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The Creative Application of Science, Technology and Work Force Innovations to the Decontamination and Decommissioning of the Plutonium Finishing Plant at the Hanford Nuclear Reservation

Prepared for the U.S. Department of Energy
Assistant Secretary for Environmental Management

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The Creative Application of Science, Technology and Work Force Innovations to the Decontamination and Decommissioning of the Plutonium Finishing Plant at the Hanford Nuclear Reservation

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The Creative Application of Science, Technology and Work Force Innovations to the Decontamination and Decommissioning of the Plutonium Finishing Plant at the Hanford Nuclear Reservation

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ABSTRACT

The Plutonium Finishing Plant (PFP) consists of a number of process and support buildings for handling plutonium. Building construction began in the late 1940's to meet national priorities and became operational in 1950 producing refined plutonium salts and metal for the United States nuclear weapons program The primary mission of the PFP was to provide plutonium used as special nuclear material for fabrication into a nuclear device for the war effort. Subsequent to the end of World War II, the PFP's mission expanded to support the Cold War effort through plutonium production during the nuclear arms race. PFP has now completed its mission and is fully engaged in deactivation, decontamination and decommissioning (D&D). At this time the PFP buildings are planned to be reduced to ground level (slab-on-grade) and the site remediated to satisfy national, Department of Energy (DOE) and Washington state requirements.

The D&D of a highly contaminated plutonium processing facility presents a plethora of challenges. PFP personnel approached the D&D mission with a can-do attitude. They went into D&D knowing they were facing a lot of challenges and unknowns. There were concerns about the configuration control associated with drawings of these old process facilities. There were unknowns regarding the location of electrical lines and process piping containing chemical residues such as strong acids and caustics. The gloveboxes were highly contaminated with plutonium and chemical residues. Most of the glovebox windows were opaque with splashed process chemicals that coated the windows or etched them, reducing visibility to near zero. Visibility into the glovebox was a serious worker concern. Additionally, all the gloves in the gloveboxes were degraded and unusable. Replacing gloves in gloveboxes was necessary to even begin glovebox cleanout. The sheer volume of breathing air needed was also an issue. These and other challenges and PFP's approach to overcome these challengers are described.

Many of the challenges to the D&D work at PFP were met with innovative approaches based on new science and/or technology and many were also based on the creativity and motivation of the work force personnel.

INTRODUCTION

During the course of the D&D of the PFP, workforce personnel at PFP applied innovative work practices, invented new ways of performing work, created new work tools and applied lessons learned from other D&D sites. The decontamination of plutonium contaminated gloveboxes, process equipment and product transfer piping, ventilation hoods and ductwork, and buildings can lead to risk of injury to workers and the environment. Work force ingenuity combined with the creative inventions and approaches to the D&D work not only made the work safer, it also made the work more efficient.

These innovations were developed mutually by PFP management and workers. They have resulted in productivity improvements, enhanced safety and improved contamination control.

PFP WORKFORCE INNOVATIONS

Chemical processing inside glove boxes has caused poor visibility through glove box windows and panels over a period of time. Historically, temporary vision improvement has been gained by wetting the inside surface of the windows with water or Vaseline with some cleaning being performed with nitric acid wipes. When severe visibility impairment precluded necessary operations, the glove box panels or windows were replaced with new ones. This task requires the breaking of glove box containment, which is time consuming, costly and hazardous. Major contamination spreads have occurred during glovebox panel change out.

Unimpeded vision within the glove boxes is necessary to perform the clean out work safely and efficiently. To avoid the cost and negative consequences of the panel change, several window cleaning methods have been applied with significant success. Because the origin of the visibility impairment is generally unknown due to the age of the system, one or more of the window cleaning methods may be required using a trial and error process.

Window cleaning processes used during PFP D&D include commercial degreasers, the Novus™[1] plastic cleaning system using rubbing compounds and the 3M Trizact™[2] abrasive disk and orbital sander system. The orbital sander system was developed to restore vision through aircraft canopies using a series of graded abrasive disks. Using these disks it has been possible to restore vision sufficiently to allow D&D operations to proceed when visibility through the glovebox was problematic. It is important to use an efficient system to clean the glovebox windows because the time that is required in cleaning results in additional radiation exposure to the worker, especially for severely damaged window panels. Additionally, the installation of remote cameras has also helped reduce the time associated with glovebox cleanout.

