E. Harasyn, and J. E. Selle, attended the Fuel Fabrication and Compatibility meeting at Savannah River conducted April 21-23, 1980.

FLIGHT SYSTEMS HARDWARE

(Activity AE 15 20 00 0, WPAS 01322)

D. E. Harasyn

The objective of this task is to supply Mound Facility with flight quality hardware components for use in the assembly of isotope heat sources. The major activity is on fabrication of iridium alloy forming blanks for isotope fuel capsules along with iridium foil for vents, decontamination covers, and weld shields. We have completed fabrication of iridium for the Galileo mission MHW heat source and have initiated fabrication of 1255 iridium blanks and associated foil for Solar-Polar Mission General Purpose Heat Source for delivery in FY 1980 and FY 1981. A new task on fabrication of carbon-bonded carbon-fiber (CBCF) thermal insulation for Light Weight Radioisotope Heating Units (LWRHU) has also been initiated.

Iridium Blank and Foil Fabrication (D. E. Harasyn)

About 730 cm^2 of 0.13-mm-thick Ir–0.3% W foil was shipped to MF in April. Of the 5800 cm^2 of foil due for shipment to MF in FY 1980, about 2540 cm^2 have been shipped.

Of the 275 GPHS blanks that were to have been shipped to MF in FY 1980, by the end of April, (see April 1, 1980, GPHS Integrated Master Schedule) 245 have been shipped. Production data for the April shipment of blanks are shown in Table 1.

L258-L263 is the last lot to be cleaned with the molten carbonate process described under "Iridium Blank Fabrication" in the February 1980 Technical Highlights. This molten carbonate cleaning process was designed specifically for the removal of aluminosilicate inclusions from the blank surfaces. Since lots after L258-L263 have been fabricated using Inconel muffle furnaces that will prevent pickup of aluminosilicate from firebrick, there should be no need for using molten Na_2CO and K_2CO_3 for cleaning future blanks.

The first blanks produced with our new 15-cm-diam WC rolls and Inconel muffle furnace had the least amount of pitting observed in any finish rolled lot and no inclusions. Unfortunately 11 blanks failed because of ultrasonic defects, 27 failed because of liquid penetrant indications, and the remaining blanks failed the visual examination. The increase in ultrasonic rejects was not surprising. We recognized after finish rolling about 200 GPHS development blanks that fewer delaminations would result when smaller diameter work rolls were used for the final passes on the Ir sheet. We therefore, expected an increase in delaminations when we moved the rolling from the Y-12 mill with 6.4-cm-diam work rolls to our Bliss mill with 15-cm-diam work rolls.

Table 1. Solar-Polar Forming Blank Production Data for April 1980

Ingot No.	Date Shipped	Blanks Machined	Blanks Shipped ID No.								Nonconformance[a] Blank ID No.								Total Shipped lot/FY
			1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8	
L258	4-11-80	8	1	1	1	1	1	1	1	1				dv		v			
L259[b]	4-11-80	8	1	1	1		1	1	1	1				p			v		
L260	4-11-80	8	1	1	1	1	1	1	1	1									
L261	4-11-80	8		1		1	1	1	1		p		p					uv	
L262	4-11-80	8		1	1	1	1	1	1	1	p			t	t	t		t	
L263[b]	4-11-80	8		1		1	1	1	1	1	up	v	p		v	v			41/245

[a]d = diameter, v = visual, p = liquid penetrant, u = ultrasonic, t = thickness.

[b]Cracks in metallography specimen.

