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HANFORD ATOMIC PRODUCTS OPERATION - RICHLAND, WASHINGTON

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TITLE

N-Reactor Fuel Development
pp 51 through 57 - HW-80908

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Staff
N-Reactor Department

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SCHEDULE 189

U. S. ATOMIC ENERGY COMMISSION

Additional Justification for Operating Costs

METALLURGY - SAFETY, CONTINUITY
OF OPERATION AND REACTOR LIFE
PROGRAM

RICHLAND
OPERATIONS OFFICE

1. Contractors: General Electric Company		Contract No. AT-(45-1)-1350		Task No.	
2. Project Titles: N-Reactor Fuel Development		189 No. M-1		3. Budget Activity No.	
4. Date Prepared: March 25, 1964		5. Method of Reporting: Monthly		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:

- (a) Scientific and Technical
(b) Other

Total

FY 1964	FY 1965	FY 1966
12	14	14
8	6	6
20	20	20

10. Costs:

- (a) Direct Labor (Including Continuity of Service)
(b) Materials, Technical Services, Subcontracts

Total Direct

- (c) Indirect Expenses

Total Operating Cost

- (d) Equipment

- (e) Irradiation Unit Cost

FY 1964	FY 1965	FY 1966
420,000	445,000	445,000
1,018,000	389,000	530,000
1,438,000	834,000	975,000
244,000	142,000	175,000
1,682,000	976,000	1,150,000
250,000	900,000	150,000
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By Authority of RM JTC
PR-24 4-13-64
By RCH Hansen, 4-17-64
Verified By G.E. Saeed, 4-18-64

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SCHEDULE 189

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 imminent use of pressurized water-cooled, metallic uranium fuel elements on a large scale in the N-Reactor not only represents an extrapolation from previous Hanford fuel technology, 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 entailed in the basic fuel concept at much reduced costs. The initial N-Reactor fuel design represents an estimate 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 relatively unhampered reactor operation. Production-scale irradiation experience will provide the feed-back required to give 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; 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 improved processing methods that will permit higher process yields at the same or higher quality levels.

Establishment of an economic design point relative to the initially-goaled operating conditions will not in itself attain the objective of achieving the full capability of the coextruded fuel

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M-1- N-Reactor Fuel Development

14. (continued)
concept.

To meet the functional fuel requirements for the more rigorous exposure conditions that pertain to potential future modes of reactor operation, optimization of the physical design of the fuel element and improvement in the irradiation properties of the materials will be required. Exposure levels of 3000-4000 MWD/T at reactor powers up to 4800 MW would necessitate reducing uranium swelling and mitigating the effects of both swelling and thermal strains on fuel cladding. Development of such fuel is not expected to materially change local fabrication costs. However, the availability of a longer-lived fuel will enable the fuel-contributed portion of production costs to be significantly reduced.

The long-range objective of this program is the provision of technology which will enable the reduction of the cost of fabrication of the N-Reactor fuel to between \$3 and \$4 per pound, (not including off-site fabrication costs), the provision of fuel having characteristics consistent with the production of 1000 kg Pu equivalents per year in the N-Reactor, and a fuel that will support both the current mode of reactor operation and future modes necessitating longer exposures and/or higher specific powers. 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, thermohydraulics. The successful completion of this program is thus an essential part of the development of the N-Reactor to a point of economic superiority.

15. Scope

Fabrication of the first load fuel elements was essentially completed in CY 1963. At the conclusion of the low level power demonstration and the final operational tests about May, 1964, power ascension will be initiated. During FY 1965 fuel performance data will be obtained by which the established first load fuel design can be judged and a basis for improvement in performance and fuel manufacturing economy can be derived. In addition, capability for continuing production testing of new improved or less costly fuel designs and for assessing fuel performance

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SCHEDULE 189

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M-1 - N-Reactor Fuel Development

at much extended exposures will have been established. The scope of the program to evaluate the performance of the first load of fuel elements recognizes the arbitrariness that was exercised when that design was frozen. There were scant data on swelling, the relative change of inner vs. outer diameters related to clad strength, and their relation to the operating characteristics of the hydraulic system. The above scope complements those of the separate programs to test improved or less costly designs and develop fuel designs for much extended exposure and power level.

The evaluation of the performance of the first load will follow stages of test, evaluate, redesign, test, evaluate, etc. The development of less costly and longer-lived fuel elements will include: testing of improved designs and new materials, evaluation of new processing methods, and improving specific processing yields.

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.

17. Technical Progress in FY 1964

The major technical progress in the evaluation of the current fuel element was highlighted by (a) data showing continued adequacy for swelling and general performance from the KER loop irradiation test program for exposures to 2100 MWD/T which exceeds the N goal by 50 percent, (b) continued study of the rate of uranium core loss from purposely defected irradiated fuel elements that were cooled down at rates simulating actual reactor conditions, (c) further capsule irradiations that defined local clad thickness variation to avoid clad failure.

