8. CONCLUSIONS AND RECOMMENDATIONS

8.1 Conclusions

This report applies new characterization data (measured and modeled) estimate inventories of irradiated beryllium disposed of in the SDA from the MTR, ETR, and ATR. Though a number of radioisotopes were modeled and documented in this study, the analysis focused on C-14 and several TRU isotopes identified as potential risk drivers for OU 7-13/14 (Becker et al. 1998). The following conclusions derive from this study.

- C-14 inventory in the buried MTR, ETR, and ATR beryllium was approximately 92.5 Ci at time of disposal.

- Before this study, it was not known whether uranium was present in sufficient concentrations in the ATR beryllium to produce a waste with a significant TRU inventory. This study verifies that TRU concentrations in beryllium from ATR exceed 100 nCi/g for TRU waste. Beryllium reflectors from the first core loadings of MTR and ETR (material that was disposed of in the SDA) exceed the 100-nCi/g limit for TRU waste.

- Approximately 2.47 Ci of TRU isotopes are attributable to disposal of beryllium from MTR, ETR, and ATR. Estimated TRU inventories in buried beryllium are small compared to total TRU inventories in the SDA.

- Computer modeling for characterization of beryllium blocks and OSCCs from ATR was validated by comparing model concentrations to measured concentrations for several isotopes at two sample point locations on Block 010R. This study is the first case in which significant measured data have been obtained from the ATR beryllium core components and then compared with computer code results. The results of these comparisons have shown that the best-estimate computer code results are generally within a factor of 2 for most measured data. The data presented in this report represent the best-estimate characterization currently available for approximately 40 radionuclides considered in this analysis.

- The calculated Pu-239 and TRU values—using both the segmented and the single-block models computed at Site 1 and Site 2 cells—are in very good agreement (usually within a factor of 2 or better) and are in agreement with the sample assay measurements taken from Site 1 and Site 2. This information validates the computer models and the basis for segmented and single-block computer models to accurately determine the total block inventory of TRU isotopes and other radionuclides of interest.

- Based on the segmented three-dimensional model calculation, more than 96% of the beryllium block mass exceeds 100 nCi/g. In addition, nearly 50% of the block mass exceeds 400 nCi/g.

- Calculated TRU total inventory for Block 010R was 277.08 nCi/g using the segmented model and associated detailed analysis. The corresponding single-block model calculated a more conservative TRU total block average concentration of 491.23 nCi/g, as reported in Tables 6-4 or 7-12. (Note: In Table 7-12, the 010R inventory is the same as that shown for Block 015L.)

- TRU concentration is a dynamic quantity and can be accurately determined from computer analysis. Primary variables that influence TRU inventory are irradiation time, initial uranium inventory, neutron flux, and decay time. During irradiation, TRU inventory tends to build up until a maximum value is reached before TRU isotopes begin to burn out and decrease total TRU concentration. However, following irradiation, TRU isotopes significantly increase in concentration because of beta decay of non-TRU isotope Pu-241 into TRU isotope Am-241.

- The segmented model provides insight into the three-dimensional distribution of important isotopes within a typical beryllium block from ATR. This distribution includes TRU isotopes, C-14, and H-3. The segmented three-dimensional model also is a powerful tool for determining alternative or representative sampling locations for future sampling.

- Elemental assay data presented in this report represent known, best-estimate information about chemical impurities in beryllium reflector material used at the INL Site and in the industry. In addition, best-estimate reactor operating conditions were assumed in the calculations for beryllium components from MTR, ETR, and ATR.

- Before this investigation, the number of Core 2 blocks disposed of was not known. This investigation indicates that two of the Core 2 blocks are still in the ATR canal and that six Core 2 blocks were disposed of on or about October 14, 1982, in the SDA. Though it was originally known that nine OSCCs had been disposed of in the SDA, whether all of these shim cylinders came from Cores 1 and 2 was not known. This study has confirmed that the OSCCs came from Cores 1 and 2, but which core positions these OSCCs occupied are still unknown. The serial numbers for the buried OSCCs and many of the reflector block serial numbers are not known.

8.2 Recommendations

Although MTR and ETR characterization data in this report apply specifically to beryllium disposed of from these reactors, with slight revision the data also could be applied to beryllium reflector materials and other core components remaining in the ETR and MTR reactors to support future waste disposal for facility deactivation, decontamination, and decommissioning. Reports by Kaiser et al. (1982) and Rolfe and Wills (1984) should be revised to reflect information in this report.

All beryllium reflector material now stored in the ATR canal or generated in the future should be modeled to estimate the total radiological inventory to support future waste path planning. In addition, modeling should be expanded to estimate the radiological inventory that will result from continued operation of the ATRC reactor.

9. REFERENCES

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Appendix A

Assay Test Data on Advanced Test Reactor Beryllium Purchased from Kawecki Berylco Industries

Appendix A

Assay Test Data on Advanced Test Reactor Beryllium Purchased from Kawecki Berylco Industries

Appendix A contains copies of test reports on KBI beryllium found in archived records at the INL Site.

PRINTED BY THE STANDARD REGISTER COMPANY U.S.A. ZIPLET 4B

CUSTOMER: Mechanical Spec. Co.

CUSTOMER LOCATION: Los Angeles, Ca.

CUSTOMER P. O. NUMBER: Mech. Spec. P.O. S51668
E.G. & G. P.O. K2557

KAWECKI BERYLCO INDUSTRIES, INC.

POST OFFICE BOX 429
HAZLETON, PENNSYLVANIA 18201

QUALITY CONTROL MATERIAL TEST REPORT

DATE: May 30, 1978

BERYLCO ORDER NO.: 58-4359

SPEC. NUMBERS: ANC-80005F

DESCRIPTION

One (1) Blank Per ANC Drawing 403228-1 Rev. B (HA 5470)

K.B.I. Unit No. 25-1001 Hot Pressing No. 616A

E.G. & G. S/N 021

NUMBER	616A		Element	616A		Element	616A
Be Assay	98.37		Pb	<0.0001		Lu	<0.00005
BeO	1.96		Si	0.0330		Sc	0.00017
C	0.065		Mo	<0.0010			
Fe	0.1460		Ti	0.0065			
Al	0.0255		B	0.00015			
Mg	0.0015		Cd	<0.0001			
~~Si~~ Mn	0.0045		Li	<0.0001			
Ni	0.0180		F	0.0070			
Cr	0.0065		Cl	<0.0050			
~~Ca~~	0.0200		Br	0.0021			
~~Co~~	0.0016		I	<0.0010			
Cu	0.0075		La	<0.0001			
Zn	0.0100		Ce	<0.0001			
Ag	0.0003		Pr	<0.0001			
U.T.S.			Nd	<0.0005			
			Sm	<0.00005			
.2% Y.S.			Eu	<0.00005			
			Gd (Cd)	<0.00002			
% El.			Tb	<0.0001			
			Dy	<0.00002			
			Ho	<0.0001			
			Er	<0.00005			
			Tm	<0.00005			
DENSITY			Yb	<0.00002			

M. S. C. MATERIAL
CODE NO. E-35

T-Count 10.654 X 10^{-6}

Sieve analysis of powder lot 5433 used to produce unit 25-1001, Pressing 616A was 99.9 % minus 200 mesh (ASTM B-214)

REMARKS: Total danger sum (Para. 3.3.2) = 31.65 (For elements listed at less than the detection limit, the detection limit has been used for calculating the total danger sum)

Two (2) 50 gram samples for customer per Para. 4.2.1/4.2.2. are appended to this report.

KAWECKI BERYLCO INDUSTRIES, INC.
P.O. BOX 429, HAZLETON, PA. 18201

By Edward A. Rash

Title Q. C. Supv

KAWECKI BERYLCO INDUSTRIES, INC.

P. O. Box 429, Hazleton, Pa. 18201
Telephone: 717 / 455-4913

Date June 30, 1973

Reviewed QC

Mech Spec. P.O. # S51668
KBI P.O. # 58-4359
Dwg # 403228-1 Rev B
Material Specification ANC-800050
ATR Beryllium Reflector Material Blank
Pressing # 642A E. G. & G. S/N 022

642A

Certification Contents

1. Chemical Composition
2. Mechanical Properties
3. Mechanical Properties Stress Strain Charts
4. Physical Properties - Density etc.
5. Radiographic Report
6. Dimensional Report
7. Liquid Penetrant Report
8. Certification of Material Compliance
9. In-Process Routing of Segment
10. In-Process Routing of Mechanical Test Specimens
11. In-Process operational sketches
12. Beryllium Powder Release

Remarks:

Edward H. Nash
Edward H. Nash
KBI Q. C. Supervisor

M. S. C. MATERIAL
CODE NO. E-38

METALS • ALLOYS • CHEMICALS

CUSTOMER: Mechanical Specialties Co.

CUSTOMER LOCATION: Los Angeles, Ca.

CUSTOMER P. O. NUMBER: Mech Spec. P.O. S51668 E.G & G. P.O. K2557

KAWECKI BERYLCO INDUSTRIES, INC.

