National Aeronautics and Space Administration

George C. Marshall Space Flight Center
Marshall Space Flight Center, AL 35812

February 17, 2024

Reply to Attn of: AS01

TO: USNRC Region I
Division of Radiological Safety and Security
475 Allendale Road - Suite 102
King of Prussia, PA 19406

FROM: AS10/Farley Davis

SUBJECT: Amendment Addendum to NASA Marshall Space Flight Center (MSFC) NRC Material License (01-06571-10)

MSFC is requesting that NRC License (01-06571-10) be amended to free-release Building 4487, Rooms C178A/B and C178C for unrestricted release based on the 100% or final radiation survey results documented in attachment (1). The final survey demonstrated that all impacted areas surveyed resulted in radiation levels below the selected Derived Concentration Guideline Level, ensuring 10 CFR 20.1402 requirements were met for unrestricted use of the rooms.

Anthony Williams, RSO, is the point of contact for this matter should you require further information. He can be reached via phone at (757) 642-4471 or e-mail at anthony.s.williams@nasa.gov.

ELBERT DAVIS Digitally signed by ELBERT DAVIS
Date: 2024.02.17 10:09:23 -06'00'

Mr. Farley Davis
Manager, Environmental Engineering and
Occupational Health Office

Enclosures: Attachment 1

cc:
AS10/D. Thaxton
ST12/J. Kolodziejczak
AS10/A. Williams

1.0 History/Purpose/Project Scope

The goal of this technical memorandum is to provide sufficient survey data to meet 10 CFR 20.1402 requirements that permit the release of Building 4487, Rooms C178A/B and C178C located at Marshal Space Flight Center (MSFC) from MSFC Nuclear Regulatory Commission (NRC) Material License (01-06571-10) for unrestricted use.

Building 4487 is physically located on the MSFC Campus, which is located on Redstone Arsenal, AL. In February 2011, the MSFC NRC Material License Amendment No. 48 was approved for use and storage of up to 40 Ci of Kr-85 in Room C178C. Rooms C178C and C178A/B hosted a Radiflo leak detection system containing Krypton-85 (Kr-85) and a gamma scintillation counting station, respectively. The Radioflo leak detection system was first filled with 20 Ci Kr-85 in November 2011 and another 10 Ci in November 2013. Two exempt Kr-85 sealed sources (5μCi each) were used to calibrate counting station equipment. Operations began in May 2012 and ceased in March 2020 according to the Kr-85 Radioflo operational logbook.

Kr-85 gas was mixed with air in the leak detection system located in C178C and used to pressurize electronic devices to evaluate their hermeticity. After each pressurization cycle the Kr-85 mixture was returned to the Radiflo storage tank. The Kr-85 pressurization system was a fully contained gas handling system, with the Kr-85 gas either contained in a lead shielded storage tank, or in the lead pressurization tank. Operators placed electronic devices in the pressurization tank. The machine evacuated the air, transferred in Kr-85/air mixture, allowed parts to “Soak” for a preset time to permit Kr-85 to leak into a defectively sealed device. Once the Kr-85 returned to the storage tank, the machine vented air into the tank and released the interlocks to allow the operator to remove the devices from the tank.

The equipment was fully interlocked to prevent the tank containing the parts to be opened if it contained Kr-85. The operator took the devices to the counting station located in C178A/B and measured each device for detection of gamma radiation. Devices that contained Kr-85 were returned to the Radiflo room and were normally placed in the Radiflo tank and evacuated out through the Radiflo exhaust. The rejects were then confirmed as ‘decontaminated’ via the gamma scintillation counter and scrapped.

The remaining Kr-85, two Kr-85 sealed sources and all equipment associated with the leak detection system, including the ceiling duct attachment, and counting station equipment including the table were removed from C178 A/B and C178C by a radiation safety representative from IsoVac Engineering, Inc., the manufacturer, and shipped to the manufacturer. The representative packaged and shipped the Kr-85 and leak detection equipment according to NRC and DOT regulations. Room surveys and swipes were conducted by the radiation safety representative within the areas that contained the Radiflo leak detection system including the leak test machine,

exhaust duct (to ceiling connection), and counting station. The area surveys, at 1 m and floor level, and swipes were at background radiation levels. The results can be seen in **Appendix A**.

There is no documented evidence of any previous release of Kr-85 into or contamination events within Rooms C178A/B and C178C based on records and an interview with the Radiation Safety Officer that was employed with MSFC during the entire time the leak detection system was operational. There would be no expected adjacent activated materials with the use of Kr-85.

Due to the nature of Kr-85 as an inert gas, no evidence of any previous contamination events or room releases, and the survey and swipe results of the manufacturer upon dismantling and transport of the equipment and Kr-85, there is no expectation of any residual activity in the defined radioactive material work area (RMWA) as noted in **Appendix B**. The 100% or final survey results of the RMWA noted later within this document confirmed that assumption.

The purpose of the 100% survey of the RMWAs that contained the leak detection equipment, including the counting station and ceiling vent, that sufficiently meet NRC release criteria to obtain the NRC's approval to release Rooms C178A/B and C178C from MSFC NRC Material License (01-06571-10) for unrestricted release. The NRC indicated that a simplified survey as describe in NUREG-1757 Vol 2, Appendix B would be sufficient to remove the rooms from the license. NUREG 1507, Vol 1 and NUREG 1757, Vol 2 were used to determine the appropriate radiation detection instruments and appropriate surveys (e.g., scanning and static), respectively. Surveys were performed under AS10-OI-028, Ionizing Radiation Surveys and MPR 1860.1, MSFC Radiation Safety Procedural Requirements.

2.0 Instrumentation

A Ludlum 2360 with 43-93 detector and Ludlum 3003 with 43-147 detector were used to perform scanning surveys of the defined RMWA, and if required, to perform static surveys. The instruments and associated detectors were calibrated with National Institute of Standards and Technology (NIST) traceable standards and to radiation emission types and energies that will provide detection capabilities like the radionuclide(s) of concern. This ensured the instruments selected have the highest levels of accuracy for detecting the radioactive contamination of concern, Kr-85. **Table 2-1** shows the calibrated efficiencies and other important information pertinent to the instruments used in this survey. The calibration certificates for Ludlum instruments and detectors used are included in **Appendix C**.

2.1: Instrument and calibration

Instrument	Serial number	Cal Date	SrY-90 NIST ID	Sr-90 Efficiency
L3002/43-93	25020406/PR389073	11/1/24	4052-02	0.3598
L3003/43-147	25035226/PR423792	1/29/25	443-69-3	0.4094

3.0 MDCs / Release Criteria

There is no site-specific, non-parametric Derived Concentration Guideline Level ($DCGL_W$) for total and removable radiation stated by the NRC for Kr-85. Therefore, the $DCGL_W$ for total contamination (fixed and removable) and removable contamination selected is 5,000 dpm/100 cm^2 and 1,000 dpm/100 cm^2, respectively, based on meeting surface contamination criteria noted in MPR 1860.1 MSFC Radiation Safety Procedural Requirements. This also ensures that 10 CFR 20.1402 requirements are met.

Instrumentation compliant with this release criteria for scanning and static surveys, if static surveys are required, was selected to ensure appropriate sensitivity to determine if the survey area is in exceedance or below the $DCGL_W$s.

