Operating Experience Summary

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Fall from Scissor Lift at Brookhaven National Laboratory Results in Serious Injuries 1

On November 29, 2011, at Brookhaven National Laboratory (BNL), a torch operator working from a mobile scaffold to cut away sectors of the Brookhaven Graphite Research Reactor fell 16 feet when the lift guardrail gave way as he leaned against it. (ORPS Report EM--BHSO-BNL-BNL-2011-0032; final report issued March 21, 2013) A joint Department of Energy (DOE)/ Brookhaven Science Associates (BSA) Accident Investigation Committee (Committee) was charged with performing a thorough investigation to determine the causes of the event, Judgments of Need (JON), and the Corrective Actions (CA) necessary to prevent recurrence.

The Event

Under a contract with the DOE Office of Science, the Environmental Restoration Projects (ERP) group scheduled torch-cutting of the 3-inch-thick steel, south wall of the decommissioned Brookhaven Graphite Research Reactor's outer biological shield. The torch-cutting operation was to be performed in the Contamination Control Enclosure (CCE) south extension, a tented area that is used to minimize fumes/smoke from hot work activities and to ensure proper ventilation flow for airborne radioactivity monitoring.

Night shift staff had erected the CCE in the week before the event. After the pre-job briefing (PJB), the Project Engineer (PE-1) and Decontamination & Decommissioning worker (D&D-1) assigned to the cutting operation signed the effective Radiological Work Permit and then parted ways to perform other individual tasks. A half-hour later, the two workers, wearing appropriate personal protective equipment to protect them from radiation and cutting slag, entered the scissor lift to start the cutting operation. Multi-gas monitoring was in place because of the hot work and to measure potential off-gassing of the previously installed sealing foam.

Neither worker inspected the scissor lift (similar to the ones shown in Figure 1-1 below) before use because each worker assumed that the other had done so. If one of the workers had performed the inspection, he would have discovered that pins designed to secure the guardrail from accidentally opening were missing. Both workers were qualified to use the lift and, therefore, knew of the requirement to perform a pre-use inspection; however, the responsibility for the inspection was not specifically assigned during the PJB.

D&D-1 raised the lift to working height and began the torch-cutting operation; PE-1 monitored gas readings. The supervisor assisted the workers by attending to filters and hoses. Soon after they started cutting, the gas monitor showed rising levels of carbon monoxide. Thus they stopped and cut a

Figure 1-1. Examples of extended and unextended Skyjacks

hole for ventilation before continuing. After a half-hour, D&D-1 had completed one horizontal cut and one vertical cut on the right side and was making a horizontal cut in an area 21 feet above the ground.

The two workers decided to switch positions on the lift because D&D-1 was experiencing difficulty performing the cuts due to his height. PE-1 took over torch-cutting and D&D-1 monitored the gas reading. A few minutes later, D&D-1 raised the lift and leaned against the guardrail, unaware that it was unsecured; the guard rail folded open, and D&D-1 fell approximately 16 feet to the floor below. He fell onto his right side, suffering multiple fractures and damaged lungs.

PE-1 immediately called for assistance, and coworkers contacted BNL fire rescue. PE-1 moved the lift away from the injured D&D-1, who was able to roll onto a backboard brought by the shift supervisor. Fire rescue moved D&D-1 out of the area, removed sections of his protective clothing, and performed a radiological survey that showed no contamination. An ambulance took him to the hospital where he was admitted.

The accident scene was secured and the ERP Director issued a memorandum suspending all work at heights in that building. Almost immediately, a Laboratory-wide Extent-of-Condition review of aerial lifts with hinged guardrail systems began.

The Investigation and Causes

A joint DOE-BSA Committee was charged with investigating the accident to determine the causes, JONs, and CAs necessary to prevent recurrence.

Immediate CAs

After the first days of Committee fact-finding, several CAs were taken to address the identified weaknesses, including the following actions.

- Verify the inspection status of equipment and the training status of operators.
- Institute a documented daily inspection of each major piece of equipment to be used on the tasks. Such an inspection would have identified the missing guardrail pins.
- Increase oversight by Environment, Safety and Health oversight personnel.
- Enhance PJBs to discuss routine hazards and controls associated with industrial equipment and high-hazard activities.

After the CAs were reviewed and approved in December 2011, eight tasks were authorized to proceed, none of which involved the use of aerial lifts.