POST OFFICE BOX 429
HAZLETON, PENNSYLVANIA 18201

QUALITY CONTROL MATERIAL TEST REPORT

DATE: June 30, 1978

BERYLCO ORDER NO.: 58-4359

SPEC. NUMBERS: ANC-80005 B

DESCRIPTION: One (1) Pc., Kawecki Berylco Be Segment Blank per Dwg # 403228-1 Rev B (PA-5/70)

KBI Unit No - 25-1002 Hot Pressing No - 642A

E. G. & G. S/N - 022

NUMBER		642A								
Be Assay		98.40			Pr	0.0027				
BeO		1.89			T	<0.0010				
C		0.050			La	<0.0001				
Fe		0.1500			Ce	<0.0001				
Al		0.0315			Pr	<0.0001				
Mg		0.0010			Nd	<0.0005				
SX Ni		0.0235			Sm	<0.00005				
Mn		0.0015			Eu	<0.00005				
Cr		0.0100			Gd	<0.00001				
Ca	<	0.0200			Tb	<0.0001				
[illegible]		0.0009			Dy	<0.00002				
Sn		0.0010			Ho	<0.0001				
Zn	<	0.0100			Er	<0.00005				
Ag		0.0005			Tm	<0.00005				
U.T.S.	Pb	< 0.0001			Yb	<0.00002				
	Si	0.0470			Lu	<0.00005				
.2% Y.S.	Mo	< 0.0030			Sc	0.0005				
	Ti	0.0015								
% El.	B	0.00015								
	Cd	< 0.0001								
	Li	< 0.0001								
	F	0.0010								
	Cl	< 0.0010								
DENSITY		1.851 g/cc								
T-Count		1.1406 X 10^{-6}								

M. S. C. MATERIAL
CODE NO. E-38

Three analyses of powder Lot 3403 used to produce unit 25-1002, processing 642A was -80 mesh, sieve 200 mesh (ASTM B-214)

REMARKS: Total danger sum (para. 3.3.2) = 32.55 (For elements listed at less than the detection limit, the detection limit has been used for calculating the total danger sum)

Two (2) 50 gram chip samples for customer per para 4.2.1/4.22 are appended to this report

7/6/78
EG&G
D.C. Fuehrer

KAWECKI BERYLCO INDUSTRIES, INC.
P.O. BOX 429, HAZLETON, PA. 18201

By Edward A. Rash
E. H. RASH

Title Q. C. SUPERVISOR

KAWECKI BERYLCO INDUSTRIES, INC.

P. O. Box 429, Hazleton, Pa. 18201
Telephone: 717 / 455-4913

Date June 30, 1972

Reviewed

Mech Spec. P.O. # S51668
KBI P.O. # 58-4359
Dwg # 403228-1 Rev B
Material Specification ANC-800050
ATR Beryllium Reflector Material Blank
Pressing # 651A E. G. & G. S/N 023

Certification Contents

1. Chemical Composition
2. Mechanical Properties
3. Mechanical Properties Stress Strain Charts
4. Physical Properties - Density etc.
5. Radiographic Report
6. Dimensional Report
7. Liquid Penetrant Report
8. Certification of Material Compliance
9. In-Process Routing of Segment
10. In-Process Routing of Mechanical Test Specimens
11. In-Process operational sketches
12. Beryllium Powder Release

Remarks:

One Copy of S.R.D.A. 0138 enclosed and copy of sketch

Edward H. Rash
Edward H. Rash
KBI Q. C. Supervisor

M. S. C. MATERIAL
CODE NO. E-37

CUSTOMER: Mechanical Spec. Co.
CUSTOMER LOCATION: Los Angeles, Ca.
CUSTOMER P. O. NUMBER: Mech. Spec. P.O. 851668 E.C. & G. P.O. K2557

KAWECKI BERYLCO INDUSTRIES, INC.

POST OFFICE BOX 429
HAZLETON, PENNSYLVANIA 18201

QUALITY CONTROL MATERIAL TEST REPORT

DATE: July 12, 1978
BERYLCO ORDER NO.: 58-1350
SPEC. NUMBERS: APC-80005 F

DESCRIPTION

One (1) Blank Per APC Drawing 103228 Rev. B

K.B.I Unit No. 25-1003, Hot Pressing No. 651A

E.C. & G. S/N 023

NUMBER	651A	Element	651A	Element	651A
Be Assay	98.31	Pb	0.0001	La	<0.0000
BeO	2.00	Si	0.0290	Sc	0.0002
C	0.065	Mo	<0.0010		
Fe	0.1590	Ti	0.0070		
Al	0.0120	B	0.00017		
Mg	0.0055	Cd	<0.0001		
Six Mn	0.0050	Li	<0.0001		
NH	0.0225	F	0.0070		
Cr	0.0090	Cl	<0.0050		
Ca	<0.0200	Br	0.0054		
Co	0.0014	I	<0.0001		
Cu	0.0120	La	<0.0001		
Zn	<0.0100	Ce	<0.0001		
Ag	<0.0001	Pr	<0.0001		
U.T.S.		Nd	<0.00005		
		Sm	<0.00005		
.2% Y.S.		Eu	<0.00005		
		Gd	<0.00002		
% El.		Tb	<0.0001		
		Dy	<0.00002		
		Ho	<0.0001		
		Er	<0.00005		
		Tm	<0.00005		
DENSITY		Yb	<0.00002		
T- Count	1.550 x 10^{-3}				

Sieve analysis of powder lot 5503 used to produce unit 25-1003, Pressing 651A was 99.0% minus 200 mesh (ASTM B-214)

Total danger sum (Para. 3.3.2)= 24.49 (For elements listed at less than the detection limit, the detection limit has been used for calculating the total danger sum).

REMARKS

Two (2) 50 gram samples for customer per Para. 4.2.1/4.2.2 are appended to this report.

EG&G
J.C. Anschel
4/13/78

KAWECKI BERYLCO INDUSTRIES, INC.
P.O. BOX 429, HAZLETON, PA. 18201

By: J. J. Daniba

Title: Q.C. Foreman

M. S. C. MATERIAL
CODE NO. E-37

HOC-1A

KAWECKI BERYLCO INDUSTRIES, INC.

P. O. Box 429, Hazleton, Pa. 18201
Telephone: 717 / 455-4913

Date August 30, 1978

Reviewed

Mech Spec. P.O. # S51668
KBI P.O. # 58-4359
Dwg # 403228-1 Rev B
Material Specification ANC-800050
ATR Beryllium Reflector Material Blank
Pressing # 679A E. G. & G. S/N 028

Certification Contents

1. Chemical Composition
2. Mechanical Properties
3. Mechanical Properties Stress Strain Charts
4. Physical Properties - Density etc.
5. Radiographic Report
6. Dimensional Report
7. Liquid Penetrant Report
8. Certification of Material Compliance
9. In-Process Routing of Segment
10. In-Process Routing of Mechanical Test Specimens
11. In-Process operational sketches
12. Beryllium Powder Release

Remarks:

M. S. C. MATERIAL
CODE NO. E-36

Edward H. Nash
KBI Q. C. Supervisor

METALS · ALLOYS · CHEMICALS

CUSTOMER	KAWECKI BERYLCO INDUSTRIES, INC.	DATE
Mechanical Spec. Co.	POST OFFICE BOX 429 HAZLETON, PENNSYLVANIA 18201	8/30/78
CUSTOMER LOCATION: Los Angeles, Calif.	QUALITY CONTROL MATERIAL TEST REPORT	BERYLCO ORDER NO.: 58-4359
CUSTOMER P. O. NUMBER: Mech. Spec. P.O. S51668 E. G. & G. P.O. K2557		SPEC. NUMBERS: ANC - 80005F

DESCRIPTION

one (1) B lank per ANC Drawing 403228-1 Rev B (HA 5470)

K.B.I. Unit 25-1004, Hot Pressing No. 679A

E. G. & G. S/N 024

NUMBER	679A	Element	679A	Element	679A
Be Assay	98.33	Pb	0.0001	Lu	<0.00005
BeO	2.00	Si	0.0340	Sc	0.00022
C	0.077	Mo	<0.0010		
Fe	0.1500	Ti	0.0070		
Al	0.0350	B	0.00020		
Mg	0.0055	Cd	<0.0001		
Mn	0.0060	Li	<0.0001		
Ni	0.0225	F	0.0070		
Cr	0.0095	Cl	<0.0050		
Ca	<0.0200	Br	0.0072		
Co	0.0014	I	<0.0010		
Cu	0.0090	La	<0.0001		
Zn	<0.0100	Ce	<0.0001		
Ag	<0.0001	Pr	<0.0001		
U.T.S.		Nd	<0.0005		
		Sm	<0.00005		
.2% Y.S.		Eu	<0.00005		
		Gd	<0.00002		
% El.		Tb	<0.0001		
		Dy	<0.00002		
		Ho	<0.0001		
		Er	<0.00005		
		Tm	<0.00005		
DENSITY		Yb	<0.00002		

M. S. C. MATERIAL
CODE NO. E-36

T-Count 2.455 x 10^{-6}

Sieve analysis of Powder Lot 5547 used to produce unit 25-1004, Pressing 679A was 99.9% minus 200 mesh (ASTM B-214)

REMARKS: Total Danger Sum (Para 3.3.2)= 35.81 (For elements listed at less than the detection limit, the detection limit has been used for calculating the total danger sum)

Two (2) 50 gram samples for customer per Para. 4.2.1/4.2.2. are appended to this report.

9-6-78

KAWECKI BERYLCO INDUSTRIES, INC.
P.O. BOX 429, HAZLETON, PA. 18201

By Edward H. Pash
Edward H. Pash

Title Q.C. Supervisor

KAWECKI BERYLCO INDUSTRIES, INC.

P. O. Box 429, Hazleton, Pa. 18201
Telephone: 717 / 455-4913

Date October 31, 1978

Mech Spec. P.O. # S51668
KBI P.O. # 58-4359
Dwg # 403228-1 Rev B
Material Specification ANC-800056
ATR Beryllium Reflector Material Blank
Pressing # 710A E. G. & G. S/N 026

Revised

Certification Contents

1. Chemical Composition
2. Mechanical Properties
3. Mechanical Properties Stress Strain Charts
4. Physical Properties - Density etc.
5. Radiographic Report
6. Dimensional Report
7. Liquid Penetrant Report
8. Certification of Material Compliance
9. In-Process Routing of Segment
10. In-Process Routing of Mechanical Test Specimens
11. In-Process operational sketches
12. Beryllium Powder Release

Remarks:

Edward H. Kaesh
Edward H. Kaesh
KBI Q. C. Supervisor

METALS • ALLOYS • CHEMICALS

CUSTOMER: Mechanical Spec. Co.

CUSTOMER LOCATION: Los Angeles, Calif.