It is generally considered good practice to select a measurement system with a capability to detect the radiation(s) of concern to a minimum detectable concentration (MDC) between 10-50% of the $DCGL_w$. In this case, 10-50% of the DCGLw is 500-2,500 dpm/100 cm^2. There is no equipment or material release criteria necessary for this survey since the equipment associated with the leak detection system was removed and transported back to the manufacturer by a manufacturer's representative. The manufacturer's report that includes the equipment and Kr-85 transported back with radiation survey results of the area that contained the detection system are included in **Appendix A**.

As shown in **Tables 3-1 and 3-2**, the scanning and static MDCs for beta radiation using 10-minute and 1-minute count times for each day the surveys were conducted provides an acceptable value below the 5,000 dpm/100 cm^2 chosen for this survey.

Table 3-1: Scan and Static MDCs for L3002/L43-93 (SN# 25020406/PR389073) for Beta Radiation

Date	Location	Background (CPM)	Scan MDC (dpm/100cm^2)	Static MDC (dpm/100cm^2)
		10 min.		1 min.
11/21/2023	Floor	186	1,245	358
11/21/2023	Wall	150	1,118	323
11/21/2023	Countertop	N/A	N/A	N/A
11/22/2023	Floor	174	1,204	347
11/22/2023	Wall	153	1,129	326
11/22/2023	Countertop	196	1,178	363
11/27/2023	Floor	187	1,248	358
11/27/2023	Wall	145	1,099	316
11/27/2023	Countertop	192	1,265	363
11/28/2023	Floor	178	1,207	350
11/28/2023	Wall	153	1,129	326
11/28/2023	Countertop	184	1,238	356

Table 3-2: MDCs for L3003/43-147 SN(s): 25035226/PR423793 for Beta Radiation

Date	Location	Background (CPM)	Scan MDC (dpm/100cm^2)	MDC (dpm/100cm^2)
2/8/2024	Stainless Steel Tabletop	481	883	Not conducted

4.0 Survey Setups

Prior to conducting the room surveys, performance checks including Chi-square tests and daily source checks were conducted to ensure the instruments were performing to proper standards. Also, multiple non-impacted background areas were selected to determine the 10-minute background count and average 1-minute background count for each area. The average background count was based on five 1-minute counts. This was performed to establish a reference for non-impacted materials and to account for differences in radiological measurements that may result from the various media that would be encountered for scanning and static surveys. The background areas were chosen to be representative of areas intended to be surveyed in Rooms C178A/B and C178C. Daily background measurements of flooring, walls, and countertops were taken to determine the static MDC for that given surface.

For areas surveyed such as metal faucet handles, drawer handles, cabinet handles, cabinets, and ventilation ducts, a representative background in a non-impacted area was not performed. Instead, conservatively, the lowest background measurement obtained, the wall, was used for the scan and static MDCs for each of these areas. **Table 4-1** shows average background counts of various reference materials for static surveys.

Table 4-1: Average Daily Background Counts for Static Scans for Beta Radiation using the L3002/43-93 instrument

Date	Location	Background (CPM) 1 min.
11/21/2023	Floor	182
11/21/2023	Wall	145
11/21/2023	Countertop	Not conducted
11/22/2023	Floor	185
11/22/2023	Wall	152
11/22/2023	Countertop	171
11/27/2023	Floor	180
11/27/2023	Wall	146
11/27/2023	Countertop	193
11/28/2023	Floor	180
11/28/2023	Wall	154
11/28/2023	Countertop	173

The 100% scan or final survey was conducted over multiple days and would encompass Rooms C178A/B and C178C The surveys were conducted by holding the probe 0.25 inches above the surface and scanning in the direction parallel to the handle.

Surveys were performed in the RMWA that encompassed leak detection activities performed by personnel. For Room C178C, the survey area included the flooring area where the detection system was installed or located and the walking path from the detection system to the entry way to Room C178A/B, which contained the gamma counting station. The survey area in Room C178C also included a hood with a sink and cabinets, a stainless-steel table, up to six-feet high on one wall adjacent to the Radiflo leak detection system, herein referred to as the South Wall in C178C, and a ceiling duct that was connected to the detection system for Kr-85 venting. The width of the wall measured was 10 ft. See **Appendix B** for the defined RMWA in Room C178C.

For Room C178A/B, the survey area included the walking pathway from C178C to the gamma counting station and the flooring area that once contained the counting station. The survey area also included up to six-feet high on one wall adjacent to the counting station, herein referred to as the North wall in C178A/B. The width of the wall that was measure was 8 ft. See **Appendix B** for the defined RMWA in Room C178A/B.

As a conservative measure, there were two non-impacted areas outside the RMWA that were scanned. The areas included a counter with sink and cabinets next to the leak detection system in C178C and a counter with cabinets next to the hood in C178C. These areas were chosen because, although they likely did not work in those areas based on interviews, they were

next to the defined RMWA so it would be possible that operators may have briefly worked in those areas. See **Appendix B** for the location of these areas.

A scan of all surface areas within the RMWA were conducted with an alpha-beta scintillation detector scanning at a rate of two inches per second. If beta counts roughly twice background were indicated, the surveyor stopped and waited for at least 20 seconds at that location before continuing. During this pause, the surveyor would track the counts per minute to determine whether it would remain above radiation level would remain above background. In each instance, the level returned to background levels. Thus, over the entire scan of the RMWA, no unbiased static and swipes were required.

Areas surveyed were marked as complete to ensure the entire RMWA was scanned.

5.0 Results

Measurements resulting from the 100% scan survey are documented in **Table 5-1**. The scans conducted for the 100% or final survey of the RMWA resulted in background radiation levels.

Table 5-1: Maximum Beta Scan Survey Readings

RMWA	Non-impacted Areas[1]
Survey	Survey
Bkg.	Bkg.

[1] Adjacent counter with cabinets to the hood and counter with sink and cabinets to the leak detection equipment in C178C

6.0 Conclusions

All scanning measurements taken were at background radiation levels and well below the selected $DCGL_W$s selected for room release. The data suggests that there is no residual contamination from any previous activities with Kr-85 use in the RMWA, and the surfaces in both the RMWA and nearby non-impacted areas (previously defined) demonstrate compliance with the release criterion found in 10 CFR 20.1402. which states the radiological criteria for unrestricted use. A site is acceptable for unrestricted use if the residual radioactivity that is distinguishable from background radiation results in a TEDE that does not exceed 25 mrem per year and the residual radioactivity is at levels that are as low as reasonably achievable (ALARA). Therefore, because all the measurements are at background radiations levels; thus, below the $DCGL_W$, it is requested that that Building 4487, Rooms C178A/B and C178C be released from any radiological restrictions or regulatory oversight for unrestricted use.

