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HANFORD ATOMIC PRODUCTS OPERATION - RICHLAND, WASHINGTON

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RL-NRD-266 EX5

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April 19, 1965

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TITLE

M-1 N-REACTOR FUEL DEVELOPMENT
Excerpts from N-Reactor Department Research and Development Budget For FY-1967 And Revision of Budget For FY-1966

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7 pages.

M-1 N-REACTOR FUEL DEVELOPMENT

Excerpts from

N-Reactor Department Research and

Development Budget For FY-1967

And Revision of Budget For FY-1966

April 19, 1965

N-Reactor Department Staff

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U. S. ATOMIC ENERGY COMMISSION

SCHEDULE 189

Additional Justification for Operating Costs

RICHLAND
OPERATIONS OFFICE

METALLURGY - SAFETY, CONTINUITY
OF OPERATION AND REACTOR LIFE
PROGRAM

1. Contractors General Electric Company		Contract No. AT(45-1)-1350	Task No.
2. Project Title: N-Reactor Fuel Development		189 No. M-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: M. Lewis		8. Project Term Continuing From To	

9. Man Years	<u>FY 1965</u>	<u>FY 1966</u>	<u>FY 1967</u>
(a) Scientific and Technical	13	8	6
(b) Other	<u>5</u>	<u>2</u>	<u>2</u>
Total	<u>18</u>	<u>10</u>	<u>8</u>
10. Costes	<u>FY 1965</u>	<u>FY 1966</u>	<u>FY 1967</u>
(a) Direct Labor (Including Continuity of Service)	400,000	200,000	178,000
(b) Materials, Technical Services, Subcontracts	344,000	56,000	42,000
Battelle-Northwest	-	244,000	128,000
Total Direct	<u>744,000</u>	<u>300,000</u>	<u>348,000</u>
(c) Indirect Expenses	126,000	72,000	52,000
Total Operating Cost	<u>870,000</u>	<u>572,000</u>	<u>400,000</u>
(d) Equipment		25,000	25,000
(e) Irradiation Unit Cost			

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RICHLAND

OPERATIONS OFFICE

M-1 - N-Reactor Fuel Development

11. Reactor Concept - Pressurized Water Cooled, Graphite Moderated
12. Materials - Uranium; Zircaloy
13. Date and Title of Publications

None

14. Need for Program, Payoff and Benefits

The use of metallic uranium fuel elements on a large scale in a pressurized water cooled power reactor environment in N-Reactor not only represents an extrapolation from previous Hanford fuel technology but it represents the only production-scale application of this concept in this country or abroad. Provision of a supporting technology is and will continue to be a major activity at Hanford as only a limited amount of directly applicable R&D will be available from other sites.

The major benefit to be achieved through an extensive and continuing fuel program is attainment of the full capabilities of the N-Reactor at much reduced fuel cycle costs. The current N-Reactor fuel design represents the best engineering judgment of what is required for adequate performance. While the design is intentionally conservative, some features may not fully provide the level of performance required to sustain efficient reactor operation. Results of production-scale irradiation experience and special test irradiations will provide direction to a continuing program to correct any excesses or deficiencies in the initial fuel design. Reduction of unwarranted conservatism in the design will lower fuel fabrication costs, and correction of deficiencies will lower irradiation costs through increased time operated efficiency. In addition to design optimization, direct savings in fuel fabrication costs will result from developing new processing methods that will permit higher process yields at the same or higher quality levels.

To permit taking advantage of the full range of product choice of which N-Reactor is capable, the fuel and target elements must withstand more rigorous exposure conditions and improvement in the irradiation properties

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of the materials will be required. For example, exposure levels of 3000 to 4000 MWD/T at reactor powers up to 4800 Mw to provide flexibility in choice of products, would necessitate reducing uranium swelling and mitigating the effects of both swelling and thermal strains on fuel cladding.

15. Scope

The long-range objective of this program is the provision of technology which will enable the cost of fabrication of N-Reactor fuel to be reduced to between \$3 and \$4 per pound, (not including off-site fabrication costs), the provision of fuel having characteristics consistent with N-Reactor production forecasts, and fuel and target elements what will support future reactor operating modes necessitating longer exposures and/or higher specific powers to provide flexibility in product choice. Attainment of the cited objective depends both on the R&D herein proposed and on other related activities of a manufacturing and operating nature, and related work in physics and thermal hydraulics. Successful completion of this program is an essential part in the demonstration of the full capabilities of N-Reactor.

The scope of the program includes the evaluation of the performance of the first load of production fuel elements and of special test fuel irradiations designed to provide knowledge about specific aspects of fuel performance; the development of new fuel and target element concepts to permit the full utilization of N-Reactor; and the study of N-Reactor capabilities for the production of the full range of products of interest to the nation for weapon and peaceful applications.

16. Relationship to Other Programs

This program is related to: 1) the process technology programs that directly support N-fuel element manufacture on-site and the provision of adequate material components from off-site sources that are converted to on-site fuel, 2) reactor programs in support of nuclear engineering materials and reactor coolant technology, 3) reactor programs related to operational aspects of the fuel in the areas of thermal hydraulic performance, fuel rupture monitoring, and the mechanical aspects of charge-discharge operations.

