AIM

Association for Information and Image Management

1100 Wayne Avenue, Suite 1100
Silver Spring, Maryland 20910
301/587-8202

Centimeter

Inches

MANUFACTURED TO AIM STANDARDS
BY APPLIED IMAGE, INC.

1 of 1

DECLASSIFIED

DOCUMENT NO.

RL-REA-2156

SERIES AND COPY NO.

DATE
June 1, 1965

GE-AEC BUSINESS RECORD

HANFORD ATOMIC PRODUCTS OPERATION - RICHLAND, WASHINGTON

☒ THIS DOCUMENT CONTAINS RESTRICTED DATA AS
DEFINED IN THE ATOMIC ENERGY ACT OF 1946
AND ITS REGULATIONS, AND DISCLOSURE OF
CONTENTS TO ANY OTHER PERSON WITHOUT
PERMISSION IS PROHIBITED.

TITLE

SEMIANNUAL RESEARCH AND
DEVELOPMENT REPORT
IRRADIATION PROCESSING DEPARTMENT

☐ OTHER OFFICIAL CLASSIFIED INFORMATION
THIS MATERIAL CONTAINS INFORMATION AFFECTING
THE NATIONAL DEFENSE OF THE UNITED STATES
WITHIN THE MEANING OF THE ESPIONAGE LAWS,
TITLE 18, U. S. C., SECS. 793 AND 794, THE TRANS-
MISSION OR REVELATION OF WHICH IN ANY MANNER
TO AN UNAUTHORIZED PERSON IS PROHIBITED BY
LAW.

AUTHOR

T. W. Ambrose

ISSUING FILE
REC-11

THIS DOCUMENT MUST NOT BE LEFT UNATTENDED. WHERE AN UNAUTHORIZED PERSON MAY HAVE ACCESS TO IT, WHEN NOT IN USE, IT MUST BE STORED IN AN APPROVED LOCKED REPOSITORY WITH AN APPROVED GUARDIAN. WHILE IN YOUR POSSESSION AND IN YOUR HOME, DO NOT LEAVE A SINGLE COPIE FROM CLIPPING FILE IN IT. YOUR CONSENT TO THE IT AND IN INTERESTS WITHIN REASONS OF THE IT AND IN FURTHER UNAUTHORIZED PERSON. IT IS PERMITTED TO, AND STORAGE IN YOUR PLACE OF RESIDENCE IS PERMITTED. IT IS NOT TO BE DUPLICATED. ADDITIONAL COPIES ARE REQUIRED TO OBTAIN THEM IN THE RELATED ISSUING FILE. ALL PERSONS RECEIVING THIS DOCUMENT ARE REQUESTED TO SIGN IN THE SPACE PROVIDED BELOW.

[illegible]

MASTER

54-3000-340 (3-57) AEC-GE RICHLAND, WASH

(CLASSIFICATION)

DECLASSIFIED

DECLASSIFIED

RL-REA-2156

This document contains Restricted Data as defined in Executive Order 11652, and its release to unauthorized person is prohibited.

This document consists of 37 pages.

SEMIANNUAL RESEARCH AND DEVELOPMENT REPORT

IRRADIATION PROCESSING DEPARTMENT

T. W. Ambrose
Research and Engineering

June 1, 1965

Classification Cancelled and Changed To

DECLASSIFIED

By Authority of DS Lewis, 4-28-94
CG-NMP-1, 5-17-94 DCH
By DCHanson, 5-17-94
Verified By Jerri Maly, 5-18-94

HANFORD ATOMIC PRODUCTS OPERATION
RICHLAND, WASHINGTON

NOTICE

This report was prepared for use within General Electric Company in the course of work under Atomic Energy Commission Contract AT(45-1) - 1350, and any views or opinions expressed in the report are those of the author only. This report is subject to revision upon collection of additional data.

LEGAL NOTICE

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

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

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

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

DECLASSIFIED

DISTRIBUTION

1.-10. AEC-RL00/Attn: A. T. Gifford

11. F. W. Albaugh - BNW	36. W. W. McIntosh
12. T. W. Ambrose	37. R. W. McMichael
13. H. E. Berg	38. W. N. Mobley
14. W. A. Blanton	39. R. E. Nightingale - BNW
15. J. J. Cadwell - BNW	40. R. Nilson
16. J. R. Carrell	41. L. C. Owen
17. F. G. Dawson - BNW	42. G. F. Owsley
18. D. R. De Halas - BNW	43. R. S. Paul - BNW
19. R. L. Dickeman	44. R. W. Reid
20. R. E. Dunn	45. W. Sale - BNW
21. G. C. Fullmer	46. O. C. Schroeder
22. R. G. Geier	47. J. S. Stoakes
23. S. M. Graves	48. J. T. Stringer
24. A. B. Greninger	49. H. F. Tew
25. H. Harty - BNW	50. R. E. Thomas
26. H. W. Heacock	51. R. E. Tomlinson
27. D. L. Hovorka	52. E. E. Voiland - BNW
28. E. R. Irish - BNW	53. M. T. Walling, Jr. - BNW
29. P. C. Jerman	54. J. H. Warren
30. R. T. Jessen	55. O. J. Wick - BNW
31. W. E. Johnson	56. W. K. Woods
32. L. E. Kusler	57. 700 Files
33. M. C. Leverett	58. Records Center
34. C. G. Lewis	
35. L. M. Loeb	

DECLASSIFIED

SEMIANNUAL RESEARCH AND DEVELOPMENT REPORT

IRRADIATION PROCESSING DEPARTMENT

INTRODUCTION

The 02 Research and Development Program for the Irradiation Processing Department in FY-1965 is contained in eight 189-forms R-1 through R-6 and M-1 and M-2. The subprograms designated by R pertain to reactor research and development, and those designated by M pertain to metallurgy or fuels research and development. This report covers the progress in each of the subprograms on an individual basis for the period November 1, 1964, through April 30, 1965. Although the reports are brief, the results are presented in semitabular form and are essentially complete. A number of items are listed in the reports on the subprograms that have been performed on product cost funds but were made possible by earlier research and development effort. The reports listed under Section VI, "Topical Reports Issued," include only those issued during FY-1965.

Several changes appear in the estimated expenditure pattern for the balance of the fiscal year. These are as follows:

<u>Program</u>	<u>Previous FY Estimate</u>	<u>Current FY Estimate</u>
R-3 Radiation Safety	96,000	76,000
R-5 Clean U-233	477,000	400,000
R-6 Product Development	86,000	239,000

At this time the research and development budget for FY-1966 is not yet firm. However, two tentative changes are anticipated in the Irradiation Processing Department format for FY-1966. The program R-3, Radiation Safety, will be combined with the program R-2, Nuclear Safety. Further, the work carried out on the program R-4, Cost Reduction and Reactor Life, will be funded from process assistance funds.

DECLASSIFIED

Program: 02 Reactor IPD
 Project: 02 50 10 10
 Title: Radioisotope Reduction Reactor Effluent (R-1)
 Responsible Manager: T. W. Ambrose
 Responsible Investigator: R. G. Geier
 Reporting Period: November 1, 1964, through April 30, 1965

	<u>Prior Year</u>	<u>FY to Date</u>	<u>Period</u>	<u>FY Estimate</u>	<u>Previous FY Estimate</u>
Costs (Thousands)	250	145	10 months	185	185
Scientific Manpower (Man-years)	4	2.5	10 months	3	3

I. Project Scope and Objective

The program is designed to develop processes for reducing the amount of radioisotopes present in the coolant leaving the Hanford reactors. Areas of study include finding methods for: (1) removing the parent materials responsible for radioisotope formation from the process water, (2) eliminating or reducing the time of adherence of parent materials to the in-reactor films by changes in the chemical constitution of water, chemical form of parent materials, or changes in the reactor film itself, and (3) treating the effluent to remove the radioisotopes after formation.

