FINAL STATUS SURVEY REPORT
BUILDING 235/236 EXTERIOR WALLS

MALLINCKRODT, INC.
COLUMBIUM- TANTULUM PROJECT- PHASE 1

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C-T PROJECT – PHASE I

FINAL STATUS SURVEY REPORT

Building 235 & 236 Exterior Walls

Survey Units 235NES and 236NSW

Revision 0

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1. INTRODUCTION

1.1. PURPOSE

1.1.1. This Final Status Survey Report (FSSR) is being submitted by Mallinckrodt, Inc. to the U.S. Nuclear Regulatory Commission (NRC) for the exterior walls of Building 235 and 236 on the Mallinckrodt St. Louis site (designated as Survey Units (SU) 235NES and 236 NSW). This report is being provided in accordance with the Mallinckrodt C-T Project, Phase I Decommissioning Plan (D Plan). This FSS was performed in accordance with the Field Instruction CT-FI-002 (FI)[1] to demonstrate that the established guidelines for unrestricted release have been met. The results of the FSS are presented in this FSSR as justification for release of this SU from License STB-401 for unrestricted use.

1.2. HISTORICAL BACKGROUND

1.2.1. From 1942 to 1961 Mallinckrodt was involved in radiological activities outside of the scope of this report which terminated in 1977. Mallinckrodt's facilities have either been released from the applicable license or are being remediated by the US Army Corps of Engineers in the affected areas. License STB-401 was issued to Mallinckrodt in 1961 by the Atomic Energy Commission (AEC) (later the Nuclear Regulatory Commission (NRC)) to allow extraction of columbium and tantalum (C-T) from natural ores and tin slag, since the ores and byproducts of processing

[1] CT-FI-002, *Final Status Survey Guide for Survey Unit 235NES and 236NSW.*

contain uranium and thorium isotopes. Mallinckrodt has not performed C-T extraction since 1987. On July 12, 1993, NRC amended License STB-401 to possession-only for D&D and license termination.

2. SCOPE OF FINAL STATUS SURVEY

2.1. DEFINITION AND CLASSIFICATION OF SURVEY UNITS

2.1.1. The exterior walls of Buildings 235 and 236 have been designated as two survey units. SU-235NES consists of the north, east, and south exterior walls of Building 235. SU-236NSW consists of the north, south, and west exterior walls of Building 236. The missing wall surface is an interior wall common to both buildings. Each survey unit was classified as Class 2.

2.1.2. Table 2.1 below contains the description provided in Appendix A of the D Plan for the areas referenced by this FSSR.

Table 2.1[2]
Survey Area Descriptions

Area	Building	Surface	Location / Surface
79	235	N	North Exterior Wall: New drum pumping station located on north east wall of building fabricated from steel and FRP siding - installed 6-00. Station is approximately 26' long and 17' wide with 10' sloped roof. New concrete foundation and floor. Old brick of north wall of building exposed inside south wall of filling station.
80	235	S	South Exterior Wall: New oxidizer installed on southwest corner of building in 1996. New concrete pad for oxidizer poured above grade, 10 to 12" thick. New FRP scrubber system installed on south wall center of building in 1998. Pad poured above grade for scrubber.
81	235	E	East Exterior Wall: New 4' thick foundation and pad poured in 1998. New steel and FRP siding structure installed over pad for hydrogenation room in 1998. Several holes core drilled in bldg. 235 east wall for piping. Approximately 4'- 5' chase between hydrogenation bldg. and existing east wall. Bricks are exposed. Thirty-five feet of exterior brick to the height of 12 feet was removed starting at the south east corner of the building prior to the building of the hydrogenator. This work was performed in the fall of 1997.
87	236	N	North Exterior Wall: All windows and sills removed. New 8" masonry block walls installed. Two new 36" mandoors installed, one on the upper level and one on the lower level. Both doors are located on the northeast corner of the building.
88	236	S	South Exterior Wall/Ledges: Windows and sills and one mandoor removed. Openings on windows blocked up with 8" masonry blocks. Mandoor blocked up with 8" masonry block with brick outside.
89	236	W	West Exterior Wall/Ledges: Windows and sills, sliding door removed, windows blocked with 8" masonry block. Sliding door replaced with two new 36" mandoors and new window above door headers for 2nd floor offices.

[2] Appendix A of D Plan.

2.1.3. A summary report listing all the surfaces and fixed apparatus assigned to SU-235NES and SU-236NSW is presented in Appendix 1. Drawings of the survey units showing the location of key fixed apparatus items are presented in Appendix 2, Figures 1.1 and 1.2.

2.2. IDENTIFICATION OF THE RADIOLOGICAL CONTAMINANTS

2.2.1. The radionuclides on the St. Louis site under license STB-401 are the uranium and thorium series. Both series are assumed to be in radioactive equilibrium and to exist in a uranium-to-thorium ratio of two to one.[3]

2.3. REFERENCE BACKGROUND LEVELS

2.3.1. When the initial characterization (CH) surveys were performed from 1992 through 1996, beta backgrounds were determined for comparable matrices. Where additional background measurements were required for the FSS, they were taken on unaffected surfaces nearby or offsite. All background levels were determined by taking direct readings on the specified matrix on unaffected surfaces using the same methods and type equipment as were used for the FSS. Natural background levels for the contaminants of interest in the survey units are presented in Table 2.2.

Table 2.2
Background Reference Data

Matrix	Mean ($dpm_p/100cm^2$)[4]	Standard Deviation ($dpm_p/100cm^2$)
Brick	192.4	16.0
Concrete	35.4	20.1
Concrete Block	96.1	21.7
Metal	24.0	15.7

2.4. RELEASE CRITERIA

2.4.1. Table 2.3 displays the Derived Concentration Guideline (DCGLw) for measurements on building surfaces and fixed equipment. This value is the primary release criterion from the D Plan and is applied net of background to building surfaces such as roofs. It also applies to items of installed apparatus such as drains, HVAC units, and piping.

2.4.2. To limit the dose from residual materials as much as possible an Administrative Release Guideline (ARG)[5] was developed and was used during the FSS as if it

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[3] Mallinckrodt C-T Project D Plan Appendix D.
[4] $Dpm_p/100\ cm^2$ refers to disintegrations per minute per 100 cm^2 for the combined nuclide series.
[5] NEXTEP Tech Memo 0211, *Recommendation for an Administrative Release Guideline for the Mallinckrodt C-T Project,* A.H. Thatcher, CHP.

were the DCGLw with certain exceptions.[6]

Table 2.3
Building Surface and Installed Apparatus Release Criteria

Criterion	($dpm_p/100\ cm^2$)
DCGLw	13,000
ARG	2,600

2.4.3. Elevated Measurements Criterion (EMC).

2.4.3.1. Because SU-235NES and SU-236NSW are classified as Class 2, all measurements in these survey units must be less than the DCGLw. Therefore, the EMC criteria do not apply to this FSS.

2.5. SURVEY INSTRUMENTS

2.5.1. The instrumentation utilized to generate FSS data was maintained, calibrated, and tested according to the requirements of the D Plan. All procedures, responsibilities, and schedules for calibrating and testing equipment have been documented.

2.5.2. Maintenance information and use limitations provided in the vendor documentation of the instruments used during this FSS were adhered to. Measuring and analyzing equipment were tested and calibrated before initial use and were recalibrated periodically and whenever previous calibrations were invalidated. Field and laboratory equipment specifically used for obtaining final radiological survey data were calibrated based on standards traceable to NIST. Minimum frequencies for calibrating equipment have been established and documented.

2.5.3. Measuring equipment were tested at least once on each day the equipment was used for FSS. Test results were recorded in tabular or graphic form and compared to predetermined, acceptable performance ranges. Equipment not conforming to the performance criteria was promptly removed from service and any data gathered in the interim evaluated for quality until the deficiencies were resolved.

2.5.4. All calibration and source check records were completed, reviewed, signed-off and retained in accordance with the Mallinckrodt Quality Assurance Program. Copies of the original Calibration Sheets for the instruments used in this FSS are provided in Appendix 3.

2.5.5. L2221/AB-100 – The primary instrument used for the detection of surface radioactivity was the AB-100 scintillation detector configured for beta detection.

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[6] Final Status Survey Design Guide (Phase I), Section 3.2, covers the rules governing use of the ARG.

The AB-100 detector houses a ZnS/BC-408 organic scintillator and is paired with the Ludlum 2221 scaler/ratemeter for fixed and scan surveys. The window of the AB-100 was modified to increase the thickness of the mylar to 7-9 mg/cm^2 for the purpose of alpha attenuation[7]. The detector window was unshielded (open) for a time period during counting at each sample location, and shielded (closed) for the same time period at the same location[8]. The difference in the two readings is attributable to beta emissions above 80 KeV in energy.[9] The sensitivity of the AB-100 was derived from experiments by Lucas and Colyott which were reported in Attachment 3 to the D Plan.[10] The actual instruments used were calibrated and normalized to the reference instrument tested by Lucas and Colyott as prescribed in CT-QA-6.1[11] .

2.5.6. L2241-2/AB-100 – The AB-100 detector mentioned above paired with the Ludlum 2241-2 scaler/ratemeter was used in the same way for direct and/or scan beta measurements.

2.5.7. Ludlum 43-89 – The Ludlum 43-89 is a newer scintillation detector very similar in form and function to the AB-100. It was used in the same manner and was paired with the same scaler or rate meters. Sensitivity of this instrument was derived from experiments by Lucas and Colyott which were reported in Attachment 4 of the D Plan.

2.5.8. L3030 – The Ludlum Model 3030 alpha/beta scaler houses ZnS(Ag) and plastic scintillators and was used to count removable contamination collected on paper swipes. Smear papers were counted in the laboratory and results were reported in βpm/100 cm^2. Removable contamination measurements were not compared with the release criteria for purposes of releasing the survey unit, but only to confirm that the removable fraction was less than 20% of the DCGLw.

2.5.9. L2221/3x3NaI - When beta measurements could not be taken, the 3"x3" Sodium Iodide (NaI) detector was used. This instrument was calibrated off site and no modification or normalization (as was required for the AB-100) was performed.

2.6. Lower Limits of Detection and Detection Thresholds

2.6.1. The terminology adopted to reflect an instrument's measurement (detection) capability is the lower limit of detection (LLD) or the minimum detectable activity (MDA); it refers to the intrinsic detection capability of the entire measurement

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[7] As specified in Appendix D of the D Plan. Measurements taken with only the mylar covering the probe were "open window" measurements.

[8] The "closed window" reading was taken with a 1/8" soft Aluminum plate covering the face of the detector. It is sufficient to exclude β rays from the U and Th series.

[9] Internal Conversion Electrons (ICE) will also be included in this number but are a second order effect and may be ignored.

[10] *Energy Dependent Calibrations for the Bicron Model AB-100 Beta Ray Survey Probe*, A. Lucas, CHP and L. Colyott, Ph.D., submitted as Attachment 3 to the Mallinckrodt Phase I Decommissioning Plan.

[11] CT-QA-6.1 - *Calibration and Control of Measuring and Survey Equipment.*

process. The LLD, or MDA, is the lowest level of radioactivity that will yield a net count, above system blank, that will be detected with at least 95% probability with no greater than a 5% probability of falsely concluding that a blank observation represents a real signal. It is desirable to express the MDA as minimum detectable areal density (MDAD) or minimum detectable concentration (MDC) in units comparable to a regulatory limit with which a measurement may be compared. For a more detailed discussion regarding LLD and equations involved in calculation of LLD, refer to CT-QA-6.1.[12]

2.6.2. The LLD requirements for the FSS have been developed in accordance with MARSSIM [13]Chapter 4 guidelines. They are contained in the Design Guide and are listed in Table 2.4.

Table 2.4
MDC Requirements for C-T FSS

Measurement Type	MDC Requirement[14]
Direct Beta Class 2	50% of ARG ARG

2.6.3. The MDCs for the instruments used in the FSS were calculated according to Appendix D of the D Plan[15]. A comparison of the MDCs calculated for the AB-100 with the requirement for this FSS is provided in Table 2.5.[16]

2.6.4. Action thresholds based upon the release criteria were calculated for each instrument in both direct and scan modes of operation. All thresholds were based on the ARG and are presented in Table 2.5. Details of the MDC calculations and derivation of the action thresholds are provided in NEXTEP Tech Memo 0230.[17]

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[12] CT-QA-6.1, Ibid.
[13] NUREG 1575, Multi *Agency Radiation Survey and Site Investigation Manual.*
[14] Requirements are stated in terms of the ARG which may be adjusted upward (not to exceed the $DCGL_W$) by the area factor or paint attenuation factor as described in Section 3.2 of the Design Guide.
[15] NEXTEP Tech Memo 0230, *Technical Basis Document for Mallinckrodt Final Status Surveys*, A.H. Thatcher, CHP, (included with FSSR 2501).
[16] MDCs for the AB-100 are typical of those for the 43-89.
[17] NEXTEP Tech Memo 0230, ibid.

Table 2.5
LLD and Action Thresholds[18]

Measurement	Units	Calculated Value	Required Value
BETA DIRECT			***Class 2***
MDC	$dpm_p/100\ cm^2$	100	1,300
Tinv[19]	cpm		2,900
BETA SCAN			
MDC	$dpm_p/100\ cm^2$	760	2,600
Tinv	cpm		2,000

2.7. INSTRUMENT SENSITIVITY, BACKSCATTER AND PAINT ATTENUATION

2.7.1. Beta direct measurements taken in the field were converted to $dpm_p/100\ cm^2$ of the parent nuclide series in accordance with Section 9 of the Design Guide using the following equation:

Equation 2

$$AD = \frac{Co - Cc}{PAF * S_i * S_b(m) * t}$$

Where:

AD	=	Areal Density in $dpm_p/100\ cm^2$ for the parent nuclides
Co	=	Counts measured in the open window configuration
Cc	=	Counts measured in the closed window configuration
PAF	=	Paint attenuation factor derived from the number of coats of paint applied to the surface since C-T operations ceased.
S_i	=	Normalized Instrument sensitivity without backscatter.
$S_b(m)$	=	Backscatter factor (a function of matrix)
t	=	Integration time in minutes.

2.7.2. No painted surfaces were surveyed. Therefore, the paint attenuation factor (PAF) was always equal to one.

2.7.3. Justification and calculations for separation of backscatter (as a function of the matrix) and instrument sensitivity were presented in NEXTEP Tech Memo 0215.[20] Reference backscatter coefficients for several matrix materials were generated using an MCNP model and are described in NEXTEP Tech Memo

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[18] All Values given are net of background.
[19] Investigation Threshold.
[20] NEXTEP Tech Memo 0215, *Separation of Backscatter & Derivation of Instrument Sensitivity*, A.H. Thatcher CHP, (included with FSSR 2501).

0213.[21] These coefficients were stored in the Matrix table in the Database and were used in the calculations according to the matrix material upon which the measurement was taken.

3. SURVEY METHODS

3.1. SURVEY PROCEDURES

3.1.1. The FSS conformed to the procedures and plans listed in Table 3.1. The primary guidance for the FSS is contained in the Design Guide and the Field Instruction.

Table 3.1

Survey Procedures and Documents
CT Decommissioning Plan (Phase I)
CT Decommissioning Project, Final Status Survey Design Guide (Phase I)
CT-FI-002, Final Status Survey Guide for Survey Unit 235NES & 236NSW
CT-QA-6.1: Calibration and Operation of Measuring and Survey Equipment
CT-RP-66: Operation of Scalers, Rate Meters, and Contamination Detectors
CT-RP-39: Performance of Radiation and Contamination Surveys
CT-RP-40: Survey Documentation and Review

3.1.2. All FSS data recorded in the field was submitted to the Quality Assurance Coordinator or designee for processing and review. The data collection forms and annotated drawings were signed by the technician taking the data and reviewed by the Radiation Protection, Health & Safety (RPHS) Manager or designee overseeing the survey. After data entry and review, QA approved the data sheets and filed them with the permanent Mallinckrodt records. The QA checklist[22] developed for quality verification of FSS data was used as a guide to data verification.

3.1.3. All the data generated by the surveys were entered into the C-T Radiation Database (RDB) and analyzed as outlined in Section 4.4 of the D Plan.

3.2. SURVEY MEASUREMENTS

3.2.1. Beta Measurements:

3.2.1.1. *Direct* – A systematic grid of direct measurements were obtained on the wall surfaces as described in the FI. Bias measurements were taken on

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[21] NEXTEP Tech Memo 0213, *Beta Backscatter Factors for Several Materials at the Mallinckrodt Site,* N. Zhang and D. Wilson, (included with FSSR 2501).

[22] NEXTEP Tech Memo 0206, *QA Data Verification for MI CT Final Status Survey Data*, B. Anderson, (included with FSSR 2501).

building surfaces and fixed apparatus at locations determined by the surveyor in an effort to fully characterize the fixed apparatus.

