ORNL-TM-4950

Monthly Highlights for Office of Nuclear Regulatory Research Programs at Oak Ridge National Laboratory

APRIL 1975

OAK RIDGE NATIONAL LABORATORY

OPERATED BY UNION CARBIDE CORPORATION • FOR THE U.S. ATOMIC ENERGY COMMISSION

ORNL-TM-4950

Contract No. W-7405-eng-26

MONTHLY HIGHLIGHTS

FOR

OFFICE OF NUCLEAR REGULATORY RESEARCH PROGRAMS

AT

OAK RIDGE NATIONAL LABORATORY

APRIL 1975

Compiled by

Gordon G. Fee

OAK RIDGE NATIONAL LABORATORY

Oak Ridge, Tennessee 37830

operated by

UNION CARBIDE CORPORATION

for the

UNITED STATES

ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION

BLANK PAGE

PROGRAM TITLE: Heavy Section Steel Technology Program

PROGRAM MANAGER: G. D. Whitman

ACTIVITY NUMBER: 40 89 01 64 1 (189a Number 10641)

TECHNICAL HIGHLIGHTS

Task 1: Program Administration — The HSST Program Review Committee met in Oak Ridge on April 8, 1975, with twenty-three members present. The Program Planning Committee met on April 9, 1975.

The HSST Program scope for FY 1976 was reviewed with C. Z. Serpan and E. K. Lynn on April 10, 1975.

Meetings were held at Westinghouse NES in Pittsburgh, Pa., on April 15 and 16, 1975 to review subcontract work on irradiation effects and fatigue crack growth.

Task 3: Fatigue and Crack Propagation — All fatigue crack growth specimens and all stress corrosion cracking specimens have been prepared for testing. The specimen types and materials from which they were fabricated are as follows.

Specimen Type	A533B	A508	A533B Submerged-arc Weldment
Fatigue Crack Growth	12	12	12
2X-WOL	7	7	7

Fatigue testing is continuing on two specimens at 0.1 and 0.5 cpm in 550°F reactor grade water at R ratios of 0.7.

Task 4: Irradiation Effects — Computation of test results for the precracked C_V specimens from the 4T-CT irradiation program was completed. Internal checking of results is in progress and preparation of a topical report has been started.

Design of the irradiation capsules and BSR facilities for additional 4T-CT irradiations continued. Several meetings were held with interested persons from Operations, Solid State, and General Engineering Divisions at ORNL to define problem areas and find mutually satisfactory solutions. The three irradiation capsules to be installed in FY 1976 will contain a total of six 4-in.-thick, six 1.6-in.-thick, twelve 0.8-in.-thick, 144 each 0.394-in.-thick compact tension specimens, 36 miniature tensile specimens, 60 Charpy V-notch impact specimens, and 144 precracked Charpy specimens. All specimens will be ASTM A533, grade B, class 1 steel, non-surface material, WR orientation from HSST plate 02. This specimen complement will provide sufficient test material to conduct static and dynamic tests and provide material for radiation damage annealing studies.

On April 16, 1975, the first 1.9T-CT irradiated specimen was tested dynamically at the Westinghouse Research and Development Center in Pittsburgh, Pa. The test was performed at 268°F and K_{Id} value of 162 ksi $\sqrt{in.}$ was obtained. A second specimen was tested on April 29 at 325°F. The preliminary results from this test indicate that the loading rate was low and the K_{Id} value was 240 ksi $\sqrt{in.}$

Task 5: Simulated Service Testing — Further contacts with the Naval Surface Weapons Center indicate that pneumatic tests of intermediate vessels can be performed at Dahlgren, Va., with pumping equipment already on hand. This equipment, purchased by Union Carbide Nuclear Division for a Y-12 Plant project, has been used to burst small steel spheres at pressures up to 50,000 psi and will be available for use in the HSST Program. The combination of equipment availability and proximity of the test site to Oak Ridge makes this site the best of those considered.

Proposed procedures for repairing intermediate vessel V-7 without stress relief in accordance with Section XI of the Boiler and Pressure Vessel Code have been received from the PVRC Advisory Task Group on Weld Repair who met at ORNL in March. Procedures recommended by this group will be used in preparing V-7 for pneumatic testing.

A purchase order was prepared for enhancement of the second series of V-9 radiographs at Goodyear Aerospace.

The determination of the Charpy-V impact energy and tensile properties of the HSST plate section 02FB stress relieved an additional 40 and 162 hr at 1150 and 1240°F followed by furnace cooling was completed. These treatments are in addition to the 40 hr at 1150°F stress relief the plate received prior to delivery to ORNL. Charpy-V results at the 30 ft-lb level after the 40 and 162 hr stress relief at 1150°F show that the transition temperature shift from the "as-received" plate was 20°F (from 20 to 40°F) and 50°F (20 to 70°F) respectively. A slight lowering of the upper shelf was also noted for the 162 hr stress relief. The 40 and 80 hr stress relief Charpy-V results do not differ significantly. The 40 hr at 1240°F stress relief Charpy-V results show a transition shift of 60° (from 20 to 80°F) at the 30 ft-lb level and an upper shelf drop of 15 ft-lb (110 to 95 ft-lb) from the "as-received" plate.

The room temperature yield and ultimate strength for the 1150°F stress relief are 68 and 90 ksi after 40 hr and 66 and 88 ksi after 162 hr, respectively. These values compare to the "as-received" values of 68 and 90 ksi. In addition, tests conducted at −100, 70, 170, and 300°F with specimens from the same 40 and 162 hr at 1150°F stress relief indicate that the yield strengths ranged from 77 ksi at −100°F (for the 40 hr stress relief) to 59 ksi at 300°F (for the 162 hr stress relief). The ultimate strengths ranged from 102 to 79 ksi for the same time-temperature stress relief conditions. Additional specimens have been prepared and further studies are contemplated especially in the stress relief temperature region between 1150°F and 1240°F.

Task 6: Thermal Shock - As a result of a meeting held with the HSST Program Review Committee, new interest was aroused in connection with circumferential cracks and the PWR vendors proclaimed most severe thermal shock. There was concern on the part of some members that the potential for growth of circumferential cracks is significantly greater than we are postulating. For this reason a circumferential-crack finite element analysis is being initiated ahead of schedule.

In response to questions regarding the severity of LOCA-ECC thermal shocks, ORNL wrote letters to the PWR vendors asking them to confirm that data transmitted to us some time ago is indeed consistent with the most severe thermal shock for their respective reactors.

Tensile data were obtained from C-oriented miniature tensile specimens from the .05, .34, .69, and .96t depth locations in the thermal shock vessel TSV-1 prolongation 002-2 ("as-received" condition). These data were obtained over a 550°F temperature range (−50 to 500°F). The 0.2% offset yield strength varied between 113 and 140 ksi and the ultimate strength varied from 156 to 176 ksi at both −50 and 500°F. A minimum in the ultimate strength (143 to 165 ksi) occurred at 250°F. Both the yield and ultimate strengths exhibited higher values for the surfaces than the center plate locations. Static fracture toughness (K_{Icd}) results from the same "as-received" prolongation over a 550°F temperature range

(−50 to 500°F) appear to be similar to those obtained from the reaustenitized V-1 prolongation (1600°F for 4 hr, W.Q.). The transition region extended from 50 ksi $\sqrt{in.}$ at −50°F to the onset of upper shelf, 125 ksi $\sqrt{in.}$ at approximately 275°F, with the average spread at the four depth locations (.05, .34, .67, and .96t) being 15 ksi $\sqrt{in.}$ A through-the-thickness sampling at four depth locations (.05, .34, .67, and .96t) indicates a fairly uniform toughness distribution through the wall.

In addition, CA and C-oriented Charpy-V and miniature tensile specimens from the "as-received" material were canned in vacuo and aged at 630°F for 8 hr followed by air cooling. Tensile results at the .15 and .86t depth locations and at −100, 70, 170, and 300°F indicate that the .2% offset yield and ultimate strengths decreased gradually from 130 and 162 ksi respectively at −100°F to about 118 and 148 ksi respectively at 300°F; the variation between the depths being about 2 to 3 ksi. Charpy-V results after aging indicate both a shift in transition range to lower temperatures and an increase in the upper shelf energy values. The transition temperatures for the outer third (1/3t) and the inner third (2/3t) depth regions decrease about 30°F (from 210 to 180°F) and 60° (from 260 to 200°F) respectively at the 30 ft-lb level. The upper shelf for these same depths increased 6 ft-lb (46 to 52 ft-lb) and 7 ft-lb (36 to 43 ft-lb) respectively. The static fracture toughness (K_{Icd}) is being determined for specimens similarly aged and precracked.

We also determined the effect of orientation in Charpy bars from the reaustenitized V-1 prolongation (1600°F for 8 hr, W.Q.) since some of our original characterization was done with CT-oriented specimens. The Charpy results indicate that at the .3 and .4t depth, no significant differences in energy exists between a crack running axially (CA) or radially (CT) in the radial crack plane. The static fracture toughness results at the same depth level indicate a shift in transition to lower temperatures and a lower upper shelf for the CA orientation. For example, 80 ksi $\sqrt{in.}$ occurs at 95°F for CA-oriented specimens and at 130°F for CT-oriented specimens. The upper shelf for the CA orientation was approximately 10 ksi $\sqrt{in.}$ lower than for the CT orientation.

