NA--LASO-LANL-TA55-2018-0013 FINAL

Occurrence Report

After 2017 Redesign

Plutonium Proc & Handling Fac

(Name of Facility)

Plutonium Processing and Handling

(Facility Function)

Los Alamos National Laboratory Los Alamos National Laboratory

(Laboratory, Site, or Organization)

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(Authorized Classifier (AC))

1. Occurrence Report Number: NA--LASO-LANL-TA55-2018-0013

Pu238 Intake during Glovebox Counterbalance Door Maintenance

2. Report Type and Date: FINAL

	Date	Time
Notification:	09/21/2018	16:27 (ETZ)
Initial Update:	11/09/2018	13:11 (ETZ)
Latest Update:	06/28/2019	17:16 (ETZ)
Final:	07/18/2019	18:37 (ETZ)

Report Level: H

4. Division or Project: Plutonium Science and Manufacturing Directorate

5. Secretarial Office: NA - National Nuclear Security Administration

6. System, Bldg., or Equipment: Glovebox Glove

7. UCNI?: No

Reviewed for Public Release:

8. Plant Area: TA-55-4

9. Date and Time Discovered: 08/18/2018 14:27 (MTZ)

10. Date and Time Categorized: 08/20/2018 08:24 (MTZ)

11. DOE HQ OC Notification:

Date	Time	Person Notified	Organization
NA	NA	NA	NA

12. Other Notifications:

Date	Time	Person Notified	Organization
09/04/2018	14:45 (MTZ)	Scott Osborn	DOE-NNSA
09/11/2018	12:40 (MTZ)	Stephen Glenn	DOE-NNSA
09/04/2018	14:45 (MTZ)	William Gordon	DOE-NNSA
09/04/2018	14:45 (MTZ)	Stephen Glenn	DOE-NNSA
09/04/2018	14:45 (MTZ)	Art Brown	DOE-NNSA

13. Subject or Title of Occurrence:

Pu238 Intake during Glovebox Counterbalance Door Maintenance

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14. Reporting Criteria:

6C(1) - Determination of a dose that exceeds the limits specified in 10 CFR Part 835, “Occupational Radiation Protection,” Subpart C, “Standards for Internal and External Exposure,” or in DOE O 458.1 Chg 3, Radiation Protection of the Public and the Environment, dated 1-15-13, paragraph 4.b(1)(a) [paragraph 2.b(1)(a) of the CRD], “Public Dose Limit.”
6C(3) - Determination of a single occupational dose, attributable to an identified event that exceeds an expected dose by: (1) 500 mrem Committed Effective Dose (CED), or (2) 100 mrem effective dose due to external exposure.
6D(1) - Any occurrence requiring offsite medical assistance for contaminated personnel, including transporting a person with personnel or clothing contamination due to DOE operations/activities that exceeds 1 times the total contamination values in 10 CFR Part 835, Appendix D to an offsite medical facility or bringing offsite medical personnel onsite to perform treatment or decontamination.
10(1) - An event, condition, or series of events that does not meet any of the other reporting criteria, but is determined by the Facility Manager or line management to be of safety significance or of concern for that facility or other facilities or activities in the DOE complex.

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15. Description of Occurrence:

MANAGEMENT SYNOPSIS: A plutonium-238 intake occurred at the Technical Area (TA)-55-4 Plutonium Facility located at Los Alamos National Laboratory (LANL) on Saturday, August 18, 2018. The intake occurred during the

execution of a quarterly mechanical preventive maintenance/corrective maintenance (PM/CM) evolution when a Nuclear Process Infrastructure (NPI)-3 worker's (W1) glovebox glove was punctured at his left ring finger by a frayed 1/16 inch wire cable. Upon realizing the glovebox glove had been breached and feeling a "light" pressure on the corresponding finger, W1 notified his co-workers (W2 and W3, both from Actinide Material Processing and Power [AMPP-1]) and asked them to contact the Operations Center. W1 removed his hands from the glovebox, self-monitored, and detected contamination.

BACKGROUND

The TA-55 Plutonium Facility is a 23,000- square-foot facility and designated as a Hazard Category 2 Nuclear Facility. The Facility houses 445 gloveboxes where the majority of the nuclear material operations occur. The gloveboxes vary in age, height, and configuration. Throughout LANL’s 45-year history supporting the Plutonium Heat Source Mission, these gloveboxes have played an integral role in ensuring the safe execution of mission- critical work. As such, the maintenance of these gloveboxes is of critical importance.

NPI-3 is charged with the maintenance of the non-credited portions of the 445 glovebox systems within PF-4 and specific credited systems for programmatic operations as defined in the Documented Safety Analysis. This work is planned and executed as programmatic maintenance work using the facility maintenance work planning and control process, P950, and the AP-WORK series documents. The work is performed under Work Order 00613342, Task 01, which had an associated moderate-hazard IWD 488243-01, "Glovebox Door Inspection, Preventive and Corrective Maintenance". The work order and IWD covered four types of glovebox doors, including the counterbalance door involved in this event.

EVENT DESCRIPTION

On Saturday, August 18, 2018, at approximately 0800 hours, W1, W2, and W3 reported to the 200 area of PF-4 to resume glovebox counterbalance door maintenance work they had started the previous day (August 17, 2018) in accordance with Work Order 00613342 Task 01. Upon arrival on-site, the room where the work was scheduled to be performed was found to be "red lit" due to a hydraulic oil spill. As a result, the cable replacement work was rescheduled to an alternate room within the wing while the hydraulic oil spill was being cleaned up.

