

AP1

GROSS ALPHA AND BETA FOR VARIOUS MATRICES

PART A

PRINCIPLE

Liquids samples are acidified, concentrated, dried in a planchette, and counted in a low-background proportional counter. Solid samples are dried and processed to provide homogeneity and a known quantity is transferred to a planchette and counted in a low-background proportional counter. The activity determined by this method is not indicative of any specific nuclide.

REFERENCES

1. Gross Alpha and Beta Activity in Water; EPA 900.0, Aug-80; U.S. EPA National Exposure Research Laboratory (NERL); Prescribed Procedures for Measurement of Radioactivity in Drinking Water (EPA/600/4-80-032), August, 1980.
2. Gross Alpha and Gross Beta in Water; CHEM-TP-GA/B.1, April 1999; U.S. Department of Energy Radiological and Environmental Services Laboratory
3. Gross Alpha and Gross Beta in Water and Wastewater; CHEM-TP-GA/B.2; April 1999; U.S. Department of Energy Radiological and Environmental Services Laboratory

Certification Record for

PROCEDURE AP1

GROSS ALPHA AND BETA FOR VARIOUS MATRICS

CHECKPOINTS

- 1. **JOB HAZARD ANALYSIS (JHA)** _____
- 2. **MSDS/HAZARDS DISCUSSED** _____
- 3. **VOLUME DETERMINATION** _____
- 4. **TRANSFER TO PLANCHETTE** _____
- 5. **SAMPLE STABILIZATION** _____
- 6. **SAMPLE COUNTING** _____
- 7. **FINAL CALCULATIONS** _____

ANALYST SIGNATURE: _____

CERTIFIED BY: _____

DATE: _____

ANALYSIS VALUE: _____

KNOWN VALUE: _____

MEASURED/KNOWN RATIO: _____

COMMENTS: _____

PART B

1.0 PURPOSE AND SCOPE

This procedure provides a screening measurement to indicate whether specific chemical analyses are required for water, soil, vegetation, and other solids. Volatile radionuclides (Tc-99, H-3, etc) will not be accurately determined using this procedure.

DISCLAIMER: Gross screening analyses are intended to provide rapid information associated with a particular action level with minimal chemical preparation; therefore, this analysis is not as accurate as specific chemical analyses.

2.0 REAGENTS

All chemicals are hazardous. See MSDS for specific precautions. **See step 2.0 of AP1 JHA.**

Nitric acid, HNO₃, 0.01 M: To 400 mL reagent water, add 0.3 mL 16 M HNO₃. Dilute to 500 mL

Nitric acid, HNO₃, 0.1 M: To 400 mL reagent water, add 3 mL 16 M HNO₃. Dilute to 500 mL

Nitric acid, HNO₃, concentrated, 16 M

Acetone/Super Glue mixture: To 200 mL acetone, add a half of a tube of super glue; mix well

Potassium sulfate, K₂SO₄, 10 mg/ mL: Dissolve 0.5 g of K₂SO₄ in 50 mL of 0.01 M HNO₃

Potassium sulfate, K₂SO₄, 20 mg/ mL: Dissolve 1.0 g of K₂SO₄ in 50 mL of 0.01 M HNO₃

Potassium sulfate, K₂SO₄, 40 mg/ mL: Dissolve 1.0 g of K₂SO₄ in 25 mL of 0.01 M HNO₃

3.0 APPARATUS

Low-background proportional counter

Stainless steel ringed planchettes

Filter paper and apparatus

Hot plate

Beakers

Graduated cylinders

Transfer Pipettes

4.0 PROCEDURE

4.1 General Requirements

Before proceeding, you must be certified as indicated in QCP1 of this manual and Section 3 of the Quality Program Manual. See page two for a copy of the certification record.