Construction of the test facility and preparation of the test specimens are progressing. However, difficulties with the flawing equipment (electron beam welder), the necessity for designing a new test specimen support stand, and the need for increasing the test specimen ID may result in minor delays.

Task 8: Reheat Cracking Studies — The heat-affected zone (HAZ) of the longitudinal weld in intermediate test vessel V-4 was nondestructively examined (NDE) by pulse-echo ultrasonic longitudinal and shear-wave techniques. The procedures employed were established in accordance with Sections III and XI of the ASME Code; however, the actual tests were performed at sensitivity levels twice that required. The initial inspection was conducted while vessel V-4 was intact. Following the NDE the fracture surfaces were removed by flame cutting. Scans were made of the HAZ from the inner surface of the cut pieces at sensitivities of up to 30 times that required by the Code. One small indication was detected.

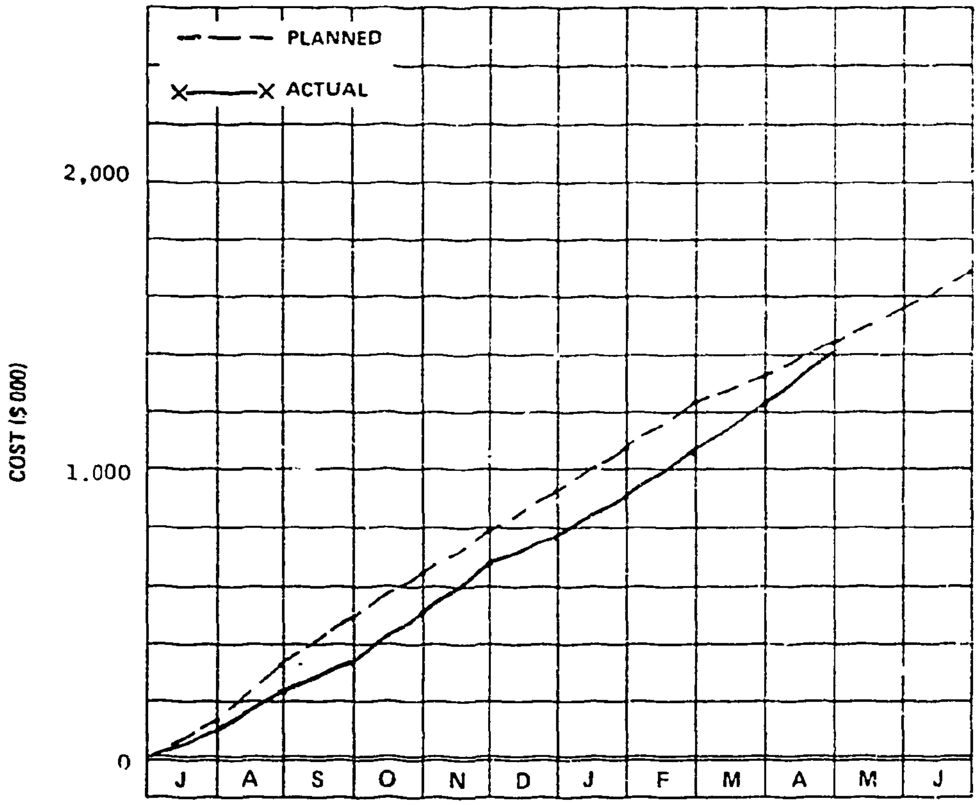
The fractured surfaces are being sectioned and the metallographic examination will be started in May.

COST/BUDGET REPORT FOR PERIOD Fiscal Year 1975

PROGRAM TITLE HEAVY SECTION STEEL TECHNOLOGY PROGRAM

[illegible] ACTIVITY 40 84 01 [illegible] 1

189a NO 10641



PLANNED ($ 000)

	J	A	S	O	N	D	J	F	M	A	M	J
MONTHLY	127	226	125	150	150	151	151	151	120	119	119	119
CUMULATIVE	127	353	478	628	778	928	1079	1230	1350	1469	1588	1707

ACTUAL ($ 000)

	J	A	S	O	N	D	J	F	M	A	M	J
MONTHLY	107	141	95	168	176	102	102	183	146	193		
CUMULATIVE	107	248	343	511	687	789	891	1074	1,220	1,413		
VARIANCE	-20	-105	-135	-117	-91	-139		-156	-130	-56		

COMMENTS

The January Cost Reporting Period is from 1/1/75 Through 1/18/75

The February Cost Reporting Period is from 1/18/75 Through 2/28/75

G. D. Whitman
PROGRAM MANAGER

Gordon G. Fee
PROGRAM DIRECTOR

PROGRAM TITLE: Fission Product Beta and Gamma Energy Release

PROGRAM MANAGERS: R. W. Peelle and J. K. Dickens

ACTIVITY NUMBER: 40 89 01 65 3 (189a No. 10653)

TECHNICAL HIGHLIGHTS

The final in-situ determination of the gamma-ray detector's response matrix was initiated using precision calibrated sources supplemented by sources made by in-pile activation of several nonfissile samples (e.g., samples isotopically enirched in ^{41}K and ^{36}S as well as such standards as Na, Al, and Au). For high-energy photons the responses are very nearly identical to those obtained in the preliminary response matrix for this detector last summer. For lower-energy photons (E_γ < 511 keV) there is a contribution observed due to source-photon back-scattering from the polyethylene rabbit holder in the counting position. The amount of this back-scattering contribution increases with decreasing E_γ, and is ≈ 8% of the total yield for E_γ = 122 keV. This contribution will be included in the response matrix used to unfold the raw spectra.

The beta-ray spectrometer was placed in the counting area and a suitable lead-shielding cave was fabricated. Calibration of this detector's response was initiated using conversion electron sources, and several beta-decay spectra were also obtained. In addition, beta spectra from several beta emitters were obtained and exhibited expected spectral distributions.

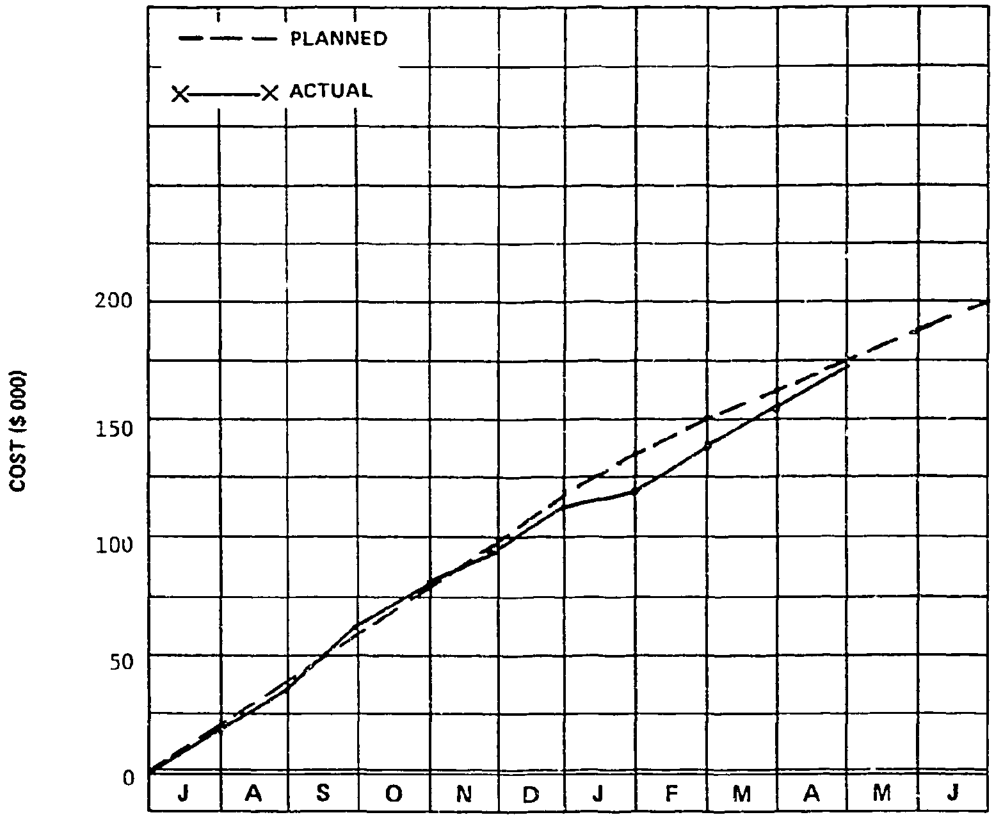
Preliminary photon data were obtained for a series of ^{235}U samples. These data were obtained for two irradiation periods (t_i), namely t_i = 2 and 100 secs. Counting periods were adjusted so that the final data may be compared with times-following-fission given in the present (October 1974) ANS-5.1 standard decay heat curve. These data were obtained for $0.14 \leq E_\gamma \leq 10$ MeV; it is planned to study the photon energy region <0.14 MeV during May, and then ro reduce these data using the response matrix currently being completed.

