

# FINAL STATUS SURVEY REPORT BUILDING 240 INTERIOR

MALLINCKRODT, INC.  
COLUMBIUM- TANTULUM PROJECT- PHASE 1

DECEMBER 2003



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MALLINCKRODT, Inc.  
C-T PROJECT - PHASE I  
FINAL STATUS SURVEY REPORT

Building 240 Interior

Survey Unit 2401

Revision 0

Prepared by

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**Joint Venture**

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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 floor of Building 240 on the Mallinckrodt St. Louis site (designated as Survey Unit (SU) 2401). This report is being provided in accordance with the Mallinckrodt C-T Project, Phase I Decommissioning Plan (D Plan). This Final Status Survey (FSS) was performed in accordance with Field Instruction (FI) CT-FI-005<sup>1</sup> 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

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<sup>1</sup> CT-FI-005, *Final Status Survey Guide for Survey Unit 2401: Building 240 Floor.*

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

### 2.1. DEFINITION AND CLASSIFICATION OF SURVEY UNIT

- 2.1.1. The affected interior surfaces of Building 240 have been designated as a single survey unit see paragraph 2.1.3. SU-2401 consists of the interior floor and doorways of Building 240. SU-2401 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 areas referenced by this FSSR.

**Table 2.1<sup>2</sup>**  
***Survey Area Descriptions***

Area	Surface	Location / Surface
170	F	Floor/Doorways

- 2.1.3. A summary report for each survey unit listing all the surfaces and fixed apparatus assigned to SU-2401 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 2.1.

### 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.<sup>3</sup>

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

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<sup>2</sup> Appendix A of D Plan.

<sup>3</sup> Mallinckrodt C-T Project D Plan Appendix D

**Table 2.2**  
***Background Reference Data***

Matrix	Mean (dpm <sub>p</sub> /100cm <sup>2</sup> ) <sup>4</sup>	Standard Deviation (dpm <sub>p</sub> /100cm <sup>2</sup> )
Concrete	35.4	20.1
Metal	24.0	15.7
Vinyl Tile	15.1	24.0
Wood	13.4	24.0

#### 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 and doors.
- 2.4.2. To limit the dose from residual materials as much as possible an Administrative Release Guideline (ARG)<sup>5</sup> was developed and was used during the FSS as if it were the DCGLw with certain exceptions.<sup>6</sup>

**Table 2.3**  
***Building Surface and Installed Apparatus Release Criteria***

Criterion	(dpm <sub>p</sub> /100 cm <sup>2</sup> )
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.

<sup>4</sup> Dpm<sub>p</sub>/100 cm<sup>2</sup> refers to the disintegrations per minute per 100 cm<sup>2</sup> for the combined parent nuclide series.

<sup>5</sup> NEXTEP Tech Memo 0211, *Recommendation for an Administrative Release Guideline for the Mallinckrodt C-T Project*, A.H. Thatcher, CHP, (included with FSSR 2501).

<sup>6</sup> Final Status Survey Design Guide (Phase I), Section 3.2, covers the rules governing use of the ARG.

## 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 for 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. 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<sup>2</sup> for the purpose of alpha attenuation<sup>7</sup>. 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<sup>8</sup>. The difference in the two readings is attributable to beta emissions above 80 KeV in energy.<sup>9</sup> The sensitivity of the AB-100 was derived from experiments by Lucas and Colyott which were reported in Attachment 3 to the D Plan.<sup>10</sup> The actual instruments used were calibrated and

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<sup>7</sup> As specified in Appendix D of the D Plan. Measurements taken with only the mylar covering the probe were "open window" measurements.

<sup>8</sup> The "closed window" reading was taken with a 1/8" soft Aluminum plate covering the face of the detector. It is sufficient to exclude  $\beta$  rays from the U and Th series.

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

<sup>10</sup> *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.

normalized to the reference instrument tested by Lucas and Colyott as prescribed in CT-QA-6.1<sup>11</sup>.

- 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. 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  $\beta\text{pm}/100\text{ cm}^2$ . 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.

## 2.6. 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 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.<sup>12</sup>
- 2.6.2. The LLD requirements for the FSS have been developed in accordance with MARSSIM<sup>13</sup> 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 <sup>14</sup>
Direct Beta	50% of ARG
Class 1 Beta Scans	ARG <sub>EMC</sub>
Class 2 or 3 Beta Scans	ARG

<sup>11</sup> CT-QA-6.1 - *Calibration and Control of Measuring and Survey Equipment.*

<sup>12</sup> CT-QA-6.1, Ibid.

<sup>13</sup> NUREG 1575, *Multi Agency Radiation Survey and Site Investigation Manual.*

<sup>14</sup> Requirements are stated in terms of the ARG which may be adjusted upward by the area factor or paint attenuation factor 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 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<sup>15</sup>.

**Table 2.5**  
**LLD and Action Thresholds<sup>16</sup>**

Measurement	Units	Calculated Value	Required Value
<b>BETA DIRECT</b>			<b>Class 2</b>
MDC	dpm <sub>p</sub> /100 cm <sup>2</sup>	100	1,300
Tinv <sup>17</sup>	cpm		2,900
<b>BETA SCAN</b>			
MDC	dpm <sub>p</sub> /100 cm <sup>2</sup>	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<sub>p</sub>/100 cm<sup>2</sup> of the parent nuclide series in accordance with Section 9 of the Design Guide using the following equation:

**Equation 1**

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

Where:

- AD = Areal Density in dpm<sub>p</sub>/100 cm<sup>2</sup> 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<sub>i</sub> = Normalized Instrument sensitivity without backscatter.
- S<sub>b</sub>(m) = Backscatter factor (a function of matrix)
- t = Integration time in minutes.

<sup>15</sup> NEXTEP Tech Memo 0230, *Technical Basis Document for Mallinckrodt Final Status Surveys*, A.H. Thatcher CHP, (included with FSSR 2501).

<sup>16</sup> All Values given are net of background.

<sup>17</sup> Investigation Threshold.



- 2.7.2. No painted surfaces were surveyed in SU-2401, so the paint attenuation factor (PAF) was equal to one for all surfaces.
- 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.<sup>18</sup> Reference backscatter coefficients for several matrix materials were generated using an MCNP model and are described in Nextep Tech Memo 0213.<sup>19</sup> 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 FI, which implemented the requirements contained in the D Plan.

Table 3.1

Survey Procedures and Documents
CT Decommissioning Plan (Phase I)
CT Decommissioning Project, Final Status Survey Design Guide (Phase I)
CT-FI-005, Final Status Survey Guide for Survey Unit 2401
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 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<sup>20</sup>

<sup>18</sup> NEXTEP Tech Memo 0215, *Separation of Backscatter & Derivation of Instrument Sensitivity*, A.H. Thatcher CHP, (included with FSSR 2501).

<sup>19</sup> NEXTEP Tech Memo 0213, *Beta Backscatter Factors for Several Materials at the Mallinckrodt Site*, N. Zhang and D. Wilson, (included with FSSR 2501).

<sup>20</sup> NEXTEP Tech Memo 0206, *QA Data Verification for MI CT Final Status Survey Data*, B. Anderson, (included with FSSR 2501).

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 floor surfaces as described in the FI. Bias measurements were taken on the floor 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 the floor surface 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 100% of all regular grid locations. 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<sup>21</sup>.

### 3.3. MEASUREMENT LOCATIONS

#### 3.3.1. Statistical Grid Data Points

3.3.1.1. The *Visual Sample Plan*® (VSP)<sup>22</sup> software was used to develop a MARSSIM grid for SU-2401. 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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<sup>21</sup> Section 3.3 of the C-T Design Guide.

<sup>22</sup> NEXTEP Tech Memo 0008, *Verification and Validation of Applicable Portions of VSP Software*, A. H. Thatcher, CHP.

**Table 3.2**  
***VSP Inputs for Building 240 Floor***

<b>DQO</b>	<b>Value</b>
Type I error rate	5%
Type II error rate	5%
Width of Gray Region	200 dpm <sub>p</sub> /100cm <sup>2</sup>
Level (ARG)	2,600 dpm <sub>p</sub> /100cm <sup>2</sup>
Estimated Std Deviation	200 dpm <sub>p</sub> /100cm <sup>2</sup>
Excess % sample points min.	20%

3.3.1.3. A rectangular grid was used for SU-2401. The grid maximum interval spacing, L, was calculated from the total area of the survey unit, A, and the required number of data points, N, according to the following equation:

**Equation 2**

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

3.3.1.4. Table 3.3 presents the calculated values for L and N for SU2401.

**Table 3.3**  
***SU-2401 Floor Calculated Grid Point Separation***

<b>Survey Unit</b>	<b>Class</b>	<b>N Number of Data Points</b>	<b>A (ft<sup>2</sup>)</b>	<b>L (ft)</b>
SU-2401	2	29	4,084	11.9

### 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<sup>23</sup>.

## 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.

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<sup>23</sup> CT-FI-002, *Final Status Survey Guide for Survey Units 235NES & 236NSW*, 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. The surface ID for a roof applies only in the case when measurements are being made on the exterior surface of a building. In this unique case the "room" assigned has the special number "999".
- 3.4.4. 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 mounted on the floor. Any systematic grid measurement points for the floor surface which landed on the air conditioner would be 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".
- 3.4.5. 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<sup>24</sup>.