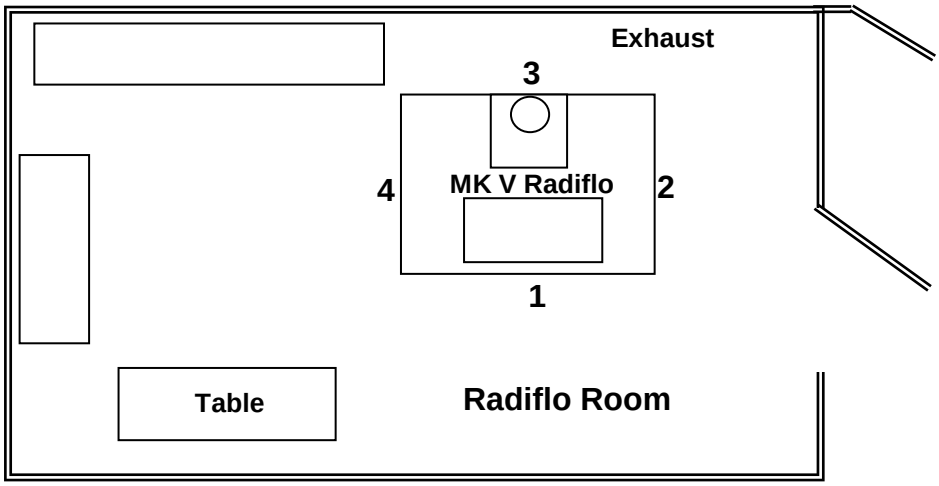
Appendix A

Survey Form Maximum Readings

■ Befor ■ After

☐ Machine was Moved ■ Machine was Vented ☐ Machine was Installed

Location	Max. Reading mr/hr	
	Before	After
1	0.1	0.01
2	0.4	0.01
3	1.6	0.03
4	1.4	0.02
5	0.02	0.01

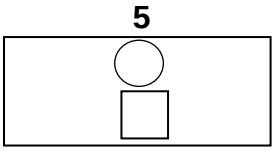


Location
Company: *NASA MSFC*
Address: *4487 MSFC*
City: *Huntsville*
State: AL 35812

Survey Instrument

Mfgr. *Ludlum*
Model: *2401-EW*
Serial No. *212376*
Cal. Due Date: 09/01/2023
By: George Bonilla Date: 08 /08, 09 / 2023

Counting Stations Area



Notes:

Gas mixture (air/ Kr85) was transferred to two Type 7A shipping containers.
The Radiflo was left under vacuum and removed from the room, as well as any
other contaminated material for final disposal.
After removing all contaminated materials, a final room survey was performed,
in all areas of the room, followed by a wipe test. The readings were 0.01 mR/hr.
Besides the room survey, a wipe test was taken in all areas previously occupied
by the Radiflo and associated equipment. The cotton swabs read background.

RADIATION SURVEY FORM

Company: ***NASA MSFC***	**Date: 08/10/2023**
Address: ***4487 George C. Marshall Space Flight Center***	
City: ***Huntsville***	**State:** ***AL 35812***
Byproduct Materials License Number: ***01-06571-10***	**Expiration Date:** ***July 7, 2026***
Radiation Safety Officer: Philip O. Brown, MSFC RSO : Tony Williams	

Survey Instrument: ***Ludlum***	**Cal. Due Date:** ***9/1/2023***
Model: ***2401-EW***	**Serial Number:** ***212376***

Areas Surveyed:

■ Before ■ After ☐ Machine was Serviced
☐ Machine was Moved ■ Machine was Vented ☐ Machine was Installed

Location	***Before***	***After***	
1. Area Radiflo Room			
Maximum Reading:	**0.1**	***0.01***	**mr/hr**
2. Area Radiflo Machine			
Maximum Reading:	**0.4**	***0.01***	**mr/hr**
3. Area Exhaust & Blower			
Maximum Reading:	**1.3**	***0.02***	**mr/hr**
4. Area Adjacent Areas			
Maximum Reading:	**1.4**	***0.02***	**mr/hr**
5. Area Counting Stations Area			
Maximum Reading:	**0.02**	***0.01***	**mr/hr**

Remarks: Gas mixture was transfered to two 55-gallon drums Type 7A shipping container. Radiflo S/N 2727 left under vacuum. Radiflo and contaminated materials were removed for disposal.

SURVEY PERFORMED BY: George Bonilla, RSO

COMPANY: ***IsoVac Engineering Inc***

DATE: August 8th and 9th, 2023

IsoVac Engineering Inc.
WIPE TEST FORM

FROM: George Bonilla, Radiation Safety Officer
IsoVac Engineering Inc.

TO: Tony Williams, NASA MSFC.

SAMPLE	DESCRIPTION OF WIPE	ISOTOPE (S)	WIPE TYPE*
1.	Cotton swab. No net readings.	**Front fl.**	**Other**
2.	Cotton swab. No net readings.	**Right fl.**	**Other**
3.	Cotton swab. No net readings.	**Back fl.**	**Other**
4.	Cotton swab. No net readings.	**Left fl.**	**Other**
5.	Cotton swab. No net readings.	**Counting**	**Other**
6.	Cotton swab. No net readings.	**Exhaust**	**Other**
7.	Cotton swab. No net readings.	Exh. Duct	**Other**
8.	Cotton swab. No net readings.	**Counter**	**Other**
9.	Cotton swab. No net readings.	**Red dye**	**Other**
10.	Cotton swab. No net readings.	**Oil cans**	**Other**

*** TYPE OF WIPE (INSERT LETTER ABOVE):**
(Q) QUARTERLY SURVEY **(T)** TRANSPORTATION
(I) INCIDENT **(C)** COMMODITY
(K) KRAFT PAPER **(O)** OTHER (PLEASE SPECIFY IN COMMENTS)

WIPE TAKEN BY:	George Bonilla, RSO	**DATE:**	August 9, 2023
PHONE:	(818)552-6200		

COMMENTS:
One time wipe tests to insure no contaminated areas are present in the Radiflo room. Removal and disposal.

EMAIL ADDRESS : radifloservice@isovac.com

NOTE: THE WIPE TESTS SHOWED
NO READINGS ABOVE BACKGROUND.

Occupational Services, Inc.

Certificate of Calibration

ISO 17025 Accredited
ANAB ACCREDITED CALIBRATION AND TESTING LABORATORY
CERT # ACT-1764

OCCUPATIONAL SERVICES, INC., RADIOACTIVE MATERIALS LICENSE NUMBER: 5149-37

Manufacturer: Ludlum Model: 2401-EW Contact Name: Bari Edwards Contact Email: bedwards@isovac.com

Customer: Iso Vac Engineering, Inc.

Calibration Site: 6397 Nancy Ridge Drive, San Diego, CA 92121

Department: N/A Serial: 212376 ID#: 1413

Batteries: Checked Detector Voltage: 549V Report Number: 220901212376

Environmental Conditions: Temperature: 20.9 C Pressure: 29.69 in Hg Humidity: 57 %

Calibrated with a Cs-137 calibration source, serial number SR-477 and SOP-CAL-09. These measurements results are traceable to the International System of Units (SI) through the National Institute of Standards and Traceability (NIST), or other national metrology institutes. The measurement of uncertainty of the calibration is +/-5%, at the 95% confidence level. The standard measurement tolerance is +/- 20% relative to the reference standard. OSI performs radiation detection instrument calibrations according with ISO 17025-2017, ANSI/NCIS Z540-1-1994 and ANSI N323AB-2013.

Calibration Frequency: ☑ Annually ☐ Semi Annually ☐ Quarterly

RANGE	REFERENCE VALUE	AS FOUND VALUES	ACCEPTED or ADJUSTED VALUE	DIFFERENCE	% ERROR
mR/hr	mR/hr	mR/hr	mR/hr	mR/hr	
200	160	150	150	-10	-6.3
200	40	40	40	0	0
20	16	16	16	0	0
20	4	4	4	0	0
2	1.6	1.6	1.6	0	0
2	0.4	0.4	0.4	0	0

Notes: None

Background: 0.01 mR/hr

Detector Type: End Window G-M Detector

Background Reading: 50 cpm Check Source Reading: N/A

Detector Efficiency: Cs-137

$\frac{10000 - 50 \text{ cpm}}{158591 \text{ dpm}} = 6.27\ \%$

Detector Type: N/A

Background Reading: cpm Check Source Reading:

Detector Efficiency: $\frac{\text{cpm}}{\text{dpm}} = \%$

Source to detector surface distance is ≤ 1 cm.