Causes

The Committee determined that the accident's *direct cause* was an unsecured guardrail system that allowed the worker to fall out of the aerial lift. The two *root causes* were (1) management and workers did not apply critical work planning and control processes in a comprehensive and disciplined manner, and (2) project conditions combined with reduced perceptions of risk fostered behaviors that were inconsistent with an effective safety culture. Finally, the Committee identified seven *contributing causes*, also called Causal Factors, outlined below.

1. Lack of focus on routine high-hazard activities during the PJB. On the day of the event, the PJB did not include a discussion of aerial-lift-specific safety issues. When workers routinely use a piece of equipment, such as an aerial lift, they may develop a level of comfort that precludes thinking about the dangers. As a result, the PJB should maintain a daily emphasis on routine high-hazard activities.
2. Lack of conduct of daily inspection by PE-1 or D&D-1. Each worker assumed that the other had inspected the lift. Workers must communicate and not assume that someone else has completed pre-job equipment inspections.

3. **Inadequate and unclear identification of roles and responsibilities regarding the aerial lift inspection.** Without a formalized process assigning roles and responsibilities for specific tasks, such as safety checks, there is no guarantee that they will be performed.

4. **Lack of accountability for ensuring installation of guardrail system pins.** The pins in the guardrail system were not installed because no one was responsible for, answerable for, or accountable for that specific action. The supervisor did not aid worker preparation by providing awareness of the critical step of ensuring that a pre-use inspection was performed, including a check to ensure that pins had been installed before entry into the aerial lift. Further, the work package did not include installation/checking of the pins as a critical step to be completed, and there were no precautions or warnings about that action.

5. **The Job Safety Analysis (JSA) failed to adequately identify hazards and implement mitigating controls.** The JSA addressed hazards at a high level, not at an equipment- and task-specific level (e.g., stating *aerial lift* or *Skyjack SJIII 3226*).

6. **Failure to properly execute worker supervision responsibilities.** As a result of job demands, the supervisor did not maintain his distance and objectivity as oversight and instead acted in the roles of both supervisor and worker (helping with filters and hoses for example). This split attention distracted him from overseeing the task at hand. Such multi-tasking is not uncommon at ERP, where workload schedules may result in a supervisor juggling multiple jobs to meet production demands.

7. **Failure of BSA Support and Oversight at ERP.** The level of oversight and support on routine activities had decreased over time as a result of the transition from a nuclear facility to a radiological facility. Management did not fully appreciate that the reduced level of oversight was not commensurate with the remaining workload and thus did not compensate via improved scheduling of available resources. As a result, audits and/or evaluations were performed too infrequently to detect system deficiencies.

Judgments of Need

The Committee identified nine JONs, including the three that follow.

1. There is a need for ERP to ensure that its supervisors can execute their key responsibilities, which are primarily project management and work oversight, for high-risk and/or routine work. Collateral duties must not deter from supervisory responsibilities.

2. There is a need for ERP to improve the rigor of PJBs to include details relevant to identified hazards and their associated controls, specific roles and responsibilities for implementation, and the appropriate condition of tools or equipment.

3. There is a need for BSA to conduct an Extent of Condition review at the institutional level for each of the identified JONs.

Opportunities for Improvement

Opportunities for improvement (OFI) were developed to address issues discovered during the analysis that were not determined to be causes of this event. Opportunities for improvement, if effectively implemented, would further enhance worker safety. Five of the 10 OFIs are described below.

1. **Worker training and qualifications – Aerial Lift Training.** Improve Job Performance Measures so they are specific to the scissor lift make and model; define the requirement to retain hardcopy training records.

2. Job Training Assessment (JTA) – Aerial Lift Training. Evaluate existing JTAs to ensure that they include all required training.
3. Inspection program – Annual Aerial Lift Inspection. Because the aerial lift did not undergo the required annual inspection, site lifts should be added into MAXIMO (the electronic site work system), which will prompt yearly inspections for all site lifts. In addition, establish a method to capture recalls and alerts for the specific equipment in the annual inspection process.
4. Aerial Lift Specification – Modify the lift specification (part of the procurement process) to indicate that outward folding safety rails are not permitted.
5. Potential Precursors – Improve BSA's evaluation of individual events using a graded approach to determine vulnerabilities at the institutional level. This is especially true for events considered to be a Near Miss of a significant consequence.