3.2.1.2. *Scans* - Beta scans were performed using the same instruments used for the direct beta measurements. Beta Scans were performed on all fixed apparatus. Scans were performed at a scan rate of less than one detector width per second with a probe height less than one inch from the surface being scanned.

3.2.2. Removable Contamination Measurements:

3.2.2.1. *Swipes* - Removable contamination samples were collected at all of the regular grid locations on the walls. The swipes were counted in the laboratory and recorded in the database. Sampling of removable contamination was performed to confirm the assumption, used in derivation of the DCGLw, that the removable fraction measures less than 20% of the DCGLw[23].

3.3. MEASUREMENT LOCATIONS

3.3.1. Statistical Grid Data Points

3.3.1.1. The *Visual Sample Plan*© (VSP)[24] software was used to develop a MARSSIM grid for both survey units. The minimum number of points required and their spacing were calculated in accordance with the statistical guidance given in MARSSIM Sections 5.5.2.2 and 5.5.2.5.

3.3.1.2. VSP uses the Data Quality Objectives (DQO) input values to calculate the number of measurement points, N, required to satisfy MARSSIM statistical guidance. The calculations include 20% excess to allow for inaccessible locations. A summary of all the input parameters used with VSP for this Report is presented in Table 3.2.

Table 3.2
VSP Inputs for Building 235 & 236 Exterior Walls

DQO	Value
Type I error rate	5%
Type II error rate	5%
Width of Gray Region	200 $dpm_p/100cm^2$
Level (ARG)	2,600 $dpm_p/100cm^2$
Estimated Std Deviation	200 $dpm_p/100cm^2$
Excess % sample points min.	20%

[23] Section 3.3 of the C-T Design Guide.
[24] NEXTEP Tech Memo 0008, *Verification and Validation of Applicable Portions of VSP Software,* A.H. Thatcher, CHP.

3.3.1.3. A rectangular grid was used for both survey units. The maximum grid interval spacing (L) was calculated from the total area (A) of the survey unit and the required number of data points (N) according to the following equation:

Equation 3

$$L \leq \sqrt{\frac{A}{N}}$$

3.3.1.4. Table 3.3 presents the calculated values for L and N for both SU 235NES and 236 NSW.

Table 3.3
SU 235NES & 236 NSW Calculated Grid Point Separation

Survey Unit	Class	N	A (ft^2)	L (ft)
SU-235NES	2	29	7544	16.1
SU-236NSW	2	29	4025	11.8

3.3.2. Bias Measurement Locations

3.3.2.1. Bias direct measurements were taken at the discretion of the HP technician performing the survey.

3.3.2.2. Bias surveys were also taken at hot spot locations identified by scans as directed in the Hot Spot Protocol[25].

3.4. REFERENCE COORDINATE SYSTEM

3.4.1. A unified reference system was prescribed for the location of all data points taken on all building surfaces and on the surface of installed apparatus. A description of the reference coordinate system is provided below.

3.4.2. A data point's unique location is specified by a combination of the following data elements: building, room, surface ID, X, and Y. The surface ID refers to the four walls, floor, ceiling and roof as shown in Table 3.4. X and Y are distances from the origin measured as shown in the table. An example of X and Y axes for floors and walls is presented in Appendix 2, Figure 3.1

[25] CT-FI-004, *Final Status Survey Guide for Survey Unit 2504,* Attachment E.

Table 3.4
Coordinate System Locators

Location	Identifier	X	Y
North Wall	N	Feet right from leftmost edge of the wall surface	Feet up from floor or the lowest point in the room
South Wall	S		
East Wall	E		
West Wall	W		
Floor	F	Feet east from western most edge of the surface	Feet North of southernmost edge
Ceiling	C		
Roof	R		

3.4.3. Systematic grid data points which fell on external surfaces of installed apparatus were located with the primary coordinate system. The ID code of the apparatus was recorded in the remarks. For example: Let Q2 be identified as a large air conditioning unit located on the roof. Any systematic grid measurement points for the roof surface which landed on the air conditioner would have been identified using the X and Y coordinates from the southwest corner of the roof. "Q2 – A/C unit" would be noted in the remarks. The surface ID would be "R".

3.4.4. All bias data points taken on installed apparatus were numbered and located on the drawings provided. This number was recorded as the X coordinate on the data sheet and amplifying information was entered in the remarks section.

3.5. DATA EVALUATION

3.5.1. All of the direct, swipe and scan data were entered into the C-T Radiation Database (RDB) for easy access and analysis. The direct beta measurements are the primary means for documenting the survey unit and justifying its release. Therefore, a special report was programmed to perform all the tests specified in Section 4.4.8 of the D Plan and to provide a clear report of the results for evaluation. The calculations in this report have been validated and verified as described in NEXTEP Tech Memo 0231[26].

3.5.2. The purpose of the screening software is to compare each direct beta reading taken in the survey unit with specified threshold levels, to apply the statistical tests called for in MARSSIM when appropriate, and to present the results in a clear and useful manner so that an analyst can accurately assess the action to be taken or declare the survey unit meets the requirements for release.

3.5.3. Some of the screening tests apply to each record in the survey unit and failure of one data point results in failure of the survey unit. Other tests do not apply to

[26] NEXTEP Tech Memo 0231, *Validation and Verification of the C-T Database Analysis Report,* B. Anderson, (included with FSSR 2501).

each survey record but generate a single PASS/FAIL verdict for the entire data set. The tests are described in the following paragraphs[27]. An abbreviated summary of these tests is presented in Table 3.5.

3.5.4. *Background Screen.*

3.5.4.1. For each MATRIX code in the database, calculate the mean background reading, its standard deviation, and its minimum value. Calculate and store the Background Threshold, T_{bk}, with its matrix code according to the following equation:

Equation 4

$$T_{bk}(m) = \overline{BK}(m) + 2 * \sigma_{bk}(m)$$

3.5.4.2. T_{bk} is equal to the mean of the background readings $\left(\overline{BK}\right)$ for a given matrix plus two times its standard deviation (2σ).

3.5.4.3. Compare each data point in the filtered survey unit with T_{bk}. If the survey reading > T_{bk} the data point fails the test. One data point failure implies failure of the background screen test for the survey unit.

3.5.5. *Min/Max Test.*

3.5.5.1. Find the maximum direct survey result, in $dpm_p/100cm^2$, for the survey data set.

3.5.5.2. Find the minimum background reading among all the background data points having MATRIX codes that match those in the data set.

3.5.5.3. If the difference between these two values is greater than DCGLw the MIN/MAX test fails for the survey unit.

3.5.6. *DCGLw Screen.*

3.5.6.1. For each matrix code calculate and store a DCGLw Threshold (T_d). T_d is calculated by adding the value of DCGLw to T_{bk}.

Equation 5

$$T_d(m) = T_{bk} + DCGLw$$

3.5.6.2. Compare each data point in the survey unit with T_d. If the survey reading > T_d the data point fails the test. One data point failure implies failure of the DCGLw screen test for the survey unit.

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[27] A more detailed explanation is provided in the Design Guide.

3.5.7. *EMC Screen.*

3.5.7.1. For each matrix code calculate and store an EMC Threshold (T_e). T_e is calculated by adding the value of EMC to T_{bk}. The EMC value selected is normally dependent upon the area involved. However, if no specific area was known, the EMC was normally set to the a priori $DCGL_{EMC}$.

3.5.7.2. Compare each data point in the filtered survey unit with T_e. If the survey reading > T_e the data point fails the test. One data point failure implies failure of the EMC test for the survey unit.

3.5.8. *DCGL Average Test.*

3.5.8.1. For each matrix material in the survey unit, calculate the mean activity density (in $dpm_p/100cm^2$), in the survey data set. Subtract from this value, the mean value of background activity for the same matrix. If the remainder is greater than DCGLw for any matrix in the survey unit, the test fails.

Equation 6

$$\overline{AD}(m) - \overline{BK}(m) > DCGL_W$$

3.5.9. Statistical Tests.

3.5.9.1. The statistical tests prescribed by MARSSIM operate only on the data points of MEASUREMENT TYPE = RG (Regular Grid) or PG (Post-Remediation Grid). The program narrows the filter to include only these points before proceeding.

3.5.9.2. The Wilcoxon Rank Sum Test[28] is applicable for survey units with measurements on a single matrix type or on matrices with similar background characteristics. Where more than one matrix was present, the Sign Test for Paired Data[29] was used.

3.5.10. The output of the Threshold Comparison Test Report (TCTR) was used for analysis of the data for Building 235 and 236 exterior walls and the results are presented in Appendix 4. Each TCTR is divided into eight sections which are briefly described in the following paragraphs to assist the unfamiliar reader.

3.5.10.1. General: date, survey unit number, class, and grid information.

3.5.10.2. Survey Unit Table: building surface included, affected fixed apparatus, and total surface area of the survey unit.

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[28] Described in Appendix I of MARSSIM.
[29] Described in NEXTEP Tech Memo 0231, ibid.

3.5.10.3. Initialization Data: On startup of the analysis report program, the analyst must tell the program which parameters to use while running the tests described in this section. The *Initialization Data* section of the report output displays the options that were chosen for the run. The measurement types listed are those chosen by the analyst to be included in the report. The date range chosen is also listed. The default value is "All Dates". Values for DCGLw (ARG) and $DCGL_{EMC}$ are also specified at the start of the run and are listed in this section. If remediated data points are included in the run, it will be noted in this section. Normally they will be excluded.

3.5.10.4. Survey Unit Test Status: Lists Pass/Fail status of all tests and gives a high level summary of key activity levels in the survey unit.

3.5.10.5. Points that failed tests: Lists all points that failed each specified threshold test (EMC, DCGL, and Background).

3.5.10.6. Points that passed all the tests: This includes the remainder of all the points in the data set. These data points have passed all the tests.

3.5.10.7. Summary of background data used in the calculations. This table includes the matrix materials included in the survey and the thresholds calculated for each of the tests discussed in this section.

3.5.10.8. Statistical Test Results: This page lists the results of the Sign Test for Paired Data or the Wilcoxon Rank Sum test, whichever is selected. If the Test Status line reads Pass then the survey unit passes the Sign Test for Paired Data. The Data Summary section lists the number of background points and the number of survey points used from the data set. If the operator selects the option to show all data, a table of all data points used in the test is printed out.

Table 3.5
Threshold Screening Tests

Test	Test Criteria for PASS
Min/Max	Difference between minimum background measurement and maximum survey value less than DCGLw
Background	All samples must be less than the background threshold[a]
$DCGL_w$	All samples must be no more than $DCGL_w$ + the background threshold
$DCGL_{avg}$	The average of all net survey values must be less than $DCGL_w$
EMC	All samples must be less than $DCGL_{EMC}$ + the background threshold
Sign Test for Paired Data	The Sign Test for Paired Data is described in detail in NUREG 1505[30]
Wilcoxon Rank Sum Test	This statistical test is described in detail in MARSSIM, Appendix I.

[a] The background threshold is equal to the mean background value plus twice σ_{BK}.

3.5.11. Provided all additional considerations such as scan data, swipes, and sampling of removable contamination or sludge from traps, etc. indicate that the survey unit meets the release criteria, the release of the survey unit can be determined from the test report according to Table 3.6.

Table 3.6
Requirements for SU Release[31]

Test	Class 1	Class 2	Class 3
Min/Max	not required[a]	not required[a]	PASS
Background	not required	not required	PASS
$DCGL_w$	not required	PASS	PASS
$DCGL_{avg}$	PASS	PASS	PASS
EMC	PASS	PASS	PASS
Sign Test for Paired Data	PASS	PASS	PASS

[a] Class 1 or 2 survey units which pass Min/Max may be released without further consideration.

[30] NUREG 1505, *A Nonparametric Statistical Methodology for the Design and Analysis of Final Status Decommissioning Surveys.*

[31] See MARSSIM, Chapter 8, Table 8.2.

4. FSS Results and Discussion

4.1. Characterization Data

4.1.1. A full set of beta direct characterization data was taken in this survey unit from 1992 to 1996. During that time, the southernmost 30 feet of the east wall was remediated, along with the bottom of the wall and other wall portions. The data from the remediated sections have been tagged as "R" in the database[32], while all the remaining characterization data have been included in the FSS data set as bias data points.

4.2. Survey Unit 235NES

4.2.1. SU-235NES was surveyed in April 2003. Measurements were taken on the north, east, and south walls.

4.2.2. Direct Beta Measurements on Building Surfaces

4.2.2.1. 125 direct beta measurements were taken on the surfaces of the survey unit. 30 of these were included in the systematic grid. A diagram of the survey unit layout of each wall with the beta measurements taken is presented in Appendix 2, Figure 4.1. Two grid locations on the east wall and one on the north wall were inaccessible and were omitted from the grid.

4.2.2.2. A summary of the direct measurement results is presented in Table 4.1 and shows that the maximum activity measured, net of background, was 587 $dpm_p/100cm^2$. The average value for the survey unit was 54 $dpm_p/100cm^2$.

Table 4.1
SU-235NES Direct Measurements Summary
(Building Surfaces Only)

Matrix	Points	Avg Net Activity[a] ($dpm_p/100cm^2$)	Max Net Activity ($dpm_p/100cm^2$)
Brick	76	59.2	302.6
Concrete	21	106.3	587.0
Concrete Block	1	21.5	21.5
Fiberglass	1	31.0	31
Metal	19	-9.3	62
Other Non Metal	7	13.6	157.7

[a] DPMp refers to disintegrations per minute of the parent nuclide series

[32] R-tagged records are normally excluded from the data set by the analysis software.

4.2.3. Direct Beta Measurement on Installed Apparatus

4.2.3.1. All 9 items of installed apparatus which are listed in Appendix 1 were surveyed by direct beta measurements. A summary of the measurements taken is provided in Table 4.2 sorted by matrix material. The values observed ranged from –47 to 70 $dpm_p/100cm^2$. All values were less than 3% of the ARG. The data confirm that essentially no residual radioactivity levels were found on the items of installed apparatus in SU-235NES.

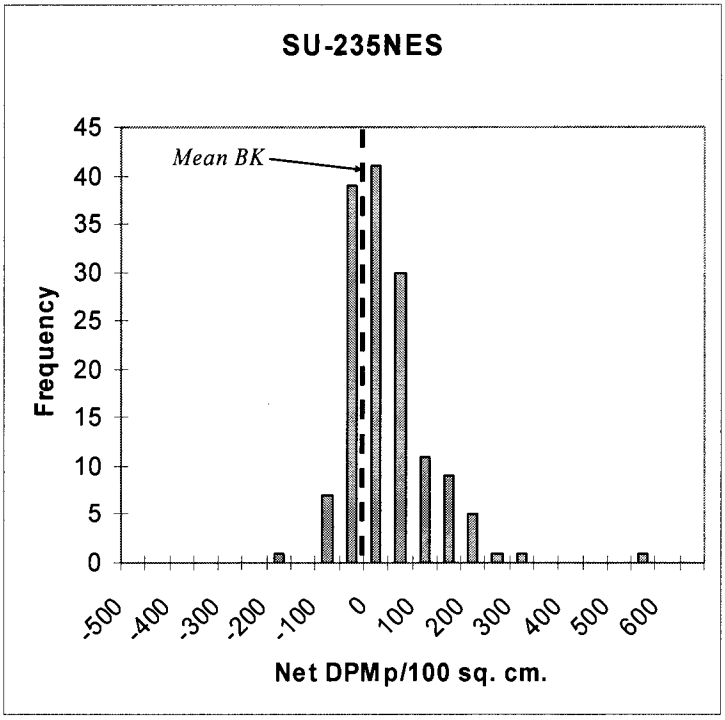
Table 4.2
SU-235NES Fixed Equipment Direct Measurements Summary

Matrix	Points	Avg Net Activity ($dpm_p/100cm^2$)	Max Net Activity ($dpm_p/100cm^2$)
Fiberglass	2	51.0	59.2
Metal	19	6.4	69.9

4.2.4. Direct Beta Measurement Distribution and Threshold Tests

4.2.4.1. A histogram of the net activity values found in SU-235NES is provided in Figure 4.1. The distribution appears to have a single mode with the majority of the data centered at approximately 25 $dpm_p/100cm^2$.[33] This is consistent with a normal distribution of background radioactivity with a small amount of contamination just above background. All measurements were well below the ARG.

[33] Actually this mode represents the number of occurrences where the activity fell between 0 and 50 $dpm_p/100cm^2$.



Histogram of Net Direct Beta Measurements
Figure 4.1

4.2.4.2. All the direct measurements in the survey unit were analyzed using the Threshold Comparison Test Report and the results are presented in Appendix 4 for SU-235NES. The TCTR report contains a complete listing of all the beta direct measurements taken in the Final Status Survey within SU-235NES sorted by test failed and by activity. The summary pages indicate that all tests described in the D Plan passed except background. All the tests required for release of Class 2 survey units were passed. A comparison of test results and requirements for release of the survey unit is presented in Table 4.3.

