AR TARGET SHEET

The following document was too large to scan as one unit, therefore, it has been broken down into section.

DOCUMENT #: (none)

EDMC#: 0022940

SECTION: 2 of 5

1100-EM-1 GROUNDWATER CHARACTERIZATION
PHASE I

DATA PACKAGE/REPORT No. 1

Revision 0

APPENDIX B

RADIOCHEMISTRY STANDARDS AND CONTROLS

Table of Contents

B01 - Detector Controls
B02 - Solution Standards
B03 - Calibration Curves
B04 - Performance Checks of Pipets and Balances

1100-EM-1

RADIOCHEMISTRY STANDARDS AND CONTROLS

This sections contains supporting documentation for radiochemical analyses performed for 1100-EM-1 project, gross beta analysis, ^{90}Sr analysis, ^{99}Tc analysis (procedure 7-40.39), liquid scintillation analysis, and tritium analysis.

Detector Controls

- Beta detector background, control, and efficiency counts
- $^{90}Sr/Y$ standards for beta counters #52733-81-1 through 52733-81-4
- $^{90}Sr/Y$ standard for beta counter #17
- Tritium liquid scintillation counter control, background, and efficiency counts

Solution standards:

- ^{90}Sr standard #52733-117-1 and #52733-117-2
- ^{99}Tc standard #54124-64-0 and #54124-64-17
- ^{99}Tc standard #52733-80-RS-4 (for LSC data)
- ^{95m}Tc standard #54124-62-100
- Strontium (stable) carrier solution
- ^{3}H Standard #52733-109-1
- ^{3}H Standard #52733-109-100

Calibration Curves

- Alpha and Beta Disintegrations per Count Determination
- $SrCO_3$ Calibration Summary
- ^{99}Tc Calibration Information

Performance checks of pipets and balances

support.eml

I1 Detector Controls

Beta Detector Background, Control, and Efficiency Counts

B01-003

COUNTER BACKGROUNDS Radio-analysis Laboratory		BETA COUNTER # 66		
DATE:	TOTAL MINUTES COUNTED	TOTAL COUNTS	COUNTS PER MINUTE	INITIALS
12-16-91	1000	17112	17.1	DZM
12-19-91	1000	16937	16.9	DZM
12-20-91	1000	16768	16.8	DZM
12-27-91	1000	17657	17.7	DZM
1-3-92	1000	17783	17.8	SB
1-6-92	1000	17602	17.6	SKF
1/10/92	3902	60066	15.4	S.K.F.
1/13/92	3811	57373	15.1	SKF
1-21-92	1000	15553	15.6	DZM
1/24/92	1000	16518	16.5	SKF
1-31-92	1000	15810	15.8	DZM
2-7-92	1000	15614	15.6	DZM
2-12-92	974	15555	16.0	DZM
2-14-92	1000	15882	15.9	DZM
2-21-92	1000	15584	15.6	DZM

Copied letter for ALO 12-27-91

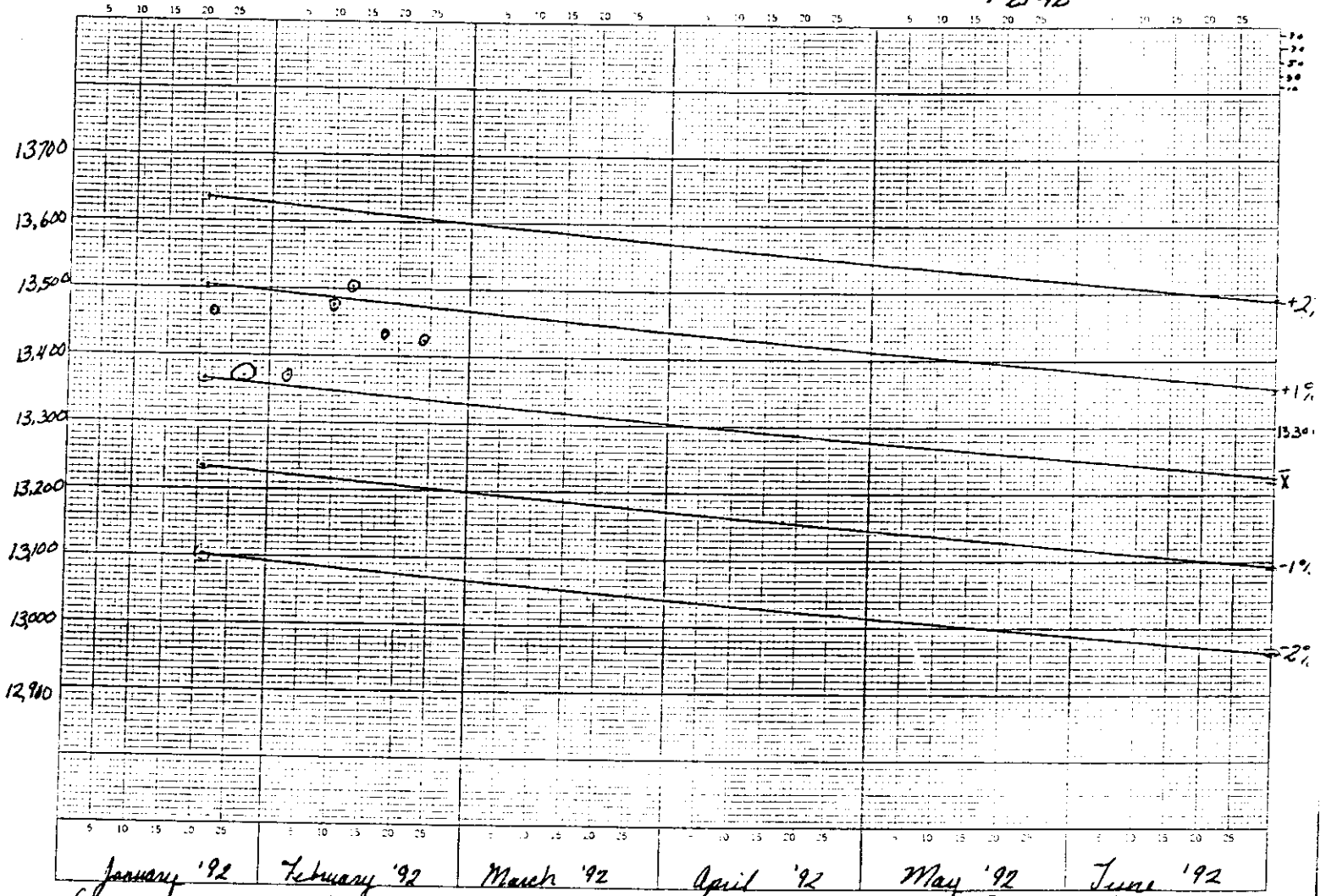
Reviewed by [illegible] 1-31-92

B01-004

K•E 6 MONTHS BY DAYS X 120 DIVISIONS KEUFFEL & ESSER CO. MADE IN U.S.A.

46 2610

M&TE #66 Control standard # 52733-81-2 $\bar{x}$ = 13,369.34 on 1-21-92



Reviewed J. K. Hedges 1/21/92

Diana L. McMullin 1-22-92

B01-005

COUNTER CONTROL DATA

M&TE# 66

STANDARD# 52733-81-21 DKJ 1/27/92

DATE	OBSERVED			BKD. C/M	CORRECTED C/M	✓ LIST	TECH	REVIEWED BY	
	TOT CTS.	MIN	C/M					DATE	INT.
1-22-92	13 4824	10	13482.4	15.6	13,466.8	✓	DXM	1/31/92	DKJ
1/27/92	133877	10	13387.7	16.5	13,371.2	✓	DKJ	1-31-92	DXM
2-3-92	133861	10	13386.1	15.8	13,370.3	✓	DXM	2/6/92	DKJ
2-10-92	134944	10	13494.4	15.6	13479.3	✓	DXM	2/14/92	DKJ
2-13-92	67592	5	13518.4	16.0	13502.4	✓	DXM	2/14/92	DKJ
2-18-92	134501	10	13450.1	15.9	13434.2	✓	DXM	2/24/92	DKJ
2-24-92	134508	10	13450.8	15.6	13435.2	✓	DXM	2/24/92	DKJ

B01-006

COUNTER CONTROL DATA

M&TE# 66

STANDARD# 52733-81-2

	DATE	OBSERVED TOT CTS.	OBSERVED MIN	OBSERVED C/M	BKD. C/M	CORRECTED C/M	✓ LIST	TECH	REVIEWED BY DATE	REVIEWED BY INT.
	Geometry check using source W-272 (or 52733-81-2).									
	Geometry check using source #R17 already performed (1/13/92).									
	On 1/20/92, activity of standard equals 24,955 +/- 926 dpm.									
	1/20/92	67631	5	13,526.2	15.1	13,511.1	✓			
	1/20/92	67439	5	13,487.8	15.1	13,472.7	✓			
	1/20/92	67257	5	13,451.4	15.1	13,436.3	✓			
	1/20/92	67401	5	13,480.2	15.1	13,465.1	✓			
	1/20/92	67646	5	13,529.2	15.1	13,514.1	✓			
	taken at 1700V, setting - 157									
	average c/m = 13,479.9 +/- 82.8									
		13,479.9 / 24,955	=	0.540	geometry	0.540 / 0.543 = 0.9836; within ±2%; OK.				
		d/c = 1.851							D.K. Tadych 1/20/92	
	Control	Source Counts		52733-81-1						
				JKJ 1/20/92						
1	1/20/92	66938	~~15.1~~ 5	13,387.6	15.1	13,372.5	✓	JKJ		
2	1/20/92	67314	5	13,463.4	15.1	13,448.3	✓	JKJ		
3	1/20/92	66724	5	13,344.8	15.1	13,329.7	✓	JKJ		
4	1/20/92	66717	5	13,343.4	15.1	13,328.3	✓	JKJ		
5	1/21/92	66756	5	13,351.2	15.1	13,336.1	✓	JKJ		
6	1/21/92	66974	5	13,394.8	15.1	13,379.7	✓	JKJ		
7	1/21/92	66965	5	13,393.0	15.1	13,377.9	✓	JKJ		
8	1-21-92	66700	5	13,340.0	15.1	13,324.9	✓	BB		
9	1-21-92	67310	5	13,462.0	15.1	13,446.9	✓	BB		
10	1-21-92	66871	5	13,364.2	15.1	13,349.1	✓	BB		
					ave:	13,369.3				
								D.K. Tadych	1/21/92	

Reviewed by
DJ McMullin 1-31-92

B01-007

COUNTER CONTROL DATA

M&TE# Beta 66

STANDARD# Source #17 CONTROL LIMITS N/A

Efficiency determination

	DATE	OBSERVED TOT CTS.	OBSERVED MIN	OBSERVED C/M	BKD. C/M	CORRECTED C/M	✓ LIST	TECH	REVIEWED BY DATE	REVIEWED BY INT.
1	1/13/92	76857	10	7,685.7	15.4	7,670.3	✓	SKF		
2		77822	10	7,782.2		7,766.8				
3		77037	10	7,703.7		7,688.3				
4		77096	10	7,709.6		7,694.2				
5		77378	10	7,737.8		7,722.4				
	voltage setting =		157	this is	equal	to 1700V				
		$\bar{x}$ = 7708.4 c/m		$\bar{s}$ =	37.6					
	dpm in	standard =	14,295 ± 535		on 1/13/92					
		d/c =	$\frac{14,295 \pm 535}{7708.4 \pm 37.6}$		=	1.855 +/-				
	efficiency	% =	$\frac{7708.4 \pm 37.6}{14,295 \pm 535}$		=	0.539 +/- 0.020		ok		
	Source	#66								
	1/16/92	74435	10	7,443.5 (BKD 4/16/92)	15.4	7428.1				
	1/16/92	74468	10	7,446.8	15.4	7431.4				
	1/16/92	74828	10	7,482.8	15.4	7467.4				
	1/16/92	74633	10	7,463.3	15.4	7447.9				
	1/16/92	74652	10	7,465.2	15.4	7449.8				
	1/17/92	74600	10	7,460.0	15.4	7444.6				
	1/17/92	74654	10	7,465.4	15.4	7450.0				
	1/17/92	74761	10	7,476.1	15.4	7,460.7				
	1/17/92	74748	10	7,474.8	15.4	stopped, discontinued to change control				
	1/17/92		10		15.4	source to new set.				
						S. L. Tackett 1/17/92				

Ard. D.L. McMullin
1-31-92

B01-008

SETTINGS CHECKLIST: **Beta #66**

(Confirmed correct settings on 1-13-92)

<u>Ortec 459</u>	
Output Voltage	1700, setting at 157
<u>Ortec 571</u>	
Amp Gain	1.0
Coarse Gain	100
Shaping Time	1
B/R Auto-PZ Adj Switch	PZ Adj
Delay Switch	down (Out)
Pos - Neg Switch	Positive
Polarity	Bipolar (This setting is not on the front of the amp and need not be checked each week.)
<u>Ortec 776</u>	
Window	10.0
Lower Level	1.0
Integral Switch	Integral
<u>Ortec 776</u>	
Discriminator	4.0
<u>P-10 Gas</u>	
Either tank at 0 psi?	If so, request P-10 gas change.

COUNTER BACKGROUNDS Radio-analysis Laboratory		BETA COUNTER # 67		
DATE:	TOTAL MINUTES COUNTED	TOTAL COUNTS	COUNTS PER MINUTE	INITIALS
12-16-91	~~DZM 12-17-91 17128~~ 1000	17128	17.1	DZM
12-19-91	1000	16786	16.8	DZM
12-20-91	1000	16617	16.6	DZM
12-27-91	1000	17354	17.4	DZM
1-3-92	1000	17405	17.4	JS
1-6-92	1000	17149	17.1	SKF
1/10/92	3902	68467	17.5	S.K.F.
1/17/92	3807	66026	17.3	SKF
1-21-92	1000	17797	17.8	DZM
1/24/92	1000	18698	18.7	SKF
1-31-92	1000	17844	17.8	DZM
2-7-92	1000	17949	17.9	DZM
2-12-92	975	17745	18.2	DZM
2-14-92	1000	18178	18.2	DZM
2-21-92	1000	17954	18.0	DZM

copied to Hence for ALD 12-27-91

SKF 1/3/92

Rad DZM 1-31-92

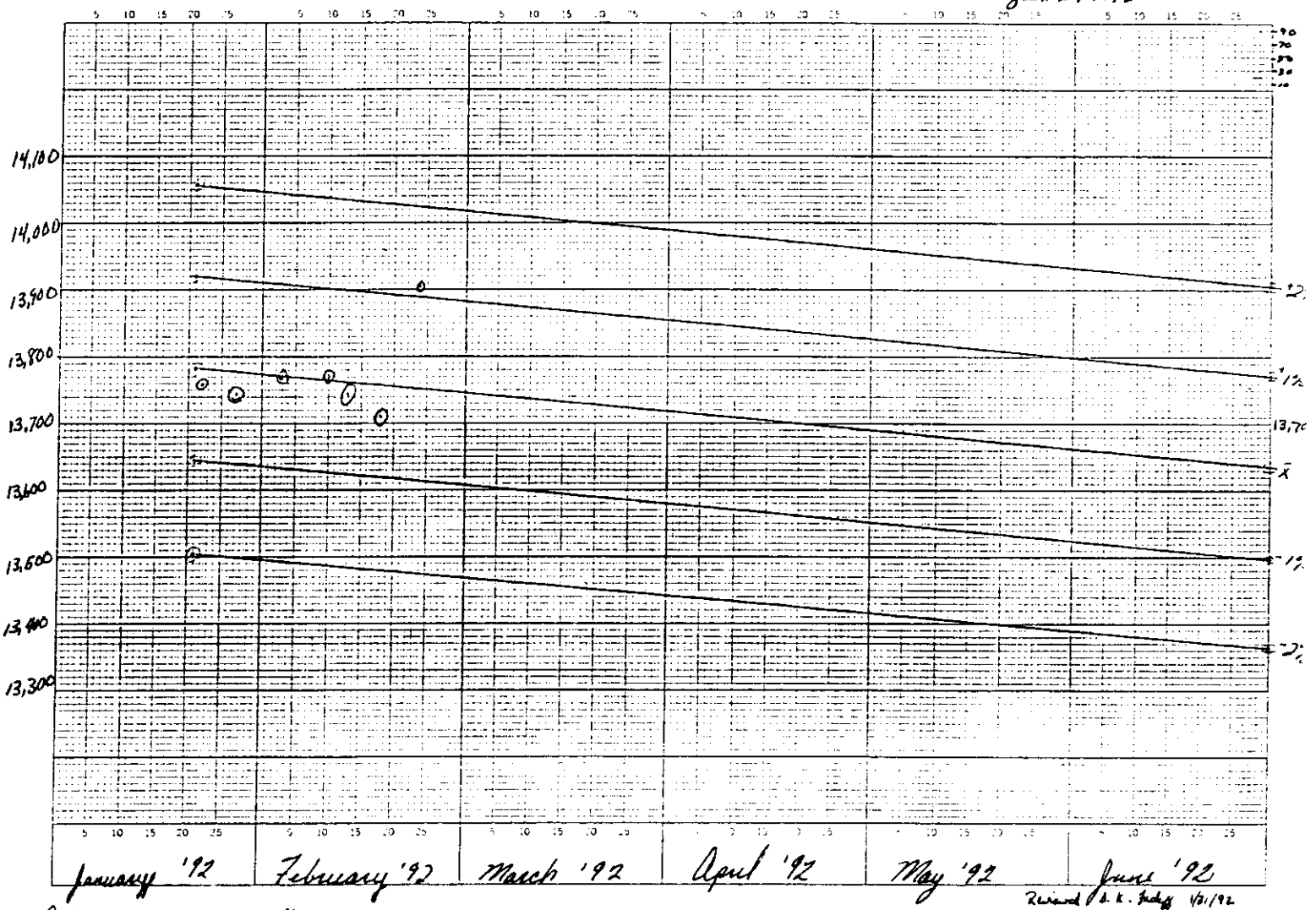
B01-010

K+E 5 MONTHS BY DAYS X 120 DIVISIONS KEUFFEL & ESSER CO. MADE IN U.S.A.

46 2610

M&TE # 67 control standard # 52733-81-2

$\bar{x}$ = 13,782.4 ±32.4 on Jan. 21, 1992



Reviewed D. K. Fudge 1/31/92

Diana L. McMullin 1-22-92

B01-011

COUNTER CONTROL DATA

M&TE# 67

STANDARD# 52733-81-2

DATE	OBSERVED			BKD. C/M	CORRECTED C/M	✓ LIST	TECH	REVIEWED BY	
	TOT CTS.	MIN	C/M					DATE	INT.
1/24/92	137627	10	13762.7	18.7	13744.0	✓	DKT		
2-3-92	137874	10	13787.4	17.8	13769.6	✓	DKM	2/6/92	DKT
2-10-92	137902	10	13790.2	17.9	13772.3	✓	DKM	2/14/92	DKT
2-13-92	68821	5	13764.2	18.2	13746.0	✓	DKM	2/14/92	DKT
2-18-92	137282	10	13728.2	18.2	13710.0	✓	DKM	2/24/92	DKT
2-24-92	139196	10	13919.6	18.0	13901.6	✓	DKM	2/24/92	DKT

B01-012

COUNTER CONTROL DATA

M&TE# 67

STANDARD# W-27-2 or 52733-81-2
^{90}Sr-Y 2.628×10^{4} ± 975 d/m 12/4/89

Establish efficiency based on new NIST standard as well as control counts based on this standard. This will allow us to eliminate source R17 as the geometry check standard.

	DATE	OBSERVED TOT CTS.	OBSERVED MIN	OBSERVED C/M	BKD. C/M	CORRECTED C/M	✓ LIST	TECH	REVIEWED BY DATE	REVIEWED BY INT.
	on 1/17/92, this standard shoo				24,959	± 926 d/m				
1	1/17/92	138552.	10	13,855.2	17.5	13,837.7				
2	1/17/92	137928	10	13,792.8	17.5	13,775.3				
3	1/17/92	137993	10	13,799.3	17.5	13,781.8				
4	1/17/92	137889	10	13,788.9	17.5	13,771.4				
	~~1/17/92~~	dkf 1/20/92								
5	1/20/92	69211	5	13,842.2	17.3	13,824.9				
	Voltage = 1660 V ;		setting = 168							
	average c/m =		13,798.2 ± 30.8							
	Geometry	13,798.2 / 24,959	= 0.553			0.553 / 0.549 =	1.007 ;	within	±2%	OK.
							S.K.	Jadiff	1/20/92	
	Control Source Counts			52733-81-2		(continue from above counts)				
6	1/20/92	69072	5	13,814.4	17.3	13,797.1	✓	dkf		
7	1/20/92	68865	5	13,773.0	17.3	13,755.7	✓	dkf		
8	1/21/92	68718	5	13,743.6	17.3	13,726.3	✓	dkf		
9	1/21/92	68915	5	13,783.0	17.3	13,765.7	✓	dkf		
10	1/21/92	69028	5	13,805.6	17.3	13,788.3	✓	dkf		
					avg	13,782.4			1-31-92	DJM
	1-22-92	137772	10	13,777.2	17.8	13,759.4	✓	DJM	MLW	1-31-92

Reviewed by
D.J.M. Millin
1-31-92

B01-015

SETTINGS CHECKLIST: **Beta #67**

(Confirmed correct settings on 1-13-92)

Ortec 459

Output Voltage	1660, setting 168

Ortec 490B

Coarse Gain	32	
Integral Switch	Integral	
Fine Gain	3.3	
Window	10.0	
Lower Level	1.0	
Polarity	Bipolar	(This setting is not on the front of the amp and need not be checked each week.)

Ortec 776

Discriminator	4.0

P-10 Gas

Either tank at 0 psi?	If so, request P-10 gas change.

COUNTER BACKGROUNDS Radio-analysis Laboratory		BETA COUNTER # 68		
DATE:	TOTAL MINUTES COUNTED	TOTAL COUNTS	COUNTS PER MINUTE	INITIALS
12-16-91	1000	14676	14.7	DZM
12-19-91	1000	13639	13.6	DZM
12-20-91	1000	14407	14.4	DZM
12-30-91	1000	14846	14.8	DZM
1-3-92	1000	15187	15.2	SB
1-6-92	1000	15323	15.3	SKF
1/10/92	3902	58279	14.9	J.L.F.
1/17/92	3811	54531	14.3	SKF
1-21-92	1000	14759	14.8	DZM
1/24/92	1000	15433	15.4	SKF
1-31-92	1000	15156	15.2	DZM
2-7-92	1000	15189	15.2	DZM
2-12-92	973	14836	15.2	DZM
2-14-92	1000	15395	15.4	DZM
2-21-92	1000	15177	15.2	DZM

copied to Hector Alo 12-17-91

SKF 1/14/92

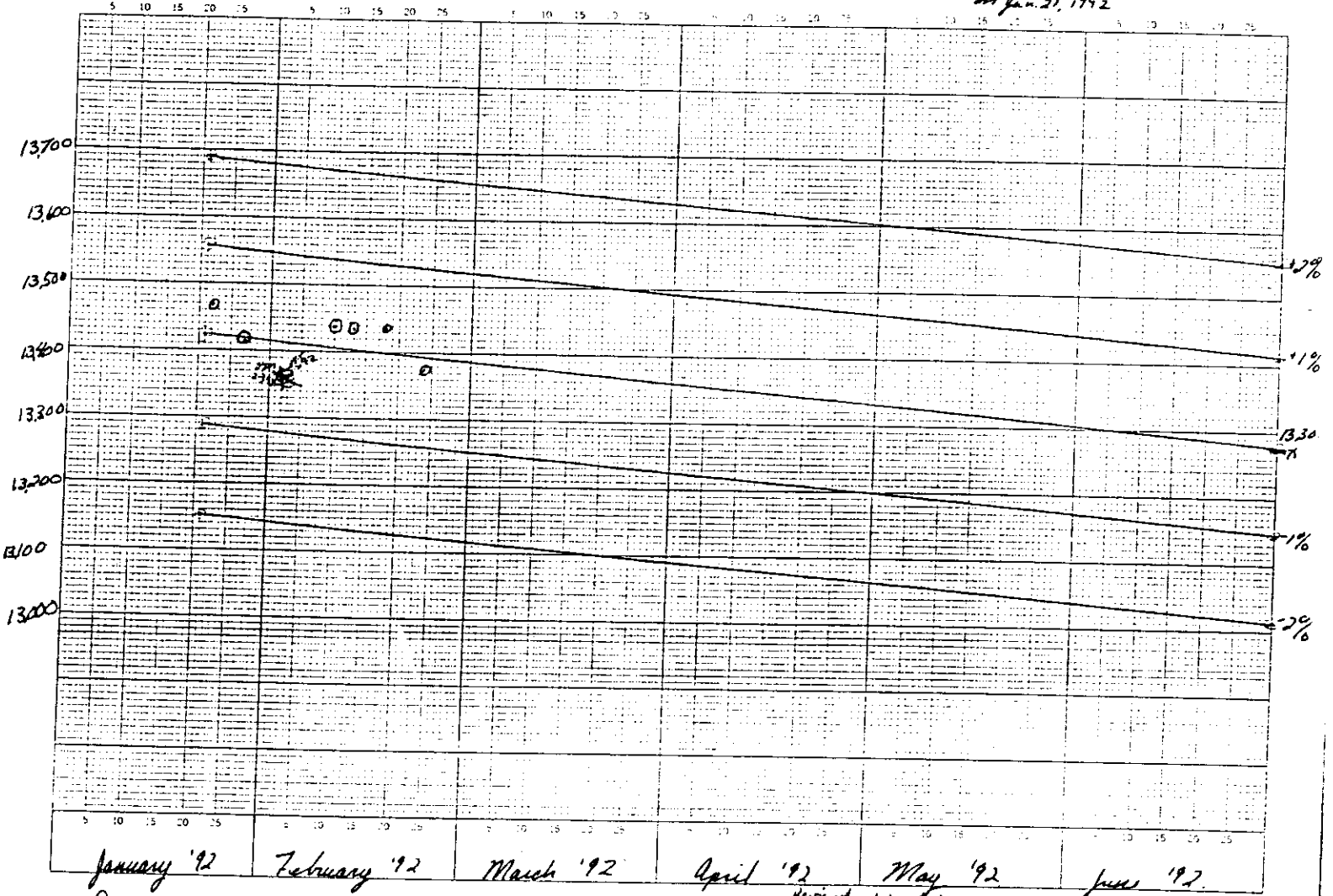
DZM 1-31-92

K+E 6 MONTHS BY DAYS X 120 DIVISIONS
KEUFFEL & ESSER CO. MADE IN U.S.A.

46 2610

MRTE #68 control Standard # 52733-81-3

$\bar{X}$ = 13,422.4 ± 54.4 on Jan. 21, 1992



Reviewed J. K. Sadoff

Diana L. McMullin 1-22-92

B01-016

COUNTER CONTROL DATA

M&TE# 68

STANDARD# 52733-81-3

Control source counts to establish a control chart

	DATE	OBSERVED TOT CTS.	OBSERVED MIN	OBSERVED C/M	BKD. C/M	CORRECTED C/M	✓ LIST	TECH	REVIEWED BY DATE	REVIEWED BY INT.
1	1/20/92	67290	5	13,458	14.3	13,443.7	✓	DKT	DYM	1-31-92
2	1/20/92	67392	5	13,478.4	14.3	13,464.1	✓	DKT		
3	1/20/92	67293	5	13,458.6	14.3	13,444.3	✓	DKT		
4	1/20/92	66733	5	13,346.6	14.3	13,332.3	✓	DKT		
5	1/21/92	67487	5	13,497.4	14.3	13,483.1	✓	DKT		
6	1/21/92	67346	5	13,469.2	14.3	13,454.9	✓	DKT		
7	1/21/92	67109	5	13,421.8	14.3	13,407.5	✓	DKT		
8	1-21-92	67419	5	13,484	14.3	13,469.5	✓	DB		
9	1-21-92	67018	5	13,403.6	14.3	13,389.3	✓	DB		
10	1-21-92	66748	5	13,349.6	14.3	13,335.3	✓	DB	DYM	1-31-92
	1-27-92	134822	10	13482.2	14.8	13,467.4	✓	DYM	1/31/92	DKT
	1/27/92	134325	10	13432.5	15.4	13417.1	✓	DKT	1-31-92	DYM
	~~2-3-92~~	~~133767~~	~~10~~	~~13376.7~~	17.8	13,358.9	✓	DYM		
	2-3-92	133767	10	13376.7	15.2	13361.5	✓	DYM	2/6/92	DKT
	2-10-92	134547	10	13454.7	15.2	13439.5	✓	DYM	2/14/92	DKT
	2-13-92	67257	5	13451.4	15.2	13436.2	✓	DYM	2/14/92	DKT
	2-18-92	134523	10	13452.3	15.4	13436.9	✓	DYM	2/24/92	DKT
	2-24-92	133897	10	13389.7	15.2	13374.5	✓	DYM	2/24/92	DKT

B01-017

COUNTER CONTROL DATA

M&TE# 68

STANDARD# R 17 Source Efficiency determination

CONTROL LIMITS N/A

	DATE	OBSERVED TOT CTS.	OBSERVED MIN	OBSERVED C/M	BKD. C/M	CORRECTED C/M	✓ LIST	TECH	REVIEWED BY DATE	REVIEWED BY INT.
1	1/13/92	76,482	10	7,648.2	14.9	7633.3	✓	SKT		
2		76,148		7,614.8		7599.9				
3		77,083		7,708.3		7693.4				
4		76,995		7,699.5		7684.6				
5	1/13/92	76,697		7,669.7		7654.8				
	voltage setting =		1620V							
	$\bar{x}$ =	7653.2	± 38.2							
	~~efficiency~~ = c/d	=	~~14,295 ± 535~~ 7653.2 ± 38.2		=	0.535 ±		out		
	1/20/92	increased voltage to 7640V 1660V setting = 166								
		on 1/20/92	1 SKT 1/20/92	activity of		R17 =	14,288 ±	535		
	1/20/92	38518	5	7703.6	14.3	7689.3				
	1/20/92	38754	5	7750.8	14.3	7736.5				
	1/20/92	38510	5	7702.0	14.3	7687.7				
	1/20/92	38341	5	7668.2	14.3	7653.9				
	1/20/92	38606	5	7721.2	14.3	7706.9				
	average c/m =		7,694.8 ± 30.2							
	geometry =	7,694.8 / 14,288		= 0.539		OK				
	Geometry check using			52733-81	-2	on 1/20/92	standard activity = 24,955 ± 926 d/m			
1	1/20/92	66931	5	13,386.2	14.3	13,371.9				
2	1/20/92	67469	5	13,493.8	14.3	13,479.5	$\bar{x}$ = 13,417.1		± 62	
3	1/20/92	67001	5	13,400.2	14.3	13,385.9				
4	1/20/92	66870	5	13374.0	14.3	13,359.7	geometry:		13,417 / 24,955	= 0.538
5	1/20/92	67515	5	13,503.0	14.3	13,488.7			OK	

S.K. Sadoff 1/20/92

DL McMullin 1-31-92

B01-018

SETTINGS CHECKLIST: Beta #68

(Confirmed correct settings on 1-20-92)

Ortec 459		
Output Voltage	1620	
Ortec 490B		
Coarse Gain	32	
Integral Switch	Integral	
Fine Gain	3	
Window	10.0	
Lower Level	1.0	
Polarity	Bipolar	(This setting is not on the front of the amp and need not be checked each week.)
Ortec 773		
Master-Slave Switch	Master	
Timer Switch	Min.	
Ortec 775		
Discriminator	~3.75	
P-10 Gas		
Either tank at 0 psi?	If so, request P-10 gas change.	

