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TITLE

DEVELOPMENTAL REQUIREMENTS FOR CANNING A LOW DENSITY THORIA DEMONSTRATION LOAD

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DEVELOPMENTAL REQUIREMENTS FOR CANNING A LOW DENSITY THORIA DEMONSTRATION LOAD

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INTRODUCTION

The feasibility of fabricating aluminum clad, low-density (~ 65 per cent theoretical density) thoria elements using thoria produced by a modified Sol Gel process, low frequency-low energy vibration for compaction, and the TIG welding process for closure welding has been demonstrated by Hanford Laboratories. They have also assembled thoria fuel elements for the initial irradiation to produce 1 to 2 kgs. of U-233. To date HL has fabricated about 1320 low density (~ 65 per cent TD) fuel elements in their laboratory facility, and by April 1, 1964 will have produced an additional 1200 high density (~ 80 per cent TD) fuel elements. Following this fabrication for the initial irradiation, HL is expected to participate and contribute in the area of longer range development activities on higher density processes while Production Fuels Section, IPD, would undertake to produce subsequent quantities of fuel elements that might be required for larger scale irradiation. At this time, it is expected that Hanford will be asked to produce about 25 kg. of "clean" U-233 and that authorization to proceed with this program could be expected sometime between now and late fall of CY 1964. The requirements in terms of equipment and manpower, and the time schedules to produce this quantity of U-233 have been published in HW-79450, "U-233 Production Studies", dated November 1, 1963. In this letter it was indicated, based on best estimates made at the time, that finished thoria fuel elements could be produced 7 months after authorization of the program, and the full 60 tons of fuel elements completed 9 months after authorization. Approximately $125,000 - 150,000 of capital equipment in Production Fuels were estimated as being required to produce the quantity of fuel elements required, including prototypes used in engineering development. This report reassesses the Production Fuels Section capability to meet the established schedules and costs in the light of the development experience accumulated by HL since November 1963.

SUMMARY

Thoria fuel elements can be produced at a rate of 17,000 per month (rate required to meet commitments after receipt of thoria) and on the forecasted schedule, providing a nominal development effort of 2 months precedes program authorization, and certain equipment ($39,100) and materials ($4800) items are procured prior to authorization. It is proposed that the 3732 Building, currently a general development laboratory, be equipped as a thoria fuel element pilot plant with the capacity to produce the fuel

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elements for the 25 kg. demonstration load on a 1 shift 5 day week. Initially the facility would be used to demonstrate and gain the technology for producing quantities of thoria fuel for the demonstration load. Subsequently the demonstration load would be fabricated, and following this, the facility would be used to develop production techniques for high density thoria elements, if required, and serve as a pilot facility for production quantities beyond the demonstration load.

A development lead time of 9 months preceding delivery of the first quantities of thoria fuel is estimated today as compared with 7 months estimated in the original study of November 1963. Associated with this development would be the procurement of $39,100 of equipment and $4800 of essential material.

An Appropriation Request for $39,100 for required equipment is currently being processed. It is recommended that this be approved prior to demonstration load authorization in order to provide the required lead time to meet commitments. After authorization, an additional $90,000 - 120,000 of equipment will be required to equip the facilities for the demonstration load.

I. STATUS OF THORIA CANNING DEVELOPMENT WORK

A. Hanford Laboratories

Essentially all thorium oxide canning development work accomplished to date has been done by the Hanford Laboratories. The scope of their work includes (1) a long range R&D program to develop basic information concerning thorium oxide properties, compactibility, irradiation properties, etc., (~ $250,000 not yet awarded) and (2) the fabrication of four tons of thorium oxide elements ($70,000).

Hanford Laboratories has assembled about 1,320 low density (~ 65 per cent TD) elements to date and is committed to deliver an initial order of about 600 high density (~ 80 per cent TD) elements to the reactors by March 10, 1964 and a second 600 element quantity by April 1, 1964. The Hanford Laboratories' canning process for low density (65 to 75 per cent TD) elements is outlined below:

1. Weigh thorium oxide.
2. Load thorium oxide manually into cans and vibrate (low-energy vibration).
3. Insert 0.1 inch thick aluminum wafer.

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4. Swab weld closure zone and outer can surface free of oxide with methanol.
5. Insert 0.2 or 0.4 inch thick aluminum wafer.
6. Weld wafer to can (TIG welding process).
7. Weld inspect visually.
8. Helium leak test.
9. Package for reactor shipment.

Their work has demonstrated that unsized thoria produced by the "modified" Sol Gel process can be compacted by means of low frequency-low energy vibration to 65 per cent TD with ease and that closure welding will not be a problem providing that the weld interface is free of thoria.

