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# THORIUM FUEL CYCLE DEVELOPMENT PROGRESS REPORT

SEPTEMBER 1969

No. 2

Compiled by

The Staff of the Chemical Technology

and

Metals and Ceramics Divisions

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CHEMICAL TECHNOLOGY DIVISION
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# THORIUM FUEL CYCLE DEVELOPMENT PROGRESS REPORT

SEPTEMBER 1969

No. 2

## I. HEAD-END REPROCESSING DEVELOPMENT

R. E. Blanco, W. E. Unger, V. C. A. Vaughen, C. D. Watson

## II. REFABRICATION DEVELOPMENT

R. G. Wymer, A. L. Lotts, R. E. Brooksbank, P. A. Haas
W. D. Bond, J. W. Snider, J. D. Sease

## III. MATERIALS IRRADIATION

A. L. Lotts, T. N. Washburn, J. D. Sease, J. H. Coobs

## IV. URANIUM-233 REPROCESSING

R. E. Brooksbank, J. R. Parrott

SEPTEMBER 1969

OAK RIDGE NATIONAL LABORATORY
Oak Ridge, Tennessee
operated by
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U. S. ATOMIC ENERGY COMMISSION

# CONTENTS


| | Page |
|---|---|
| Abstract | 1 |
| Introduction | 1 |
| I. HEAD-END REPROCESSING DEVELOPMENT | 2 |
| Studies with Irradiated Fuels | 2 |
| Head-End Engineering Studies | 2 |
| II. REFABRICATION DEVELOPMENT | |
| Particle Preparation | 3 |
| Fueled Graphite Fabrication Development | 8 |
| III. MATERIALS IRRADIATION | |
| Irradiation of Prototype Recycle Fuels | 13 |
| IV. URANIUM-233 REPROCESSING | |
| Dissolution and Purification | 14 |
| Storage and Distribution | 14 |
| LWBR Support | 15 |

# THORIUM FUEL CYCLE DEVELOPMENT PROGRESS REPORT

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## ABSTRACT

This is the second in a series of monthly reports which will give the progress on programs relating to the thorium-$^{233}U$ fuel cycle. The programs, which are almost solely directed toward application in HTGR's include head-end processing, refabrication development, and irradiation testing of fuels. This series of reports continues the reporting previously done in this area in the ORNL Fuel Cycle Studies Report.

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## INTRODUCTION

The thorium fuel cycle development at ORNL is directed almost solely at HTGR fuels. These fuels consist of large blocks of graphite containing coolant channels and fuel and blanket holes. The fuel and blanket are made of microspheres of uranium or thorium separately, or of mixtures of them in a single microsphere. The microspheres are coated with layers of pyrolytically deposited carbon and in some cases silicon carbide. The microspheres are retained in the holes in the graphite blocks in either unbonded or bonded forms.

Development work on all aspects of HTGR fuel recycle is in progress at ORNL. In addition, a major recycle development facility, the Thorium-Uranium Recycle Facility (TURF), has been built at ORNL, and the Coated Particle Development Laboratory (CPDL) has been put into operation in Building 4508. TURF is intended to be used as a development pilot plant for fuel recycle. The CPDL is for engineering development studies leading to design of the pilot plant equipment.

# I. HEAD-END REPROCESSING DEVELOPMENT

(R. E. Blanco, W. E. Unger)

The objective of this program is to evaluate head-end processes for converting irradiated HTGR fuels to a form suitable for recovery and decontamination of the thorium and uranium by the solvent extraction process. Small samples of irradiated and unirradiated fuel are processed to determine irradiation effects which affect fuel reprocessing steps and to provide a comparison with metallographic studies. An important objective is the determination of the amount of breakage of coatings and the resultant amount of cross contamination of the fertile Th-$^{233}$U and fissile $^{235}$U components in alternative reprocessing steps. Mechanical systems are being developed for degrading the fuels and providing a material suitable for use in studies of the burn-leach steps using fluidized bed or fixed bed burners. The mechanical and burn-leach engineering development work is carried out using full scale unirradiated fuel and is designed to provide scale-up data for use in the design of pilot or full scale processing plants.

## 1. Studies with Irradiated Fuels

(V. C. A. Vaughen, J. H. Goode, G. Davis)

Evaluation of the data from the crush-burn-leach experiment on Dragon fuel is still in progress. The reduction in funding in this area and the unavailability of irradiated fuel has temporarily stopped all work except data evaluation and reporting.

