

**FINAL ADDENDUM 1  
TO THE  
FINAL SAMPLING AND ANALYSIS PLAN  
FOR THE BASE-WIDE SEWER SYSTEMS  
(Field Sampling Plan and Quality Assurance Project Plan)  
July 11, 2006**

**BASE-WIDE STORM DRAIN AND  
SANITARY SEWER REMOVAL  
HUNTERS POINT SHIPYARD  
SAN FRANCISCO, CALIFORNIA**

**DCN: ECSD-RACIV-06-0335**

**Prepared for:**

**Base Realignment and Closure  
Program Management Office West  
1455 Frazee Road, Suite 900  
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**CONTRACT NO. N62473-06-D-2201  
CTO No. 0006**

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*7/12/2006*

Date

FINAL  
SAMPLING AND ANALYSIS PLAN (FIELD SAMPLING PLAN  
AND QUALITY ASSURANCE PROJECT PLAN)  
BASE-WIDE STORM DRAIN AND SANITARY SEWER REMOVAL  
REVISION 3

IS APPENDIX A OF THE FINAL PROJECT WORK PLAN  
BASE-WIDE STORM DRAIN AND SANITARY SEWER REMOVAL  
REVISION 3

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## 1.0 INTRODUCTION

This addendum to the Sampling and Analysis Plan (SAP) (*Final Sampling and Analysis Plan for the Base-wide Sewer Systems*, Hunters Point Shipyard, San Francisco, California, DCN: FWSD-RAC-06-0675 [Tetra Tech EC, Inc. (TtEC), 2006]) (referred to as original SAP) was prepared to include the option of using the on-site radiological laboratory for strontium-90 ( $^{90}\text{Sr}$ ) analysis. This addendum to the SAP was prepared on behalf of the Naval Facilities Engineering Command, Southwest (NAVFAC SW) by TtEC, under Remedial Action Contract (RAC) No. N62473-06-D-2201, Contract Task Order (CTO) No. 0006. The original SAP was prepared under CTO No. 0072 for RAC No. N68711-98-D-5713. This addendum complies with the requirements of revising the SAP when a scope or regulation change occurs during the course of the work in accordance with *Environmental Work Instruction (EWI) #2, 3EN2.2, Review, Approval, Revision, and Amendment of Sampling and Analysis Plans (SAPs)* (Southwest Division Naval Facilities Engineering Command, 2001). This addendum to the SAP includes only changes to the sections of the SAP that require modification relevant to the addition of on-site analysis of  $^{90}\text{Sr}$ .

$^{90}\text{Sr}$  may be analyzed by the on-site radiological laboratory to expedite the removal action of the storm drains and sanitary sewer systems. The required information for analysis of  $^{90}\text{Sr}$  by the on-site laboratory is included in this addendum. This addendum will be used in conjunction with the original SAP.

Sections and tables of the original SAP that required revision are as follows:

- Section 1.0
- Section 4.0
- Section 5.0
- Section 10.0
- Section 12.0
- Section 13.0
- Table A.5-1

### 1.1 OBJECTIVES AND SCOPE

*Revised paragraph 5:*

All soil and sediment samples collected will be analyzed for gamma spectroscopy by the on-site radiological laboratory. Samples with concentrations of cesium-137 ( $^{137}\text{Cs}$ ) at or above 0.113 picocuries per gram (pCi/g) or at a minimum 10 percent of the samples analyzed for gamma spectroscopy will be analyzed for  $^{90}\text{Sr}$  by either the on-site laboratory managed by New World Technology, Inc. (NWT) or off-site laboratory. In addition, samples with concentrations of  $^{137}\text{Cs}$

at or above 0.113 pCi/g and/or concentrations of <sup>90</sup>Sr at or above 2 pCi/g will be analyzed for alpha spectroscopy analysis for isotopic plutonium and uranium by the off-site laboratory. Swipe samples will be analyzed on site for alpha and beta/gamma radiation. Non-radiological chemical analyses of soil samples will be performed at an off-site laboratory.

## 4.0 SAMPLING STRATEGY

### 4.1 PIPE REMOVAL SAMPLING

Sampling strategy (sample locations and analyses to be performed) is presented in the original SAP.

*Revised paragraph 8 with the following;*

Soil and sediment samples will be analyzed for gamma spectroscopy by the on-site radiological laboratory. Ten percent of the samples will be randomly selected and sent to an off-site radiological laboratory for gamma spectroscopy analysis for quality assurance (QA) purposes.

