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**PROCEDURE FOR SEPARATION OF Se AND
DETERMINATION OF Se-79 BY LIQUID SCINTILLATION (U)**

by

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A document prepared for:

at

from thru

DOE Contract No. **DE-AC09-89SR18035**

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WSRC-RP-91-865

11 August 1991

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PROCEDURE FOR SEPARATION OF Se AND DETERMINATION OF Se-79 BY LIQUID SCINTILLATION BETA COUNTING (U)

This report describes the development work and demonstration of a technique for separation of selenium suitable for determination of Se-79 by liquid scintillation counting. The technique has been demonstrated on actual DWPF sludge samples which contain very large loads of Sr-90 activity. The separation required a decontamination of selenium from Sr by a factor of over 10^6 , from Co and Cs by factor of 10^4 , and from Tc-99 by a factor of 100, while still maintaining a selenium recovery of about 50%.

Using this technique we have determined Se-79 in five actual DWPF samples with a precision of about 70% relative standard deviation. This separation has not been demonstrated on actual DWPF samples which have the largest Cs-137 loads. We do not anticipate that these untested samples will present a difficult problem.

APPLICABILITY

This procedure was developed originally for high level defense waste supernate and dissolved sludge and was revised to include samples from the DWPF Melter Feed Tank and the Melter Glass pour stream. It is applicable to DWPF samples which have been prepared by Na_2O_2 fusion (DPST-88-272)¹ or by microwave dissolution (DPST-88-273)².

BASIS OF METHOD

Selenium is separated from all other radioactive species for subsequent determination of Se-79 by liquid scintillation β -decay counting. The sample is oxidation state adjusted to place selenium in the H_2SeO_3 neutral molecular form. In this form the selenium is passed through a mixed bed ion exchange column onto which most other species load. Selenium is then precipitated as elemental Se. The solid is washed with 0.5M nitric acid to scrub away entrained tritium and redissolved with strong acid. Product purity is assessed by γ -PHA, ICP-scan, and by observation of the product β -decay spectrum. Selenium recovery is measured by ICP analysis, and Se-79 activity is determined from the product decay rate.

Derivative Classifier

N/A ROY

QUALITY OF DATA

The error in this method will be about 70% for all DWPF samples taken throughout the DWPF Waste Farm, feed, and process. The large error is a result of the presence of so little Se-79 compared to other radioactive species and not to the difficulty or reliability of this separation and measurement technique. Dissolved samples from various points in the DWPF process can generally be expected to have Se-79 activities in the range 10-1000 dpm/ml. In U-235/Pu-239 thermal fission, the mass 79 is produced at an atom rate about 1/100 that of each of the mass 90-100 isobars and mass 133-145 isobars. When decay rates are factored in, the relative activity of Se-79 to total β -decay activity is near 1:1000000.

The separation described in this report has been tested with 15 actual DWPF sludge samples. The sample manipulations performed in the laboratory are fairly difficult, but the separation is very reliable to provide a 10^6 decontamination of Se-79 from other β -emitters and to obtain a recovery of selenium near 50%. For a hypothetical sample with Se-79 activity near $1\mu\text{Ci/ml}$, this separation scheme could be expected to yield a measurement error of less than 0.1%.

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9. M. C. Day and J. Selbin, Theoretical Inorganic Chemistry, 2nd Edition, (Van Nostrand Reinhold, 1969), p. 344-348.
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APPARATUS

Assorted vials
50-ml Pyrex centrifuge tubes
Centrifuge
Assorted plastic bottles
Scintillation vials
Disposable plastic pipets
2 dram gamma tube vials and outer double-seal shell
Hot plate in radioactive hood
Vacuum service
115-ml 0.4 mesh suction filter devices
Assorted micropipets

CHEMICALS AND REAGENTS

Concentrated hydrobromic acid (HBr), 48%.

Concentrated nitric acid, (HNO₃).

0.5M nitric acid, (HNO₃). Add 3ml of concentrated nitric acid to 100ml of distilled water. Mix well.