## 2. Head-End Engineering Studies

(C. D. Watson, R. S. Lowrie)

The head-end engineering studies are comprised of two principal areas of investigation — mechanical and burn-leach. The present general approach involves the mechanical dissection by sawing of full-sized graphitic blocks containing fuel sticks followed by comminution to size fractions suitable for the downstream burn-leach process. However, recent decisions leading to the possible use of loose fuel particles rather than fuel sticks may alter this approach quite drastically in future work.

There is nothing to report in this area this month.

# II. REFABRICATION DEVELOPMENT

## 1. Particle Preparation

(R. G. Wymer - Coordinator)

The fuel material of primary interest for ORNL recycle studies is the $ThO_2$-$UO_2$ particle, which has a thorium-to-uranium ratio of about 4.25. The uncoated fuel particles are to be microspheres 350 ± 100 μ in diameter, made by the sol-gel process. Fuel preparation includes development and demonstration of all process steps involved in making remotely the $ThO_2$-$UO_2$ microspheres. The steps include demonstrating a reliable, remote method for reproducibly mixing $Th(NO_3)_4$ and $UO_2(NO_3)_2$ solutions in the desired thorium-to-uranium ratio, preparing the mixed, stable $ThO_2$-$UO_3$ sol in concentrations exceeding 1 g-mole of oxides per liter, and forming $ThO_2$-$UO_3$ gel microspheres to dense $ThO_2$-$UO_2$ in good yield.

### 1.1 Sol and Microsphere Preparation Development

(P. A. Haas)

Experimental engineering studies of processes and equipment for preparation of sols and microspheres are reported here. The present emphasis is on processes, procedures, and prototype equipment for preparation of oxide microspheres in the Thorium-Uranium Recycle Facility (TURF). Tests of flowsheets and procedures to be used for test materials preparation are also included.

During May a four-day run was made in the Coated Particle Development Laboratory equipment to prepare 43.2 kg of $ThO_2$-$UO_2$ microspheres. Material balances and product analyses are tabulated below (Table 1-1). The $ThO_2$-$UO_3$ sol used in preparing the microspheres was produced by a solvent extraction process as part of a campaign to prepare 100 kg of sol in 10 days of continuous operation of engineering equipment.

A 99.5% material balance was obtained across the entire sphere forming operation, from sol fed to the column to fired spheres. About 10% of the material was diverted as samples for analyses and other studies. Of the 90.1% that appeared

Table 1-1. Material Balance for Five-Day Run in Coated Particle Development Laboratory

Conditions: (1) All weights refer to $ThO_2$-$UO_2$ content of described material

(2) Feed was $ThO_2$-$UO_3$, low nitrate, solvent extraction type sol
Th/U ratio: 4.25/1

| | Quantity of $ThO_2$-$UO_2$ (kg) | Quantity as Percent of Material Fed |
|---|---|---|
| I. Material fed into column (from sol weight and concentration) | 43.206 | 100.0 |
| II. Materials removed from column and dryer | | |
| <u>Normal Process Wastes or Losses</u> | | |
| Solids in waste 2EH | 0.102 | |
| Dust from dry material transfers (filters) | 0.156 | |
| Equipment clean-out following run | 0.265 | |
| Wastes removed from large settler | 0.133 | |
| Solid lost through distillate to waste drain | 0.001[a] | |
| Subtotal | 0.657 | 1.5 |
| <u>Product Materials</u> | | |
| Calcined product (assuming that all dryer product had been calcined, i.e., no samples removed) | 38.135 | |
| Removed after non-process column upsets | 1.192[b] | |
| Samples removed for laboratory uses | 0.994[b] | |
| Left-over beads dried separately in laboratory | 1.994 | |
| Subtotal | 42.315 | 98.0 |
| Total Removed (or accounted for) | 42.972 | 99.5 |
| Discrepancy (apparent loss) | 0.234 | 0.5 |

[a]This represents the only non-recoverable loss from system under ideal operation. [b]See discussion.

as fired spheres, 76.5% were of product specifications (i.e., they were at least as good as the specifications imposed by GGA with respect to composition, density, roundness, and size). The results show that both size control and shape control worsened progressively throughout the run. Installation of on-stream viewing and sampling will improve this situation.

