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Special

RECOVERY OF URANIUM FROM PIQUA
COLD SCRAP FUEL ELEMENTS

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1. INTRODUCTION

The shutdown of the experimental organic cooled reactor at Piqua, Ohio, left freshly fabricated AEC owned fuel in storage at Atomics International, Canoga Park, California. The AEC placed the fuel in their cold scrap account and requested bids for recovery of the contained uranium. In addition to the private industrial bids received, an AEC out-of-pocket cost estimate was submitted by the National Lead Company of Ohio, contract operator of the AEC Feed Material Production Center. The estimate was significantly lower than the industrial bids; therefore the work was assigned to NLO. The assignment specified detailed surveillance of all costs and material losses so that actual recovery costs could be determined. This report describes the recovery process for 7148 uranium pounds of 1.94% U-235 Piqua cold scrap from receipt of material to production of pure uranyl nitrate, control methods, material balances, surveillance, and costs that were required to fulfill the AEC production order.⁽¹⁾ The costs are divided into three groups: total operating, AEC out-of-pocket, and special surveillance.

2. SUMMARY

The Piqua cold scrap was declad, digested, and the contained uranium extracted with a material loss of 0.28%, based on uranium feed weight. The molybdenum in the alloy required additions of ferric nitrate in the digestion operation to prevent the formation of uranyl polymolybdate solids, and extraction conditions had to be selected to determine if the molybdenum had a detrimental influence on the extraction system. The total cost, which includes material losses for the recovery of the uranium from the Piqua cold scrap, was \$19,689 or \$2.75 per pound of uranium feed. The downgrading cost of \$19,689 was not included in the total cost because it was necessary to use the Piqua cold scrap, originally scheduled for the 2% U-235 campaign, for the 0.947% U-235 enriched campaign.

The National Lead Company of Ohio out-of-pocket cost estimate to the AEC was \$1,355, but the actual AEC out-of-pocket cost was \$2,314. The higher than estimated AEC out-of-pocket cost was due primarily to a decision on a mechanical decladding route rather than the planned lower cost chemical decladding process. The mechanical process was chosen to avoid equipment priority problems in drum digestion, to make the best use of manpower available at the time, and for convenience in materials control.

The special surveillance costs were \$3,778. The special surveillance was undertaken to demonstrate and record that the large scale FMPC facilities can process relatively small quantities of special material for uranium recovery at low cost and minimum material loss.

All phases of Piqua recovery operations were routine and without problems except that a shipper-receiver difference of 58 U pounds was detected during the process and was verified by the overall material balance. The gross fuel element weights, however, were in agreement.

3. MATERIAL DESCRIPTION

The Piqua fuel consisted of inner and outer elements as shown in Figure 1.

Figure 1 - Piqua Fuel Elements, Inner Element on Left,
Outer Element on Right

These had been fitted together to form a tube-in-tube assembly. Both inner and outer elements were hollow cylinders of a uranium-molybdenum-aluminum alloy electroplated with nickel and clad with aluminum. The spiral fins were machined into the surface of the exterior and interior cladding at fabrication. The physical dimensions were:

	Outer Element (In.)	Inner Element (In.)
O.D. aluminum cladding	5.124	4.096
O.D. uranium alloy tube	4.840	3.812
I.D. uranium alloy tube	4.420	3.392
I.D. aluminum cladding	4.136	3.108
Length uranium alloy tube	13.127	13.127
Length aluminum cladding	13.605	13.605
Thickness of nickel plate	0.0015	0.0015

The combined group of 164 inner and 164 outer fuel elements contained 7,148 pounds of uranium at 1.94% U-235 enrichment in a 3.8% Mo-0.2% Al alloy.

4. PROCESS DESCRIPTION

4.1 Material Receipt

The 164 inner elements and 164 outer elements of the Piqua cold scrap were counted and weighed upon receipt. The National Lead Company of Ohio weight of 8,318 material pounds was within normal scale tolerance of the Atomics International weight of 8,328 material pounds. However, subsequent decladding and assay work did determine the shipper-receiver differences that are listed in Table 1.

