RISK REDUCTION BENEFITS FROM INNOVATIVE TECHNOLOGY USE IN THE LOS ALAMOS LARGE SCALE DEMONSTRATION AND DEPLOYMENT PROJECT

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ABSTRACT

The Los Alamos Large Scale Demonstration and Deployment Project (LSDDP) in support of the US Department of Energy (DOE) Deactivation and Decommissioning Focus Area (DDFA) identified and demonstrated technologies to reduce the cost and risk of management of transuranic element contaminated large metal objects, i.e. gloveboxes. The demonstrations supported development and design of the Decontamination and Volume Reduction System (DVRS) at Los Alamos National Laboratory (LANL).

Previous project reports and presentations documented the cost savings from technology demonstrations initially supporting "front end" characterization and size reduction and subsequently decontamination of the gloveboxes themselves (1). The cost savings estimates were based on demonstrations that carefully evaluated of the technologies side-by-side with the baseline technologies. It was recognized that several of the technologies provided an additional risk benefit that was not readily quantified in the cost savings calculations.

This paper provides an approach to the risk evaluation of the use of innovative technologies in an operating facility. Since the DVRS is a non-reactor nuclear facility, a quantitative Safety Analysis was not required, but a Hazards Analysis was performed and approved. The basis for this review is the Hazards Analysis, which qualitatively assesses the risk to two population groups, workers and the general public, resulting from identified potential accident scenarios. The risk impact of each of the demonstrated LSDDP technologies was reviewed to assess benefits across the identified populations and hazard scenarios. It is noted that approval of the Hazards Analysis means all DVRS activities are protective of the public health and the environment. In addition, the DVRS mission is volume reduction of TRU contaminated metal objects, which are a relatively small dose effect. With this background, the general conclusions are:

- The demonstrated technologies that improved characterization of the crated large metal objects provide an operational efficiency that was not readily quantified in the cost analysis. Improved characterization supports better planning for DVRS operation, and enhanced worker safety by precluding "surprises" and enhanced efficiency of operation (faster work/lower risk).

- Improved size reduction technologies provided a cost savings from enhanced operational efficiencies and a reduction of industrial accident potential. In addition, these technologies meet the operational objective of "As Low As Reasonably Achievable" (ALARA).
- Since TRU waste dose effects are small, limited dose reduction is realized by implementation of the innovative technologies.

INTRODUCTION

The Los Alamos National Laboratory has been the host site for an LSDDP that identifies and demonstrates technologies that enhance both the cost and safety of treatment for disposal of plutonium contaminated gloveboxes and other large metal objects contaminated with TRU elements. Numerous reports (Innovative Technology Summary Reports) documented the cost savings based on application of the technologies in actual practice. However, it has been recognized that several of the technologies provided a risk benefit that was not readily quantified in the cost savings calculations. This paper describes an approach to evaluating the risk benefit of the technologies.

RISK REDUCTION – IDENTIFIED APPLICATIONS

DVRS is currently authorized as a non-reactor nuclear facility at LANL and is repackaging TRU waste. It is not currently authorized to size reduce or decontaminate large metal objects, which will require upgrading of the authorization basis. The current DVRS hazards analysis reviewed the general safety of DVRS operations and identified 20 specific operations with safety implications worthy of analysis. Therefore, the hazards analysis was selected as the basis for a review of the impact of new technologies on overall process safety and risk. This review assesses whether improvements of the overall risk is possible with the demonstrated technologies, when applied to the ultimate DVRS mission.

Table I lists the identified DVRS hazards and the associated probability. Table I lists only the likelihood (frequency) ranking. This likelihood ranking progresses (improves) from "frequent" to "probable" to "occasional" to "improbable", and finally to "remote". A consequence ranking is also provided, but not included here. Each of the demonstrated LSDDP technologies was evaluated for effects on these identified hazards with emphasis on the frequency of the event. The technologies and associated impacts are discussed individually.