Table 4.3
Requirements for SU Release

Test	Class 2	SU-235NES
Min/Max	not required[a]	P
Background	not required	F
$DCGL_w$	PASS	P
$DCGL_{avg}$	PASS	P
EMC	PASS	P
Sign Test for Paired Data	PASS	P

[a] Class 2 survey units which pass Min/Max may be released without further consideration..

4.2.4.3. As the histogram in Figure 4.1 shows, some residual radioactivity exists above the background level but far below the administrative release guideline of 2,600 $dpm_p/100cm^2$. These results are consistent with a failure of the background test only for this survey unit.

4.2.5. Measurements of Removable Contamination

4.2.5.1. Swipes were taken at each location where a direct grid measurement was performed. The results of the measurements are presented in Table 4.4.

Table 4.4
SU-235NES Removable Contamination Summary

Surface	Points	Avg Net Beta ($\beta pm/100cm^2$)	Max Net Beta ($\beta pm/100cm^2$)	Avg Net Activity[a] ($dpm_p/100cm^2$)	Max Net Activity ($dpm_p/100cm^2$)
N	6	-2.8	18	-0.6	3.8
E	12	-1.7	26	-0.3	5.4
S	12	1.6	29	0.3	6.0

[a] Activity was converted to $dpm_p/100\ cm^2$ from $\beta pm/100\ cm^2$ using an approximate figure of 4.8 betas per disintegration.

4.2.5.2. The results show that removable contamination averages very near zero $dpm_p/100cm^2$ and varies between –7 and +6 $dpm_p/100cm^2$. The data confirm that virtually no removable contamination is present within the survey unit.

4.2.6. Beta Scan Measurements

4.2.6.1. Beta scans were performed on about 25% of the surface of the exterior walls. A diagram of the areas surveyed is presented in Appendix 2, Figure 4.2.

4.2.6.2. The scan threshold used for these surveys was 2,000 cpm (net of background) which corresponds to the ARG of 2,600 $dpm_p/100cm^2$. The calculation of threshold count rate and MDC for scans is presented in NEXTEP Tech Memo 0230[34].

4.2.6.3. All scans performed on the wall surfaces were taken on brick. The average background value used for analysis of the raw data was obtained from the average of all the open window beta readings (in cpm) taken in the background data set. For brick this value was 552 cpm. The average of all open window survey readings taken on brick in this survey unit was 610 cpm.

[34] NEXTEP Tech Memo 0230, *Technical Basis Document for Mallinckrodt Final Status Surveys*, A.H. Thatcher CHP, (included with FSSR 235 Roof).

4.2.6.4. During the surveys the maximum and average gross count rates were recorded for each area scanned. The beta scan data are summarized for SU-235NES and presented in Table 4.5.

Table 4.5
SU-235NES Scan Measurements Summary

Survey Unit	Areas	Maximum (cpm)	Average (cpm)	Max Net (cpm)	Avg Net (cpm)
235NES	5	950	660	398	108

4.2.6.5. The maximum net scan value of 398 is well below the scan threshold of 2000 cpm. No scans were observed above the scan threshold.

4.3. SURVEY UNIT 236NSW

4.3.1. SU-236NSW was surveyed in April 2003. Measurements were taken on the north, south, and west walls.

4.3.2. Direct Beta Measurements on Building Surfaces

4.3.2.1. 120 direct beta measurements were taken on the surfaces of the survey unit. 32 of these were included in the systematic grid. A diagram of the survey unit layout of each wall with the beta measurements taken is presented in Appendix 2, Figure 4.3. One inaccessible grid measurement on the west wall of Building 236 was omitted.

4.3.2.2. A summary of the direct measurement results is presented in Table 4.6 and shows that the maximum activity measured, net of background, was 452 $dpm_p/100cm^2$. The average value for the survey unit was 119 $dpm_p/100cm^2$.

Table 4.6
SU-236NSW Direct Measurements Summary
(Building Surfaces Only)

Matrix	Points	Avg Net Activity[a] ($dpm_p/100cm^2$)	Max Net Activity ($dpm_p/100cm^2$)
Brick	59	135.2	451.8
Concrete	7	74.8	113.7
Concrete Block	4	18.2	66.2
Metal	2	-5.8	-2.3

4.3.3. Direct Beta Measurements on Installed Apparatus

4.3.3.1. All 4 items of installed apparatus which are listed in Appendix 1 were surveyed by direct beta measurements. A summary of the measurements taken is provided in Table 4.7. The values observed ranged from –27 to 116 $dpm_p/100cm^2$. All values were less than 5% of the ARG. The data

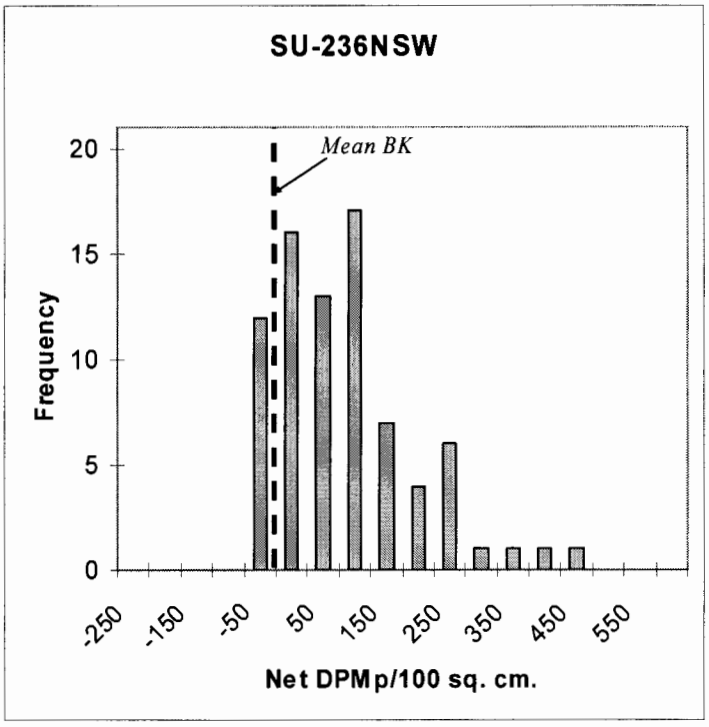
confirm that negligible residual radioactivity levels were found on the items of installed apparatus in SU-236NSW.

Table 4.7
SU-236NSW Fixed Equipment Direct Measurements Summary

Matrix	Points	Avg Net Activity ($dpm_p/100cm^2$)	Max Net Activity ($dpm_p/100cm^2$)
Metal	7	17.3	115.8

4.3.4. Direct Beta Measurements, Distribution, and Threshold Tests

4.3.4.1. A histogram of all the net activity values found in SU-236NSW is provided in Figure 4.2. The distribution appears to represent a background distribution with the majority of the data centered at approximately 75 $dpm_p/100cm^2$ as well as a second distribution, possibly representing residual activity, at a slightly higher concentration interval. The distribution is skewed to the left. All data are well below the ARG.



Histogram of Net Direct Beta Measurements
Figure 4.2

4.3.4.2. All the direct measurements in the survey unit were analyzed using the Threshold Comparison Test Report and the results are presented in Appendix 4 for SU-236NSW. The summary pages indicate that all tests described in the D Plan passed except background. A comparison of test results and requirements for release of the survey unit is presented in

Table 4.8. All the tests required for release of Class 2 survey units were passed.

Table 4.8
Requirements for SU Release

Test	Class 2	SU-236NSW
Min/Max	not required[a]	P
Background	not required	F
$DCGL_w$	PASS	P
$DCGL_{avg}$	PASS	P
EMC	PASS	P
Sign Test for Paired Data	PASS	P

[a] Class 2 survey units which pass Min/Max may be released without further consideration.

4.3.4.3. As the histogram in Figure 4.2 shows, some residual radioactivity exists above the background level but far below the administrative release guideline of 2,600 $dpm_p/100cm^2$. These results are consistent with a failure of the background test only for this survey unit.

4.3.5. Measurements of Removable Contamination

4.3.5.1. Swipes were taken at each location where a direct grid measurement was performed. The results of the measurements are presented in Table 4.9.

Table 4.9
SU-236NSW Removable Contamination Summary

Surface	Points	Avg Net Beta ($\beta pm/100cm^2$)	Max Net Beta ($\beta pm/100cm^2$)	Avg Net Activity[a] ($dpm_p/100cm^2$)	Max Net Activity ($dpm_p/100cm^2$)
N	9	2.2	26	0.5	5.4
S	9	-4.9	15	-1.0	3.1
W	14	2.8	26	0.6	5.4

[a]Activity was converted to $dpm_p/100\ cm^2$ from $\beta pm/100\ cm^2$ using an approximate figure of 4.8 betas per disintegration.

4.3.5.2. The results show that removable contamination averages very near zero $dpm_p/100cm^2$ and varies between –6.0 and +5.4 $dpm_p/100cm^2$. The data confirm that virtually no removable contamination is present within the survey unit.

4.3.6. Beta Scan Measurements

4.3.6.1. Beta scans were performed on about 20% of the surface of the exterior walls. A diagram of the areas surveyed is presented in Appendix 2, Figure 4.4.

4.3.6.2. The scan threshold used for these surveys was 2,000 cpm (net of background) which corresponds to the ARG of 2,600 $dpm_p/100cm^2$.

4.3.6.3. All scans performed on the wall surfaces were taken on brick. The average background value used for analysis of the raw data was obtained from the average of all the open window beta readings (in cpm) taken in the background data set. For brick this value was 552 cpm. This average of all open window beta readings taken on brick on the survey unit was 741 cpm.

4.3.6.4. During the surveys the maximum and average gross count rates were recorded for each area scanned. The beta scan data are summarized for SU-236NSW and presented in Table 4.10.

Table 4.10
SU-236NSW Scan Measurements Summary

Survey Unit	Areas	Maximum (cpm)	Average (cpm)	Max Net (cpm)	Avg Net (cpm)
236NSW	6	1200	692	648	140

4.3.6.5. The maximum net scan value of 648 cpm is well below the scan threshold of 2000 cpm. No scans were observed above the scan threshold.

5. CONCLUSIONS

5.1. SU-235NES passed all the tests described in the D plan except background. All the tests required for release of a Class 2 Survey unit were passed. (Par. 4.2.4.2)

5.2. No significant residual radioactivity was measured on the 9 items of installed apparatus in SU-235NES.(Par. 4.2.3.1)

5.3. Virtually no removable contamination is present within SU-235NES. (Par. 4.2.5.2)

5.4. No beta scan data were observed in SU-235NES above the scan threshold of 2,000 cpm. (Par. 4.2.6.5)

5.5. SU-235NES meets all the requirements of the D Plan and MARSSIM for unconditional release.

5.6. SU-236NSW passed all the tests described in the D plan except background. All the tests required for release of a Class 2 Survey unit were passed. (Par. 4.3.4.2)

5.7. No significant residual radioactivity was measured on the 4 items of installed apparatus in SU-236NSW.(Par. 4.3.3.1)

5.8. Virtually no removable contamination is present within SU-236NSW. (Par. 4.3.5.2)

5.9. No beta scan data were observed in SU-236NSW above the scan threshold of 2,000 cpm. (Par. 4.3.6.5)

5.10. SU-236NSW meets all the requirements of the D Plan and MARSSIM for unconditional release.

6. RECOMMENDATIONS

6.1. SU-235NES should be released from the license.

6.2. SU-236NSW should be released from the license.

Appendix 1
Building Survey Unit Listing for
Buildings 235 & 236 Exterior Walls

Building Survey Unit Listing

SurfaceCode	*Xmax*	*Ymax*	*Area (sq.ft.)*	*Paint (Coats)*	*Description*
SurveyUnitID: 235NES					***Class:*** 2
Room 999					
N	120.0	23.0	2,760	0.0	
S	120.0	23.0	2,760	0.0	
E	88.0	23.0	2,024	0.0	
Q25			0	0.0	Copper Roof Flashing
Q27			0	0.0	2 runs of 4" to 6" gray piping, and hydrogen gasline
Q28			0	0.0	Supports for acces ladder
Q29			0	0.0	Red fire box and conduit
Q30			0	0.0	Blower and related piping
Q31			0	0.0	Vertical silver piping
Q32			0	0.0	support brackets, upper supply lines
Q33			0	0.0	24" vertical pipe and connected piping
Q34			0	0.0	Gray platform
Summary for Room 999 (12 detail records)			*7,544* **Sq. Feet**		
TOTAL for Survey Unit 235NES			*7,544* Sq. Feet		

Building Survey Unit Listing

SurfaceCode	*Xmax*	*Ymax*	*Area (sq.ft.)*	*Paint (Coats)*	*Description*
SurveyUnitID: 236NSW					***Class:*** 2
Room 999					
N	45.0	23.0	1,035	0.0	
S	45.0	23.0	1,035	0.0	
W	85.0	23.0	1,955	0.0	
Q25			0	0.0	Copper roof flashing
Q26			0	0.0	Yellow 2" gas line
Q27			0	0.0	2 runs of 4" to 6" gray piping, and hydrogen gasline
Q32			0	0.0	Support brackets
Summary for Room 999 (7 detail records)			***4,025*** **Sq. Feet**		
TOTAL for Survey Unit 236NSW			***4,025*** **Sq. Feet**		

