The Greening of a Plutonium Facility through Personnel Safety, Operational Efficiency, and Infrastructure Improvements - 12108

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ABSTRACT

Chemical and metallurgical operations involving plutonium and other hazardous materials account for most activities performed at the Los Alamos National Laboratory's Plutonium Facility (TA-55). Engineered barriers provide the most effective protection from hazardous materials. These safety features serve to protect workers and provide defense in depth against the hazards associated with operations. Although not designed to specifically meet environmental requirements the safety-based design does meet or exceed the requirements of the environmental regulations enacted during and since its construction. TA-55's Waste Services Group supports this safety methodology by ensuring safe, efficient and compliant management of all radioactive and hazardous wastes generated at the TA-55. A key function of this group is the implementation of measures that lower the overall risk of radiological and hazardous material operations. Processes and procedures that reduce waste generation compared to current, prevalent processes or procedures used for the same purpose are identified. Some of these "Best Practices" include implementation of a chemical control system, elimination of aerosol cans, reduction in hazardous waste, implementation of zero liquid discharge, and the recyclization of nitric acid.

INTRODUCTION

There are many criteria that might be employed in measuring the toxicity of a substance such as plutonium [1]. Almost all of these criteria would relegate plutonium (Pu) to the category of highest toxicity and greatest hazard. Only injury statistics would indicate otherwise, for there have been no demonstrable injuries attributable to less than supra-critical concentrations of Pu. Many factors have contributed to this enviable safety record, but chief among them was the recognition of the hazardous nature of Pu before enough Pu existed to constitute a hazard. Increased knowledge of its physiological and toxicological behavior has kept pace with its greater availability.

Chemical and metallurgical operations involving plutonium and other nuclear materials account for most activities performed at TA-55. Although plutonium is produced in reactors, TA-55 is not a reactor facility. Plutonium is processed for purity at TA-55. Primary activities include [2]:

- **Actinide Process Chemistry**–Provides aqueous recovery operations; pyrochemical operations converting oxides to metal; and further purification, research, and development activities to advance scientific knowledge in areas of expertise.
- **Weapons Component Technology**–Provides pit surveillance, fabrication, assembly, and engineering services for the continual stewardship and management of the plutonium components in the nuclear weapon stockpile.

- **Plutonium-238 Science and Engineering**–Handles plutonium-238 (^{238}Pu) oxide, metal, and solutions in substantial quantities.
- **Actinide and Fuel Cycle Technologies**–Focuses on the stabilization and storage of plutonium oxide materials, the development of transmutation fuel forms, and the recovery of offsite radioactive sources.
- **Pit Disposition Science and Technology**–Dismantles the core of nuclear weapons, converts plutonium from pits into oxides, and performs nuclear fuel activities.
- **Nuclear Materials Science**–Characterizes new and aged pit construction materials and develop technologies for advanced actinide materials characterization.
- **Actinide Analytical Chemistry**–Focuses on the analysis of samples in actinide matrices, including determining the assay and isotopic composition of actinide metals and oxides, and tracing impurities in actinide samples.

The 1970's were a decade an environmental awakening and many new regulations became law in the 70's. The Los Alamos National Laboratory's Plutonium Facility (TA-55) was designed, constructed, and began operation during this period, as shown in Figure 1.

Fig. 1. The Los Alamos National Laboratory's Plutonium Facility

TA-55 design worked to meet environmental requirements because its design was intended to keep chemical and radiological materials separated from workers. TA-55 design had not been changed to comply with rapidly evolving environmental regulations.

Engineered barriers provide the most effective protection from radioactive and hazardous materials [3]. The barriers at TA-55 have been incorporated through architectural and structural design and employ differential pressure zones, High-Efficiency Particulate Air (HEPA) filtration, gloveboxes and radiation shielding in the design of the facility. Administrative procedures augment these passive safety features with the identification of radiological control areas, routine monitoring programs, use of

personnel protective clothing and detailed work instructions. Extensive safety analysis reports document these controls and evaluate “design basis accidents” to ensure that stipulated release limits, under accident conditions, are not exceeded [4]. Safety-significant structures, systems and components critical to the proper operation of engineered safety systems are identified. Surveillance and test criteria are established to verify their operability. All operations conducted within the facility must be performed within the established “safety envelope.”