COUNTER BACKGROUNDS Radio-analysis Laboratory		BETA COUNTER # Lo Beta 1		
DATE:	TOTAL MINUTES COUNTED	TOTAL COUNTS	COUNTS PER MINUTE	INITIALS
12-12-91	1000	640	0.640	DZM
12-19-91	1000	594	0.594	DZM
12-20-91	1000	675	0.675	DZM
12-27-91	1000	644	0.644	DZM
1-3-92	1000	646	0.646	SG
1-14-92	1000	622	0.622	JHK.
1/17/92-1827	1000	738	0.738	DKT
1/24/92	not counted			DKT
1-28-92	1000	702	0.702	GBB
1-31-92	1000	765	0.765	GB
2-7-92	1000	680	0.680	GB
2-12-92	800	613	0.766	GB
2-18-92	1000	747	0.747	GB
2-19-92	~~1000~~ 902.03 DZM 3-20-92	547	0.606	GB/DZM
2-21-92	1000	568	0.568	DZM

copied for ALOLuHerc 12-27-91

B01-020

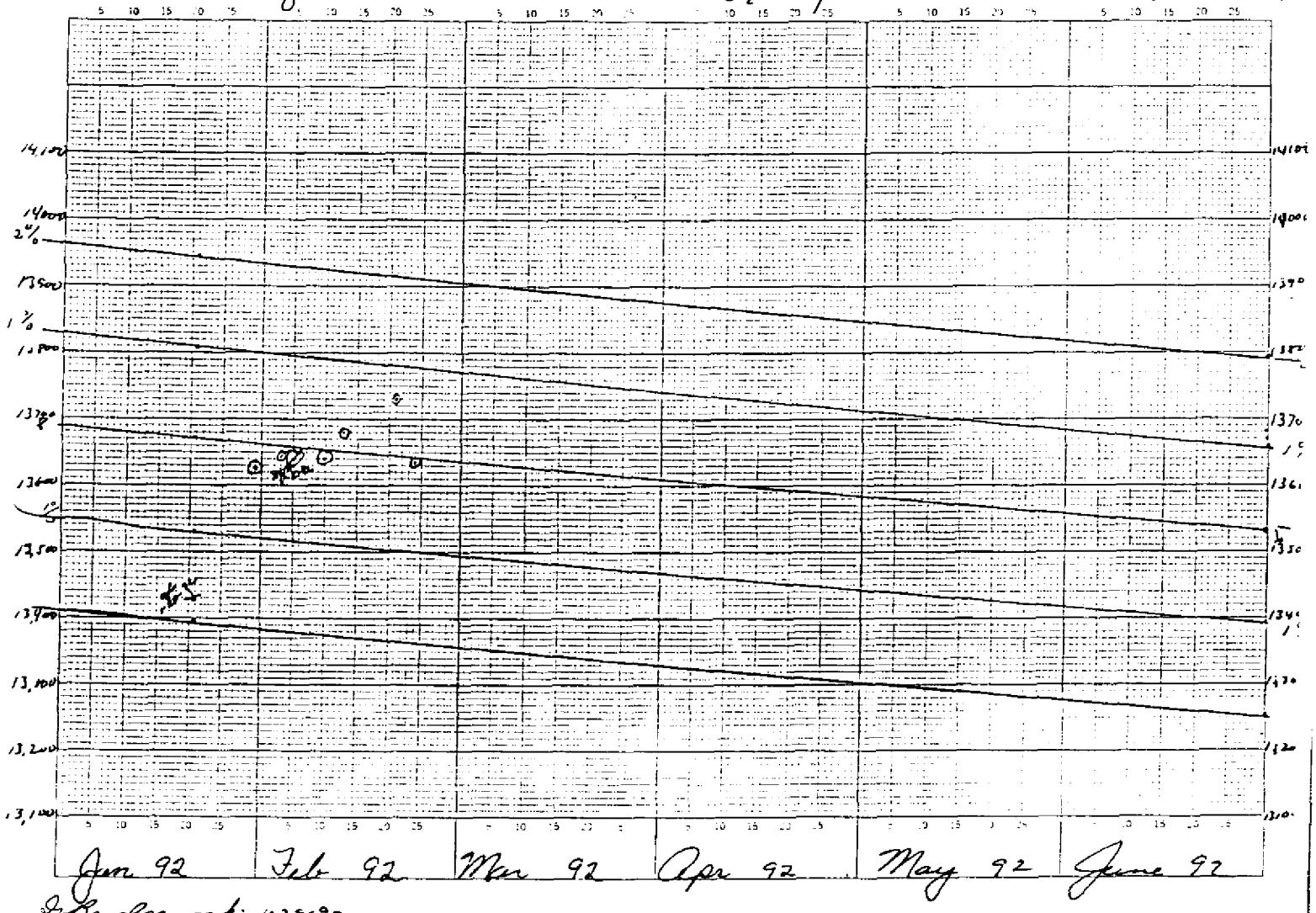
K+E 6 MONTHS BY DAYS X 120 DIVISIONS
KEUFFEL & ESSER CO. MADE IN U.S.A.

46 2610

Low Blz Beta 1

$\bar{t}$ 13671.5 G/m 1-21-92
t_t 28.5Y

STD 52733 Pt 1



D Bendzsynski 1-29-92

B01-021

COUNTER CONTROL DATA

M&TE# Ko Beta 1

STANDARD# 52733-81-1

DATE	OBSERVED			BKD. C/M	CORRECTED C/M	✓ LIST	TECH	REVIEWED BY	
	TOT CTS.	MIN	C/M					DATE	INT
1-29-92	68126	5	13625.2	~~0.565~~ 0.702	13624.5	✓	[illegible]	2/14/92	DKJ
2-3-92	136433	10	13643.3	0.765	13642.5	✓	[illegible]	2/14/92	DKJ
2-10-92	136410	10	13641.0	0.680	13640.3	✓	[illegible]	2/14/92	DKJ
2-13-92	68407	5	13681.4	0.766	13680.6	✓	[illegible]	2/14/92	DKJ
2-20-92	137310	10	13731.0	0.606	13730.4	✓	[illegible]	2/24/92	DKJ
2-24-92	136333	10	13633.3	0.568	13632.7	✓	[illegible]	2/24/92	DKJ

B01-022

COUNTER CONTROL DATA

M&TE# Lo Beta 1

STANDARD# 52733-81-1

	DATE	OBSERVED			BKD. C/M	CORRECTED C/M	✓ LIST	TECH	REVIEWED BY	
		TOT CTS.	MIN	C/M					DATE	INI.
1	1/20/92	68769	5	13,753.8	0.738	13,753.1	✓	JKT		
2	1/20/92	68563	5	13,712.6	0.738	13,711.9	✓	JKT		
3	1/20/92	68563	5	13,712.6	0.738	13,711.9	✓	JKT		
4	1/20/92	67822	5	13,564.4	0.738	13,563.7	✓	JKT		
5	1/21/92	68524	5	13,704.8	0.738	13,704.1	✓	JKT		
6	1-21-92	68351	5	13,670.2	0.738	13,669.5	✓	BB		
7	1-21-92	67923	5	13,584.6	0.738	13,583.9	✓	BB		
8	1-21-92	68681	5	13,736.2	0.738	13,735.5	✓	BB		
9	1-21-92	68251	5	13,650.2	0.738	13,649.5	✓	BB		
10	1-21-92	68165	5	13,633.0	0.738	13,632.3	✓	BB		
					$\bar{x}$ =	13671.5				

B01-025

COUNTER CONTROL DATA

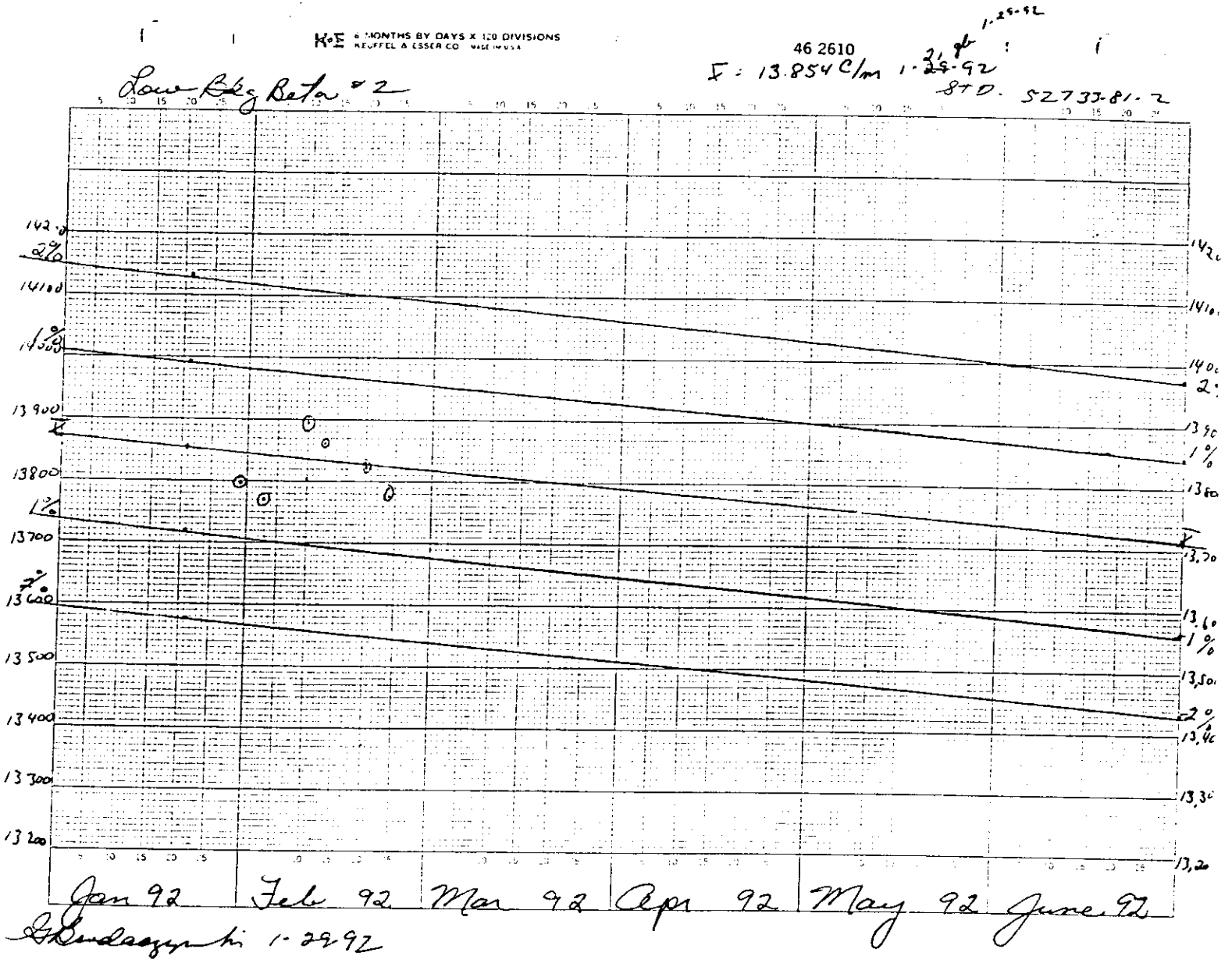
M&TE# Lo Beta #1

STANDARD# ^{90}Sr-Y (R149) #17 CONTROL LIMITS N/A

DATE	OBSERVED TOT CTS.	OBSERVED MIN	OBSERVED C/M	BKD. C/M	CORRECTED C/M	✓ LIST	TECH	REVIEWED BY DATE	REVIEWED BY INT.
1/16/92	12:00 79070	10	7,907.0	0.622	7,906.4				
	02:00 78879	10	7,887.9		7,887.3				
	04:00 78448	10	7,844.8		7,844.2				
	06:00 79443	10	7,944.3		7,943.7				
1/16/92	08:00 78788	10	7,878.8		7,878.2				
$\bar{x}$ =	7892.0		7892.0 / 14295	= 0.552	OK				
S =	36.7								
Geometry check using			#52733-81-2 control source				24,955	done on	1/20/92
1/20/92	68853	5	13,770.6	~~0.622~~ 0.738*	~~13,770.0~~ 69.9*				
1/20/92	68857	5	13,771.4		13,770.8 7*				
1/20/92	69367	5	13,873.4		13,872.7				
1/20/92	69263	5	13,852.6		13,851.9				
1/20/92	69291	5	13,858.2	~~0.622~~ 0.738*	13,857.5				
					*S.K. Jadoff 1/20/92				
average c/m =		13,824.5 +/-		50.1					
geometry	13,824.5 / 24,955		= 0.554		OK				
					S. K. Jadoff		1/20/92		

B01-024

COUNTER BACKGROUNDS Radio-analysis Laboratory		BETA COUNTER # Lo Beta 2		
DATE:	TOTAL MINUTES COUNTED	TOTAL COUNTS	COUNTS PER MINUTE	INITIALS
12-12-91	1000	489	0.489	DXM
12-19-91	1000	491	0.491	DXM
12-20-91	1000	472	0.472	DXM
copied to here for ALD 12-27-91 ~~DXM 12-23-91~~				
12-27-91	1000	499	0.499	DXM
1-3-92	1000	558	0.558	JS
1-14-92	1000	567	0.567	J.H.K.
1-17-92/1827	1000	570	0.570	D.T.
1-28-92	1000	545	0.545	GB
1-31-92	1000	550	0.550	GB
2-7-92	1000	536	0.536	GB
2-12-92	800	463	0.579	GB
2-18-92	1000	539	0.539	GB
2-19-92	~~1000~~ 902.4 DXM 2-20-92	498	0.552	GB/DXM
2-21-92	1000	561	0.561	DXM



G Bendazzoli 1-29-92

COUNTER CONTROL DATA

M&TE# Lo Beta 2

STANDARD# 52133-81-2

DATE	OBSERVED			BKD. C/M	CORRECTED C/M	✓ LIST	TECH	REVIEWED BY	
	TOT CTS.	MIN	C/M					DATE	INT.
1-29-92	68995	5	13799	0.565	13799.4	✓	[illegible]	2/14/92	DKF
2-3-92	137706	10	13770.6	0.550	13770.1	✓	[illegible]	2/14/92	DKF
2-10-92	138971	10	13897.1	0.536	13896.6	✓	[illegible]	2/14/92	DKF
2-13-92	69311	5	138622	0.579	13861.6	✓	[illegible]	2/14/92	DKF
2-20-92	138121	10	13812.1	0.552	13811.5	✓	[illegible]	2/24/92	DKF
2-24-92	137788	10	13778.8	0.561	13778.2	✓	[illegible]	2/24/92	DKF

B01-027

COUNTER CONTROL DATA

M&TE# Lo Beta #2

STANDARD# ^{90}Sr-Y #17 CR-149 CONTROL LIMITS N/A

DATE	OBSERVED TOT CTS.	OBSERVED MIN	OBSERVED C/M	BKD. C/M	CORRECTED C/M	✓ LIST	TECH	REVIEWED BY DATE	REVIEWED BY INT.
1/16/92	78851	10	7,885.1	0.567	7884.5				
	78678	10	7,867.8		7867.2				
	78755	10	7,875.5		7874.9				
	78280	10	7,828.0		7827.4				
	78377	10	7,837.7		7837.1				
1/16/92	78318	10	7,831.8	0.567	7831.2				
$\bar{x}$ =	7853.7		$\frac{78537}{14295}$ =		0.549	OK			
S =	24.7								
Geometry check using #52733-81-2 control source 24,955 dpm on 1/20/92									
1 1/20/92	69270	5	13,854.0	0.570	13,853.4				
2 1/20/92	69149	5	13,829.8		13,829.2				
3 1/20/92	69209	5	13,841.8		13,841.2				
4 1/20/92	69160	5	13,832.0		13,831.4				
5 1/20/92	69600	5	13,920.0	0.570	13,919.4				
average c/m =			13,854.9 +/- 37.3						
geometry =	$\frac{13,854.9}{24,955}$		= 0.555	OK					
					Sandra	K. Jadoff	1/20/92		
6 1/21/92	69730	5	13,946	.570	13,945.4				
7 1/21/92	69287	5	13,857.4		13,856.8				
8 1/21/92	69413	5	13,882.6		13,882.0				
9 1.21.92	69293	5	13,858.6		13,858.0				
10 1.21.92	69133	5	13,826.6		13,826.0				

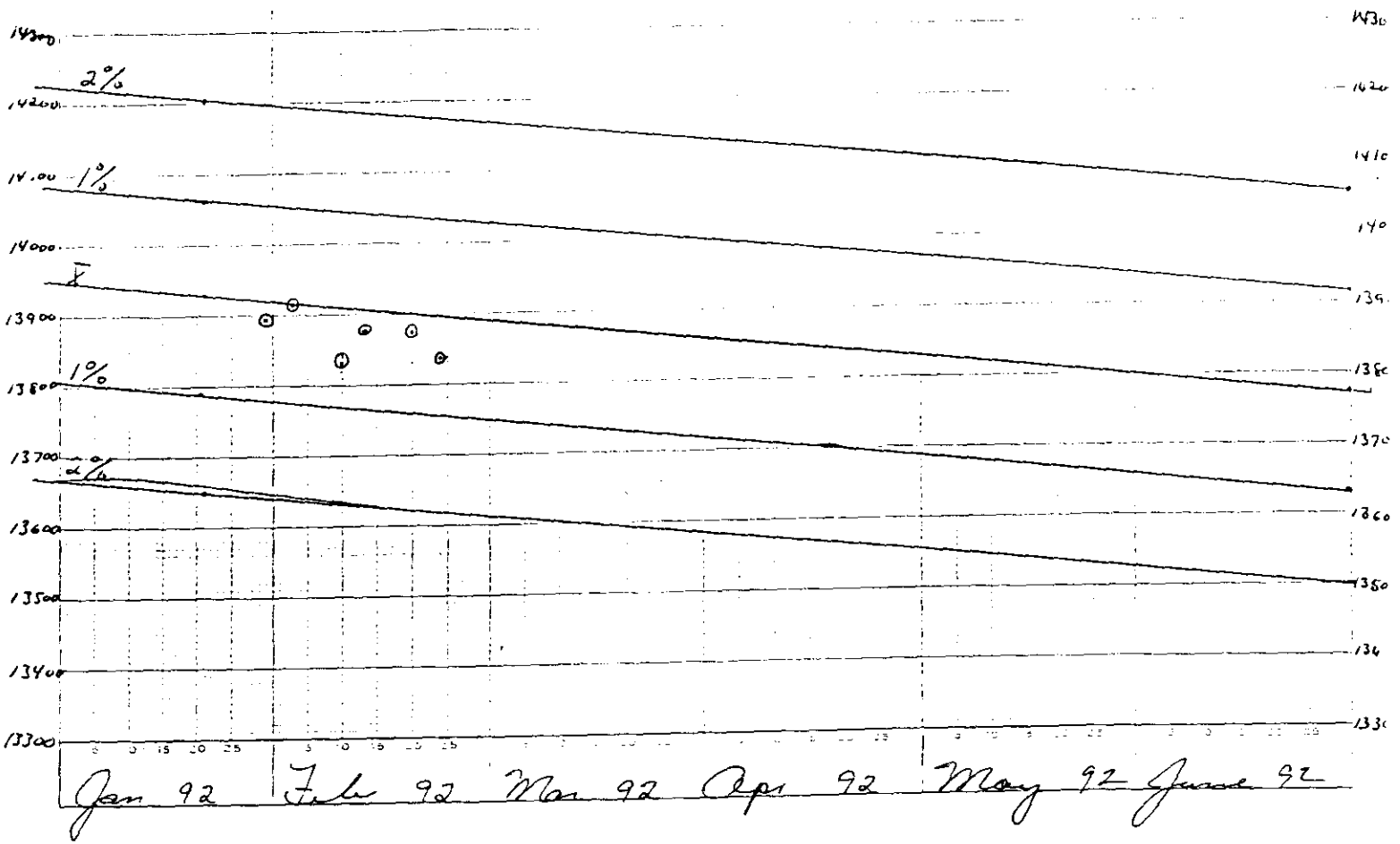
COUNTER BACKGROUNDS Radio-analysis Laboratory		BETA COUNTER # Lo Beta 3		
DATE:	TOTAL MINUTES COUNTED	TOTAL COUNTS	COUNTS PER MINUTE	INITIALS
12-12-91	1000	546	0.546	DYM
12-19-91	1000	590	0.590	DYM
12-20-91	1000	572	0.572	DYM
12-27-91	1000	496	0.496	DYM
1-3-92	1000	472	0.472	DYM/GB
1-14-92	1000	571	0.571	JHK
1-17-92/1827	1000	709	0.709	DKJ
1-28-92	1000	683	0.683	BBK
1-31-92	1000	637	0.637	BBK
2-7-92	1000	716	0.716	BK
2-12-92	800	463	0.579	GB
2-18-92	1000	574	0.574	GB
2-19-92	~~1000~~ 902.04	~~547~~ 623	~~0.547~~ 0.691	GB/DYM
2-21-92	1000	694	0.694	DYM

copied to new log 12-27-91

B01-029

Low Bkg Beta 3

$\bar{x}$ · 13927.2 1-21-92 970 5-2733-81-3



B01-030

COUNTER CONTROL DATA

M&TE# Lo Beta 3

STANDARD# 52733.81-3

DATE	OBSERVED			BKD. C/M	CORRECTED C/M	✓ LIST	TECH	REVIEWED BY	
	TOT CTS.	MIN	C/M					DATE	INI.
1-29-92	69470	5	13894	.683	13893.3	✓	[illegible]	2/14/92	DKJ
2-3-92	139150	10	13915.0	0.637	13914.4	✓	[illegible]	2/14/92	DKJ
2-10-92	138318	10	13831.8	0.716	13831.1	✓	[illegible]	2/14/92	DKJ
2-13-92	69386	5	13877.2	0.579	13876.6	✓	[illegible]	2/14/92	DKJ
2-20-92	138724	10	13872.4	0.691	13871.7	✓	[illegible]	2/24/92	DKJ
2-24-92	138404	10	13840.4	0.694	13839.7	✓	[illegible]	2/24/92	DKJ

B01-031

COUNTER CONTROL DATA

M&TE# Low Beta 3

STANDARD# 52733-81-3

	DATE	OBSERVED			BKD. C/M	CORRECTED C/M	✓ LIST	TECH	REVIEWED BY	
		TOT CTS.	MIN	C/M					DATE	INT.
1	1/20/92	69808	5	13,961.6	0.709	13,960.9	✓	DKT		
2	1/20/92	69853	5	13,970.6	0.709	13,969.9	✓	DKT		
3	1/20/92	70020	5	14,004.0	0.709	14,003.3	✓	DKT		
4	1/21/92	69850	5	13,970.0	0.709	13,969.3	✓	DKT		
5	1-21-92	69288	5	13,857.6	0.709	13,856.9	✓	BG		
6	1-21-92	69718	5	13,943.6	0.709	13,942.9	✓	BG		
7	1-21-92	69814	5	13,962.8	0.709	13,962.0	✓	BG		
8	1-21-92	69619	5	13,923.8	0.709	13,923.1	✓	BG		
9										
10						$\bar{X}$				
						13948.5 ± 43.6				

Utilizing the two next counts, 13,893 and 13,914.4 cpm an average of 13,940 is calculated +- 13. This is essentially the same as the average calculated for 8 determinations above. Therefore the QC chart calculated with the average of 8 determinations is fine.

D.K. Tackett 2/25/92

COUNTER CONTROL DATA

M&TE# Lo Beta #3

STANDARD# ^{90}Sr-Y (R-149) #17 CONTROL LIMITS N/A

DATE	OBSERVED			BKD. C/M	CORRECTED C/M	✓ LIST	TECH	REVIEWED BY	
	TOT CTS.	MIN	C/M					DATE	INT.
1/15/92	78970	10	7897.0	0.571	7896.4				
↓	79108	10	7910.8	0.571	7910.2				
	79178	10	7917.8	0.521	7917.2				
↓	79262	10	7926.2	0.571	7925.6				
1/15/92	79365	10	7936.5	0.571	7935.9				
voltage	= 1650V								
$\bar{x}$ =	7917.1		dpm in standard =		14,295				
σ =	15.0								
2% =	158		$\frac{7917.1 \times .5}{14,295 \times .333}$ =		0.554	OK.			
Geometry check using			#52,733	-81-2	control source		24,955 dpm on 1/20/92		
1/20/92	69931	5	13,986.2	0.709	13,985.5				
1/20/92	69237	5	13,847.4	0.709	13,846.7				
1/20/92	69380	5	13,876.0	0.709	13,875.3				
1/20/92	69610	5	13,922.0	0.709	13,921.3				
1/20/92	69508	5	13,901.6	0.709	13,900.9				
average c/m =		13,905.9	+/-	52.5	13,905.5	±43.6	$\bar{x}$ =	13927.2	±30.1
geometry =		$\frac{13,905.9}{24,955}$ =		0.557	OK				
					J. K. Jadyff	1/20/92			

B01-033

$^{90}Sr/Y$ Standards for Beta Counters #52733-81-1 through 52733-81-4

B01-034

Received 4 ^{90}Sr-^{90}Y sources from Malin Weiler. Each contains 2.695×10^4 ± 7.7% dpm on 12-14-89 and are traceable to NIST. Documentation is in our files in Rm 104.

Our No.	Malin's No.
52733-81-1	W-27-1
52733-81-2	W-27-2
52733-81-3	W-27-3
52733-81-4	W-27-4

LAB 52733

Each is on a standard 1" beta disk.

12-22-89 [illegible]
02-05-92 [illegible]

SEE FILE

Project No. _____ Date of Work _____

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Signed 1. _____ Date _____

2. _____ Date _____

NIST SRM [illegible]
Shannon Thompson
PNL | Chem + Anal
12-7-69 NCW

Source for X-ray Spectrometer Calibration : ~1 g NIST SRM #4276C, 10 ml soln, LSC vial

empty LSC vial : 16.4493 → 16.4493
vial + 1000λ SRM : 17.7112 → 17.7111

17.7111 ± 0.0001
− 16.4493 ± 0.0001
1.2618 ± 0.00014 grams SRM 4276C-23 #85-24

weighed on minimer #451999

8.50 ml 3N HCl + 30 ppm each Sm, Eu solution added to vial.

Amersham Mixed γ
Shannon Thompson
PNL | Chem + Anal
12-7-69 NCW

Source for X-ray Spectrometer Calibration : ~1 g Amersham QCY 44, LSC vial

empty LSC vial : 16.4011 → 16.4010
vial + 1000λ QCY44 : 17.4692 → 17.4692

17.4692 ± 0.0001
− 16.4010 ± 0.0001
1.0682 ± 0.00014 grams QCY44, J99665 RO/270/41

#85-18

Thompson to add suitable diluent to 10.00 ml total volume.

Y Wyckoff 90Y Sec.
PNL | Chem + Anal
12-13-69 NCW
W-27-1,2,3,4

^{90}SrY Sources : 25,000 - 30,000 β/m on 1" ss disks, lightly Kapton sprayed. N.L. Wyckoff. 4 each

preparation & dilution : 2.48 ml ^{90}SrY RS-11-3 diluted to 10.0 ml with 1% HNO_3 + 10 ppm each Sm, Y solution.

10 ml vol flask : 15.7066 → 15.7066
flask + RS-11-3 : 18.1909 → 18.1909
flask diluted to vol : 25.9331 → 25.9334

18.1909 ± 0.0001
− 15.7066 ± 0.0001
2.4843 ± 0.00014 grams RS-11-3

25.9334 ± 0.0001
− 15.7066 ± 0.0001
10.2268 ± 0.0001 grams total solution

RS-11-3 [data from BNW-52615 pp 49-50]

6.0960 ± 0.0002 grams Isotope Products ^{90}Sr Standard Solution ~~[illegible]~~ # 7040-4 lot 16-96-A-3 [RS-6] diluted to 99.6060 ± 0.0020 grams.

