BALL STATE UNIVERSITY

COLLEGE OF SCIENCES AND HUMANITIES
DEPARTMENT OF PHYSICS AND ASTRONOMY

Muncie, Indiana 47306-0505
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MEMO

To: Bryan A. Parker
NRC, Region III Office
Lisle, IL 60532-4351

From: Mohammed S. Islam
RSO, Ball State University
Muncie, IN 47306

Date: 1/28/2013

Re: Ball State University's License Renewal Application (control number 578078)

This Memo is in response to questions arising during your review of Ball State University's NRC license renewal application, and our conversation over the telephone as well as email exchanges on 1/24/13. Our current license number is 13-06231-01.

1) Materials listing (Page 1 of application)

The table containing the list of isotopes has been modified to reflect our current use and inventory. This new table will replace one which was part of our original license application. The modified table is attached.

2) The RSO Delegation of Authority

A signed version of the RSO Delegation of Authority (page D-1) is attached and should replace the one without signature which was submitted with the original application.

3) Neutron Generator Decommissioning Report

A full version of the Neutron Generator Facility Decommissioning report is attached. Pages J-3 to J-29 of Appendix-J of our original application will be replaced by the content of this file.

I appreciate you assistance in the review of our renewal application. If you have additional questions, my phone number is (765) 285-8066 and e-mail is mislam@bsu.edu.

5. Radioactive Materials

Byproduct, source, and/or special nuclear material	Chemical and/or physical form	Maximum amount that licensee may possess at any one time under this license	Proposed Use
Any byproduct material with atomic numbers 1 through 83 with half-lives less than 120 days	Any	10 millicuries per radionuclide and 500 millicuries total	In vitro studies
C-14	Any	25 mCi	In vitro studies
H-3	Any	100 mCi	In vitro studies
Ca-45	Any	2 mCi	In vitro studies
I-125	Bound/non-volatile	2 mCi	RIA/In vitro studies

BALL STATE UNIVERSITY

ACADEMIC AFFAIRS
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AND DEAN OF THE GRADUATE SCHOOL

Muncie, Indiana 47306-0155
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MEMO

To: All Ball State University Employees

From: Robert J. Morris
Associate Provost for Research and Dean of the Graduate School

Subject: Delegation of Authority for Radiation Safety Officer

Mohammed Islam has been appointed Radiation Safety Officer and is responsible for ensuring the safe use of byproduct material. The Radiation Safety Officer is responsible for managing the radiation safety program; identifying radiation safety problems; initiating, recommending, or providing corrective actions; verifying implementation of corrective actions; and ensuring compliance with regulations for the use of byproduct material. The Radiation Safety Officer is hereby delegated the authority necessary to meet these responsibilities.

The Radiation Safety Officer has the authority to immediately stop any operations involving the use of byproduct material in which health and safety may be compromised or may result in non-compliance with Nuclear Regulatory Commission requirements.

I accept this appointment to be Radiation Safety Officer at Ball State University.

Islam

Neutron Generator Facility Decommissioning Report

Ball State University
2201 Riverside Ave.
Muncie, IN

Work Performed Under
Ball State University
US Nuclear Regulatory Commission
Radioactive Materials License No. 13-06231-01

February 2010

Prepared by:
Chase Environmental Group, Inc.
109 Flint Road
Oak Ridge, TN 37830
865-207-3664

CHASE
Environmental Group INC.

Neutron Generator Facility Decommissioning Report

Ball State University
2201 Riverside Ave.
Muncie, IN 47303

U.S. Nuclear Regulatory Commission Radioactive Materials License Number 13-06231-01

2/10/2010

Prepared: _____ Project Manager Date: 2/10/2010
Ken Gavlik

Approved: _____ Radiological Engineer Date: 2/10/2010
Dave Culp

Prepared by:
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109 Flint Road
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APPENDICES

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Appendix C – Instrument Calibration Records
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ACRONYM LIST

ALARA	As Low As Reasonably Achievable
Chase	Chase Environmental Group, Inc.
CFR	Code of Federal Regulations
DAC	Derived Air Concentration
DAW	Dry Active Waste
DCGL	Derived Concentration Guideline Level
DQO	Data Quality Objective
DSV	Default Screening Value
DWP	Decommissioning Work Plan
GM	Geiger-Mueller
FSS	Final Status Survey
FSSR	Final Status Survey Report
H_0	Null Hypothesis
H_A	Alternate Hypothesis
HSA	Historical Site Assessment
MARSSIM	Multi-Agency Radiation Survey and Site Investigation Manual
MDC	Minimum Detectable Concentration
NRC	U.S. Nuclear Regulatory Commission
NIST	National Institute of Standards and Technology
RSO	Radiation Safety Officer
RWP	Radiation Work Permit
TEDE	Total Effective Dose Equivalent
TMMC	Toxco Materials Management Center
WRS	Wilcoxon Rank Sum Test

1.0 EXECUTIVE SUMMARY

Ball State University (BSU) removed its neutron generator from service and decommissioned their vault facility located at the Cooper Science Complex, 22091 Riverside Ave., Muncie, Indiana, 47303. The accelerator was historically used to generate neutrons by bombarding tritium targets.

BSU retained Chase Environmental Group, Inc. (Chase) to perform accelerator removal, characterization, transportation, waste disposal, surveys, and reporting. No aggressive remediation was required. Decommissioning activities were performed under BSU's US Nuclear Regulatory Commission (NRC) Radioactive Materials License Number 13-06231-01. All activities were performed in accordance with a Decommissioning Work Plan (DWP). On-site decommissioning activities were performed from December 14 to December 17, 2009.

The DWP was developed using the guidance provided in NUREG-1757, "Consolidated NMSS Decommissioning Guidance" and NUREG-1575, "Multi-Agency Radiation Survey and Site Investigation Manual" (MARSSIM) and provided the approach, methods, and techniques for the radiological decommissioning of impacted areas of the facility. Final status surveys were designed using the guidance provided in MARSSIM to demonstrate compliance with the default screening values specified in NUREG-1757, Volume 1, Appendix B. These methods ensure technically defensible data are generated to aid in determining compliance with release criteria for unrestricted use specified in 10CFR20.1402 (25mrem/yr.).

This report presents sufficient data to support the conclusion that the facility meets the release criteria. Final status surveys demonstrate that building structural surfaces included in the scope of this report are below release criteria and are suitable for unrestricted release. Based on the building occupancy scenario, the Total Effective Dose Equivalent (TEDE) to an average member of the critical group is < 1.0 mrem/year (< 4% of the release criterion of 25 mrem/yr).

2.0 FACILITY DESCRIPTION

The Neutron Generator Facility, located in the basement of the Cooper Science Complex, has a footprint of approximately 140 square feet and consists of one room (a concrete vault) and a facility entrance and exit walkway. The vault is equipped with metal ventilation ducting, a sink, and a drain sump. A neutron generator resided in the room along with the associated electric supply, transformer and vacuum pumps. The ventilation system duct extended along the back (east) wall inside the vault to the courtyard where it exited horizontally through the wall. The general layout of the facility is depicted in Appendix A.

3.0 RELEASE CRITERIA

The radiological release criteria are that of 10CFR20.1402, "Radiological criteria for unrestricted use": "A site will be considered acceptable for unrestricted use if the residual radioactivity that is distinguishable from background radiation results in a Total Effective Dose Equivalent (TEDE) to an average member of the critical group that does not exceed 25 mrem (0.25mSv) per year, including that from groundwater sources of drinking water and the residual radioactivity has been reduced to levels that are as low as reasonable achievable (ALARA). Determination of the levels which are ALARA must take into account consideration of any detriments, such as deaths from transportation accidents, expected to potentially result from decontamination and waste disposal."

4.0 DERIVED CONCENTRATION GUIDELINE LEVELS (DCGL)

The Derived Concentration Guideline Level (DCGL) is the radionuclide-specific surface contamination or volumetric concentration that could result in a dose equal to the release criterion. $DCGL_W$ is the concentration limit if the residual activity is essentially evenly distributed over a large area. Gamma scans conducted during characterization indicated that there was no detectable activation of building structures. As such, the facility was classified as non-impacted by activation products. However, dose rate surveys were conducted to provide a statistically-based systematic protocol for verification of non-impacted status.

The release criteria for loose equipment and materials from the vault were per FC 83-23, "Guidelines for the Decontamination of Facilities and Equipment Prior to Release for Unrestricted Use or Termination of Byproduct, Source or Special Nuclear Material Licenses." These limits were also used as site DCGL's[3] for release of vault structures. These limits are:

- 5,000 dpm/100 cm^2 average total surface contamination over any 1 m^2
- 15,000 dpm/100 cm^2 maximum total surface contamination limited to 100 cm^2
- 1,000 dpm/100 cm^2 removable surface contamination

5.0 SURVEY INSTRUMENTATION

Laboratory and portable field instruments were calibrated within the previous year with National Institute of Standards and Technology (NIST) traceable sources. Portable instrument calibration records are included as Appendix C.

5.1 Functional Checks

Functional checks were performed at least daily when in use. The background, source check, and field measurement count times were determined to ensure measurements were

[3] H-3 is the only nuclide of concern for decommissioning. However, the survey design includes C-14 for conservatism. The NRC default screening values are 1.2E8 dpm/100cm^2 for H-3 and 3.7E6 dpm/100cm^2 for C-14.

statistically valid. Background readings were taken as part of the daily instrument check and compared with the acceptance range for instrument and site conditions.

5.2 Instrumentation Used

The instrumentation used for facility decommissioning surveys is summarized in Table 5-1 and Table 5-2.

Table 5-1 Instrumentation Specifications

Detector Model	Detector Type	Detector Area	Meter Model	Window Thickness	Typical 4π Efficiency
Ludlum 43-68	Gas Flow Proportional	126 cm^2	Ludlum 2221	0.8 mg/cm^2	13 % (C-14)
Ludlum 43-37	Gas Flow Proportional	582 cm^2	Ludlum 2241	0.8 mg/cm^2	13 % (C-14)
Ludlum 44-10	2" x 2" Sodium Iodide	N/A	Ludlum 2241	N/A	900 cpm per μR/hr (Cs-137)
Bicron MicroRem	Organic Scintillator	N/A	N/A	N/A	N/A
Beckman	Liquid Scintillation	N/A	N/A	N/A	60% (H-3) 80% (C-14)
Ludlum 43-10-1	Dual Phosphor	N/A	Ludlum 2929	0.4 mg/cm^2	10% (C-14)

Table 5-2 Typical Instrument Operating Parameters and Sensitivities

Measurement Type	Detector Model	Max. Scan Rate	Count Time	Bkg. Count Time	Background (cpm)	MDC ($dpm/100cm^2$)
Surface Scans (Beta)	Ludlum 43-68	10 in./sec.	N/A	60 sec.	500	2,279
Surface Scans (Beta)	Ludlum 43-37	10 in./sec.	N/A	60 sec.	1000	612
Total Surface Activity (Beta)	Ludlum 43-68	N/A	6 sec.	60 sec.	500	1087
Volumetric Scans (Gamma)	Ludlum 44-10	5 in./sec.	N/A	60 sec.	17,000	1.45 μR/hr
Removable Activity	Beckman	N/A	60 sec.	60 sec.	30	28
Removable Activity	2929/ 43-10-1	N/A	180 sec.	600 sec.	60	185

5.3 Determination of Counting Times and Minimum Detectable Concentrations

Minimum counting times for background determinations and measurement of total and removable contamination were chosen to provide a Minimum Detectable Concentration (MDC) that met the criteria specified in the DWP. MARSSIM equations relative to building surfaces were modified to convert to units of dpm/100cm^2. Count times and scanning rates were determined using the following equations:

5.3.1 Static Counting

Static counting Minimum Detectable Concentration at a 95% confidence level is calculated using the following equation, which is an expansion of NUREG 1507, "Minimum Detectable Concentrations with Typical Radiation Survey Instruments for Various Contaminants and Field Conditions", Table 3.1 (Strom & Stansbury, 1992):

$$MDC_{static} = \frac{3 + 3.29\sqrt{B_r \cdot t_s \cdot (1 + \frac{t_s}{t_b})}}{t_s \cdot E_{tot} \cdot \frac{A}{100cm^2}}$$

Where:

MDC_{static} = minimum detectable concentration (dpm/100cm^2)
B_r = background count rate (counts per minute)
t_b = background count time (minutes)
t_s = sample count time (minutes)
E_{tot} = total detector efficiency for radionuclide emission of interest (cpm/dpm)
A = detector probe area (cm^2)

5.3.2 Surface Ratemeter Scanning

Scanning Minimum Detectable Concentration at a 95% confidence level is calculated using the following equation, which is a combination of MARSSIM equations 6-8, 6-9, and 6-10:

$$MDC_{scan} = \frac{d'\sqrt{b_i}\left(\frac{60}{i}\right)}{\sqrt{p} \cdot E_{tot} \cdot \frac{A}{100cm^2}}$$

Where:

MDC_{scan} = minimum detectable concentration (dpm/100 cm^2)
d' = desired performance variable (1.38)
b_i = background counts during the residence interval (counts)
i = residence interval (seconds)
p = surveyor efficiency (0.5)
E_{tot} = total detector efficiency for radionuclide emission of interest (cpm/dpm)
A = detector probe area (cm^2)

5.3.3 Smear Counting

Smear counting Minimum Detectable Concentration at a 95% confidence level is calculated using the following equation, which is NUREG 1507, "Minimum Detectable Concentrations with Typical Radiation Survey Instruments for Various Contaminants and Field Conditions", Table 3.1 (Strom & Stansbury, 1992):

$$MDC_{smear} = \frac{3 + 3.29\sqrt{B_r \cdot t_s \cdot (1 + \frac{t_s}{t_b})}}{t_s \cdot E}$$

Where:

MDC_{smear} = minimum detectable concentration level (dpm/smear)
B_r = background count rate (counts per minute)
t_b = background count time (minutes)
t_s = sample count time (minutes)
E = instrument efficiency for radionuclide emission of interest (cpm/dpm)

6.0 REMOVAL ACTIVITIES

6.1 Accelerator Equipment Removal

Chase personnel disassembled and removed the accelerator and ancillary equipment. All activities were performed under a Radiation Work Permit (RWP), authorized by the Radiation Safety Officer (RSO) and conducted to control the spread of contamination and to maintain personnel exposures ALARA. Monitoring for airborne particulate radioactivity was conducted during removal and disassembly and the highest sample result was below the MDC of 2.0E-12 µCi/ml.