The large increase in liquid penetrant indications was surprising. It is disturbing that most of the indications were linear rather than pit type. Linear indications have occurred in less than 1% of the finish rolled GPHS blanks. Examination of the blank surfaces that were trapping penetrant at 30× revealed numerous surface cracks. Viewed at 400×, these cracks had measurable depths of 7 μm. Those blanks that did not trap penetrant did appear to have the same surface crack pattern when viewed at 30×, which resulted in their failure to meet the visual specification; however, at 400× the cracks had no apparent depth. These surface cracks are revealed only after electroetching. No cracks can be detected with liquid penetrant on the as-rolled surface. We are certain that electroetching is not causing the cracks, but rather removing smeared over metal, thereby revealing the cracks. Examination of GPHS development blanks finish rolled with the mill at Y-12 revealed similar patches of surface cracking. However, the apparent "cracking" was not as prominent and not as frequent as in the first blanks rolled with the Bliss mill. Also they had no depth and did not trap liquid penetrant. Of the many variables that might be influencing this surface cracking, we intend to investigate the effects of rolling speed, sheet preheat temperature, and roll body temperature. It may turn out that the roll diameter and its consequent effects on stress and temperature distribution within the deforming Ir sheet may be the dominant variable. These investigations will proceed on a second priority basis.

Our first priority at present is to modify equipment at Y-12 to permit the finish rolling of Ir sheet. This will return us to our development setup which we know will produce satisfactory hardware and high yields. We are building an Inconel muffle to use at Y-12 in order to eliminate the problem of aluminosilicate inclusions from firebrick muffles. The main disadvantage of moving production back to Y-12 is that we will not have sole control over the equipment, and our schedules will occasionally have to give way to weapons work. Our delivery schedule, which was presented at the GPHS Review Meeting on April 2, is no longer applicable. We should be able to work out a schedule next month providing equipment modifications are finished and fabrication of flight quality hardware is firmly reestablished.

MATERIALS TECHNOLOGY SUPPORT

(Activity AE 15 35 00 0, WPAS 01495)

C. T. Liu

The primary objective of this task is to characterize and improve the metallurgical and mechanical properties of noble base alloys, mainly DOP-26 (Ir-0.3% W doped with 60 ppm Th and 50 ppm Al), to meet the requirements of cladding material in radioisotope heat resources for the Galileo and Solar-Polar space missions. The current efforts are concentrated on four areas: (1) to characterize the impact properties of Ir alloys in the temperature range 800–1400°C, (2) to improve the low-temperature impact properties of welds in the DOP-26 alloy, (3) to identify the mechanism and sources that degrade the mechanical and metallurgical properties of doped Ir alloys under heat-source environments, and (4) to develop ductile high-temperature alloys acceptable for future flight missions.

Effect of Fe and Cr Contamination on Impact Properties of DOP-26 Ir-0.3% W

(D. E. Harasyn, and C. T. Liu)

We have studied two DOP-26 Ir-0.3% W tensile samples annealed under high iron and chromium vapor pressures in order to determine how impact properties would be affected. The samples were cut from the sheet L217 which was analyzed by SSMS and found to contain 51 μg/g thorium and 58 μg/g aluminum. They were annealed 19 h at 1500°C in a vacuum furnace which had been used for over 2 years to anneal stainless steels at high temperature. Consequently the elements and heat shields of the furnace were covered with heavy deposits of iron and chromium. These deposits readily volatilized when the furnace was brought to 1500°C. After the anneal, the weight of each sample had increased by 0.4%. The samples were impact tested at 1350°C at 85 m/s. The uniform elongation exceeded 30% and reduction of area was about 93% which is normal for uncontaminated DOP-26 Ir-0.3% W with a similar thermal history.

A metallographic cross section of impacted sample showed a reaction layer approximately 10 μ thick. A semi-quantitative investigation of this cross section with secondary ion mass spectrometry (SIMS) indicated very high levels of iron and chromium in the reaction layer. Nickel was also found, but its signal was down by a factor of about 100 in this layer. Very little diffusion of iron and chromium into the Ir bulk was observed. Based on a comparison to the Al peak, the total of Fe and Cr within the Ir matrix was 10 to 20 μg/g. Segregation of thorium to the grain boundaries and precipitates was observed. There was no indication of segregation of iron, chromium, or any other element. A sample was also examined with Auger electron spectroscopy. This analysis of a fresh fracture surface showed the normal segregation of thorium to the grain boundaries and no detectable segregation of any other element.

