FINAL STATUS SURVEY REPORT
BUILDING 91 CRANE PAD

MALLINCKRODT, INC.
COLUMBIUM- TANTULUM PROJECT- PHASE 1

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C-T PROJECT – PHASE I

FINAL STATUS SURVEY REPORT

Building 91 Crane Pad

Survey Unit 9101

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 crane pad in Building 91 on the Mallinckrodt St. Louis site (designated as Survey Unit (SU) 9101). This report is being provided in accordance with the Mallinckrodt C-T Project, Phase I Decommissioning Plan. This Final Status Survey (FSS) was performed in accordance with the Final Status Survey Plan (FSSP) for SU 9101[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 survey unit 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

[1] Final Status Survey Plan: Survey Unit 9101: Building 91 Crane Pad.

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 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 (FSS)

2.1. DEFINITION AND CLASSIFICATION OF THE SURVEY UNIT

2.1.1. The 2nd floor crane pad of Building 91 has been designated as a single survey unit. SU-9101 consists of the floor of the crane pad located on the 2nd floor of Building 91[2]. It is classified as Class 2.

2.1.2. Table 2.1 below contains the description provided in Appendix A of the D Plan for the area referenced by this FSSR. Although Appendix A of the D Plan classified this area as Class 3, subsequent survey measurements directed reclassification of the survey unit to Class 2.

Table 2.1[3]
Survey Area Descriptions

Area	Surface	Location / Surface
10	Floor	2nd Floor crane pad.

2.1.3. A summary report listing all the surfaces and fixed apparatus assigned to SU-9101 is presented in Appendix 1. A drawing of the survey unit showing the location of key fixed apparatus items is presented in Appendix 2, Figure 1.1.

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.[4]

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 several matrix materials. 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.

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[2] The crane pad floor is assigned as "room" 101 for database management purposes.
[3] Appendix A of D Plan.
[4] Mallinckrodt C-T Project D Plan Appendix D.

Natural background levels for the contaminants of interest in the survey unit are presented in Table 2.2.

Table 2.2
Background Reference Data

Matrix	Mean ($dpm_p/100cm^2$)[5]	Standard Deviation ($dpm_p/100cm^2$)
Metal	24.0	15.7
Concrete	35.4	20.1

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 floors. 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)[6] was developed and was used during the FSS as if it were the DCGLw with certain exceptions.[7]

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 all the measurements within a Class 2 survey unit must be less than the DCGLw, there is no EMC criterion applicable to this survey.

2.5. SURVEY INSTRUMENTS

2.5.1. The instrumentation used 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.

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[5] $Dpm_p/100\ cm^2$ refers to the disintegrations per minute per 100 cm^2 for the combined nuclide series.

[6] NEXTEP Tech Memo 0211, *Recommendation for an Administrative Release Guideline for the Mallinckrodt C-T Project,* A.H. Thatcher, CHP, (included with FSSR 2501).

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

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. 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. 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[8]. 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[9]. The difference in the two readings is attributable to beta emissions above 80 KeV in energy.[10] The sensitivity of the AB-100 was derived from experiments by Lucas and Colyott which were reported in Attachment 3 to the D Plan.[11] The actual instruments used were calibrated and normalized to the reference instrument tested by Lucas and Colyott as prescribed in CT-QA-6.1[12].

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.

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

[9] 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.

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

[11] *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.

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

2.5.7. L43-89 – The Ludlum 43-89 scintillation detector is a newer design that is functionally and physically equivalent to the AB-100. It has a slightly higher efficiency as a rule, and it may be paired on the same ratemeters and scalers.

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 process. The LLD, or MDA, is the smallest concentration of radioactive material in a sample 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.[13]

2.6.2. The LLD requirements for the FSS have been developed in accordance with MARSSIM [14]Chapter 4 guidelines. They are contained in the Design Guide and are listed in Table 2.4.

Table 2.4
MDC Requirements for CT FSS

Measurement Type	MDC Requirement[15]
Direct Beta	50% of ARG
Class 2 Beta Scans	ARG

[13] CT-QA-6.1, ibid.
[14] NUREG 1575, *Multi Agency Radiation Survey and Site Investigation Manual.*
[15] Requirements are stated in terms of the ARG which may be adjusted upward by the area factor or paint attenuation factor (not to exceed the DCGLw) as described in Section 3.2 of the Design Guide.

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

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].

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.

[16] LCD calculations for the AB-100 detector are also representative if the Ludlum 43-89 for the purpose of this survey.

[17] NEXTEP Tech Memo 0230, *Technical Basis Document for Mallinckrodt Final Status Surveys*, A.H. Thatcher CHP, (included with FSSR 2501).

[18] All Values given are net of background.

[19] Investigation Threshold.

2.7.2. No painted surfaces were surveyed in SU-9101, so the 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 matrices were generated using an MCNP model and are described in NEXTEP Tech Memo 0213.[21] These coefficients were stored in the Matrix table in the Database and were used in the calculations according to the matrix upon which each 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 FSSP.

Table 3.1

Survey Procedures and Documents
CT Decommissioning Plan (Phase I)
CT Decommissioning Project, Final Status Survey Design Guide (Phase I)
Final Status Survey Plan, SU-9101, Building 91, Crane Pad
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 were submitted to the Quality Assurance Manager 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.

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[20] NEXTEP Tech Memo 0215, *Separation of Backscatter & Derivation of Instrument Sensitivity*, A.H. Thatcher CHP, (Included with FSSR 2501).