7.0 RADIOACTIVE MATERIALS MANAGEMENT

All operational and disassembly wastes were moved to BSU's on-site waste storage facility pending milk-run transportation to the Toxco Material Management Center (TMMC) in Oak Ridge, TN for processing and disposal.

Waste consists of eight 2 ft^3 fiberboard boxes of activated metal and dry active waste (DAW) weighing 455 lbs., the diffusion pump weighing 110 lbs., and ½ gallon of vacuum pump oil.

8.0 SURVEYS

Surveys were performed using the Data Quality Objectives (DQO) process to demonstrate that residual radioactivity in the vault satisfied the predetermined criteria for release for unrestricted use. Vault interior surfaces were considered a single survey unit. Surveys were conducted by performing the appropriate combination of scan surveys, total activity measurements, dose rate measurements and removable activity measurements.

8.1 Data Quality Objectives

The following is a list of the major DQOs for the survey design:

- Static measurements will be taken to achieve an MDC_{static} of less than 5,000 dpm/100cm^2.
- Scanning will be conducted at a rate to achieve an MDC_{scan} of less than 5,000 dpm/100cm^2.
- Smear counting will be conducted to achieve an MDC of less than 200 dpm/100cm^2.
- Individual measurements will be made to a 95% confidence interval.
- Decision error probability rates will be set at 0.05 for both α and β.
- The null hypothesis (H_0) and alternate null hypothesis (H_A) are that of NUREG 1505 scenario A:
  H_0 is that the survey unit does not meet the release criteria
  H_A is that the survey unit meets the release criteria
- Characterization and in-process waste packaging surveys will be conducted under the same quality assurance criteria as final status surveys such that the data may be used as final status survey data to the maximum extent possible.
- Quality Assurance Surveys will be conducted at a rate of 5%.

8.2 Area Classifications

Based on the facilities operational history and previous survey results, the facility areas were initially classified as impacted areas and non-impacted areas for the purposes of characterization.

8.2.1 Non-Impacted Area

Non-impacted areas were areas without residual radioactivity from licensed activities and were not surveyed during final status surveys. Surfaces outside the vault were classified as non-impacted. Thorough surveys of vault entrances/exits and ventilation exhausts were conducted to provide adequate assurance that any residual contamination was contained within the building structure.

8.2.2 Impacted Areas

Impacted areas were those areas that had potential residual radioactivity from licensed activities. Impacted areas were subdivided into Class 1, Class 2 or Class 3 areas. Class 1 areas have the greatest potential for contamination and therefore receive the highest degree of survey effort for the final status survey using a graded approach, followed by Class 2, and then by Class 3. Impacted sub-classifications are defined as follows:

- Class 1 Area: Areas with the highest potential for contamination, and meet the following criteria: (1) impacted; (2) potential for delivering a dose above the release criterion; (3) potential for small areas of elevated activity; and (4) insufficient evidence to support classification as Class 2 or Class 3.
- Class 2 Area: Areas that meet the following criteria: (1) impacted; (2) low potential for delivering a dose above the release criterion; and (3) little or no potential for small areas of elevated activity.
- Class 3 Area: Areas that meet the following criteria: (1) impacted; (2) little or no potential for delivering a dose above the release criterion; and (3) little or no potential for small areas of elevated activity.

8.3 Survey Units

A survey unit is a geographical area of specified size and shape for which a separate decision will be made whether or not that area meets the release criteria. A survey unit is normally a portion of a building or site that is surveyed, evaluated, and released as a single unit. Areas of similar construction and composition were grouped together as survey units and tested individually against the DCGLs and the null hypothesis to show compliance with the release criteria. Survey units are homogeneous in construction, contamination potential, and contamination distribution. Survey unit designations and classifications are as follows:

- Survey Unit 0101: Accelerator Vault Internal Surfaces – Class 1
- There were no Class 2 areas
- There were no Class 3 areas

8.4 Surface Scans

Scanning was used to identify locations within the survey unit that exceeded the investigation level. 100% of accessible building structural surfaces were scanned using a gas flow surface contamination detector. Additionally, surfaces in the vault were scanned for volumetric activation products using a 2" x 2" NaI detector.

8.5 Total Surface Activity Measurements

Direct surveys (static measurements) were taken on building surfaces and system internals to the extent practical in impacted areas utilizing instrumentation of the best geometry based on the surface at the survey location.

8.6 Dose Rate Measurements

Dose rate measurements were taken on building surfaces in the accelerator room and in a background reference area. The background reference area was selected outside the accelerator room near concrete surfaces, yet away from potentially activated portions of the vault. Dose rate measurements were taken at each accelerator room sample location and in the background reference area. At each location, a measurement was taken at 1 m from the surface to determine the dose rate at the midpoint of a receptor.

Dose rate measurements were performed with a tissue equivalent Bicron MicroRem meter. This instrument was selected due to its flat energy response. Additionally, a one-minute count was performed at each location using a 2" x 2" sodium iodide detector. Because the Bicron is a ratemeter, an average of ten instantaneous rates was determined at each location by covering the meter and recording the measurement observed when it is uncovered (this is a relatively unbiased method to obtain an average).

8.7 Determining the Number of Samples

A minimum number of samples are needed to obtain sufficient statistical confidence that the conclusions drawn from the samples are correct. The number of samples depends on the Relative Shift (the ratio of the concentration to be measured relative to the statistical variability of the contaminant concentration).

The minimum number of samples is obtained from MARSSIM tables or calculated using equations in Section 5 of MARSSIM.

8.7.1 Determination of the Relative Shift

The number of required samples depends on the ratio involving the activity level to be measured relative to the variability in the concentration. The ratio to be used is called the Relative Shift, Δ/σ_S and is defined in MARSSIM as:

$$\Delta / \sigma_S = \frac{DCGL - LBGR}{\sigma_S}$$

Where:

DCGL = derived concentration guideline level
LBGR = concentration at the lower bound of the gray region. The LBGR is the average concentration to which the survey unit should be cleaned in order to have an acceptable probability of passing the test
σ_S = an estimate of the standard deviation of the residual radioactivity in the survey unit

The actual calculations are provided below:

$$\Delta/\sigma_S = \frac{1.2E8 - 6.0E7}{25000} = 2400$$

Since MARRSIM Table 5.5 does not include relative shifts above 3 and the number of samples required decreases with an increasing relative shift, the relative shift for structural surface activity was conservatively set at 3.

8.7.2 Determination of Acceptable Decision Errors

A decision error is the probability of making an error in the decision on a survey unit by passing a unit that should fail (α decision error) or failing a unit that should pass (β decision error). MARSSIM uses the terminology α and β decision errors; this is the same as the more common terminology of Type I and Type II errors, respectively. The decision errors are 0.05 for Type I errors and 0.05 for Type II errors.

8.7.3 Determination of Number of Data Points (Sign Test)

The number of direct measurements for a particular survey unit, employing the Sign Test, is determined from MARSSIM Table 5.5, which is based on the following equation (MARSSIM equation 5-2):

$$N = \frac{\left(Z_{1-\alpha} + Z_{1-\beta}\right)^2}{4\left(SignP - 0.5\right)^2}$$

Where:

N	=	number of samples needed in the survey unit
$Z_{1-\alpha}$	=	percentile represented by the decision error α
$Z_{1-\beta}$	=	percentile represented by the decision error β
SignP	=	estimated probability that a random measurement will be less than the DCGL when the survey unit median is actually at the LBGR

Note: SignP is determined from MARSSIM Table 5.4

MARSSIM recommends increasing the calculated number of measurements by 20% to ensure sufficient power of the statistical tests and to allow for possible data losses. MARSSIM Table 5.5 values include an increase of 20% of the calculated value. The following calculations were made to determine this number:

$$N = \frac{\left(1.645 + 1.645\right)^2}{4\left(0.998650 - 0.5\right)^2} = 11$$

$Z_{1-\alpha}$ and $Z_{1-\beta}$ are equal to 1.645 using the error rate of 0.05 from MARSSIM Table 5.2. SignP is equal to 0.998650 from MARSSIM Table 5.4. Adding an additional

20% to account for data losses resulted in a value of 14. Therefore, the determined number of samples per survey unit for planning purposes was **14.**

8.8 Determination of Sample Locations

Determination of Class 1 survey unit sample locations is accomplished by first determining sample spacing and then systematically plotting the sample locations from a randomly generated start location. The random starting point of the grid provides an unbiased method for obtaining measurement locations to be used in the statistical tests.

8.8.1 Determining Class 1 Sample Locations

In Class 1 survey units, the sampling locations are established in a unique pattern beginning with the random start location and the determined sample spacing. After determining the number of samples needed in the survey unit, sample spacing is determined from MARSSIM equation 5-8:

$$L = \sqrt{\frac{A}{N}} \text{ for a square grid}$$

Where:

L = sample spacing interval
A = the survey unit area
N = number of samples needed in the survey unit

A map was generated of the survey unit's permanent surfaces included in the statistical tests (floors, walls, ceilings, etc.) and folded out in a 2-dimensional view. A random starting point is determined using computer-generated random numbers coinciding with the x and y coordinates of the total survey unit. A grid was plotted across the survey unit surfaces based on the random start point and the determined sample spacing. A measurement location was plotted at each intersection of the grid plot. Survey unit map showing sample locations is presented in Appendix B.

8.9 Removable Contamination Measurements

Removable contamination measurements (smears) were collected on building structural surfaces at each sample location and internal surfaces of building systems. For each sample, an area of approximately 100cm^2 was wiped. Smears were collected and counted using a both a liquid scintillation counter (LSC) and a phoswich counter scaler (2929).

Both instruments were set up for one (1) minute count times. The LSC ran each smear three (3) times and provided a maximum and mean for the three (3) sample counts. For conservatism, the maximum value was used for the results provided in Appendices D,E, and F.

8.10 Surveys of Building Mechanical System Internals

Surveys of various building system components were performed. Survey design for these systems is out of the scope of MARSSIM. For the purposes of identifying potential residual contamination within these systems, scan surveys, total activity measurements, and removable contamination measurements of accessible ventilation exhaust points and the floor drain sump.

8.11 Survey Investigation Levels

Investigation levels are used to flag locations that require special attention and further investigation to ensure areas are properly classified and adequate surveys are performed. These locations are marked and receive additional investigations to determine the concentration, area, and extent of the contamination. The survey investigation levels for each type of measurement are listed by classification in Table 14.2.

Table 14.2 Survey Investigation Levels

Survey Unit Classification	Flag Direct Measurement or Sample Result When:	Flag Scanning Measurement Result When:	Flag Removable Measurement Result When:
Class 1	>75% of DCGL	>MDC	> 200 dpm/100cm^2

8.12 Volumetric Scan Results

Sodium iodide scans were performed to detect areas of elevated activity as a result of activation based on the audible response. No areas of elevated activity were detected.

8.13 Surface Scan Results

No areas of elevated activity were detected during the scans of building structural surfaces inside the vault.