The Keel Haul Tool (Fig. 1) also known as "Sponge Bob" after the resemblance to the cartoon character was invented at PFP to assist in the non destructive assay (NDA) of objects encountered during the D&D process. NDA is used to determine the level of contamination of an object.

[1] Novus™ Novus is a registered trademark of T.C.G. International, Canada
[2] 3M™ Trizact™ is a registered trademark of 3M Company3M Corporate Headquarters, 3M Center St. Paul, MN

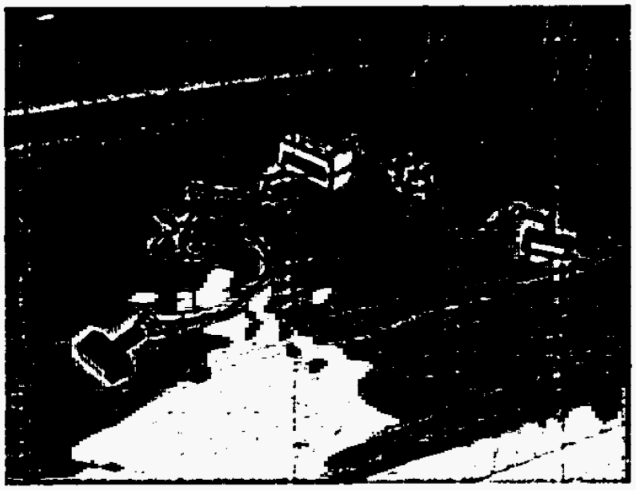

Fig. 1. "Sponge Bob" and magnets arrangement for D&D.

To complete the Surface Contaminated Object (SCO) process on the reflux hoods located within the PFP, the backside of the hood's baffle plate must be accessible for a direct radiological survey. Cutting or removing the hood baffle plate is required to allow access for the SCO survey probe and completion of the SCO process. A concern over the buildup of lint and the potential for chemical and radiological contamination in removing these baffles caused the D&D team to identify ways to mitigate these potential hazards. Subsequently the team developed a tool called the Keel Haul Tool which allows the backside of the baffle plate to be cleaned by pulling a sponge attached to cables. This tool reduces contamination risks and enhances as low as reasonably achievable (ALARA) practices in the decommissioning of the PFP's open faced hoods.

Also used to assist in wipe downs of inaccessible areas are magnets. Neodymium magnets are extremely powerful for their size and for this reason, they have been selected for use in ventilation duct clean out work. Where ducts are readily accessible, magnets outside the duct can be magnetically coupled to magnets on tools inside the duct making it possible to manipulate the clean out tools from outside the duct.

There are cautions to be considered with the use of magnets, however. There is concern that the extremely strong magnetic fields from the magnets may set off CAMS and criticality alarms. The manufacturer warns that the magnets should be kept away from any magnetic based storage devices, such as tapes, hard drives, credit cards etc. with the warning to keep the magnets at least one foot away from these items at all times. There is a special warning regarding pacemakers.

The strength of even the strongest magnets drops off exponentially with distance from the magnet. A Neodymium magnet with a 90.7 kg (200 lb.) lifting strength (at zero distance) was tested using a compass to determine how far away from the magnet the compass needle would be affected. At an 81.3 cm (32-in.) distance east of the compass the needle deflection was barely perceptible. At a 91.4 cm (36-in.) distance east of the compass needle, there was no perceptible needle movement. Magnet location either East or West of the compass needle was determined to have the greatest affect on the compass needle.

Glovebox decontamination at PFP (Fig. 2) is facilitated by the use of French decontamination systems using cerium nitrate. Most of the process equipment and gloveboxes at PFP are contaminated with transuranic (TRU) waste. If the equipment is not decontaminated, it must all be disposed at the Waste Isolation Pilot Plant as TRU waste. This is not advantageous from a cost and waste minimization standpoint. PFP scientists and management determined that a more practical and efficient method to the D&D of this equipment would be to decontaminate the equipment from a TRU level to a low level and dispose the equipment as low level waste. Consequently, a French Gel decontamination technology was investigated at PFP by PFP and Pacific Northwest National Laboratory (PNNL) chemists and technicians. These technologies place cerium nitrate into a gel that attaches to acid etched steel wall allowing for deeper chemical milling of the walls.