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<sup>24</sup> NEXTEP Tech Memo 0231, *Validation and Verification of the C-T Database Analysis Report*, B. Anderson, (included with FSSR 2501).

- 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 each survey record but generate a single PASS/FAIL verdict for the entire data set. The tests that were performed are described in the following paragraphs<sup>25</sup>. 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 3

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

- 3.5.4.2.  $T_{bk}$  is equal to the mean of the background readings ( $\overline{BK}$ ) for a given matrix plus two times its standard deviation ( $2\sigma$ ).
- 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  $\text{dpm}/100\text{cm}^2$ , 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  $T_{bk}$ .

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<sup>25</sup> A more detailed explanation is provided in the Design Guide.

## Equation 4

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

- 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 DCGL<sub>w</sub> 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<sub>EMC</sub>.
- 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<sub>p</sub>/100cm<sup>2</sup>), 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 DCGL<sub>w</sub> for any matrix in the survey unit, the test fails.

## Equation 5

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

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<sup>26</sup> 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<sup>27</sup> was used.
- 3.5.10. The output of the Threshold Comparison Test Report (TCTR) was used for analysis of the data for the Building 240 interior and the results are presented in

<sup>26</sup> Described in Appendix I of MARSSIM.

<sup>27</sup> Described in NEXTEP Tech Memo 0231, *ibid*.

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.

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 DCGL<sub>w</sub> (ARG) and DCGL<sub>EMC</sub> 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 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 DCGL <sub>w</sub>
Background	All samples must be less than the background threshold <sup>a</sup>
DCGL <sub>w</sub>	All samples must be no more than DCGL <sub>w</sub> + the background threshold
DCGL <sub>avg</sub>	The average of all net survey values must be less than DCGL <sub>w</sub>
EMC	All samples must be less than DCGL <sub>EMC</sub> + the background threshold
Sign Test for Paired Data	The Sign Test for Paired Data is described in detail in NUREG 1505 <sup>28</sup>
Wilcoxon Rank Sum Test	This statistical test is described in detail in MARSSIM, Appendix I.

<sup>a</sup> The background threshold is equal to the mean background value plus twice  $\sigma_{BK}$ .

- 3.5.11. Provided all additional considerations such as scan data, swipes, sampling of removable contamination or sludge from traps, etc. indicate that the survey unit met 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<sup>29</sup>**

Test	Class 1	Class 2	Class 3
Min/Max	not required <sup>a</sup>	not required <sup>a</sup>	PASS
Background	not required	not required	PASS
DCGL <sub>w</sub>	not required	PASS	PASS
DCGL <sub>avg</sub>	PASS	PASS	PASS
EMC	PASS	PASS	PASS
Sign Test for Paired Data	PASS	PASS	PASS

<sup>a</sup> Class 1 or 2 survey units which pass Min/Max may be released without further consideration.

<sup>28</sup> NUREG 1505, *A Nonparametric Statistical Methodology for the Design and Analysis of Final Status Decommissioning Surveys*.

<sup>29</sup> See MARSSIM, Chapter 8, Table 8.2.



## 4. FSS RESULTS AND DISCUSSION

### 4.1. CHARACTERIZATION DATA

- 4.1.1. The characterization data taken in these survey units 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 2401

- 4.2.1. SU-2401 was surveyed in May 2003. Measurements were taken on the floor and on the doorways.

#### 4.2.2. Direct Beta Measurements on Building Surfaces.

- 4.2.2.1. 42 direct beta measurements were taken on the floor surfaces of the survey unit.<sup>30</sup> 28 of these were included in the systematic grid. A diagram of the survey unit layout of the floor 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 floor surfaces is presented in Table 4.1 and shows that the maximum activity measured, net of background, was 121 dpm<sub>p</sub>/100cm<sup>2</sup>. The average value for the survey unit was -4.7 dpm<sub>p</sub>/100cm<sup>2</sup> after background subtraction.

**Table 4.1**  
***SU-2401 Direct Measurements Summary***

Matrix	Points	Avg Net Activity (dpm <sub>p</sub> /100cm <sup>2</sup> )	Max Net Activity (dpm <sub>p</sub> /100cm <sup>2</sup> )
Concrete	24	-15.0	43.9
Vinyl Tile	18	9.0	120.6

#### 4.2.3. Direct Beta Measurements on Installed Apparatus

- 4.2.3.1. All 19 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 4.4 sorted by matrix. The values observed ranged from -48 to 65 dpm<sub>p</sub>/100cm<sup>2</sup>. All values were less than 3% of the ARG. The data confirm that no significant residual radioactivity was measured on the 19 items of installed apparatus in SU-2401.

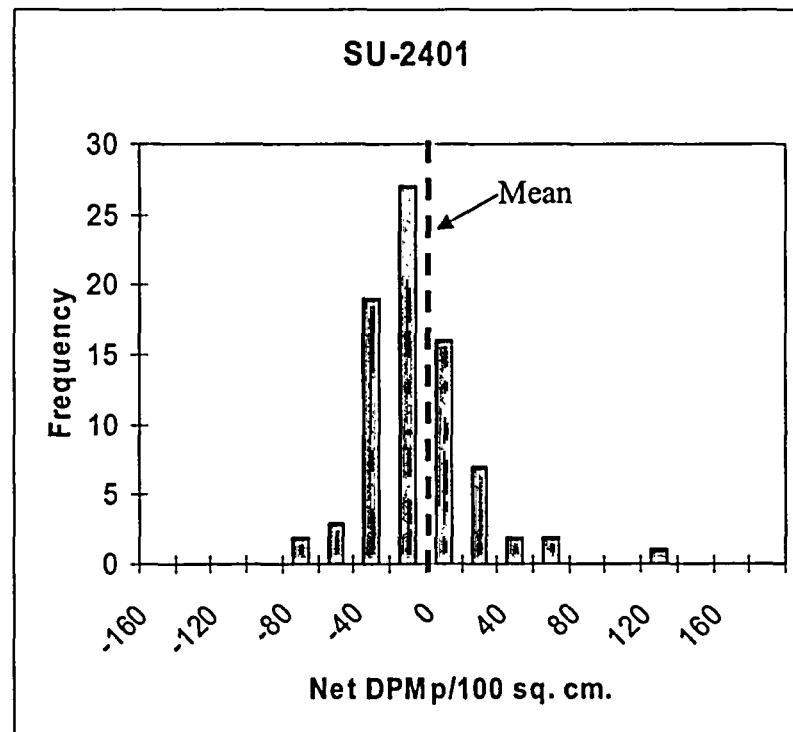
<sup>30</sup> Excluding measurements on installed apparatus.

**Table 4.2**  
***SU-2401 Fixed Equipment Direct Measurements Summary***

Matrix	Points	Avg Net Activity (dpm <sub>p</sub> /100cm <sup>2</sup> )	Max Net Activity (dpm <sub>p</sub> /100cm <sup>2</sup> )
Metal	14	-16.6	19.3
Wood	23	0.1	65.4

**4.2.4. Direct Beta Measurement Distribution and Threshold Tests**

4.2.4.1. A histogram of the net activity values found in the survey unit is provided in Figure 4.1. The distribution appears to have a single mode with the majority of the data centered at approximately -10<sup>31</sup> dpm<sub>p</sub>/100cm<sup>2</sup>. This is consistent with a normal distribution of background radioactivity. One point fell slightly outside of the background distribution. All measurements were well below the ARG.



**Figure 4.1**  
**Histogram of Net Direct Beta Measurements**

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-2401. The TCTR report contains a complete listing

<sup>31</sup> Actually this mode represents the number of occurrences where the activity fell between -25 and 0 dpm<sub>p</sub>/100cm<sup>2</sup>.

of all the beta direct measurements taken in the Final Status Survey within SU-2401 sorted 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-2401
Min/Max	not required <sup>a</sup>	P
Background	not required	F
DCGL <sub>w</sub>	PASS	P
DCGL <sub>avg</sub>	PASS	P
EMC	PASS	P
Wilcoxon Rank Sum Test	PASS	P

<sup>a</sup> 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, the survey unit surfaces are at background levels with the exception of one measurement. These results are consistent with a passing of all tests except background for this survey unit.