Table 1 - Material Receipt Summary

Item	National Lead Company of Ohio	Atomics International ¹	Difference
Weight, Received or Shipped	8,318 lbs.	8,328 lbs.	AI + 10 lbs.
Cladding Weight	864 lbs. ²	813 lbs.	NLO+ 51 lbs.
Alloy Weight	7,454 lbs.	7,515 lbs.	AI + 61 lbs.
Assay	95.89%	95.89%	--
Uranium Weight	7,148 lbs. ³	7,206 lbs.	AI + 58 lbs. or 0.81%

¹ LAE-FVA 14 and 15.

² From Figure 2 - 850 pounds of aluminum cladding in storage and 14 aluminum pounds discharged to the waste pit.

³ Digestion of the alloy has confirmed NLO's determination of the contained uranium.

4.2 Decladding Operation

4.2.1 Test and Evaluation: Several Piqua pieces were sent to the Laboratory Machine Shop for decladding tests. At this time wafers were cut for metal dissolution evaluations. These two operations on two inner and two outer elements generated the only uranium-bearing residues that were produced in the Laboratory Machine Shop and the Laboratory. The flowsheet (Figure 2) indicates the main flow and the routing used to return the residues to the process.

Figure 2 - Decladding Flowsheet and Material Balance

The two uranium pounds remaining in residue storage are estimated by difference. Visual inspection indicates very little uranium in the cladding residues. This could be recovered by acid leaching, but at excessive cost for such a small quantity.

4.2.2 Production Decladding: The production decladding operation was assigned to the Laboratory Machine Shop because the limited quantity of Piqua material did not warrant the transfer of the operation to a production plant.

The first step in removing the cladding involved cutting two threads per inch through the exterior aluminum jacket to the nickel plate (Figure 3).

Figure 3 - Threading the Exterior Aluminum Cladding

The next step was to unwind manually the aluminum ribbon formed by the threading operation (Figure 4). As can be seen, these were clean operations which generated little or no uranium-bearing residues.

Figure 4 - Manual Removal of the Aluminum Ribbon

Note in Figure 5 that the nickel sheet (indicated by arrows) between the uranium alloy and the aluminum cladding was torn, not cut. This shows that the threading tool did not touch the uranium alloy surface.

The interior cladding was removed by first crimping one end of the cladding with hand tools and then using a hydraulic press to drive wedges between the uranium alloy cylinder and the cladding (Figure 6).

Figure 5 - Aluminum Ribbon after Removal. Arrows indicate torn nickel sheet.

Figure 6 - Pushing the Wedges in the Tube.

When the wedges were withdrawn the collapsed interior cladding was removed from the uranium alloy tube (Figure 7).

Figure 7 - Removal of the Collapsed Interior Cladding

4.3 Metal Dissolution

The Piqua enrichment (1.94% U-235) and the specified material control necessitated the use of the Refinery drum digestion system for dissolution of the Piqua cold scrap.

- 4.3.1 Equipment Description: The drum digestion system consists of eight stations for heating, agitating and ventilating 55-gallon stainless steel digestion vessels. (The mechanical agitators and the heating systems were not required for dissolution of the Piqua cold scrap.) Each station has its own head tank for measuring reagent additions. These head tanks are charged from two storage tanks. One storage tank contains nitric acid. The other is equipped to handle reagents that are slurried in nitric acid or water. The digestion product (uranyl

nitrate) is removed from the digestion vessels by a power syphon and then pumped through a series of filters to one of two product storage tanks. Liquors from the isolation sump are also pumped through the filters to the product tank.

4.3.2 Equipment Preparation: Preparation required the emptying and cleaning of the entire system (reagent tanks, filters, digestion stations and vessels, product tanks, ventilation system, and the isolation sump). With the exception of the two reagent storage tanks, the system was flushed with four molar nitric acid to ensure removal of any residual materials. When flushing was completed, new cartridges were installed in the filters.