[30.040 ± 0.741 mCi/g][2.22 × 10^6 d/m/μCi][5.0960 ± 0.0002 g]/[99.6060 ± 0.0020 g]

= 2.2715$_5$ × 10^6 ± 8.39$_9$ × 10^4 d/m/g 5-19-67 ^{90}Sr [99% cl]

5-19-67 → 12-14-69 = 963 d = 2.63660 y

triple 24.90 ± 0.05 λ [calibrated micropipette] above dilution of RS-11-3 source bottom area of four 1" ss disks. Dry. Spray lightly with clear Kapton acrylic spray. Label W-27-1,2,3,4.

[2.2715$_5$ × 10^6 ± 8.39$_9$ × 10^4 d ^{90}Sr/m/g][2.000012 $\frac{90Sr}{90Y}$][2.4843 ± 0.00014 g][$e^{-\frac{\ln 2 \cdot (2.6366)}{28.78 \pm 0.24}}$][0.02490 ± 0.00005 ml]/[10.00 ± 0.0221]

= 26267$_{90}$ ± 976$_{99}$ ^{90}Sr-Y β/m 12-14-69 [99% cl]

source verification: count each source on a β proportional counter. Use the observed counts to verify that no source is an outlier to the others [pipetting error]. Calculate the activity of each source using current BPC calibration data and compare results with calculated activity values.

BNW
#52815

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Project No. _____ Date of Work _____
Entered By _____ Date _____
Disclosed To and Understood By
Signed 1. _____ Date _____
2. _____ Date _____

B01-036

62 N.L. Wynhoff 239Pu Std. Srcs. (continued)

BATTELLE-NORTHWEST

ANALYTICAL LABORATORIES - BETA AND GAMMA COUNTER DATA SHEET

Sample Number	Wt.	Time	Inst. No.	Shelf No.	Mass	Int.	Absorber	Total Counts	Background Rate	Count Period	Net Rate	Efficiency	Disintegration Rate
[illegible]	[illegible]	[illegible]	[illegible]				[illegible]	[illegible]			[illegible]	[illegible]	[illegible]
[illegible]		[illegible]					[illegible]	[illegible]			[illegible]		[illegible]
[illegible]		[illegible]					[illegible]	23362			[illegible]		[illegible]
[illegible]		[illegible]					[illegible]	23310			[illegible]		[illegible]

BNW 52815 page 64.

None of the sources are outliers

Measured activities agree with calculated activity.

N.L. Wynhoff 239Pu Std. Srcs. PNL Chem. Anal. 12-13-69 N.L.W. W-28-1, 2, 3

239Pu Sources: 2500 d/m on 1½" ss disks. Ignite on hot plate. N.L. Wynhoff. 3 each

NIST certified 239Pu solution no. [illegible] T-1500-19 opened 12-13-69

19.97 ± 0.04 λ [calibrated micropipette] pipetted onto bottom of three 1½" ss disks. Dry. Heat on a hot plate to anneal the activity to the disk. Labeled W-28-1, 2, and 3.

$[1.33 \times 10^5 \pm [illegible] \times 10^3$ d/m/ml$][0.01997 \pm 0.00004$ ml$] = \underline{2.66 \times 10^3 \pm 28.}$ d/m October 1979

Source verification; Count each source on the alpha scintillation counter. Use the observed counts to verify that no source is an outlier to the others [pipetting error]. The 1½" disk is not in standard geometry; the activity cannot be calculated from the count data for comparison with the calculated activity.

BATTELLE-NORTHWEST

ALPHA COUNTER DATA SHEET

Sample Number	Date Counted	Inst. No.	Int.	Background	Total Counts	Background Rate	Count Period	Net Rate	Efficiency	Disintegration Rate
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]			
[illegible]	[illegible]			[illegible]	5171					
[illegible]	[illegible]			[illegible]	5210					

BNW 52815 page 64

Project [illegible]

Entered By ______ Date ______

Disclosed To and Understood By

Signed 1. ______ Date ______

2. ______ Date ______

BNW #52815

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B01-037

CERTIFICATE OF BETA STANDARD SOLUTION

Radionuclide: Sr-90 Half-life: 28.82 ± 0.14 Y

Customer: Battelle Northwest P.O. No.: U0659AR-8

Solution No.: 186-98-A-3 Catalog No.: 7090-4

Description of Standard Solution

a. Mass of solution: 5.1709 gm

b. Chemical form: $SrCl_2$ in 0.1 N HCl

c. Carrier content: None Added

d. Solution density: 0.9996 gm/ml at 20° C

Radioimpurities

None Detected

Radioactive Daughters

Y-90 Daughter in Equilibrium

Radionuclide Concentration

a. The concentration was 20.04 μCi/gm (103.6 μCi Total)

b. Reference Date: May 19, 1987

Method of Calibration

Weight aliquots of the solution were assayed using

( ) Liquid scintillation counter.

( ) Internal gas flow proportional counter.

Uncertainty of Measurement

a. Systematic uncertainty in instrument calibration: ± 2.1 %

b. Random uncertainty

1. In assay: ± 1.5 %
2. In weighing(s): ± 0.1 %

c. Total Uncertainty: ± 3.7 % at the 99% confidence level.

NBS Traceability

This calibration is implicitly traceable to the National Bureau of Standards.

Notes

1. Nuclear data were taken from "Table of Isotopes", Seventh Edition, edited by C. Michael Lederer et al.
2. IPL participates in an NBS measurement assurance program to establish and maintain implicit traceability for a number of nuclides, based on the blind assay (and later NBS certification) of Standard Reference Materials. (As in NRC Regulatory Guide 4.15)

Michael Devine
Quality Control

Accepted
NW Given 4/28/88

ISOTOPE PRODUCTS LABORATORIES
1800 No. Keystone St., Burbank, California 91504
(818) 843-7000

RECEIVED
APR 27 1988
N.W. GIVEN, C.O.

B01-038

$^{90}Sr/Y$ Standard for Beta Counter #17

B01-039

Battelle
Pacific Northwest Laboratories

BETA COUNTING DATA

REQUESTED BY	DATE ANALYZED	SAMPLE TYPE	CHARGE CODE
NEW	1-4+5-90		

REMARKS: Calibration of ^{90}Sr-^{90}Y source #17 (R-149, 28312 dpm 6-14-63) against d/c obtained on same beta set with ^{90}Sr-^{90}Y #52733-81-3

DESIGNATION	SAMPLE	SAMPLED	DATE - TIME	CARRIER (ML)	PROCESS	WT.-VOL. ANALYZED	WT. RESIDUE	ANALYST	SET NUMBER	SHELF	COUNTED	DATE - TIME	COUNTS	MINUTES	BKG. C/M	C/M	BKG. CORR.	TECHNICIAN	CALCULATIONS (C/M) (VOLUME FACTOR) = (4.20)(2.22×10^6)(1.5)(.02)(.854)(.44)(.71)(.10)	RESULTS UNITS OF ____ μc/____
Source #17										68	1	1-4-90	81257	10	16.0		8109.7			
													81467				8130.7			
													80727				8056.7			
													81134				8097.4		± 41.96 (1σ) $\bar{x}$ = 8072.68 cpm	
												1-5-90	79977				7981.7			
													81103				8094.3		geo = 8072.68 cpm / 14839 dpm = 0.544	
													80990				8083.0		∴ -0.9% from 0.549 geo set in 1959.	
													80531				8037.1			
													80905				8074.5			
													80777				8061.7			
							± 41.96 8072.68 cpm					± .019 1.860 =	± 562 15015 dpm				4+5 on 1-5-90		Conclusion: Δ = 1.2% overlaps 1σ	

t = 9701.5 d, $t_{1/2}$ = 10409.3 d 28312 dpm / 6-14-63 → 14839 dpm 1-4+5-90

OK!!

1/8/90

ED-1700-045 (12-71)

№ 1671

53293-8

B01-040

53293-8

COUNTER CONTROL DATA

Set No 68 Detector No

Standard No. #52733-81-3 Window

Date	Volts	Observed Total Cts.	Observed Time	Observed C/M	BKD.	Corrected C/M	Geom.	Tech.
Geometry	check:	new ^{90}Sr-Y std #52733-81-3 (				W-27-3,		MW
		$2.625 \times 10^4 \pm 475$		d/m	11-14-89)			
1-5-90		141484	10		16.0	14132.4		
		140832				14067.2		
		141653				14149.3		
		141312				14115.2		
		141632				14152.2		
		141189				14103.9		
		140873				14071.3		
		140940				14078.0		
		140905				14074.5		
		141380				14122.0		

net cpm $\bar{x} = 14106.5 \pm 32.56$ (1σ)

$t = 22$ d; $t_{\frac{1}{2}} = 10409.3$ d → $2.624 \pm 974 \times 10^4$ dpm on 1-5-90

$d/c = \frac{2.624 \times 10^4 \pm 974 \text{ dpm}}{14106.5 \pm 32.56 \text{ cpm}} = 1.860 \pm 0.069$ d/c

geo = 0.538 ← This is 2% different than required geo of 0.549 (with source #17) & that is within limits (±2%).

This reconfirms that calib of source #17 is OK.

MW 1/8/90

A 1700 180 (10 87)

B01-041

G.V. Cole
^{133}Ba source
(continued)
9-26-90 HW

[3034.73 ± 44.9 c/m][2607.0$_5$ ± 65.8$_6$ d/c]/[0.06545 ± 0.000157 ml]
= 9.969$_5$ × 10^7 ± 2.771$_2$ × 10^6 d/m/ml 9-26-90 1200 PST

Source I:

1. Prepare three separate sources by pipetting [calibrated glass micropipette] aliquots of 199.97 λ, 199.97 λ, and 149.98 λ + 50.14 λ as point sources on the adhesive face of polyester tape
2. Air dry.
3. Apply the adhesive faces of the two 199.97 λ sources together, then apply the remaining source face down to create a 3 layer polyester tape sandwich, the active areas in registration.
4. Cut out the active area as a 1/2" circle. Mount it in a 1" ss disk with DUCO cement.
5. Fill the disk bowl with the flange with Buehler Fast Cure Epoxy #20-8128. Allow to set.

$$\frac{[(199.97 \pm 0.215) + (199.97 \pm 0.215) + (149.98 \pm 0.206) + (50.14 \pm 0.040)]\,\text{ml}\,[9.969_5 \times 10^7 \pm 2.771_2 \times 10^6\ \text{d/m/ml}]}{2.22 \times 10^6\ \text{d/m/}\mu\text{Ci}}$$

= 26.030$_0$ ± 0.723$_2$ μCi Ba^{133} 9-26-90 1200 PST [95% cl]

Source II:

1. Prepare a point source by pipetting [calibrated glass micropipette] 49.94 λ Ba^{133} nic on the adhesive face of polyester tape. Air dry.
2. Cover with a second piece of polyester tape, adhesive faces together.
3. Proceed as in steps 4 and 5, Source I.

[0.04994 ± 0.000100 ml][9.969$_5$ × 10^7 ± 2.771$_2$ × 10^6 d/m/ml]/[2.22 × 10^6 d/m/μCi]
= 2.2461 ± 0.0123 μCi Ba^{133} 9-26-90 1200 PST [95% cl]

Internal Use
3H std
W-64
10-3-90, HW

3H Standard for Biomedy Quality Control Program use: nominal 1 × 10^4 d/m/ml

W-23: NIST 3H std ref. model 4926-C:
3.40$_0$ × 10^3 d/s/g ± 0.63% [99% cl] 9-9-78
± 0.63% = 0.18% random error and data + 0.25% systematic error + 0.2% geometric + weight error
since at 6-1 = 5 df 99% cl error = 4.032 σ, σ = 0.0018/4.032 = 0.0004464
at 6-1 = 5 df 95% cl error = 2.571 σ, (2.571)(0.0004464) = 0.001147 = 0.12%
total error [95% cl] = 0.12% + 0.25% + 0.2% = 0.57% [95% cl].
3.40$_0$ × 10^3 ± 0.57% d/s/g = 3.40$_0$ × 10^3 ± 19.$_4$ d/s/g 9-9-78 [95% cl.]

BNW
#52815

Project No. _____ Date of Work _____
Entered By _____ Date _____
Disclosed To and Understood By
Signed 1. L.R. Greenwood Date 10-25-90
2. _____ Date _____

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B01-042

106 Internal Use
^3H SRM
W-65
(continued)
10-2-90, [illegible]

Weight ~1000 λ ^3H SRM # 4426-C into a 10 ml [type A] volumetric flask. Dilute to volume with deionized water [system # WB-37299, 10-2-90, 16.0 MΩ-cm]. Reweigh.

empty flask:	17.4042	17.4045	17.4045
flask + SRM:	18.4215	18.4214	18.4214
flask at volume:	27.3764	27.3764	@ 24.54°C

Mettler Semimicro # 45/999

weight ^3H SRM # 4426-C: (18.4214 ± 0.0001) − (17.4045 ± 0.0001) = 1.0169 ± 0.00014 g
total weight ^3H in W-65: (27.3764 ± 0.0001) − (17.4045 ± 0.0001) = 9.9719 ± 0.00014 g

9-3-76 → 10-4-90 = 4414 days = 12.085/3146 years
$(3.40_0 \times 10^8 \pm 19.4\ d/s/g)(60 \pm 0\ g/m)(6^{-(4.4)(12.085/3146)/12.26 \pm 0.03})(1.0169 \pm 0.00014\ g)/(9.9719 \pm 0.00014\ g)$
$= 1.05_{90} \times 10^9 \pm 6._3 \times 10^7$ d/m/g 10-4-90 [95% cl]
$(3.40_0 \times 10^8 \pm 19.4\ d/s/g)(60 \pm 0\ g/m)(6^{-(4.4)(12.085/3146)/12.26 \pm 0.03})(1.0169 \pm 0.00014\ g)/(10.0000 \pm 0.0221\ ml)$
$= 1.05_{90} \times 10^9 \pm 6._3 \times 10^7$ d/m/ml 10-4-90 at 24.54°C [95% cl]

Internal Use
^3H SRM
W-66
10-2-90, [illegible]

^3H Standard for liquid scan on internal standard: nominal 10^9 d/m/ml, for FG Hold

Weight ~1000 λ ^3H SRM # 4426-C into a 10 ml [type A] volumetric flask. Dilute to volume with deionized water [system # WB-37299, 10-2-90, 16.0 MΩ-cm]. Reweigh.

empty flask:	17.0379	17.0379	17.0380
flask + SRM:	18.0426	18.0426	
flask at volume:	27.0054	27.0053	27.0054

Mettler Semimicro # 45/999
@ 24.54°C

weight ^3H SRM # 4426-C: (18.0426 ± 0.0001) − (17.0379 ± 0.0001) = 1.0047 ± 0.00014 g
total weight ^3H in W-66: (27.0054 ± 0.0001) − (17.0379 ± 0.0001) = 9.9675 ± 0.00014 g

9-3-76 → 10-4-90 = 4414 d = 12.085/3146 years
$(3.40_0 \times 10^8 \pm 19.4\ d/s/g)(60 \pm 0\ g/m)(6^{-(4.4)(12.085/3146)/12.26 \pm 0.03})(1.0047 \pm 0.00014\ g)/(9.9675 \pm 0.00014\ g)$
$= 1.04_{93} \times 10^9 \pm 6._4 \times 10^7$ d/m/g 10-4-90 [95% cl]
$(3.40_0 \times 10^8 \pm 19.4\ d/s/g)(60 \pm 0\ g/m)(6^{-(4.4)(12.085/3146)/12.26 \pm 0.03})(1.0047 \pm 0.00014\ g)/(10.0000 \pm 0.0221\ ml)$
$= 1.03_{94} \times 10^9 \pm 6._4 \times 10^7$ d/m/ml 10-4-90 at 24.54°C [95% cl]

BNW
#52815

Project No. _____ Date of Work _____
Entered By _____ Date _____
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Signed 1. E. R. [illegible] Date 10-25-90
2. _____ Date _____

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Page: 152
LRB No.: 52815

The following provides evidence of surveillance and/or technical reviews of this LRB in accordance with MG 4.3. When completed, this sheet is to be inserted into the LRB each month.

SURVEILLANCE REVIEWS
(Monthly for Impact Level I or II LRB entries by the Line Manager or delegate, and, if appropriate, by the Project Manager):

Pages Reviewed: 71 ← 152
Date Reviewed: 1-8-92
Basis of Review: Check for legibility, completeness, traceability of entries, and a sample of requirements (1-14) of MG 4.3.
Results:

Reviewer's Dated Signature: G O Harvey 1/8/92

TECHNICAL REVIEWS
(Monthly reviews for Impact Level I or II LRB entries and prior to Project close out by a technically competent individual):

Pages Reviewed:
Date of Review:
Objective/Approach of Review: To determine (check one or more):
✓ 1) adequacy/appropriateness of methodology
✓ 2) if inferences and conclusions are soundly based
✓ 3) if data reduction and/or calculations are correct
__ 4) other (specify):

Results/Conclusions:

Reviewer's Dated Signature: G O Harvey 1/8/92

Project No. _____ Date of Work _____
Entered By _____ Date _____
Disclosed To and Understood By
Signed 1. _____ Date _____
2. _____ Date _____

U.S. Department of Commerce
Juanita M. Kreps
Secretary

National Bureau of Standards
Ernest Ambler, Director

THIS IS A FACSIMILE OF THE CERTIFICATE
WHICH IS BEING MAILED TO YOU UNDER
SEPARATE COVER.

National Bureau of Standards Certificate

Standard Reference Material 4926-C

Radioactivity Standard

Hydrogen-3

This Standard Reference Material consists of approximately 18 milliliters of a master solution of tritiated water, in a flame-sealed borosilicate-glass ampoule.

Aliquots of this master solution and of the 1961 tritiated water standard, SRM 4926, were made up gravimetrically with liquid scintillator into 18 and 45 vials, respectively, and intercompared by liquid-scintillation counting. The radioactivity concentration of SRM 4927 (which was the master solution for SRM 4926) that had been measured in 1961 (W.B. Mann, R.W. Medlock, O. Yuro, Int. J. appl. Radiat. Isotopes, 15, 351 (1964)), was redetermined by gas counting in 1978 using the National Bureau of Standards length-compensated internal gas proportional counters. Based on these 1978 measurements, the gravimetric dilution factors, and the liquid-scintillation counting intercomparison, the radioactivity concentration of 4926-C, as of September 3, 1978, was

$$*3.40_6 \times 10^3\ s^{-1}g^{-1} \pm 0.63\%*.$$

The uncertainty of the radioactivity concentration, 0.63 percent, is the linear sum of 0.18 percent, which is the limit of the random error of the gas-counting measurements at the 99-percent confidence level (4.032 S_m, where S_m is the standard error computed from 6 determinations), 0.25 percent, which is the estimated upper limit of conceivable systematic error in the gas counting and sample preparation, and 0.2 percent, which is the estimated upper limit of the error in the gravimetric dilutions and the liquid-scintillation measurements.

The radioactivity concentration of 4927 as determined in 1978 is 0.7 percent higher than the results determined in 1961, using a half life of 12.35 years. They agree, however, within the estimated overall uncertainties.

This Standard Reference Material was prepared in the Center for Radiation Research, Nuclear Radiation Division, Radioactivity Section, W. B. Mann, Chief.

Washington, D.C. 20234
January, 1979

J. Paul Cali, Chief
Office of Standard Reference Materials

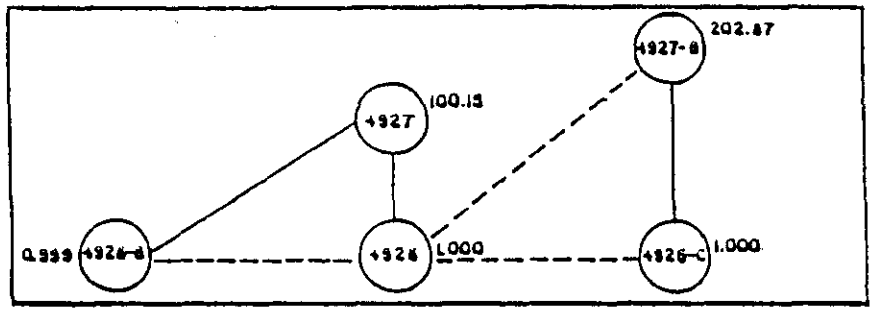
SRM 4926-C

NOTES ON THE NBS STANDARDS FOR HYDROGEN-3-WATER

SRM-4926, 4926-B, 4926-C and SRM-4927, 4927-B

A recalibration has been made on the NBS standard for ^3H-water by means of gas counting, and new batches of material have been prepared. Because of the large number of the earlier standards still in use (1) and because of their importance in international hydrology measurements (2), it is important that the relative radioactivity concentrations of the five existing NBS tritium standards be given. The diagram shown here gives the radioactivity concentrations relative to SRM-4926, as of Sept. 1, 1978. It may be seen that the three low-level materials are essentially equivalent.

RELATIVE RADIOACTIVITY CONCENTRATIONS OF ^3H-WATER SRM'S



The links represented by solid lines were computed from gravimetric dilution factors for which the uncertainties are less than 0.1%. The links represented by the dashed lines are based on liquid-scintillation intercomparisons, for which the uncertainties are less than 0.2%.

Based on gas-counting measurements of six samples of the 1961 SRM-4927 made in 1978, the following radioactivity concentration values are obtained:

SRM	Radioactivity Concentration ($s^{-1}g^{-1}$) September 1, 1978
4926	$3.406 \times 10^4 \pm 0.4_1\%$
4926-B	$3.403 \times 10^4 \pm 0.4_1\%$
4926-C	$3.406 \times 10^4 \pm 0.6_1\%$
4927	$3.411 \times 10^5 \pm 0.4_1\%$
4927-B	$6.909 \times 10^5 \pm 0.6_1\%$

On the basis of the 1961 gas-counting measurements, the radioactivity concentration of SRM-4927 was $0.8793 \times 10^6\ s^{-1}g^{-1} \pm 1\%$ as of September 1, 1961. The relative agreement between the 1961 and 1978 gas-counting measurements cannot be established unequivocably, however, because of the uncertainty in the half life (If a half life of 12.35 y is used, the 1961 and 1978 standards agree to within 0.7%; for complete agreement, it would be necessary to use a half life of 12.44 y.)

---

(1) Mann, W.B., Medlock, R.W. and Yura, O. Int. J. appl. Radiat. Isotopes, 15, 351 (1964)

(2) Taylor, C.B., Int. J. appl. Radiat. Isotopes, 29, 39 (1978).

Tritium Liquid Scintillation Counter Control,
Background, and Efficiency Counts

Control Counts LRB 53952

DATE	BKG	^3H	^{14}C	Initials	Comments	Rev'd by
1-24-92	14.52	58363.15	—	DJM	200-BP1 pkg #12	mw 1-31-92
2-3-92	14.20	58093.42	—	DJM	200-BP-1 pkg #12	JK.T. 2/14/92
2-7-92	14.75	57845.45	—	DJM	1100EM1	JKT 2/14/92
2-11-92	14.11	58103.94	—	DJM		JKT 2/10/92
2-12-92	15.02	57418.18	—	DJM	1100EM1	JKT 2/20/92

Project No. _____ Date of Work _____

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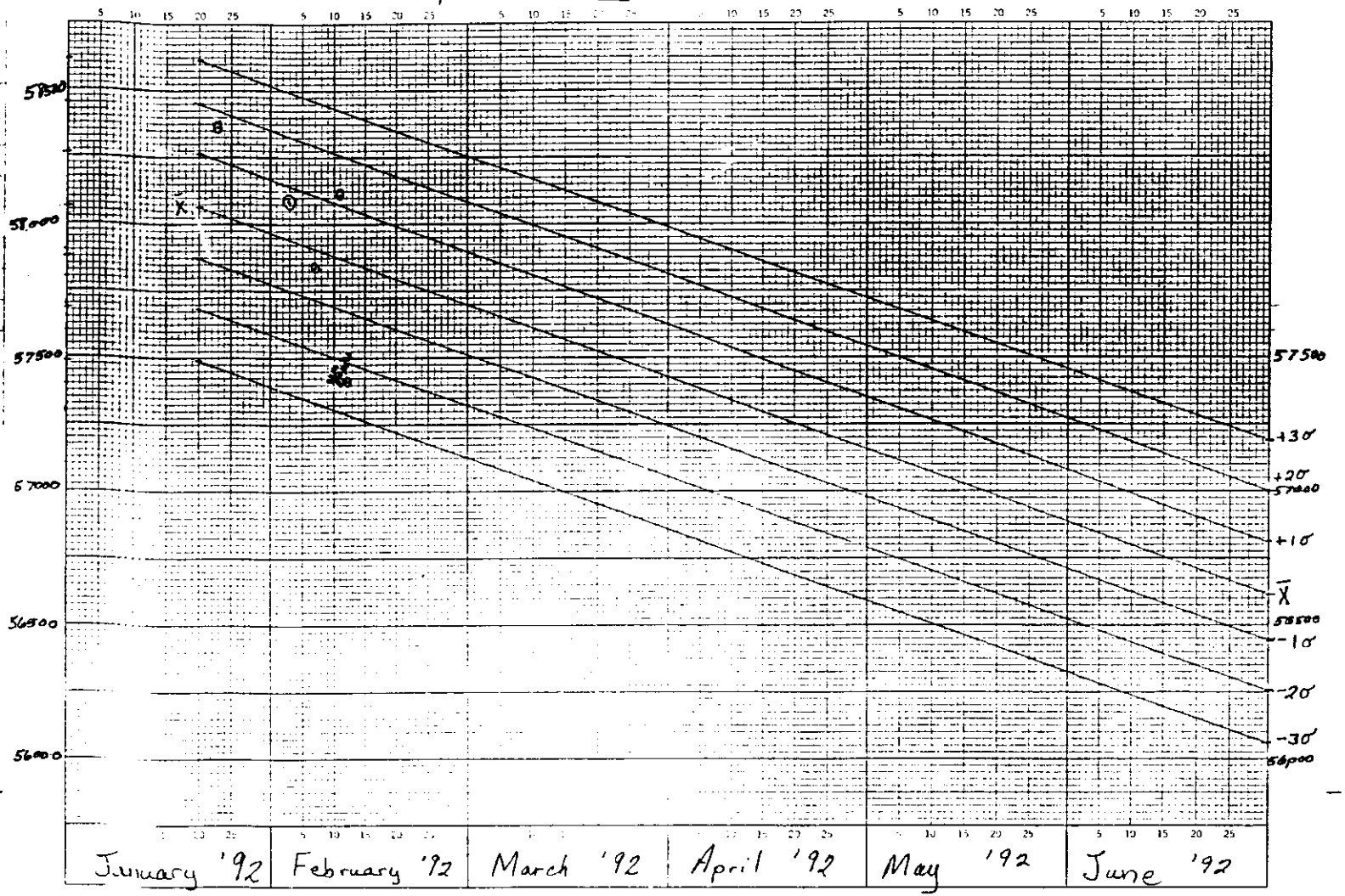
2. _____ Date _____

K+E 6 MONTHS BY DAYS X 120 DIVISIONS KEUFFEL & ESSER CO. MADE IN U.S.A.

46 2610

3H HD000608

$\bar{X}$ = 58,067.439 on 1-20-92



Diane L. McMullin 1-20-92

LRB 53952 3H 32

Control Chart 1-20-92 to 6-30-92 HD000608 Diane McMullin 1-20-92

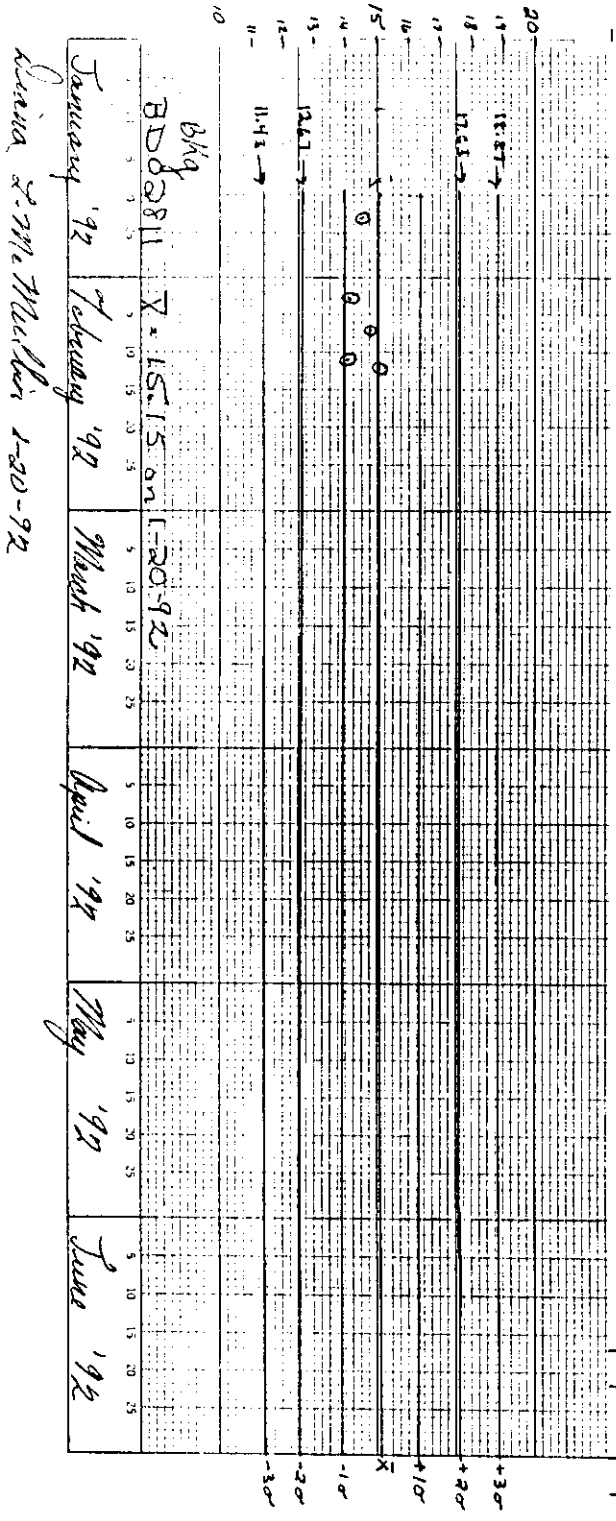
B01-049

LRB 53952
33

Bkg control chart
1-20-92 to 6-30-92

BD02811

D. McMullin
1-20-92



Bkg control chart
Bkg BD02811 $\bar{X}$ = 15.15 on 1-20-92
January '92 February '92 March '92 April '92 May '92 June '92
D. McMullin 1-20-92

Project No.
Entered By
Disclosed To and Unc
Signed 1.
2.