4.2 Water Samples

- 4.2.1 If total activity is desired, the sample should be acidified with nitric acid or hydrochloric acid to a pH of 2. **See step 4.2.1 of AP1 JHA.**
- 4.2.2 If dissolved and suspended solid activities are desired, the sample should be filtered using a 0.45 micrometer pore size membrane filter. The filter paper should be retained and counted. The filtered sample should be acidified as in 4.2.1. **See step 4.2.2 of AP1 JHA.**
- 4.2.3 Determine the amount of dissolved solids by drying 5.0 mL of sample on a tared, stainless steel planchette. The planchette may need to be flamed and reweighed. Use the following equation or the GAB program to calculate the volume of sample to analyze.

$$120 \text{ mg} \times \frac{5 \text{ mL}}{\text{mg of residue}} = \text{mL of sample}$$

If the value obtained is greater than 250 mL, use 250 mL of sample. The test planchette may be used for sample analysis by subtracting 5.0 mL from the total volume.

- 4.2.4 Measure an appropriate aliquot of sample (from above) by weight, into a graduated cylinder, or a volumetric container and quantitatively transfer to an appropriate size beaker. **See step 4.2.4 of AP1 JHA.**
- 4.2.5 Heat until approximately 5-10 mL of the solution remains. **See step 4.2.5 of AP1 JHA.**
- 4.2.6 Add 10 mL 16 M nitric acid and heat until 5-10 mL remain. Repeat nitric acid addition and heat until 5-10 mL remain. **See step 4.2.6 of AP1 JHA.**
- 4.2.7 Quantitatively transfer the remaining solution to a tared stainless steel planchette using 0.1 M nitric acid. **See step 4.2.7 of AP1 JHA.**
- 4.2.8 Slowly evaporate to dryness on a hotplate to avoid spattering. Heat the dried planchette over a low flame Bunsen burner or on a very hot hotplate for two minutes to ensure all nitrate salts are converted to oxide salts. (Note: volatile radionuclides may be lost or partially lost at this step). **Go to step 4.3.5. See step 4.2.8 of AP1 JHA.**

4.3 Solid Samples

- 4.3.1 Weigh approximately 0.1 g of ashed or dried, previously homogenized, and sieved sample on an analytical balance and transfer to a centrifuge tube. Record the weight as the sample quantity on the data sheet. Samples must be dried and passed through a 35 - 50 mesh sieve. Samples with especially high organic content may require ashing and sieving, prior to analysis. **See step 4.3.1 of AP1 JHA.**
- 4.3.2 Transfer the sample to a tared planchette by adding water to the sample and transferring using a plastic disposable transfer pipette. **See step 4.3.2 of AP1 JHA.**
- 4.3.3 Add approximately 2 mL reagent water or 95% ethanol to the planchette using a disposable transfer pipette. Spread the sample uniformly on the planchette. Gently suspend sample in water using the transfer pipette. Slowly evaporate on a hot plate. **See step 4.3.3 of AP1 JHA.**
- 4.3.4 Add 5-10 drops of the glue/acetone mixture to seal sample in planchette. Allow to dry. **See step 4.3.4 of AP1 JHA.**
- 4.3.5 Count the sample on a low background proportional counter long enough to meet MDC requirements, if possible. **See step 4.3.5 of AP1 JHA.**
- 4.3.6 Weigh the planchette. Record total planchette and sample weight for counting efficiency calculation on the data sheet. **See step 4.3.6 of AP1 JHA.**

5.0 CALIBRATIONS

- 5.1 NIST traceable standards of Pu-239 and Cs-137 or Sr-90 are selected to generate the gross alpha and gross beta efficiency/attenuation curves.
- 5.2 Weigh the planchettes needed for each efficiency/attenuation curve and record the weight either electronically or manually on the assignment sheet. The mass range for the gross alpha and gross beta curves are 0 mg to 120 mg in 10 mg increments.
- 5.3 Add approximately 1000 pCi of the alpha standard to each alpha planchette and approximately 1000 pCi of the beta standard to each beta planchette.

NOTE: If the standard solution is in HCl, you cannot add directly to planchette. Add the standard solution to a beaker containing 3 to 5 mL of concentrated HNO₃ and reduce the volume to approximately 1 mL. Repeat three times. Do not permit the solution to go to dryness.