Condition Received: ☐ In Tolerance ☑ Out of Tolerance

Condition Left: ☑ In Tolerance ☐ Out of Tolerance

Detector Exposure Orientation: ☐ N/A ☐ Parallel ☑ Perpendicular

Calibrated By: Marius Barron Date of Calibration: 9/1/2022

Q.A. Review: Marius Barron Next Due Date: 9/1/2023

Issue Date: 9.1.22

Occupational Services, Inc. - 6397 Nancy Ridge Drive - San Diego, CA 92121
Tel 858-558-6736 - fax 858-558-6756 - www.occserv.com

IsoVac Engineering Inc.

Radiflo® Service Form

Work Order Number

9962

Contract: LM05229 / Net 30	Service Date(s): **August 8-10, 2023**
Customer: **L & M Technologies, Inc.**	Service address: **NASA / MSFC**
4631 Saturn Road	ES43
Huntsville, AL 35812	Huntsville, AL 35812
ATTN: Invoice@LMTechnologies.com	**ATTN: Daniel Powers , Tony Williams**

PARTS USED

Qty.	P/N	Description	Unit Price	Total Price
		ALL RADIATION SURVEYS TAKEN WITH ISOVAC'S PORTABLE SURVEY METER (SEE CAL. CERTIFICATE)		

Machines Serviced: MK V ☑ MK VI ☐ S/N 2727 **S/N**_____ **S/N**_____ **S/N**_____ **S/N**_____

Counting Stations: S/N 2778 **S/N**_____ **S/N**_____ **S/N**_____

Service Summary & Remarks: Decommission * Upon ARRIVALS I FOUND THE BLOWER WAS OFF AND WATER CONDESATION IN ALL SURFACES IN THE RADIFLO. * PROCEEDED TO DRY ELECTRONIC BOARDS AND SWITCHES. SOME FUNCTIONS WERE NOT AVAILABLE. TURNED BLOWER ON. RAD. SURVEY. * Storage pressure WAS 96 PSIG. TOGGLE SWITCHES WORKED FINE. * TRANFERED GAS MIXTURE INTO TWO TYPE 7A CONTAINERS AND SHIPPED THEM VIA FEDEX EXPRESS. SEE DRUMS' SURVEY. * PREPARED RADIFLO, COUTING STATION AND ALL CONTAMINATED PARTS TO BE SHIPPED TO ISOVAC. SEE RAD. SURVEY AFTER TRANSFER. * AFTER REMOVING ALL EQUIPMENT FROM THE CONTROLLED AREA I CONDUCTED A FINAL SURVEY AND WIPE TEST.

~~**Recommended Parts:**~~ * FINAL SURVEY AND WIPE TEST SHOWED NO READINGS ABOVE BACKGROUND : 0.01 TO 0.02 mR/hr. * READINGS ON THE CRATE AND PALLET AT BACKGROUND LEVEL. * RADIFLO CRATE WAS LABELED WITH A UN 2910 EXCEPTED LABEL.

~~**Next Service Scheduled:**~~ * CAL. CERT, RAD. SURVEYS, SERVICE FORM GIVEN TO DANIEL POWERS & TONY WILLIAMS.

Service Performed By: GBonilla

Print Name: George Bonilla

Date: 10 AUGUST 2023

Approved by: [signature]

Print Name: Daniel Powers

Date: 10 August 2023

 Isol'ac Engineering, Inc. 614 Justin Ave.. Glendale. CA 91201 (818) 552 - 6200 Sales@isovac.com FAX: (818) 241 - 0781

Occupational Services, Inc.

ISO 17025 Accredited

ANAB ACCREDITED CALIBRATION AND TESTING LABORATORY

CERT # ACT-1764

Certificate of Calibration

OCCUPATIONAL SERVICES, INC., RADIOACTIVE MATERIALS LICENSE NUMBER: 5149-37

Manufacturer: Ludlum Model: 2401-EW Contact Name: Bari Edwards Contact Email: bedwards@isovac.com

Customer: Iso Vac Engineering, Inc.

Calibration Site: 6397 Nancy Ridge Drive, San Diego, CA 92121

Department: N/A Serial: 212376 ID#: 1413

Batteries: Checked Detector Voltage: 549V Report Number: 220901212376

Environmental Conditions: Temperature: 20.9 C Pressure: 29.69 in Hg Humidity: 57 %

Calibrated with a Cs-137 calibration source, serial number SR-477 and SOP-CAL-09. These measurements results are traceable to the International System of Units (SI) through the National Institute of Standards and Traceability (NIST), or other national metrology institutes. The measurement of uncertainty of the calibration is +/-5%, at the 95% confidence level. The standard measurement tolerance is +/- 20% relative to the reference standard. OSI performs radiation detection instrument calibrations according with ISO 17025-2017, ANSI/NCIS Z540-1-1994 and ANSI N323AB-2013.

Calibration Frequency: ☑ Annually ☐ Semi Annually ☐ Quarterly

RANGE	REFERENCE VALUE	AS FOUND VALUES	ACCEPTED or ADJUSTED VALUE	DIFFERENCE	% ERROR
mR/hr	mR/hr	mR/hr	mR/hr	mR/hr	
200	160	150	150	-10	-6.3
200	40	40	40	0	0
20	16	16	16	0	0
20	4	4	4	0	0
2	1.6	1.6	1.6	0	0
2	0.4	0.4	0.4	0	0

Notes: None

Background: 0.01 mR/hr

Detector Type: End Window G-M Detector

Background Reading: 50 cpm Check Source Reading: N/A

Detector Efficiency: Cs-137

$\frac{10000 - 50 \text{ cpm}}{158591 \text{ dpm}} = 6.27\ \%$

Detector Type: N/A

Background Reading: cpm Check Source Reading:

Detector Efficiency: $\frac{\text{cpm}}{\text{dpm}} = \%$

Source to detector surface distance is ≤ 1 cm.

Condition Received: ☐ In Tolerance ☑ Out of Tolerance

Condition Left: ☑ In Tolerance ☐ Out of Tolerance

Detector Exposure Orientation: ☐ N/A ☐ Parallel ☑ Perpendicular

Calibrated By: Marius Barron Date of Calibration: 9/1/2022

Q.A. Review: Marius Barron Next Due Date: 9/1/2023

Issue Date: 9·1·22

Occupational Services, Inc. - 6397 Nancy Ridge Drive - San Diego, CA 92121
Tel 858-558-6736 - fax 858-558-6756 - www.occserv.com

IsoVac Engineering Inc.

Kr-85 Type 7A Cylinder Readings

Measured By: *George Bonilla, RSO* Date: *08/08/2023*

Cylinder S/N: *044* Volume (cc): *2200*

Specific Activity (mCi/atmcc): *TBD* Pressure (PSIA): *160 PSIA*

Fill Date: *08-Aug-2023* Curies Amount Transfered (Ci) : *6.5 Ci +/- 20%*

Source No.: *NASA MSFC* Catalog No.: *GS-85*

Survey Meter Information

Make: *Ludlum* Model: *2401-EW* S/N: *212376*

Calibration Date: *9/1/2022* Calibration Due Date: *9/1/2023*

Batery Check: OK ☑

Surface Readings Before Transfer

0.01 mr/Hr

0.01 mr/Hr  ***0.01*** mr/Hr

0.01 mr/Hr

Surface Readings After Transfer from Radiflo S/N: 2727

9.5 mr/Hr

9.0 mr/Hr  ***9.5*** mr/Hr

10.0 mr/Hr

TI (Transport Index): 1.0

Notes: FEDEX tracking 651693557368, 55 gallon drum.

