WM '02 Conference, February 24-28, 2002, Tucson, AZ

DECONTAMINATION, DISMANTLEMENT, AND PACKAGING OF A PLUTONIUM-CONTAMINATED GLOVE BOX

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ABSTRACT

In 1980, Congress enacted the West Valley Demonstration Project (WVDP) Act that required the U.S. Department of Energy (DOE) to demonstrate the safe solidification of liquid high-level radioactive waste and clean up the former reprocessing facility, among other things. Having successfully pre-treated and vitrified nearly 600,000 gallons of liquid high-level radioactive waste, the WVDP is now in the decontamination and deactivation (D&D) phase. This phase involves the D&D of several cells used during former reprocessing operations from 1966 to 1972.

In 2001, one of the successfully completed D&D projects at the WVDP was the decontamination, dismantlement, and packaging of a huge stainless steel glove box that was used during reprocessing operations to package purified plutonium nitrate for off-site shipment. The glove box was 18 feet long, 16 feet tall, and 4 feet wide, and was housed in a portion of the Main Plant called the Plutonium Product Packaging & Handling (PPH) Area.

The project represented a challenge to complete not only because of its size, but also due to high alpha contamination (30E+06 dpm/100cm^2) and difficult access to the glove box interior in order to obtain radiological data. Specific challenges faced and met included space restrictions, the inability to use standard containment techniques, specialized hoisting and rigging requirements, the use of dual fixatives to contain contamination, and engineered ventilation controls.

The PPH glove box project was completed between December 2000 and June 2001, with no dose to workers, no spread of contamination, and no injuries. The glove box was separated and removed in four sections and placed in special waste containers procured for packaging the individual glove box sections.

This paper will discuss how these D&D challenges were met through planning, scheduling, use of resources, characterization, and safe operations. The paper will also provide important lessons learned from the WVDP operations to help others successfully perform D&D work involving plutonium and high alpha contamination.

INTRODUCTION

System Description

The Product Packaging & Handling (PPH) Area is located on the east side of the Main Process Plant at elevation 100'-0", adjacent to the Waste Reduction and Packaging Area (WRPA). The concrete floor is 12" thick with a large sump (27'-6" long by 7'-0" wide by 4'-2" deep). The west wall is a 3'-0" thick concrete wall and the north, south, and east walls are constructed of 8" thick concrete block. The ceiling is a 6" concrete slab over metal decking. The PPH housed a large stainless steel glove box that was used for filling bottles of plutonium nitrate [$Pu(NO_3)_4$] to be shipped off site. The glove box was used as a containment allowing West Valley Nuclear Services Co. (WVNSCO) operators to handle the plutonium remotely. The alpha particles from the plutonium nitrate could become airborne, posing a severe threat to the operator's health if ingested or inhaled. The glove box was constructed of stainless steel with plexiglass windows, was approximately 18' long by 4' wide by 16' tall, and consisted of the following three sections:

- ❑ the plutonium filling station
- ❑ the plutonium bottle decontamination station
- ❑ the plutonium handling station

During the late 1960s and early 1970s, plutonium was purified in the Product Purification Cell (PPC) and then transferred to Measuring Tank 5D-17, which is located inside the PPC. The measuring tank was used to measure the quantity of product to be packaged. Empty 10-liter bottles were weighed and then taken to the decontamination section of the glove box. The internal hoist was used to move an empty bottle to the bottle cart. Once in the cart, the bottle was transferred to the filling station. The measured plutonium product was then transferred into the bottle by means of opening a valve inside the filling station of the glove box.

The filled bottle was moved to the decontamination section of the glove box via the internal hoist once the transfer was complete. The bottle was then checked for contamination and was decontaminated if necessary. The weight of the bottle was determined and then the bottle was transferred to a birdcage.[1] Once the birdcage was filled with bottles, the birdcage was transported to a storage location for eventual shipment.

PROJECT DESCRIPTION

Preparatory Work/Mock-Ups

It was necessary to replace some of the existing gloves in order to commence the D&D of the PPH glove box. The existing gloves were the original gloves used during the operation of the glove box. Because the glove box had been out of service for approximately 30 years, some of the gloves were deteriorated and therefore new gloves were required. New gloves would provide a safe means for Radiation Protection to obtain radiological surveys of the interior of the glove box.