APPENDIX 2
Figures

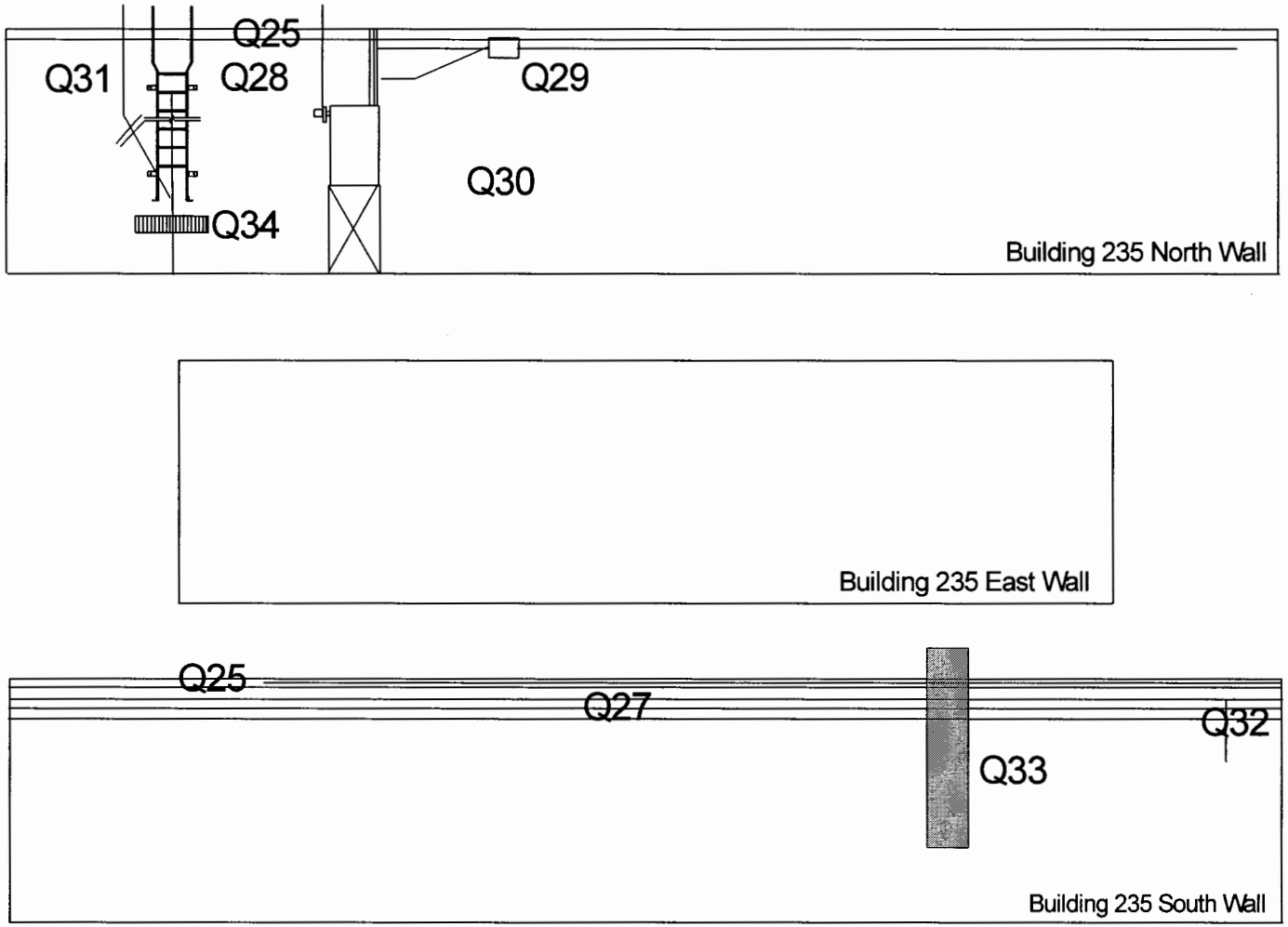


Figure 1.1
Survey Unit 235NES

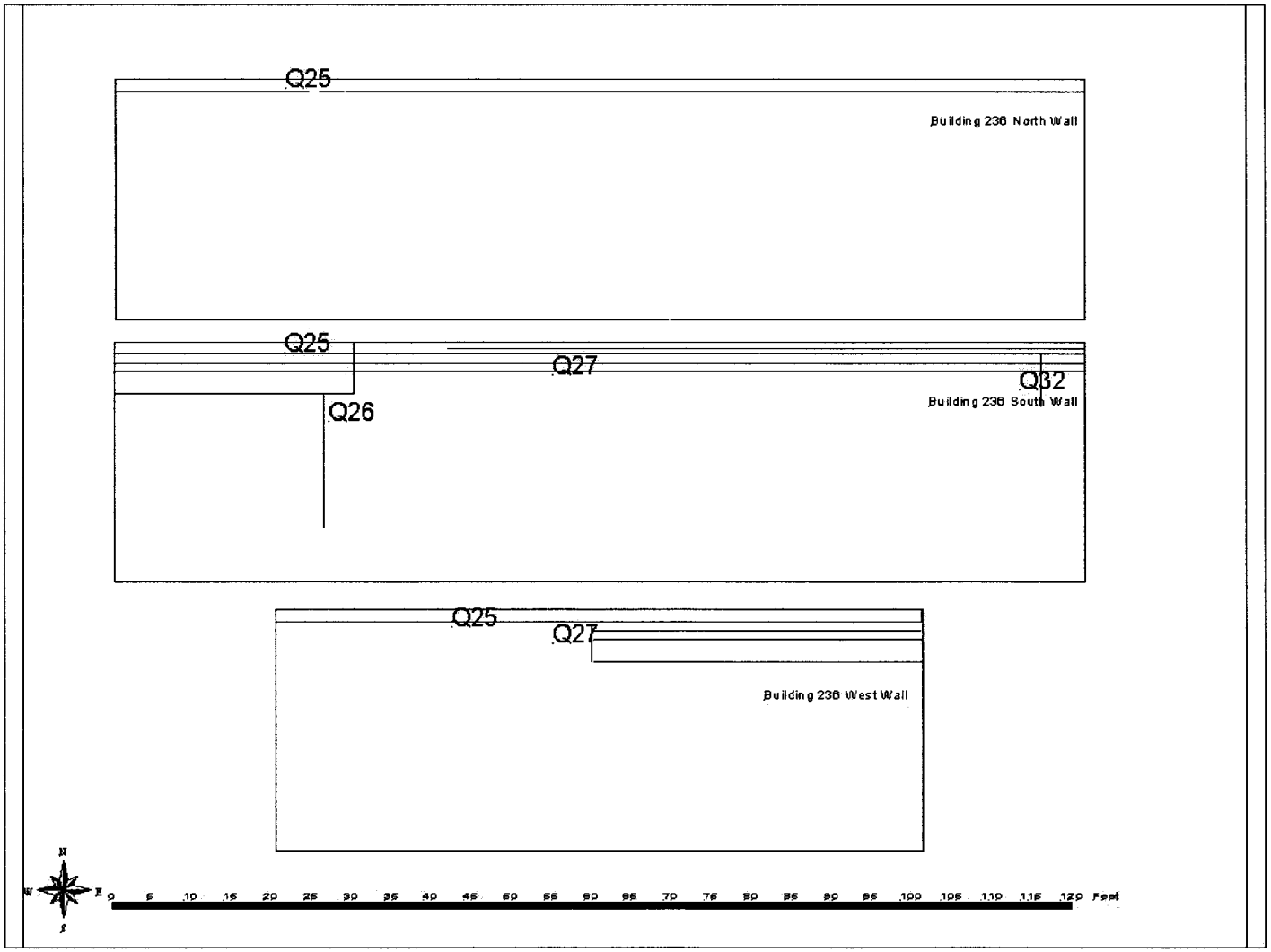
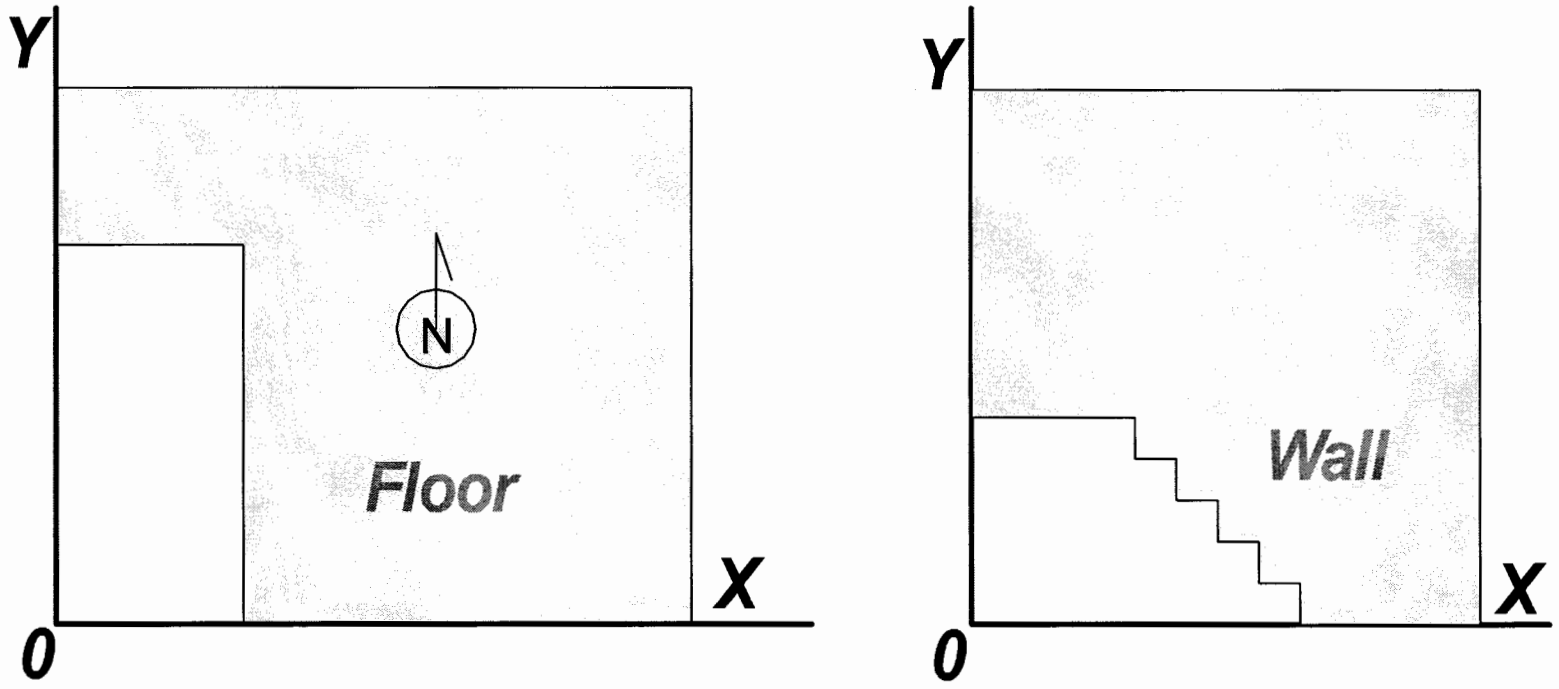
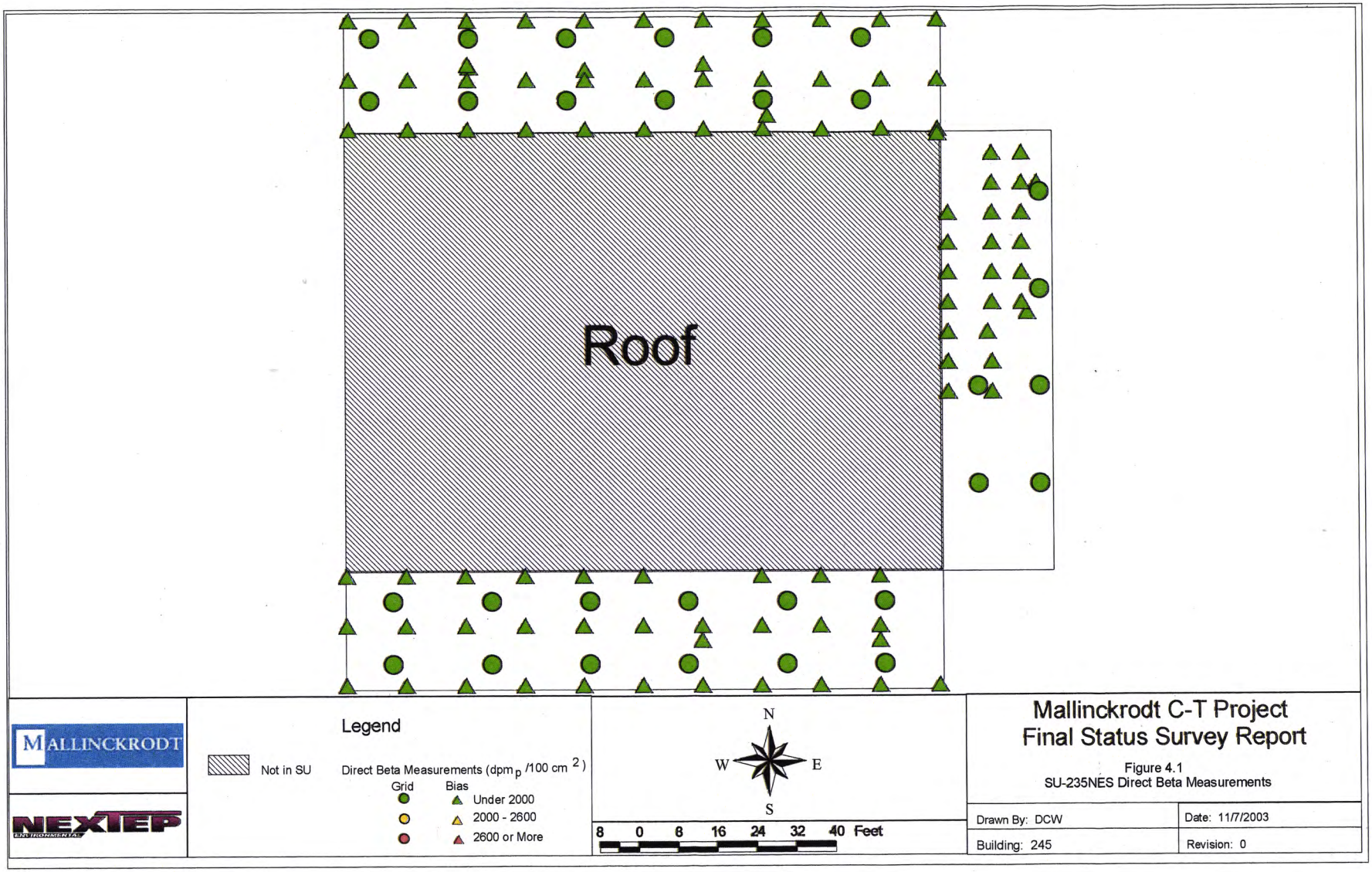


Figure 1.2
Survey Unit 236NSW



Coordinate System

Figure 3.1


Roof
MALLINCKRODT
NEXTEP
ENVIRONMENTAL
Legend
Not in SU
Direct Beta Measurements (dpm p /100 cm 2)
Grid
Bias
Under 2000
2000 - 2600
2600 or More
N
W
E
S
8 0 8 16 24 32 40 Feet
Mallinckrodt C-T Project
Final Status Survey Report
Figure 4.1
SU-235NES Direct Beta Measurements
Drawn By: DCW
Date: 11/7/2003
Building: 245
Revision: 0

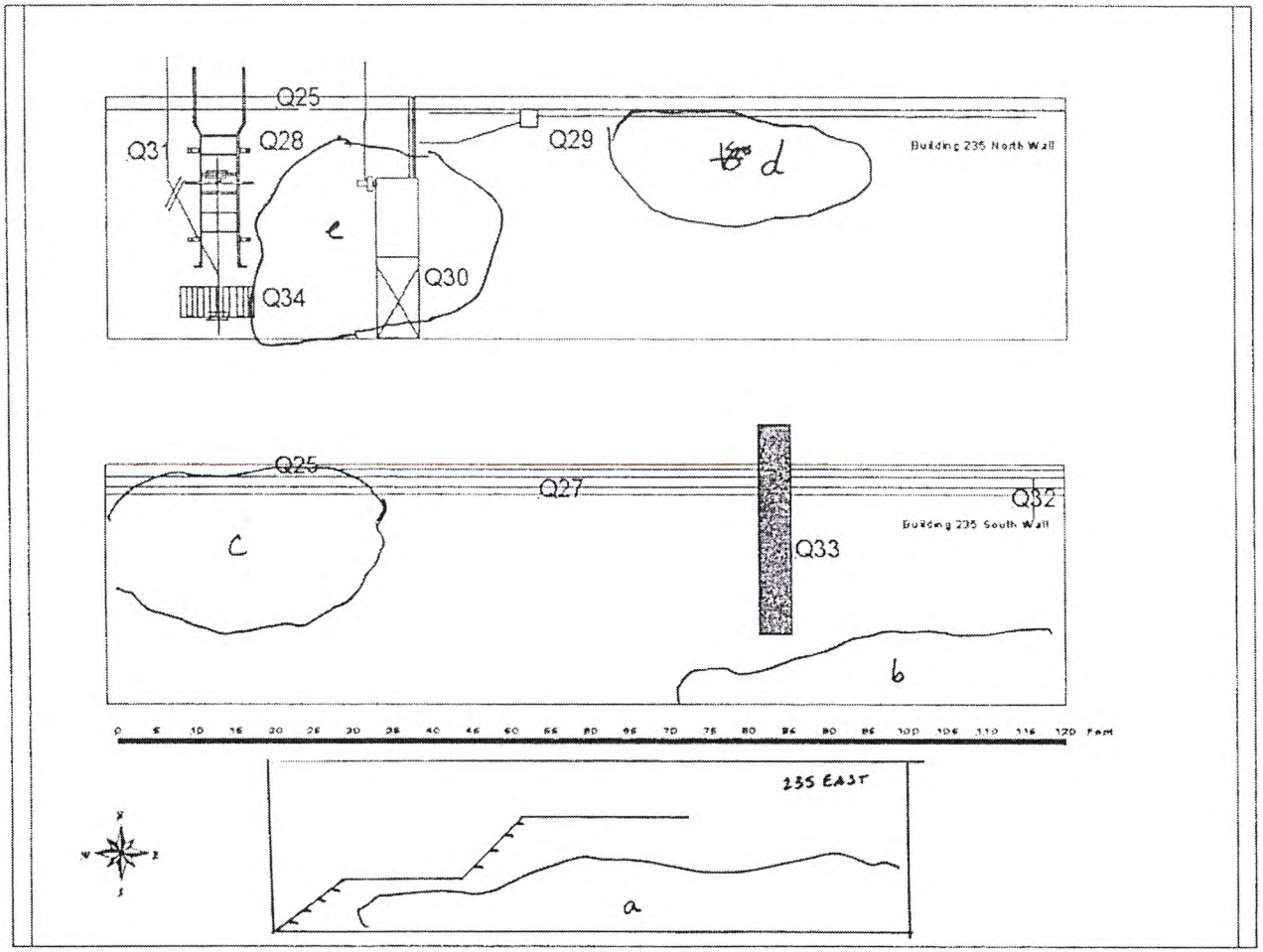
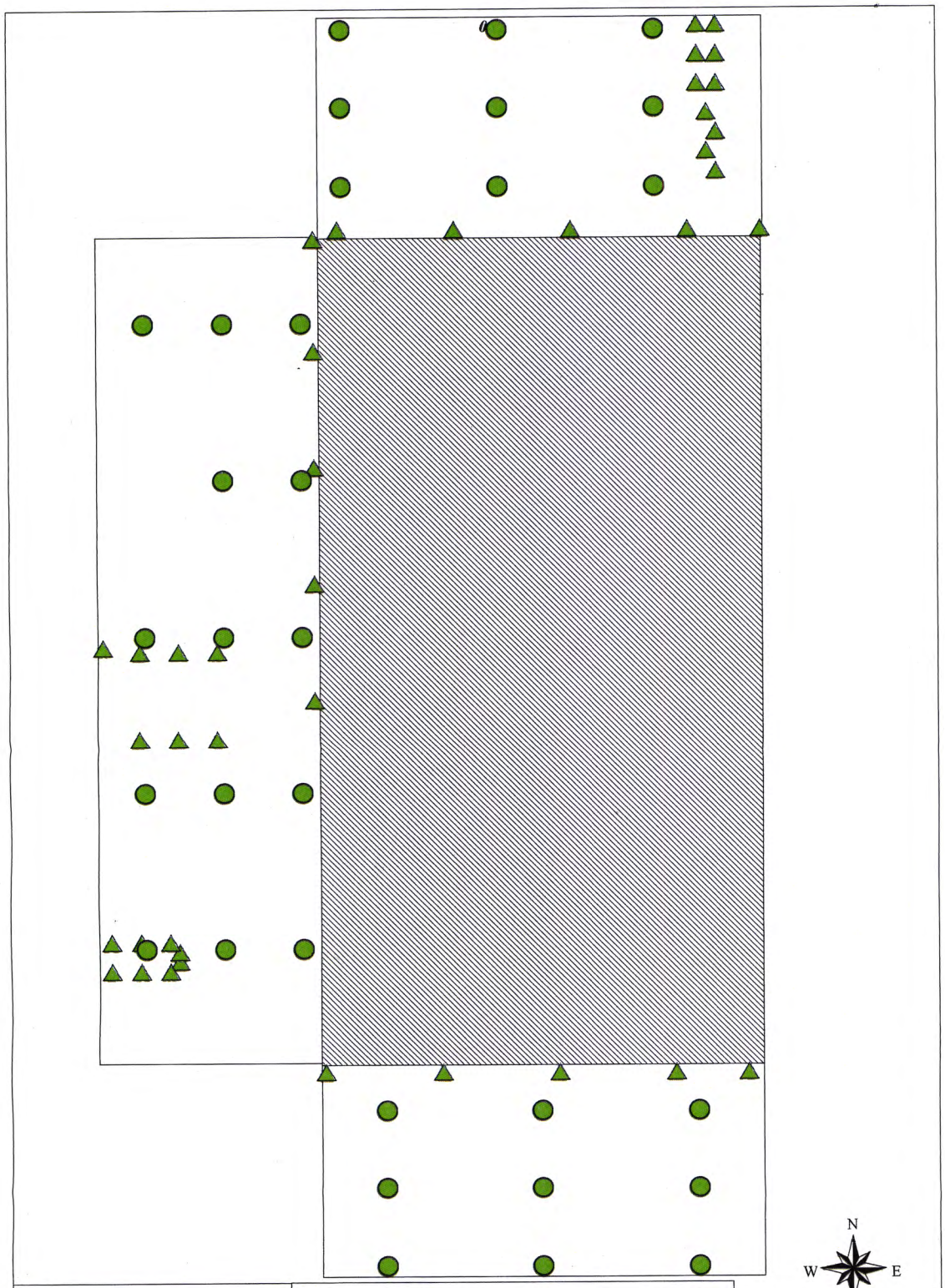