B. Production Fuels Section

The Production Fuels Section has been responsible for furnishing components, component cleaning, thorium oxide procurement, and reactivity testing in support of the fabrication of the four-ton load by Hanford Laboratories.

1. Component Cleaning

Component cleaning problems were encountered early which resulted in poor closure welding. This has been overcome by adding an aluminux etch step following the detergent rinse and this modified process can be used for fabricating the demonstration load. Additional longer-range development work is needed in this area, however, because of the desirability of using the cap and can machine for cleaning. Previous tests have shown the cap and can machine cleaning process to be inadequate for acceptable weldability. The tests revealed an obvious need for certain equipment modifications. The extent of improvement which might be gained by these modifications alone is unknown at this time.

2. Component Filling

One piece of equipment for can filling and compacting has been fabricated by Equipment Development and has undergone very limited testing. This equipment was designed with a pilot scale application in mind and contains an "O" ring seal to eliminate contamination of the weld interface. This equipment looks promising; however, much more test work will be required to optimize the design and process parameters and to obtain process capability data.

3. Magneform Swaging

The feasibility of the use of the Magneform for swaging in the washer has been demonstrated by General Dynamics and samples of their work have been supplied to General Electric. There were a total of twelve samples prepared using 6061-T6 aluminum washers. The washers withstood greater than 200 pounds static load and the diameter reduction of the can on either side of the washer was less than 0.010 inch.

II. DEVELOPMENT REQUIREMENTS

The Production Fuels Section has essentially all of the basic information required for beginning the development of a pilot scale process which has been proposed for assembling 24,000 to 61,000 low density thoria elements at a rate of about 17,000 elements per month. The present status of thoria canning technology does not indicate any major changes in the proposed process flow for low density (65 per cent TD) elements with the exception of the addition of an ultrasonic water rinse following the welding operation and the possible elimination of the second magneform operation by locating the welder within the can filling hood. Equipment for the ultrasonic rinse is available in the 306 Pilot Plant. The immediate process and equipment development work which must be completed before Production Fuels begins to can the demonstration load is summarized below:

A. Oxide Handling and Contamination Control

A hooded system for transferring about 2,500 pounds of oxide per shift from shipping container to hopper-blender-to weigh feeder-to cans without incurring personnel contamination or particle size segregation is required. Compaction efficiency is a function of particle size distribution; therefore, a maximum effort should be made to produce uniformly dispersed particles in the finished element and compaction capability studies should be conducted using a reasonable semblance of the blending and feeding system to be used later. Minor problems with contamination control are anticipated to begin with. A major effort may be required in obtaining efficient blending and preventing segregation in the feeding system subsequent to blending.

B. Compactibility

Compaction efficiency is a function of particle size distribution, as mentioned previously, and the compaction process. Vibratory compaction is proposed for obtaining the required density. The capability for a range of density levels and the within and between-element uniformity must be established. The best available information at this time suggests that a major effort in obtaining the highest uniform density possible with no major change in the proposed over-all process is justified.

C. Weldability

The TIG welding process is acceptable for closure welding; however, good component cleaning and the prevention of oxide contamination in the weld interface are mandatory. Component cleaning presents little problem. Oxide contamination of the interface presents a welding problem and cleaning the weld interface after filling and compacting is undesirable for pilot-scale work because the oxide has a tendency to embed in the aluminum, making cleaning very difficult. The approach for pilot-scale work is one of preventing oxide contact with the weld interface during filling and compacting. This will be accomplished by making an "o" ring seal between a filler pipe and a washer swaged in place near the can mouth. Development work to be performed in support of this concept is summarized below:

1. Washer Swaging

   Determine optimum dimensional tolerances and operating parameters for magnetically swaging in an aluminum washer near the can mouth. All equipment, with the exception of field shapers, used by General Dynamics in preparing HAPO samples is available within Hanford Laboratories and apparently can be used for some development work. With this in mind, the field shaper used by General Dynamics in preparing the samples has been ordered.

2. Oxide Seal

   The filler pipe and oxide seal mechanism must undergo rigorous testing and some development work will undoubtedly be required.

3. Welding

   A limited amount of weld parameter optimization and equipment modification work will be required. Useful data will be available from the Hanford Laboratories' canning experience. However, there will be some component dimensional changes which will undoubtedly require minor equipment and process revisions.

III. DEVELOPMENT PROPOSAL FOR THE PRODUCTION FUELS SECTION

It is proposed that a facility be established within Fuels Engineering with the objectives of (1) gaining the technology necessary for canning the demonstration load, (2) assembling the demonstration load of low-density (approximately 65 per cent TD) thoria, and (3) serving ultimately as a pilot facility for future high density thoria canning development work. It is proposed that this facility be located in the 3732 Building in 303 Area and that the equipment layout, design, and procurement and test work necessary to accomplish the first objective be started immediately.