8.14 Total Surface Activity Results

Direct surveys (static measurements) for total surface activity were taken on building surfaces inside the vault (survey unit 0101) using gas flow proportional detectors. Static measurements were taken in impacted areas at each identified sample location. Scaler count times were determined to achieve the detection sensitivities stated in the DQOs. Field measurements were converted to an activity concentration using the following equation:

Equation 1

$$\text{Activity}\,(\text{dpm}/100\text{cm}^2) = \frac{cpm_{sample} - cpm_{background}}{E_{total} \cdot \frac{A}{100cm^2}}$$

The results of total surface activity measurements are presented in Appendix D.

8.15 Removable Contamination Results

Removable contamination measurements were collected by wiping an area of approximately 100 cm^2 on structural surfaces for Liquid Scintillation and Counter-Scaler measurement. Samples were then counted for one minute on a Beckman Liquid Scintillation Counter and three minutes on Ludlum Model 2929 Counter-Scaler. Smear results were converted to an activity concentration using the following equation:

Equation 2

$$\text{Activity}(\text{dpm}/100\text{cm}^2) = \frac{cpm_{sample} - cpm_{background}}{E_{total}}$$

The results of removable surface activity measurements are presented in Appendix E

8.16 Dose Rate Measurement Results

Dose rate measurement results from the background reference area and the accelerator room are presented in Table 8-1 and
Table 8-2.

Table 8-1 MicroRem Measurements in Background Reference Area

	Bicron Instantaneous Measurements (µRem/hr)											
Loc.	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**SD**	**Mean**
1	3	3	4	3	4	4	3	5	4	5	0.8	3.8
2	5	4	5	4	4	5	4	4	5	5	0.5	4.5
3	4	4	4	4	5	4	5	5	5	4	0.5	4.4
4	6	6	6	5	4	5	5	6	5	4	0.8	5.2
5	5	4	4	4	5	5	4	4	4	4	0.5	4.3
6	4	4	3	4	5	5	6	5	4	4	0.8	4.4
7	4	4	4	5	4	4	4	4	5	4	0.4	4.2
8	4	4	4	3	4	4	5	4	5	4	0.6	4.1
9	3	3	3	4	4	3	4	4	5	5	0.8	3.8
10	4	5	6	5	5	5	5	5	5	5	0.5	5
11	5	6	6	5	5	6	6	5	4	4	0.8	5.2
12	4	4	4	4	5	4	5	6	6	5	0.8	4.7
13	5	6	5	5	5	6	7	6	5	5	0.7	5.5
14	4	4	3	4	4	5	4	3	4	4	0.6	3.9
15	4	3	4	4	.	4	4	5	5	5	0.7	4.1
16	4	5	4	5	5	4	4	4	5	5	0.5	4.5
17	4	3	4	5	6	5	6	5	5	6	1.0	4.9
18	5	4	4	5	4	4	4	4	4	4	0.4	4.2
19	5	4	5	4	5	4	4	5	5	4	0.5	4.5
20	4	5	4	4	4	4	4	4	4	4	0.3	4.1
21	3	3	4	4	4	3	4	4	4	5	0.6	3.8

22	4	4	5	5	6	5	5	4	5	5	0.6	4.8
23	5	5	6	6	6	5	5	4	4	4	0.8	5
											Mean	**4.5**
											SD	**0.6**

Table 8-2 MicroRem Measurements in Accelerator Room

Loc.	**Bicron Instantaneous Measurements (μRem/hr)**											
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**SD**	**Mean**
1	4	4	4	5	5	4	5	4	4	5	0.5	4.4
2	5	5	6	5	6	6	5	5	6	5	0.5	5.4
3	5	5	6	7	7	6	7	6	5	6	0.8	6
4	5	5	4	5	5	6	5	5	5	6	0.6	5.1
5	4	4	4	4	5	4	4	4	4	4	0.3	4.1
6	4	4	3	4	4	3	4	4	4	4	0.4	3.8
7	6	6	5	7	6	5	5	6	5	5	0.7	5.6
8	5	6	6	5	6	5	5	4	5	5	0.6	5.2
9	6	6	5	6	5	6	5	5	5	5	0.5	5.4
10	4	5	4	4	3	4	3	4	4	4	0.6	3.9
11	4	4	4	5	5	5	4	5	5	4	0.5	4.5
12	4	4	4	5	4	4	4	5	4	5	0.5	4.3
13	7	6	5	6	7	6	6	5	6	5	0.7	5.9
14	5	4	5	5	4	4	5	5	6	5	0.6	4.8
15	4	5	4	4	4	4	5	4	4	4	0.4	4.2
16	5	5	4	5	5	6	5	4	5	5	0.6	4.9
17	4	5	6	5	6	4	5	6	6	5	0.8	5.2
18	4	4	5	4	4	4	4	5	5	4	0.5	4.3
19	5	5	4	4	5	5	5	4	4	4	0.5	4.5
20	6	6	5	7	5	5	4	5	5	6	0.8	5.4
21	5	6	5	5	5	6	5	5	4	5	0.6	5.1
22	5	5	4	4	4	5	4	4	5	4	0.5	4.4
23	6	6	5	6	5	5	5	6	5	5	0.5	5.4
											Mean	**4.9**
											SD	**0.6**

9.0 DATA QUALITY ASSESSMENT AND INTERPRETATION OF SURVEY RESULTS

The statistical guidance contained in Section 8 of MARSSIM was used to determine if areas are acceptable for unrestricted release and whether additional surveys or sample measurements were required.

9.1 Data Validation

Field data were reviewed by the Project Manager and validated to ensure:

- Completeness of forms
- Proper types of surveys were performed
- The MDCs for measurements met the established data quality objectives
- Independent calculations were performed on a representative sample of data sheets
- Satisfactory instrument calibrations and daily functionality checks were performed as required

9.2 Preliminary Data Review

A preliminary data review was performed for each survey unit to identify any patterns, relationships or anomalies. Additionally, measurement data were reviewed and compared with the DCGLs and ALARA goals to confirm the correct classification of survey units. All calculations of means, standard deviations, minimum and maximum values, and comparisons between survey data and ALARA goals and investigation levels are presented in the following tables. Structural surfaces final status survey results are presented in Appendix D.

Table 9-1 Structural Surfaces - Total Beta Surface Activity Summary

Survey Unit	# of Sample Locations	Mean	MDC	Standard Deviation	Min.	Max.	Investigation Level	Any Result Exceeding Investigation Level?
		(dpm/100 cm^2)						
0101	23	98	297	108	-36	407	5000	NO

Table 9-2 Structural Surfaces - Removable Surface Activity Summary

Survey Unit	# of Sample Locations	Mean	MDC	Standard Deviation	Min.	Max.	Investigation Level	Any Result Exceeding Investigation Level?
		(dpm/100 cm^2)						
0101 (2929)	23	-13	171	31	-93	53	200	NO
0101 (LSC)	23	24	5	7	13	42	200	NO

Table 9-3 Systems - Total Surface Activity Summary

Survey Unit	# of Sample Locations	Mean	MDC	Standard Deviation	Min.	Max.	Investigation Level	Any Result Exceeding Investigation Level?
		(dpm/100 cm^2)						
N/A	2	198	297	288	-5	402	5000	NO

Table 9-4 Systems - Removable Surface Activity Summary

Survey Unit	# of Sample Locations	Mean	MDC	Standard Deviation	Min.	Max.	Investigation Level	Any Result Exceeding Investigation Level?
		(dpm/100 cm^2)						
2929N/A	2	7	171	40	-21	36	200	NO
LSCN/A	2	142	5	177	17	267	200	YES

9.3 Determining Compliance for Building Surfaces and Structures

Survey results were initially compared to the investigation levels. No total activity results in survey unit 0101 were above the investigation level, and were well below the DCGL. Removable activity results in survey unit 0101 were above the investigation level, but were well below the DCGL. For surface activity, the Sign test is used to determine the minimum number of sample locations. Because all surface activity measurements are less than the DCGL, the survey unit passes the Sign Test. Therefore, the null hypothesis can be rejected and the survey unit meets the release criterion and is suitable for release for unrestricted use.

The results of the data quality assessment and calculations of the dose from each structural surface survey unit are presented in Table 10-5.

Table 9-5 Structural Surfaces - Total Beta Surface Activity Dose Calculations

Survey Unit	Standard Deviation (dpm/100 cm^2)	# Samples Required	# of Samples	Adequate # of Samples?	Mean (dpm/100 cm^2)	Calculated Annual TEDE[4] (mrem/yr)
0101	107	11	23	YES	98	.0013

[4] The TEDE shown is calculated by multiplying 25 mrem/yr by the ratio of the mean total surface activity to the C-14 DCGL of 3.7E6 dpm/100cm^2 and then multiplying by 2 to account for the ISO 7503-1 surface efficiency.

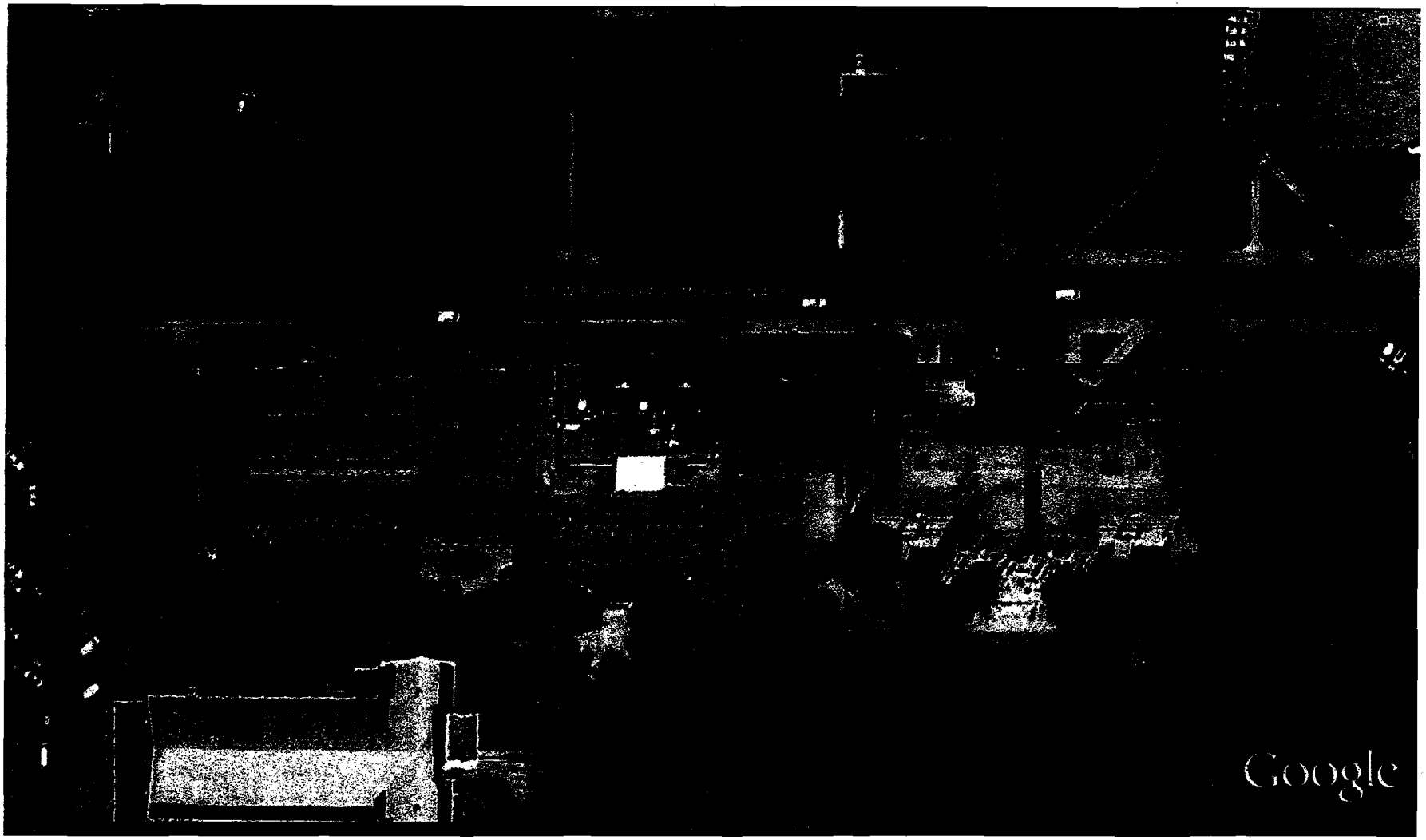
9.4 Determining Compliance for Building Systems

All total and removable surface activity measurements were compared directly to the investigation levels to determine if an area required further examination. All measurements were less than the investigation levels, therefore all systems meet the release criteria and are suitable for release for unrestricted release.