CUSTOMER P. O. NUMBER: Mech. Spec. P.O. S51668
E.G.&G. P.O. K2557

KAWECKI BERYLCO INDUSTRIES, INC.

POST OFFICE BOX 429
HAZLETON, PENNSYLVANIA 18201

QUALITY CONTROL MATERIAL TEST REPORT

DATE: October 30, 1978

BERYLCO ORDER NO.: 58-4359

SPEC. NUMBERS: ANC-80005 F

DESCRIPTION: One (1) Blank Per ANC Dwg. 403228 Rev. B

K.B.I.UNIT No. 25-1007 Hot pressing No. 710A

E.G. & G. .S/No. 026

NUMBER	710A			710A
Be Assay	98.25		Pb	< 0.0001
BeO	2.0		Si	0.0315
C	0.107		Mo	< 0.0010
Fe	0.1565		Ti	0.0045
Al	0.0345		B	0.00028
Mg	0.0045		Cd	< 0.0001
XK Ni	0.0290		Li	< 0.0001
Mn	0.0050		F	0.0080
Cr	0.0100		Cl	< 0.0050
Ca	< 0.0200			
Co	0.0009			
Cu	0.0090			
Zn	< 0.0100			
Ag	0.0002			
U.T.S.				
.2% Y.S.				
% El.				
DENSITY	1.856	g/cc		
T-Count	.6720 x 10^{-6}			

Sieve analysis of powder Lot 5625 used to produce unit 25-1007, Pressing 710A was 99.9 % minus 200 mesh (ASTM B-214).

Total danger sum (Para. 3.3.2) -34.49 (for elements listed at less than the detection limit). ~~(CASS~~(The detection limit has been used for calculating the total danger sum).

Two(2) 50 Grams Samples for customer per Para. 4.2.1/4.2.2 are appended to the report.

KAWECKI BERYLCO INDUSTRIES, INC.
P.O. BOX 429, HAZLETON, PA. 18201

By J.A. Dzuiba

J.A. Dzuiba

Title Q.C. Forman

10-31-78

KAWECKI BERYLCO INDUSTRIES, INC.

P. O. Box 429, Hazleton, Pa. 18201
Telephone: 717 / 455-4013

Date February 20, 1979

Mech Spec. P.O. # S51668
KBI P.O. # 58-4359
Dwg # 403228-1 Rev B
Material Specification ANC-800050
ATR Beryllium Reflector Material Blank
Pressing # 761A E. G. & G. S/N 028

Reviewed

Certification Contents

1. Chemical Composition
2. Mechanical Properties
3. Mechanical Properties Stress Strain Charts
4. Physical Properties - Density etc.
5. Radiographic Report
6. Dimensional Report
7. Liquid Penetrant Report
8. Certification of Material Compliance
9. In-Process Routing of Segment
10. In-Process Routing of Mechanical Test Specimens
11. In-Process operational sketches
12. Beryllium Vendor Release

Remarks:

Edward H. Kash
KBI Q. C. Supervisor

METALS · ALLOYS · CHEMICALS

CUSTOMER: Mechanical Specialty Co.

CUSTOMER LOCATION: Los Angeles, California

CUSTOMER P. O. NUMBER: S51668

KAWECKI BERYLCO INDUSTRIES, INC.
POST OFFICE BOX 429
HAZLETON, PENNSYLVANIA 18201

QUALITY CONTROL MATERIAL TEST REPORT

DATE: April 23, 1979

BERYLCO ORDER NO: 58-4359

SPEC. NUMBERS: AMC-80005F

DESCRIPTION: One (1) Blank per AMC Drawing 403228 Rev. B

K.B.I. Unit No. 25-1010, Hot Pressing No. 761A E646 SN 028

NUMBER	761A	Element	761A	Element	761A
Be Assay	98.35	Pb	< 0.0001	Lu	< 0.00005
BeO	1.98	Si	0.0340	Sc	0.0003
C	0.063	Mo	< 0.0010		
Fe	0.1380	Ti	0.0055		
Al	0.0100	B	0.0002		
Mg	0.0060	Cd	< 0.0001		
Ni	0.0200	Li	< 0.0001		
Mn	0.0070	F	0.0065		
Cr	0.0105	Cl	< 0.0050		
Ca	< 0.0200	Br	0.0061		
Co	< 0.0010	I	< 0.0010		
Cu	0.0070	La	< 0.0001		
Zn	< 0.0100	Ce	< 0.0001		
Ag	0.0001	Pr	< 0.0001		
U.T.S.		Nd	< 0.0005		
		Sm	< 0.00005		
.2% Y.S.		Eu	< 0.00005		
		Gd	< 0.00002		
% El.		Tb	< 0.0001		
		Dy	< 0.00002		
		Ho	< 0.0001		
		Er	< 0.00005		
		Tm	< 0.00005		
DENSITY		Yb	< 0.00002		

T-Count - 2.1900×10^{-6}

Sieve analysis of Powder Lot 5722 used to produce unit 25-1010, Pressing 761A was 99.9 % minus 200 mesh (ASTM B-214)

Total Danger Sum (Para. 3.3.2) = 35.28 (For elements listed at less than the detection limit, the detection limit has been used for calculating the total danger sum)

REMARKS

Two (2) 50 gram samples for customer per Para. 4.2.1/4.2.2 are appended to this report.

KAWECKI BERYLCO INDUSTRIES, INC.
P.O. BOX 429, HAZLETON, PA. 18201

By J. A. Dzuiba

Title Q. C. Foreman

OK. D.W. Smith
EC&G QE 5/8/79

CUSTOMER: Mechanical Spec. Co.

CUSTOMER LOCATION: Los Angeles, California

CUSTOMER P. O. NUMBER: Mech. Spec. Co. S51668 E.G.&G. P.O. K2557

KAWECKI BERYLCO INDUSTRIES, INC.

POST OFFICE BOX 429
HAZLETON, PENNSYLVANIA 18201

QUALITY CONTROL MATERIAL TEST REPORT

DATE: February 20, 1979

BERYLCO ORDER NO.: 58-4559

SPEC. NUMBERS: ANC-80005G

DESCRIPTION: One (1) Blank per ANC Drawing 403228-1 Rev. B (HA-5470)

K.B.I. Unit No. 25-1010 Hot Pressing No. 761A S/N 028

NUMBER	761A			761A
Be Assay	98.35		Pb <	0.0001
BeO	1.98		Si	0.0340
C	0.063		Mo <	0.0010
Fe	0.1380		Ti	0.0055
Al	0.0400		B	0.0002
Mg	0.0060		Cd <	0.0001
XX Ni	0.0200		Li <	0.0001
Mn	0.0070		F	0.0065
Cr	0.0105		Cl <	0.0050
Ca	< 0.0200			
Co	0.0010			
Cu	0.0070			
Zn	< 0.0100			
Ag	0.0001			
U.T.S.				
.2% Y.S.				
% El.				
DENSITY				

T-Count: 2.19×10^{-6}

Sieve Analysis of Powder Lot 5722 used to produce unit 25-1010, Pressing 761A was 99.9% minus 200 mesh (ASTM B-214)

REMARKS: Two (2) 50 gram chip samples for customer per Para. 4.2.1/4.2.2 are appended to the report.

NOTE: The T.D.A. will be completed and submitted on corrected certification upon receipt of additional analysis report from vendor laboratory. Final acceptance of material will be based upon acceptance of these values.

KAWECKI BERYLCO INDUSTRIES, INC.
P.O. BOX 429, HAZLETON, PA. 18201

By: Edward H. Rash

Edward H. Rash

Title: Q. C. Supervisor

2 (2) 79

HQC-1A

Appendix B

Analytical Test Data on Beryllium Samples from the Advanced Test Reactor at the Materials and Fuels Complex

Appendix B

Analytical Test Data on Beryllium Samples from the Advanced Test Reactor at the Materials and Fuels Complex

Appendix B contains reproduced reports from the MFC (formerly Argonne National Laboratory-West) on their measurements of various constituents of samples taken from the beryllium reflector blocks now in the canal at ATR.

ARGONNE NATIONAL LABORATORY-WEST
P.O. Box 2528, Idaho Falls Idaho 83403-2528 Telephone: (208) 533-7318

NT-AL-(JRK)-01-090
November 7, 2001

Randy Rice
BBWI,LLC, WGS
Central Facilities Area 615
MS 4110
P.O.Box 1625
Idaho Falls, Idaho 83415-4110

Reference: WGS-047-01 Sampling and Analysis Plan for the Transuranic Content from the High Neutron Flux Region of ATR Beryllium Block SN-010R

Dear Mr. Rice,

Two beryllium samples described in the reference document have been analyzed for uranium, transuranic isotopes, fission product Cs-137, activated Co-60, and stable Hg isotopes. The results are given in Table I. Samples were assigned an Analytical Laboratory number. This number is shown in row 1. The information given in the second row is your sample identification information. The analytical number identifies the sample in our database. The Table 1 data provides a cross-reference between the INEEL identification number and our database.

Analyses. The activity of these samples required the initial analytical work to be performed remotely in a shielded facility where contamination is a concern. Any surface contamination was removed by etching with hydrofluoric acid. 2.3410 grams of beryllium were dissolved in a mixture of 2 M HF and 9M HCl. The dissolved samples were than treated with boric acid and EDTA to ensure complete dissolution and to prevent loss of actinides by precipitation as a fluoride. The standard and "blind" were dissolved using a procedure developed for all other beryllium samples previously analyzed.

Inductively coupled plasma-mass spectroscopy (ICP-MS) and radiochemical measurements where made on both the original dissolver solutions and on separated fractions. Separations were required to remove activity, isobaric interference, and provide alpha energy discrimination. Separations were performed after aliquots of the original dissolver solutions were converted to the appropriate acid matrix. The prepared aliquots were loaded onto resin columns. The actinides were eluted selectively. Selectivity is accomplished by changing the molarity and composition of the eluant. Am and Cm were first eluted using 10 M HCl. Pu was eluted with 10 M HCl/0.1 M HI, and Np was eluted with 4M HCl. Uranium was eluted last with a 0.1 M HCl solution.