II. Major Accomplishments to Date

During the course of the program, several methods have been devised which are each capable of reducing the effluent activity by a factor of about two for the isotopes of most concern. The methods are:

1. Water treatment using high aluminum sulfate feed rates. This process has been in use since July 1961.
2. Water treatment using high aluminum nitrate feed rates with nitric acid for pH adjustment.
3. The addition of sodium silicate to treated water.
4. Passage of the reactor effluent through aluminum beds.

In addition, schemes for effluent disposal by an inland lake and by trenching were conceived.

DECLASSIFIED

III. Progress During Report Period

1. It had been demonstrated that the substitution of nitrate for sulfate in water treatment produced a reduction in effluent activity. To determine whether the substitution of CO₂ for the sulfuric acid used for pH adjustment would produce a similar effect, a single-tube in-reactor test was initiated on October 24, 1965. During the test, the coolant was flocculated with aluminum sulfate which reduced the pH to 7.3. The additional reduction to 6.6 was obtained by added CO₂. A sodium dichromate concentration of 1.0 ppm was maintained. The test completed two metal cycles on April 12, 1965, and has been discontinued temporarily to permit fuel examination for corrosion evaluation. No operating difficulties were observed throughout the test. Preliminary analysis of the effluent data indicate no difference between the P-32 and As-76 concentrations from a tube cooled with CO₂ adjusted coolant and the concentrations from tubes cooled with sulfate adjusted coolant.
2. In order to determine the effect of water plant variables on effluent activity, a half-plant test was initiated at DR Reactor on September 28, 1964, to compare the difference between a filter run time determined by river conditions and one 25 per cent shorter. The actual filter run times were 7 hours on the control side and 5.25 hours on the test side. An alum feed rate of 18 ppm, a sodium dichromate feed rate of 1.0 ppm, and a coolant pH of 6.6 were maintained throughout the test which terminated December 30, 1964. No significant difference was found in the P-32 and As-76 concentration from the two sides of the reactor. It can be concluded that in the range explored, filter run time is not a significant factor in effluent activity.
3. A second half-reactor test to continue the exploration into the effects of water plant operating variables on effluent activity was initiated at H Reactor on November 8, 1964. The control side was operated normally with the settling basins and filters running at pH 7.0 and acid addition to produce coolant having a pH of 6.6 at the filter effluent flume. On the test side, all of the acid to produce pH 6.6 coolant was added to the bauxite conversion box. Throughout the test period, the sodium dichromate feed rate was 1.0 ppm and the alum feed rate was 15 ppm. The concentrations of P-32 and As-76 were 25 and 40 per cent lower, respectively, in the side for the period December 1964 through March 1965.
4. The program of analyzing raw and filtered water from B Area on a five-day-per-week basis for phosphate, sulfate, and iron continued. Some variations, presumably seasonal, have been observed in the raw water analysis; but the filtered water results have remained essentially constant.

DECLASSIFIED

5. Laboratory and single-tube in-reactor tests had indicated that the addition of sodium silicate to process water at a concentration of 20 ppm SiO_2 would reduce the amount of radioactivity in reactor effluent. In order to determine the magnitude of the effluent activity reduction as well as the filming and corrosion effects of using sodium silicate, a half-reactor test was initiated in late January. Preliminary results indicate that reductions in As-76, Np-237, and Cu-51 by factors of two to three are achieved. The reduction in P-32, if any, is appreciably less. Some filming was evident in the fringe tubes.
6. A small-scale trenching experiment was completed. The test showed that large volumes of water can be infiltrated into the soil at F Area. Rates in excess of 1000 gallons per square foot per day were achieved. The decontamination factors for Cu-51 and Zn-65 were 3 and 120, respectively. For total beta, the decontamination factor was 20.
7. A half-reactor continuous purge test was run for about one month. During the test, one-half part diatomaceous earth was added to the reactor coolant. There was no apparent effect on effluent activity, but the purge appeared to cause severe pitting of the fuel element jackets.
8. A half-reactor test was carried out using pH adjusted, dichromated, and filtered but unflocculated coolant to one side. The P-32 concentrations on the test side were a factor of four to five higher. The concentration of As-76 on the test side also increased but not to the extent of the P-32 increase.
9. A half-reactor validity test was carried out using sodium bromide addition to one side. Monitoring the Br-82 concentration in the effluent from both sides showed about a seven per cent crossover of coolant.

IV. Evaluation of Effort to Date

The program has devised several methods for reducing effluent activity. However, each of the methods is expensive and particularly so when considered in light of the benefits which might be obtained. Continued work at approximately the same level of effort will be directed toward conceiving new and more economical processes, resulting in effluent activity reductions as well as improvements through optimization of the present process and its control.

DECLASSIFIED

V. Next Report Period Activities

1. The evaluation of sodium silicate addition will be completed.
2. Additional testing of water plant variables will be carried out with particular attention to the point of addition of the sulfuric acid for pH adjustment.
3. The effect of adding activated silica downstream of the filters will be evaluated.
4. The effect of using lithium silicate coated as well as Zircaloy fuel elements will be investigated.
5. Studies using deionized water and chemical additions will be reinitiated.
6. Tests using super-filtered water will be carried out.
7. The role of filtration in parent isotope removal will be explored.
8. A half-plant test to determine the effluent activity effects of reducing the sodium dichromate from 1.0 to 0.5 ppm will be initiated.

VI. Topical Reports Issued

1. HW-81412, "The Effect of Deionized Water on Reactor Effluent Activity - Part I: New Tubes and Fuel Charges," W. B. Silker and C. W. Thomas, September 1964.
2. HW-81413, "The Effect of Deionized Water on Reactor Effluent Activity - Part II: Zirconium and Aluminum Clad Fuel," W. B. Silker and C. W. Thomas, October 24, 1964.
3. "Mechanical Defilming Test," R. G. Geier and E. A. Wegener, September 10, 1964. (Confidential-Undocumented)
4. HW-84182, "The Effect of Coolant pH on Phosphorus-32 Concentration in Small Reactor Effluent," R. G. Geier, September 22, 1964.
5. RL-REA-50, "Production Test IP-728, Half-Plant Sodium Silicate Test," R. G. Geier, October 26, 1964.
6. RL-REA-249, "Production Test IP-738, Continuous Purge for 105-C," R. W. Pitman and D. K. Clem, December 4, 1964.
7. RL-REA-272, "Production Test IP-740, Phosphate Capture Subsequent to Filtering," R. W. Pitman, December 9, 1964.

DECLASSIFIED

8. RL-REA-532, "Production Test IP-750, Raw Water as a Reactor Coolant," R. W. Pitman, January 22, 1965.
9. RL-REA-687, "Final Report: Production Test IP-719, The Effect of Water Plant Variables on Reactor Effluent Activity," R. G. Geier, February 23, 1965.
10. RL-REA-922, "Preliminary Investigation of Water Coagulation Characteristics as Affects Reactor Effluent Radionuclides," J. W. Frymier, April 5, 1965.

DECLASSIFIED

Program: 02 Reactor IPD
Project: 02 50 10 10
Title: Nuclear Safety (R-2)
Responsible Manager: T. W. Ambrose
Responsible Investigator: R. Nilson
Reporting Period: November 1, 1964, through April 30, 1965

	<u>Prior Year</u>	<u>FY to Date</u>	<u>Period</u>	<u>FY Estimate</u>	<u>Previous FY Estimate</u>
Costs (Thousands)	187	128	10 months	167	167
Scientific Manpower (Man-years)	5	3	10 months	4	4

I. Project Scope and Objective

The effort comprises a continuing nuclear safety program which has the prime objective of upgrading the safety status of the reactors and/or providing development as necessary to assure that deterioration of reactor components and proposed operating techniques and conditions do not reduce the safety of the reactors. The program consists of studies in both physics and engineering fields.

