WM2008 Conference, February 24 – 28, 2008
Abstract # 8026

Retrofit of an Engineered Gloveport to a Los Alamos National Laboratory's Plutonium Facility Glovebox

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ABSTRACT

At the Los Alamos National Laboratory's Plutonium Facility (TA-55), various isotopes of plutonium along with other actinides are routinely handled such that the spread of radiological contamination and excursions of contaminants into the operator's breathing zone are prevented through the use of a variety of gloveboxes (the glovebox coupled with adequate negativity providing primary confinement). The current technique for changing glovebox gloves are the weakest part of this engineering control. 1300 pairs of gloves are replaced each year at TA-55, generating approximately 500 m^3/yr of transuranic (TRU) waste and Low Level Waste (LLW) waste that represents an annual disposal cost of about 4 million dollars. By retrofitting the LANL 8" gloveport ring, a modern "Push-Through" technology is utilized. This "Push-Through" technology allows relatively fast glove changes to be done by operators with much less training and experience and without breaching containment. A dramatic reduction in waste is realized; exposure of the worker to residual contamination reduced, and the number of breaches due to installation issues is eliminated. In the following presentation, the evolution of the "Push-Through" technology, the features of the gloveport retrofit, and waste savings are discussed.

INTRODUCTION

At the Los Alamos National Laboratory's Plutonium Facility (TA-55), various isotopes of plutonium along with other actinides are routinely handled such that the spread of radiological contamination and excursions of contaminants into the operator's breathing zone are prevented through the use of a variety of gloveboxes (the glovebox coupled with adequate negativity providing primary confinement). Evaluating the glovebox configuration, the glovebox gloves are the most vulnerable part of this engineering control. TA-55 proactively investigates processes and procedures that reduce glove malfunctions through the Glovebox Glove Integrity Program (GGIP). This is the sixth paper on these issues [Ref. 1-5]. The glovebox gloves are the weakest part of this engineering control. In a typical installation, a glovebox glove is stretched around the ring of a gloveport and is clamped in place, as shown in Figure 1.

