**Facility:** Sandia National Laboratories

**Best Practice Title:** Repurposing and Downgrading of Existing Hazard Category 1, 2, and 3 Nuclear Facilities

**Point of Contact:** Michael Greutman, Manager - Nuclear Safety Analysis, (509) 371-4429, mrgreutm@Bechtel.com,

Jeffrey W. Marr, Safety Basis Engineer, (505) 284-2064, jwmarr@sandia.gov

**Brief Description of Best Practice:** This best practice involves the repurposing and downgrading of existing Hazard Category 1, 2, and 3 DOE nuclear facilities (hereafter referred to as 'nuclear facilities') to either radiological or non-nuclear facilities (hereafter referred to as 'non-nuclear facilities') in an effort to manage facility operations with a rigor appropriate for its inherent hazards. DOE Standard 1027 provides the following guidance for facility categorization and segmentation: "Many DOE facilities conduct a wide variety of activities in one facility, ranging from simple assay or lab experiments to complex fluid flow separations. It is necessary to avoid placing excessive requirements on simple or even trivial co-located operations."

As a facility's mission evolves or as the facility progresses through its lifecycle, the activities performed in the facility and associated hazards may change over time. Factors such as changes in customer's needs or the conclusion of a temporary mission may lead to the repurposing of the facility. Also, there has been a desire to reduce the nuclear footprint or consolidate material throughout the DOE Complex which can lead to repurposing of facilities.

These changes are appropriately managed within existing practices, such as the Unreviewed Safety Question (USQ) process and Documented Safety Analysis (DSA) annual updates. However, at some point in the lifetime of the facility, the hazards associated with its operation may no longer necessitate the requirement to operate the facility under 10 CFR 830, Subpart B requirements. In many cases, this is due to the reduction of nuclear material located within the facility. Thus the facility is able to downgrade from a nuclear to a non-nuclear facility.

This best practice describes the process by which Sandia National Laboratories repurposed and downgraded two nuclear facilities to radiological facilities, and by which is reducing the nuclear boundary of an existing nuclear facility to allow a non-nuclear operation. The process helps ensure an efficient transition from a nuclear operation to a radiological or non-nuclear operation with minimal operational impacts during the transition. The process also ensures that the appropriate level of hazards analyses, hazard control, and operational readiness is identified and achieved and identifies the roles for the NNSA and local contractor Safety Basis Approval Authority (SBAA). The best practice will address the benefits and problems associated with its implementation. Existing non-nuclear facilities may also be proposed for repurposing to a nuclear facility mission, however, this best practice does not address that process.

**What are the benefits of the best practice:** The benefits of repurposing and downgrading a nuclear facility is to ensure the facility is operated commensurate with its hazards. In the case of the examples to be provided in the best practice, a significant cost savings was realized while still maintaining a safe operating environment. By having a process in place to ensure an effective transition, the impacts to operations were minimized, while still ensuring that the enduring operation was appropriately analyzed, controlled, and non-nuclear operational readiness was achieved. Although the hazard controls for the recategorized facility were similar to the nuclear operation, they did not have the same rigor and compliance based requirements as the nuclear facility.

In addition to reduction of the nuclear footprint, the cost benefit of repurposing and downgrading a nuclear facility can extend beyond the specific examples presented in this paper. The rigor of analysis, controls, and operations for a nuclear facility can be much higher than the repurposed end state. Areas for which this rigor could be reduced include:

- Maintenance of the facility's safety basis documentation;
- Facility SSCs which were credited for consequence reduction (potential for reduced maintenance or need for equipment);
- Facility or site safety management programs / administrative programs (e.g., USQ process);
- Fire Protection, Criticality Safety, and/or Emergency Preparedness; and
- Facility security and security features associated with the protection of SNM.

**What problems/issues were associated with the best practice:** The common issues associated with the repurposing and recategorization of a nuclear facility is ensuring that the new activity is appropriately analyzed and controlled[1], and that the non-nuclear infrastructure is in place and operational readiness is demonstrated. This can be complex, as the transition from a nuclear infrastructure (people, processes, and equipment) to a non-nuclear infrastructure is difficult without adversely affecting current operations. Also, personnel may have different perceptions regarding the point in time for when the nuclear facility is considered to be formally operating as a non-nuclear facility. By having an established process and a documented plan, these issues are minimized. Involving stakeholders early in the planning stages, and continued communication is also necessary to mitigate issues.

**How the success of the Best Practice was measured:** Sandia National Laboratories have successfully repurposed and recategorized two nuclear facilities, and have cost and schedule data to measure the success of the process. Background details on repurposing these two facilities is provided on the following pages.

**Description of process experience using the Best Practice:** Sandia has exercised this process twice in the last 4 years (see Attachments 1 and 2). Sandia may use this process in the near future to reduce the nuclear facility footprint of another facility as soon as existing Hazard

[1] SAND2016-3906C, An Industrial Facilities Perspective of the Nuclear Facility Downgrade Process, Kelsey L. F. Curran, Michael R. Greutman & Timothy S. Stirrup, Sandia National Laboratories, Clover Leaf Solutions, Inc. April, 2016.

Category-3 radioactive materials are shipped from the facility. Sandia National Laboratories has revised the process each time, and has documented the process in its Safety Basis Manual. Figure 1 provides a recommended work process flow for repurposing and downgrading a facility.

Lawrence Livermore National Laboratory has also documented a case where a facility was repurposed an HC-2 nuclear facility to a radiological facility[2].

Before proceeding further, consider the future state of the facility – will it be continuing the same operations with lower MAR (downgrading) or different operations (repurposing)? If the operations are different, e.g., different hazards, consider those differences in the nonnuclear safety basis program (e.g., HAR or HAD).

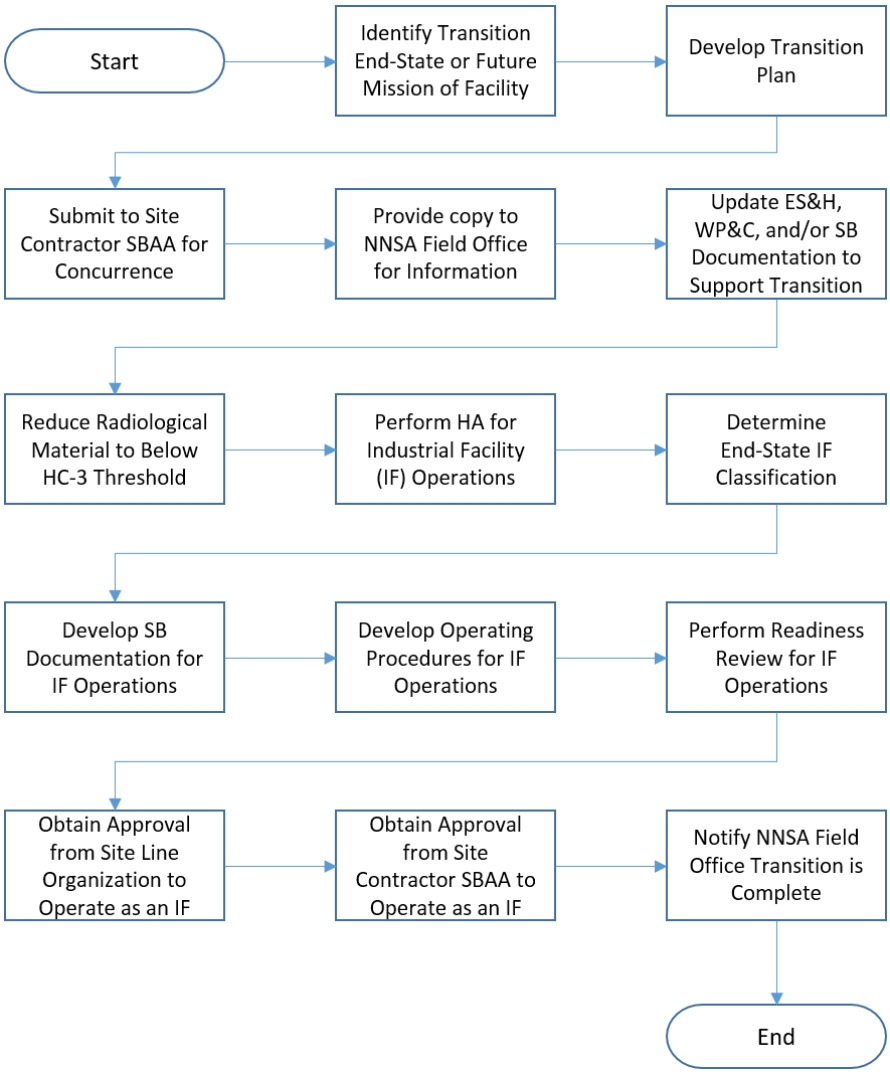


Figure 1. Transition from a Nuclear Facility to an Industrial Facility

[2] UCRL-CONF-220555, The LLNL Heavy Element Facility – Facility Management, Authorization Basis, and Readiness Assessment Lessons Learned in the Heavy Element Facility (B251) Transition from Category II Nuclear Facility to Radiological Facility, M. Mitchell, B. Anderson, E. Brown, L. Gray, April 12, 2006.

Note that this approach succeeded for Sandia and LLNL because those sites already had in place approved nonnuclear safety basis processes and procedures. For sites where this is not the case, an additional step may be required, e.g., the nonnuclear safety basis document (e.g., HAR or HAD) to obtain the necessary approval (e.g., DOE approval).

# Attachment 1: Repurposing the Manzano Nuclear Facilities (MNF)

The SNL Waste Management and Pollution Prevention Department (WMPPD, Org. 4144) operated two Hazard Category 3 (HC-3) nuclear waste facilities at SNL: the MNF, which operated for more than a decade, and HC-3 Transportation (HC3T), which operated for approximately four years. The MNF and HC3T "facilities" supported the handling, management, storage, and on-site transportation of HC-3 quantities of radioactive waste and materials. The MNF consisted of multiple 1940s-era storage bunkers (Manzano Base) tucked into the Manzano Mountains on the eastern edge of the Kirtland Air Force Base (KAFB). Each bunker was considered an independent segment for the purposes of categorization, in accordance with DOE-STD- 1027-92. HC3T was not a physical facility, but rather an operation authorized to move HC-3 quantities of radioactive waste/materials in closed containers. Each HC3T transfer could move one or more containers between the MNF bunkers and SNL Technical Area V (TA-V). Neither the MNF nor the HC3T operation performed work involving open containers.

In early 2014, Sandia Labs launched a concerted effort to downgrade both facilities from nuclear waste facility status. DOE's imperative to conclude the MNF and HC3T HC-3 nuclear waste operations was driven by the objective to continue the reduction of the nuclear facility "footprint" and the associated oversight support.

During the downgrade process, some vital actions had to be accomplished to ensure the project's success:

- All individual HC-3 packages were transferred from the MNF to TA-V facilities by the end of FY13.
- Radiological containers were moved or sent to other bunkers, as needed, to achieve below HC-3 roll-up.
- Positive verification of inventory was performed to ensure that the total radiological inventory for each bunker (segment) was less than the HC-3 threshold quantities (TQ).
- WMPPD's set of technical work documents (TWDs) was modified to remove those controls specific to HC-3 nuclear operations, and to ensure that those documents met the IFSB criteria.
- The WMPPD's computer-based tracking system was modified to ensure that each bunker's inventory was calculated based on HC-3 TQs using the latest DOE-STD-1027 sum-of-the-ratios methodology.
- Once the radiological inventory had been verified, a readiness review was performed to ensure that the bunkers were ready to operate as an industrial facility under the revised safety basis.
- The NNSA Sandia Field Office (SFO) staff was notified when the bunkers were downgraded, when HC-3 onsite transportation activities were discontinued, and when the two nuclear facility safety basis documents were inactivated (an authority not specifically, but implicitly, belonging to SNL).

The actions described in the transition plan were completed, and the SFO was informed of the downgrade on March 26, 2014. With the termination of nuclear operations at the MNF and HC3T, the DSAs and TSRs were retired (i.e., the requirements of 10 CFR 830 Subpart B no longer applied), and the industrial facility safety basis infrastructure took over.

The Documented Safety Analyses (DSAs) and Technical Safety Requirements (TSRs) that formed the safety basis for MNF and HC3T activities have been retired. The bunkers still operate as radiological storage facilities, but neither their demolition nor their return to KAFB custody is planned at this time. Currently the operational infrastructure is driven by Industrial Facility Safety Basis (IFSB) imperatives, as defined in the Sandia National Laboratories *Safety Basis Manual*. Onsite HC-3 transfers between technical areas are no longer conducted as approved activities.