The results reported for Pu-238 were calculated from radiochemical data. The results for the rest of the radionuclides reported in Table I were calculated from ICP-MS data. Results for several radionuclides calculated from radiochemical data are reported here for your information (Pu-239/240 = 0.78 μg/g, Pu-242 = 0.27 μg/g, Am-241 = 0.07 μg/g, Am-243 = 0.32 μg/g, and Cm-244/243 = 0.29 μg/g). Np-237 was not detected by either ICP-MS or counting.

Quality Assurance. NIST traceable standards were used where available. Other standards were prepared at ANL-W and standardized using standard radiochemical techniques. The standards using for this effort are listed below:

Uranium	High Purity Standards Catalog Number ICP-MS-KIT-A
Plutonium	CRM-126
Neptunium	ANL-W Prepared standard
Americium	ANL-W Prepared Standard
Curium	Isotopes Product Laboratory Source Number 678-14
Mercury	High Purity Standards Catalog Number ICP-MS-KIT-C

The ICP-MS was calibrated for curium using Am-243. The ionization potentials for all of the measured actinides are within 1.3 % and the calibration slopes were essentially identical.

Control standards, calibrated detectors, and reviewed and approved procedures were used to ensure radiochemical quality control

If you have any questions, please feel free to call me at 208-533-7318.

Sincerely,

John Krsul
Manager, Analytical Laboratory

JRK:bb

Att.
Final Reports

pc:
Steve Aumeier
Charles D. Brooks, MS 7106
Michael L. Carboneau, MS 3885
Teresa Carlson
Michael J. Connolly, MS 3710
Jeff Giglio
Donna F. Haney, MS 4110
Steve Johnson
Carlan K. Mullen, MS 4142
Marianne Noy
Doug Porter

Table I. Results of Uranium, Transuranium, Fission Cesium-137, and Co-60 Measurements in Irradiated Beryllium.

Nuclide	Unit	82589 99A162	82590 Blind	82553A SN-010R W04701011TR	82553B SN-010R W04701012TR	Average (µg/g)	Average (nCi/g)	
Tot U	µg/g	73	51					
U-235	µg/g	0.72 w/o	0.69 w/o	<.03	<.01			
U-238	µg/g	99.27w/o	99.31w/o	11.1	9.5	10.3		
Np-237	µg/g							
Tot Pu								
Pu-238	µg/g			0.002	0.002	0.002	34.3	Counting
Pu-239	µg/g			0.25	0.23	0.24	14.9	ICP-MS
Pu-240	µg/g			0.25	0.21	0.23	52.2	ICP-MS
Pu-241	µg/g			0.02	0.02	0.02		ICP-MS
Pu-242	µg/g			0.16	0.14	0.15	0.6	ICP-MS
Am-241	µg/g			0.07	0.07	0.07	241	ICP-MS
Am-242	µg/g							
Am-243	µg/g			0.21	0.20	0.205	41	ICP-MS
Cm-244	µg/g			0.38	0.38	0.38		ICP-MS
Cm-245	µg/g			0.03	0.03	0.03	5.2	ICP-MS
Cm-246	µg/g			0.15	0.15	0.15	45.6	ICP-MS
Cm-247	µg/g			0.007	0.007	0.007	0.0006	ICP-MS
Tot TRU							**435**	
Cs-137	µCi/g			49	51	50 µCi/g		
Co-60	µCi/g			375	375	375 µCi/g		
Hg 198	µg/g			0.025	0.025	0.025		
Hg 199	µg/g			0.03	0.03	0.03		
Hg 200	µg/g			0.15	0.17	0.16		
Hg 201	µg/g			<.017	<.017	<.017		
Hg 202	µg/g			<.015	<.015	<.015		
Hg 204	µg/g			<.015	<.015	<.015		
Hg, Min	µg/g			0.205	0.225	0.215		
Hg, Max	µg/g			0.252	0.272	0.262		

ARGONNE NATIONAL LABORATORY-WEST
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NT-AL-(JRK)-01-029
April 9, 2001

Charles D. Brooks
BBWI
MS 7106
Idaho Falls, Idaho 83415-3860

Dear Mr. Brooks,

Reference: Modification No. 2 to Inter-Contractor Purchase No. F00-564335 Bechtel BWXT Idaho, LLC

Eight beryllium samples and a standard have been analyzed for uranium, niobium and plutonium. The results of the analyses are given in Table I.

Table I. Uranium, Niobium, and Plutonium results.

Analytical Number.	Sample ID	Sample Description	Sample Wt. (g)	ICP-MS Nb-93 (µg/g)	ICP-MS Uranium (µg/g)	U-235 U-238 Ratio	ICP-MS Pu-239 (ng/g)	Fluorimetry Uranium (µg/g)
79778	W03699051NC	SN-010R	0.1550	1	30	.0053	70	37
79779	W03699061NC	SN-015R	1.1513	16	32	.0053	45	27
79780	W03699071NC	SN-016L	NA	NA	NA	NA	NA	NA
79781	W03699081NC	SN-016R	0.9662	23	24	.0053	51	31
79782	W03699091NC	SN-017L	NA	NA	NA	NA	NA	NA
79783	W03699101NC	SN-017R	0.0571	18	24	.0056	ND	NA
79784	W03699111NC	SN-018R	0.3004	21	25	.0056	59	28
79785	W03699121NC	SN-020L	0.1773	13	25	.0054	52	32
79786	W03699131NC	SN-021L	0.3522	11	27	.0053	70	26
79787	W03699141NC	SN-022L	NA	NA	NA	NA	NA	NA
79788	W03699151NC	SN-11R	NA	NA	NA	NA	NA	NA
79789	WO3699161NC	SN-15L	0.0432	2	41	.0070	ND	NA
Standard	S200F	U (65 µg/g)	0.3620	0.6	57	.0073	ND	55

NA = Not Analyzed
ND = Not Detected

Uranium was measured using fluorimetry and ICP-MS. The results for each method are given in Table I for comparison purposes. Samples 79783 and 79789 were not analyzed for uranium using fluoresence because of the small mass available, 0.051 and 0.0432 grams, respectively. The amount of uranium available may have been too low for the sensitivity of this method. ICP-MS was used to collect

information to determine and calculate niobium and plutonium data. The estimated errors for these measurements are: uranium by ICP-MS = ± 10%, niobium for all analyses except #79778 & 79789 ± 10%, niobium (79778 & 79789) = ± 25% and plutonium = ± 25%. A brief description of each method is given below for information purposes.

Uranium analysis by fluorimetry involves the excitation of electrons in uranium to a higher energy state using ultraviolet radiation. After excitation, the electrons always return to their ground state energy. During this process, the excess energy is released as photons (green light in the visible spectrum at a wavelength of 550 nm). The relaxation process by which this occurs is called "fluorescence". The spectral wavelengths of the fluorescent radiation are always longer than the wavelengths of the excitation source.

The fluorimeter consists of a sample excitation source (UV source with peak radiation at 355 nm). Once the excited sample has released its excess energy, the energy passes through a filter system before arriving at the detector. The detector is a photomultiplier tube. This then converts the radiant energy into an electrical signal. The signal is displayed on a digital readout. Prior to any analysis, the fluorimeter must be calibrated with a standard of known uranium composition. The signal in the standard is relative to the quantity of uranium present. Blanks and spiked samples are run with each analysis.

Uranium, plutonium and niobium were measured using ICP-MS. The technique of quadrupole-based ICP-MS employs radio frequency plasma generated in pure argon gas. Plasma temperatures are typically in the range of 5000 to 8000 degrees Celsius. The plasma is generated in a quartz tube or torch. The torch is designed to aspirate an aerosol of sample into the central region of the plasma, where the sample and solvent atoms and molecules are atomized and ionized to varying degrees, depending on the plasma temperature and the ionization energy of the particular element. For example, most transition metal atoms are 85 to 99% ionized. The plasma is drawn into the mass spectrometer section through a water-cooled nickel cone with a 1 mm sampling orifice, and on through a number of differentially pumped vacuum chambers. Differential pumping allows an atmospheric pressure sample introduction to a high-vacuum region through a series of turbopumped chambers connected by small (on the order of 1mm) orifices; the pressure in each chamber lowers as you progress toward the high vacuum region where the mass analyzer resides. Electrically charged cylindrical "lenses" serve to first accelerate and then focus the ionized atom "beam" through these orifices and into the entrance of a quadrupole mass spectrometer.

The quadrupole acts as a mass filter with a resolution of ~1 atomic mass unit. This means, that while a quadrupole can separate Mg-24 from Mg-25, it cannot resolve Cr-50 from Ti-50. When such same-mass, or isobaric interference occurs, correction schemes must be applied by using other isotopes of a particular elemental species to determine the contribution of that element to the overall signal at the given mass. The quadrupole allows only one mass at a time through to the detector, where the signal at that mass is determined in counts per second. This count rate is used along with the calibration curve to quantitate the mass. Note that prior separation of two elements is not necessary when their isotopes are at different masses.

The calibration of the ICP-MS is typically external, using 3 to 4 elemental standards of known concentration to generate a calibration curve. A non-interfering internal standard such as In-115

or Rh-103 is used to normalize the count rates in samples and standards to correct for possible instrumental response "drift" during an analytical run. ICP-MS is well known for its sensitivity for metals, which can range from ug/L to pg/L in solution; in addition, the calibration curves are usually linear over 5 to 7 orders of magnitude.

Since quadrupole ICP-MS separates the ions according to mass for quantitation, niobium, at mass 93 (and a radioisotope Nb-94) does not need prior separation from tantalum, at masses 180 and 181. This is one of the great advantages of atomic mass spectrometry.

Samples of beryllium were dissolved in a mixture of HCL and HF. The resulting dissolver solution was brought to a known volume. Aliquots of each dissolver solution where treated chemically and diluted for each instrumental method of analysis.