4.3.3 Operation and Material Balance: In addition to nitric acid, ferric nitrate was required for the dissolution of the Piqua cold scrap in order to prevent the formation of uranyl polymolybdate solids.⁽²⁾ Therefore, the first dissolution step was to digest 1780 pounds of scrap drums, lids, and locking rings in the metal dissolver. The resultant ferric nitrate solution was transferred to the reagent slurry storage tank. After both the reagent slurry storage tank and the nitric acid storage tank were filled, their inlets were sealed, the volumes measured, and the material sampled. The measurement and sampling was repeated at the end of the digestion operation.

The Piqua cold scrap digestion charges were weighed on a 0.1-pound graduated scale that was calibrated at the start of the operations. The charge weight ranged between 90 and 95 alloy pounds. A red precipitate was formed during the first digestion batches. The acid addition sequence was adjusted and the precipitate formation was eliminated for the remainder of the run. The precipitate that had been formed was pumped into the filters where it was dissolved by the free acid in the remaining batches.

After completion of the run, the drum digestion system was shut down and cleaned. It was flushed with four molar nitric acid. All cleanout liquors were transferred to the product tanks. The volume was measured and the material was sampled before the product tank outlets were unsealed. Although the filter cartridges showed no apparent material build-up, they were removed at the end of the run and placed in storage for resolution of the uranium balance.

The above operations were closely followed by a surveillance team consisting of non-production salaried personnel. They were responsible for checking the preparation and shut down of the drum digestion system along with verifying the measurement of all feeds entering and products discharged from the system. The following flowsheet (Figure 8) was developed from the surveillance data.

Figure 8 - Dissolution Flowsheet and Material Balance

4.4 Extraction Feed Preparation (Isotopic Blending Flowsheet and Material Balance)

Close material control within the physical operating limits of the extraction system required careful preparation of the extraction feed. A continuous digestion batch of low enriched material (0.803% U-235) was made and held in the isotopic blend tanks. The material was agitated and cycled between the two tanks until one uniform batch was obtained.

The Piqua digestion solution was used to adjust the isotopic level of the material in one of the blend tanks. This blending was required to: (a) increase the quantity of feed above the minimum requirement for a controlled extraction operation, and (b) reduce the molybdenum concentration in the Piqua solution in order to minimize the possibility of uranyl polymolybdate solids loss in the raffinate.

The other blend tank was adjusted with uranyl nitrate (2.261% U-235) obtained by digestion of pure uranium dioxide (CAP*). The CAP adjusted material, in the second tank, was required (a) to provide a standard for comparison in case there was an operational imbalance, and (b) to provide a lead feed material to bring the operation to equilibrium before introducing the Piqua material.

The control for this operation involved checking all calculations and sampling the blend feeds and products which are illustrated in Figure 9. Surveillance was not required.

*CAP: Commercial Assay Program, material returned by lessees to AEC for credit.

Figure 9 - Isotopic Blending Flowsheet and Material Balance

*Except where otherwise noted

4.5 Extraction

4.5.1 Equipment and Process Description: The extraction operation consists of four major phases: extraction, scrub, re-extraction or strip, and solvent treatment. The aqueous feed (bearing uranyl nitrate) is pumped at a constant rate to two extraction pulse columns (operating in parallel) where it contacts the organic solvent. The uranium is transferred to the solvent, and the raffinate (the aqueous phase) is discharged to hold tanks for measurement and sampling prior to disposal. The solvent is transferred from the extraction columns to a four-stage mixer-settler scrub system where the solvent is contacted with deionized water for removal of impurities. The water (aqueous phase) containing impurities is discharged to the feed tank for re-entry into the extraction system and eventual discharge with the raffinate to the chemical waste pit. The solvent is discharged from the scrub system to two strip pulse columns (operating in parallel) where it is contacted with deionized water for removal of uranium. The strip column aqueous phase, containing uranyl nitrate, is collected in batch tanks where it is measured and sampled. The uranium-barren solvent is transferred to the solvent treatment system to be cleaned by contact with sodium carbonate and reacidified with nitric acid prior to its return to the extraction columns. The carbonate and acid waters from the solvent treatment system are collected with the extraction floor sump wastes, and for this run were measured and sampled prior to discharge to the Refinery sump system.

