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FUEL ELEMENT RECOVERY AND ITS RELATIONSHIP
TO URANIUM SCRAP

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FUEL ELEMENT RECOVERY AND ITS RELATIONSHIP
TO URANIUM SCRAP

I. PURPOSE & SCOPE

At the request of the manager of Process Engineering, a study was made of the fuel element recovery operation and its relationship to the HAPO uranium scrap losses.

Three fundamental questions formed the basis for this study. They are:

1. What is the amount of the yearly uranium scrap loss at HAPO?
2. What contribution does the existing fuel element recovery process make to this loss?
3. What should be done to reduce this loss?

The purpose of this report is to answer these questions and make specific recommendations aimed at reducing these scrap losses. The basis for these recommendations will be explained in the DISCUSSION section of this report.

II. FINDINGS

A. HAPO Losses

The uranium scrap generated at HAPO consists mainly of the bare cores rejected for seams, striations and underweight, and uranium removed from the cores in the recovery and pickle solutions.

The dollar loss results from the difference between the price charged to HAPO for the bare fuel element and the credit HAPO receives for scrap

SPECIAL RE-REVIEW

FINAL DETERMINATION

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BY TE Barker DATE 8/6/81

BY W Jordan DATE 8/7/81

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uranium returned to the supplier for reprocessing, plus freight charges. It does not include HAPO conversion or recovery costs. It is estimated that this loss will amount to 1.5 million dollars during FY '59.¹

Seventy to eighty per cent of this loss results from the fuel element recovery process.

B. Fernald Losses

In order to conform to our metal quality standards, Fernald is rejecting about 13% of their production for seams and striations. To estimate the dollar loss resulting from this scrap, it was necessary to assume that this scrap suffers the same loss in value as that generated at HAPO. Of course, no freight charges are made for Fernald scrap.

On this basis, then, it was estimated that the Fernald scrap losses (for seams and striations only) will amount to 3.5 million dollars in FY '59.

C. Total Losses

Thus, the total loss resulting from uranium scrapped for metal quality defects will amount to approximately \$5,000,000 in FY '59.

If the recommendations of this report are followed and prove successful, most of the HAPO loss can be eliminated. It is the author's opinion that there is nothing we can do at the present time to reduce the Fernald losses.

III. RECOMMENDATIONS

A. To Reduce Scrap Loss With Present Process

1. Metal Quality Standards

It is recommended that no changes be made in the present inspection standards for seams and striations until the reactors have reached their goal of 98°C bulk outlet temperature. If, at that time the rupture rate attributable to core failures is still low enough to indicate that relaxation of core quality standards may be feasible, and if in the meantime, other conditions have not changed so as to wipe out the potential savings, then the matter should be reconsidered.

2. Striations and Weight Loss

In order to reduce striations and weight loss, the following steps are recommended:

1. Based on the Official Production Forecast, F.P.D., May, 1958 through September, 1959, HW-55761RD.

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- a. Determine, for each type fuel element, the optimum stripper and treater cycle to minimize uranium loss. (This step is presently in progress).
- b. Incorporate these cycles into the process standards and establish whatever controls are necessary to insure compliance.
- c. Educate Operations and Quality Assurance in the importance of close control of the Recovery process.

B. Replacement of Recovery Process

It is recommended that we proceed as quickly as possible with development of the melt recovery and direct re-can process. By this process the fuel elements are recovered by melting off the jacket in an AlSi bath and then re-canned directly, without going through any chemical treatment. If successful, this process will eliminate about 85% of the HAPO scrap. It is under development by C. H. Allen.

C. Improvements To Present Recovery Process

It is estimated that it will require at least 18 months to develop and install the melt recovery process. In the meantime, there are several improvements which should be made in the present process to reduce uranium loss and improve working conditions.

1. Replace the existing exhaust fan for the stripper and treater tanks with an exhauster of sufficient capacity to prevent fumes from the stripper from entering the work area. (This item has been included in the Equipment Not Included in Construction Projects Budget for FY '59).
2. Provide an overflow tank for the neutralizer.
3. Interlock the treater transfer pump with the #1 tank agitator, to preclude the possibility of operating the pump with the agitator inoperative. To do so constitutes a safety hazard.
4. It is recommended that action on the proposals for a conveyor system and sludge removal system be postponed until more definite results are obtained with the melt recovery process.
5. No action to increase recovery capacity is recommended.

IV. DISCUSSION

A. Reject Categories

Most of the uranium scrap with which we are concerned falls into four general categories:

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	<u>Per Cent of Total Scrap</u>
1. Seams and striations - Virgin Z Lot	21% 51%
2. Underweights	13%
3. Transformation test and heat treat and Destructive test	8%
4. C-6 sludge	7%

Let us briefly consider each category:

Striations are the result of non-metallic impurities rolled into the metal in the form of minute stringers. When exposed to the nitric acid (in the pickling process) these impurities are removed, leaving what is believed to be a shallow smooth-bottomed trough in the surface of the fuel elements. There is considerable disagreement as to whether or not these troughs constitute stress raisers which would lead to failure of the core under conditions of thermal cycling in the reactors. The author was unable to find sufficient evidence to prove either point of view. It is estimated that striations account for 80 - 90% of the HAP0 Z-lot rejects.