TA-55’s Waste Services Group support this safety methodology by ensuring safe, efficient and compliant management of all radioactive and hazardous wastes generated at the TA-55. In order to achieve and sustain accident/incident rates, waste service operations are continuously improved, through the use of Lean Manufacturing and Six Sigma business practices (LSS) [5]. A detailed account of this approach to TA-55 operations has been described, previously [6,7,8]. A key function of this group is the implementation of measures that lower the overall risk of radiological and hazardous waste operations.

A primary objective throughout the U. S. Department of Energy’s (DOE) complex and TA-55 is that appropriate consideration be given to Pollution Prevention/Waste Minimization (P2/WMin) objectives, including:

1. Reduction of volume and/or toxicity of wastes during facility operations.
2. Elimination/reduction of hazardous and pollutant materials during facility operations.
3. Proper control of hazardous and pollutant material not otherwise eliminated through substitution or alternate design.

More specifically, Executive Orders 13101, “Greening the Government through Waste Prevention, Recycling, and Federal Acquisition,” requires the practice of pollution prevention whenever feasible.

In a previous paper reported in this journal, P2/WMin initiatives in the design of a new nuclear research facility were presented [9]. This paper reports on the greening of TA-55 through personnel safety, operational efficiency and infrastructure improvements. Resulting improvements to the radioactive and hazardous waste operations are discussed.

P2/WMIN OPPORTUNITIES

Personnel Attributes

An educated, well-trained work force is key to compliance with environmental and safety-based regulations, as shown in Figure 2.

Fig. 2. Employees Using Gloveboxes

TA-55 attracts the best workers. After a rigorous selection process, they undergo extensive training including safety, security, waste generation, and radiological control. The workers must have Q-Level security clearance, be on the Human Reliability Program, maintain mandated qualification standards, and endure pre-employment and random monitoring for drug and alcohol abuse.

Personnel at TA-55 who perform activities that generate waste are required to do:
- Minimize waste in their operations
- Identify and use less hazardous substitute chemicals
- Complete a Waste Management and Environmental Compliance Questionnaire for new or significantly changed processes to identify potential waste management issues
- Identify and characterize waste
- Segregate compatible waste by type for proper storage and management
- Notify waste management personnel when processes or chemicals change that could affect waste characteristics

Facility Attributes

TA-55 has been upgraded from a Perimeter Intrusion Detection Alarm System (PIDAS) to a Perimeter Intrusion Detection, Assessment and Deterrent System (PIDADS). The new PIDADS improvements include:
- Eliminates erosion from earthen areas
- Combines several surface water discharges
- Controls surface water discharge rates

Other facility features include:
- Waste Storage Pad has “No Exposure Certification”
- Negative facility pressure

- HEPA filter system
- Air discharges monitoring

Environment Compliance

TA-55 has six Treatment, Storage, and Disposal Facilities (TSDFs) and three less than 90 Day Storage Areas. TSDFS are storage facilities for radioactive and hazardous wastes. Resource Conservation and Recovery Act (RCRA) inspections are conducted 5 times a year; four by LANL's environmental compliance organization and one annual inspection by NM Environment Department. Waste containers, storage areas, contingency plans, worker training records, storage records, manifests, etc. are inspected.