IsoVac Engineering Inc.

Kr-85 Type 7A Cylinder Readings

Measured By: *George Bonilla, RSO* Date: *08/08/2023*

Cylinder S/N: 048 Volume (cc): *2200*

Specific Activity (mCi/atmcc): *TBD* Pressure (PSIA): *155 PSIA*

Fill Date: *08-Aug-2023* Curies Amount Transfered (Ci) : *6.5 Ci +/- 20%*

Source No.: *NASA MSFC* Catalog No.: *GS-85*

Survey Meter Information

Make: *Ludlum* Model: *2401-EW* S/N: *212376*

Calibration Date: *9/1/2022* Calibration Due Date: *9/1/2023*

Batery Check: OK ☑

Surface Readings Before Transfer

0.01 mr/Hr

0.01 mr/Hr  ***0.01*** mr/Hr

0.01 mr/Hr

Surface Readings After Transfer from Radiflo S/N: 2727

9.0 mr/Hr

9.0 mr/Hr  ***9.5*** mr/Hr

9.5 mr/Hr

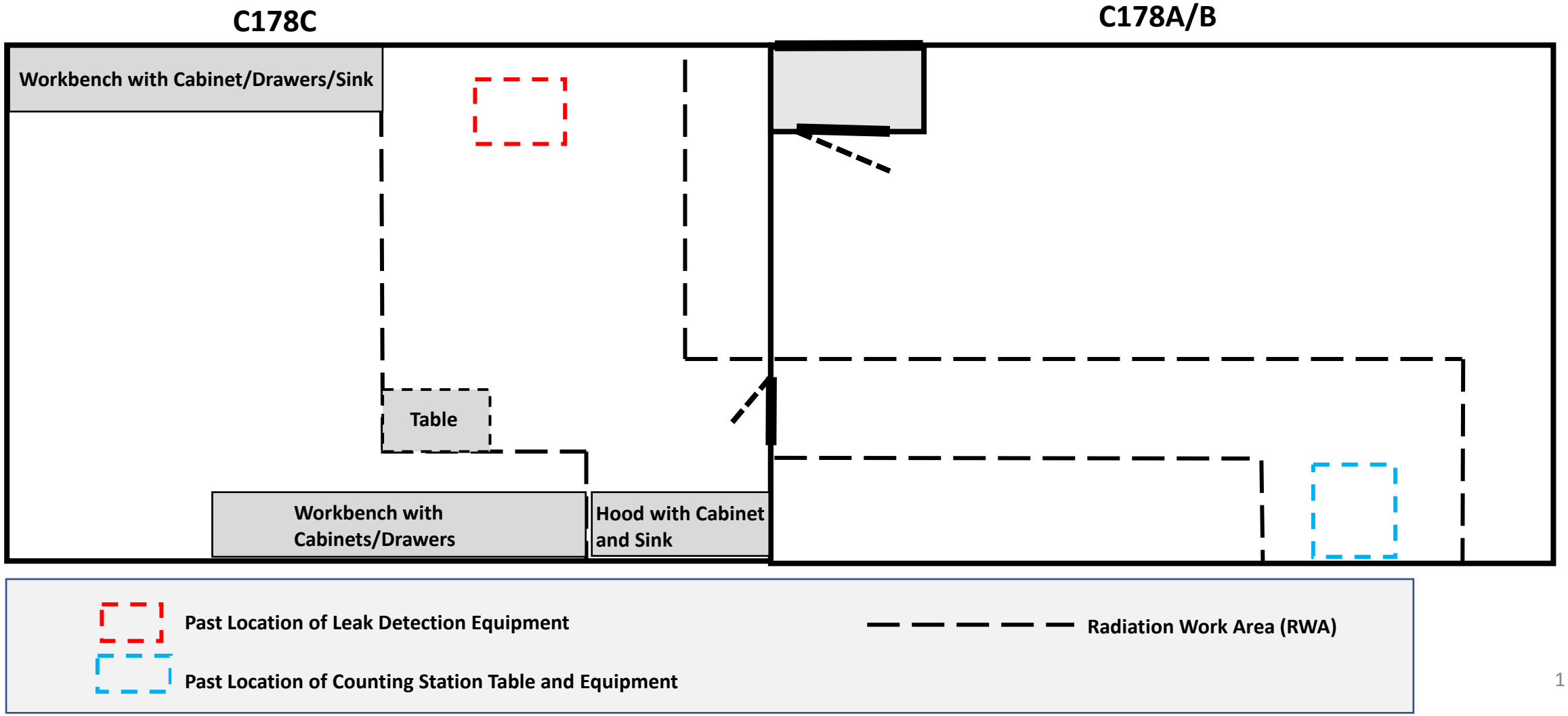
TI (Transport Index): 1.0

Notes: FEDEX tracking 651693557379, 55 gallon drum.