A seam, on the other hand, is a crack or fold in the metal which usually occurs at the time it is rolled into rod. From a theoretical standpoint, at least, there is reason to believe that this type of defect is more detrimental than striations. Approximately 0.5% of the virgin material received from Fernald is rejected at pickle inspection. Most of this is for seams. There is considerable disagreement concerning the ability of visual inspection methods to differentiate between seams and striations with sufficient accuracy and consistency to segregate them.

Underweight cores are canned by the removal of uranium in the canning, recovery, and pickle processes. The specified minimum weight is based on two conditions:

1. Any core which has reached the minimum weight limit has, in all probability, been through the canning and recovery cycle three times. Due to thermal cycling effects, this is considered the maximum permissible.
2. The loss of reactivity in the reactors is considered prohibitive beyond this point.

The third category is not related to the Recovery process, so was not considered within the scope of this report.

The fourth category, C-6 sludge, contains the uranium which is recovered from the process solutions, such as the treater solution, rinse water, and

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pickle acid.

B. Determination of Scrap Losses

1. The average reject rate for seams and striations at Fernald during the period of August, 1957 to March, 1958 was 13.65%. For a rough approximation, it was assumed that this rate was constant for all four types of material; that is, solid and I & E normal and solid and I & E enriched. Using the predicted HAPO bare uranium receipts for FY '59⁽¹⁾ and this reject rate, the amount of scrap was calculated for each type of material. It was then assumed that this scrap suffered the same loss in value as uranium scrapped at HAPO. The uranium price averages for the past 12 month period were used to calculate the resulting loss. These prices are tabulated below for reference.

Material	New \$/lb.	Scrap \$/lb.	Diff. \$/lb.	Diff. \$/T.
Normal - 8" Solid	14.62	13.40	1.22	2440.00
8" I & E	15.07	13.40	1.67	3340.00
Enriched - 6" Solid	30.32	26.00	4.32	8640.00
6" I & E	31.32	26.00	5.32	10640.00

As stated previously, it was estimated that this loss would amount to approximately 3.5 million dollars for FY '59.

2. The cost of the scrap generated at HAPO would, of course, depend upon the yield assumed. It also depends upon the pickle inspection reject rate for recovered ("2" lot) material.

Based on the uranium scrap returns predicted by the Official Production Forecast, the scrap generated at HAPO during FY '59 will result in a loss of approximately 1.5 million dollars, including freight costs.

Examination of the trend in yield rates over the past eight months however, indicates that more optimistic yields than those used in the official forecast might reasonably be assumed. Assumptions must also be made for the pickle inspection reject rate (where the cores are inspected for seams and striations). The average reject rate was computed for the six month period from November, 1957 through April, 1958 and was found to be 10.86% for solid material and 6.5% for I & E. These averages were used to estimate the amount of scrap generated at the assumed yield rates.

(1) Official Production Forecast, F.P.D., May, 1958 through September, 1959, HW-55761RD.

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Assuming then, a 90% yield for solid material, with a 10.86% pickle inspection reject rate and an 85% yield for I & E, with a 6.5% pickle inspection reject rate, the HAPO scrap loss for FY '59 would amount to approximately \$415,000.

C. Metal Quality Standards

It has been shown that scrap losses due to seams and striations at Fernald are costing about 3.5 million dollars/year and at HAPO, somewhere between \$415,000 and 1.5 million/year, depending upon the yields obtained. The obvious question then is, "can we reduce this loss by relaxing the metal quality inspection standards?"

It should be borne in mind that the existing metal quality standards were established on a "best judgement" basis at a time when the reactors were experiencing an epidemic of ruptures attributed to core failures. There was no technological basis for believing that all material which does not meet these standards will fail in the pile, and that which does not meet these standards will not. As far as this writer was able to determine, there exists today no more technological basis for the establishment of metal quality standards, (at least relative to seams and striations), than existed then. Therefore, any change in standards made in the immediate future would again have to be made on a "best judgement" basis.

It should also be kept in mind that conformance to these standards depends entirely upon visual inspection. Therefore, even if a sharp line of demarcation could be drawn between satisfactory and unsatisfactory material, it is extremely doubtful that the material could be segregated accordingly with our present inspection methods.

It requires from two to four months from the time the cores are shipped from Fernald until they are charged into the reactors. It would probably require a year of exposure to determine that an increase in ruptures was due to the change in core quality. Thus, there would be a total time lag of fourteen to sixteen months between a change in standards and indication of effect. During that time, we would be processing and charging our entire production, with no way of retrieving the "bad" material if we found ourselves in difficulty.

Now let us assume that by relaxing the standards we could save \$1,000,000 of the \$5,000,000 total annual scrap loss. It would take only twelve ruptures to wipe out the savings, or, an increase of 1 per month.