# Attachment 2: Repurposing the Gamma Irradiation Facility (GIF)

The GIF building is a single-story structure located inside the northeast quadrant of the fenced security perimeter of TA-V. The structure consists of a central High Bay with an ancillary Low Bay for offices, storage, and HVAC equipment. Three (3) test cells are located in the center of the High Bay. Two (2) of the test cells are 3 meters (m) by 3 m and one (1) is 5.5 m by 9.1 m. Each of the cells has thick concrete walls and ceilings with access through a locked door and a maze hallway. The 5.3 m deep stainless steel-lined pool can store approximately 1.5 MCi of $_{60}$Co of gamma-ray sources.

The GIF operated as a HC-3 facility for more than a decade. In 2011 and 2012, Sandia Labs launched a concerted effort to downgrade the facility from nuclear facility status. DOE's imperative to conclude the GIF nuclear operations was driven by the objective to continue the reduction of the nuclear facility "footprint" and the associated oversight support.

During the downgrade process, some vital actions were necessary to ensure the project's success:

- A Safety Analysis Report for Packaging (SARP) amendment that involved the conceptual and final designs for a cask insert.
- The development of a Safety Basis Supplement (SBS) for the pin loading operation and removal of non-certified $_{60}$Co sources to reduce the radioactive material inventory.
- Development of facility work planning and control (WP&C) documents, including a Job Safety Analysis (JSA).
- Perform work operations to remove the non-certified $_{60}$Co sources[3].
- Revise the Material at Risk (MAR) control procedure, perform a safety committee review, and provide training.
- Perform the DOE-STD-1027 verification for sealed sources to ensure documentation is in place to demonstrate sources have been tested and passed tests specified by the Department of Transportation (DOT) or American National Standards Institute (ANSI).
- Develop the Final Hazard Categorization document.
- Update technical work documents (TWDs) to remove controls specific to HC-3 nuclear operations.
- Revise other WP&C/SB documents (i.e., Primary Hazards Screening) for operations as a radiological facility.

The actions described in the transition plan were completed in 2012. With the termination of nuclear operations at the GIF, the DSAs and TSRs were retired (i.e., the requirements of 10 CFR 830 Subpart B no longer applied), and the industrial facility safety basis infrastructure took over.

The Documented Safety Analyses (DSAs) and Technical Safety Requirements (TSRs) that formed the safety basis for HC-3 GIF activities have been retired. Current activities include

[3] SAND2012-3108C, Gamma Irradiation Facility (GIF) Cobalt-60 Sealed Sources Transfer Operation, Don Alsbrooks, Sandia National Laboratories, H&P Incorporated, April 2012.

irradiation experiments using certified sealed $^{60}$Co sources that are stored in the GIF pool. The sources are raised into the GIF cells to expose experiments. Other radiation sources located outside the pool may be used in irradiations providing the total quantity of 1027-accountable material remains within the limits specified in the industrial safety basis documentation.

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Sandia National Laboratories




# Repurposing Best Practice Summary


## Jeff Marr, Michael Greutman, Mark Mitchell


## March 2017

U.S. DEPARTMENT OF ENERGY | NNSA National Nuclear Security Administration


Sandia National Laboratories is a multi-mission laboratory managed and operated by Sandia Corporation, a wholly owned subsidiary of Lockheed Martin Corporation, for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000.

# Repurposing Philosophy

"Many DOE facilities conduct a wide variety of activities in one facility, ranging from simple assay or lab experiments to complex fluid flow separations. **It is necessary to avoid placing excessive requirements on simple or even trivial co-located operations**."

# Best Practice Description

- Repurposing existing nuclear facilities (i.e., Hazard Category 1, 2, and 3 DOE nuclear facilities) to non-nuclear facilities (e.g., radiological)
- Process by which SNL repurposed two nuclear facilities
  - Gamma Irradiation Facility (GIF)
  - Manzano Nuclear Facilities (MNF)
- Process, by reference, by which LLNL repurposed one nuclear facility
  - LLNL Heavy Element Facility

# Best Practice Benefits

- Facility operated in manner commensurate with hazards
- Some cost savings – similar set of controls, but lower rigor
- Though SNL experienced moderate cost savings, a potential exists for higher level of cost savings depending on situation
  - Maintenance of SB documentation
  - Reduction in required facility SSCs
  - Reduction in required SMPs/ACs
  - Potential reduction in Fire Protection, Crit. Safety, and/or Emergency Preparedness
  - Facility security / security features

# Problems/Issues

- Ensuring new activity is appropriately analyzed and controlled
- Non-nuclear infrastructure in place and operational readiness is demonstrated
- Perception of when facility is formally operating as a rad/industrial facility
- Importance of having a repurposing/downgrade plan

# Gamma Irradiation Facility (GIF)

Sandia National Laboratories

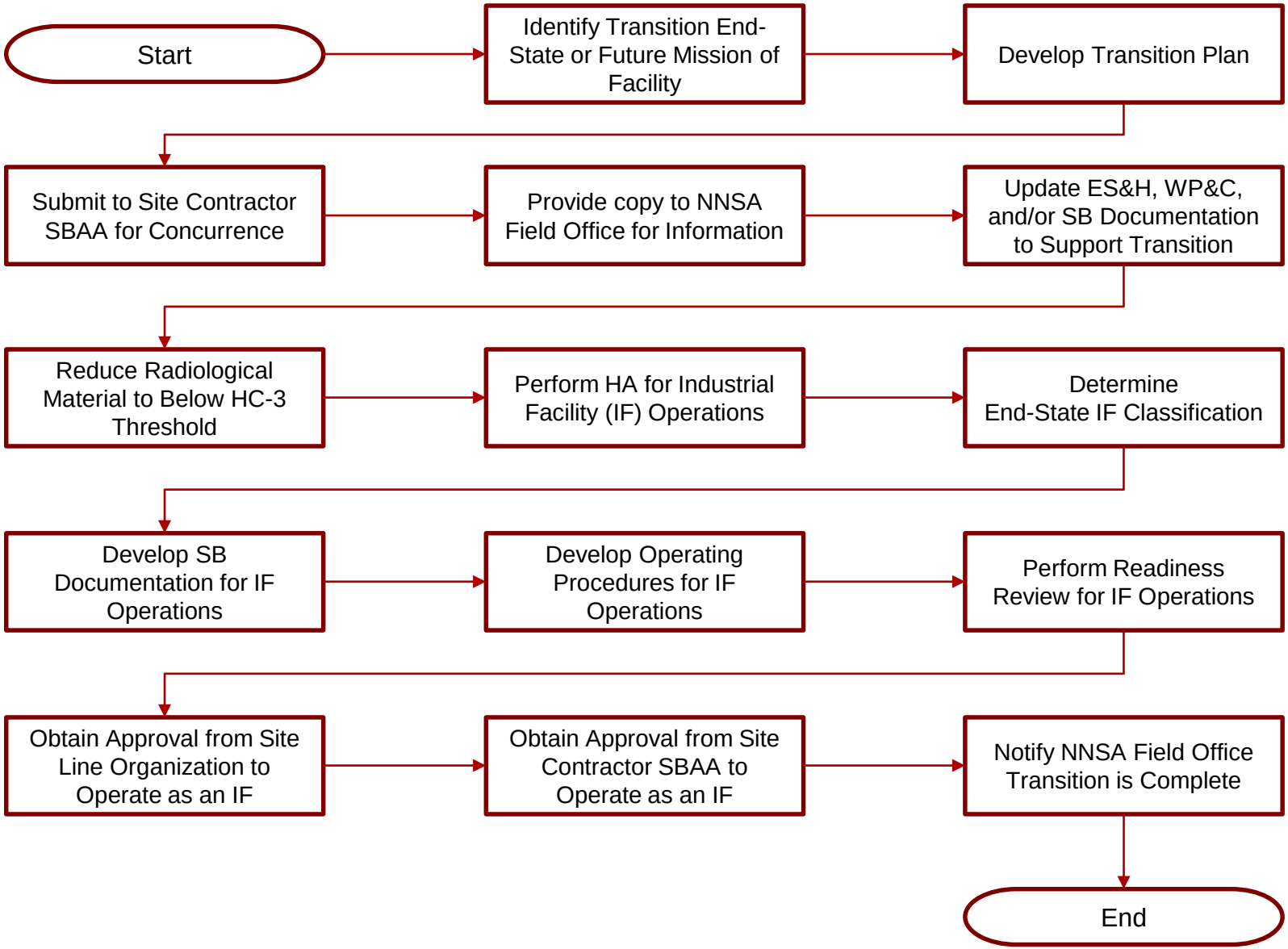
- Development of Safety Analysis Report for Packaging (SARP) amendment.
- Development of Safety Basis Supplement (SBS) for pin loading operations and removal of non-certified $_{60}$Co sources.
- Development of Work Planning and Control (WP&C) documents, including a Job Safety Analysis (JSA)
- Removal of non-certified $_{60}$Co sources.
- Revision to Material-at-Risk (MAR) control procedure.
- Verification of special form sealed sources.
- Development of final hazard categorization document.
- Updated Technical Work Documents (TWDs) to remove controls specific to nuclear operations.
- Revise other WP&C/SB documents for radiological facility operations.

# Manzano Nuclear Facilities (MNF)

Sandia National Laboratories

- Transferred HC-3 packages from the MNF to TA-V facilities.
- Transferred radiological containers to other bunkers, as needed.
- Positive verification of inventory.
- Modification of TWDs to remove controls specific to HC-3 nuclear operations.
- Modification of tracking system to ensure that each bunker's inventory was calculated using latest HC-3 TQs.
- Performance of readiness review performed to ensure that bunkers were ready to operate as an industrial facility under the revised safety basis.
- Notification to NNSA Sandia Field Office (SFO) staff upon completion of downgrade, when HC-3 onsite transportation activities were discontinued, and when the safety basis documents were inactivated on 3/26/2014.

# Repurposing/Transition Process



# An Industrial Facilities Perspective of the Nuclear Facility Downgrade Process

Lead Author: Kelsey L. F. Curran, CIH

Co-Authors: Michael R. Greutman & Timothy S. Stirrup

Sandia National Laboratories, New Mexico/Clover Leaf Solutions, Inc.

klfcurr@sandia.gov

Abstract

Many variables must be taken into account and analyzed when downgrading a facility from one type to another—in this case, from a nuclear facility to an industrial facility. One variable that may be overlooked is the process required to integrate the safety basis of the former nuclear facility into an industrial facility safety basis, which does not require a Documented Safety Analysis, while still maintaining the rigor and integrity of an the Hazard Analysis. Hazards not previously carried forward for analysis as a nuclear facility may be identified, and may require further analysis as hazards pertinent to an industrial facility. These hazards may have been previously screened out based on the receptor, material quantity, or the potential hazards' inability to impact the operator. The Process Safety Management element may also be a new concept that new industrial facilities will need to incorporate into their facility documentation.

This presentation will highlight the "lessons learned" during the downgrade from a nuclear facility to an industrial facility from the Industrial Facilities Safety Basis standpoint. We will focus on the struggles encountered, as well as the improvements made durring the downgrade process/protocol at Sandia National Laboratories, and will identify the areas found to be most problematic when bridging the gap between the nuclear facilities safety basis and the industrial facilities safety basis processes.

Introduction

At Sandia National Laboratories (SNL), facilities/activities are categorized as either nuclear facilities or industrial facilities. Nuclear facilities are classified as Nuclear Hazard Category 1, 2, 3 facilities, or radiological. Industrial facilities at SNL are classified as business occupancy (office), standard industrial hazard (SIH), low, moderate, high, or accelerator facilities. As a result of this integration between nuclear and industrial facilities, SNL not only has to implement the Safety Basis for nuclear facilities, but is also required to incorporate and apply Safety Basis principles to its industrial facilities. Consequently, SNL, along with its Department of Energy (DOE) counterpart at the Sandia Field Office (SFO), maintains the industrial facility safety basis (IFSB) branch as part of the corporate Safety Basis group.