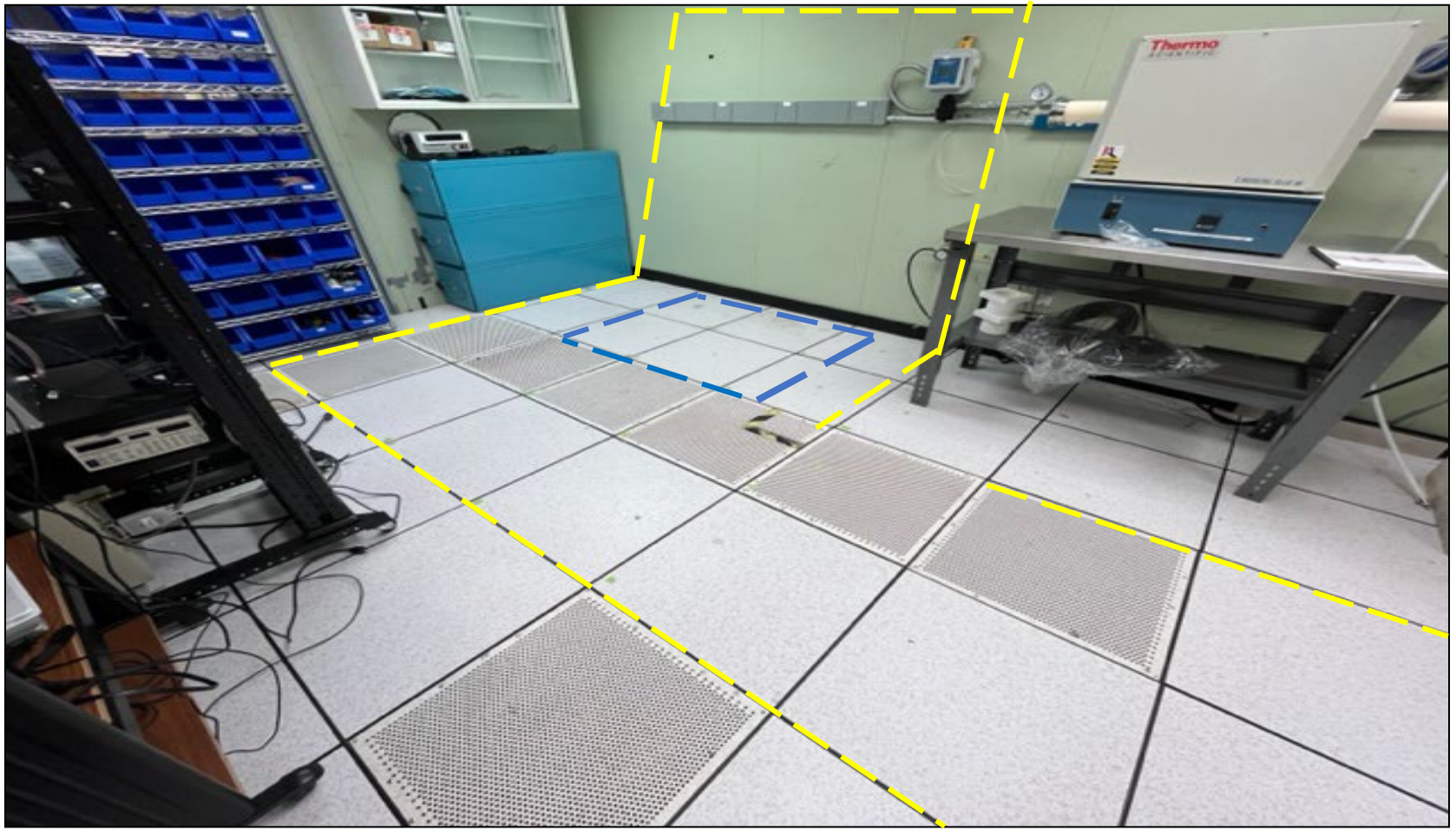
Appendix B

Project: Decommissioning, Bldg. 4487, Rooms C178A/B and C178C Date: 11/21/2023

Rooms C178A/B and C178C Layout



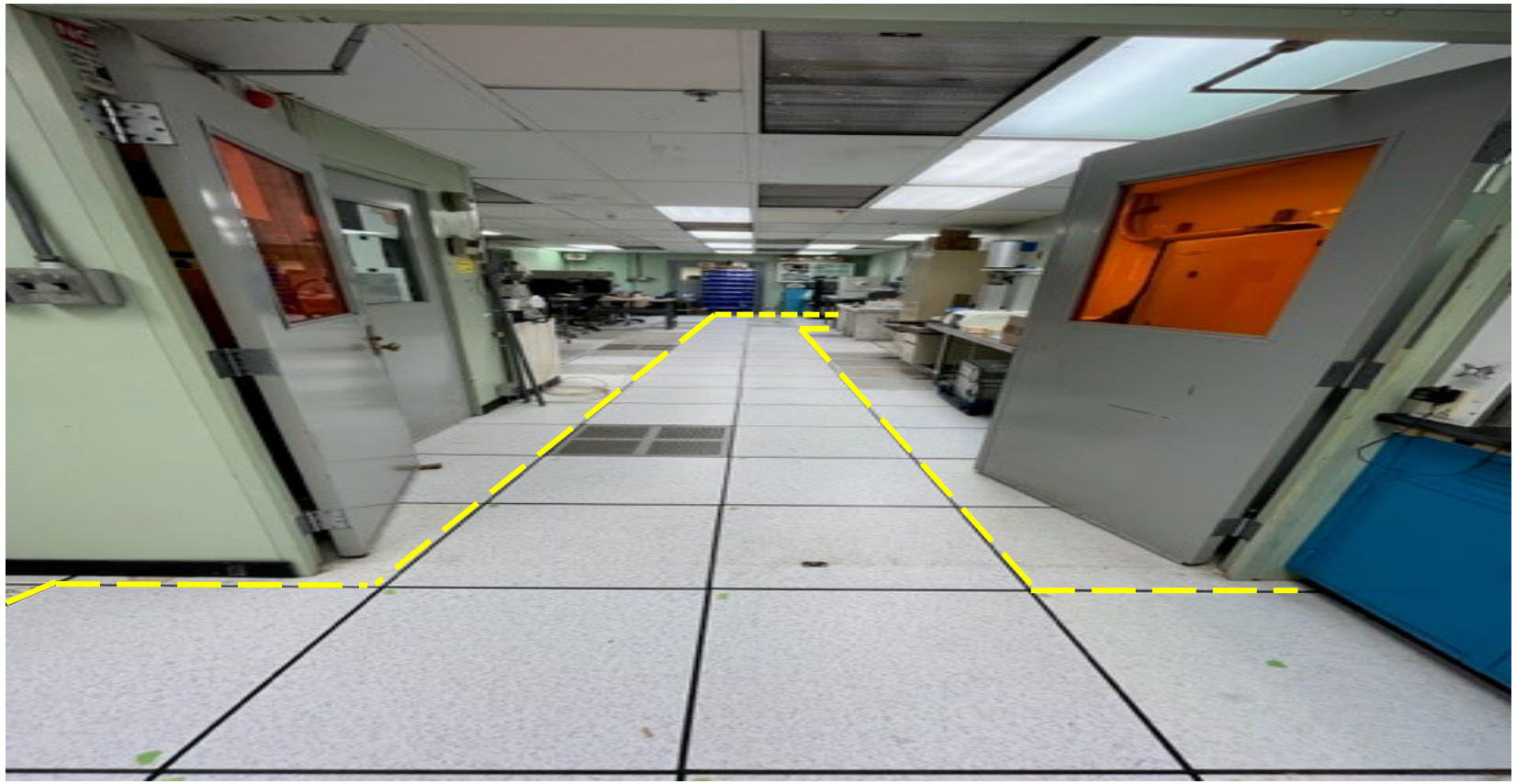
C178A/B - Location of the Counting Station