[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).

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 was obtained on the floor surface as described in the FSSP. Bias measurements were taken 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 and within selected areas compromising approximately 15% of each Class 2 survey unit. 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 regular grid locations on the floor. 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 the survey unit. 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 receives the Data Quality Objective (DQO) input values necessary 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.

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[23] Section 3.3 of the CT Design Guide.

[24] NEXTEP Tech Memo 0008, *Verification and Validation of Applicable Portions of VSP Software, A.* H. Thatcher, CHP, (Included with FSSR 2501).

Table 3.2
VSP Inputs for Building 91 Crane Pad

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%

3.3.1.3. A rectangular grid was used for SU-9101. The maximum grid interval spacing, L, was calculated from the area of the total 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 SU -9101.

Table 3.3
SU 9101 Calculated Grid Point Separation

Survey Unit	Class	N Number of Data Points	A (ft^2) SU Area	L (ft)
SU-9101	2	29	542	4.3

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.

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

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

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. Any systematic grid measurement points for the floor surface which landed on the air conditioner would have been identified using the X and Y coordinates from the southwest corner of the room. "Q2 – A/C unit" would be noted in the remarks. The surface ID would be "F".

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

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

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 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 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

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

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

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.

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 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) and 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 SU 9101 and the results are presented in Appendix 4. The 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.

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

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

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 SU.

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 Statistical Test. 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 meet 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. The characterization data taken in this survey unit from 1992 to 1996 was very limited. Since the data on file in the characterization report were all taken with an HP-210 instrument they cannot be normalized to the AB-100 calibration standards and therefore are not included in the data set.

4.2. SURVEY UNIT 9101

4.2.1. SU-9101 was surveyed in January 2003. Measurements were taken on the floor of the crane pad and on all items of fixed equipment.

4.2.2. Direct Beta Measurements.

4.2.2.1. 31 direct beta measurements were taken on the floor of the survey unit. All of these were included in the systematic grid. A diagram of the survey unit layout with the beta measurements taken is presented in Appendix 2, Figure 4.1.

4.2.2.2. A summary of the direct measurement results taken on the floor surface is presented in Table 4.1 and shows that the maximum activity measured, net of background, was 216 $dpm_p/100cm^2$. The average net value for all the floor data points was 123 $dpm_p/100cm^2$.

Table 4.1
SU-9101 Floor Direct Measurements Summary

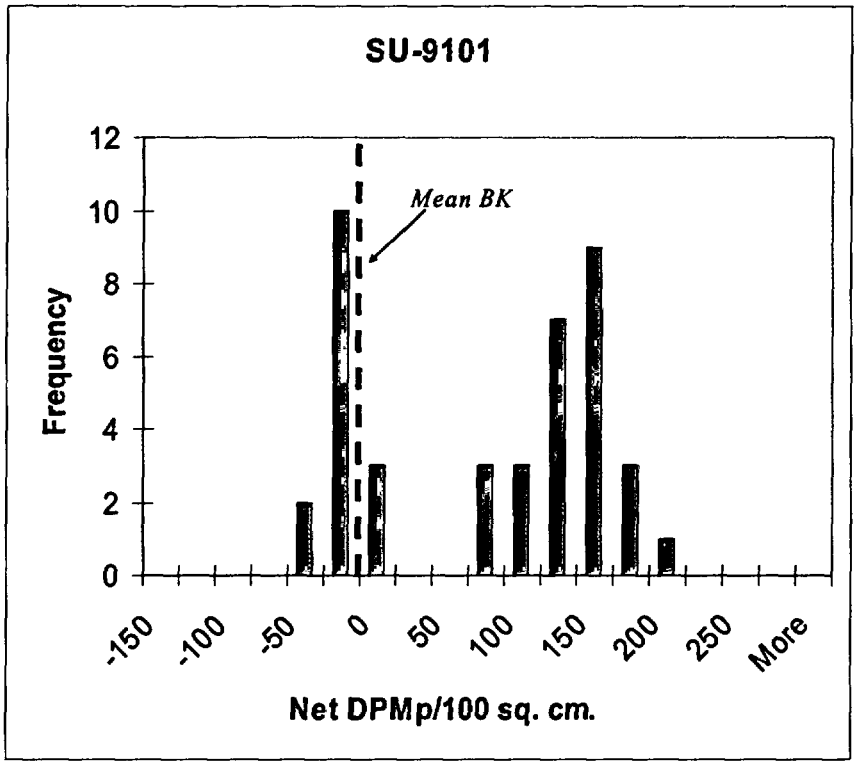
Matrix	Points	Avg Net Activity ($dpm_p/100cm^2$)	Max Net Activity ($dpm_p/100cm^2$)
Concrete	28	135.7	215.6
Metal	3	-0.6	24.6

4.2.2.3. All 3 items of installed apparatus which are listed in Appendix 1 were surveyed by direct beta measurements. A diagram of the survey unit layout with the beta measurements taken (represented by numbers) is provided in Appendix A, Figure 4.2. A summary of the measurements taken is provided in Table 4.2. The values observed ranged from –33 to 5 $dpm_p/100cm^2$. All values were at background levels. The data confirm that no residual radioactivity was found on the 3 items of installed apparatus in SU-9101.