W1 (the person in charge, PIC) was asked to support the decontamination of the hydraulic oil, and W2 and W3 were tasked with conducting visual inspections in accordance with the approved glovebox maintenance work package in the alternate room. W2 and W3 proceeded to the alternate room in the facility to begin the visual inspection work while W1 supported the hydraulic oil decontamination. Around 1200, decontamination efforts were deemed successful and the room was released. W1, W2, and W3 broke for lunch.

At approximately 1345 hours, W1, W2, and W3 reported back to the originally scheduled room to execute the replacement of the door counterbalance cables. W1, as the designated PIC for the work, conducted the pre-job briefing for W2 and W3. Frayed cables as a sharps hazard were acknowledged at the pre-job briefing, as they had been the previous day. As the work required placing hands in the glovebox, each employee conducting the work donned cotton glove liners and Trionic (a blend of natural latex, neoprene, and nitrile) gloves prior to placing hands into the 30-mil lead-lined glovebox gloves. The actions to replace the glovebox door cable included the following: 1) disconnect either end of the existing cable from an eyebolt; 2) configure a loop-to-loop knot between the existing cable and the replacement cable; 3) "fish" the cable assembly through pulleys; 4) disconnect the existing cable from the new cable; 5) remove the cable from the existing attachment eyebolt; and 5) connect the replacement cable ends to the eyebolts.

At approximately 1427 hours, W2 was completing the last scheduled cable replacement of the day on the glovebox counterbalance doors. W2 had successfully executed a loop-to-loop knot between the replacement cable (C2) and the existing cable (C1) and pulled C2 through the pulley system. W2 was working to disconnect C1 from the end of C2 when a knot in the connection was identified, which W2 communicated to W3. W2 removed his hands from the glovebox, and W3 placed his hands in the glovebox and attempted to loosen the knot. W3's attempt was not successful. W3 then connected an additional new cable (C3) via a loop-to-loop knot to the terminal end of C2. While passing C2 back through the pulley system, the connection between C2 and C3 was unable to clear the second pulley. W2 worked

to pull the cable connection through the pulley system but was unsuccessful. At this point, W1, who was completing the required work-package paperwork nearby, became aware of the issue and approached the glovebox, indicating he would work to resolve the issue. W3 then removed his hands from the glovebox, and W1 placed his hands in the glovebox.

W1 worked to pull the C2/C3 connection through the pulley but was unsuccessful. W1 then pulled the wire cable C2/C3 connection between the two pulleys so he could more easily access the connection. W1 began working to disconnect the cables by holding the C2/C3 wire cable connection in his left hand and using forceps in his right hand to loosen the connection. At some point, W1 felt his left glove breach and a "light" pressure on his left ring finger in the area at about the same height as, and adjacent to, his left pinky finger. W1 notified W2 and W3 of the breach and requested that the Operations Center be notified. W1 then pulled his left hand from the glovebox, self-monitored, and detected contamination on his left Trionic anti-C glove. W2 notified the Operations Center of the glove breach.

EVENT RESPONSE

The first Radiological Control Technician (RCT1) responded to the room and observed W2 and W3 inside near the door to the corridor. RCT1 observed that there were no CAMs alarming and located W1 by the glovebox where the work was being conducted. RCT1 surveyed W1's left hand and confirmed 2000 dpm contamination on W1's outer left-hand glove. RCT1 had W1 form a fist and helped W1 to the front of the room. RCT2 arrived to perform a whole-body survey of W1 and contained the contamination on the left glove with tape. W1 was then escorted to the decontamination room for further contamination evaluation by RCT1 and RCT2. During the walk to the decontamination room, RCT2 asked W1 if he had felt any skin penetration, any wound. W1 replied, "No." In parallel, W2 and W3 had monitored out of the room and waited in the hallway, where they were subsequently met by RCT3 and RCT4.

In the decontamination room, RCT2 removed W1's protective glove and surveyed W1's hand. Contamination on W1's left pinky finger (400 dpm) and left ring finger (2000 dpm) was detected. No visible wound or area of irritation was present on either finger. The tape compression decontamination method was employed and successful on the pinky finger after the first attempt. Four attempts on the left ring finger resulted in no decrease in detected activity.

RCT1 then contacted the TA-55 ESH Manager (M1) by phone to request permission to begin wet decontamination methods. Permission was granted and wet decontamination methods were employed. After the second wet method attempt, contamination on the left ring finger was at NDA. W1 was again asked if he had felt anything touch his skin; he again replied, "No." M1 was then contacted by phone, the NDA results were shared, and M1 asked if there was any visible irritation or wound on the affected finger. Both RCTs and W1 stated there was not, therefore a wound count was not performed.

RCT1 then escorted W1 to the exit of wing 2; W1 exited PF-4 without incident, following the prescribed protocol of monitoring out through an in-place Hand and Foot Monitor and a Personnel Contamination Monitor. W1 was instructed to shower prior to leaving TA-55 for home. Notifications were made to the ES&H Group Leader (GL), the Operations Center, and the NPI-3 Responsible Line Manager (M2) of W1. Additionally, a Radiation Protection Initial Notification (RPIN) was issued.