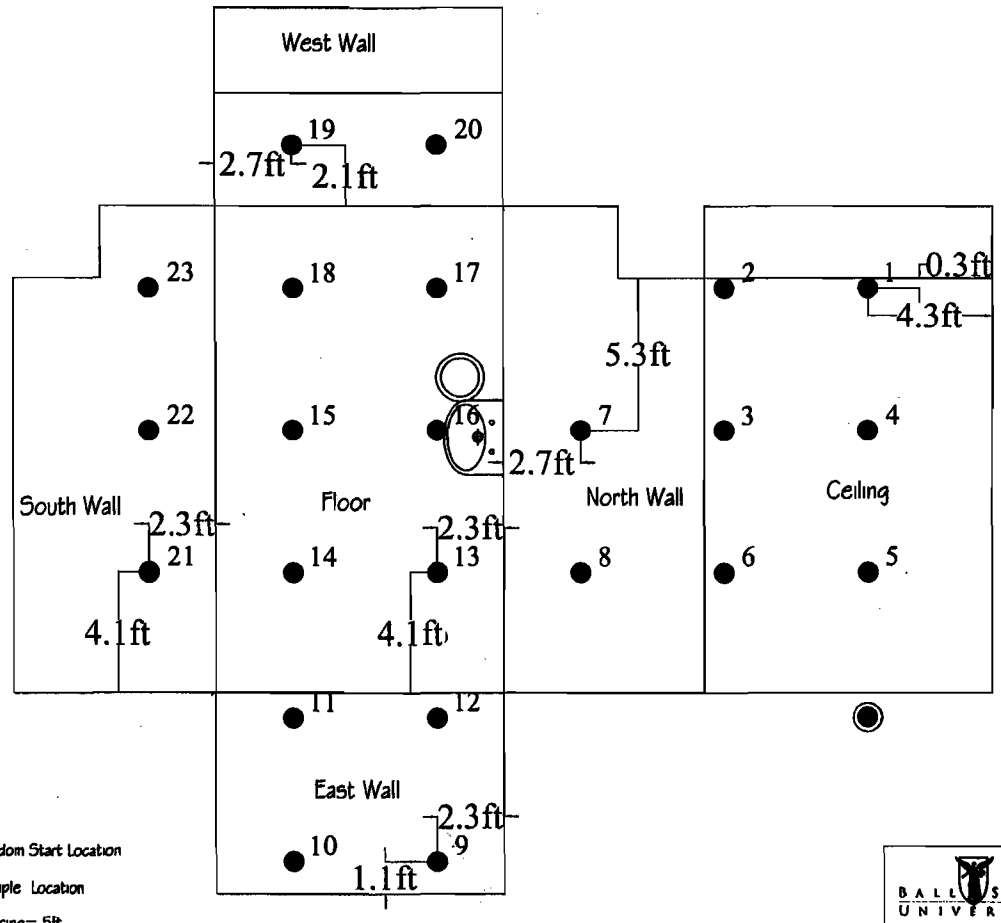
10.0 REFERENCES

- Ball State University US NRC Radioactive Materials License Number 13-06231-01
- NUREG-1575, "Multi-Agency Radiation Survey and Site Investigation Manual" (MARSSIM)
- NUREG-1505, "A Nonparametric Statistical Methodology for the Design and Analysis of Final Decommissioning Surveys"
- NUREG-1507, "Minimum Detectable Concentrations with Typical Radiation Survey Instruments for Various Contaminants and Field Conditions"
- NUREG-1757, Volume 1 "Consolidated NMSS Decommissioning Guidance," September, 2002
- NUREG-1757, Volume 2 "Consolidated NMSS Decommissioning Guidance," September, 2002
- USNRC Policy and Guidance Directive FC 83-23, "Guidelines for the Decontamination of Facilities and Equipment Prior to Release for Unrestricted Use or Termination of Byproduct, Source, or Special Nuclear Material Licenses."
- ISO-7503-1, "Evaluation of Surface Contamination – Part 1: Beta Emitters and Alpha Emitters." 1988
- Decommissioning Work Plan

Appendix A
Site Map


Google

Appendix B
FSS Location Maps



BALL STATE UNIVERSITY	Ball State University Neutron Generator Facility Decommissioning Report FSS	CHASE Environmental Group
Building: V01	Survey Unit:0101	Page: B.1 of B.1

Appendix C
Inst Calibration Records

GRIFFIN INSTRUMENTS

CALIBRATION CERTIFICATE FOR 2929 SERIAL# 149121

Owner: CHASE ENV.

DATE: 10/28/09 LOCATION: Griffin Inst

TECH: Joanne Glenn DATE LAST CAL EXPIRES: 12/18/09

Reason For Calibration: (•) Due For Calibration ( ) Repair (See Remarks)

CABLE LENGTH: 39" ( ) Other (See Remarks) ( ) Due and Repair (See Remarks)

NIST TRACEABLE EQUIPMENT USED DURING CALIBRATION

MODEL: M-500 SERIAL #: 114512 CAL. DUE: 09/05/10

MODEL: SERIAL #: CAL DUE:

Condition: (•) Sat ( ) Unsat

AF Mechanical Zero: 0

AL Mechanical Zero: 0

Set/Function/Check	Acceptance	Actual		
Beta Channel Window (4-50 mV):	4-48	A.F.		
Alpha Channel Window (175 mV, 120 for 3030):	175	A.F.		
Alpha Counts w/Pulser @ 10,000 CPM:	9,946	A.F.	% Error:	0.5%
Beta Counts w/Pulser @ 10,000 CPM:	9,946	A.F.	% Error:	0.5%
HIGH VOLTAGE POWER UNIT CAL (2250volts)				
1 KV Reading (R-5 on HV Board):	1	A.F.		
Max HV (1600 V +):	(•) Sat	( ) Unsat		

REMARKS:

Does Instrument Meet Final Acceptance Criteria?: (•) Yes ( ) No

Calibration Sticker Attached?: (•) Yes ( ) No

Date Instrument is Due For Next Calibration: 10/28/10

INSTRUMENT MARRIED WITH 43-10-1 # PR150791

Performed/Reviewed by: Joanne Glenn Date: 10/28/2009 Entered by: _____ Initials

Calibrations performed to ANSI N323A-1997 standards.

GRIFFIN INSTRUMENTS

CALIBRATION CERTIFICATE FOR 43-10-1 PROBE # PR150791

Owner: CHASE ENV

DATE: 10/26/09 LOCATION: Griffin Inst

TECH: Joanne Glenn DATE LAST CAL EXPIRES: 12/18/09

REASON FOR CALIBRATION:

(●) Due For Calibration ( ) Repair (See Remarks) ( ) Other (See Remarks) ( ) Due and Repair

CABLE LENGTH: 39" INPUT SENSITIVITY: dual

NIST TRACEABLE EQUIPMENT AND STANDARDS USED DURING CALIBRATION

MODEL: 2929 SERIAL #: 146121 CAL. DUE: 10/26/10

NIST TRACEABLE SOURCES USED

Source Number	Isotope	4 pi Activity	Assay Date	2 pi Activity
00TC470-0854	Tc99 SS	17,300 dpm	06/15/09	10,800 cpm
94TH470-1593	Th230	16,700 dpm	06/16/09	8,170 cpm
2696-00	Pu239	18,500 dpm	07/18/06	9,380 cpm
2697-00	Sr90	12,200 dpm	03/01/00	8,530 cpm
PX 728	C14	46,780 dpm	01/21/08	18,660 cpm

Efficiencies from last cal.:

Condition: (●) Sat ( ) Unsat

Pu:		Th:	36.29%	Sr:	
Tc ss:	26.33%	C14:		Tc Ni:	

As Found (AF) Efficiencies:

HV / Vernier:	Tc-99 Source Response Nickel (CPM):			Pu-239 Source Response (CPM):			Background (CPM):		Tc-99 Source Response Stainless Steel (CPM):		
	A ch.	B ch.	Net Eff.	A ch.	B ch.	Net Eff.	A ch.	B ch.	A ch.	B ch.	Net Eff.
800 / 3.16				7290	263	39.41%	0	84	1	4627	26.26%

Net A to B Xtalk: <10%	B to A Xtalk: <1%
2.3%	<1%

	Pu239	Tc99 Ni	Tc99 ss	Th-230	Sr90	C-14
AF CPM:	7290		4627	6159	4042	6851
AF 4 pi eff:	39.41%		26.26%	36.88%	40.86%	11.82%
AF 2 pi eff:	*77.64%*		*42.06%*	*76.39%*	*58.44%*	*30.91%*

Is as found efficiency within 20% of the efficiency from the last cal? (●) Yes ( ) No (See Remarks)

Note: If the as found data is within 10% of the last calibration and the B-A Xtalk is <1% and the A-B Xtalk is <10%, then the technician may N/A the plateau section and go directly to remarks.

GRIFFIN INSTRUMENTS

PROBE #: PR150791
Date: 10/28/09

PLATEAU AND SET POINT DATA

HV./ Vernier:	Tc-99 Source Response SS (CPM):			Pu-239 Source Response (CPM):			Background (CPM):		Net A to B Xtalk: <10%	B to A Xtalk: <1%
	A ch.	B ch.	Net Eff.	A ch.	B ch.	Net Eff.	A ch.	B ch.		
700 / 2.72	0	3428	19.8%	6515	222	35.2%	0	44	2.7%	<1%
750 / 2.90	0	3935	22.4%	6946	253	37.5%	0	66	2.6%	<1%
775 / 3.00	1	4234	24.1%	7058	221	38.2%	0	66	2.1%	<1%

Alpha / Beta Bkg (cpm)		0	66				
HV / Vernier		Pu-239	Tc-99 Ni	Tc-99 SS	Th-230	C-14	Sr-90
775 / 3.00	CPM:	7058		4234	6009	4628	4203
4 pi AL Efficiencies:		38.15%		24.09%	36.96%	9.35%	42.71%
2 pi AL Efficiencies:		*75.17%*		*38.59%*	*73.55%*	*24.45%*	*61.09%*

REMARKS:

Does Instrument Meet Final Acceptance Criteria?: (●) Yes ( ) No

Calibration Sticker Attached?: (●) Yes ( ) No

Date Instrument is Due For Next Calibration: 10/28/10

INSTRUMENT MARRIED WITH 2929 # 149121

Performed/Reviewed by: James Harris Date: 10/28/2009 Entered by: _____ Initials

2 pi efficiencies denoted in italics. Calibrations performed to ANSI N323A-1997 standards.

GRIFFIN INSTRUMENTS

CALIBRATION CERTIFICATE FOR 2929 SERIAL# 160013

Owner: CHASE ENV

DATE: 08/18/09 LOCATION: Griffin Inst

TECH: Joanne Glenn DATE LAST CAL EXPIRES: 09/05/09

Reason For Calibration: (●) Due For Calibration ( ) Repair (See Remarks)

CABLE LENGTH: 39" ( ) Other (See Remarks) ( ) Due and Repair (See Remarks)

NIST TRACEABLE EQUIPMENT USED DURING CALIBRATION

MODEL: M-500 SERIAL #: 114612 CAL. DUE: 09/05/09

MODEL: SERIAL #: CAL DUE:

Condition: (●) Sat ( ) Unsat

AF Mechanical Zero: 0

AL Mechanical Zero: 0

[redacted]	[redacted]	[redacted]	
Beta Channel Window (4-60 mV):	4-60	A.F.	
Alpha Channel Window (175 mV, 120 for 3030):	175	A.F.	
Alpha Counts w/Pulser @ 10,000 CPM:	9,994	A.F.	% Error: 0.2%
Beta Counts w/Pulser @ 10,000 CPM:	9,994	A.F.	% Error: 0.1%
[redacted]			
1 KV Reading (R-5 on HV Board):	1	A.F.	
Max HV (1800 V +):	(●) Sat	( ) Unsat	

REMARKS:

Does Instrument Meet Final Acceptance Criteria?: (●) Yes ( ) No

Calibration Sticker Attached?: (●) Yes ( ) No

Date Instrument is Due For Next Calibration: 08/18/10

INSTRUMENT MARRIED WITH 43-10-1 # PR167231

Performed/Reviewed by: Joanne Glenn Date: 8/18/2009 Entered by: ____ Initials

Calibrations performed to ANSI N323A-1997 standards.

