AIM

Association for Information and Image Management

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

Centimeter

Inches

2

MANUFACTURED TO AIM STANDARDS
BY APPLIED IMAGE, INC.

1 of 1

**DECLASSIFIED
BUSINESS RECORD**

GENERAL ELECTRIC

HANFORD ATOMIC PRODUCTS OPERATION - RICHLAND, WASHINGTON

DOCUMENT NO.

RL-NRD 266 EX6

SERIES AND COPY NO.

DATE _____

April 19, 1965

X

THIS DOCUMENT CONTAINS RESTRICTED DATA AS
DEFINED BY THE ATOMIC ENERGY ACT OF 1954
IT IS TRANSMITTED BY THE DISSEMINATION OF
INFORMATION BY THE BURNER OF THE AUTHOR
PERSON IS PROHIBITED.

TITLE

C-1 COPRODUCT DEVELOPMENT FOR N REACTOR
Excerpts from N-Reactor Department Research and Development Budget For FY-1967 and Revision of Budget For FY-1966

7

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 TRANSMISSION OR REVELATION OF WHICH IN ANY MANNER TO AN UNAUTHORIZED PERSON IS PROHIBITED BY LAW.

AUTHOR

Staff, N-Reactor
Department

ISSUING FILE

THIS DOCUMENT MUST NOT BE LEFT UNATTENDED OR WHERE AN UNAUTHORIZED PERSON MAY HAVE ACCESS TO IT. WHEN NOT IN USE, IT MUST BE STORED IN AN APPROVED LOCKED REPOSITORY WITHIN AN APPROVED CLASSIFIED AREA UNTIL IT IS IN YOUR POSSESSION. UNTIL YOU HAVE OBTAINED A SIGNED RECEIPT FROM THE ISSUING OFFICE, IT IS YOUR RESPONSIBILITY TO KEEP IT AND ITS CONTENTS WITHIN THE LIMITS OF THIS PROJECT AND FROM ANY UNAUTHORIZED PERSON. ITS TRANSMITTAL TO, AND STORAGE AT YOUR PLACE OF RESIDENCE IS PROHIBITED. IT IS NOT TO BE DUPLICATED. IF ADDITIONAL COPIES ARE REQUIRED, OBTAIN THEM FROM THE RELATED ISSUING OFFICE. ALL PERSONS READING THIS DOCUMENT ARE REQUESTED TO SIGN IN THE SPACE PROVIDED BELOW.

ROUTE TO:

PAYROLL NO.

LOCATION

[illegible]

SIGNATURE AND DATE

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

(CLASSIFICATION)

DECLASSIFIED

DECLASSIFIED

RL-NRD-266 EX6

This document consists of
9 pages.

C-1 COPRODUCT DEVELOPMENT FOR N-REACTOR

Excerpts from

N-Reactor Department Research and

Development Budget For FY-1967

And Revision of Budget For FY-1968

April 19, 1965

Staff, N-Reactor Department

DISTRIBUTION

1. G. Last
2. J. E. Minor

Classification Cancelled and Changed To

DECLASSIFIED

By Authority of DS LEWIS

CG-PR-2 (LPR-2) 4-25-94

By DK Hanson 5-11-94

Verified By G E Smiley 5-16-94

ds
DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

DECLASSIFIED

MASTER

PREPARED BY THE GENERAL ELECTRIC COMPANY, CONTRACTOR FOR

MAN-RL-NRD-266

U. S. ATOMIC ENERGY COMMISSION

SCHEDULE 189

Additional Justification for Operating Costs

RICHLAND
OPERATIONS OFFICE

PROGRAM

1. Contractors General Electric Company		Contract No. AT(45-1)-1350	Task No.
2. Project Title Coproduct Development for N-Reactor		189 No. C-1	3. Budget Activity No.
4. Date Prepared March 15, 1965	5. Method of Reportings Semiannual		6. Working Locations 100-300 Areas
7. Person in Charge M. C. Leverett Principal Investigators J. W. Riches		8. Project Term From 1964 To 1967	

9. Man Years	<u>FY 1965</u>	<u>FY 1966</u>	<u>FY 1967</u>
(a) Scientific and Technical	20	9	7
(b) Other	3	1	1
Total	23	10	8
10. Costes	<u>FY 1965</u>	<u>FY 1966</u>	<u>FY 1967</u>
(a) Direct Labor (Including Continuity of Service)	475,000	252,000	192,000
(b) Materials, Technical Services, Subcontracts	417,000	60,000	50,000
Battelle-Northwest	-	380,000	148,000
Total Direct	892,000	692,000	390,000
(c) Indirect Expenses	150,000	104,000	60,000
Total Operating Cost	1,042,000	796,000	450,000
(d) Equipment	---	---	---
(e) Irradiation Unit Cost			