In addition to the industrial facility classification (office, SIH, low, moderate, high, or accelerator), a "radiological" designation is given to those industrial facilities having radiological material or radiological generating devices below the Hazard Category 3 (HC-3) threshold limits, as required by NA-1 SD G 1027, *Guidance on Using Release Fraction and Modern Dosimetric Information Consistently with DOE STD 1027-92, Hazard Categorization and Accident Analysis Techniques for Compliance with DOE Order 5480.23, Nuclear Safety Analysis Reports, Change Notice No. 1.*

The Safety Basis hazard classification process is consistent with the SNL Integrated Safety Management (ISM) process, and meets the requirements of the SNL Prime Contract, Clauses I-72, *Laws Regulations and DOE Directives*, and I-78, *Integration of Environment, Safety, and Health into Work Planning and Execution*, which establish the Safety Basis foundation at SNL. In addition to being a requirement per the SNL ISM and the SNL Prime Contract, the Safety Basis hazard classification process determines the appropriate approval authority level between SNL and the SFO, as well as the appropriate level of documentation, and the associated facility controls.

SNL takes a graded approach to the application of the Industrial Facility Safety Basis (IFSB) at industrial facilities located throughout the Laboratories. Many of the concepts associated with the Nuclear Facility Safety Basis (NFSB) were used as a guide to shape the IFSB process. When downgrading from a nuclear facility to an industrial facility, it is important to remember that many of the nuclear concepts are still in play for an industrial facility: hazard analysis, control derivation, safety envelope, reviews, change control, etc.

Recently, SNL has downgraded two former nuclear facilities to an industrial facility hazard classification status. This paper discusses some of the general aspects of the downgrade process, including documentation requirements and a general overview of industrial facility hazards, and also provides some lessons learned, from the IFSB perspective, about the development of the Stand-Alone Hazard Analysis (S-HA) document.

Safety Basis Documentation

The required SNL Safety Basis documentation for low-hazard industrial facilities or activities includes an approved Primary Hazard Screen (PHS) document and an integral hazard analysis (HA). For low-hazard industrial operations at SNL, managers are required to ensure both a PHS document is approved, and the integral HA section of the PHS is completed or an S-HA is prepared for all low hazards identified in the PHS. In the case of a downgraded former nuclear facility, an S-HA might also be a required part of the downgrade process/plan.

In either case, the S-HA will 1) identify the hazards, as well as the controls necessary to mitigate or prevent the impacts of the hazards, and 2) serve as the Safety Basis documentation for the facility. If an S-HA will be used to support hazard classification, the S-HA should use a risk-based assessment to identify both the hazards and the corresponding controls. The set of controls represents the safety envelope for the facility or activity. The risk-based assessment performed by the IFSB group is typically includes a qualitative risk analysis (QRA). The QRA matrices and the associated frequency and consequence terminology and designations used for the NFSB and the IFSB may differ slightly. Below is an example of an IFSB QRA matrix commonly used at SNL.

**Table 1 – Consequence Guidelines**

| Abbreviation | Consequence Level | Worker Impact | Environmental Impact | Mission Impact |
|---|---|---|---|---|
| H | High | Life Threatening – death, permanent total disability requiring hospitalization. | Irreversible significant reportable environmental impact; permit NOV with fines & required facility shutdown. | Monetary loss equal to or exceeding $1M.<br><br>Loss of mission requiring restart. |
| M | Moderate | Near Life Threatening – permanent partial disability, injuries or occupational illness that may result in hospitalization. | Reversible significant reportable environmental impact; permit NOV with fines. | Monetary loss equal to or exceeding $100K but less than $1M.<br><br>Delay of mission requiring restart. |
| L | Low | Less than Life Threatening – injury or occupational illness that may require medical treatment beyond first aid. | Reversible moderate reportable environmental impact; permit NOV without fines. | Monetary loss equal to or exceeding $10K but less than $100K.<br><br>Delay of mission not requiring restart. |
| N | Negligible | Minor Injury – injury or occupational illness that may require first aid. | Minimal non-reportable environmental impact; no permit NOV. | Monetary loss less than $10K.<br><br>No mission impact. |

**Table 2 – Frequency Guidelines**

| Abbreviation | Frequency Level | Description |
|---|---|---|
| A | Anticipated | Expected to occur in lifetime of facility/operation. |
| U | Unlikely | May occur in lifetime of facility/operation. |
| EU | Extremely Unlikely | May not occur in lifetime of facility/operation. |
| BEU | Beyond Extremely Unlikely | Not expected to occur in lifetime of facility/operation. |

**Table 3 – Risk Bins**

| Likelihood → Consequence ↓ | Anticipated (A) | Unlikely (U) | Extremely Unlikely (EU) | Beyond Extremely Unlikely (BEU) |
|---|---|---|---|---|
| High (H) | 1 | 1 | 2 | 3 |
| Moderate (M) | 1 | 2 | 3 | 4 |
| Low (L) | 2 | 3 | 4 | 4 |
| Negligible (N) | 3 | 4 | 4 | 4 |

| | |
|---|---|
| 1 | Unacceptable – Mitigated with engineering and/or administrative controls |
| 2 | Undesirable – Mitigated with engineering and/or administrative controls |
| 3 | Reasonably Low Risk – Mitigated with engineering and/or administrative controls |
| 4 | Reasonably Low Risk |

IFSB documentation, including the S-HA, should include, at a minimum, the following key sections:

- Site/facility description,
- Process operation description,
- Hazards analysis (HA),
- Accident analysis (as needed),
- Summary of safety controls (including safety management programs [SMPs]), and safety envelope [limits]), and
- Change control process.

Some of this information can be adapted from the pre-existing nuclear documentation and the Documented Safety Analysis (DSA). It is important that the information adapted and incorporated from the DSA is still traceable to its origin. As an example, the structural analysis for a facility design basis event would not have to reside within the IFSB S-HA documentation. This information should, however, be referenced and kept in the archives as supporting documentation for the statements made within the S-HA.

Industrial Facility Hazards

The IFSB approach focuses on a broader scope of hazards than those considered in the traditional NFSB approach. In addition to the radiological hazard, IFSB also focuses on potential chemical, explosive, laser, non-ionizing radiation, miscellaneous aviation/airborne hazards, use of equipment outside the manufacturer's recommendations, non-commercial equipment, biological, and other potential hazards. In the IFSB vernacular, all receptors (worker, collocated worker, public, environment, facility, mission) may be evaluated with respect to each hazard identified. If certain receptors will not be evaluated, justification must be presented to support this decision. Hazards associated with IFSB hazard classification are described as follows:

Radiological Material and Radiation Generating Devices

Hazard classifications for radioactive materials are based on the thresholds defined in NA-1 SD G 1027, *Guidance on Using Release Fraction and Modern Dosimetric Information Consistently with DOE STD 1027-92, Hazard Categorization and Accident Analysis Techniques for Compliance with DOE Order 5480.23, Nuclear Safety Analysis Reports, Change Notice No. 1.* Radioactive materials falling below the HC-3 thresholds result in a "low hazard" classification. Hazard classification for accelerators is based on the applicability of DOE O 420.2C, *Safety of Accelerator Facilities*, and the listed exemptions.

Chemicals

The chemical criterion for industrial facilities categorization is based on a consequence analysis to determine significant onsite or offsite impacts. A hazard classification review by IFSB is triggered by:

- Inventories of flammable gases exceeding 1000 cubic feet released from a single container, manifolded series of containers, or house gas system.
- Inventories of highly hazardous chemicals exceeding Process Safety Management (PSM) threshold quantities.
- Inventories of toxic and highly toxic chemicals exceeding threshold quantities based on ERPG-3 values.

Based upon quantities, the IFSB analyst will verify the inventory of chemicals to address potential credible release events. Typically, the quantity of a chemical used for evaluation of a given release event is based on the potential for release from a single, common event. Chemical dispersion modeling may be required as a part of the hazard classification review.

Explosives

For explosives, significant consequences are based on the explosive type, the quantity-distance (QD) arc identified in either the Explosives Site Plan (ESP) or the explosives building license (EBL), as required by the Department of Defense (DOD); DOE and SNL explosives safety documents; and access control.

Lasers

For lasers, significant consequences are based on either the potential for lasers to reflect, or whether receptors could be exposed to any class of visible laser (400-700 nanometers), or to any Class 3B or Class 4 laser directed into navigable airspace.

Non-ionizing Radiation

For non-ionizing radiation, significant consequences are based on the potential for receptors to have unrestricted access into an area that exceeds the published exposure limits for radio frequencies or microwaves.

Miscellaneous Hazards

For miscellaneous hazards, significant consequences are based on the potential for significant impacts to receptors resulting from aviation activities and airborne objects. The following hazards must be evaluated as a part of the IFSB documentation:

- Aviation activities that pose risks greater than those accepted by the "general public,"
- Airborne objects that cause injury or exposure to someone not associated with the operation, or that have an offsite impact, and
- Activities that involve the carry, use, test, transport, or control of firearms or munitions.

Significant onsite or offsite consequences are based on the severity to the receptor (e.g., fatality, irreversible injuries/damage). Typically, impact from an airborne object or aircraft would be considered a significant impact.

Equipment Outside of Manufacturer Recommendations

For equipment used outside of manufacturer recommendations, significant consequences are determined based on 1) whether the equipment, tools, or materials used in this capacity could cause injury/exposure to anyone not associated with the operations, or 2) the potential for an offsite impact. Significant onsite or offsite consequences are based on the severity (e.g., fatality, irreversible injuries) of the injury to onsite personnel or the public.

Non-Commercial Equipment

For non-commercial equipment, significant consequences are determined based on the potential for equipment to either cause injury/exposure to someone not associated with the operations, or to have an offsite impact. Significant onsite or offsite consequences are based on the severity of the injury (e.g., fatality, irreversible injuries) to onsite personnel or to the public.

Biological Hazards

For biological hazards, significant consequences reflect the given biosafety levels (BSLs) established by the Centers for Disease Control (CDC), and/or the types of

biological agents. Currently, SNL only houses biological laboratories using biological agents associated with BSL-1 and BSL-2 activities. Activities involving human or primate prions, vertebrate laboratory animals, Risk Group 3 or 4 agents, or BSL 3 or 4 laboratory activities require a case-by-case hazard classification review based on the facility location, the biological agents, and the BSL capability of the facility.

Process Safety Management

Managers of operations with hazards that involve either 1) highly hazardous chemicals, or 2) flammable liquids or gases exceeding OSHA Process Safety Management (PSM) standards are required to ensure that the 14 elements of PSM are completed for compliance with the requirements of OSHA 29 CFR 1910.119, *Process Safety Management of Highly Hazardous Chemicals*. The 14 elements of PSM are as follows:

1. Employee Participation
2. Process Safety Information (chemical hazards, process technology, process equipment, good engineering practices, and codes and standards)
3. Process Hazard Analysis (hazards, previous incidents, engineering and administrative controls, facility siting, human factors, and qualitative effects of control failure)
4. Operating Procedures (development and implementation)
5. Training Program (development and implementation)
6. Contractors (contractor interface with PSM requirements, e.g., required health and safety plan, job site hazard analysis, etc.)
7. Pre-Startup Safety Review (review against design, safety operation and maintenance, and employee training)
8. Mechanical Integrity (develop and implement procedures for maintenance, training, and inspection of equipment)
9. Hot Work Permits
10. Management of Change (develop and implement a process to manage change of chemicals, technology, equipment, procedures, and facility controls)
11. Incident Investigation
12. Emergency Planning (develop and implement an emergency response plan)
13. Compliance Audits (perform management self-assessments of implementing documentation and controls prior to startup/restart)
14. Trade Secrets (make all necessary information available for compliance with PSM standard).

Lessons Learned

One of the most valuable lessons learned in the downgrade process is to involve and incorporate IFSB into the process as early as possible. It is easy to overlook the importance of IFSB support when downgrading, because the level of rigor involved with updating and maintaining a DSA is very different from the level of effort expected

for an IFSB S-HA. The incorporation of IFSB principles early into the downgrade process, and the S-HA effort, can provide an opportunity to incorporate the lessons learned from the pre-existing DSA. Similarly, lessons can also be incorporated from new technology, applicability of new and/or existing controls, modification of legacy information and/or equipment, and the opportunity to rectify potential inconsistencies or legacy errors from the DSA.

Starting the S-HA process from the HI phase can have significant benefits. For example, the pre-existing/legacy DSA HI tables can be used to "seed" the effort, but should be used objectively, looking not only for nuclear hazards, but also for industrial ones. It is important to understand the origin of each hazard type and associated quantities/magnitude instead of relying on the institutional knowledge of the original DSA authors. Although the updated information may not carry forward for further analysis, it is important to capture an accurate description of the hazards as the facility undergoes the transitional period from a nuclear facility to an industrial facility. Commonly overlooked hazards could include anything from external flammable gas storage areas, facility house gas systems (experimental or comfort heating), ozone generation, facility loading dock areas/procedures, etc.