GRIFFIN INSTRUMENTS

CALIBRATION CERTIFICATE FOR 43-10-1 PROBE # PR167231

Owner: CHASE ENV

DATE: 08/18/09 LOCATION: Griffin Inst
TECH: Joanne Glenn DATE LAST CAL EXPIRES: 09/05/09

REASON FOR CALIBRATION:

(●) Due For Calibration ( ) Repair (See Remarks) ( ) Other (See Remarks) ( ) Due and Repair

CABLE LENGTH: 39" INPUT SENSITIVITY: dual

NIST TRACEABLE EQUIPMENT AND STANDARDS USED DURING CALIBRATION

MODEL: 2929 SERIAL #: 160013 CAL. DUE: 08/18/10

NIST TRACEABLE SOURCES USED

Source Number	Isotope	4 pi Activity	Assay Date	2 pi Activity
94TH470-1593	Th230	16,700 dpm	06/18/09	8,170 cpm
00TC470-0854	Tc99 SS	17,300 dpm	08/15/09	10,800 cpm
2697-00	Sr90	12,200 dpm	03/01/00	8,530 cpm
2696-00	Pu239	18,500 dpm	07/18/06	9,390 cpm
PX 728	C14	48,780 dpm	01/21/08	18,880 cpm

Condition: (●) Sat ( ) Unsat

Efficiencies from last cal.:

Pu:	37.77%	Th:	33.64%	Sr:	40.49%
Tc ss:	22.31%	C14:	10.84%	Tc Ni:	

As Found (AF) Efficiencies:

HV / Vernier:	Tc-99 Source Response Nickel (CPM):			Pu-239 Source Response (CPM):			Background (CPM):		Tc-99 Source Response Stainless Steel (CPM):		
	A ch.	B ch.	Net Eff.	A ch.	B ch.	Net Eff.	A ch.	B ch.	A ch.	B ch.	Net Eff.
850 / 3.50				7067	337	38.18%	3	81	2	4567	25.93%

Net A to B Xtalk: <10%	B to A Xtalk: <1%
3.5%	<1%

	Pu239	Tc99 Ni	Tc99 ss	Th-230	Sr90	C-14
AF CPM:	7067		4567	5980	3864	6258
AF 4 pi eff:	38.18%		25.93%	35.67%	38.80%	12.66%
AF 2 pi eff:	*75.23%*		*41.54%*	*72.91%*	*55.49%*	*33.10%*

Is as found efficiency within 20% of the efficiency from the last cal? (●) Yes ( ) No (See Remarks)

Note: If the as found data is within 10% of the last calibration and the B-A Xtalk is <1% and the A-B Xtalk is <10%, then the technician may N/A the plateau section and go directly to remarks.

GRIFFIN INSTRUMENTS

PROBE #: PR167231
Date: 08/18/09

PLATEAU AND SET POINT DATA

HV / Vernier:	Tc-99 Source Response SS (CPM):			Pu-239 Source Response (CPM):			Background (CPM):		Net A to B Xtalk: <10%	B to A Xtalk: <1%
	A ch.	B ch.	Net Eff.	A ch.	B ch.	Net Eff.	A ch.	B ch.		
700 / 2.90	0	2517	14.3%	6369	317	34.4%	1	47	4.1%	<1%
750 / 3.10	2	3194	18.1%	6684	308	36.1%	0	59	3.8%	<1%
800 / 3.32	1	4174	23.7%	6870	328	37.1%	1	68	3.7%	<1%
850 / 3.50							1	103		

Alpha / Beta Bkg (cpm) 2 73

HV / Vernier		Pu-239	Tc-99 Ni	Tc-99 SS	Th-230	C-14	Sr-90
800 / 3.32	CPM:	6832		4134	5868	4779	4098
	4 pi AL Efficiencies:	38.92%		23.47%	35.25%	9.65%	41.39%
	2 pi AL Efficiencies:	72.74%		37.60%	72.04%	25.22%	59.20%

REMARKS: Noticed erratic bkg - Reset mylar that slipped.

Does Instrument Meet Final Acceptance Criteria?: (●) Yes ( ) No

Calibration Sticker Attached?: (●) Yes ( ) No

Date Instrument is Due For Next Calibration: 08/18/10

INSTRUMENT MARRIED WITH 2929 # 160018

Performed/Reviewed by: [signature] Date: 8/18/2009 Entered by: DP Initials

2 pi efficiencies counted in tulips.

Calibrations performed to ANSI N323A-1997 standards.

GRIFFIN INSTRUMENTS

CALIBRATION CERTIFICATE FOR 2241-3 SERIAL# 253346

Owner: CHASE ENV

DATE: 08/18/09 LOCATION: Griffin Inst

TECH: Joanne Glenn DATE LAST CAL EXPIRES: 08/13/09

Reason For Calibration: (●) Due For Calibration ( ) Repair (See Remarks)
( ) Other (See Remarks) ( ) Due and Repair (See Remarks)

NIST TRACEABLE EQUIPMENT USED DURING CALIBRATION

MODEL: M-500 SERIAL #: 114612 CAL. DUE: 09/05/09

MODEL: SERIAL #: CAL DUE:

[x] Fast/Slow Switch working properly [x] Audio Response [ ] Geotropism CABLE LENGTH 10'

CONDITION: Sat

NEW BATTERIES: ( ) Yes (●) No BATTERY CHECK: Sat

HV TEST ( ) N/A (●) Sat ( ) Unsat

AF INPUT SENSITIVITY (mV) #1:	2.5	AL INPUT SENSITIVITY (mV) #1:	4
AF INPUT SENSITIVITY (mV) #2:	2.5	AL INPUT SENSITIVITY (mV) #2:	4
AF INPUT SENSITIVITY (mV) #3:	2.5	AL INPUT SENSITIVITY (mV) #3:	4
AF INPUT SENSITIVITY (mV) #4:	2.5	AL INPUT SENSITIVITY (mV) #4:	4

RATE CPM	AS FOUND		% ERROR	AS LEFT	% ERROR
250	251		0.4%	A.F.	
2500	2498		0.1%	A.F.	
25K	24.993	K	0.0%	A.F.	
250K	249.955	K	0.0%	A.F.	

Is the As Found Data Within 2% of the Set Point?:
(●) Yes ( ) No

DETECTOR 1:		DETECTOR 2:		DETECTOR 3:		DETECTOR 4:	
AF 1-6	AL 1-6	AF 1-6	AL 1-6	AF 1-6	AL 1-6	AF 1-6	AL 1-6
0000 S-6	A.F.	0000 S-6	A.F.	0000 S-6	A.F.	0000 s-6	A.F.
0100 -2	A.F.	0100 -2	A.F.	0100 -2	A.F.	0100 -2	A.F.
c/	A.F.	c/	A.F.	c/	A.F.	C/	A.F.
m	A.F.	m	A.F.	m	A.F.	M	A.F.
1	A.F.	1	A.F.	1	A.F.	1	A.F.
000s	A.F.	000s	A.F.	000s	A.F.	000s	A.F.

REMARKS: See side of instrument for HV settings and detectors.

Does Instrument Meet Final Acceptance Criteria?: (●) Yes ( ) No

Calibration Sticker Attached?: (●) Yes ( ) No

Date Instrument Is Due For Next Calibration: 08/18/10

INSTRUMENT MARRIED WITH #

Performed/Reviewed by: Joanne Glenn Date: 8/18/2009 Entered by: JG Initials

Calibrations performed to ANSI N323A-1997 standards.

GRIFFIN INSTRUMENTS

CALIBRATION CERTIFICATE FOR 43-68 PROBE # PR216394

Owner: CHASE ENV

DATE: 08/18/09 LOCATION: Griffin Inst
TECH: Joanne Glenn DATE LAST CAL EXPIRES: 08/13/09

REASON FOR CALIBRATION:

(●) Due For Calibration ( ) Repair (See Remarks) ( ) Other (See Remarks) ( ) Due and Repair

CABLE LENGTH: 10' INPUT SENSITIVITY: 4 mV

NIST TRACEABLE EQUIPMENT AND STANDARDS USED DURING CALIBRATION

MODEL: 2241-3 SERIAL #: 253346 CAL. DUE: 08/18/10

NIST TRACEABLE SOURCES USED

Source Number	Isotope	4 pi Activity	Assay Date	2 pi Activity
94TH470-1593	Th230	16,700 dpm	06/16/09	8,170 cpm
00TC470-0664	Tc99 SS	17,300 dpm	06/15/09	10,800 cpm
2696-00	Pu239	18,600 dpm	07/18/06	9,390 cpm
2697-00	Sr90	12,200 dpm	03/01/00	6,530 cpm
PX 726	C14	48,780 dpm	01/21/06	18,660 cpm

Efficiencies from last cal.:

Condition: (●) Sat ( ) Unsat Pu: Th: 20.31% Sr:

Tc ss: 25.60% C14: 15.38% Tc Ni:

As Found (AF) Efficiencies:

HV / Vernier:	Tc-99 Source Response Nickel (CPM):			Pu-239 Source Response (CPM):			Background (CPM):		Tc-99 Source Response Stainless Steel (CPM):		
	A ch.	B ch.	Net Eff.	A ch.	B ch.	Net Eff.	A ch.	B ch.	A ch.	B ch.	Net Eff.
1250 / 1650				4764		25.75%	1	149		4642	25.97%

Net A to B Xtalk: <10%	B to A Xtalk: <1%

	Pu239	Tc99 Ni	Tc99 ss	Th-230	Sr90	C-14
AF CPM:	4764		4642	4139	3521	7682
AF 4 pi eff:	25.75%		25.97%	24.75%	34.67%	15.40%
AF 2 pi eff:	50.72%		41.80%	50.65%	49.59%	40.26%

Is as found efficiency within 20% of the efficiency from the last cal? (●) Yes ( ) No (See Remarks)

Note: If the as found data is within 10% of the last calibration and the B-A Xtalk is <1% and the A-B Xtalk is <10%, then the technician may N/A the plateau section and go directly to remarks.

GRIFFIN INSTRUMENTS

PROBE #: PR216394
Date: 08/18/09

PLATEAU AND SET POINT DATA

HV / Vernier:	Tc-99 Source Response SS (CPM):			Pu-239 Source Response (CPM):			Background (CPM):		Net A to B Xtalk: <10%	B to A Xtalk: <1%
	A ch:	B ch.	Net Eff.	A ch.	B ch.	Net Eff.	A ch.	B ch.		
N/A										

Alpha / Beta Bkg (cpm) 1 149

HV / Vernier		Pu-239	Tc-99 Ni	Tc-99 SS	Th-230	C-14	Sr-90
1250 /1650	CPM:	4764		4642	4139	7662	3521
	4 pi AL Efficiencies:	25.75%		25.97%	24.78%	15.40%	34.67%
	2 pi AL Efficiencies:	*50.72%*		*41.60%*	*50.65%*	*40.26%*	*49.59%*

REMARKS:

Does Instrument Meet Final Acceptance Criteria?: (●) Yes ( ) No

Calibration Sticker Attached?: (●) Yes ( ) No

Date Instrument is Due For Next Calibration: 08/18/10

INSTRUMENT MARRIED WITH 2241-3 # 253348

Performed/Reviewed by: Eugene Glover Date: 8/18/2009 Entered by: ____ Initials

2 pi efficiencies denoted in italics. Calibrations performed to ANSI.N323A-1997 standards.

GRIFFIN INSTRUMENTS

CALIBRATION CERTIFICATE FOR 2241 SERIAL# 215484

Owner: CHASE ENV

DATE: 01/13/09 LOCATION: Griffin Inst

TECH: Joanne Glenn DATE LAST CAL EXPIRES: 04/02/09

Reason For Calibration: ○ Due For Calibration ○ Repair (See Remarks)
◉ Other (See Remarks) ○ Due and Repair (See Remarks)

NIST-TRACEABLE EQUIPMENT USED DURING CALIBRATION

MODEL: M-600 SERIAL #: 42386 CAL. DUE: 05/15/09

MODEL: SERIAL #: CAL DUE:

☐ Fast/Slow Switch working properly ☑ Audio Response ☐ Geotropism CABLE LENGTH 5'

CONDITION: Sat

NEW BATTERIES: ○ Yes ◉ No BATTERY CHECK: Sat

HV TEST ○ N/A ◉ Sat ○ Unsat

AF INPUT SENSITIVITY (mV) #1:	10	AL INPUT SENSITIVITY (mV) #1:	A.F.
AF INPUT SENSITIVITY (mV) #2:	N/A	AL INPUT SENSITIVITY (mV) #2 :	N/A
AF INPUT SENSITIVITY (mV) #3:	N/A	AL INPUT SENSITIVITY (mV) #3:	N/A
AF INPUT SENSITIVITY (mV) #4:	N/A	AL INPUT SENSITIVITY (mV) #4:	N/A

RATE CPM	AS FOUND	% ERROR	AS LEFT	% ERROR
250	251	0.4%	A.F.	
2500	2492	0.3%	A.F.	
25K	24.885 K	0.5%	A.F.	
250K	248.520 K	0.5%	A.F.	

Is the As Found Data Within 2% of the Set Point?:
◉ Yes ○ No

DETECTOR 1:		DETECTOR 2:		DETECTOR 3:		DETECTOR 4:	
AF 1-6	AL 1-6	AF 1-6	AL 1-6	AF 1-6	AL 1-6	AF 1-6	AL 1-6
0000 S-6	A.F.	N/A	N/A	N/A	N/A	N/A	N/A
0100 -2	A.F.	N/A	N/A	N/A	N/A	N/A	N/A
c/	A.F.	N/A	N/A	N/A	N/A	N/A	N/A
m	A.F.	N/A	N/A	N/A	N/A	N/A	N/A
100	A.F.	N/A	N/A	N/A	N/A	N/A	N/A
000 s	A.F.	N/A	N/A	N/A	N/A	N/A	N/A

REMARKS: Client requested cal. Re-set up with new 44-10 #RN012930 on 4/28/09.