II. Major Accomplishments to Date

1. Computer codes have been acquired or developed, codes have been grouped into chains, and codes have been modified to provide a useful and highly efficient library of codes applicable to nuclear safety studies.
2. Theoretical work of significance has been accomplished in the field of scattering kernels, multigroup diffusion theory, exponential pile data reduction, reactor kinetics, reduced delayed neutron constants, control rod calculations, fission product buildup, and physics engineering aspects of reactor design. Significant completed studies involved scattering law calculations by exact treatment of two resonances and modified gas model studies for graphite-uranium and graphite-plutonium systems.
3. Basic kinetic investigations have been used to quantitatively establish operating parameters for the automatic instrument package currently under development which will cover all levels of operation.

DECLASSIFIED

4. A comprehensive review and evaluation of safety control criteria and requirements have been initiated to evaluate safety system serviceability in view of moderator distortion. The physics work will serve as a bases for establishing firm control requirements and for determining adequacy of various alternative courses of action.
5. Comprehensive exponential pile measurements of the multiplicative properties of enriched uranium-water lattices have provided basic critical mass data of importance to safe fuel storage.
6. Comprehensive theoretical and experimental work has been carried out over a number of years to enable evaluation of the consequences of the loss of coolant accident in the Hanford reactors. The work has included void coefficient measurements in many lattice arrangements, boilout measurements, safety system response determinations, analog and digital computer analyses, and establishment of basic control criteria.
7. Hazards Summary Reports for the production reactors have been prepared.
8. Measurements were made on the control worth of splines and how the worth varied with boron depletion and spline corrosion. These measurements have enabled more economic use of splines.
9. A comprehensive analytical review of instrumentation protection has been completed which, for the first time, establishes quantitatively and realistically technical bases for upgraded reactor instrumentation systems.
10. A fundamental laboratory program of cross section measurements has been partially supported over the past years. Knowledge of cross sections of important reactor materials is fundamental to reactor safety.
11. Unstable boiling and burnout conditions for Hanford process tubes under a large variety of possible operating situations have been identified. Most recent studies have been directed toward characterizing the behavior of self-supported fuel element designs.
12. The behavior of the fuel columns during flow-loss and power-surge accidents, including experimental investigations of front connector failures, loss of pumping capability, and sudden plugging of the process tube system, have been established.
13. The effect of fuel eccentricity on the burnout heat flux has been determined.

DECLASSIFIED

14. The effect of local disturbances in the coolant flow passage, such as self-supports or bumpers on the fuel surface, on the conditions resulting in local boiling in the fuel column have been evaluated.
15. The effect to improve the understanding of and compensate for moderator contraction has resulted in the following achievements:
 - a. Efficient channel broaching techniques have been developed.
 - b. Projections of future stack distortion have been obtained from experimental irradiations.
 - c. A probe was developed which provides accurate measurement of channel dimensions and distortion.
 - d. A flexible safety rod which can follow channel curvature has been developed.
16. A prototypical in-core flux monitor has been installed on-reactor.

III. Progress During Report Period

1. A Hazards Summary Report was issued for the Hanford Test Reactor.
2. Experimental determinations were made of the effect of poison burnout and corrosion on spline worths. The results of the measurements permit the use of splines for a longer period of time.
3. Vibration measurements at several plant locations were made during various blasting operations on site as a part of a basic program to characterize the seismic properties of the Hanford reservation.
4. The reactivity effects of coolant voiding in supercell lattices of different loading patterns were measured at H Reactor following shutdown.
5. Theoretical safety studies continued in the following fields:
 - (1) evaluation of control requirements and adequacy of alternate control systems,
 - (2) evaluation of meeting control criteria for new lattices,
 - (3) nuclear computer code development,
 - (4) critical mass, and
 - (5) instrumentation.
6. Development work continued in the area strap-on temperature detectors, immersion temperature detectors, and thermocouples, with the goal of providing a device with a ten-year life. It was found that various coatings and platings were not as satisfactory as the standard uncoated Monel.

DECLASSIFIED

7. A tester based on gamma activity measurements to prevent the premature shipment of irradiated fuel was developed.
8. The development of basic instrumentation for intermediate range flux monitoring was completed.
9. Thermal hydraulic studies were directed toward determining unstable boiling and fuel burnout conditions for self-supported fuel elements in smooth-bore process tubes at specific power levels 50 per cent above current operating conditions.
10. The behavior of alternate fuel supports and rear process tube hardware was investigated.
11. The over-all program to study graphite contraction and control system operability has led to the conclusion that present controls can be kept operating satisfactorily and safely for the next ten years. Both flexible control rods and a method to minimize the effect of a Ball 3X system drop are required.

IV. Evaluation of Effort

The research and development effort in support of reactor safety has always been considered of primary importance, and a continuous program has been in progress. The fact that the Hanford reactors are operating at many times their design basis without nuclear incident is conclusive proof of the value of the program. An analysis of the safety of new reactor loadings and the safety impact of changes due to reactor aging or operating modifications can be made efficiently and satisfactorily. In order to insure maintaining these capabilities, a similar level of effort is anticipated for FY-1966.

V. Next Report Period Activities

1. Both experimental and theoretical physics studies in the area of nuclear safety will emphasize those problems pertinent to new lattices. Theoretical work will be continued to improve existing reactor kinetics codes. Planned improvements include the extension of the calculational model into two phase flow conditions.
2. Renovation of rupture monitoring instrumentation will be initiated to permit earlier detection and more precise location of ruptured fuel elements.
3. The thermal hydraulic studies carried out in FY-1965 at steady state will be extended to include an experimental investigation of coolant flow, coolant pressure, and fuel temperature transients following simulated flow reduction accidents at the higher tube powers visualized for fuel target, loadings. Also included in the studies will be the effect of fuel-tube eccentricity on the course of the transients.

DECLASSIFIED

VI. Technical Reports Issued

1. HW-83152, "Ball Drop Implications at K Reactor, Operational Physics Analysis," A. D. Vaughn, June 30, 1964.
2. HW-81660, "An Evaluation of the Experimental Determination of the Effects of Burnout and Corrosion on Spline Worth," W. A. Blyckert, July 13, 1964.
3. "Boilout of Process Tubes with Thoria Fuel Elements," G. M. Hesbon, July 30, 1964. (Undocumented)
4. HW-83939, "Effects of Horizontal Control Rods in Total Control Compensation," A. D. Vaughn, September 4, 1964.
5. HW-83870, "Hydraulic Supply and Demand Characteristics of Thorium Target Elements in B, C, D, and K Process Tubes," C. W. Angle, September 15, 1965.
6. RL-REA-58, "Neutron Kinetics Constants in the Hanford IPD Reactors for a Standard Weapons-Grade Fuel Load and Enriched-Thoria Load," J. P. Hamric, October 27, 1964.
7. HW-84477, "Hydraulic Characteristics of Arch-Rail KVE and KVN Fuel Elements in the K Zircaloy Process Tube," C. W. Angle, October 30, 1964.
8. RL-REA-183, "Universal Vertical Safety Rod Reactivity Evaluation," W. A. Blyckert, November 18, 1964.
9. RL-REA-252, "A Comparison of Speed-of-Control Requirements for an E-Q and a Natural Uranium Load in the Hanford IPD Reactors," J. P. Hamric, December 7, 1964.
10. HW-75010, "Power Backup Requirements for Reactor Instrumentation," B. R. Cremer, R. Nilson, W. A. Blyckert, and S. M. Graves, December 14, 1964.
11. "Safety Analysis of the C-1 Loop," P. A. Carlson and T. L. Deobald, December 31, 1964.
12. RL-REA-229, "Ball Drop Implications at C Reactor - Operational Physics Analysis," A. D. Vaughn, February 1, 1965.
13. RL-REA-609, "Speed-of-Control Power Limits in Hanford IPD Reactors - Urania Fuel," J. P. Hamric and J. H. Scott, February 4, 1965.
14. BNCC-8, "Hydraulic Characteristics of CVIAN I&E Fuel in C Overbore Process Tube," C. W. Angle, February 5, 1965.

