Summary of Los Alamos National Laboratory Weight of Evidence Memoranda

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INTRODUCTION

This presentation summarizes the two Weight of Evidence Memoranda for Los Alamos National Laboratory (LANL):

Weight of Evidence Supports NIOSH's Ability to Bound LANL TA-53 Doses for 1996–2005

- Published by the National Institute for Occupational Safety and Health (NIOSH) on August 15, 2023
- Referred to as **Weight of Evidence 2023** or NIOSH [2023] for this presentation

Weight of Evidence Supports NIOSH's Ability to Bound LANL TA-53 Doses for 1996–2005: Evaluation of Radiological Work Permits

- Published February 22, 2024, by NIOSH
- Referred to as **Weight of Evidence 2024** or NIOSH [2024] for this presentation

Weight of Evidence Supports NIOSH's Ability to Bound LANL TA-53 Doses for 1996–2005

Dated August 15, 2023

WEIGHT OF EVIDENCE 2023 BACKGROUND

The Advisory Board on Radiation and Worker Health LANL Work Group questioned NIOSH's ability to bound doses from "exotic radionuclides" for unmonitored workers from 1996 through 2005 [NIOSH 2019]

The Work Group specifically discussed exotic radionuclide exposures at the Los Alamos Neutron Science Center (LANSCE) in TA-53 (technical area 53)

- TA-53 included an accelerator and various experimental facilities
- In this setting, exotic radionuclides included activation and spallation products produced (directly or indirectly) by the proton beam of the accelerator

DEFINING THE WORKFORCE: ROUTINE WORK

Routine Work:

- **Roles:** Includes guards, custodians, other supporting staff
- **Work Environment/Authorization:** Not performing work under specific radiological work permit (RWP)
- **Monitoring Focus:** Includes air and surface contamination monitoring as needed, bioassay for plutonium, uranium, and/or tritium as needed
- **Exposure Potential Target:** LANL designed their radiological control program to comply with 10 C.F.R. Part 835 and with an intended outcome that workers performing routine work (including unmonitored individuals) would be unlikely to receive doses greater than 100 millirem (mrem)/year committed effective dose (CED)

DEFINING THE WORKFORCE: NON-ROUTINE WORK

Non-Routine Work:

- **Roles:** Experimental scientists, maintenance, radiation control technicians, etc.
- **Work Environment/Authorization:** Work often performed within radiologically posted areas, under RWPs, and utilizing ALARA (As Low As Reasonably Achievable) protocols
- **Monitoring Focus:** Air and surface contamination; bioassay as required. Suspected radiation intakes subsequently monitored by nasal smears or whole body count measurement
- **Exposure Potential Target:** Health physics personnel monitored work with the goal of maintaining non-routine worker radiation doses under 100 mrem/year CED

ACCESS CONTROL SYSTEMS

LANSCE accelerator operations employed robust, engineered access control systems to prevent inadvertent access to radiological areas during beam operations

LANL's access controls included:

- **Radiation Security System (RSS)** - automatically terminated beam delivery in response to pre-defined abnormal conditions
- **Personnel Access Control System (PACS)** - two-key system, prevented personnel from accessing the area when the beam was active
- **Experimental Personnel Access Control System (EPACS)** - ensured personnel did not enter a high-radiation testing area while the beam shutter was open
- **Beam Area "Sweeps"** - performed prior to and after beam operation to confirm no workers were present in the beam area

SURVEYS OF CONTAMINATION AREA BOUNDARIES

LANL required health physics (HP) personnel to do the following

- **Weekly**: collect smear surveys in areas bordering all established, accessible contamination areas at TA-53
- **Quarterly**: conduct smear surveys on all primary and secondary beam line areas, Meson Physics Facility (MPF)-3 (Area A), and other areas specified in *HSR-1/TA-53 Routine Monitoring Instructions*
    - When beam operations prevented access to these areas, personnel collected smears during the next quarter that they were due

PORTAL AND GATE MONITORING

TA-53 HP personnel also used portal and gate monitors to identify and control worker contamination