Human Performance Factors

Within DOE, most serious events do not happen during high-hazard or complex operations because workers are paying attention, many people are involved, things move slowly, and everyone is mindful. Most serious events occur during so-called "routine" operations such as working on a scissor lift. It is during these routine operations that a focus on safe behaviors is crucial. Opportunities for error, such as failing to perform a pre-work equipment inspection, must be identified and additional controls put into place to provide a second barrier to failure. In this work area, controls such as the ones that follow would formalize accountability for the pre-job inspection. Once these controls are instituted and followed, they can help prevent recurrence.

- Identify guardrail pin inspection as a critical step.
- Clarify exactly who is responsible for the task of daily pre-use inspection of the aerial lift.
- Formalize the pre-job inspection with a procedure or work instruction step, a checklist, and a supervisor sign-off.

Corrective Actions

Eighty-one CAs in the Corrective Action Plan were approved by DOE: 48 were Graphite Research Reactor-specific; 33 were institutional. The CAs will substantially improve safety of work conducted from aerial lifts and scissor lifts, the rigor of work planning, and the oversight provided for work at heights.

KEYWORDS: Scissor lift, D&D, transition, oversight, aerial lift, fall, guardrail, pre-job briefings, supervision

ISM CORE FUNCTIONS: Define the Scope of Work, Analyze the Hazards, Develop and Implement Hazard Controls, Perform Work within Controls, Provide Feedback and Improvement

Accident Investigation: Contamination at Los Alamos Neutron Science Center Due to Deficiencies in Conduct of Operations

2

On August 25, 2012, radioactive contamination was identified at Flight Path-04 (FP-04), an experimental area of the Lujan Center at the Los Alamos National Laboratory Neutron Science Center (LANSCE). The Operating Contractor quickly determined that the contamination had spread offsite and immediately brought in response teams. The investigation determined that the contamination resulted from an individual opening an uncontrolled sample canister containing radioactive Lutetium Technetate ($Lu_2Tc_2O_7$) powder. The root cause of this event has been identified as the lack of sufficiently rigorous formality of operations and quality assurance programs for handling radioactive and toxic samples as well as inadequate work controls. (ORPS Report NA--LASO-LANL-ACCCOMPLEX-2012-0004; final report issued March 7, 2013)

Because of the nature of the radionuclide involved, the event did not affect the safety of workers, the public, or the environment. An Accident Investigation Board (Board) was appointed to investigate the event, determine its causes, and identify Judgments of Need (JON) to prevent recurrence of a similar event. The Board's report is available at: http://www.hss.doe.gov/sesa/corporatesafety/aip/docs/accidents/typea/10-18-2012_LANSCE_Federal_AI_Report.pdf.

Background

The Lujan Center hosts visiting scientists from national and international laboratories, universities, industry, and research facilities and conducts defense and civilian research in nuclear and condensed-matter sciences. FP-04 is an experimental area in the Lujan Center that houses an instrument called the High-Pressure Preferred Orientation Neutron Diffractometer (HIPPO). One type of experiment irradiates sample materials in a neutron beam.

Between 2010 and 2012, such experiments were conducted with materials containing Technetium-99 (Tc-99), a radionuclide that emits low energy beta particles. These sample materials were already radioactive on receipt at LANSCE; this intrinsic radioactivity was not a result of irradiation at LANSCE. Irradiation in the HIPPO neutron beam resulted in additional (mostly short-lived) activation products in the samples. Because Tc-99 has a low energy beta that will not penetrate the sample canister wall, it is difficult or impossible to detect the radioactivity by radiological monitoring of the external part of the canisters. This concern applies to canisters with other low energy radioactive materials and, even more so, to canisters containing hazardous materials because, without some external identifier (e.g., labeling), it is impossible to recognize which canisters contain hazardous materials. As a result, clear labeling and reliable, compliant seals are crucial in maintaining control of the radioactive materials.

Accident Description and Analysis of Events

This accident may be described as having two components: the loss of control (leading to the loss of containment) and the loss of containment (leading to the spread of contamination).

Events Leading to the Loss of Sample Control

In 2010, the LANSCE Person-in-Charge (PIC) made arrangements with University of Nevada-Las Vegas (UNLV) personnel to prepare and ship three samples to LANSCE for irradiation: Neodymium Technetate; Praseodymium Technetate; and Lutetium Technetate. The amount of radioactive material in each sample was well below levels that had to be tracked to ensure compliance with contractual facility safety requirements and well below levels expected to result in health hazards if released. However, the total activity in each sample—about 2 millicuries (mCi)—was high enough that it would need to be handled in an area established to control radioactive contamination if the samples were not in containers that could be relied upon to prevent release. In this case, the samples were in a highly dispersible form with the particle size being approximately 3 to 4 microns.