All remaining solid beryllium samples have been consumed. A limited amount of dissolver solution (approximately 40 mls) of each sample listed above is available for additional work. These samples will be disposed in 30 days unless additional work is requested.

If you have any questions, please feel free to call me at (208) 533-7318 or Jeff Berg at (208) 533-7276.

Sincerely,

John Krsul, Manager
Analytical Laboratory

Att.
Final Reports

pc: J. Berg
M. Carboneau MS 3885
T. Carlson
D. Crawford
D. Cummings
S. Johnson
C. Mullen MS 4142
J. Sterbentz MS 3885

ARGONNE NATIONAL LABORATORY-WEST
P.O. Box 2528, Idaho Falls Idaho 83403-2528 Telephone: (208) 533-7318

July 10, 2000

Roger Piscitella
BBWI
P.O. Box 3860
MS 4142
Idaho Falls, Idaho 83415-3860

Reference: WGS-036-99 Abbreviated Sampling and Analysis Plan for TRA ATR Beryllium Blocks Supports-Phase IA of the ATR Comprehensive Beryllium Disposition Plan.

Dear Mr. Piscitella

Twelve beryllium samples described in the reference document have been analyzed. The results are given Table I. Samples were assigned an Analytical Laboratory number. This number is shown in column 1. The information given in the second column is your sample identification information. The analytical number identifies the sample in our database. The Table provides a cross-reference between your identification number and our database.

Table I. Samples Analysis Results.

Analytical Number	Sample ID	Sample Description	Density (g/cc)	C-14 (μCi/g)	Co-60 (μCi/g)	Cs-137 (μCi/g)	Nitrogen (ppm)	Carbon (ppm)	Activity (mr/hr/g)
79778	W03699051NC	SN-010R	1.851	0.61	13.1	0.2	203	734	32
79779	W03699061NC	SN-015R	1.852	0.24	25.4	0.1	178	637	49
79780	W03699071NC	SN-016L	1.862	0.58	17.6	0.2	208	824	40
79781	W03699081NC	SN-016R	1.854	0.35	52.5	0.1	181	804	41
79782	W03699091NC	SN-017L	1.853	0.18	15.7	0.1	152	693	48
79783	W03699101NC	SN-017R	1.853	0.41	74.1	0.1	224	681	85
79784	W03699111NC	SN-018R	1.854	0.36	46.0	0.2	160	650	136
79785	W03699121NC	SN-020L	1.856	0.52	47.4	0.2	253	1099	84
79786	W03699131NC	SN-021L	1.853	0.51	46.4	0.3	287	678	98
79787	W03699141NC	SN-022L	1.857	0.29	26.2	0.1	252	715	73
79788	W03699151NC	SN-11R	1.861	0.33	2.41	0.1	186	665	5
79789	W03699161NC	SN-15L	1.851	0.35	2.44	0.1	181	761	3

Table II gives the results of the analysis of two standards and two unknowns submitted with the 12 samples.

Table II. Results of the Analysis of Standards

Sample ID	Description	No.	Nitrogen (ppm)	Sample ID	Description	No.	Nitrogen (ppm)
W03699011N2	99-A-163	1	357	W03699031N2	S200F (99-A-162)	1	218
		2	359			2	214
		3	363			3	223
		Average	359			Average	218
		SD	3			SD	±5
W03699021N2	99-A-156	1	200	W03699041N2	S65C (99-A-157)	1	73
		2	198			2	85
		3	206			3	64
		Average	201			Average	74
		SD	2			SD	±10

W03699011N2 is a LECO steel pin standard (359±7 ppm). W03699021N2 is a beryllium metal nitrogen standard (202 ±12 ppm nitrogen). W03699031N2 and W03699041N2 are beryllium chips. The nitrogen concentrations were not given in the reference document, but were later identified as 548 ppm and 58 ppm, respectively.

Sample Preparation. The samples, received with Chain-of-Custody, were packaged in 250-ml polybottles filled with water. The samples were stored as received until analysis. Visual observations of the samples showed that some containers contained a single sample and others contained several pieces. The activity of each sample was estimated with a portable survey meter. The samples were prepared for analysis using the following procedure. Water was drained from each container to retrieve the samples. While the samples were still wet, a wet weight was obtained. The samples were dried, weighed and than weighed after a period of time to a constant weight. The dry weights and the wet weights were used to calculate the densities. Beryllium was sized for various analyses by breaking the samples with a center punch, chisel, and a hammer. This step was performed using a stainless steel beaker fitted with a lid. The lid had a hole for access to the center punch or chisel. Using this technique, the irradiated ATR beryllium was easily sized providing material for carbon-14, nitrogen, and gamma analyses.

Carbon-14 Analysis. Radioactive samples are routinely analyzed for total carbon using a remote furnace LECO HF-400/IR-412 carbon analyzer. The sample is placed in a ceramic crucible along with an accelerator to provide coupling for the induction furnace heating in an oxygen environment. Sample combustion releases all sample carbon in the form of CO and CO_2, which is quantitatively converted to CO_2 by passage through a hot rare earth-copper oxide (350°C) reagent tube. Total carbon is measured by CO_2 IR absorption. The CO_2 is then trapped in a removable solid sorbent CO_2 trap. The trap is removed from the system and purged to remove all carbon dioxide, which is trapped by bubbling through an amine solution. The solution is mixed with a compatible liquid scintillation cocktail and counted for C-14 beta activity.

Table III gives the results for the repeated measurement of known C-14 activity deposited on stainless steel using this method.

Table III. Results of C-14 Standard Assay.

Standard ID	Date	C-14 Activity	Recovered Activity	% Recovery
1	9/3/99	22644	23028	102
2	9/8/99	22644	22374	98.8
3	9/9/99	22644	21057	93.0
4	9/13/99	22644	22341	98.7

For the ATR beryllium, samples of beryllium were sectioned from the bulk material, weighed, and placed into polybottles. The samples were transferred into the Analytical Laboratory Hot Cells, and submitted to the analyzer to release and collect the carbon as CO_2. The separated radiocarbon was counted with a Packard Tri-Carb 2700 TR liquid scintillation analyzer. The error, ±7.5% 1-sigma, given for the carbon data is estimated from the repeated measurement of radiocarbon standards, percent recoveries, and overall process errors associated with hot cell operations.

Nitrogen Analysis. The remote furnace LECO EF-400/TC-436 nitrogen/oxygen analyzer is used to determine total oxygen and nitrogen content and nitride/oxide concentrations of irradiated reactor hardware and unirradiated and conditioned metallic spent fuel. The sample is placed in a graphite crucible in the furnace. Sample fusion releases oxygen and nitrogen in a helium atmosphere. Helium carrier gas transfers the released nitrogen and oxygen through a thermal conductivity cell and IR cell, respectively, to measure the amount of each gas released. A determination begins by placing an empty graphite crucible between the two electrodes in the furnace. The crucible is sealed and purged of all atmospheric gases. High current is then passed through the crucible; high heat is generated which drives off gases trapped in the graphite (called outgassing). Next, a sample is dropped from the loading mechanism into the crucible. High current is again passed through the crucible driving off gases in the sample. To prevent further outgassing during analysis, a lower current is used during analysis to drive off sample gases. The oxygen released from the sample combines with the carbon from the crucible to form carbon monoxide. The sample gases pass through heated rare earth copper oxide which converts the carbon monoxide to carbon dioxide. The sample gases are then passed through the IR cell which detects the oxygen as carbon dioxide. After detection, carbon dioxide is removed with Lecosorb® to prevent detection by the TC cell. Water is formed when the carbon dioxide is trapped and the water vapor, which would also be detected by the TC cell, is removed with Anhydrone™. Gas flow passes through the thermal conductivity cell which detects nitrogen.

Considerable development work was required to develop a technique to prepare samples of beryllium for nitrogen determination. For these analyses small pieces of beryllium and nickel flux were weighed and placed in a nickel capsule. The capsule was formed into a pellet using a press. Duplicates were prepared for each sample. Multiple samples were prepared for the standards and unknowns. The measuring of nitrogen in irradiated beryllium proved to be difficult, shown by the precision obtained for duplicate measurements. There are a number of variables that may effect the precision. These variable include the small sample size, pellet forming difficulties, uncertainty resulting from the loading of the pellet into the analyzer, and the operation of the analyzer itself. The overall error for these measurements is estimated to be ±21 ppm at 1- sigma. Samples 79781, 79786 and 79789 are

exceptions, with an estimated error of ±31 ppm. The precision is essentially the largest part of the uncertainty for these measurements. The analyzer was calibrated using LECO 501-645 Steel Pin NO Standard. The certified standard concentration is 265± 7ppm nitrogen.

Gamma Analysis of Dissolved ATR Beryllium. Weighed samples of beryllium were dissolved in hydrofluoric acid, hydrochloric acid and hydrogen peroxide. The resulting dissolver solution was brought to volume with IX water. For gamma analysis of dissolved ATR beryllium, the dissolved sample was made up in a 50-ml vial for gamma spectrometry, typically containing 50 to 200 mg of the original beryllium. The resulting spectra were subsequently subjected to gamma-ray analysis. The gamma-ray spectra were mostly composed of Co-60. Due to the predominance and high gamma-ray energy of Co-60, most other gamma-ray emitters were hidden in the Compton plateau of the spectrum. The only observed gamma-ray emitter, other than the Co-60, was Cs-137.

Density Measurement. Density measurements were made using a procedure based on Archimedes' principle in determining sample volume. The estimated error for the density measurement is 0.005%.

If you have any questions, please feel free to call me at (208) 533-7318 or Jeff Berg at (208) 533-7276.