Samples with concentrations of  $^{137}\text{Cs}$  at or above 0.113 pCi/g or a minimum 10 percent of the samples analyzed for gamma spectroscopy will be analyzed for  $^{90}\text{Sr}$  by either the on-site laboratory managed by NWT or off-site laboratory. For samples analyzed for  $^{90}\text{Sr}$  by the on-site laboratory, 10 percent of the samples will be sent to an off-site laboratory for QA purposes.

Results of  $^{137}\text{Cs}$  and  $^{90}\text{Sr}$  for samples analyzed by the off-site laboratory for QA purposes will be compared. Acceptance criteria of relative percent difference (RPD) for each pair is established at 20 percent for  $^{137}\text{Cs}$  and  $^{90}\text{Sr}$  for this project. If the RPD is not within the established acceptance criteria, then the Radiological Affairs Support Office (RASO) and the Department of the Navy (DON) will be notified and corrective action will be identified and implemented.

In addition, samples with concentrations  $^{137}\text{Cs}$  at or above 0.113 pCi/g and/or concentrations of  $^{90}\text{Sr}$  at or above 2 pCi/g will be analyzed for alpha spectroscopy analysis for isotopic plutonium and uranium by the off-site laboratory.

### 4.3 WASTE CHARACTERIZATION SAMPLING

*Revised paragraph 5:*

Soil and sediment samples will be analyzed for gamma spectroscopy by the on-site radiological laboratory. Ten percent of the samples will be randomly selected and sent to an off-site radiological laboratory for gamma spectroscopy analysis for QA purposes. Samples with concentrations of  $^{137}\text{Cs}$  at or above 0.113 pCi/g or a minimum 10 percent of the samples analyzed for gamma spectroscopy will be analyzed for  $^{90}\text{Sr}$  by either the on-site laboratory managed by NWT or off-site laboratory. For samples analyzed for  $^{90}\text{Sr}$  by the on-site laboratory, 10 percent of the samples will be sent to an off-site laboratory for QA purposes.

Results of  $^{137}\text{Cs}$  and  $^{90}\text{Sr}$  for samples analyzed by the off-site laboratory for QA purposes will be compared. Acceptance criteria of RPD for each pair is established at 20 percent for  $^{137}\text{Cs}$  and  $^{90}\text{Sr}$  for this project. If the RPD is not within the established acceptance criteria, then the RASO and the DON will be notified and corrective action will be identified and implemented.

In addition, samples with concentrations of  $^{137}\text{Cs}$  at or above 0.113 pCi/g and/or concentrations of  $^{90}\text{Sr}$  at or above 2 pCi/g will be analyzed for alpha spectroscopy analysis for isotopic plutonium and uranium by the off-site laboratory.

#### 4.4 FINAL STATUS SURVEYS AND SAMPLING

*Removed 4<sup>th</sup> sentence in paragraph 4.*

*Revised paragraphs 6 and 7:*

Solid samples for the Final Status Survey will be analyzed for gamma spectroscopy by the on-site radiological laboratory. Ten percent of the samples will be randomly selected and sent to an off-site radiological laboratory for gamma spectroscopy analysis for QA purposes. Samples with concentrations of  $^{137}\text{Cs}$  at or above 0.113 pCi/g or a minimum 10 percent of the samples analyzed for gamma spectroscopy will be analyzed for  $^{90}\text{Sr}$  by either the on-site laboratory managed by NWT or off-site laboratory. For samples analyzed for  $^{90}\text{Sr}$  by the on-site laboratory, 10 percent of the samples will be sent to an off-site laboratory for QA purposes.

Results of  $^{137}\text{Cs}$  and  $^{90}\text{Sr}$  for samples analyzed by the off-site laboratory for QA purposes will be compared. Acceptance criteria of RPD for each pair is established at 20 percent for  $^{137}\text{Cs}$  and  $^{90}\text{Sr}$  for this project. If the RPD is not within the established acceptance criteria, then the RASO and the DON will be notified and corrective action will be identified and implemented.

In addition, samples with concentrations of  $^{137}\text{Cs}$  at or above 0.113 pCi/g and/or concentrations of  $^{90}\text{Sr}$  at or above 2 pCi/g will be analyzed for alpha spectroscopy analysis for isotopic plutonium and uranium by the off-site laboratory.

