Environmental Health and Safety

One University Boulevard
Saint Louis, MO 63121-4499
Telephone: 314-516-6363
314-516-6362

Date: March 28, 2011
To: Lionel Rodriguez
Nuclear Regulatory Commission
From: Steven Struck
University of Missouri-St. Louis

Mr. Rodriguez,

Attached is the survey report revision 1 to the University's request to release laboratory R430 for unrestricted use. Included in this revision are the amended history of radiological usage of laboratory R430, beta survey results including screening levels and efficiencies for P-32, and expanded information concerning the survey approach used for Co-57.

Please contact me if you have any questions or concerns or if you need further information concerning the release of laboratory R430.

Respectfully,
Steven D. Struck
UMSL Radiation Safety Officer
(314)516-6362 Office
(314)516-6309 Fax

RECEIVED MAR 3 1 2011

From Science to Solutions

March 17, 2011

Dear Mr. Struck:

Enclosed you will find the results of the Research Building Laboratory 430 Survey Report Revision 1 performed by SAIC on March 10, 2011. If you have any questions regarding the results of this report, please do not hesitate to contact me at the phone number listed below.

I hope that you are satisfied with the results of this report and that we can do business again in the future.

Regards,

Eric Schrumpf

(314) 770-3005 (direct line)
(314) 393-3002 (cell phone)

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EXECUTIVE SUMMARY

The University of Missouri, St. Louis (UMSL) is authorized by U.S. Nuclear Regulatory Commission (NRC) Radioactive Materials License 24-00513-38, to possess radioactive materials. This report presents the results of a final status survey performed in the UMSL Research Building, laboratory room R-430 to demonstrate that residual levels of phosphorus-32 (P-32) and cobalt-57 (Co-57) , the only radionuclides used or stored in Room 430, were compliant with Nuclear Regulatory Commission (NRC) guidelines. The guideline used for this assessment for Co-57 is the screening level derived concentration guideline level (DCGL) prescribed in NRC NUREG 1757 for Co-57 (i.e., 2.1 x 10 disintegrations per minute per 100 square centimeters [dpm/100 cm]). Given the lack of a screening level DCGL for P-32, the "Acceptable Surface Contamination Levels" applicable to P-32 as specified in NRC Regulatory Guide 1.86 is used as the applicable criterion thus contamination is limited to an average of 5,000 dpm/100cm^2 with a maximum of 15,000 dpm/100cm^2 and a limit on removable activity of 1,000 dpm/100 cm^2.

Given that residual levels of radioactivity did not exceed the above stated values, it is concluded that Room 430 achieves levels prescribed in Title 10, Code of Federal Regulations, Part 20, Subpart E, for release without radiological restrictions.

1.0 INTRODUCTION

This report presents the results of surveys performed in laboratory R-430 at the University of Missouri – St. Louis (UMSL). The final status survey was requested by the UMSL Radiation Safety Officer (RSO) and performed by health physics staff of Science Applications International Corporation (SAIC). Radiological survey information was collected to confirm that residual radioactive material from UMSL licensed activities present inside laboratory R-430 was less than the acceptable screening levels. As listed in Table 1, the radionuclides of concern (ROC) are limited to Cobalt-57 (Co-57) and Phosphorus-32 (P-32). Radiological survey instrumentation was selected to maximize the ability to detect the gamma emissions from any Co-57 and the beta emissions from any P-32 that was present. Cobalt-57 decays by electron capture. Given that Co-57 decays by electron capture, assessment of gamma emissions was necessarily required while beta emissions of P-32 were evaluated for the presence of any residual P-32. A liquid scintillation counter was used to detect the presence of removable Co-57 and P-32. Surveys were performed consistent with the requirements stated in the Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM). Given the short half-life of P-32, the fact that P-32 had not been used or stored in the room in over 12 years and that surveys supported the conclusion that levels of radioactivity was in the range of background, designation as a MARSSIM Class 3 area was supportable. (See Appendix A for History of Radioactive Materials Used in Laboratory R-430 which reflects that it has been about 30 half-lives since P-32 was used or stored in R-430.) Nonetheless, appropriately conservative MARSSIM Class 2 surveys were implemented.

Table 1. Radionuclide Contaminant of Concern

Radionuclide	Half-life	Tenth Half-life	Principal Radiation
Co-57	271.8 days	7.5 years	Electron Capture (122 keV,136keV)
P-32	14.3 days	143 days	Beta (1710 keV max)

2.0 BACKGROUND

The use of the unsealed radionuclide Co-57 and P-32 had been previously authorized in the laboratory R-430 under the UMSL's U.S. Nuclear Regulatory Commission (NRC) radioactive materials license in the recent past.

In October of 2009, the current UMSL RSO requested that a survey be performed to verify that no residual licensed radioactive material in excess of the screening limits provided in Table 2 are detected in laboratory R-430.

Laboratory R-430

Laboratory R-430 is located in the Research Building and is approximately 7 m^2. The room is approximately 12' X 6'. The laboratory is a research room with cabinets on both sides. There is a fume hood as well as a sink in the room. A history of usage is attached in Appendix A.

3.0 SUMMARY OF SURVEY APPROACH

The NRC pre-established screening criteria for license termination will be used for the purpose of removing the laboratory from the UMSL NRC License. The "Screening Values of Common Radionuclides for Building-Surface Contamination Levels," as defined in NUREG 5512 Volume

3, lists "Decommissioning and Demolition (D&D) Screening Values." The screening level Derived Concentration Guideline Level (DCGL) specified represented the 90th percentile of the output dose distribution equivalent to 25 mrem/yr for Co-57. The NRC staff acknowledged that there are several areas in which modeling used to develop screening level DCGL was overly conservative. One such area is in the selection of resuspension factors. Consequently, NRC issued guidance in "*Re-Evaluation of the Indoor Resuspension Factor for the Screening Analysis of the Building Occupancy Scenario for NRC's License Termination Rule - Draft Report*" (NUREG-1720) which recommends a resuspension factor of 1×10^{-6} m^{-1}. SAIC recalculated Co-57 screening level DCGL using D&D Version 2.1 with the only change being the modification of the value of the resuspension factor to the recommended value of 1×10^{-6} m^{-1}. Using a 95 percent confidence level, this change resulted in derivation of the screening level DCGL as specified in Table 2. Nonetheless, given the small difference in the DCGL, the value of 2.1×10^{5} is carried forward as screening level DCGL.) Due to the short half-life of the P-32 it is unnecessary to survey for P-32. However, laboratory R-430 was surveyed with instrumentation capable of detecting P-32 beta emissions.