### 1.2 Sphere-Forming Column Chemistry

(W. D. Bond, A. B. Meservey, J. W. Snider, P. A. Haas)

Our previous studies have shown that pH, surfactant concentration and water content of 2-ethyl-1-hexanol (2EH) are important variables in the microsphere forming process. We are presently examining methods for improving the control of pH and surfactant concentration during continuous operation of sphere forming columns. Our present system for controlling the water content is adequate. For water content control, a portion of the used solvent is heated at 150-160°C to remove most of the water, and the desired water content is obtained by mixing this relatively dry 2EH with the remaining wet solvent.

In the past, sphere forming columns have been operated continuously by making periodic additions of surfactants to offset the losses of surfactant caused largely by reaction of the nitric acid (extracted from the sol) with the surfactants during removal of water by distillation. In addition to reactions during distillation, a relatively small amount of reaction occurs in the forming column as evidenced by slow discoloration of the solvent when the forming column is batch operated without a distillation system. The pH or acid contents of the 2EH that have been employed in continuous operation, have been mainly those governed by the amount of acid extracted from the sol which can subsequently be maintained in the 2EH with the distillation system operating. When higher acid contents are required, nitric acid must be added to the 2EH, and reactions with surfactants and 2EH are increased.

Laboratory studies have shown that reactions of nitric acid with 2EH and surfactants during distillation could essentially be eliminated by removal of the acid prior to distillation by contacting the 2EH with alkaline solutions. The acid content

of the alcohol could then be maintained by adding nitric acid to the alcohol after the removal of water by distillation. We are presently evaluating this procedure as a means of controlling the pH and surfactant concentration of the engineering development sphere forming column during continuous operation. We are also studying a total 2EH purification method in which the 2EH is recovered by distillation; the used surfactants are discarded, and the 2EH is recycled to the forming column after surfactants, water and nitric acid are added. Studies are continuing on the effect of surfactant and water content, and the pH of 2EH on sphere forming using different sols in batch operated laboratory forming columns.

## Studies with Engineering Development Microsphere Forming Column

Studies of solvent regeneration of the sphere-forming alcohol during sphere forming with $UO_2$ sols are continuing (see Sect. 2.3 of the LMFBR Fuel Cycle Studies Report for September 1969). Laboratory determination of extraction coefficients for various species between the alkaline scrubbing solutions and the 2EH is continuing. Results on the extraction of Span 80, Ethomeen S/15, $NH_4OH$ and nitrate are reported in the September LMFBR Fuel Cycle Studies Progress Report. Formic acid addition to the 2EH caused clustering of $UO_2$ gel spheres in batch-operated laboratory forming columns.

## Recovery of 2EH by Distillation

Laboratory studies on 2EH distillation are being carried out in a continuous distillation unit. Good recovery (95-99%) has been obtained using 2EH that has been used in the engineering development microsphere forming column and therefore contains a typical spectrum of impurities. However, excessive foaming occurs in the distillation pot and a de-entrainment section may be required for long-term operations and high boil-up rates. To date, distillations have been carried out at atmospheric pressure. Vacuum distillation tests are in progress.

We have briefly examined steam distillation for recovering the 2EH. At 120°C the distillate composition is 40 vol % 2EH and 60% water. Obviously some method must be employed for subsequent phase separation.

## 1.3 Preparation of Test Materials

(J. R. Parrott, F. L. Daley, R. J. Shannon)

The Solex Development Laboratory is currently in operation to produce 6 kg of $ThO_2$-$^{235}UO_3$ sol for forming into microspheres in the Cell IV facility. The product, after coating, will be incorporated into test elements and irradiated in the Peach Bottom Reactor as part of the National HTGR Recycle Development Program.

The Solex Laboratory was operated to prepare six 1-kg batches of sol during the month. During preparation of the first batch equilibrium was being attained, and poor sol was produced. The second run produced sol having a $NO_3^-$/metal ratio too high to be used to form microspheres. The third batch was of good quality and was used to produce 1 kg (metal) of microspheres in the microsphere forming facility. Following a mechanical failure which aborted the fourth run, the next two batches were denitrated to a $NO_3^-$/metal ratio of 0.07%, resulting in gelation during the concentration step. Efforts to adjust the ratio by $HNO_3$ addition were unsuccessful. It is interesting to note that the $NO_3^-$/metal ratio began to decrease gradually after run No. 2. A reduction of the extractant (Amberlite LA-2 in n-paraffin diluent) flow by 15% produced sol in the desirable range (0.12 $NO_3^-$/metal).