DECLASSIFIED

15. RL-REA-930, "Kinetics Characteristics of the Ball 3X System at B, C, and D Reactors," J. P. Hamric and J. H. Scott, February 10, 1965.
16. RL-REA-931, "ZTM Grid Study - Small Hanford IPD Reactors," J. P. Hamric, March 5, 1965.
17. RL-REA-929, "Enriched-Depleted Uranium Physics Calculations for the IPD Reactors," J. P. Hamric, R. A. Dieterich, and R. E. Tiller, March 29, 1965.
18. RL-REA-1022, "Interim Report II, RTD Corrosion Studies," D. B. Lovett, April 8, 1965.

DECLASSIFIED

Program: 02 Reactor IPD
Project: 02 50 10 10
Title: Personnel Radiation Exposure Reduction (R-3)
Responsible Manager: T. W. Ambrose
Responsible Investigator: P. C. Jerman
Reporting Period: November 1, 1964, through April 30, 1965

	<u>Prior Year</u>	<u>FY to Date</u>	<u>Period</u>	<u>FY Estimate</u>	<u>Previous FY Estimate</u>
Costs (Thousands)	60	44	10 months	76	96
Scientific Manpower (Man-years)	2	1	10 months	2	2

I. Project Scope and Objective

The program comprises a broad spectrum of studies directed toward minimizing the exposure of personnel to radiation. It includes reducing high dose rate conditions, minimizing the number of personnel required at the job site, warning personnel when appreciable dose rates are encountered, and minimizing contamination spread.

II. Major Accomplishments to Date

1. In the area of reactor decontamination, much progress has been made. Decontaminating agents have been developed which are compatible from the standpoint of corrosion with the various reactor components. The use of decontaminating techniques has markedly reduced exposure during maintenance activity.
2. In the area of fixed radiation monitoring instrumentation, a log picoammeter was developed which appears to far surpass anything in the line of area radiation monitoring equipment produced to date. Prototypes have been produced by several vendors.
3. Progress has been made in the development of pocket sized alarm devices to warn personnel that a certain level of radiation dose rate or dose has been exceeded.
4. A dose rate telemetering system has been developed to a good state of refinement. The unit has the capability of integrating dose rate information to dose. Specifications to permit off-site procurement of a prototype have been completed.

DECLASSIFIED

III. Progress During Report Period

1. Techniques were devised for the decontamination of the reactor and reactor building prior to placing them in standby or abandoned status. The techniques were applied during the cleanup of the DR facility with a high degree of success.
2. Fifty pocket size dose alarm devices of a Hanford modified Chalk River design were received.
3. Studies directed toward the exposure problems that would be encountered in the U-233 program were continued.
4. A calorimeter was designed and fabricated to measure the heat generation rate from an irradiated fuel element freshly discharged from a reactor. The calorimeter also incorporated radiation measurement chambers so that dose rate measurements can be obtained at the same time.
5. A contract was awarded to Tracerlab, Inc., for the fabrication of a six channel dose rate telemetering system which will integrate dose rate information to dose.

IV. Evaluation of Effort to Date

The success of the program to date is evidenced by the following:

1. The decontamination of reactors has reduced the dose rates received by personnel working in the discharge area during outages by up to a factor of four.
2. Completely satisfactory equipment has been made available for replacing outmoded and worn out fixed radiation monitoring equipment at all the reactors.
3. Three satisfactory instruments have been developed for warning personnel of high dose and dose rate conditions. The use of these instruments, plus the radiation alarm systems scheduled for installation, should go a long way in alleviating the need for radiation monitor coverage to monitor changing dose rate conditions for radiation work performed by operating and maintenance personnel.

V. Next Report Period Activities

1. Development work associated with reactor decontamination will continue but will be directed toward those areas requiring special application.

DECLASSIFIED

2. Technical guidance will be supplied to engineering groups so that features which minimize personnel exposure will be incorporated in the development of tools and equipment for high exposure application.
3. The current concepts for pocket size dose and dose rate alarms will be available for field testing early in FY-1966.
4. The thoria irradiation program will be monitored closely to determine its effect on personnel.
5. Testing will be carried out to determine the feasibility of employing condensation nuclei counters for in-line measurement of the efficiency of the confinement system for retaining particulates and halogens.

VI. Topical Reports Issued

1. I&EDO Memo 64-08, "Dose Rate Preset Alarm Development," P. J. Horvath, July 27, 1964.
2. HW-84269, "Reactor Plant Deactivation, Decontamination Guide," H. C. Copeland, September 25, 1964.
3. HW-56001 J, "Interim Report No. 11, Chemical Decontamination Activities 105 Reactors - During the Period October 1963 through October 1964," H. F. Jensen, November 5, 1964.
4. HW-79084, "Production Test IP-622-A, Radiological and Physics Investigation of Fuel Discharged from an Operating Reactor," K. L. Hladek and S. M. Graves, July 8, 1964.

DECLASSIFIED

Program: 02 Reactor IPD
Project: 02 50 10 10
Title: Cost Reduction and Reactor Life (R-4)
Responsible Manager: T. W. Ambrose
Responsible Investigator: R. Nilson
Reporting Period: November 1, 1964, through April 30, 1965

	<u>Prior Year</u>	<u>FY to Date</u>	<u>Period</u>	<u>FY Estimate</u>	<u>Previous FY Estimate</u>
Costs (Thousands)	420	230	10 months	275	275
Scientific Manpower (Man-years)	10	5	10 months	6	6

I. Project Scope and Objective

A base level of research, development, and testing is maintained for the production reactors for the purposes of reducing the cost of operation and assuring that reactor and component deterioration is minimized as necessary to maintain reactor life. Detailed examination is made of the factors which affect reactor life, and a course of corrective action is recommended, based on technical and engineering facts as they can best be determined. Included are basic engineering and physics studies providing a broad base of reactor knowledge necessary for operational improvements consistent with nuclear safety requirements and for seeking solutions to phenomena threatening reactor life.

II. Major Accomplishments to Date

1. Smooth-bore Zircaloy tubes were developed for use in the Hanford reactors. The development program resolved the following problems:
 - a. The establishment of a commercial source of satisfactory tubes.
 - b. The determination of the hydraulic characteristics of smooth-bore tubes charged with self-supported fuel elements.
 - c. The evaluation of the corrosion and irradiation characteristics of Zircaloy tubes under irradiation conditions.
 - d. The techniques required for tube installation which would minimize graphite damage and tube distortion.

DECLASSIFIED

2. Graphite oxidation due to oxygen from air in-leakage into the reactor gas atmosphere has been substantially reduced through improvements in gas system instrumentation and operation.
3. Basic lattice physics measurements over a wide range of fuel-to-moderator ratios have been carried out. The studies have well characterized the cold lattice physics parameters of Hanford type reactors, have enabled the construction of physics models, and have led to better understanding of the neutronic processes.
4. Basic theoretical physics investigations, both with regard to neutron reactions and with regard to models and calculational aids, have led to efficient, useful computer codes. The codes have been extremely useful in the rapid evaluation of complex reactor problems so that the effects of proposed programs can be fully evaluated prior to actual reactor demonstrations.
5. A xenon override technique was developed and successfully tested on-reactor.
6. A broad, basic assessment of the modern role of the Ball 3X system in reactor safety has been carried out. A new philosophy, which recognizes reactor safety improvements, which realistically assesses certain accident probabilities, and which takes into consideration the present condition of the reactor stacks, has been established. Implementation of this philosophy through proposed circuit changes is believed to be capable of significantly reducing the potential of an inadvertent, and perhaps serious, ball drop.
7. Corrosion studies have broadened the understanding of the effects of coolant composition on aluminum corrosion. Increased process tube life at a coolant pH of 6.6 and the adequacy of reduced inhibitor concentration have been demonstrated on a full reactor basis.