On Monday, August 20, 2018, M1 met with W1 and W1's First Line Manager (FLM1) to issue a special bioassay kit. Additionally, M1 restricted W1's access to TA-55-4 and other radiological controlled areas (RCAs) pending the return of his filled bioassay kit, in accordance with Radiation Protection policy for a skin contamination event greater than1000 dpm of Pu or Americium. On that same date, the TA-55 Operations Manager categorized the event as sub-threshold reportable pending a fact finding.

On Wednesday, August 22, 2018, the TA-55 Operations Manager held a fact-finding where the event categorization was retained pending the results of W1's bioassay.

On Thursday, August 23, 2018, W1 returned his filled bioassay kit, which was delivered to Chemistry Division for analysis.

On Monday, August 27, 2018, W1's access to TA-55-4 and RCAs was reinstated.

On Thursday, August 30, 2018, M1 received notification from Internal Dosimetry staff that W1's bioassay results were elevated. M1 notified W1 and met with W1, FLM1, and M2. W1 was taken to the LANL Occupational Health Facility where a wound count was conducted and found to be elevated. Medical intervention for a Pu-238 injection was initiated for W1 and completed in October 2018. M1 also notified the TA-55 Operations Manager. At 1715 hours, the TA-55 Operations Manager declared a reportable Management Concern under Group 10(1), Report Level Informational, pending final dose analysis results.

On Friday, August 31, 2018, a non-LANL medical expert excised the wound at the LANL Occupational Health facility. Following excision, which removed ninety-five percent (95%) of activity, final wound count results were 0.4 nCi.

On that same day, the Laboratory Director appointed the Deputy Associate Director for Threat Identification and Response to lead the Event Investigation Team (EIT). Members of the team included subject matter experts (SMEs) in Radiation Protection & Health Physics, nuclear facility Conduct of Operations, Training, Human Performance Improvement, Facilities Operations Management & Maintenance, and Event Investigation & Causal Analysis. This team was charged to investigate the event and provide recommendations for corrective actions to prevent recurrence.

At 1400 on Tuesday, September 4, 2018, the TA-55 Operations Manager held a second fact finding where the Management Concern event categorization was confirmed pending final dose analysis results.

At 1225 on Tuesday, September 11, 2018, following notification, the TA-55 Operations Manager added the Group 6D(1) reporting criterion to the event due to off-site medical personnel being brought on-site to perform the wound excision. This changed the occurrence Report Level from Informational to High. TA-55 Operations personnel notified the DOE-NNSA Facility Representative of the event categorization addition.

On January 28, 2019, the Triad Laboratory Director accepted the EIT report. The EIT report covers the glovebox glove breach and the response up to the point where the wound count was conducted. Excerpts from the EIT report are included in this occurrence report. (Ref.: LA-UR-19-20258, "LANL Investigation Report: Investigation of TA-55 PF-4 238Pu Intake during Glovebox Cable Maintenance", dated October 19, 2018.)

On Thursday, May 16, 2019, the TA-55 FOD received the final dose results. Following consultation with the Radiation Protection subject matter expert, the TA-55 FOD added the following reporting criteria:

1. Group 6C(1), Report Level High, due to the fact that the bone surfaces internal dose of 118.5 rem exceeded the 10CFR835 organ dose limit of 50 rem.
2. Group 6C(3), Report Level Low, due to the fact that the whole body internal dose of 3.6 rem exceeded the internal dose threshold in this criterion of 500 mrem Committed Effective Dose (CED).

MANAGEMENT RESPONSE

In response to this event, ADPSM and Associate Directorate for Environment, Safety, and Health (ADESH) management took the actions described below. These actions remain in place and are being tracked in the institutional Issues Management Tool (see the Corrective Actions section of this report).

On September 4, 2018, all cable replacements on the counterbalance doors were paused. On September 12, 2018, ADPSM issued a memo (ADPSM: 18-031) directing all PF-4 GLs and FLMs to:

• conduct an extent-of-condition assessment of all gloveboxes and hoods with the workers who operate in those enclosures and identify and document items that could potentially penetrate a glovebox glove, to include fixed features of the glovebox;
• ensure all PF-4 glovebox operations, or "hot jobs," with a potential to come into contact with any sharp to have completed a sharps screening in accordance with PA-RD-01015, "TA-55 PF-4, RLUOB and CMR Glovebox Safety Program";
• evaluate results of the sharps review/screening for adequacy and ensure no work occurs until personal protective

equipment is incorporated into authorizing-work documents and is available and used prior to work execution; and
• meet with employees and emphasize the importance of controlling sharps in gloveboxes or other plutonium-contaminated environments. Discussion to include items that may not have previously been considered a sharp.

On September 12, 2018, ADESH issued Standing Order RP-SO-005, "Skin Contamination Requirements". The Standing Order communicated new requirements following skin contamination events and required a confirmatory count by RP-SVS when:

• skin contamination is detected or thought to have occurred and the radioactive contaminant is an alpha emitter or hard-to-detect beta/gamma nuclide and
• a wound or suspected wound occurred and the skin or potential damage occurred in areas posted for radiological hazards (exception external radiation) or during work with radioactive material.

The Standing Order will remain in place until the new requirements are incorporated into the relevant Radiation Program procedures. Group Leaders briefed their radiation protection staff and team leaders and had them complete the required reading per Curriculum 116.