Sincerely,

John Krsul, Manager
Analytical Laboratory

Att.
Final Reports

pc: Jeff Berg
Charlie Brooks
Mike Carboneau
Teresa Carlson
Jacqueline Fonnesbeck
Donna Hanney
David Maddison
Cal Morgan
Carlan Mullen
Doug Porter
James Sommers
James Stirbentz

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NT-AL-(JRK)-01-012
February 2, 2001

K. Jean Holdren
BBWI
P.O. Box 3860
MS 3920
Idaho Falls, Idaho 83415-3860

Reference: WGS-036-99 Abbreviated Sampling and Analysis Plan for TRA ATR Beryllium Blocks Supports-Phase IA of the ATR Comprehensive Beryllium Disposition Plan.

Dear Ms. Holdren,

Two beryllium samples described in the reference document have been analyzed for niobium. The results are given Table I. Samples were assigned an Analytical Laboratory number. This number is shown in column 1. The information given in the second column is your sample identification information. The analytical number identifies the sample in our database. The Table provides a cross-reference between your identification number and our database.

Table I. Samples Analysis Results

Analytical No.	Sample ID	Sample Description	Sample Wt. Gram	Nb-93 µg/g	Nb-94 µg/g
79785	W03699121NC	SN-20	0.6851	11.5	<.03
79788	W03699151NC	SN-11R	0.4889	0.13	<.03

Nb Analysis. The samples of beryllium were dissolved in 7 MHCl/0.2M HF. Samples were prepared for ICP-MS analysis using Rh-103 as an internal standard to correct for drift. A 50 ppb calibration standard was used as a check standard. At the end of the run the check standard was measured to be 51.9 ppb. Calibration standards were prepared by dilution of a High Purity Nb 10 ug/ml standard (expiration date May 2001). Natural zirconium and molybdenum impurities found in the beryllium samples were used to correct mass 94 interferes for niobium 94 Minimum limits of detection are reported for Nb-94. The total estimated error, <5%, is calculated from limits of quantification and drift values.

If you have any questions, please feel free to call me at 208-533-7318.

Sincerely,

John Krsul
Manager, Analytical Laboratory

Att.: Final Reports

pc: Bruce Becker MS 3920
Charlie Brooks MS 7106
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NT-AL-(JRK)-02-020
March 18, 2002

Gary L. Anderson
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PO Box 1625
Idaho Falls, Idaho 83415-3710

Reference: Inter-Contractor Purchase No. 00003249 Laboratory Analysis of the ATR Beryllium Sample Collected from Block 010R. Laboratory Analyses includes the following: Carbon-14, H-3, RCRA metal concentration in beryllium, Toxicity Characteristic Leaching Procedure on beryllium metal, Cs-137, Be concentration in TCLP leachate solution, uranium and transuranium nuclides.

Dear Mr. Anderson

The analyses identified in the reference document have been completed and the results are shown on the attached Table and ANL-W Analytical Laboratory Final Report. The Analytical Laboratory received a beryllium sample collected from the high-flux region (site2) of ATR block 010R. The toxicity and radioactive aspect of this sample required the initial analytical work to be performed remotely in a shielded facility where contamination is a concern. The received sample was stored under water inside its 500 ml plastic shipping container. The sample was removed, rinsed with de-ionized water, and allowed to air dry before obtaining a dried sample receipt weight of 21.1713 grams. The sample consisted of approximately twenty-three pieces ranging in weight from 5-10 mg to 11 grams. Dry sample weights were obtained on these pieces and then stored in clean individual containers under de-ionized water. The samples received provided adequate sample sizes for all analyses with exception of the toxicity characteristic leaching procedure (TCLP) Method 1311, described in the test methods for evaluating solid waste physical/chemical properties (SW-846). As described below, less than 100 grams of beryllium were used for the TCLP procedure.

Toxicity Characteristic Leaching Procedures. After sizing, 10.6952 grams of beryllium was contacted with 213.904 g of leach solution described by Method 1311, "Toxicity Characteristic Leaching Procedure", in Test Methods for Evaluating Solid Waste Physical/Chemical Methods (SW-846). An aliquot of this leachate solution was removed from the shielded facility in order to determine the RCRA metal concentrations, Cs-137 activity, along with the beryllium concentration. The RCRA metals were digested and analyzed by Method 3010, "Acid Digestion of Aqueous Samples and Extracts for Total Metals for Analysis by FLAA or ICP Spectroscopy".

Total RCRA metals, cesium-137, uranium and transuranics. Three beryllium samples were selected for sample dissolution required for total RCRA metal concentrations in beryllium, Cs-137, uranium and transuranium nuclides. Any surface contamination was removed by etching with hydrofluoric acid, and followed by rinsing with de-ionized water. The samples were allowed to air dry in order to obtain a cleaned sample weight. The samples were dissolved in a mixture of 2M hydrofluoric acid and 9M hydrochloric acid. Two of the three samples were spiked with known amounts of RCRA metals prior to sample dissolution to validate recovery of these analytes. The dissolved samples were then treated with boric acid and EDTA to ensure complete dissolution and to prevent the loss of actinides by precipitation as fluorides. A reagent blank was performed along with these three samples in order to provide background information and access possible sample contamination during the dissolution procedure. All sample dissolution steps were performed remotely in a shielded facility. Blank and sample aliquots were removed from the shielded facility for the subsequent analytical measurements required.

Tritium and carbon-14. Four beryllium samples were selected for tritium and carbon-14 analyses. A LECO® remote furnace carbon analyzer (IR-412/HF-400) was used for the combustion of the solid sample inside the shielded facility. The sample tritium and carbon were quantitatively collected as tritiated water and carbon dioxide during this process. The tritiated water was collected on an anhydrone trap. The carbon dioxide was collected on a carbon molecular sieve trap. Both traps were located outside the shielded facility. The anhydrone was dissolved in water, diluted to a known volume, and an aliquot was obtained for liquid scintillation counting. The carbon dioxide was purged from the carbon molecular

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NT-AL-(JRK)-02-022
March 20, 2002

Gary L. Anderson
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Idaho Falls, Idaho 83415-3710

Reference: Inter-Contractor Purchase No. 00003249 Laboratory Analysis of the ATR Beryllium Sample Collected from Block 010R. Laboratory Analyses includes the following: Carbon-14, H-3, RCRA metal concentration in beryllium, Toxicity Characteristic Leaching Procedure on beryllium metal, Cs-137, Be concentration in TCLP leachate solution, uranium and transuranium nuclides.

Dear Mr. Anderson

Attached please find corrected table to our letter NT-AL-(JRK)-02-020, dated March 18, 2002. The % Total in the Radiochemistry Section for Cs-137 and Co-60 were changed to correct errors and show additional significant figures.

If you have any questions, please feel free to call me at 208-533-7318.

Sincerely,

John Krsul, Manager
Analytical Laboratory

cc:
Michael L. Carboneau, MS 3885
Robert J. Carpenedo, MS 3920
Michael J. Connolly, MS 3710
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Operated by The University of Chicago for The United States Department of Energy

Appendix C

Beryllium Shipment Records and Grouted Beryllium Locations

Appendix C

Beryllium Shipment Records and Grouted Beryllium Locations

The following tables list all known shipments that indicate beryllium through:

- Beryllium or tritium explicitly mentioned in the shipment description
- Beryllium or tritium listed as a shipment isotope
- Tritium identified by tritium survey at a shipment disposal location.

High resolution surface geophysical and tritium survey data were used to verify disposal locations. Survey results are in Appendix C of the beryllium grouting final report (Lopez 2005). Locations grouted (in CY 2004) were based on the survey results rather than the shipment disposal locations reported in the shipment documents. The tables are grouped by disposal location as indicated by the shipment document.

Trench 52

Document ID	Shipment Description	Curies	Comments	Grouted 2004
TRA603SR004/21/70145415010	Unknown number of galvanized steel containers containing irradiated Be core reflector and LB pieces (unknown weight for Co60).	125	MTR operations , survey identified tritium at 6 in. and 2 ft.	Yes
TRA603SR004/21/7081014017	Unknown number of galvanized steel containers containing irradiated Be core reflector and LB pieces. Highly contaminated, high radiation, and beryllium contamination (unknown weight for Co60).	125	MTR operations, survey identified tritium at 6 in. and 2 ft.	Yes
TRA603SR004/21/708005015	Unknown number of galvanized steel containers containing irradiated Be core reflector and LB pieces. Highly contaminated, high radiation, and beryllium contamination (unknown weight for Co60).	125	MTR operations , survey identified tritium at 6 in. and 2 ft.	Yes
TRA603SR005/01/7080030020	Unknown number of galvanized steel containers containing irradiated LB pieces, cadmium, reg. pads and aluminum A pieces. Highly contaminated, high radiation, and beryllium contamination (unknown weight for Co60).	100	MTR operations, tritium not detected at location.	No

Trench 54

Document ID	Shipment Description	Curies	Comments	Grouted 2004
TRA642SR012/02/70800	Scrap stainless steel, aluminum, and beryllium (1.02E-03 g of Cr51, 1.82E+01 g of Co60, 9.00E-02 g of Fe59, 2.07E-02 g of H3).	59,500	ETR operations, tritium not detected at location, 200 Ci tritium reported in shipment document.	Yes
TRA642SR012/02/70810	Scrap stainless steel and aluminum (6.71E-04 g of Cr51, 5.73E-02 g of Fe59, 2.24 g of Co60).	28,000	ETR operations, survey identified tritium at 6 in. and 2 ft.	Yes
TRA642SR012/11/7080050035	Scrap stainless steel and aluminum (4.05E-03g of Cr51, 3.51E-01g of Fe59, 3.68E+01g of Co60, 3.25E-02g of H3).	196,000	ETR operations, survey data did not indicate H-3 at this location, 314 Ci tritium reported in shipment document.	No

Trench 57
No locations were grouted in Trench 57.