Table 1. Acceptable Screening Level for Unconditional Release

Radionuclide	Symbol	Acceptable Screening Level DCGL (dpm/100 cm^2)
Cobalt-57	Co-57	210.000
Phosphorus-32	P-32	Average: 5,000 Maximum: 15,000 Removable: 1,000

On 4 October 2009, an SAIC Health Physicist set-up, tested, and performed quality control checks on SAIC radiological instrumentation consisting of Ludlum 44-9 (pancake) beta-gamma detector and Ludlum Model 44-10 2-inch by 2-inch thallium-activated sodium iodide gamma detector. Initial set-up utilized UMSL NIST-traceable cesium-137 sources and was performed in the S-44 instrument calibration lab. Background measurements were taken in an adjacent laboratory with consistent contents and composition. In addition, UMSL's Packard Bell Liquid Scintillation Counter was set up by the UMSL RSO to measure the Co-57 gamma emissions (i.e., 122 keV and 136 keV) as well as the P-32 beta emissions. (Refer to Appendix C for the energy response curve for the Ludlum 44-10.) The laboratory was surveyed in accordance with guidance from MARSSIM. A background reference area was selected for use in quantifying background activity and variability. Based on surveys of the reference area, it was determined that a minimum of 8 systematic measurements should be collected in the reference area and in each class 2 area. This number was increased to 10 to ensure compliance with MARSSIM (SAIC 2008).

The scan minimum detectable concentration (MDC) and scan MDC were determined using the approach defined in MARSSIM to equate to 2,000 and 4,200, respectively. As such, both the static measurement and scan MDCs are capable of measuring P-32 at the stated limits from NRC Regulatory Guide 1.86. (Scan MDC calculations are in incorporated with survey results in Appendix B.)

For laboratory R-430, a MARSSIM Class 2 grid was placed over the area of both the floor and walls to a height of 6 feet above the floor. In addition, cabinets, sink, and fume hood were also surveyed. A systematic static measurement and removable contamination smear was collected from each location. The smear samples were collected by the SAIC HP, and then counted on the

UMSL liquid scintillation counter by the RSO. The efficiency of the UMSL liquid scintillation counter was 71% for Co-57 (PKRD 1995) and 98% for P-32. These efficiencies were subsequently used to calculate the removable activity of both P-32 and Co-57.

Laboratory R-430 was scanned with a Ludlum Model 44-10 sodium iodide detector coupled with a Ludlum Model 2221 scaler. Based on the energy response curve of the instrument compared to the COC, it was determined both that the instrument over-responded significantly to Co-57 relative to cesium-137 and could detect Co-57 at levels below the applicable screening level DCGL. Refer to Appendix C for instrument information to include calibration and quality control documentation. In addition to the Ludlum 44-10, Laboratory R-430 was scanned with a Ludlum Model 44-9 pancake GM detector to detect P-32. Static measurements were collected from twenty locations as well as a 100% scan on all accessible areas in laboratory R-430 including the inside of the ventilation hood. Refer to Appendix B for survey results.

The static counts for P-32 were converted to dpm/100cm^2 using the manufacturer's efficiency for P-32 using a 44-9 pancake GM detector. The radionuclide specific 4π efficiency from Ludlum is approximately 32%. The P-32 activity was determined, using the 2π efficiency, determined to be 0.231, a source efficiency of 0.50, and a probe correction factor of 0.155.

Laboratory R-430

As noted in Section 3 above, 100 percent of the floors, walls to a height of six feet above the floor, cabinets, and sink excluding p-trap internals, were surveyed. In addition, although ventilation screens and ducting were not within the scope of the survey effort, the interior portion of the fume hood was surveyed.

Survey results were recorded on standard SAIC forms as provided in health physics procedure HP-11, "Radiological Monitoring". The survey forms included a sketch of the laboratory and indicated the areas surveyed and are included in Appendix B.

4.0 SURVEY RESULTS

Survey forms and associated survey maps are provided in Appendix B to this report.

Instrument calibration and quality control check information is provided in Appendix C to this report.

Scan and fixed point (i.e., static) measurements revealed no areas of detectable radioactivity.

A total of 10 smear samples were collected from laboratory R-430 systematic locations. Removable activity as determined by the collection of swipes and their analysis by liquid scintillation counting exhibited results of up to 76 dpm/100 cm^2 above background. NRC guidance (NUREG-1757, Vol 2, Rev 1) states that "Screening levels are based on the assumption that the fraction of removable surface contamination is equal to 0.1. For cases when the fraction of removable contamination is undetermined or higher than 0.1, users may assume for screening purposes that 100% of surface contamination is removable, and therefore the screening levels should be decreased by a factor of 10." Assuming that 10% of the total activity was removable would result in total activity of 760 dpm/100cm^2 or about 0.3 percent of the DCGL. Given that the actual percentage of the total activity that is removable is commonly much lower, it is reasonable to assume a lower percent removable to establish and upper bound. As such, assuming a value of 0.001 (rather than 0.1) for the removable fraction of the total activity for Co-

57 activity at the University of Missouri, St. Louis would result in a worst case maximum of 76,000 dpm/100cm^2 or about one-third of the DCGL.

Modeling using MicroShield was used to calculate the dose rate 10 centimeters above a semi-infinite plane with contamination equating to the screening level DCGL results in a dose of 19 microroengen per hour. Given 8040 counts per minute per micro-roentgen per hour would result in 1.5 X 10^5 counts per minute on a Ludlum Model 44-10 with a 2-inch by 2-inch sodium iodide detector at a distance of 10 centimeters. The maximum count rate encountered on any surfaces within the room potentially contaminated with Co-57 is 8860 gross counts per minute with an average count rate of 7658 counts per minute and a reference area background of 7211 counts per minute. As such, it is reasonable to conclude that Co-57 contamination could not exceed a maximum of 1.1% of the DCGL and is reasonably about 0.3% of the limit based on the mean of the count rate measurements.

Maximum Co-57 Activity = (Max count – Background) / (1.5 X 10^5 cpm)

Maximum Co-57 = (8860 – 7211) / (1.5 X 10^5) = 1.1% of Screening Level DCGL

Average Co-57 Activity = (Avg count – Background) / (1.5 X 10^5 cpm)

Average Co-57 = (7658 – 7211) / (1.5 X 10^5) = 0.3% of Screening Level DCGL

5.0 CONCLUSIONS AND RECOMMENDATIONS

Radiological surveys confirm that P-32 and Co-57 are not present in Room R-430 of the UMSL Research Building at levels exceeding the criteria prescribed in Table 2 with all results being within the range of background. As such, this room is clearly compliant with NRC dose limits prescribed in 10 CFR 20 Subpart E for release without radiological restrictions and removal of this room from UMSL Radioactive Materials License 24-00513-38 is hereby requested.

6.0 REFERENCES

NRC 2006. U.S. NRC Radioactive Materials License for UMSL, No. 24-00513-38, Amendment No. 25, dated February 10, 2009.

NRC 2003. *Consolidated NMSS Decommissioning Guidance*, NUREG-1757, US Nuclear Regulatory Commission, Volume 2, Final, September, 2003, Table H-1, "Acceptable License Termination Screening Values of Common Radionuclides for Building-Surface Contamination".

NRC 1997. *Minimum Detectable Concentration with Typical Radiation Survey Instruments for Various Contaminants and Field Conditions*, NUREG-1507.

NRC 1997. *Multiagency Radiation Survey and Site Investigation Manual*, NUREG-1575.

NRC 2002. *Re-Evaluation of the Indoor Resuspension Factor for the Screening Analysis of the Building Occupancy Scenario for NRC's License Termination Rule-Draft Report*, NUREG-1720.

NRC 1999. Residual Radioactive Contamination from Decommissioning. Parameter Analysis, NUREG-5512.

PKRD 1995. *Tricarb LS Analizers Model 2100 TR, 2300 TR*, Packard Information Inc., 1995.