COST/BUDGET REPORT FOR PERIOD Fiscal Year 1975

PROGRAM TITLE: FISSION PRODUCT BETA & GAMMA ENERGY RELEASE

ORNL ACTIVITY: 40 89 01 65 3

189a NO.: 10653



PLANNED ($ 000)

	J	A	S	O	N	D	J	F	M	A	M	J
MONTHLY	20	20	19	20	20	19	16	16	12	13	12	13
CUMULATIVE	20	40	59	79	99	118	134	150	162	175	187	200

ACTUAL ($ 000)

	J	A	S	O	N	D	J	F	M	A	M	J
MONTHLY	18	17	27	18	14	16	8	19	18	16		
CUMULATIVE	18	35	62	80	94	110	118	137	-155	171		
VARIANCE	-2	-5	+3	+1	-5	-8		-13	-7	-4		

COMMENTS

The January Cost Reporting Period is from 1/1/75 Through 1/18/75
The February Cost Reporting Period is from 1/18/75 Through 2/28/75

R. W. Peelle/J. K. Dickens
PROGRAM MANAGER

Gordon G. Fee
PROGRAM DIRECTOR

TX 4696
(12-74)

PROGRAM TITLE: LOCA Release from LWR Fuel

PROGRAM MANAGER: A. P. Malinauskas

ACTIVITY NUMBER: 40 89 01 64 8 (189a No. 10648)

TECHNICAL HIGHLIGHTS:

Installation of experimental equipment in the hot cell was completed. Component testing has included: (1) induction heating of an unfueled Zircaloy specimen in argon, (2) operation of the gamma radioactivity scanner in conjunction with a single channel analyzer and log count rate meter, (3) operation of the steam generator and heated transfer lines to the furnace tube, and (4) in-place testing of the vacuum pump and thermal conductivity meter (for hydrogen detection). All components functioned satisfactorily. Although the induction heating system demonstrated some instabilities at the higher power levels, improved circuit tuning or use of a voltage reduction transformer should improve stability. The system is being prepared for the control experiments, in which known species (I_2, CH_3I, CsI, and Cs) containing radioactive tracers will be injected separately and analyzed.

Cost estimates were received from three hot cell facilities for the preparation of test specimens from H. B. Robinson 2 fuel rods.

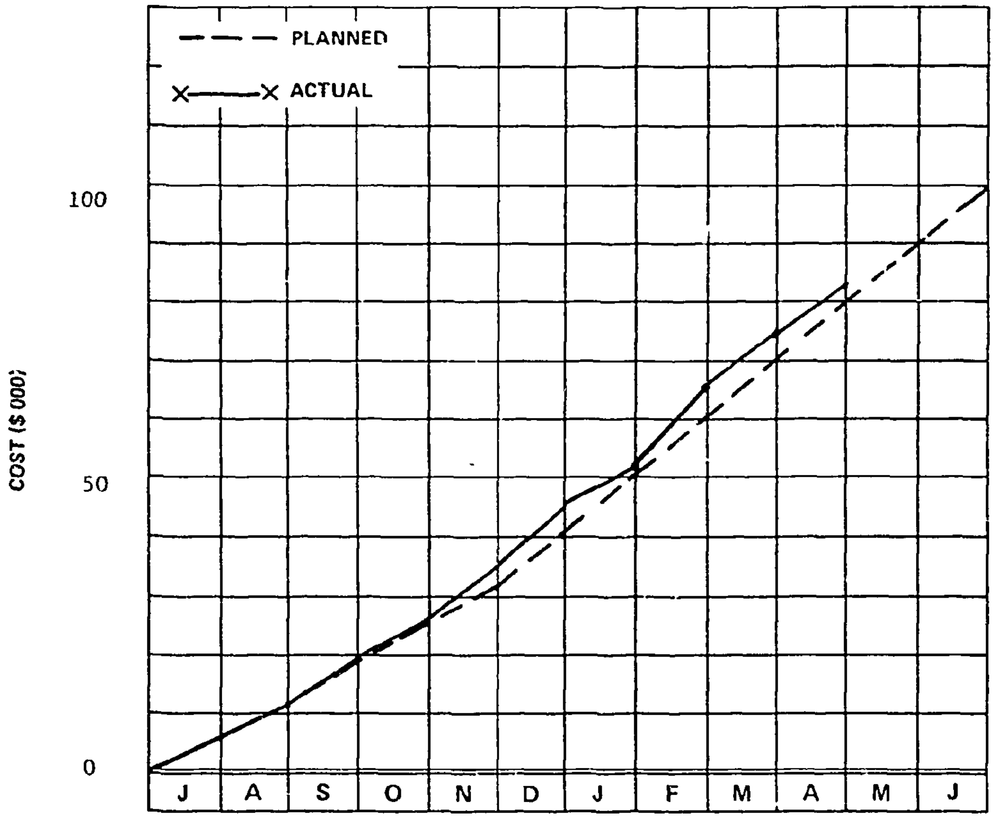
A Knudsen effusion cell and mass spectrometer system has been returned to operation by Y-12 Analytical Chemistry staff and experiments to study the vapor species released from UO_2-cesium compound mixtures have been initiated. A sample of pure UO_2 was examined as a calibration test, and samples of UO_2-Cs_2O and UO_2-CsI have been prepared for study.

COST/BUDGET REPORT FOR PERIOD ____ Fiscal Year 1975

PROGRAM TITLE: FISSION PRODUCT RELEASE FROM LWR FUEL

HNL ACTIVITY: 40 89 01 64 8

189a NO: 10648



PLANNED ($ 000)

	J	A	S	O	N	D	J	F	M	A	M	J
MONTHLY	6	6	6	7	7	8	10	10	10	10	10	10
CUMULATIVE	6	12	18	25	32	40	50	60	70	80	90	100

ACTUAL ($ 000)

	J	A	S	O	N	D	J	F	M	A	M	J
MONTHLY	6	6	7	7	9	11	5	16	8	11		
CUMULATIVE	6	12	19	26	35	46	51	67	75	86		
VARIANCE	–	–	+1	+1	+3	+6		+7	+5	+6		

The January Cost Reporting Period is from 1/1/75 Through 1/18/75
The February Cost Reporting Period is from 1/18/75 Through 2/28/75

COMMENTS

A. P. Malinauskas
PROGRAM MANAGER

Gordon G. Fee
PROGRAM DIRECTOR

TX 4696
(12-74)

PROGRAM TITLE: Multirod Burst Tests

PROGRAM MANAGER: R. H. Chapman

ACTIVITY NUMBER: 40 89 01 34 4 (189a 10344)

TECHNICAL HIGHLIGHTS:

For production purposes the combined EPRI and HNL Zircaloy tubing orders were processed as two lots of tubing (from the same ingot), with each customer being allocated approximately half of his order from each lot. Although well within specifications, one lot of the tubing has a wider range of ovality than the other and may have subtle differences in characteristics due to slight variations in processing history. This information has been transmitted to the various researchers, since it may affect interpretation of subsequent experimental results. The tubing was shipped April 30 (approximately three weeks later than originally promised) and should arrive in mid-May.

Delivery of the first group (~10) of tantalum sheathed thermocouples for test and evaluation was delayed by the supplier; shipment is now scheduled for May 7, with the remainder scheduled for shipment later in the month. One hundred stainless steel sheathed thermocouples have been shipped, but not yet received. Requests for an extension of the closing bid date were granted in order to obtain responsive proposals on the special stainless steel sheathed, type S exposed hot junction thermocouples for use (on the outside of the cladding) in temperature mapping of the first 4x4 bundle. An order for these thermocouples should be placed by the end of May; delivery is needed in September.

Bids for 20 prototype heaters for use in the initial tests were received from each of the three vendors who supplied development heaters for test and evaluation. Options to be exercised after successful demonstration of the adequacy of the initial 20 heaters were also obtained for an additional 40 heaters. Table I summarizes the bid information. Uniformity of heater sheath heat flux (influenced by element concentricity and density of boron nitride insulation), heater straightness, and thermocouple groove specifications are particularly important to success of the tests and to proper interpretation of the experimental results. Based on the information supplied and on our test and evaluation of the development heaters, we concluded the following:

1. Since the thermocouple grooves present unusual difficulties to the manufacturers, resulting in exceptions to the specifications and high associated costs, we will groove the heaters in-house. Later in the program, when significant quantities of heaters are being purchased, it may be economically desirable to have the manufacturers develop this capability.
2. The use of Watlow's proprietary BN prefilling treatment will necessitate demonstration that the proposed technique produces high-temperature characteristics equivalent to (or better than) those known to be obtained with the specified procedure.
3. Quoted delivery 's approximately the same for all three vendors, if the time required to demonstrate adequacy of Watlow's BN pretreatment is included.
4. Watlow's best-effort basis on concentricity and straightness does not give assurance that specifications will be met; the lower costs do not justify the risks involved.