III. Progress During Report Period

1. An order has been placed for three full length ribbed Zircaloy tubes. The material has been supplied, and the tubes are currently being fabricated. Delivery is expected in July 1965.
2. The Zircaloy tubes in the K Reactors have shown evidence of hydriding. Six tubes have been removed to date and all show evidence of hydride formation in the region downstream of the fuel charge. The hydriding appears to progress in intensity linearly from the end of the fuel charge to the downstream end of the tube. A program has been initiated to define the extent of the problem, the rate of progression, the mechanism of the hydride formation, means of eliminating the formation, and methods of reconditioning the tubes if this is found to be necessary.

DECLASSIFIED

3. Ceramic balls containing samarium and gadolinium have been obtained as candidates for use in the Ball 3X system. The balls were tested in the Hanford Test Reactor and found to be adequately black for present operating conditions. Carbon balls have also been ordered for evaluation as alternates to the present boron containing steel balls.
4. In-reactor testing of the graphite-CO₂ reaction is in progress. The tests will be completed by the end of the fiscal year.
5. The laboratory studies of the water-graphite reaction have been delayed due to equipment procurement difficulties. The work will get under way in June.
6. The fabrication of graphite coring equipment is complete. An evaluation of their capability will be undertaken at F Reactor after shutdown.
7. The feasibility of operating with graphite temperatures in the neighborhood of 1000 F is being investigated. The major problem areas appear to be the effect on distortion and the graphite-water reaction.
8. The effort to apply Monte Carlo techniques to the solution of complex reactor physics problems continued.
9. Electrical resistance probes used to monitor in-reactor corrosion continued to supply useful data.
10. Testing was initiated to determine the corrosion effects of adding sodium silicate (20 ppm as SiO₂) to process coolant.
11. The single-tube tests to evaluate the use of CO₂ for coolant pH adjustment completed two metal cycles. The corrosion data are now being obtained.
12. During a half-reactor continuous purge test (0.5 ppm diatomaceous earth), it was observed that fuel from the test side of the reactor exhibited groove corrosion to the extent of 25 per cent while there was none on the test side. If the groove corrosion is caused by the purge, it is the first time that this phenomenon has been produced in-reactor in a controllable fashion.
13. Corrosion evaluations are under way to determine the effect of using pH adjusted, dichromated but unflocculated coolant.
14. Testing is continuing to determine the applicability of nitrite, nitrate, and silicate compounds as alternates for sodium dichromate inhibitor.

DECLASSIFIED

15. Ex-reactor testing was started to determine the applicability of materials, such as polyacrylamides, potentially useful for reducing friction in flowing systems.

IV. Evaluation of Effort to Date

The studies ascribed to this program have for many years been part of reactor research and development. The effort has been eminently successful in providing the technology required to reduce costs, increase productivity and extend the useful life of the Hanford reactors. Examples of more recent achievements include:

1. The installation of 5000 Zircaloy tubes in the K Reactor was completed on schedule for 70 per cent of the originally estimated cost.
2. Corrosion studies resulted in defining the conditions which would markedly increase process tube life.
3. The lattice physics effort in providing improved understanding of reactor neutronics has provided a means of rapidly determining the effects of changes proposed for cost reductions or increased life.

Although the FY-1966 budget is not firm at this time, it is tentatively planned that the activities carried out under this program will be funded from Process Assistance funds. Thus, the work will no longer be covered in this report.

V. Topical Reports Issued

1. HW-83201, "Stress Corrosion of Stainless Steel RTD Models," R. B. Richman and R. D. Henry, July 1964.
2. RL-REA-14, "Increased Graphite Temperature Limit - F Reactor," A. Russell, October 19, 1964.
3. HW-80343, "Continuous Corrosion Measurement in a Nuclear Reactor," R. B. Richman, November 1964.
4. HW-80555, "Static Tests of Corrosion Inhibitors for Aluminum and Carbon Steel," R. B. Richman, November 1964.
5. HW-84500, "Aluminum and Steel Corrosion in Low pH water at D Reactor," R. B. Richman and V. F. Fitzpatrick, November 1964.

DECLASSIFIED

-
6. RL-REA-2038, "Program for Investigation of Zircaloy-2 Hydriding," S. M. Graves and W. K. Alexander, May 5, 1965.
 7. HW-84455, "Corrosion of Copper and Nickel Alloys in Ethylene Glycol Mixtures," R. B. Richman and A. P. Larrick, October 1964.
 8. BNWL-9, "Aluminum and Steel Corrosion in Low pH Water at D Reactor," V. F. Fitzpatrick and R. B. Richman, January 1965.
 9. "Continuous On-Reactor Measurement of Instantaneous Corrosion Rates," Trans. Am. Nuclear Soc., Vol. 7, No. 2, p. 439, November 1964.
 10. HW-83708, "Production Test IP-715, Zircaloy Process Tube Monitoring," W. K. Alexander, August 18, 1964.
 11. RL-REA-14, "Production Test IP-725, Increased Graphite Temperature Limit - F Reactor," A. Russell, December 1, 1964.
 12. RL-REA-14 SUP A, "Production Test IP-725, Supplement A, Increased Graphite Temperature Limit - F Reactor," A. Russell, March 19, 1965.
-

Program: 02 Reactor IPD
 Project: 02 50 10 10
 Title: Production of Clean U-233 (R-5)
 Responsible Manager: T. W. Ambrose
 Responsible Investigator: W. K. Woods
 Reporting Period: November 1, 1964, through April 30, 1965

	<u>Prior Year</u>	<u>FY to Date</u>	<u>Period</u>	<u>FY Estimate</u>	<u>Previous FY Estimate</u>
Costs (Thousands)	282	342	10 months	400	477
Scientific Manpower (Man-years)	6	4.5	10 months	5	6

I. Project Scope and Objective

The program is designed to develop and demonstrate the technology required to optimize a process for the large-scale production of uranium-233 containing low amounts of uranium-232 contaminant. It includes studies to define low cost methods of fabricating thorium target elements for irradiation, intensive investigation of the reactor physics and the reactor engineering related to thorium loadings in Hanford reactors and the chemical and isotopic analyses of irradiated specimens.

The research and development required to define a thorium dissolution process, a chemical reprocessing scheme, and the conversion of uranyl-233 nitrate and thorium nitrate to other forms is covered in a separate program (Project 02-50-10-15-1, Subprogram 12, "Separations - Innovation and New Business").

II. Major Accomplishments to Date

1. The rate of formation of U-232 and U-233 in the core of a small Hanford reactor has been established by small-scale irradiations, and the feasibility of producing U-233 containing only 1 ppm of U-232 has been demonstrated.
2. The ratios of enriched uranium fuel to thorium targets required to provide proper reactivity balance were demonstrated in three different reactor locations on a scale involving several dozen tubes.
3. The effect on U-232 production by thorium-230 contamination of thorium-232 has been established. Photon-neutron effects contributing to U-232 formation were observed and evaluated.
4. Thorium specifications were developed, and an economical method of fabricating target elements was developed.

DECLASSIFIED

5. The irradiation and chemical processing of six tons of thorium was completed, and the results confirmed the predicted rate of U-233 and U-232 buildup.