Microsphere forming was performed in the Cell IV facility. The tapered glass column, previously used to produce $^{233}UO_2$-$ThO_2$ microspheres, was used to contact the sol droplets with the drying agent (2-ethyl-1-hexanol, 0.1% Ethomeen S/15, 0.01 M $HNO_3$). The sol feed device was changed from the two-fluid nozzle to the perforated plate ("bucket"-type)[1] since the desired microsphere size was relatively large (450 μ diam ± 100 μ). The use of this constant head device permitted the use of an air lift to feed the sol to the column, eliminating the syringe-type pump.

Following formation, the microspheres were steam-dried to 200°C then calcined at 1150°C in Ar–4% $H_2$ for 4 hr.

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[1] P. A. Haas, et al., Engineering Development of Sol-Gel Processes at Oak Ridge National Laboratory, ORNL-TM-1978, pp. 37-40 (Jan. 1968).

## 2. Fueled Graphite Fabrication Development

(F. J. Furman, J. D. Sease, and R. A. Bowman)

We are developing processes and equipment for the refabrication of HTGR recycle fuel, as detailed in the National HTGR Recycle Program Plan. The fuel consists of microspheres of thorium and/or uranium as the oxide or carbide, coated with multiple layers of pyrolytic carbon and silicon carbide. These particles are typically made into a fuel stick which is then inserted into a hexagonal graphite log, which contains both fuel holes and coolant holes.

Our work is divided into particle coating, particle handling and inspection, particle blending, fuel stick molding and inspection, fuel element assembly, fuel stick carbonization, and fuel element inspection. This month we emphasized particle coating and handling, although some work was done on particle inspection and particle blending.

### 2.1 Particle Coating

The 5-in.-diam prototype remote coating furnace is an advanced version of our 5-in.-diam laboratory furnace which we have successfully operated for over two years. The improvement incorporated in the prototype furnace will allow reliable remote, production-scale operation and maintenance. We are continuing tests on the recently constructed prototype furnace.

We discovered the cooling of the electrodes (power feeds to the heating element) was inadequate. We have modified the coolant system and have found it now to be satisfactory.

The original design of the heating element produced a heated region shorter than that which was needed. A second element has been designed, fabricated, and tested. This heating element has an 8-in.-long region which does not vary more than 40° at 1300°C.

To reach 1650°C (required for silicon carbide coatings) the prototype furnace needed radiation baffles. We have completed the baffles for the furnace and tested

them to 1600°C. At this temperature, the thermal expansion of one component caused excessive warping of the baffle surrounding the heating element. This component has been redesigned to eliminate the problem.

Silicon carbide coatings require the injection of a silane into a gas flow of $H_2$. Previously, this injection was accomplished by using a reflux condenser to control the quantitiy of silane (typically a liquid at room temperature) injected into a precise portion of the gas stream. We are planning to pump a metered amount of liquid silane into a flash evaporator connected directly to the coating gas line. This system should be considerably simpler than the previous one.

We have just tested the injection system including the metering pump and find that we can inject silane at any rate between 2 and 90 $cm^3$/min. Typical injection rates required will be 30 $cm^3$/min.

We are improving our laboratory 5-in.-diam coating furnace, which is used to produce material for other phases of the program such as head-end reprocessing and fuel stick fabrication. We are installing a new top section on the lab furnace which should simplify cleaning operations. Previously, the exhaust from the coating operation, consisting mostly of $H_2$, was burnt as it came out of the furnace. The amount of $H_2$ which could be burnt limited the coating rate. Also, safety precautions which had to be employed complicated the operation. We are now eliminating the problem by connecting the laboratory coating furnace exhaust to the off-gas system of the prototype furnace. This system was designed to handle the $H_2$ exhaust of two furnaces. The connecting of the lab furnace exhaust to this system will allow testing of the capability of the off-gas equipment in addition to solving a difficult exhaust handling problem.

## 2.2 Particle Handling

Particle handling involves the transfer of particles between equipment and the processing of the particles after particle forming, drying, and firing and before particle coating.

One aspect of the processing is the removal of under-end oversized particles prior to coating. We plan to screen the particles using SWECO[1] gyratory screens with self-cleaning units. The cleaning units keep the screens from blinding, thereby eliminating the need for frequent manual cleaning of the screens. We are modifying the equipment for handling in a hot-cell by manipulators.

