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TITLE

BLENDING UNH STREAMS OF DIFFERENT URANIUM ENRICHMENTS

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HANFORD ATOMIC PRODUCTS OPERATION
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BLENDING UNH STREAMS OF DIFFERENT URANIUM ENRICHMENTS

- Reference: (1) HAN-68482, "Blending UNH Streams of Different Uranium Enrichments," by A. T. Gifford, dated March 7, 1958 (01:RLP)
- (2) HW-51688, "Change in Specifications for 0.94 Enriched Uranium," by W. E. Johnson, dated July 7, 1957
- (3) HW-30263, "Manual for Acceptance Specifications for HAPO Slug Cores," dated January 1, 1954

INTRODUCTION AND SUMMARY

As requested by the Commission (Reference 1), the cost and feasibility of blending UNH streams of different uranium enrichments at HAPO has been evaluated on a preliminary basis. The two cases studied were: (1) blending 37.5 percent enriched UNH with depleted E metal UNH to yield a 0.947 percent enriched end product; and (2) blending depleted E metal UNH with our regular stream of depleted natural uranium to yield a 0.7115 percent enriched end product.

An analysis of the study results indicates that a reasonable degree of feasibility exists for such a blend program at HAPO, although considerably more exhaustive engineering work will be required for corroborative purposes before feasibility could firmly be established. Capital and operating costs associated with each of the blend programs were estimated by considering only those requirements that would be in addition to expenditures presently planned for the E metal segregation program. These costs are estimated as follows:

	0.947% End Product	0.7115% End Product
Incremental Project Costs	\$ 331,500	\$ 182,000
Operating Costs Per Year	88,000	71,000
Downgrading Costs Per Year	1,794,000	436,000

In evaluating over-all feasibility of the blend program, it is recognized that all problems of mutual and individual concern to each of the production sites involved in the fuel cycle must be considered. In this study, because of its preliminary nature, we have investigated only those problems of concern within HAPO production facilities, except for indirect reference to certain potential off-site involvements. Indications are that isotopic build-up caused by fuel recycling would probably be tolerable for a continuing blend program. Assay limitations are expected to be satisfactory for meeting U-235 specifications for 0.947% enriched material. It appears, however, that we would be unable to meet existing reactor specifications for U-235 content in blending to the 0.7115% end product. Also indicated, in the event the blend program is pursued further, is the need for development work as associated with UO_2 powder quality requirements, analytical capability needs, purity requirements for HAPO UNH feed streams and equipment prototyping needs. A resume of the study results as related to each particular area of investigation is presented below.

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REACTOR FUEL RECYCLING

A review was made of the isotopic changes that could be expected by repeated recycling of a reconstituted fuel through the reactors. This included a study of the nuclear reactions and decay patterns involved in the formation of U-232, U-236, U-237, and Pu-238 over a period of several cycles. Under the most stringent assumption that a given quantity of reconstituted fuel would retain its identity (would experience no dilution with normal fuel or be redirected through the cascades) throughout the recycling program, it has been ascertained that the isotopes U-232 and Pu-238 should create no problems even after as many as ten fuel cycles.

Reactor reactivity effects would be experienced, however, due to build-up of the isotope U-236. In this regard, it is estimated that a reactor fully charged with reconstituted fuel that had undergone five cycles would experience a reactivity loss of about 72 inhours due to U-236 buildup. Of course, it is improbable that sufficient fuel of this type would be available to fully charge any one reactor because of dilution and distribution of depleted material between the cascades and the blend program during the course of each cycle.

Increases in U-237 content can likewise be expected after each cycle through the reactors. Calculations indicate that if batch identity of recycled fuel is retained, the U-237 content, as related to that present at the end of the first cycle, would double after three cycles and increase about four times after the seventh cycle. In view of the relatively short half-life of U-237 (approximately 7 days), however, the buildup of this isotope can easily be compensated by increasing cooling time about seven and fourteen days at the end of the third and seventh cycles, respectively. Here again it is very probable that blending and redirection of depleted material through the cascades would obviate retention of any significant amount of material through five uninterrupted blend-irradiation cycles under the conditions of the 0.7115% program.