## 5.0 REQUEST FOR ANALYSIS

### 5.1 ANALYTICAL METHODS

*Additional text:*

#### On-site Laboratory

- $^{90}\text{Sr}$  analysis by the on-site laboratory will follow NWT's Standard Operating Procedure.

### 5.2 SAMPLE CONTAINERS, PRESERVATIVES, AND HOLDING TIMES

Table A.5-1A has been added to include the on-site analysis of  $^{90}\text{Sr}$  that was not listed in the original SAP.

## 10.0 ANALYTICAL QUALITY CONTROL PROCEDURES (ON-SITE LABORATORY)

### 10.1 LABORATORY QUALIFICATION

*Revised text:*

NWT will perform gamma spectroscopy, gross alpha/beta and low-energy beta analyses using NWT's SOPs approved by RASO. California Department of Health Services (DHS) certification and Naval Facilities Engineering Service Center (NFESC) evaluation are not required for the on-site radiological laboratory per written confirmation from DHS and U.S. Environmental Protection Agency (EPA).

NWT may also analyze  $^{90}\text{Sr}$  on site using NWT's SOP, which will be approved by RASO prior to analyzing  $^{90}\text{Sr}$  samples on site. In addition, NWT will perform method validation as described in Section 10.8.

### 10.8 METHOD VALIDATION OF $^{90}\text{Sr}$ ANALYSIS

*New section.*

Samples analyzed by the on-site laboratory will be performed by NWT in accordance with an approved SOP "Determination of Strontium 90 Radioactivity using Gas Proportional Counting System" (Attachment 1). The SOP must be reviewed and approved by RASO prior to analyzing field samples.

After method performance characteristics are determined, 12 samples will be analyzed by the on-site (NWT) laboratory for method validation. The 12 samples are prepared from each of the three previously analyzed samples for  $^{90}\text{Sr}$ . One sample was reported as having  $^{90}\text{Sr}$  at a concentration below the project Radiological Remedial Objectives (RRO) and two samples are above the project RRO.

Six aliquots are taken to prepare two sets of three samples from each of the original samples. One set will be analyzed by the NWT laboratory and the second set will be analyzed by the Eberline off-site laboratory. Results will be reviewed by TtEC and RASO prior to analyzing field samples.

## 12.0 QUALITY ASSURANCE OVERSIGHT

### 12.1 FIELD AUDITS

*Revised paragraph 5:*

The on-site laboratory will be assessed at a minimum of once every 6 months.

## 13.0 REFERENCES

Southwest Division Naval Facilities Engineering Command. 2001. *Environmental Work Instruction (EWI) #2, EVR.2, Review, Approval, Revision, and Amendment of Sampling and Analysis Plans (SAPs)*. April.

Tetra Tech EC, Inc. (TtEC) *Final Sampling and Analysis Plan for the Base-wide Sewer Systems, Hunters Point Shipyard, San Francisco, California*. DCN: FWSD-RAC-06-0675. 2006.

## **TABLES**

TABLE A.5-1A

## SAMPLE CONTAINERS, PRESERVATIVES, AND HOLDING TIMES

Analyte	Analytical Method	Container	Preservative	Holding Time <sup>1</sup>
<b>SOIL SAMPLES</b>				
Strontium-90 (on-site laboratory)	On-site laboratory SOPs	250-mL or 500-mL plastic container	None	6 months

**Notes:**

<sup>1</sup> Holding time is defined as the time by which the analyses should be completed. Holding times have not been established for radiological sample analysis; however, 6 months is usually used as a recommended holding time.

mL - milliliter

SOP - Standard Operating Procedure

**ATTACHMENT 1**

**PROCEDURE FOR DETERMINATION  
OF STRONTIUM 90 RADIOACTIVITY  
USING GAS PROPORTIONAL COUNTING SYSTEM**

ATTACHMENT 1 – PROCEDURE FOR DETERMINATION OF  
STRONTIUM 90 RADIOACTIVITY USING GAS  
PROPORTIONAL COUNTING SYSTEM

THIS ATTACHMENT IS COMPLETE AS SUBMITTED.