SAIC 2008. *Final Status Survey Report of Laboratories R-411, R-412, R-417, R-433, R-439, and S-466*, July

Appendix A

History of Radioactive Materials Use Areas

Environmental Health and Safety

One University Boulevard
Saint Louis, MO 63121-4499
Telephone: 314-516-6363
314-516-6362

Date: March 16, 2011

From: Steven Struck, UMSL RSO

Subject: History of Radioactive Materials Use in Lab R430 (Amended)

Memo NO.: RSM 09-01

In an amendment request dated September 10, 2010, The University of Missouri – St. Louis requested the removal of laboratory R430 from the list of Radioactive Materials Use Areas. On March 7, 2011, NRC inspector Lionel Rodriguez contacted the University ask asked for more information concerning the prior usage of lab R430. After investigating prior license amendments and interviews with Biology Department personnel, the following history has been determined.

Prior to the License Amendment dated October 15, 1998, laboratory R430 was used for the decay in storage of P-32 waste. This amendment added the Dangerous Chemical Storage Building as the University's location for decay in storage of radioactive wastes. Radioactive materials were removed from the laboratory R430 and it was surveyed for release, the University does not currently have on file records of this release survey, and the lab was used for common storage by the Biology Department.

In the University's application for license dated August 1, 2002, R430 is not listed in the Radioactive Materials Use Areas Chart. In a Facsimile dated January 15, 2003, the contract RSO, for reasons unknown to the University, made changes to the license application that included a Radioactive Materials Use Areas Chart which listed R430 and other labs not included in the 2002 application. The additional areas added by this facsimile have been surveyed and released for unrestricted use in the license amendment #25 dated May 1, 2009, except for R430, due to the laboratory being in use at the time of the surveys.

On January 14, 2004, the University of Missouri- St. Louis sent a letter to the Nuclear Regulatory Commission requesting an amendment to its license, including the addition of laboratories R423 and R430 of the Research Building for the use and storage of radioactive materials by Dr. Colin MacDiarmid.

After receiving NRC approval for this amendment, and approval from the Missouri Department of Health and Senior Services to possess Co-57, Dr. MacDiarmid received 1mCi of cobalt 57 on May 9, 2006. The cobalt 57 was stored and used only in lab R430, no other radioactive material was possessed in lab R423.

On July 28, 2009, Dr. MacDiarmid informed the Radiation Safety Officer that he was leaving the University and would no longer need to use or store Co-57 in lab R430. On July 31, 2009, all radioactive materials were removed from R430 and placed in the radioactive waste storage facility.

On October 4, 2009, the University conducted a release survey of lab R430 and found no indications of residual radioactive materials. Additional survey readings were taken on March 10, 2011, including beta energy readings due to the discovery of prior P-32 storage usage of the laboratory. Again no indications of residual radioactive materials were found.

Steven D. Struck
UMSL Radiation Safety Officer
(314) 516-6362

Appendix B

Radiological Survey Forms, Maps, and Calculations

SAIC RADIOLOGICAL SURVEY REPORT

SURVEY LOCATION: UMSL Lab R-430 | HSWP: NA | Page 1 of 1

PURPOSE OF SURVEY: Smear Results for R-430 | DATE: 10/4/09 | TIME: 1145

Instrument Type(s):	Detector Area (cm²)	Serial Number: meter	Serial Number: detector	Cal. Due Date meter	Cal. Due Date detector	Background: (CPM) Alpha (α)	Background: (CPM) Beta (βγ)	Efficiency: (%) Alpha (α)	Efficiency: (%) Beta (βγ)
☒ Ludlum 2929 / 43-10-1 ___	100	UMSL	Liquid	Scintillation	Counter	NA	46	NA	71.0%
☐ Ludlum 2360 / 43-89 ___	125								
☐ Ludlum 2221 / 44-9 ___	15.5								
☐ Micro - R ___	N/A								

Contamination Limits: (dpm/100cm²)	Removable α ___	Removable βγ 230000	Total α ___	Total βγ ___
Instrument MDA: (dpm/100cm²)	α MDA ___	βγ MDA NA	α MDA ___	βγ MDA ___

Sample No.	Description / Location	Gross CPM α Removable	Net CPM α Removable	dpm/100cm² α Removable	Gross CPM β Removable	Net CPM β Removable	dpm/100cm² β Removable	Gross CPM α Total	Net CPM α Total	dpm/100cm² α Total	Gross CPM β Total	Net CPM β Total	dpm/100cm² β Total	uR/hr
1	Floor by entrance				44	0	0							
2	Floor under table				50	4	6							
3	Floor by hood				44	0	0							
4	Floor by table				40	0	0							
5	Wall				56	10	14							
6	Wall				48	2	3							
7	Wall by hood				45	0	0							
8	Wall by hood				45	0	0							
9	Wall by shelf				40	0	0							
10	Wall by door				53	7	10							

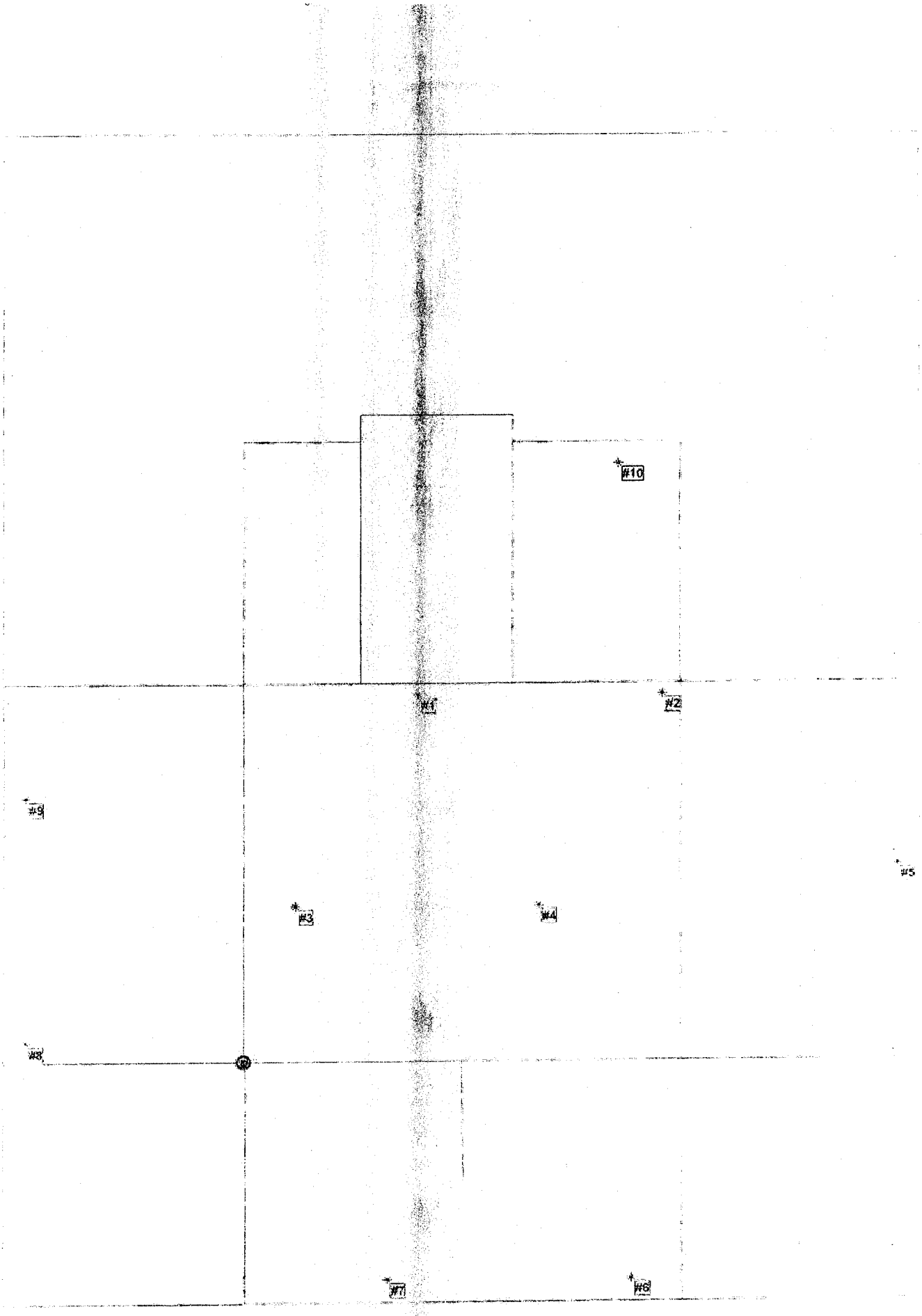
REMARKS: UMSL Liquid Scintillation Counter used to count smears. See attached print out of sample results and sample locations.