Ref.: IM Record Nos. 2018-1847 (Parent record) and 2019-503, 2019-504; 2019-505; 2019-506; and 2019-507 (Child records)

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16. Is Subcontractor Involved? No

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19. Immediate Actions Taken and Results:

1. The workers paused the glovebox counterbalance door maintenance. On May 18, 2019, after work documentation was updated, affected workers briefed and the work walked down, NPI Division management authorized the resumption of glovebox maintenance work.

2. RCTs surveyed W1's left Trionic glove detecting contamination of 2000 dpm on the glove, 2000 dpm on the skin of his left ring finger, and 400 dpm on the skin of his left pinky finger after removing his protective gloves.

3. RCTs decontaminated W1's left ring and pinky fingers to NDA. Since there was no visible indication of a skin break, abrasion or blood, no further actions were taken at the time.

4. RCTs red lit the room, decontaminated the area and changed out the breached glove. Afterwards, the RCTs unlit and released the room.

5. Radiation protection staff issued W1 a diagnostic bioassay kit and restricted his access to TA-55-4 and other RCAs pending return of filled bioassay kit. On August 23, 2019, W1 returned his filled kit that was subsequently sent for analysis. On August 27, 2019, W1's access to TA-55-4 and other RCAs was reinstated.

6. On Thursday, August 30, 2018, positive bioassay results were returned. Medical intervention was executed and completed in October 2018. Radiation Protection management placed W1 on additional bioassay monitoring to determine potential dose and restricted W1's access to TA-55-4 and RCAs. On May 29, 2019, W1’s access to TA-55-4 and RCAs was reinstated.

7. On Friday, August 31, 2018, the Laboratory Director appointed a team to investigate the event and to provide recommendations for any corrective actions needed to prevent recurrence. On January 28, 2019, the Triad Laboratory Director accepted the EIT report.

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20. ISM:

1) Define the Scope of Work
2) Analyze the Hazards
3) Develop and Implement Hazard Controls
4) Perform Work Within Controls
5) Provide Feedback and Continuous Improvement

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21. Cause Code(s):

A4B1C06 - Previous industry or in-house experience was not effectively used to prevent recurrence
A4B5C01 - Problem identification methods did not identify need for change
A3B2C02 - Signs to stop were ignored and step performed incorrectly
-->couplet - A4B1C01 - Management policy guidance / expectations not well-defined, understood or enforced
A4B3C11 - Inadequate work package preparation
A4B3C06 - Planning not coordinated with inputs from walkdowns/task analysis
A4B4C03 - Appropriate level of in-task supervision not determined prior to task
A4B1C04 - Management follow-up or monitoring of activities did not identify problems
A4B3C08 - Job scoping did not identify special circumstances and/or conditions

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22. Description of Cause:

ISM SUMMARY

Step 1, Define the Scope of Work
• The Integrated work document (IWD) performance steps did not reflect the actual steps for a loop-to-loop knot replacement techniques.

Step 2, Analyze the Hazards
• Frayed cable hazard not identified in 2017 IWD review.
• Differences in consequences between Pu238 and Pu239 from an injection was not fully appreciated or recognized. This resulted in inadequate work planning and controls for Pu238 injection hazards.

Step 3, Develop and Implement Hazard Controls
• Although previously acknowledged by workers, management response to mitigate sharps hazard from frayed wires was less than adequate.

Step 4, Perform the Work in Accordance
• When workers encountered the unexpected cable condition, they did not recognize the need to stop or pause work and re-evaluate the work plan and controls.
• The IWD renewal process did not follow the LANL or Maintenance work management requirements; therefore, the proper reviews or task validation walk down did not occur.
• Management did not fully understand or implement the skill-of-craft requirements to identify worker training and qualification requirements for the task.

Step 5, Provide Feedback and Continuous Improvement
• This event illustrated that microscopic amounts of radioactive material can be injected into the body even if there is NOT an observable wound or break in the skin.

EXTENT OF CONDITION REVIEW

The TA-55 FOD assessed the need for an Extent of Condition (EOC) in accordance with DOE Order 232.2, Occurrence Reporting and Processing of Operations Information and determined one was warranted. In coordination with the Associate Laboratory Director for Weapons Production (ALDWP), the TA-55 FOD initiated the following actions: 1) Examined a total of 440 gloveboxes to determine if there were any other operations lacking a sharps review. All the

gloveboxes examined had a sharps review accounted for. No additional locations were identified that lacked a sharps review. 2) Issued Standing Order PA-SO-01058, which paused all TA-55 programmatic maintenance work activities that used a manufacturer's manual until programmatic work requirements are established. 3) Complete a gap analysis to identify aspects of P950, P300, the Maintenance AP-WORK series and PA-AP-01000 that apply to planning and execution of programmatic maintenance activities in a nuclear facility. 4) Formalize a programmatic maintenance work planning and execution process that address the gaps identified from the gap analysis. 5) Enhance the facility maintenance and construction work planning and execution process that addresses the gaps identified from the gap analysis. 6) Evaluate the effectiveness of the qualification program for personnel conducting maintenance activities in PF-4 to determine if the task to training process ensures that an activity is demonstrated safely and compliantly; therefore, can be managed as "skill of craft" or that specific work steps in sequence are incorporated in the maintenance activity procedure/work package. These actions are captured in the respective IM record and are being tracked to closure (see Corrective Actions Section of this report).