4.5.2 Operation (Material Balance): The extraction operation was monitored by an independent surveillance team which measured and sampled the extraction inflows and outflows on an hourly basis and the internal process check points every two hours. The process check was required in case a system imbalance occurred. However, the process data was not needed because system balance was maintained, as expected.

The extraction system was started using the CAP adjusted material as the lead feed. As anticipated, startup instability did occur for the first eight to ten hours of operation. After equilibrium conditions were reached, the CAP adjusted material was fed for about one day to obtain a comparison base to use in the evaluation of the Piqua run. Then the feed was switched to Piqua adjusted material. The Piqua-CAP comparison is presented later in this report.

The surveillance data was used to construct a material balance around the extraction system. Because the Piqua adjusted material was routed into the system directly behind the CAP adjusted material, there was a problem in determining the discharge break points between the two. This was resolved by applying the CAP-Piqua feed time ratio to the discharge times. Even then adjustments had to be made to the time-flow charts because the strip water was started early and sump flows ended late. Once the charts were completed the following uranium balance was obtained (Figure 10).

Figure 10 - Extraction Uranium Balance and Flowsheet

A comparison (Table 2) of Piqua-CAP extraction operations indicates that no abnormal operation or material loss occurred.

Table 2 - Piqua-CAP Operational Comparison

<u>Item</u>	<u>U g/l*</u>	
	<u>Piqua</u>	<u>CAP</u>
Feed Concentration	308	286
Product High Concentration	97	88
Product Low Concentration	87	80
Average Mo Concentration (Product) ppm	5	2
Raffinate High Concentration	0.065	0.059
Raffinate Low Concentration	0.017	0.016
Solvent Carbonate Wash High Concentration	0.035	0.40
Solvent Carbonate Wash Low Concentration	0.034	0.19
Solvent Acid Wash High Concentration	0.0007	0.001
Solvent Acid Wash Low Concentration	0.0005	0.0005
Sump Liquors (floor sump plus solvent treatment wastes)		
High Concentration	3.1	2.0
Low Concentration	0.6	1.45

*Except where otherwise indicated.

4.6 Overall Piqua Uranium Balance

The Piqua uranium balance covering from receipt to extraction product is presented in Table 3. It should be noted that receipt to product difference using NLO receipt weight as a basis is only 1.09%. A portion of that material is recoverable which reduces the receipt to product loss to 0.28%. (Commercial contracts usually allow a 1.5% "measured loss and unaccounted for" difference, which is

comparable with the 0.28% overall loss. The NLO losses are well within normal losses experienced by commercial recovery units.)

Table 3 - Overall Piqua Uranium Balance

<u>Item</u>	<u>Uranium Pounds</u>	<u>% Difference Based on NLO Receipt Wts.</u>
<u>Overall Difference</u>		
Received from AI	7148	--
Extraction Product	7070	--
Overall Difference	78	1.09
<u>Recoverable</u>		
Machining Residue	1	
Metal Dissolution	2	
Extraction Sump	55	
Recoverable Total	58	0.81
<u>Unrecoverable</u>		
Machining Residue	1	
Extraction Sump	1	
Extraction Raffinate	9	
Unrecoverable Total	11	0.15
<u>Overall Loss (Comparable to Commercial "measured loss and unaccounted for") = Overall Difference Minus Recoverable</u>		
	20	0.28
<u>Unaccounted For = Overall Difference Minus Recoverable and Unrecoverable</u>		
	9	0.13

5. COSTS

The costs for recovery of the Piqua cold scrap have been determined on both a total cost and an AEC out-of-pocket cost basis. The special surveillance (or control) costs are treated as an item separate from total and AEC out-of-pocket costs because they would not be incurred in a normal production operation.