#### 4.2.5. Measurements of removable contamination

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

**Table 4.4**  
***SU-2401 Removable Contamination Summary***

Surface	Points	Avg Net Beta ( $\beta$ pm/100cm <sup>2</sup> )	Max Net Beta ( $\beta$ pm/100cm <sup>2</sup> )	Avg Net Activity <sup>a</sup> (dpm <sub>p</sub> /100cm <sup>2</sup> )	Max Net Activity (dpm <sub>p</sub> /100cm <sup>2</sup> )
F	41	-15.8	22.0	-3.3	4.6

<sup>a</sup> Activity was converted to dpm<sub>p</sub>/100 cm<sup>2</sup> from  $\beta$ pm/100 cm<sup>2</sup> using an approximate figure of 4.8 betas per disintegration.

4.2.5.2. The results show that removable contamination averages near zero dpm<sub>p</sub>/100cm<sup>2</sup> and varies between -15.6 and +4.6 dpm<sub>p</sub>/100cm<sup>2</sup>. The data confirm that virtually no removable beta contamination is present within SU-2401.

#### 4.2.6. Beta Scan Measurements

- 4.2.6.1. Beta scans were performed on about 15% of the surface of the floor. 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/100cm<sup>2</sup>. The calculation of threshold count rate and MDC for scans is presented in NEXTEP Tech Memo 0230<sup>32</sup>.
- 4.2.6.3. All scans performed on the floor surface were taken on concrete or vinyl tile. The average background value used for analysis of the concrete raw data was obtained from the average of all the open window, direct beta readings (in cpm) taken in the survey unit. This value was 211 cpm. The average of all open window survey readings taken on concrete in the background data set was 331 cpm. For vinyl tile, the average of all the open window, direct beta readings in the background data set was used. This value was 161 cpm. The average of all open window direct beta survey readings taken on vinyl tile in the survey unit was 252 cpm.
- 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-2401 and presented in Table 4.5.

**Table 4.5**  
***SU-2401 Scan Measurements Summary***

Matrix	Areas	Maximum (cpm)	Average (cpm)	Max Net (cpm)	Avg Net (cpm)
Concrete	3	400	266.6	189.3	56.0
Vinyl Tile	4	650	317.5	489.4	156.9

- 4.2.6.5. The maximum net scan value of 489 cpm is well below the scan threshold of 2000 cpm which corresponds to the ARG. No beta scan data were observed in SU-2401 above the scan threshold.

## 5. CONCLUSIONS

- 5.1. SU-2401 passed all the tests described in the D Plan except background. All tests required for release of a Class 2 Survey unit passed. (Par. 4.2.4.2)
- 5.2. No significant residual radioactivity was measured on the 19 items of installed apparatus in SU-2401.(Par. 4.2.3.1)
- 5.3. Virtually no removable beta contamination is present within SU-2401. (Par. 4.2.5.2)

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<sup>32</sup> NEXTEP Tech Memo 0230, *ibid.*

5.4. No beta scan data were observed in SU-2401 above the scan threshold of 2,000 cpm which corresponds to the ARG. (Par. 4.2.6.5)

5.5. SU-2401 meets all the requirements of the D Plan for unconditional release.

## **6. RECOMMENDATIONS**

6.1. SU-2401 should be released from the license.

**Appendix 1**  
**Building Survey Unit Listing for**  
**Building 240 Interior**

## *Building Survey Unit Listing*

	<i>SurfaceCode</i>	<i>Xmax</i>	<i>Ymax</i>	<i>Area (sq.ft.)</i>	<i>Paint (Coats)</i>	<i>Description</i>
<b>SurveyUnitID: 2401</b>						<b>Class: 2</b>
<b>Room 101</b>						
	F	9.0	9.0	81	0.0	
	Q1				0.0	door/doorway
<b>Summary for Room 101 (2 detail records)</b>						<b>81 Sq. Feet</b>
<b>Room 102</b>						
	F	9.0	9.0	81	0.0	
	Q1				0.0	door/doorway
<b>Summary for Room 102 (2 detail records)</b>						<b>81 Sq. Feet</b>
<b>Room 103</b>						
	F	14.0	9.0	126	0.0	
	Q1				0.0	door/doorway
<b>Summary for Room 103 (2 detail records)</b>						<b>126 Sq. Feet</b>
<b>Room 104</b>						
	F	9.0	9.0	81	0.0	
	Q1				0.0	door/doorway
<b>Summary for Room 104 (2 detail records)</b>						<b>81 Sq. Feet</b>
<b>Room 105</b>						
	F	9.0	9.0	81	0.0	
	Q1				0.0	door/doorway
<b>Summary for Room 105 (2 detail records)</b>						<b>81 Sq. Feet</b>
<b>Room 106</b>						
	F	14.0	24.6	296	0.0	
	Q1				0.0	door/doorway
<b>Summary for Room 106 (2 detail records)</b>						<b>296 Sq. Feet</b>

## Building Survey Unit Listing

	SurfaceCode	Xmax	Ymax	Area (sq.ft.)	Paint (Coats)	Description
<hr/>						
Room	107					
	F	10.0	9.0	90	0.0	
	Q1				0.0	door/doorway
Summary for Room 107 (2 detail records)					90 Sq. Feet	
<hr/>						
Room	108					
	F	10.0	9.0	90	0.0	
	Q1				0.0	door/doorway
Summary for Room 108 (2 detail records)					90 Sq. Feet	
<hr/>						
Room	109					
	F	9.0	9.0	81	0.0	
	Q1				0.0	door/doorway
Summary for Room 109 (2 detail records)					81 Sq. Feet	
<hr/>						
Room	110					
	F	10.0	14.0	126	0.0	
	Q1				0.0	door/doorway
Summary for Room 110 (2 detail records)					126 Sq. Feet	
<hr/>						
Room	111					
	F	20.0	24.0	330	0.0	
	Q1				0.0	door/doorway
Summary for Room 111 (2 detail records)					330 Sq. Feet	
<hr/>						
Room	112					
	F	9.0	16.0	144	0.0	
	Q1				0.0	door/doorway
Summary for Room 112 (2 detail records)					144 Sq. Feet	