Table 4.2
SU-9101 Installed Apparatus Direct Measurements Summary

Matrix	Points	Avg Net DPMp ($dpm_p/100cm^2$)	Max Net DPMp ($dpm_p/100cm^2$)
Metal	10	-9.5	4.9

4.2.2.4. A histogram of the net activity values found in SU-9101 is provided in Figure 4.1. A majority of the survey measurements are clustered around 150 $dpm_p/100cm^2$, just above background. A smaller group of measurements fell close to background. This is consistent with a normal distribution of residual radioactivity concentrated just above the background level and is well below the ARG.



Histogram of Net Direct Beta Measurements
Figure 4.1

4.2.2.5. 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-9101. The TCTR reports in Appendix 4 contain a complete listing of all the beta direct measurements taken in the Final Status Survey within SU-9101 sorted by test and by activity. The summary pages indicate that all tests described in the D Plan passed except background. All tests required for release of a Class 2 survey unit 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-9101
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.

4.2.2.6. 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.

4.2.3. Measurements of removable contamination

4.2.3.1. 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-9101 Removable Contamination Summary

Survey Unit	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 ($dpm_p/100cm^2$)
9101	31	-3.1	20.6	-0.7	4.3

[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.

4.2.3.2. The results show that removable contamination averages very near zero $dpm_p/100cm^2$ and varies between –6.1 and +4.3 $dpm_p/100cm^2$. The data confirm that virtually no removable contamination is present within the survey unit.

4.2.4. Beta Scan Measurements

4.2.4.1. Beta scans were performed on about 25% of the crane pad floor surface. A diagram of the areas surveyed is presented in Appendix 2, Figure 4.2.

4.2.4.2. 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[32].

4.2.4.3. 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 concrete this value was 331 cpm. This average of all open window beta readings taken on the survey unit was 875 cpm.

4.2.4.4. During the surveys the maximum and average gross count rates were recorded for each area scanned. The beta scan data are summarized for SU-9101 and presented in Table 4.5.

Table 4.5
SU-9101 Scan Measurements Summary

Survey Unit	Areas	Maximum (cpm)	Average (cpm)	Max Net (cpm)	Avg Net (cpm)
9101	3	975	860	644	529

4.2.4.5. The maximum net scan value of 644 cpm is well below the scan threshold of 2000 cpm.

5. CONCLUSIONS

5.1. The distribution of direct survey measurements net of background in SU-9101 shows a majority of the data centered at approximately 150 $dpm_p/100cm^2$ above mean background. This is consistent with a normal distribution of residual radioactivity concentrated just above the background level and well below the ARG (Par. 4.2.2.4).

5.2. SU-9101 passed all the tests described in the D plan except background. All tests required for release of a Class 2 Survey unit passed. (Par. 4.2.2.5)