FOR ADDITIONAL INFORMATION, CONTACT:

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NEW WORLD TECHNOLOGY  
ANALYTICAL PROCEDURE

**DETERMINATION OF STRONTIUM 90 RADIOACTIVITY USING  
GAS PROPORTIONAL COUNTING SYSTEM**

New World Technology  
448 Commerce Way  
Livermore, CA 94551

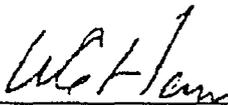
Effective Date:	4-28-06	Subject:	Procedure	Procedure:	RCHL-A-07
			Determination of Strontium 90	Page:	3 of 14
			Radioactivity Using Gas Proportional	Revision	2006-0
			Counting System		

New World Technology

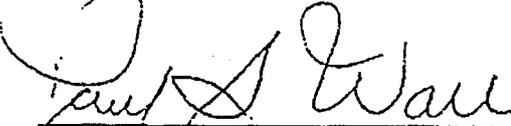
APPROVAL PAGE

Procedure Number/Title: RCHL-A-07, Determination of Strontium 90  
Radioactivity Using Gas Proportional Counting  
System

APPROVAL SIGNATURES:

  
\_\_\_\_\_  
William G. Haney, Vice President, Operations

5/26/06  
Date

  
\_\_\_\_\_  
Paul S Wall, Laboratory Manager

5/26/06  
Date

  
\_\_\_\_\_  
Donald Wadsworth, President

7/9/06  
Date

Effective Date:	4-28-06	Subject:	Procedure	Procedure:	RCHL-A-07
			Determination of Strontium 90	Page:	3 of 15
			Radioactivity Using Gas Proportional	Revision	2006-0
			Counting System		

New World Technology

**APPROVAL PAGE**

Procedure Number/Title: **RCHL-A-07, Determination of Strontium 90  
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William G. Haney, Vice President, Operations

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<b>Effective Date:</b>	<b>4-28-06</b>	<b>Subject:</b>	<b>Procedure</b>	<b>Procedure:</b>	<b>RCHL-A-07</b>
			<b>Determination of Strontium 90</b>	<b>Page:</b>	<b>4 of 15</b>
			<b>Radioactivity Using Gas Proportional</b>	<b>Revision</b>	<b>2006-0</b>
			<b>Counting System</b>		

**Section**

**Title**

**Introduction**

- 1.0 Scope**
- 2.0 Purpose**
- 3.0 References**
- 4.0 Precautions and Limitations**
- 5.0 Equipment**
- 6.0 Terminology**
- 7.0 Reagents**
- 8.0 Procedures**
- 9.0 Calculations**
- 10.0 Appendix A: Chemistry Terminology Definitions**

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## 1.0 SCOPE

1.1 This procedure is a rapid, reliable and cost effective method for measurement of strontium-90 in soil using gas proportional counting.

## 2.0 PURPOSE

2.1 This method utilizes extraction chromatography techniques to determine strontium 90(Sr-90) concentrations in soils and liquids.

## 3.0 REFERENCES

- (1) Banavali, A.D., et al., "Strontium-89-90 Analysis by Eichrom Column Chemistry and Cerenkov Counting," 38<sup>th</sup> Annual Conference on Bioassay, Analytical and Environmental Radiochemistry. Santa Fe, NM, November, 1992.
- (2) Dietz, M.L., et al., "An Improved Method for Determination of Sr-89 and Sr-90 in Urine," Health Physics. 61 (1991), 871-877.
- (3) Horwitz, E.P., et al., "A Novel Strontium Selective Extraction Selective Chromatographic Resin," Solvent Extraction and Ion Exchange. 10 (1992), 313-336.
- (4) Nelson, D.M., "Purification of Strontium in Water before Strontium-89/Strontium-90 Measurement," DOE Methods of Compendium, RP500.
- (5) Maxwell, S.L., et al, "High Speed Separations to Measure Impurities in Plutonium-238 Oxide and Trace Radionuclides in Waste," 34<sup>th</sup> ORNL-DOE on Analytical Chemistry in Energy Technology. Gatlinburg, TN, October, 1993.
- (6) ASTM Standards: D1890 "Test Method for Beta Particle Radioactivity of Water" and D3648 "Practices for the Measurement of Radioactivity"

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#### **4.0 PRECAUTIONS AND LIMITATIONS**

- 4.1 Strontium must be separated from other interfering beta emitting isotopes.
- 4.2 The presence of elemental strontium in the sample may bias the gravimetric yield determination. If it is suspected that natural strontium is present in the sample, its concentration should be determined by a suitable means and the yield calculation appropriately modified.
- 4.3 All laboratory safety and radiological safety procedures must be adhered to in accordance with NWT Health and Safety Chemical Hygiene Plan and Laboratory Safety Manual.

