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HANFORD ATOMIC PRODUCTS OPERATION - RICHLAND, WASHINGTON

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TITLE

Co-Product Development for N-Reactor
pp 58 through 64 - HW-80908

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AUTHOR

**Staff, N-Reactor
Department**

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81548RD
HAN- HW-80908

SCHEDULE 189

U. S. ATOMIC ENERGY COMMISSION

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: Co-Product Development for N-Reactor	189 No.	3. Budget Activity No.
4. Date Prepared: February 3, 1964	5. Method of Reporting: Monthly	6. Working Location: 100 - 300 Areas
7. Person in Charge: M. C. Leverett Principal Investigators: J. W. Riches	8. Project Term: Continuing From: To:	

9. Man Years:	FY 1964	FY 1965	FY 1966
(a) Scientific and Technical	7	22	14
(b) Other	3	5	4
Total	10	27	18

10. Costs:	FY 1964	FY 1965	FY 1966
(a) Direct Labor (Including Continuity of Service)	220,000	610,000	335,000
(b) Materials, Technical Services, Subcontracts	200,000	544,000	260,000
Total Direct	440,000	1,154,000	595,000
(c) Indirect Expenses	75,000	196,000	105,000
Total Operating Cost	515,000	1,350,000	700,000
(d) Equipment	0	0	0
(e) Irradiation Unit Cost	0	0	0

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By DE HANSON 4-17-84
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Co-Product 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 Multi-Product Operation of the N-Reactor," September 9, 1963,
by Staff, Research and Engineering Section, N-Reactor Department.

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 and E. G. Pierick.

14. Need for Program, Payoff, and Benefits

Continuing production studies reveal that the production of weapons 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, co-product 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 \$6 per gram equivalent when compared to other modes of operation of N-Reactor that yield only weapons 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. Analysis 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 driver to permit the specification of a production fuel and target design. The incremental cost of this continuing

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program is estimated to be \$2.4 million. The proposed schedule of expenditure is FY-1965 - \$1.35 million; FY-1966 - \$0.7 million and FY-1967 - \$0.35 million.

The principal benefits to be derived from this expenditure of research and development funds are lower unit costs for both tritium and weapons grade plutonium. The co-product mode of operation would make N-Reactor the most economical production reactor 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 will be performed to define engineering limitations for heat generation and boiling burnout for new geometries and higher heat fluxes, to establish optimum nuclear characteristics of exposure transients and temperature coefficients compatible 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. The results relative to metallic fuel development derived from this program and the AEC sponsored Heavy Water Moderated Power Reactor Program should be of mutual benefit. Knowledge gained from programs sponsored by the Division of Research and Division of Reactor Development also will contribute to the success of the Co-Product Program.

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17. Technical Progress in FY-1964

Two results were obtained with major significance for the ultimate success of the program:

1. Tolerable swelling of a prototypic fuel made from ingot grade uranium (no iron or silicon additions) was obtained for irradiation conditions of 1200 MWD/T at a peak core temperature of 600 C.
2. No significant migration nor loss of tritium was measured at 300 C in in-reactor gas release tests nor in aluminum-lithium target elements irradiated at N-Reactor coolant temperatures to an exposure of GVR 30 to 35 which is twice the exposure planned for production.

Prototypical fuel elements were fabricated from standard N-uranium (150 ppm iron and 100 pm silicon added) and the swelling resistant British composition (800 ppm aluminum and 400 ppm iron added) to measure their behavior under irradiation conditions simulating those to be encountered during co-product production in N-Reactor. A broad spectrum of uranium alloy samples are being irradiated in capsules to test swelling theories and define the best alloy for co-product service.

Prototypic fuel and target elements were designed for test irradiation. Uranium enrichments of 1.25 and about 2.0 per cent U-235 will be tested to encompass the range of tritium production best suited for N-Reactor. Sufficient fuel and target elements were fabricated for 1.25 per cent U-235 test to permit charging a 36 tube square pattern from which both production data and material behavior data will be obtained to simulate production of 2.5 kg tritium per year in N-Reactor.

Conversion ratios for both plutonium and tritium were calculated for a broad range of fuel and target designs and reactor operating conditions to permit the selection of a production design as data are accumulated to specify materials, engineering and physics limitations more exactly.

18. Expected Results in FY-1965

During FY-1965, the performance of several uranium alloys will be measured under irradiation conditions

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typical of co-production operation of N-Reactor. It is expected that an alloy resistant to swelling at core temperatures up to 600 C and exposures up to 1700 MWD/T will be demonstrated. The relationship between the high temperature swelling of uranium under irradiation and the microstructure and other metallurgical properties will be determined.

Production capability to 2.5 kg of tritium will be demonstrated upon the successful completion of 36 tube production test of 1.25 per cent U-235 co-product elements. It is expected that solutions will be found to the more vigorous materials and fuels problems associated with economical production of 5 kg of tritium through irradiation of about 10 fuel columns of co-product elements containing uranium of about 2 per cent enrichment.

Boiling burnout experiments with short heated sections of selected co-producer designs will be completed by the middle of the fiscal year. Construction of an electrically heated test section equipped with prototypic inlet and outlet connectors and fittings will be complete and ready for testing by the end of FY-1965. As they become available, the results of boiling burnout analysis will be factored into production fuel and target design and hazards analyses.

Detailed calculations of control strengths, temperature and exposure transients, base reactivity, and reactivities for abnormal conditions will be based upon experimental results from the PCTR. Measurements in the PCTR of k_{∞} and β for prototypical 1.95% fuel elements will be done on the wet and dry lattice both with and without the target element in place. The fuel temperature coefficient of k_{∞} will be measured for the dry lattice. Measurements of Δk for simulated slumped fuel elements or targets are planned to provide information for hazards evaluation. Measurements of bucklings and control strengths in the expotential piles will be started during this year. Kinetics studies and other information required for final hazards analysis will be in progress.

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19. Expected Results in 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 co-product elements will be designed. Practical and economic fabrication and heat treating processes will be developed for the new uranium alloy and the aluminum-lithium target alloy. Pilot quantities of production elements will be thoroughly tested both out of reactor and under irradiation to further verify the design.

Experiments will be made, with a half-column test section representing a selected co-producer design, to determine two-phase flow performance under steady-state and transient conditions simulating tube leaks, pluggings and other abnormal situations. Results of these experiments will be interpreted in terms of actual process tube performance.

The measurements of buckling and control strengths in the exponential piles will be completed and analyzed. The calculations of control margins for both normal and abnormal operating conditions will be completed and compared with the laboratory experiments for normalization. Detailed calculations of temperature and exposure transients will be completed. Further work on kinetics and control studies will be completed for hazards evaluation and analysis. Plans will be made for the in-reactor experimental physics program which will provide the operational bases for resumption of full power operation with a full reactor loading of the target-driver fuel elements.

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.

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21. Proposed Future Related Construction Projects

Modest plant and equipment modifications are needed to convert N-Reactor to co-product 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 per cent 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 desolver 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 Acquisition and Construction Budgets for FY 1965, 1966, and 1967. The total cost is estimated to be about \$1,800,000.

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