E01-050

I2 Solution Standards

LAB # 52733

117

Lois Abbey: $^{90}Sr - ^{90}Y$ std

2 containers of same std solution prepared by Malin Weiler on 3-14-80. One has been in use since then and one is still sealed. Malin's calibrated value (original) is 1.47×10^4 dpm/ml $^{90}Sr - ^{90}Y$ on 3-14-80.

52733-117-1 Opened container
52733-117-2 unopened, sealed container

M. Zipkoff 10-24-90

An aliquot of 52733-117-1 was submitted to Malin Weiler for AE CALIBRATION. He assigned it # W-74.

New values are: $1.110_{14} \times 10^3 \pm 2.7_{625} \times 10^1$ dpm/ml 10-24-90
[1σ] $^{90}Sr - Y$

SEE FILE

M. Zipkoff 12/21/90
[illegible] 2.5.92

Project No.
Entered By
Disclosed To and Understood By
Signed 1.
2.

Date of Work
Date
Date
Date

DATE 10-30-90

TO Nancy FROM Malin

Enclosed is a copy of the recalibration of your SrY-90 standard solution submitted for recalibration as #W-74.

The original calibration, 1.47×10^3 D/m/ml 3-14-80 decay corrected to 10-24-90 is ~~1.110~~ 1.13 $\times 10^3$ D/m/ml. The ratio of the values (recalibration)/(original calibration) is 0.9771, within the error ranges of the two values.

52733-117

Malin

MJW 12-17-90 per LAB # 52815 p. 114

Note: This std. is numbered 52733-117-1. A duplicate (still sealed) std. is #52733-117-2. MJ Wyatt 12/21/90

B02-005

BATTELLE-NORTHWEST
RICHLAND, WASHINGTON

ANALYTICAL LABORATORIES – BETA AND GAMMA COUNTER DATA SHEET

SAMPLE: Sr-Y-90 Std # W-47-2

SUBMITTED BY: MRW

COUNTED BY: MRW

REMARKS: 100.052, 1" ss disks. Four replicate counts.

SAMPLE NUMBER	DATE 19__	TIME	INST. NO.	SHELF NO.	ABSBR. MG/CM²	INT. (MIN) T	RECORDER READING SCALE OF +	TOTAL COUNTS N	RECORDED RATE R = N/T	COINC. CORR'N C	BGD B	NET RATE X=R−B+C	NORMALIZING RATE N.F.	NORMALIZED RATE COUNTS/MIN.
1	10-24-90	1015	1	1	0	20.00	+	11824			24.0			
2	↓	1046	↓	↓	↓	↓	+	11744			↓			
3		1218					+	11790						
4		1246					+	11596						
							+							
							+	Background $\sigma_{240} = \sqrt{240}/10 = 1.673$ c/m [Lab. data sheet for 10 min counts]						
							+							
							+	W-47-2:						
							+	N = 4						
							+	$\bar{x}$ = 11735.50						
							+	σ = 100.49769						
							+	95% cl at 4-1 = 3 $\hat{E}$ = 3.182 σ = 319.78						
							+							
							+	(11738.50 ± 319.78)/20.00 − (240 ± 1.673) = 558.92$_5$ ± 16.07$_6$ c/m						
							+	7-25-90 → 10-24-90 = 91 d = 0.24914974						
							+	(5038.$_{98}$ ± 164.$_{15}$ ^{90}Sr β/min)(2.0000 ^{90}Sr atoms/^{90}Sr β)(e$^{-(\ln 2 \times 0.24914974)/28.8 \text{ yr}}$) × 0.10005 ± 0.000177 atoms						
							+	(558.92$_5$ ± 16.07$_6$ c/m)						
							+	= 1.793$_{03}$ ± 0.078$_{01}$ β/c ^{90}Sr atoms/^{90}Y						
							+							
							+							
							+							
							+							
							+							
							+							
							+							

B02-004

BATTELLE-NORTHWEST
RICHLAND, WASHINGTON

ANALYTICAL LABORATORIES – BETA AND GAMMA COUNTER DATA SHEET

SAMPLE: Sr-Y-90 #W-74

SUBMITTED BY: MRW

COUNTED BY: MRW

REMARKS: two 249.72 λ aliquots plated on each of four replicate 1" ss disks

SAMPLE NUMBER	DATE 19__	TIME	INST. NO.	SHELF NO.	ABSBR. MG/CM²	INT. (MIN) T	RECORDER READING SCALE OF ___	TOTAL COUNTS N	RECORDED RATE R = N/T	COINC. CORR'N C	BGD B	NET RATE X=R−B+C	NORMALIZING RATE N.F.	NORMALIZED RATE COUNTS/MIN.
1	10-24-90	1312	1	1	0	20.00	+	6676			26.0			
2	↓	1340	↓	↓	↓	↓	+	6769			↓			
3		1406					+	6770						
4		1438					+	6763						
							+							
							+	Background $\sigma_{BGD} = \sqrt{260}$	10 = 1.673 c/m			[U, data derived from 12 min count]		
							+							
							+	W-74	7750	5/21	90			
							+	N = 4						
							+	$\bar{x}$ = 6744.50						
							+	σ = 45.771169						
							+	95% cl at 4-1 = 3 F = 3.152 σ = 145.64 c/m						
							+							
							+	(6744.50 ± 145.64)/20.00 − (26.0 ± 1.673) = 309.22 ± 7.47 c/m						
							+							
							+	(309.22 ± 7.47 cl−)(1793 ± 0.078 β/c $^{90}Sr+^{90}Y$)/(0.24972 ± 0.000170 μ)(2)						
							+	= 1.110 × 10³ ± 55. β/m/μ $^{90}Sr+^{90}Y$ 10-24-90 [95% cl]						
							+							
							+							
							+							
							+							
							+							
							+							
							+							
							+							

B02-005

Internal use
3H (residual)
W-73
(continued)
10-24-90 [illegible]

Count Data Summary:

[illegible]	N=3	$\bar{x}$ = 25.740 cpm	σ = 1.326604
2-5 after W-73-1 and -2	N=12	$\bar{x}$ = 2170.59	σ = 16.600893
0-7 3H reference	N=12	$\bar{x}$ = 2222.64	σ = 15.450743

subtract W-73-1 and -2:

net count = 2170.59 − 25.74 = 2145.10 cpm 95% cl at 4-1 = 3.82 σ = 3.182 σ = 53.46

3H reference: nominal activity $1.05_{44} \times 10^{4} \pm 0.7$ β/ml/ml 10-4-90 [refer to page 166].

net count = 2222.64 − 25.74 = 2196.95 cpm 95% cl at 4-1 = 3.82 σ = 3.182 σ = 49.16

10-4-90 → 10-23-90 = 19 d = 0.052020 y

$$\frac{(1.05_{44} \times 10^{4} \pm 0.7\ \beta/ml/ml)\left(e^{\frac{-(0.693)(0.052020)}{12.3226}}\right)(0.4977 \pm 0.000237\ ml\ W\text{-}05)\left(\frac{2145.10 \pm 53.46\ cpm\ W\text{-}73\ data}{2196.95 \pm 49.16\ cpm\ W\text{-}05}\right)}{(0.4977 \pm 0.000237\ ml\ W\text{-}73\ aliquot)}\left[\frac{10.0000 \pm 0.0221\ ml}{0.10012 \pm 0.000137\ ml}\right]$$

$$= \underline{1.02_{59} \times 10^{4} \pm 3.4_{73} \times 10^{2}\ \beta/ml/ml \quad 10\text{-}23\text{-}90 \quad [95\%\ cl]}$$

Original calibration and decay: 3-13-90 → 10-23-90 = 3977 d = 10.61467 y

$$(1.39_{44} \times 10^{4}\ \beta/ml/ml)\,e^{\frac{-(0.693)(10.61467)}{12.32}} = 1.04_{27} \times 10^{4}\ \beta/ml/ml \quad 10\text{-}23\text{-}90$$

recalibration / original calib = 0.7496

Internal use
^{90}Sr (residual)
W-74
10-24-90 [illegible]

Recalibration of N. Wyckoff ^{90}Sr-Y Solution: nominal 1.47×10^{4} β/ml/ml 3-14-90

Prepare four replicate counts of ^{90}Sr-Y solution #W-74 on 1" stainless steel disks: two aliquots of 249.72 [calibrated flow micropipette] each count. Plate on separate aliquots, drying the first before plating the second, so as to confine the entire deposit to ½" diameter area of the plate flow. Activity must not contact the disk walls.

Prepare four replicate counts of ^{90}Sr-Y Reference Solution #W-47-2 on 1" stainless steel disks: 100.05 [calibrated flow micropipette] each count. Plate so as to confine the entire deposit to ~½" diameter area of the plate flow. Activity must not contact the disk walls.

BNW
#52815

Calibration: Count the sets relative to each other on a gas-flow proportional beta counter, shelf 1 [highest efficiency position], 20 minutes each count.

Project No. _____ Date of Work _____
Entered By [illegible] Date 10-25-90
Disclosed To and Understood By
Signed 1. [illegible] Date 10-25-90
2. _____ Date _____

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Internal Use
^{90}Sr-Y (continued)
W-74
(continued)
10-26-90 KCW

Counting Data Summary:

BATTELLE-NORTHWEST ANALYTICAL LABORATORIES - BETA AND GAMMA COUNTER DATA SHEET

BNW 52515
page 113

W-47-2: [refer to page 41]: 5038.$_{30}$ ± 164.$_{84}$ ^{90}Sr β/min/mL 7-26-90 [556 mL]

7-26-90 → 10-26-90 = 91 d = 0.2491497 y

$$\frac{(5038._{30} \pm 164._{84}\ ^{90}\text{Sr-Y}\ \beta/\text{min/mL})(1.0000\ ^{90}\text{Sr+}^{90}\text{Y}/^{90}\text{Sr})(e^{-\frac{(\ln 2)(0.249114)}{28.6 \pm 0.4}})(0.10005 \pm 0.000177\ \text{mL})}{(556.42_{5} \pm 16.07_{6}\ \text{mL})}$$

$= 1.793_{03} \pm 0.074_{01}$ β/c ^{90}Sr+^{90}Y

BATTELLE-NORTHWEST ANALYTICAL LABORATORIES - BETA AND GAMMA COUNTER DATA SHEET

BNW 52515
page 113

BNW
#52815

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11-1

Internal Use
^{90}Sr (mixed)
W-74
(continued)
10-24-90 MB

W-74:

$(304.23_{0} \pm 7.47_{0}\ c/m)(1.773_{03} \pm 0.078_{01}\ \beta/c\ ^{90}Sr+^{90}Y)/(0.24972 \pm 0.000170\ ml/mg)(2\ mg)$
$= \underline{1.110_{18} \times 10^{3} \pm 55_{26}\ \beta/m\ ml\ ^{90}Sr+^{90}Y\ \ 10-24-90\ \ [95\%\ cl]}$

Original calibration and decay:

$3-14-90 \rightarrow 10-24-90\ 4.3876\ d = 10.6121\ 86\ y$
$(1.47 \times 10^{3}\ \beta/m\ ml) \times e^{-(\ln 2)(10.6121\ 86)/28.6} = 1.13_{6} \times 10^{3}\ \beta/m\ ml\ ^{90}Sr+^{90}Y\ \ 10-24-90$
calibration / original calib. $= 1.110 \times 10^{3} / 1.13_{6} \times 10^{3} = 0.9771$

Internal Use
^{239}Pu Standard
W-75
10-25-90 MB

^{239}Pu Standard for liquids use as an internal standard: nominal 500 dpm/ml : for Tapan Maiti

40.30 g [calibrated glass micropipette] ^{239}Pu Reference Standard #T-1350-15 diluted to 10.00 ml [Class A volumetric flask] with ~N HNO_3.

$(1.97_{6} \times 10^{3} \pm 10.2\ dpm/g)(40 \pm 0\ g/m)(1.1261_{6} \pm 0.0008_{4}\ g/ml)(0.04030 \pm 0.000040\ ml)/(10.0000 \pm 0.0221\ ml)$
$= \underline{533_{1} \pm 5_{12}\ dpm/ml\ ^{239}Pu\ \ 10/90\ \ [95\%\ cl]}$

Internal Use
U [natural] Standard
W-76
10-25-90 MB

U [natural] Standard : nominal 10 µg U/ml : T. Maiti

99.90 g [calibrated glass micropipette] U [natural] Standard # W-36 diluted to 10.00 ml [Class A volumetric flask] with 2N HNO_3.

$(100\ g_{00} \pm 2.99\ \mu g\ U/ml)(0.09990 \pm 0.000177\ ml)/(10.0000 \pm 0.0221\ ml)$
$= \underline{10.02_{17} \pm 0.03_{17}\ \mu g\ U[natural]/ml\ \ [95\%\ cl]}$

Dusting
$^{90}Sr + ^{137}Cs$ Mixed Sources
10-11-90 MB

$^{90}Sr + ^{137}Cs$ Mixed Sources: 12 sources, 1" diameter cotton swabs on 47 mm diameter filter paper stock provided by customer. These sources are to simulate sources taken in the field; wet the filter paper which is used to keep the swabs on the surface.

Apply at least four coats of acrylic clear acrylic spray to each face of the filter, drying completely between applications. Spray the two faces alternately to minimize curling.

BNW
#52815

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^{99}Tc Standard #54124-64-0 and #54124-64-17

Battelle
Pacific Northwest Laboratories

Project Number 19432

Internal Distribution

File/LB

Date March 4, 1992

To Standards File

From Sandy Fadeff

Subject Tc-99 Standard Preparation for 1100EM1

A ^{99}Tc standard was obtained by Eric Wyse from NIST. This standard was originally prepared by NBS and is labelled 4288-77 and contains 3.759×10^4 Bq/g. This standard information was entered into LRB #54526 pg 5 - 7. Dilution of the standard was made and entered into LRB #53960 pg 28. A copy of this dilution information was entered into LRB # 54526 pg 10. A sample of this dilution was provided to the radioanalytical chemistry group and was called 53960-28.

A copy of the standard certificatte and dilution information was entered in the radiochemistry standards noteboook LRB #53293 pg 32 as well as into the 329 building radiochemistry standards notebook LRB #54124 pg 64. In keeping with the usual numbering system of the radionuclide standards for the 329 builidng, the standard, originally given us by Eric Wyse, was given a new identification: 54124-64-0. This standard was diluted again (1.4553 ml to 25 ml, a 1:17 dilution) and the diluted standard is called 54124-64-17.

tc99.std

E54-1900-001 (10/89)

B02-010

Department of Commerce
Malcolm Baldrige
Secretary
National Bureau of Standards
Ernest Ambler, Director

Received 12/31/91
1/16/92

THIS IS A PHOTOCOPY OF THE CERTIFICATE WHICH IS BEING MAILED TO YOU UNDER SEPARATE COVER.

54124-640

National Bureau of Standards

BNW LRB #54526 pg 5
Ref 53293-32

Certificate

Standard Reference Material 4288

Radioactivity Standard

Radionuclide	Technetium-99
Source identification	4288-77
Source description	Liquid in NBS borosilicate-glass ampoule
Solution composition	59.31 μg of Tc(VII) as potassium pertechnetate per gram of approximately 0.001 molar KOH (1)*
Mass	4.910 grams
Radioactivity concentration	3.759×10^4 Bq g^{-1}
Reference time	November, 1982
Measuring instrument	Liquid-scintillation counter (2)
Random uncertainty	0.27 percent (3)
Systematic uncertainty	1.35 percent (4)
Total uncertainty (Random plus systematic)	1.62 percent
Photon-emitting impurities	None observed (5)
Half life	$(2.111 \pm 0.036) \times 10^5$ years (6)

This Standard Reference Material was prepared in the Center for Radiation Research, Nuclear Radiation Division, Radioactivity Group, Dale D. Hoppes, Group Leader.

Washington, D.C. 20234
November, 1982

George A. Uriano, Chief
Office of Standard Reference Materials

*Notes on back

B02-011

BNW LRB # 54526 pg 6

54526 pg 6

see 53293-32

FOOTNOTES

(1) The $KTcO_4$ was prepared by M.W. Heitzmann of the U.S. Food and Drug Administration from NH_4TcO_4 obtained from Oak Ridge National Laboratory. The solution density is 0.998 g cm^{-3} at 21.8°C, and the $KTcO_4$ concentration is 0.00060 molar. The UV spectrum of this material exhibited only the characteristic doublets at 243 and 287 nm [A].*

(2) Two liquid-scintillation counters were calibrated using the method of J.A.B. Gibson [B,C,D]. Three different radionuclides were used as the standard: ^3H, ^{14}C, and ^{60}Co. The results obtained using the three radionuclides agreed to within 0.32 percent. The ^{14}C result was used for confirmation only. The value given here is the unweighted mean of the ^3H and ^{60}Co results.

(3) Half the 99-percent confidence interval for the average of the ^3H result and the ^{60}Co result. The standard deviation of the mean of the ^3H result is 0.15 percent based on 6 degrees of freedom, and the standard deviation of the mean of the ^{60}Co result is 0.09 percent based on 9 degrees of freedom.

(4) The systematic uncertainty is the average of that for the ^3H result, 1.20 percent, and that for the ^{60}Co result, 1.49 percent. These values are linear sums of estimated upper limits of uncertainties due to the following:

	^3H	^{60}Co
a) reference material for standard radionuclide	0.63	0.68
b) source preparation	0.07	0.17
c) theoretical model	0.30	0.20
d) gamma-ray contribution to beta-particle detector		0.24
e) quenching	0.10	0.10
f) interpolation from calibration curve	0.10	0.10
	1.20	1.49

(5) The master solution from which these standards were prepared was examined with germanium gamma-ray spectrometers and no impurity was found. Limits of detection as a ratio of gamma-ray-emission rate to technetium-99 activity are

1×10^{-6} between 90 and 300 keV
1×10^{-7} between 300 and 1900 keV.

(6) NBS-measured half life based on the formula $T_{\frac{1}{2}} = N \ln(2)/A$, where N is the number of atoms, computed using an atomic mass for technetium-99 of 98.906254 ± 0.000002 grams and the gravimetrically determined mass of technetium-99, and A is the activity determined by liquid-scintillation counting. The value recommended by the Oak Ridge Nuclear Data Project is $(2.13 \pm 0.05) \times 10^5$ years. [E]

* References on last page

4288

see 53293-32

The following individuals and organizations contributed to the characterization of this Standard Reference Material.

J.A.B. Gibson
Atomic Energy Research Establishment
Environmental and Medical Sciences Division
Harwell
United Kingdom

M.W. Heitzmann
U.S. Food and Drug Administration
Division of Drug Chemistry
Washington, D.C.

J.C. Leak
U.S. Food and Drug Administration
Division of Oncology and
Radiopharmaceutical Drug Products
Rockville, MD

For further information please contact Dr. Bert M. Coursey at (301) 921-2383.

REFERENCES

A. Boyd, G.E., J. Chem. Ed., 36, 3 (1959).

B. Gale, H.J. and Gibson, J.A.B., Atomic Energy Research Establishment Report AERE-R5067 (1965), Harwell, United Kingdom.

C. Gibson, J.A.B. and Marshall, M., Int. J. Appl. Radiat. Isotopes, 23, 321 (1972).

D. Gibson, J.A.B., Computed counting efficiencies as a function of merit figure for 14 beta-particle-emitting radionuclides (July, 1980). Unpublished data.

E. Kocher, D.C., Radioactive Decay Data Tables DOC/TIC-11026, p. 108 (1981). Available from NTIS, Springfield, VA.

BNW LRB # 54526 Pg 7

JIB 1/15/92 AS 100 BALANCE (512-06-01-014) PERFORMANCE CHECK
CAL. EXP. 1/16/92

53223.32

WEIGHT	BALANCE READING
10 mg	0.0100 g
200 mg	0.1998 g
1 g	1.0000 g

PERFORMANCE OK JIB 1/15/92

PIPET	VOLUME	TRIAL 1	2	3	4	5	$\bar{x} \pm \sigma$
EDP-2	210 µl	.2071	.2068	.2075	.2062	.2072	.2070
A022998	250 µl	.2464	.2464	.2490	.2471	.2461	.2470
	1 ml	.9873	.9957	.9929	.9928	.9912	.9920

PREPARATION OF (SPIKE) SOLUTION STANDARD 53960-28: Tc-99

USING ABOVE CALIBRATED PIPET, PIPETTED 210 µl (.2070 ml) INTO A 250 ml VOL. FLASK HALF FILLED WITH DI H_2O AND 84.7 mg KOH. DILUTED TO VOLUME WITH DI H_2O.

FINAL CONCENTRATION: $\frac{(.2070\ ml)(59.191\ ng/ml)}{250\ ml}$

= 49.01 ng/ml Tc-99 (0.8309 nCi/ml)

= 49.01 ppb in 0.006 M KOH

BNW LRB # 54526 pg 10

(from BNW LRB # 53960 pg 28)

54124.00

Project No. _____ Date of Work _____
Entered By _____ Date _____
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1-17-92

A dilution was made of ^{99}Tc standard 53960-28. 1455.3 ± 3.4λ was diluted to 25ml in a volumetric flask with ~.006 M KOH

107.4 dpm/ml

Pipet 10 A-27

Vancys 53293-32 G Brodaczynski 1-17-92

Has been entered in DREs log book as

54124-64-0 _ dilution received from Eric Wyse.

54124-64-17 second dil. 1455.3 ± 3.4λ → 25ml.

G Brodaczynski, 2-11-92

~~yield is~~

Dpm/ml of 54124-64-17 is 107.4 using Eric Wyse's Calc. - When calculating directly from Certificate dpm ref 108.5 dpm/ml

Dpm of 54124-64-0 is 1864 dpm/ml

Gwen G Brodaczynski
2-14-92

Battelle
Pacific Northwest Laboratories

Page ____ of ____

ENGINEERING WORKSHEET

Prepared By:	Date:	Project:

Title/Subject: ^{99}Tc spike activity calculation of # 54124-64-0

NIST value: 3.759×10^9 +/- 609 Bq/g

Eric Wyse dilution

$$(3.759 \times 10^9 \pm 609\ Bq/g)\left(\frac{0.998\ g}{ml}\right)\left(\frac{60\ sec}{min}\right)\left(\frac{d/sec}{Bq}\right)\left(\frac{0.207\ ml}{250\ ml}\right) = 1{,}864 \pm 30\ dpm/ml$$

54124-64-0 = 1,864 +/- 30 dpm/ml

54124-64-17 :

$$(1{,}864 \pm 30\ dpm/ml)\left(\frac{1.4553 \pm 0.0034\ ml}{25\ ml}\right) = 108.5\ dpm/ml$$

S. K. Fadeff 3/18/92

copied from 1100 EM1 Beta analysis batch 1

N S Wyse 3-18-92

B02-016

^{99}Tc Standard #52733-80-RS-4 (for LSC data)

10

Entered 3/5/88 by R. C. Leaf

Tc-99 Stnd See page 8 and 9
Amersham 80 9412 TC 64
12.54 micro Curie per gram of solution
±0.4% ±0.4%
12.54 μCi/g x 2.22 x10^6 dpm/μCi = 2.784 x10^7 dpm/g ± 1.11 x10^5 dpm/g
Balance 360-04-03-003 Expires 3-26-88
Tc99 Stnd + Tare : 72.3765
100ml vol flask Tare : 67.4143
4.9622 g ±.0005 ±.010%

99Tc PRIMARY
1.381x10^8 ±5.66x10^3 d/m/ml
1.386x10^8 ±5.55x10^4 d/m/g.
BNW 52626 Page 8-10
3/10/88 RS-3

TOTAL dilution wt: 167.0110
Tare : 67.4143
99.5967 g

±0.4% ±0.010% ±0.4% ±5.52x10^4
2.784 x10^7 dpm/g x 4.9622 g = 1.38 x10^8 dpm 99Tc ±~~1.10x10^4~~ dpm

BNW 52626

±0.4% ±.5% ±.4% ±5.66x10^3
1.381 x10^8 dpm 99Tc ÷ 100 ±.08 ml = 1.381 x10^6 ± ~~1.10x10^4~~ 5.66x10^3 dpm/ml

±0.4% ±0.4%
1.381 x10^8 dpm 99Tc ÷ 99.5967 g = 1.386 x10^6 ± 5.55x10^4 dpm/g

Second dilution:
10ml Dilution 1 - above tare : 80.5960
100ml vol flask tare: 70.4880 g
10.1080

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Total dilution Wt: 170.1240
Tare 70.4880
99.6360 g

6-30-88
53133 ~~50097~~ 80 - RS-4

±0.4% ±0.4%
10.1080 g x 1.386 x10^6 dpm/g = 1.4013 x10^7 dpm 99Tc ± 5.60x10^4

99Tc SECONDARY
1.4013x10^7 ±5.74x10^2 d/m/ml
1.4064x10^7 ±5.62x10^2 d/m/g
BNW 52626 Page 8-10
3/10/88 RS-4

±0.4% ±.4% ±5.74x10^2 dpm/ml
1.4013 x10^7 dpm ÷ 100 ±.08 ml = 1.4013 x10^5 ± ~~1.12x10^4~~ dpm/ml
1.4013 x10^7 dpm ÷ 99.6360 g = 1.4064 x10^5 ±.4% dpm/g ± 5.62x10^2

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Entered By _____ Date _____
Disclosed To and Understood By _____
Signed _____ Date _____

Amersham MARKETING COMMUNICATIONS

TRACEABILITY TO NBS

The radiation measurement value reported for this product is the result of measurement procedures which are considered to be "NBS traceable" and which satisfy requirements outlined in Regulatory Guide 4.15, Revision 1, February 1979. These claims are supported by the following considerations:

1) Many direct activity measurement intercomparisons have been made between Amersham and NBS over a period of many years. Some specific examples that illustrate the magnitude of the work which has occurred are listed below:

   a) Randomly selected samples of each production batch of the QCY.44, QCY.46, and QCD.1 mixed radionuclide products are measured by NBS and a Report of Traceability issued to Amersham. During the period 1978 through 1984, 65 separate solution standards and point sources have been intercompared in this manner.

   b) Amersham participates in intercomparison exercises with NBS which involve single nuclides in standardized solution form. During the period 1983 through 1984, nuclides which were intercompared in this manner included Cs-137/Ba-137m, Sr-89 and Ba-133. In addition, 17 separate nuclides have been intercompared during the period 1971 through 1982, and repeat intercomparisons of some of these nuclides at different times bring the total to 24.

   c) To further strengthen Amersham's direct links to NBS, it is planned, for the period 1985 through 1987, to carry out intercomparison exercises between NBS and Amersham which will include the following radionuclides:

i)	Am-241	alpha	reference source
ii)	Ni-63	beta	solution
iii)	C-14	beta	solution
iv)	Cl-36	beta	solution
v)	Sr-90	beta	solution
vi)	Pm-147	beta	solution
vii)	Tl-204	beta	solution
viii)	Ba-133	gamma	point source
ix)	Am-241	gamma	point source
x)	I-129	beta	solution

   These comparisons will be in addition to the mixed nuclide standard intercomparisons.

BNW 52626 P9

BNW LABORATORY NOTEBOOK NO. 52626

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Amersham International plc
Amersham UK

RS-1

[redacted]

Approval No. 0146

52733-80-0

Description Principal radionuclide: Technetium-99 Product code: TCZ.64

Solution number: 56/60/12

Measurement

Reference time:	1200 GMT on 1 January 1987	
Radioactive concentration of technetium-99:	12.54	microcuries per gram of solution
which is equivalent to:	464	kilobecquerels per gram of solution
Mass of solution:	5.0299	grams
Total activity of technetium-99:	63.1	microcuries
which is equivalent to:	2.33	megabecquerels

Method of measurement used (see reverse of the certificate): K

Accuracy Overall uncertainty in the radioactive concentration quoted above: ± 1.20 % ÷ 3 = ± 0.4% 99.7CL 67%CL

Random uncertainty: ± 0.43 % Systematic uncertainty: ± 0.77 %

Overall uncertainty is defined on the reverse of the certificate.

Radionuclidic Purity The estimated activities of any radioactive impurities are listed below expressed as percentages of the activity of the principal radionuclide at the reference time.

Other radionuclides less than 0.01 %

Chemical Composition 0.01M NH_4OH containing 740 micrograms of technetium per ml as ammonium pertechnetate

Physical Data Recommended half life: $(2.13 \pm 0.05) \times 10^5$ years

100% beta particle emission.

BNW
52626 i
p 8

Remarks This product meets the quality assurance requirements of NRC Regulatory Guide 4.15 for achieving implicit NBS traceability as defined in NCRP 58 (1985).