0.1M nitric acid, (HNO₃). Add 1500 μ l concentrated nitric acid to 250ml of distilled water. Mix well.

Opti-Fluor scintillation cocktail.

10g/l selenium carrier. See separate ADS procedure³ for preparation of selenium carrier.

AG-1,X-4 or X-8 anion exchange resin, Cl⁻ form, 50 to 400 mesh.

Dowex 50W-X4 or AG-50W,X-8 cation exchange resin, H⁺ form, 50 to 200 mesh.

200g/l hydroxylamine hydrochloride, (NH₂OH·HCl). Dissolve 20g of NH₂OH·HCl in 70ml distilled water. Dilute to 100ml with water. This solution must be prepared fresh weekly.

9M hydrochloric acid, HCl. Prepare by diluting 75ml of concentrated HCl to 100ml with distilled water. Always add the acid to the water - slowly.

Reagent grade bromine, Br₂.

SAFETY PRECAUTIONS

1. Monitor the sample for beta-gamma activity. Samples reading less than 100 mr/hr at 12 inches from the source surface may be handled with

- self-monitoring. Comply with the requirements of the appropriate radiation control procedure when handling any radioactive sample.
2. Frequently monitor the work area and equipment to detect any contamination. Hands and arms must be monitored immediately after withdrawal from the hood. If any contamination is found, immediately notify supervision and decontaminate according to proper radiation control procedure.
 3. Inspect all glassware before and after use for cracks and chipped or jagged edges. Remove from service and dispose of faulty glassware.
 4. Concentrated nitric is toxic by all routes of exposure. This material is irritating to the skin, eyes, and mucous membranes. It is corrosive to teeth. Violent reactions occur with several materials, including acetic acid, formic acid, ammonium hydroxide, anion exchange resins, cyclohexane, hydrazine, and sulfamic acid. Nitric acid is dangerous when heated to decomposition, for highly toxic fumes may be emitted. It will also react with water or steam to produce heat and toxic, corrosive fumes. When handling nitric acid, work in a hood and wear rubber gloves, safety glasses, and a lab coat. If any nitric acid contacts the skin, flush the affected area immediately with water. Do not wipe up nitric acid spills with cellulose sponges.
 5. Concentrated hydrobromic acid may cause irritation of the eyes, nose, and throat. If a solution is splashed on the skin or in the eyes it will cause a burn. Repeated or prolonged exposure to hydrobromic acid may cause irritation of the nose and throat with mucous production and indigestion. When handling hydrobromic acid, work in a hood and wear rubber gloves, safety glasses, and a lab coat. If any hydrobromic acid contacts the skin, immediately flush the affected area with water.
 6. Always add acid to water instead of the converse.
 7. Hydroxylamine hydrochloride is very irritating to skin, eyes, and mucous membranes. If any contacts the skin, immediately flush the affected area with water. When handling hydroxylamine hydrochloride, work in a hood and wear rubber gloves, safety glasses, and a lab coat.
 8. Prepare all solutions in a fume hood and wear plastic gloves when handling any chemical.

PROCEDURE

Prior to use of this procedure it is assumed that the sample has been dissolved by Na_2O_2 fusion (DPST-88-272)¹ or by HF/HCl microwave dissolution (DPST-88-273)². After the initial dissolution a cesium removal by phosphotungstate precipitation must be performed prior to removal of the sample from the analytical cell. The Cs removal procedure is contained in the DWPF radioanalytical procedures document (WSRC-RP-89-1045)⁴ and introduces a 4:1 dilution, which must be included in the calculation of Se-79

content. The cesium removal is used on four of the five sample aliquots specified in the procedure below. One aliquot is run with no cesium removal. The initial dissolution also introduces a predetermined dilution factor which must be included.

