Title: DESIGN IMPROVEMENTS FOR GLOVEBOXES USED 238PU02 PROCESS OPERATIONS

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DESIGN IMPROVEMENTS FOR GLOVEBOXES USED $^{238}\text{PuO}_2$
PROCESS OPERATIONS

Abstract: Since the start of operations at Los Alamos National Laboratory’s (LANL’s) plutonium facility (building PF-4), a significant amount of floor space has been devoted to $^{238}\text{PuO}_2$ process operations. Processing capabilities that are located in the $^{238}\text{PuO}_2$ processing facility include receipt and nondestructive evaluation of encapsulated $^{238}\text{PuO}_2$ heat sources and powders, $^{16}\text{O}$ exchange treatment, comminution, hot and cold pressing, heat treatment and sintering, encapsulation welding, decontamination, and decommissioning of obsolete heat sources. All of these operations are housed in a complex of 76 gloveboxes and introductory hoods connected by means of an overhead trolley housed in a tunnel. Because a significant number of the gloveboxes used for $^{238}\text{PuO}_2$ processing were installed before the original startup of the facility in 1978, they have been in service for nearly 20 years.

During a recent heat source production campaign, numerous contamination releases in the $^{238}\text{PuO}_2$ processing area were traced to degraded elastomer gaskets used for glovebox connections, and attachment of feed-throughs, service panels, and windows. Evaluation of the degraded gaskets revealed that a combination of radiolytic degradation related to the high specific activity of $^{238}\text{Pu}$, and extended service at high altitude in a low (to extremely low) humidity environment had resulted in accelerated gasket aging. However, it was also apparent that gasket design was the most important factor in actual contamination release. All of the contamination releases that were traced to degraded gaskets occurred in variations of a design that used a spline to expand an elastomeric gasket into the space between a connecting flange, window, or service panel, and a glovebox opening. No contamination releases were traced to the gasket design that employed bolted clamps to compress the gasket between a connecting flange, window, or panel, and the exterior surface of a glovebox opening.

As a result of these findings, the Actinide Ceramics group at LANL (NMT-9) has initiated a routine replacement and upgrade program to replace aging gloveboxes. All of the new gloveboxes will utilize the preferred gasket design, which is expected to reduce the number and frequency of contamination releases.
INTRODUCTION

Los Alamos National Laboratory (LANL) initiated operations at its plutonium facility (building PF-4) in 1978. Since the start of operations at this facility, a significant amount of floorspace has been devoted to $^{239}$PuO$_2$ operations. These operations include receipt and nondestructive evaluation of encapsulated $^{239}$PuO$_2$ heat sources and powders, O exchange treatment of $^{238}$PuO$_2$ powders, comminution, hot and cold pressing of fuel powders, heat treatment and sintering, encapsulation welding, decontamination, decommissioning of obsolete or excess heat sources, and long-term heat source surveillance and testing.

The $^{239}$PuO$_2$ operations in building PF-4 are housed in a complex of 76 gloveboxes, dropboxes, and introductory hoods. The gloveboxes and introductory hoods are arranged into lines built around a dropbox. Each dropbox provides access to a fully-contained overhead trolley system that services the entire $^{239}$PuO$_2$ processing area.

Connections between gloveboxes, window and service panel installations, and other large glovebox penetrations are generally made by means of elastomeric gaskets used in one of two attachment schemes (Fig. 1). The first, and most common method, is termed a "zippered" gasket and uses a removable elastomer spine to force the gasket to seal against the glovebox and connecting flange, service panel, window, etc. (Fig. 2). This type of penetration seal was the preferred gasketing scheme for gloveboxes installed at the startup of building PF-4, and is the most common feature of gloveboxes still in use throughout the facility. Many of the zippered gaskets currently installed in PF-4 gloveboxes date from the original installation, and have performed well for nearly 20 years.

The second type of penetration seal used in PF-4 gloveboxes is the "bolted" gasket (Fig. 3). In this configuration, an elastomeric gasket is clamped between the outer surface of the glovebox and the window, connecting flange, service panel, etc, by means of a bolted clamp. Because this type of penetration seal requires the installation of numerous threaded studs on the glovebox exterior, it was not extensively used in gloveboxes installed at the startup of building PF-4. However, even the gloveboxes of this vintage did use bolted gaskets for large, high-load, or low clearance penetrations where a zippered gasket would not provide adequate support, or where the manipulations required to install a zippered gasket would be difficult or impossible to perform.