Lujan Center personnel shipped three empty sample canisters to UNLV, where university personnel put the samples into the canisters and attached the caps. They used indelible markers to mark the aluminum collars of the canisters, and then sealed them, using only three of the six possible screws. The canisters had six screw holes to ensure that the canisters would be robustly sealed with screws in all six holes, but personnel used only three screws to attach the canister cap. Using only three screws was inconsistent with the safety review expectations and posed an increased risk of the canister seal failing (Figures 2-1 and 2-2).

Figure 2-1. Top of Neodymium Technetate sample canister showing three used screw heads and three unused screw holes

Figure 2-2. Sample canisters with handwritten labels

LANSCE had not performed a formal engineering analysis to determine specifications for how the canisters must be assembled and sealed to ensure that the canisters would provide confinement. In addition, LANSCE had not requested—and UNLV did not provide—documentation on how the canisters were to be assembled and sealed.

The safety review of the proposed experiments implicitly assumed that robust seals on the canisters would provide containment while at the Lujan Center and that canisters would not be opened in the facility. As a result, the hazard level was categorized as MEDIUM, and no additional controls were established or required to ensure the validity of the assumptions.

Events Leading to the Loss of Sample Containment

Two of the three samples were irradiated at the Lujan Center in late 2010 and returned to storage. The third, containing Lutetium Technetate, was irradiated in January 2012. Scientists and the Principal Investigator (PI) met at FP-04 to set up the irradiation experiment. The PI mounted the sample canister onto the displex (experimental apparatus), but did not remain for the experiment. Neither the PIC nor the Alternate PIC (APIC) was in the facility, and there is no documentation that a pre-job briefing was held to discuss the hazards of working with Technetium or Lutetium in preparation for the January irradiation experiment. Interviews indicated that there was confusion about who was responsible for ensuring that everyone present understood the hazards of the experiment.

After the experiment, the Lutetium Technetate sample canister was removed from the displex, but there is no record of who removed it, when it was removed, or where it was subsequently stored. There is no record of the location or status of the sample canister for the period from January through August.

On August 20, 2012, an instrument operator in the Lujan Center put Tungsten powder into a sample canister and sealed it with a cap and three screws. The canister was to be used in a procedure to align an experimental apparatus. It was later discovered that this sample canister was built using parts from the Lutetium Technetate sample canister. When retrieved during the investigation, the internal contents of the canister were found to be contaminated with Tc-99. On August 24, a whole body monitor alarmed while a worker was self-monitoring after exiting the LANCE Experimental Area room. On August 25, contamination was identified. Based on the record later recreated by the Operating Contractor, the spread of contamination began on the day of the alignment procedure (August 20), probably when the third sample canister was mistakenly opened for re-use.

Loss of sample control was due to multiple conditions existing in the facility, some of which are listed below.

- There were no clear roles and responsibilities established to ensure consistent handling of samples and sample canisters. Confusion over roles and responsibilities was not limited to handling the Lutetium Technetate sample canister.
- No one at FP-04 maintained records regarding the disposition of canisters removed from the displex. When a sample canister was to be sent to the Radiological Control Technician's (RCT) station, the practice was to put it into a plastic bag, prepare a label, and place the label in or on the bag (Figure 2-3). However, because a copy of the label was not retained at FP-04, there is no conclusive evidence that the canister containing Lutetium Technetate was sent to the RCT station or surveyed.
- Sample canisters were not always sent to the RCT station following irradiation. If sent, they were placed into a common in-box. Because RCT hours are limited, an RCT may not have been present to verify that all paperwork was properly completed.
- There was no systematic naming protocol to ensure a correlation between the Flight Path run logs and the RCT logs.