Beyond Compliance

Upstream (prevention) improvements include:
- New Activity Approval Process
- Centralized Warehouse System
- Chemical Control System
- Aerosol Cans Elimination Program
- Zero Liquid Discharge Program
- Wood Pallet Replacement Program
- Packaging Material Elimination Program
- 1'x 1'x 2' Cardboard Box Elimination Program
- Microbial Fire Fighting Foam Program

Downstream (recycling) improvements include:
- Nitric Acid Recycling Program
- Cardboard, Metal, and Wood Recycling Program
- Electronic Component Release and Recycling Program
- Lead Shielding Reuse/Recycling Program
- Battery Recycling Program

Energy Conservation

Energy Conservation efforts include:
- Light-Emitting Diode (LED) Program
- Energy Efficient Equipment Program
- Employee Commuter Program

TA-55 has over 1000 employees. Fifty-eight percent commute from outside Los Alamos. Public Transportation offers a few solutions:
- Park and Ride Service
- Free rides on county bus
- LANL shuttle service to/from bus terminal

Green Focused Infrastructure Expansion

The first phase of the Chemistry and Metallurgy Research Replacement (CMRR) Project consists of the design and construction of a Radiological Laboratory/Utility/Office Building (RLUOB). RLUOB is high performance sustainable building, as shown in Figure 3.

Fig. 3. Radiological Laboratory/Utility/Office Building (RLUOB)

It is LEED certified. LEED, or Leadership in Energy and Environmental Design, is an internationally-recognized green building certification system, developed by the U.S. Green Building Council (USGBC) in March 2000. LEED involves a suite of rating systems that recognize projects that implement strategies for better environmental and health performance.

DISCUSSION

Personnel at TA-55 must be knowledgeable of the hazards and risks that they face, and training is designed to reinforce their understanding [10]. Technicians participate in the evaluation of their operations to identify and quantify hazards inherent in work activities. Mitigating factors (both engineered and administrative) are considered that reduce risk to acceptable levels [11]. These hazards analyses are documented and provide the basis for the development of work instructions that are used to perform the work. Personnel are trained and qualified on these hazards analysis and work instructions. In addition to classroom training, new personnel are mentored by experienced operators before being allowed to work independently. The better-trained the worker is, the higher the awareness of environmental and safety issues is as well. This higher-level of awareness relates to the number of environmental awards to be discussed later. This safety methodology has resulted in low accident/ incident rates. Serious accidents involving chemicals and radioactive materials are rare.

In order to shift from a PIDAS to a PIDADS, sloped areas have been replaced by terraces. Multiple surface water discharge points have been eliminated combined to a single controlled discharge. This prevents peak flows that might erode the canyon near TA-55.

Radioactive liquid effluents are now discharged through monitored double-containment lines to the Radioactive Liquid Waste Treatment Facility (TA-50). Sanitary waste is monitored at discharge as well. This allows sanitary waste to be treated at a permitted

waste water treatment plant. The Waste Storage Pad “No Exposure Certification” gives it a Clean Water Act (CWA) designation. There is a limited chance for stored materials to contact surface water. A robust secondary containment for materials is available. The Waste Storage Pad has had no previous spills and eliminates surface water runoff monitoring after precipitation events and most reporting requirements. The negative facility pressure prevents any gaseous discharges from escaping from TA-55. Air is processed though a series of HEPA filters and discharged through two stacks.

Over the last five years, there have been no CWA or Clean Air Act violations or significant findings reported. Findings were documented for three flashlight batteries and one flashlight bulb. There was a short-term lapse in operator training. Last, there was a date on a log book that was off by one day.

The new Activity Approval Process includes all new or revised activities. New/changed activities must be compatible with existing facility systems. Materials, energy needs, water consumption types, and volumes of waste to be generated need to be identified. The Centralized Warehouse System controls purchases and eliminates non-compatible items. There are hazardous waste challenges in unused/unspent chemicals. The Chemical Control System addresses this issue by controlling the type and volume of stored chemicals. Chemical containers are bar-coded, an owner assigned, and periodic updates required. Multiple employees can access a given chemical. This helps eliminate excess and waste.

Aerosol cans are convenient and easy to use but a disposal problem. Empty containers/cans aren’t difficult to dispose of but one cannot prove non-radioactive internals. Partially full cans are easy to prove not to have internal contamination, however, it still contains some of the chemical. Pressurized aerosol cans cannot be disposed. Eliminating the purchase of aerosol cans reduces hazardous waste.