These results indicate that DOP-26 Ir-0.3% W is not embrittled by exposure to chromium and iron vapors. Since the exposure was done in a vacuum furnace operating at about 1×10^{-5} torr (10^{-3} Pa) there was no oxide formed which might have immobilized the iron and chromium. Since the temperature was 1500°C, it probably represents thousands of hours at 1330°C given the exponential dependency of diffusion rates upon temperature. We believe that DOP-26 Galileo hardware will not be embrittled by exposure to external sources of iron and chromium (as opposed to alloying with iron or chromium during fabrication) such as found in Galileo fuel (e.g., 340 ppm iron in MHFT-65 fuel).

AES Analyses of P-Doped DOP-26 (C. L. White and R. A. Padgett)

We have previously reported Auger electron spectroscopic (AES) results on P-doped* DOP-26 alloys in an effort to clarify the relationship between phosphorus contamination at DOP-26 grain boundaries and reduced high temperature impact (HTI) ductility. Phosphorus doping results in large phosphorus concentrations on the DOP-26 grain boundaries, and reduced HTI ductility. Annealing P-doped specimens in vacuum at 1500°C reduces the level of phosphorus at the grain boundaries.

In order to determine how much variation in grain boundary phosphorus concentration might be expected for specimens having the same doping history, Specimen 800026 (OLMF-8A_2) was analyzed and compared to Specimen 800013 (OLMF-8A_2). Both specimens were examined in the "as doped" condition. Average P (120 eV)/Ir (229 eV) peak height ratios were determined from three series of spot analyses, and three areal analyses (see Fig. 2). Three rows of ten spots each were analyzed to obtain P/Ir ratios. In order to reduce any edge effects, ratios for spots nearest the edge of the fracture surface (spots 1, 10, 11, 20, 21, and 30) were not included in the averages. Each vertical row of spots (2-9, 12-19, and 22-29) was averaged separately. These averages, P/Ir ratios for the three areas, and an overall average are presented in Table 2 for each specimen. The ratios for Specimen 800026 are somewhat lower than for 800013, however still significantly higher than for specimens having a vacuum anneal following P-doping.

Preliminary AES results on Specimen 800023 were reported last month. This specimen was P-doped, then annealed for 1 h in vacuum, in order to provide a P/Ir ratio between that for Specimen 800013 and Specimen 800014. The P/Ir ratio of 0.39 reported at that time was for Area C. More detailed results, tabulated in the same way as for Specimen 800026, are presented in Table 2. The overall average for this specimen is 0.31.

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*Phosphorus doping was performed at LASL, and consisted of a 1 h/1500°C anneal in a graphite crucible with P_2O_5.