BNW LABORATORY NOTEBOOK NO. 52626 i

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Approved Signatory

Amersham

B02-020

99
TC 52733-80-0 note, this STD WAS received from C. LEAF by NANCY Wynhoff
→ SEE NOTE BELOW

Amersham International plc
Amersham UK

52733-80-0 RS-1

[redacted]

BRITISH CALIBRATION SERVICE

Description: Principal radionuclide: Technetium-99 — Product code: TC.64 — Solution number: 56/60/12

Measurement

Reference time:	1200 GMT on 1 January 1987	
Radioactive concentration of technetium-99:	12.54	microcuries per gram of solution
which is equivalent to:	464	kilobecquerels per gram of solution
Mass of solution:	5.0299	grams
Total activity of technetium-99:	63.1	microcuries
which is equivalent to:	2.33	megabecquerels

Method of measurement used (see reverse of the certificate): K

Accuracy

Overall uncertainty in the radioactive concentration quoted above: ± 1.20 % (±3 s) ±0.4%

Random uncertainty: ± 0.43 % Systematic uncertainty: ± 0.77 %

Overall uncertainty is defined on the reverse of the certificate.

Radionuclidic Purity

The estimated activities of any radioactive impurities are listed below expressed as percentages of the activity of the principal radionuclide at the reference time.

Other radionuclides less than 0.01 %

Chemical Composition

0.01M NH_4OH containing 240 micrograms of technetium per ml as ammonium pertechnetate

Physical Data

Recommended half life: (2.13 ± 0.05) × 10^5 years

100% beta particle emission.

BNW 52626 i pg

NOTE: Clyde LEAF made A primary + secondary dilution of this STD - SEE file

Remarks

This product meets the quality assurance requirements of NRC Regulatory Guide 4.15 for achieving implicit NBS traceability as defined in NCSLP 56 (1985).

We took the 99TC SECONDARY Labeled RS-4 and poured it into a 20 ml vial - I ~~52626~~ NOV 11 '88 Labeled it 52733-80-RS-4

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Approved Signatory

NO DILUTION WAS made

Amersham

Project No.
Entered By Donald R. Edwards — Date of Work
Date 12-18-89
Disclosed To and Understood By
Signed 1. — Date
2. — Date

B02-021

Strontium (stable) Carrier Solution

BNW - 523/144

28 C3-96

N. Upchoff

Sr standard

11-1-90 MRW

Strontium Standard Solution: 20 mg/ml Sr as $Sr(NO_3)_2$ in H_2O : 2 liters

Preparation:

1. Accurately weigh 96.630 grams anhydrous $Sr(NO_3)_2$ into a 100 ml beaker

material: $Sr(NO_3)_2$ anhydrous, Baker Mallinckrodt #6256 lot #KHDV

balance: Mettler semimicro #461999

beaker:	65.6404	65.6409	65.6407	65.6409	162.2701 ± 0.0001
+ $Sr(NO_3)_2$	162.2701	162.2701			− 65.6409 ± 0.0001
					96.6292 ± 0.00014 grams

2. Transfer to a 2 liter type A volumetric flask. Dissolve in distilled H_2O rinsings of the weighing beaker. Dilute to volume with distilled H_2O. Stir

3. The solution was slightly turbid with a few undissolved particles. Acidified slightly with three drops conc. reagent HNO_3 and filtered through Whatman no 1 filter paper into two 32 oz glass screw-cap bottles. Label #C-96-1 and #C-96-2

calculated concentration:

$(96.6292\ g\ Sr(NO_3)_2)\left(\frac{87.62\ Sr}{211.65\ Sr(NO_3)_2}\right) / 2.0000\ L = 20.00_{3r}$ mg Sr/ml (g Sr/L)

Standardization:

1. Prepare three replicate 5 ml aliquots in 100 ml beakers from #C-96-1 labeled 96-1-1, 96-1-2, and 96-1-3 and three replicate 5 ml aliquots in 100 ml beakers from #C-96-2 labeled 96-2-1, 96-2-2, and 96-2-3 using the 5002.01 λ calibrated glass micropipette. After each pipetting rinse the pipette three times with 5 ml aliquots of distilled water, adding the rinses to the respective beakers. Dry the pipette with alcohol and vacuum between sample pipettings.
2. Add glass covered stir bars to each beaker, then with gentle stirring add 1000 λ [automatic pipettor] conc. reagent NH_4OH.
3. Heat on a hot plate to near-boiling, occasionally stirring. With stirring, slowly add 10 ml [graduated cylinder] 14 mg $(NH_4)_2CO_3 \cdot H_2O$/ml solution. Return to hot plate and digest 5 minutes at near boiling with frequent stirring
4. Add 2 ml 14 mg $(NH_4)_2CO_3 \cdot H_2O$/ml solution while stirring. Digest 5 minutes at near boiling with frequent stirring. Cool to room temperature.
5. Filter through tared sintered glass crucible, completing the precipitate transfer with at least four 3 ml H_2O rinses of the beaker. Wash the filtered precipitate by running four 3 ml portions of water through the crucible; rinsing the precipitate with 3 ml absolute ethanol and suction dry.

Project No. _____ Date of Work _____

Entered By _____ Date _____

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Signed _____

-96
. Uyeloff
- Standard
continued)
-1-90 HBW

6. Dry the crucibles 30 minutes at 110°C in an oven. Cool 30 minutes in a desiccator.
7. Weigh, Mettler semimicro balance #451.9991

filter crucible #1: sample C-96-1-1

tare: 22.2957 22.2957 — 22.4661 ± 0.0001 − 22.2957 ± 0.0001

sample: 22.4460 22.4661 — 0.1704 g ± 0.00014

filter crucible #2: sample C-96-1-2

tare: 22.5059 22.5059 — 22.6755 ± 0.0001 − 22.5059 ± 0.0001

sample: 22.6755 22.6756 — 0.1697 g ± 0.00014

filter crucible #3: sample C-96-1-3

tare: 27.3461 27.3460 27.3460 — 27.5170 ± 0.0001 − 27.3460 ± 0.0001

sample: 27.5166 27.5167 27.5170 27.5170 — 0.1690 g ± 0.00014

filter crucible #4: sample C-96-2-1

tare: 25.2247 25.2247 — 25.3946 ± 0.0001 − 25.2247 ± 0.0001

sample: 25.3946 25.3946 — 0.1699 g ± 0.00014

filter crucible #5: sample C-96-2-2

tare: 19.9905 19.9903 19.9903 — 20.1601 ± 0.0001 − 19.9903 ± 0.0001

sample: 20.1602 20.1601 20.1601 — 0.1698 g ± 0.00014

filter crucible #6: sample C-96-2-3

tare: 23.5962 23.5960 23.5960 — 23.7664 ± 0.0001 − 23.5960 ± 0.0001

sample: 23.7664 23.7664 — 0.1704 g ± 0.00014

Average of crucibles 1, 2, 4, 5, and 6: 0.1700_4 gram $\sigma = 0.000336$

$$\frac{(0.1700_4 \text{ g } SrCO_3)(1000 \text{ mg/g})}{(5.00261 \text{ ml})}\left(\frac{87.63 \text{ Sr}}{147.64 \text{ } SrCO_3}\right) = \underline{20.17_{46} \text{ mg Sr/ml}}$$

$$\frac{(0.1700_4 \pm 0.000336)(1000)\left(\frac{87.63}{147.64}\right)}{(5.00261 \pm 0.00237 \text{ ml})} = 20.17_{46} \pm 0.04_{09} \text{ mg Sr/ml} \quad (1\sigma)$$

Project No. _____ Date of Work _____

Entered By _____ Date _____

Disclosed To and Understood By

Signed 1 _____ Date

^{3}H Standard #52733-109-1

LAB 52733

Tritium Std for Lots Abbey in 2 bottles

100

52733-109-1 Open bottle
52733-109-2 Unopened bottle

This std was prepared by Malia Weiler for Ric Kirby in March 1980 and calibrated against NBS Std ^3H solutions. 2 liters in 2 [illegible] 3-21-80 was prepared, calibrated and then stored in 2 separate bottles.

Calibrated activity is $1.89_{84} \times 10^6 \pm 1.54_{42} \times 10^4$ dpm/ml on 3-12-80

M Weiler 9-21-90

52733-109-1 was RECALIBRATED by Malia Weiler. His i.d. no. was W-73 (in LAB # 52815).

New value: $1.02_{15} \times 10^6$ dpm/ml on 10-23-90
$\pm 1.74_{8} \times 10^4$ dpm/ml [1σ]

This is 2.04% different from original calibration.
52733-109-100 was prepared on 12-6-90. This is a 1:100 dilu of 52733-109-1. Activity is:

$1.02_{40} \times 10^4$ dpm/ml on 10-23-90
$\pm 1.76_{0} \times 10^2$ dpm/ml [1σ]

SEE FILE

M Weiler 12-19-90
[illegible] 2-5-92

Project No.
Entered By
Disclosed To and Understood By
Signed 1.
2.

Date of Work
Date
Date
Date

Re calibration of

\# 52733-109-1

Malin's # W-73 is 329 Bldg std no. #52733-109-1

New activity is $1.02_{15} \times 10^6$ dpm/ml on 10-23-90
$\pm 1.7_{48} \times 10^4$ [1σ]

This is 2.04% different from original calibration.

12-19-90

B02-027

Initial the 3H (month) W-73 10-24-90 MW

Establishing of Kirby 3H Standard Solution: assumed $1.89_{W} \times 10^{6}$ pCi/ml 3-12-90

Prepare duplicate dilution of W-73:

100.1 g [calibrated glass micropipette] 3H std @ W-73 diluted to 10.00 ml [Class A volumetric flask] with distilled H_2O [system @ WA-57249, 10-2-90, 15.0 MΩ-cm]. Label the dilution W-73-1 and dilution W-73-2.

Prepare samples for liquid scintillation counting as follows:

1. Blank: one vial only, 5.0 g distilled H_2O [as above] + 15.0 ml [graduate cylinder] Packard Ready Gel scintillation cocktail.

2,3 Sample W-73 dilution W-73-1: duplicate vials 499.7 g [calibrated glass micropipette] W-73-1 + 15.0 ml [graduate cylinder] Packard Ready Gel scintillation cocktail.

4,5 Sample W-73 dilution W-73-2: duplicate vials 499.7 g [calibrated glass micropipette] W-73-2 + 15.0 ml [graduate cylinder] Packard Ready Gel scintillation cocktail.

6,7,8,9 3H Reference: four replicate vials 499.7 g [calibrated glass micropipette] 3H standard @ W-65 [gravimetric dilution of NBS 3H SRM 4926-C] + 15.0 ml [graduate cylinder] Packard Ready Gel scintillation cocktail.

Count on Packard Model 4430 liquid scintillation counter @ WA-53507: 30 minute counting time and region A: lower level = 0 upper level = 19

region B: lower level = 2 upper level = 19

region C: lower level = 19 upper level = 2000

Count three cycles of all nine vials, inserting vials in sample position corresponding to sample #.

```
PROGRAM #-    14                                          24/10/90   02:37
PROGRAM #=    14                                          23/10/90   20:25
PROGRAM #=    14                                          23/10/90   14:13
REGION A:    LL-UL=    0-  19  LCR=    0  BKG=    .00  % 2 SIGMA=    .0
REGION B:    LL-UL=    2-  19  LCR=    0  BKG=    .00  % 2 SIGMA=    .0
REGION C:    LL-UL=   19-2000  LCR=    0  BKG=    .00  % 2 SIGMA=    .0
TIME=  30.00   K= 1.000 QIP=SIS
```

P#	S#	TIME	CPMA/K	%DEV	CPMB/K	%DEV	CPMC/K	%DEV	SIE	SIS	FLAGS	MIN
14	1	30.00	26.37	7.11	21.83	7.81	36.33	6.06	.000	22.643		30
14	2	30.00	2157.23	.79	1633.00	.90	38.10	5.92	.000	13.868		61
14	3	30.00	2166.10	.78	1639.53	.90	38.93	5.85	.000	13.898		92
14	4	30.00	2129.50	.79	1618.63	.91	38.87	5.86	.000	13.900		123
14	5	30.00	2162.47	.79	1645.97	.90	39.03	5.84	.000	13.950		154
14	6	30.00	2208.53	.78	1685.03	.89	41.07	5.70	.000	13.981		184
14	7	30.00	2214.30	.78	1673.23	.89	38.80	5.86	.000	13.885		215
14	8	30.00	2233.83	.77	1686.20	.89	39.70	5.80	.000	13.8[illegible]		246
14	9	30.00	2197.77	.78	1664.33	.90	38.30	5.90	.000	1[illegible].711		[illegible]

WA-53515 page 111

Disclosed To and Understood By

Signed 1. L. R. Greenwood Date 10-25-90

2. Date

Indicated use
3H (tritiated)
W-73
(continued)
10-24-90

Count Data Summary:

position 1: Blank — N = 3, $\bar{x}$ = 25.798 cpm, σ = 1.326608

2-5 Aliquots W-73-1 and -2 — N = 12, $\bar{x}$ = 2170.57, σ = 14.600693

6-9 3H Reference — N = 12, $\bar{x}$ = 3222.64, σ = 15.4592745

Aliquots W-73-1 and -2:

net count = 2170.57 − 25.79 = 2144.78 cpm 95% cl of 4-1 = 3.82 = 3.162 σ = 53.46

3H reference: nominal activity: $1.05_{44} \times 10^{6}$ 3H/g/hr 10-4-90, [refer to page 106].

net count = 3222.64 − 25.79 = 3196.85 cpm 95% cl of 4-1 = 3.82 = 3.162 σ = 49.6

10-4-90 → 10-23-90 = 19 d = 0.052054 y

LRB
5.2.815

$$\frac{(1.05_{44}\times10^{6}\ 3H/g/hr)\left(e^{-\frac{(\ln 2)(0.052054\ y)}{12.26\ (0.05)}}\right)(0.4977 \pm 0.000317\ mL\ W\text{-}65)\left(\frac{2144.78 \pm 53.46\ cpm\ W\text{-}73\ aliq}{3196.85 \pm 49.6\ cpm\ W\text{-}65}\right)\left[\frac{10.0000 \pm 0.0021\ mL}{0.1000 \pm 0.000317\ mL}\right]}{(0.4977 \pm 0.000317\ mL\ W\text{-}73\ aliq)}$$

$$= \underline{1.02_{19}\times10^{6} \pm 3.4_{93}\times10^{4}\ 3H/g/hr\ \ 10\text{-}23\text{-}90\ \ [95\%\ cl]}$$

Required calibration and decay: 3-12-90 → 10-23-90 = 3677 d = 10.06467 y

$$(1.17_{94}\times10^{6}\ 3H/g/hr)\,e^{-\frac{(\ln 2)(10.06467)}{12.26}} = 1.04_{33}\times10^{6}\ 3H/g/hr\ \ 10\text{-}23\text{-}90$$

recalibration / original calib = 0.8796

Indicated use
^{90}Sr (tritiated)
W-74
10-24-90

Recalibration of H. Wyckoff ^{90}Sr-Y Solution: nominal 1.47×10^{6} 3H/g/hr 3-14-90

Prepare four replicate counters of ^{90}Sr-Y solution #W-74 on 1" stainless steel disks: two aliquots of 249.72 g [calibrated flow micropipette] each count. Place on separate aliquots, drying the first before placing the second, or on to confine the entire deposit to ½" diameter area of the plate flow. Activity count not contact the disk walls.

Prepare four replicate counters of ^{90}Sr-Y Reference Solution #W-47-2 on 1" stainless steel disks: 100.05 g [calibrated flow micropipette] each count. Place on or to confine the entire deposit to ½" diameter area of the plate flow, activity count not contact the disk walls.

Calibration: Count the entire solution to each other on a gas-flow proportional beta counter, shelf 1 [highest efficiency position], 20 minutes each count.

Project No. _____ Date of Work _____
Entered By L. R. Uhle Date 10-25-90
Disclosed To and Understood By
Signed 1. L. R. Brumwood Date 10-25-90
2. _____ Date _____

^{3}H Standard #52733-109-100

Activity of ^{3}H std #52733-109-100
(a 1:100 dilution of #52733-109-1)

$$\frac{(1.02_{15} \times 10^{6}\ \text{dpm/ml}\ \#52733\text{-}109\text{-}1 \text{ on } 10\text{-}23\text{-}90)(1.0026\text{ml} \pm 0.0016\text{ml})}{100\text{ml}}$$

$\pm 1.7_{48} \times 10^{4}$

$$= \boxed{1.02_{40} \times 10^{4}\ \text{dpm/ml} \pm 1.7_{60} \times 10^{2}\ [1\sigma]}\ \boxed{\text{on } 10\text{-}23\text{-}90}$$

MJ Wyatt
12-19-90

X

Test Instructions
Tritium Determination in Water Samples
Batch 1

on 3-12-80

1. Tritium standard number 52733-109-1 (1.89×10^6) needs to be diluted 100 fold. Using a calibrated pipet, pipet 1ml of the standard into a clean (well rinsed with low tritium water) 100ml volumetric flask. Be very careful to bring the meniscus to the mark using the low tritium water as the diluent. Mix well.

Pipet No. 4A-12 (1000 ul) Date pipetted 12-4-90

Calibrated volume ~~1.0058~~ 1.0025 ml ± ~~0.0042~~ 0.0016 ml error ← NJW 12-19-90 corrections from 4A Pipet Log

Transfer into a clean, dry glass jar with a screw cap lid. Label the jar with the new standard identification (52733-109-100). Also record the new standard identification and preparation into LRB 52733 (Don Edward's). Bring the pipet calibration to Sandy or Nancy and we will calculate the activity of this new tritium standard.

2. Be sure to sign and date the reading assignment form before continuing.

3. When taking aliquots, be sure to use the sample from the unacidified bottle specifically sent for tritium analysis.

4. Prepare the following samples, blanks and spikes according to the procedure PNL-ALO-441. Double distill all except 53289-35-1 A,B, and C by repeating Sec. 5.1 - 5.2.

	Sample ID	Type	Volume	Spike Sol.	Spike Vol.
(1)	90-5346	Water	50ml	-	
(2)	90-5347	Water	50ml	-	
(3)	90-5347D	Water	50ml	(duplicate sample)	
(4)	90-5352	Water	50ml	-	
(5)	90-5353	Water	50ml	-	
(6)	BL-5346T	Deep well water	50ml	-	
(7)	BS-5346T1	Deep well water	50ml	#52733-109-100	500ul
(8)	BS-5346T2	Deep well water	50ml	#52733-109-100	500ul
(9)	53289-31A	Water	50ml	redistilled - was 38ml redistilled 20ml Double check vol	
(10)	53289-31B	Water	50ml	-	
(11)	53289-31C	Water	50ml	-	
(12)	53289-35-1A	Water	15ml	- } Direct pipet 4ml aliquots to	
(13)	53289-35-1B	Water	15ml	- } Count. Do not distill NJW	
(14)	53289-35-1C	Water	15ml	- } 12-4-90	

Water Standards and Blanks (See Exhibit 2, page 1 of PNL-ALO-441):
- 2 4 ml blanks pipetted from stock of distilled deep well water
- 2 4 ml aliquots of 53289-35-2 (EMSL-LV background water)
- Distilled deep well water with 50ul spike of #52733-109-1
- Distilled deep well water with 100ul spike of #52733-109-1
- Use a calibrated pipet for all spike additions.

N E Alley 12-6-90 NJWyatt 12-6-90

Re calibration of

#52733-109-1

Malin's #W-73 is 329 Bldg std no. #52733-109-1

New activity is $1.02_{15} \times 10^6$ dpm/ml on 10-23-90
$\pm 1.7_{48} \times 10^4$ [1σ]

This is 2.04% different from original calibration.

12-19-90

Calibrated Glass
3H (Cocktail)
W-75 L
10-24-90 MB

Recalibration of Kirby 3H Standard Solution: nominal $1.59_{dp} \times 10^6$ A/m/ml 3-12-60

111

Prepare duplicate dilution of W-75:

100.12 g [calibrated glass micropipette] 3H std & W-75 diluted to 10.00 ml [Type A volumetric flask] with deionized H_2O [system # WA-37399, 10-2-90, 18.0 MΩ-cm]. Label these dilution W-75-1 and dilution W-75-2

Prepare samples for liquid scintillation counting as follows:

1. Blank (one vial only) 500 g deionized H_2O [as above] + 15.0 ml [graduate cylinder] Beckman Ready Gel scintillation cocktail

2,3 Sample W-75 dilution W-75-1 duplicate vials 497.7 g [calibrated glass micropipette] W-75-1 + 15.0 ml [graduate cylinder] Beckman Ready Gel scintillation cocktail.

4,5 Sample W-75 dilution W-75-2 duplicate vials 497.7 g [calibrated glass micropipette] W-75-2 + 15.0 ml [graduate cylinder] Beckman Ready Gel scintillation cocktail.

6,7,8,9 3H Reference from replicate vials 497.7 g [calibrated glass micropipette] 3H standard & W-65 [gravimetric dilution of NBS 3H SRM 4926-C] + 15.0 ml [graduate cylinder] Beckman Ready Gel scintillation cocktail.

Count on Packard Model 4430 liquid scintillation counter & WA-62507 30 minute counting

all region A: lower level = 0 upper level = 19
region B: lower level = 2 upper level = 19
region C: lower level = 19 upper level = 2000

count three cycles of all nine vials, inserting vials in carrousel position corresponding to no.

```
PROGRAM #      14                                                    21/10/90   00:37
PROGRAM #=     14                                                    23/10/90   20:25
PROGRAM #=     14                                                    23/10/90   14:13
REGION A:      LL-UL=     0-  19  LCR=     0  BKG=     .00  % 2 SIGMA=     .0
REGION B:      LL-UL=     2-  19  LCR=     0  BKG=     .00  % 2 SIGMA=     .0
REGION C:      LL-UL=    19-2000  LCR=     0  BKG=     .00  % 2 SIGMA=     .0
TIME=  30.00   K= 1.000 DIP=SIS
```

P#	S#	TIME	CPM0/E	%DEV	CPM8/E	%DEV	CPMC/E	%DEV	SIE	SIS	FLAGS	MIN
14	1	30.00	26.37	7.11	21.83	7.01	26.33	6.06	.000	22.643		30
14	2	30.00	2157.23	.79	1633.00	.90	38.10	5.92	.000	13.868		61
14	3	30.00	2166.10	.78	1639.53	.90	38.93	5.85	.000	13.898		92
14	4	30.00	2129.50	.79	1618.63	.91	38.87	5.86	.000	13.900		123
14	5	30.00	2162.47	.79	1645.97	.90	39.03	5.84	.000	13.950		154
14	6	30.00	2208.53	.78	1685.03	.89	41.07	5.70	.000	13.901		184
14	7	30.00	2214.30	.78	1673.23	.89	38.80	5.86	.000	13.885		215
14	8	30.00	2233.83	.77	1686.20	.89	39.70	5.80	.000	13.1[illegible]		[illegible]
14	9	30.00	2197.77	.78	1664.33	.90	38.70	5.90	.000	[illegible]		

AWH 63115
page 111

Disclosed To and Understood By

Signed 1. L. R. Greenwood Date 10-25-90

2. _____ Date _____

Internal use
^{3}H (counting)
W-73
(continued)
10-24-90 [illegible]

Count Data Summary:

position 1: Blank — N = 3, B = 25.794 cpm, σ = 1.326607

2-5 dilution W-73-1 and -2 — N = 12, B = 2170.59, σ = 16.000693

6-9 ^{3}H Reference — N = 12, B = 2222.64, σ = 15.459743

dilution W-73-1 and -2:

net count = 2170.59 − 25.79 = 2145.10 c/m ± 95% cl of N-1 = 3 ≈ 3.182 σ = 53.46

^{3}H reference: nominal activity: $1.05_{44} \times 10^{4}$ ± 2.7 β/ml/ml 10-4-90, [refer to page 100].

net count = 2222.64 − 25.79 = 2196.85 c/m ± 95% cl of N-1 = 3 ≈ 3.182 σ = 49.46

10-4-90 → 10-22-90 = 18 d = 0.05205479 y

LRB
82815

$$\frac{(1.05_{44} \times 10^{4} \pm 2.7\ \beta/ml/ml)\left(e^{-\frac{(0.693)(0.05205479)}{(5.0526 \pm 0.05)}}\right)(0.4773 \pm 0.000237\ \text{net W-73})\left(\frac{2145.10 \pm 53.46\ c/m\ \text{W-73-dil}}{2196.85 \pm 49.46\ c/m\ \text{W-73-std}}\right)}{(0.4777 \pm 0.000267\ \text{net W-73 dilution})}\left[\frac{10.0000 \pm 0.0321\ ml}{0.10013 \pm 0.00017\ ml}\right]$$

$$= \underline{1.02_{15} \times 10^{6} \pm 3.4_{33} \times 10^{4}\ \beta/ml/ml\ \ 10\text{-}22\text{-}90\ \ [95\%\ cl]}$$

Original calibration and decay: 3-12-90 → 10-22-90 = 3677 d = 10.0167 y

$$(1.17_{44} \times 10^{6}\ \beta/ml/ml)\, e^{-\frac{(0.693)(10.0167)}{12.26}} = 1.04_{37} \times 10^{6}\ \beta/ml/ml\ \ 10\text{-}22\text{-}90$$

recalibration / original calib = 0.9796

Internal use
^{90}Sr (counting)
W-74
10-24-90 [illegible]

Recalibration of H. Wyckoff ^{90}Sr-Y Solution: nominal 1.47×10^{6} β/ml/ml 3-14-90

Prepare four replicate mounts of ^{90}Sr-Y solution #W-74 on 1" stainless steel disks: Use aliquots of 249.72 g [calibrated glass micropipette] each mount. Plate an separate aliquots, drying the first before plating the second, so as to confine the active deposit to 1/2" diameter area of the plate flow. Activity must not contact the disk walls.

Prepare four replicate mounts of ^{90}Sr-Y Reference Solution #W-47-2 on 1" stainless steel disks: 100.05 g [calibrated glass micropipette] each mount. Plate so as to confine the active deposit to 1/2" diameter area of the plate flow. Activity must not contact the disk walls.

Calibration: Count the both solutions to each other on a gas-flow proportional beta counter, shelf 1 [highest efficiency position], 20 minutes each count.

Project No. _____ Date of Work _____
Entered By L. R. Upton Date 10-25-90
Disclosed To and Understood By
Signed 1. L. R. Sherwood Date 10-25-90
2. _____ Date _____

O.V. Cole
^{133}Ba source
(continued)
9-26-90 [illegible]

[5034.75 ± 44.9 c/m][2507.0$_5$ ± 55.$_6$ 0'C]/[0.06545 ± 0.000157 ml]
= 9.9691$_5$ × 10^7 ± 2.771$_2$ × 10^6 d/m/ml 9-26-90 1200 PST

Source I:

1. Prepare three separate sources by pipetting [calibrated glass micropipette] aliquots of 199.93 λ, 199.97 λ, and 149.56 λ + 50.14 λ as point sources on the adhesive face of polyester tape
2. Air dry.
3. Apply the adhesive faces of the four 199.93 λ sources together, then apply the remaining source face down to create a 3 layer polyester tape sandwich, the active areas in registration.
4. Cut out the active area as a 1/2" circle. Cement it in a 1" ss disk with ACO cement.
5. Fill the disk level with the plug with Buehler Fast Cure Epoxy #20-6138. Allow to set.

$$\frac{[(199.93 \times 10^{-3}) + (199.97 \times 10^{-3}) + (149.56 \times 10^{-3}) + (50.14 \times 0.0100)]\,ml\,[9.9691_9 \times 10^7 \pm 2.771_2 \times 10^6\ d/m/ml]}{2.22 \times 10^6\ d/m/\mu C}$$

= 36.030$_4$ ± 0.723$_2$ μC ^{133}Ba 9-26-90 1200 PST [95% cl]

Source II:

1. Prepare a point source by pipetting [calibrated glass micropipette] 49.54 λ Ba^{133} nitrate on the adhesive face of polyester tape. Air dry.
2. Cover with a second piece of polyester tape, adhesive faces together.
3. Proceed as in steps 4 and 5, Source I.

[0.04964 ± 0.000100 ml][9.9691$_9$ × 10^7 ± 2.771$_2$ × 10^6 d/m/ml]/[2.22 × 10^6 d/m/μC]
= 2.2381$_1$ ± 0.0123$_2$ μC ^{133}Ba 9-26-90 1200 PST [95% cl]

Internal use
3H std
W-65
10-3-90, [illegible]

^{3}H Standard for Bioassay Quality Control Program use: nominal 1 × 10^4 d/m/ml

W-23: NBS ^{3}H std ref. std 4922-C:
3.40$_6$ × 10^3 d/s/g ± 0.63% [95% cl] 9-3-78
± 0.63% = 0.16% random error cal data + 0.25% systematic error + 0.2% gravimetric + weight error
error at 6-1 × 5% 95% cl error = 4.032 m, p = 0.0016/4.032 = 0.000 4064
at 6-1 × 5% 95% cl error = 3.571 m, (3.571)(0.000 4064) = 0.001147 = 0.12%
total error [95% cl] = 0.12% + 0.25% + 0.2% = 0.57% [95% cl].
3.40$_6$ × 10^3 ± 0.57% d/s/g = 3.40$_6$ × 10^3 ± 19.$_4$ d/s/g 9-3-78 [95% cl.]