Does Instrument Meet Final Acceptance Criteria?: ◉ Yes ○ No

Calibration Sticker Attached?: ◉ Yes ○ No

Date Instrument is Due For Next Calibration: 01/13/10

INSTRUMENT MARRIED WITH 44-10 # RN012930

Performed/Reviewed by: Joanne Glenn Date: 1/13/2009 Entered by: ____ Initials

Calibrations performed to ANSI N323A-1997 standards.

GRIFFIN INSTRUMENTS

CALIBRATION CERTIFICATE FOR 44-10 PROBE # RN012930

Owner: CHASE ENV

DATE: 04/28/09 LOCATION: Griffin Inst
TECH: Joanne Glenn DATE LAST CAL EXPIRES: 08/19/09

○ Due For Calibration ◉ Other (See Remarks) Cable Length: 5'
○ Repair (See Remarks) ○ Due and Repair L.S.: 10 mV

NIST TRACEABLE EQUIPMENT AND STANDARDS USED DURING CALIBRATION

MODEL: 2241 SERIAL #: 215484 CAL. DUE: 01/13/10

SOURCE #: 99-1816 ISOTOPE: Cs137 ACTIVITY: 1.23 uCi ASSAY DATE: 08/12/99

GEOMETRY: Jig upside down with source underneath, activity side up.

Physical Condition: ◉ Sat ○ Unsat

Efficiency From Last Calibration: 5.4% Previous HV Set Point: 1050 V

Counts (CPM)	Background (CPM)	Net CPM:
128140	10180	117960

AF Efficiency: 5.40%

Is the AF efficiency within 20% of the efficiency from the last calibration? ◉ Yes ○ No

Reproducibility: 128140 129080 129850 Average: 129023.33

Are the individual counts within 10% of the average? ◉ Yes ○ No

High Voltage:	Source Response (CPM):	Background (CPM):	Net CPM:
900	107980	5890	102090
950	119110	7760	111350
1000	122350	9450	112900
1050	128140	10180	117960

HV	RESPONSE	BACKGROUND	NET CPM	
1000 V	122350	9450	112900	Efficiency: 5.17%

REMARKS: Calibrated with new meter. Cal due 1/13/10 to match box.

Does Instrument Meet Final Acceptance Criteria?: ◉ Yes ○ No

Calibration Sticker Attached?: ◉ Yes ○ No

Date Instrument Is Due For Next Calibration: 01/13/10

INSTRUMENT MARRIED WITH 2241 # 215484

Performed/Reviewed by: Joanne Glenn Date: 4/28/2009 Entered by: ____ Initials

Calibrations performed to ANSI N323A-1997 standards

GRIFFIN INSTRUMENTS

CALIBRATION CERTIFICATE FOR MICRO REM SERIAL# B226L

Owner: CHASE ENV

DATE: 08/19/09 LOCATION: Griffin Inst

TECH: Joanne Glenn DATE LAST CAL EXPIRES: 09/11/09

REASON FOR CALIBRATION: Due for Calibration

NIST TRACEABLE EQUIPMENT AND SOURCES USED DURING CALIBRATION

PULSER MODEL: MP-2 PULSER SERIAL: 1000 PULSER CAL DUE: 07/13/10

SOURCE NUMBE 10250 ISOTOPE: Cs137 ASSAY DATE: 08/30/07

☑ Geotropism TEMP 71.6 F BARO PRESS: 30.08" HUMIDITY 42%

	A.F.Data	A.F. % ERROR	A.L.Data	A.L. % ERROR	
uR/hr					
x0.1 Scale*	4	0.0%	A.F.		*Pulsed Scale
x0.1 Scale*	16.5	3.1%	A.F.		
x1 Scale*	40	0.0%	A.F.		
x1 Scale*	160	0.0%	A.F.		
mR/hr					
x10 Scale	0.4	0.0%	A.F.		
x10 Scale	1.0	0.0%	A.F.		
x10 Scale	1.6	0.0%	A.F.		
x100 Scale	4	0.0%	A.F.		
x100 Scale	10	0.0%	A.F.		
x100 Scale	15.25	4.7%	A.F.		
x1000 Scale	40	0.0%	A.F.		
x1000 Scale	100	0.0%	A.F.		
x1000 Scale	150	6.3%	A.F.		

Is the As Found Data Within 20% of the Set Point?:

◉ Yes ○ No, See Remarks

REMARKS:

Does Instrument Meet Final Acceptance Criteria?: ◉ Yes ○ No

Calibration Sticker Attached?: ◉ Yes ○ No

Date Instrument is Due For Next Calibration: 08/19/10

Performed/Reviewed by: Joanne Glenn Date: 8/19/2009 Entered by:_____Initials

Calibrations performed to ANSI N323A-1997 standards.

Appendix D
Struct Surfaces Results

Radiological Survey Record

Location: Ball State University	Area: Neutron Generator Vault	Survey: V01-0101	Date: 12/16/2009	Time: 4:00 PM
Surveyor: Ken Gavlik	Reviewed: Mike Culp	Notes: Final Status Survey		

Instrument / Serial # Detector / Serial #	Source Check	Cal. Due	Alpha/ Beta	Total/ Removable	Bkgd (cpm)	Efficiency	Count Time (min) Sample	Count Time (min) Bkg.	Area (cm^2)	MDC ($dpm/100cm^2$)
Ludlum 2241-3 / 253346 43-68 / PR216394	SAT	8/18/2010	Beta	Total	138	15.40%	1	1	126	297
Ludlum 2929 / 149121 43-10-1 /PR150791	SAT	10/28/2010	Beta	Removable	48	9.35%	3	10	100	171

Location	Total Surface Activity: Gross Counts	Net CPM	Activity ($dpm/100cm^2$)	Notes	Removable Surface Activity: Gross Counts	Net CPM	Activity ($dpm/100cm^2$)	Notes	Description
1	136	-2	-10	<MDC	143	0	-4	<MDC	Ceiling
2	165	27	139	<MDC	144	0	0	<MDC	Ceiling
3	145	7	36	<MDC	137	-2	-25	<MDC	Ceiling
4	142	4	21	<MDC	145	0	4	<MDC	Ceiling
5	176	38	196	<MDC	159	5	53	<MDC	Ceiling
6	134	-4	-21	<MDC	146	1	7	<MDC	Ceiling
7	170	32	165	<MDC	136	-3	-29	<MDC	Wall
8	171	33	170	<MDC	141	-1	-11	<MDC	Wall
9	192	54	278	<MDC	138	-2	-21	<MDC	Wall
10	132	-6	-31	<MDC	118	-9	-93	<MDC	Wall
11	146	8	41	<MDC	127	-6	-61	<MDC	Wall
12	146	8	41	<MDC	137	-2	-25	<MDC	Wall
13	174	36	186	<MDC	139	-2	-18	<MDC	Floor
14	156	18	93	<MDC	136	-3	-29	<MDC	Floor
15	131	-7	-36	<MDC	148	1	14	<MDC	Floor
16	151	13	67	<MDC	140	-1	-14	<MDC	Floor
17	217	79	407		139	-2	-18	<MDC	Floor
18	152	14	72	<MDC	156	4	43	<MDC	Floor

(1-23) min:	-36	(1-23) min:	-93
(1-23) max:	407	(1-23) max:	53
(1-23) average:	98	(1-23) average:	-13
(1-23) SD:	108	(1-23) SD:	31

Radiological Survey Record

Location: Ball State University	Area: Neutron Generator Vault	Survey: V01-0101	Date: 12/16/2009	Time: 4:00 PM
Surveyor: Ken Gavlik	Reviewed: Mike Culp	Notes: Final Status Survey		

Instrument / Serial # Detector / Serial #	Source Check	Cal. Due	Alpha/ Beta	Total/ Removable	Bkgd (cpm)	Efficiency	Count Time (min) Sample	Count Time (min) Bkg.	Area (cm^2)	MDC ($dpm/100cm^2$)
Ludlum 2241-3 / 253346 43-68 / PR216394	SAT	8/18/2010	Beta	Total	138	15.40%	1	1	126	297
Ludlum 2929 / 149121 43-10-1 /PR150791	SAT	10/28/2010	Beta	Removable	48	9.35%	3	10	100	171

Location	Total Surface Activity: Gross Counts	Net CPM	Activity ($dpm/100cm^2$)	Notes	Removable Surface Activity: Gross Counts	Net CPM	Activity ($dpm/100cm^2$)	Notes	Description
19	157	19	**98**	<MDC	144	0	**0**	<MDC	Wall
20	133	-5	**-26**	<MDC	137	-2	**-25**	<MDC	Wall
21	156	18	**93**	<MDC	147	1	**11**	<MDC	Wall
22	160	22	**113**	<MDC	134	-3	**-36**	<MDC	Wall
23	169	31	**160**	<MDC	132	-4	**-43**	<MDC	Wall

(1-23) min:	-36	(1-23) min:	-93
(1-23) max:	407	(1-23) max:	53
(1-23) average:	98	(1-23) average:	-13
(1-23) SD:	108	(1-23) SD:	31

Radiological Survey Record

Location: Ball State University	**Area:** Neutron Generator Vault	**Survey:** V01-0101	**Date:** 12/16/2009	**Time:** 4:00 PM
Surveyor: Ken Gavlik	**Reviewed:** Mike Culp	**Notes:** Final Status Survey		

Instrument / Serial # Detector / Serial #	**Source Check**	**Cal. Due**	**Alpha/ Beta**	**Total/ Removable**	**Bkgd (cpm)**	**Efficiency**	**Count Time (min) Sample**	**Count Time (min) Bkg.**	**Area (cm^2)**	**MDC ($dpm/100cm^2$)**
Ludlum 2241-3 / 253346 43-68 / PR216394	SAT	8/18/2010	Beta	Total	138	15.40%	1	1	126	297
LSC Beckman 6500	SAT	N/A	Beta	Removable	0	60.00%	1	1	100	5

Location	**Total Surface Activity**				**Removable H-3 Surface Activity**				**Description**
	Gross Counts	**Net CPM**	**Activity ($dpm/100cm^2$)**	**Notes**	**Gross Counts**	**Net CPM**	**Activity ($dpm/100cm^2$)**	**Notes**	
1	N/A	N/A	N/A		15	15	**25**		Ceiling
2	N/A	N/A	N/A		10	10	**17**		Ceiling
3	N/A	N/A	N/A		20	20	**33**		Ceiling
4	N/A	N/A	N/A		25	25	**42**		Ceiling
5	N/A	N/A	N/A		22	22	**37**		Ceiling
6	N/A	N/A	N/A		19	19	**32**		Ceiling
7	N/A	N/A	N/A		14	14	**23**		Wall
8	N/A	N/A	N/A		13	13	**22**		Wall
9	N/A	N/A	N/A		15	15	**25**		Wall
10	N/A	N/A	N/A		12	12	**20**		Wall
11	N/A	N/A	N/A		12	12	**20**		Wall
12	N/A	N/A	N/A		12	12	**20**		Wall
13	N/A	N/A	N/A		20	20	**33**		Floor
14	N/A	N/A	N/A		14	14	**23**		Floor
15	N/A	N/A	N/A		13	13	**22**		Floor
16	N/A	N/A	N/A		12	12	**20**		Floor
17	N/A	N/A	N/A		13	13	**22**		Floor
18	N/A	N/A	N/A		12	12	**20**		Floor

(1-23) min: 13
(1-23) max: 42
(1-23) average: 24
(1-23) SD: 7

Radiological Survey Record

Location: Ball State University	**Area:** Neutron Generator Vault	**Survey:** V01-0101	**Date:** 12/16/2009	**Time:** 4:00 PM
Surveyor: Ken Gavlik	**Reviewed:** Mike Culp	**Notes:** Final Status Survey		

Instrument / Serial # Detector / Serial #	**Source Check**	**Cal. Due**	**Alpha/ Beta**	**Total/ Removable**	**Bkgd (cpm)**	**Efficiency**	**Count Time (min) Sample**	**Count Time (min) Bkg.**	**Area (cm^2)**	**MDC ($dpm/100cm^2$)**
Ludlum 2241-3 / 253346 43-68 / PR216394	SAT	8/18/2010	Beta	Total	138	15.40%	1	1	126	297
LSC Beckman 6500	SAT	N/A	Beta	Removable	0	60.00%	1	1	100	5