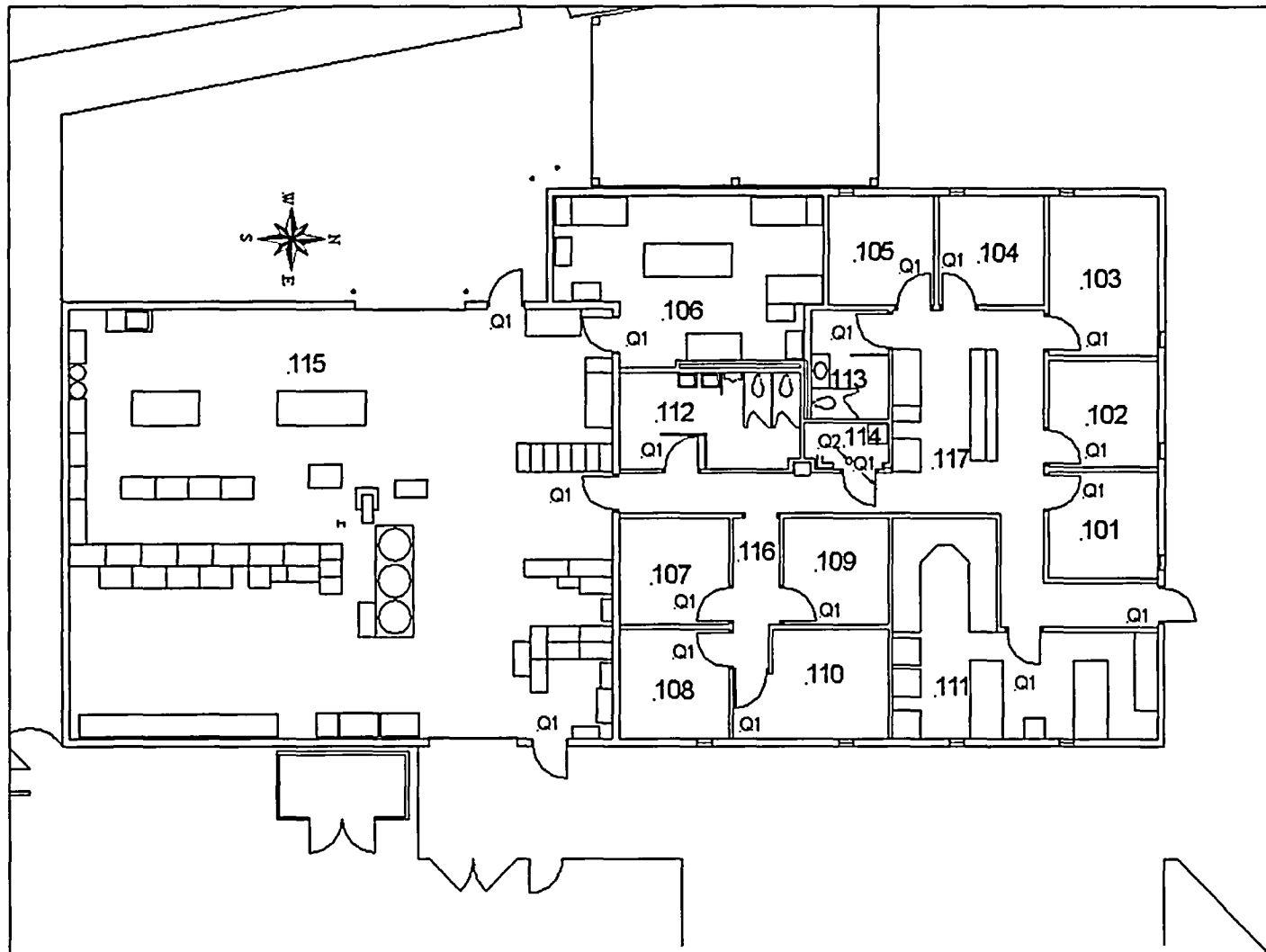


## *Building Survey Unit Listing*

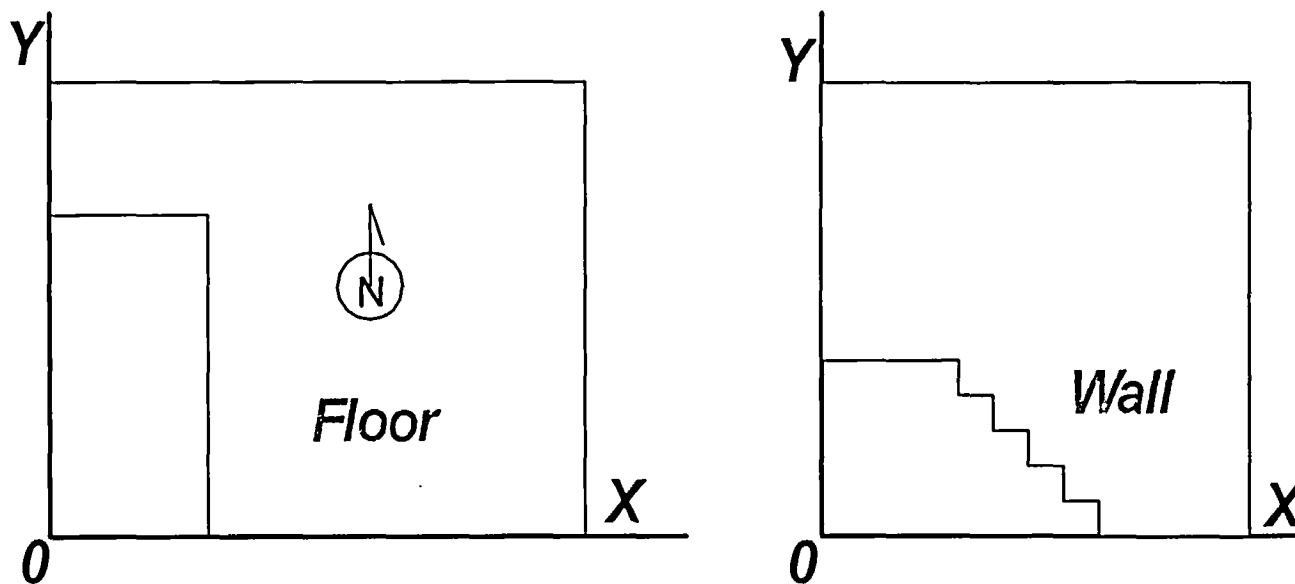
	<i>SurfaceCode</i>	<i>Xmax</i>	<i>Ymax</i>	<i>Area (sq.ft.)</i>	<i>Paint (Coats)</i>	<i>Description</i>
<hr/>						
<i>Room 113</i>						
	F	11.0	8.0	88	0.0	
	Q1				0.0	door/doorway
	Q2				0.0	Valve box in floor
<i>Summary for Room 113 (2 detail records)</i>					<b>88 Sq. Feet</b>	
<hr/>						
<i>Room 114</i>						
	F	4.0	8.0	32	0.0	
	Q1				0.0	door/doorway
	Q2				0.0	floor drains (1)
<i>Summary for Room 114 (3 detail records)</i>					<b>32 Sq. Feet</b>	
<hr/>						
<i>Room 115</i>						
	F	38.0	50.0	1,900	0.0	
	Q1				0.0	doors/doorways (3)
<i>Summary for Room 115 (2 detail records)</i>					<b>1,900 Sq. Feet</b>	
<hr/>						
<i>Room 116</i>						
	F	14.0	4.0	52	0.0	
<i>Summary for Room 116 (2 detail records)</i>					<b>52 Sq. Feet</b>	
<hr/>						
<i>Room 117</i>						
	F	27.0	47.0	405	0.0	
	Q1				0.0	doors/doorway
<i>Summary for Room 117 (2 detail records)</i>					<b>405 Sq. Feet</b>	
<hr/>						
<b>TOTAL for Survey Unit 2401</b>					<b>4,084 Sq. Feet</b>	