Figure 4.2
Survey Unit 235NES Scans


N
W
E
S
6 0 6 12 18 24 30 Feet
MALLINCKRODT
NEXTEP ENVIRONMENTAL
Legend
Not in SU
Direct Measurements (dpm$_p$/100cm^2)
Grid Bias
Less Than 2000
2000 - 2600
2600 or More
Mallinckrodt C-T Project
Final Status Survey Report
Figure 4.3
Building 236 Exterior Walls
Direct Beta Measurements
Drawn by: DCW
Date: 12/4/03
Building 240
Revision: 0

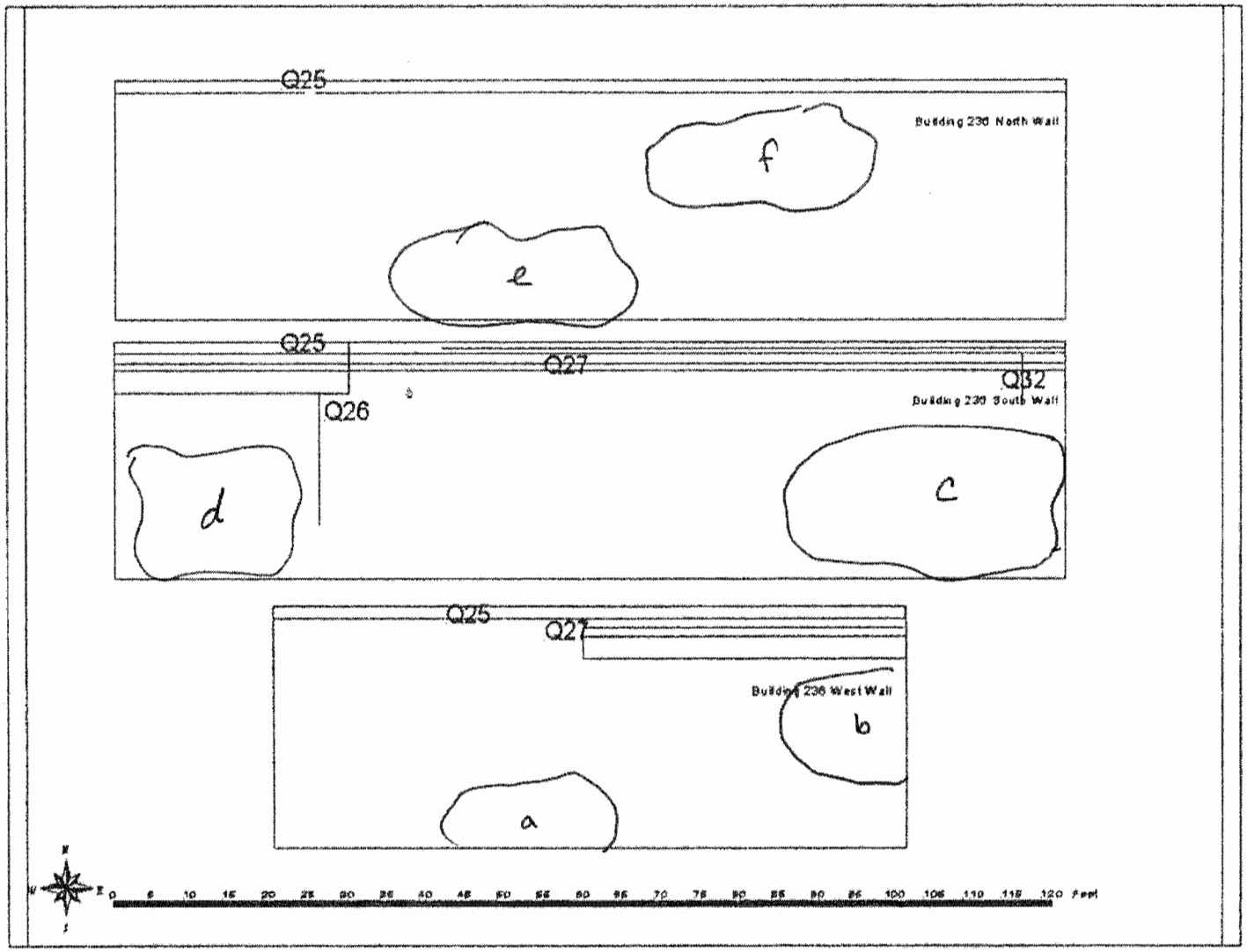


Figure 4.4
Survey Unit 236NSW Scans

APPENDIX 3

Instrument Calibration Sheets for 235 & 236 Exterior

Type	S/N	Cal Date
Beta	106729/A0281	1/5/1995
	117332/A0447	1/17/1995
	127210/B861N	4/12/2000
	131410/B860N	11/7/2002
	163666/B426W	1/16/2003
	117362/B860N	1/18/1996 3/5/1996 10/20/1999
Swipe	179562	11/8/2002 7/22/2003

TMA
Thermo Analytical

TMA/Eberline
601 Scarboro Rd.
Oak Ridge, TN 37830
(615) 481-0683 Fax (615) 483-4521

Site: —
Job #: —

ABP-100
~~AC 3-7~~
CALIBRATION DATA SHEET

ABP-100
~~AC 3-7~~ SN: A 0281 Property of: EBERLINE INST.
Readout Inst.: 200 2200 SN: 106729 Cal. Exp. Date: 4-4-95
BETA
~~Alpha~~ Source: Y2 SR-90 SN: 1239/92 Activity: 22800 DPM
Date of Cal.: 10-3-94
PLATEAU: * CALIBRATED @ 35mV I.S.

High Voltage	Source (CPM) ALPHA	BETA	BKGD	High Voltage	Source (CPM) ALPHA	BETA	Background Check
~~650~~				1050	203	6979 187	High Voltage CPM
650	SEE NOTE	—		1100	225	7123 219	Op. Voltage -50 NA
700		—		1150	286	7183 264	Op. Voltage
750		—		1200	355	7382 339	Op. Voltage +50
800	—	1164	12	1250	—	8116 483	
850	—	2172	23	1300	—	9863 902	
900	—	4111	78	1350		—	
950	—	5439	125	1400		—	
1000	—	6426	147				

NOTE: MYLAR SHEET ADDED TO ATTENUATE ALPHA RESPONCE TO "0" CPM CONTRIBUTION. ALPHA SOURCE @ 7500 DPM NOM.

High Voltage set at: 1100 Volts

Efficiency:
5 Minute Gross Counts: A Pos @ FORWARD CNTR POS. B Pos @ REAR CNTR POS.

Pos "A": 34932 Pos "B": 32230
Average (A + B)/2: 33481.0 Gross CPM: 6696.2
Background: CPM: 296.2 Net CPM: 6400.0
1481

$$\text{Efficiency} = \frac{\text{Net CPM}}{\text{DPM}} \times 100 = 28.1\ \%$$

Date of Calibration: 1-5-95 Expiration Date: 7-5-95
Calibrated by: KENNETH MURPHY (Print Name) Kenneth Murphy (Signature)
Reviewed by: R.W. Doane Date: 1/5/95

EA4.10
Rev: 1
Date: 25 Jan 88

EA4.10rpt

L2200/ABP-100
S/N: 106729/A0281
1/5/95

TMA
Thermo Analytical

TMA/Eberline
601 Scarboro Rd.
Oak Ridge, TN 37830
(615) 481-0683 Fax (615) 483-4621

Site: MALT-5
Job #: —

ABP-100
~~AC-3-7~~
CALIBRATION DATA SHEET

ABP-100
~~AC-3-7~~ SN: A 0447 Property of: EAC

Readout Inst.: LOQUM 2221 SN: 117332 Cal. Exp. Date: 7-17-95

BETA
~~Alpha~~ Source: SR4-90 SN: 1239/92 Activity: 22800 DPM

Date of Cal.: 10-3-94

PLATEAU: * CALIB. @ 35 mV

High Voltage	Source (CPM)	High Voltage	Source (CPM)
600	—	1050	3100
650	—	1100	4382
700	—	1150 / 1175	5184·185 / 5527·233
750	—	1200 / 1225	5767·290 / 5934·306
800	—	1250	6475·407
850	—	1300	7364
900	618	1350	—
950	1269	1400	—
1000	2118		

Background Check

High Voltage	CPM
Op. Voltage −100	96
−50	185
Op. Voltage	290
+50	407
Op. Voltage +100	527

High Voltage set at: 1200 volts

Efficiency:

A = FORWARD CNTR POS
B = REAR CNTR POS

5 Minute Gross Counts:

	CNTR		
Pos "A": 25943	29159	Pos "B": 28277	
Average (A + B)/2: 27793.0		Gross CPM: 5558.6	
Background: CPM: 252.4 / 1262		Net CPM: 5306.2	

$$\text{Efficiency} = \frac{\text{Net CPM}}{\text{DPM}} \times 100 = 23.3\ \%$$

Date of Calibration: 1-17-95 Expiration Date: 7-17-95

Calibrated by: KENNETH MURPHY (Print Name) Kenneth Murphy (Signature)

Reviewed by: Marianne McNamee Date: 1-17-95

EA4.10
Rev: 1
Date: 25 Jan 88

EA4.10-c2

L2221/ABP-100
S/N: 117332/A0447
1/17/95

Thermo NUtech
A ThermoRetec Company
601 Scarboro Road
Oak Ridge, TN 37830

Bicron
AB-100
~~AC 3-7~~

ThermoRetec
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CALIBRATION DATA SHEET

(423) 481-0683 Phone
(423) 481-0121 Fax
www.thermoretec.com

AB-100
~~AC 3-7~~ SN: B861N Property of: TR

Readout Inst.: 2221 SN: 127210 Cal. Exp. Date: 4/11/01

~~Alpha~~ Beta Source: Sr-90 SN: 1238/92 Activity: 15200 DPM

Date of Cal.: 10/20/99

PLATEAU: *@35mV I.S.

High Voltage	Source (CPM)	High Voltage	Source (CPM)
600	1	1050	9261
650	22	1100	
700	248	1150	
750	1083	1200	
800	2656	~~1250~~ 925	6077
850	4397	~~1300~~ 950	6185
900	5663	~~1350~~ 975	6558
950	6206	~~1400~~	
1000	6990		

Background Check	
High Voltage	CPM
Op. Voltage ~~-50~~ -25	247
Op. Voltage	305
Op. Voltage ~~+50~~ +25	283

High Voltage set at: 950 volts

Efficiency:

5 Minute Gross Counts:

Pos "A": 31549 /5 = ~~Pos "B"~~: 6309.8

~~Average (A + B)/2~~:

Background: CPM: 273.6 (1368/5) Gross CPM:

Net CPM: 6036.2

$$\text{Efficiency} = \frac{\text{Net CPM}}{\text{DPM}} \times 100 = 39.7\ \%$$

Date of Calibration: 4/12/00 Expiration Date: 4/12/01

Calibrated by: Randall H. Selk (Printed Name) (Signature)

Reviewed by: Date: 4/13/00

EA4.10
Rev: 1
Date: 25 Jan 99 * Replaced Mylar

EA4.10-55

L2221/AB-100
S/N: 127210/B861N
4/12/00

Bicron
AB-100
~~AG-3-7~~

CALIBRATION DATA SHEET

AB-100 ~~AG-3-7 SN~~: B860N Property of: E.S. (MALT)

Readout Inst.: Lud 2241-2 SN: 131410 Cal.Exp.Date: 11-7-03

Beta ~~Alpha~~ Source: Sr-Y-90 SN: 2158/96 Activity: 17100 DPM

Date of Cal.: _____

PLATEAU:

High Voltage	Source (CPM)	High Voltage	Source (CPM)
600	———	1050	7435
650	———	1100	———
700	———	~~1150~~ 975	5738
750	———	~~1200~~ 1000	6204
800	1801	~~1250~~ 1025	6672
850	3496	~~1300~~ 1050	7532
900	4845	1350	———
950	5595	1400	———
1000	6415		

Background Check

High Voltage	CPM
Op. Voltage ~~-50~~ 1000	331
Op. Voltage	431
Op. Voltage ~~+50~~ 1050	799

High Voltage set at: 1025 volts @ DET 1 & 2

Efficiency:

5 Minute Gross Counts:

1 min @ 6742

1 min Bkg 431

6361 / 17100 dpm

37.2 % ok

Pos "A": _____ Pos "B": _____

Average (A + B)/2: ~~_____~~ Gross CPM: ~~_____~~

Background: CPM: ~~_____~~ Net CPM: ~~_____~~

$$\text{Efficiency} = \frac{\text{Net CPM}}{\text{DPM}} \times 100 = 37.2\ \%$$

Date of Calibration: Qlts 9-H-11-7-02 Expiration Date: 11-7-03

Calibrated by: Randall N. Selk (Print Name) _____ (Signature)

Reviewed by: _____ Date: 11/8/02

cA4.10
Rev: 2
Date: 25 Feb 99

L2241-2/AB-100
S/N: 131410/B860N
11/7/02

CALN100A

Thermo NUtech

For Mallinckrodt Chemical, Inc

NATIONAL NUCLEAR ABP-100
MATERIAL SPECIFIC CALIBRATION DATA SHEET

ABP-100 SN: B860N HIGH VOLTAGE: 1025 V PROPERTY OF: E.S. (MALL)