CAUSAL ANALYSIS METHODOLOGY

During the investigation, the EIT conducted numerous interviews, document and evidence reviews, and physical evidence examinations to identify actions, inactions, and conditions present that resulted in a worker intake of Pu-238 during glovebox door counterbalance cable replacement. A root causal analysis using the Enhanced 5-Whys, Barrier Analysis, Event and Causal Factors Charting, and Human Performance Improvement methodologies were performed to identify the direct, root and contributing cause(s) and human errors for this event. The team identified one (1) direct cause, five (5) contributing causes, and six (6) root causes for the event and the event response. The EIT then assigned a cause code to each contributing and root cause from the DOE Causal Analysis Tree as described in DOE Standard DOE-STD-1197-2011, "DOE Occurrence Reporting Causal Analysis Standard".

ROOT CAUSE ANALYSIS

Direct Cause

The EIT determined the direct cause of the event to be a puncture of a Pu-238 glovebox glove by frayed wires resulting in a puncture wound and worker Pu-238 intake. The causal factor that best describes this deficiency is A3B2C02, Signs to stop were ignored and step performed incorrectly coupled with A4B1C01, Management policy, guidance/expectations not well-defined, understood or enforced as described Root Cause 3, 4 and 5 below.

Contributing Causes

The EIT identified the following contributing causes:

1. Previous post-job reviews did not identify the need to implement sharps hazard controls because the frayed cables were not recognized as a latent sharp. The causal factors that best describe this deficiency are A4B1C06, Previous industry or in-house experience was not effectively used to prevent recurrence and A4B5C01, Problem identification did not identify need for change.

2. When workers encountered the unexpected cable condition, they did not recognize the need to stop or pause work and re-evaluate the work plan and controls. Instead, W1, W2, and W3 continued the evolution to remedy the cable condition. The human performance causal factor that best describes this deficiency is A3B2C02, Signs to stop were ignored and step performed incorrectly coupled with A4B1C01, Management policy, guidance/expectations not well-defined, understood or enforced as described in Root Cause 4 below.

3. Work Order Task Integrated Work Document (IWD) steps were generic and did not match actual work activity steps/process because the work was considered skill-of-the-craft and the work steps allowed workers skill-of-the-craft decision making based on their training and work experience. However, the IWD work steps were numbered and, in accordance with Conduct of Operations (CoO), were required to be strictly followed step-by-step such that any deviation would require a pause work. The IWD failed to integrate both skill-of-the-craft and CoO requirements. The causal factor that best describes this work process oversight is A4B3C11, Inadequate work package preparation.

4. A validation walkdown of the IWD was not performed because the frayed cable hazard was not identified in the 2014 or 2017 Work Order IWDs due to the lack of application of the AP-01000 requirements to NPI-3 maintenance activities. The causal factor that best describes this work validation deficiency is A4B3C06, Planning not coordinated with inputs from walk-downs/task analysis.

5. W1 did not provide supervision of W2 and W3's work execution because he did not recognize the need to provide constant supervision of W2 and W3. The causal factor that best describes this supervision oversight is A4B4C03, Appropriate level of in-task supervision not determined prior to task.

Root Causes

As described below, the EIT identified the following root causes of the event and event response:

1. Frayed wire hazard did not get addressed within NPI-3 when identified. Wires extending past the crimped portion of the cable are a fabricated feature. Frayed wires existed at both ends of the fabricated cable. The causal factors that best describe this hazard resolution oversight are A4B5C02, Change not implemented in a timely manner and A4B1C08, Corrective action responses to a known or repetitive problem was untimely.

2. The IWD renewal process did not follow the P300 and AP-WORK requirements per the MSS work planning process. This oversight resulted from: a) previous post-job reviews did not identify the need to implement sharps hazard controls because frayed cables were not recognized as a latent sharp; b) a validation walkdown of the IWD was not performed; c) the IWD was informally managed as a "standing" IWD outside of the Standing IWD process; and d) AP-WORK Standing IWD renewal requirements (i.e., subject matter expert [SME] reviews, etc.) were not implemented. The causal factor that best describes this work planning deficiency is A4B3C11, Inadequate work package.

3. SME reviews were less than adequate (LTA), including hazard identification and field validation, because NPI management did not implement the 2015 PA-AP-01000 revision that expanded scope to include programmatic maintenance worker activities. As a result, the frayed cable hazard was not identified in the 2017 Work Order IWD; a validation walkdown of the IWD did not occur; and PA-AP-01000 work planning review was not applied to the work order/IWD reviews. The causal factors that best describe this program implementation deficiency are A4B1C01, Management policy guidance/expectations not well-defined, understood or enforced and A4B1C04, Management follow-up or monitoring of activities did not identify problems.

4. NPI-3 management did not fully understand or implement skill-of-the-craft requirements. Because of this lack of understanding and implementation, the WO Task IWD steps were generic and did not match actual work activity steps/processes. Work was considered "skill-of-the-craft" and work steps allowed workers skill-of-the-craft decision-making based on training/work experience. Maintenance qualification was not identified as required for glovebox maintenance, therefore, it did not get assigned to W2 and W3. The skill-of-the-craft requirement was not fully defined in the Maintenance Worker Qualification. The causal factor that best describes this Skill of the Craft implementation deficiency is A4B1C01, Management policy guidance/expectations not well-defined, understood or enforced.