5.1 Total Costs

The costs for recovery of the Piqua cold scrap excluding downgrading costs are presented in Table 4. Downgrading costs of \$19,689 (found in Table 5) are not considered part of the total cost because the Piqua cold scrap was actually scheduled for the 2% U-235 Refinery campaign. Scheduling delays caused by feed preparation and feed availability produced limitations in the blend stock which increased the possibility of Piqua material losses. Therefore, the Piqua run was shifted to the 0.947% U-235 campaign.

Table 4 - Total Costs (Not Including Downgrading Costs)

	(Column 1) <u>Plant 1</u>	(Column 2) <u>Laboratory Machine Shop</u>	(Column 3) <u>Refinery</u>
Wages	\$ 220	\$1,196	\$ 403
Salaries	112	300	76
Direct Material	--	--	--
Other Supplies & Expenses	2	--	1
Maintenance Wage	--	358	204
Maintenance Material	1	71	133
Electricity	<u>--</u>	<u>35</u>	<u>2</u>
Sub-total	\$ 355	1,960	\$1,069
Water & Steam	57	37	136
General & Adminis- trative	<u>398</u>	<u>1,986</u>	<u>839</u>
Direct & Indirect	\$ 790	\$3,983	\$2,044
Depreciation	<u>100</u>	<u>0</u>	<u>406</u>
Plant Total	\$ 890	\$3,983	\$2,450

Table 4 contd

A. Production (Total Columns 1, 2 & 3) \$ 7,323

Chemical Department

Salaries \$2,554
General & Administrative 2,171

B. Total - Chemical 4,725

Analytical Department

Digestion
Salaries 735
General & Administrative 772

Extraction
Salaries 33
General & Administrative 34

C. Total - Analytical 1,574

Advance Planning

D. Salaries - General & Administrative 684

Engineering

E. Salaries - General & Administrative 2,182

Total Direct and Indirect \$16,488
(Total of Items A through E)

AEC Cost (15%) 2,472

Operating Cost \$18,961

Material Loss

The 0.803% U-235 blend fraction of the Piqua run losses would have been experienced through normal NLO operations and is not considered as part of the Piqua recovery loss.

Piqua Material Loss

20 uranium pounds at 1.94% U-235

Separative Work
 $20 \times 0.454 \frac{\text{pounds}}{\text{Kg}} \times 2.07380 \text{ Sep. Wk. (Kg)}$
 $\times \$14.13/\text{Kg} =$

\$ 266

Table 4 contd

<u>Feed</u>	
20 x 3.40509	<u>pounds normal</u> x \$6.78/pound normal = \$ 462
	<u>pounds 1.94%</u>
	U-235
<hr/>	
Total Material Loss	\$ 728
<hr/>	
Total Costs (Operating and Loss)	\$19,689

The unit total cost was \$2.75 per pound of Piqua uranium feed.

Table 5 - Theoretical Downgrading Costs

Blend Components

Piqua Material at 1.94% U-235	
Extraction Product	7070 U pounds
Extraction Residues	<u>55 U pounds</u>
Piqua Total	7125 U pounds
7125 U pounds x 0.454 <u>pounds</u> x	
	<u>Kg</u>
2.07380 Sep. Wk. (Kg) x \$14.13/Kg =	\$94,787
Low Grade Material at 0.803% U-235	
Extraction Product	48730 U pounds
Extraction Residues	<u>383 U pounds</u>
Low Grade Total	49113 U pounds
49113 U pounds x 0.454 <u>pounds</u> x	
	<u>Kg</u>
0.10773 Sep. Wk. (Kg) x \$14.13/Kg =	<u>33,942</u>
Component Value	\$128,729

Blend Product

Value of blend product at 0.947% U-235	
56238 U pounds x 0.454 <u>pounds</u> x 0.30227	
	<u>Kg</u>
Sep. Wk. (Kg) x \$14.13/Kg =	<u>109,049</u>
Unadjusted Downgrading Cost	\$ 19,680

Table 5 contd

Adjustment to Downgrading Costs

Three uranium pounds of Piqua cold scrap which are not accounted for in loss material or in the downgrading calculations will eventually be recovered from the Machining and Metal dissolution residues into the 0.947% U-235 stream.