READOUT INST: Lud 2241-2 SN: 131410 CAL EXPIRE DATE: 11-7-03

ABP-100 EFFICIENCY TO SrY-90 ON 47 mm DISK: 37.2% CAL DATE: 11-7-02

	BACKGROUND		BR	SOURCE		SR		SA	Efficiency
SURFACE MATERIAL	OPEN Cts/2 min	SHIELD Cts/2 min	NET CPM	OPEN Cts/1 min	SHIELD Cts/1 min	NET CPM	Source #	Source Activity	SR-BKG SA
Concrete	~~472~~ 470	572	198	8301	354	7947	6-A	33500	23.7
				8313	331	7982			23.8
				8442	321	8121			24.2
				8417	325	8092			24.2
268 X 125 = 33500 dpm								Average =	24.0
								Std Dev =	0.26
Wood	0	0	0	6375	324	6051	M-2	22000	27.5
	0	0	0	6489	302	6187			28.1
	0	0	0	6337	334	6003			27.3
	0	0	0	6388	328	6060			27.6
176 X 125 = 22000 dpm								Average =	27.6
								Std Dev =	0.36
Muscovite	0	0	0	6402	317	6085	M-2	22000	27.7
	0	0	0	6360	284	6076			27.6
	0	0	0	6434	299	6135			27.9
	0	0	0	6489	300	6189			28.1
								Average =	27.8
								Std Dev =	0.22
Aluminum	0	0	0	7108	308	6800	M-2	22000	30.9
	0	0	0	7218	292	6921			31.5
	0	0	0	7216	282	6934			31.5
	0	0	0	7090	321	6769			30.1
								Average =	31.0
								Std Dev =	0.66

DATE OF CALIBRATION: 11-7-02 EXPIRATION DATE: 11-7-03

CALIBRATED BY: Randall H. Selk (Print Name) (Signature)

REVIEWED BY: Don Gregory DATE: 11/8/02

*Cable Checks OK

L2241-2/AB-100
S/N: 131410/B860N
11/7/02

CT-RP-66
Chi Squared Test

Instrument Model #	2241	Date:	11.14.02
Instrument Serial#	131410	Source Nuclide:	SrY90
Probe Model #	AB 100	Source Serial #	2178-96
Probe Serial #	B860n	Source dpm (4π):	56836
Window Setting:		Efficiency (cpm/dpm):	0.33
Threshold Setting:	35 mV	Background cpm:	291.2
High Voltage:	1025	BKGD N-1	4
		BKGD Count Time (min):	1

Count # (n)	Gross Counts Observed	Expected	Background Counts
1	18759	18817	293
2	18818	18817	293
3	18944	18817	286
4	18652	18817	298
5	18973	18817	286
6	18894	18817	
7	18801	18817	
8	18782	18817	
9	18895	18817	
10	18751	18817	
11	18803	18817	
12	18814	18817	
13	19145	18817	
14	18853	18817	
15	18763	18817	
16	18763	18817	
17	18619	18817	
18	18819	18817	
19	18850	18817	
20	18650	18817	

sample mean (xbar) =	18817	Multiplier to convert	
sample variance (s^2) =	14316	to dpm:	3.0
background variance (b^2) =	28.7		
sample sigma (s) =	120		
(95% Confidence) 2.752 s =	330		
(99% Confidence) 3.615 s =	433		
		MDA(cpm) =	**82**
df = n-1 =	19	MDA(dpm) =	**249**
chitest = p(x<χ^2) =	7.566E-01		
chisquare (χ^2) =	**14.455**		
Acceptable χ^2 min =	8.907		
Acceptable χ^2 max =	32.852		
χ^2 test passes (yes/no)?	**YES**		
99% Conf. Interval Test min =	18093		
95% Conf. Interval Test min =	18197		
Daily Source Check Mean Net Counts	**18526**		
95% Conf. Interval Test max =	18856		
99% Conf. Interval Test max =	18959		

Test performed by: Steve Struck 11-14-02

Checked by: Date: 11.14.02

L2241-2/AB-100
S/N: 131410/B860N
11/7/02

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A ThermoRetec Company
601 Scarboro Road
Oak Ridge, TN 37830

LUDLUM 2221
CALIBRATION DATA SHEET

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Ludlum2221S/N: 163666 Property Of

Battery Check OK @ 5.6 Volts
Replace @6.4

High Voltage Check

HV Meter: Fluke 29 S/N: 65410232 Cal Exp. Date 1-30-03

Meter Reading	Pre Cal	Post Cal	Tolerance
600 Volts	660	605	10 %
1000 Volts	1100	1005	10 %
1400 Volts	1540	1410	10 %

Input Sensitivity:

(Threshold @ 10 mv) Pre Cal: 35 mV, Post Cal: 35 mV
MP-2 S/N: 684 Calibration Exp. Date: 1-29-03

Rate/ Meter	MP-2	2221	Digital Display	Analog Display	Tol
400 CPM	x1		400	400	10%
4K CPM	x10		3998	4000	10%
40K CPM	x100		39999	40000	10%
400K CPM	x1000		400080	400000	10%
Scaler: 100K CPM	0.5 sec		50010	100000	10%
100K CPM	1.0 min		100020		10%
100K CPM	2.0 min		200039		10%
100K CPM	5.0 min		500097		10%

Log 400 400 4K 4K 40K 40K 400k 400k

Functional Check:

Ext Count ✓ Reset ✓ Speaker ✓ Headphones ✓ Light ✓

Date Of Calibration: 1-16-03 Expiration Date: 1-16-03

Calibrated By: Randall H. Sells (Print) (Signature)

Reviewed By: [signature] Date: 1/30/03

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a Thermo Electron company

L2221/AB-100
S/N: 163666/B426W
1/16/03

CALN100A

Thermo NUtech

For Mallinckrodt Chemical, Inc

NATIONAL NUCLEAR ABP-100
MATERIAL SPECIFIC CALIBRATION DATA SHEET

ABP-100 SN: B426W HIGH VOLTAGE: 875 V PROPERTY OF: ~~Tyco~~ RMS E.S.

READOUT INST: Lud 2221 SN: 163666 CAL EXPIRE DATE: 7-16-03

ABP-100 EFFICIENCY TO SrY-90 ON 47 mm DISK: 42.0 % CAL DATE: 1-22-03

	BACKGROUND		BR	SOURCE		SR		SA	Efficiency
SURFACE MATERIAL	OPEN Cts/2 min	SHIELD Cts/2 min	NET CPM	OPEN Cts/1 min	SHIELD Cts/1 min	NET CPM	Source #	Source Activity	SR/SA
Concrete	561	416	73	6857	232	6625	6-A	33250	19.9
				6853	246	6607			19.9
				6846	242	6604			19.9
				6784	236	6548			19.7
266 x 125 = ~~335~~ 33250 dpm								Average =	19.9
								Std Dev =	0.1
Wood	0	0	0	5222	238	4984	M-2	22250	22.4
	0	0	0	5281	240	5041			22.5
	0	0	0	5181	224	4957			22.3
	0	0	0	5296	232	5064			22.8
178 dpm x 125 = 22250								Average =	22.5
								Std Dev =	0.2
Masonite	0	0	0	5296	232	5064	M-2	22250	22.8
	0	0	0	5302	234	5068			22.9
	0	0	0	5311	248	5063			22.8
	0	0	0	5366	236	5130			23.1
178 dpm x 125 = 22250								Average =	22.9
								Std Dev =	0.2
Aluminum	0	0	0	6037	223	5814	M-2	22250	26.1
	0	0	0	5706	256	5470			24.6
	0	0	0	6013	248	5765			25.9
	0	0	0	5892	227	5665			25.5
178 dpm x 125 = 22250								Average =	25.5
								Std Dev =	0.7

DATE OF CALIBRATION: 1-29-03 EXPIRATION DATE: 7-29-03

CALIBRATED BY: Randall H. Sells (Print Name) (Signature)

REVIEWED BY: [signature] DATE: 1/30/03

L2221/AB-100
S/N: 163666/B426W
1/16/03

CT-RP-66
Chi Squared Test

Instrument Model #	2221	Date:	02/04/2003
Instrument Serial#	163666	Source Nuclide:	SrY90
Probe Model #	AB 100	Source Serial #	2178-96
Probe Serial #	B426W	Source dpm (4π):	56489
Window Setting:	3720	Efficiency (cpm/dpm):	0.28
Threshold Setting:	352	Background cpm:	183.4
High Voltage:	875	BKGD N-1	4
		BKGD Count Time (min):	1

Count # (n)	Gross Counts Observed	Expected	Background Counts
1	15380	15546	185
2	15361	15546	193
3	15477	15546	179
4	15662	15546	179
5	15520	15546	181
6	15587	15546	
7	15476	15546	
8	15392	15546	
9	15639	15546	
10	15609	15546	
11	15401	15546	
12	15433	15546	
13	15601	15546	
14	15743	15546	
15	15608	15546	
16	15828	15546	
17	15577	15546	
18	15518	15546	
19	15510	15546	
20	15599	15546	

sample mean (xbar) =	15546	Multiplier to convert to dpm:	3.6
sample variance (s^2) =	15181		
background variance (b^2) =	34.8		
sample sigma (s) =	123		
(95% Confidence) 2.752 s =	339		
(99% Confidence) 3.615 s =	446		
		MDA (cpm) =	66
		MDA (dpm) =	240
df = n-1 =	19		
chitest = p(x<χ^2) =	4.858E-01		
chisquare (χ^2) =	**18.554**		
Acceptable χ^2 min =	8.907		
Acceptable χ^2 max =	32.852		
χ^2 test passes (yes/no)?	**YES**		
99% Conf. Interval Test min =	14917		
95% Conf. Interval Test min =	15023		
Daily Source Check Mean Net Counts	**15363**		
95% Conf. Interval Test max =	15702		
99% Conf. Interval Test max =	15809		

Test performed by: Steve Struck 2/4/03

Checked by: Ann C. Woodford Date: 2-4-03

L2221/AB-100
S/N: 163666/B426W
1/16/03

Site: _____
Job #: _____

AB-100
~~AC-3-7~~
CALIBRATION DATA SHEET

AB-100
~~AC-3-7~~ SN: B860N Property of: EAC

Readout Inst.: Ludlum 2221 SN: 117362 Cal. Exp. Date: 7-8-96

SrY-90
~~Alpha~~ Source: 1239/92 SN: 1239/92 Activity: 20300 DPM

Date of Cal.: 10-1-95

PLATEAU: * CALIB @ 35 mV

High Voltage	Source (CPM)	High Voltage	Source (CPM)
600	_____	1050	_____
650	_____	1100	_____
700	_____	1150	_____
750	_____	1200	_____
800	4460	1250	_____
850	6636	1300	_____
875	7338		
900	7759	1350	_____
925	8008		
950	8115	1400	_____
975	8286		
1000	8656		

Background Check	
High Voltage	CPM
Op. Voltage -50	284
Op. Voltage	440
Op. Voltage +50	574

High Voltage set at: 950 volts

Efficiency:

A: FRONT CNTR POS.
B: REAR CNTR POS.
CNTR 'C'

5 Minute Gross Counts:

Pos "A": 38683 40964 Pos "B": 40956

(A+B+C)/3 Average ~~(A + B)/2~~: 40181 Gross CPM: 8036.2

Background: 1982 CPM: 396.4 Net CPM: 7639.8

$$\text{Efficiency} = \frac{\text{Net CPM}}{\text{DPM}} \times 100 = 37.6\ \%$$

Date of Calibration: 1-18-96 Expiration Date: 7-18-96

Calibrated by: SARA SMITH (Print Name) Sara Smith (Signature)

Reviewed by: Randall A. Dulls Date: 1-23-96

EA4.10
Rev: 1
Date: 25 Jan 88

EA4.10-66

L2221/AB-100
S/N: 117362/B860N
1/18/96

Site: _____
Job #: _____

AB-100

~~AC-3-7~~

CALIBRATION DATA SHEET

AB-100
~~AC-3-7~~ SN: B860N Property of: EAC

Readout Inst.: 2221 SN: 117362 Cal. Exp. Date: 7-8-96

~~Alpha~~ Beta Source: Sr-90 SN: 1239/92 Activity: 20300 DPM

Date of Cal.: 10-25-95

PLATEAU:

High Voltage	Source (CPM)	High Voltage	Source (CPM)
600	0	1050	8796
650	2	1100	15162
700	106	1150	N/A
750	699	1200	
800	2042	1250	
850	4403	1300	
900	6287	1350	
950	7569	1400	
1000	7950		

Background Check

High Voltage	CPM
Op. Voltage -50	
Op. Voltage	
Op. Voltage +50	

High Voltage set at: 950 volts

Efficiency:

5 Minute Gross Counts:

Pos "A": 37171
Average (A + B)/2: N/A
Background: CPM: 247.8
1239

Pos "B": N/A
Gross CPM: 7434.2
Net CPM: 7186.4

$$\text{Efficiency} = \frac{\text{Net CPM}}{\text{DPM}} \times 100 = 35.4\ \%$$

Date of Calibration: 3-5-96 Expiration Date: 9-5-96

Calibrated by: Randall H. Sells (Print Name) Randall H. Sells (Signature)

Reviewed by: _____ Date: _____

EA4.10
Rev: 1
Date: 25 Jan 88

EA4.10-66

L2221/AB-100
S/N: 117362/B860N
3/5/96

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Bicron
AB-100
~~AC-37~~

CALIBRATION DATA SHEET

AB-100
~~AC-37~~ SN: B860N Property of: TR

Readout Inst.: 2221 SN: 117362 Cal.Exp.Date: 7/21/2000

Beta
~~Alpha~~ Source: Sr-90 SN: 123892 Activity: ~~15400~~ DPM 15200 dpm
RHS

Date of Cal.: 4/20/99

* @35mV
@Contact Geometry

PLATEAU:

High Voltage	Source (CPM)	High Voltage	Source (CPM)
600	—	1050	6942
650	—	1100	9136
700	—	1150	—
750	—	~~1200~~ 925	5077
800	1062	~~1250~~ 950	5652
850	2726	~~1300~~ 975	6046
900	4438	~~1350~~ 1000	6324
950	5594	~~1400~~ 1025	6493
1000	6470		

Background Check

High Voltage	CPM
Op. Voltage -~~50~~ 25	245
Op. Voltage	261
Op. Voltage +~~50~~ 25	261

1050 − 6913

High Voltage set at: 1000 volts

Efficiency:
5 Minute Gross Counts:

Pos "A": 30485 Pos "B": 31943
Average (A + B)/2: 31214 Gross CPM: 6242.8
Background: CPM: 257.2 Net CPM: 5985.6
1286

$$\text{Efficiency} = \frac{\text{Net CPM}}{\text{DPM}} \times 100 = 39.4\ \%$$

Date of Calibration: 10/20/99 Expiration Date: 10/20/2000

Calibrated by: Randall H. Sells (Print Name) Randall H Sells (Signature)

Reviewed by: Alan Flagler Date: 10/20/99

EA4.10
Rev: 2
Date: 25 Feb 99

L2221/AB-100
S/N: 117362/B860N
10/20/99

Designers and Manufacturers of Scientific and Industrial Instruments

LUDLUM MEASUREMENTS, INC.
POST OFFICE BOX 810 PH. 915-235-5494
501 OAK STREET FAX NO. 915-235-4672
SWEETWATER, TEXAS 79556, U.S.A.

CERTIFICATE OF CALIBRATION

CUSTOMER TYCO/HEALTHCARE/MALLINCKRODT ORDER NO. 288367 / 268024

Mfg. Ludlum Measurements, Inc. Model 3030 Serial No. 179562

Cal. Date 8-Nov-02 Cal Due Date 8-May-03 Cal. Interval 6 Months

Check mark ☑ applies to applicable instr. and/or detector IAW mfg. spec. T. 72 °F RH 32 % Alt 699.8 mm Hg

☐ New Instrument Instrument Received ☑ Within Toler. ±10% ☐ 10-20% ☐ Out of Tol. ☐ Requiring Repair ☐ Other-See comments

☑ Mechanical ck. * ☑ Window Operation

☐ Audio ck.

Alpha Sensitivity 120 mV Beta Sensitivity 4 mV Beta Window 50 mV

☑ Calibrated in accordance with LMI SOP 14.8 rev 12/05/89.

Instrument Volt Set 625 V High Voltage set with detector connected.