BNW
#52815

Project No. _____ Date of Work _____
Entered By _____ Date _____
Disclosed To and Understood By
Signed 1. [illegible] Date 10-25-90
2. _____ Date _____

BEST COPY AVAILABLE

106 [illegible]

^{3}H SRM

W-66

([illegible])

10-3-90, [illegible]

Weight ~1000 g ^{3}H SRM # 4426-C into a 10 ml [type A] volumetric flask. Dilute to volume with deionized water [system # WB-37299, 10-2-90, 16.0 MΩ-cm]. Reweigh.

empty flask:	12.4045	12.4045	12.4045
flask + SRM:	13.4219	13.4219	13.4219
flask at volume:	37.3764	37.3764	@ 24.5°C

Mettler Semimicro # 45/999

weight ^{3}H SRM # 4426-C: (13.4219 ± 0.0001) − (12.4045 ± 0.0001) = 1.0169 ± 0.00014 g

total weight ^{3}H in W-66: (37.3764 ± 0.0001) − (12.4045 ± 0.0001) = 24.9719 ± 0.00014 g

7-3-78 → 10-3-90 = 4414 days = 12.085/3146 years

$(3.40_{0} \times 10^{3} \pm 1.4_{4}\ \text{DPS/g})(0.0250\ \text{g/ml})(e^{-\frac{(\ln 2)(12.085/3146)}{12.26 \pm 0.03}})(1.0169 \pm 0.00014\ \text{g})/(24.9719 \pm 0.00014\ \text{g})$

$= 1.05_{90} \times 10^{7} \pm 4.4_{4} \times 10^{4}$ DPS/ml 10-4-90 [95% cl]

$(3.40_{0} \times 10^{3} \pm 1.4_{4}\ \text{DPS/g})(0.0250\ \text{g/ml})(e^{-\frac{(\ln 2)(12.085/3146)}{12.26 \pm 0.03}})(1.0169 \pm 0.00014\ \text{g})/(10.0000 \pm 0.0221\ \text{ml})$

$= 1.05_{90} \times 10^{7} \pm 4.4_{4} \times 10^{4}$ DPS/ml 10-4-90 at 24.5°C [95% cl]

Internal line

^{3}H SRM

W-66

10-3-90, [illegible]

^{3}H standard for liquid scintillation counting; nominal activity 10^7 DPS/ml; for PG Nell

Weight ~1000 g ^{3}H SRM # 4426-C into a 10 ml [type A] volumetric flask. Dilute to volume with deionized water [system # WB-37299, 10-2-90, 16.0 MΩ-cm]. Reweigh.

empty flask:	12.0379	12.0379	12.0380
flask + SRM:	13.0426	13.0426	
flask at volume:	22.0054	22.0053	22.0054

Mettler Semimicro # 45/999 @ 24.5°C

weight ^{3}H SRM # 4426-C: (13.0426 ± 0.0001) − (12.0379 ± 0.0001) = 1.0047 ± 0.00014 g

total weight ^{3}H in W-66: (22.0054 ± 0.0001) − (12.0379 ± 0.0001) = 9.9675 ± 0.00014 g

7-3-78 → 10-3-90 = 4414 d = 12.085/3146 years

$(3.40_{0} \times 10^{3} \pm 1.4_{4}\ \text{DPS/g})(0.0250\ \text{g/ml})(e^{-\frac{(\ln 2)(12.085/3146)}{12.26 \pm 0.03}})(1.0047 \pm 0.00014\ \text{g})/(9.9675 \pm 0.00014\ \text{g})$

$= 1.04_{19} \times 10^{7} \pm 4.4_{4} \times 10^{4}$ DPS/g 10-4-90 [95% cl]

$(3.40_{0} \times 10^{3} \pm 1.4_{4}\ \text{DPS/g})(0.0250\ \text{g/ml})(e^{-\frac{(\ln 2)(12.085/3146)}{12.26 \pm 0.03}})(1.0047 \pm 0.00014\ \text{g})/(10.0000 \pm 0.0221\ \text{ml})$

$= 1.03_{94} \times 10^{7} \pm 4.4_{4} \times 10^{4}$ DPS/ml 10-4-90 at 24.5°C [95% cl]

BNW

#52815

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Page: 152
LRB No.: 52815

The following provides evidence of surveillance and/or technical reviews of this LRB in accordance with MG 4.3. When completed, this sheet is to be inserted into the LRB each month.

SURVEILLANCE REVIEWS
(Monthly for Impact Level I or II LRB entries by the Line Manager or delegate, and, if appropriate, by the Project Manager):

Pages Reviewed: 76 to 152
Date Reviewed: 1-8-92
Basis of Review: Check for legibility, completeness, traceability of entries, and a sample of requirements (1-14) of MG 4.3.
Results:

Reviewer's Dated Signature: [signature] 1/8/92

TECHNICAL REVIEWS
(Monthly reviews for Impact Level I or II LRB entries and prior to Project close out by a technically competent individual):

Pages Reviewed:
Date of Review:
Objective/Approach of Review: To determine (check one or more):
✓ 1) adequacy/appropriateness of methodology
✓ 2) if inferences and conclusions are soundly based
✓ 3) if data reduction and/or calculations are correct
__ 4) other (specify):

Results/Conclusions:

Reviewer's Dated Signature: [signature] 1/8/92

Project No. _____ Date of Work _____
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2. _____ Date _____

9PD 1778-777-783

U.S. Department of Commerce
Juanita M. Kreps
Secretary

National Bureau of Standards
Ernest Ambler, Director

THIS IS A PHOTOCOPY OF THE CERTIFICATE
WHICH IS BEING MAILED TO YOU UNDER
SEPARATE COVER.

National Bureau of Standards Certificate

Standard Reference Material 4926-C

Radioactivity Standard

Hydrogen-3

This Standard Reference Material consists of approximately 18 milliliters of a master solution of tritiated water, in a flame-sealed borosilicate-glass ampoule.

Aliquots of this master solution and of the 1961 tritiated water standard, SRM 4926, were made up gravimetrically with liquid scintillator into 18 and 45 vials, respectively, and intercompared by liquid-scintillation counting. The radioactivity concentration of SRM 4927 (which was the master solution for SRM 4926) that had been measured in 1961 (W.B. Mann, R.W. Medlock, O. Yuro, Int. J. appl. Radiat. Isotopes, 15, 351 (1964)), was redetermined by gas counting in 1978 using the National Bureau of Standards length-compensated internal gas proportional counters. Based on these 1978 measurements, the gravimetric dilution factors, and the liquid-scintillation counting intercomparison, the radioactivity concentration of 4926-C, as of September 3, 1978, was

$$*3.40_6 \times 10^3\ s^{-1}g^{-1} \pm 0.63\%*.$$

The uncertainty of the radioactivity concentration, 0.63 percent, is the linear sum of 0.18 percent, which is the limit of the random error of the gas-counting measurements at the 99-percent confidence level (4.032 S_m, where S_m is the standard error computed from 6 determinations), 0.25 percent, which is the estimated upper limit of conceivable systematic error in the gas counting and sample preparation, and 0.2 percent, which is the estimated upper limit of the error in the gravimetric dilutions and the liquid-scintillation measurements.

The radioactivity concentration of 4927 as determined in 1978 is 0.7 percent higher than the results determined in 1961, using a half life of 12.35 years. They agree, however, within the estimated overall uncertainties.

This Standard Reference Material was prepared in the Center for Radiation Research, Nuclear Radiation Division, Radioactivity Section, W. B. Mann, Chief.

Washington, D.C. 20234
January, 1979

J. Paul Cali, Chief
Office of Standard Reference Materials

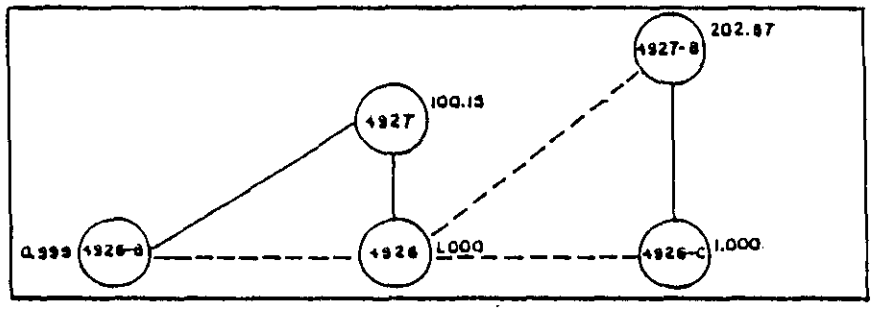
B02-039

NOTES ON THE NBS STANDARDS FOR HYDROGEN-3-WATER

SRM-4926, 4926-B, 4926-C and SRM-4927, 4927-B

A recalibration has been made on the NBS standard for ^{3}H-water by means of gas counting, and new batches of material have been prepared. Because of the large number of the earlier standards still in use (1) and because of their importance in international hydrology measurements (2), it is important that the relative radioactivity concentrations of the five existing NBS tritium standards be given. The diagram shown here gives the radioactivity concentrations relative to SRM-4926, as of Sept. 3, 1978. It may be seen that the three low-level materials are essentially equivalent.

RELATIVE RADIOACTIVITY CONCENTRATIONS OF ^{3}H-WATER SRM'S



The links represented by solid lines were computed from gravimetric dilution factors for which the uncertainties are less than 0.1%. The links represented by the dashed lines are based on liquid-scintillation intercomparisons, for which the uncertainties are less than 0.2%.

Based on gas-counting measurements of six samples of the 1961 SRM-4927 made in 1978, the following radioactivity concentration values are obtained:

SRM	Radioactivity Concentration($s^{-1}g^{-1}$) September 3, 1978
4926	$3.406 \times 10^3 \pm 0.4_1\%$
4926-B	$3.403 \times 10^3 \pm 0.4_1\%$
4926-C	$3.406 \times 10^3 \pm 0.6_1\%$
4927	$3.411 \times 10^3 \pm 0.4_1\%$
4927-B	$6.909 \times 10^3 \pm 0.6_1\%$

On the basis of the 1961 gas-counting measurements, the radioactivity concentration of SRM-4927 was $0.8793 \times 10^4\ s^{-1}g^{-1} \pm 1\%$ as of September 3, 1961. The relative agreement between the 1961 and 1978 gas-counting measurements cannot be established unequivocably, however, because of the uncertainty in the half life (If a half life of 12.35 y is used, the 1961 and 1978 standards agree to within 0.7%; for complete agreement, it would be necessary to use a half life of 12.44 y.)

---

(1) Mann, W.B., Medlock, R.W. and Yura, O. Int. J. appl. Radiat. Isotopes, 15, 351 (1964)

(2) Taylor, C.B., Int. J. appl. Radiat. Isotopes, 29, 39 (1978).

I3 Calibration Curves

Alpha and Beta Disintegrations per Count Determination

Alpha and Beta Disintegrations per Count Determination

By S. K. Fadeff and D. L. Fassler McMullin
August 13, 1991

Introduction

The previously used disintegrations per count (d/c) factor was not appropriate for the determination of total alpha and beta content prepared according to PNL-ALO-460 and PNL-ALO-462. The more solids loading on the plate, the further the d/c value varies from the previously used value. The original d/c value was obtained from plates stippled with known activity by the ACL Standards Laboratory with essentially zero solids loading. Using this d/c value, low matrix and blank spike recoveries were obtained for total alpha determination of soils for the 200-BP-1 project. Low matrix spike recoveries were obtained for total beta determination in soils. It appeared the solids were masking significant percentages of the alpha and beta particles. Intuitively this makes sense for the solids loading contribute to shielding of alpha and, to a lesser extent, beta particles. It was necessary to define the effect of the shielding due to solids loading, relative to the disintegrations per count, thus establishing a calibration curve.

As an outgrowth of this original study, it became apparent that the sample geometry (as the sample is loaded and dried on the plate) also differs significantly from that provided by the ACL Standards Laboratory; this in turn affects the d/c value. This was concluded because the plates with zero solids loading consistently showed higher d/c values than the ACL Standards Lab plates. A separate study of alpha plates spiked with known activity and prepared according to PNL-ALO-460 was performed and documented under separate cover.

Experimental

Soils previously analyzed for the 200-BP-1 program and found to contain no detectable amounts of beta or alpha activity, were used as blank soils for this experiment. The alpha analysis was performed twice on two different soils at different times. The beta analysis was performed once on one type of soil. The soil samples were leached according to PNL-ALO-106, Acid Digestion for Preparation of Samples for Radiochemical Analysis. This entails two digestions in hot nitric acid and one digestion in hot water. These solutions were separated from the soils and combined.

The spiking solution for the alpha count was ^{239}Pu, 538 +/- 5 dpm/ml (ID# 52733-118-0) for the first experiment and ^{239}Pu, 534 +/-5 dpm/ml (ID# 52733-144-1) for the second experiment. The spiking solution for total beta was ^{90}Y-Sr 1104 +/- 55 dpm/ml (ID# 52733-117-0). A known aliquot of one standard spike solution was added to a tarred plate and an aliquot of soil leach solution was added to this plate. This was repeated such that a range of 0 to 350mg solids were loaded onto various plates with known spike solutions. Prior to drying, the plates were moved to promote a swirling/mixing action in order to obtain a uniform distribution of the radionuclide in solution on the plate. The plates were dried in the usual manner according to PNL-ALO-460, Source Preparation for Gross Alpha Analysis and PNL-ALO-462, Source Preparation for Gross Beta Analysis.

This opportunity was taken to determine how much time is required to obtain

a stable weight on the dish. Four alpha plates (15, 40, 200, and 300mg loading) were further dried on the hot plate as per the procedure. They were weighed immediately after cooling and at succeeding 1 hour increments for about 4 hours, then again approximately 17 hours later. Six beta plates (15, 30, 40, 45, 60, and 200mg loading) were also dried on the hot plate and the same weighing exercise was performed. The plates were counted after each weight was taken to determine if count rate discrepancies correlated with any weight shifts. Care was taken to be sure the plates were located relative to the detector in the same position for each count.

Once the proper time interval between drying the alpha plates and subsequent counting was determined, the plates for the alpha and beta calibration curve were counted. The plates were counted according to procedures PNL-ALO-461 and PNL-ALO-463, Alpha Counting and Beta Counting, respectively. For purposes of determining the calibration curve, the samples were counted long enough to obtain approximately 10,000 counts, thus reducing statistical counting errors.

Since it became obvious the sample solutions tended to flow up out of the dish and onto the dish outer edge, another experiment was tried. This entailed applying a very thin layer of stopcock grease on the outer dish edge as a barrier to the aqueous mixture. Two blanks, 40, 50, 100, and 200mg solids loading were run to determine the effect on the alpha curve.

Results and Discussion

After heating the alpha dishes on the hot plates and cooling to room temperature, it was noticed the weight increases. Apparently, after about one hour the weight is constant to within about 3% relative through the 21 hours monitored. The beta plates are not routinely heated on the hot plate prior to counting. The plates that were heated as part of this experiment showed the same trends as the alpha plates. The weight stabilized after about 1 hour equilibration with the atmosphere varying by about 3%. The count rates on these plates were also monitored. The count rates showed no variation with respect to the slight increase in weight during the initial 1 hour equilibration.

After the extended count times to obtain the 10,000 counts, the counts per minute were calculated along with the total disintegrations per minute added to the plate. A disintegrations per count (D/C) versus total milligram solids loading curve could then be established for both the total alpha and total beta analyses. See figures 1 and 2. The total alpha data from the two independent soil leach solutions were combined to define one curve. The results are indistinguishable on the d/c curve. It appears the soil source is not a significant factor in the d/c determination. The curves defined by the data did not fit a linear relationship but good fits were obtained by quadratic equations:

$$D/C\ alpha = 2.9864 + 0.05917(x\ mg) + 0.000097(x\ mg)^2$$

error in terms:	2.9864	+/-	0.2031
	0.05917	+/-	0.00485
	0.000097	+/-	0.000015

$$D/C\ beta = 1.8904 + 0.007202(x\ mg) - 0.00000718(x\ mg)^2$$

error in terms:	1.8904	+/-	0.02185
	0.007202	+/-	0.000427
	0.00000718	+/-	0.0000010148

A summary of the data is included in Tables 1 and 2.

The alpha d/c increases dramatically with the solids content on the dish.

The beta d/c also increases significantly but appears to level off at about 500mg solids loading. Using stopcock grease on the outer lip edge appears to have no discernable effect on the d/c calibration curve. It should help with sample handling practices in that the plate can be handled by the outer edge without disturbing the sample itself.

Conclusions

In order to perform a total alpha and beta analysis on samples leaving measurable residues on alpha and/or beta plates, three new steps should be followed. (1) Stopcock grease should be applied to the outer edge of the dishes to preclude sample creep up and over the dish edge. (2) The alpha plate should equilibrate with the atmosphere after heating and prior to weighing. (3) A correction will have to be made utilizing the calibration curve defined in this paper.

Reference LRB53293, pages 20, 23-27, Pacific Northwest Laboratory

D-C50

FIGURE 1

D/C curve for total solids loading on alpha plate

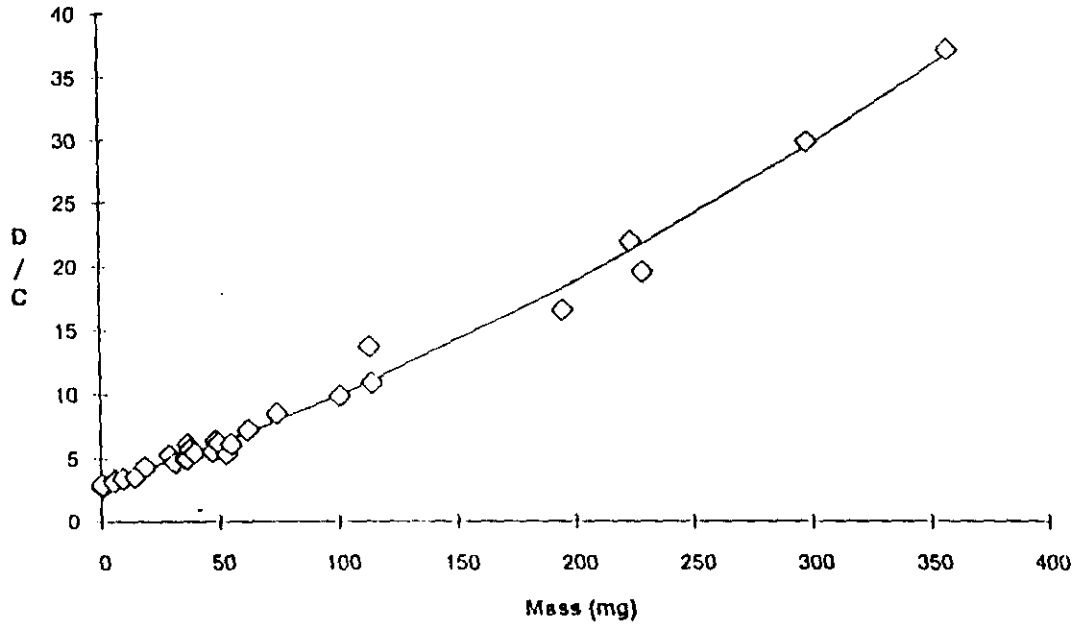
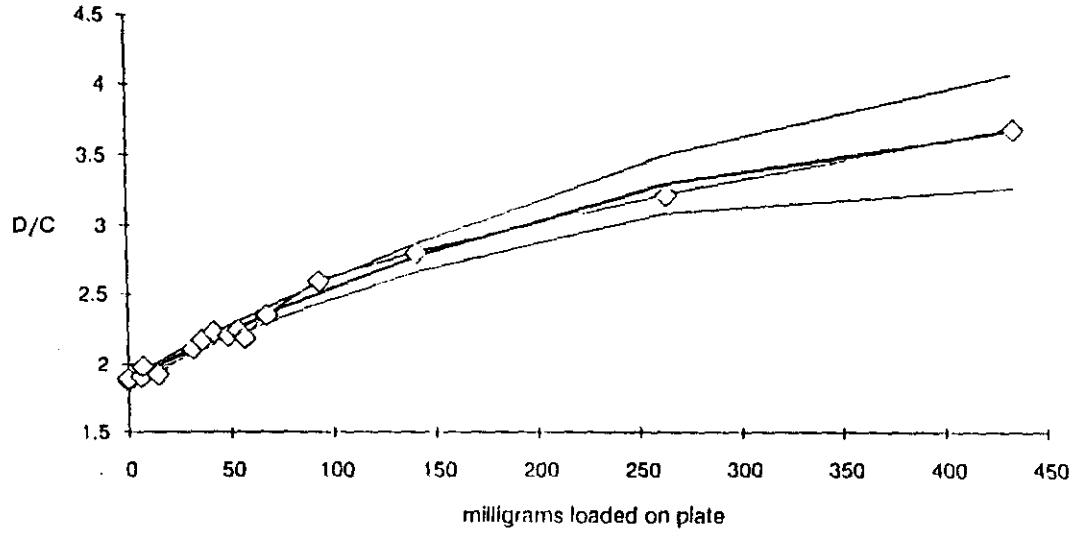


FIGURE 2

D/C Curve For Total Solids Loading On Beta Plate



Alpha response with varying amounts of solids loading

TABLE 1

Target wt	Actual wt mg	+/- 1 sigma	Counts	Minutes counted	Bckgrnd cpm	Net cpm	+/- 1 sigma	Net dpm added	+/- 1 sigma	dpm/cpm	+/- 1 sigma	+ 1 S	-1S	% error	Calc. Curve fit	Residuals (Calculated d/c ÷ Actual d/c)-1
0	0	0	10003	250	0.076	39.9	0.40	107.0	1.07	2.679	0.038	2.717	2.641	1.415	2.8696	0.071
0	0	0.0	10170	250	0.13	40.6	0.40	107.0	1.07	2.639	0.037	2.676	2.602	1.409	2.8696	0.087
15	5.2	0.2	12206	360	0.076	33.8	0.31	107.0	1.07	3.163	0.043	3.206	3.120	1.349	3.2077	0.014
15	5.1	0.2	13075	402.01	0.13	32.3	0.28	107.0	1.07	3.310	0.044	3.354	3.266	1.330	3.2012	-0.033
25	14.2	0.6	10776	360	0.051	29.9	0.29	107.0	1.07	3.581	0.050	3.630	3.531	1.389	3.0037	0.062
30	30.0	1.2	10600	469.37	0.116	22.7	0.22	107.0	1.07	4.723	0.066	4.789	4.657	1.393	4.9303	0.046
35	35.0	1.4	8536	400	0.051	21.3	0.23	107.0	1.07	5.026	0.074	5.100	4.952	1.475	5.2326	0.041
40	39.2	1.6	11000	600	0.116	19.6	0.18	107.0	1.07	5.473	0.074	5.547	5.398	1.361	5.5300	0.010
45	46.9	1.9	10021	260	0.051	38.5	0.38	214.0	2.07	5.560	0.077	5.637	5.482	1.391	6.0027	0.094
50	49.6	2.0	10469	303.43	0.116	34.4	0.34	214.0	2.07	6.223	0.086	6.309	6.138	1.376	6.2700	0.009
50	48.2	1.9	10706	323	0.051	33.3	0.32	214.0	2.07	6.418	0.088	6.506	6.331	1.365	6.1770	-0.030
60	62.0	2.5	17041	600	0.116	29.6	0.22	214.0	2.07	7.225	0.098	7.314	7.137	1.224	7.1953	-0.004
80	73.0	3.0	15114	600	0.051	25.1	0.20	214.0	2.07	8.513	0.108	8.620	8.405	1.264	8.0913	-0.049
120	113.4	4.5	7837	500	0.051	15.6	0.10	214.0	2.07	13.690	0.204	13.902	13.494	1.409	11.2602	-0.177
200	229.0	9.2	13625	500	0.051	27.2	0.23	532.4	10.30	19.574	0.414	19.988	19.160	2.116	22.0402	0.126
300	298.9	12.0	10030	558.30	0.116	17.0	0.10	532.4	10.30	29.032	0.650	30.402	29.102	2.179	29.6364	-0.007
	350.6	14.3	14293	900.50	0.007	14.409	0.122	537.2	2.9	37.076	0.371	37.448	36.705	1.002	36.7702	-0.000
	223.9	9.0	24100	900.50	0.049	24.520	0.150	537.2	2.9	21.901	0.104	22.006	21.717	0.042	21.5179	-0.010
	114.3	4.6	10600	934.59	0.093	19.017	0.146	216.1	2.0	10.905	0.129	11.034	10.775	1.104	11.3435	0.040
	53.0	2.1	26120	650	0.007	40.090	0.249	216.1	2.0	5.309	0.060	5.449	5.329	1.114	6.5276	0.211
	37.5	1.5	12310	650	0.093	18.045	0.171	100.0	1.0	5.731	0.074	5.005	5.657	1.297	5.4093	-0.056
	36.2	1.4	10209	460.61	0.007	21.069	0.217	100.0	1.0	4.930	0.067	5.005	4.071	1.357	5.3173	0.077
	20.4	1.1	13272	650	0.049	20.369	0.177	100.0	1.0	5.302	0.067	5.369	5.235	1.271	4.7714	-0.100
	10.3	0.7	0961	360	0.093	24.799	0.263	100.0	1.0	4.355	0.061	4.416	4.294	1.409	4.0796	-0.063
	8.0	0.4	10704	330.70	0.007	31.745	0.307	100.0	1.0	3.402	0.046	3.448	3.357	1.339	3.4445	0.012
	0.1	0.0	12637	330.61	0.049	37.271	0.332	100.0	1.0	2.898	0.037	2.935	2.860	1.285	2.9761	-0.007
	0	0.0	6542	100	0.004	36.260	0.450	107.22	1.16	2.957	0.049	3.006	2.908	1.646	2.0696	-0.030
	0	0.0	6622	100	0.12	36.669	0.453	107.22	1.16	2.924	0.048	2.972	2.876	1.642	2.0696	-0.019
	0.1	0.0	6443	100	0.111	35.603	0.447	107.22	1.16	3.005	0.050	3.054	2.955	1.654	2.0761	-0.043
0	0	0.0	13192	360	0.098	36.546	0.319	106.4	1.1	2.911	0.039	2.951	2.872	1.354	2.0696	-0.014
0	0	0.0	13436	360	0.130	37.104	0.323	106.4	1.1	2.861	0.039	2.900	2.023	1.350	2.0696	0.003
40	36.7	1.5	11469	660	0.092	17.205	0.163	106.4	1.1	6.156	0.086	6.242	6.069	1.390	5.3526	-0.130
50	54.7	2.2	22042	660	0.090	34.511	0.229	212.7	2.1	6.163	0.073	6.236	6.090	1.102	6.6527	0.079
100	100.7	4.0	14240	660	0.130	21.450	0.101	212.7	2.1	9.916	0.120	10.044	9.700	1.293	10.2200	0.031
200	195.2	7.0	10316	400	0.090	25.692	0.254	425.5	4.1	16.562	0.220	16.790	16.334	1.377	10.6590	0.127

Residual avg 0.010

Residual std dev 0.074

B03-008

TABLE 2

Beta response with varying amounts of solids loading
These were counted on the regular beta detectors, not the low background detectors.

Target wt	Actual wt mg	+/- 1 sigma	Counts	Minutes counted	Bckgrnd cpm	Net cpm	+/- 1 sigma	Net dpm added	+/- 1 sigma	dpm/cpm	+/- 1 sigma	+ 1 S	-1S	% error	Calculate d/c	Residuals (d/c calc./d/c from 1) -1
0	0	0	13408	100	16.3	117.8	1.09	221	11	1.876	0.095	1.971	1.781	5.062	1.890	0.0073
0	0	0.0	13197	100	15.4	116.6	1.08	221	11	1.896	0.096	1.992	1.800	5.063	1.898	-0.0329
15	6.5	0.3	13130	100	15.4	115.9	1.08	221	11	1.907	0.097	2.005	1.810	5.065	1.937	0.0158
15	6.6	0.3	12679	100	15.5	111.5	1.05	221	11	1.986	0.101	2.086	1.885	5.067	1.930	-0.0243
25	14.6	0.6	13112	100	15.3	114.8	1.07	221	11	1.925	0.097	2.022	1.827	5.064	1.994	0.0368
30	31.8	1.3	11999	100	15.4	104.6	1.02	221	11	2.113	0.107	2.220	2.006	5.073	2.112	-0.0004
35	36.3	1.4	11679	100	15.4	101.4	1.01	221	11	2.180	0.111	2.290	2.069	5.075	2.140	-0.0180
40	41.8	1.7	11464	100	15.5	99.1	1.00	221	11	2.229	0.113	2.342	2.116	5.078	2.179	-0.0225
45	48.7	1.9	12965	60	15.5	208.6	1.95	442	22	2.204	0.112	2.315	2.092	5.060	2.224	0.0093
50	53.6	2.1	12750	60	15.4	197.1	1.91	442	22	2.243	0.114	2.356	2.129	5.062	2.256	0.0059
50	58.6	2.3	13015	60	15.4	201.5	1.93	442	22	2.193	0.111	2.304	2.082	5.060	2.275	0.0371
60	67.5	2.7	12262	60	16.3	188.1	1.77	442	22	2.350	0.119	2.469	2.231	5.066	2.344	-0.0027
80	93.5	3.7	11186	60	16.3	170.1	1.69	442	22	2.598	0.132	2.730	2.466	5.075	2.501	-0.0373
120	141.5	5.7	10397	60	15.4	157.9	1.62	442	22	2.800	0.142	2.942	2.657	5.082	2.766	-0.0121
200	264.5	10.5	21424	60	15.4	341.7	2.39	1100	58	3.220	0.171	3.391	3.048	5.319	3.293	0.0229
300	435.1	17.4	18027	60	15.3	298.5	2.23	1100	58	3.685	0.196	3.882	3.489	5.325	3.665	-0.0055

avg 0.0026
std dev 0.0204

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BetaCurv

B03-009

$SrCO_3$ Calibration Summary

^{90}Sr Calibration curve (d/c vs mg $SrCO_3$)

BNW 53293, p 16

Date: December 21, 1990

Subject: STRONTIUM-90 CALIBRATION PROCEDURE SUMMARY

By: J. H. Kaye J. H. Kaye

I have reviewed the Sr-90 calibration data, which is in the enclosed data package.

The procedure involved the following steps:

1) Addition of Sr-85 tracer to an equilibrium mixture of Sr-90/Y-90 and the amount of Sr carrier needed to yield the desired weight of SrCO3 on the counting dish.

2) Separation of the Sr-90 from the Y-90 by means of two ferric hydroxide precipitaions. The Y-90 is carried with the precipitate and the Sr-90 remains in solution.