Orders have been placed for 20 heaters (without thermocouples grooves) from both RAMA and SEMCO. Accepting the proposals from these two suppliers will further development of competitive sources for heater procurement in the immediate future. The option to purchase 40 additional heaters from one of these two suppliers will be delayed until some of the initial heaters are received, tested, and evaluated to determine compliance with purchase order requirements and suitability for use in the intended application. Materials have been shipped to the vendors for use in fabricating the heaters. We will continue to work with the vendors to expedite delivery of acceptable heaters at the earliest possible date. Upon arrival of the heaters at HNL, acceptance inspection will be performed, thermocouple grooves machined, and a protective spray coating applied.

Authorization was given April 10 to proceed with construction of the Multirod Test Facility. Drawings were issued and work orders written for the contractor to proceed with site preparations and with modifications to the dc power supply. Purchase requisitions were submitted for the pressure transducers, excitation power supplies, secondary standard Bourdon-type pressure gauge, and thermocouple extension wire for use in the 4x4 bundle tests.

Control circuits and interlocks were designed for the single rod test stand. Mechanical design drawings for the No. 1 4x4 rod bundle were reviewed.

The development heater supplied by SEMCO (see previous monthly report) was swaged down to permit its use in a prototype fuel pin simulator. A length of Zircaloy-4 tubing was oxidized in 950°F steam for one-half hour in the pretreatment facility. Although this tubing was pretreated for use in the prototype simulator, sections of the tubing will be analyzed to determine the quality and thickness of oxide layer formed on both the inside and outside surfaces. Further tests are planned to define the proper pretreatment parameters.

A new proposal for the lower seal gland on fuel pin simulator was received from the manufacturer. The new concept is designed to circumvent seal and isolation difficulties reported last month. A prototype was obtained for test and evaluation.

TABLE I - BID COMPARISON FOR MRBT HEATERS

	Watlow			RAMA			SEMCO		
	Heater[a] Unit Cost ($)	Delivery (weeks)	Notes	Heater[a] Unit Cost ($)	Delivery (weeks)	Notes	Heater[a] Unit Cost ($)	Delivery (Weeks)	Notes
20 heaters			b			c			d
Grooved as specified	No bid			796.32	12		No bid		
Modified grooves	521.25	8-9	e				800.00	8-10	f,g
Without grooves	366.25	8-9		461.00	10		575.00	10-12	h
40 additional heaters			b			c			d
Grooved as specified	No bid			781.32	12		No bid		
Modified grooves	335.63	15	e				745.00	8-10	f,g
Without grooves	282.12	15		444.40	10		546.00	10-12	h

[a]Excludes $27.50 materials cost for heater sheath, heater element, and boron nitride supplied by HNL.

[b]Watlow quoted on all heaters with the following exceptions: (1) use proprietary BN prefilling treatment instead of specified vacuum bakeout and (2) best effort on concentricity and straightness.

[c]RAMA made no exceptions on heaters with or without grooves.

[d]SEMCO made no exceptions on ungrooved heaters.

[e]Grooving on best effort basis.

[f]Delivery date with 70% confidence level.

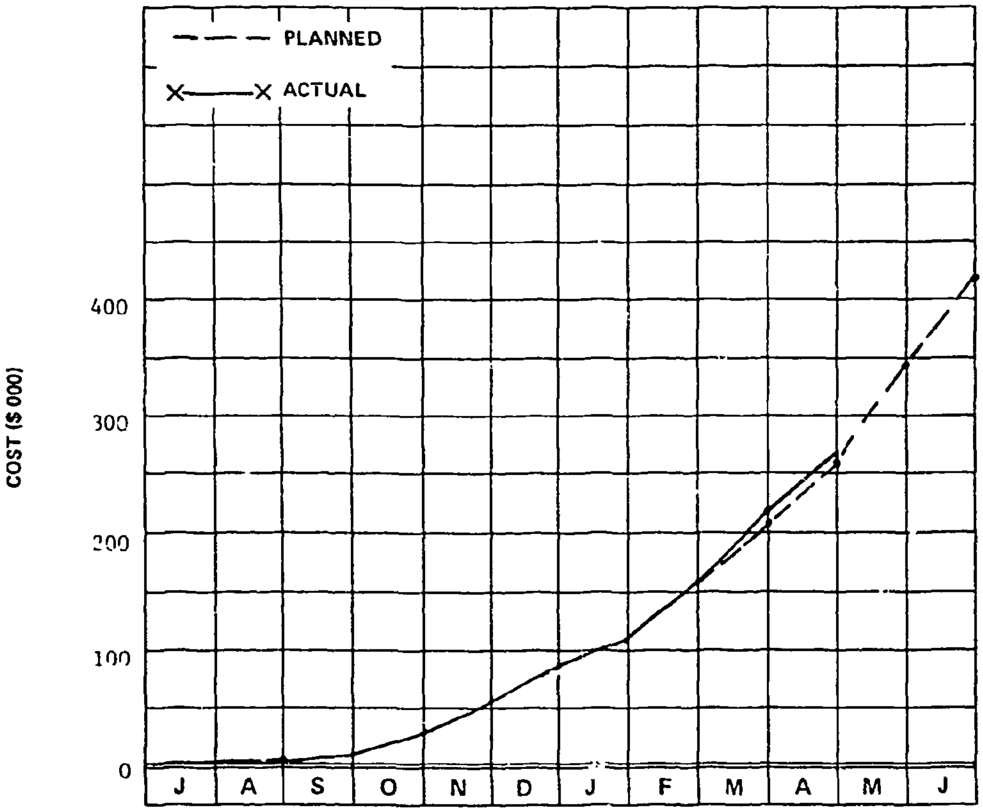
[g]Groove exceptions: (1) Radial location $\pm 2^{\circ}$ instead of specified $\pm 1/2^{\circ}$, (2) groove depth $0.023 {}^{+0.005}_{-0.000}$ instead of specified $0.023 {}^{+0.002}_{-0.000}$ and (3) groove bottom "with sharp corners" instead of specified radius of 0.015.

[h]Delivery date with 65% confidence level.

COST/BUDGET REPORT FOR PERIOD Fiscal Year 1975

PROGRAM TITLE: Multi-Rod Burst Test HNL ACTIVITY: 40 89 01 34 4

189a NO.: 10344



	J	A	S	O	N	D	J	F	M	A	M	J
PLANNED ($ 000)												
MONTHLY	2	3	10	19	27	24	23	58	39	50	90	70
CUMULATIVE	2	5	15	34	61	85	108	166	205	255	345	415
ACTUAL ($ 000)												
MONTHLY	2	3	10	19	27	24	23	58	49	44		
CUMULATIVE	2	5	15	34	61	85	108	166	215	259		
VARIANCE									+10	+4		

The January Cost Reporting Period is from 1/1/75 Through 1/18/75
The February Cost Reporting Period is from 1/18/75 Through 2/28/75

COMMENTS

R. H. Chapman
PROGRAM MANAGER

Gordon G. Fee
PROGRAM DIRECTOR

TX 4696
(12 74)

<u>PROGRAM TITLE</u>: Nuclear Safety Information Center

<u>PROGRAM MANAGER</u>: William B. Cottrell

<u>ACTIVITY NUMBER</u>: 40 89 01 63 9 (189 No. 10639) and
HN 70 01 (189 No. 10160)

<u>TECHNICAL HIGHLIGHTS</u>:

During the month of April the staff of the Nuclear Safety Information Center (a) processed 1073 documents, (b) responded to 115 inquiries (73 technical), (c) received 8 visitors and attended 13 meetings. "Design Data Sheets" were completed for the two unit Pebble Springs Nuclear Plant in Oregon and for the two unit Blue Hills Station in Texas. An indexed bibliography was prepared for the ACRS including all their reports processed during March, i.e., 82 reports.

Three NSIC reports were issued; ORNL-NSIC-117 "Protection of Nuclear Power Plants Against External Disasters", ORNL-NSIC-116 "Index to Nuclear Safety" (Volume 11(1) — Volume 15(6)), and ORNL-NSIC-119 "A Selected Bibliography on Pressure Vessels for Light-Water-Cooled Power Reactors." In addition, ORNL-NSIC-55 (Volume IV) "Design Data and Safety Features of Commercial Nuclear Power Plants" (Docket 50-452 through 50-503) is in reproduction. The final drafts of two other reports, ORNL-NSIC-120 "Annotated Bibliography of Hydrogen Considerations in Light-Water-Power Reactors" and ORNL-NSIC-121 "Abnormal Reactor Operating Experiences 1972 — 1974", are nearing completion. In addition, work is progressing on several other reports including ORNL-NSIC-118 "Siting of Nuclear Facilities, Selections from *Nuclear Safety*" and ORNL-NSIC-122 "Annotated

Bibliography of Safety Related Occurrences in Nuclear Power Plants as Reported in 1974."

Early in the month we were advised that *Nuclear Safety* had won the Award of Merit (3rd place) in the Technical Journal Category of the Society for Technical Communications Sixth International Publication Competition. After hearing that there were approximately 330 entries in this particular category, we were more reconciled to our award. The month was further enlivened by the writing of 189s, the preparations for the Reactor Division Information Meeting, and NSIC's participation in the 37th Annual Meeting of the American Power Conference in Chicago.