Following the full-scale HI effort, the HE should also be revalidated to 1) reaffirm or modify existing scenarios, 2) capture new industrial hazard scenarios, and 3) align the IFSB methodologies and nomenclature associated with frequency and consequence. Initial conditions, assumptions, controls (engineering and administrative), and the integration of safety management programs (SMPs) should also be revalidated as a part of this process.

The elements of the S-HA may, or may not, flow from the pre-existing DSA. A typical IFSB S-HA document at SNL consists of the following sections:

- Chapter 1 – Introduction, purpose, and authority.
- Chapter 2 – Facility description, facility operations, applicable SMPs, and historical occurrences.
- Chapter 3 – Hazard analysis overview, hazard identification, hazard screening process, and hazards carried forward for analysis.
- Chapter 4 – Hazard evaluation methods (frequency, consequence, and risk), initial conditions, and summary results.
- Chapter 5 – Controls derived through evaluations (all engineered, administrative, and defense-in-depth controls).
- Chapter 6 – Safety Envelope, including functional requirements and an inspection-and-review schedule for initial conditions, engineering controls, and administrative controls (which may include SMPs).
- Chapter 7 – Management of Change Process.

- Chapter 8 – References.
- Attachment A – Hazard Identification Tables.
- Attachment B – Hazard Evaluation Tables.

From an IFSB perspective, Chapter 6, *Safety Envelope*, and Chapter 7, *Management of Change*, are the most important chapters of the S-HA. The *Safety Envelope* chapter discusses all of the credited controls, which will need to be protected throughout the lifetime of the facility. The *Management of Change* (MOC) chapter discusses what is required to keep the analysis current. Similar to a DSA, the IFSB S-HA is a living document that must be reviewed and updated regularly, on a schedule not to exceed five years. Many of the SNL industrial facilities have incorporated an MOC process similar to the Unreviewed Safety Question (USQ) process employed at nuclear facilities. As in the USQ process, authors and reviewers must be qualified in the MOC process for a given facility.

It is recommended the facility participate in an industrial facility "readiness-like" function, i.e., a self-assessment and/or an independent validation review (IVR), as a part of the S-HA review/finalization process to ensure the integrity of the safety envelope, as described within the IFSB S-HA document. As a part of this process, MOC training may be provided to ensure 1) the integrity of the S-HA, and 2) the downgrade effort does not degrade over time.

As a result of some of the lessons learned during the downgrade of two former SNL nuclear facilities to industrial facility status, the Safety Basis Department is currently updating the SNL Safety Basis Requirements Document (SNL Safety Basis Manual) to reflect some of the identified challenges. The Safety Basis Requirements Document update also reflects the timeframe between the initiation of the downgrade, at which time DOE deems the facility will no longer be considered a "nuclear" facility (based on the quantity/form of radiological material present), and the finalization of the IFSB S-HA documentation and the associated "readiness-like" activity, self-assessment, and/or IVR process.

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# The LLNL Heavy Element Facility -- Facility Management, Authorization Basis, and Readiness Assessment Lessons Learned in the Heavy Element Facility (B251) Transition from Category II Nuclear Facility to Radiological Facility

M. Mitchell, B. Anderson, E. Brown, L. Gray

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# The LLNL Heavy Element Facility -- Facility Management, Authorization Basis, and Readiness Assessment Lessons Learned in the Heavy Element Facility (B251) Transition from Category II Nuclear Facility to Radiological Facility

Mark Mitchell[1], Brian Anderson, Erik Brown, Leonard Gray
Lawrence Livermore National Laboratory[*]
Livermore, California

## ABSTRACT

This paper presents Facility Management, Readiness Assessment, and Authorization Basis experience gained and lessons learned during the Heavy Element Facility Risk Reduction Program (RRP). The RRP was tasked with removing contaminated glove boxes, radioactive inventory, and contaminated ventilation systems from the Heavy Element Facility (B251) at Lawrence Livermore National Laboratory (LLNL). The RRP was successful in its goal in April 2005 with the successful downgrade of B251 from a Category II Nuclear Facility to a Radiological Facility. The expertise gained and the lessons learned during the planning and conduct of the RRP included development of unique approaches in work planning/work control ("*Expect the unexpected and confirm the expected"*) and facility management. These approaches minimized worker dose and resulted in significant safety improvements and operational efficiencies. These lessons learned can help similar operational and management activities at other sites, including facilities restarting operations or new facility startup.

B251 was constructed at LLNL to provide research areas for conducting experiments in radiochemistry using transuranic elements. Activities at B251 once included the preparation of tracer sets associated with the underground testing of nuclear devices and basic research devoted to a better understanding of the chemical and nuclear behavior of the transuranic elements. Due to the age of the facility, even with preventative maintenance, facility safety and experimental systems were deteriorating. A variety of seismic standards were used in the facility design and construction, which encompassed eight building increments constructed over a period of 26 years. The cost to bring the facility into compliance with the current seismic and other requirements was prohibitive, and simply maintaining B251 as a Category II nuclear facility posed serious cost considerations under a changing regulatory environment. Considering the high cost of maintenance and seismic upgrades, the RRP was created to mitigate the risk of dispersal of radioactive material during an earthquake by removing the radioactive materials inventory and glove box contamination. LLNL adopted the goal of reducing the hazard categorization of the Facility from a Category II Nuclear Facility to a Radiological Facility.

To support the RRP, B251 transitioned from a standby to a fully operational Category II Nuclear Facility, compliant with current regulations. A work control process was developed, procedures were developed, Authorization Basis Documents were created, work plans were written, off-normal drills practiced, a large number of USQ reviews were conducted, and a "Type II" Readiness Assessment (RA) was conducted to restart operations. Subsequent RA's focused on specific operations. Finally, a four-step process was followed to reach Radiological Status: (1) Inventory Reduction and D&D activities reduced the inventory and radiological contamination of the facility below the Category III threshold (DOE-STD-1027), (2) Radiological Safety Basis Document (SBD aka HAR) was approved by NNSA, (3) the inventory control system for a Radiological Facility was implemented, and (4) verification by NNSA of radiological status was completed.

**Figure 1. The LLNL Heavy Element Facility**

[1] For referral to the appropriate author, contact to whom questions should be addressed.

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Key to this success is the RRP philosophy in a schedule driven paradigm.

- *"Expect the unexpected and confirm the expected"*
- Recognize when you reach the point of diminishing returns,
- Develop robust processes that anticipate and can handle surprises,
- Plan, plan, and re-plan *"Measure twice, cut once"*




**Staff from multiple organizations played significant roles in downgrading B251 from Nuclear Category 2 to Radiological**

**Impressive safety accomplishment**
**No one had decontaminated facilities with this level and variety of high specific activity isotopes (e.g. $^{244}$Cm, $^{238}$Pu)**
**Dramatic cost savings, $250 million under current regulations**



## 1.0 INTRODUCTION

The Risk Reduction Program (RRP) successfully downgraded the LLNL Heavy Element Facility (B251) from a Category II Nuclear Facility to a Radiological Facility. The expertise gained and the lessons learned during the planning and conduction of the RRP included development of unique approaches in work planning/work control ("*Expect the unexpected and confirm the expected"*) and facility management. These approaches minimized worker dose and resulted in significant safety improvements and operational efficiencies. These lessons learned can help similar operational and management activities at other sites, including facilities restarting operations or new facilities starting new operations. To support the RRP, B251 transitioned from a standby to a fully operational Category II Nuclear Facility, compliant with current regulations. A work control process was developed, procedures were developed, Authorization Basis Documents were created, work plans were written, off-normal drills practiced, a large number of USQ reviews were conducted, and a "Type II" Readiness Assessment (RA) was conducted to start up operations. Subsequent RA's focused on specific operations. Finally, a four-step process was followed to reach Radiological Status. Best management practices for Facility Management, Authorization Basis, and Readiness Assessments were a key factor in this success.

## 2.0 HISTORY

B251 was constructed at LLNL to provide research areas for conducting experiments in radiochemistry using transuranic elements. B251 activities once included the preparation of tracer sets associated with the underground testing of nuclear devices and basic research devoted to a better understanding of the chemical and nuclear behavior of the transuranic elements. Highlights of B251's history include:

- Approximately 20 nuclides discovered using B251 fabricated accelerator targets.

- B251 prepared accelerator target contributed to 1974 discovery of Element-106, subsequently named seaborgium.
- B251 developed capabilities to separate and purify exotic isotopes, e.g., $^{242m}$Am.
- B251 conducted research on quantitative use of gamma spectroscopy to measure concentrations of fissile isotopes. This work aided development of safeguards systems for nuclear materials accountability.

The B251 Facility safety systems and experimental systems were deteriorating with age, even with preventative maintenance. A variety of seismic standards were used in the facility design and construction, which encompassed eight building increments constructed over a period of 26 years. In 1993, the high cost to meet new regulatory requirements (e.g. seismic upgrade) drove LLNL to discontinue programmatic operations. In 1995, B251moved from Operational to Standby mode.

The RRP was created to mitigate the risk of dispersal of radioactive material during an earthquake by removing the radioactive material inventory and glove box contamination. The cost to bring the facility into compliance with the current seismic and other requirements was prohibitive, and simply maintaining B251 as a Category II nuclear facility posed serious cost considerations under a changing regulatory environment. LLNL therefore adopted the goal of reaching Radiological Facility status. In 2002, the RRP began establishing an integrated plan to de-inventory and decontaminate the facility to Radiological Status. DOE granted B251 a two-year schedule exemption from 10 CFR 830 to conduct the RRP. RRP activities were motivated by a schedule driven paradigm.

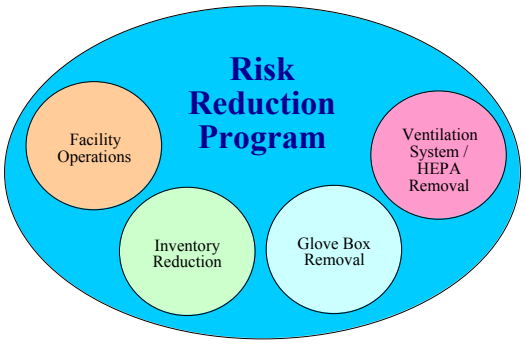
The RRP inherited a contaminated and aging facility. Anticipating return of funding and operations, researchers had left experiments in glove boxes, blue caves, hot cells, etc. This posed a unique challenge for facility management and the RRP. Facility management began to restart B251 as a Category II nuclear facility under the current regulatory environment, while the RRP searched for new homes for rare, and useful, materials. This included contacting the Inventory Disposition Path Development–Nonactinide Isotope and Sealed Source Management Group (NISSMG), Inactive Actinides Working Group (AIWG), and conducting presentations at meetings & personal contacts within LLNL, DOE Complex, and industry.

B251 successfully completed a Readiness Assessment (RA) to Restart Operations, an RA to perform source encapsulation, and two subsequent RAs to conduct D&D activities. The RRP transferred rare and useful radioactive materials to other sites, decontaminated and decommissioned (D&D) glove boxes and ventilation systems, and packaged and shipped waste offsite. By November 2003, inventory was reduced to 20% of the initial inventory and on April 8, 2005, B251 achieved Radiological Status. Subsequently, unique and large equipment, such as an isotope separator and the blue caves (large shielded gloveboxes with manipulators), were decontaminated and dispositioned, and the RRP was completed.

**Figure 3. Isotope Separator**

## 3.0 RRP ACTIVITIES

The RRP was composed of facility management and three projects: Inventory Reduction, Glovebox Removal (D&D), and Ventilation System Removal. These projects are discussed in several publications, for more information, see the References section.




## 4.0 RESTART: TRANSITIONING FROM STANDBY TO OPERATING CATEGORY II NUCLEAR FACILITY

The facility restart required B251 to develop staff, work processes/facility, and regulatory infrastructure within the safety basis (e.g. ES&H, AB, USQ, CM, QA, CAPs) as a fully operational Category II nuclear facility.

## 4.1 Staffing

To accomplish its goals within schedule required recruitment of experienced individuals in key positions, and consult with facility retirees who provided a knowledge base on operations dormant for the past decade was vital. During Standby, B251 was staffed with three people. The RPP needed sufficient staffing for multiple teams to conduct concurrent operations. We recruited staff with the required training and who had experience with high specific activity alpha emitting isotopes. Most staff required training in the current regulatory environment. Most staff required training for the RRP's unique work practices, including:

- Open air transfers, pass in/pass out
- Blue cave manipulator operations

Hazards Control staff was essential for safe operations; the RPP found that an in-house Health Physicist and at least 3 hazard control technicians were required to conduct concurrent operations.