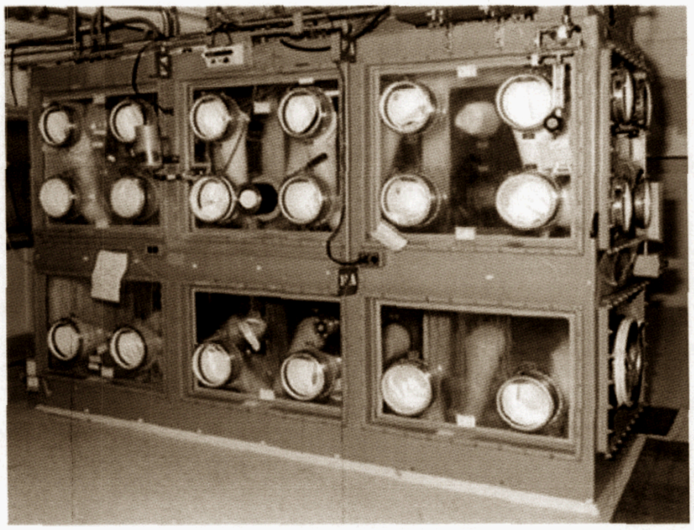

Fig. 2. Glovebox decontamination at PFP.

Four candidate chemical decontamination technologies have been investigated for decontaminating plutonium contaminated gloveboxes at Hanford's PFP. Treatability Studies under the CERCLA have been conducted.[1,2] These technologies are cerium nitrate/nitric acid, EAI corporation's RadPro™[3], (Wet Method Decontamination) STMI's Glygel™[4] Decontamination process and CEA/COGEMA's ASPIGEL 100™ [5](Dry Method Decontamination). PFP and PNNL personnel have investigated chemical reactivity hazards of wastes arising from these technologies as they are applied in the field. PFP is the only facility in

[3] RadPro™ is a registered trademark of EAI , Lansing Michigan
[4] Glygel™ is a registered trademark of STMI (AREVA group), France
[5] ASPIGEL 100™ is a registered trademark of CEA/COGEMA, Marcoule, France.

the DOE complex to perform these studies in order to ensure the safety of the decontamination chemicals both in use and as residual stored in waste drums.[3]

HIGH EFFICIENCY PARTICULATE AIR (HEPA) FILTER EXCHANGE

There are hundreds of HEPA filters in the PFP, which all have to be changed periodically. The use of glove bags for the exchange of HEPA filters is difficult. A typical HEPA filter exchange would generally cause the containment tent to become highly contaminated and induce high airborne conditions. Preplanning for changing HEPA filters at PFP identified a need to control contamination and airborne activity. A rigid double barrier was conceived, tested, practiced on a mockup and is now in use throughout the plant. This innovation has resulted in the confinement of plutonium particulate resulting in a small risk for the spread and generation of airborne contamination during filter exchange.

Passive Aerosol Generation (PAG) was used to transform the Plutonium Reclamation Facility (PRF) main airlock from an airborne radioactivity area to a radiological buffer area. In order to reduce the time and resources required to decontaminate and decommission the PRF canyon, PAG was determined to be the best technology. The PRF main airlock was remotely fogged with a PAG using a commercial product capture coating. The PAG uses patented technology to create a very fine aerosol to disperse the capture coating throughout the entire volume of the airlock. After several hours, the aerosol forms an encapsulating film over all the surfaces. As the aerosol settles it adheres to and removes airborne particulates in the area which eliminates airborne radioactivity.

After the airborne radioactivity has been controlled, a number of entries into the airlock were made by workers to remove gross debris and wet and remove thick piles of dirt and/or dust.