ASSAY LIMITATIONS AND TOLERANCES

In keeping with our past experience in mass spectrographic analysis, it is estimated that assay precisions of ± 0.005 absolute percentage units could be achieved in our determinations of U-235 isotopic content of the blends involved. This precision allows for only minor errors due to memory effect and minor fluctuation in blending and sampling uncertainties. It is assumed that the above variables can be minimized to the degree necessary by development of adequate procedures. Statistical analysis of isolated spectrographic analyses of our present UO_3 product has on occasion shown precision capability in the range of 0.001 absolute percentage units. It is improbable, however, that such a degree of accuracy would be sustained on a continuing production basis for individual assays. Present specifications for U-235 isotopic content of E metal (Reference 2) is listed as 0.947 percent $\pm .006$ percent, indicating compatibility with our expected assay precision.

Natural uranium specifications have been set forth at HAPO (Reference 3) as 0.711% $\pm 0.001\%$, U-235 content. As indicated above it is improbable that blends can be produced at HAPO with this degree of precision. It is possible, however, that further blending of the 0.7115% HAPO product could subsequently be made with natural uranium to the extent necessary to meet final pile fuel specifications.

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CONCEPTUAL BLEND SCHEMES

Our conception of facility requirements for the production and subsequent calcination of the required UNH blends is based on the following scope assumptions.

1. For either blend case a new mass spectrograph would be required at the 222-S Laboratory. The unit recently excessed was not reliable for this work.
2. The 37.5 percent enriched feed stream will be delivered to HAPO as UNH (Reference 1) of 2 molar concentration. Critically safe containers of 2 to 3 gallon capacity will be provided by HAPO for transportation and limited storage of this material.
3. A critically safe geometry for containment of the 37.5 percent enriched uranium would be provided by vessels with a maximum diameter of 6 inches. The maximum permissible safe U-235 isotopic content for any geometry and volume was assumed as 2 percent in a homogeneous nitrate solution. Studies are currently in progress to ascertain this parameter more accurately. Present information indicates that the always safe U-235 enrichment is not less than 1.8 percent.
4. The basic discharge rate of E metal from the Hanford reactors was assumed to be 50 tons per month.
5. Exposure concentrations of the E metal and normal metal streams were assumed to be approximately 800 MWD/T.
6. Blend processing capacity was assumed as that necessary to sustain a continuous throughput rate of 5 tons per day when blending to 0.947 percent end product and a rate of 10 tons per day when blending to 0.7115 percent end product. These rate requirements were assumed necessary to minimize curtailment of overall UO_3 processing capacity.

To effect the required blend of 37.5 percent enriched UNH and depleted E metal, it is visualized that final blending would be carried out in the new 15,000 gallon concentrator feed tank (X-37) to be provided by the UO_3 segregation project (CG-767). Incoming 37.5 percent enriched material would be received and stored in lots of 12 to 17 containers in a secure storage area. At the time of receipt each container would be weighed and appropriate analyses performed for accountability purposes. Blending would be initiated after sufficient feed materials are accumulated from the Redox Plant and the off-site supplier. Each blend would be comprised of approximately one shipment of 37.5 percent feed which would be blended to a critically safe 2 percent U-235 UNH solution with depleted E metal UNH, in an intermediate blend tank. This step will require positive means for blending 37.5 material down to 2.0 percent U-235. On the basis of conceptual design it is anticipated that this can be accomplished without resorting to a design geometry that necessitates protection from 37.5 percent enriched material in the intermediate blend tank.