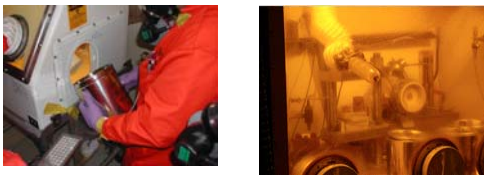


**Figure 4. Open air transfer and legacy enclosure**

## 4.2 Develop Work Processes

B251 developed work processes for a fully operational Category II nuclear facility. This rapid transition occurred in months. The RPP developed a large variety of procedures and work plans for doing diverse and unique operations. Facility management developed robust processes that could handle surprises from legacy unknowns:

- a characterization process involving several techniques, including radiography and gamma spectroscopy;
- a work planning process including Hazards Control review; and
- strategic Authorization Basis documents.

Key lessons learned include:

- develop procedures and training for off-normal conditions, develop flexibility in work plans,
- maintain a prudent margin below regulatory inventory limits (e.g., potentially exposed material (PEM) and material at risk (MAR)) during operations in case legacy inventory items were found or determined to be of higher activity than records indicate, and
- develop work planning process to ensure controls are in place to do work safely.

A noteworthy, and often overlooked, lesson learned is that an effective Document Control Center (DCC) greatly increases efficiency of engineering staff and is essential in a schedule driven paradigm.

# 5.0 RISK REDUCTION PHILOSOPHY IN SCHEDULE PARADIGM

B251's success resulted from a guiding philosophy that carefully balanced key factors:

- Regulatory Compliance
- Schedule
- Dose
  - Dose exposure during decontamination for D&D activities;
  - Dose exposure during handling/repackaging for inventory activities;
- Cost
  - Decontamination cost for D&D activities (LLW vs. TRU);
  - Repackaging cost for inventory activities;
  - Waste disposal cost (LLW vs. TRU).

Adapting to a schedule driven paradigm in the current regulatory environment can be challenging. The RRP operated compliant within the current regulatory environment. B251 was held and audited to similar regulatory standards (DNFSB, NNSA, OA, USQ, CM, ALARA, DOE-HQ Training, etc…) as NNSA's Plutonium Facilities. New personnel were often frustrated by the complex and bureaucratic rules of nuclear facility operations. Staff often take time to transition to the DOE Complex's current regulatory environment. Several approaches helped smooth this transition: the strong guidance of the RRP management's *"safety first"* philosophy, teaming of less experienced personnel with more experienced personnel, and a strong team *"can do"* attitude. The knowledge that the RPP was of significant importance to LLNL and NNSA, combined with strong upper management support, spurred the team to be extra diligent, pay greater attention to safety, and put in the extra effort to make the RPP a success.

Schedule driven paradigm requires foresight and planning. Key schedule lessons learned include:

- Recognize what you control and what you don't (e.g. NNSA approval of RAs, positive USQDs, Safety Basis Amendments, shipping).
- Prepare for changes in regulator interpretations of requirements (e.g. DOE-STD-1027).
- Foresight in preparation for changing regulatory environment is critical to meeting schedule, preventing delays from audits, corrective action plans, being shutdown.

- Plan for potential delays during interactions with regulators (e.g. waiting for regulator approval of RA's, positive USQDs, and Safety Basis Amendments).
- Direct/line item funding essential to match regulator expectations with funding and schedule. Proper budgeting critical to ensure proper staffing levels.
- "*One person deep*" creates failure points and stress in schedule driven paradigm. Recognizing these failure points, cross training of personnel and having backup signatory authorities is critical for schedule. Understand connection between productivity and happiness. Positive reinforcement. Match skills and needs.
- Overshoot inventory reduction goals because shipping delays, container issues, and other work delays will occur and regulatory expectations/ interpretations may change.
- Schedule based upon current regulations – not upon "old rules" in force at time facility operational.
- Add contingency for changing regulatory environment
  - do not assume Readiness Assessments successfully completed and approvals received in timely manner,
  - do not assume outside audits & rule changes kept to minimum, and will not impact schedule, and
  - do not assume Authorization Basis reviews and approvals received in timely manner.
- Add contingency for project considerations (e.g. accidents, responding to accidents, shipping delays, delays in receiver site identification and shipment approvals obtained).
- *"Better to be Radiological than to be Right!"* A successful general knows which battles to lose and which battles to win in order to win the war, i.e. assess when it is best to stop fighting regulators' unusual interpretations and instead perform the work they request.
- *"How clean is clean enough?"* In a schedule driven paradigm for D&D, first determine the endpoint. This is especially important when there are significant uncertainties concerning inventory or contamination. At the beginning of a D&D project, it is important to establish attainable goals for decontamination, determine stopping point for decontamination (diminishing returns), and when to instead explore alternative options (shipping or waste disposal).

## 6.0 FACILITY MANAGEMENT APPROACHES

B251 Facility Management found that transparent business practices and building trust with the regulators was essential for successful operations and meeting schedule. Several best practices for facility management were observed.

"*Clear goals and interpretations"* It is important to obtain clear, defined goals formally approved by NNSA *in writing.* An example of such goals is the objectives to reach Radiological status:

1) Reduce inventory to below the Category III threshold (DOE-STD-1027),
2) Obtain approval for a Radiological Safety Basis Document (SBD aka HAR),
3) Demonstrate a Radiological inventory system,
4) NNSA verification step .

*"We don't always think alike"* recognize that NNSA field offices may interpret requirements differently than the contractor.

*"Keep an ear to the ground"* to determine expectations to ease transitions and not be surprised; recognize regulatory priorities and conservative interpretations.

*"Bite the bullet"* recognize the impact of audit findings on schedule driven projects. It is very difficult to cope with audit findings and still make schedule. As the regulatory environment continues to get stricter, it is better to do work right the first time rather than later under even more strict interpretations. Pace yourself with workload balancing – assess rules and proactively respond at a time of your choosing as you won't have time to react later.

*"Keep upper management in the loop"* as upper management's backing and interpersonal interactions are critical.

*"Good relationships are good business practices"* LLNL's Chemistry and Environmental Services (CES) increased characterization throughput by factor of 20. Good relationships with numerous organizations across the DOE Complex helped facilitate timely response at receiving sites (onsite and offsite) via shipping agreements. In 3 weeks, one organization achieved an equivalent of 1 year of normal waste throughput. Personal interactions are critical to finding new homes for items and facilitating shipments in a timely manner. It is

important to work with receiving facilities early in the process, to ensure container and shipping issues are resolved in a timely fashion. This also helps minimize unnecessary repackaging activities.

*"Embrace the Matrix"* the matrix organizational approach to staffing helped supply necessary manpower from multiple organizations (e.g. Transportation, Materials Management, Hazards Control, Chemistry, Engineering, Waste Management). The matrix organization structure allows for rapid staffing across diverse technical skill sets. To be successful with this approach, it is important to have prioritization on staff and budget.

## 7.0 REGULATORY AND FACILITY INFRASTRUCTURE

Facility management developed facility & regulatory infrastructure (e.g. AB, USQ, CM, QA, ES&H, CAPs) and conducted 364 USQ reviews over the course of the RRP, coordinated 15 major Authorization Basis documents, developed a new TSR and Facility Safety Plan (FSP), and obtained approval for a Radiological Safety Basis Document (SBD) – the first of its kind under new institutional requirements. Although a "graded approach" was originally planned under the Risk Reduction Plan, B251 ended up paving new ground in unexplored regulatory arenas, with first of a kind documents. The following sections address Authorization Basis strategies, best practices, and organizational structure; Facility Infrastructure strategies, and Readiness Assessment strategies.

### 7.1 Authorization Basis Strategies

An overall authorization basis strategy is to anticipate the full scope of work at the beginning of a program. Submit positive USQDs/Safety Basis Amendments early in project, recognizing the time required for the DOE approval process. Anticipate issues with legacy equipment, like-for-like replacements simply may not exist; assess these legacy issues early as this may result in program delays while equivalent parts are analyzed and USQDs prepared. Delay for resolving AB issues is not acceptable in an aggressive schedule, so anticipate potential positive USQDs and tackle the problems early. Plan for adequate implementation time for completing NNSA commitments (e.g. SAR/TSR implementation, TSR Verification, FSP training, annual updates). Utilizing conservative assumptions in USQDs will *increase* productivity. Assume conservative, bounding values for legacy radioactive inventory, don't assume precise values to the last significant digit (e.g. assume 20 Ci instead of 11.1 Ci), as you may find surprises. Be aware that process impurities may be a bigger concern than daughter products for some isotopes. Assume conservative impact on equipment important to safety (EITS) given legacy equipment and wide variations possible in D&D.

An effective overall AB strategy considers the Safety Basis and planned work. Strategic DSA preparation increases USQD efficiency and can assume issues at system level for legacy/D&D environment. A strategic, conservative hazard analysis/accident analysis is essential to allowing work to proceed. Minimize credited controls and develop clear system boundaries. Whenever possible, base accident analysis on inventory assumptions (e.g. PEM vs. MAR) instead of crediting mitigating controls (e.g. facility systems). It is important to understand a system's or SSC's safety function. Lack of understanding can inappropriately increase USQD workload. Staff may not recognize legacy issues with infrastructure and may not address potential D&D activities. Specific Limiting Conditions of Operations (LCOs) for specific systems and rooms may be utilized instead of facility-wide MODE change. Realistically anticipate potential conditions. Ensure that the time for TSR Required Actions is realistic given the infrastructure conditions. Replacement parts may not be available to bring systems back on line as soon as desired. Develop Required Actions such as the use of portable generators, portable CAMs, and other equipment in a legacy, D&D environment. These strategies were essential in the RRP achieving its objective.

### 7.2 AB Best Practices

Several best practices for Authorization Basis (AB) strategies were observed.

*"Keep an open mind"* Feedback & lessons learned are important, either as opportunity for improvement or alternative pathway to keep in your back pocket. Plan for the unexpected so work can proceed on schedule when surprises occur – and they will occur.

*"Assess & Adhere"* Assess the relevant regulations and strictly adhere to them; no less and no more unless benefits outweigh the costs. Adhering to regulations is essential in a schedule driven paradigm; there is no time to do the work twice.

*"Feedback Mechanisms"* Develop, disseminate and implement feedback via monthly meetings with NNSA, biweekly with institutional AB management, feedback distributed to staff (e.g. completed USQDs,

audit findings), discuss key points, emphasize need to meet NNSA expectations.

*"In the loop"* Recognize the potential impact of frequently changing NNSA and auditor expectations. It is essential to provide feedback mechanisms for safety analysts so they can continue to meet regulator expectations. A best practice is to, when possible, use safety analysts to perform all aspects of the USQ process and keep them *"in the loop."* Staff who perform USQ reviews infrequently may not be able to keep up with frequent regulatory changes or may not be receiving the necessary feedback on changing expectations. This approach allows workers to focus on conducting their work and safety analysts to focus on safety analysis.

*"Consistency"* Centralized USQ process promotes consistency and higher quality USQDs meeting expectations.

*"Templates"* Develop strong USQDs for each type of work (e.g. key facility SSC maintenance, inventory operations, D&D operations, ventilation D&D) and boilerplate reminders of NNSA expectations (e.g., answer the questions, address interim hazards and worker safety issues, provide the appropriate level of detail, and use clear DSA/TSR citations).

*"Do it right the first time"* Better to produce good work the first time – it will survive audits and can be re-used. Do not rush, redo, and then fight the auditors.

## 7.3 AB Organizational Structure

An effective facility management organization can greatly enhance the productivity of projects conducting work in the facility. Organization of facility staff requires foresight and is developed over time in response to lessons learned and best management practices. This organizational structure was extremely efficient and very responsive while maintaining the necessary focused expertise in their respective areas. B251 organized AB staff into 3 focused teams: the USQ Review Team, the AB Document Team, and the Special Projects Team.