DECLASSIFIED

PREPARED BY THE GENERAL ELECTRIC COMPANY, CONTRACTOR FOR

HAN-RL-NRD-266

U.S. ATOMIC ENERGY COMMISSION

SCHEDULE 189

RICHLAND

OPERATIONS OFFICE

C-1 - Coproduct Development for N-Reactor

11. Reactor Concept - Pressurized Water Cooled, Graphite Moderated

12. Materials - Zircaloy components, enriched uranium fuel, and aluminum-lithium target alloys

13. Dates and Titles of Publications

HW-78864, "A Program for Multiproduct Operation of the N-Reactor," By Staff, Research and Engineering Section, NRD, September 9, 1963

HW-79289, "Co-Product Program N-Reactor," October 17, 1963, R. L. Dickeman

HW-79306, "Production of Special Nuclear Materials in N-Reactor," October 21, 1963, D. L. Condotta, E. G. Pierick

HW-76242, "Preliminary Study of NPR Capabilities," February 4, 1963, K. W. Norwood, et al

HW-77198, "Production Studies - N-Reactor," April 4, 1963, N-Reactor Staff

HW-78671, "Special Product Study - N-Reactor," April 16, 1963, R. L. Dickeman

HW-77470, "Burnout Heat Fluxes for NPR Tube-in-Tube Fuel Elements," June 6, 1963, J. K. Anderson, et al

HW-80692, "Thermal and Hydraulic Characteristics of an N-Reactor Fuel Column," June 25, 1964, J. K. Anderson, et al

HW-84154, "Co-Product Operation of N-Reactor," September 21, 1964, E. G. Pierick, J. W. Riches

HW-81327, "Production Test NR-8 Coproducer Demonstration Test (1.25)," May 4, 1964, T. W. Evans

RL-NRD-74, "Progress Report: Coproduct Operation of N-Reactor," December 15, 1964, N-Reactor Department

DECLASSIFIED

U.S. ATOMIC ENERGY COMMISSION

SCHEDULE 189

RICHLAND

OPERATIONS OFFICE

C-1 - Coproduct Development for N-Reactor

14. Need for Program, Payoff, and Benefits

Continuing production studies reveal that the production of weapon grade plutonium and tritium is an economically attractive mode of operation for N-Reactor. With the successful completion of the proposed research and development program, coproduct production in N-Reactor could begin in January 1967. Approximately 5 kg of tritium could be produced at a reduction in unit total cost of up to \$7 per gram equivalent when compared to other modes of operation of N-Reactor that yield only weapon grade plutonium.

Achieving this production level and unit cost requires a fuel and target design that will subject the materials to more severe temperature and exposure conditions than for the tube-in-tube design. Analyses of existing knowledge and experimental results obtained to date are very encouraging. However, there is a continuing need for additional experimental verification of the limiting conditions for both fuel and target to permit the specification of a production fuel and target design. The incremental cost of this program is estimated to be \$1,055 million in FY-1965, \$0.796 million in FY-1966 and \$0.450 million in FY-1967 for a total of \$2.3 million.

The principal benefits to be derived from this expenditure of research and development funds are lower unit costs for both tritium and weapon grade plutonium. When the reactor reaches equilibrium operation as a dual-purpose reactor producing process steam for credit, it will be a highly competitive producer of plutonium and tritium in the AEC complex.

15. Scope

The scope of the research and development program encompasses work in physics, reactor engineering, materials and fuels areas necessary to define a fuel and target design and reactor operating characteristics compatible with production economy and nuclear safety. Both experimental and analytical work must be performed to define engineering limitations for heat generation and boiling burnout for new geometries and higher heat fluxes, to establish nuclear characteristics of exposure transients and temperature coefficients compatible

DECLASSIFIED

U. S. ATOMIC ENERGY COMMISSION

SCHEDULE 189

RICHLAND

OPERATIONS OFFICE

C-1 - Coproduct Development for N-Reactor

with available control strengths under normal and accident conditions, to develop fuel materials capable of high temperature, long exposure operation and target materials compatible with production and nuclear hazards requirements.

16. Relationship to Other Programs

The work described in this report is in direct support of N-Reactor. Data relative to N-Reactor developed under the 02-Base Case Research and Development Program will be utilized throughout. Knowledge gained from programs sponsored by the Division of Research and Division of Reactor Development also will contribute to the success of the Coproduct Program.