3) Addition of saturated Na2CO3 solution to precipitate SrCO3. The precipitate is centrifuged, transferred to the tared counting dish, dried under a heat lamp and weighed.

4) The dried sample is counted within one hour after separation of Y-90, so that the in-growth of Y-90 is less than one percent.

5) The sample is later counted with a NaI(Tl) detector to determine the recovery of Sr-90, which is on the order of 80 percent.

Three measurements were made for each nominal weight of SrCO3 precipitate except for the 60 and 80 mg SrCO3 points, where only two measurements were made. A linear least-squares fitting routine was used to determine the best fit to the experimental data.

d/c = (1.980 +/- 0.061) + (0.0151 +/- 0.0015)*(wt SrCO3)

Reference - Statistics for Analytical Chemistry, J. C. Miller and J. N. Miller, Halsted Press (John Wily & Sons) 1984, pp 82-93.

For details, see "Sr Calibration Data Package" folder filed under 53293 - 16 in 329 office 8 and LRB 53332, pp 60-66.

James H. Kaye 9/24/91

Reviewed by, N J Wyatt 9-24-91

Project No. _____ Date of Work _____

Entered By _____ Date _____

Disclosed To and Understood By

Signed 1. _____ Date _____

2. _____ Date _____

^{99}Tc Calibration Information

Battelle
Pacific Northwest Laboratories

Project Number 19432

Internal Distribution

File/LB

Date March 4, 1992

To 1100EM1 File

From Sandy Fadeff S.C. Fadeff N.J. Dyl 3-4-92

Subject Technetium-99 Calibration Curve

Technetium-99 is a relatively soft beta emitter and as such is relatively easily shielded by salts on a beta plate. (The maximum beta energy for ^{99}Tc is 0.29 MeV, for ^{90}Sr it is 0.55 MeV and for ^{90}Y it is 2.3 MeV.) In order to determine the blank spike recovery and matrix spike recovery, and make a legitimate comparison of sample results between the total beta analysis method and the Tc-99 by the ICP/MS method, a calibration curve needed to be constructed. This calibration curve corrects the dpm/cpm, or efficiency, for the various mass loadings on beta plates.

In order to best "re-create" the sample matrix, a low level beta 1100EM1 sample (B01574) was chosen to be the source of the matrix mass. Various volumes of this sample were spiked with a constant amount of ^{99}Tc standard in sufficient quantity to overwhelm the sample beta activity contribution. Several samples at essentially zero mass loading were taken along with masses ranging from 8 mg to 107 mg.

The stock sample did have a small amount of activity. This required a small correction in calculating the beta activity. The activity due to the sample needed to be subtracted to determine the net count rate due to the spike. An approximation was set up based on the duplicate analytical runs of the sample in the initial beta analysis. The average gross beta activity of 5.23 pCi/L, calculated with the ^{90}Sr-Y calibration, was used and a net cpm was back calculated from this value. (The net count rate was not used due to the significant variation in the plate loading between the duplicate samples; the calibration used tries to correct for that.) This builds in an uncertainty of around 10% which is unavoidable without further studies. The uncertainty stems from three sources. 1) The 5.23 pCi/L was based on the ^{90}Sr-Y calibration, but the samples could be ^{99}Tc or some mixture of beta emitters representing various beta energies. These other beta emitters (especially the ^{99}Tc) may vary in counting efficiency more as a function of plate loading, than is represented in the ^{90}Sr-Y calibration. 2) The d/c factor (2) used in back calculation is a reasonable approximation for the Sr/Y calibration. However, the d/c varies from 1.89 to 2.58 with mass loadings ranging from 0 to 107 milligrams. 3) There is also an uncertainty in the sample duplicate average. The count rate per sample volume corresponds to about 0.0058 cpm/ml which was used to make the subsequent sample activity corrections.

Once the estimated sample component of the total activity could be calculated, it was subtracted from the total activity providing the net spike activity. The dpm added divided by the net cpm provides an efficiency for each data point. This was plotted against the corresponding mass loading on

E54-1900-001 (10/88)

B03-013

the plate and a curve fitting program was utilized to provide a second order fit. The resulting efficiency versus milligram loading on the beta plate curve was calculated and is defined as:

$$\text{efficiency } (d/c) = 2.486 + 0.0566(X) - 0.000123(X)^2$$

where X equals the milligram loading on the dish.

A transcription error was uncovered during the technical review of this effort. The sample mass entered as 23.1 was actually 23.7 milligrams. The effect of this on the data was very small and actually improves the agreement between the calculated and obtained d/c (3.76 and 4.21 respectively). Because the error was so small it was determined any impact on the data would also be negligible. Correcting the d/c equation and subsequently correcting all the ^{99}Tc calculation spreadsheets and associated calculations would have been a major task with no measurable benefit. Therefore no further corrections were made. This can be done upon client request.

This is an approximate efficiency or calibration curve. A better calibration curve could be determined using blank groundwater where for which no sample activity would need to be corrected. This method was used because we had no blank groundwater available nor the knowledge of what salts and other solids may be present to synthesize our own. This does provide a good estimate or approximation of the calibration and is accurate to about 10% as evidenced by the ^{99}Tc matrix spike recoveries on 1100EM1 beta analyses.

1100-EM-1 Total Beta Analysis D/C Calculation of Tc-99
Efficiency (d/c) Based on mg Plate Loading
Tc-99 Standard used: #54124-64-0 and a 1:17 dilution of this standard which is called #54124-64-17.

Equation from curve fit program
d/c = 2.4859 + 0.056633X − 0.0001235X^2 where X = mg loading on plate
Errors in terms: a: 0.1045 b: 0.006105 c:0.0000645 from d/c = a + bx + cx^2

mg loading	92-02726 vol (ml)	cpm from sample*	cpm	Std Added (dpm)	d/c**	d/c from above equation	delta %***
0	0	0	75.03	184.9	2.46	2.49	99.1
0	0	0	76.86	184.9	2.41	2.49	96.8
0.1	0	0	71.56	184.9	2.58	2.49	103.7
2.2	0	0	45.4	108.5	2.39	2.61	91.6
2.3	0	0	43.1	108.5	2.52	2.62	96.2
2.6	0	0	42.3	108.5	2.57	2.63	97.4
8	20.8	0.12	61.03	184.9	3.04	2.93	103.6
23.7	59	0.34	44.3	184.9	4.21	3.76	111.9
35.9	80	0.46	42.04	184.9	4.45	4.36	102.0
43.8	100.4	0.58	38.7	184.9	4.85	4.73	102.6
51.4	120	0.70	35.88	184.9	5.26	5.07	103.6
56.8	120	0.70	39.97	184.9	4.71	5.30	88.8
64.8	140.3	0.81	34.16	184.9	5.55	5.64	98.4
83.1	204	1.18	30.56	184.9	6.29	6.34	99.3
107.2	250	1.45	26.89	184.9	7.27	7.14	101.8

* Assume average efficiency of 2 dpm/cpm. This is not exactly right for each sample due to variation in the milligram loading on the beta plate, and the beta may not be Sr/Y-90, but this is a reasonable approximation.

$$\text{cpm from sample:} \quad \frac{\text{vol of sample} * 5.23\text{pCi/L} * 2.22\text{dpm/pCi}}{(1000\text{ml/L}) * 2\text{dpm/cpm}}$$

$$** \ d/c = \frac{\text{dpm added}}{\text{total cpm} - \text{cpm from sample}}$$

$$*** \ \text{delta \%} = \frac{d/c}{d/c \text{ from equation}} \times 100$$

A.K. Jadeff
3/18/92

B03-015

1100-EM-1 Total Beta Analysis D/C Calculation of Tc-99
Efficiency (d/c) Based on mg Plate Loading

Equation from curve fit program
d/c = 2.4859 + 0.056633X - 0.0001235X^2 where X = mg loading on plate
Errors in terms: a: 0.1045 b: 0.006105 c:0.0000645 from d/c = a + bx + cx^2

mg loading	92-02726 vol (ml)	cpm from sample*	cpm	Std Added (dpm)	d/c**	d/c from above equation	delta %***
0	0	0	75.03	184.9	2.46	2.49	99.1
0	0	0	76.86	184.9	2.41	2.49	96.8
0.1	0	0	71.56	184.9	2.58	2.49	103.7
2.2	0	0	45.4	108.5	2.39	2.61	91.6
2.3	0	0	43.1	108.5	2.52	2.62	96.2
2.6	0	0	42.3	108.5	2.57	2.63	97.4
8	20.8	0.12	61.03	184.9	3.04	2.93	103.6
23.1	59	0.34	44.3	184.9	4.21	3.73	112.8
35.9	80	0.46	42.04	184.9	4.45	4.36	102.0
43.8	100.4	0.58	38.7	184.9	4.85	4.73	102.6
51.4	120	0.70	35.88	184.9	5.26	5.07	103.6
56.8	120	0.70	39.97	184.9	4.71	5.30	88.8
64.8	140.3	0.81	34.16	184.9	5.55	5.64	98.4
83.1	204	1.18	30.56	184.9	6.29	6.34	99.3
107.2	250	1.45	26.89	184.9	7.27	7.14	101.8

* Assume average efficiency of 2 dpm/cpm. This is not exactly right for each sample due to variation in the milligram loading on the beta plate, and the beta may not be Sr/Y-90, but this is a reasonable approximation.

$$\text{cpm from sample:} \quad \frac{\text{vol of sample} * 5.23\text{pCi/L} * 2.22\text{dpm/pCi}}{(1000\text{ml/L}) * 2\text{dpm/cpm}}$$

$$** \ d/c = \frac{\text{dpm added}}{\text{total cpm} - \text{cpm from sample}}$$

$$*** \ \text{delta \%} = \frac{d/c}{d/c \text{ from equation}} \times 100$$

J.L. Fadeff 3/14/92

B03-016

Task to Determine Efficiency of ^{99}Tc Beta Counting
Versus mg Plate Loading of Groundwater Samples

Use a low level sample from the 1100-EM-1 sample series (92-02726).

Measure various volumes of this sample so that a range of 0 mg to 100 mg of solids will result on a beta dish.

Spike each sample with a known dpm ^{99}Tc, large enough to make any sample counts become relatively insignificant.

Procede with the beta analysis procedure, PNL-ALO-462 and beta counting procedure, PNL-ALO-463.

Spike Volumes

Isotope 99Tc Pipet No. 10A-17
Pipet Vol. .0992 +/- 0.0002 Date 1-28-92
Spike ID ~~52440-64-0~~ 54124-64-0 3-18-92 Spike Activity 184.9 ± 3 dpm/.0992 l

Sample ID	Sample Vol.	Weights Gross Dish	Tare	Net Dish
92-02726				
	20.8 ml	-	-	8.0 mg
	59.0 ml			23.7 mg
	100.4 ml			43.8 mg
	140.3 ml			64.8 mg
	80 ml			35.9 mg
	120 ml			56.8 mg
	120 ml			51.4 mg
	204 ml			83.1 mg
	250 ml			107.2 mg

[illegible] 2-13-92
Reviewed J.L. Fadeff 2/13/92
Reviewed again, J.L. Fadeff 3/18/92

B03-017

1100 EM 1 ^{99}Tc efficiency

Calculation of ^{99}Tc, # 54124-64-0, diluted into sample, dpm.

$$(0.0992 \pm 0.0002\,mL)(3.759 \times 10^{+} \pm 6.0?\ Bq/g)\left(\frac{0.998\,g}{mL}\right)\left(\frac{60\,sec}{min}\right)\left(\frac{0.207\,mL}{250\,mL}\right) = 184.9 \pm 3\ dpm$$

S.K. Fadeff 2/12/92

G.G. Brodzczynski 2-12-92

Battelle

BETA COUNTING DATA

REQUESTED BY

DATE ANALYZED

SAMPLE TYPE

CHARGE CODE

REMARKS: Efficiency study for Counting Varying amounts of sample 92-2726 ^{99}Tc Pipet 10A-17 1-24-92 Elec 99.2±0.2λ 54124-64-0 dpm/g

SAMPLE DESIGNATION	DATE - TIME SAMPLED	CONTAINER PROCESS	WT.-VOL. ANALYZED (ML)	WT. RESIDUE	ANALYST	SIT NUMBER LRB	SHELF	DATE - TIME COUNTED	COUNTS	MINUTES	ENG. C.M.	ENG. CORR. C.M.	TECHNICIAN	CALCULATIONS (CONVERSION FACTOR)	RESULTS UNITS OF pCi/g
2.0.8ml				8.0mg		2	1	1-28-92 0855	6160	100	5%	61.03		184.9±3 / 61.03±.89	3.03±.07
59.0ml				23.7		3	1	↓	4501	1.7	0%	44.30		184.9±3 / 44.30±.82	4.17±.10
100.4ml				43.8 / ~~48.8~~ gk 2-13-92		1	1	1-28-92 10:40	3944	1	1%	38.70		184.9±3 / 38.70±.80	4.78±.13
140.3ml				64.8		2	1	↓	3473		5%	34.16		184.9±3 gk 2-13-92 / 34.16±.77	5.41±.16
80ml				35.9		1	1	1-30-92 0850	2139	50	1.3%	42.04		184.9 / 42.04	4.40±.12
120ml				56.8		2	1	↓	2027		5%	39.97		184.9±3 / ~~42.04~~ 39.97 gk 2-13-92	4.63±.13
99.2±0.2λ 99Tc 53960-64-0				0.1		1	1	1-30-92 1330	2169	36	1.3%	71.56		184.9±3 / X = 74.48±2.69	2.48±.10 dpm/g
2				0		2			2268		5%	75.03			Out
3				0		3			2327		1.4%	76.86			

G. L. Brodziaczynski 2-13-92

Reviewed S. L. Fadeff 2/13/92

FD-1750-C45 (1-2-1)

№ 1267

B03-019

Battelle

BETA COUNTING DATA

REQUESTED BY

DATE ANALYZED: 2-6-92

SAMPLE TYPE: 99.2 ± 0.2 ~~52440~~ 64.0 99Tc

CHARGE CODE: 54124

REMARKS: 92-02726 varied amounts Blue ~~100x~~ for efficiency curve

ab 3-3-92

Dupl 10A-17 2-5-92

SAMPLE DESIGNATION	DATE - TIME SAMPLED	CARRIER (ML)	PROCESS	DIL. - VOL. ANALYZED	WT. RESIDUE	ANALYST	ST NUMBER	SHELF	DATE - TIME COUNTED	COUNTS	MINUTES	BKG. C/M	SMPL. C/M	BKG. CORR.	TECHNICIAN	CALCULATIONS	RESULTS UNITS OF
120 ml		NA			51.4		1		1540 2-6-92	3665	10	.65	35.88			184.9 / 35.88	5.15
204					83.1		2			3111		.55	30.56			184.9 / 30.56	6.05
250					107.2		3			2753		.63	26.89			184.9 / 26.89	6.88

Gwen G Brodacznak 3-3-92

Reviewed S. L. Fadeff 2/13/92

FD-1709-045 (12-71)

№ 0109

B03-020

Xeroxed from
batch 1
total beta analysis
1100 EM1
AKJ

1100 EM1 Total Beta analysis Batch 1

Spike Recoveries

Sr calibration curve

Blank Spike Sr on 1/22/92 activity of Sr-90 = 1077 +/- 53 dpm/ml

$$\frac{(0.1989 \pm 0.0009\ ml)(1077 \pm 53\ dpm/ml)}{(0.1\ L)\ (2.22\ dpm/pCi)} = 964.9 \pm 47.7\ pCi/L$$

$$\frac{1002.8 \pm 13.3}{964.9 \pm 47.7} \times 100 = \underline{104 \pm 5\ \%\ \text{recovered}}$$

Matrix Spike Sr

$$\frac{(0.1989 \pm 0.0009\ ml)(1077 \pm 53\ dpm/ml)}{(0.1109 \pm 0.0002\ L)(2.22\ dpm/pCi)} = 870.1 \pm 43.0\ pCi/L$$

$$\frac{927.1 \pm 15.9}{870.1 \pm 43.0} \times 100 = \underline{107 \pm 6\ \%}\ \text{recovered}$$

Blank Spike Tc Calculation of spike activity #54124-64-0

$$3.759 \times 10^{4 \pm 60}\ Bq/g \left(\frac{0.7989}{ml}\right)\left(\frac{60\ sec}{min \pm 2}\right)\left(\frac{0.207\ ml}{250\ ml}\right) = 1{,}864 \pm 30\ dpm/ml$$

^{99}Tc 54124-64-17

$$(1{,}864 \pm 30\ dpm/ml)\left(\frac{1.4553\ ml \pm 0.0034}{25\ ml}\right) = 108.5\ dpm\ \text{on}\ 11/15/82$$

$$\frac{(0.1989 \pm 0.0009\ ml)(108.5 \pm 2\ dpm/ml)}{(0.1\ L)\ (2.22\ dpm/pCi)} = 97.2 \pm 2\ pCi/L$$

S.K. Fadeff 2/11/92
GG Bodzczynski 2-12-92

B03-021

Leaching Data Sheet

Procedure PNL-ALO-106 Rev.0, leach: Check if used ✓

Date Sample Leach Started 1-20-92 Date Completed 1-21-92

Tracer or Spike Volumes

Isotope Sr-Y 90 Sample Added to: BS 02724
Pipette No. 10A-18 Volume 198.91 +/- 0.91 Date Pipetted 1-17-92
Spike ID 52733-117-1 Spike Activity 1.47x10³ dpm/ml

Isotope 99 Tc Sample Added to: BS02724 TC
Pipette No. 10A-18 Volume 198.91 +/- 0.92 Date Pipetted 1-20-92
Spike ID ~~53960-18-1 53293-3L~~ 54124-64-17 JKJ 3/4/92 Spike Activity ~~107.4~~ 108.5 dpm/ml SLF 2/11/92

Sample ID, Aliquot Size, and Leachate Volume

Balance Number 510-06-01-006 Temperature (if weighing water samples) 22°

	Sample ID	Beaker Wt.	Bker + Sampl	Sample Wt or Vol	~~Dilu. Volume~~ factor 1.0021	~~Dilu Vol. Uncertainty~~ 2σ 93.88	
	BL-02724			100 ml			
	BS-02724	NA		100 ml			
	BS-02724TC			100 ml			
B01572	92-02724	110.08 g	200.10 g	90.02 g	90.22 ml		
B01573	92-02725	103.88 g	199.71 g	95.83 g	96.04 ml		
B01574	92-02726	107.08 g	202.01 g	94.93 g	95.14 ml		
B01574	92-02726 D	107.79 g	201.46 g	93.67 g	93.88 ml		
B01575	92-02727	106.46 g	193.93 g	87.84 g	88.03 ml		
B01559	92-02728	106.09 g	204.85 g	98.76 g	98.98 ml		
B01571	92-02729	106.32 g	204.48 g	98.16 g	98.38 ml		

Sample Volumes (if a pipet was used for small aqueous samples)

Pipette No. NA Volume NA +/- NA Date Pipetted NA

Susan G Brodzczyski 1-23-92 J. L. Jadoff 2/11/92
Analyst Date Reviewer Date

LECHDATA.LOG

Xeroxed from Batch 1
JKJ 3/4/92

Battelle
Pacific Northwest Laboratories

BETA COUNTING DATA

Pg 1 of 3

REQUESTED BY

DATE ANALYZED: 1-22-92

SAMPLE TYPE: Total Beta

CHARGE CODE

REMARKS: 1100 EM-1

^{99}Tc Standard used: 54124-64-17

Xerox from patch 1 SKG 3/4/92

SAMPLE DESIGNATION	SAMPLED DATE - TIME	CARRIER (ML)	PROCESS	WT.-VOL. ANALYZED	WT. RESIDUE	ANALYST	SET NUMBER	SHELF	COUNTED DATE - TIME	COUNTS	MINUTES	BKG. C/M	C/M	BKG. CORR.	TECHNICIAN	CALCULATIONS (C/M) (VOLUME FACTOR) = (GEO)(2.22 x 10^8)(.55)(.89)(.554)(AW)(YIELD)	RESULTS UNITS OF µc/
direct plate 1 ml 99 Tc std 107.4 dpm/ml 1		dc	1 ml	2.3 mg			66	1	1-22-92 11:15	606	10		15.6	45.0			
2				2.6			67	1		613			17.8	43.5			
3				2.2			68	1		584			14.8	43.6			
1		dc		2.3			66	1	1-22-92 11:30	4380	100	.738		43.1		from Tracewipe calc 107.4 dpm = 2.46 dc	
2				2.6				2		4285		.570		42.3		43.6 C/m	
3				2.2				3		4612		.709		45.4			
200 µl dil MSR 2726			104.6 g	51.4				1	1-22-92 15:15	817	100	.738		7.43		from Cert. calc. 108.5 dpm = 2.49 dc / 43.6	
MSSr 2726			110.2 g	50.8				3		10,271		.709		102.0			
92-02724			90.0 g	43.5				1	1-22-92 17:00	1198	100	.738		0.46			
92-02725			95.8 g	20.5				2		909		.570		0.34			
92-02726			94.8 g	39.3				3		1263		.709		0.55			
200 µl Tc dil BS 02724			~~1-23-92~~ 1-23-92	0.1				1	1-23-92 10:00	8016	100	.738		7.28			
200 µl Sr BS 02724				0				2		24,494	20	.570		117.8		Gwen G Rudasynski 2-11-92	
92-02727			87.84 g	43.7 ~~53.6~~				2	1-23-92 13:30	4093	100	.570		3.52			

BD-1700-049 (12-71)

Reviewed S.K. Fadeyev 2/11/92

No. 1263

B03-023

Battelle
Pacific Northwest Laboratories

BETA COUNTING DATA

pg 2 of 3

REQUESTED BY

DATE ANALYZED: 1-22-92

SAMPLE TYPE: total Beta

CHARGE CODE

REMARKS: 94Tc standard used 54124-64-17

Xerox from batch 1 SKJ 3/4/92

1100 EH1

SAMPLE DESIGNATION	SAMPLED DATE - TIME	CARRIER (ML)	PROCESS	WT.-VOL. ANALYZED	WT. RESIDUE	ANALYST	SET NUMBER	SHELF	COUNTED DATE - TIME	COUNTS	MINUTES	BKG. C/M	C/M	BKG. CORR.	TECHNICIAN	CALCULATIONS (C/M) (VOLUME FACTOR) = (GEO)(2.22 x 10^6)(%S)(BS)(SSA)(AW)(YIELD)	RESULTS UNITS OF µc/
					53.0 mg				1-0-92								
92-2726 D					93.6 g ~~43.7 mg~~		3		13:30	1152		100	.709	0.44			
92-2728					98.76 g	71.3	1		1-24-92 1400	4094		100	.738	3.36			
92-2729					98.16 g	82.6	2			4813			.570	4.24			
92-2730					97.5 g	76.8	3			4503			.709	3.79			
Incl 99Tc std BS-D2726				84.1 g	~~49.5~~	425	1		1-26-92 1100	2308		100	.738	22.34			
92-02731					98.36 g	62.2	2			3550		100	.570	2.98			
92-2732					104.4 g	97.1	3			3889		100	.709	3.42			
92-02733					112.6 g	69.6	1		1-26-92 12:35	4105			.738	3.37			
Recount HS TC 2726						51.4	1		1-28-92 0855	716		100	.738	6.42			
92-02734						105.0	1		1-28-92 1355	4103		100	[illegible]	3.40		2.80 2-11-92	
92-02735						53.9	2			6960			.570	6.39			
lost some alt. 92-02736						28.5	3			927			.683	0.24			
92-02737						38.7	1		~~1-30-92~~ 1315	1273		100	.709	0.57		1-30-92 SB 3-4-92	
92-02738						69.7	2			5937			.570	5.37		Steven G. Brodbeck 2-11-92	

BD-1700-049 (12-71)

Reviewed S.K. 2/11/92

No 1264

B03-024

from 1100 EMI
Batch 1
for original documentation on this sample and the duplicate, see Batch 1 Gross Beta analysis
SKF
2/27/92

SPREADSHEET FOR CALCULATION OF TOTAL BETA ACTIVITY

Date calculated	11-Feb-92
Enter Radiochem Sample Number (XXXX)	92-02726
Enter Log-In Number ('90-XXXX)	92-02726
Enter Client Sample ID	b01574
Enter File Name	2726TB
Initial amount of sample used	95.14 +\- 0.2000
Which units, ml, g or sample?	ML
If leached, enter final leach soln volume (ml)	1 +\- 0.0001
If leached, enter ml of leach soln analyzed	1 +\- 0.0001
Enter total counts observed	1263
Enter count time in minutes	1000
Enter background (cpm)	0.709
Calculated net cpm	0.5540 +\- 0.0444
Weight of residue on dish (NOT IN GRAMS) - in MG	39.3 +\- 0.1
d/c for detector based on mg loading	2.1624 +\- 0.0276

S ture J.G. Bradzaymski 2-11-92
(Entered by) (Date)

Total Beta Activity 5.672 pCi/L = 0.005672 pCi/ml

avg. = $\frac{5.672 + 4.787}{2}$ = 5.230 ± [illegible]

Error in activity units* 0.461 pCi/L = 0.000461 pCi/ml

Percent Error 0.12 %

Minimum detectable activity NA

S.K. Fadeff
2/13/92

Signature S. K. Fadeff 2/12/92
(Reviewed by) (Date)

3-4-92

CALCULATION OF SAMPLE ACTIVITY:

$$\frac{(\text{net cpm})(\text{d/c})(\text{pCi}/2.22\text{dpm})(\text{ml leachate})}{(\text{initial sample amount})(\text{ml subsampled})}$$

Note: The propagated error includes the error associated with the d/c calculation based on the mg loading on the plate.

otal Beta Spreadsheet Revision 3, 6/28/91
JTBETA

B03-025

from 1100 EMI
Batch 1

SPREADSHEET FOR CALCULATION OF TOTAL BETA ACTIVITY

Date calculated	11-Feb-92
Enter Radiochem Sample Number (XXXX)	DUP-2726
Enter Log-In Number ('90-XXXX)	DUP-2726
Enter Client Sample ID	DUP-2726
Enter File Name	DUP2726

Initial amount of sample used	93.88 +\- 0.2000
Which units, ml, g or sample?	ML
If leached, enter final leach soln volume (ml)	1 +\- 0.0001
If leached, enter ml of leach soln analyzed	1 +\- 0.0001
Enter total counts observed	1152
Enter count time in minutes	1000
Enter background (cpm)	0.709
Calculated net cpm	0.4430 +\- 0.0431
Weight of residue on dish (NOT IN GRAMS) - in MG	53 +\- 0.1
d/c for detector based on mg loading	2.2519 +\- 0.0316

Signature G G Brodzeyski 2-11-92
(Entered by) (Date)

Total Beta Activity	4.787 pCi/L =	0.004787 pCi/ml
Error in activity units*	0.471 pCi/L =	0.000471 pCi/ml
Percent Error	9.84 %	
Minimum detectable activity	NA	

Signature S. L. Fadeff 2/12/92
(Reviewed by) (Date)

CALCULATION OF SAMPLE ACTIVITY:

$$\frac{(\text{net cpm})(\text{d/c})(\text{pCi}/2.22\text{dpm})(\text{ml leachate})}{(\text{initial sample amount})(\text{ml subsampled})}$$

*Note: The propagated error includes the error associated with the d/c calculation based on the mg loading on the plate.

Total Beta Spreadsheet Revision 3, 6/28/91
TOTBETA

B03-026

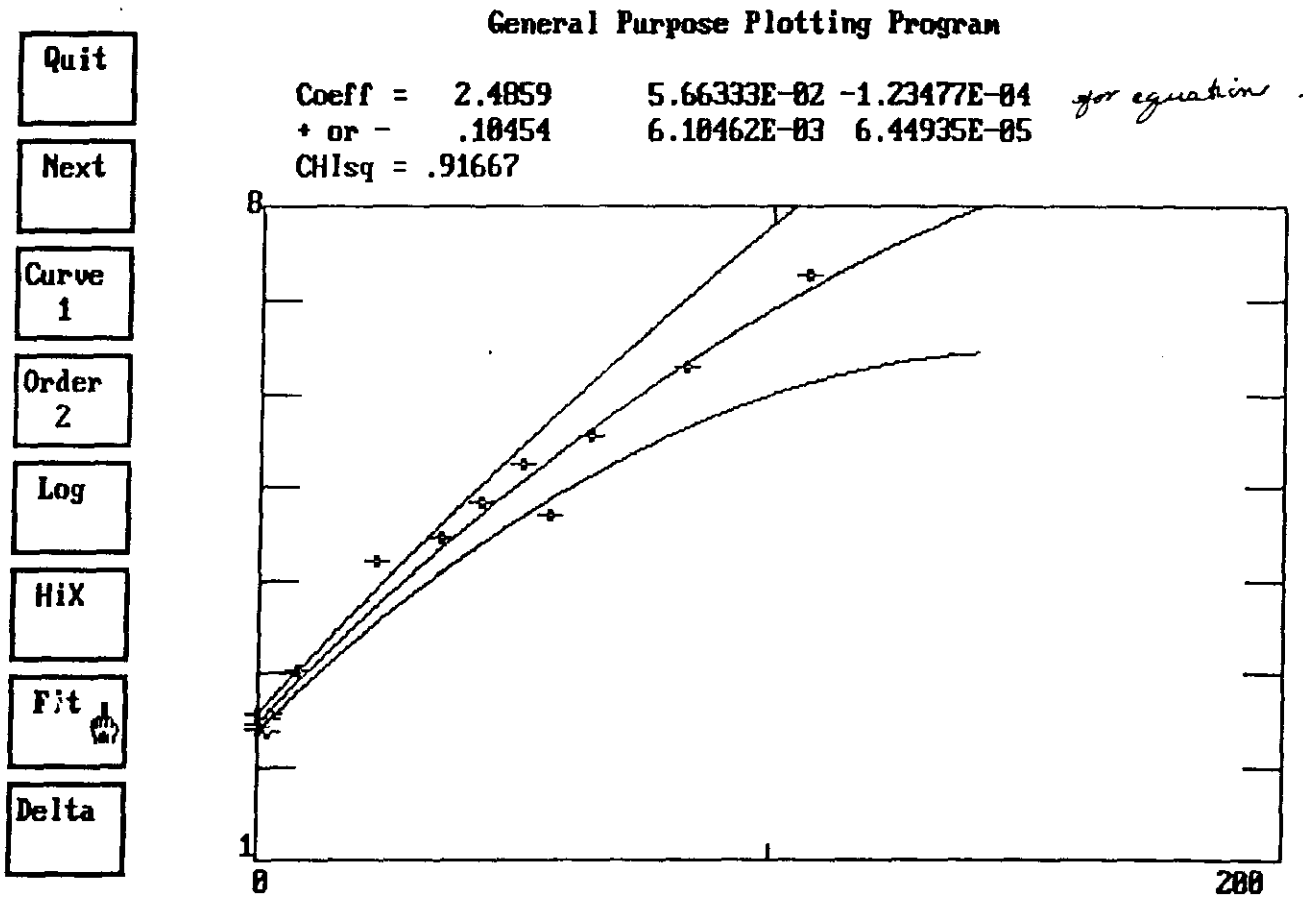
1100 EM1 file used in curve fit program to determine equation which defines the equilibrium versus plate loading.