5. Skill-of-the-craft and training/qualification identification were LTA because NPI management did not implement the 2015 PA-AP-01000 revision that expanded scope to include programmatic maintenance work activities. W2 and W3 did not have qualified maintenance worker training. Training requirements in IWD for the work activity only required glovebox work qualification and experience. IWD did not get a Systematic Approach to Training (SAT) review. Furthermore, W1 did not provide supervision of W2 and W3's work execution because he did not recognize the need for constant supervision. When they encountered the unexpected cable condition, workers did not recognize the need to stop or pause work and re-evaluate the work plan and controls. The causal factors that best describe this program implementation deficiency are A4B1C01, Management policy guidance/expectations not well-defined, understood or enforced and A4B1C04, Management follow-up or monitoring of activities did not identify problems.

6. The difference in consequence between Pu-238 versus Pu-239 from an injection was not fully recognized. The injection pathway is uncommon for Pu-238 exposure, whereas the airborne pathway is common and is controlled. With

respect to hazard analysis and response protocols, the need to consider the intrinsic properties of Pu-238 from an injection standpoint was identified. Throughout the investigation, workers, managers, and SMEs clearly articulated the difference in controls and understanding for the inhalation and external dose hazards associated with Pu-238. However, the understanding of a small amount of Pu-238 that could be injected and result in a significant dose was not well understood or articulated. This intrinsic property of Pu-238, coupled with the ease with which the isotope can be shielded from conventional field survey equipment, points to a need to better evaluate radionuclides based on their intrinsic properties. These properties include: type and energy emitted radiations, chemical properties, particle size, solubility, biokinetic behavior of intakes, dose coefficients, and specific activities. The properties, coupled with the ability to easily detect (or shield) an isotope are critical criteria when evaluating hazards, defining controls, and determining the need for confirmatory counts and timely distribution of bioassay kits. The causal factor that best describes this hazard recognition deficiency is A4B3C08, Job scoping did not identify special circumstances and/or conditions.

HUMAN PERFORMANCE IMPROVEMENT

The Anatomy of an Event was used to assess the Human Performance Improvement (HPI) aspects of this investigation. It is important to recognize that human performance tools and practices are implemented within the Integrated Safety Management (ISM) framework, not as a stand-alone program outside of ISM. Below is a summary of this integration.

Work was defined and implemented in accordance with IWD 488243-01. IWD instructions were minimal and relied on skill-of-the-craft to accomplish the task. Interviews identified that there are variances in the way workers execute this task. In this case, a loop-to-loop connection between an old cable and a new (replacement) cable was employed by pulling on the old cable so the new cable can follow into position. Others interviewed who have performed this task indicated a different method: they remove the old cable and then thread the new cable into position. Tape is used to cover exposed wire frays (sharps) prior to handling and again if there is a need to connect two cables together.

During task execution, W1, W2, and W3 failed to recognize that the knotted/stuck cable condition deviated from the envisioned or planned scope of work. Potential deviations from expected outcomes are typically discussed in the Pre-Job Brief by asking a question like, "What is the most likely consequence should an error occur?" It is at this point where contingencies, including pausing work, are considered and agreed upon prior to starting work.

Sharps were discussed at the pre-job briefing. However, the sharps hazard analysis due to cable frays or degraded cables was not adequate in two instances. The first was in the planning stage of the IWD, when specific sharps controls were prescribed for Task 5 but not for Task 6. The second was at the point of contact—when the knot occurred. In this situation, the need to pause and reassess the new situation was not adequately executed.

Just prior to the event, W2 encountered an unexpected condition when the cable connection became knotted. A slight pause was utilized to assess the situation; however, it quickly transitioned into problem solving. W3 added a second new cable, and this connection subsequently became stuck between the two pulleys. W1 then attempted to resolve the situation.

Failure to consider how these new conditions changed the scope of work and hazards did not result in a change in controls.

Once the glove breach occurred, stress became a major factor for W1. W1's demeanor noticeably changed. Uncertainty of W1's responses due to W1's psychological condition led RCTs, RP supervision, and co-workers (W2 and W3) to repeatedly ask and look for evidence of a wound (observable blood, break, or abrasion in the skin). Finding no evidence of a wound, the RCTs followed skin contamination protocols.

JUDGMENTS OF NEED

The EIT identified the following Judgments of Need (JONs):

JON 1: Management implementation of P950, AP-WORK series, PA-AP-01000 was LTA with respect to no SME

review; hazard analysis LTA; SAT determination not performed; and identification of on-shift training requirements LTA which collectively resulted in a management breakdown to fully implement conduct of operations requirements.

JON 2: IWD performance steps LTA due to conflicts between skill of the craft requirements and conduct of operations procedure development.

JON 3: Management follow-up LTA to eliminate frayed wire hazard.

JON 4: Workers did not identify the need to pause work in accordance with LANL P101- 18.

JON 5: Management did not fully appreciate the difference in the injection hazard posed by isotopes with different intrinsic properties, in this case, greater specific activity.

As noted in the Corrective Actions section of this report, the responsible line management have developed corrective actions to address each of the JONs. The corrective actions have been entered into the Issues Management Tool for tracking through closure.

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25. Corrective Actions

(* = Date added/revised since final report was approved.)