- 5.4 Starting with the 10 mg planchette for each curve and continuing in 10 mg increments until 120 mg is reached, add the appropriate volume of K₂SO₄ solution to yield the desired mg weight on each planchette.
- 5.5 Take the solution in each planchette to dryness using a hot plate and allow cooling. Weigh record each weight on the assignment sheet.
- 5.6 Submit the planchettes for counting. Count long enough to achieve the desired counting statistics of less than 1 percent.
- 5.7 After all planchettes have been counted, the system software will generate the efficiency/attenuation curve.
- 5.8 The Laboratory Manager or designee must review and approve each curve.

6.0 CALCULATIONS

Critical data values will be documented on approved assignment and calculation forms referenced to the current procedure and revision. See pages 8-10 of this procedure for approved forms. Critical records are maintained as hard copy in the archived site file or electronically. The following equations define the critical data values. All data will be recorded and reduced according to these calculations.

Gross Beta Equations

$$C_{\beta} = \frac{[(GC_{\beta} - B_{\beta}) - (GC_{\alpha} - B_{\alpha}) \cdot \chi_{\alpha \rightarrow \beta}]}{E_{\beta} \cdot Q \cdot T \cdot [1 - (\chi_{\alpha \rightarrow \beta} \cdot \chi_{\beta \rightarrow \alpha})]} = pCi / unit$$

$$2\sigma CU_{\beta} = \frac{1.96 \sqrt{\sigma_{GC\beta}^2 + \sigma_{B\beta}^2 + (GC_{\alpha} - B_{\alpha})^2 \cdot \sigma_{\chi_{\alpha \rightarrow \beta}}^2 + (\chi_{\alpha \rightarrow \beta})^2 \cdot (\sigma_{GC\alpha}^2 + \sigma_{B\alpha}^2)}}{E_{\beta} \cdot Q \cdot T \cdot [1 - (\chi_{\alpha \rightarrow \beta} \cdot \chi_{\beta \rightarrow \alpha})]} = pCi / unit$$

When $GC_{\alpha} - B_{\alpha} = 0$, 1 will replace the term $(GC_{\alpha} - B_{\alpha})^2 \cdot \sigma_{\chi_{\alpha \rightarrow \beta}}^2$ in the CU_{β} equation.

$$2\sigma TPU_{\beta} = \frac{1.96 \sqrt{\sigma_{GC\beta}^2 + \sigma_{B\beta}^2 + (GC_{\alpha} - B_{\alpha})^2 \cdot \sigma_{\chi_{\alpha \rightarrow \beta}}^2 + (\chi_{\alpha \rightarrow \beta})^2 \cdot (\sigma_{GC\alpha}^2 + \sigma_{B\alpha}^2) + RE_{\beta}^2 + RQ^2 + R(\chi_{\alpha} \chi_{\beta})^2}}{E_{\beta} \cdot Q \cdot T \cdot [1 - (\chi_{\alpha \rightarrow \beta} \cdot \chi_{\beta \rightarrow \alpha})]} = pCi / unit$$

$$MDC_{\beta} = \frac{3 + 4.65\sqrt{B_{\beta}}}{E_{\beta} \cdot Q \cdot T \cdot [1 - (\chi_{\alpha \rightarrow \beta} \cdot \chi_{\beta \rightarrow \alpha})]} = pCi / unit$$

Gross Alpha Equations

$$C_{\alpha} = \frac{[(GC_{\alpha} - B_{\alpha}) - (GC_{\beta} - B_{\beta}) \cdot \chi_{\beta \rightarrow \alpha}]}{E_{\alpha} \cdot Q \cdot T \cdot [1 - (\chi_{\beta \rightarrow \alpha} \cdot \chi_{\alpha \rightarrow \beta})]} = pCi / unit$$

$$2\sigma CU_{\alpha} = \frac{1.96\sqrt{\sigma_{GC\alpha}^2 + \sigma_{B\alpha}^2 + (GC_{\beta} - B_{\beta})^2 \cdot \sigma_{\chi_{\beta \rightarrow \alpha}}^2 + (\chi_{\beta \rightarrow \alpha})^2 \cdot (\sigma_{GC\beta}^2 + \sigma_{B\beta}^2)}}{E_{\beta} \cdot Q \cdot T \cdot [1 - (\chi_{\beta \rightarrow \alpha} \cdot \chi_{\alpha \rightarrow \beta})]} = pCi / unit$$