Location	**Total Surface Activity**				**Removable H-3 Surface Activity**				**Description**
	Gross Counts	**Net CPM**	**Activity ($dpm/100cm^2$)**	**Notes**	**Gross Counts**	**Net CPM**	**Activity ($dpm/100cm^2$)**	**Notes**	
19	N/A	N/A	N/A		12	12	**20**		Wall
20	N/A	N/A	N/A		14	14	**23**		Wall
21	N/A	N/A	N/A		8	8	**13**		Wall
22	N/A	N/A	N/A		11	11	**18**		Wall
23	N/A	N/A	N/A		13	13	**22**		Wall

(1-23) min: 13
(1-23) max: 42
(1-23) average: 24
(1-23) SD: 7

Radiological Survey Record

Location: Ball State University	Area: Neutron Generator Vault	Survey:QA-V01-0101	Date: 12/17/2009	Time: 9:00 AM
Surveyor: Mike Culp	Reviewed: Ken Gavlik	Notes: Final Status Survey 5% QA		

Instrument / Serial # Detector / Serial #	Source Check	Cal. Due	Alpha/ Beta	Total/ Removable	Bkgd (cpm)	Efficiency	Count Time (min) Sample	Count Time (min) Bkg.	Area (cm^2)	MDC ($dpm/100cm^2$)
Ludlum 2241-3 / 253346 43-68 / PR216394	SAT	8/18/2010	Beta	Total	134	15.40%	1	1	126	293
Ludlum 2929 / 149121 43-10-1 /PR150791	SAT	10/28/2010	Beta	Removable	43	9.35%	3	10	100	163

Location	Total Surface Activity: Gross Counts	Net CPM	Activity ($dpm/100cm^2$)	Notes	Removable Surface Activity: Gross Counts	Net CPM	Activity ($dpm/100cm^2$)	Notes	Description
2	162	28	144	<MDC	136	2	25	<MDC	Ceiling
15	208	74	381		113	-5	-57	<MDC	Floor
19	133	-1	-5	<MDC	112	-6	-61	<MDC	Wall

min:	-5	min:	-61
max:	381	max:	25
average:	174	average:	-31
SD:	195	SD:	48

Radiological Survey Record

Location: Ball State University	Area: Neutron Generator Vault	Survey:QA-V01-0101	Date: 12/17/2009	Time: 9:00 AM
Surveyor: Mike Culp	Reviewed: Ken Gavlik	Notes: Final Status Survey 5% QA		

Instrument / Serial # Detector / Serial #	Source Check	Cal. Due	Alpha/ Beta	Total/ Removable	Bkgd (cpm)	Efficiency	Count Time (min) Sample	Count Time (min) Bkg.	Area (cm^2)	MDC ($dpm/100cm^2$)
Ludlum 2241-3 / 253346 43-68 / PR216394	SAT	8/18/2010	Beta	Total	134	15.40%	1	1	126	293
LSC Beckman 6500	SAT	N/A	Beta	Removable	0	60.00%	1	1	100	5

Location	Total Surface Activity Gross Counts	Net CPM	Activity ($dpm/100cm^2$)	Notes	Removable H-3 Surface Activity Gross Counts	Net CPM	Activity ($dpm/100cm^2$)	Notes	Description
2	N/A	N/A	N/A		21	21	35		Ceiling
15	N/A	N/A	N/A		21	21	35		Floor
19	N/A	N/A	N/A		13	13	22		Wall

min:	0	min:	22
max:	0	max:	35
average:	#DIV/0!	average:	31
SD:	#DIV/0!	SD:	8

Appendix F
Systems Results

Radiological Survey Record

Location: Ball State University	**Area:** Neutron Generator Vault	**Survey:Systems**	**Date:** 12/16/2009	**Time:** 3:00 PM
Surveyor: Mike Culp	**Reviewed:** Ken Gavlik	**Notes:**		

Instrument / Serial # Detector / Serial #	**Source Check**	**Cal. Due**	**Alpha/ Beta**	**Total/ Removable**	**Bkgd (cpm)**	**Efficiency**	**Count Time (min) Sample**	**Bkg.**	**Area (cm^2)**	**MDC ($dpm/100cm^2$)**
Ludlum 2241-3 / 253346 43-68 / PR216394	SAT	8/18/2010	Beta	Total	138	15.40%	1	1	126	297
Ludlum 2929 / 149121 43-10-1 /PR150791	SAT	10/28/2010	Beta	Removable	48	9.35%	3	10	100	171

Location	**Total Surface Activity**				**Removable Surface Activity**				**Description**
	Gross Counts	**Net CPM**	**Activity ($dpm/100cm^2$)**	**Notes**	**Gross Counts**	**Net CPM**	**Activity ($dpm/100cm^2$)**	**Notes**	
48	137	-1	-5	<MDC	138	-2	-21	<MDC	Ventilation
51	216	78	402		154	3	36	<MDC	Drain Sump

min:	-5	min:	-21
max:	402	max:	36
average:	198	average:	7
SD:	288	SD:	40

Radiological Survey Record

Location: Ball State University	**Area:** Neutron Generator Vault	**Survey:Systems**	**Date:** 12/16/2009	**Time:** 3:00 PM
Surveyor: Mike Culp	**Reviewed:** Ken Gavlik	**Notes:**		

Instrument / Serial # Detector / Serial #	**Source Check**	**Cal. Due**	**Alpha/ Beta**	**Total/ Removable**	**Bkgd (cpm)**	**Efficiency**	**Count Time (min) Sample**	**Count Time (min) Bkg.**	**Area (cm^2)**	**MDC ($dpm/100cm^2$)**
Ludlum 2241-3 / 253346 43-68 / PR216394	SAT	8/18/2010	Beta	Total	138	15.40%	1	1	126	297
LSC Beckman 6500	SAT	N/A	Beta	Removable	0	60.00%	1	1	100	5

Location	**Total Surface Activity**				**Removable H-3 Surface Activity**				**Description**
	Gross Counts	**Net CPM**	**Activity ($dpm/100cm^2$)**	**Notes**	**Gross Counts**	**Net CPM**	**Activity ($dpm/100cm^2$)**	**Notes**	
48	N/A	N/A	N/A		10	10	**17**		Ventilation
51	N/A	N/A	N/A		160	160	**267**		Drain Sump

min:	0	min:	17
max:	0	max:	267
average:	#DIV/0!	average:	142
SD:	#DIV/0!	SD:	177

Appendix G
Mat'l Release Results

Radiological Survey Record

Location: Ball State University		Area: Neutron Generator Vault		Survey: Release of Materials			Date: 12/15/2009		Time: 3:00 PM	
Surveyor: Ken Gavlik		Reviewed: Mike Culp		Notes: Free release surveys of materials and equipment from vault						
Instrument / Serial # Detector / Serial #	Source Check	Cal. Due	Alpha/ Beta	Total/ Removable	Bkgd (cpm)	Efficiency	Count Time (min) Sample	Count Time (min) Bkg.	Area (cm^2)	MDC ($dpm/100cm^2$)
Ludlum 2241-3 / 253346 43-68 / PR216394	SAT	8/18/2010	Beta	Total	137	15.40%	1	1	126	296
Ludlum 2929 / 149121 43-10-1 /PR150791	SAT	10/28/2010	Beta	Removable	45	9.35%	3	10	100	166

Location	Total Surface Activity				Removable Surface Activity				Description
	Gross Counts	Net CPM	Activity ($dpm/100cm^2$)	Notes	Gross Counts	Net CPM	Activity ($dpm/100cm^2$)	Notes	
1	125	-12	**-62**	<MDC	134	0	**-4**	<MDC	Ionization Vacuum Gauge
2	142	5	**26**	<MDC	132	-1	**-11**	<MDC	Ionization Vacuum Gauge
3	135	-2	**-10**	<MDC	145	3	**36**	<MDC	Power Guard
4	128	-9	**-46**	<MDC	147	4	**43**	<MDC	Harrison 6516A DC Power Supply
5	141	4	**21**	<MDC	137	1	**7**	<MDC	Harrison 6516A DC Power Supply
6	112	-25	**-129**	<MDC	132	-1	**-11**	<MDC	Thermocouple Ionization Control
7	138	1	**5**	<MDC	140	2	**18**	<MDC	Powercord
8	123	-14	**-72**	<MDC	132	-1	**-11**	<MDC	Powercord
9	140	3	**15**	<MDC	168	11	**118**	<MDC	Ortec Highvoltage Power Supply
10	127	-10	**-52**	<MDC	156	7	**75**	<MDC	Ortec Highvoltage Power Supply
11	120	-17	**-88**	<MDC	141	2	**21**	<MDC	Harrison 6516A DC Power Supply
12	139	2	**10**	<MDC	151	5	**57**	<MDC	Harrison 6516A DC Power Supply
13	139	2	**10**	<MDC	126	-3	**-32**	<MDC	Vacuum Pump
14	132	-5	**-26**	<MDC	145	3	**36**	<MDC	Kinney Vacuum
15	119	-18	**-93**	<MDC	155	7	**71**	<MDC	Poly Source Storage
16	135	-2	**-10**	<MDC	146	4	**39**	<MDC	Poly Source Storage
17	121	-16	**-82**	<MDC	174	13	**139**	<MDC	Light
18	161	-440	**-2268**	<MDC	161	9	**93**	<MDC	Light

min:	-2268
max:	26
average:	-158
SD:	528

min:	-32
max:	139
average:	38
SD:	47

Radiological Survey Record

Location: Ball State University	Area: Neutron Generator Vault	Survey: Release of Materials	Date: 12/15/2009	Time: 3:00 PM
Surveyor: Ken Gavlik	Reviewed: Mike Culp	Notes: Free release surveys of materials and equipment from vault		

Instrument / Serial # Detector / Serial #	Source Check	Cal. Due	Alpha/ Beta	Total/ Removable	Bkgd (cpm)	Efficiency	Count Time (min) Sample	Count Time (min) Bkg.	Area (cm^2)	MDC ($dpm/100cm^2$)
Ludlum 2241-3 / 253346 43-68 / PR216394	SAT	8/18/2010	Beta	Total	137	15.40%	1	1	126	296
Ludlum 2929 / 149121 43-10-1 /PR150791	SAT	10/28/2010	Beta	Removable	45	9.35%	3	10	100	166

Location	Total Surface Activity: Gross Counts	Net CPM	Activity ($dpm/100cm^2$)	Notes	Removable Surface Activity: Gross Counts	Net CPM	Activity ($dpm/100cm^2$)	Notes	Description
19	164	27	**139**	<MDC	155	7	**71**	<MDC	Light
20	135	-2	**-10**	<MDC	129	-2	**-21**	<MDC	Lamp
21	125	-12	**-62**	<MDC	144	3	**32**	<MDC	Intercomm
22	149	12	**62**	<MDC	153	6	**64**	<MDC	Powercords
23	125	-12	**-62**	<MDC	143	3	**29**	<MDC	Flask Stand
24	156	19	**98**	<MDC	143	3	**29**	<MDC	Hastings Vacuum Pump
25	140	3	**15**	<MDC	131	-1	**-14**	<MDC	Vacuum Pump
26	132	-5	**-26**	<MDC	162	9	**96**	<MDC	Box Powercords
27	**54943**	**54806**	**282447**		157	7	**78**	<MDC	Target Holder **(Disposed of as Rad Waste)**
28	**82717**	**82580**	**425582**		137	1	**7**	<MDC	Beam Tube Internal **(Diposed of as Rad Waste)**
29	152	15	**77**	<MDC	161	9	**93**	<MDC	RAD Box DAW
30	142	5	**26**	<MDC	137	1	**7**	<MDC	RAD Box Beam Tubes
31	143	6	**31**	<MDC	150	5	**53**	<MDC	RAD Box Beam Stop, Diff Pump Tube
32	141	4	**21**	<MDC	147	4	**43**	<MDC	Stool
33	121	-16	**-82**	<MDC	149	5	**50**	<MDC	Powercords
34	134	-3	**-15**	<MDC	166	10	**111**	<MDC	Chair
35	125	-12	**-62**	<MDC	149	5	**50**	<MDC	RAD Box Diff Pump Gate Valve
36	121	-12	**-62**	<MDC	139	1	**14**	<MDC	RAD Box DAW (Tubing)

min:	-82
max:	425582
average:	39340
SD:	117082

min:	-21
max:	111
average:	44
SD:	38

Radiological Survey Record

Location: Ball State University	Area: Neutron Generator Vault	Survey: Release of Materials	Date: 12/16/2009	Time: 3:00 PM
Surveyor: Ken Gavlik	Reviewed: Mike Culp	Notes: Free release surveys of materials and equipment from vault		