## **APPENDIX 2**

### **Figures**

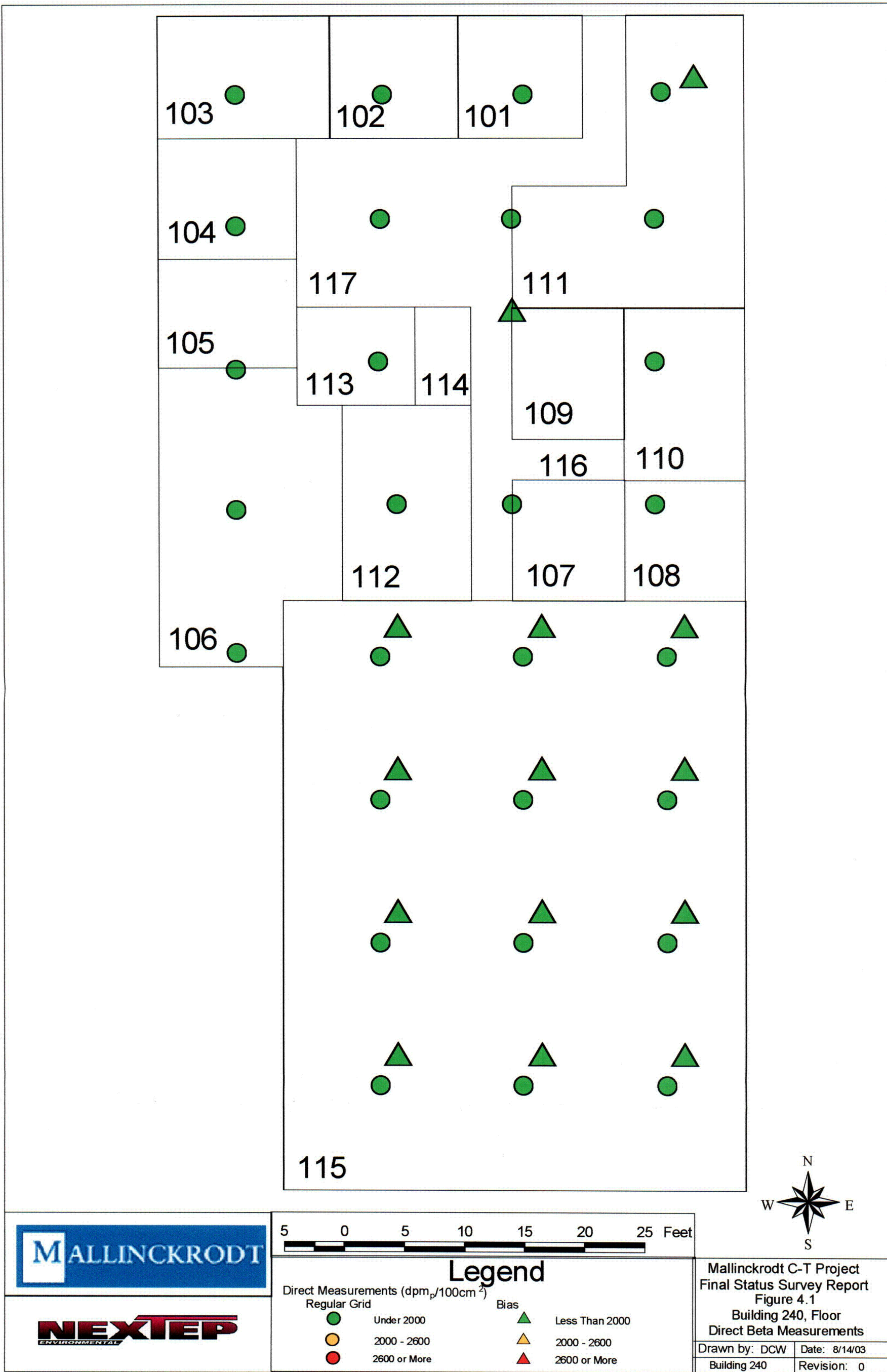


**Figure 2.1**  
***SU-2401 Floor Only***



Coordinate System

Figure 3.1



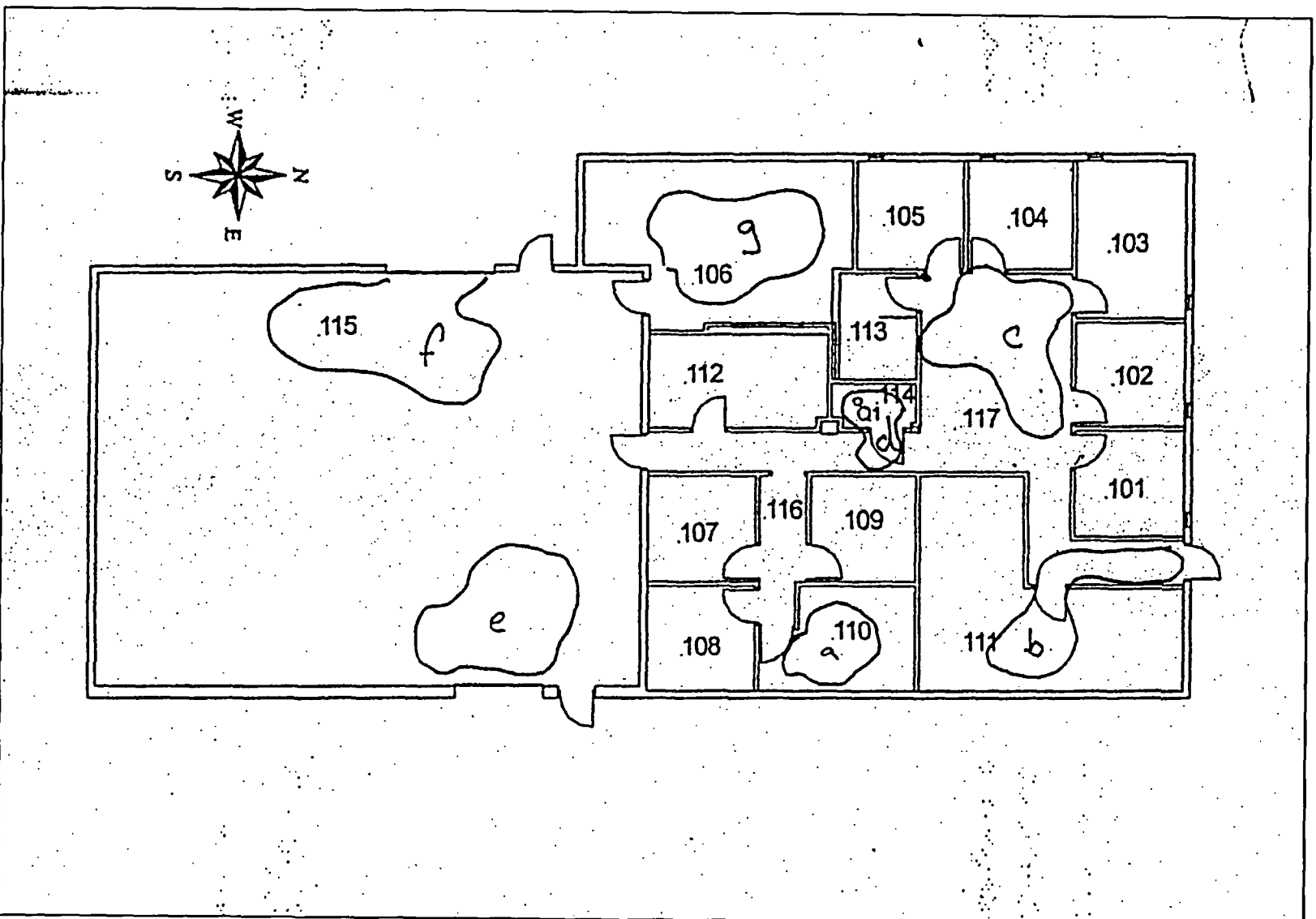


Figure 4.2  
Survey Unit 2401 Scans

## APPENDIX 3

### Calibration Sheets

Type	S/N	Cal Date
Beta	131415/188704	6/17/2003
	163666/B426W	1/16/2003
Swipe	179562	11/8/2002 7/22/2003
	179577	2/26/2003

Ludlum  
43-89  
AG-3-T  
CALIBRATION DATA SHEET

43-89  
AG-3-T SN: 188704

Property of: BIALT

Readout Inst.: 2241-2

SN: 131415

Cal. Exp. Date: 6-12-04

Beta  
Alpha Source: 44-514-90  
RHS

SN: 2158/96

Activity: 16700 DPM

Date of Cal.: 10-24-00

PLATEAU:

High Voltage	Source (CPM)	High Voltage	Source (CPM)	Background Check	
600	<u>N/A</u>	<del>1050</del> <u>850</u>	<u>1598</u>	High Voltage	CPM
650	<u>f</u>	<del>1100</del> <u>875</u>	<u>2165</u>	Op. Voltage <del>-25</del>	<u>131</u>
700	<u>f</u>	<del>1150</del> <u>900</u>	<u>2631</u>	Op. Voltage	<u>169</u>
750	<u>f</u>	<del>1200</del> <u>925</u>	<u>3251</u>	Op. Voltage <del>+25</del>	<u>239</u>
800	<u>1552</u>	<del>1250</del> <u>950</u>	<u>3698</u>		
850	<u>2771</u>	<del>1300</del> <u>975</u>	<u>4235</u>		
900	<u>3737</u>	1350	<u>—</u>		
950	<u>4542</u>	1400	<u>—</u>		
1000	<u>5755</u>	High Voltage set at: <u>900</u> <u>RHS</u> volts			
			<u>975</u>		

Efficiency:

5 Minute Gross Counts:

Pos "A": —  
Average (A + B)/2: —  
Background: CPM: —

Pos "B": —  
Gross CPM: —  
Net CPM: —

1 min Qt. 3213

1 min Bkg 185

3030 / 16700

$$\text{Efficiency} = \frac{\text{Net CPM}}{\text{DPM}} \times 100 = \underline{18.1} \%$$

18.1 %

Date of Calibration: 6-17-03

Expiration Date: 12-17-03

Calibrated by: Randall H. Sells

Randall H. Sells

Reviewed by: [Signature]

Date: 6/18/03

EA4.10

Rev: 2

Date: 25 Feb 99

Page 4 of 4

L224-2/L43-89  
S/N: 131415/188704  
6/17/03



CALN100A

**Thermo NUTECH**  
For Mallinckrodt Chemical, Inc

**NATIONAL NUCLEAR ABP-100  
MATERIAL SPECIFIC CALIBRATION DATA SHEET**

43-89

ABP-100 SN: 188704 HIGH VOLTAGE: 925 V PROPERTY OF: MALTREADOUT INST: 2241-Z SN: 131415 CAL EXPIRE DATE: 12-12-03ABP-100 EFFICIENCY TO SrY-90 ON 47 mm DISK: 18.1 % CAL DATE: 6-17-03

SURFACE MATERIAL	BACKGROUND		BR	SOURCE		SR	Source #	SA	Efficiency
	OPEN	SHIELD	NET	OPEN	SHIELD	NET		Source Activity	
	Cts/2 min	Cts/2 min	CPM	Cts/1 min	Cts/1 min	CPM			
Concrete	396	308	88	5005	181	4824	6-A	25900	18.3
↓	↓	↓	↓	4945	179	4766	↓	↓	18.1
↓	↓	↓	↓	4951	210	4741	↓	↓	18.0
↓	↓	↓	↓	5113	184	4929	↓	↓	18.4
259 x 100 = 25900									Average = 18.1
									Std Dev = 0.3

Wood	0	0	0	4007	226	3781	M-2	17400	21.5
↓	0	0	0	3876	216	3660	↓	↓	21.0
↓	0	0	0	3971	211	3760	↓	↓	21.3
↓	0	0	0	3887	240	3647	↓	↓	21.0
174 x 100 = 17400									Average = 21.3
									Std Dev = 0.4

Masonry	0	0	0	3964	249	3715	M-2	17400	21.4
↓	0	0	0	3889	191	3698	↓	↓	21.3
↓	0	0	0	3853	234	3619	↓	↓	20.5
↓	0	0	0	3946	198	3748	↓	↓	21.5
									Average = 21.2
									Std Dev = 0.5

Aluminum	0	0	0	4362	224	4138	M-2	17400	23.8
↓	0	0	0	4399	211	4186	↓	↓	24.1
↓	0	0	0	4358	257	4101	↓	↓	23.6
↓	0	0	0	4390	230	4160	↓	↓	23.0
									Average = 23.5
									Std Dev = 0.6

DATE OF CALIBRATION: 6-17-03EXPIRATION DATE: 12-17-03CALIBRATED BY: Randall H. SellsSignature: Randall H. SellsREVIEWED BY: Alan FreigleyDATE: 6/18/03