III. Progress During Report Period

1. It was demonstrated that thorium densities in target elements ranging from 70 to 75 per cent of the theoretical maximum could be achieved using low frequency vibration. Sizing and blending of "sol-gel" densified thorium samples to obtain discrete particle size fractions have yielded target element densities up to 82 per cent of the theoretical maximum. Limited data indicate that pressing or a combination of pressing and vibration compaction offers a means of achieving densities of 85 per cent or higher. Laboratory equipment for further investigation has been procured.
2. Some target element failures have occurred due to weld defects. It was observed that under certain conditions the thorium reacts with water causing swelling of the target. Inasmuch as the swelling causes operational problems, programs, both to improve weld closure and provide specifications for nonreactive oxide, have been initiated. Inasmuch as firing temperatures, firing time, etc. can affect the dissolution rate of the thorium, the latter program is closely integrated with the Chemical Processing Department dissolution studies program.
3. The analysis of samples from the six tons of thorium permitted refinement of the physics calculations for the initial loadings for the production of the 140 kg of U-233. Criticality predictions and temperature coefficient predictions matched very well with the actual operating experience.
4. Chemical processing of the material from the six-ton thorium irradiation was completed, and the results confirmed the rate of U-233 and U-232 buildup.
5. The reactor loadings required for the production of 140 kg of U-233 were essentially completed, and the irradiation will be completed shortly after the end of the fiscal year.

IV. Evaluation of Effort to Date

A complete evaluation of the program must await the results of the 100 kg production effort which will not be available until FY-1966. However, initial results indicate that the effort has been quite effective as evidenced by the present ability to fabricate target elements on a production scale and analytical results which confirm that U-233 containing small quantities of U-232 can be produced in Hanford reactors.

REF ASSIFIED

V. Next Report Period Activities

1. The technical basis for firm thorium product and process specifications will be established. Ex-reactor and in-reactor testing will be continued to determine the influence of thorium properties on target element density, the reaction with water, and chemical dissolution rates.
2. Alternate target element end closure welding and testing techniques will continue to be investigated.
3. In view of the fact that minimum cost U-233, regardless of U-232 contamination may be desired, studies will be initiated to determine the irradiation effects in thorium elements subjected to higher accumulated exposures than have yet been encountered.
4. Physics studies aimed at optimizing U-233 production by alteration of loading pattern and/or utilization of fuels of higher enrichment.

VI. Topical Reports Issued

1. HW-82789, "Production Test IP-695-AC, Thorium Oxide Irradiation - K Reactors," P. D. Gross, et al., July 7, 1964.
2. HW-83411, "Preliminary Hazards Evaluation for Enriched Uranium-Thorium (E-Q) Loading - Hanford IPD Reactors," R. Nilson, et al., July 23, 1964.
3. HW-83503-RD, "Irradiation of Thorium Elements GEH-4-102 to 106," (Irradiations at MTR) L. A. Pember, July 31, 1964.
4. HW-82076, "Irradiation Summary Report, Production Test IP-627-A, Irradiation of Thorium Oxide Elements," J. L. Manuel and K. L. Hladek, August 31, 1964.
5. HW-74094 SUP1, "Hazards Summary Report, Supplement 1, Slightly Enriched Uranium-Thorium Loading, Six Small Hanford Production Reactors," Staff of Irradiation Processing Department, September 1, 1964.
6. HW-83949, "U-233 Production Schedule Proposal," P. D. Gross and K. L. Hladek, September 4, 1964.
7. HW-83559 REV1, "Provisional Product Specifications for Thorium Oxide Target Elements," F. E. Panisko, et al., September 8, 1964.
8. HW-84021, "PITA-31, Fringe-Blanket Irradiation of Thorium Oxide," P. D. Gross and K. L. Hladek, September 11, 1964.
9. Supplement 1 on October 23, 1964.

DECLASSIFIED

10. Supplement 2 on November 23, 1964.
11. Supplement 3 on December 18, 1964.
12. Supplement 4 on December 23, 1964.
13. Supplement 5 on January 21, 1965.
14. HW-74095 SUP1, "Hazards Summary Report, Supplement 1, Slightly Enriched Uranium-Thoria Loading, Hanford K Production Reactors," R. Nilson, et al., September 15, 1964.
15. HW-84271, "U-233 Reactor Costs for 60% and 90% Density Thoria," L. E. Kusler, September 28, 1964.
16. RL-GEN-3, "Cost Estimates - U-233 Production Study Cases," W. E. Johnson, October 16, 1964.
17. RL-REA-64, "PITA-33, Central Zone Irradiation of Thorium Oxide," P. D. Gross and K. L. Hladek, November 2, 1964.
18. Supplement 1 on January 8, 1965.
19. RL-REA-171, "Production Test IP-733, HAP0-322, Thoria Irradiation in Test Hole 3674, KW Reactor," P. J. Zimmerman, November 20, 1964.
20. RL-REA-321, "U-233 Production Schedule - Proposal II," P. D. Gross and K. L. Hladek, December 22, 1964.
21. RL-REA-488, "PITA IP-34, Central Zone Irradiation of Thorium Oxide, Smaller Reactors," P. D. Gross and K. L. Hladek, January 20, 1965.
22. RL-REA-518, "PITA IP-35, Central Zone Irradiation of Thorium Oxide, K Reactors," P. D. Gross and K. L. Hladek, January 25, 1965.
23. RL-REA-788, "Th-228 Contamination in Irradiated Thoria," W. K. Woods, March 8, 1965.

DECLASSIFIED

Program: 02 Reactor IPD
Project: 02 50 10 10
Title: Product Development Studies (R-6)
Responsible Manager: T. W. Ambrose
Responsible Investigator: R. Nilson
Reporting Period: November 1, 1964, through April 30, 1965

	<u>Prior Year</u>	<u>FY to Date</u>	<u>Period</u>	<u>FY Estimate</u>	<u>Previous FY Estimate</u>
Cost (Thousands)	36	175	10 months	239	86
Scientific Manpower (Man-years)	2	4.5	10 months	6	3

I. Project Scope and Objective

The objectives of this program are to develop the technology for efficient production of specific isotopes, particularly exploiting the unique advantages of the IPD production reactors, and to develop the technological basis for producing a wide variety of products. Irradiation techniques receiving consideration are different fuels -- higher enriched metallic uranium, enriched uranium-aluminum alloys, and plutonium-aluminum alloys; the production of plutonium of high Pu-240 content from irradiation of depleted uranium; the creation of a high flux zone in a reactor for materials testing and rapid product formation; and the use of test hole facilities for special irradiations.

II. Major Accomplishments to Date

1. Fundamental studies of Np-237 production in the Hanford reactors have led to quantitative understanding of the formation rates of this isotope in nonrecycle fuel. Similar studies of Np-237 production in recycle fuel while not yet yielding the same degree of understanding have established the advantages of recycle.
2. Preliminary calculations have provided some encouraging information concerning the safety aspects of using plutonium fuels in the Hanford production reactor lattices.
3. Results of irradiations of uranium depleted to 0.2 per cent U-235 performed in 1958 established the correctness of calculations which stated that such irradiations could produce plutonium high in Pu-240.
4. Emphasis on diversification has been responsible for many studies on production of isotopes. Important among those isotope studies

DECLASSIFIED

are Co-60, Po-210, Tm-170, Cm-242, Cm-244, Am-241, and U-233. The studies, which are continuing, have been instrumental in critically assessing the flexibility of the IPD reactors and have led to new irradiation techniques of significant importance.

5. An optimum E-N lattice has been developed through successive E-N irradiations in H Reactor. This loading, which produces tritium and plutonium, has proved to be safe and significantly more productive than a normal plutonium producing loading (at least 11 per cent).
6. A comprehensive study on the physics of an overbore lattice has been carried out. Nuclear safety advantages and improved product yields (including Np-237) have been identified and demonstrated in experimental tests. Laboratory measurements verified that, at 500 mils overbore, the lattice is fail-safe on coolant loss. In-reactor conversion ratio tests verified expected gain in plutonium conversion, Np-237 production, and higher isotope yields.