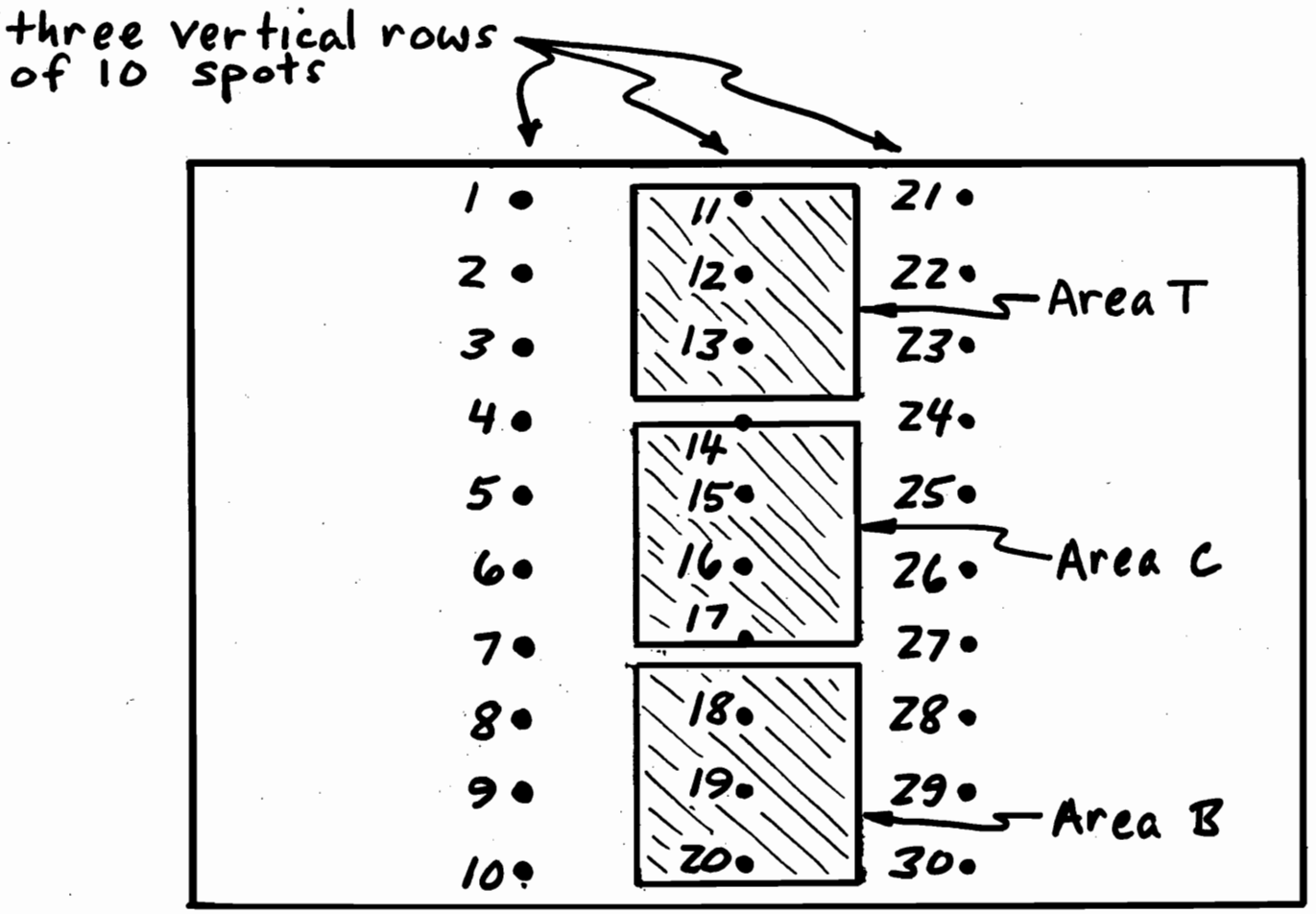

Fig. 2. Fracture Surface Schematic.

Table 2. Summary of AES Analyses on P-Doped DOP-26

Specimen	Condition	Area Analyses			Spot Analyses			
		C	T	B	2-9	12-19	22-29	Aug
800013 (OLMF-8A$_1$)	As Doped	0.60	0.64	0.62	0.50	0.54	0.54	0.57
800026 (OLMF-8A$_2$)	As Doped	0.53	0.51	0.54	0.47	0.41	0.44	0.49
800023 (OLMF-8AC)	As Doped + 1 h/1500°C/Vac	0.39	0.35	0.30	0.29	0.26	0.26	0.31
800014 (OLMF-8AB)	As Doped + 2 h/1500°C/Vac	0.30	0.19	0.25	0.19	0.18	0.16	0.21

Development of Pt-Base Alloys (J. R. Keiser and J. F. Newsome)

The purpose of this work is to develop platinum-base alloys having a high eutectic temperature with graphite as fuel-cladding materials for future flight missions. This study has determined the eutectic temperatures of graphite with 10 platinum base alloys. The more promising of these alloys were rolled into sheet and tensile specimens were prepared. These specimens were impact tested at 800°C and 61 m/s (200 ft/s). Results of the tests are:

Alloy	Total Elongation
Pt-8 Re	17.2%
Pt-16 Re	17.2%
Pt-15 Ru	12.7%
Ir-0.3% W (typical)	8.5%

Additional sheets of these alloys are being prepared to enable us to better characterize the alloys.