We ran a series of tests to determine the most advantageous settings for the adjustments on the SWECO unit. The adjustments include top motor weights, bottom motor weights, and lead angle between the top and bottom motor weights. The top motor weights were adjusted as recommended by the factory for a four-deck unit, i.e., three weight plates, besides the permanently mounted weight. We were using three decks each with self-cleaning units, thus approximately equaling four decks in weight. Using a 40° lead angle, we obtained the results shown in Table 1 when we screened a batch of sol-gel thoria. The material used ranged in diameter from 330 to 380 μ with a 75% less than 354 μ screen size used in the test. The formula[2] used to calculate efficiency was:

$$\text{Efficiency} = 100 \left[ \frac{100\,(P_{fF} - P_{fC})}{P_{fF}(100 - P_{fC})} \right]$$

where $P_{fF}$ = fines in feed material and $P_{fC}$ = % fines in coarse-size fraction.

While the highest efficiency (89.7%) was obtained with only one bottom motor plate, only a limited range of feed rates gave high efficiencies. Two bottom plates are optimum for this type feed material since the efficiencies are almost 95% high (85 to 89%) over a fairly broad range of feed rates (225 to 710$^{+}$ g/min).

The lead angle was reduced and a 5% decrease in efficiency occurred. A greater lead angle is considered undesirable because the material accumulates on the screen unless lower, and less controllable, feed rates are used.

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[1] Southwestern Engineering Company, Los Angeles, California.

[2] Clyde Orr, Jr., Particulate Technology, p. 353, Macmillian Co., New York, 1966.

Table 1. Efficiencies with Various Feed Rates
and Number of Bottom Motor Weights
for a SWECO Separator

| Bottom Plates | 1 | | 2 | | 3 | |
|---|---|---|---|---|---|---|
| | Feed Rate ( g/min ) | Efficiency (%) | Feed Rate (g/min ) | Efficiency (%) | Feed Rate (g/min ) | Efficiency (%) |
| | 165 | 83.4 | 195 | 81.0 | 215 | 71.4 |
| | 225 | 82.9 | 235 | 85.1 | 275 | 75.9 |
| | 240 | 89.7 | 400 | 88.1 | 320 | 78.7 |
| | 285 | 89.0 | 440 | 89.1 | 370 | 81.3 |
| | 330 | 85.6 | 495 | 88.2 | 370 | 81.3 |
| | 375 | 85.4 | 565 | 87.5 | 480 | 81.6 |
| | 425 | 82.8 | 640 | 88.2 | 480 | 82.9 |
| | 615 | 82.4 | 710 | 86.7 | 485 | 77.8 |
| | 740 | 72.5 | 2500 | 80.1 | 490 | 83.9 |
| | | | | | 550 | 83.1 |
| | | | | | 1065 | 80.8 |
| | | | | | 1470 | 78.1 |

## 2.3 Particle Inspection

To economically produce coated particles, the accurate size of the particles must be known immediately before and after coating. We are developing a particle size analyzer to provide this information. Our current equipment exhibits some drift in the electronics which necessitates frequent checks and recalibrations. We are currently investigating the source of this drift to determine if it can be eliminated.

## 2.4 Particle Blending

Prior to fuel stick molding, three types of particles must be blended together. We have just finished the design of a device we call the filler-blender which will blend the particles while the fuel stick mold is being filled. This design is based on work done by R. L. Hamner in 1967.[3] The design of instrumentation to determine the flow of each particle type is not yet complete.

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[3] J. M. Robbins, R. L. Hamner, and H. Beutler, "Bonding of Coated Fuel Particles in Fuel Elements," Status and Progress Report for Thorium Fuel Cycle Development for 1967 and 1968, ORNL-4429, August 1969, pp. 83-85.

# III. MATERIALS IRRADIATION

(A. L. Lotts, T. N. Washburn, J. D. Sease, and J. H. Coobs)

## 1. Irradiation of Prototype Recycle Fuels

(A. R. Olsen and F. J. Furman)

The HTGR recycle program requires irradiation tests. The twofold objectives of these tests are: (1) to provide irradiation fuel for head-end process studies, and (2) to provide irradiation proof tests of the products of the various stages of process development for the Thorium-Uranium Recycle Facility. The test conditions have been defined as fuel temperatures between 750 and 1300°C with fast fluence exposures from 4 to 8 $\times$ $10^{21}$ neutrons/$cm^2$ and burnup levels up to 20% FIMA.

A multi-stage program has been proposed with two stages to be implemented during FY-1970. These two stages involve accelerated capsule tests in the Advanced Test Reactor and eight test elements to be irradiated in the Peach Bottom Reactor.