Document ID	Shipment Description	Curies	Comments	Grouted 2004
TRA632SR010/03/731005	Two metal barrels containing ATR-ETR beryllium (4.47E+02g of Be10; 100 total curies).	10	Survey identified tritium at 6 in. and 2 ft.	No

Trench 58

Document ID	Shipment Description	Curies	Comments	Grouted 2004
TRA603SR005/05/771000	One insert containing canal trash and beryllium (1.72E-04 g of Cr51, 1.46E-02 g of Fe59, 5.69E-01 g of Co60).	7,150	Survey identified tritium at 6 in. and 2 ft.	Yes
TRA603SR005/05/771001	One insert containing canal trash and beryllium (3.60E-05 g of Cr51, 3.06E-03 g of Fe59, 1.19E-01 g of Co60).	1,500	Survey identified tritium at 6 in. and 2 ft.	Yes
TRA603SR005/10/771015	One insert containing canal trash and beryllium (2.06E-03 g of Cr51, 1.75E-01 g of Fe59, 6.82 g of Co60).	85,800	Survey identified tritium at 6 in., no data at 2 ft.	Yes
TRA603SR005/10/771500	One insert containing canal trash and beryllium (1.57E-03 g of Cr51, 1.33E-01 g of Fe59, 5.20 g of Co60).	65,400	Survey identified tritium at 6 in., no data at 2 ft.	Yes

Trench 58

Document ID	Shipment Description	Curies	Comments	Grouted 2004
TRA603SR005/10/77815	One insert containing canal trash and beryllium (3.43E-04 g of Cr51, 2.91E-02 g of Fe59, 1.14 g of Co60).	14,300	Survey identified tritium at 6 in., no data at 2 ft.	Yes
TRA603SR005/12/771000	One insert containing canal trash and beryllium (2.81E-04 g of Cr51, 2.38E-02 g of Fe59, 9.31E-01 g of Co60).	11,700	Survey identified tritium at 6 in., no data at 2 ft.	Yes
TRA603SR005/12/771430	One insert containing canal trash and beryllium (1.56E-03 g of Cr51, 1.32E-01 g of Fe59, 5.17 g of Co60).	65,000	Survey identified tritium at 6 in. and 2 ft.	Yes
TRA603SR005/26/771400	One insert containing canal trash and beryllium (1.56E-04 g of Cr51, 1.32E-02 g of Fe59, 5.17E-01 g of Co60).	6,500	Survey identified tritium at 6 in. and 2 ft.	Yes
TRA603SR006/01/77900	One insert containing canal trash and beryllium (4.06E-05 g of Cr51, 3.44E-03 g of Fe59, 1.34E-01 g of Co60).	1,690	Survey identified tritium at 6 in. and 2 ft.	Yes
TRA670SR011/17/761405	One insert containing beryllium blocks (4.81 g of Co60, 4.86E-02 g of Co60).	5,500	Survey identified tritium 40 ft west of reported disposal location.	Yes
TRA670SR012/01/761000	One insert containing beryllium blocks (6.39 g of Co60, 6.45E-02 g of Co60).	7,300	Survey identified tritium 40 ft west of reported disposal location.	Yes
TRA670SR012/02/761015	One insert containing beryllium blocks (6.65 g of Co60, 6.72E-02 g of Co60).	7,600	Survey identified tritium 40 ft west of reported disposal location.	Yes
TRA670SR012/03/761115	One insert containing beryllium blocks (6.39 g of Co60, 6.45E-02 g of Co60).	7,300	Survey identified tritium 40 ft west of reported disposal location.	Yes

SVR 12

No locations were grouted in SVR 12.

Document ID	Shipment Description	Curies	Comments	Grouted 2004
TRA670SR010/14/823068	ATR Canal Trash Liner 2	38,000	Comment on shipment document “600 P radiated Be.”	No

SVR 17

Document ID	Shipment Description	Curies	Comments	Grouted 2004
TRA67007/08/874573	Core Structural Parts	35	Survey identified tritium at 6 in. and 2 ft.	Yes
TRA67007/13/874575	Core Structural Parts	35	Survey identified tritium at 2 ft.	Yes
TRA67008/26/874599	Core Structural Parts	13	Survey identified tritium at 2 ft.	Yes
TRA67009/15/874577	Core Structural Parts	180	Survey identified tritium at 2 ft.	Yes
TRA67002/06/924620	50% Core Structural Parts, 50 % Core Subassembly Parts	96.9	6.01E-10 Ci reported in shipment document.	No
TRA67003/09/934635	50% Core Structural Parts, 50 % Core Subassembly Parts	1,180	1.1E-4 Ci reported in shipment document.	No

SVR 20

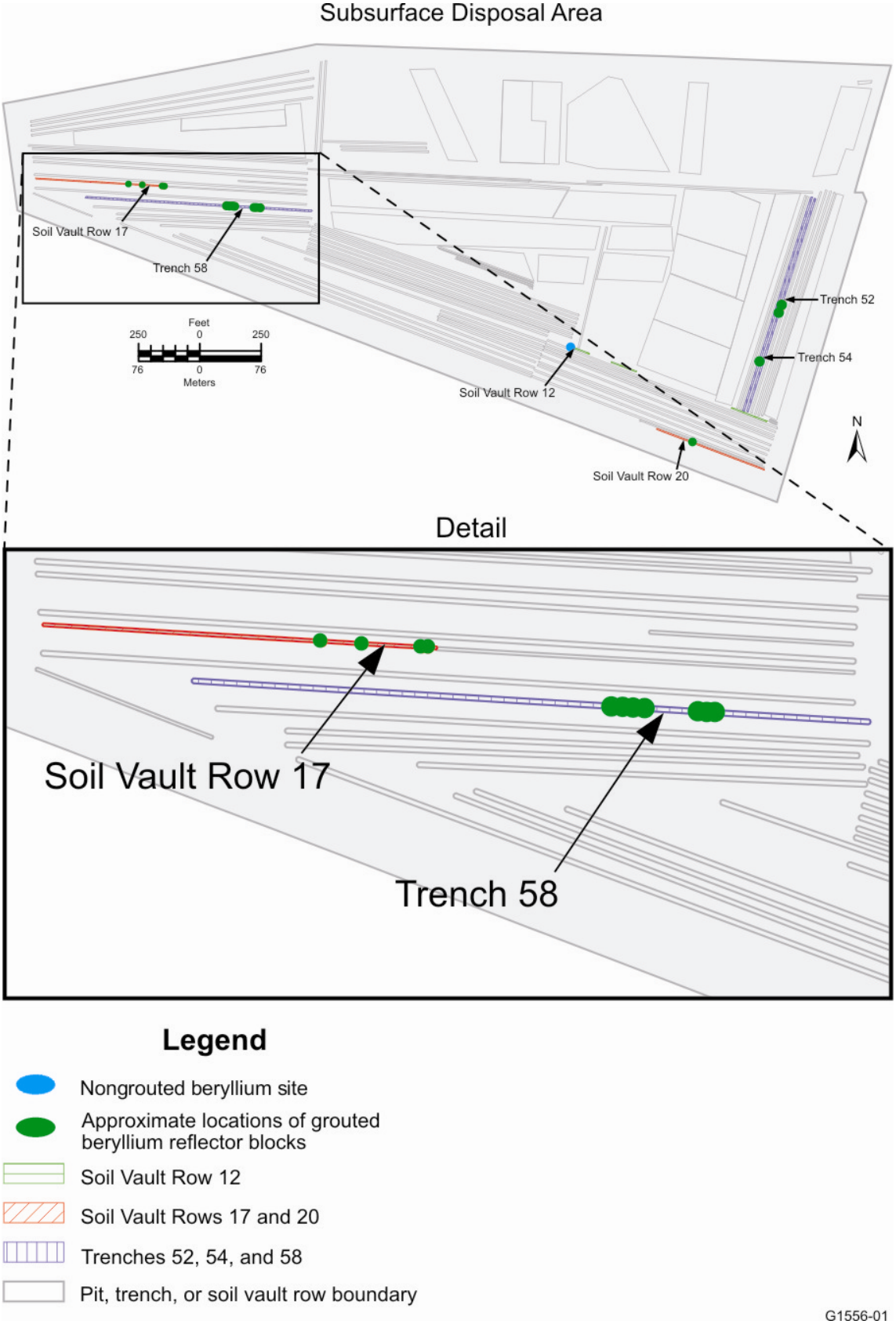
Document ID	Shipment Description	Curies	Comments	Grouted 2004
TRA67005/13/936011	Core Structural Parts	99,500	98,200 Ci tritium reported in shipment document, ATR operations: two reflector blocks.	Yes
TRA67006/15/93	Core Structural Parts	99,290	97,980 Ci tritium reported in shipment document, ATR operations: two reflector blocks.	Yes
TRA67008/04/936014	Core Structural Parts	98,120	96,820 Ci tritium reported in shipment document, ATR operations: two reflector blocks.	Yes
TRA67005/02/946101	50% Core Structural Parts, 50% Core Subassembly Parts	104.3	0.0000018 Ci tritium reported in shipment document.	No