5.3. No residual radioactivity was measured on the 3 items of installed apparatus in SU-9101.(Par. 4.2.2.3)

5.4. Virtually no removable contamination is present within SU-9101. (Par. 4.2.3.2)

5.5. No beta scan data were observed in SU-9101 above the scan threshold of 2,000 cpm. (Par. 4.2.4.5)

5.6. SU-9101 meets all the requirements of the D Plan for unconditional release.

6. RECOMMENDATIONS

6.1. SU-9101 should be released from the license.

[32] NEXTEP Tech Memo 0230, *ibid.*

Appendix 1
Building Survey Unit Listing for
Building 91 Crane Pad

Building Survey Unit Listing

SurveyUnitID: 9101 ***Class:*** 2

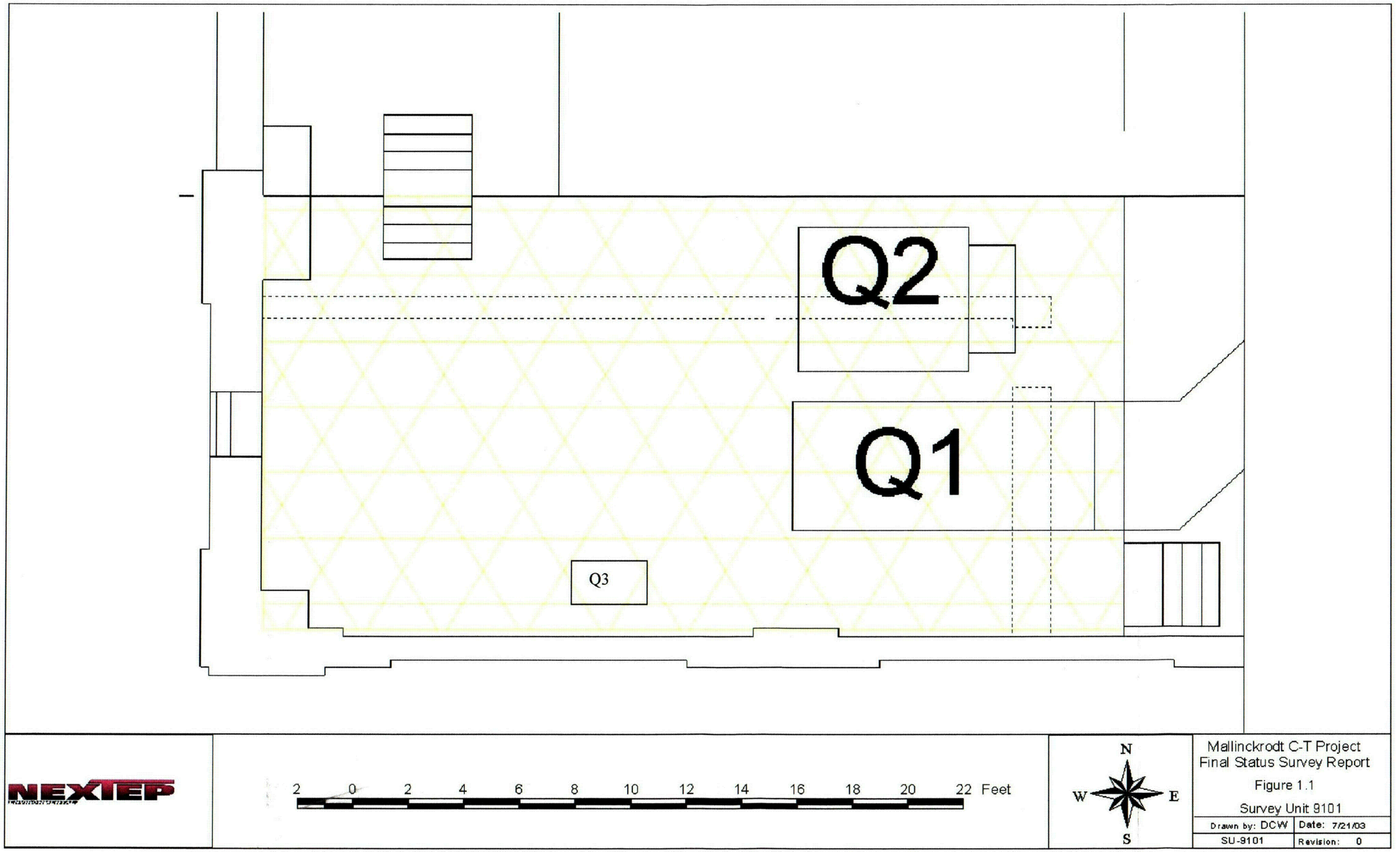
Room 101

Area	*SurfaceCode*	*Xmax*	*Ymax*	*(sq.ft.)*	*Paint (Coats)*	*Description*
	F	34.3	15.8	542	0.0	Crane Pad
	Q1				0.0	S Air Handler & Ducts
	Q2				0.0	N Air Handler & Ducts
	Q3				0.0	Electrical Box on Floor

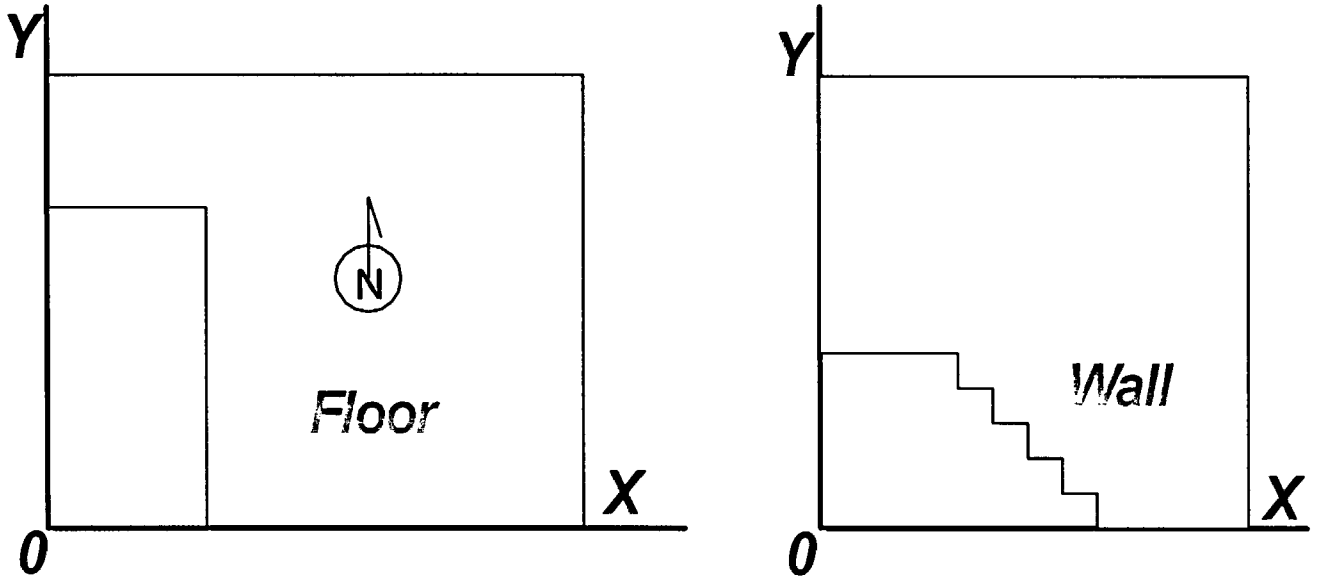
Summary for Room 101 (4 detail records) ***542*** **Sq. Feet**

