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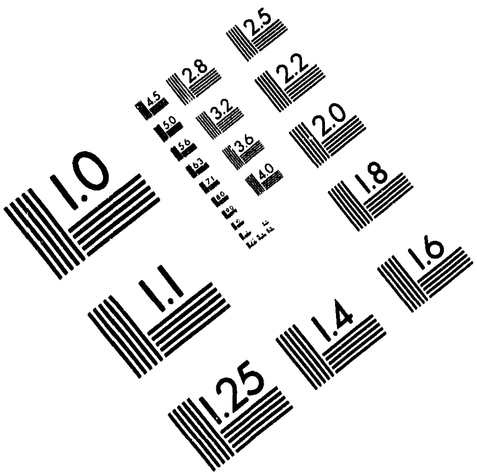

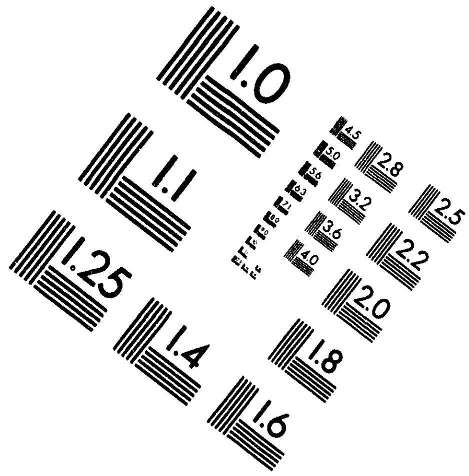

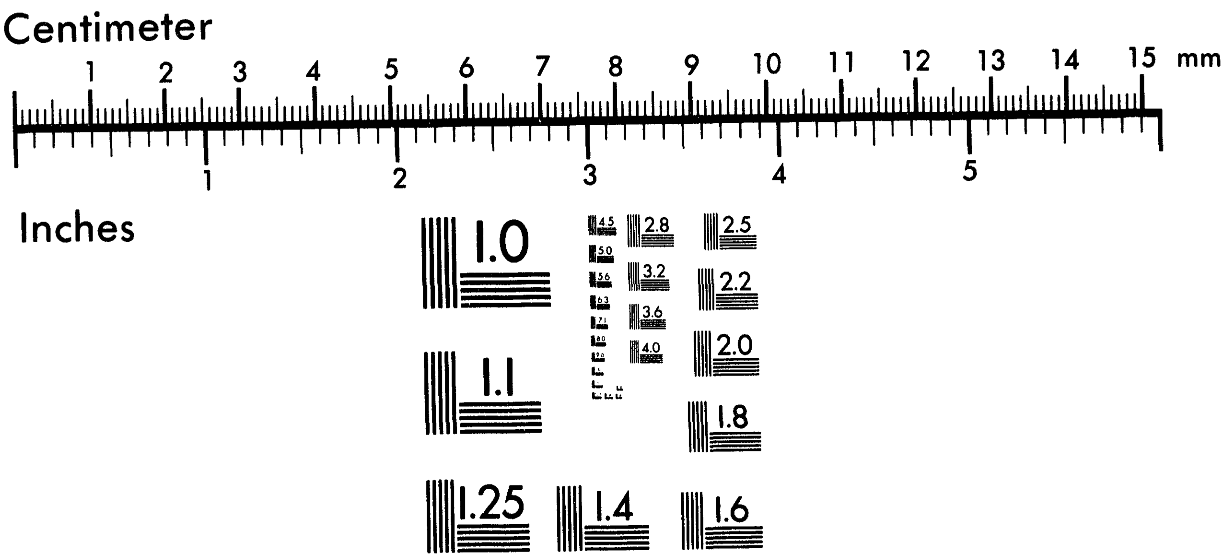

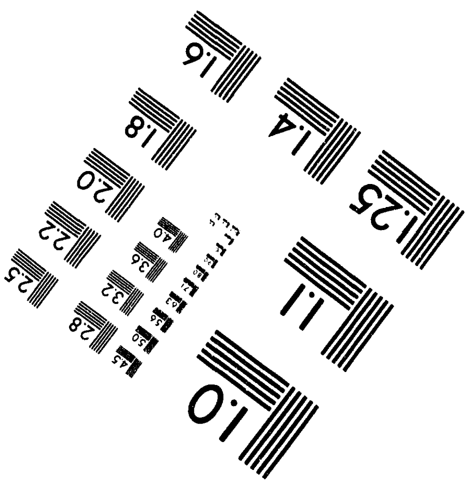

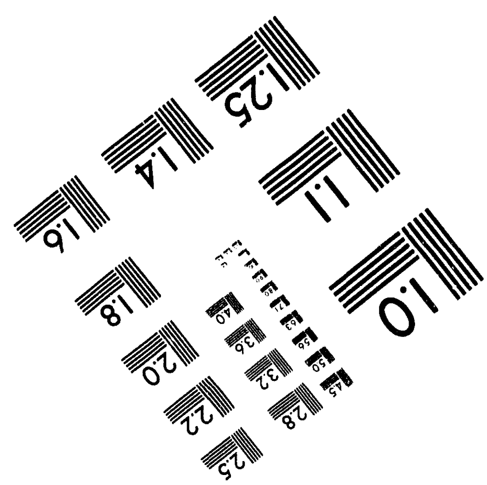

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LONGER ENRICHED FUEL ELEMENTS FOR H REACTOR

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LONGER ENRICHED FUEL ELEMENTS FOR H REACTOR

By

I. L. Huffman

IRRADIATION PROCESSING DEPARTMENT

September 18, 1963

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IRRADIATION PROCESSING DEPARTMENT

COST IMPROVEMENT PROPOSAL*

DATE: 9-18-63

TITLE: Longer Enriched Fuel Elements for H Reactor

REFERENCES:

ORIGINATED BY: I. L. Huffman

ORGANIZATION: H Processing

EFFECTIVE DATE:

SAVINGS COMPUTATION

	MATERIAL	LABOR	OTHER	TOTAL
COST - PRESENT METHOD	$	$	$	$
COST - PROPOSED METHOD	SEE ATTACHED.			
ESTIMATED ANNUAL SAVINGS				

PRESENT METHOD:

SEE ATTACHED.

PROPOSED METHOD:

SEE ATTACHED.

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APPROVALS - EVALUATOR

CONCURRENCE - FINANCIAL

A-6000-104 (3-61)

* USE ATTACHMENTS AS NECESSARY FOR DETAIL COMPUTATIONS AND ILLUSTRATIONS.

[redacted]

LONGER ENRICHED FUEL ELEMENTS FOR H REACTOR.

Summary

This Cost Improvement Proposal recommends an increase in the length of enriched fuel elements (for H Reactor only) from 6.64" to 8.1". A cost improvement would result as follows:

Annual Out-of-Pocket Cost Savings $121,000
Annual Outage Time Savings - 65 Hours, worth 4,550 MWD
Annual Production Level Gain - 7,000 MWD

Since the Production Fuels Section and off-site suppliers are already equipped to handle elements of this length, the cost to make the change should be insignificant compared to the annual savings.

Present Method