In order for workers to perform work in the airlock, however, a fixative was needed to ensure contaminants were contained on the surface of the airlock. Therefore, a lead-free, waterborne, acrylic enamel coating was applied with a common airless spray system. The capture coating is applied to a dry film thickness of approximately six millimeters. This coating is engineered to absorb the Capture Coating from the fogging process and still adhere to the various substrates in the area. This spray fixitive will adhere to steel, concrete, drywall, plastic, glass, and various other materials within the area.

To ensure that the fixative is not disturbed or abraded through workers ingress and egress, a layer of self leveling floor coating was applied to the floor and first 1.8 m (6-ft.) of the walls. This floor coating system is a two-part, zero VOC epoxy system composed of 100% solids formulated to yield an abrasion resistant and chemical resistant floor surface. This methodology ensures that the ensuing work in the airlock will not chip or abrade the encapsulating spray fixitive.

MODIFICATION OF GLOVEBOX PORT RINGS FOR D&D

During processing of plutonium at PFP, glove box port rings and port covers were used when necessary to gain access to the glove box using gloves, for equipment and waste seal in and seal out, and for viewing ports through clear port covers. D&D operations require new uses for port rings and port covers. Several useful modifications have been made to both port rings and port covers to meet specific needs of the D&D worker, which have increased productivity and safety while reducing costs and increasing efficiency. Port covers have been modified to provide routing for 110 volt electrical power, SCO detector wiring, and remote camera wiring into the glove box.

Port rings of various sizes have been mounted on port covers to provide a new uncontaminated port ring for seal out, which greatly reduces the chances of contamination spread. Port rings of smaller size have been mounted on port covers in order to reduce the size of the seal out bag. The smaller the seal out bag, the easier it is to perform the seal out operation, which increases the safety of the operation.

PFP's special augers (Fig. 3), machined out of Teflon™[6] blocks and mounted on stainless steel cores, are being used with "quick connect" extension rods to clean out legacy plutonium-bearing materials held up in piping. The extension rods can be added as needed to reach legacy material in the lines. The auger is simply pushed into a pipe, rotated, and pulled out, with the held-up material dropping into pre-staged, critically safe containers through a transparent "tee" (short branch) attached to a line flange. Special scrapers, brushes, and core drill bits have also been developed by PFP D&D teams to address various challenges. Larger versions of the auger also are being used to clean out the mercury vacuum headers in PFP's duct level between the first and third floors. In many cases, the augers have allowed hold-up removal to proceed without actually removing pipes, thus saving time.

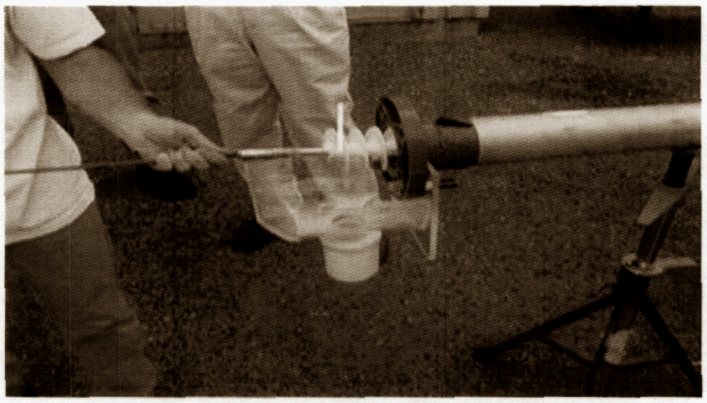

Figure 3. Demonstration of PFP's special augers.

Removal of old process system glass tanks that were used in converting plutonium solutions to plutonium metal presented a potential hazard to D&D workers. (e.g. breached gloves). Operators developed an innovative collapsible sleeve (Fig. 4) that can be fitted over glass tanks that hang on flanges and rod assemblies inside the gloveboxes. The sleeve is made of heavy rubber like material and can fit over tanks up to six 1.8 m (6-ft.) long. The sleeve is an open cylinder. The lower end fits inside a critically safe metal container, sized to be able to contain all of the broken glass tank pieces. Once the sleeve is installed around the glass tank and the lower end is fit inside the metal container, operators reach into the glovebox and break the tank inside

[6] Teflon™ is a registered trademark of DuPont

the sleeve device. Pieces of glass fall in to the container. The sleeve is then collapsed into the metal container and sealed out as a waste package. With this innovation productivity has improved and operators never touch the contaminated glass thereby reducing the probability of puncturing a glove.