The USQ Review Team organized safety analyst staff based along the lines of the projects, dedicating specific staff to the inventory reduction project, the D&D project (i.e., glove boxes), the ventilation project, and facility operations. One primary safety analyst was assigned to each project as the USQD preparer. Each project prioritized their safety analyst's work. This approach eliminated inherent inefficiencies with staffing reassignments, aka "Robbing Peter to pay Paul." A few safety analysts were kept in reserve. USQDs were prepared by dedicated safety analysts who maintained knowledge of the frequently changing NNSA and auditor expectations, lessons learned, and other feedback issues. The senior safety analyst reviewed the USQDs and served as the mentor and trainer, but did *not* have to manage the safety analysts' workload. Finally, the USQD approver served as the final quality check of USQDs and consistency of USQDs across projects. The USQD approver also served as the technical and communication link between the USQ Review Team and the AB Document Team, while providing the common interface with regulatory organizations (e.g. NNSA and auditors) as well as other facilities and the central institutional AB organization. The benefits of this approach:

- increased efficiency in USQ reviews by enforcing discipline in priorities, minimizing staff reassignment fluctuations and work balancing by AB management, and increased productivity while minimizing conflict;
- resulted in positive project/system engineer/safety analyst interfaces; and
- staff came up to speed faster on technical and applicable USQD issues.

The AB Document Team focused staff on key regulatory documents such as DSA/TSR, SBD/HAR, and FSP. In a schedule driven paradigm, it is essential to preserve the focus of the USQ review team and utilize another team for document production. This team developed and maintained expertise in specific regulatory issues, e.g. DOE-STD-3009, DOE-STD-3011, and DOE-STD-1186. The team had three priorities:

- Serve as "Plan B", the contingency for 10CFR830 Compliance if the Risk Reduction Program did not accomplish it's objectives. The contingency was development of a 10CFR830 Compliant DSA and TSR.
- Produce the large documents, e.g. SAR/TSR annual updates, Radiological Safety Basis Document (SBD aka HAR) and Facility Safety Plans.
- Serve as the Reserve for the USQ team, filling in when needed on rushes.

The Special Projects Team staff focused on particular objectives, the special projects pertaining to authorization basis and facility management issues. This included conducting TSR Implementation, performing assessments, verifying compliance with DOE-STD-3011 and 10CFR830, supporting activities pertaining to DOE-STD-1027, responding to DNFSB

issues and results of DNFSB Recommendations, and planning and performing Radiological Verification activities. They developed expertise in very specific areas involving local NNSA interpretations.

## 7.4 Facility Infrastructure Strategies

Keeping a legacy facility operational in a challenging and changing regulatory environment is crucial for meeting schedule and a significant challenge.

Good configuration management is an essential starting point. Facility engineers must know the safety function of each system and its critical components, integrate configuration management into work control processes, and understand the relationship with the Safety Basis. Early on, B251's system engineers developed system design descriptions for equipment important to safety. These efforts increased efficiency and effectiveness of work control for inventory reduction operations, D&D, and facility operations, including maintenance. Auditor scrutiny verified the effectiveness of these efforts.

Several best practices for facility infrastructure strategies are noted below.

- *"Expect the unexpected and confirm the expected"* Recognize that legacy systems were not designed for optimal D&D and include legacy hazards such as inaccurate as-built drawings, hard wiring of equipment, "abandoned" in place systems, electrocution hazards, and component degradation issues (e.g. bags, window gasket seals, fan motors, bearings).
- *"Infrastructure Contingencies"* It is important to proactively prepare for legacy system issues. Understand the safety function for equipment important to safety. Recognize that legacy components such as seals and exhaust fans can fail. Facility maintenance to support the RRP was far higher than anticipated; many systems unexpectedly required maintenance or replacement. Recognize legacy facility equipment may be at end of their operational life.
  - Perform proactive like-in-kind determinations for legacy systems and develop an Approved Equivalent Parts List as like-for-like components may be difficult or impossible to obtain for some legacy equipment.
  - Pre-purchase replacement parts for long lead time items (e.g. SS/SC systems, particularly exhaust fans). A few extra dollars to buy or refurbish spare parts may save significant down time in the future.
  - When a trend is identified, act on it. Proactive replacement of key components reaching end-of-service life is critical to minimizing impacts of failure during operations (e.g. exhaust fan motors). After several exhaust fan motors failed, as a precaution 100% of fumehood exhaust fans were replaced during the RRP's preplanned maintenance windows.
- *"Spill happens"* so prepare standing contingency practices
  - decontamination carts containing tools, spare parts, spill decontamination kits, bags, glove box gloves, extra meters, Radiac wash, Stripcoat, tape, extra respirators;
  - include spill clean up procedure in every work plan;
  - conduct extensive dry runs, then work on lower level D&D before moving up to higher level D&D and then finally $^{244}Cm/^{238}Pu$ in complicated equipment.
- *"Escalating Contingencies"* There are a number of legacy issues that can result in operational issues escalating, e.g. legacy containers may not be in the state anticipated due to degradation. It is important to have contingency infrastructure operational prior to starting work activities. If conducting work in a room, have a fumehood pre-approved as operational with canners ready. If doing work in a fumehood, have a glove box pre-approved as operational.
- *"How we know what we know"* In a legacy facility with multiple concurrent operations, it is important to institute procedures for periodic walkdowns of work areas by ES&H safety disciplines and facility staff. Develop effective communication tools including paging procedures, information centers, and on-going verification of system operability. On the longer term, conduct Configuration Management reviews and implement effective mechanisms for ensuring and confirming TSR Implementation.
- *"Use existing facility infrastructure"* Carefully assess the facility to determine what can be used. In a schedule driven paradigm, this is crucial – you simply don't have time to install new major systems. For example, hot cells can be used for safely conducting radiography and staging for shipment, low background areas can be used for gamma spectroscopy, and existing glove boxes, enclosures, and fumehoods can be used for repackaging, solidification, and contingency work areas.
- *"Ask why and look at the big picture"* Carefully assess all aspects of the work activity and

evaluate the entire worker safety envelope - don't fall into the trap of listening to one reviewer who may have a myopic view and is unaware of other issues, solving one problem only to create a different safety hazard or waste disposal problem.
    - It is important to assess infrastructure and spatial parameters. Several glove boxes were relocated and seismically stabilized to support Inventory Reduction and D&D, thereby creating free work space important for improving safety of operations.
    - Scaffolding was required for elevated work above enclosures. It is important to recognize solutions to fall protection may cause secondary problems, e.g. hindering safe response to CAM alarms, scaffolding hitting glove boxes/ventilation, or harnesses inappropriately being connected to equipment important to safety.
    - Tenting is not always the solution; it may not be necessary and may get in the way, causing worker safety issues.
- *"Open air transfers are safe!!!"* The RRP successfully conducted hundreds of open air transfers. This is the result of extensive planning and drills, including preparation for off-normal events.

## 7.5 Readiness Assessment (RA) Strategies

B251's strategies resulted in significant safety improvements and operational efficiencies. As a result of robust processes and application of lessons learned, B251 successfully completed a Facility Startup Readiness Assessment (RA) [with NNSA] as well as three operational RAs [institutional with NNSA oversight].

B251's success with the four RAs was a direct result of extensive proactive preparation. Best practices for RAs include:

- Develop facility processes, project documentation and procedures, personnel interfaces.
- Develop presentations that demonstrate the facility and project's response for each CRAD; clearly show the assessors why the CRAD is satisfied. Involve appropriate personnel and proactively anticipate RA questions
- Conduct extensive dry runs as training
    - Dress rehearsals with PPE in operational glove boxes are very helpful for simulating the real work, use techniques such as talcum powder and black lights to mimic contamination during material handling and repackaging.
    - Demonstrate D&D activities with cold glove boxes and mock-ups.
    - Conduct off normal event drills and testing (e.g. contamination, component failure, personnel issue such as heart attack).
- Obtain pre-approval of all possible requirements (e.g. USQDs, environmental monitoring, NEPA, BAAQMB, Criticality).
- Front load the schedule, do not delay work until the end. Do the legwork initially prior to the RA to minimize findings and under your schedule, rather than responding to NNSA and DNFSB afterwards during schedule crunch time.

# 8.0 OPERATIONAL STRATEGIES: ROBUST PROCESSES THAT "*EXPECT THE UNEXPECTED*"

B251 developed safe work control processes. The success of these processes is demonstrated by an excellent safety record and the successful completion of a Facility Startup Readiness Assessment (RA) [with NNSA] as well as three operational RAs [institutional]. Robust processes significantly improved safety and contributed to the RRP's success by supporting:

- Facility Management (Work Planning, Work Control, ALARA, and Safety Analyses).
- Inventory Reduction,
- D&D process development, and
- D&D activities.

## 8.1 "Building Block" Work Plan Process

B251 utilized a "building block" work plan process. Such a process provides flexibility, ease of use, and is best suited for situations where performing the same operation may be required for a multitude of activities. Once the initial effort to write the procedures is complete, creating a work plan is relatively simple in comparison to other facility's work control process used around the DOE Complex. Another important benefit of the building block approach is that employees are trained to each procedure, and can effectively perform each individual task, whereas giant work plans that do not follow this approach are difficult to train to and effectively implement.

The following discussion describes how the "building block" work plan process functions. A project leader identifies what needs to be done and determines how

they would like to perform that activity. The overall order of the process is as follows:

1. Assembles procedures for an overall activity from a selection of previously approved procedures for specific operations that make up that activity. For example, to repackage an item in a glove box, select procedures for checking infrastructure functionality (e.g. room ventilation, glove box ventilation, continuous air monitors), entering specific locations and retrieving items, and open air transfers into and out of a glove box.
2. "Plug in" results from Characterization (e.g. gamma spectroscopy) about the specific items in question.
3. Conduct a standing meeting with reviewers to assess the proposed work package. Reviewers may include: ES&H safety disciplines (e.g. health physics, industrial hygiene, industrial safety, fire protection, environmental analysts), safety analysts (USQ), facility engineering (Configuration Management), and facility management. The reviewers assess and assimilate the reviewer's comments and develop a completed, *final* work package.

This approach minimizes review time as reviewers already understand each operation and focus their assessment on the integrated activity and specific hazards. This approach allows reviewers to assess each inventory item individually, which is important when radiation levels may vary greatly for the same operation depending on isotope (e.g. from a few mRem/hr to 5 Rem/hr). Thus ALARA controls may vary between items, and these details are discussed in pre-start meetings.

Additionally, the "building block" work plan process provides operational flexibility so you don't have to stop work to re-enter the paperwork processes. The project leader and reviewers consider possible issues and builds in contingency plans with previously approved procedures (e.g. glove changes, filter changes, spill plans). They expect the unexpected, and take steps to anticipate potential surprises when conducting the work, such as by monitoring for both neutrons and α/β/γ and establishing hold points for radiation levels and contamination. These hold points are based upon input from characterization (e.g. gamma spectroscopy) that helps the project leader to better understand the work environment.

Several best practices of the building block work plan process are:

- Assemble procedures for an activity from a selection of previously approved procedures for specific operations (e.g. facility operating procedures, OSPs, numerous IWSs, surveillance procedures).
- Conduct standing meetings with reviewers (e.g. ES&H, safety disciplines, USQ, CM, facility management) to assess proposed activities and then completed, *final* work package.
    - This approach minimizes review time as reviewers already understand each operation and focus their assessment on the integrated activity and specific hazards.
    - Assess each inventory item individually, radiation levels may very greatly for the same operation depending on isotope. ALARA controls may vary, discuss in pre-start.
    - Assures each sub-task is considered and procedure is up to date.
- *"Expect the unexpected and confirm the expected"* add steps to verify infrastructure operability, continue to verify status, and perform radiation and contamination checks.
- Build in operational flexibility so you don't have to stop work to re-enter paperwork processes unnecessarily. Contingency plans and procedures may include:
    - glove changes, filter changes, spill plans
    - hold points for radiation levels and contamination
    - Bullets vs. numbering - carefully consider order of steps – is ordering important?
- The project leader assembles the initial information and shepherds it through the entire regulatory process and then conducts the work. The project leader is the most knowledgeable individual on the activity and assimilates all relevant aspects of the work.

## 8.2 Work Control and Continuous Batch Processing

The RRP utilized a continuous batch process where the current activity was conducted while planning the next activity. These activities involved coordinating multiple organizations. Characterization was pivotal in work planning. The overall order of operations was as follows:

1. Plan the work, prepare the work plan, facilitate safety and regulatory reviews, and obtain approval to do work.
2. Characterize the material (e.g. inventory item or contaminated equipment).
3. Plan the work using characterization results; update the work plan as required.
4. Conduct the work.

a. Repackage and stage the material, and obtain appropriate documentation.
b. Plan the shipment, develop shipper/ receiver agreement, facilitate shipment.
c. Ship in batches.
d. Conduct a Lessons Learned to facilitate improvements for the next batch.