AeroGo Air Pallets

The AeroGo, Inc., air pallet system includes air casters, an air hose, and a pressure manifold distribution control box to "float" loads on a frictionless film of air and was demonstrated at the LANL Solid Waste Disposal Area. The reduced friction allows an operator to manually position or move a heavy crate or load in a limited workspace without use of a forklift. Lifting capacity can range from a few hundred pounds to hundreds of tons. Once loads are elevated, only oderate force is needed to maneuver and position a load. Loads can be accurately positioned as needed for non-destructive assay analysis or for disassembly (2).

Table I DVRS hazards analysis summary

Number	Hazard[i]	Public consequence	Worker consequence	Likelihood
1	Breached container caused by improper moving/handling	None	None	Improbable
2	Breached container resulting in fuel spill or fire	None	Minor injury	Improbable
3	Primary container - breach small due to degradation	None	None	Improbable
4	Primary container - breach due to box falling apart on its own	None	None	Improbable
5	Unsheathing - worker cuts into waste, spreads contamination, saw kicks back, saw cuts worker	None	Severe injury	Improbable
6	Unsheathing – results in fire caused by sparks, produced by cutting or electrical short	None	Minor injury	Improbable
7	Shear baler - hydraulic oil spray catches fire	None	Minor injury	Improbable
8	Unanticipated internally-shielded radiological source	None	Minor injury	Improbable
9	Shear baler - size reduction results in release of radiological contaminants	Negligible	Minor injury	Improbable
10	Breathing air system gets contaminated or fails	None	Minor injury	Occasional
11	Chemical exposure resulting from waste unsheathing or handling	Negligible	Minor injury	Improbable
12	Shear baler – metal pinches and kicks out of shear baler	None	None	Improbable
13	Loss of power	None	None	Probable
14	Criticality	None	Fatality	Remote
15	Seismic event causes building damage impacting waste (may or may not result in a fire)	None	Minor injury	Occasional
16	Lightning impacts the facility (may or may not result in a fire)	None	None	Probable
17	High winds cause part or all of the building to collapse	None	None	Probable
18	Wild fire causes building to catch on fire	None	Minor injury	Improbable
19	Worker being crushed in the shear baler during operation	None	Severe injury	Improbable
20	Worker being crushed in the shear baler during maintenance	None	Severe injury	Improbable

Since the Air Pallet use facilitates simple manual movement and positioning of heavy packages, forklift use is minimized and the associated accident potential is significantly reduced. The first three identified hazards in Table I address breaching of crates during handling. Since air pallets replace forklift movement of crates, and the resulting movement is readily managed using manual manipulation of the air pallet pressures, the crate movement hazards and potential breaching are reduced in frequency.

Crate contents identification using the Vehicle and Cargo Inspection System (VACIS™) or the Large Crate Interrogation System.

Two demonstrated technologies provided information on the contents of the crated waste to be treated by DVRS. Records of crate contents vary in completeness and clarity. The Los Alamos LSDDP demonstrated the mobile Vehicle and Cargo Inspection System (VACIS™) unit in June 1999 to evaluate effectiveness in imaging the contents of the crated waste. In the mobile unit tested at LANL, a radioactive source and detectors are mounted on a boom truck, with the source positioned in a shielded box at the end of the boom and the detectors mounted on a stalk on the truck. As the waste container passes between the source and detector, the VACIS™ unit's on-board computer constructs a composite image of the contents from the detector readings (3).

The demonstration took place within a temporary structure at the LANL Solid Waste Operations Area, Technical Area 54, Area G. Waste containers consisting of fiberglass reinforced plywood (FRP) crates and standard waste boxes (SWBs) were loaded onto flatbed trucks, driven to the demonstration area and imaged using VACIS™. Once positioned, the driver exited the truck and the VACIS™ unit drove along the flatbed, compiling the image. Images were reviewed in near real-time and were recorded on disk. Personnel from the US Army's Thunder Mountain Test and Evaluation Center (TMEC) from Fort Huachuca, AZ operated the VACIS™, along with representatives from the unit's developer, Science Applications International Corporation (SAIC).

The VACIS™ mobile unit provided quality images of the crate and waste container contents in which items such as gloveboxes, equipment, debris and equipment inside gloveboxes, and filter media were clearly visible. Once the flatbed truck was positioned, an image was obtained in less than 30 seconds. Figure 1 is a VACIS image of a truck and two LANL waste crates containing gloveboxes.