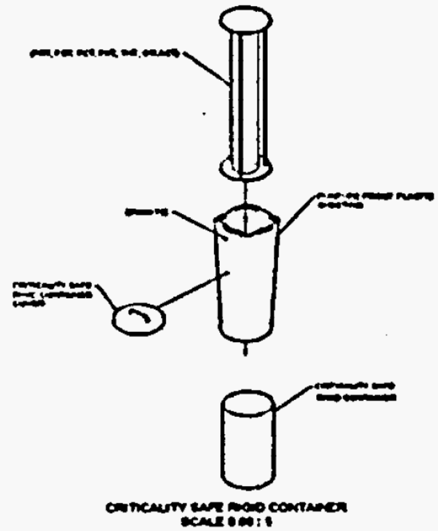

Fig. 4. PFP's Collapsible Sleeve

RIGID PORT BAG AND LAZY SUSAN

Because of the plastic sleeves in gloveboxes, each piece of contaminated equipment from a glovebox had to be thoroughly padded and taped inside the glovebox then slowly and carefully brought out through the plastic sleeve in order to avoid tearing the sleeve. A tear in the sleeve meant contamination spread with undesirable consequences: worker exposure, lost productivity, and decontamination and cleanup of the area. The rigid port bag or "Turkey Fryer" is a new innovative approach enables operators to seal out as much as four times the contaminated equipment from gloveboxes per shift as achieved with traditional equipment. The device looks like a "turkey fryer" consisting of a stainless steel can with handles on each side, near the top, and a seal out bag that fits around the outer rim. It then connects to the glovebox port with a large elastic band similar to a bungee cord. With this approach glovebox cleanout progresses more quickly, radiation dose exposure, time, and costs are reduced while ergonomic conditions are improved.

The 232-Z incinerator facility personnel recommended that a Lazy Susan style turntable be used to place sealed out waste packages on to perform dose rating and portable Nondestructive assay. The operator now has a platform where they will place each waste package after sealout and contamination survey. This will allow the position of the package to be changed with minimal handling, thereby reducing dose to the fissile material handler. This approach also reduces the risk of breaching plastic layers by abrasion or puncturing from multiple lifting and movements required to obtain adequate dose rates and NDA measurements of the package.

Workforce Personnel Have a Better Idea

Forty-four assemblies of pencil tanks and processing columns ranging from 1.2 to 10.4 m (4 to 34 ft.) long were used during plutonium purification operations in the canyon portion of the PRF. The original baseline plan was to move the pencil tank assemblies into the South Canyon Airlock for size reduction and disposition. This approach was changed to utilize the maintenance cell at the North end of the PRF Canyon for the following reasons:

- The hazards analysis revealed many complications associated with performing this work in the South Canyon airlock
- Worker input during the planning phase preferred performing this work in the maintenance cell. Analysis indicated that size reduction and removal would be equally efficient at this location
- Workers pointed out that pencil tank size reduction and removal at the maintenance cell was successfully performed in the past.
- Using the maintenance cell instead of the South Canyon Airlock allows introduction of equipment to clean the canyon floor through the South Canyon Airlock.

The current concept is to move pencil tank assemblies into the existing maintenance cell. Each assembly will undergo nondestructive analysis (NDA). The pencil tanks and the top dunnage will be size reduced and lowered to the bottom of the cell. There they will be bundled and moved to the Canyon Mezzanine where each bundle will be analyzed for contamination and then sealed out through the existing 50.8 cm (20-in.) port into a waste container. Six of these containers can be loaded into a Solid Waste Boxes and removed from PRF for disposition. The support dunnage will be returned to the canyon wall to be removed with the final canyon D&D.

Benefiting from D&D Lessons Learned

Part of the PFP Closure Project requires the demolition of sixty-one buildings. To expedite physical demolition of these facilities, PFP plant management brought in Project Management and D&D workers that had been involved with the recent open air demolition of the 233-S Plutonium Extraction Facility on the Hanford Site. Their knowledge, experience, training and numerous lessons learned are instrumental in the accelerated progress of this activity.