H Reactor has a special H Loading which consists of about 1170 central tubes loaded with "striped" charges of enriched fuel and target elements, 636 tubes loaded with enriched fuel, 170 fringe tubes loaded with target elements, plus 28 miscellaneous channels. Each "striped" charge consists of 40 enriched fuel elements, 1 natural fuel element (water mixer), and 3 target elements.* Each enrichment column is charged with 43 enriched fuel elements. The target material in the fringe tubes is not significant to this proposal. The lengths of the present elements that are significant to this proposal are:

Enriched Fuel: 6.54" plus 0.1" true-line end.

Target Element: 5.0" plus 0.1" true-line end.

The enriched fuel element is 2.32" shorter than the 8.864" natural fuel element used at the other reactors. The purpose of the length difference is to facilitate the separation of the enriched and the natural elements at the other locations. The apparent reason for the use of the shorter enriched elements at H Reactor is to avoid the manufacture of another type of fuel element.

Proposed Method

H Reactor uses only one type of fuel element (enriched). Therefore, there is no internal reason for using short enriched fuel elements. The length of the fuel element at H Reactor should be determined by factors other than the consideration for keeping two types of fuel elements separate.

* This evaluation is based on the assumption that the current PITA which includes a 102-tube test will prove the feasibility of changing to the type of charge shown.

[redacted]

It is proposed that the enriched fuel elements (for H Reactor only) should be manufactured approximately 8.1 inches long (over-all), plus or minus about 0.1 inch depending on final reactivity studies. The reason for choosing this precise length instead of a greater length is to make the length compatible with the dimensions of the storage basin buckets. The internal dimensions of the buckets are 17 inches square. Elements with the chosen lengths could be stacked in the buckets like two rows of cordwood. There would be a ½ inch space between the rows, which would be an adequate tolerance for bucket loading purposes. Also, this length would be about two-thirds of an inch shorter than regular fuel elements. This would enable positive identification and separation from the regular fuel elements in the 300 Area.