D&D Operations personnel, with the guidance of the Radiation Protection supervisor, performed a mock-up for replacement of the existing gloves in the PPH glove box. In addition, a mock-up for replacing, sealing, and sleeving the bag-out bags was performed. Once the mock-ups were complete, approximately ten glove box gloves were replaced. A bag-out bag was also replaced. The bag-out bag allowed the operators to insert tools and instrumentation (e.g., alpha probe) into the glove box. The bag-out bag also served as a means for removal of debris from the glove box.

A mock-up was performed by Waste Characterization Services (WCS), Radiation Protection, and D&D personnel for obtaining samples of the glove box in addition to the mock-up for replacement of the existing gloves. The mock-ups allowed D&D personnel to replace the gloves and obtain samples without releasing any contamination into the area.

Radiological Surveys

Extensive radiological surveys of the interior and exterior of the glove box were obtained to ensure contamination levels in the glove box were known. The surveys were performed to aid in radio-chemical characterization and provide preliminary contamination data of the glove box. In addition, the surveys served as a baseline for future use of decontamination techniques such as the application of fixatives to the interior surfaces of the glove box.

Historical data and process knowledge indicated that the only source of contamination expected in the glove box was the plutonium product. The radiological survey results revealed contamination levels up to 30E+06 dpm/100cm^2 alpha (α) inside the glove box. The magnitude of contamination present proved to be the greatest obstacle for removing the glove box. Extreme precautions were implemented during removal of the glove box to prevent airborne contamination since alpha particles are known to become airborne at the slightest disturbance. It was important that there was no leakage of contamination into the PPH Area and areas within the vicinity of the PPH.

Sampling

Data Quality Objectives (DQOs) were prepared by WCS to determine the number and location of samples to be collected for analysis. The DQOs served as guidance for obtaining the data required for characterization of the waste to be packaged. Furthermore, the DQOs would help determine the waste streams for disposal.

WCS was tasked with determining whether the glove box would be disposed of as transuranic (TRU) waste or as low-level radioactive waste (LLRW). Initial radiological smears of the glove box were obtained. The radiological survey reports and three of the radiological smears were sent to the Analytical and Process Chemistry (A&PC) Laboratory for a total radiological analysis. Using the results of the analysis, WCS concluded that the radiological distribution was consistent throughout the glove box. The radiological distribution was then used to perform a preliminary characterization of the high-efficiency particulate air (HEPA) filters, thereby allowing WCS personnel to determine the type of container needed for packaging the HEPA filters.

Using a holesaw, D&D operators obtained six 2" diameter stainless steel samples from the "skin" of the glove box. The samples were shipped off site for radiological analyses. The analyses performed determined that the glove box and HEPA filters would be disposed of as TRU waste. The lead transfer cart located inside the glove box was characterized as mixed waste because of its lead content. All piping, conduit, and personnel protective equipment (PPE) was disposed of as LLRW. Sample results determined that the combined inventory of fissile material in the glove box was less than 5.46 grams. Fissile material in the glove box was distributed evenly throughout the box and there were no criticality concerns.

Asbestos Abatement

An inspection of the PPH Area was performed by Waste Management Operations (WMO) as a prerequisite to dismantling the glove box. During the inspection, WMO personnel determined that there was asbestos insulation on the piping adjacent to the glove box and on the overhead piping that would require removal.

An activity involving the removal of 24 linear feet of asbestos insulation from pipes adjacent to the PPH glove box was performed. The pipe insulation was removed within a glove bag in accordance with Standard Operating Procedure (SOP) 15-44, "Asbestos Removal - Minor Projects," in accordance with New York State Code Rule 56 and documented as Job # 2001-06. Approximately one month later, additional piping inside the PPH was identified as obstructing the removal of the glove box. Among this piping was a steam line that was insulated with asbestos containing material (ACM). WMO removed an additional 45 linear feet of asbestos insulation from this steam pipe.

Approximately 70 linear feet of asbestos insulation was removed from the utility piping inside the PPH. An additional six linear feet was removed from the Lower Extraction Aisle (LXA) to support the utility pipe isolations.

Isolations

Isolation of all energy sources to the glove box was essential to removal of the glove box. Electrical isolations were performed by WVNSCO's Maintenance electricians. The electrical isolations consisted of determinating the 480- and 120-volt power supply to the glove box and verifying there was no voltage source present. Existing light fixtures also proved to be obstructions for removal of the glove box. The lights were isolated from electrical energy sources and the light fixtures were removed. Once the old light fixtures were removed, temporary lighting was installed to aid in glove box removal activities.