17. Technical Progress in FY-1965

Experience with heavier single tube fuel has demonstrated the feasibility of fabricating coproduct driver elements. Over 1000 driver elements for two production tests of 1.25 and 1.95 percent enriched coproduct assemblies have been made. Pilot lots of heavier single tube elements with standard uranium and new uranium alloys have also been fabricated.

Fabrication of Al-Li target elements likewise demonstrated the feasibility to produce target elements in pilot plant quantities. Nearly 2000 ft. of Al-Li target elements were fabricated for the PCTR tests and 1.25 and 1.95 percent enriched irradiation tests.

Production capability to 2.5 kg of tritium was largely demonstrated with near completion of the 36 tube production test of 1.25 percent U-235 coproduct elements. Chemical analyses of the fuel and target elements to determine actual product yields will carry into FY-1966.

Analysis of swelling data from the irradiation testing of single tube fuel containing iron silicon (150 ppm iron and 100 ppm silicon) and iron-aluminum uranium (300 ppm aluminum and 400 ppm iron) alloys provided further

DECLASSIFIED

U. S. ATOMIC ENERGY COMMISSION

SCHEDULE 189

RICHLAND

OPERATIONS OFFICE

C-1 - Coproduct Development for N-Reactor

confidence that the more severe operating conditions associated with coproduct operation can be safely accommodated. This fuel operated satisfactorily at temperatures in excess of 525 C and to exposures of 2500 MWD/T. Selected tubes from the 36 tube 1.25 percent U-235 coproduct test will remain in the reactor to provide fuel driver and target performance at exposures in excess of goal and core temperatures up to 530 C. A proof loading of about 18 tubes of 1.95 percent enriched assemblies operating at uranium temperatures up to 580 C and to an average exposure of 1700 MWD/T will be loaded in the reactor about April 1965. This loading will use the basic fuel design chosen for the full reactor load.

Experiments in the Physical Constants Test Reactor (PCTR) on the 1.95 percent enriched fuel were completed and provided essential empirical checkpoints for infinite multiplication (k_{∞}) and thermal utilization (f) for both a wet and dry lattice. Initial analysis showed close agreement between PCTR results and the FLEX 3 computer code. Experiments to measure buckling (B^2) and control strengths in an exponential pile for the wet and dry lattice were made. These experiments were performed using the basic fuel design chosen for the full reactor load in an N-Reactor graphite lattice. Preliminary results verified that the margin of control strength under both normal and accident conditions is adequate for 1.95 percent enriched coproduct fuel.

A preliminary safeguards analysis for a full load of coproduct in N-Reactor of 1.95 percent enrichment was carried out. A series of experiments designed to determine the behavior of the target alloy under various accident conditions were underway. Early results on unirradiated targets revealed that when targets are heated to temperatures of 1100 C the molten aluminum-lithium alloy is normally contained by the Zircaloy jacket. When jacket failure has occurred, the aluminum-lithium alloy reacts with the Zircaloy jacket forming a highly refractory compound that contains the lithium within the target. Irradiated target elements were also subjected to a similar temperature cycle, causing rupture of the clad and expulsion of about 2/3 of the aluminum-lithium alloy from the target. Analysis of the target core materials dislocated during the tests revealed that the ratio of lithium-6 to aluminum remained relatively constant indicating that vaporization of lithium from the alloy should not be a problem. Detailed analysis of the distribution of lithium-6 in the reactor following a loss of water accident was initiated. The excess reactivity that would result should the aluminum-lithium content of the reactor be depleted could exceed the local control strength. To avoid this depletion, a target with a non-melting

DECLASSIFIED

[REDACTED]

PREPARED BY THE GENERAL ELECTRIC COMPANY, CONTRACTOR FOR
U.S. ATOMIC ENERGY COMMISSION

HAN-RL-NRD-266

SCHEDULE 189

RICHLAND

OPERATIONS OFFICE

C-1 - Coproduct Development for N-Reactor

poison core is being tested. Also, alternate fuel designs and loading patterns are being investigated to avoid the potential problems of excess reactivity resulting from target melting

Critical mass exponential experiments were completed for the coproducer fuel element with and without target poison in various water lattices to verify calculations. No insurmountable safeguards problems are expected in satisfying nuclear safety criteria for either pre-irradiated or post-irradiated phases of material handling.