After adequate blending and analytical determinations, the 2 percent enriched solution would then be blended with approximately 25 tons of depleted E metal in the final blend tank. Additional agitation would be necessary in this vessel

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(X-37) to insure the degree of mixing required. On the basis of analytical determinations, butting would then be carried out to bring the aggregate blend in specification. The final blend would then be concentrated and processed through the calciners in a segregated manner as permitted by facility modifications planned in the present UO_3 segregation project.

In consideration of the need to meet rather exacting U-235 content specifications, provisions for reworking off-standard powder will be necessary. Such material would be handled in the conventional 5 ton containers, introduced into a dissolution vessel, and returned to the final blend tank for adjustment. For containment and control of possible leakage and spills at the 37.5 percent unloading station, a critically safe sump would have to be provided.

The second proposed blend scheme involving production of a 0.7115 percent end product is somewhat more simplified than the foregoing by virtue of elimination of the highly enriched feed stream. Except for the rework facility and mass spectrograph, incremental equipment needs are expected to consist of only a pump and pipeline, sampler, and an additional agitator. Depleted natural UNH would be delivered to the final blend tank (X-37) from the present concentrator feed tank (X-2). Depleted E metal UNH would be received in a vessel (X-36) also provided for by the UO_3 segregation project (CG-767), and from there, by controlled delivery, would be added to the final blend tank.

Blend cycle times in the order of 36 hours and 24 hours are expected to be achieved for production of the 0.947 percent and 0.7115 percent end products, respectively. This should be adequate to maintain the assumed continuous rates. It could be expected, however, that the need for excessive butting during the blend procedures could result in occasional intermittent operation of the calciners.

COSTS

A summary of incremental project costs, operating expenses, and downgrading costs is presented below. Downgrading costs have been included since they represent a realistic monetary loss that must be considered in evaluating the over-all economic justification for such a project.

	<u>End Product Enrichment Case</u>	
	<u>0.947%</u>	<u>0.7115%</u>
A. <u>PROJECT COSTS</u>		
1. Architectural	\$ 30,000	\$ -
2. Blend System	82,000	16,000
3. Rework Facility	37,000	37,000
4. Mass Spectrograph	75,000	75,000
5. Engineering and Contingencies	<u>107,000</u>	<u>54,000</u>
Total Project Cost	\$ 331,500	\$ 182,000

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End Product Enrichment Case
0.947%   0.7115%

B. OPERATING EXPENSES

1. Labor	\$ 88,000	\$ 71,000
2. Net loss of product value by blending	<u>1,794,000</u>	<u>436,000</u>
Total Operating Costs	\$1,882,000	\$ 507,000
Incremental Unit Cost	\$1.57/# blend U	\$0.17/# blend U

The above operating costs are exclusive of amortization of capital equipment. Also if frequent powder rework is necessary to meet isotopic specifications, an additional operator will be necessary in each case. Downgrading costs were based on a value of \$30 per unit of separative work and assumes feed stream U-235 isotopic contents of 37.5 percent and 0.84 percent for production of the 0.947 percent end product, and 0.84 percent and 0.625 percent for blending to a 0.7115 percent end product.

PROJECT TIMING

It is estimated that the controlling factor for project timing will be the procurement and installation of the new mass spectrograph. On this basis, blending operations could be initiated approximately 18 months after project authorization.

DEVELOPMENT REQUIREMENTS

Prior to final resolution of the feasibility aspects of the blend program at HAPO, considerable development work will have to be pursued. Among the problem areas that will have to be investigated more exhaustively, the following items are especially significant.

1. Determination of the adequacy of continuous UO_3 powder quality for efficient reduction to metal with present equipment.
2. Performance of analytical development work to enable determinations on UO_3 powder for metal specifications. The existing emission spectrograph standards and procedures at HAPO do not enable us to perform all of the analyses required for metal specifications.
3. Process development work may be necessary to achieve the required purity of the uranium product of the chemical separations plants.
4. Early prototyping of the 2 percent (U-235 isotopic content) blend system would be desirable for determining optimum blending procedures.

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Production Operation

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