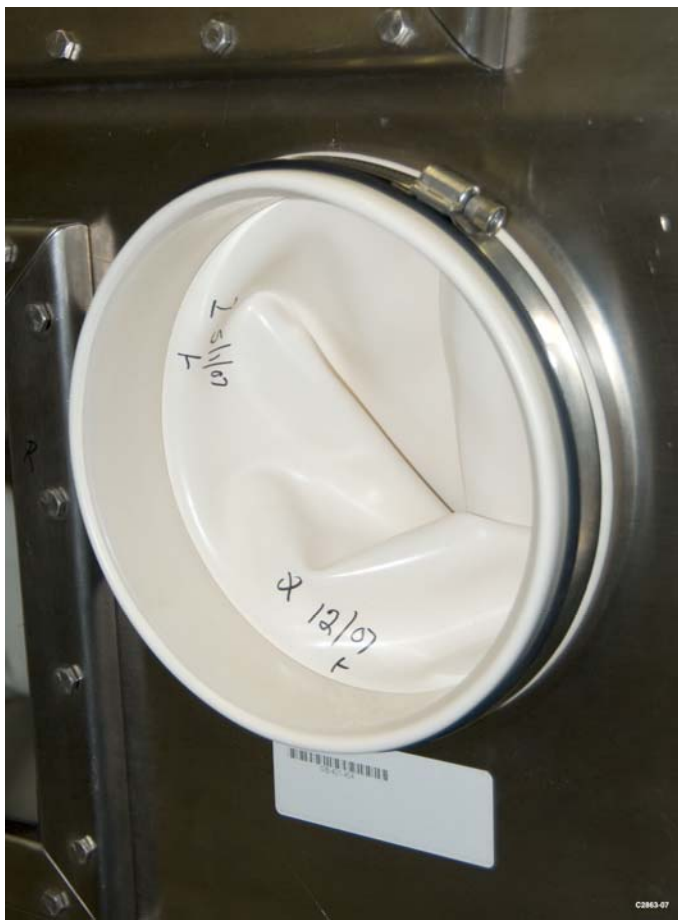

Figure 1. LANL 8" Gloveport Ring Configuration

At both Los Alamos National Laboratory (LANL) and at the Atomic Weapons Establishment in England, this specific mounting of a glove to the glove ring, which is based solely on the design of the gloveport ring is referred to as the LANL 8" gloveport ring. At TA-55, the majority of the 8000+ gloveports still used are the LANL 8" gloveport ring. Replacement of the glovebox glove requires a well-trained technician to perform this task without creating a major breach in containment. Although all glove changes at minimum create a minor breach, the resultant of which exposes the worker to residual contamination that exists on the surface of the gloveport ring and the inner cuff of the glove. In general, at least 15 minutes are required to change a glovebox glove (not including pre-operation setup time). Changing of gloves is considered "hot work" therefore all normal programmatic operations must come to a halt and all individuals involved in the glove change task must be in respirator.

In the late sixties, the French Nuclear Industry developed a gloveport technology which would allow relatively fast glove changes to be done by operators with much less training and experience and without breaching containment. By retrofitting the LANL 8” gloveport ring, a modern “Push-Through” technology may be utilized. A dramatic reduction in waste will be realized; exposure of the worker to residual contamination reduced, and the number of breaches due to installation issues would be eliminated. In the following presentation, the evolution of the “Push-Through” technology, the features of the retrofit, and waste savings are discussed.

“PUSH-THROUGH” TECHNOLOGY

The French Nuclear Industry developed a glove port technology which would allow relatively fast glove changes to be done by operators with much less training and experience [Ref. 6]. A special glove bead was mounted around a "support ring," this assembly was placed into a special "push-tool" which in turn was mounted on the glove ring, and by multiple rotation of a wheel, the new glove assembly pushed the old glove assembly out of the ring while seating the new glove assembly into the ring without breaching containment.

In the early seventies, under license agreement, a U.S. company introduced the technology to the U.S. nuclear industry. After years of use, questions started to arise about the consistency of the seal of the “Push-Through” technology, due to the fact that some gloves were much harder to push than others. The glove-dipping technology was the cause of this inconsistency. Some users were experiencing glove-cuff region thickness variance of ± 0.3 millimeters in thicker gloves which made precision rolling of the bead (the key to the seal) difficult and costly. Much more control was required of the glove manufacturer to produce the required cuff bead to make the system work consistently well. New designs were developed to attempt to resolve the operational inconsistencies caused by the gloves. One of the new designs, herein called the O-ring design, changed the support ring design slightly and added a set diameter O-ring over the glove cuff. The O-ring has much tighter tolerances and is more controllable than the glove bead thickness. Some modifications were made to the “push-tool” and both weld in and clamp in designs became available. The other design, we will call the Lip Seal design, was a complete redesign of the whole system. The Lip Seal design created a two piece support ring that sandwiches the glove bead between the two pieces and added a lip seal on the outside of the support ring to create the seal with the port. The idea of the lip seal was to completely separate the inconsistency of the glove from the operation and leak tightness of the system. Last, a CAM-locking safety ring was added to securely lock the glove from being pushed or pulled out of position. The mechanism of this concept is shown in Figure 2.