1. Prepare six 4-dram sample vials with 2000 λ Se carrier, 1000 λ 0.5M HNO₃, 500 λ HBr, and 200 λ Br₂ in each. Label the sixth vial as Se-B for later identification. Label the five sample vials as Se-n (n = 1,2,3,4,5).
 - a. Vials 1 - 4 will be used for the Cs-removed sample, vial 5 will be used for the direct sample (no Cs removal), and vial 6 will be the standard for subsequent measurement of Se recovery.
2. To vials 1 - 4 add 1000 λ of the supernate phase of the sample after Cs removal. Mix well.
3. To vial 5 add 500 λ of the direct sample (no Cs removal). Mix well.
 - a. The excesses of Br⁻ and Br₂ will hold selenium as H₂SeO₃.
4. Prepare five ion exchange columns by placing 1-ml of the AG-1, X-4 anion resin in the column and placing 1-ml of the AG-50W, X-8 cation resin on top of the AG-1.
5. Flush each column with 5ml of 0.5M HNO₃ and then with 10ml of 9M HCl. Discard the eluate.
6. Transfer each of the five samples to the separate columns and collect the eluates in appropriately labeled 6-dram vials.
 - a. Selenium will not load onto the columns, but will collect in the elution vial. Most of the other activity will load on the mixed bed columns.
 - b. Do not pass vial 6 (Se-B) through any column. It will remain unused until step 19 of this procedure.
7. Rinse each of the five sample vials with two 1-ml aliquots of 0.5M HNO₃ plus one drop of HBr. Add each of the rinses to the appropriate column and continue eluting into the same elution vial.
8. Discard the columns and add 4000 λ 48% HBr to each of the 5 elution vials.
 - a. Br⁻ provides a more reducing matrix for the subsequent reduction of selenium to elemental Se.
9. To each of the five samples (elution vials) slowly add 10ml of the 200g/l hydroxylamine hydrochloride.
10. Place each of the vials on a hot plate on the lowest heat setting for 1/2 hour.

- a. The low heat will speed the reduction of selenium to elemental Se. The solutions will turn orange or lavender.
11. After 1/2 hour, remove the vials from the heat and allow them to cool 1/2 hour. Then centrifuge each on a low setting for 4 minutes.
12. If the solid Se has settled satisfactorily, decant a portion of the supernatant liquid.
 - a. If the solid is still suspended throughout the supernatant liquid, disregard this step and proceed.
13. Pour each sample (supernate plus solid phase) onto a separate suction filtration apparatus. Rinse each sample vial with four 5-ml aliquots of 0.1M HNO_3 and use the rinse to wash the precipitate on the filtration apparatus.
 - a. The wash removes entrained tritium from the precipitate.
14. Discard each filtrate (liquid phase), and transfer each filter paper to a separate, fresh vial.
15. Dissolve the precipitate by washing it off of the filter paper with 2000 λ of fuming nitric acid.
16. Add 2000 λ of distilled water to the solutions of step 15 and remove and discard the filter paper.
17. Prepare a blank by washing a blank filter paper with 2000 λ fuming nitric acid and adding 2000 λ distilled water. Remove the filter paper and label this blank as Se-BG.
18. Transfer 1000 λ of each of the samples of step 16 and of Se-BG prepared in step 17 to fresh vials and add 3000 λ distilled water. Submit for ICP analysis of Se, Sr, Zr, Ni, and Na.
19. Prepare a separate vial by placing 3000 λ of distilled water in it and adding 200 λ of the blank of step 1 (vial Se-B). Label this diluted aliquot of Se-B as Se-C and submit it along with those of step 18 for ICP analysis of Se, Sr, Zr, Ni, and Na.
20. Prepare five liquid scintillation vials with 14 ml of Opti-Fluor. To each add an aliquot of one of the samples from step 16 and count by liquid scintillation β -spectroscopy for Se-79 content.
21. Prepare another liquid scintillation vial with 14 ml of Opti-Fluor. Add 1000 λ of Se-BG. Count by liquid scintillation spectroscopy for Se-79 content. This sample, Se-BG, will constitute the blank spectrum.