1. REVISION OR EXTENSION OF THIS ACTION REQUIRES FACILITY OPERATIONS DIRECTOR APPROVAL. Title: Develop and Implement Corrective Actions to Address JON 1. Action: The responsible ALDWP organizations have developed corrective actions for implementation to address Judgment of Need 1 (JON1). Following is a summary of these actions: - Revised glovebox door maintenance IWD and approved with SME review to require cable replacements with stainless steel cables have an engineered control for cable ends. - Created new work document to perform preventive and corrective maintenance on glovebox counterbalance doors. - Issued memo issued instructing NPI-3 staff to get work planners to get SME reviews per PA-AP-01000. - Issued Standing Order pausing programmatic maintenance work that use manufacturer's manual until such maintenance work requirements are established. - Conduct gap analysis to identify aspects of P950, P300, AP-work series and PA-AP-01000 that apply to programmatic maintenance work. - Conduct independent assessment to determine how facility and programmatic maintenance activities are conducted in the field. - Formalize programmatic maintenance work planning and execution and enhance facility construction work planning and execution process based on gap analysis results. Deliverable: See specific actions for deliverables. Due/Completion Date: See specific actions for due or completion dates. Responsible Organization: ALDWP See IM Tool No 2019-503, Actions 1 through 9 for action closure and objective evidence. These actions address cause codes A3B2C02, A4B3C11, A4B1C06, A4B5C01, A4B3C06, A4B1C01, A4B1C04 and A4B4C03, which are identified in the causal analysis. NOTE: This action has been closed in ORPS based on the documented completion of the Issues Management Tool entry.

Target Completion Date: 06/24/2019	**Completion Date:** 06/24/2019

2. REVISION OR EXTENSION OF THIS ACTION REQUIRES FACILITY OPERATIONS DIRECTOR APPROVAL. Title: Develop and Implement Corrective Actions to Address JON 2. Action: The responsible ALDWP organization has developed corrective actions for implementation to address Judgment of Need 2 (JON2). Following is a summary of these actions: - Evaluate qualification program effectiveness for personnel conducting maintenance at PF4. - Develop any corrective actions warranted from effectiveness evaluation. Any actions developed will be entered and tracked to closure in IM Tool. Deliverable: See specific actions for deliverables. Due/Completion Date: See specific actions for due or completion dates. Responsible Organization: ALDWP See IM Tool No 2019-504, Actions 1 and 2 for action closure and objective evidence. These actions address cause codes A4B3C11 and A4B1C01, which are identified in the causal analysis. NOTE: This action has been closed in ORPS based on the documented completion of the Issues Management Tool entry.

Target Completion Date: 06/24/2019	**Completion Date:** 06/24/2019

3.

REVISION OR EXTENSION OF THIS ACTION REQUIRES FACILITY OPERATIONS DIRECTOR APPROVAL. Title: Develop and Implement Corrective Actions to Address JON 3. Action: The responsible ALDWP organizations have developed corrective actions for implementation to address Judgement of Need 3 (JON3). Following is a summary of these actions: - Identified requirements for over gloves use with sharps and shards unless Division level management grants variance after evaluation of corresponding process. - Revised 26Y-202048 to include double crimp to protect workers from puncture hazard posed by cable wire ends in the current configuration. - Developed a schedule for gloveboxes and doors that cable replacement is required. Also identified TNC hoists that require cable replacement. - Revise PA-RD-01015 to provide link for work planning and execution documents within ALDWP to include PA-AP-01000 and/or any document developed per JON1, Action 7. - Develop and communicate to Division management requirements for a controlled and systematic exit from existing Sharps Standing Order. - Complete cable replacement of glovebox doors in Areas 100, 200 and 400 via work package. - Provide engineering evaluation, material and equipment specifications and/or design to replace cable hoist with chain hoists. Deliverable: See specific actions for deliverables. Due/Completion Date: See specific actions for due or completion dates. Responsible Organization: ALDWP See IM Tool No 2019-505, Actions 1 through 14 for action closure and objective evidence. These actions address cause codes A4B5C02 and A4B1C08, which are identified in the causal analysis. NOTE: This action has been closed in ORPS based on the documented completion of the Issues Management Tool entry.

Target Completion Date: 06/24/2019	**Completion Date:** 06/24/2019

4. REVISION OR EXTENSION OF THIS ACTION REQUIRES FACILITY OPERATIONS DIRECTOR APPROVAL. Title: Develop and Implement Corrective Actions to Address JON 4. Action: The responsible ALDWP organizations have developed corrective actions for implementation to address Judgment of Need 4 (JON4). Following is a summary of these actions: - Briefed fissionable material handlers and supervisors of on-shift training/unqualified workers requirements; specifically that qualified workers must supervise unqualified workers. - Refine PIC roles and responsibilities to require supervision of unqualified workers. - Evaluate non-FMO programmatic and facility maintenance work with respect to PIC responsibilities and develop actions to address any gaps identified. Any actions developed will be entered and tracked to closure in IM Tool. - Evaluate training and qualification for PIC position and responsibilities based on JON4, Actions 2-4 and revise as warranted. - Establish an "infrequent and abnormal events" annual training for PF4 workers focused on events and emphasizing pause work expectations. - Better define line between NPI-2, maintenance and construction, moderate hazard work and high hazard work to capture PF4 work that requires 100 percent PIC coverage. Once defined, issue Standing Order. Deliverable: See specific actions for deliverables. Due/Completion Date: See specific actions for due or completion dates. Responsible Organization: ALDWP See IM Tool No 2019-506, Actions 1 through 9 for action closure and objective evidence. These actions address cause codes A3B2C02, A4B1C01, A4B1C04 and A4B4C03, which are identified in the causal analysis. NOTE: This action has been closed in ORPS based on the documented completion of the Issues Management Tool entry.