We are developing the cost information and mechanics, as required, to implement the ERDA-NRC Cost Recovery Policy early next year. In that connection preliminary contacts have been made with the Electric Power Research Institute concerning their possible participation in the support of NSIC.

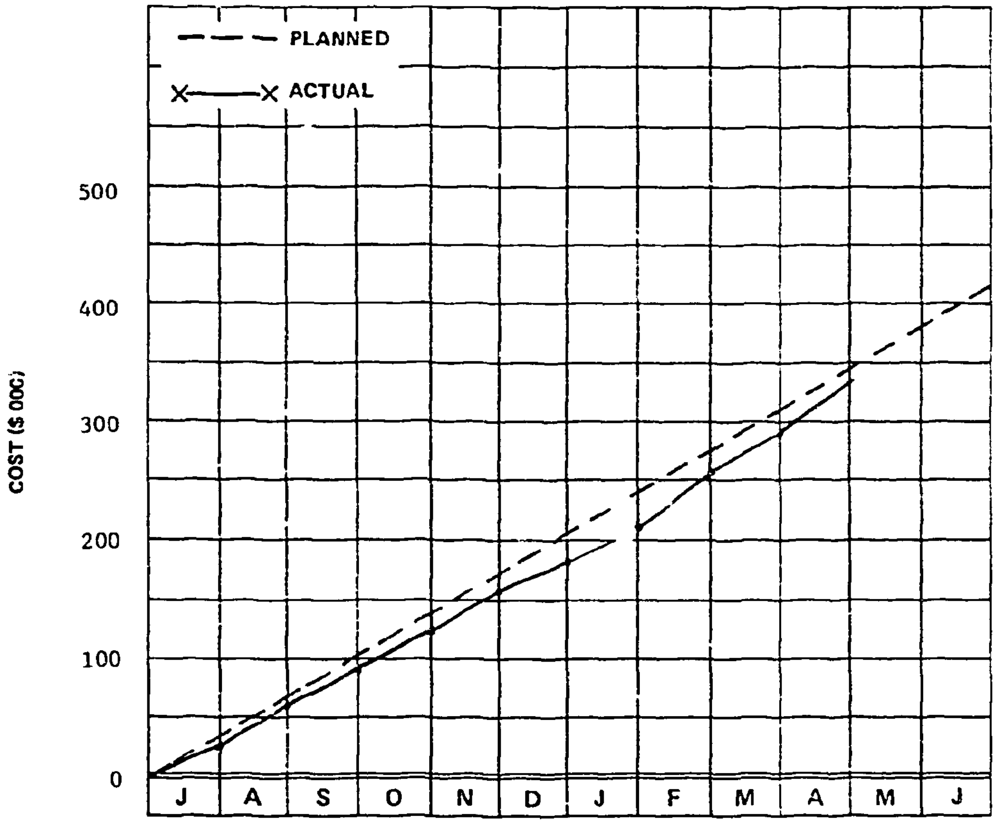
The final copy for *Nuclear Safety* 16(3) is at the printers and distribution should be effected by the end of May. The Current Events material for *Nuclear Safety* 16(4) which covers the two months, March and April, is being prepared. All articles for *Nuclear Safety* 16(5), (except the Current Events material) are being edited for final typing before being sent to TIC and Headquarters. The paid subscriptions to *Nuclear Safety*, which had dropped to 2587 for *Nuclear Safety* 15(6), has since recovered to 3054 for *Nuclear Safety* 16(2). There is no explanation for these perturbations in the paid subscribers except for the difficulties in dealing with the Government Printing Office. The print run continues to be $\sim$6000.

COST/BUDGET REPORT FOR PERIOD Fiscal Year 1975

PROGRAM TITLE: NUCLEAR SAFETY INFORMATION CENTER

HNL ACTIVITY: 40 89 01 63 9

189a NO.: 10639



PLANNED ($ 000)

	J	A	S	O	N	D	J	F	M	A	M	J
MONTHLY	34	35	34	35	34	35	34	35	34	35	35	35
CUMULATIVE	34	69	103	138	172	207	241	276	310	345	380	415

ACTUAL ($ 000)

	J	A	S	O	N	D	J	F	M	A	M	J
MONTHLY	29	32	33	29	34	31	21	47	35	43		
CUMULATIVE	29	61	94	123	157	188	209	256	291	334		
VARIANCE	-5	-8	-9	-15	-15	-19	-32	-20	-19	-11		

The January Cost Reporting Period is from 1/1/75 Through 1/18/75
The February Cost Reporting Period is from 1/18/75 Through 2/28/75

COMMENTS

W. B. Cottrell
PROGRAM MANAGER

Gordon G. Fee
PROGRAM DIRECTOR

TX-4696
(12-74)

PROGRAM TITLE: PWR Blowdown Heat Transfer-Separate Effects

PROGRAM MANAGER: D. G. Thomas

ACTIVITY NUMBER: 40 89 01 58 3 (189a No. 10583)

TECHNICAL HIGHLIGHTS:

Task 1. Testing of the production heater rod now installed in the FCTF continued. This rod has now survived for a total operating time of 67.2 hr, 26.0 of which were at full power; included in this 67.2 hours of operation were a total of 11 blowdowns and one steady-state CHF measurement. There are still no indications of leaks from the Viton O-ring seals at the top of the heater rod. For the last blowdowns, sheath and interior thermocouples gave substantially the same readings prior to blowdown when the rod was at full power and loop flow and pressure were the same. Prior to this, these thermocouples had indicated progressively higher temperatures after heatup to the same operating conditions subsequent to each blowdown. Testing of a second production heater rod is to begin soon to determine whether the results of testing the first rod were atypical.

Tests involving step changes in heat flux, heat-transfer coefficient, and surface temperature have begun for the production heater rod now installed in the FCTF and for a prototypical heater previously installed in the FCTF. The dynamic responses of the heaters observed during these tests should provide: (1) an estimate of uncertainty in our dynamic temperature measurements during a blowdown; (2) information pertinent to the establishment of standard tests by which the level of performance of a heater is measured; (3) a data set for comparison with responses predicted analytically; and (4) generation of heater time constants.

Task 2. Calculations are continuing using RELAP4 to model powered blowdowns in the THTF. At a constant total break area of 0.0135 ft^2 the inlet break fractions calculated are 0.2, 0.4, 0.5, 0.6, and 0.8. Full power (7.056 MW) is maintained for 10 seconds into the blowdown, followed by a step drop to zero power. The pressurizer communicates freely with the loop. The pump is shut off and allowed to coast down immediately upon blowdown.

One run stopped early due to water packing in the modeled RELAP volume adjacent to the inlet break. The problem was restarted with smaller minimum and maximum timesteps during a short interval and ran to completion.

Task 3. A second blowdown was attempted on Friday, April 18, 1975. This blowdown was scheduled to be an isothermal test (with a dummy test section instead of the heater rod bundle) from a pressure of 2250 psi and a temperature of 550°F with a loop flow rate of 550 gpm. Before reaching test conditions the outboard seal on the Bingham pump failed. There were no injuries and no damage to equipment except for the pump seal. At the time of seal failure the pressure was 1910 psi, loop temperature was 380°F and loop flow was 505 gpm. Almost all process instrumentation appeared to have performed well prior to seal failure. One turbine meter malfunctioned, apparently one probe pickup failed. Two of the three gamma densitometers had a drift problem perhaps due to temperature. All primary liquid temperature sensors appear to have been in excellent agreement with steady-state conditions around the loop. After disassembling the pump seal there was no apparent reason for the seal failure. One hypothesis is that a small amount of "crud" may have lodged in a cooling slot on the seal resulting in dynamic imbalance. Of course the seal faces were scored as the loop contents discharged through the seal. The seal surfaces have now been reground flat to within one light band and the pump seal is being reassembled.

Task 4. Numerous air-water two-phase flow tests have been conducted with a THTF instrumented spool piece oriented for discharge downward through the spool piece. The spool piece has been equipped with a drag disk, turbine meter and a gamma densitometer; the drag disk is upstream of the turbine. The tests included effects of different designs of flow dispersers located at the inlet flange of the spool piece, approximately 6 in. upstream of the drag disk and 30 in. upstream of the turbine.

Assuming homogeneous flow, readings from the three instruments in the spool piece can be combined in three different ways to obtain mass flow, (1) Turbine meter – densitometer, (2) Drag disk – turbine meter, and (3) Drag disk – densitometer. For Case 1, calculated mass flows were consistently low while for Case 3, calculated flows were consistently high while for Case 2, the results were intermediate and gave best agreement with the actual flow rates. Further, earlier studies with the turbine meter upstream of the drag disk showed that the turbine readings were relatively insensitive to different flow dispersers located at the inlet flange.

A series of tests have recently been conducted with the spool piece oriented with the drag disk upstream of the turbine. Flow dispersers were fabricated with a heavy screen wire (8 mesh, 62-mil wire diameter); two-phase pressure drop of a single screen was about twice that of the spool piece alone. For one test a single screen was located at the spool piece inlet flange and a second disperser (single screen) was machined to fit inside the spool piece and rest on the turbine meter housing. For the second test, dispersers consisting of two of the heavy screens were located at the inlet flange and inside the spool piece. Results showed little effect on the turbine meter reading and, consequently, little effect on calculated mass flow rates due to locating dispersers inside the spool piece. It is expected, however, that internal dispersers will be necessary where flow is such that the turbine is upstream of the drag disk.