☑ HV Readout (2 points) Ref./Inst. 499 / 500 V Ref./Inst. 1506 / 1500 V

Instrument in DPM mode.
SC mode turned OFF.
Firmware version: 3901110
Overload set at 1/4 turn past OFF.
Battery voltage measured at 12V0 Vdc.
C-14 Efficiency = 9 %(4 pi) Net

(EEPROM Settings)
(PC) Count Time: 10
Alpha Alarm: 50000 cpm
Beta Alarm: 50000 cpm
Alpha/Beta Alarm: 50000 cpm
Calibration Due Date: 8May03
LOC (Loss of Count) time = 30 minutes (default)

	REFERENCE CAL POINT	INSTRUMENT RECEIVED	INSTRUMENT METER READING*
Alpha Channel Digital Readout	400K cpm	399364	399264
	40K cpm	39827	39827
	4K cpm	3993	3993
	400 cpm	400	400
	40 cpm	40	40
	REFERENCE CAL POINT	INSTRUMENT RECEIVED	INSTRUMENT METER READING*
Beta/Gamma Channel Digital Readout	400K cpm	399449	399449
	40K cpm	39950	39950
	4K cpm	3995	3995
	400 cpm	400	400
	40 cpm	40	40

*Uncertainty within ± 10% C.F. within ± 20% (D) Indicates 0.1 minute count

COMMENTS:
Eff. for Th-230 s/n 2748-00, 3070cpm, read [illegible] in 1 minute = 10% 2pi

Ludlum Measurements, Inc. certifies that the above instrument has been calibrated by standards traceable to the National Institute of Standards and Technology, or to the calibration facilities of other International Standards Organization members, or have been derived from accepted values of natural physical constants or have been derived by the ratio type of calibration techniques. The calibration system conforms to the requirements of ANSI/NCSL Z540-1-1994 and ANSI N323-1978. State of Texas Calibration License No. LO-1963

Reference Instruments and/or Sources:

☑ Alpha S/N Th-230 2748-00, Ra-226 [illegible] ☑ Beta S/N Tc-99 M1-67 ☐ Other

☑ m 500 S/N 134709 ☐ Oscilloscope S/N ☐ Multimeter S/N

Calibrated By: Conrad DiBiase Date 8Nov02

Reviewed By: Rhonda Harris Date 11Nov02

This certificate shall not be reproduced except in full, without the written approval of Ludlum Measurements, Inc.
FORM C25-2 05/03/2002

AC Inst. Only ☐ Passed Dielectric (Hi-Pot) and Continuity Test ☐ Failed:

L3030
S/N: 179562
11/8/02

Ludlum Measurements, Inc.
Model 3030 Plateau Data

11/11/02
11:25:35 AM

Header 1: John Q Public
Header 2: Serial#179562
Header 3: Site:Building 1
Header 4: Room 7 EastWall
Header 5: More Comments?
Header 6: More Comments?

Calibration Due Date: 5/8/03

Model 3030 Date: 11/8/02
Model 3030 Time: 10:16:23 AM

User PC Time: 1.0

Alpha Isotope: Pu-239
Alpha Source Size (dpm): 25200
Alpha Source Size (µCi): 0.011351351

Beta Isotope: Tc-99
Beta Source Size (dpm): 22600
Beta Source Size (µCi): 0.01018018

Starting High Voltage: 625
Starting High Voltage: 750
High Voltage Increment: 25

Plateau Count Mode: SCALER
Source Count Time (min): 0001.0
Background Count Time (min): 1.0

	ALPHA					BETA				
HV	Source (Beta)		Background	Eff	CrossTalk	Source (Alpha)		Background	Eff	Crosstalk
625	9306	(348)	1	36.9%	3.5%	5347	(0)	25	23.5%	0.0%
650	9467	(311)	2	37.6%	2.9%	6243	(4)	40	27.4%	0.0%
675	9632	(328)	3	38.2%	3.0%	7209	(3)	41	31.7%	0.0%
700	9755	(340)	5	38.7%	3.0%	8087	(1)	43	35.6%	0.0%
725	9627	(267)	2	38.2%	2.1%	8928	(3)	68	39.2%	0.0%
750	9773	(316)	3	38.8%	1.4%	9646	(3)	183	41.9%	0.0%

L3030
S/N: 179562
11/8/02

Ludlum Measurements, Inc.

Model 3030 MDA Calculation Data

11/11/02
11:25:19 AM

Alpha Background(cpm): 3.0
Beta Background(cpm): 41.0

Alpha Efficiency %: 38.2
Beta Efficiency %: 31.7

Confidence Level: 95%

Count Time	Alpha MDA(dpm)	Beta MDA(dpm)
0.1	120.4	305.9
0.5	50.0	132.2
1.0	28.2	102.5
2.0	21.8	85.7
5.0	17.8	74.5
10.0	16.4	70.6
50.0	15.2	67.1
PC (1.0)	28.2	102.5

L3030
S/N: 179562
11/8/02

Designer and Manufacturer of Scientific and Industrial Instruments

CERTIFICATE OF CALIBRATION

LUDLUM MEASUREMENTS, INC.
POST OFFICE BOX 810 PH. 325-235-5494
501 OAK STREET FAX NO. 325-235-4672
SWEETWATER, TEXAS 79556, U.S.A.

CUSTOMER TYCO/ MALLINCKRODT ORDER NO. 200546 / 274002

Mfg. Ludlum Measurements, Inc. Model 3030 Serial No. 179562

Cal. Date 22-Jul-03 Cal Due Date 22-Jan-04 Cal. Interval 6 Months

Check mark ☑ applies to applicable instr. and/or detector IAW mfg. spec. T. 73 °F RH 39 % Air 703.8 mm Hg

☐ New Instrument Instrument Received ☑ Within Toler. +-10% ☐ 10-20% ☐ Out of Tol. ☐ Requiring Repair ☐ Other-See comments

☑ Mechanical ck. ☐ Window Operation
☑ Audio ck.

Alpha Sensitivity 120 mV Beta Sensitivity 4 mV Beta Window 50 mV

☐ Calibrated in accordance with LMI SOP 14.8 rev 12/05/89.

Instrument Volt Set 650 V High Voltage set with detector connected.

☑ HV Readout (2 points) Ref./Inst. 503 / 500 V Ref./Inst. 1512 / 1500 V

(EEPROM Settings)
(PC) Count Time: 10
Alpha Alarm: 999999 cpm
Beta Alarm: 999999 cpm
Alpha/Beta Alarm: 999999 cpm
Calibration Due Date: 01/22/2004
LOC (Loss of Count) time = 30 minutes (default)

GC mode turned OFF.
Firmware version: 39913NO
Overload set at 1/4 turn past OFF.
Battery voltage measured at 13.56 Vdc.
24.1% Efficiency = 7.1 %(4 pi) Net

	REFERENCE CAL POINT	INSTRUMENT RECEIVED	INSTRUMENT METER READING*
Alpha Channel Digital Readout	400K cpm	399903	399903
	40K cpm	39992	39992
	4K cpm	3995	3995
	400 cpm	400	400
	40 cpm	40	40
Beta/Gamma Channel Digital Readout	REFERENCE CAL POINT	INSTRUMENT RECEIVED	INSTRUMENT METER READING*
	400K cpm	399507	399507
	40K cpm	39952	39952
	4K cpm	3997	3997
	400 cpm	400	400
	40 cpm	40	40

*Accuracy within ± 10% C.F. within ± 20% (0) indicates 0.1 minute count

COMMENTS:
Eff. for Th-230 s/n 2748-00, 3070cpm read 2377 in 1 minute = 77% 2pi

Ludlum Measurements, Inc. certifies that the above instrument has been calibrated by standards traceable to the National Institute of Standards and Technology, or to the calibration facilities of other International Standards Organization members, or have been derived from accepted values of natural physical constants or have been derived by the ratio type of calibration techniques. The calibration system conforms to the requirements of ANSI/NCSL Z540-1-1994 and ANSI N323-1978. State of Texas Calibration License No. LO-1963

Reference Instruments and/or Sources:

☐ Alpha S/N ☐ Beta S/N ☐ Other

☑ m 500 S/N 134709 ☐ Oscilloscope S/N ☑ Multimeter S/N 57390613

Calibrated By: [signature] Date 22 Jul 03

Reviewed By: [signature] Date 22 July 03

FORM C25-3 04/09/2003

AC Inst. Only ☐ Passed Dielectric (Hi-Pot) and Continuity Test ☐ Failed:

L3030
S/N: 179562
7/22/03

Ludlum Measurements, Inc.
Model 3030 Plateau Data

7/22/03
9:48:42 AM

Header 1: John Q Public
Header 2: Serial#179562
Header 3: Site:Building 1
Header 4: Room 7 EastWall
Header 5: More Comments?
Header 6: More Comments?

Calibration Due Date: 5/8/03

Model 3030 Date: 7/19/04
Model 3030 Time: 8:32:16 AM

User PC Time: 1.0

Alpha Isotope: Pu-239
Alpha Source Size (dpm): 25200
Alpha Source Size (µCi): 0.011351351

Beta Isotope: Tc-99
Beta Source Size (dpm): 22600
Beta Source Size (µCi): 0.01018018

Starting High Voltage: 600
Starting High Voltage: 750
High Voltage Increment: 25

Plateau Count Mode: SCALER
Source Count Time (min): 0001.0
Background Count Time (min): 1.0

	ALPHA				BETA				
HV	Source (Beta)	Background	Eff	CrossTalk	Source (Alpha)	Background	Eff	Crosstalk
600	9397 (383)	0	37.3%	3.7%	4580 (2)	32	20.1%	0.0%
625	9455 (358)	1	37.5%	3.5%	5493 (3)	29	24.2%	0.0%
650	9483 (363)	0	37.6%	3.5%	6502 (3)	33	28.6%	0.0%
675	9586 (357)	1	38.0%	3.3%	7454 (3)	36	32.8%	0.0%
00	9537 (343)	0	37.8%	3.2%	8354 (0)	34	36.8%	0.0%
25	9618 (305)	0	38.2%	2.5%	9100 (6)	63	40.0%	0.1%
750	9666 (356)	1	38.4%	0.8%	10029 (5)	276	43.2%	0.0%

L3030
S/N: 179562
7/22/03

Ludlum Measurements, Inc.
Model 3030 MDA Calculation Data

7/22/03
8:43:53 AM

Alpha Background(cpm): 0.0
Beta Background(cpm): 33.0

Alpha Efficiency %: 37.6
Beta Efficiency %: 28.6

Confidence Level: 95%

Count Time	Alpha MDA(dpm)	Beta MDA(dpm)
0.1	72.1	313.9
0.5	14.4	133.4
1.0	7.2	102.9
2.0	3.6	85.7
3.0	1.4	74.3
10.0	0.7	70.3
50.0	0.1	66.8
60 (1.0)	7.2	102.9

L3030
S/N: 179562
7/22/03

APPENDIX 4
Threshold Comparison Test Reports (TCTR)

MALLINCKRODT C-T DECOMMISSIONING PROJECT

Threshold Comparison Test Report - Buildings

Run Date: Monday, December 08, 2003
Survey Unit Number: 235NES Class: 2 Data Points: Beta Grid Type: R Spacing: 16.1 ft.

SURVEY UNIT TABLE

Bldg	*Rm*	*Surface*	*Fixed Equipment*	*Surface Area Included (sq. ft)*	*Remarks*
B235	999	NSE	Q25,27-34	7544	x dimension to start of B236
			Total Area	7544	

INITIALIZATION DATA

Measurement Types Selected: RG, BI, CH
Date Range: All
Thresholds:
EMC: 13,000 DCGLw: 2,600

SURVEY UNIT TEST STATUS

Test Performed	Status			$dpm_p/100\ cm^2$
Min/Max	Pass	Maximum Survey Value	C	622.2
Background	Fail	Minimum Background	M	1.0
DCGLw	Pass	Difference		621.0
DCGLavg	Pass	Average Activity		159.5
EMC	Pass	Average Below DCGL		159.5
Wilcoxon Rank Sum Test	N/A	Average Background		77.9
Sign Test for Paired Data	Pass			

MALLINCKRODT C-T DECOMMISSIONING PROJECT

Threshold Comparison Test Report - Buildings

THE FOLLOWING DATA POINTS FAILED THE EMC TEST:

NONE

THE FOLLOWING DATA POINTS FAILED THE DCGLw TEST:

NONE

THE FOLLOWING DATA POINTS FAILED THE BACKGROUND TEST:

Survey Unit # 235NES Building: B235

Room	SFC	X (ft)	Y (ft)	Mtx	Meas. Type	Min	SID	Gross Activity ($dpm_p/100cm^2$)	Remarks	Exc	Res.
999	E	84.0	6.0	B	CH	2	1370	495.0		C	
999	E	72.0	6.0	B	CH	2	1361	458.4		C	
999	E	76.0	2.3	B	RG	1	5499	440.8		C	
999	E	78.0	3.0	B	CH	2	1365	438.3		C	
999	E	56.4	2.3	B	RG	1	5498	429.8		C	
999	E	54.0	6.0	B	CH	2	1349	428.3		C	
999	E	66.0	6.0	B	CH	2	1357	391.7		C	
999	E	60.0	6.0	B	CH	2	1353	378.8		C	
999	E	66.0	12.0	B	CH	2	1358	360.1		C	
999	E	52.0	5.0	B	CH	2	1347	358.0		C	
999	E	78.0	6.0	B	CH	2	1366	346.5		C	
999	E	36.9	2.3	B	RG	1	5497	334.6		C	
999	E	60.0	12.0	B	CH	2	1354	329.3		C	
999	E	42.0	12.0	B	CH	2	1339	279.8		C	
999	E	54.0	21.0	B	CH	2	1351	261.3		C	
999	E	36.9	14.8	B	RG	1	5495	253.3		C	
999	E	17.3	14.8	B	RG	1	5494	246.7		C	
999	E	36.0	21.0	B	CH	2	1336	246.5		C	
999	E	48.0	13.0	B	CH	2	1343	240.7		C	
999	E	72.0	12.0	B	CH	2	1362	238.9		C	
999	E	84.0	12.0	B	CH	2	1371	238.9		C	
999	E	54.0	12.0	B	CH	2	1350	234.9		C	
999	E	72.0	21.0	B	CH	2	1363	231.0		C	
999	N	94.9	9.4	B	BI	1	5615	309.2	window ledge	C	
999	N	23.3	22.0	B	CH	2	1412	256.8		C	
999	N	47.3	9.0	B	CH	2	1403	246.5		C	
999	N	15.2	16.4	C	RG	1	5470	188.5		C	
999	N	47.3	22.0	O	CH	2	1405	157.7		C	
999	N	0.0	0.0	C	CH	2	1416	143.8		C	
999	N	35.2	16.4	C	RG	1	5471	130.2		C	
999	N	83.3	0.0	C	CH	2	1391	126.7		C	
999	N	75.0	16.4	C	RG	1	5473	120.8		C	
999	N	59.3	0.0	C	CH	2	1398	119.1		C	
999	N	47.3	0.0	C	CH	2	1402	119.1		C	
999	N	94.9	16.4	C	RG	1	5474	117.4		C	
999	N	95.3	0.0	C	CH	2	1387	106.6		C	
999	N	11.3	0.0	C	CH	2	1413	93.5		C	
999	N	55.1	16.4	C	RG	1	5472	91.7		C	
999	N	34.4	19.3	M	BI	1	5616	86.0	old pipe near flashing	C	
999	N	47.3	12.0	O	CH	2	1404	48.9		C	

MALLINCKRODT C-T DECOMMISSIONING PROJECT

Threshold Comparison Test Report - Buildings

Room	SFC	X (ft)	Y (ft)	Mtx	Meas. Type	Min	SID	Gross Activity ($dpm_p/100cm^2$)	Remarks	Exc	Res.
999	N	23.3	12.0	O	CH	2	1411	39.3		C	
999	N	15.2	3.8	FG	RG	1	5476	31.0		C	
999	Q25	4.0	0.0	M	BI	1	5597	86.7		C	
999	Q25	2.0	0.0	M	BI	1	5595	86.0		C	
999	Q25	3.0	0.0	M	BI	1	5596	63.7		C	
999	Q27	1.0	0.0	M	BI	1	5598	93.9		C	
999	Q31	1.0	0.0	M	BI	1	5605	58.4		C	
999	Q33	1.0	0.0	FG	BI	1	5609	59.2		C	
999	Q33	2.0	0.0	FG	BI	1	5610	42.8		C	
999	S	120.0	0.0	C	CH	2	1454	622.4		C	
999	S	72.0	9.0	B	CH	2	1440	397.7		C	
999	S	0.0	22.0	B	CH	2	1422	368.1		C	
999	S	12.0	0.0	B	CH	2	1423	357.8		C	
999	S	24.0	0.0	B	CH	2	1426	338.5		C	
999	S	9.4	4.1	B	RG	1	5488	323.0		C	
999	S	29.3	4.1	B	RG	1	5489	308.8		C	
999	S	9.4	16.7	B	RG	1	5482	302.6		C	
999	S	24.0	22.0	B	CH	2	1428	286.4		C	
999	S	12.0	22.0	B	CH	2	1425	269.0		C	
999	S	48.0	22.0	B	CH	2	1434	251.0		C	
999	S	96.0	22.0	B	CH	2	1445	249.0		C	
999	S	69.2	4.1	B	RG	1	5491	242.9		C	
999	S	0.0	0.0	B	CH	2	1420	231.0		C	
999	S	36.0	22.0	B	CH	2	1431	231.0		C	
999	S	0.0	12.0	B	CH	2	1421	227.2		C	
999	S	12.0	12.0	B	CH	2	1424	224.6		C	
999	S	109.1	16.7	C	RG	1	5487	160.2		C	
999	S	72.0	0.0	C	CH	2	1439	153.3		C	
999	S	60.0	0.0	C	CH	2	1435	145.8		C	
999	S	49.3	16.7	C	RG	1	5484	121.6		C	
999	S	29.3	16.7	C	RG	1	5483	90.8		C	
999	S	69.2	16.7	C	RG	1	5485	88.2		C	
999	S	108.0	0.0	C	CH	2	1450	86.0		C	
999	S	89.2	16.7	C	RG	1	5486	82.2		C	