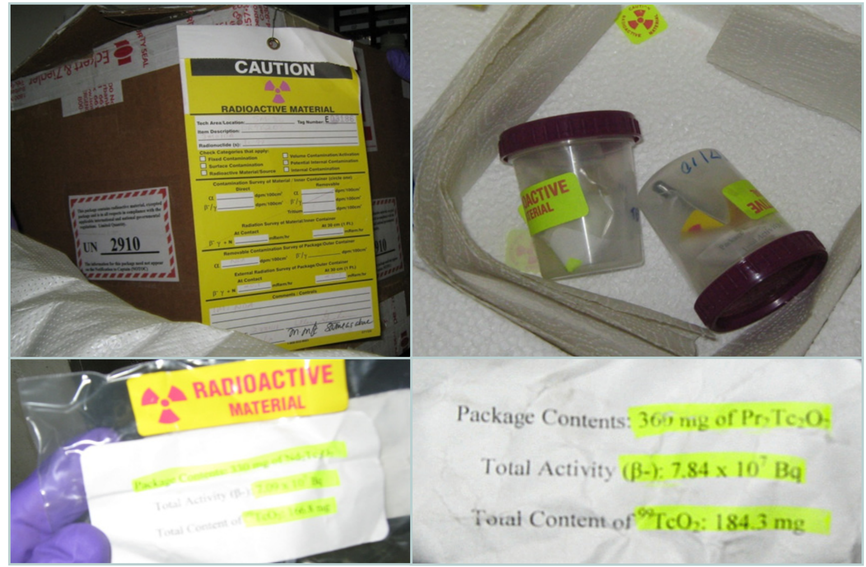

Figure 2-3. Sample canisters were shipped inside plastic bags, held inside plastic cups. The cups, bags, and box were all well marked to indicate their contents and that the contents were radioactive.

- There was no formal tracking or logbook to track samples from the time that they were placed into canisters until the time that they were disposed of or returned to the user. In addition, inventories or sign-in/sign-out logs were not maintained for hazardous or intrinsically radioactive materials stored in radioactive material storage cabinets (Figures 2-4 and 2-5).
- Sample canisters did not have unambiguous features, such as serial numbers, stamped into collars or caps to enable consistent tracking. Instead, information was hand-written on the canister tubes and/or on the cap with indelible markers. Sometimes positive identification was difficult because the labels were illegible.

Figure 2-4. FP-04 radioactive material storage cabinet

Figure 2-5. Inside of FP-04 radioactive material storage cabinet

- Neither UNLV nor Principal Investigator-1 (PI-1) expressed active interest in getting the Lutetium Technetate sample returned, so there was no driver to look for the sample before the August 25, 2012, incident.

The Investigation

The Causes

The Board determined that the *direct cause* of the contamination accident was that an individual opened an uncontrolled sample canister containing hazardous Lutetium Technetate powder, resulting in widespread contamination. The Board determined that the *root cause* was that Lujan Center management did not ensure development and implementation of sufficiently rigorous formality of operations and quality assurance programs for the handling of radioactive and toxic samples. In addition, the Board identified 29 contributing causes, several of which are summarized below.

Contributing Causes

- The amount of radioactive material in each sample was below levels that had to be tracked to comply with facility safety requirements or Title 10 Code of Federal Regulations 835, *Occupational Radiation Protection*, requirements and below levels expected to result in health hazards if released.
- Existing practices relied on administrative controls when simple engineered measures could have protected safety review assumptions. For example, sample canisters were not designed to provide a visible, uniform, tamper-resistant, positive indication that they contained hazardous material and were not to be opened.
- Written procedures did not require qualified canisters or a clear, documented chain of custody.
- Lessons learned from the 2005 Americium contamination event at the Sigma facility were not effectively implemented at the Lujan Center. The Type B Accident Investigation Report for that event can be located at: http://homer.ornl.gov/sesa/corporatesafety/aip/docs/accidents/typeb/LANL_Am_Type_B.pdf.

> The Lujan Center did not implement engineering and administrative controls that ensured intrinsically radioactive samples were identified and controlled in a manner consistent with As Low As Reasonably Achievable (ALARA) requirements.

Formality and Control of Operations

The Board noted the lack of control as it related to canister parts storage. For example, one scientist built a canister with parts that he took from drawers in the cabinet on the sample desk in FP-04. The contents of the drawers in the sample cabinet included various components in various stages of assembly, and parts from one canister were often found in multiple drawers. New canisters, caps, and screws were also available from the APIC, who kept them in a box that he had recently moved to the Lujan Center. Although the sample canisters differed from one another, adapters permitted canisters assembled for one device to be used for another, and the threading on the tubes allowed them to be threaded into collars and caps designed for multiple devices. The opportunity for canister mix-ups was heightened due to multiple personnel preparing samples for other experiments and procedures at the same time, the assembly not always being accomplished in one day, and no control of parts. Further complicating the scenario was the fact that personnel assigned to FP-04 have diverse backgrounds, expectations, and cultural differences including proficiency in English. Those differences had not been systematically explored and addressed to ensure effective workplace management and work control.