Contact Geometry

L224-2/L43-89

S/N: 131415/188704

6/17/03

# CT-RP-66 Chi Squared Test

Instrument Model #	2241	Date:	06/24/2003
Instrument Serial#	131415	Source Nuclide:	SrY80
Probe Model #	43-89	Source Serial #	2178-96 <i>OK</i>
Probe Serial #	188704	Source dpm (4x):	56039
Window Setting:		Efficiency (cpm/dpm):	0.19
Threshold Setting:		Background cpm:	135.2
High Voltage:	925	BKGD N-1	4
		BKGD Count Time (min):	1

Count # (n)	Gross Counts		Background Counts
	Observed	Expected	
1	10358	10449	121
2	10405	10449	130
3	10502	10449	122
4	10336	10449	148
5	10281	10449	155
6	10198	10449	
7	10620	10449	
8	10468	10449	
9	10454	10449	
10	10328	10449	
11	10525	10449	
12	10403	10449	
13	10382	10449	
14	10418	10449	
15	10471	10449	
16	10669	10449	
17	10552	10449	
18	10880	10449	
19	10392	10449	
20	10525	10449	

sample mean (xbar) =	10449	Multiplier to convert	
sample variance (s^2) =	15903	to dpm:	5.4
background variance (b^2) =	239.7		
sample sigma (s) =	127		
(95% Confidence) 2.752 s =	350		
(99% Confidence) 3.615 s =	459		

df = n-1 =	19	MDA(cpm) =	57
chitest = $p(x < \chi^2)$ =	6.727E-02	MDA(dpm) =	306
chisquare ( $\chi^2$ ) =	28.919		

Acceptable $\chi^2$ min =	8.907
Acceptable $\chi^2$ max =	32.852
$\chi^2$ test passes (yes/no)?	YES
99% Conf. Interval Test min =	9854
95% Conf. Interval Test min =	9964
Daily Source Check Mean Net Counts	10313
95% Conf. Interval Test max =	10663
99% Conf. Interval Test max =	10773

Test performed by: Steve Struck 

Checked by:

Date:

L224-2/L43-89  
S/N: 131415/188704  
6/17/03

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

LUDLUM 2221  
CALIBRATION DATA SHEET

Ludlum2221S/N: 163666 Property of ThermoRetec

Smart Solutions. Positive Outcomes.

Battery Check OK @ 5.6 V  
Replace @ 6.4

High Voltage Check

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

HV Meter: Fulke 29 S/N: 65410232 Cal Exp. Date: 1-30-03  
Meter Reading Pre Cal Post Cal Tolerance

600 Volts	<u>660</u>	<u>665</u>	10 %
1000 Volts	<u>1100</u>	<u>1085</u>	10 %
1400 Volts	<u>1540</u>	<u>1410</u>	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/ MP-2 2221 Display Display Tol

Meter			Digital	Analog	
400 CPM	<u>x1</u>		<u>400</u>	<u>400</u>	10%
4K CPM	<u>x10</u>		<u>3998</u>	<u>4000</u>	10%
40K CPM	<u>x100</u>		<u>39999</u>	<u>40000</u>	10%
400K CPM	<u>x1000</u>		<u>400080</u>	<u>400000</u>	10%

Scaler:

100K CPM	<u>0.5 sec</u>	<u>50010</u>	<u>100000</u>	10%
100K CPM	<u>1.0 min</u>	<u>100020</u>	<u>f</u>	10%
100K CPM	<u>2.0 min</u>	<u>200039</u>	<u>f</u>	10%
100K CPM	<u>5.0 min</u>	<u>500087</u>	<u>f</u>	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) Randall H. Sells (Signature)

Reviewed By: M. H. Sells Date: 1/30/03

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

**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: RHS  
 READOUT INST: Lud 2221 SN: 1636666 CAL EXPIRE DATE: 7-16-03  
 ABP-100 EFFICIENCY TO SrY-90 ON 47 mm DISK: 42.0 % CAL DATE: 1-22-03

SURFACE MATERIAL	BACKGROUND		BR	SOURCE		SR	Source #	SA	Efficiency
	OPEN	SHIELD	NET	OPEN	SHIELD	NET		Source Activity	
	Cts/2 min	Cts/2 min	CPM	Cts/1 min	Cts/1 min	CPM			SR-SP
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 = <del>335</del> 33250 dpm									Average = 19.9
									Std Dev = 0.1

Wood	0	0	0	5222	238	4984	M-2	22250	22.3
↓	0	0	0	5281	240	5041	↓	↓	22.3
↓	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

Wbsonite	0	0	0	5296	232	5064	M-2	22250	22.8
↓	0	0	0	5302	234	5068	↓	↓	22.8
↓	0	0	0	5311	248	5063	↓	↓	22.8
↓	0	0	0	5366	236	5130	↓	↓	22.8
178 dpm x 125 = 22250									Average = 22.8
									Std Dev = 0.2

Aluminum	0	0	0	6037	223	5814	M-2	22250	26.1
↓	0	0	0	5708	236	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: 1-29-03EXPIRATION DATE: 7-29-03

CALIBRATED BY:

Randall H. Sells  
Print NameRandall H. Sells  
Signature

REVIEWED BY:

MA  
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 (4x)	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		Background Counts
	Observed	Expected	
1	15380	15546	185
2	15381	15546	193
3	15477	15546	179
4	15662	15546	179
5	15520	15546	181
6	15587	15546	
7	15478	15546	
8	15392	15546	
9	15639	15546	
10	15609	15546	
11	15401	15546	
12	15433	15546	
13	15801	15546	
14	15743	15546	
15	15608	15546	
16	15828	15546	
17	16577	15546	
18	15518	15546	
19	15510	15546	
20	15509	15546	

sample mean (xbar) =	15546	Multiplier to convert	
sample variance (s^2) =	15181	to dpm:	3.6
background variance (b^2) =	34.8		
sample sigma (s) =	123		
(95% Confidence) 2.762 s =	339		
(99% Confidence) 3.615 s =	446		

MDA (cpm) =	66
MDA (dpm) =	240

df = n-1 =	19
chitest = $p(x < \chi^2)$ =	4.858E-01
chisquare ( $\chi^2$ ) =	18.654
Acceptable $\chi^2$ min =	8.907
Acceptable $\chi^2$ max =	32.852
$\chi^2$ test passes (yes/no)?	YES
99% Conf. Interval Test min =	14917
95% Conf. Interval Test min =	15023
Daily Source Check Mean Net Counts	15383
95% Conf. Interval Test max =	15702
99% Conf. Interval Test max =	15809

Test performed by: Steve Struck

Checked by:

*Jim C. Woodford*

Date:

*2/4/03*  
*2-4-03*

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



Scientific and Industrial  
Instruments

MALLINCKRODT

### CERTIFICATE OF CALIBRATION

#2114 P-009  
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. 285367 / 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. ☐ 10-20% ☐ Out of Tol. ☐ Requiring Repair ☐ Other-See comments  
☒ Mechanical ck. ☒ Window Operation  
☐ Auto 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. 1504 / 1500 V

(EEPROM Settings)  
Instrument in DPM mode. (PC) Count Time: 10  
GC mode turned OFF. Alpha Alarm: 50000 cpm  
Firmware version: 200110 Beta Alarm: 50000 cpm  
Overload set at 1/4 turn past OFF. Alpha/Beta Alarm: 50000 cpm  
Battery voltage measured at 11.40 Vdc. Calibration Due Date: 8 May 03  
C-14 Efficiency = 9 % (4 p) Net LOC (Loss of Count) time = 30 minutes (default)

	REFERENCE CAL POINT	INSTRUMENT RECEIVED	INSTRUMENT METER READING*
Alpha Channel Digital Readout	400K cpm	<u>399264</u>	<u>399264</u>
	40K cpm	<u>39927</u>	<u>39927</u>
	4K cpm	<u>3993</u>	<u>3993</u>
	400 cpm	<u>400</u>	<u>400</u>
	40 cpm	<u>40</u>	<u>40</u>
Beta/Gamma Channel Digital Readout	400K cpm	<u>399449</u>	<u>399449</u>
	40K cpm	<u>39950</u>	<u>39950</u>
	4K cpm	<u>3995</u>	<u>3995</u>
	400 cpm	<u>400</u>	<u>400</u>
	40 cpm	<u>40</u>	<u>40</u>

\*Uncertainty within  $\pm 10\%$  C.F. within  $\pm 20\%$  (Q) indicates 0.1 minute count

COMMENTS:  
Std. for Th-230 s/n 2748-00, 3070cpa, read 455 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/NCS Z39-1-1994 and ANSI N425-1-1994. State of Texas Calibration License No. LC-11903

Reference Instruments and/or Sources:  
☒ Alpha S/N 78-210 508-00 R-03 002-0 ☒ Beta S/N 70-99 41-01 ☐ Other \_\_\_\_\_  
☒ m 500 S/N 134709 ☐ Oscilloscope S/N \_\_\_\_\_ ☐ Multimeter S/N \_\_\_\_\_

Calibrated By: Barad J. Dink Date 8 Nov 02  
Reviewed By: Rhonda Harris Date 11 Nov 02

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

☒ AC Inst. ☐ Passed Dielectric (1-10<sup>6</sup> V) and Continuity Test  
Only ☐ Fail-safe

L3030  
S/N: 179562  
11/8/02

JUL 16 2003 16:53 314 654 1251  
 Ludlum Measurements, Inc.  
 Model 3030 Plateau Data

MALLINCKRODT

#2114 P.011

11/31/02  
 12:25:35 AM

Header 1: John O 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 (uCi): 0.011351351

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

HV	ALPHA				BETA			
	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%	5243 (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  
 S/N: 179562  
 11/8/02

JUL 16 2003 16:53:31 EST 1251

MALLINCKRODT

#2114 P.010

Radium Measurements, Ltd.