TECHNICIAN(S) SIGNATURE/ DATE: [signature] / 10/4/09 ___ / ___

REVIEWER SIGNATURE/ DATE: [signature] / ___ / ___

Output #: 5 Name:Co-57 14-Oct-2009 11:43
Region A: LL-UL= 0.0-120. Lcr= 0 Bkg= 0.00 %2 Sigma=0.00
Region B: LL-UL= 0.0-136. Lcr= 0 Bkg= 0.00 %2 Sigma=0.00
Region C: LL-UL= 0.0-2000 Lcr= Bkg= 0.00 %2 Sigma=0.00
Cmu = 1.00 CIP = SIS

C#	TIME	CPMA	CPMA	CPMC	SIS	FLAG
1	1.00	36.00	36.00	46.00	55.016	Background
2	1.00	28.00	28.00	44.00	56.452	
3	1.00	30.00	30.00	50.00	77.842	
4	1.00	29.00	29.00	44.00	76.929	
5	1.00	23.00	23.00	40.00	37.124	
6	1.00	36.00	36.00	56.00	70.620	
7	1.00	27.00	27.00	48.00	130.95	
8	1.00	24.00	24.00	45.00	56.689	
9	1.00	26.00	26.00	45.00	119.70	
10	1.00	24.00	24.00	40.00	84.864	
11	1.00	33.00	33.00	53.00	42.897	


#10
#1
#2
#9
#5
#3
#4
#8
#7
#6

Area: Area 1

X Coord	Y Coord	Z Coord	Label	Value	Type	Historical	Surface	LX	LY
61	8	0	#3	0	Systematic		Floor	1	4
67	8	0	#4	0	Systematic		Floor	7	4
64	13	0	#1	0	Systematic		Floor	4	9
70	13	0	#2	0	Systematic		Floor	10	9
63	4	5	#7	0	Systematic		Wall 4	7	5
70	4	5	#6	0	Systematic		Wall 4	1	5
71	9	5	#5	0	Systematic		Wall 3	5	5
69	13	5	#10	0	Systematic		Wall 2	9	5
60	10	5	#9	0	Systematic		Wall 1	7	5
60	4	5	#8	0	Systematic		Wall 1	1	5

SAIC - MINIMUM DETECTABLE CONCENTRATION (MDC) WORKSHEET [4]

Survey Number:	UMSL R-430	Date:	3/10/2011	Inst. Letter:	A

Alpha		Beta	
$Static\ MDC = \dfrac{3 + 3.29\sqrt{(R_b)(t_g)\left(1+\frac{t_g}{t_b}\right)}}{(t_g)(\varepsilon_i)(\varepsilon_s)\left(\frac{Probe\ Area}{100}\right)}$	Alpha *Static MDC* = #DIV/0! (dpm/100cm^2)	$Static\ MDC = \dfrac{3 + 3.29\sqrt{(R_b)(t_g)\left(1+\frac{t_g}{t_b}\right)}}{(t_g)(\varepsilon_i)(\varepsilon_s)\left(\frac{Probe\ Area}{100}\right)}$	Beta *Static MDC* = 2,005 (dpm/100cm^2)
$P(n \geq 1) = 1 - e^{\frac{(-G)(\varepsilon_i)(d)}{(60)(v)}}$	Alpha Scan Probability = #DIV/0! (should be ≥ 0.85)	$i = \frac{w}{s}$ $MDCR = d\sqrt{b*\left(\frac{i}{60}\right)}*\left(\frac{60}{i}\right)$ $MDC = \frac{MDCR}{(\sqrt{p})(\varepsilon_i)(\varepsilon_s)\left(\frac{Probe\ Area}{100}\right)}$	i = 2.0 $MDCR$ = 53 Beta Scan *MDC* = 4,222 (dpm/100cm^2)

Alpha Information			Beta Information		
Background count rate (R_b)		(cpm)	Background count rate (R_b) or (b)	50	(cpm)
Background count time (t_b)		(minutes)	Background count time (t_b)	1	(minutes)
Sample count time (t_g)		(minutes)	Sample count time (t_g)	1	(minutes)
Instrument efficiency (e_i)		(cpm/dpm)	Instrument efficiency (e_i)	0.231	(cpm/dpm)
Surface efficiency (e_s)		(decimal)	Surface efficiency (e_s)	0.5	(decimal)
Probe area (PA)		(cm^2)	Probe area (PA)	15.5	(cm^2)
Width of the probe face (d) or (w)	7.6	(cm)	Width of the probe face (w) or (d)	5	(cm)
Scan speed (v) or (s)		(cm/sec)	Scan speed (s) or (v)	2.5	(cm/sec)
-----	-----	-----	Index of detectability (d')	1.38	-----
-----	-----	-----	Surveyor efficiency (p)	0.5	-----
Investigation level (G)		(dpm/100cm^2)	-----	-----	-----

1 in/sec = 2.5 cm/sec 2 in/sec = 5.1 cm/sec 3 in/sec = 7.6 cm/sec : The width of the probe face for a Ludlum 44-9 is approximately 5 cm

RADIOLOGICAL SURVEY REPORT

SURVEY LOCATION: Universtiy of Missouri St. Louis	RWP: NA	Page 1 of 3	
PURPOSE OF SURVEY: FSSE Laboratory R-430	DATE: 3/10/11	TIME: 0900	