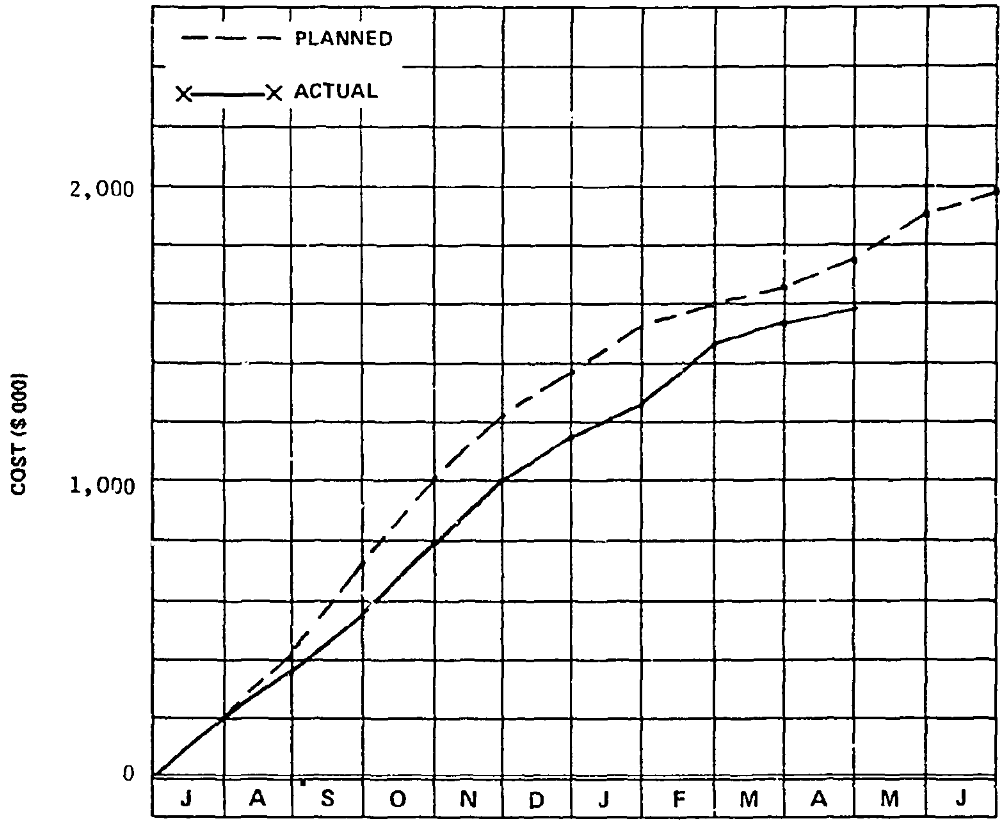
As a result of recent developments in the PWR-Blow Down Heat Transfer Program (189 number 10583), it appears that it will not be possible to expend all of the FY 1975 allocated operating funds. This has come about because of a slippage in delivery of a $55,000 order for bundle thermocouples and the delay in installation of bundle number one, due to the problems being encountered with the high-pressure THTF pump. In the case of thermocouples, the vendor, Kaman Manufacturing Company, has encountered severe technical problems and as a result will not deliver any materials before July 1. In fact, there is some possibility they may even deflault on the contract. As a consequence, HNL would like to recommend that $100,000 of the BDHT budget be transferred to the Heavy Section Steel Technology Program (189 number 10641).

COST/BUDGET REPORT FOR PERIOD Fiscal Year 1975

PROGRAM TITLE: BLOWDOWN HEAT TRANSFER PROGRAM

HNL ACTIVITY: 40 89 01 58 3

189a NO.: 10583



PLANNED ($ 000)

	J	A	S	O	N	D	J	F	M	A	M	J
MONTHLY	214	224	298	260	232	159	100	90	72	100	141	100
CUMULATIVE	214	438	736	996	1228	1387	1487	1577	1649	1749	1890	1990

ACTUAL ($ 000)

	J	A	S	O	N	D	J	F	M	A	M	J
MONTHLY	213	183	185	220	210	139	98	192	84	70		
CUMULATIVE	213	396	581	801	1011	1150	1248	1440	1,524	1,594		
VARIANCE	-1	-42	-155	-195	-217	-237		-137	-125	-155		

The January Cost Reporting Period is from 1/1/75 Through 1/18/75
The February Cost Reporting Period is from 1/18/75 Through 2/28/75

COMMENTS

A $90,000 to $100,000 underrun is projected for the BDHT Program at this time (see explanation under financial comments section on page 28).

D. G. Thomas
PROGRAM MANAGER

Gordon G. Fee
PROGRAM DIRECTOR

TX-4696
(12-74)

PROGRAM TITLE: Zircaloy Fuel Cladding Collapse Studies

PROGRAM MANAGER: D. O. Hobson

ACTIVITY NUMBER: 40 89 01 34 5 (189a Number 10345)

TECHNICAL HIGHLIGHTS:

The anodized aluminum eddy-current displacement coils have been tested at temperatures up to 800°F and their drift characteristics are being examined. The insulation provided by the thin (3000-4000 °A) oxide films is apparently sufficient for the temperatures planned for the collapse tests. Long-time thermal soaking tests to determine calibration techniques are being conducted. A prototype five-coil block is being assembled and will be tested this coming month. It is anticipated that at least four such blocks will be needed to monitor a collapse test.

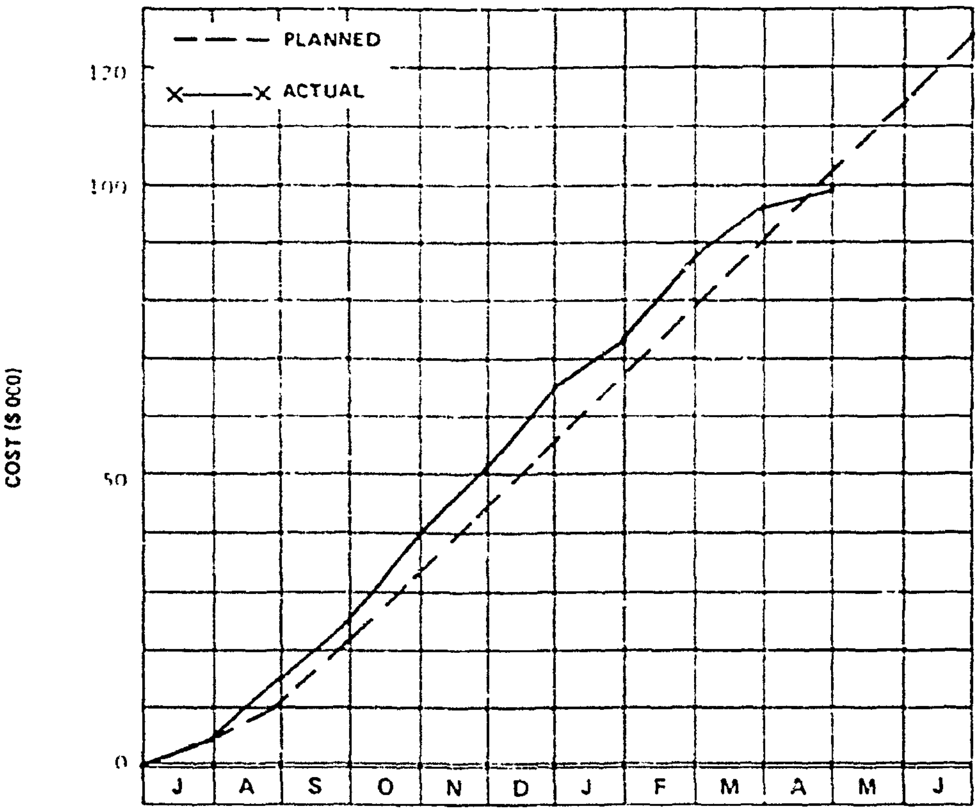
Equipment installation in the autoclave pit is proceeding as the pressurizing and temperature-control equipment is received from the various manufacturers.

COST/BUDGET REPORT FOR PERIOD Fiscal Year 1975

PROGRAM TITLE ZIRCALOY FUEL CLADDING COLLAPSE STUDIES

RDD ACTIVITY 40 99 01 34 5

189a NO 10345



PLANNED ($ 000)

	J	A	S	O	N	D	J	F	M	A	M	J
MONTHLY	6	5	11	11	11	11	12	11	12	12	11	12
CUMULATIVE	6	11	22	33	44	55	67	73	90	102	113	125

ACTUAL ($ 000)

	J	A	S	O	N	D	J	F	M	A	M	J
MONTHLY	5	11	9	15	12	13	8	15	8	4		
CUMULATIVE	5	16	25	40	52	65	73	88	96	100		
VARIANCE	-1	+5	+3	+7	+8	+10		+10	+6	-2		

COMMENTS

The January Cost Reporting Period is from 1/1/75 Through 1/18/75
The February Cost Reporting Period is from 1/18/75 Through 2/28/75

D. O. Hobson
PROGRAM MANAGER

Gordon G. Fee
PROGRAM DIRECTOR

TX 4696
(12 [illegible])

PROGRAM TITLE: Zirconium Metal-Water Oxidation Kinetics

PROGRAM MANAGER: C. J. McHargue

ACTIVITY NUMBER: 40 89 01 05 5 (189a No. 10655)

TECHNICAL HIGHLIGHTS:

Level "B" Milestone, "Select methods for experimental analysis for diffusion of oxygen in β-Zircaloy" and "Assemble main components of isothermal oxidation rate apparatus" was completed as was the Level "C" Milestone, "Complete comparative calibration of 'used' thermocouple from reaction rate studies."