CALCULATIONS

For each of the samples the selenium recovery is measured from the ICP data. Recall the product phase samples were diluted 4:1 for ICP analysis, and the untreated starter sample Se-B was diluted 16:1 and named Se-C for ICP analysis. Therefore recovery $R(n)$ for each treated sample n is calculated from

$$R(n) = 0.25 \times [\text{Se}(n)]_{\text{ICP}} / [\text{Se-C}]_{\text{ICP}} \quad (1)$$

The Se-79 contents are calculated from the liquid scintillation data. For samples Se- n , ($n = 1,2,3,4$)

$$[\text{Se-79}](\text{dpm/ml}) = \frac{\text{CPM}(n) - \text{CPM}(\text{BG})}{R(n)} \times 16. \quad (2)$$

For sample Se-5

$$[\text{Se-79}](\text{dpm/ml}) = \frac{\text{CPM}(5) - \text{CPM}(\text{BG})}{R(5)} \times 8. \quad (3)$$

Note the units for each value are dpm/ml. We have assumed 100% counting efficiency by the liquid scintillation counter. With no Se-79 standard available and no quench indicating parameter efficiency curve stored in the liquid scintillation counter, this is the best estimation of counting efficiency available.

The precision of these measurements are fairly poor because the expected Se-79 count rate will be near background for each sample. It is important to include the precision of the background measurement when calculating the overall precision of each measurement. The liquid scintillation counter determines the two sigma precision for each count rate measured in units of percent of measured rate. The percent precision for each sample rate must be added geometrically to the background percent precision to determine overall precision for each sample.

QA REVIEW OF Se-79 SEPARATION AND COUNTING

INTRODUCTION

To test this procedure it was necessary to demonstrate

- 1) That Se was recovered in the sample treatment by at least 10% and in the Cs removal by at least 50%.
- 2) That we can measure the selenium recovery using ICP.
- 3) That selenium is purified from other β -emitters by a factor of 10^6 .
- 4) That selenium is purified from all γ -emitters to the extent that none are detectable by γ -PHA in the product phase.

- 5) That the product phase liquid scintillation β -spectrum has no evidence of radioactivity above the Se-79 151 keV endpoint energy.
- 6) That the product phase is pure of Ni measured by ICP. Since radioactive Ni-63 has a 66-keV endpoint energy, one might not otherwise recognize it as a contaminant in the β -spectrum.

EXPERIMENTAL DEVELOPMENT

The procedure of this document was developed by modifying the previous ADS procedure Se-79-Dist-1(5). The adopted procedure was tested with three sets of actual Tank 51-A Sludge dissolved in the SRL Shielded Cell Facility (SCF). The data from these experiments demonstrated that we could obtain adequate and measurable recovery of selenium and that we can obtain a fraction of selenium pure of other radioactive species.

Selenium recovery in the two cesium removal procedures was tested with a set of experiments very similar to those described in references 6 and 7. The experiment to test Se recovery is documented in reference 8 on page 101. We obtained greater than 85% recovery of Se in these experiments.

The first experimental test to produce a pure fraction of selenium involved the use of 3 aliquots prepared from sample 2-27779, which was dissolved in the SRL SCF. Samples labeled Se-n, ($n = 1, 2, 3$) were prepared consisting of 1000 λ 2-27779-CsR, 2000 λ Se carrier, and 1000 λ 0.5M HNO₃, where 2-27779-CsR is the cesium removal supernate from the Cesium Removal by Precipitation⁽⁶⁾ treatment of the original SCF sample. To Se-1 and Se-3 we added 500 λ concentrated HBr, and to Se-2 we added 100 λ of the same. HBr was added to provide excess Br⁻. This maintains the oxidation potential of the matrix near -1.1V and is intended to keep Se in the H₂SeO₃ form. Using varying values of [Br⁻] tested the sensitivity of the system to Br⁻ content.