Target Completion Date: 06/24/2019	**Completion Date:** 06/24/2019

5. REVISION OR EXTENSION OF THIS ACTION REQUIRES FACILITY OPERATIONS DIRECTOR APPROVAL. Title: Develop and Implement Corrective Actions to Address JON 5. Action: The responsible ALDESHQSS organizations have developed corrective actions for implementation to address Judgment of Need 5 (JON5). Following is a summary of these actions: - Issued Standing Order that described what happened and wound count requirement revisions. Standing Order will remain in place until requirements are incorporated into relevant procedures. - Revised RP-SOP-015 to incorporate new requirements for obtaining scans of the skin for contamination. Revised procedure distributed to RCTs, HPFCs, HPs and ESH managers via electronic mail. - Issued event lessons learned document from radiation protection program perspective at the local and institutional levels. - Evaluate rapid bioassay methodology, and if deemed viable, document a plan for using its capability. - Revise Treatment Guidelines for Radiation and Biologic Exposures Procedure to address activation/inclusion of behavioral response resources. - Review DOE-NNSA Field Office feedback regarding event response activities. Develop actions as warranted, enter and manage to closure in IM Tool. Deliverable: See specific actions for deliverables. Responsible Organization: ALDESHQSS See IM Tool No 2019-507, Actions 1 through 6 for action closure and objective evidence. These actions address cause code A4B3C08, which is identified in the causal analysis. NOTE: This action has been closed in ORPS based on the documented completion of the Issues

Management Tool entry.	
Target Completion Date: 06/24/2019	**Completion Date:** 06/24/2019

6. REVISION OR EXTENSION OF THIS ACTION REQUIRES FACILITY OPERATIONS DIRECTOR APPROVAL. Title: Develop and Implement Corrective Actions to Address Other Identified Issues. Action: The responsible ALDWP organizations have developed corrective actions for implementation to address other identified issues relative to the event. Following is a summary of these actions: - Issued event lessons learned document on performing sharps/shards review when introducing tools and components into a glovebox. - Perform an Effectiveness Evaluation on the event. Deliverable: See specific actions for deliverables. Responsible Organization: ALDWP See IM Tool No 2019-1847, Actions 1 and 8 for action closure and objective evidence. These actions address cause codes A4B1C06, A4B5C01, A3B2C02, A4B1C01, A4B3C11, A4B3C06, A4B4C03, A4B1C04, and A4B3C08, which are identified in the causal analysis. NOTE: This action has been closed in ORPS based on the documented completion of the Issues Management Tool entry.

Target Completion Date: 06/24/2019	**Completion Date:** 06/24/2019

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26. Lessons Learned:

When is a wound a wound? During the event, neither the RCTs nor W1 believed there was a break in the skin or a wound. Since there was not a break in the skin or wound identified, a wound count was not required. From a radiological perspective, this event taught us that microscopic amounts of radioactive material could be injected into the body even if there is NOT an observable wound or break in the skin. Even without the presence of associated skin contamination, a pinch, poke, scrape, twist, or other skin annoyance in areas where high specific activity isotopes are used should alert radiation protection personnel of a potential injection of radioactive material; therefore, requiring a screening measurement.

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27. Similar Occurrence Report Numbers:

DP-ALO-LA-LANL-TA55-2000-0009
DP-ALO-LA-LANL-TA55-2003-0017
NA--LASO-LANL-TA55-2008-0019
NA--LASO-LANL-TA55-2017-0007
EM-ID--FID-AMWTF-2018-0004

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30. HQ Keyword(s):

06C--Radiological - Skin Contamination
06F--Radiological - External Exposure
12N--EH Categories - Radiological Skin Contaminations/Uptakes/Overexposures
14L--Quality Assurance - No QA Deficiency

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31. HQ Summary:

On August 18, 2018, during glovebox counterbalance door maintenance in the 200 Area of Technical Area 55, Building 4, a Nuclear Process Infrastructure worker felt a breach to the glovebox glove on his left ring finger. The worker was attempting to resolve a knot at a cable connection using forceps, when he felt a breach to his left glove, exited the glovebox gloves and self-monitored at the glovebox monitor. The monitor alarmed. The workers paused the glovebox door maintenance and notified the Operations Center who called for a Radiation Control Technician (RCT) response. Upon response, RCTs surveyed the worker's left Trionic glove and detected 2,000 disintegrations per minute (dpm) alpha contamination. 2,000 dpm alpha was detected on the skin of the worker's left ring finger, and 400 dpm alpha was detected on the skin of his left pinky finger. The fingers were decontaminated. Later that day, the breached glove was replaced, the decontamination was completed, and the RCTs released the room. Radiation protection staff issued the

worker a diagnostic bioassay kit and restricted his access to radiological controlled areas pending return of filled bioassay kit. On August 30, the Facility Operations Director was informed the bioassay results were positive.