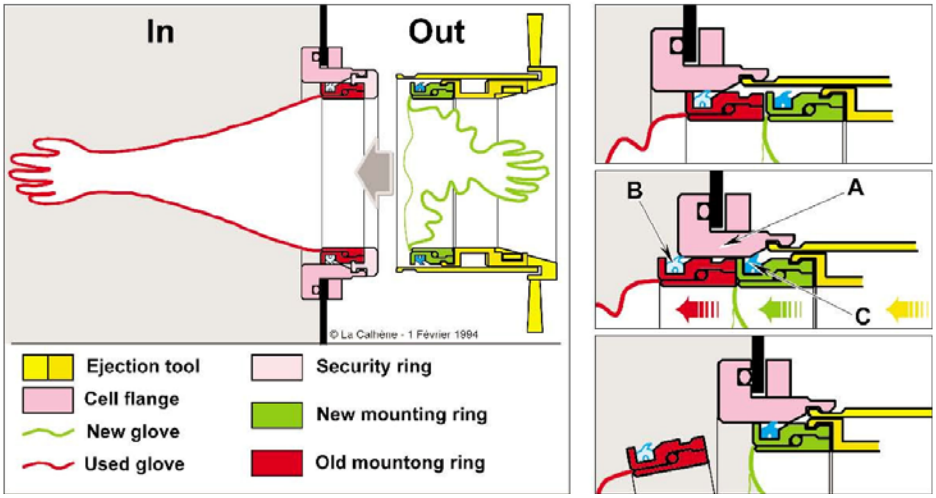

Figure 2. "Push-Through" Concept.

In summary, the glove is changed mechanically via a circumferential pressure "push-tool". The glove is mounted on a supporting ring and the assembly is mounted into the tool. The "push-tool" is mounted on the gloveport "cell ring" and the tool is rotated to push the new glove assembly into place while ejecting the old glove assembly into the glovebox. During this operation, the continuity of containment is assured by seals (B) and (C) making contact with the cell flange (A). In this report, we will discuss how the LANL 8" gloveport is retrofitted to accommodate the Lip Seal design developed by Getinge la Calhène.

GLOVEPORT RETROFIT

The gloveport retrofit is built under a strict, approved ISO9001: 2000 Quality Program and is based on the standard Getinge la Calhène AD gloveport flange configuration. The gloveport retrofit utilize all standard AD tools, glove assemblies, plugs, windows, bag assemblies, etc. The AD gloveport retrofit converts the LANL standard 8" gloveport ring to "Push-Through" technology (AD gloveport configuration) without the need to cut, weld, or drill. The 200 millimeter ID of the flange mates with the outside edge of the LANL 8" gloveport ring so that the standard AD appurtenance pushes through the 8" ID of the LANL gloveport ring without interference. A counter-flange is made with a 211 millimeter ID to mount around the OD of the LANL 8" gloveport ring. The counter-flange has 8 equidistant threaded holes to allow bolts passing through the same equidistant holes on the flange to be tightened to pull the flange and counter-flange together. There are 6 setscrews around the outside of the counter-flange that are tightened toward the ID, to lock onto the LANL 8" gloveport ring.

A specific shaped PVC or Viton seal fits in a "compression seal" arrangement between the flange and counter-flange. When the two flanges come together, the seal is compressed and expanded inward toward the LANL 8" gloveport ring OD, creating a E-06 cc/sec helium leak tight seal and locking the AD gloveport retrofit securely in place on the glovebox. Polyvinyl chloride (PVC) was chosen for its inherent benefits for nuclear seal applications due to its ability to withstand radiation dose up to ~9 E07 Radiation Absorbed Dose (rad) before it critically degrades, as well as its wide range of chemical compatibility. PVC is used in nuclear application as a seal material where Plutonium and Uranium oxide processing and chemistry activities are performed. Viton is chosen for its wider range of resistance to highly acidic chemicals. Viton can withstand radiation dose up to ~3 E07 rad before it critically degrades. The assembled gloveport retrofit is shown in Figure 3.

Figure 3. Assembled Gloveport Retrofit. [1]

DISCUSSION

TA-55 has inventory of over 600 gloveboxes, most of them fitted with the LANL 8" gloveport ring. A standard size glovebox (1.2 m X 1.2 m X 0.9 m) designed to be used in a nuclear facility costs about $50 thousand to build, $450 thousand to install, and $500 thousand to remove. Therefore, it is not cost-effective to replace a glovebox with a new one just because a superior technology for replacing one of its components has emerged. Nevertheless, 1300 pairs of gloves are replaced each year at TA-55; generating approximately 500 m^3/yr of transuranic (TRU) waste and Low Level Waste (LLW) waste. This represents an annual disposal cost of about 4 million dollars.