- The 1994 *LANL Radiological Control Manual* specified how staff should respond to a personnel contamination monitor alarm
- LANL required HP personnel to collect weekly large-area swipes on walkways leading from contamination areas to personnel contamination monitors to ensure that walkways leading up to the portal monitors were free of removable contamination [HSR-1/TA-53, LANL 2005]
- A formal procedure [ESH-1/TA-53-DP-304-R0, LANL 1998] detailed the process for responding to gate alarms
- LANL used a gate (exit) monitor to check vehicles and associated equipment for contamination when leaving the TA-53. The requirements for an alarm were [LANL 1998]:
    - the presence of a vehicle over the road detector, and
    - the detection of radiation at some level above background

WEIGHT OF EVIDENCE 2023 SUMMARY

This memo shows:

- LANL strictly controlled access to the beam line and hot area
- All work performed in beam areas, during and after beam operation, was controlled by RWP directives and radiological monitoring
- LANL required workers to self-monitor for potential contamination when exiting posted areas, and staff investigated all alarms. Vehicles leaving TA-53 were monitored for contamination using gate detectors
- Department of Energy data from the Radiation Exposure Monitoring System (REMS) database show no worker in TA-53 received over 100 mrem CED in any year from 1996 through 2005
- For TA-53 routine workers monitored by whole body counting, NIOSH can bound doses using the method described in *Dose Estimation from Intakes of Exotic Radionuclides at LANSCE, 1996–2005*

WEIGHT OF EVIDENCE 2023 CONCLUSION

The evaluation of LANL's administrative and engineering controls at TA-53 supports NIOSH's ability to bound radiation doses at 100 mrem/year CED with sufficient accuracy for unmonitored LANL TA-53 workers from 1996 through 2005.

Weight of Evidence Supports NIOSH's Ability to Bound LANL TA-53 Doses for 1996–2005: Evaluation of Radiological Work Permits

Dated February 22, 2024

WEIGHT OF EVIDENCE 2024 BACKGROUND

- LANL issues RWPs to inform workers of area radiological conditions within TA-53 and to establish radiological controls for intended activities
- In support of this evaluation, NIOSH performed data capture activities in 2019 and 2023 and obtained copies of all TA-53 RWPs identified by LANL staff for 1996–2005
- NIOSH captured and evaluated 1,349 RWPs from the 1996–2005 period, covering various locations within TA-53

RWPs (1996–2005) GROUPED BY YEAR

Year	First Date	Last Date	Number of RWPs	Percentage of RWPs
1996	1/1/1996	12/31/1996	235	17.4
1997	1/2/1997	12/31/1997	234	17.3
1998	1/5/1998	12/31/1998	178	13.2
1999	1/4/1999	12/31/1999	228	16.9
2000	1/10/2000	12/31/2000	88	6.5
2001	1/2/2001	12/31/2001	124	9.2
2002	1/2/2002	12/31/2002	79	5.9
2003	1/2/2003	12/31/2003	59	4.4
2004	1/5/2004	12/31/2004	58	4.3
2005	1/1/2005	12/31/2005	66	4.9

RWPs (1996–2005) GROUPED BY LOCATION

Location	Number of RWPs	Percentage of RWPs
All Areas	5	<1
Area A	194	14.4
Beam line/Flight Path	252	18.7
Blue Room	75	5.6
Boneyard	6	<1
Experimental Area	107	7.9
General Target Area	251	18.6
High Resolution Spectrometer (HRS)	30	2.2
Isotope Production Facility (IPF)	38	2.8
Low Energy Demonstration Accelerator	5	<1
Proton Storage Ring (PSR)	241	17.9
Radioactive Liquid Waste/Waste Handling	35	2.6
Support	102	7.6
Time of Flight Isochronous Spectrometer	8	<1

EXPECTED RADIONUCLIDES

RWPs label radionuclides of interest as “expected,” “measured,” or “anticipated”

The following Table summarizes the number of RWPs listing a particular “expected” radionuclide

- All radionuclides of interest have been tallied regardless of the label used, but only the “expected” label results are presented
- At LANSCE, various activities involved actinide sources, and activation and spallation products. For tallying purposes in the 2024 Weight of Evidence memo, the activation and spallation products are combined and referred to as “MASP”
- The presence (or absence) of cobalt-60 was also tallied in support of the proof-of-concept method described in Report 0107

EXPECTED RADIONUCLIDES LISTED IN RWPs

Radionuclides	Number of RWPs	Percentage of RWPs
MASP with Co-60	741	54.9
MASP without Co-60	88	6.5
Tritium	20	1.5
Actinides	97	7.2
None Identified	407	30.2

Some RWPs listed both MASP and actinides as radionuclides of interest. Therefore, the total number of RWPs on the table exceeds 1,349.