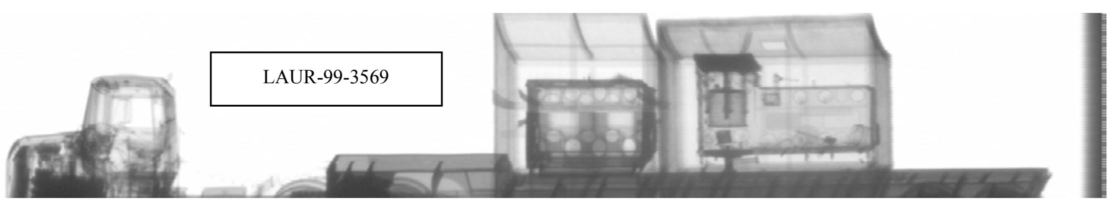

Fig. 1 VACIS Image of crated waste

Mobile Characterization Systems (MCS) operated a Large Box Real Time Radiography (RTR) system to non-intrusively image the contents of waste storage crates and containers. The unit is similar to RTR systems for certification of waste packages for the DOE's Waste Isolation Pilot Plant (WIPP). To image a waste container, it is loaded onto a turntable trolley conveyor system and moved into a lead shielded x-ray vault, which is inside a large shielded truck trailer. Once a container is moved into the vault, the doors are closed and x-ray generation is initiated. The system images or radiographs approximately a 15 cm by 15 cm segment at any instant. The combination of the moving trolley conveyor and the elevation control on the x-ray system facilitates imaging of the entire waste container from top to bottom and end to end.

In January 2000 the Los Alamos LSDDP demonstrated the large box RTR system on twenty pre-selected containers and items. The containers included fiberglass reinforced plywood (FRP) crates, metal Standard Waste Boxes (SWB) and one unknown metal cylinder provided by LANL waste management operations. The containers were transported to the RTR trailer using a truck or forklift. The forklift placed the containers on the RTR system trolley, and the MCS technicians initiated imaging. Once the container was positioned on the RTR trolley, it took from 15 to 60 minutes to obtain the complete image and associated audio description.

The MCS RTR unit provided detailed radiographic images of the contents of all containers and packages. Items such as plastic bagging, nails in crate construction, electrical connectors, wiring, piping, and fittings were clearly visible. Large metal items were easily located and their position and general shape was understood. Containers of filter media required much less detail to review than containers of complex items and miscellaneous trash.

A particularly significant result of the demonstration was the identification of a vessel that contained several gallons of liquid. The liquid was identified by the wave action that was created as the trolley moved through the field of the x-ray head. Wave motion in the vessel was distinct and unmistakable. Identification of this vessel and liquid will allow planning for liquid capture when the crate is ultimately repackaged. An aerosol can was also located in a container of mixed trash. The unknown cylinder was found to contain an apparent radiation source.

These two characterization technologies provided information that supports better planning for crate disassembly and waste handling. This information reduces the risk on several identified DVRS hazards:

- Number 5 – An unsheathing incident in which the cut plan inadvertently cuts into the waste leading to contamination spread.
- Number 6 – An unsheathing incident resulting in a fire due to tool use in the cutting operation.
- Number 8 – Opening a crate that has a radioactive source that was not detected by the survey system due to unknown shielding in the crate.
- Number 11 – Chemical exposure due to unidentified waste crate contents
- Number 14 – Criticality from crate contents that were not identified in the assay due to shielding.

Cutting Platform

The LSDDP supported two design reviews to refine requirements and designs for a crate cutting system that would enhance the safety of opening the large fiberglass reinforced plywood (FRP) crates. An equipment review evaluated small tools for crate opening including; seven saws, three dust removal/capture systems, three drills, three optical probe devices, a mechanical spreader, and a remote controlled robotic cutting device. Based on these reviews, a crate cutting fixture was designed with a combination of a unique cutting saw mounted in a fixture that could be fixed to the FRP crate. The Crate Size Reduction Platform (CSRP) was developed and constructed at Florida International University's Hemispheric Center for Environmental Technologies (FIU-HCET). The prototype consists of a scaffold-based frame with guides to hold the saw against the crate to be sectioned. The saw can move left and right as well as up and down in an X-Y vertical plane configuration. The saw can be rotated 90 degrees to cut vertically or horizontally along the sides of the boxes.