A. Estimated expenditures necessary to the accomplishment of this first objective are shown below:

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	Equipment Acq. Cost	Direct Labor	Other	Total
1. Hood	$11,500	$2,000	$2,500	$16,000
2. Absolute Filter System	5,000	800	1,100	6,900
3. Drum Unload Facility				
a. Drum Holding and Tilting Equipment	3,000	500	600	4,100
b. Jaw Crusher System	500			500
4. Hopper-Blender System Including Flow Controls	4,000	300	400	4,700
5. Weigh Feeder System	1,000			1,000
6. Can Filling and Compaction System	2,000			2,000
7. Decanning System	200			200
TOTAL	$27,200	$3,600	$4,600	$35,400
Design				1,500
Contingency				2,200
TOTAL (Equipment)				$39,100
8. Essential Materials				
a. Aluminum Component Sets (5,000 @ $0.60 Per Set)			3,000	3,000
b. Thorium Oxide (Sol Gel) (500 pounds @ $2.00 Per Pound)			1,000	1,000
Contingency				800
TOTAL (Essential Materials)				$ 4,800
GRAND TOTAL				$43,900

These expenditures should provide the Production Fuels Section with the essential facilities, equipment, and materials for obtaining the technology required for assembling the demonstration load of thoria elements. The equipment utilized during this period would also be utilized for the demonstration load and additional expenditures would be required as shown in HW-79588 at the time of approval of the demonstration load.

B. Time Schedule

A tight but realistic time schedule for the accomplishment of the required development work is shown below:

TIME SCHEDULE FOR
EACH PHASE OF PROGRAM REQUIREMENT

Program	Starting Date ↓ 1st Mo.	2nd Mo.	3rd Mo.	4th Mo.	5th Mo.	6th Mo.	7th Mo.
		Progression Phase Completed*					
A. Facility Layout & Renovation	1 2	3					
B. Essential Materials							
1. Al Caps & Cans	1 2			3	4		
2. Al Washers		1 2		3	4		
3. ThO_2	1 2			3	4		
C. Equipment							
1. Hood, Air Supply & Filter System	1	2	3	4	5		
2. ThO_2 Drum Unload Facility	1	2		3 4	5		
3. Storage Hopper-Blender System	1	2		3 4	5		
4. Weigh Feeder System	1	2	3 4	5			
5. Can Filling & Compaction System	1	2 3	4	5			
D. Product Specifications						1	
E. Process Development							
1. Washer Swaging	1 2					3	4
2. Vibrational Compaction					1 2	3	4
3. Cap Welding					1 2	3	4
4. Finished Dimensions & Surface Quality					1	2 3	4

* Legend for Progression Phases shown on next page.

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Progression Phase for Each Program

Program	Phase Completed
A. Facility Layout and Removation	1. Process Layout 2. Equipment Relocation 3. Installation of ThO_2 Control Area Wash Facilities, Floor Covering
B. Essential Materials	1. Design and Specifications 2. Place Orders 3. Receive Material 4. Complete Acceptance Sampling
C. Equipment	1. Design or Bid Procurement and Funding Approval 2. Order 3. Receive 4. Install 5. Debug
D. Product Specifications	1. Write Product Specifications
E. Process Development	1. Receive Essential Materials and/or Equipment 2. Equipment Demonstration 3. Capability Analysis 4. Write Quality Control Standards

It is felt that this work can be successfully accomplished in seven months and that a minimum of two additional months should be scheduled between the completion of this work and the delivery of the first twenty tons of acceptable elements for irradiation.

IV. DEPARTURE FROM THE INITIAL PROPOSAL

The initial proposal was based upon the use of the Special Products room for fabrication of the demonstration load. The primary advantage of this was the availability of the component cleaning line. The disadvantages are that due to lithium and other special production requirements, early use of the facility for development work could be extremely limited and the hood and compacting facility would be of limited value subsequent to the demonstration load whereas a facility located in 3732 would be available for future development work. The installation of a component cleaning line in the 3732 Building would result in an increase in the previously estimated capital expenditures for the demonstration load by about $45,000. While a

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component cleaning line for this facility may be justified in the future, it is felt that immediate component cleaning development work can be done in the 306 Pilot Plant and that with proper scheduling and some inconvenience to Materials Handling, the Special Products component cleaning line could be used for the demonstration load.

Other expenditures resulting from relocation of the facility would be primarily those of relocating existing equipment and would have an insignificant effect upon the original proposal.

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