EXTERNAL DOSIMETRY REQUIREMENTS IN RWPs

Type	Number of RWPs	Percentage of RWPs
TLD (thermoluminescent dosimeter)	1,331	98.7
EPD (electronic personal dosimeter)	804	59.6
Neutron	87	6.4
Supplemental/Secondary	335	24.8
Extremity	13	<1
None	8	<1

Some RWPs specified requirements for multiple types of dosimeters. Therefore, the total number of RWPs on the table exceeds 1,349.

PERSONAL PROTECTIVE EQUIPMENT

- 73% (988 of 1,349) of the TA-53 RWPs required one or more types of personal protective equipment (PPE)
- NIOSH carefully reviewed the details of the RWPs that did not designate PPE requirements
- On the RWPs that did not designate PPE
  - Primary concern was external radiation exposure
  - No elevated derived air concentrations (DACs), nasal swipe requirements, or elevated nasal swipe results were noted
  - Associated work included inspections, equipment installation and repair, operational checks, and general maintenance
  - 94% required intermittent or continuous radiological control technician (RCT) coverage for workers

HEALTH PHYSICS COVERAGE

- All 1,349 RWPs required some type of HP coverage
  - Types of coverage included intermittent and continuous worker coverage and equipment (or “other”) surveys

TA-53 Health Physics Coverage Requirements in RWPs (1996–2005)

Type of Health Physics Coverage	Number of RWPs	Percentage of RWPs
Intermittent	398	29.5
Continuous	908	67.3
Equipment/Other	43	3.2

Coverage associated with 5 RWPs in the Equipment/Other category is undetermined because monitoring requirement pages were not included.

TRAINING REQUIREMENTS IN RWPs

TA-53 Training Requirements in RWPs (1996–2005)

Required Training	Number of RWPs	Percentage of RWPs
Radiological Worker 1	176	13.0
Radiological Worker 1 + Radiological Worker 2	1,064	78.9
Facility Specific	848	62.9

Some RWPs specified multiple training requirements in a single RWP. Therefore, the total number of RWPs on the table exceeds 1,349.

CONTAMINATION SURVEYS AND AIR MONITORING

NIOSH evaluated the TA-53 RWPs to determine the extent of air monitoring and contamination surveys conducted before, during, and after work completion:

- Prejob surveys were performed for 1,244 RWPs (92.2%)
- Postjob surveys were performed for 1,052 RWPs (78.0%)
- 1,470 in-process surveys (not including prejob, postjob, item release, offsite shipment, or on-site shipment) were collected during the execution of 379 RWPs (28.1%)
- Prejob airborne radioactivity DAC values were “NA” (not applicable) or blank for 652 RWPs (48.3%)
- 207 RWPs contained air monitoring results obtained during jobs with the potential for airborne radioactivity release
- Postjob airborne radioactivity DAC values were marked “NA” or not noted in 934 RWPs (69.2%)

LANL did not require documentation of in-process surveys during work performed under RWPs

AIR CONCENTRATIONS AND WORKER MONITORING

NIOSH assessed RWPs meeting any of three conditions that suggest elevated potential for worker intake:

1. **High airborne radioactivity levels**: Reported radionuclide air concentrations for either prejob or postjob work equal to, or greater than, or possibly greater than 10% DAC (46 of 1,349 RWPs; 3.4%)
2. **Nasal swipes required:** Nasal swipe tests were required in 192 of 1,349 RWPs (14.2%)
    - If necessary, follow-up bioassay (e.g., in vivo, in vitro, or chest count) was performed
    - LANL required a Radiation Protection Observation Report if the sum of nasal swipe readings in both nostrils was greater than or equal to 50 disintegrations per minute (dpm) alpha or 500 dpm beta
3. **Elevated monitoring during work:** Air monitoring during execution of the RWP recorded elevated levels in 5 of 1,349 RWPs (0.003%)