Instrument / Serial # Detector / Serial #	Source Check	Cal. Due	Alpha/ Beta	Total/ Removable	Bkgd (cpm)	Efficiency	Count Time (min) Sample	Count Time (min) Bkg.	Area (cm^2)	MDC ($dpm/100cm^2$)
Ludlum 2241-3 / 253346 43-68 / PR216394	SAT	8/18/2010	Beta	Total	138	15.40%	1	1	126	297
Ludlum 2929 / 149121 43-10-1 /PR150791	SAT	10/28/2010	Beta	Removable	48	9.35%	3	10	100	171

Location	Total Surface Activity: Gross Counts	Net CPM	Activity ($dpm/100cm^2$)	Notes	Removable Surface Activity: Gross Counts	Net CPM	Activity ($dpm/100cm^2$)	Notes	Description
37	135	-3	**-15**	<MDC	141	-1	**-11**	<MDC	Neutron Generator Stand
38	139	1	**5**	<MDC	149	2	**18**	<MDC	Neutron Generator Stand
39	126	-12	**-62**	<MDC	133	-4	**-39**	<MDC	Neutron Generator Stand
40	136	-2	**-10**	<MDC	148	1	**14**	<MDC	Neutron Generator Stand
41	135	-3	**-15**	<MDC	121	-8	**-82**	<MDC	Neutron Generator Stand (Disposed of as Rad Waste)
42	147	9	**46**	<MDC	139	-2	**-18**	<MDC	Neutron Generator Stand (Disposed of as Rad Waste)
43	168	30	**155**	<MDC	152	3	**29**	<MDC	Neutron Generator Stand (Disposed of as Rad Waste)
44	137	-1	**-5**	<MDC	148	1	**14**	<MDC	Neutron Generator Stand
45	141	3	15	<MDC	143	0	**-4**	<MDC	Transformer
46	105	-33	-170	<MDC	162	6	**64**	<MDC	Transformer
47	97	-41	**-211**	<MDC	149	2	**18**	<MDC	Steel Ramp
48	137	-1	**-5**	<MDC	138	-2	**-21**	<MDC	Ventilation
49	144	6	**31**	<MDC	142	-1	**-7**	<MDC	Metal Container
50	121	-17	**-88**	<MDC	149	2	**18**	<MDC	Metal Container
51	216	78	**402**		154	3	**36**	<MDC	Drain Sump
52	136	-2	**-10**	<MDC	141	-1	**-11**	<MDC	Metal Can
53	139	1	**5**	<MDC	155	4	**39**	<MDC	Metal Can
54	141	3	**15**	<MDC	135	-3	**-32**	<MDC	Metal Can

min:	-211
max:	402
average:	5
SD:	127

min:	-82
max:	64
average:	1
SD:	34

Radiological Survey Record

Location: Ball State University	Area: Neutron Generator Vault	Survey: Release of Materials	Date: 12/16/2009	Time: 3:00 PM
Surveyor: Ken Gavlik	Reviewed: Mike Culp	Notes: Free release surveys of materials and equipment from vault		

Instrument / Serial # Detector / Serial #	Source Check	Cal. Due	Alpha/ Beta	Total/ Removable	Bkgd (cpm)	Efficiency	Count Time (min) Sample	Count Time (min) Bkg.	Area (cm^2)	MDC ($dpm/100cm^2$)
Ludlum 2241-3 / 253346 43-68 / PR216394	SAT	8/18/2010	Beta	Total	137	15.40%	1	1	126	296
Ludlum 2929 / 149121 43-10-1 /PR150791	SAT	10/28/2010	Beta	Removable	48	9.35%	3	10	100	171

Location	Total Surface Activity: Gross Counts	Net CPM	Activity ($dpm/100cm^2$)	Notes	Removable Surface Activity: Gross Counts	Net CPM	Activity ($dpm/100cm^2$)	Notes	Description
55	156	19	98	<MDC	151	2	25	<MDC	Metal Can

min:	98	min:	25
max:	98	max:	25
average:	98	average:	25
SD:	#DIV/0!	SD:	#DIV/0!

Radiological Survey Record

Location: Ball State University	Area: Neutron Generator Vault	Survey: Release of Materials	Date: 12/15/2009	Time: 3:00 PM
Surveyor: Ken Gavlik	Reviewed: Mike Culp	Notes: Free release surveys of materials and equipment from vault		

Instrument / Serial # Detector / Serial #	Source Check	Cal. Due	Alpha/ Beta	Total/ Removable	Bkgd (cpm)	Efficiency	Count Time (min) Sample	Count Time (min) Bkg.	Area (cm^2)	MDC ($dpm/100cm^2$)
Ludlum 2241-3 / 253346 43-68 / PR216394	SAT	8/18/2010	Beta	Total	137	15.40%	1	1	126	296
LSC Beckman 6500	SAT	N/A	Beta	Removable	0	60.00%	1	1	100	5

Location	Total Surface Activity Gross Counts	Net CPM	Activity ($dpm/100cm^2$)	Notes	Removable Surface Activity Gross Counts	Net CPM	Activity ($dpm/100cm^2$)	Notes	Description
1	N/A	N/A	N/A		17	17	28		Ionization Vacuum Gauge
2	N/A	N/A	N/A		18	18	30		Ionization Vacuum Gauge
3	N/A	N/A	N/A		22	22	37		Power Guard
4	N/A	N/A	N/A		10	10	17		Harrison 6516A DC Power Supply
5	N/A	N/A	N/A		11	11	18		Harrison 6516A DC Power Supply
6	N/A	N/A	N/A		13	13	22		Thermocouple Ionization Control
7	N/A	N/A	N/A		12	12	20		Powercord
8	N/A	N/A	N/A		11	11	18		Powercord
9	N/A	N/A	N/A		17	17	28		Ortec Highvoltage Power Supply
10	N/A	N/A	N/A		13	13	22		Ortec Highvoltage Power Supply
11	N/A	N/A	N/A		9	9	15		Harrison 6516A DC Power Supply
12	N/A	N/A	N/A		12	12	20		Harrison 6516A DC Power Supply
13	N/A	N/A	N/A		51	51	85		Vacuum Pump
14	N/A	N/A	N/A		9	9	15		Kinney Vacuum
15	N/A	N/A	N/A		83	83	138		Poly Source Storage
16	N/A	N/A	N/A		29	29	48		Poly Source Storage
17	N/A	N/A	N/A		8	8	13		Light
18	N/A	N/A	N/A		14	14	23		Light

min:	0	min:	13
max:	0	max:	138
average:	#DIV/0!	average:	33
SD:	#DIV/0!	SD:	31

Radiological Survey Record

Location: Ball State University	Area: Neutron Generator Vault	Survey: Release of Materials	Date: 12/15/2009	Time: 3:00 PM
Surveyor: Ken Gavlik	Reviewed: Mike Culp	Notes: Free release surveys of materials and equipment from vault		

Instrument / Serial # Detector / Serial #	Source Check	Cal. Due	Alpha/ Beta	Total/ Removable	Bkgd (cpm)	Efficiency	Count Time (min) Sample	Count Time (min) Bkg.	Area (cm^2)	MDC ($dpm/100cm^2$)
Ludlum 2241-3 / 253346 43-68 / PR216394	SAT	8/18/2010	Beta	Total	137	15.40%	1	1	126	296
LSC Beckman 6500	SAT	N/A	Beta	Removable	0	60.00%	1	1	100	5

Location	Total Surface Activity Gross Counts	Net CPM	Activity ($dpm/100cm^2$)	Notes	Removable Surface Activity Gross Counts	Net CPM	Activity ($dpm/100cm^2$)	Notes	Description
19					13	13	**22**		Light
20	N/A	N/A	N/A		16	16	**27**		Lamp
21	N/A	N/A	N/A		18	18	**30**		Intercomm
22	N/A	N/A	N/A		16	16	**27**		Powercords
23	N/A	N/A	N/A		16	16	**27**		Flask Stand
24	N/A	N/A	N/A		19	19	**32**		Hastings Vacuum Pump
25	N/A	N/A	N/A		29	29	**48**		Vacuum Pump
26	N/A	N/A	N/A		18	18	**30**		Box Powercords
27	N/A	N/A	N/A		**446016**	**446016**	**743360**		**Target Holder (Disposed of as Rad Waste)**
28	N/A	N/A	N/A		**918306**	**918306**	**1530510**		**Beam Tube Internal (Diposed of as Rad Waste)**
29	N/A	N/A	N/A		26	26	**43**		RAD Box DAW
30	N/A	N/A	N/A		144	144	**240**		RAD Box Beam Tubes
31	N/A	N/A	N/A		26	26	**43**		RAD Box Beam Stop, Diff Pump Tube
32	N/A	N/A	N/A		43	43	**72**		Stool
33	N/A	N/A	N/A		35	35	**58**		Powercords
34	N/A	N/A	N/A		202	202	**337**		Chair
35	N/A	N/A	N/A		31	31	**52**		RAD Box Diff Pump Gate Valve
36	N/A	N/A	N/A		21	21	**35**		RAD Box DAW (Tubing)

min:	0	min:	22
max:	0	max:	1530510
average:	#DIV/0!	average:	126388
SD:	#DIV/0!	SD:	391642

Radiological Survey Record

Location: Ball State University	Area: Neutron Generator Vault	Survey: Release of Materials	Date: 12/16/2009	Time: 3:00 PM
Surveyor: Ken Gavlik	Reviewed: Mike Culp	Notes: Free release surveys of materials and equipment from vault		

Instrument / Serial # Detector / Serial #	Source Check	Cal. Due	Alpha/ Beta	Total/ Removable	Bkgd (cpm)	Efficiency	Count Time (min) Sample	Count Time (min) Bkg.	Area (cm^2)	MDC ($dpm/100cm^2$)
Ludlum 2241-3 / 253346 43-68 / PR216394	SAT	8/18/2010	Beta	Total	138	15.40%	1	1	126	297
LSC Beckman 6500	SAT	N/A	Beta	Removable	0	60.00%	1	1	100	5

Location	Total Surface Activity Gross Counts	Net CPM	Activity ($dpm/100cm^2$)	Notes	Removable Surface Activity Gross Counts	Net CPM	Activity ($dpm/100cm^2$)	Notes	Description
37	N/A	N/A	N/A		17	17	**28**		Neutron Generator Stand
38	N/A	N/A	N/A		46	46	**77**		Neutron Generator Stand
39	N/A	N/A	N/A		42	42	**70**		Neutron Generator Stand
40	N/A	N/A	N/A		26	26	**43**		Neutron Generator Stand
41	N/A	N/A	N/A		525	525	**875**		Neutron Generator Stand **(Disposed of as Rad Waste)**
42	N/A	N/A	N/A		158	158	**263**		Neutron Generator Stand **(Disposed of as Rad Waste)**
43	N/A	N/A	N/A		419	419	**698**		Neutron Generator Stand **(Disposed of as Rad Waste)**
44	N/A	N/A	N/A		13	13	**22**		Neutron Generator Stand
45	N/A	N/A	N/A		10	10	**17**		Transformer
46	N/A	N/A	N/A		17	17	**28**		Transformer
47	N/A	N/A	N/A		16	16	**27**		Steel Ramp
48	N/A	N/A	N/A		10	10	**17**		Ventilation
49	N/A	N/A	N/A		14	14	**23**		Metal Container
50	N/A	N/A	N/A		12	12	**20**		Metal Container
51	N/A	N/A	N/A		160	160	**267**		Drain Sump
52	N/A	N/A	N/A		13	13	**22**		Metal Can
53	N/A	N/A	N/A		13	13	**22**		Metal Can
54	N/A	N/A	N/A		22	22	**37**		Metal Can

min:	0	min:	17
max:	0	max:	875
average:	#DIV/0!	average:	142
SD:	#DIV/0!	SD:	249

Radiological Survey Record

Location: Ball State University	Area: Neutron Generator Vault	Survey: Release of Materials	Date: 12/16/2009	Time: 3:00 PM
Surveyor: Ken Gavlik	Reviewed: Mike Culp	Notes: Free release surveys of materials and equipment from vault		

Instrument / Serial # Detector / Serial #	Source Check	Cal. Due	Alpha/ Beta	Total/ Removable	Bkgd (cpm)	Efficiency	Count Time (min) Sample	Count Time (min) Bkg.	Area (cm^2)	MDC ($dpm/100cm^2$)
Ludlum 2241-3 / 253346 43-68 / PR216394	SAT	8/18/2010	Beta	Total	137	15.40%	1	1	126	296
LSC Beckman 6500	SAT	N/A	Beta	Removable	0	60.00%	1	1	100	5

Location	Total Surface Activity: Gross Counts	Net CPM	Activity ($dpm/100cm^2$)	Notes	Removable Surface Activity: Gross Counts	Net CPM	Activity ($dpm/100cm^2$)	Notes	Description
55	N/A	N/A	N/A		15	15	25		Metal Can

min:	0	min:	25
max:	0	max:	25
average:	#DIV/0!	average:	25
SD:	#DIV/0!	SD:	#DIV/0!