### 1.1 Capsule Irradiations

The design of the capsules for accelerated irradiation tests in the ATR requires a good understanding of the neutron flux energy spectrum in the region of the proposed irradiations. J. D. Jenkins of the Reactor Division has started to develop a shell source for these test locations similar to the water spectrum source currently being used for Engineering Test Reactor irradiations. This source will be used to calculate the fission rates for the capsules using the ANISN code.

Currently, we understand that the ATR Core 1 operation has been rescheduled for late October. This delay should not influence our proposed testing to start in January.

### 1.2 Large-Scale Irradiations

The original test parameters which concentrated on bonded beds of TRISO coated fuel and a revised set of test parameters, concentrating on loosely bonded beds of BISO coated fuel, were transmitted to Gulf General Atomic for their comments.

## IV. URANIUM-233 REPROCESSING

(J. R. Parrott, R. G. Nicol, W. A. Shannon)

ORNL serves as a national distribution center for $^{233}U$. The $^{233}U$ facility, which contains a small batch leacher, a batch dissolver, and a single-cycle solvent extraction system, is capable of purifying $^{233}U$ at the rate of 25 kg per week. It includes storage systems for liquids and solids, with capacities of 500 and 120 kg of $^{233}U$ respectively.

### 1. Dissolution and Purification

A total of seven dissolutions, containing 4320 g $^{233}U$, were made during the month. The material dissolved consisted of waste $UO_2$-$ThO_2$ microspheres generated during the preparation of fuel for the High Temperature Lattice Test Reactor, scrap $UO_2$ powder, and analytical waste. A solvent extraction run (No. 769698) was started. The amount of $^{233}U$ being purified is 18,035 g.

### 2. Storage and Distribution

The facility presently contains 226 kg of $^{233}U$ which varies in isotopic purity between 84 and 98% and $^{232}U$ content between 4 and 250 ppm.

Analysis of Raschig rings removed from storage tank U-3 (after the tank had contained uranyl nitrate solution for one year) showed the boron content and isotopic ratio ($^{10}B/^{11}B$) to have remained constant. Boron content is 3.75 wt % and $^{10}B/^{11}B$ is 0.25. Both values are acceptable from a nuclear safety standpoint.

One shipment of $UO_2$ (2,288 g of $^{233}U$) was received and one shipment of purified uranyl nitrate solution (984 g of $^{233}U$) was shipped during the month.

We also have a facility (TRUST - Thorium Reactor Uranium Storage Tank) in which we store 1047 kg of highly enriched uranium (76.5% $^{235}U$, 9.7% $^{233}U$) in the form of a uranyl nitrate solution. This material is the uranium product from the Indian Point Reactor fuel, which was purified by solvent extraction at the Nuclear Fuels Services Plant. The solution will be stored indefinitely since the

$^{232}U$ content (120 ppm) prohibits its direct refabrication into fuel elements, and the low $^{233}U$ content makes it of little interest for reactors demonstrating the thorium fuel cycle.

The contents of this storage tank (P-25) were analyzed this month. Analytical results show that concentrations of the various ingredients have remained constant for the past four months. The latest data follow:

| | | | |
|---|---|---|---|
| Total U: | 1053 kg | $Cd^{+2}$ : | 20.0 g/liter |
| $H^+$: | 2.6 M | $GD^{+3}$ : | 2.0 g/liter |

The concentrations of the soluble neutron poisons in the stored solution will be increased to 21.47 g/liter in cadmium and 2.52 g/liter in gadolinium (the required values) as soon as chemical analysis of the recently purchased $Gd_2O_3$ has been confirmed.

Tests have been made to determine the best method of reducing the radiation background in the vessel off-gas pipe line from the storage tank during sparging, preparatory to sampling. Results show that uranium is being entrained in the sparge gas and that the paper filters were most efficient in trapping the uranium and highly radioactive $^{232}U$ daughters. The silica gel trap was nearly as efficient as the paper filters in removing uranium and the charcoal trap was less efficient than the silica gel trap. Results of the water scrubber test are incomplete.

### 3. LWBR Support

At the request of Bettis Atomic Power Laboratory, we submitted a proposal to receive, store and purify approximately 600 kg of $^{233}U$ for the Navy's Light Water Breeder Reactor Program. This proposal also included the recovery of uranium from scrap generated during the fuel fabrication program.

A second proposal, which consists of converting the uranium to a ceramic-grade oxide suitable for blending with thoria for pellet pressing, is presently being formulated.

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