We then prepared 3 mixed bed ion exchange columns consisting of AG-50W cation resin placed on AG-1X8 anion resin. Each column was flushed with 10ml 9M HCl and with 5ml 0.5M HNO₃ to place the resins in the Cl⁻ and H⁺ forms respectively. Each sample Se-n was loaded onto a column and eluted into a vial labeled Se-n-A. Each sample vial was rinsed with two 1-ml aliquots of 0.5M HNO₃ and loaded onto the column with continued elution into Se-n-A. Most of the cations and anions of each sample should load onto the columns, while neutral H₂SeO₃ will pass through the column into vial Se-n-A. Maintaining the oxidation potential near -1.1V prevented reduction of H₂SeO₃ to Se/Se⁻² or oxidation to SeO₄⁻² (reference 9), which would load onto the resins.

To each vial Se-n-A we added 4ml 48% HBr to make the matrix a more reducing medium. A γ -PHA count was then made on a 1000 λ aliquot of each sample Se-n-A. No transitions were observed in any aliquot, demonstrating a good separation from all of the γ -ray emitting species. An aliquot of each sample Se-n-A was also transferred for analysis by ICP-scan for subsequent analysis of selenium and other elements in the ion exchange separation.

To each vial Se-n-A we added 10ml of 0.22g/ml $\text{NH}_2\text{OH}\cdot\text{HCl}$ to reduce the selenium to its elemental state. The samples were cooled in an ice bath 1/2 hour and then centrifuged for five minutes. An orange precipitate was obtained. The supernates were discarded, and the precipitates were dissolved with 2000 λ concentrated nitric acid. These samples were split, and each half was given the label Se-n-B. The first half was diluted 4:1 with distilled water and analyzed by ICP-scan for Se content and for a variety of other species. The second split of each was added to 15ml of Opti-Flour and counted by liquid scintillation spectroscopy.

The results of each of the six ICP analyses and of the three liquid scintillation counts are recorded in Laboratory Notebook DPSTN-4753 on pages 134 and 137(8). The ICP analyses indicated we obtained recovery of all of the selenium in the Se-n-B phases, (i.e. none was detected in the Se-n-A phases). Of the 26 elements scanned, only Na, Al, and Ca had measurable recovery in the B phases, and none of these presents a problem with regard to β -decay counting. In particular the Sr and Ni recovery in the B phases was below the detection limit or less than 0.7% in each case.

The liquid scintillation spectra had no activity above the Se-79 endpoint energy, indicating the B phases were very pure of non-Se-79 activity (especially Sr-90/Y-90). The spectra appeared to be grossly contaminated with tritium or some other low-energy emitter, which we concluded was very unlikely to be Se-79. Thus this method appeared to be a good starting point for selenium purification, but required a better removal of tritium and possibly of Ni-63. There was no selenium recovery effect by the varying Br⁻ content between samples.

The experiment was repeated with samples labeled Se-n ($n = 4, \dots, 9$). A 0.01 μCi spike of Ni-63 was added to samples $n=4,5,7,8$ to observe a possible Ni-63 effect in the liquid scintillation spectra. 200 λ HBr was used in the sample preparation for each sample. At the end of the sample treatment, 1000 λ of Sr carrier was added to each of the dissolved selenium precipitates. The samples were centrifuged to remove precipitated $\text{Sr}(\text{NO}_3)_2$, and elemental selenium was reprecipitated by reduction with HBr and $\text{NH}_2\text{OH}\cdot\text{HCl}$ and redissolved with 2000 λ 8M HNO_3 . These samples labeled Se-n-B were then counted by liquid scintillation spectroscopy. No transitions were observed in the γ -PHA data. The liquid scintillation spectra closely resembled the spectra expected for Se-79, and only sample Se-4-B had evidence of a Ni-63 effect. Still the spectra appeared to be contaminated with tritium.

Our final test and measurement of Se-79 was conducted with 6 samples labeled Se-m ($m = 10, \dots, 15$). Each sample was made from a matrix of 2000 λ 8g/l Se carrier, 1000 λ 0.5M HNO_3 , and 500 λ HBr. To Se-10, Se-11, Se-13, and Se-14 we added 1000 λ of the supernate phase of the cation exchange Cs removal procedure(7) of SCF sample 2-43299. To Se-12 and Se-15 we added a direct 1000 λ and 500 λ aliquot respectively of the SCF sample 2-43299 (with no Cs removal treatment). To Se-10 and Se-11 we added 2000 λ Br_2 , and to Se-12 we added 1000 λ Br_2 . The molecular bromine was added to samples $m=10,11,12$ to have excesses of both it and Br⁻ to maintain the oxidation potential at -1.1v.