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	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
2C (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 % Alt 703.8 mm Hg

☐ New Instrument ☐ Instrument Received ☐ Within Toler.  $\pm 10\%$  ☐ 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. 501 / 500 V Ref./Inst. 1512 / 1500 V

(EEPROM Settings)

(PC) Count Time: 10

SC mode turned OFF.

Firmware version: 39213M10

Overload set at 1/4 turn past OFF.

Battery voltage measured at 11.36 Vdc.

6.9 Efficiency = 7.1 % (4 pf) Net

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)

Alpha Channel  
Digital Readout

REFERENCE CAL POINT

INSTRUMENT RECEIVED

INSTRUMENT METER READING\*

400K cpm

399901

399901

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  $\pm 10\%$  C.F. within  $\pm 20\%$

(\*) Indicates 0.1 minute count

## COMMENTS:

See Ser 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 520 S/N 134709 ☐ Oscilloscope S/N ☒ Multimeter S/N 57390613

Calibrated By: Conrad Padua

Date 22 Jul 03

Received By: WJ Rubin

Date 22 Jul 03

This certificate shall not be reproduced except in full, without the written approval of Ludlum Measurements, Inc.  
FORM C25-3 04/09/2003

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

L3030  
S/N: 179562  
7/22/03

Mallinckrodt C-T Project-Phase I  
Final Status Survey Report Building 240 Interior

Revision: 0  
December 2003  
APPENDIX 3

**Ludlum Measurements, Inc.**  
**Model 3030 Plateau Data**

7/22/03

8:48:42 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 (cpm): 25200  
 Alpha Source Size (µCi): 0.011351351

Beta Isotope: Tc-99  
 Beta Source Size (cpm): 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

Energy	ALPHA				BETA			
	Source (Beta)	Background	Eff	CrossTalk	Source (Alpha)	Background	Eff	Crosstalk
100	9397 (383)	0	37.3%	3.7%	4580 (2)	32	20.1%	0.0%
125	9455 (358)	1	37.5%	3.5%	5493 (3)	29	24.2%	0.0%
150	9483 (363)	0	37.6%	3.5%	6502 (3)	33	28.6%	0.0%
175	9566 (357)	1	38.0%	3.3%	7454 (3)	36	32.8%	0.0%
200	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

9:42:53 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
5.0	1.4	74.3
10.0	0.7	70.3
30.0	0.1	66.8
90 (1.0)	7.2	102.9

L3030  
S/N: 179562  
7/22/03



Scientific and Industrial  
Instruments

# CERTIFICATE OF CALIBRATION

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

CUSTOMER TYCO / MALLINCKRODT ORDER NO. 292439 / 270031  
Mfg. Ludlum Measurements, Inc. Model 3030 Serial No. 179577

Cal. Date 26-Feb-03 Cal Due Date 26-Aug-03 Cal. Interval 6 Months

Check mark ☒ applies to applicable instr. and/or detector IAW mfg. spec. T. 72 °F RH 20 % Alt 701.8 mm Hg

☐ New Instrument ☐ Instrument Received ☐ Within Toler.  $\pm 10\%$  ☐ 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 225 V High Voltage set with detector connected.

☒ HV Readout (2 points) Ref./Inst. 495 / 500 V Ref./Inst. 14.6 / 1500 V

(EEPROM Settings)

(PC) Count Time: 1.0

QC mode turned OFF.

Firmware version: 39012H12

Overload set at 1/4 turn past OFF.

Battery voltage measured at 12.22 Vdc.

Efficiency = 11 % (4 pt) Net

Alpha Alarm: 999999 cpm

Beta Alarm: 999999 cpm

Alpha/Beta Alarm: 999999 cpm

Calibration Due Date: 03/26/2003

LOC (Loss of Count) time = 30 minutes (default)

	REFERENCE CAL POINT	INSTRUMENT RECEIVED	INSTRUMENT METER READING*
Alpha Channel Digital Readout	400K cpm	<u>399414</u>	<u>399414</u>
	40K cpm	<u>39944</u>	<u>39944</u>
	4K cpm	<u>3995</u>	<u>3995</u>
	400 cpm	<u>400</u>	<u>400</u>
	40 cpm	<u>40</u>	<u>40</u>
Beta/Gamma Channel Digital Readout	400K cpm	<u>399439</u>	<u>399439</u>
	40K cpm	<u>39945</u>	<u>39945</u>
	4K cpm	<u>3995</u>	<u>3995</u>
	400 cpm	<u>400</u>	<u>400</u>
	40 cpm	<u>40</u>	<u>40</u>

\*Accuracy within  $\pm 10\%$  C.F. within  $\pm 20\%$

(\*) Indicates 0.1 minute count

## COMMENTS:

Est. for S-9142 2m 4016, 44506 gpm, read 297K in one minute = 69% 291  
Est. for T-130 2m 2745-00, 3070 gpm, read 2444 in one minute = 80% 291

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 technique. The calibration system conforms to the requirements of ANSI/NCSL Z540-1:1994 and ANSI N323-1978. State of Texas Calibration License No. 10-10A3

## Reference Instruments and/or Sources:

☒ Alpha S/N 20-239 3744 ☐ Beta S/N 7-99 11-11 ☐ Other \_\_\_\_\_  
☒ m ECD S/N 134709 ☐ Oscilloscope S/N \_\_\_\_\_ ☐ Multimeter S/N \_\_\_\_\_

Calibrated By: Conrad Galindo Date 26 Feb 03

Reviewed By: Rhonda Horn Date 4 March

This certificate shall not be reproduced except in full without the written approval of Ludlum Measurements, Inc.  
FORM 025-3 10/22/2002

AC Inst. ☒ Passed Dielectric (4-Pot) and Continuity Test  
Only ☐ Fail

L3030  
S/N: 179577  
2/26/03

001.10 2003 10.32 314 004 1231  
LUCIUM MEASUREMENTS, INC.  
Model 3030 Plateau Data

MALLINCKRODT

#2114 P.007

2/26/03  
1:38:50 PM

Header 1: John Q Public  
Header 2: Serial#179577  
Header 3: Site:Building 1  
Header 4: Room 7 EastWall  
Header 5: More Comments?  
Header 6: More Comments?

Calibration Due Date: 2/26/04

Model 3030 Date: 2/26/03  
Model 3030 Time: 11:42:00 AM

User PC Time: 1.0

Alpha Isotope: Pu-239  
Alpha Source Size (dpm): 365000  
Alpha Source Size ( $\mu$ Ci): 0.164414414

Beta Isotope: Tc-99  
Beta Source Size (dpm): 22600  
Beta Source Size ( $\mu$ Ci): 0.01018018

Starting High Voltage: 675  
Starting High Voltage: 800  
High Voltage Increment: 25

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

KV	ALPHA				BETA			
	Source (Beta)	Background	Eff	CrossTalk	Source (Alpha)	Background	Eff	Crosstalk
675	137685 (3889)	0	37.7%	2.8%	6010 (1)	36	26.4%	0.0%
700	137877 (3657)	0	37.8%	2.6%	6966 (1)	45	30.6%	0.0%
725	138583 (2500)	2	38.0%	1.8%	7969 (1)	49	35.0%	0.0%
750	137851 (1493)	0	37.8%	1.0%	8551 (3)	50	37.6%	0.0%
775	137047 (1071)	1	37.5%	0.7%	9470 (1)	70	41.6%	0.0%
800	137105 (783)	1	37.6%	0.4%	10082 (2)	203	43.7%	0.0%

L3030  
S/N: 179577  
2/26/03

DUPLICATE MEASUREMENTS, INC.

Model 3030 MDA Calculation Data

2/26/03

1:42:00 PM

Alpha Background(cpm): 2.0

Beta Background(cpm): 49.0

Alpha Efficiency %: 38.0

Beta Efficiency %: 35.0

Confidence Level: 95%

Count Time	Alpha MDA(dpm)	Beta MDA(dpm)
0.1	111.9	295.7
0.5	35.5	129.5
1.0	24.4	100.8
2.0	18.6	84.5
5.0	14.8	73.6
10.0	13.6	69.8
50.0	12.5	66.5
EC (1.0)	24.4	100.8

L3030  
S/N: 179577  
2/26/03

## **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: 2401      Class: 2      Data Points: Beta      Grid Type: R      Spacing: 11.9 ft.