Past Location of Counting Station Table and Equipment

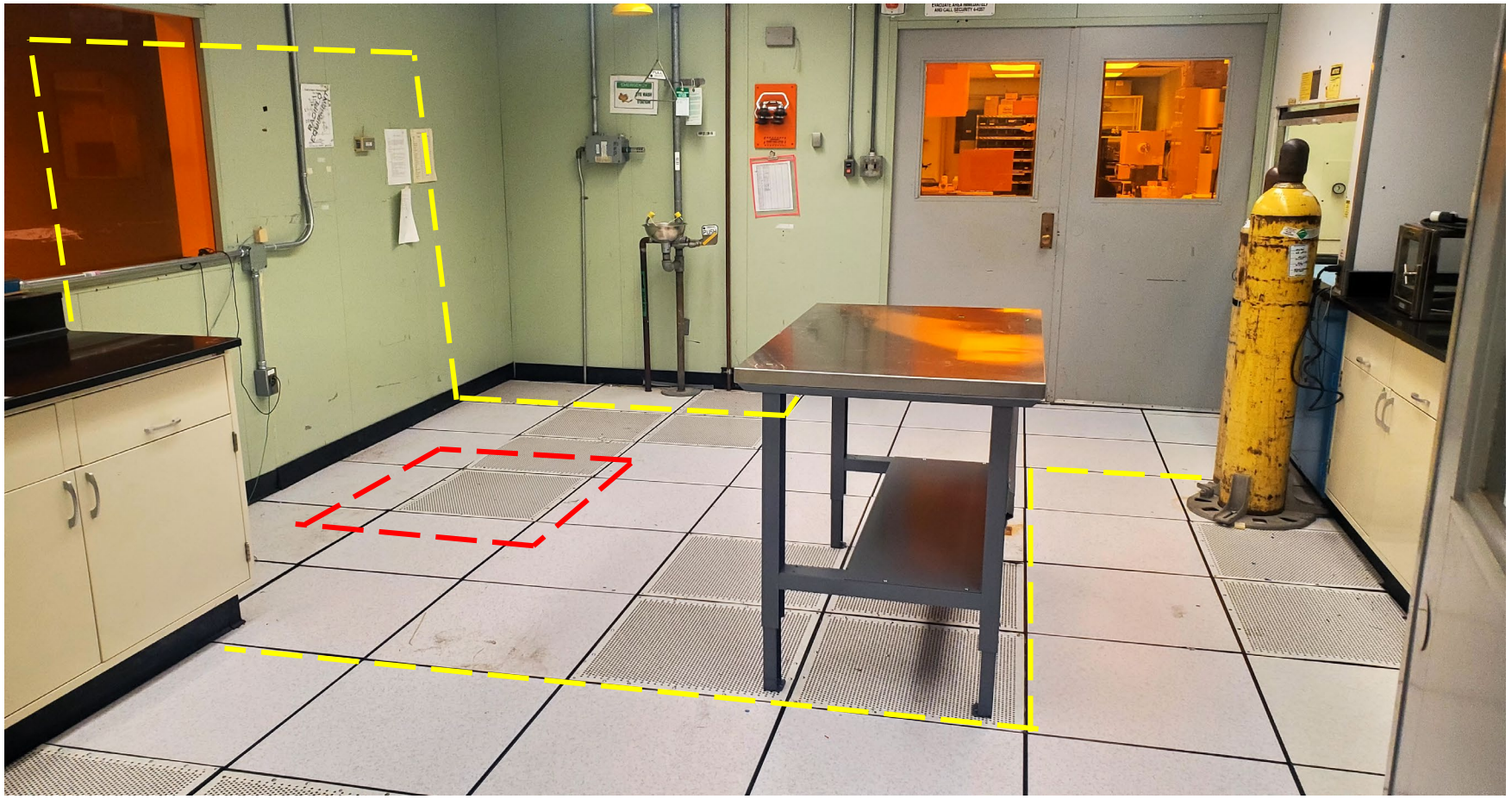
Ram Material Working Area (RMWA)

Rooms C178C to C178A/B View



RWA

Room C178C View of RMWA



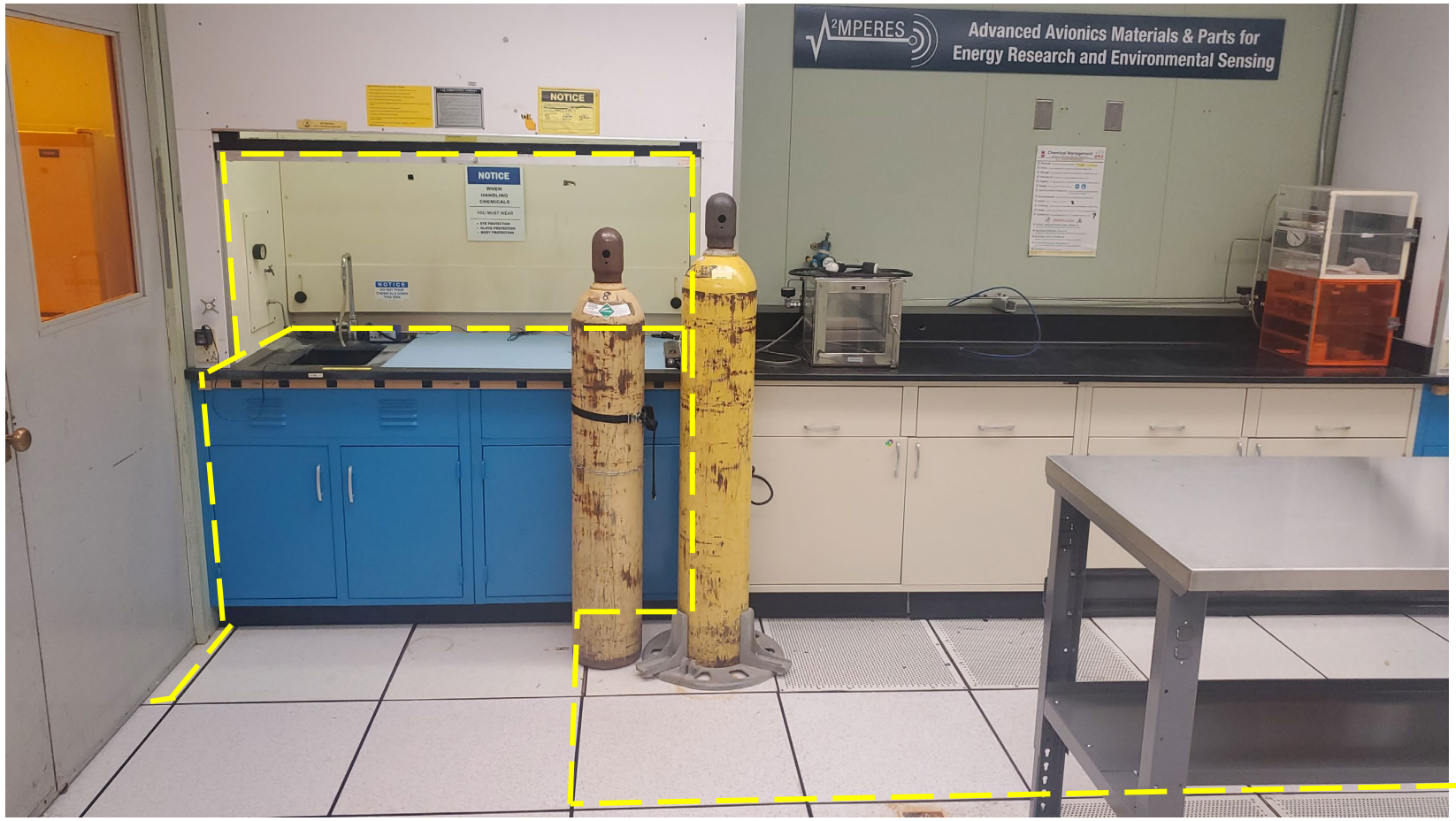
Past Location of Leak Detection Equipment

RMWA

Room C178C South Wall Counter and Sink

RMWA

Room C178C – North Wall Hood and Adjacent Counter with Cabinets



RMWA

Room C178C View of Ceiling Vent Connection

Appendix C

Safety and Ecology Corporation
10512 Lexington Drive, Suite 200
Knoxville, TN 37932
Calibration Certificate

Procedure # SEC-IS-425

Meter Model:	3002		**Date:**	11/1/2023
Meter Serial Number:	25020406		**Customer Name:**	Perma-Fix Lab
Meter Bar Code Number:			**Technician:**	Jacob Galyon
Probe Model:	43-93		**Reason:**	Due for Cal
Probe Serial Number:	PR389073		**Probe Bar Code Number:**	

M&TE

Model	Serial No.	Due
Ludlum 500-2	268940	7/3/2024

Previous Pu-239 Eff:	20.78%
Previous Tc-99 Eff:	14.37%
Previous Th-230 Eff:	20.56%
Previous SrY-90 Eff:	35.98%

N.I.S.T. Source(s)

Material	Serial No.	Activity	Assay
Pu-239	99PU470-0268	14196 dpm	1/30/2023
Tc-99	4050-02	36799 dpm	1/30/2023
Th-230	4049-02	30197 dpm	1/30/2023
SrY-90	4052-02	14194 dpm	1/30/2023