Two blanks were prepared for subsequent analysis by ICP to obtain a direct measure of the Se recovery. The blanks, Se-B and Se-C, had the contents

Se-B	2000λ Se carrier	Se-C	2000λ Se carrier
	1000λ 0.5M HNO ₃		1000λ 0.5M HNO ₃
	1000λ 4M HNO ₃		1000λ 4M HNO ₃
	2000λ Br ₂		

Each of the samples (but not Se-B or Se-C) was loaded onto a mixed bed ion exchange resin and eluted into Se-m-A as prescribed in the procedure. The sample vials were rinsed with two 1-ml aliquots of 0.5M nitric acid plus one drop HBr, and the rinses were added to the column and eluted into Se-m-A. 4000λ 48% HBr was added to each elution vial, and a 1000λ aliquot was taken for γ-PHA. No transitions were observed in any sample.

To each remaining portion of Se-m-A we slowly added 10ml of 0.25g/ml NH₂OH·HCl in distilled water. Each sample was placed on a hot plate set on the lowest setting for 1/2 hour. The reduction to elemental Se is speeded with low heating as opposed to cooling which we had used previously. The samples resulting were centrifuged for 5 minutes, and a lavender precipitate was obtained in each.

The supernatant phase of each sample was partly decanted, and the remaining contents of each sample was poured onto a suction filtration apparatus and suction filtered. The precipitate phase was washed with four 5-ml portions of 0.5M HNO₃. The liquid filtrate was discarded. The large acid scrub volume was designed to wash out entrained tritium.

Each of the filter papers was removed to a vial labeled Se-m-B, and the precipitate was rinsed off and dissolved with 2000λ fuming nitric acid. In each case the filter paper was partly dissolved, so a blank was prepared labeled Se-N-B, consisting of a blank filter paper rinsed with 2000λ fuming nitric acid. To each Se-m-B and to Se-N-B we added 2000λ distilled water.

The samples Se-m-B (m = 10,...,15) and Se-N-B were split for analysis by ICP and by liquid scintillation counting. 1000λ of each ICP split was added to 3000λ distilled water for ICP analysis, and 1000λ of each remaining split was added to 15 ml Opti-Fluor for liquid scintillation counting. In addition, 200λ of each of Se-B and of Se-C (the blanks prepared above) were added to 3000λ distilled water, labeled as Se-B-A and Se-C-A, and submitted for ICP analysis.

The sample treatments and all measured data are recorded in Laboratory Notebook 56-521 on pages 113-116(10). The ICP data are shown in Table 1, and the liquid scintillation data are shown in Table 2. The selenium recoveries and calculated Se-79 contents are shown in Table 3. Sample Se-11 was lost, and we failed to obtain the ICP data for Se-12. Sample Se-15 was partly spilled during filtration, which accounts for its very low recovery. The recovery of Se-12 was taken to be 0.5, which represents an average of the recoveries of the remaining three samples Se-m (m = 10,13,14).

The liquid scintillation spectra of samples Se-15-B and Se-12-B are shown in the figure. Note each has an endpoint energy of about 150 kev with no apparent contamination from tritium. Thus the acid wash of the filtered precipitate was very effective. The decay rate for each sample was barely above the background rate observed in sample Se-N-B. Thus the precision for each measurement is quite poor. However the measured data from sample to sample are in good agreement.

CONCLUSION

We have developed a technique for separation of Se suitable for determination of Se-79 by liquid scintillation counting. The technique has been demonstrated on actual DWPF sludge samples which contained very large loads of Sr-90 activity. This required a decontamination of selenium from Sr by a factor of over 10^6 ; from Ru, Pm and Eu by a factor of 10^5 ; from Ni, Co, and Cs by a factor of 10^4 ; and from Tc-99 by a factor of 100, while still maintaining a selenium recovery of about 50%.