[1] Patent Pending

The manufacturing cost of one gloveport retrofit for LANL is $1500. By converting the LANL 8" gloveport to one that employs "Push-Though" technology, reduction in lab preparation, glove installation, the number of operators, and waste generated is observed, as shown in Table I.

Table I. Glove Change Comparison

Cost Factors	LANL Gloveport	Retrofit
Lab Preparation	Yes	None
Change Time (min)	15	1
Contamination issues	Yes	None
Operators required	3	2
Waste Generated (M^3)	0.17	< 0.03
$ to change 1 glove	$1,500	$180

Once the retrofit is in place, $1.3M in savings is realized every time 1000 gloves are changed. Waste generated during a glove change is reduced by more than a factor of 10. Operational efficiency is improved because operations downtime is reduced by a factor of 10 and one less operator are needed. Since operators need less training and experience to perform glove changes, operational safety is also improved. Furthermore, contamination issues are eliminated, since no breach of containment occurs during the glove change procedure. In summary, for about the cost of one glove change, the LANL 8" gloveport can be upgraded to one that utilizes "Push-Though" technology.

More waste is generated when a glove breach produces a contamination incident. Significant costs are incurred from a contamination incident due to the loss in production, cost of the cleanup, and preparation of incident documentation. "Push-Though" technology addresses this issue two ways:

1. By simplifying the change process, glovebox operators are more willing to change a glove versus waiting for the glove to fail.
2. For gloves that are not routinely used, gloveport plug can be installed, as shown in Figure 4.

Figure 4. Gloveport Plug Configuration.

When the need for the glove becomes necessary, the plug can be quickly replaced with a "Push-Through" glove assembly, the task accomplished, then another "Push-Through" plug installed. Placing gloveport plugs on all non-routinely used gloveports significantly expands the safety envelope of a glovebox, since a gloveport plug is a much safer configuration than a glove.

Glovebox glove information at TA-55 has been tracked on the GGIP database since 1993. This information is used to recommend service life intervals, determine an optimal schedule for changing gloves, select glove types for specific working environments, and document "*Lessons Learned*" from glovebox glove breaches and failures to improve the hazard control process. The key attributes tracked include those related to location, the glovebox glove, type and location of breaches, the worker, and the consequences resulting from breaches. A more detailed description of this statistical analysis has been reported previously [Ref. 1]. Robust statistical methods have been developed to better analyze and interpret data and to construct statistical models that allow for an accurate assessment of the data set, identify root causes of glove failures, and ultimately minimize breaches and failures and decide the replacement strategy for glovebox gloves [Ref. 7-9]. Using these statistical methods, it has been determined that breaches due to the expander tools used during installation of glovebox gloves on the LANL 8" ports represented one fourth of all breaches documented at TA-55 last year. Since expander tools are not used with "Push-Though" technology, this root cause of glove breaches is eliminated.

SUMMARY

A primary objective of an organization should be to maintain a safe and healthful workplace for personnel and to protect the public and the environment. Replacing LANL 8" gloveports with "Push-Through" technology achieves this objective by providing the glovebox user a safer and easier way to maintain glovebox systems. The cost of one retrofit is recovered during the next glove change operation. Contamination issues are mitigated on glove changes. In conclusion, improvements to the safety configuration of an engineered system contribute to an organization's scientific and technological excellence by increasing its operational safety.

ACKNOWLEDGMENTS

The authors would like to acknowledge the Department of Energy and LANL's Stockpile Manufacturing & Support and Nuclear & High Hazard Operations directorates, for support of this work.

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