#### **5.0 EQUIPMENT**

- 5.1 Beta detector-gas proportional counter
- 5.2 Centrifuge and carriers-to hold 50 ml tubes
- 5.3 Centrifuge tubes: 50 ml disposable, polyethylene, conical bottomed tubes.
- 5.4 Column Rack
- 5.5 Column Reservoirs-250 ml
- 5.6 Column Reservoirs-25ml
- 5.7 Stainless Steel 2 inch counting planchets-with raised sides
- 5.8 Glass Beakers
- 5.9 Graduated Cylinders
- 5.10 Hot Plate-located inside a fume hood
- 5.11 Watch Glasses

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## 6.0 TERMINOLGY

6.1 See Appendix A

## 7.0 REAGENTS

7.1 Cation Exchange Resin-Hydrogen form, 100-200 mesh

7.2 Unless otherwise indicated, all references to water should be understood to mean de-ionized water.

7.3 Hydrogen Peroxide (30%)

7.4 Nitric Acid (3M) – Add 191 ml of concentrated HNO<sub>3</sub> (sp gr 1.42) to 400 ml of water and dilute to 1 liter with water.

7.5 Oxalic acid solution (0.05M) – Add 191 ml of concentrated HNO<sub>3</sub> (sp gr 1.42) and add 6.36 grams of oxalic acid dehydrate to 800 ml of water and dilute to 1 liter with water.

7.6 Nitric Acid (15.7M) – concentrated nitric acid (sp gr 1.42).

7.7 Nitric Acid Solution (8M) – Add 510 ml of concentrated nitric acid (sp gr 1.42) to 400 ml of water and dilute to 1 liter with water.

7.8 Nitric Acid (0.1M) – Add 6.4 ml of concentrated HNO<sub>3</sub> to 800 ml water dilute to 1 liter with water.

7.9 Sr Resin – pre-packed column, 0.7 grams medium particle size resin (100-150µm), or small particle size (50-100 µm) in appropriate plastic column.

7.10 Strontium Carrier (5mg/ml) – Dissolve 6.04 grams of Sr(NO<sub>3</sub>)<sub>2</sub> in water and dilute to 500 ml with water.

7.11 Nitric Acid (0.05M) – Add 3.18 ml of concentrated nitric acid (sp gr 1.42) to 400 ml of water and dilute to 1 liter with water.

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## 8.0 PROCEDURES

### 8.1 Sr-90 and Y-90 Calibration and Standardization

- 8.1.1 Prepare a blank and a set of three calibration samples.
- 8.1.2 Pipet 1.0 ml of strontium carrier into 3 small glass beakers.
- 8.1.3 Add 0.5 ml of NIST traceable Sr-90 solution to each beaker containing the strontium carrier and evaporate to near dryness on a hot plate.
- 8.1.4 Re-dissolve the residue in 5.0 ml of 8M nitric acid by placing a watch glass over each beaker and gently heat..
- 8.1.5 Once residue is dissolved, remove beakers from heat and cool.
- 8.1.6 Set up four strontium extraction columns by removing the bottom end cap from each column, pressing the top frit down snugly to the resin surface using a glass rod, letting packing water gravity drain from the column, adding 5 ml of 8M nitric acid and gravity draining to a plastic beaker.
- 8.1.7 Carefully transfer each sample solution to its respective resin column reservoir. (Add half of the solution and let drain before adding the remaining portion).
- 8.1.8 Rinse each sample beaker with 3 ml of 8M nitric acid, then, add rinse to each respective column following passage of the sample feed.
- 8.1.9 Repeat step 8.1.8
- 8.1.10 Rinse each column with 10 ml of 8M nitric acid.
- 8.1.11 Record the time of completion of the last rinse as the yttrium-90 separation(start of Y-90 in-growth,  $t_1$ ).
- 8.1.12 Elute the strontium 90 from each column with two 5 ml portions of 0.05M nitric acid into a labeled plastic beaker.