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17. Technical Progress in FY-1965

The major technical progress during FY-1965 in the evaluation of the current fuel element was highlighted by:

- a) successful performance and integrity of the fuel elements at exposures to at least 2100 MWD/T were predicted from KER loop irradiations. This technical appraisal of the design adequacy has been further strengthened by the absence of failures in the first load of fuel elements attributable to inadequate design, and the large number of rapid shutdowns of the reactor that the elements have successfully withstood.
- b) Better definition has been obtained on both the mode of the damage mechanism and the rate of corrosion of the uranium core material in irradiated fuel elements that have been deliberately defected and flow tested in water at reactor operating temperatures.
- c) Project Proposal (CGN-149) was initiated to procure special handling and examination equipment for irradiated fuel research and development.

The major items of technical progress on the evaluation of the advanced fuel element program were: a) the development of adequate primary uranium processing methods and coextrusion techniques for fabricating low alloy uranium fuel, b) the initiation of irradiation testing of single tube fuel in several uranium alloys of interest, c) the development of fabrication methods for shaped, brazed end closures and their charging into the reactor in production test quantities, d) the development of an alternate closure, the semi-bonded TIC welded and brazed design, and initiation of irradiation testing, e) the development of a "T" cross section outer support forged from Zircaloy wire that is at least a factor of three stronger than the current design of support, f) the use of pre-attachment annealing in production to avoid inner support cracking during assembly from directional hydride formation.

Major contributions towards the reduction of fuel costs were: a) a comprehensive review of fuel criteria and specifications to pinpoint areas of potential relaxation or areas where data are needed to improve the specifications, b) the introduction of "Class II" fuel with incrementally more variable cladding in less demanding locations in the reactor based on pre-N-Reactor irradiation data, c) the development of reliable re-welding

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procedures that avoid the necessity for shortening and re-closing defective fuel tubes, d) the introduction of a simplified, improved, and less expensive engineering data system to replace the original "NUF" system, and e) the development and introduction of a proven billet surface conditioning procedure that permits higher utilization of feed site product. Analytical studies were completed assessing the economic and production incentives for potential N-Reactor operating modes and fuel designs.

Preliminary studies to evaluate the capabilities of N-Reactor to produce isotopes such as Po-210 and Pu-238 were completed. Results were sufficiently promising that more detailed studies were initiated. Studies were completed showing the best methods for maximizing Np-237 production in N-Reactor through recycle of the fuel. The benefits and disadvantages of converting N-Reactor to uranium oxide fuel for weapon production were evaluated. No strong incentive to convert N-Reactor to an oxide fuel cycle was discovered.

18. Expected Results in FY-1966

The major areas of expected progress in FY-1966 are: a) continuation of a vigorously conducted fuel performance evaluation program based on characterization of fuel element variables both before and after irradiation and correlation of the changes expressed as a function of irradiation and fabrication process variables; b) completion of an evaluation of the performance of the first reactor loading in which fuel behavior will be analyzed with respect to design conservatism and design deficiencies; c) completion of the initial series of irradiation tests directed towards increased fuel capability and the reduction of fuel fabrication costs; d) complete, through in-reactor testing initiated in FY-1965, the demonstration of a single tube fuel element as an alternate mode of achieving economy in operation and initiate testing of an optimized model; e) demonstrate a breadth and depth of technical competence to explain mechanisms of failure peculiar to the N-Reactor fuel concept and means by which the onset of such mechanisms can be delayed or prevented, f) initiate development of a high exposure, up to 4000 MWD/T metallic uranium fuel that would be adequate for producing high Pu-240 plutonium. Analytical studies will be directed at a) scoping the fuel designs and economics for a reactor operating mode designed to optimize production of Np-237 and Pu-238, b) providing a thorough, technical and economic description of alternate approaches to Po-210 production in N-Reactor including its impact on the current fuel design, c) outlining the optimum modes of N-Reactor operation during the next

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M-1 - N-Reactor Fuel Development

four years, based on environmental conditions expected to exist, d) reviewing all possible applications of N-Reactor technology that are consistent with the needs of the nation and where necessary setting forth desirable and feasible courses of action with respect to each.

19. Expected Results FY-1967

The major goals for the fuel element development program in FY-1967 will be to: a) demonstrate through in-reactor testing the capability of an optimized single fuel tube design for economical plutonium or plutonium and isotope productions, b) demonstrate through in-reactor testing the feasibility of the metallic fuel concept for high exposure use, c) continue to investigate new fuel designs that will provide the product mix best suited to the capability of N-Reactor and the needs of the nation.

20. Description and Explanation of Major Materials, Equipment, and Offsite Contracts

Special materials required for fabrication of test fuels and capsules. Special services as required for irradiated fuel examination. Specialized equipment is required for development and testing of new fuel and target designs in support of new products.

21. Proposed Future Related Construction Projects

None

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