Calibration Data

	As Found	As Left
α BG:	2	1
β BG:	162	171
Pu-239 α :	1850	2890
Pu-239 β:	486	330
A-B Xtalk:	17.53%	5.50%
Pu-239 Eff :	13.02%	20.35%
Tc-99 α:	2	6
Tc-99 β:	2770	5340
A-B Xtalk:	0.00%	0.09%
Tc-99 Eff :	7.09%	14.05%
Th-230 α :	3210	5770
Th-230 Eff :	10.62%	19.10%
SrY-90 β:	3110	5140
SrY-90 Eff :	20.77%	35.01%

	As Found	As Left
High Voltage	625V	625V
	As Found	As Left
α Threshold	120	120
β Threshold	3.5 - 35.0	3.5 - 35.0
	Readings	% Error
Cal Point	As Found	As Found
200 cpm	199	-0.50%
800 cpm	799	-0.13%
2 kcpm	1.99	-0.50%
8 kcpm	7.99	-0.12%
20 kcpm	19.9	-0.50%
80 kcpm	79.9	-0.12%
200 kcpm	199	-0.50%
800 kcpm	799	-0.13%

Slope & Offset Settings	As Found	As Left
HV Slope	1.056	1.056
HV Offset	-10.419	-10.419
α Thr Slope	1.02222	1.02222
α Thr Offset	0.005	0.005
α Win Slope	1.01247	1.01247
α Win Offset	-5.50E-05	-5.50E-05
β Thr Slope	1.01586	1.01586
β Thr Offset	-0.0007	-0.0007
β Win Slope	1.01784	1.01784
β Win Offset	0.001	0.001

Reproducability (SrY-90)

Counts:	5170	5040	5020
	5076.67		

Comments/Remarks: Repaired broken mirror in 43-93.

Calibration done with N.I.S.T. traceable source(s) and/or calibrated test equipment.

Calibration acceptance criteria +/- 10% of actual input rate.

If 'As Found' readings are greater than +/- 20% then values are circled in red and customer is contacted.

Calibration performed per Ludlum Procedure.

All efficiencies are in 4π.

Date Instruments are due for Next Calibration: 11/1/2024

Performed by: Jacob Galyon
Printed Name: Jacob Galyon

Reviewed by:
Date Reviewed: 11/1/23

CALIBRATION CERTIFICATE

CERT #4084.01

LUDLUM MEASUREMENTS, INC.
501 Oak Street
325-235-5494
Sweetwater, TX 79556, USA

Customer: MARSHALL SPACE FLIGHT CENTER
Address: BLDG 4316, SATURN RD
PC-11977436
HUNTSVILLE, AL 35812
USA

Temp: 73.9 °F
Rel. H: 30%
Alt: 705.6mm Hg

Order No: 20457091

Cal Date: 29-Jan-24
Cal Due Date: 29-Jan-25
Cal Interval: 1 year

Mfg.: Ludlum Measurements, Inc.	**Model: 3003**	Desc.: survey meter	Serial No.: 25035226
Mfg.: Ludlum Measurements, Inc.	**Model: 43-147**	Desc.: Scintillator	Serial No.: PR423793

Calibration tolerance is 10%

Voltage measurements uncertainty 1.2%, Gamma Exposure/Dose uncertainty 5.6%, Neutron Dose uncertainty 7.0%, Count rate uncertainty 5.6%

Model 3003 Parameters:
- ☑ New Instrument
- Serial No.: 25035226
- ☑ Alarm Setting Ck.
- ☑ Audio Check
- ☑ Battery Check
- ☑ F/S Resp. Check
- ☑ HV Readout
- ☑ Mechanical Check
- ☑ Window Operation
- Firmware: F.4.3.1232
- Ref./Inst.: 600 / 600 V
- Ref./Inst.: 2000 / 2001 V
- Scaler Count: 6 second(s)
- ☑ LMI SOP 14.8
- Primary Units: cpm

Ratemeter

Reference Point	Direct Reading
5 Mcpm	5.00 Mcpm
2 Mcpm	2.00 Mcpm
800 kcpm	799 kcpm
200 kcpm	199 kcpm
80 kcpm	79.9 kcpm
20 kcpm	19.9 kcpm
8 kcpm	8.00 kcpm
2 kcpm	1.99 kcpm
800 cpm	800 cpm
200 cpm	200 cpm

Scaler

Reference Point	Direct Reading
5 Mcpm	500 kcount
2 Mcpm	200 kcount
800 kcpm	80.0 kcount
200 kcpm	19.9 kcount
80 kcpm	8.00 kcount
20 kcpm	2.00 kcount
8 kcpm	800 count
2 kcpm	200 count
800 cpm	80 count
200 cpm	20 count

COMMENTS:

See attachments for all other settings.

DET1: 43-147 millivotages

ALPHA MILLIVOLTAGE: 120 mv
BETA MILLIVOLTAGE: 3.5mv
BETA WINDOW: 30mv

Model 43-147 Parameters:
Serial No.: PR423793
Det. #: 1
Det. Color: RED
Det. Unit (Primary): cpm
Det. Unit (Secondary): cpm
Detector Operation: 650 V at comment mV
OL Protection Confirmed To: set with Am241, 91Mdpm

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.
All pass/fail determinations are based on the manufacturer's specifications without considering uncertainty factors.
Measurement results represent expanded uncertainties expressed at approximately the 95% Level of confidence, using a coverage factor of k=2.
The calibration system conforms to the requirements of ANSI/NCSL Z540-1-1994 and ANSI N323AB-2013.

ISO/IEC 17025: 2017 (E)
State of Texas Calibration License No. LO-1863

Form ID #: AC242629520103

Reference Instruments and/or Source(s):
Alpha: PU239 #4338 Beta: TC99 #636/83, SR90Y90 #443-69-3
Pulser: 364780 Multimeter: 44380152

Calibrator: Leonor Ortega Leonor Ortega Title: Calibrator Date: 29-Jan-24

QC'd by: Diana Hedges Title: Final QC Date: 29 Jan 24

Order #: 20457091
Customer: MARSHALL SPACE FLIGHT CENTER
Detector: 43-147 **Serial No.:** PR423793
Instrument: M3003 **Serial No.:** 25035226
BKG Time: 60
Distance: SURFACE
Selected HV: 650
Date: Monday, January 29, 2024
Notes:
Signature: Lemon Utley

Channel(s)

Name	Threshold	Window
Beta	3.5 mV	30 mV
Alpha	120 mV	999 mV

Source(s)

Name	ID	Activity	Time	Type
PU239	4338	397 kdpm	60	α
TC99	636/83	224 kdpm	60	β
SR90Y90	443-69-3	18 kdpm	60	β

High Voltage	Background		PU239 : 4338				TC99: 636/83				SR90Y90: 443-69-3			
	α	β	α	β	Cross Talk	Efficiency	α	β	Cross Talk	Efficiency	α	β	Cross Talk	Efficiency
550	1	11	1,850	18,342	991.40 %	0.47%	0	327	0.00%	0.14%	0	713	0.00%	3.90%
600	0	91	62,511	7,884	12.47 %	15.75 %	1	18,911	0.01%	8.40%	0	3,939	0.00%	21.38 %
650	0	288	91,010	11,529	12.35 %	22.92 %	4	46,824	0.01%	20.78 %	1	7,657	0.01%	40.94 %
700	0	514	98,510	95,978	96.91 %	24.81 %	4	66,333	0.01%	29.38 %	4	8,931	0.05%	46.76 %
750	6	2,989	100,151	754,495	750.42 %	25.23 %	5	106,407	0.00%	46.17 %	101	12,311	1.02%	51.79 %