This technology reduces the probability of incident from both crate unsheathing hazards (numbers 5 and 6) as the cutting platform gives better control of cutting and provides a stable platform for the crate cutting saw operation.

Race Scan Communication System

D&D technicians in contaminated environments must wear Personal Protective Equipment (PPE) including full-face respirators, which severely inhibit communications between workers and supervision. To communicate, technicians shout through their respirators or use hand signals and signs. On some occasions, technicians must doff their PPE and leave the work area in order to communicate with outside supervision personnel. These forms of communication lead to worker frustration, decreased work productivity, and reduced safety.

The Race-Scan EarMic system was developed by Race-Scan Communications and is marketed exclusively by Radiation Protection Systems for nuclear facility operations. The system was originally developed for use in the auto racing industry for communications between racecar drivers and their pit crew. It includes two earpieces, a push-to-talk switch, a radio, and associated wiring (Fig. 2). The right earpiece serves as a speaker and the left earpiece acts as a microphone picking up voice sonics within the ear canal. In-the-ear mounting of the earpieces reduces noise of the work area.

The Los Alamos LSDDP demonstrated the Race Scan EarMics in two operational settings at LANL (4). These operations were (1) waste drum retrieval from an above ground berm and (2) waste crate venting carried out within a PermaCon structure. In both operations, communication between the workers within the work zone is limited by loud background noise. In the crate venting operation, the walls of the PermaCon structure limit communication between workers and outside supervision.

In both operational phases of the demonstration, it was observed by LSDDP overseers that EarMic supported operations proceeded more smoothly and that workers spent significantly less time and effort communicating with each other and supervision. No limitations on transmission clarity were noted due to the walls of the PermaCon for the waste crate venting phase of the demonstration. Measured efficiencies in these operations improved from 20 to 40%.

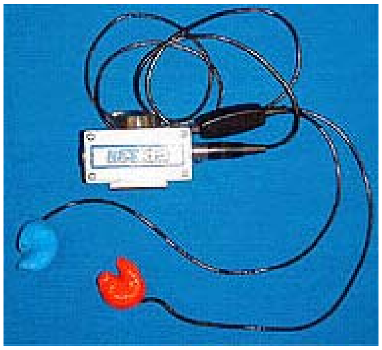

Fig. 2 EarMic system showing right and left ear pieces and push-to-talk button.

The Ear Mic systems reduce the risk in the following DVRS hazards:

- Number 9 – Shear-baler incident leading to contamination release incident impact can be minimized by immediate communication with supervision and proper response to the incident.
- Number 10 – Breathing air incident impacts are minimized as supervision can quickly communicate with the technicians and provide guidance on actions.
- Number 13 – During a Loss of Power incident the ability of the technicians to communicate with each other supports a safe egress. Supervision communication is also supported so that the technicians can be coached out of the environment.
- Number 19 – The likelihood of worker injury during shear-baler operation is reduced due to better communication among technicians in the area as well as improved communication with supervision to ensure workers are aware of shear baler operation.
- Number 20 - Worker injury during shear-baler maintenance is also reduced in risk with continuous and simple communication between supervision and maintenance workers outside of the enclosure.

NTvision for Improved Waste Crate Filling Documentation

A demonstration of the NTvision System was performed to determine if a video recording system is an improved technology over manual observation for management of the information on the contents of Low-Level Waste (LLW) and TRU crates (5). This technology facilitates pictorial recording of the waste package contents as well as the documentation of the date and time of the package loading.

One feature of NTvision is the "on for action" mode wherein the system stops recording when there is no movement in the video frame. Thus, for typical waste package loading operations, there is a relatively small electronic file that is readily retrieved and is non-subjective documentation of waste package contents. Another feature of the NTvision software is it's ability to electronically subtract the "before" and "after" images displaying the object that initiated the event. This feature is useful in waste packaging since an image will be produced for each object that is loaded in waste containers. Once installed, the system may be operated unattended. This LSDDP demonstration showed that a fulltime waste documentation technician could be eliminated from the repackaging area and reduce the technician risk accordingly.