Instrument Type(s):		Detector Area (cm²)	Serial Number: meter	Serial Number: detector	Cal. Due Date meter	Cal. Due Date detector	Background: (CPM) Alpha (α)	Background: (CPM) Beta (βγ)	Efficiency: (%) Alpha (α)	Efficiency: (%) Beta (βγ)
☐ Ludlum 2929 / 43-10	NA	N/A								
☐ Ludlum 2360 / 43-89	NA	125								
☐ Ludlum 2221 / 44-9	A	15.5	212129	197792	9/8/11	9/8/11	N/A	50	N/A	23.1%
☐ Ludlum 2221/44-10	A	N/A	155595	N/A	5/13/11	N/A	N/A	7211	N/A	NA

Contamination Limits: (dpm/100cm²)		Removable α			Removable βγ			Total α			Total βγ			
Sample No.	Description / Location	Gross CPM α Removable	Net CPM α Removable	dpm/100cm² α Removable	Gross CPM β Removable	Net CPM β Removable	dpm/100cm² β Removable	Gross CPM α Total	Net CPM α Total	dpm/100cm² α Total	Gross CPM β Total	Net CPM β Total	dpm/100cm² β Total	Gross CPM γ Total
1	Floor #1										51	1	56	7362
2	Floor #2										46	0	0	7136
3	Floor #3										39	0	0	6757
4	Floor #4										54	4	223	6722
5	Floor #5										34	0	0	7619
6	Floor #6										41	0	0	7064
7	Floor #7										37	0	0	7427
8	Floor #8										40	0	0	8083
9	Floor #9										39	0	0	7699

REMARKS: Measurements were collected on contact. Measurements were collected at systematic locations as well as 10 additional locations to ensure enough data was collected.

TECHNICIAN(S) SIGNATURE/ DATE: [signature] 3-17-11 /

REVIEWER SIGNATURE/ DATE: [signature] 3-17-11 /

RADIOLOGICAL SURVEY REPORT

SURVEY LOCATION: University of Missouri - St. Louis

Contamination Limits: (dpm/100cm²)		Removable α _____			Removable βγ _____			Total α			Total βγ			
Sample No.	Description / Location	Gross CPM α Removable	Net CPM α Removable	dpm/100cm² α Removable	Gross CPM β Removable	Net CPM β Removable	dpm/100cm² β Removable	Gross CPM α Total	Net CPM α Total	dpm/100cm² α Total	Gross CPM β Total	Net CPM β Total	dpm/100cm² β Total	Gross CPM γ Total
10	Floor #10										50	0	0	7917
11	Wall #1										33	0	0	8449
12	Wall #2										39	0	0	7203
13	Wall #3										37	0	0	8205
14	Wall #4										46	0	0	8272
15	Wall #5										44	0	0	6525
16	Wall #6										40	0	0	8860
17	Wall #7										45	0	0	8031
18	Wall #8										47	0	0	7810
19	Wall #9										32	0	0	7914
20	Wall #10										37	0	0	8096
21														
22														
23														
24														

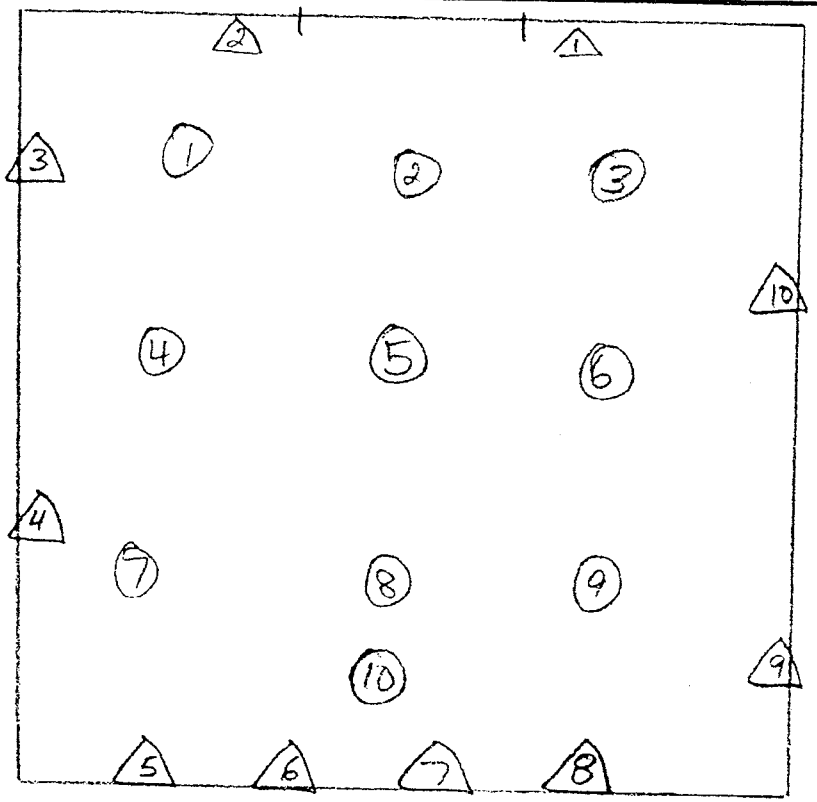
REMARKS: Measurements were collected with on contact. Measurements were collected at systematic locations as well as 10 additonal locations to ensure enough data was collected.

TECHNICIAN(S) SIGNATURE/ DATE: [signature] 3-17-11 /

REVIEWER SIGNATURE/ DATE: [signature] 3-17-11 /

RADIOLOGICAL SURVEY REPORT

SURVEY LOCATION: UMSL R-430	RWP: NA	Page 3 of 3
LEGEND: (fill in blank) NA = Smear Location NA = G/A Dose Rate ☐ mR/hr ☐ uR/hr	DATE: 3/10/11	TIME: 0900



(#) Floor Location

△# Wall Location

44-10 Bkgd = 7211 cpm

44-9 Bkgd = 50 cpm

REMARKS:

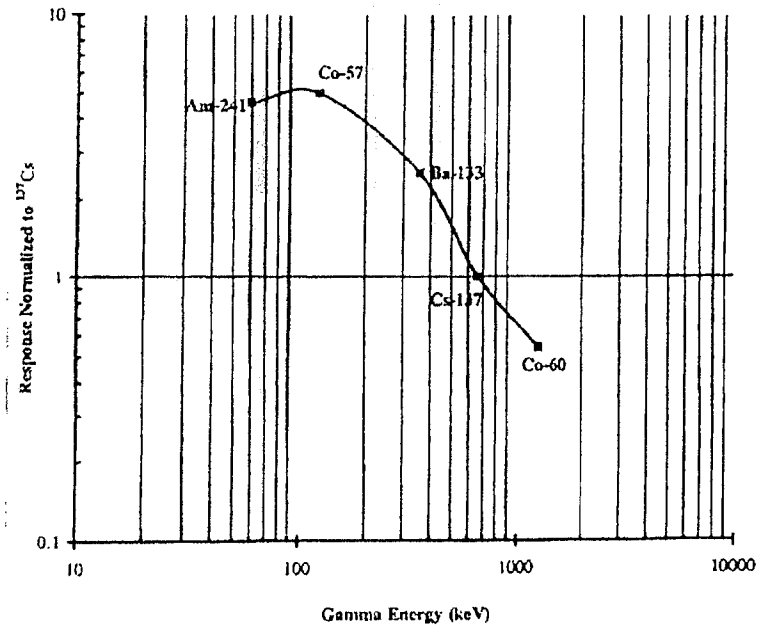
TECHNICIAN(S) SIGNATURE/ DATE: [signature] 3-17-11 /