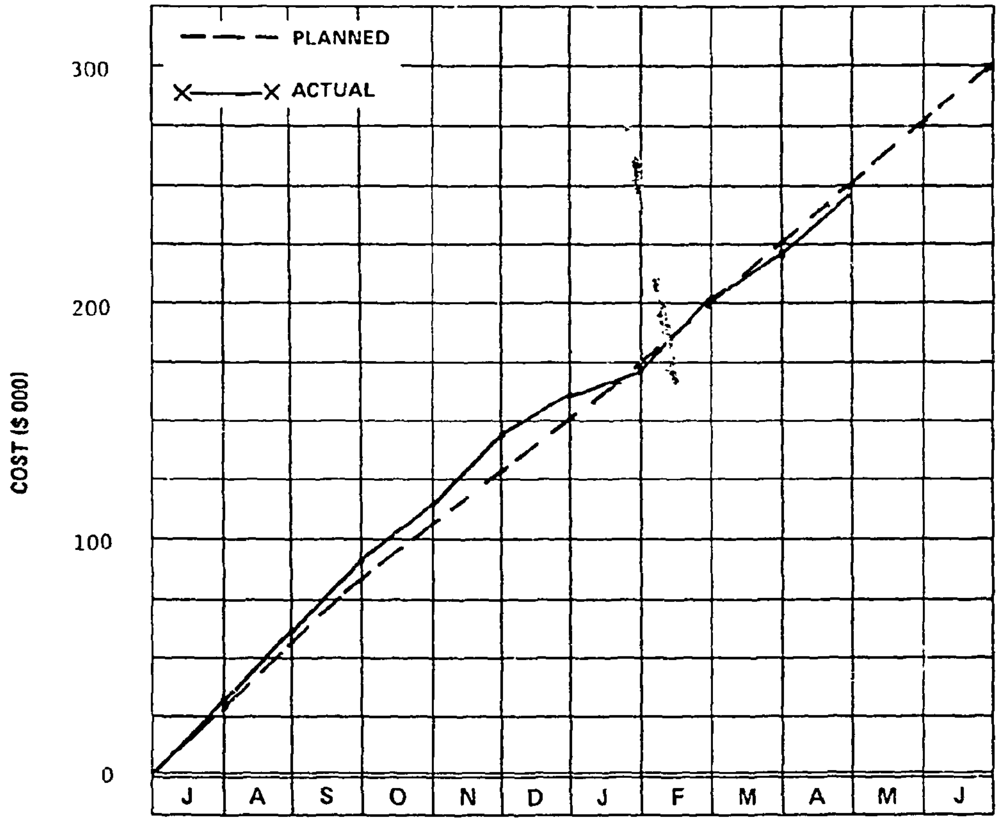
During its calibration the optical pyrometer to be used in our diffusion studies was found to be defective. It has been returned to the manufacturer for repair or replacement, and in the interim we are using a borrowed pyrometer. It is now uncertain, however, that we will be able to meet the deadline for the completion of the calibration of the pyrometer (6-30-75).

COST/BUDGET REPORT FOR PERIOD Fiscal Year 1975

PROGRAM TITLE ZIRCONIUM METAL-WATER OXIDATION KINETICS

HHL ACTIVITY 40 89 01 65 5

189a NO.: 10655



PLANNED ($ 000)

	J	A	S	O	N	D	J	F	M	A	M	J
MONTHLY	28	27	28	22	23	22	25	25	25	25	25	25
CUMULATIVE	28	55	83	105	128	150	175	200	225	250	275	300

ACTUAL ($ 000)

	J	A	S	O	N	D	J	F	M	A	M	J
MONTHLY	29	29	35	21	26	19	14	28	20	26		
CUMULATIVE	29	58	93	114	140	159	173	201	221	247		
VARIANCE	+1	+3	+10	+9	+12	+9		+1	-4	-3		

The January Cost Reporting Period is from 1/1/75 Through 1/18/75
The February Cost Reporting Period is from 1/18/75 Through 2/28/75

COMMENTS

C. J. McHargue
PROGRAM MANAGER

Gordon G. Fee
PROGRAM DIRECTOR

TX 4696
(12 74)

PROGRAM TITLE: Transient Release from LMFBR Fuel

PROGRAM MANAGER: M. H. Fontana

ACTIVITY NUMBER: 40 09 02 [illegible] (Ledger Number [illegible])

TECHNICAL HIGHLIGHTS:

Five additional fuel simulant vaporization tests were conducted at the Arnold Engineering Development Center's (AEDC) von Karman facility. These additional tests were designed to improve the good aerosol yield observed in the previously reported Test 6.

One method for improving aerosol yield, attempted in Tests 7 and 8, was to use a thicker (4 mm) quartz containment sleeve compared to that used in Test 6 (2 mm). Tests 7 and 8 differed in that Test 7 employed 40% (by weight) UO_2 pellets and UO_2 microspheres as the fuel simulant sample. Test 8 utilized only UO_2 microspheres. Disassembly was observed for both tests within about the same time and energy input range as was observed in Test 6, but the new tests appeared to have yielded less aerosol.

The AEDC series included preliminary tests on effects of cladding during fuel vaporization. Toward this end, stainless steel was added to the UO_2 microspheres in Test 9. In this case, energy input before disassembly was more than double the highest input experienced previously, and the aerosol yield appeared to exceed that observed in Test 6. This improvement is thought to be due to a lower resistivity-temperature coefficient resulting from the presence of the stainless steel.

This would tend to flatten the radial temperature profile and significantly reduce the power density along the fuel centerline during the electrical discharge.

Test 10 was an attempt to reduce the heating power level without significantly dropping the voltage and the stored energy in the capacitor bank. Hence to increase the electrical resistance of the assembly, a longer and smaller diameter fuel assembly was employed. Although a reduction in total power level did result, aerosol production appeared to be about the same as observed during Test 8.

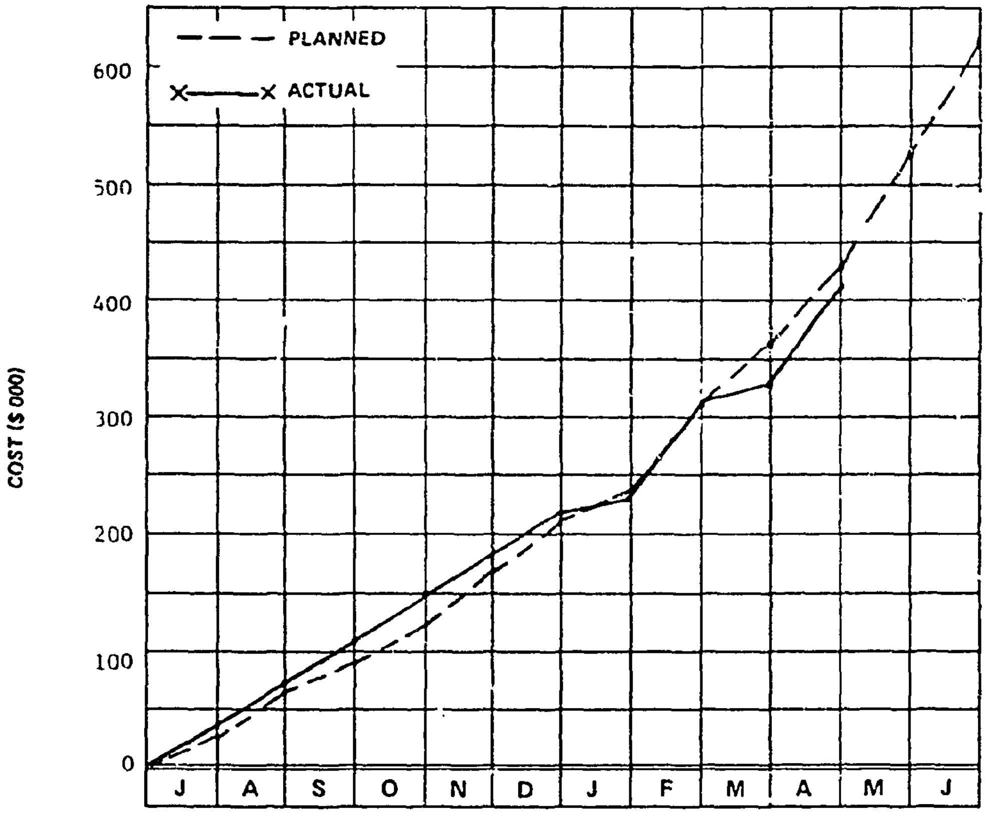
The Test 11 fuel simulant sample was contained in a heavy (14 mm thick) quartz tube along the front 60 mm of fuel length. This quartz containment was reduced to 1.5 mm thickness for the last 20 mm of length at the low voltage end of the assembly. The intent was to cause the thin-walled area to rupture first allowing the current at the ruptured end of the assembly to be carried by a low impedance arc. The results were disappointing in that the entire assembly apparently disassembled after about the same energy input as in Test 10, and with a lower aerosol yield.