Upon completing all the necessary isolations, a source of electrical power was installed for the use of equipment and power tools. A portable electrical power rack was staged in the WRPA to provide temporary electrical power. The unit was fed from the 480-volt, 3-phase service outlet located in the Lower Warm Aisle (LWA). An emergency circuit was installed to maintain power on the primary portable ventilation unit (PVU). This would allow the PVU to continue operating if there was a sudden power outage.

The next phase consisted of isolating all mechanical energy sources to the glove box. The necessary lockout/tagout requirements were established for removal of the utility piping to ensure that D&D personnel would not be subjected to the release of potential energy. All instrument air lines tying into the glove box, overhead utility lines, and miscellaneous equipment were removed and packaged. The steam condensate lines were drained prior to removal, and the process lines were tell-taled and drained by D&D Operations personnel.

Approximately 100 ml of plutonium product was recovered from the process lines. The recovered plutonium was transported to the A&PC Laboratory for analysis.

Contamination Control

The vast majority of the alpha contamination was contained within the glove box. Contamination also existed in the product fill line, the drain lines, the glove box ventilation filters and piping, and to a lesser extent in the bottle fill vent line. Contamination was also detected outside the glove box, primarily in the PPH pit. Extensive decontamination techniques were implemented to decontaminate the PPH Area; an essential step for the commencement of any D&D activities.

Ventilation was provided by the Main Plant Ventilation System. The ventilation system provided contamination control during preparation activities for removal of the glove box, such as replacement of gloves and removal of debris. This system provided negative pressure on the glove box and an airflow into the glove box in the event there was a breach in the glove box or gloves. Since there was a negative pressure (vacuum) being drawn on the glove box, the operators were able to perform these tasks in anti-contamination clothing and canister mask. Once the HEPA filters were removed, the Main Plant ventilation system was no longer available, therefore ventilation was provided by two PVUs. Each PVU assembly had an air movement capacity of 1000 cubic feet per minute (cfm) and consisted of a blower unit, a housed HEPA filter, an air diversion tee (pipe fitting), and a rigid and a flexible ventilation duct. The diversion tee allowed a negative pressure to be applied to the glove box while the glove box was completely closed and, by closing a bypass slide gate, increased the airflow through glove box openings when necessary. One PVU was used to provide ventilation during preparations for separation of the glove box. A second PVU was employed since there was a need for increased airflow to the glove box during the separation.

After the loose debris was removed from the glove box the contamination within the glove box was fixed using two methods. The first method consisted of using a "fogging" technology. Master-Lee Decon Services (MLDS) personnel were brought in to perform the fogging of the glove box. The fogging procedure utilized a passive aerosol generator (PAG) to inject capture polymers, in the form of an aerosol, into the glove box (see Figures 1 & 2). These aerosol polymers condensed and covered approximately 98% of the interior surfaces of the glove box with a viscous, tacky coating, rendering the contaminants immobile. The interior surfaces were coated with a fixative after the interior of the glove box was fogged. The combination of these techniques allowed the operators limited access to the internals of the glove box for removal of the internal hoist and monorail, and the eventual separation of the glove box sections.

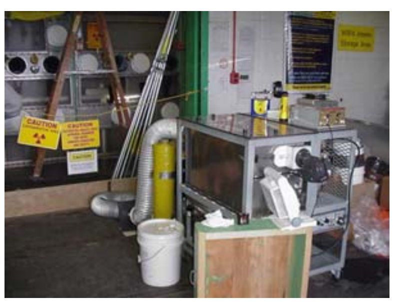

Fig. 1. PAG Fogging Unit

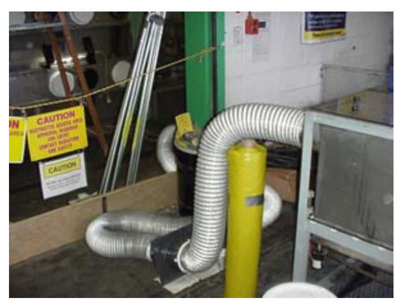

Fig. 2. Aerosol Flow to the Glove Box

A "tell-taling" technique developed at WVNSCO was employed for draining excess water from the piping and for coating the interior of the piping. This technique provided a means for draining any contaminated liquid present in the piping and also provided a means for determining the level of contamination within the piping. Furthermore, the technique allowed the operators to inject a fixative into the piping prior to cutting the pipe. Containment during piping removal was supplemented with the use of containment bags when contamination levels within the piping dictated the need for containment.