### SURVEY UNIT TABLE

Bldg	Rm	Surface	Fixed Equipment	Surface Area Included (sq. ft)	Remarks
B240	101	F	Q1	81	
B240	102	F	Q1	81	
B240	103	F	Q1	126	
B240	104	F	Q1	81	
B240	105	F	Q1	81	
B240	106	F	Q1	296	
B240	107	F	Q1	90	
B240	108	F	Q1	90	
B240	109	F	Q1	81	
B240	110	F	Q1	126	
B240	111	F	Q1	330	
B240	112	F	Q1	144	
B240	113	F	Q1Q2	88	
B240	114	F	Q1Q2	32	
B240	115	F	Q1	1900	
B240	116	F	Q1	52	
B240	117	F	Q1	405	
Total Area				4084	

### 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 <sub>p</sub> /100 cm <sup>2</sup>
Min/Max	Pass	Maximum Survey Value VT 136.0
Background	Fail	Minimum Background VT -26.0
DCGLw	Pass	Difference 162.0
DCGLavg	Pass	Average Activity 16.9
EMC	Pass	Average Below DCGL 16.9
Wilcoxon Rank Sum Test	N/A	Average Background 30.9
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 # 2401

Building: B240

Room	SFC	X (ft)	Y (ft)	Mtx	Meas. Type	Min	SID	Gross Activity (dpm/100cm <sup>2</sup> )	Remarks	Exc	Res.
103	Q1	10.0	0.0	W	BI	1	5978	77.5		C	
108	Q1	26.0	0.0	W	BI	1	5994	78.8		C	
110	F	2.1	5.5	VT	RG	1	5950	135.7		C	
115	F	31.3	32.6	C	RG	1	7329	79.3		C	

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

Survey Unit # 2401

Building: B240

Room	SFC	X (ft)	Y (ft)	Mtx	Meas. Type	Min	SID	Gross Activity (dpm/100cm <sup>2</sup> )	Remarks	Exc	Res.
101	F	5.4	2.9	VT	RG	1	5941	-2.6			
101	Q1	6.0	0.0	W	BI	1	5974	11.6			
101	Q1	5.0	0.0	W	BI	1	5973	-3.9			
102	F	3.7	2.9	VT	RG	1	5940	-18.1			
102	Q1	8.0	0.0	W	BI	1	5976	60.7			
102	Q1	7.0	0.0	W	BI	1	5975	2.6			
103	F	6.2	2.9	VT	RG	1	5939	20.7			
103	Q1	9.0	0.0	W	BI	1	5977	-6.5			
104	F	6.2	1.9	VT	RG	1	5943	42.6			
104	Q1	12.0	0.0	W	BI	1	5980	20.7			
104	Q1	11.0	0.0	W	BI	1	5979	12.9			
105	Q1	14.0	0.0	W	BI	1	5982	5.2			
105	Q1	13.0	0.0	W	BI	1	5981	1.3			
106	F	6.2	12.8	VT	RG	1	5951	33.6			
106	F	6.2	24.6	VT	RG	1	5947	0.0			
106	F	6.2	0.8	VT	RG	1	5955	-16.8			
106	Q1	36.0	0.0	M	BI	1	6004	2.3			
106	Q1	35.0	0.0	M	BI	1	6003	-16.2			
107	F	0.2	7.4	VT	RG	1	5953	-14.2			
107	Q1	27.0	0.0	W	BI	1	5995	23.3			
107	Q1	28.0	0.0	W	BI	1	5996	15.5			
108	F	2.1	7.4	VT	RG	1	5954	42.6			
108	Q1	25.0	0.0	W	BI	1	5993	-3.9			
109	F	0.2	8.9	VT	BI	1	5949	42.6			
109	Q1	21.0	0.0	W	BI	1	5989	25.8			
110	Q1	23.0	0.0	W	BI	1	5991	-22.0			
110	Q1	24.0	0.0	W	BI	1	5992	-34.9			
111	F	12.1	6.7	VT	RG	1	5946	40.1			
111	F	12.8	17.3	VT	RG	1	7319	36.0			

# MALLINCKRODT C-T DECOMMISSIONING PROJECT

## Threshold Comparison Test Report - Buildings

Room	SFC	X (ft)	Y (ft)	Mtx	Meas. Type	Min	SID	Gross Activity (dpm/100cm <sup>2</sup> )	Remarks	Exc	Res.
111	F	15.4	18.7	VT	BI	1	5942	18.1			
111	F	0.2	6.7	VT	RG	1	5945	6.5			
111	Q1	4.0	0.0	M	BI	1	5972	13.9			
111	Q1	3.0	0.0	M	BI	1	5971	5.4			
112	F	4.5	7.4	VT	RG	1	5952	29.7			
112	Q1	19.0	0.0	W	BI	1	5987	9.0			
112	Q1	20.0	0.0	W	BI	1	5988	-10.3			
113	F	7.8	2.1	VT	RG	1	5948	6.5			
113	Q1	15.0	0.0	W	BI	1	5983	23.3			
113	Q1	16.0	0.0	W	BI	1	5984	0.0			
113	Q2	1.0	0.0	M	BI	1	5968	2.3	Valve Box		
114	Q1	17.0	0.0	W	BI	1	5985	31.0			
114	Q1	18.0	0.0	W	BI	1	5986	-7.8			
114	Q2	1.0	0.0	M	BI	1	6005	43.3	Drain		
115	F	32.6	11.3	C	BI	1	5967	69.6			
115	F	31.3	8.6	C	RG	1	7323	57.5			
115	F	20.7	11.3	C	BI	1	5966	43.4			
115	F	7.3	8.6	C	RG	1	7321	39.6			
115	F	7.3	32.6	C	RG	1	7327	39.6			
115	F	31.3	44.6	C	RG	1	7332	37.1			
115	F	32.6	35.3	C	BI	1	5961	34.3			
115	F	20.7	47.3	C	BI	1	5957	33.3			
115	F	19.2	44.6	C	RG	1	7331	28.1			
115	F	20.7	23.3	C	BI	1	5963	27.3			
115	F	8.7	11.3	C	BI	1	5965	19.2			
115	F	32.6	47.3	C	BI	1	5958	14.1			
115	F	32.6	23.3	C	BI	1	5964	13.1			
115	F	19.2	32.6	C	RG	1	7328	12.8			
115	F	19.2	20.6	C	RG	1	7325	9.0			
115	F	7.3	44.6	C	RG	1	7330	6.4			
115	F	8.7	47.3	C	BI	1	5956	3.0			
115	F	19.2	8.6	C	RG	1	7322	1.3			
115	F	7.3	20.6	C	RG	1	7324	-3.8			
115	F	8.7	23.3	C	BI	1	5962	-4.0			
115	F	31.3	20.6	C	RG	1	7326	-16.6			
115	F	20.7	35.3	C	BI	1	5960	-25.2			
115	F	8.7	35.3	C	BI	1	5959	-28.3			
115	Q1	32.0	0.0	M	BI	1	6000	15.5			
115	Q1	34.0	0.0	M	BI	1	6002	12.4			
115	Q1	29.0	0.0	M	BI	1	5997	9.3			
115	Q1	31.0	0.0	M	BI	1	5999	8.5			
115	Q1	30.0	0.0	M	BI	1	5998	6.2			
115	Q1	33.0	0.0	M	BI	1	6001	-3.9			
117	F	8.0	6.7	VT	RG	1	5944	29.7			
117	Q1	1.0	0.0	M	BI	1	5969	6.2	Entrance		
117	Q1	2.0	0.0	M	BI	1	5970	-0.8			

# 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

<i>Matrix</i>	<i>Number of Data Points</i>	<i>Average Background</i>	<i>Sigma</i>	<i>Background Threshold (Tbk)</i>	<i>DCGLw Threshold (Td)</i>	<i>EMC Threshold (Tc)</i>
		(dpm/100cm <sup>2</sup> )	(dpm/100cm <sup>2</sup> )	(dpm/100cm <sup>2</sup> )	(dpm/100cm <sup>2</sup> )	(dpm/100cm <sup>2</sup> )
C	90	35.4	20.1	75.5	2,675	13,075
M	10	24.0	15.7	55.3	2,655	13,055
VT	10	15.1	24.0	63.0	2,663	13,063
W	10	13.4	24.0	61.3	2,661	13,061

# MALLINCKRODT C-T DECOMMISSIONING PROJECT

## *Threshold Comparison Test Report - Buildings*

### STATISTICAL TEST RESULTS

Run Date: 12/3/2003 9:50:42 PM  
Survey Unit Number 2401 Class: 2  
Selected Test: SIGN TEST FOR PAIRED DATA  
Test Status Pass  
Thresholds:

EMC 13,000 DCGL 2,600

### DATA SUMMARY TABLE

28 Survey points processed and 2 matrices processed

S+ = 28 Wc = 18

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