REVIEWER SIGNATURE/ DATE: Jennifer R. Chambert 3-17-11 /

Appendix C

Survey Instrument Calibration and Quality Control Information

Energy Response for Ludlum Model 44-10



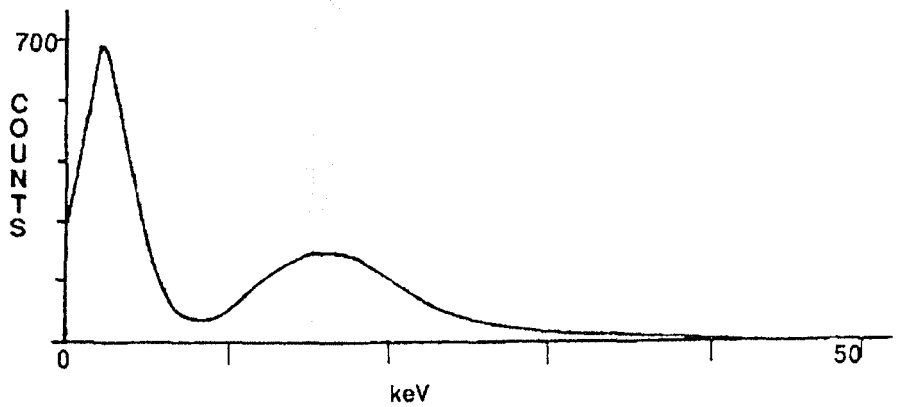


Figure 3-10. Spectrum Plot of ^{125}I Using LSC.

Spectrum Analysis can be successfully applied to quantify and qualify gamma radionuclides. Modern liquid scintillation analysis (LSA) techniques such as Spectrum Unfolding and Transformed Spectral Index (tSIE) calculations allow fast counting of gamma radionuclides, even for multilabel experiments involving beta and gamma emitters. Gamma–emitting radionuclides can often be counted with equal or higher counting efficiencies by a liquid scintillation analyzer than with a gamma counter. Table 3–1 compares the approximate counting efficiencies for a number of frequently used radionuclides.

Table 3–1 Approximate counting efficiencies for gamma radionuclides in a liquid scintillation analyzer (LSA) and a gamma counter.

Table 3-1. Approximate Counting Efficiencies.

Radionuclide	LSA Efficiency*	Gamma Counter Efficiency**
^{22}Na	96%	56%
^{51}Cr	34%	4 to 5%
^{57}Co	71%	78%
^{59}Fe	95%	25%
^{125}I	78%	78%

*Samples were counted in Packard Insta–Gel® cocktail.
**Measured with a 2–inch NaI (Tl) detector.

Typical Detection Efficiencies For Radionuclides

NUCLEAR DATA					COUNTING DATA Detection Efficiencies				
							Gamma		
Nuclide	Half-life	Radiation	Max energy (MeV)	Abundance %	LSC	Cerenkov	2"	3"	ET Counting
H-3	12.43y	Beta	0.018	100	60	NA	NA	NA	No
C-14	5730y	Beta	0.156	100	95	NA	NA	NA	Yes
Na-22	2.6y	Beta Beta EC Gamma Gamma	0.54 1.83 0.004 0.51 1.28	90 0.06 10 90 100	90	–	30	55	Yes
Na-24	15h	Beta Gamma Gamma	1.39 1.37 2.75	99 99 99	97	32.5	–	–	Yes
P-32	14.3d	Beta	1.71	100	98	40	NA	NA	Yes
P-33	25.3d	Beta	0.25	100	96	NA	NA	NA	Yes
S-35	87.2d	Beta	0.167	100	95	NA	NA	NA	Yes
Cl-36	3.1×10^5y	Beta EC	0.709 0.005	98 1.9	98	4.5	NA	NA	Yes
K-40	1.26×10^9y	Beta Gamma	1.31 1.46	89 11	96	35	1.2	2.2	Yes
K-42	12.4h	Beta Beta Gamma Gamma	3.5 1.97 1.54 0.31	82 18 18 0.2	96	70	5.6	7.9	Yes
Ca-45	165d	Beta	0.25	100	96	NA	NA	NA	Yes
Cr-51	27.8d	EC Gamma	0.005 0.32	100 8	35	NA	5.4	6	No
Mn-54	312d	Gamma EC	0.835 0.005	100 100	35	NA	17	22	No
Fe-55	2.6y	EC	0.006	100	36	NA	NA	NA	No
Co-57	271.8	EC Gamma Gamma Gamma	0.006 0.014 0.122 0.136	100 9 89 11	80	NA	80	85	No
Co-58	71d	EC Beta Gamma Gamma Gamma Gamma	0.006 0.47 0.81 0.87 0.51 1.61	85 15 100 1.4 15 0.6	15	NA	42	56	No

2221 Scaler/Ratemeter Calibration Report

Date Calibrated: 05/05/2009 11:52:27 AM

Technician: B. French Customer: SAIC Order Number SAIC20090505-007

Temperature (F): 73 Humidity (%): 30 Altitude (asl): 660 Barametric Pressure ("Hg): 29.15

Repair Instrument

Serial Number: 149971 Manufacturer: Ludlum Model: 2221 Meterface: 202-159

Received: Within 10%

Last Calibrated: 4/29/2008 Calibration Interval: 1yr. Next Calibration Due: 5/5/2010

- [x] Mechanical OK
- [x] Meter Zeroed
- [x] Battery Ck. - Min. Volt.
- [x] Input Sens. Linearity
- [x] F/S Resp. OK
- [x] Reset OK
- [x] Geotropism
- [x] Window Operation
- [x] Audio OK
- [ ] Alarm Setting OK
- [ ] Background Subtract
- [x] Voltage Set 1300 V at 10 mV Det. Op. 1300 V at 10 mV Threshold Dial ratio 100 = 10
- [x] HV readout Ref. 1 500 Volts Inst. 1 500 Volts Ref. 2 2000 Volts Inst. 2 2000 Volts
- [x] Calibrated in accordance with ANSI N323A-1997 and the manufacturers procedure

CTV* Analog Reading

Multiplier	Ref. Cal Poin	Inst. As Found	Inst. As Left
X 1000	400 K cpm	400 K cpm	400 K cpm
X 1000	100 K cpm	100 K cpm	100 K cpm
X 100	40 K cpm	40 K cpm	40 K cpm
X 100	10 K cpm	10 K cpm	10 K cpm
X 10	4 K cpm	4 K cpm	4 K cpm
X 10	1 K cpm	1 K cpm	1 K cpm
X 1	400 cpm	400 cpm	400 cpm
X 1	100 cpm	100 cpm	100 cpm

- [x] Multimeter ser. # 93470436
- [ ] Oscilloscope ser. #
- [x] m500 ser. # 201462
- [ ] Other ser. #

CTV* Digital

Reference Pt.	Inst. as Found	Inst. as Left
400 K cpm	40010 (0) cpm	39995 (0) cpm
40 K cpm	3997 (0) cpm	4000 (0) cpm
4 K cpm	400 (0) cpm	400 (0) cpm
400 cpm	40 (0) cpm	40 (0) cpm
40 cpm	4 (0) cpm	4 (0) cpm