TOTAL for Survey Unit 9101 ***542*** **Sq. Feet**

APPENDIX 2
Figures

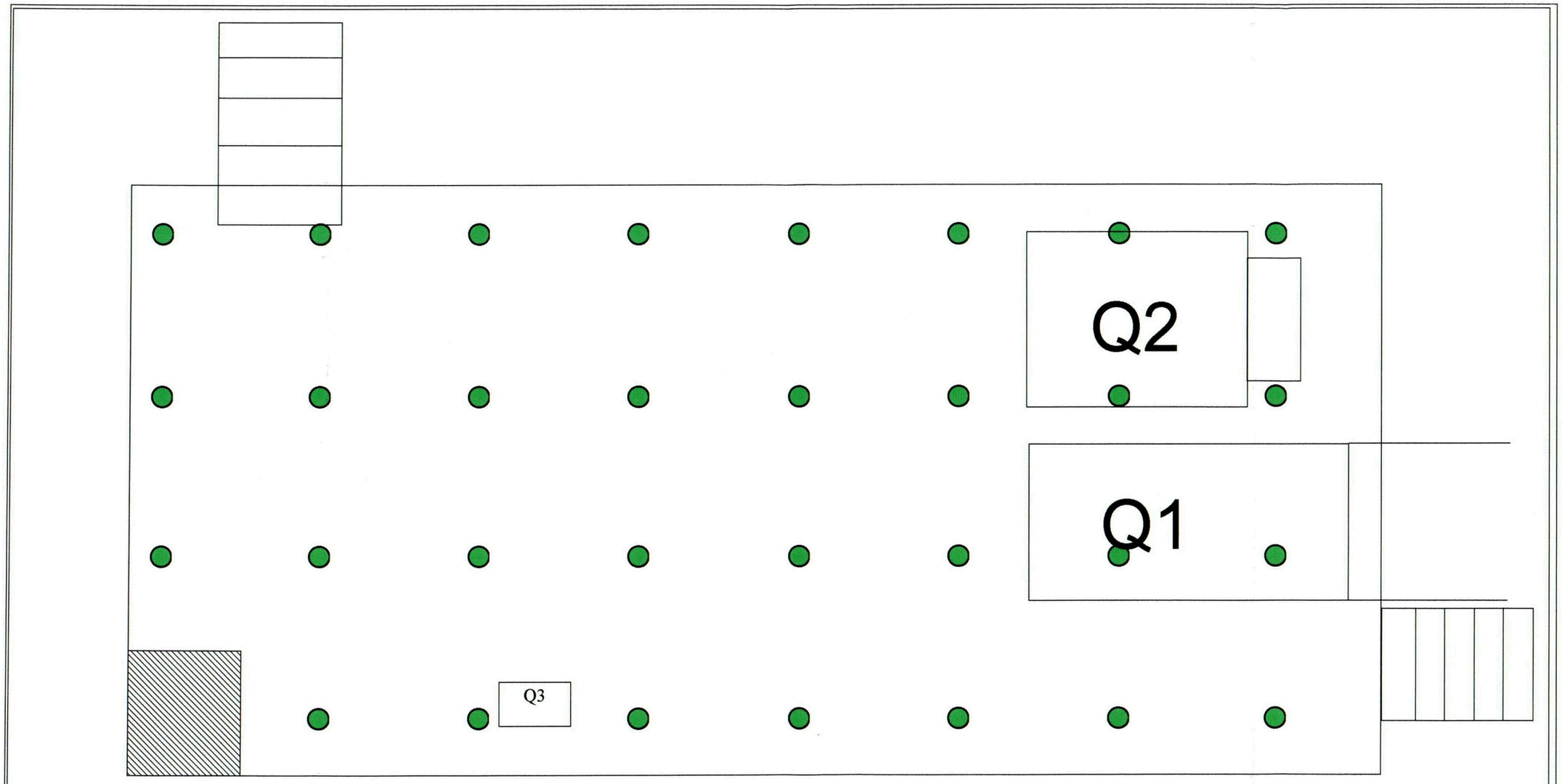

Q2
Q1
Q3
2 0 2 4 6 8 10 12 14 16 18 20 22 Feet
N
W
E
S
Mallinckrodt C-T Project
Final Status Survey Report
Figure 1.1
Survey Unit 9101
Drawn by: DCW
Date: 7/21/03
SU-9101
Revision: 0

C01



Coordinate System

Figure 3.1



MALLINCKRODT

NEXTEP ENVIRONMENTAL

Legend

Inaccessible

Direct Beta Measurements ($dpm_\beta/100\ cm^2$)