Blend Components

Piqua Material at 1.94% U-235 - 3 U pounds
 $3 \text{ U pounds} \times 0.454 \frac{\text{pounds}}{\text{Kg}} \times 2.07380$

Sep. Wk. (Kg) x \$14.13/Kg = \$ 40

Low Grade Material at 0.803% U-235
 $3(1.94) + x(0.803 = (3+x)(0.947)$
 $X = 21 \text{ U pounds at } 0.803\% \text{ U-235}$

$21 \text{ U pounds} \times 0.454 \frac{\text{pounds}}{\text{Kg}} \times 0.10773$

Sep. Wk. x \$14.13/Kg = 16

Component Value \$ 56

Blend Product

Value of blend product at 0.947% U-235
 $24 \text{ U pounds} \times 0.454 \frac{\text{pounds}}{\text{Kg}} \times 0.30227$

Sep. Wk. (Kg) x \$14.13/Kg - \$ 47
 Downgrading Adjustment \$ 9

Total Theoretical Downgrading Cost \$19,689

5.2 AEC Out-Of-Pocket Costs

The AEC out-of-pocket costs are tabulated in Table 6. The difference of \$959 between the estimated cost of \$1,355 and the actual AEC out-of-pocket cost of \$2,314 is due to a process change. Although the estimate was based on chemical decladding, the slightly more expensive mechanical route was selected to avoid scheduling conflicts with the succeeding enriched 2% U-235 campaign.

Table 6 - AEC Out-Of-Pocket Costs

	(Column 1) <u>Plant 1</u>	(Column 2) <u>Laboratory Machine Shop</u>	(Column 3) <u>Refinery</u>
Wage	\$220	\$1,196	\$403
Direct Material	--	--	250
Maintenance Wage	--	--	--
Maintenance Material	1	71	133
Other Supplies & Expense	2	--	1
Electricity	<u>--</u>	<u>35</u>	<u>2</u>
Plant Total	\$223	\$1,302	\$789

Total Columns 1, 2 and 3 = \$2,314 AEC Out-Of-Pocket Costs

5.3 Surveillance and Other Special Costs

Earlier portions of this report mentioned the use of surveillance teams to monitor the operation. This monitoring was required to insure detection of any abnormal operations and the accumulation of related costs that would not be available under normal operating procedures. The costs that are related to the surveillance are in Table 7. The costs (\$3,778) are not included in any other portion of this report.

Table 7 - Surveillance and Other Special Costs

<u>Project Labor Pool</u>		
Wages	\$ 54	
Salaries	20	
General & Administrative	<u>138</u>	
		\$ 212
<u>Analytical Department</u>		
<u>Digestion</u>		
Salaries	216	
General & Administrative	<u>227</u>	
<u>Extraction</u>		
Salaries	676	
General & Administrative	<u>710</u>	
		1,829

Table 7 contd

<u>Surveillance Team</u>	
<u>Digestion</u>	
Salaries -	
General & Administrative	274
<u>Extraction</u>	
<u>Salaries -</u>	
General & Administrative	<u>1,463</u>
	<u>1,737</u>
Total Special Costs	\$3,778

6. ACKNOWLEDGEMENTS

This work was a team effort and required the services of many people. In particular, acknowledgements are made to J. S. Simonds for development of the decladding operation, N. R. Leist for assistance in developing the Refinery control and check system, and M. M. Julliard in preparing the cost data.

Departmental contribution of manpower for the Surveillance Teams were:

Process Engineering	4 men
Nuclear Materials Control	2 men
Quality Control	3 men
Advance Planning	2 men
Chemical	2 men

7. REFERENCES

1. AEC-CAO Production Order No. M-501, December 11, 1968.
2. Report: E. H. Krautter, J. H. Muller, and N. R. Leist to J. H. Cavendish, Subject: Dissolution of Piqua Fuel Elements in Nitric Acid, January 28, 1969.