Path: A:\
File: D_CEM1 .PRN 374 .a.. 2-12-92 3:03:58 pm Page 1

0	2.46
0	2.41
0.1	2.58
2.2	2.39
2.3	2.52
2.6	2.57
8	3.04
23.1	4.21
35.9	4.45
43.8	4.85
51.4	5.26
56.8	4.71
64.8	5.55
83.1	6.29
107.2	7.27

S. K. Fadeff 2/13/92

∞ EMI efficiency versus mg loading for ^{99}Tc in groundwaters - Beta analysis



for equation $y = a + bx + cx^2$

Coefficients generated from the plotting program / curve fit program.

S. K. Fadeff 2/13/92

B03-028

This spreadsheet incorporates a new d/c calculation based on ^{99}Tc response and mg loading.

See cell #s F26 & H26.

S.K. Fadeff 2/12/92

```
A9:  SPREADSHEET FOR CALCULATION OF TOTAL [illegible] TECHNETIUM
A11: 'Date calculated
F11: (D1) @NOW
A12: 'Enter Radiochem. Sample Number (XXX)
F12: A 'test1
A13: 'Enter Log-In Number (92-XXXX)
F13: A 'test1
A14: 'Enter Client Sample ID
F14: A 'test1
A15: 'Enter File Name
F15: A 'test1
I16: '((I(n)/G(n))^2
A17: 'Initial amount of sample used
F17: A 1
G17: '+\-
H17: (F4) A 0.0001
I17: (H17/F17)^2
A18: 'Which units, g, l or sample?
F18: A 'ml
A19: 'If leached, enter final leach soln volume (l)
F19: (F3) A 1
G19: '+\-
H19: (F4) A 0.0001
I19: (H19/F19)^2
A20: 'If leached, enter % of leach soln analyzed
F20: A 1
G20: '+\-
H20: (F4) A 0.0001
I20: (H20/F20)^2
A21: 'Enter total counts observed
F21: A 5
A22: 'Enter count time in minutes
F22: A 10
A23: 'Enter background (cpm)
F23: A 0.05
A24: 'Calculated net cpm
F24: (F4) (F21/F22)-F23
G24: '+\-
H24: (F4) @SQRT((F21+(F23*F22)))/F22
I24: (H24/F24)^2
A25: 'Weight of residue on dish (NOT IN GRAMS) - in g
F25: A 10
G25: '+\-
H25: (F1) A 0.1
A26: 'd/c for detector based on mg loading
F26: (F4) A 2.4859+(0.056637*F25)-(0.0001[illegible]42*F25^2)
G26: A '+\-
H26: (F4) A @SQRT((0.10454)^2+(0.056637*H25)^2+(0.0[illegible]105*F25^2*H25)^2+(0.00212348)^2*(F25)^2+(0.0000[illegible]44935)^2*(F25)^4)
I26: (H26/F26)^2
A29: 'Signature ____
B29: \_
C29: \_
D29: \_
E29: \_
A30:            (Entered by)
E30: '(Date)
```

B03-029

```
A33: 'Total Beta Activity
D33: (F3) +F24*(F19/F20)*(F26)*(1/2.22)/@IF(F18=[illegible]
E33: @IF(F18="sample","pCi/sample",@IF(F18=[illegible]
F33: (F6) @IF($F$18=[illegible]1",D33/1000," ")
G33: @IF($F$18="pl",'pCi/pl"," ")
A35: 'Error in activity, counts*
D35: (F3) +D33*@SQRT(I17+I19+I20+I24+I25)
E35: @IF(F18="sample","pCi/sample",@IF(F18=[illegible]
F35: (F6) @IF($F$18=[illegible]1",D35/1000," ")
G35: @IF($F$18="pl", pCi/pl"," ")
A37: 'Percent Error
D37: (F2) +D35/D33*100
E37: '%
A39: 'Minimum detectable activity  =
D39: (F3) @IF(D33<=0&D35<=D37)=50,2*@SQRT(F21*F22+F23+F24+F25+F26)/F20/@IF(F18="pl",F17/1000,F17),"      NA")
E39: @IF(D33<=0&D35<=D37)=50,@IF(F18="sample",[illegible]"pCi/g","pCi/L ")),"  ")
F39: (F6) @IF(D33<=0&D35<=D37)=50,@IF($F$18=[illegible]1",[illegible]1000,"[illegible]
G39: (F6) @IF(D33<=0&D35<=D37)=50,@IF($F$18=[illegible]"pCi/pl",[illegible]
A42: 'Signature  ____
B42: \_
C42: \_
D42: \_
E42: \_
A43: '            (Reviewed by)
E43: '(Date)
A46: 'CALCULATION OF SAMPLE ACTIVITY:
A48: '       (net cpm)(2.22dpm/pCi) (weight)
A49:         ----------------------------------------
A50: '        (initial sample amount)(1 minute plus)
A53: '*Note:  The propagated error includes the error associated with
A54: '        the c/c calculation based on the [illegible] counting on a [illegible] plate.
A57: 'Total Beta Spreadsheet Revision 3, [illegible]
A58: 'TOTBETA
```

with ^{99}Tc d/c, TOTBETA calculation gave:

92-2736 → 11.86 pCi/L
Dup-2736 → 10.93

$\bar{x}$ = 11.4 pCi/L

$$* \frac{11.4\ pCi/L \times vol, ml \times 2.22\ dpm/pCi}{1000\ ml \times Tc\ d/c} = new\ cpm$$

vol	d/c	new cpm from sample *	new d/c **	
20.8	2.93	0.18	3.039	Very good
250	7.14	0.89	7.111	

$$** \text{ new d/c} = \frac{\text{dpm added}}{\text{total cpm} - \text{new cpm from sample}}$$

This iteration shows good agreement with first approximation.

Reviewer [illegible] 3-4-92

Spot check of calculations:

- $\frac{20.8\ ml \times 5.23\ pCi/L \times 2.22\ dpm/pCi}{1000\ ml/L \times 2\ d/c} = 0.121$ cpm from sample ✓

120 ml → 0.697 cpm from sample ✓

- $\frac{184.91\ dpm\ added}{61.03\ cpm - 0.12\ cpm} = 3.036\ d/c$ ✓

$\frac{184.91}{39.97 - .70} = 4.709\ d/c$ ✓

- $2.4859 + 0.056633\,(83.1\ mg) - 0.0001235\,(83.1\ mg)^2 = 6.33$

- $\frac{4.45}{4.36} \times 100 = 102.1\%$ ✓

Reviewer: [illegible] 3-4-[illegible]

from 1100EM1 Batch 1

SPREADSHEET FOR CALCULATION OF TOTAL BETA ACTIVITY DUE TO TECHNETIUM

Date calculated	18-Feb-92
Enter Radiochem Sample Number (XXXX)	duplicate 92-02726
Enter Log-In Number ('90-XXXX)	DUP-2726
Enter Client Sample ID	DUP-2726
Enter File Name	2726DTC

Initial amount of sample used	93.88 +\-	0.0200
Which units, ml, g or sample?	ml	
If leached, enter final leach soln volume (ml)	1 +\-	0.0001
If leached, enter ml of leach soln analyzed	1 +\-	0.0001
Enter total counts observed	1152	
Enter count time in minutes	1000	
Enter background (cpm)	0.709	
Calculated net cpm	0.4438 +\-	0.0431
Weight of residue on dish (NOT IN GRAMS) - in MG	53 +\-	0.1
for detector based on mg loading	5.1406 +\-	0.3853

Signature G.G. Bodaczynski 2.18-92
(Entered by) (Date)

Total Beta Activity	10.927 pCi/L =	0.010927 pCi/ml
Error in activity units*	1.343 pCi/L =	0.001343 pCi/ml
Percent Error	12.29 %	
Minimum detectable activity	NA	

Signature S.K. Tadros 2/18/92
(Reviewed by) (Date)

CALCULATION OF SAMPLE ACTIVITY:

$$\frac{(\text{net cpm})(\text{d/c})(\text{pCi}/2.22\text{dpm})(\text{ml leachate})}{(\text{initial sample amount})(\text{ml subsampled})}$$

*Note: The propagated error includes the error associated with the d/c calculation based on the mg loading on the plate.

B03-033

Total Beta Spreadsheet Revision 3, 6/28/91
TOTBETA

from 1100 EM1 Batch 1

for original documentation on this sample and the duplicate, see Batch 1 Gross Beta Analysis.

3-4-92

SPREADSHEET FOR CALCULATION OF TOTAL BETA ACTIVITY DUE TO TECHNETIUM

Date calculated	14-Feb-92
Enter Radiochem Sample Number (XXXX)	92-02726
Enter Log-In Number ('90-XXXX)	92-02726
Enter Client Sample ID	B01574
Enter File Name	2726TCB
Initial amount of sample used	95.14 +\- 0.0200
Which units, ml, g or sample?	ml
If leached, enter final leach soln volume (ml)	1 +\- 0.0001
If leached, enter ml of leach soln analyzed	1 +\- 0.0001
Enter total counts observed	1263
Enter count time in minutes	1000
Enter background (cpm)	0.709
Calculated net cpm	0.5540 +\- 0.0444
Weight of residue on dish (NOT IN GRAMS) - in MG	39.3 +\- 0.1
d/c for detector based on mg loading	4.5209 +\- 0.2001

Signature G.G. Chodzynski 2-18-92
(Entered by) (Date)

Total Beta Activity	11.858 pCi/L =	0.011858 pCi/ml
Error in activity units*	1.201 pCi/L =	0.001201 pCi/ml
Percent Error	10.13 %	
Minimum detectable activity	NA	

Signature A. K. Fadyb 2/18/92
(Reviewed by) (Date)

CALCULATION OF SAMPLE ACTIVITY:

(net cpm)(d/c)(pCi/2.22dpm)(ml leachate)

(initial sample amount)(ml subsampled)

*Note: The propagated error includes the error associated with the d/c calculation based on the mg loading on the plate.

Total Beta Spreadsheet Revision 3, 6/28/91
TOTBETA

B03-034

d/c calculated from mg residue + Sr-Y-90 calibration curve for gross beta (from TOTBETA, Rev.3, 6-28-91

mg	Sr-Y d/c
0	1.8904
0.1	1.8911
2.2	1.9062
2.3	1.9069
2.6	1.9091
8	1.9476
23.1	2.0529
23.7	2.0571
35.9	2.1397
43.8	2.1921
51.4	2.2416
56.8	2.2763
64.8	2.3278
83.1	2.4393
107.2	2.5800

Using 0mg + 107.2mg points only:

$\bar{x} = 2.235$

$s = 0.488$ —OR— 2.2 ± 0.5

So 2=d/c is a reasonable approximation. Reviewer

M J Wyrick

3-4-92

I4 Performance Checks of Pipets and Balances

2-13-92 Balance 509-06-03-003 21° 1.00198

200λ 10A18

16.0485	16.2462	16.4432	16.6409	16.8386
15.8509	16.0485	16.2462	16.4432	16.6409
.1976	.1977	.1970	.1977	.1977

$\bar{X}$ = .1975 × 1.00198 = .1979 197.9 ± 0.3λ
S = .00030 × 1.00198 = .00031

G Brodaczynski 2-13-92

10-A-22 1000λ

14.2860	15.2748	16.2683	17.2726	18.2737
13.2915	14.2860	15.2748	16.2683	17.2726
.9945	.9888	.9935	1.0043	1.0011

$\bar{X}$ = 0.9953 (64*) × 1.00198 = 0.9972 (84*)
S = .0065 (2*) × 1.00198 = 0.0065 (2*)

998.4 ± 6.2 λ*
~~997.2 ± 6.5 λ~~
* S. L. Jadoff 2/24/92

G Brodaczynski 2-13-92

2.19.92 Balance 509.06-03.003 20° 1.00177 Vol factor
~~2/20~~ 2/19/92 100λ - 10A-17 ~~2/19/92~~ Cl. wt - 1g = 1.0001

13.1799	13.2784	~~13.3774~~	13.3764	13.4766
13.0802	13.1799	~~13.1799~~	13.2784	13.3764
.0997	.0985	~~5~~	.0980	.1002

13.5773 $\bar{X}$ = .0994 × 1.00177 = .0996
13.4766 S = .0011 × 1.00177 = .0011
.1007

G Brodaczynski 2.19.92

510.06.01.006 · 100g = 100.01 G Brodaczynski 2.19.92

2.20-92 Balance 509-06-03-003 2g = 2.0000

LRB 54372

Project No. _____ Date of Work _____
Entered By _____ Date _____
Disclosed To and Understood By
Signed 1. S. L. Jadoff Date 2/26/92
2. _____ Date _____

2-7-92 continued from p. 16

pipet # 4A-10 500λ 1100EM1 3H

9.7568	10.2598	10.7564	11.2562
9.2592	9.7568	10.2598	10.7564
0.4976	0.5030	0.4966	0.4998

$\bar{X}$ 0.4993 X 1.00198 = 0.5002 ml $\bar{S}$ = 0.0028 X 1.00198 = 0.0028 ml

pipet # 4A-13 @ ~4ml 1100EM1 3H

21.0202	24.9386	28.8584	32.7645
17.1065	21.0202	24.9386	28.8584
3.9137	3.9184	3.9198	3.9061

$\bar{X}$: 3.9145 X 1.00198 = 3.9223 ml S: 0.0062 X 1.00198 = 0.0062 ml

Diana L. McMullin 2-7-92
Reviewed S.K. Tadeff 2/18/92

2-11-92 Performance Check Bal# 509-06-03-004
2g : 2.0001 g ok
H_2O temp: 21°C vol factor 1.00198
for BS 300W
pipet # 4A-6 100λ

7.9615	8.0610	8.1603	8.2598
7.8630	7.9615	8.0610	8.1603
0.0985	0.0995	0.0993	0.0995

$\bar{X}$ = 0.0992 X 1.00198 = 0.0994 ml S: 0.0005 X 1.00198 = 0.0005 ml
2-11-92

Diana L. McMullin 2-11-92

2-18-92 Performance Check Bal# 509-06-03-004 2g: 2.0001 ok
for CMSL A,B H_2O temp: 21°C vol factor 1.00198
pipet # 4A-6 100λ

7.9618	8.0607	8.1598	8.2590
7.8628	7.9618	8.0607	8.1598
0.0990	0.0989	0.0991	0.0992

$\bar{X}$ 0.09905 X 1.00198 = 0.0992 ml S: 0.0001 X 1.00198 = 0.0001 ml
pipet # 4A-5 50λ

8.3082	8.3575	8.4065	8.4556
8.2590	8.3082	8.3575	8.4065
0.0492	0.0493	0.0490	0.0491

X: 0.04915 X 1.00198 = 0.0492 ml
S: 0.0001 X 1.00198 = 0.0001 ml
Diana L. McMullin 2-18-92

Project No. _____ Date of Work _____

LRB 54370

Entered By _____ Date _____

Disclosed To and Understood By

Signed 1. D. K. Tadeff Date 2/24/92

2. _____ Date _____

2-6-92

Performance Check Bal # 509-06-03-004
2.0g : 2.0000g ok

for 1100 EMI 3H MS&BS

H_2O temp 21°C vol factor 1.00198

pipet # 4A-14

38.8625	48.4561	58.0714	67.7043
29.2213	38.8625	48.4561	58.0714
9.6412	9.5936	9.6153	9.6329

$\bar{X}$ = 9.62075 x 1.00198 = 9.6398ml S = 0.02108 x 1.00198 = 0.02112 ml

Diana L. McMullin 2-6-92

2-7-92

Performance Check Bal # 509-06-03-004
0g : 2.0001g ok
H_2O temp : 21°C vol factor : 1.00198

pipet 4A-5 50λ

7.9121	7.9610	8.0103	8.0598
7.8629	7.9121	7.9610	8.0103
0.0492	0.0489	0.0493	0.0495

1100EMI 3H

$\bar{X}$ 0.0492 x 1.00198 = 0.0493ml S = 0.0003 x 1.00198 = 0.0003 ml

pipet # 4A-6 100λ 1100 EMI 3H

8.1585	8.2575	8.3563	8.4551
8.0598	8.1585	8.2575	8.3563
0.0987	0.0990	0.0988	0.0989

$\bar{X}$ 0.0989 x 1.00198 = 0.0990ml S = 0.0001 x 1.00198 = 0.0001 ml

pipet 4A-7 200λ EMSL-LV Pu

8.6547	8.8545	9.0567	9.2592
8.4551	8.6547	8.8545	9.0567
0.1996	0.1998	0.2022	0.2025

$\bar{X}$ 0.2010 x 1.00198 = 0.2014ml S = 0.0015 x 1.00198 = 0.0015 ml

continued on p. 17
Diana L. McMullin 2-7-92

Project No. _____ Date of Work _____

LRB 54370

Entered By _____ Date _____

Disclosed To and Understood By

Signed 1. D.K. Fadoff Date 2/18/92

2. _____ Date _____

1-17-92 10A-18 200λ 22°

13.6611	13.8605	14.0588	14.2578	14.4566
13.4640	13.6611	13.8605	14.0588	14.2578
.1971	.1994	1983	.1990	.1988

$\bar{X}$ = .1985 x 1.00221 = 198.9 ± 0.9 λ
S = .0009 x 1.00221 = .0009 G Brodzynski 1-17-92

10A-16 50λ 22° Balance 509-06-03-003

13.1866	13.2361	13.2857	13.3352	13.3845
13.1369	13.1866	13.2361	13.2857	13.3352
.0497	.0495	.0496	.0495	.0493

$\bar{X}$ = .0495 x 1.00221 = .0496
S = .00015 x 1.00221 = .00015 49.6 ± 0.2 λ

G G Brodzynski 1-17-92

10A-27 at 1500λ 22°

14.5630	16.0142	17.4612	18.9170	20.3714
13.1111	14.5630	16.0142	17.4612	18.9170
1.4519	1.4512	1.4470	1.4558	1.4544

$\bar{X}$ = 1.4521 x 1.00221 = 1.4553 1455.3 ± 3.4 λ
S = .0034 x 1.00221 = .0034

G G Brodzynski 1-17-92

1-20-92 Balance 510-06-01-006 wt check 100g = 100.01

G G Brodzynski 1-20-92

509-06-03-003 wt check 1.0g = 1.0001

G Brodzynski 1-20-92

Project No. _____ Date of Work _____
Entered By _____ Date _____
Disclosed To and Understood By
Signed 1. D. L. Tedeff Date 2/11/92
2. _____ Date _____

8

LRB-54372

Balance 509-06-03-003 wt Check 1g = 1.0001g 22°

pipet 10A-22 1000 λ

14.1840	15.1863	16.1849	17.1828	18.1792
13.1955	14.1840	15.1863	16.1849	17.1828
.9885	1.0023	.9986	.9979	.9964

19.1792	20.1799	21.1750	22.1687	23.1[illegible]
18.1792	19.1792	20.1799	21.1750	22.1687
1.0000	1.0007	.9951	.9937	.9955

$\bar{x}$ = 0.9969 x 1.00221 = 0.9991 999.1 ± 4.0 λ

S = .0040 x 1.00221 = .0040

G Bradaczynski 1-21-92

Balance 509-06-03-003 performance Check 500mg = .5000

G Bradaczynski 1-22-92

2-5-92 Balance 509-06-03-003

wt Check 1g = 1.0000 21°

pipet 10A-18 200 λ

13.3668				
13.1682	13.1682	13.5643	13.7605	13.9568
12.9692		13.3668	13.5643	13.7605
.1990	.1986	.1975	.1962	~~.1953~~ 0.1963

$\bar{x}$ = 0.1978 5* x 1.00198 = 0.1980 79* 8 = .0018 3* x 1.00198 = .0017 3* *ΔK9 2/11/92

pipet 10A-22 1000 λ

14.9490	15.9398	16.9299	17.9284	~~18.9101~~
13.9567	14.9490	15.9398	16.9299	17.9180
1.0923	.9908	1.0901	.9985	.9921

$\bar{x}$ = ~~1.0328~~ x 1.00198 = 1.0348 ml do not use this

S = ~~.0534~~ x 1.00198 = .0535 calibration. tip

Gwen G Bradaczynski 2-6-92 was apparently loose

Project No. _____ Date of Work _____

Entered By _____ Date _____

Disclosed To and Understood By

Signed 1. S. K. Fadoff Date 2/11/92

2. _____ Date _____

B04-006

LRB-54372 9

2-6-92 22° 509-06-03-003
1g = 1.000

10A-22 resate tip

14.2782	15.2719	16.2609	17.2506	19.2318
13.2838	14.2780	15.2719	16.2608	18.2371
.9944	.9939	.9890	.9900	.9947

$\bar{X}$ = 0.9924g x 1.00221 = 994.6λ
S = 0.0027 x 1.00221 = 2.7λ

Gwen G Brodzczyski 2-6-92

2-7-92 Balance check 509-06-03-003
1g. = 1.0001 g.
10 2-7-92
5~~0~~-06-01-006 5g. = 5.00

G Brodzczyski 2-7-92

2-10-92 Balance check 509-06-03-003
2g = 2.0000

Gwen G Brodzczyski 2-10-92
Reviewed to here S. K. Podey 2/10/92

2-11-92 Check wt 1g = 1.0002 509-06-03-003
project 10A-14 10λ temp. 22° vol factor 1.00221

13.2596	13.2695	13.2796	13.2896	13.2995
13.2496	13.2595	13.2695	13.2796	13.2896
.0100	.0100	.0101	.0100	.0099

$\bar{x}$ = .0100 x 1.00221 = 10.02λ
S = .000071 x 1.00221 = +.000071λ

Gwen G Brodzczyski 2-11-92

Project No. _____ Date of Work _____
Entered By _____ Date _____
Disclosed To and Understood By
Signed 1. S. K. Podey Date 2/26/92
2. _____ Date _____

B04-007

10

LRB 54372
2-12-92 Balance 509-06-03-003 Ck wt 1g = 1.0001
pipet 10A-25 25λ Temp = 22° Vol factor 1.00221

13.3041	13.3286	13.3530	~~13.3773~~	13.4017
13.2796	13.3041	13.3286	~~13.3286~~	13.3772
.0245	.0245	.0244	~~.0487~~	.0245

was interrupted pipetted twice discard. BB 2-12-92

13.4260
13.4017
.0243

$\bar{x}$ = 24.44 x 1.00221 = 24.49 λ
S = .089 x 1.00221 = .09 λ

500λ 10A-26

13.9155	14.4046	14.8959	15.3852	15.8789
13.4256	13.9155	14.4046	14.8959	15.3852
4899	.4891	.4913	.4893	.4937

$\bar{x}$ = .49066 x 1.00221 = 491.7 λ
S = .00190 x 1.00221 = 1.9 λ

G G Brodacznski 2-12-92

2-13-92 Balance 509-06-03-003 Check wt 1g - 1.000
sml pipettor 10A-27 22° 1.00221 Vol factor

33.9430	38.9439	43.9301	48.9191
28.9306	33.9430	38.9439	43.9301
5.0124	5.0009	4.9862	4.9890

~~54.2100~~	~~54.2070~~	59.1364
~~48.9191~~	~~48.9191~~	54.1897
~~909~~	~~889~~	4.9467

$\bar{x}$ = 4.9870 x 1.00221 = 4.9981 4.998ml ± .024ml
S = .02489 x 1.00221 = .02489

G G Brodacznski 2-13-92

Project No. _____ Date of Work _____
Entered By _____ Date _____
Disclosed To and Understood By
Signed 1. D. L. Fudge Date 2/26/92
2. _____ Date _____

2-13-92 Balance 509-06-03-003 21° 1.00198

200λ 10A 18

16.0485	16.2462	16.4432	16.6409	16.8386
15.8509	16.0485	16.2462	16.4432	16.6409
.1976	.1977	.1970	.1977	.1977

$\bar{X}$ = .1975 × 1.00198 = .1979 197.9 ± 0.3λ
S = .00030 × 1.00198 = .00031

G Brodaczynski 2-13-92

10-A-22 1000λ

14.2860	15.2748	16.2683	17.2726	18.2737
13.2915	14.2860	15.2748	16.2683	17.2726
.9945	.9888	.9935	1.0043	1.0011

$\bar{X}$ = 0.9953 × 1.00198 = 0.9972 (64*)
S = .0065 × 1.00198 = 0.0065 (64*)

998.4 ± 6.2 λ*
~~997.2 ± 6.5 λ~~
* S.K. Jadeff 2/26/92

G Brodaczynski 2-13-92

2.19.92 Balance 509.06-03-003 20° 1.00177 Vol factor

100λ - 10A-17 Cl. wt - 1g = 1.0001

13.1799	13.2784	~~13.3779~~	13.3764	13.4766
13.0802	13.1799	~~13.1799~~	13.2784	13.3764
.0997	.0985	~~5~~	.0980	.1002

13.5773
13.4766
.1007

$\bar{X}$ = .0994 × 1.00177 = .0996
S = .0011 × 1.00177 = .0011

G Brodaczynski 2-19-92

510-06-01-006 · 100g = 100.01 G Brodaczynski 2-19-92

2.20-92 Balance 509-06-03-003 2g = 2.0000

LRB 54372

Project No _____ Date of Work _____
Entered By _____ Date _____
Disclosed To and Understood By
Signed 1. S. K. Jadeff Date 2/26/92
2. _____ Date _____

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2-20-92
LRB 54372

Performance Check Bal# 509-06-03-033 2g : 2.0000
H_2O temp 21°C vol factor 1.00198

pipet # 10A-18 200λ

13.7568	13.9541	14.1531	14.3539
13.5577	13.7568	13.9541	14.1531
0.1991	0.1973	0.1990	0.2008

$\bar{x}$ = 0.1991 X 1.00198 = 0.1994 ml S = 0.0014 X 1.00198 = 0.0014 ml

pipet # 10A-22 1000λ

15.3567	16.3566	17.3496	18.3435
14.3539	15.3567	16.3566	17.3496
1.0028	0.9999	0.9930	0.9939

$\bar{x}$ = 0.9974 X 1.00198 = 0.9994 ml S = 0.0047 X 1.00198 = 0.0047 ml

Duane L. McMullen 2-20-92
Reviewed S.K. Tadyff 2/21/92

2-24-92 Performance Check Balance 509-06-03-003
1g = 1.0000
G Brodaczynski 2-24-92

2-25-92 Performance Check Balance 509-06-03-003
1g = 1.0000
G Brodaczynski 2-25-92

2-25-92 Balance 509-06-03-003 temp : 21° Vol. factor 1.001
pipette 10A-19 250λ

13.5175	~~13.7676~~	13.7676	14.0157	14.2656
13.2655	~~13.2655~~	13.5175	13.7676	14.0156
.2520	~~2X~~ 2-25-92	.2501	.2481	.2500

$\bar{X}$ = .2500 x 1.00198 = .2505 ml
S = .0016 X 1.00198 = .0016 ml
G Brodaczynski 2-25-92

Project No. _____ Date of Work _____
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2-27-92 Balance 509-06-03-003

Check wt 1g = 1.0000 22° = 1.00221 vol factor

150λ pipette # 5A-10

13.2615	13.4072	13.5542	13.7036
13.1133	13.2615	13.4072	13.5542
.1482	.1457	.1470	.1494

$\bar{x}$ = .1476 x 1.00221 = 147.9λ

S = .0016 x 1.00221 = 1.6λ

pipet calibrations 2-27-92 150λ & 500λ by GGB

500λ pipette # 10A-26

14.1990	14.6929	15.1846	15.6781
13.7034	14.1990	14.6929	15.1846
.4956	.4939	.4917	.4935

$\bar{x}$ = .4937 x 1.00221 = 494.8λ

S = .0016 x 1.00221 = 1.6λ

[illegible]
2-27-92

Attached to
LRB-54372 - pg 13

Reviewed by Diana L. McMullin 3-5-92

Project No. _____ Date of Work _____

Entered By _____ Date _____

Disclosed To and Understood By

Signed 1. _____ Date _____

2. _____ Date _____

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3-3-92 Performance check Balance 509-06-03-003
2g = 2.0000

G Bradacynski 3-3-92

3-4-92 Performance Check Balance 509-06-03-003
2g = 2.0001

G Bradacynski 3-4-92

3-5-92 Performance Check Balance 509-06-03-003
100mg = 0.1000

Gwen G Bradacynski 3-5-92
Reviewed S. L. Fedoff 3/5/92

Project No. _____ Date of Work _____
Entered By _____ Date _____
Disclosed To and Understood By
Signed 1. _____ Date _____
2. _____ Date _____