**Figure 5. Application of Integrated Safety Management (ISM)**

The guiding motto of the Risk Reduction Program (RRP) was to "*Expect the unexpected and confirm the expected.*" The RRP utilized a variety of characterization tools, including: Gamma spectroscopy; Radiography; Alpha/Beta/Gamma (α/β/γ ) measurements; Neutron measurements; Entry and concurrent radiation (during job) surveys; Pre-job, post-job, and concurrent contamination surveys. This selection of characterization tools resulted from lessons learned during Risk Reduction activities. Monitoring progress in a continuous batch process requires careful consideration of incremental progress. As inventory reduction reflects progress as a step function, it does not show incremental progress of steps prior to the inventory leaving the facility. It is important to monitor the progress of preliminary steps such as characterization, solidification, and repackaging. Simply monitoring inventory is insufficient for monitoring overall project progress.

## 8.3 Work Control Key Lessons Learned

Several best management practices for work control are noted below:

- Meetings can be very beneficial.
  - Pre-start meetings with staff, management, and safety personnel ensure awareness of planned work activities.
  - Transition to tailgate meetings only after sufficient expertise is demonstrated.
  - Standing safety meetings for ES&H team review & approval (e.g. Health Physics, Industrial Hygiene, Fire).
- Monitor the state of the facility using:
  - pre-job surveys for contamination,
  - post-job surveys for contamination,
  - infrastructure checks (e.g. CAMs, glove box exhaust, room exhaust, contingency workstations),
  - facility status information centers communicating which systems are operable and available for programmatic use,
  - *"How-we-know-what-we-know"* procedures and processes, in event of facility issues during operations, and
  - training on how equipment works, e.g. potential issues for false alarms when Radon is not pre-eliminated when working with $^{244}$Cm and less common isotopes.
- Radiation monitoring for unknowns, not just anticipated radiation:
  - when entering legacy areas,
  - when accessing legacy items,
  - use neutron and alpha/beta instruments,
  - use hold points for radiation levels and contamination.
- Active communication is important!
  - Facility Manager, Health Physicist, and the Responsible Individuals actively communicate.

## 8.3 Work Control Improves Safety

B251 developed a unique work control process that increased operational efficiency and safety. The two-step work control process (ALARA review/dose prediction) utilized gamma spectroscopy for ALARA and operational efficiency. First, RRP staff reviewed historical and process records to better understand the material in question (inventory item or contaminated equipment). Particular attention was paid to sister isotopes, process impurities, and daughter products, which often weren't considered by the original researchers working with the materials. This information provided the input to the 1$^{st}$ ALARA Review, which estimated conservative doses and planned the initial characterization. The RRP conducted the work with survey measurements and hold points from the ALARA review. Second, RRP staff characterized the material in question and compared the results with historical and process records. This information provided the input to the 2$^{nd}$ ALARA Review, which used characterization results as input to dose calculation codes (e.g. Microshield) for developing more accurate dose estimates and planning the hands-on work. RRP conducted hands-on work (e.g. repackaging, neutralization/solidification, special form encapsulation, decontamination). Finally, the parcel

was assayed for shipper/receiver documentation (for reuse in other programs or as waste).

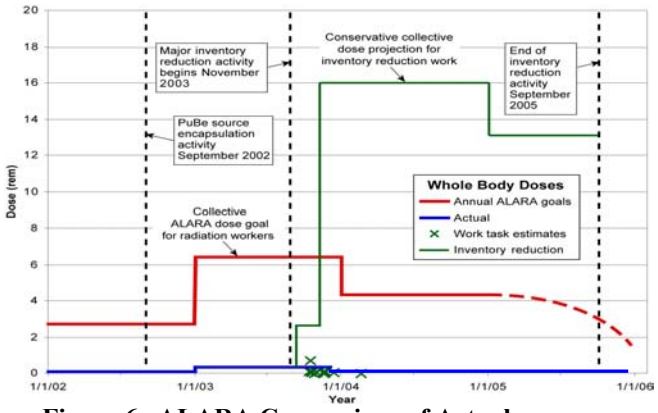



**Figure 6. ALARA Comparison of Actual vs. Predicted Dose Demonstrates Success of Work Control Practices**

There was little experience in the DOE complex in decontaminating facilities with this level and variety of high specific activity, alpha emitting isotopes (e.g. $^{244}$Cm, $^{238}$Pu). As a result of the B251 work control process, the RRP maintained an excellent safety record. There were no major contamination incidents, no radiation over-exposures (in fact, doses were far lower than dose predictions), and no major injuries. Individual and collective doses were maintained ALARA. The success of B251 work control processes was demonstrated by the excellent safety record (Fig. 6). Collective annual whole body doses were at least three times lower than ALARA goals and more than 10 times lower than conservation dose projections. Individual annual external whole body doses were less than 150 mrem.

## 8.4 Characterization

In a legacy facility, it is critical to develop robust processes that can handle surprises from legacy unknowns. B251's inventory control and work control processes resulted in significant safety improvements and operational efficiencies. The RRP followed a formal, rigorous process utilizing an independent, state certified, peer-reviewed gamma spectroscopy program in conjunction with other characterization techniques (e.g. radiography, α/β/neutron measurements), process knowledge, and historical records. This provided information for:

- Work planning, work prioritization, work control and safety analyses (e.g. development of stop work points and bounding hazard analysis);
- Helps define operational approaches to achieve ALARA, e.g. hold points, stop work points, appropriate engineering controls, PPE, workstations, and time/distance/shielding.

De-inventorying and decontaminating a legacy facility that had not been operated for almost a decade presented unusual challenges. Some items dated back over 40 years and were stored in a variety of conditions, including underground storage vaults (USVs), Mosler safes, hot cells, and rooms in variety of engineered containers (e.g. centrifuge cones, slip-lid cans, dog bones, and USV containers).

**Figure 7. Legacy Inventory**

Characterization facilitated efficiently and safely packaging legacy items for reuse onsite and shipment offsite, and disposition to waste. Characterization helped the RRP reduce the number of items requiring handling and opening down to the source level, allowing simpler repackaging operations and thereby minimizing dose. Furthermore, characterization facilitated efficient repackaging of co-located items, reducing the number of repackaging steps and avoiding severe schedule implications that otherwise be required to repackage a large number of co-located items.

## 8.5 Self-checking Inventory Control Process

The RRP utilized a self-checking process for inventory control that followed the guiding principle of *"Expect the unexpected and confirm the expected."* Records had been kept to requirements of the times, and often did not meet modern standards; many records included cryptic hand-written entries. There was a large risk of unknown legacy items. The RRP characterized each stored inventory item and each repackaged parcel. Inventory both increased and decreased due to characterization results. The RRP created a robust system for examining process knowledge in combination with characterization (Fig. 8). This systematic approach was a fundamental key to the success of B251.


**Figure 8. Self-checking Inventory Control Process**

The first part of the inventory control process was to review records and conduct interviews. RRP staff reviewed hand-written process notebooks, Materials Management records, interviewed previous facility managers and numerous previous facility residents, and contacted legacy offsite suppliers. In the time since legacy items originated with offsite suppliers, numerous changes occurred at those suppliers (name changes, mergers, out-of-business, etc.). These corporate changes at legacy suppliers required investigation, i.e. many supplier records were not as easily retrieved as anticipated. The second part of the inventory control process was characterization. Characterization included: gamma spectroscopy, X-ray radiography, alpha spectroscopy, visual examination, and Alpha/Beta/Gamma ($\alpha/\beta/\gamma$) measurements.

## 8.6 X-ray Radiography in Hot Cell

Radiography was essential for safe and efficient inventory reduction. Used in conjunction with other characterization tools such as gamma spectroscopy, radiography was a very powerful tool in inventory reduction. Radiography helped determine the condition of unknown legacy packaging, understand shielding issues with respect to gamma spectroscopy, minimize required repackaging and dose, helped plan repackaging operations efficiently and safely, facilitated shipments, and supported shipping documentation.

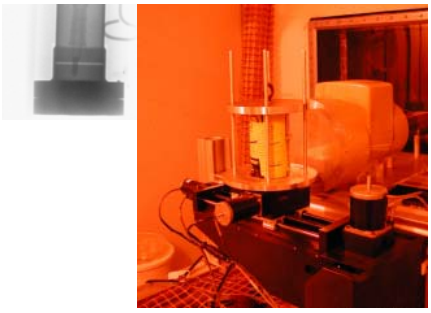


**Figure 9. Radiography Increases Safety and Efficiency**

## 8.7 Shipping

Shipping was important to RRP's success. Key lessons learned include the need to recognize package availability and shipping constraints; develop shipper/receiver agreements (which often required a great deal of lead time and was important to tackle early in the planning process); develop clear, agreed upon expectations for known issues; schedule for waste characterization, paperwork processing, acceptance, and transportation; and be aware that a large number of parcels can swamp characterization programs and transportation. Multiple paths are important because unanticipated events can occur at receiving facilities, e.g. for mixed LLW disposition. Furthermore, it is critical to select and obtain correct containers dependent on the receiving site:

- Pipe Overpack Container (POC) for high dose items,
- Standard Waste Box (SWB) for TRU glove boxes not decontaminated to LLW,
- 10 Drum Overpack for blue cave enclosures,
- Custom Type A Containers for special contaminated enclosures (glove boxes), and
- Special Form Container for sealed sources.

# 9.0 RESULTS

The Risk Reduction Program was an impressive success! No one had decontaminated facilities with this level and variety of high specific activity isotopes (e.g. $^{244}Cm$, $^{238}Pu$). All enclosures were characterized (gamma spectroscopy, alpha-swipe tab sampling). The RRP completed D&D of 40 of 49 Enclosures in 1 year and completed the rest shortly thereafter. Details include:

- 37 lower-contaminated glove boxes through D&D and shipped as LLW,
- 2 highly-contaminated Blue Cave enclosures emptied with little or no contamination
- 2 fume hoods carefully disconnected and relocated for new programmatic use

The RRP generated over 800 waste parcels, 84 TRU drums, and numerous LLW drums. Contaminants included: $^{166m}$Ho, $^{232}$U, $^{233}$U, $^{235}$U, $^{237}$Np, $^{238}$Pu, $^{239}$Pu, $^{240}$Pu, $^{241}$Pu, $^{242}$Pu, $^{241}$Am, $^{242m}$Am, $^{243}$Am, $^{243}$Cm, $^{244}$Cm, $^{246}$Cm, $^{248}$Cm, $^{249}$Cf. Special packaging included:

- 1 high activity glove box transferred as TRU Waste in a Standard Waste Box (SWB),
- 1 transferred as TRU Waste in a Type A Box

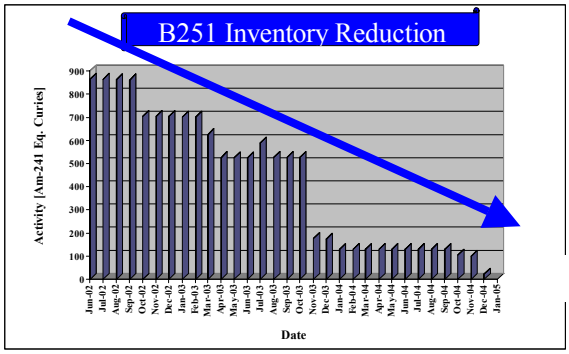



**Figure 10. Dramatic inventory reduction**

## 10.0 CONCLUSIONS

During the program, key lessons were learned. The Facility Management, Readiness Assessment, and Authorization Basis lessons learned during the Risk Reduction Program (RRP) can improve upon similar activities at other facilities. Key to this success is the RRP philosophy in a schedule driven paradigm.