Some of the justifications for the longer enriched fuel elements are:

1. Reduced fuel element canning costs.

2. Improved fuel charging rates.

3. Improved pickup and bucketing rates for irradiated fuel.

4. Increased reactivity and/or reduced fuel requirements.

5. Improved charge machine operation.

6. Decreased rupture potential.

7. Increased coolant flow (fewer slug junctures, shorter columns).

8. Improved "striped" load.

9. Reduced storage basin bucket requirements.

10. Improved separation of target and fuel elements.

EVALUATION

Basic Assumptions

One outage hour is worth 70 MWD, determined as follows: at 80% TOE, the reactor operates about 7000 hours per year and produces about 500,000 MWD per year. Each operating hour produces about 70 MWD.

Each slug rupture costs about 10 outage hours.

The two end-caps on a fuel element are 0.487" ± .04" thick.

One inch or uranium fuel core weighs 0.886 lb. This is computed by dividing the core length (6.053 inches) into the factor weight (5.36 pounds per slug).

[redacted]

Approximately 5000 columns of fuel and target elements are irradiated each year. 1 gpm coolant flow is worth about 6 MWD per year. This is determined by dividing the total coolant flow into the annual MWD production.

Incremental Enriched Fuel Cost:

from off-site	$1750/ton
Canning	450
Chemical Processing	530
	$2730 per ton

The following approximate evaluation is presented:

1. Reduced Fuel Element Canning Costs

The proposed longer elements would reduce the number of elements per charge by eight (a 20% reduction). Approximately 5000 charges per year are irradiated at H Reactor. This proposal would reduce the number of elements used per year by 40,000. The out-of-pocket savings would be $1.20 per element for caps, cans and chemicals. The annual savings for 40,000 elements would be $48,000.

2. Improved Fuel Charging Rates

The time required to charge a tube is determined largely by the number of elements to be charged and the strokes per minute of the charge machine. The machine speed is 26 strokes per minute (approximately 2 seconds per fuel element). A reduction of 8 elements per charge would reduce the charging time at least 16 seconds per charge. Considering the number of interruptions during the charging of a tube (feed time and machine rate out of synchronization), it is estimated that the average savings per tube would be about 20 seconds. This would amount to a savings of 28 outage hours per year.

However, the pickup and bucketing of the irradiated enriched fuel is usually the limiting factor during charge-discharge operations and the improved charging time would apply only to the re-charging of empty tubes. In the past, charging empty tubes has amounted to about 2000 (of the 5000 total) tubes per year, mostly for probologging and tube replacement purposes. It is expected that this number will be reduced by half in the future. Therefore, the actual savings for improved charging rates would be only about 5.5 hours per year (one-fifth of the previous 28 hour estimate).

3. Improved Pickup and Bucketing Rates of Irradiated Material.

All enriched fuel must be bucketed as it is discharged due to criticality considerations. It is not feasible to separate the enriched fuel from the target material, the dummies and the natural mixers. Therefore, the special pickup and bucketing of irradiated material amounts to 60 pieces per tube.

[redacted]

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The current bucketing rate is about 28.5 tubes per hour. The reduced number of pieces to be handled should permit a bucketing rate of over 32 tubes per hour, an improvement of 3.5 tubes per hour. The total outage time savings derived from this item would be 20 hours per year.

4. Increased Reactivity and/or Reduced Fuel Requirements.

The reduction of eight fuel elements per tube would eliminate 16 aluminum end caps. This would amount to four inches of aluminum per tube. Thus, an equal length column would contain four more inches of uranium which would yield more reactivity, more target product and a higher conversion ratio. The actual value of the higher conversion ratio is not within the scope of this study; however, since the 4 inches is a 1.64% increase in the amount of fuel, it is reasonable to expect a 1.64% increase in the amount of target material production.

On the other hand, the fuel column could be shortened by 4 inches after the elimination of the 16 end caps. The total amount of fuel would be the same as the present amount of fuel in each column, but the reactivity would be greater by some finite amount because the column would be shorter (more condensed) and because four inches of aluminum would have been eliminated. Following this line of reasoning a step further, it can be seen that a finite amount of fuel could be eliminated without reducing the reactivity, the target material production or the conversion ratio. It has been estimated* that the elimination of 4 inches of aluminum throughout the metal column would permit the elimination of three times the length (12 inches) of fuel at the ends of the column. Thus, a finite fuel savings would accrue. Each inch of fuel core weighs 0.89 pounds, and 12 inches weighs 10.67 pounds. This would result in an annual fuel savings of 53,400 pounds (26.7 tons), worth $72,900 per year.