When $G_{\beta} - B_{\beta} =$ zero, 1 will replace the term $(GC_{\beta} - B_{\beta})^2 \cdot \sigma_{\chi_{\beta \rightarrow \alpha}}^2$ in the CU equation.

$$2\sigma TPU_{\alpha} = \frac{1.96\sqrt{\sigma_{GC\alpha}^2 + \sigma_{B\alpha}^2 + (GC_{\beta} - B_{\beta})^2 \cdot \sigma_{\chi_{\beta \rightarrow \alpha}}^2 + (\chi_{\beta \rightarrow \alpha})^2 \cdot (\sigma_{GC\beta}^2 + \sigma_{B\beta}^2) + RE_{\alpha}^2 + RQ^2 + R(\chi_{\alpha} \chi_{\beta})^2}}{E_{\alpha} \cdot Q \cdot T \cdot [1 - (\chi_{\beta \rightarrow \alpha} \cdot \chi_{\alpha \rightarrow \beta})]} = Ci / unit$$

$$MDC_{\alpha} = \frac{3 + 4.65\sqrt{B_{\alpha}}}{E_{\alpha} \cdot Q \cdot T \cdot [1 - (\chi_{\beta \rightarrow \alpha} \cdot \chi_{\alpha \rightarrow \beta})]} = pCi / unit$$

where:

- CU_{α} = alpha counting uncertainty
- CU_{β} = beta counting uncertainty
- E_{α} = alpha counting efficiency, cpm/pCi
- E_{β} = beta counting efficiency, cpm/pCi
- B_{α} = alpha background counts
- B_{β} = beta background counts
- GC_{α} = alpha gross sample counts
- GC_{β} = beta gross sample counts
- Q = quantity in units liter (L), sample (S), gram (g), filter (F), or total (T)
- T = count time, minutes. Count time of samples = count time of background.
- C_{α} = alpha concentration of sample in pCi/unit
- C_{β} = beta concentration of sample in pCi/unit
- $\chi_{\alpha \rightarrow \beta}$ = fractional alpha into beta crosstalk (spillover)

$\chi_{\beta \rightarrow \alpha}$ = fractional beta into alpha crosstalk (spillup)
 TPU_{α} = alpha total propagated uncertainty
 TPU_{β} = beta total propagated uncertainty
 MDC_{α} = alpha minimum detectable concentration
 MDC_{β} = beta minimum detectable concentration
 RE_{α} = 1σ relative uncertainty of the alpha efficiency
 RE_{β} = 1σ relative uncertainty of the beta efficiency
 RQ = 1σ relative uncertainty of the quantity
 $\sigma\chi_{\alpha \rightarrow \beta}$ = 1σ uncertainty of the alpha into beta crosstalk
 $\sigma\chi_{\beta \rightarrow \alpha}$ = 1σ uncertainty of the beta into alpha crosstalk
 $R(\chi_{\alpha}\chi_{\beta})$ = 1σ relative uncertainty of the beta times alpha crosstalk
 $\sigma_{B_{\alpha}}$ = 1σ uncertainty of alpha background counts = $\sqrt{B_{\alpha}}$
 $\sigma_{B_{\beta}}$ = 1σ uncertainty of beta background counts = $\sqrt{B_{\beta}}$
 $\sigma_{GC_{\alpha}}$ = 1σ uncertainty of alpha gross counts = $\sqrt{GC_{\alpha}}$
 $\sigma_{GC_{\beta}}$ = 1σ uncertainty of beta gross counts = $\sqrt{GC_{\beta}}$