- Under 2000
- 2000 - 2600
- 2600 or More

N W E S

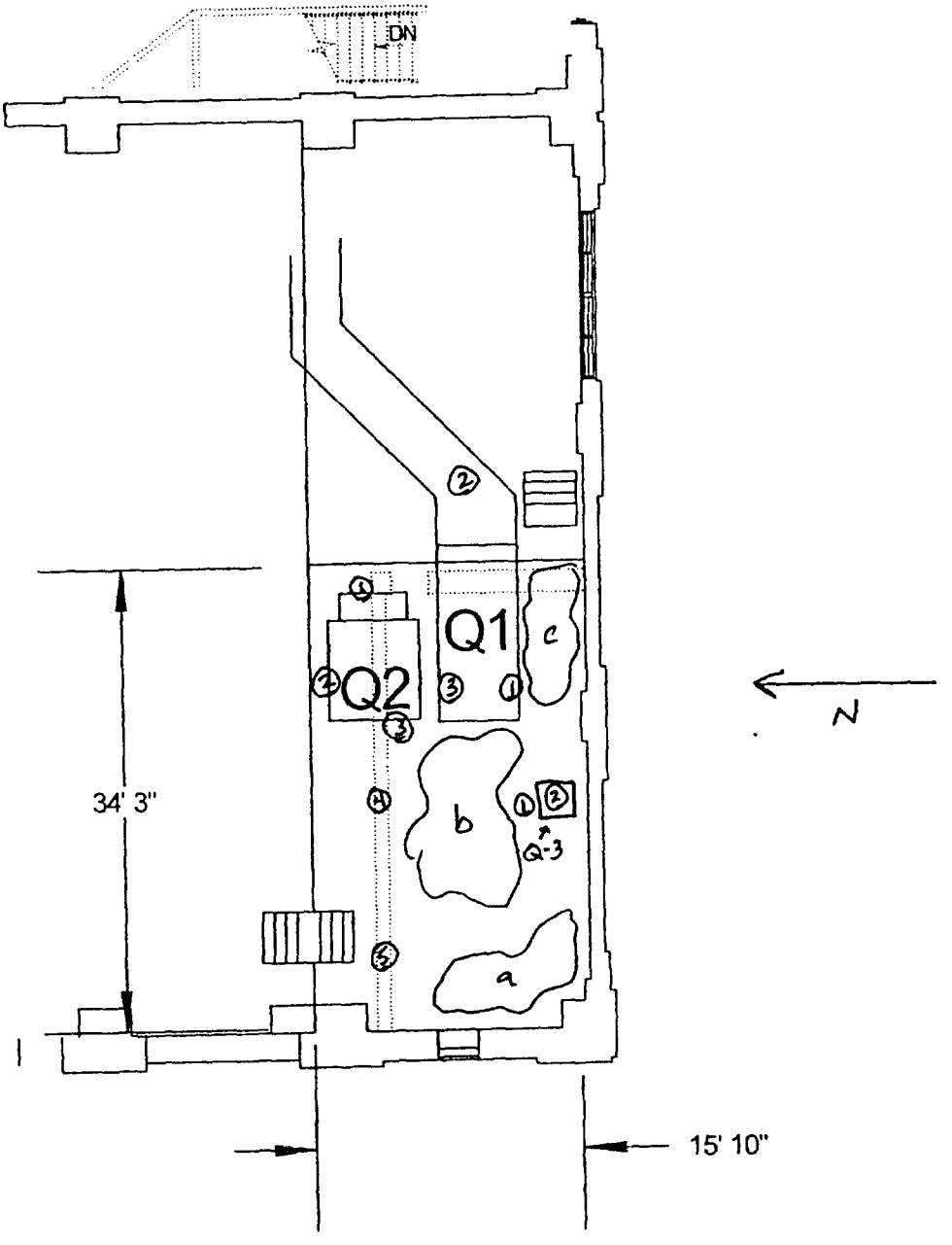
1 0 1 2 3 Feet

Mallinckrodt C-T Project
Final Status Survey Report

Figure 4.1
SU-9101 Direct Beta Measurements

Drawn by: DCW	Date: 11/7/2003
Building: 91	Revision: 0

C02



Survey Unit 9101
Figure 4.2

APPENDIX 3
Calibration Sheets

Type	S/N	Cal Date
Beta	131410/B860N	11/7/2002
Swipe	179562	11/8/2002 7/22/2003

Bicron
AB-100
~~AG-87~~

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	7533
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 @ 6792

1 min Bkg 431

6361 / 17100

37.2 % ok JJ

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: 9-H - 11-7-02 Expiration Date: 11-7-03

Calibrated by: Ronald W. Selk Ronald W. Selk
(Print Name) (Signature)

Reviewed by: Allen Fiegley Date: 11/8/02

EA4.10
Rev: 2
Date: 25 Feb 99

Page 4 of 4

L2241-2/AB-100
SN: 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. (illegible)

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
Concrete	~~totz Pb~~ 570	572	198	8301	354	7947	6-A	33[illegible]	
				8313	331	7982			
				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.
	0	0	0	6337	334	6003			27.3
	0	0	0	6388	328	6060			[illegible]
196 X 125 = 22000 dpm								Average =	[illegible]
								Std Dev =	[illegible]
Masonite	0	0	0	6902	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.
								Average =	[illegible]
								Std Dev =	[illegible]
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: Alan Priegley DATE: 11/8/02

#Cable Checks OK

L2241-2/AB-100
SN: 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	18550	18817	

sample mean (xbar) =	18817	Multiplier to convert to dpm:	3.0
sample variance (s^2) =	14316		
background variance (b^2) =	26.7		
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
SN: 131410/B860N
11/7/02

JUL.10.2003 16:52 314 654 1251 MALLINCKRODT #2114 P.009

Designer and Manufacturer of Scientific and Industrial Instruments

CERTIFICATE OF CALIBRATION

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.

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

(EEPROM Settings)

Instrument in DPM mode.
SC mode turned OFF.
Firmware version: 390110
Overload set at 1/4 turn past OFF.
Battery voltage measured at 12.40 Vdc.
C-14 Efficiency = 9 %(4 pi) Net

(PC) Count Time: 10
Alpha Alarm: 50000 cpm
Beta Alarm: 50000 cpm
Alpha/Beta Alarm: 50000 cpm
Calibration Due Date: 8 May 03
LOC (Loss of Count) time = 30 minutes (default)

Alpha Channel Digital Readout	REFERENCE CAL POINT	INSTRUMENT RECEIVED	INSTRUMENT METER READING*
	400K cpm	399264	399264
	40K cpm	39927	39927
	4K cpm	3993	3993
	400 cpm	400	400
	40 cpm	40	40