Through the Zero Liquid Discharge program, the liquid waste treatment facility eliminated liquid discharges in 2011 by converting the discharge stream to a solid waste form. This involved the installation of an evaporator. Substituting metal pallets for wood ones is prudent for two reasons: metal pallets can be reused indefinitely and metal pallets can be recycled when damaged. Eliminating packaging material and cardboard boxes prevent the generation of suspect radioactive paper, cardboard, and wood. In addition combustible loading is reduced as well.

Microbial fire fighting foam contains wetting agents, nutrients, and several strains of safe, non-pathogenic *Bacillus* bacteria. It is applied on parking lot oil/gas leaks. Wetting agents break down the contaminants into smaller molecules. Microbes degrade these molecules into harmless by-products like carbon dioxide, water, and trace salts.

In 2008, the installation of light-emitting diode (LED) lights began. LED lights have low energy consumption, contain no mercury, and can be recycled through the manufacture. The Energy Efficient Equipment Program includes the purchase and installation of energy efficient equipment, endorsed by Energy Start, The Federal Energy Management Program, and Electronic Product Environmental Assessment Tool.

CONCLUSIONS

P2/WMin opportunities have been implemented in the areas of personnel and facility attributes, environmental compliance, energy conservation, and green focused infrastructure expansion with the overall objective of minimizing raw material and energy consumption and waste generation. This increases technical knowledge and augments operational safety.

ACKNOWLEDGEMENTS

The authors would like to acknowledge the U.S. Department of Energy and LANL's Plutonium Science & Manufacturing and Nuclear & High Hazard Operations directorates for support of this work.

REFERENCES

1. Paraphrased from Plutonium Handbook, A Guide to the Technology, O.J. Wick, editor, American Nuclear Society, Vol. II, 1980, and p. 833.
2. Cournoyer, M.E., et al., "Minimizing Glovebox Glove Failures," *Journal of the American Society of Mechanical Engineers, Proceeding from WM'04*, Tucson, Arizona, February 29 – March 4, 2004.
3. LA-UR-04-1883, Successful Implementation of a Behavioral Safety Program at Los Alamos National Laboratory's Plutonium Facility.
4. DOE Order 440.1A, *Worker Protection Management for DOE Federal and Contractor Employees*, U.S. Department of Energy, Washington DC, March 27, 1998.
5. **http://lanl.gov/orgs/adbs/lss/index.shtml**: link verified April 3, 2012.
6. Cournoyer, M.E., et al., "Lean Six Sigma Tools for a Glovebox Glove Integrity program," *J. Chem. Health Safety*, JANUARY/FEBRUARY Vol. 18, No. 1 (2011) 13.
7. Cournoyer, M.E., et al., "Lean Six Sigma Tools, Part II: Output Metrics for a Glovebox Glove Integrity Program," *J. Chem. Health Safety*, JANUARY/FEBRUARY Vol. 18, No. 1 (2011) 22.
8. Cournoyer, M.E., et al., "Lean Six Sigma Tools, Part III: Input Metrics for a Glovebox Glove Integrity Program," *J. Chem. Health Safety*, JANUARY/FEBRUARY Vol. 18, No. 1 (2011) 31.
9. Cournoyer, M.E., et al., "Addressing Pollution Prevention Issues in the Design of a New Nuclear Research Facility," *Journal of the American Society of Mechanical Engineers, Proceeding from WM'03*, Tucson, Arizona, February 23 – 27, 2003.
10. Dare, J.; Cournoyer, M.E., "A Risk Determining Model for Hazardous Material Operations," *Proceedings from Probabilistic Safety Assessment and Management 6*.
11. Cournoyer, M.E., "A Risk Determining Model for Hazardous Material Operations: Part II," *Proceedings from Probabilistic Safety Assessment and Management 7 (PSAM 7)*, Berlin, Germany, June 14-18, 2004.