CTV* Log Scale

Reference Pt.	Inst. as Found	Inst. as Left
500 K cpm	450 K cpm	450 K cpm
50 K cpm	50 K cpm	50 K cpm
5 K cpm	5 K cpm	5 K cpm
500 cpm	500 cpm	500 cpm
50 cpm	50 cpm	50 cpm

* Conventionally True Value ** Uncertainty within +/- 10% All range(s) calibrated electronically

Comments

Performed By: _____ Date: _____

Reviewed By: _____ Date: _____

44-10 Gamma Calibration Report

Date Calibrate 05/05/2009 Time: 12:03:56 PM Customer: SAIC

Technician: B. French Order Number: SAIC20090505-008

Repair Instrument

Serial Number 155593

Manufacture Ludlum Model: 44-10 Last Calibrated: 10/25/2006

Reason for recalibration: Due for Calibration

Calibration Instrument

Serial Number: 149971 Inst. Type: 2221 Calibration Due: 5/5/2010

Calibration Sources

Gamma Source ID: SAIC-0051

Isotope: Cs-137 Current Activity: 6.66 uCi Assay Date: 12/11/1998

Gamma as Found

Background 1 minute counts	Source 1 minute counts
NA	NA

Percent Efficiency: NA

Gamma as Left

Background 1 min. counts	Source 1 min. counts
6679	110762

Percent Efficiency: NA

Physical Condition: Sat High Voltage: 1300 Volts

Last Calibrated Efficiency: NA Gamma Threshold: 10 mv Next Calibration Due: 5/5/2010

No efficiency calculated, use for qualitative data only

Performed By: _____ Date: _____

Reviewed By: _____ Date: _____

PLATEAU CALIBRATION

Model #: 44-10 Source I.D.: SAIC-0051

Serial #: 155573 Attach. N/A

Calibration Points (Volts)	Background Counts	Source Counts
300		
350		
400		
450		
500		
550		
600		
650		
700		
750		
800		
850	4480	95582
900	5493	101040
950	6061	103349
1000	6058	105208
1050	6271	107873
1100	6578	108474
1150	6603	109648
1200	6554	109573
1250	6479	110127
1300	6679	110702
1350	6684	110470
1400	6564	111769
1450	6914	113268
1500	7557	121020

Determined HV Settings: 1300 V Determined Threshold Setting: 10mV

Reviewed By: [signature] Date: 5/7/09

SAIC
An Employee-Owned Company
500 Northwest Plaza
Suite 1250
St. Ann, MO 63074
(314) 209-2950 Phone

Scaler/Ratemeter Calibration Report

Date Calibrated: 05/13/2010 3:53:03 PM Order Number: SAIC20100513-004

Technician: B. French Customer: SAIC

Temperature (F): 73 Humidity (%): 42 Altitude (asl): 660 Barametric Pressure ("Hg): 29.35

Repair Instrument

Serial Number: 149966 Manufacturer: Ludlum Model: 2221 Meterface: 202-159

Received: Within 10%

Last Calibrated: 5/5/2009 Calibration Interval: 1 yr. Next Calibration Due: 5/13/2011

- [x] Mechanical OK
- [x] Meter Zeroed
- [x] Battery Ck. - Min. Volt.
- [ ] Input Sens. Linearity
- [x] F/S Resp. OK
- [x] Reset OK
- [x] Geotropism
- [x] Window Operation
- [x] Audio OK
- [ ] Alarm Setting OK
- [ ] Background Subtract
- [x] Voltage Set 950 V at 10 mV Det. Op. 950 V at 10 mV Threshold Dial ratio: 100 = 10
- [x] HV readout **Ref. 1** 500 Volts **Inst. 1** 500 Volts **Ref. 2** 1997 Volts **Inst. 2** 2000 Volts
- [x] Calibrated in accordance with ANSI N323A-1997 and the manufacturers procedure

CTV* Analog Reading

Multiplier	Ref. Cal Poin	Inst. As Found	Inst. As Left
X 1000	400 K cpm	400 K cpm	400 K cpm
X 1000	100 K cpm	100 K cpm	100 K cpm
X 100	40 K cpm	40 K cpm	40 K cpm
X 100	10 K cpm	10 K cpm	10 K cpm
X 10	4 K cpm	4 K cpm	4 K cpm
X 10	1 K cpm	1 K cpm	1 K cpm
X 1	400 cpm	400 cpm	400 cpm
X 1	100 cpm	100 cpm	100 cpm

- [x] Multimeter ser. # 76130105
- [ ] Oscilloscope ser. #
- [x] m500 ser. # 154177
- [ ] Other ser. #

CTV* Digital

Reference Pt.	Inst. as Found	Inst. as Left
400 K cpm	39987 (0) cpm	39995 (0) cpm
40 K cpm	3998 (0) cpm	4000 (0) cpm
4 K cpm	400 (0) cpm	400 (0) cpm
400 cpm	40 (0) cpm	40 (0) cpm
40 cpm	4 (0) cpm	4 (0) cpm

CTV* Log Scale

Reference Pt.	Inst. as Found	Inst. as Left
500 K cpm	500 K cpm	500 K cpm
50 K cpm	50 K cpm	50 K cpm
5 K cpm	5 K cpm	5 K cpm
500 cpm	500 cpm	500 cpm
50 cpm	50 cpm	50 cpm

* Conventionally True Value ** Uncertainty within +/- 10% All range(s) calibrated electronically

Comments

Performed By: Date: 5/13/10

Reviewed By Date: 5/19/10

Calibration Certificate
PLATEAU CALIBRATION

Model #: 44-10 Source I.D.: SAIC-0051

Serial #: 155595 Attach. N/A

Calibration Points (Volts)	Background Counts	Source Counts
300		
350		
400		
450		
500		
550		
600		
650		
700	2201	91050
750	2965	98032
800	3526	101890
850	3788	105355
900	3850	108502
950	4089	108661
1000	3950	109307
1050	4123	108922
1100	4137	110304
1150	4275	111558
1200	4706	122146
1250	6084	172579
1300		
1350		
1400		
1450		
1500		

Determined HV Settings: 950 Determined Threshold Setting: 10mV

Reviewed By: [signature] Date: 5/19/10

SAIC
An Employee-Owned Company
500 Northwest Plaza
Suite 1250
St. Ann, MO 63074
(314) 209-2950 Phone

Gamma Calibration Report

Date Calibrate 05/13/2010 Time: 3:56:31 PM Customer: SAIC

Technician: B. French Order Number: SAIC20100513-005

Repair Instrument

Serial Number: 155595

Manufacturer: Ludlum Model: 44-10 Last Calibrated: 5/5/2009

Reason for recalibration: Due for Calibration

Calibration Instrument

Serial Number: 149966 Inst. Type: 2221 Calibration Due: 5/13/2011

Calibration Sources

Gamma Source ID: SAIC-0051

Isotope: Cs-137 Current Activity: 6.51 uCi Assay Date: 12/11/1998

Gamma as Found

Background 1 minute counts	Source 1 minute counts
NA	NA

Percent Efficiency: NA

Gamma as Left

Background 1 minute counts	Source 1 minute counts
4089	108661

Percent Efficiency: NA

Physical Condition: Sat High Voltage: 950 Volts

Last Calibrated Efficiency: NA Gamma Threshold: 10 mv Next Calibration Due: 5/13/2011