III. Progress During Report Period

1. The irradiation of 22 tons of depleted uranium for the demonstration of a process to produce plutonium containing between 18 and 25 per cent Pu-240 is scheduled to be completed by the end of FY-1965.
2. The development of an adequate model for evaluating the basic physics parameters for utilizing plutonium fuels in the IPD reactors proceeded to the point that experimental data are required to confirm the adequacy of the model. Physical Constants Test Reactor testing has been scheduled to determine the wet and dry reactivities of various plutonium-aluminum alloys.
3. Studies have continued on the production of Po-210. Twelve, 500 mil overbore bismuth target elements have been fabricated and are being irradiated to firm up cross-section estimates.
4. Samples of process tubing containing an envelope of cobalt as a possible means of Co-60 production have been fabricated and ex-reactor testing to determine the adequacy of its mechanical properties is underway.
5. A detailed study defining Hanford's capability to produce Pu-238 was completed.
6. Preliminary calculations leading to the design of a uranium oxide fuel element were completed. The fabrication of pilot quantities of fuel for test irradiations has been scheduled.

DECLASSIFIED

IV. Evaluation of Effort to Date

The program has been successful in establishing incentives in many areas of diversification. Three programs -- the tritium producing E-N load, the overbore facility, and Np-237 production are quantitatively understood. Others are in various stages of development. Substantial work to define both the physics, engineering, and economic parameters of the new processes is anticipated in future years.

V. Next Report Period Activities

1. Completion of the 22-ton test irradiation of depleted uranium will permit an evaluation of the irradiation behavior and the operating characteristics of the load. Analytical results will permit a safety and economic assessment of large-scale depleted uranium loadings.
2. A feasibility study of burning U-235 to U-236 will be made.
3. PCTR tests to define the wet and dry reactivity, the fuel temperature coefficients, and the reactivity effect of fuel melting when using plutonium fuel in IPD reactors will be completed. Preliminary hydraulic and heat transfer studies will be performed to establish acceptable plutonium fuel geometries. The irradiation of 12 plutonium fuel elements will be initiated.
4. Experimental verification will be obtained for the void coefficients and control rod worths for uranium oxide lattices. The fabrication of fuel elements for a two tube test irradiation will be completed and the irradiation will be initiated.
5. A test irradiation of 1.25 per cent enriched uranium having current fuel geometry will be initiated to permit engineering and physics evaluations.
6. The economic, engineering, and physics parameters associated with the production of other isotopes will continue to be investigated.

VI. Topical Reports Issued

1. HW-84308, "Operating Physics Aspects of E-N Loading," E. L. Conner and A. DePino, July 1, 1964.
2. "Neptunium Production Forecasts - IPD - 1964-1973," R. Nilson, July 10, 1964.
3. HW-83150 RD, "Cost of a mk-Year," G. F. Owsley, July 2, 1964.

DECLASSIFIED

4. HW-83673, "Small Reactor Channel Enlargement," Staff of IPD, September 1, 1964.
5. HW-83940, "Three Kilogram Polonium Production Study," L. E. Kusler, et al., September 4, 1964.
6. HW-84102, "Reactivity Measurement of Cored Lithium-Aluminum Cylinders," W. A. Blyckert, September 15, 1964.
7. HW-84351, "Uranium Burnout Values for Long Range Studies," R. Nilson and H. Toffer, October 5, 1964.
8. HW-83150 REV, "Cost of a mk-Year," G. F. Owsley, October 7, 1964.
9. "KE-KW Operating Characteristics with E-Q Loading," P. A. Carlson, October 10, 1964.
10. RL-REA-159, "Commercial Isotope Production in a Small Graphite Moderated Reactor," L. E. Kusler, et al., November 12, 1964.
11. "Plutonium Fuels Research and Development Program," G. F. Owsley, November 30, 1964.
12. RL-REA-220, "Reactivity Measurements of Various Target Elements," W. A. Blyckert, December 1, 1964.
13. RL-REA-463, "Production Test IP-746, Polonium Production in the C Overbore Facility," R. E. Baars and L. E. Kusler, January 13, 1965.
14. RL-REA-606, "Physics Testing at H Reactor Deactivation," G. C. Masche and A. D. Vaughn, February 1, 1965.
15. RL-REA-556, "Process Channel Enlargement B and C Reactors," Staff of IPD, February 5, 1965.
16. BNCC-13, "Hydraulic Characteristics of Uranium, Bismuth, and Flux Monitor Mixed Fuel Charge in C Overbore Process Tube," C. W. Angle, February 9, 1965.
17. RL-REA-663, "Technical Feasibility of Using Uranium Oxide Fuels at Hanford," Engineering Staffs of IPD, NRD, and CPD, February 15, 1965.
18. RL-REA-771 SUP, "Irradiation Processing Department 1964 Production Studies - Overbore-Oxide Case-Neptunium Forecasts," R. Nilson, March 10, 1965.
19. RL-REA-893, "Production Test IP-766, Irradiation of Aluminum-Plutonium Fuel Elements," R. E. Baars and G. F. Owsley, March 26, 1965.

DECLASSIFIED

Program: 02 Metallurgy IPD
Project: 02 50 10 05
Title: Alternate Cladding Process (M-1)
Responsible Manager: J. T. Stringer
Responsible Investigator: H. F. Tew
Reporting Period: November 1, 1964, through April 30, 1965

	<u>Prior Year</u>	<u>FY to Date</u>	<u>Period</u>	<u>FY Estimate</u>	<u>Previous FY Estimate</u>
Costs (Thousands)	380.5	214	10 months	302	302
Scientific Manpower (Man-years)	4	3	10 months	4	4

I. Project Scope and Objective

Attractive fuel manufacturing incentives and payout exist for replacing the present Al-Si process with an alternate hot-die-sizing process. Other advantages of the hot-die-sizing process are: (1) increased flexibility in fuel geometry and length, (2) amenability to mechanization, (3) ease of control, and (4) it produces a more uniform and higher quality fuel which will satisfy current or more severe reactor conditions warranted by product diversification programs.

This program will advance the technology of the hot-die-sizing process. Areas being investigated include: (1) the effects of process variables on fuel quality and irradiation stability, (2) simplification of process techniques, (3) establishing the technology to use tubular and potentially more corrosion resistant high-silicon aluminum alloy cladding components, and (4) developing techniques for producing self-supported fuel with integral ribs.

II. Major Accomplishments to Date

1. Laboratory-scale equipment was installed for the development of the hot-die-sized process.
2. Improvements in uranium core surface pretreatment and plating rack design have provided an electro-deposited nickel plate with excellent adhesion properties, uniform thickness, and relatively free of defects.
3. Process parameters have been developed and provisional specifications have been issued to produce fuel elements with high integrity uranium-nickel-aluminum diffusion bonds. Formal specifications have been prepared for approval.

DECLASSIFIED

4. Because of the inherent advantages of induction over resistance end bonding, equipment was installed and test quantities of induction end bonded fuel elements have been fabricated and irradiated with minor reductions in fuel diameter growth. Irradiation tests designed to evaluate the effect of uranium heat treating variables on diameter growth showed a marked improvement for oil-quenched cores.
5. Fabrication techniques were developed, process feasibility was demonstrated, and the irradiation testing of fuel elements assembled in more economical tubular cladding components was initiated with favorable results.
6. The feasibility of producing integral ribbed fuel elements having a rib configuration which closely approaches the collapsibility features of the standard bridge-rail for self-supported fuel, has been demonstrated.

III. Progress During Report Period

1. Priority was given to resolving the hot-die-sized fuel element diameter growth problem experienced in initial irradiation tests. Postirradiation data showed that the average diameter of hot-die-sized fuel increased six to eight mils more at the midpoint than the Al-Si control pieces. An irradiation test to compare the effects of core blank oil quenching versus water quenching after heat treatment showed a marked reduction in the diameter growth of the oil-quenched material. The average diameter growth at midpoint was 3.4 mils as compared to 12 mils for the water-quenched hot-die-sized pieces or about half that of standard water-quenched Al-Si bonded fuel elements.
2. A test is underway to evaluate uranium additives (Al, Fe, and Si up to 300 ppm) and other heat treating techniques on irradiation behavior.
3. A preliminary in-reactor test of more economical 8001 aluminum alloy tube cladding components was completed. Examination shows satisfactory behavior.
4. Ex-reactor corrosion tests on high silicon alloys were completed. Test results both in terms of increased corrosion resistance and fuel fabrication favor a modified 8001 alloy containing 10 per cent silicon.
5. A run-to-rupture test is being prepared. Reactor charging is anticipated in June.
6. Pilot scale production of up to 5000 fuel elements per month for irradiation was initiated in February, 1965.