NTvision will reduce the impact of hazard 14, the criticality incident. Since one waste data recording technician is eliminated from the active area, the impact of the incident is reduced.

RISK REDUCTION – ANTICIPATED APPLICATIONS

The existing DVRS hazards analysis is for current operations as a non-reactor nuclear facility, one dealing with low-inventory radioactive waste. Documentation has been submitted to upgrade the status to a radiological facility. At that time additional hazards will be incurred as glovebox management operations take place. Other demonstrated technologies are expected to support risk reduction at that time.

Blade Cutting Plunger

The Blade Plunging Cutter is a portable, hydraulic cutting tool with a piston-forced cutter with a 4-inch blade. The cutter severs metal shapes in a guillotine fashion during the 8-inch stroke. The baseline technology for this demonstration was the Porter Cable variable speed Tiger Saw, as representative of reciprocating saws. Typical applications of this type of metallic waste volume reduction include cutting glovebox legs, pipe, conduit, and other metallic appendages.

Glovebox leg removal was demonstrated on a non-radioactive mockup of a glovebox bottom constructed to allow easy leg replacement (6). Two representative glovebox leg types were used (Nominal 3-inch Schedule 40 pipe and standard (1 5/8 in.) Unistrut). The following were the key results:

- The Mega-Tech Blade Plunging Cutter, BPC-4, successfully cut all the glovebox legs with an average cutting rate of 70 seconds for pipe legs and 18 seconds for Unistrut. The reciprocating saw used as baseline required 29 seconds to cut the Unistrut and 117 seconds for the pipe legs. Replacement of the reciprocating saw blades was an issue for technicians in PPE with several pairs of gloves.
- Minimal airborne contamination was noted during the BPC-4 demonstration, but there was airborne emission from the reciprocating saw near the end of blade life.
- The BPC-4 was judged to reduce health and safety hazards to the technicians performing the cutting. International Union of Operating Engineers health and safety personnel indicated a slight advantage to the ergonomic factors for BPC-4.

Evolution 180 Saw

The Evolution 180 saw is a portable handheld circular saw that cuts stainless steel and other metals up to 0.6 cm thickness without heating the metal or producing sparks. The Evolution 180 saw was demonstrated for the glovebox de-shielding operation at LANL (7).

Fig. 3 Jancy Engineering Evolution 180 Saw Model

Four technicians were required to perform this activity: two saw operators, a supervisor, and a radiological control technician (RCT). To remove the lead shielding, the depth of the outer layer of the glovebox stainless skin was confirmed. The saw cutting depth was set, so that the blade would make minimal contact with the lead beneath the glovebox skin. The glovebox skin was cut along pre-determined paths where the saw blade could travel without contacting the lead plates. One technician operated the saw, while the other held the glovebox skin being cut. The second technician also manipulated the vacuum hose and performed a safety watch. After the glovebox skin was cut, it was removed or bent out of the way so that the lead shielding was exposed for removal. The saw speed was over up to 14 cm per minute – almost ten times the baseline technology speed.

Glovebox Decontamination Technologies

The DVRS waste inventory includes approximately 200 "legacy" TRU waste gloveboxes. These gloveboxes will be processed through the DVRS to decontaminate the glovebox itself to LLW contamination levels. The accepted LANL LLW activity level has been established as less than 50,000 disintegrations per minute per 100 cm^2. Traditionally, gloveboxes were decontaminated by scrubbing using nitric acid and polypropylene rags. A large number of contaminated rags are generated which must be disposed of as TRU waste. In an effort to find more efficient means of decontaminating these gloveboxes, four decontamination technologies were demonstrated and monitored using LSDDP test planning and methodologies. The technologies were:

1. A LANL developed electrochemical decontamination technology using a recycled electrolyte that contacts the glovebox surface in a fixture fastened to the glovebox surface (8).
2. A commercial three-step decontamination technology specifically developed to address TRU contaminated metal objects (9).
3. A modification of the cerium nitrate decontamination process specifically developed by Rocky Flats Environmental Technology Site for glovebox work (10).
4. A Russian electrochemical decontamination technology using low voltage alternating current and a recycled electrolyte (11)

The commercial three-step technology was the one was identified by the LANL technical and operational staff as preferable in their applications. This technology will reduce the hazards associated with glovebox decontamination by virtue of its reduced manpower requirement and the associated reduction in potential exposure.