Procedures were implemented to reduce the contamination levels inside the PPH Area in addition to reducing the contamination in the glove box. Decontamination products such as ALARA[2] 1146® cavity decon, polymeric barrier system (PBS), and Oakite® were used for contamination control and reduction of contamination levels.

ENGINEERING STUDY

Methods for Removal

The planning phase required extensive engineering analysis for determination of the safest and most cost-effective method for removal of the glove box. The three methods that were considered for removal of the glove box were (see Table I for the dismantlement comparison):

1. Plasma torch for size reduction
2. Mechanical cutting (Sawzalls®, nibblers, and reciprocating saws) for size reduction
3. Removal in large sections by hoisting and rigging.

Initially, the removal of the glove box via plasma torch and mechanical cutting tools was considered. Cutting techniques would allow the operators to cut the glove box into pieces that could be handled manually. Also, it would allow for efficient packaging of the pieces. In evaluating this method, extensive benchmarking was conducted with personnel at the Rocky Flats Environmental Technology Site (RFETS). D&D personnel at RFETS were experienced in dismantling plutonium glove boxes with plasma torches. Thus, they were familiar with the techniques and associated risks with the use of a plasma torch for cutting alpha-contaminated glove boxes. WVNSCO's Radiation Protection engineers worked closely with the radiological and design engineers at RFETS to work out the details for the use of a plasma torch to dismantle the PPH glove box. During discussions with personnel at RFETS, WVNSCO engineers learned that the removal of glove boxes at RFETS was performed within another glove box. RFETS engineers designed glove boxes that were used as containment for the glove boxes to be size reduced. With the proper ventilation and radiological controls, D&D personnel at RFETS were able to safely size reduce their plutonium glove boxes. The challenge imposed on WVNSCO was the difficulty in designing a cost-effective enclosure for the existing glove box since the PPH glove box was inside a 4'-0" deep pit with limited working space.

Moreover, in conjunction with the plasma torch, mechanical tools would be necessary for dismantling the glove box. Mechanical tools such as Sawzalls®, nibblers, and reciprocating saws, however, would cause excess vibration. The vibration would increase the chances of disturbing some of the fixed contamination causing it to become airborne. The disturbance of the fixative would cause the contamination to become airborne.

Another consideration was ergonomics as there were tight areas that were difficult to reach. The use of mechanical tools was ruled out because of concerns of reach, vibration, and thickness of the glove box. The wall thickness of the glove box ranged from ⅛ to ¼ inch thick, therefore making it difficult to cut through the stainless steel with mechanical tools. The plasma torch, however, would have worked, but there was a concern of spreading airborne contamination while using a plasma torch.

Another alternative was to remove the glove box in individual sections, i.e., the glove box sections would be removed using hoisting and rigging techniques and each section packaged individually. Removal of the glove box in large sections was the preferred method.

Table I. Dismantlement Comparison for the Removal of a Plutonium-Contaminated Glove Box

Mechanical Cutting	Plasma	Large Pieces
PPE: - Double suit-ups	**PPE:** - Double suit-up w/supplied air - Fireproof outer layer Nomex® - Shielding for eyes when cutting	**PPE:** - Supplied air - Double suit-up
Ventilation: - 2 PVUs - No filter change required	**Ventilation:** - Smoke, numerous HEPA filter changes - Use of a precipitator, roughing, & HEPA filters - Design of ventilation system approx. 3-4 weeks	**Ventilation:** - 2 PVUs No filter change

Table 1. Dismantlement Comparison for the Removal of a Plutonium-Contaminated Glove Box (continued)