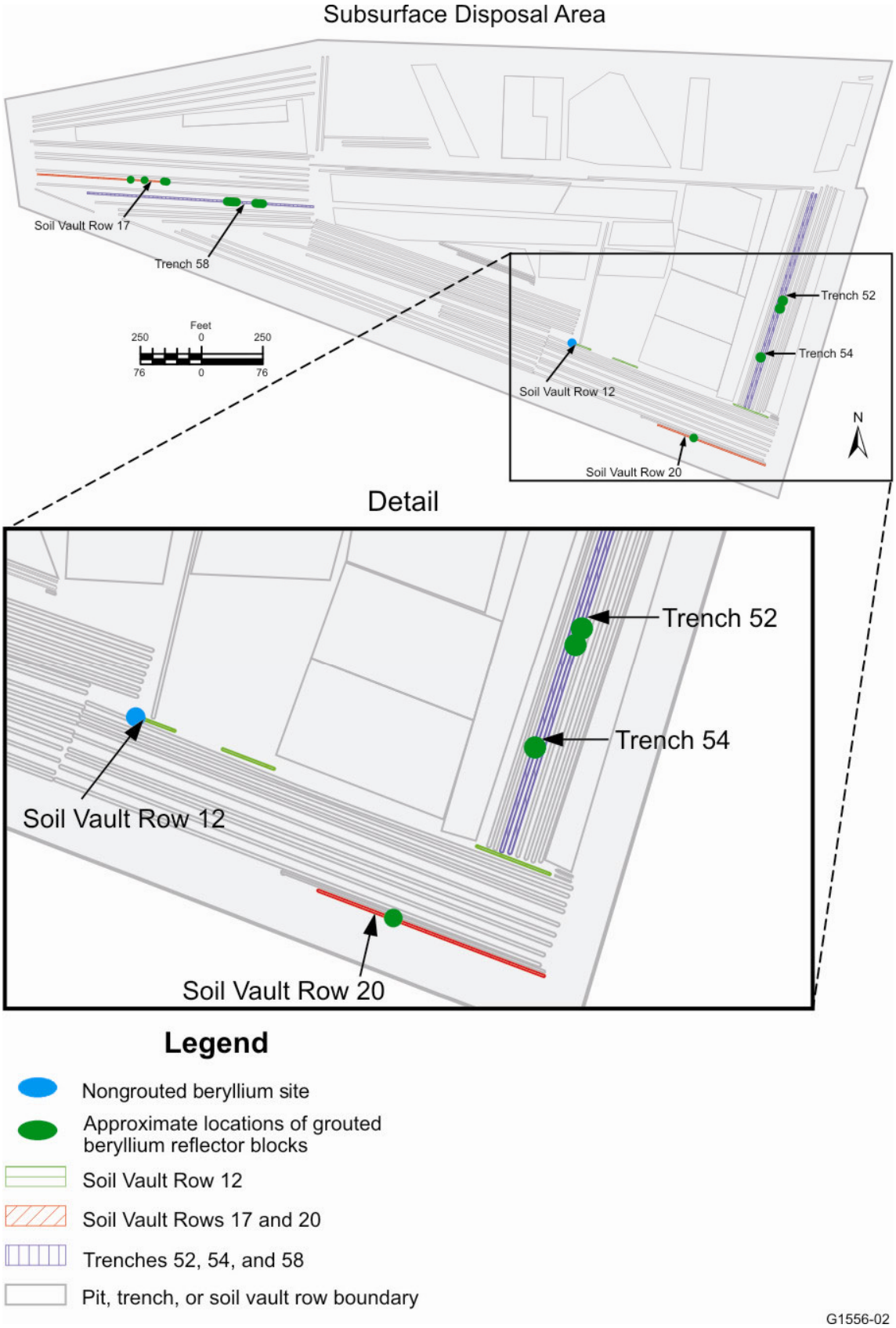
Pre-1970 Shipments with Beryllium

The following are shipments before 1970 containing beryllium with greater than 100 Ci. TRA-603 is MTR. The final irradiated date for MTR was July 3, 1969. There is no indication whether the beryllium in these shipments was part of the reflector. No locations were grouted in Trenches 49 or 50.

Document ID	Shipment Description	Curies	Comments	Disposal Location	Grouted 2004
TRA603SR006/26/69810101	(1) Metal galvanized containers of canal trash, aluminum, stainless, beryllium, and cadmium, solid, radioactive. (No isotope; 104 total Ci.)	10,000	MTR operations.	Trench 49	No
TRA603SR008/19/698001000100	(1) Metal galvanized containers of canal trash, aluminum, stainless, beryllium, and cadmium. (Unknown isotope; 1,000 total Ci.)	1,000	MTR operations.	Trench 50	No
TRA603SR008/21/6980060025	(1) Metal galvanized containers of canal trash, aluminum, stainless, beryllium, and cadmium. (Unknown isotope; 600 total Ci.)	600	MTR operations.	Trench 50	No
TRA603SR008/18/6981030024	(1) Metal galvanized Containers of canal trash, aluminum, stainless, beryllium, and cadmium. (Unknown isotope; 300 total Ci.)	300	MTR operations.	Trench 50	No
TRA603SR008/20/6980025010	(1) Metal galvanized containers of canal trash, aluminum, stainless, beryllium, and cadmium. (Unknown isotope; 250 total Ci.)	250	MTR operations.	Trench 50	No

The following figures show the locations of the beryllium buried in the SDA.


Subsurface Disposal Area
Soil Vault Row 17
Trench 58
Feet
250
0
250
76
0
76
Meters
Soil Vault Row 12
Trench 52
Trench 54
Soil Vault Row 20
N
Detail
Soil Vault Row 17
Trench 58
Legend
Nongrouted beryllium site
Approximate locations of grouted beryllium reflector blocks
Soil Vault Row 12
Soil Vault Rows 17 and 20
Trenches 52, 54, and 58
Pit, trench, or soil vault row boundary
G1556-01


Subsurface Disposal Area
Soil Vault Row 17
Trench 58
Feet
250
0
250
76
0
76
Trench 52
Trench 54
Soil Vault Row 12
Soil Vault Row 20
N
Detail
Trench 52
Trench 54
Soil Vault Row 12
Soil Vault Row 20
Legend
Nongrouted beryllium site
Approximate locations of grouted beryllium reflector blocks
Soil Vault Row 12
Soil Vault Rows 17 and 20
Trenches 52, 54, and 58
Pit, trench, or soil vault row boundary
G1556-02

Appendix D

Comparison of Grouted and Ungrouted Beryllium

Appendix D

Comparison of Grouted and Ungrouted Beryllium

The known locations of buried irradiated beryllium were grouted in situ as a non-time-critical removal action under the National Oil and Hazardous Substances Pollution Contingency Plan (Lopez 2004). Locations were determined from shipment records and confirmed using geophysical and tritium survey results. Irradiated beryllium buried in the SDA includes MTR Core 1; ETR Core 1; eight reflector blocks from ATR Core 1; six reflector blocks from ATR Core 2; six reflector blocks from ATR Core 3; and nine ATR OSCCs. The burial location of beryllium from ATR Core 2 was determined after the non-time-critical removal action was completed; therefore, this beryllium was not grouted. All other beryllium was grouted in the course of the non-time-critical removal action. Approximately 89.7% by mass (i.e., 4,253,761 g of 4,742, 281 g) of the beryllium from ATR, ETR, and MTR was grouted. Table D-1 compares the isotopic activities of the grouted and ungrouted beryllium at time of disposal.

Table D-1. Comparison of grouted and ungrouted beryllium isotopic activity.

Isotope	Grouted (Ci)	Ungrouted (Ci)	Total (Ci)	Percent Activity Grouted
H-3	2.68E+06	9.09E+04	2.77E+06	96.72%
Be-10	1.09E+01	7.26E-01	1.16E+01	93.73%
C-14	8.66E+01	5.83E+00	9.25E+01	93.69%
Cl-36	8.34E-01	4.89E-02	8.83E-01	94.46%
Co-60	5.20E+03	5.00E+02	5.70E+03	91.22%
Ni-59	1.32E+00	1.22E-01	1.45E+00	91.56%
Ni-63	2.79E+02	2.16E+01	3.00E+02	92.80%
Sr-90	2.83E+01	1.83E+00	3.01E+01	93.92%
Nb-94	1.96E-01	1.31E-02	2.09E-01	93.73%
Tc-99	1.12E-02	7.51E-04	1.20E-02	93.73%
I-129	9.36E-05	5.53E-06	9.92E-05	94.42%
Cs-137	9.72E+01	5.91E+00	1.03E+02	94.27%
Eu-152	2.89E-01	2.46E-01	5.35E-01	54.00%
Eu-154	5.11E+01	1.03E+01	6.14E+01	83.21%
Pb-210	1.06E-09	1.34E-11	1.07E-09	98.75%
Ra-226	1.24E-10	5.00E-12	1.29E-10	96.11%
Ra-228	1.39E-07	1.35E-08	1.52E-07	91.12%
Ac-227	6.31E-07	3.61E-08	6.67E-07	94.59%
Th-228	1.20E-03	5.15E-05	1.26E-03	95.90%
Th-229	5.24E-07	3.43E-08	5.58E-07	93.85%
Th-230	3.19E-08	1.86E-09	3.38E-08	94.49%
Th-232	1.69E-07	2.13E-08	1.90E-07	88.80%

Table D-1. (continued).

Isotope	Grouted (Ci)	Ungrouted (Ci)	Total (Ci)	Percent Activity Grouted
Pa-231	2.39E-06	1.73E-07	2.57E-06	93.26%
U-232	1.43E-03	5.54E-05	1.48E-03	96.27%
U-233	4.07E-04	4.65E-05	4.53E-04	89.74%
U-234	1.31E-04	1.04E-05	1.42E-04	92.66%
U-235	1.54E-08	3.67E-09	1.91E-08	80.75%
U-236	6.46E-06	8.78E-07	7.34E-06	88.04%
U-238	2.95E-05	4.10E-06	3.36E-05	87.81%
Np-237	1.36E-05	1.17E-06	1.47E-05	92.05%
Pu-238	1.26E+00	5.60E-02	1.31E+00	95.73%
Pu-239	1.34E-01	1.51E-02	1.49E-01	89.85%
Pu-240	2.15E-01	2.50E-02	2.40E-01	89.57%
Pu-241	4.91E+01	5.05E+00	5.42E+01	90.68%
Pu-242	5.09E-03	3.61E-04	5.45E-03	93.38%
Pu-244	1.03E-08	3.00E-10	1.06E-08	97.17%
Am-241	5.97E-01	5.82E-02	6.55E-01	91.11%
Am-243	6.65E-02	3.51E-03	7.00E-02	94.99%
Cm-243	2.06E-02	1.35E-03	2.20E-02	93.85%
Cm-244	4.39E+01	9.27E-01	4.48E+01	97.93%
Cm-245	3.74E-03	5.33E-05	3.79E-03	98.59%
Cm-246	1.27E-02	6.13E-05	1.28E-02	99.52%
Cm-247	1.39E-07	2.50E-10	1.39E-07	99.82%
Cm-248	3.16E-06	1.67E-09	3.16E-06	99.95%