ISOTOPE FUEL DEVELOPMENT

(Activity AE 15 35 00 0, WPAS 02314)

R. S. Crouse

$^{90}SrF_2$ Compatibility (R. S. Crouse)

Last month it was reported that only 9 of the 12 samples reportedly shipped from BNL had been found by the people at the Fission Product Development Lab (FPDL). When the shipment arrived at Bldg. 3525 from FPDL all 12 were there. Metallographic examinations proceeded at that point. By the end of April all samples had been mounted, polished, and partially photographed. The May report will contain a summary of the metallographic examination.

Two $^{90}SrF_2$ samples from the TZM capsules have been sent to Analytical Chemistry for spectrographic analysis. A report will be given in the May report.

TERRESTRIAL RADIOISOTOPE APPLICATION DEVELOPMENT

(Activity AE 15 35 00 0, WPAS 01367)

F. N. Case, K. W. Haff, and F. J. Schultz

Cesium-137 Low Solubility Compounds

The modified saw, which will be used to section the pollucite pellets, and its accompanying off-gas scrubber system were transferred into the hot cell. Sectioning of pellets was begun and all but the final cut of one pellet was accomplished. Before sectioning of the pellet can be completed the top and side of the partially sectioned pellet will be painted (white for the top and green for the side) to facilitate the identification and orientation of each sectioned piece with respect to the original radial axis. This is an important consideration in determining the radial cesium distribution in the pollucite pellet. After sectioning of the sample pollucite pellets is completed two sections from each pellet will be transferred to the HRLEL facility for optical microscopy, electron microprobe, and X-ray diffraction studies. An additional section from each pellet will be placed in a Soxhlet extractor apparatus for leachability determinations.

Leach testing of the three sections of tracer level ^{137}Cs pollucite pellets continued this month. The leach rate of each pellet section is given in Table 3.

Table 3. Tracer Level Cesium-137 Pollucite Pellet Leach Rates

Pellet No.	Accumulated Leaching Period (days)	Leach Rate ($g/cm^{-2}day^{-1}$)
39	316	24.6×10^{-6}
40	316	8.31×10^{-6}
41	316	20.1×10^{-6}

The above leach rates fall within the previously reported ranges for the steady-state values.

Krypton-85 Light Source Development

A meeting was held at DOE Headquarters to brief Air Force personnel concerning the status of the ^{85}Kr light program. Eight lights are needed for the June/July demonstration test at Andrews Air Force Base. Concern was expressed because of the limited inventory of ^{85}Kr available for supplying larger quantities of lights should the June/July demonstration

trigger a demand of 200 in the 1981-1982 time period and 1000-2000 in the 1984 time period.

The Air Force is in the process of deciding between a motor generated system and the ^{85}Kr light system. As the program now stands it appears that the ^{85}Kr activated lights, as well as tritium activated lights, have application potential for fast deployment airport minimum lighting systems.

BENEFICIAL APPLICATIONS OF RADIATION TECHNOLOGY

(Activity AE 15 35 00 0, WPAS BART001)

C. S. Sims

On April 28, the BART team's draft assessment of the Cs-137 irradiation technology program was mailed to the distribution specified by DOE. The draft assessment is a 50-page document containing 62 recommendations in 11 technical areas. The conclusion is that the technology supports the construction and operation of a carefully monitored demonstration plant, but more extensive research and evaluation of health risks are required before sludge irradiation can be commercialized.

A report on the status of the March 20 DOE-issued action items assigned to ORNL was issued on April 18. Items related to the final assessment and the program plan are still outstanding.

Three members of the BART team attended a University of Florida/EPA sponsored symposium on evaluation of health risks associated with animal feeding and/or land application of municipal sludge.

Arrangements were made for Dr. E. S. Josephson of the Massachusetts Institute of Technology to present a seminar on food preservation by irradiation at ORNL on July 24.

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