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- 8.1.13 Clean four counting planchets by moistening a paper towel with methanol, wiping the planchet and letting it dry.
- 8.1.14 Weigh each planchet to 0.1mg, record the weight.
- 8.1.15 Place the four sample planchets under a heat lamp in a fume hood.
- 8.1.16 Evaporate each strontium eluate onto its respective planchet by adding small portions, approximately 2.0 to 3.0 ml, to each planchet and allowing each portion to evaporate to near dryness between additions.
- 8.1.17 Following the evaporation of each sample, cool the planchets to room temperature in a desiccator and re-weigh each planchet. Record the weight to 0.1mg.
- 8.1.18 Count the samples as soon as possible after evaporation on a low background alpha/beta gas proportional system(Counting should be completed within 3 hours of column elution).

## 8.2 Soil Sample Preparation

- 8.2.1 Weigh required amount of dry sample into a tared 250 ml glass beaker on an analytical balance. (5 grams to 25 grams).
- 8.2.2 Weigh the sample several times to get a stable dry weight.
- 8.2.3 Add 10 to 100 ml of concentrated HNO<sub>3</sub> to each beaker. Add 1.0 ml of strontium carrier (for gravimetric yield option) to the appropriate beakers.
- 8.2.4 Place a watch glass over each beaker and heat the beakers at a low heat for 3-4 hours.
- 8.2.5 Stir the solution occasionally during the leaching process.
- 8.2.6 Remove beakers from hot plate and allow to cool.
- 8.2.7 Transfer the leaching solution and the residue from the beaker into a centrifuge tube and centrifuge at 3700 rpm for 30 min.

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8.2.8 Decant the supernate into a clean labeled beaker.

8.2.9 Wash the remaining residue in the centrifuge tube with 10 to 100 ml of DI water.

8.2.10 Centrifuge at 3700 rpm an additional 30 min and decant the supernate into beaker from step 8.2.8.

8.2.11 Place beaker on hotplate at low to medium heat and evaporate the solution to near dryness.

Note: Add few drops of 30% H<sub>2</sub>O<sub>2</sub> if required to decompose residual organics, during evaporation.

8.2.12 Dissolve the residue with 10 ml to 100 ml of 0.1M HNO<sub>3</sub> acid, cover and set aside

### 8.3 Pre-loading of Sr with Eichrom Cation exchange resin column

8.3.1 Prepare a cation exchange column containing 10 ml of 100-200 mesh resin.

8.3.2 Precondition the column by passing 50-55 ml of 0.1M HNO<sub>3</sub> through the column, then discard the eluate..

8.3.3 Pass the solution prepared from step 8.2.12 through the column and discard eluate.

8.3.4 Rinse the column with 25-30 ml of 0.1 M HNO<sub>3</sub> and discard eluate.

8.3.5 Elute strontium with 50 ml of 8M HNO<sub>3</sub> into a 150 ml beaker.

8.3.6 Evaporate the eluate from step 8.3.5 to near dryness

8.3.7 Re-dissolve the residue in 10 ml of 8M HNO<sub>3</sub> acid.

8.3.8 Cover 150 ml Sr beaker with a watch glass and set aside..

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## 8.4 Sr Separation using Sr Resin Column

- 8.4.1 For each sample dissolved, place a Sr column in the column rack.
- 8.4.2 Place a beaker below each column, remove the bottom plug and top caps from each column and allow to drain, then discard drain solution.
- 8.4.3 Attach column reservoirs to each column.
- 8.4.4 Pipet 5 ml of 8M HNO<sub>3</sub> into each column to condition resin and allow to drain, then discard drain solution.
- 8.4.5 Transfer each re-dissolved sample from step 8.3.8 into the appropriate Sr column by pouring or by using a plastic transfer pipet and discard eluate..
- 8.4.6 Add 5 ml of 8M HNO<sub>3</sub> to rinse each beaker from step 8.3.8 and transfer each solution into the appropriate Sr column and discard eluate.
- 8.4.7 If Pu<sup>+4</sup>, Np<sup>+4</sup> or Ce<sup>+4</sup> may be present, add 10 ml of 3M HNO<sub>3</sub> – 0.05M oxalic acid into each column and allow to drain.
- Note: The 3M HNO<sub>3</sub> – 0.05M oxalic acid removes Pu<sup>+4</sup>, Np<sup>+4</sup> or Ce<sup>+4</sup>, which is retained by Sr resin. If these interferences are known to be absent, this step may be skipped.
- 8.4.8 Add 5 ml of 8M HNO<sub>3</sub> to each Sr column and discard eluate rinse solution.
- Note: This additional 8M HNO<sub>3</sub> rinse removes any residual oxalic acid and ensures full removal of K<sup>+</sup> and Ba<sup>+2</sup> that may be present.
- 8.4.9 Record the time when the last rinse completely drains through each column as the start of Yttrium in-growth.
- 8.4.10 Ensure labeled plastic beakers are below each column.