Using this technique we have determined Se-79 in five actual samples. The precision of the measurements is about 70% relative standard deviation, and so the measured values might reasonably be regarded as upper limits of activity only. However from the U-235/Pu-239 fission yield curves, we note that Se-79 is produced on an atom per atom basis at a rate of approximately $1/100^{\text{th}}$ that of the peak masses in the regions 90-100 and 133-143. Factoring in the decay constants compounds the difficulty of the purification, such that these measurements should be regarded as a solid accomplishment.

The relative activities of Se-79 to Sr-90, Tc-99, Cs-137, and Pu-238 have been predicted in the DWPF washed Sludge-Slurry to be $1:1.4 \times 10^6$, $1:64$, $1:46000$, and $1:36000$ respectively¹¹. Comparing the Se-79 values obtained in this report to previous measurements, we observe that these relative activities are respectively $1:(20000 - 100000)$, $1:(10 - 70)$, $1:(1000 - 9000)$, and $1:(9000 - 60000)$. These ratios compare well and lend firm credibility to the Se-79 measurements.

This separation technique has not been demonstrated on actual DWPF samples which have the largest Cs-137 loads. We do not anticipate that these untested samples will present a difficult problem. Each of the samples is treated especially for cesium removal before beginning the specific treatment to obtain a pure selenium fraction.

Table 1. Measured ICP data for the selenium product phases and starting material samples Se-B-A and Se-C-A. Sample Se-N-B is the blank.

Sample	Measured Elemental Contents (ppm)						
	Sr	Ni	Ca	Zn	Na	Se	Zr
Se-10-B	<0.002	<0.050	0.364	1.221	3.354	588.60	0.098
Se-B-A	0.009	0.053	16.854	4.553	509.74	232.02	3.826
Se-N-B	<0.002	0.126	1.205	1.353	4.248	<0.200	<0.020
Se-13-B	<0.002	1.258	0.709	1.342	3.843	294.04	<0.020
Se-14-B	<0.002	7.577	0.853	1.451	4.361	357.55	<0.020
Se-15-B	<0.002	1.461	0.452	1.283	3.708	74.276	<0.020
Se-C-B	0.008	0.024	0.319	0.127	458.99	193.44	4.649

Table 2. Measured liquid scintillation decay counts in selenium product phases Se-m-B (m= 10,...15) and in the blank Se-N-B. The data are tabulated in energy windows, where the window ranges are in units of kev. The Se-79 data are taken to be those counts in the window 14 - 180 kev. The values in parentheses are the 2 sigma standard deviations in the last digit or digits expressed.

Sample	Measured Activity (0 - 14 kev)	In Energy Range (14 - 180 kev)	Denoted (cpm) (180 - 1400 kev)
Se-10-B	1099(25)	25(4)	10(2)
Se-12-B	1018(18)	44(4)	15(2)
Se-N-B	2644(31)	24(3)	18(2)
Se-13-B	347(18)	35(5)	12(3)
Se-14-B	540(21)	30(5)	11(3)
Se-15-B	855(13)	29(2)	10(1)

Table 3. Measured Se-79 Contents For Dissolved DWPF Feed Sample 2-43299. The values in parentheses are the one sigma standard deviations.

Sample Aliquot	Measured Activity (cpm BG subtracted)	Recovery	Dilution Factor	[Se-79] (dpm/ml)
Se-10-B	1(5)	0.634	16:1	20(100)
Se-11-B	Lost Aliquot			
Se-12-B	20(5)	~0.5	4:1	160(50)
Se-13-B	11(6)	0.380	16:1	460(250)
Se-14-B	6(6)	0.462	16:1	200(200)
Se-15-B	5(4)	0.096	8:1	400(300)
Overall Weighted Average:				200(100)

M91aug022.01

Liquid scintillation β -decay spectra of samples Se-12-B and Se-15-B and of the blank Se-N-B.

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END