Mechanical Cutting	Plasma	Large Pieces
Containment: - No need for containment box for saw chips and openings - Need to remove crane from north end w/ containment - Slight re-contamination during removal	**Containment:** - Do we need to drape the walls w/plastic? - Primary containment required - Need to remove crane from north end w/containment - Major re-contamination during removal, therefore need to re-coat every piece before a cut is made - Stitching requirements	**Containment:** - Need to be able to separate sections of the glove box and contain the opened ends - No need to remove crane prior to dismantlement - Need to cut a section of the monorail and lower the monorail for packaging - No re-contamination
Scaffolding: - Extensive scaffolding	**Scaffolding:** - Extensive scaffolding - Work space restriction	**Scaffolding:** - Rolling scaffolding
Worker Fatigue: - Heat stress (limited) - Ergonomic concerns: Tight working areas	**Worker Fatigue:** - Heat stress (limited) - Ergonomic concerns: Tight working areas	**Worker Fatigue:** - n/a
- Modified tooling - yes	- Modified tooling - yes	- Modified tooling - n/a
- Need to remove debris and gloves, and seal all penetrations	- Need to remove debris and gloves, and seal all penetrations	- Need to remove debris and gloves, and seal all penetrations

Table 1. Dismantlement Comparison for the Removal of a Plutonium-Contaminated Glove Box (continued)

Mechanical Cutting	Plasma	Large Pieces
Special boxes: - Two required (1 ea. for north & south sections) - S70s/B25s for other sections cut into smaller pieces	**Special Boxes:** - n/a	**Special Boxes:** - Four
Rigging: - How to handle pieces once they are removed	**Rigging:** - How to handle pieces once they are removed	**Rigging:** - Extensive rigging - Rigging plan required
Access: - No access to rear of box - Cutting performed with long-handled tools from inside	**Access:** - No access to rear of box - Cutting performed with long-handled tools from inside	**Access:** - No access to rear of box - Removing bolts and studs with long-handled tools
Contamination Control: - Internal fixative required - Evaluated use of fogging mist, hard fixative, or combination of both - Impacts cutting tools	**Contamination Control:** - Internal fixative required - Evaluated use of fogging mist, hard fixative, or combination of both - Impacts cutting tools	**Contamination Control:** - Internal fixative required - Evaluated use of fogging mist, hard fixative, or combination of both

Table 1. Dismantlement Comparison for the Removal of a Plutonium-Contaminated Glove Box (continued)

Mechanical Cutting	Plasma	Large Pieces
Assumptions: - High risk for release of contamination - Long duration - Safety concerns with handling sharp edges (potential internal update from cuts) - Ref. RFETS benchmarking	**Assumptions:** - High risk for release of contamination - Long duration - Safety concerns with handling sharp edges (potential internal update from cuts) and heat exhaustion - Ref. RFETS benchmarking	**Assumptions:** - Lower risk for release of contamination - Fogging of internals a major benefit - Supported by RFETS benchmarking - Rigging plan provided by Higgins Crane Company

STRUCTURAL PREPARATION

Based on the engineering analysis it was determined that removal of the glove box would be performed in sections. The analysis indicated that removal in large sections was the most economical and the safest. An engineering plan was developed for removal of the glove box.

The proposed engineering plan consisted of erecting new structural beams with chain-operated trolley hoists inside the PPH Area. The beam and trolley hoist assembly would be used for hoisting and rigging the individual glove box sections. Installation of the new beams and hoists posed a major challenge for WVNSCO engineers because the installation required the removal of an existing structural support beam. The existing beam was set in place to support the east wall of Process Sample Cell #1 (PSC1), located above the PPH in the Lower Extraction Aisle (LXA). Although PSC1 is no longer in use it could not be removed because of radiological concerns.

A structural analysis was performed by WVNSCO's structural engineers to ensure that the removal of the existing structural beam (WF16x36) in the PPH would not result in catastrophic failure. The analysis determined that a temporary support system would have to be installed in the LXA to support the PSC1 wall prior to removal of the beam inside the PPH. WVNSCO's structural engineers designed a system that would support the PSC1 wall once the WF16x36 was removed. Once the system was installed and there were no signs of deflection in the beam assembly, the WF16x36 was relocated. The support system installed in the LXA served its purpose. The PSC1 wall was now being supported and WVNSCO personnel proceeded with the removal activities.

READINESS EVALUATION

A Readiness Team was developed that consisted of three WVNS management personnel and one senior staff manager; all who were not directly associated with the glove box removal. The objective of the Team was to determine all the activities that needed to be completed prior to initiating the separation process of the glove box. The Team utilized a Readiness Evaluation Checklist prepared in accordance with Section 5.8 of WVDP-342, "Operational Readiness Determination Manual Startup and Restart of WVDP Facilities," for determining whether all activities required for removal of the glove box were completed and all hazards identified. Some of the topics covered in the checklist were: 1) criticality safety analysis and 2) training for personnel. Any concerns with the work documents for completion of the project were discussed with the cognizant engineers. All concerns were addressed and rectified before the Readiness Team allowed WVNSCO personnel to proceed with separation of the glove box.