7.0 RECORDS

- 7.1 Reference QA Manual for general record requirements.
- 7.2 The raw count data are saved during the daily incremental backup of the Low Background Alpha/Beta counter to the ORISE network disks. A disk image backup is performed once a month.
- 7.3 Hard copies of assignment and calculation sheets are maintained in the archived site file. Electronic copies of assignment and calculation sheets are saved during the daily incremental backup of the network system. The following data sheets show the required data and information. These forms or the equivalent should be completed and retained:
- GAB Analysis Assignment Form
 - GAB Lab Data Sheet
 - GAB Concentration and Uncertainty Report (This report may be generated using approved Excel spreadsheets or from the database, if available.)

AP1(Rev 17) - GAB ANALYSIS ASSIGNMENT FORM

(PAGE 1 OF 2, SEE OTHER SIDE)

Assigned To: _____ Date: _____ Batch: _____

Task #: _____ LWR #: _____ Activity Lev*: _____

Sample #'s: _____

QC REQUIRED

BLANK

REPLICATE

LCS

MATRIX SPK

SAMPLE # _____ # Replicates _____

ALPHA STD # _____ QUANTITY _____ INITIALS _____
UNITS _____

Pipette # _____ Volume _____ Weight _____

BETA STD # _____ QUANTITY _____
UNITS _____

Pipette # _____ Volume _____ Weight _____

SAMPLE # _____
ALPHA STD # _____ QUANTITY _____

BETA STD # _____ QUANTITY _____

SPECIAL INSTRUCTIONS: _____

* If Activity Level is indicated Moderate or High, perform area survey.

AP1(Rev 17) - GAB LAB DATA SHEET

(PAGE 2 OF 2, SEE OTHER SIDE)

Carrier #							
Sample #							
Sample Quantity							
Quantity Units							
Smp + Plan Wt.							
Planchet Wt.							
5 ml Sample + Planchet Wt.							
Analysis Volume							
Wt. Units							

Carrier #							
Sample #							
Sample Quantity							
Quantity Units							
Smp + Plan Wt.							
Planchet Wt.							
5 ml Sample + Planchet Wt.							
Analysis Volume							
Wt. Units							

Carrier #							
Sample #							
Sample Quantity							
Quantity Units							
Smp + Plan Wt.							
Planchet Wt.							
5 ml Sample + Planchet Wt.							
Analysis Volume							
Wt. Units							

Carrier #			
Sample #			
Sample Quantity			
Quantity Units			
Smp + Plan Wt.			
Planchet Wt.			
5 ml Sample + Planchet Wt.			
Analysis Volume			
Wt. Units			

AP1(Rev 17) - GROSS ALPHA/BETA ACTIVITY & ERROR REPORT

Analyst: _____

Date: _____

Batch #: _____

Task #: _____

CARRIER #	SAMPLE ID	SAMPLE + PLANCHET, g	PLANCHET, g	SAMPLE WT., mg	SAMPLE QUANTITY	UNITS (F,G,L,T)	COUNT TIME, min	ALPHA GROSS COUNTS	ALPHA BKG COUNTS	BETA GROSS COUNTS	BETA BKG COUNTS	COUNT DATE

SAMPLE ID	ALPHA ACTIVITY	CU	TPU	MDC	UNITS

SAMPLE ID	BETA ACTIVITY	CU	TPU	MDC	UNITS

α Known	α Unc	Meas./Known	M/K Unc

β Known	β Unc	Meas./Known	M/K Unc

BLANK CORRECT? YES[] NO[]
 LCS CORRECT? YES[] NO[]
 SAMPLE mg CORRECT? YES[] NO[]
 IF NO, SPECIFY REASON: _____

INIT _____ ANALYST REVIEW: _____ DATE: _____
 INIT _____ REVIEWED BY: _____ DATE: _____
 INIT _____ GIVEN TO: _____ DATE: _____
 QC ENTERED BY: _____ DATE: _____
 LWR CLOSED: _____ DATE: _____