- *"Expect the unexpected and confirm the expected"*
- Recognize when you reach the point of diminishing returns,
- Develop robust processes that anticipate and can handle surprises,
- Plan, plan, and re-plan *"Measure twice, cut once"*

## Key Contributors to B251's Success

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**NOTE: Figures 11 – 13 are located on subsequent pages.**

# Preparing, emptying, decontaminating, disconnecting, packaging, characterizing, and shipping enclosures





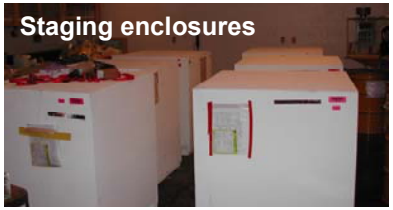



**Figure 11. Examples of D&D Activities**

# Enclosure D&D: Conditions of Legacy Equipment

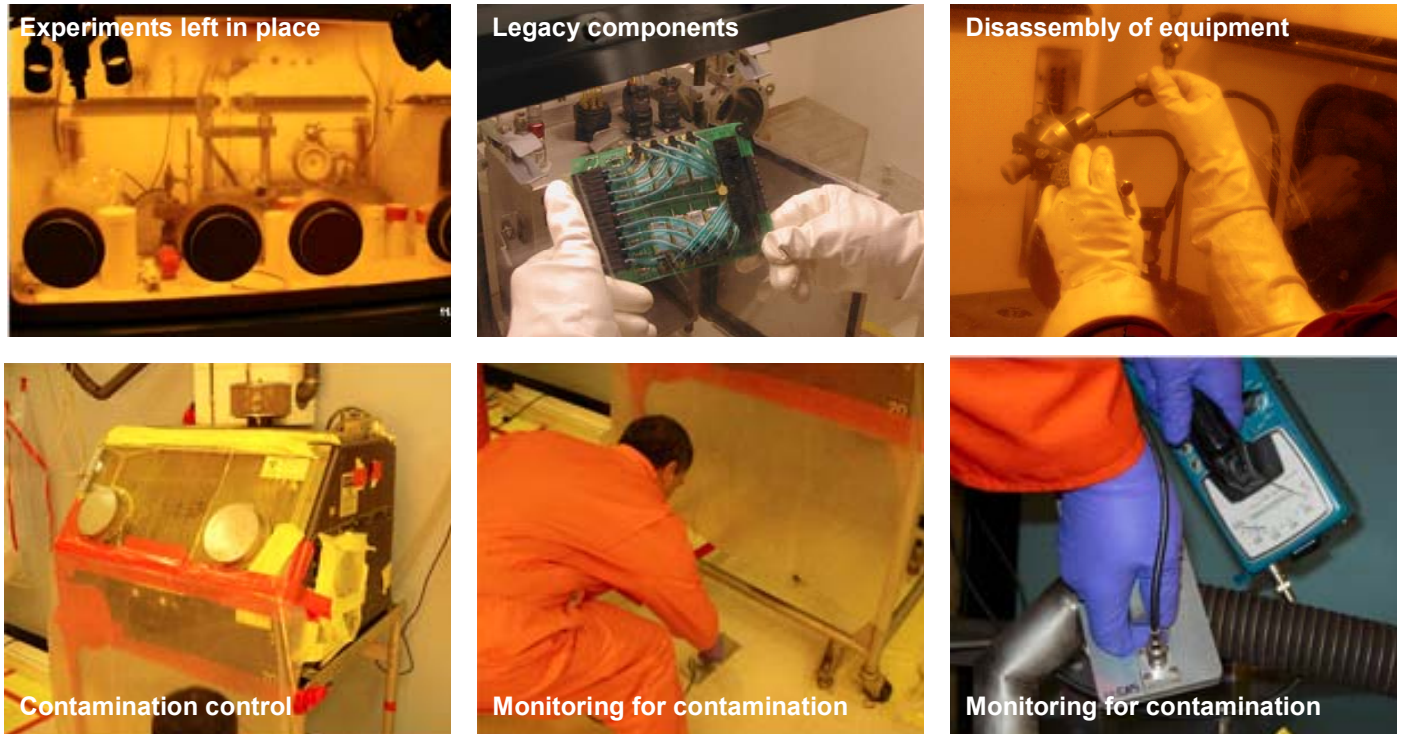


**Figure 12. Examples of Legacy Equipment and Contamination**

# Enclosure D&D: Before and After







B251 Experimental Decontamination Results:

- Emptying removes large fraction of activity.
- One or two passes of Strip Coat removes bulk of loose activity. Scrubbing surface with acidic solution loosens remainder of surface activity. Material removed by another pass of strip coat.
- Additional passes of acid wash and Strip Coat remove less and less residual activity because residual material embedded under metal surface.

**Figure 13. Before and After D&D**

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# Gamma Irradiation Facility (GIF)
# Cobalt-60 Sealed Sources Transfer Operation

Don Alsbrooks
Sandia National Laboratories, odalsbr@sandia.gov
H&P Incorporated, donalsbrooks@hpregulatoryservices.com

Sandia National Laboratories is a multi-program laboratory managed and operated by Sandia Corporation, a wholly owned subsidiary of Lockheed Martin Corporation, for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000

## INTRODUCTION

In an effort to reduce the amount of non-certified $^{60}$Co sealed sources (pins) stored at Sandia National Laboratories (SNL) Technical Area V (TA-V) Gamma Irradiation Facility (GIF), so that the facility can transition from a Hazard Category 3 (HC-3) nuclear facility to a radiological facility, a sealed source transfer operation at the GIF will be removing approximately 10k curies of non-certified $^{60}$Co sealed sources from the GIF. Removing the $^{60}$Co sealed sources will reduce the nuclear foot print at SNL and provide a cost benefit by not having to maintain Documented Safety Analysis (DSA) (GIF DSA, 2011), Technical Safety requirements (TSRs) (GIF TSR, 2011), Unreviewed Safety Question Determinations (USQDs), Annual Updates, etc.

The first part of this paper will describe the GIF facility to the extent that is needed to understand the operation and a description of the Pin transfer operation itself. The second part will describe the cask insert, its functional requirements and controls needed based on the hazard analysis (HA) and presents a unique solution to a source transfer problem.

### FACILITY DESCRIPTION

The GIF building is a single-story structure located inside the northeast quadrant of the fenced security perimeter of TA-V. The structure consists of a central High Bay with an ancillary Low Bay for offices, storage, and H-VAC equipment. In the center of the High Bay are three (3) test cells. Two (2) of the test cells are 3 meters (m) by 3 m and one (1) is 5.5 m by 9.1 m. Each of the cells has thick concrete walls and ceilings with access through a locked door and a maze hallway. The 5.3 m deep stainless steel-lined pool can store approximately 1.5 MCi of $^{60}$Co of gamma-ray sources. The sources are in the form of pins and can be shared between the test cells. The $^{60}$Co pins, in various arrays and source strengths, can be raised into the test cells by an elevator located in each cell so that irradiation experiments can be performed. The building has rollup metal doors and space beside the pool to allow access for tractor trailer trucks to back in to offload DOT Type-B transfer casks. This is where the GIF Pin Transfer Operation will take place.

### PIN TRANSFER OPERATION

The GIF Pin Transfer Operation involves bringing a pin basket, cask insert and a DOT Type-B transfer cask into the GIF High Bay. The following activities make up the GIF Pin Transfer Operation:

1. The GIF will receive a pin basket specifically-made to fit in the cask insert into which the pins will be installed.
2. The source basket will be placed in GIF pool and $^{60}$Co pins will be inserted into the source basket.
3. When the cask insert is received from the vendor, the cask insert lid is removed and the gasket and the shield cavity accessible areas are visually inspected.
4. The cask insert will be placed into the pool. The basket with the $^{60}$Co pins will then be placed into the cavity of the cask insert.

5. The cask insert lid will then be replaced and secured.
6. Once the trailer with DOT transfer cask arrives, the cask will be moved into the GIF and the DOT transfer cask will stay on trailer.
7. The DOT transfer cask lid will then be removed.
8. The cask insert will be removed from the GIF pool, and the water drained from the insert cavity, and the lid bolts torqued.
9. The cask insert cavity will then be vacuumed dry.
10. The drain ports will then be closed.
11. The cask insert will then be placed inside the DOT transfer cask and the lid of the DOT transfer cask will be sealed.
12. The trailer with the DOT transfer cask will then be moved out of the GIF.

## HAZARD ANALYSIS

### CASK INSERT

The cask insert and the DOT transfer cask are the two main ways of controlling direct radiation during normal operations and preventing and mitigating direct radiation during accident conditions. The cask insert with 10k Ci $^{60}$Co will be out of the protective confines of the pool for approximately thirty (30) minutes while the cask insert drains, the vacuum lines are hooked up, vacuuming is performed, vented, the drain is closed and cask insert placed in the DOT transfer cask. During these operations, facility personnel will be in close proximity to the cask insert. The estimate is that the direct radiation levels for worker contact with the cask insert vacuum line and the drain valve is Thirty (30) □ ninety (90) seconds per operation due to the quick-connect couplings. The DOT transfer cask has been analyzed in the GIF DSA and the cask insert is performing the same safety functions in the GIF Pin Transfer Operation. Table 1, "Cask Insert and DOT Transfer Cask Functional Requirement Comparison," evaluates the functional requirements of the DOT transfer cask and cask insert and shows that the cask insert does not meet functional requirements #1, 3 and 4 under the "DOT transfer cask" column. For mitigating the hazard scenarios in the initial Hazard Analysis, the cask insert was defined as a Design Feature (DF) only for attenuating the direct radiation levels. The DF TSR requires that an In-Service Inspection (ISI) be performed to ensure the cask insert lid is securely installed on the cask insert prior to removal from the GIF pool.

Other operation controls require that radiological control technicians be responsible for providing access control to the operational area of the GIF Pin Transfer Operation. They will set up high-radiation areas and monitor the operation to ALARA. Additionally, they will have facility personnel wear personal dosimetry to ensure that they receive an ALARA dose.

**Table 1. Cask Insert and DOT Transfer Cask Functional Requirement Comparison**

| Cask Insert | DOT Transfer Cask |
|---|---|
| 1) The cask insert attenuates the direct radiation levels from sources such that the dose rate any point on the external surface of the cask insert is less than (<) 10 rem/hr. at contact. This is a functional requirement of the cask insert design feature. | 1) The DOT transfer cask attenuates the radiation field from sources such that the dose rate at any point on the external surface of the DOT transfer cask is less than (<) 200 mrem/hr. |
| 2) The cask insert lid is secured to the transfer cask prior to removing from the GIF Pool. This is an SAC. | 2) The DOT transfer cask lid is secured to the DOT transfer cask. |
| 3) No credit is taken for DOT drop, crushes or puncture requirements of 10CFR71.73 (CFR, 2004) once the bolts are loosened on the DOT transfer cask in the existing GIF DSA (2011). There is no comparable functional requirement for the cask insert. In addition, the hazard scenarios result in a consequence level that does not require TSR-level controls. | 3) The DOT transfer cask meets the qualification requirements of 10 CFR 71.73, "Hypothetical Accident Conditions," for drops, crushes, and punctures. |
| 4) There is no comparable functional requirement for the cask insert. In addition, the hazard scenarios result in a consequence level that does not require TSR-level controls. | 4) The DOT transfer cask meets the qualification requirements of 10 CFR 71.73 for thermal "Hypothetical Accident Conditions." |

This HA is to be submitted to the Sandia Site Office (SSO) for approval to ensure the functional requirement gap between the DOT transfer cask and the cask insert is understood and authorized.

**SOURCE TRANSFER TOOL**

Since the $^{60}Co$ sealed sources are located at the bottom of an 18 ft. deep pool, specialized tools had to be built in order to move the sources. Some of the source transfer tools are at least 18 ft. long, intended to reach the bottom of the GIF pool. All are made of light metal (usually aluminum) and are either solid or have flooding holes to prevent a voided tube, which could result in radiation streaming to the top of the pool. During development of the procedure for the GIF Pin Transfer Operation, it was determined that the pins in the basket were too heavy (approximately 100 lbs.) to pick up by hand using the standard source transfer tools. In order to lift the pin basket in the cask insert, facility personnel developed

a rope-and-pulley system with a buoy to lift the pin basket into the cask insert. The system consists of a two-pulley nylon rope system suspended by a buoy attached to the pin basket. This effectively reduces the effort of the lift by half. As one operator picks up the pin basket with the rope, another operator guides the buoy over the cask insert and lines up the pin basket. The operator then lowers the pin basket into the cask insert. The rope-and-pulley system meets the functional requirements, as well as passed the In-Service Inspections, as listed in the TSRs. This operation was successfully demonstrated during operational dry-runs.

## CONCLUSION

The GIF Pin Transfer Operation is an effort by SNL to reduce the amount of non-certified $^{60}Co$ sealed sources (pins) stored at the GIF so that the facility can be transitioned from a HC-3 nuclear facility to a radiological facility, thereby reducing the nuclear foot print at SNL and providing a cost savings benefit. The HA showed that the cask insert controlled the direct radiation hazard to an acceptable level with the minimum amount of new TSRs. The ingenuity of the facility operator to develop the rope-and-pulley source transfer system allowed them to overcome the problem presented in not being able to use the standard source transfer tools due to the weight. Over all, this proved to be a successful operation.

## REFERENCES


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