Beta/Gamma Channel Digital Readout	REFERENCE CAL POINT	INSTRUMENT RECEIVED	INSTRUMENT METER READING*
	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% (0) Indicates 0.1 minute count

COMMENTS:
Eff. for Th-230 s/n 2748-00, 3070cpm, read 2455 in 1 minute = 80% 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, Pu-239 ☑ Beta S/N Tc-99 Ni-6Y ☐ Other

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

Calibrated By: [signature] Date 8 Nov 02

Reviewed By: [signature] Date 11 Nov 02

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

L3030
SN: 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

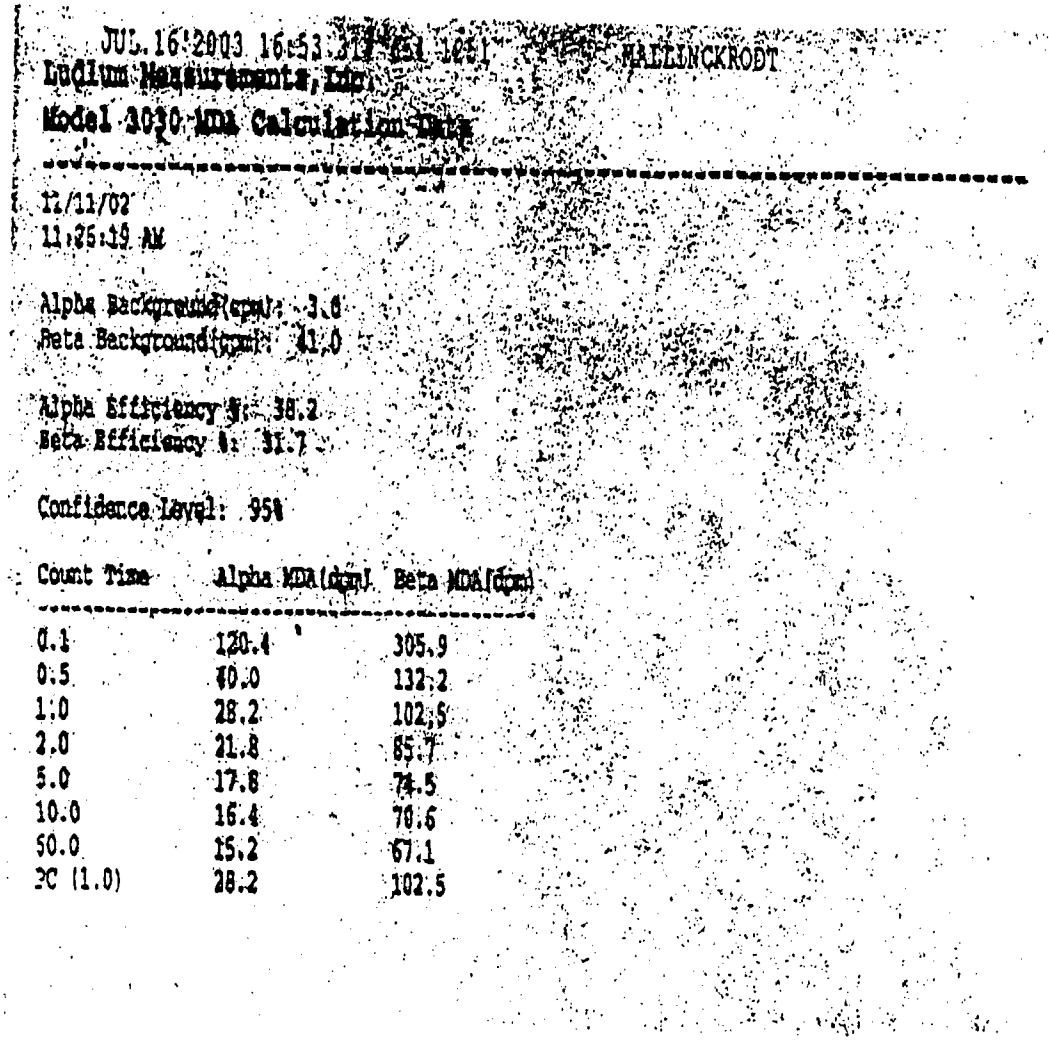
Beta Isotope: Tc-99
Beta Source Size (dpm): 22600
Beta Source Size (µCi): 0.01018018

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%	5387 (0)	25	23.5%	0.0%
650	9467 (311)	2	37.6%	2.9%	6243 (4)	40	27.6%	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
SN: 179562
11/8/02



JUL.16'2003 16:53 [illegible] MALLINCKRODT #2114 P.010

Ludlum Measurements, Inc.

Model 3030 MDA Calculation Data

12/11/02
11:35:19 AM

Alpha Background(cpm): 3.6
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	40.0	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
SN: 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 % Alt 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

GC mode turned OFF. Alpha Alarm: 999999 cpm

Firmware version: 39013N10 Beta Alarm: 999999 cpm

Overload set at 1/4 turn past OFF. Alpha/Beta Alarm: 999999 cpm

Battery voltage measured at 13.56 Vdc. Calibration Due Date: 01/11/2004

Cs137 Efficiency = 7.1 %(4 pi) Net LOC (Loss of Count) time = 30 minutes (default)

	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	400K cpm	399507	399507
	40K cpm	39952	39952
	4K cpm	3997	3997
	400 cpm	400	400
	40 cpm	40	40

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

COMMENTS:
Det. Nal 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: Date 22 Jul 03

Reviewed By: Date 22 July 03

This certificate shall not be reproduced except in full, without the written approval of Ludlum Measurements, Inc.
FORM C25-3 04/29/2003

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

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

	ALPHA					BETA				
	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	9435	(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%
700	9537	(343)	0	37.8%	3.2%	8354	(0)	34	36.8%	0.0%
725	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
9:42:58 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
5.0	1.4	74.3
10.0	0.7	70.3
[illegible]	0.1	66.8
50 [illegible]	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: Wednesday, December 03, 2003

Survey Unit Number: 9101 Class: 2 Data Points: Beta Grid Type: R Spacing: 4.3 ft.