No efficiency calculated, use for qualitative data only

Performed By: _____ Date: 5/13/10

Reviewed By: _____ Date: 5/19/10

Scaler/Ratemeter Calibration Report

Date Calibrated: 09/08/2010 9:32:17 AM Order Number: SAIC HARRISBURG20100908-001

Technician: B. French Customer: SAIC HARRISBURG

Temperature (F): 75 Humidity (%): 39 Altitude (asl): 660 Barametric Pressure ("Hg): 29.5

Repair Instrument

Serial Number: 197792 Manufacturer: Ludlum Model: 2221 Meterface: 202-159

Received: Within 10%

Last Calibrated: 9/17/2009 Calibration Interval: 1 yr. Next Calibration Due: 9/8/2011

- [x] Mechanical OK
- [x] Meter Zeroed
- [x] Battery Ck. - Min. Volt.
- [ ] Input Sens. Linearity
- [x] F/S Resp. OK
- [x] Reset OK
- [x] Geotropism
- [x] Window Operation
- [x] Audio OK
- [ ] Alarm Setting OK
- [ ] Background Subtract
- [x] Voltage Set 900 V at 55 mV Det. Op. 900 V at 55 mV Threshold Dial ratio: 100 = 10
- [x] HV readout **Ref. 1** 498 Volts **Inst. 1** 500 Volts **Ref. 2** 2003 Volts **Inst. 2** 2000 Volts
- [x] Calibrated in accordance with ANSI N323A-1997 and the manufacturers procedure

CTV* Analog Reading

Multiplier	Ref. Cal Poin	Inst. As Found	Inst. As Left
X 1000	400 K cpm	400 K cpm	400 K cpm
X 1000	100 K cpm	100 K cpm	100 K cpm
X 100	40 K cpm	40 K cpm	40 K cpm
X 100	10 K cpm	10 K cpm	10 K cpm
X 10	4 K cpm	4 K cpm	4 K cpm
X 10	1 K cpm	1 K cpm	1 K cpm
X 1	400 cpm	400 cpm	400 cpm
X 1	100 cpm	100 cpm	100 cpm

- [x] Multimeter ser. # 93470436
- [ ] Oscilloscope ser. #
- [x] m500 ser. # 201462
- [ ] Other ser. #

CTV* Digital

Reference Pt.	Inst. as Found	Inst. as Left
400 K cpm	40012 (0) cpm	39995 (0) cpm
40 K cpm	4000 (0) cpm	4000 (0) cpm
4 K cpm	400 (0) cpm	400 (0) cpm
400 cpm	40 (0) cpm	40 (0) cpm
40 cpm	4 (0) cpm	4 (0) cpm

CTV* Log Scale

Reference Pt.	Inst. as Found	Inst. as Left
500 K cpm	500 K cpm	500 K cpm
50 K cpm	50 K cpm	50 K cpm
5 K cpm	5 K cpm	5 K cpm
500 cpm	500 cpm	500 cpm
50 cpm	50 cpm	50 cpm

* Conventionally True Value ** Uncertainty within +/- 10% All range(s) calibrated electronically

Comments

Performed By: [signature] Date: 9/8/10

Reviewed By [signature] Date: 9/9/10

Beta Calibration Report

Date Calibrated: 09/08/2010 9:50:33 AM Order Number: SAIC HARRISBURG20100908-002

Technician: B. French Customer: SAIC HARRISBURG

Repair Instrument

Serial Number: 212129 Manufacturer: Ludlum Model: 44-9 Last Calibrated: 9/17/2009

Reason for recalibration: Due for Calibration

Calibration Instrument

Serial Number: 197792 Inst. Type: 2221 Calibration Due: 9/8/2011

Calibration Sources

4π	Beta Source ID: SAIC-0001	Isotope: SrY-90	Current Activity: 9842.02dpm	Assay Date: 3/23/2004
2π	Beta Source ID: SAIC-0001	Isotope: SrY-90	Current Activity: 6889.42cpm	Assay Date: 3/23/2004

Beta as Found	Beta as Left
Background 1 min. counts NA	Background 1 min. counts 33
Source 1 min. counts NA	Source 1 min. counts 2075
4π % efficiency: 0	4π % efficiency: 20.75
2π % efficiency: 0	2π % efficiency: 29.64

Beta Threshold: 55mV High Voltage: 900V Next Calibration Due: 9/8/2011

Comments

Performed By: [signature] Date: 9/8/10

Reviewed By [signature] Date: 9/9/10

ASST #16134

EBERLINE SERVICES

CERTIFICATE OF CALIBRATION

Electroplated Beta Standard

S.O.# 6620
P.O.# 2007000355

Description of Standard:

Model No. DNS-14 Serial No. 5781-07 Isotope SrY-90

Electroplated on polished Ni disc, 0.79 mm thick.

Total diameter of 4.77 cm and an active diameter of 4.45 cm.

The radioactive material is permanently fixed to the disc by heat treatment without any covering over the active surface.

Measurement Method:

The 2pi beta emission rate was measured using an internal gas flow proportional chamber. Absolute counting of beta particles emitted in the hemisphere above the active surface was verified by counting above, below, and at the operative voltage. The calibration is traceable to NIST by reference to an NIST calibrated beta source S/N 4002-02.

Measurement Result:

The observed beta count rate from the surface of the disc per minute (cpm) on the calibration date was:

11,900 ± 357

The total disintegration rate (dpm) assuming 40 % backscatter of beta particles from the surface of the disc, was:

17,000 ± 511 (0.00768 μCi)

The uncertainty of the measurement is 3 %, which is the sum of random counting error at the 99% confidence level, and the estimated upper limit of systematic error in this measurement.

Calibrated by: ART REUST Reviewed by: [signature]

Calibration Technician: [signature] for Q.A. Manager: [signature]

Calibration Date: 4-17-2007 Reviewed Date: 4-18-2007

7021 Pan American Freeway NE
Albuquerque, New Mexico 87109-4238
(505) 262-2694 Fax (505) 262-2698
www.eberlineservices.com

4 Pi Efficiency

ALPHA

For Portable Counters:

Detector Area (cm2) =	
Efficiency (%) =	
Surface Efficiency =	
Background (cpm) =	
Background count time =	
Gross count time =	
MDA (dpm/100cm2) =	

BETA

For Portable Counters:

Detector Area (cm2) =	
Efficiency (%) =	
Surface Efficeincy =	
Background (cpm) =	
Background count time =	
Gross count time =	
MDA (dpm/100cm2) =	

2 Pi Efficiency

ALPHA

For Portable Counters:

Detector Area (cm2) =	
Efficiency (%) =	
Surface Efficiency =	
Background (cpm) =	
Background count time =	
Gross count time =	
MDA (dpm/100cm2) =	#DIV/0!

BETA

For Portable Counters:

Detector Area (cm2) =	15.5
Efficiency (%) =	23.1000
Surface Efficeincy =	0.50
Background (cpm) =	50.0
Background count time =	1.0
Gross count time =	1.0
MDA (dpm/100cm2) =	20.1