THE FOLLOWING DATA POINTS PASSED BACKGROUND, DCGLw, AND EMC SCREENING TESTS:

Survey Unit # 235NES Building: B235

Room	SFC	X (ft)	Y (ft)	Mtx	Meas. Type	Min	SID	Gross Activity ($dpm_p/100cm^2$)	Remarks	Exc	Res.
999	E	42.0	21.0	B	CH	2	1340	216.9			
999	E	48.0	21.0	B	CH	2	1344	214.9			
999	E	60.0	21.0	B	CH	2	1355	209.8			
999	E	66.0	21.0	B	CH	2	1359	207.9			
999	E	78.0	12.0	B	CH	2	1367	207.3			
999	E	36.0	12.0	B	CH	2	1335	204.4			
999	E	17.3	2.3	B	RG	1	5496	147.3			
999	N	11.3	22.0	B	CH	2	1415	207.9			
999	N	59.3	22.0	B	CH	2	1400	206.6			
999	N	0.0	22.0	B	CH	2	1418	204.6			
999	N	55.1	3.8	B	RG	1	5478	201.6			

999	N	95.3	9.0	B	CH	2	1388	196.9
999	N	0.0	12.0	B	CH	2	1417	196.9
999	N	119.3	22.0	B	CH	2	1383	192.4
999	N	71.3	22.0	B	CH	2	1397	191.1
999	N	107.3	22.0	B	CH	2	1386	183.4
999	N	83.3	12.0	B	CH	2	1392	180.2
999	N	95.3	22.0	B	CH	2	1390	180.2
999	N	59.3	12.0	B	CH	2	1399	171.2
999	N	83.3	22.0	B	CH	2	1393	168.0
999	N	114.9	16.4	B	RG	1	5475	150.2
999	N	94.9	3.8	B	RG	1	5480	149.9
999	N	35.3	22.0	B	CH	2	1408	138.4
999	N	107.3	12.0	B	CH	2	1385	129.3
999	N	119.3	0.0	B	CH	2	1381	124.2
999	N	114.9	3.8	CB	RG	1	5481	117.6
999	N	119.3	12.0	B	CH	2	1382	113.9
999	N	107.3	0.0	B	CH	2	1384	112.0
999	N	23.3	0.0	C	CH	2	1409	66.4
999	N	0.0	23.0	M	CH	2	1419	47.4
999	N	35.2	3.8	M	RG	1	5477	13.9
999	N	35.3	0.0	M	CH	2	1406	12.3
999	N	71.3	10.0	M	CH	2	1395	11.9
999	N	75.0	3.8	M	RG	1	5479	1.5
999	N	95.3	12.0	O	CH	2	1389	-5.1
999	N	71.3	0.0	M	CH	2	1394	-7.3
999	N	11.3	12.0	O	CH	2	1414	-10.9
999	N	35.3	12.0	O	CH	2	1407	-55.3
999	N	71.3	12.0	O	CH	2	1396	-79.2
999	Q25	1.0	0.0	M	BI	1	5594	45.3
999	Q27	2.0	0.0	M	BI	1	5599	53.2
999	Q27	3.0	0.0	M	BI	1	5600	7.9
999	Q28	2.0	0.0	M	BI	1	5602	43.3
999	Q28	1.0	0.0	M	BI	1	5601	-10.5
999	Q29	1.0	0.0	M	BI	1	5603	17.1
999	Q29	2.0	0.0	M	BI	1	5604	-11.8
999	Q31	2.0	0.0	M	BI	1	5606	3.3
999	Q32	2.0	0.0	M	BI	1	5608	37.4
999	Q32	1.0	0.0	M	BI	1	5607	13.1
999	Q33	3.0	0.0	M	BI	1	5611	-0.7
999	Q33	4.0	0.0	M	BI	1	5612	-2.6
999	Q34	1.0	0.0	M	BI	1	5613	16.4
999	Q34	2.0	0.0	M	BI	1	5614	-23.0
999	S	109.1	4.1	B	RG	1	5493	218.3
999	S	108.0	22.0	B	CH	2	1453	217.5
999	S	60.0	22.0	B	CH	2	1437	206.6
999	S	84.0	22.0	B	CH	2	1442	201.4
999	S	60.0	12.0	B	CH	2	1436	189.8
999	S	36.0	0.0	B	CH	2	1429	157.7
999	S	108.0	9.0	M	CH	2	1451	47.0
999	S	36.0	12.0	B	CH	2	1430	37.3
999	S	96.0	12.0	M	CH	2	1447	18.1
999	S	24.0	12.0	M	CH	2	1427	13.1
999	S	48.0	12.0	M	CH	2	1433	12.3
999	S	108.0	12.0	M	CH	2	1452	11.6
999	S	89.2	4.1	M	RG	1	5492	10.8
999	S	48.0	0.0	M	CH	2	1432	8.5
999	S	72.0	12.0	M	CH	2	1441	7.3
999	S	84.0	12.0	M	CH	2	1444	4.2
999	S	84.0	0.0	M	CH	2	1443	1.9
999	S	96.0	0.0	M	CH	2	1446	-5.8
999	S	49.3	4.1	M	RG	1	5490	-16.2

MALLINCKRODT C-T
DECOMMISSIONING PROJECT

Threshold Comparison Test Report - Buildings

Summary of Background Data and Thresholds Used in this Analysis

Measurement Type: BK ***DCGL:*** 2,600 ***EMC:*** 13,000

Matrix	*Number of Data Points*	*Average Background*	*Sigma*	*Background Threshold (Tbk)*	*DCGLw Threshold (Td)*	*EMC Threshold (Tc)*
		($dpm_p/100cm^2$)	($dpm_p/100cm^2$)	($dpm_p/100cm^2$)	($dpm_p/100cm^2$)	($dpm_p/100cm^2$)
B	30	192.4	16.0	224.4	2,824	13,224
C	90	35.4	20.1	75.5	2,675	13,075
CB	51	96.1	21.7	139.4	2,739	13,139
FG	0	0.0	0.0	0.0	2,600	13,000
M	10	24.0	15.7	55.3	2,655	13,055
O	0	0.0	0.0	0.0	2,600	13,000

MALLINCKRODT C-T
DECOMMISSIONING PROJECT

Threshold Comparison Test Report - Buildings

STATISTICAL TEST RESULTS

Run Date: 12/8/2003 2:57:37 PM
Survey Unit Number 235NES Class: 2
Selected Test: SIGN TEST FOR PAIRED DATA
Test Status Pass
Thresholds:

EMC 13,000 DCGL 2,600

DATA SUMMARY TABLE

30 Survey points processed and 5 matrices processed

S+ = 30 **Wc =** 20

******** The survey unit has passed the SIGN TEST FOR PAIRED DATA ********

MALLINCKRODT C-T DECOMMISSIONING PROJECT

Threshold Comparison Test Report – Buildings

Run Date: Monday, December 08, 2003
Survey Unit Number: 236NSW Class: 2 Data Points: Beta Grid Type: R Spacing: 11.8 ft.

SURVEY UNIT TABLE

Bldg	*Rm*	*Surface*	*Fixed Equipment*	*Surface Area Included (sq. ft)*	*Remarks*
B236	999	NSW	Q25Q26Q27Q32	4025	x dimension includes wall between 235 and 236
			Total Area	4025	

INITIALIZATION DATA

Measurement Types Selected: RG, BI, CH
Date Range: All
Thresholds:
EMC: 13,000 DCGLw: 2,600

SURVEY UNIT TEST STATUS

Test Performed	Status			$dpm_\beta/100\ cm^2$
Min/Max	Pass	Maximum Survey Value	B	644.0
Background	Fail	Minimum Background	M	1.0
DCGLw	Pass	Difference		643.0
DCGLavg	Pass	Average Activity		264.3
EMC	Pass	Average Below DCGL		264.3
Wilcoxon Rank Sum Test	N/A	Average Background		77.9
Sign Test for Paired Data	Pass			

MALLINCKRODT C-T DECOMMISSIONING PROJECT

Threshold Comparison Test Report - Buildings

THE FOLLOWING DATA POINTS FAILED THE EMC TEST:

NONE

THE FOLLOWING DATA POINTS FAILED THE DCGLw TEST:

NONE

THE FOLLOWING DATA POINTS FAILED THE BACKGROUND TEST:

Survey Unit # 236NSW Building: B236

Room	SFC	X (ft)	Y (ft)	Mtx	Meas. Type	Min	SID	Gross Activity ($dpm_p/100cm^2$)	Remarks	Exc	Res.
999	N	4.5	1.0	B	CH	2	1586	389.3		C	
999	N	6.5	1.0	B	CH	2	1583	332.0		C	
999	N	6.5	7.0	B	CH	2	1585	327.8		C	
999	N	10.8	1.5	B	RG	1	5506	307.5		C	
999	N	5.5	14.0	B	CH	2	1591	302.1		C	
999	N	6.5	4.0	B	CH	2	1584	295.2		C	
999	N	4.5	16.0	B	CH	2	1592	287.0		C	
999	N	43.0	9.5	B	RG	1	5505	270.8		C	
999	N	5.5	10.0	B	CH	2	1589	260.8		C	
999	N	4.5	4.0	B	CH	2	1587	256.2		C	
999	N	43.0	1.5	B	RG	1	5508	246.8		C	
999	N	4.5	12.0	B	CH	2	1590	226.8		C	
999	Q27	1.0	0.0	M	BI	1	5619	139.9		C	
999	Q32	1.0	0.0	M	BI	1	5622	59.1		C	
999	S	6.3	9.9	B	RG	1	5512	401.3		C	
999	S	38.4	9.9	B	RG	1	5514	376.1		C	
999	S	38.4	1.8	B	RG	1	5517	337.2		C	
999	S	6.3	1.8	B	RG	1	5515	334.6		C	
999	S	22.3	9.9	B	RG	1	5513	322.4		C	
999	S	22.3	1.8	B	RG	1	5516	245.5		C	
999	S	24.0	22.0	B	CH	2	1617	242.0		C	
999	S	43.5	22.0	B	CH	2	1619	231.7		C	
999	S	22.3	18.0	C	RG	1	5510	149.1		C	
999	S	6.3	18.0	C	RG	1	5509	144.8		C	
999	S	38.4	18.0	C	RG	1	5511	125.1		C	
999	W	42.5	8.0	B	CH	2	1460	644.2		C	
999	W	42.5	12.0	B	CH	2	1461	595.0		C	
999	W	75.5	4.0	B	CH	2	1594	549.6		C	
999	W	42.5	4.0	B	CH	2	1459	538.6		C	
999	W	51.5	8.0	B	CH	2	1457	482.6		C	
999	W	73.5	8.0	B	CH	2	1600	460.5		C	
999	W	24.8	12.7	B	RG	1	5524	453.9		C	
999	W	74.5	8.0	B	CH	2	1599	450.0		C	
999	W	75.5	7.0	B	CH	2	1595	448.6		C	
999	W	51.5	12.0	B	CH	2	1458	446.3		C	
999	W	41.0	12.7	B	RG	1	5525	436.4		C	
999	W	41.0	4.6	B	RG	1	5529	432.8		C	
999	W	51.5	4.0	B	CH	2	1456	416.4		C	
999	W	72.5	7.0	B	CH	2	1598	375.6		C	
999	W	72.5	1.0	B	CH	2	1596	366.4		C	

MALLINCKRODT C-T DECOMMISSIONING PROJECT

Threshold Comparison Test Report - Buildings

Room	SFC	X (ft)	Y (ft)	Mtx	Meas. Type	Min	SID	Gross Activity ($dpm_\beta/100cm^2$)	Remarks	Exc	Res.
999	W	35.5	22.0	B	CH	2	1605	356.5		C	
999	W	41.0	20.8	B	RG	1	5520	356.4		C	
999	W	57.2	12.7	B	RG	1	5526	352.0		C	
999	W	24.8	20.8	B	RG	1	5519	342.1		C	
999	W	75.5	1.0	B	CH	2	1593	341.6		C	
999	W	73.3	4.6	B	RG	1	5531	316.5		C	
999	W	57.2	4.6	B	RG	1	5530	314.0		C	
999	W	8.7	20.8	B	RG	1	5518	313.6		C	
999	W	72.5	4.0	B	CH	2	1597	282.4		C	
999	W	57.2	20.8	B	RG	1	5521	275.2		C	
999	W	11.5	22.0	B	CH	2	1608	266.4		C	
999	W	0.0	22.0	B	CH	2	1609	263.2		C	
999	W	73.3	20.8	B	RG	1	5522	256.6		C	
999	W	23.5	22.0	B	CH	2	1607	237.5		C	
999	W	8.7	12.7	CB	RG	1	5523	162.3		C	
999	W	42.0	0.3	C	BI	1	5624	140.5	base of wall on	C	

THE FOLLOWING DATA POINTS PASSED BACKGROUND, DCGLw, AND EMC SCREENING TESTS:

Survey Unit # 236NSW Building: B236

Room	SFC	X (ft)	Y (ft)	Mtx	Meas. Type	Min	SID	Gross Activity ($dpm_\beta/100cm^2$)	Remarks	Exc	Res.
999	N	19.5	22.0	B	CH	2	1612	201.4			
999	N	4.5	7.0	B	CH	2	1588	193.8			
999	N	31.5	22.0	B	CH	2	1611	187.9			
999	N	7.5	22.0	B	CH	2	1613	186.6			
999	N	0.0	22.0	B	CH	2	1614	186.0			
999	N	43.5	22.0	B	CH	2	1610	184.0			
999	N	26.9	9.5	CB	RG	1	5504	114.0			
999	N	10.8	9.5	CB	RG	1	5503	94.3			
999	N	10.8	17.6	C	RG	1	5500	74.5			
999	N	26.9	17.6	C	RG	1	5501	71.1			
999	N	43.0	17.6	C	RG	1	5502	66.0			
999	N	26.9	1.5	M	RG	1	5507	21.7			
999	Q26	2.0	0.0	M	BI	1	5618	40.7			
999	Q26	1.0	0.0	M	BI	1	5617	8.5			
999	Q27	2.0	0.0	M	BI	1	5620	46.6			
999	Q27	3.0	0.0	M	BI	1	5621	-2.6			
999	Q32	2.0	0.0	M	BI	1	5623	-3.3			
999	S	36.0	22.0	B	CH	2	1618	220.1			
999	S	0.0	22.0	B	CH	2	1615	199.5			
999	S	12.0	22.0	B	CH	2	1616	180.2			
999	W	47.5	22.0	B	CH	2	1604	222.0			
999	W	73.3	12.7	CB	RG	1	5527	86.6			
999	W	8.7	4.6	M	RG	1	5528	14.7			

MALLINCKRODT C-T DECOMMISSIONING PROJECT

Threshold Comparison Test Report – Buildings

Summary of Background Data and Thresholds Used in this Analysis

Measurement Type: BK ***DCGL:*** 2,600 ***EMC:*** 13,000

Matrix	*Number of Data Points*	*Average Background*	*Sigma*	*Background Threshold (Tbk)*	*DCGLw Threshold (Td)*	*EMC Threshold (Tc)*
		($dpm_p/100cm^2$)	($dpm_p/100cm^2$)	($dpm_p/100cm^2$)	($dpm_p/100cm^2$)	($dpm_p/100cm^2$)
B	30	192.4	16.0	224.4	2,824	13,224
C	90	35.4	20.1	75.5	2,675	13,075
CB	51	96.1	21.7	139.4	2,739	13,139
M	10	24.0	15.7	55.3	2,655	13,055

MALLINCKRODT C-T
DECOMMISSIONING PROJECT

Threshold Comparison Test Report – Buildings

STATISTICAL TEST RESULTS

Run Date: 12/8/2003 3:13:19 PM
Survey Unit Number 236NSW Class: 2
Selected Test: SIGN TEST FOR PAIRED DATA
Test Status Pass
Thresholds:

EMC 13,000 DCGL 2,600

DATA SUMMARY TABLE

32 Survey points processed and 4 matrices processed

S+ = 32 **Wc =** 21

******** The survey unit has passed the SIGN TEST FOR PAIRED DATA ********