Management processes tolerated deviations from expectations, both in terms of work expectations and control of materials and equipment. For example, violations of procedural requirements, even when recognized, were not effectively resolved to ensure personnel complied with safety requirements. In addition, irradiated canisters that the scientists thought (but did not verify) were non-hazardous were sometimes opened in the work area (Figure 2-6), even though multiple personnel agreed that the practice was contrary to requirements to use a glovebox when opening them.

Figure 2-6. Work area/accident scene — Sample canisters are seen on top of supply cabinet and new sample canister/sample staged for preparation on desk.

The Board's final report states that, given these conditions, an accident was inevitable and not attributable to the actions of any one individual. Rather, the accident was the result of management conditions and routine practices developed over years, which were incompatible with a non-routine hazard.

Integrated Safety Management (ISM)

LANL's Integrated Work Procedure, *Integrated Work Management* (P300–3/30/12), establishes Laboratory expectations and outlines the process to ensure that all work is governed by the five ISM Core Functions: Define the Scope of Work; Analyze the Hazards; Develop and Implement Hazard Controls; Perform Work within Controls; and Provide Feedback and Improvement.

As recently as January 2010, the Los Alamos Site Office (LASO) issued a memorandum to the Laboratory asserting that institutional learning and sustained focus on safety had not been embraced across the site. The Laboratory response indicated that, although P300 was a good process, clear gaps existed in implementing that procedure in the research and development environment. Later, Contractor Assurance Office and LANL assessments found that LASO and LANL had placed significant management attention and resources on improving ISM implementation and took appropriate actions in accordance with contract requirements. However, after its investigation, the Board arrived at the following conclusions regarding Core Function implementation at the Lujan Center.

Core Function 1 – Define the Scope of Work

The Board found that the scope of work had been significantly changed without formal review and approval and the experiments were conducted differently than proposed. The three sample canisters containing Technetate were supposed to be examined at ambient temperature and pressure, but in fact were subjected to temperatures as low as 20° Kelvin. PI-1 turned over responsibility to Scientist-1 (S-1) by email, without a briefing or technical document review. As a result, S-1 was not aware of the radiological and chemical hazards associated with Lutetium Technetate.

Core Function 2 – Analyze the Hazards

Neither of the Safety Review Committee appraisals associated with the three sample canisters containing highly dispersible Tc-99 compounds required additional controls for the radiological hazard associated with its release. No engineering review was conducted to ensure that the design of the sample canisters was appropriate to contain radiological material throughout extended experiments or determine if three screws were sufficient to seal them. The safety reviews also assumed that the canisters would not be opened in the Lujan Center.

And, finally, because Health Physics reviews did not recognize the possibility of an uncontrolled release, no measures had been implemented to detect a release and prevent contamination from escaping from the controlled area.

Core Function 3 – Develop and Implement Controls

Although the Safety Review Committee appraisals identified conditions important for safe experiment performance, they did not identify the controls necessary to ensure that these critical assumptions would be protected. In addition, although work document LUJAN-FP-04-006, *General Neutron Scattering Experiments on HIPPO*, specified that radioactive materials required additional work controls, no separate work document or Radiological Work Permit was prepared. The Point of Contact did not ensure that personnel, including the person conducting the experiment, were familiar with the hazards and controls for this work. Written and verbal communication was not tailored to reflect the multi-cultural environment, researchers' lack of proficiency in the English language, or cultural differences in responding to and communicating with authority figures, even though a high number of personnel/researchers were from diverse and multi-ethnic backgrounds. There were no documented work plans or requirements for controlling and tracking the sample or for marking the canister after the RCT's survey.

Core Function 4 – Perform Work Safely

The Board reviewed the previous three LANSCE run cycle readiness reviews from 2010 to 2012. All three reviews assessed the same functional areas and concluded that radiation (sample) safety was well addressed, but atypical conditions were not addressed. Although housekeeping concerns were mentioned for radiation storage cabinets with samples, the Board did not believe that the reviews placed sufficient attention on flowdown of experiment safety controls or atypical conditions. Housekeeping, sample control, and material control procedures were informal, and deviations from expected procedures were common place, known, and tolerated by both Los Alamos National Security and LASO.