DECLASSIFIED

7. Tooling and component dimension development was completed to produce both four and eight integral-ribbed fuel elements. Hydraulic testing is underway on fuel assembled with rib configurations which closely approach the collapsibility features of the present collapsible bridge rail for self-supported fuel.

IV. Evaluation of Effort to Date

Engineering and development studies encompassed by the effort to date have demonstrated the feasibility and versatility of the hot-die-sizing process for fuel production. Definition of process parameters required to support the conversion of fuel manufacturing facilities to the hot-die-sizing process is progressing on schedule. It is anticipated that research and development findings will be ample to warrant project action by FY-1966.

V. Next Report Period Activities

1. Basic studies of nickel plating will be continued to minimize porosity and reduce plate thickness.
2. Process optimization will be accelerated through pilot-scale irradiation and the evaluation of fuel with higher enrichment.
3. Studies will continue in the following areas:
 - a. hot-die-sizing and uranium parameters to achieve optimum fuel stability,
 - b. tubular cladding components,
 - c. high-silicon cladding alloys, and
 - d. integral ribbed fuel elements.
4. The production capability for the more massive IAE overbore fuel will be demonstrated by irradiation in the C Reactor test facility.
5. Studies to develop the technology required to combine the die sizing and end bonding process will be initiated.

VI. Topical Reports Issued

1. HW-82472, "Production Test IP-684-A, Hot Die Sized Parameters Evaluation," K. L. Hladek, July 16, 1964.
2. HW-79706A, "Development Status and Incentives for the Hot Die Sizing Process - Supplement A - Case V Incentives for Five Operating Reactors," W. A. Blanton, August 14, 1964.

DECLASSIFIED

3. HW-83454, "Production Test IP-708, Oil-Quenched Hot Die Sized Element Evaluation," K. L. Hladek, August 24, 1964.
4. HW-83454D, "Fabrication of Hot Die Sized Diffusion Bonded Fuel Elements from Oil and Water-Quenched Cores for Production Test IP-708-A," C. A. Strand, September 15, 1964.
5. HW-83770, "Interim Report, High-Silicon Aluminum Cladding for Hot Die Sized Fuel Elements," C. A. Strand, September 17, 1964.
6. RL-REA-598, "Replacement Fuel Production Process (Hot Die Sizing), Project Proposal CAI-170," R. E. Daling, January 1, 1965. (Secret)
7. RL-REA-497, "The Effect of Holding Time Between Nickel Plating and Hot Die Sizing," C. A. Strand, January 27, 1965. (Unclassified)
8. RL-REA-59 REV, "Status of Development Work on the Hot Die Size Fuel Element Growth Problem," C. A. Strand, February 18, 1965. (Secret)
9. RL-REA-42, "PITA-IP-32, Use of Semi-Production Quantities of Hot Die Sized Fuel Elements," R. E. Baars, March 12, 1965. (Secret)
10. RL-REA-42 SUP B, "PITA-IP-32 Supplement B: Phase 3, HDS Fuel for C Over-bore Facility," R. E. Baars, December 30, 1964. (Secret)
11. RL-REA-42 SUP B ADD, "Addendum to Supplement B, PITA-IP-32, Oil Quenched HDS Fuel," R. E. Baars, March 12, 1965. (Secret)
12. RL-REA-839, "Evaluation of the AlSi Wafer in HDS Fuel Element Production," G. M. Schweikhardt, March 15, 1965. (Confidential)
13. RL-REA-928, "Summary of Technical Programs and Progress on Hot Die Sizing," J. T. Stringer, March 30, 1965. (Secret)

DECLASSIFIED

Program: 02 Metallurgy IPD
Project: 02 50 10 05
Title: Fuel Development (M-2)
Responsible Manager: J. T. Stringer
Responsible Investigator: J. T. Stringer
Reporting Period: November 1, 1964, through April 30, 1965

	<u>Prior Year</u>	<u>FY to Date</u>	<u>Period</u>	<u>FY Estimate</u>	<u>Previous FY Estimate</u>
Costs (Thousands)	246	94	10 months	149	149
Scientific Manpower (Man-years)	2	1.5	10 months	2	2

I. Project Scope and Objective

A major part of the funds for this project will be used for the "C" basin examination of fuel irradiated under development programs. The remaining funds will be used for: (1) basic studies of uranium additives and heat treatment to provide the technology for producing stable fuel elements of longer length and capable of withstanding more severe service required by product diversification programs, (2) investigation of cladding alloys offering potentially improved corrosion resistance, (3) defining a better means of fuel identification than length, and (4) basic studies required to resolve fuel quality or performance problems.

II. Major Accomplishments to Date

1. Fuel evaluation studies show a strong correlation between fuel element warp, total bond count, and the rupture resistance of nonbumper fuel to accelerate corrosion "hot spot" failures.
2. An evaluation of induction heat-treated, oil-quenched uranium cores showed no significant difference in the dimensional behavior of this material and standard salt heat-treated, water-quenched cores.
3. An initial test to compare the dimensional stability of water-quenched six-inch and ten-inch enriched fuel cores showed no significant difference in average warp (about five mils) and only minor differences in diameter change. An evaluation of 12-inch natural fuel cores was unsuccessful because of excessive warp during canning, which was attributed to mechanical straightening of the core blanks after heat treating.
4. Advances in basic technology have resulted in improved reproducibility and accuracy of the nondestructive testing equipment.

DECLASSIFIED

5. Techniques and equipment have been developed to size and control the support height of self-supported fuel models.
6. A stronger arch-rail has been developed, evaluated, and accepted as a replacement for the present collapsible bridge rail on K Reactor self-supported fuel models.

III. Progress During Report Period

1. Postirradiation measurements were continued in the C Reactor metal examination facility and the Radiometallurgy Laboratory in support of fuel development programs.
2. It has been determined that high-silicon cladding alloys are the only potential candidates at this time for improving fuel cladding corrosion resistance.
3. Studies were initiated to determine the effects of uranium additives (Al, Fe, and Si up to 300 ppm), heat treatment methods, core blank dimensions, warp, and surface hydrogen content on fuel quality and irradiation behavior. An initial test indicates that minor increases in the diameter of core blanks yield a statistically significant reduction in total bond count.
4. An evaluation of induction heat treated oil-quenched uranium was continued on pilot scale quantities.

IV. Evaluation of Effort

Advances in basic technology falling within the scope of this program have resulted in improved fuel quality and performance. Further progress can be made in fuel uniformity or grading with respect to performance. The development of stable fuel elements of longer lengths will lead to lower fuel fabrication costs.

V. Next Report Period Activities

1. Any new aluminum cladding alloys or coatings offering improved corrosion resistance will be evaluated.
2. Fuel examinations will continue in the Metal Examination Facility at C Reactor in support of development programs.
3. Studies to establish the basic technology to provide relatively stable fuel elements of present and higher enrichments will be continued.
4. Nondestructive testing technology in the area of bond testing capable of distinguishing between mechanical and metallurgical bonds will be expanded.

DECLASSIFIED

VI. Topical Reports Issued

1. Undocumented, "Analysis of Data from PT-654, Evaluation of Ten-Inch Uranium Fuel Elements," R. R. Bloomstrand, September 17, 1964.
(Confidential)
2. HW-84323, "Analysis of Quality Certification Data," R. R. Bloomstrand, October 9, 1964. (Secret)
3. RL-REA-89, "Increased Fuel Element Lengths," W. N. Mobley, November 5, 1964. (Secret)

DECLASSIFIED

**DATE
FILMED**

9/12/94

END