COST/BUDGET REPORT FOR PERIOD Fiscal Year 1975

PROGRAM TITLE TRANSIENT RELEASE FROM LMFBR FUEL

ERDA ACTIVITY 40 89 02 65 2

189a NO 10652



PLANNED ($ 000)

	J	A	S	O	N	D	J	F	M	A	M	J
MONTHLY	35	36	35	35	36	36	27	74	47	71	94	94
CUMULATIVE	35	71	106	141	177	213	240	314	361	432	526	620

ACTUAL ($ 000)

	J	A	S	O	N	D	J	F	M	A	M	J
MONTHLY	31	32	28	33	47	40	27	76	15	82		
CUMULATIVE	31	63	91	124	171	211	238	314	329	411		
VARIANCE	-4	-8	-15	-17	-6	-2			-32	-21		

COMMENTS

The January Cost Reporting Period is from 1/1/75 Through 1/18/75
The February Cost Reporting Period is from 1/18/75 Through 2/28/75

M. H. Fontana
PROGRAM MANAGER

Gordon G. Fee
PROGRAM DIRECTOR

TX 4696
(12 74)

PROGRAM TITLE: HTGR Safety Analysis and Research

PROGRAM MANAGER: J. P. Sanders

ACTIVITY NUMBER: HNL 40 89 05 06 4 (189a Number 10664)
ERDA 40 10 01

TECHNICAL HIGHLIGHTS:

General: Work on the development of codes to simulate the dynamics of HTGR components has continued. Codes received from GAC are being evaluated and implemented on ORNL computers. The Fort St. Vrain Reactor Dynamics Testing Program is being developed under the subcontract with the University of Tennessee.

HTGR Steam Generator Model Development: The plotting package has been incorporated into the code and has been debugged. The general model has been reduced in size by 100 K bytes to form a basis for the model which is to be used in the overall system simulation. The smaller package has been executed with the implicit solution technique to solve the basic transients, and the results show good agreement with the general model. The smaller model also includes the plotting package to be used by the overall system simulation.

Core Model for Use in Overall NSS Code: The calculation of the film heat transfer coefficient was expanded to include the transition and laminar flow regimes for reduced flow conditions. Calculations were performed to determine the peak fuel temperature in the FSV reactor for post-shutdown, reduced flow conditions.

The time response of the power, average channel outlet temperature, and mixed mean outlet temperature to a small perturbation in reactivity was determined for the FSV reactor for two different values (1600 and 400 Btu hr^{-1} ft^{-2} $°F^{-1}$) of the average conductance of the gap between the fuel stick and bulk moderator. The frequency response of the system was computed from the time response using Samulon's method and the power-to-reactivity transfer function was analyzed. This was done to determine if an approximate value for the average gap conductance might be determined from dynamics testing, or at least if changes in the gap conductance could be detected. The results are being evaluated.

Core Auxiliary Cooling System: A detailed description of the Core Auxiliary Cooling Tower (CACT) for the Delmarva Summit Power Station has been obtained from its proposed vendor, the Marley Company. Present work has included development of a code for the CACT for interfacing with the code for the CAHE, and modification of the entire program so that sections of it can be made subroutines of the MATEXP code for a comparison of efficiency and results.

Core Simulation for Emergency Cooling Analysis: The ORECA code (an ORNL code similar, in part, to the RECA code of GAC) was used to calculate the response of the FSV reactor to a postulated depressurization accident. The sensitivity of the results (maximum core temperature) to variations in model assumptions and input values was also determined.

Digital Computer Program Implementation: A complete package of five computer tapes representing the RECA program was received from GAC. These included (a) a FORTRAN program called RECGEN that is a nodal point generator which prepared input for the CINDA-3G preprocessor with input data for RECGEN, (b) the GAC version of the CINDA-3G preprocessor, called PREPRO, with input data that was generated by RECGEN, (c) the steady-state RECA program which is the output of the CINDA-3G preprocessor with required input data for this RECA program, (d) a binary data tape written on the UNIVAC 1108 by PREPRO to be used as input to the steady-state RECA program, (e) a transient RECA program that is obtained from the steady-state version by limited card substitution together with the required input data for the transient program, and (f) a binary data tape written by the steady-state RECA to be used as input for the transient RECA program.

The RECGEN program has been modified so that it is compatible with the IBM FORTRAN IV compiler; it has been compiled and executed to reproduce the sample output. This output is being modified to be compatible with the local CINDA preprocessor.

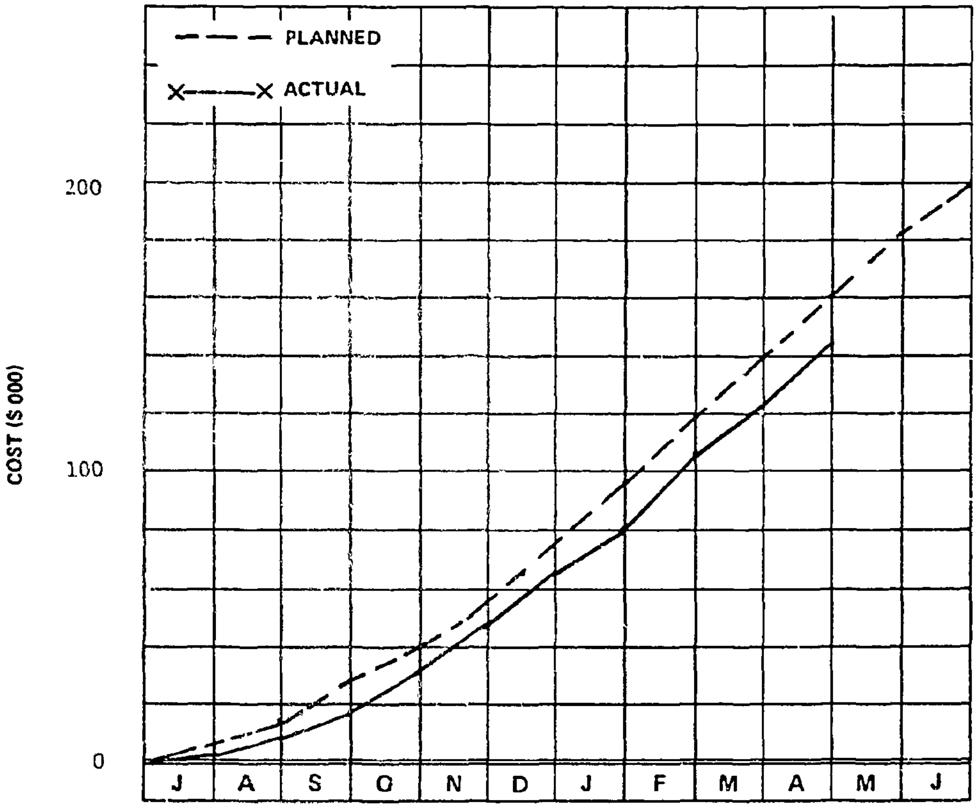
Work has continued on the conversion of the binary tapes. A code to convert the binary bit pattern to produce comparable information for the IBM 360 system has been completed. The only problem area in this conversion routine relates to what is known as the "X array". The GAC binary data tapes contain a mix of floating point numbers and integer numbers in the "X array". Since this array contains only 50 entries, it is easier to prepare an input card set to overlay the integer values on tape than to modify the code to detect the different types of numbers. The two tapes have been converted to a compatible IBM 360 version.

COST/BUDGET REPORT FOR PERIOD Fiscal Year 1975

PROGRAM TITLE. HTGR SAFETY ANALYSIS AND RESEARCH

HNL ACTIVITY. 40 89 03 66 4

189a NO.: 10664



PLANNED ($ 000)

	J	A	S	O	N	D	J	F	M	A	M	J
MONTHLY	5	8	12	14	17	18	22	20	20	22	20	22
CUMULATIVE	5	13	25	39	56	74	96	116	136	158	178	200

ACTUAL ($ 000)

	J	A	S	O	N	D	J	F	M	A	M	J
MONTHLY	1	6	9	13	14	19	18	26	22	17		
CUMULATIVE	1	7	16	29	43	62	80	106	128	145		
VARIANCE	-4	-6	-9	-10	-13	-12		-10	-8	-13		

COMMENTS

The January Cost Reporting Period is from 1/1/75 Through 1/18/75
The February Cost Reporting Period is from 1/18/75 Through 2/28/75

J. P. Sanders
PROGRAM MANAGER

Gordon G. Fee
PROGRAM DIRECTOR

TX 4696
(12 74)