This leads to a re-evaluation of the foregoing Items No. 2 and 3.

Item 2: Faster Fuel Charging Rates

The elimination of 1.5 fuel elements per charge would probably be accomplished by eliminating 2 elements from each charge in the 1170-tube block; the fringe enrichment charges would be the same length. This would save another hour per year for charging time.

Item 3: Faster Pickup and Bucketing Time

A reduction of two more elements from each special tube charge would further decrease the bucketing time, saving an additional four hours per year for outage time.

The total annual savings that would accrue from this item would be $72,900 for fuel and 5 outage hours.

* By E. L. Conner, H Reactor assigned Physicist.

[redacted]

It is possible that reactivity studies will show that it is more economical to use full-length columns and receive the benefits of an improved conversion. In this case, it appears self-evident that the improved conversion would be worth more per year than $72,900 and 5 outage hours.

5. Improved Charge Machine Operation

The feed trays on the charge machines are wide enough to handle 8 inch dummies. The fuel that is charged is only 6.54 inches long. Occasionally, a fuel element does not feed straight into the machine because its length is not entirely compatible with the width of the feed tray. When this occurs, the element is caught off-center by the ram and is damaged. It must be rejected and re-canned. However, it appears from out-of-pile examination of ruptured elements that some damaged elements have not been detected and have been charged into the reactor. A machine-damage type of rupture occurs about once per year. Additional maintenance is required to minimize the number of damaged elements; some of the maintenance work costs outage time.

Although it is very difficult to estimate the losses from this item, it appears reasonable to assume that the longer elements could save 15 hours of outage time per year.

6. Decreased Rupture Potential

The rupture potential is proportional to the number of elements in the reactor. Since this proposal would reduce the number of elements about 25%, the number of ruptures should be reduced by about two per year. This would save about 20 outage hours per year.

7. Increased Coolant Flow

The flow through a process tube is determined in part by the length of the fuel column and, to a lesser extent, by the number of slug junctures. It has been estimated* that a 16" reduction in the length of a column would increase the tube flow by about 1 gpm. This would increase the total reactor flow by 1170 gpm, and would increase the annual production by 7000 MWD per year.

8. Improved "Striped" Load

The present "striped" load is the best balance possible using the lengths of elements that are presently available. It is probable that a better "striped" load could be designed if element lengths were determined by the need for the best "striped" load. The target element length is already being changed to permit an improved "striped" load; it permits reducing the types of charges from five to two and it permits an identical number of target elements and fuel elements in all charges. The new "striped" pattern is presently undergoing a 100-tube irradiation test that looks favorable.

* By P. A. Carlson, Process and Reactor Development Sub-Section.

[redacted]

It is believed that a precise fuel element length (within the 8.1" ± 0.1") can be established that will provide an even better reactivity balance. However, an evaluation of this item is not possible at present.

9. Reduced Storage Basin Bucket Requirements

At present, there is a limit on the amount of enriched fuel that may be stored in a basin bucket. This limit is based on critical mass considerations and Chemical Processing batch requirements. As long as this limit is in effect, no savings can be realized from the longer fuel elements. However, it is possible that the limit may be increased when the need for additional buckets becomes acute. The present element length (6.64") is not as compatible with the bucket dimensions (17" x 17") as the proposed element length (8.1"). More fuel of the proposed length could be loaded into each bucket, and additional buckets would not have to be bought. This would also reduce the number of cask car shipments to the Chemical Processing plants.

10. Improved Separation of Irradiated Target and Fuel Elements

The future target elements will be 5.0" long, which is only 1.6" shorter than the enriched fuel elements. A greater length differential is desirable to insure the separation of the two types of irradiated elements in the pick-up chutes. The proposed fuel element length will provide a 3.1" length differential, which is adequate to minimize inadvertent mixing of the products. Until the 100-tube test load is discharged, it is not possible to predict how much trouble will develop from the mixing of the 5" and the 6.6" elements. However, it is suspected that the amount of trouble could dictate either a return to the shorter target elements (and the five types of charges) or the development of longer enriched elements as recommended by this proposal.

I. L. Huffman
Analyst
H Processing

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END

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