DOCUMENTS CITED WITHIN RWPs

- LANL supplemented many of the RWPs with references to existing procedures and safety-related documents
- Examples of references include:
  - standard operating procedures
  - hazard control plans
  - special work permits
  - test plans
  - integrated work documents
  - security plans
- Some of the 1,349 RWPs also contained full-text copies of such documents
- 225 of 1,349 RWPs (16%) cited at least one of these document types

WEIGHT OF EVIDENCE 2024 SUMMARY

The 2024 evaluation of 1,349 TA-53 RWPs confirmed that LANL regularly utilized RWPs to assess hazards and exposure potentials, specify monitoring and PPE requirements, and enforce administrative and engineering controls needed to keep worker radiation doses under 100 mrem/year CED. Key findings include:

- External monitoring use was stipulated in over 99% of the RWPs
- Though elevated airborne radioactivity occurrences were not common, the evaluated RWPs provide evidence of appropriate precautions, monitoring, and follow-up bioassay when warranted
- Radiation Protection Observation Reports were issued in the event of unplanned/unexpected work events
- There is evidence of RCT authority to make on-the-job adjustments to monitoring and PPE needs
- Training requirements were consistently noted
- A majority of RWPs required prejob and postjob contamination surveys

WEIGHT OF EVIDENCE 2024 CONCLUSION

Captured evidence supports the NIOSH conclusion that LANL's radiation protection program applied the same rigor to operations with potential exposures to exotic radionuclides as they applied to operations involving their primary radionuclides.

This evaluation identified no evidence to the contrary.

KEY REFERENCE DOCUMENTS (PART 1)

Archuleta S [2022]. LANL response to data request FY22-003 information related to the bioassay program. April 5. [SRDB Ref ID: 192418]

NIOSH [2012]. Special Exposure Cohort Petition Evaluation Report Petition SEC-00109 Rev. 1 Los Alamos National Laboratory (LANL) May 29, 2008. August 13. [SRDB Ref ID: 165232]

NIOSH [2017]. Special Exposure Cohort Petition Evaluation Report Petition SEC-00109 Addendum Los Alamos National Laboratory (LANL). April 24. [SRDB Ref ID: 173741]

NIOSH [2019]. ABRWH Los Alamos National Laboratory work group Thursday, July 25, 2019. Transcript. [SRDB Ref ID: 184933]

NIOSH [2023]. Weight of Evidence Supports NIOSH's Ability to Bound LANL TA-53 Doses for 1996-2005. August 15. [SRDB Ref ID: 198013]

NIOSH [2024]. Weight of Evidence Supports NIOSH's Ability to Bound LANL TA-53 Doses for 1996-2005: Evaluation of Radiological Work Permits. February 22. [SRDB Ref ID: 204633]

KEY REFERENCE DOCUMENTS (PART 2)

ORAUT [2022]. Review of Potential Exposure to Exotic Radionuclides Using Radiological Work Permit Data at Los Alamos National Laboratory. ORAUT-RPRT-0103 Rev. 00, August 15. [SRDB Ref ID: 193468]

ORAUT [2023a]. Bounding Intakes of Exotic Radionuclides at Los Alamos National Laboratory. ORAUT-RPRT-0101 Rev. 01, August 30. [SRDB Ref ID: 197263]

ORAUT [2023b]. Dose Estimation from Intakes of Exotic Radionuclides at LANSCE, 1996–2005. ORAUT-RPRT-0107 Rev. 00, September 15. [SRDB Ref ID: 198630]

Thank you.