Core Function 5 - Feedback and Improvement

The Board found that management did not place sufficient attention on either the flowdown of experimental safety controls into Integrated Work Documents or the atypical conditions of intrinsically radioactive, toxic, or internally contaminated samples. The Board also found that, although management recognized some of the weaknesses and vulnerabilities in sample management practices, they did not take sufficient actions to fully address concerns raised in an earlier Management Observation Verification. Three instances were noted where personnel had loaded or unloaded radioactive samples without RCT coverage. The Board also reviewed the Type B investigation of the 2005, Americium 241 contamination event at the Sigma Facility and determined that lessons learned from that event were not effectively implemented at the Lujan Center. For example, the Sigma event report stated that there had been no significant LASO presence in Sigma or LASO awareness of the status of radiological operations in the facility for the past few years, and no viable external oversight. The report indicated that the absence of LASO oversight and field presence had resulted in a lost opportunity for the National Nuclear Security Administration to observe and assess contractor implementation and the effectiveness of the Integrated Work Management processes. The final report concluded that "the lack of LANL and LASO oversight of Sigma likely contributed to the failure to identify and correct accepted practices and assumed requirements that had developed in the facility in conflict with the formally established requirements of LANL and DOE." Crucial lessons learned were not heeded.

(See the Accident Investigation of the Americium Contamination Event final report at http://www.hss.doe.gov/sesa/corporate-safety/aip/docs/accidents/typeb/LANL_Am_Type_B.pdf.)

Human Performance Indicators

The goal of Human Performance Improvement (HPI) is to facilitate the development of a facility structure that recognizes human attributes and develops defenses that proactively manage human error and optimize the performance of individuals, leaders, and the organization. HPI evaluations identify situations and environments that result in error-prone conditions – conditions in which errors are likely to be made and result in an accident or near miss. Error-prone conditions may involve latent organizational weaknesses that, when combined with a specific worker action, make an accident more likely. Error-prone situations in this event included the following.

- Engineering and administrative controls were not implemented to ensure that samples were identified and controlled consistent with As Low As Reasonably Achievable (ALARA) requirements.
- Sample canisters assembled at UNLV were not marked to indicate contents.
- Clear roles and responsibilities were not established.
- Numerous closed, used sample canisters were found on and in the sample desk and in offices, with vague and often illegible markings to indicate their contents, thus increasing the chances of mishandling.
- Housekeeping, sample control, and material control procedures were informal and known deviations were normalized.

The Board placed special focus on the Lujan Center's high concentration of personnel from diverse and multi-cultural backgrounds. Cultural differences, proficiency in the English language and, perhaps more importantly, differences in normative behavior when responding to authority may have helped create an error-prone condition. Such cultural differences complicated FP-04 operations and may have played a role in the accident.

Judgments of Need

JONs are the managerial controls and safety measures that the Board determined to be necessary to prevent or minimize the probability or severity of a recurrence. JONs are linked directly to causal factors and form the basis for corrective action plans, which must be developed by line management. Fourteen JONs resulted from this event and several of them are summarized below. (More than half of the JONs are intended to eliminate or mitigate the existing error-prone situations in the Lujan Center.) Additional details for each JON can be found in the final report.

- Revise Lujan Center policies and procedures to ensure risks associated with samples containing intrinsically radioactive and hazardous materials are fully identified, documented, and controlled. (JON 1)
- Establish processes by which risks are effectively communicated to workers by readily identifiable features on the sample canisters and in routine pre-job and safety briefings. (JON 2)
- LASO oversight activities need to periodically sample work practices at the experimental and activity level. (JON 4)
- Revise the work control process to ensure that work scope remains consistent with reviewed and approved proposals. (JON 11)
- Conduct a thorough investigation of material in Experimental Area Rooms 1 and 2, offices, and the Chemistry Laboratory to ensure containers do not contain the remnants of the Lutetium Technetate sample. (JON 13)

KEYWORDS: Lutetium Technetate, researcher, Lujan, canister, Flight Path, FP-04, Conduct of Operations

ISM CORE FUNCTIONS: Define the Scope of Work, Analyze the Hazards, Develop and Implement Hazard Controls, Perform Work within Controls, Provide Feedback and Improvement

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