CONCLUSION

Table II summarizes the risk impact from the application of the technologies in the DVRS as applied to the identified hazards. The frequency of occurrence is reduced in eleven of the twenty identified hazards. In several others a risk benefit is likely, but the benefit is small enough that it does not change the ranking. Keeping in mind that approval of the DVRS Hazards Analysis indicates a safe operation, several generalized conclusions from this review can be made:

- The demonstrated technologies that improved characterization of the crated large metal objects provided an operational efficiency that is not readily quantified in cost estimates. These technologies support better planning, enhanced worker safety, and enhanced efficiency of operation (faster work/reduced risk).

- Improved size reduction technologies provided a cost savings from enhanced operational efficiencies and thereby provide a reduction of industrial accident potential. In addition, these technologies meet the objective of "As Low As Reasonably Achievable."
- Since TRU waste dose effects are small, limited dose reduction is realized by implementation of the innovative technologies.
- The demonstrations and the resultant application of the risk-reducing technologies complies with the DOE Integrated Safety Management System based on the analysis of the activity and identification of alternative methods.

Table II Impact of new technologies on DVRS

	Hazard[ii]	Public consequence	Worker consequence	Technology Applied[iii]	Likelihood Change[iv]	Benefit of Technology Application
1	Breached container caused by improper moving/handling	None	None	AeroGo	Improbable ↓ Remote	Reduces risk of breach by reducing forklift use
2	Breached container resulting in fuel spill or fire	None	Minor injury	AeroGo	Improbable ↓ Remote	Reduces risk of breach by reducing forklift use and reduces frequency of available fuel source
3	Primary container - breach due to degradation	None	None	AeroGo	Improbable ↓ Remote	Slightly reduces risk of breach by reducing forklift use
5	Unsheathing - worker cuts into waste, spreads contamination, saw kicks back, cuts worker	None	Severe injury	VACIS/MCS Cutting Platform	Improbable ↓ Remote	Visualization provides better understanding of waste within box, metal cutting saw to cut waste if necessary, cutting platform better cut on crate
6	Unsheathing – fire caused by sparks, produced by cutting or electrical short	None	Minor injury	VACIS/MCS Cutting Platform	Improbable ↓ Remote	Visualization provides better understanding of waste within box, cutting platform better cut on crates
8	Unanticipated internally-shielded radiological source	None	Minor injury	VACIS/MCS	Improbable ↓ Remote	Reduces risk of unanticipated waste material
9	Shear baler – size reduction results in release of radiological contaminants	Negligible	Minor injury	Race Scan	Improbable ↓ Remote	Better communication would prevent worker proximity to operating baler
10	Breathing air system gets contaminated or fails	None	Minor injury	Race Scan	Occasional ↓ Improbable	Better communication alerts worker of breathing air system problem – reduces consequence
11	Chemical exposure resulting from waste unsheathing or handling	Negligible	Minor injury	VACIS/MCS NTvision	Improbable ↓ Remote	Reduces risk of unanticipated waste material
13	Loss of power	None	None	Race Scan	Probable	Enhanced communication supports safer egress, but no impact on likelihood.
14	Criticality	None	Fatality	VACIS/MCS NTvision	Remote	Reduces risk of unanticipated waste material in excess of criticality limits, but already low risk.
19	Worker being crushed in the shear baler during operation	None	Severe injury	Race Scan	Improbable ↓ Remote	Better communication would prevent worker proximity to operating baler
20	Worker being crushed in the shear baler during maintenance	None	Severe injury	Race Scan	Improbable ↓ Remote	Better communication would prevent worker proximity to baler when powered
	General			Decon Technologies	likelihood reduced due to less processing	Decontamination technology application reduces volume of waste processed through DVRS

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FOOTNOTES

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[i] Identified in the DVRS Hazards Analysis Report
[ii] Identified in DVRS Hazards Analysis Report
[iii] LSDDP technology applied
[iv] Reduction in probability from Hazards Analysis assigned risk