Considerable work has been expended narrowing the range of coproducer fuel designs for the first full load coproducer fuel. Generalizations have been developed as follows: a) once the quantity of tritium to be produced by N-Reactor has been established, the corresponding enrichment level of the fuel to produce this quantity becomes fixed. b) After specific uranium enrichment has been chosen, increasing the weight of fuel per foot decreases the unit product cost. c) The maximum fuel weight is limited by the maximum allowable core temperature, by heat dissipation requirements, by control strength available, by driver-target effective cross sections, by nuclear safety requirements, and by reactivity behavior. The effect of these limits are in the last phase of evaluation for coproduct fuel designs that will produce about 4 to 5 kg of tritium per year.

18. Expected Results FY-1966

Based upon analyses of irradiation test results and physics and engineering experiments and calculations, the fuel and target for the first production load of coproduct elements will be designed. Fuel performance data from three large scale production tests (PT-8, 13, and 36) will be obtained during the first half of FY-1966. Analysis of these data and of fuel fabrication experience will permit selection of a fuel composition which will be adequate for use in the coproducer driver element. Particularly significant is the proof loading of about 20 tubes of 1.95 percent enriched assemblies (PT-13) that will be operated to uranium temperatures up to 580 C and to average exposures beyond 1700 MWD/T. Single tube loadings of 0.947 percent enriched fuel (PT-36) will be irradiated to test uranium alloys for swelling resistance. Test columns of prototypical fuel will be irradiated to evaluate the validity of calculated limits such as peak uranium temperatures, clad thickness variation and target designs.

DECLASSIFIED

RICHLAND

OPERATIONS OFFICE

C-1 - Coproduct Development for N-Reactor

Rates and degree of migration of molten target alloy under accident conditions will be defined. In excessive reactor reactivity gains are prognosticated as based on migration experiments, appropriate changes in target design, loading patterns, or materials of construction will be made to eliminate problems.

Evaluation of the results of the two in-reactor test blocks will be completed providing experimental data on reactivity behavior and product yields. A final hazards summary report will be prepared, describing the physics behavior of a full reactor load of coproduct fuel under normal and accident conditions and assessing the adequacy of available reactor safety systems. Should the final fuel design deviate significantly from the prototypical design already investigated, PCTR tests will be undertaken to verify calculated physics parameters. A method of providing fringe enrichment to enhance pile flattening efficiency will be developed. If required, a PCTR test will be carried out to verify calculated reactivity parameters of fringe enrichment columns. Plans will be made for the in-reactor experimental physics program which will provide the operational bases for full power operation with a full reactor loading of the target-driver fuel elements.

Both boiling burnout experiments and two phase pressure drop studies of the coproducer fuel will be completed. Data from these experiments will assist in determining essential operating safety limits under coproduct operation and will also be used in studies made in support of safeguards analysis.

19. Expected Results FY-1967

Program emphasis during FY-1967 will be largely determined by the results of the testing programs initiated during FY-1965 and FY-1966. It is expected that analytical work will be required in the areas of reactor physics and thermal hydraulics to permit interpretation of the results of earlier testing programs. Through engineering analysis and test programs, the problems associated with operating coproduct fuel at 120 percent of the design power will be assessed. Test fuel columns charged to evaluate engineering limits will reach goal exposure and the results interpreted with respect to feasibility for more rigorous service for the fuel and target assembly.

DECLASSIFIED

PREPARED BY THE GENERAL ELECTRIC COMPANY, CONTRACTOR FOR

HAN - RL-NRD-266

U.S. ATOMIC ENERGY COMMISSION

SCHEDULE 189

RICHLAND

OPERATIONS OFFICE

C-1 - Coproduct Development for N-Reactor

20. Description and Explanation of Major Materials and Offsite Contracts

Research and development in support of a new material or fuel concept is characterized by high materials and services costs because of the need to work with production size components and to perform tests and examinations on highly radioactive materials.

21. Proposed Future Related Construction Projects

Plant and equipment modifications are needed to convert N-Reactor to coproduct operation. In the fuels plant, new or revised cleaning, assembly, welding, and inspection equipment will be required for the target element. The single tube driver with about 2 percent enrichment will require some equipment modifications because of the change in size and weight and to assure nuclear safety. The reactor plant will require equipment to separate the target from the driver and to remove the zirconium jacket from the target, minor modifications to fuel handling equipment and the acquisition of casks and cask cans for shipment of the target. Because of the higher enrichment, the separations plant will require new dissolver inserts, processing tanks, and calciner. Modification of the on-site cask cans may be required. These plant and equipment items will be included in the Plant Acquisiting and Construction Budgets for FY-1966, 1967, and 1968. The total cost is estimated to be about \$2,000,000.

DECLASSIFIED

DATE

FILMED

10 / 4 / 94

END