During PFP decommissioning planning in 2004, one of the issues identified was the increased work requiring supplied air during D&D. Many of the areas are difficult to access, and the number of air bottles required to be handled daily was going to be very difficult to manage without delaying work. During the investigation of alternatives to solve the bottle handling issue, personnel recently transferred to PFP from Rocky Flats noted they had the same issue. Rocky Flats personnel resolved the issue by providing large volumes of breathing air by using trailer mounted compressors and distribution piping to needed locations. Additionally, the compressors provided enough volume to provide cooling air using commercially available "vortex tubes" to individuals solving another persistent issue of heat stress while wearing several layers of protective clothing.

Heat stress while wearing protective clothing has been a significant issue at Hanford both from a safety and a productivity standpoint. Initial demonstrations at PFP are very positive. PFP engineers adopted this demonstrated approach and the system is now being installed in PFP to support the PFP decommissioning efforts. DOE will benefit from using a system already proven effective at Rocky Flats (positive lessons learned) and will save money by reusing equipment already owned by DOE to reduce heat stress on workers and improve productivity at Hanford.

Part of the D&D effort at the PFP complex involves removing loose and tightly adhered plutonium solids from the PRF canyon floor. This area also contains overflowed process liquids including entrained solids, dissolved metals, nitrate and aluminum salts, and organic degradation products.

Part of the PFP D&D Project includes the decontamination and demolition of the highly contaminated 232-Z facility that was previously operated to recover plutonium scrap material. The 232-Z glovebox has been decontaminated as much as practicable and cocooned for shipment to T Plant where it will be size reduced for ultimate disposal at the Waste Isolation Pilot Plant in Carlsbad, New Mexico. The successful removal of the glovebox from the facility was the result of outstanding teamwork in the planning and execution of the work from nearly every craft on the Hanford Site beginning with glovebox cleanout to decontamination and subsequent shrink wrapping and removal from the facility.

The ALARA Center

The ALARA Center is a resource provided by the DOE, Richland Operation Office, though Fluor Hanford. It has been a valuable asset for the PFP workforce. The center sponsors vendor demonstrations on a frequent basis to bring potential buyers and sellers of safety technology together. The PFP has benefited from this service in purchasing HEPA filtered vacuum cleaners, improving glovebox window visibility for D&D. Workforce personnel have also used the ALARA Center gloveboxes for training prior to executing a work evolution in the field.

CONCLUSION

The management and workforce at PFP have gained efficiency and increased safety through the development of special tools and devices to assist in the D&D effort. During the course of the D&D of the PFP, workforce personnel have applied innovative work practices, invented new ways performing work, created new work tools and applied lessons learned from other D&D sites. These innovations were developed mutually by PFP management and workers. They have resulted in productivity improvements, enhanced safety and improved contamination control. Many of the challenges to the D&D work at PFP were met with innovative approaches based on new science and/or technology and many were also based on the creativity and motivation of the work force personnel. For example, by applying a system used to restore vision through aircraft panels developed by 3M™, visibility was restored to glovebox panels. Another technological innovation is the use of French chemical/gel plutonium decontamination systems for gloveboxes. Two new systems are now being tested at PFP. The gel systems do not rely on the use of wipes in the decontamination process which may have been implicated in a fire at Rocky Flats. PFP is the only facility to test such systems for safety in the DOE complex.

Other work force innovations include the special auger machined out of Teflon™ blocks and mounted on stainless steel cores for cleaning out legacy plutonium-bearing materials held-up in piping. A collapsible sleeve was developed by the workers to remove glass tanks safely and package them for disposal at the same time. To prevent the potential contamination spread from removing sharp objects through gloveports, the workers developed a rigid system called a Rigid Port Bag, more commonly known as the "Turkey Roaster" or "Turkey Fryer." Special scrapers, brushes, and core drill bits have also been developed by PFP D&D teams.

The decontamination of plutonium contaminated gloveboxes, process equipment and product transfer piping, ventilation hoods and ductwork, and buildings can lead to risk of injury to workers and the environment. Work force ingenuity combined with the creative inventions and approaches to the D&D work not only made the work safer, it also made the work more efficient.

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