GLOVE BOX REMOVAL

The first step in removing the glove box was the removal of the HEPA filters. Removal of the HEPA filter housings was accomplished by drilling holes in the ventilation piping near the separation points and injecting a fixative material. The separation points were sleeved, the flange bolts removed, and the separation made within the sleeving. Once the separation was accomplished, the sleeving was tightly gathered and the sleeving cut. The filter housings were then removed leaving all contamination within the ventilation piping contained within the sleeving.

Furthermore, all exterior obstructions, such as piping, instrumentation, and electrical conduit, were removed. In addition, the lead-shielded bottle transfer cart, the monorail hoist, and the monorail located inside the glove box were removed. The steel system for rigging the individual sections was then erected and the glove box centered in the pit for ease of rigging. The first section to be separated was section "D." Once separated, section "D" was staged in the PPH until the remaining sections were separated and removed. The separation of sections "B" and "C" was then performed and their respective openings were sealed with metal covers. Section "A" was separated from section "B" and the lead-shielded transfer cart removed and packaged in a box designed by D&D Engineering. The open ends of sections "A" and "B" were covered with metal covers. Once the separations were completed, each section was rigged out of the PPH pit, laid on rollers, and rolled out of the PPH onto a flat bed truck. The individual sections were picked up with a mobile crane and packaged for disposal (see Figures 3 & 4).

Fig. 3. Removal of Glove Box Section C

Fig. 4. Packaging of Glove Box Section C

WAS TE MINIMI ZATI ON/GENERA TION

A total of three TRU waste containers were filled with glove box waste; the HEPA filters were packaged as TRU waste. Four special boxes were purchased for packaging and shipping the individual glove box sections. The glove box sections were also packaged as TRU waste. As stated previously, various decontamination methods were implemented that helped reduce the contamination levels. In some cases, TRU waste was reduced to LLRW because of the decontamination methods.

LESSONS LEARNED

Integrated Safety Management System (ISMS)

D&D of the PPH glove box was a challenging project, consisting of many phases. The project required the coordination and involvement of various supporting groups. In addition to the high potential for personnel contamination, there were many health hazards associated with the project. Some hazards were the intense heat and use of PPE during hot summer days, the use of power tools, working in a confined space, working on scaffolding, and isolation of the systems. The greatest risk was the high alpha contamination inside the glove box.

The contamination was fixed by introducing a fogging agent that worked well. However,

D&D Engineering, Radiation Protection, and D&D Operations observed that the agent worked best when it was introduced at a high level in the glove box. Also, the overuse of the polymeric barrier system (PBS) caused the PBS to drip and settle at the bottom of the glove box. This was due primarily because of the airtight glove box. Some of the excess liquid was drained; the remaining fixative dried once the vent duct to the glove box was opened allowing make-up air to flow in.
The Project Team effort implemented allowed for the proper identification of potential hazards to be addressed in the work documents and pre-job briefings. An important phase for removal of the PPH glove box was the electrical and mechanical isolations. All electrical conduits and piping to be cut were labeled with D&D isolation tags per SOP 00-30, "System and Component Labeling." The use of D&D labels to signify whether a conduit or pipe was safe for removal was an excellent strategy for maintaining a safe work environment.

In addition, walkdowns were performed to describe the scope of the various tasks before the work documents were written. Draft work documents were then prepared and presented at the Work Review Group (WRG) for initial comments. Upon receipt of the comments, the work documents were revised to address the essential comments, and then walked down by Operations before approval. In practicing ISMS principles, the PPH glove box was removed safely. From a safety standpoint, there were no injuries to personnel and there was no damage to equipment. Furthermore, because of the radiological controls that were implemented, there was no loss of contamination to the area or personnel.

The success of the project was a result of the initial planning process in which the scope of the project was clearly identified and a schedule was developed and implemented. Weekly project integration meetings were held with team members to status the project activities and resolve any issues. Implementing the ISMS principles allowed WVNSCO personnel to complete a difficult task without incurring any injuries or releasing any contamination.

FOOTNOTES

[1] Criticality storage rack for the safe storage of filled plutonium bottles.
[2] As Low As Reasonably Achievable