SURVEY UNIT TABLE

Bldg	Rm	Surface	Fixed Equipment	Surface Area Included (sq. ft)	Remarks
B91	101	F	Q1Q2Q3	542	Floor only
			Total Area	542	

INITIALIZATION DATA

Measurement Types Selected: RG, BI

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	251.0
Background	Fail	Minimum Background	M	1.0
DCGLw	Pass	Difference		250.0
DCGLavg	Pass	Average Activity		122.1
EMC	Pass	Average Below DCGL		122.1
Wilcoxon Rank Sum Test	N/A	Average Background		34.2
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 # 9101 Building: B91

Room	SFC	X (ft)	Y (ft)	Mtx	Meas. Type	Min	SID	Gross Activity ($dpm_\beta/100cm^2$)	Remarks	Exc	Res.
101	F	18.4	14.5	C	RG	1	5263	251.0		C	
101	F	9.6	14.5	C	RG	1	5261	233.9		C	
101	F	5.2	1.3	C	RG	1	5283	220.2		C	
101	F	14.0	14.5	C	RG	1	5262	212.4		C	
101	F	31.6	5.8	C	RG	1	5282	208.2		C	
101	F	22.8	1.3	C	RG	1	5287	203.9		C	
101	F	0.8	5.8	C	RG	1	5275	201.3		C	
101	F	5.2	5.8	C	RG	1	5276	194.5		C	
101	F	5.2	10.1	C	RG	1	5268	191.0		C	
101	F	14.0	10.1	C	RG	1	5270	189.3		C	
101	F	27.3	14.5	C	RG	1	5265	189.3		C	
101	F	22.8	10.1	C	RG	1	5272	187.6		C	
101	F	31.6	14.5	C	RG	1	5266	186.7		C	
101	F	0.8	14.5	C	RG	1	5259	183.3		C	
101	F	18.4	10.1	C	RG	1	5271	180.7		C	
101	F	14.0	5.8	C	RG	1	5278	176.5		C	
101	F	9.6	1.3	C	RG	1	5284	172.2		C	
101	F	0.8	10.1	C	RG	1	5267	168.8		C	
101	F	9.6	5.8	C	RG	1	5277	165.3		C	
101	F	27.3	5.8	C	RG	1	5281	161.9		C	
101	F	18.4	1.3	C	RG	1	5286	158.5		C	
101	F	18.4	5.8	C	RG	1	5279	154.2		C	
101	F	31.6	1.3	C	RG	1	5289	150.8		C	
101	F	5.2	14.5	C	RG	1	5260	135.3		C	
101	F	27.3	1.3	C	RG	1	5288	134.5		C	
101	F	9.6	10.1	C	RG	1	5269	119.9		C	

MALLINCKRODT C-T
DECOMMISSIONING PROJECT

Threshold Comparison Test Report - Buildings

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

Survey Unit # 9101 Building: B91

Room	SFC	X (ft)	Y (ft)	Mtx	Meas. Type	Min	SID	Gross Activity ($dpm_\beta/100cm^2$)	Remarks	Exc	Res.
101	F	27.3	10.1	C	RG	1	5273	53.1			
101	F	22.8	14.5	M	RG	1	5264	48.6			
101	F	22.8	5.8	M	RG	1	5280	20.4			
101	F	14.0	1.3	C	RG	1	5285	6.0			
101	F	31.6	10.1	M	RG	1	5274	1.3			
101	Q1	3.0	0.0	M	BI	1	5292	22.3			
101	Q1	2.0	0.0	M	BI	1	5291	21.0			
101	Q1	1.0	0.0	M	BI	1	5290	13.1			
101	Q2	2.0	0.0	M	BI	1	5294	23.6			
101	Q2	5.0	0.0	M	BI	1	5297	15.8			
101	Q2	3.0	0.0	M	BI	1	5295	11.8			
101	Q2	1.0	0.0	M	BI	1	5293	7.2			
101	Q2	4.0	0.0	M	BI	1	5296	-8.5			
101	Q3	1.0	0.0	M	BI	1	5298	28.9			
101	Q3	2.0	0.0	M	BI	1	5299	9.8			

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)*
	($dpm_\beta/100cm^2$)	($dpm_\beta/100cm^2$)	($dpm_\beta/100cm^2$)	($dpm_\beta/100cm^2$)	($dpm_\beta/100cm^2$)	($dpm_\beta/100cm^2$)
C	90	35.4	20.1	75.5	2,675	13,075
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: 12/3/2003 7:55:02 PM

Survey Unit Number 9101 Class: 2

Selected Test: SIGN TEST FOR PAIRED DATA

Test Status Pass

Thresholds:

EMC 13,000 DCGL 2,600

DATA SUMMARY TABLE

31 Survey points processed and 2 matrices processed

S+ = 31 Wc = 20

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