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8.4.11 Pipet 10 ml of 0.05M HNO<sub>3</sub> into each column and allow to drain to elute the strontium from the resin columns into labeled plastic beakers..

## 8.5 Gas Proportional Counting

8.5.1 For each sample analyzed, clean a counting planchet by moistening a paper towel with methanol, wiping the planchet and letting it dry.

8.5.2 Weigh the counting planchet(s) on an analytical balance and record the weight to 0.1mg.

8.5.3 Place each counting planchet under a heat lamp in a fume hood.

8.5.4 Evaporate the column strip solutions from step 8.4.11 by placing into each planchet ≈ 2 to 5 ml volumes.

8.5.5 Allow each volume to evaporate to near dryness between additions.

8.5.6 Rinse the beakers containing the column strip solution with ≈ 5 ml of 0.05M HNO<sub>3</sub> and transfer to the counting planchet.

8.5.7 After all the solution has evaporated to dryness, cool each planchet in a desiccator to room temperature.

8.5.8 Reweigh each counting planchet, and record the weight to 0.1mg.

8.5.9 Count each planchet using a gas proportional counting system.

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## 9.0 Calculations

9.1 Calculate the strontium yield using stable Sr carrier added :

$$\text{Yield: } \frac{R_w - T_w - B_w}{C_w}$$

Where:

$R_w$  = Residue + planchet, mg

$T_w$  = Tare weight of planchet, mg

$B_w$  = Blank weight, mg (extractant loss from resin column)

$C_w$  =  $\text{Sr}(\text{NO}_3)_2$  added, mg

Percent Yield = Yield X 100

9.2 Calculate  $\text{Sr}^{90}$  Concentration:

$$\text{Sr}^{90} \text{ Activity (picoCi/g): } \frac{C_s - C_b}{(V)(Y_{\text{Sr}})(C)(I)e^{-\lambda_s(t-t_1)}}$$

Where:

$C_s$  = CPM of sample

$C_b$  = CPM of background

$Y_{\text{Sr}}$  = Chemical yield of Sr carrier recovery

$V$  = Grams

$I$  = In-growth Factor =  $E_s + E_y(1 - e^{-\lambda_s(t-t_1)})$

$\Delta t$  = Change in time from sample analysis and separation (in hours)

$C$  = Conversion factor = 2.22 dpm/picoCi

$T_s$  = Count time in minutes

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## APPENDIX A

# CHEMISTRY TERMINOLOGY DEFINITIONS

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## **10.0 APPENDIX A: CHEMISTRY TERMINOLOGY DEFINITIONS**

Acid – A substance that produces  $H^+(aq)$  ions in aqueous solution.

Alpha Particle – Helium ion with 2+ charge; an assembly of two protons and two neutrons.

Anion – A negative ion; an atom or group of atoms that has gained one or more electrons.

Background Radiation – Radiation extraneous to an experiment. Usually low level natural radiation from cosmic rays and trace radioactive substances present in our environment.

Base – A substance that produces  $OH^-(aq)$  ions in aqueous solution.

Beta Particle – Electron emitted from the nucleus when a neutron decays to a proton and an electron.

Bronsted-Lowery Acid – A proton donor.

Bronsted-Lowery Base – A proton acceptor.

Cation – A positive ion; an atom or group of atoms that has lost one or more electrons.

Dissociation – In an aqueous solution, the process in which a solid ionic compound separates into its ions.

Dissociation Constant – Equilibrium constant that applies to the dissociation of a complex ion into a simple ion and coordinating species.

Eluent – The solvent used in the process of elution, as in liquid chromatography.

Eluate – The mobile phase that passes through the stationary phase (resin beads in an ion exchange column) and removes the sample components from the stationary phase.

Molarity – Number of moles of solute per liter of solvent.

Mole – The amount of pure substance containing the same number of chemical units as there are atoms of Carbon-12.

Solute – The dispersed (dissolved) phase of a solution.

Solvent – The dispersing medium of a solution.