There are other reasons why relaxation of metal quality standards is not advisable at this time:

- (1) As the reactors strive for higher and higher power and exposure levels, quality of the core, particularly its resistance to stresses imposed by thermal cycling, will become increasingly critical. Tests conducted

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by Johnson, Gard and O'Claire² established a definite correlation between core quality and failure under thermal cycling.

- (2) Dingot material, which is essentially free of striations, is expected to provide half of HAPO input in the next few months. This should reduce the scrap loss very significantly.
- (3) An investigation of the feasibility of recovering striated elements by machining to a smaller size is being carried out by C. A. Burgess. This, too, would reduce the scrap by a substantial amount.

Consideration was given to the possibility of obtaining some technological basis for our metal quality standards by means of a reactor test. There are several reasons why this is not practical at the present time.

- (1) Previous attempts to measure core quality on the basis of reactor performance have been discouraging. There are many reasons for this, the explanation of which is beyond the purpose of this report. Suffice to say that there is serious doubt as to the validity of such tests.
- (2) In order to obtain sufficient statistical basis for evaluating results, the material to be tested (all material presently being rejected for striations) would have to be segregated in FPD and lot-charged into the reactors. Exposure and rupture data would have to be compiled over a long period of time. It is estimated that such a test would require about three years. During this time, the reactors will be raising power levels and tube outlet temperatures. Since these conditions have a strong effect on core performance, it would be impossible to correlate performance to metal quality.
- (3) The charging of large quantities of "sub-standard" material, at the very time when the reactors are striving for higher power and exposure levels would be a very difficult thing to sell to IPD.
- (4) Such a test would inevitably bring about an increase in ruptures and the resulting costs in reactor down-time could quickly offset the potential savings.

For these reasons, it is recommended that, until the reactors reach their stated goals, we accept the 3.5 million dollar scrap loss at Fernald as the price we must pay to be assured of the core quality required, and turn our attention to the HAPO losses, over which we may have some control.

D. Reducing HAPO Scrap

1. Melt Recovery and Direct Re-can

From 70 to 80% of the HAPO uranium scrap loss is directly or indirectly

2. Correlation Study Involving Results Of The MIZ-2 Test, The Induction Cycling (woodsplitter) Test, and Other Physical & Chemical Tests on Uranium, by H. A. Johnson, J. J. Gard and E. H. O'Claire, HW-34427, January 12, 1955.

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caused by the present recovery process. The melt recovery and direct re-can process should eliminate this portion of the HAPU scrap, thus saving \$300,000 to \$1,200,000 per year. (This would not be a net savings, since installation costs are not considered).

It would seem reasonable to question why these figures are so far apart. It should be understood that both the amount of the scrap loss and the percentage of that loss caused by the present recovery process depend upon the yield rates, but they are not directly proportional. Thus a change in assumed yields results in a disproportionate change in losses (or gains). This anomaly will show up again in the following discussion.

2. Reduction of Uranium Removal in Recovery

A comparison between reject rates for seams and striations in virgin material and recovered material indicates that striations are being uncovered by the removal of uranium in the canning, recovery and pickle processes. Since about 95% of this loss takes place in the recovery process, efforts are presently being concentrated in this area. It is the writer's opinion (shared by others) that we can reduce this loss significantly by closer control of the stripper and treater. Uniform stripping is essential to minimizing metal removal and several methods of obtaining this are under consideration. They are:

- (1) Mechanical removal of the cap
- (2) Use of inhibited caustic
- (3) Mechanical stripping
- (4) Two-step stripper process

Several attempts have been made by others over a period of several years to mechanically remove the cap and can, with varying degrees of success. All were on a laboratory scale and, although the same principles might be applicable to a production machine, considerable development and experimentation would be required.

In order to make some estimate of the potential savings, it was hypothetically assumed that we might reduce the present pickle inspection reject rate (for seams and striations) by one-half. Again assuming a 90% yield for solid material and an 85% yield for I & E, the resulting scrap loss for FY '59 would amount to \$193,000. This would be a saving of \$224,000 over the previous estimate based on the same yields. Using the yields predicted in the Official Forecast, the savings would amount to approximately \$780,000. It should be understood that the purpose in calculating and presenting these figures was not to say that this much can be saved, but rather to point out a worthy target and obtain some measure of its size. In this manner, it provides a basis for deciding how much money should be spent on improving the existing recovery process.

3. Neutralizer Overflow Tank

The design of the existing facilities for neutralizing the treater solution was based on the assumption that the solution would be at a constant con-

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centration of 50%. In practice, it is neither 50% concentration nor constant. Since there is no direct indication of concentration, it frequently happens that the neutralizer is full while the solution is still acid. It then becomes necessary to drain off part of the solution, to make room for more caustic, and dump it down the drain. This results in an estimated yearly loss of \$4000 worth of uranium. The installation of an overflow tank is economically justified and recommended.

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Process Engineering Operation
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