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KEY TERMS AND ACRONYMS (PART 1)

Term	Definition
10 C.F.R. 835.402(c)(1)	Section of the Code of Federal Regulations (C.F.R.) that requires internal dosimetry monitoring for radiological workers who, under typical conditions, are likely to receive a committed effective dose of 0.1 rem (100 mrem) or more from all occupational radionuclide intakes in a year
actinides	Refers to any of a series of radioactive metallic chemical elements, many of which are also considered “exotic” radionuclides in the LANL petition evaluation
ALARA As Low as Reasonably Achievable	Core principle of radiation safety that emphasizes keeping radiation exposures as low as reasonably achievable
beam line	Locations within LANL’s technical area 53 containing specialized instruments (such as an accelerator) that are used to direct high-energy particles to targets for scientific research

KEY TERMS AND ACRONYMS (PART 2)

Term	Definition
CED committed effective dose	Sum of the effective doses to various tissues or organs in the body each multiplied by the appropriate tissue weighting factor and committed for a 50-year period following an acute intake or the onset of chronic intake. It does not include contributions from external dose The internal dose measurement LANL used to decide if a worker needed routine bioassay monitoring
DAC derived air concentration	Represents the concentration of a radionuclide in the air that a worker can breathe for a working year without exceeding the annual limit on intake
dosimetry thresholds	Describes the point at which radiological personnel monitoring will be performed
dpm disintegrations per minute	A unit of radioactivity
EPACS Experimental Personnel Access Control System	An experimental-area personal access control system that prevented workers from accessing a high-radiation testing area

KEY TERMS AND ACRONYMS (PART 3)

Term	Definition
EPD electronic personal dosimeter	Wearable, battery-powered device used to provide real-time radiation measurements
exotic radionuclides referred to as “**exotics**”	All radionuclides other than $^{234/235/238}$Uranium, $^{238/239}$Plutonium, tritium, ^{241}Americium, and ^{137}Cesium
hot area	An area known to (at times at least) contain elevated external radiation levels
LANL Los Alamos National Laboratory	U.S. Department of Energy laboratory in New Mexico
LANSCE Los Alamos Neutron Science Center	This complex includes the linear proton accelerator
MASP mixed activation and spallation products	Refers to a summation of activation and spallation radionuclides of interest that were produced directly or indirectly by the accelerator’s proton beam

KEY TERMS AND ACRONYMS (PART 4)

Term	Definition
mrem millirem	A unit measuring radiation dose (1,000 mrem = 1 rem).
NIOSH National Institute for Occupational Safety and Health	A Federal agency responsible for conducting research and making recommendations for the prevention of work-related injuries and illnesses
non-routine work	Work being performed under a radiological work permit
ORAUT Oak Ridge Associated Universities Team	Contractor team assisting NIOSH with fulfilling its responsibilities under the Energy Employees Occupational Illness Compensation Program Act (EEOICPA) ORAUT includes teaming partners (ORAU, MJW, NV5-Dade Moeller)
PACS Personnel Access Control System	A two-key system that prevented workers from accessing the area when the beam was active

KEY TERMS AND ACRONYMS (PART 5)

Term	Definition
postjob surveys	Radiological survey conducted after the conclusion of work activities to assess the conditions of the work area
PPE **Personal Protective Equipment**	Specialized clothing or gear worn to minimize exposure to hazards
prejob surveys	Radiological survey conducted before the start of work activities to assess the conditions of the work area
RCT radiological control technician	An individual that ensures safety by monitoring radiation levels, conducting contamination surveys, and enforcing radiation protection procedures
routine work	Work that was not being performed under a specific radiological work permit
RPRT	An abbreviation for report It is used as part of the ORAU team's official report number (e.g., ORAUT-RPRT-0101)

KEY TERMS AND ACRONYMS (PART 6)

Term	Definition
RSS Radiation Security System	Automatically terminated beam delivery in response to pre-defined abnormal conditions
RWP radiological work permit	The document that establishes worker protection and monitoring requirements and contains specific approvals for radiological work activities The RWP serves as an administrative process for planning and controlling radiological work and informing the worker of the radiological conditions
SEC Special Exposure Cohort	Designation that applies to certain classes of employees that allows eligible claimants to be compensated without the completion of a NIOSH dose reconstruction
SRDB Site Research Database	A comprehensive record repository used by the NIOSH Dose Reconstruction Program Cited references include the associated SRDB number
TA technical areas	Subdivisions of work locations at the LANL site that generally reflect operational activities

KEY TERMS AND ACRONYMS (PART 7)

Term	Definition
TLD thermoluminescent dosimeter	Badge containing crystals inside its case that can store the energy from radiation passing through the badge housing and then striking the crystals