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SCHEDULE 189

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M-1 - N-Reactor Fuel Development

17. (continued)

(d) the completion of the data storage and analysis programs for the fuel element manufacturing variables and attributes that will be automatically computed and analyzed on the 7090 IBM computer, (e) the special loading of 97 columns of measured and weighed fuel elements to monitor the in-reactor performance of the first fuel load.

The major items of technical progress on the evaluation of the advanced fuel element program were; (a) the initial successful irradiation of a single-tube prototype for high-temperature performance, (b) the mechanical and thermal processing behavior, suitability to fuel element manufacturing, and in-reactor evaluation of the dilute uranium alloy used by the British, (c) further evaluation of the in-reactor performance of specially-shaped fuel elements, (d) an economic analysis of the cost of the single tube as an advanced fuel element in N-Reactor.

The major progress in reducing fuel element costs and/or attaining improved design features in the current fuel element included: (a) demonstration of the in-reactor stability of a shaped end cap in both the as-brazed and the as-unbonded condition, (b) the development and evaluation of a thermo couple element as a crud monitor.

18. Expected Results in FY 1965

The major areas of expected progress in FY 1965 are: 1) the initiation of a vigorously sustained fuel performance evaluation program based on characterization of the fuel element attributes both before and after irradiation and the correlation of the changes in attributes expressed as a function of the irradiation and fabrication process variables, 2) the development of reasonably conclusive definition of any deficiencies in the design of the first load fuel elements, 3) the initiation of production testing of design changes directed towards improve

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SCHEDULE 189

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M-1 - N-Reactor Fuel Development

18. (continued)

fuel capability and towards reducing fuel manufacturing costs.

Major FY 1965 goals relative to fuel evaluation are: 1) to complete and demonstrate adequate capability of the fuel examination facility, 2) to complete the development of IBM programs for fuel data handling and engineering analysis, 3) make substantial progress toward a performance analysis of first load fuel.

Major FY 1965 goals relative to design definition are: 1) irradiate a series of fuel charges to assess cladding requirements in terms of minimum nominal clad thickness, magnitude of local clad variations, and optimum distribution of fuel volume increases by varying inner to outer clad ratios, 2) irradiate several uranium alloys with potential for reduced swelling susceptibility, 3) initiate extended exposure tests to explore for threshold limits of strain from swelling for both the clads and the end closure, 4) conduct irradiation tests to determine if the mid-point inner fuel tube supports are required, the locking clips can be eliminated, and whether the vibrational environment evidenced in reactor operation requires a less rigorous fuel criterion with regard to avoid fretting.

Major FY 1965 goals relative to backup fuel capability and cost reduction are: 1) to irradiate significant numbers of fuel with completely bonded and partially bonded shaped end closures, 2) to develop and test an improved unbonded closure concept, 3) irradiate fuel with reduced clad thickness, 4) conduct exploratory irradiations to support ex-reactor data indicating that acceptance criteria for product attributes and characteristics are too conservative.

19. Expected Results in FY 1966

The major goals for the fuel element development program in FY 1966 will be to: 1) conduct a multifaceted evaluation program for the irradiated fuel element performance and establish a

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SCHEDULE 189

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M-1 - N-Reactor Fuel Development

19. (continued)

"norm" of quality to which continuing changes in both the design and the method of manufacturing the fuel elements can be compared, 2) demonstrate through in-reactor test, a single tube fuel element concept that will operate with full confidence of superior performance as an alternate mode of achieving greater economy of operation, 3) demonstrate a breadth and depth of technical competence to explain the mechanisms by which swelling is controlled and such that no other deformation process-limits the use of metallic uranium fuel at higher levels of power and exposure.

20. Description and Explanation of Major Materials, Equipment, and Off-site Contracts

N fuel R&D is characterized by high material costs (Zircalov and other reactive metal alloys), the commitment of a large minimum unit of representative manufacture for tests, the production size coextrusion of each clad fuel tube geometry, non-typical equipment for handling reactive and radioactive materials, and high expense related to the examination of irradiated fuel.

Facilities for irradiated fuel handling and evaluation will be provided and operated as part of this program. These facilities include equipment for special pickup of irradiated fuel to avoid damage upon discharge, equipment for measuring the dimensions of irradiated fuel elements, a device to weigh the fuel to determine the change in density (swelling) and instruments to measure clad thickness and bonding.

Nuclear Metals, Inc. will be retained as expert consultants and to perform specialized research and development in support of the program.

The reduced level of services reflects the change over from fuel testing in in-reactor loops funded from R&D to testing in N-Reactor where tests elements will contribute to production from the reactor

21. Proposed Future Related Construction Projects

None.

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