In 1993, in anticipation of the production of $^{238}$PuO$_2$ heat sources for NASA's Cassini mission to Saturn, the Actinide Ceramics group at LANL (NMT-9) developed an comprehensive gasket inspection and replacement program for all of the gloveboxes used in the $^{238}$PuO$_2$ operations area. This inspection program identified a number of zippered gaskets, primarily on the flanges between glovebox connecting spools (Fig. 4) that required replacement. The deteriorated gaskets were subsequently replaced, and it was felt that the facility was well prepared for the heat source production effort.

OPERATIONAL EXPERIENCE

The Cassini heat source production campaign began in January 1994, and continued through September of 1996. During this time period, more than 43 kg of $^{238}$PuO$_2$ were processed in building PF-4 gloveboxes. Over the course of the production campaign, a number of contamination releases were traced to degraded gaskets used for glovebox connections, feed-throughs, service panels, and windows. All of the degraded gaskets were of the zippered design, and had been recently inspected. In addition, although post-service inspection of the failed gaskets always revealed some evidence of degradation, the deep
Figure 1. Two Types of glovebox gaskets are used in the 238Pu02 processing area.
Figure 2. A typical zippered gasket used to install a glovebox window.

Figure 3. A typical bolted gasket used to install a glovebox window.

Figure 4. Routine inspection revealed that many of the zippered connecting-ring gaskets were badly degraded and contained deep cracks.
cracking previously observed on failed connecting flange gaskets (Fig. 4) was generally absent.

DISCUSSION

It appears that the failure of zippered gaskets experienced during the heat source production effort can be traced to four factors: gasket age, service environment, accelerated radiolytic degradation, and design. As mentioned previously, many of the zippered gaskets in use at the plutonium facility have been in service for nearly 20 years. Although the life of an elastomeric gasket may be affected by a number of factors including exposure to heat, corrosives, solvents, etc., there is always an upper limit of useful life beyond which a significant portion of components will fail. On the basis of the increasing frequency of gasket failures, it appears that the useful, or design life, of zippered gaskets used in the \(^{239}\text{PuO}_2\) operations area is less than 20 years.

It is also likely that the routine service environment of building PF-4 gloveboxes has had a significant effect on gasket life. With the exception of introductory hoods, which have an atmosphere that is essentially equivalent to the laboratory room, all of the gloveboxes in building PF-4 contain atmospheres that range from dry (-40° dewpoint), to extremely dry (ppm levels of water vapor). In addition, because the plutonium facility is located at approximately 7000 ft above sea level, there is a small but predictable level of degradation due to altitude.

A third factor in the degradation of these gaskets was accelerated radiolytic degradation. During the heat source production campaign, which was conducted over the course of 33 months, more than 43 kg of \(^{239}\text{PuO}_2\) were processed in building PF-4 gloveboxes. In addition, the physical form of this material as a finely divided powder during some production operations, such as comminution, permitted intimate contact with the glovebox gaskets. Coupled with the high specific activity of \(^{239}\text{Pu}\), the exposure of the interior gasket surfaces to a distribution of 1-2\(\mu\)m particles of \(^{239}\text{PuO}_2\) provided a perfect opportunity for accelerated radiolytic degradation. It appears that this degradation resulted in accelerated cracking, crazing, and hardening of the exposed gasket surfaces.

Finally, the actual design of the zippered gasket should be considered as a root cause of many gasket failures. Given that no failures were observed with the bolted gasket design in many of the same operating conditions, it is reasonable to conclude that the zippered gasket design has a low degradation tolerance. Comparison of the two designs shown in Fig. 1 reveals that while both designs depend on the integrity and flexibility of the gasket material to maintain an effective seal, the zippered gasket has a much higher proportion of its surface area exposed to the glovebox interior. In contrast, the bolted gasket exposes only a narrow area to the glovebox interior. Consequently, any conditions inside the glovebox that enhance gasket degradation would be expected to have a more rapid and significant effect on a zippered gasket.

CONCLUSIONS

1. Wherever possible, the bolted gasket design should be used for all new gloveboxes installed in the \(^{239}\text{PuO}_2\) operations area. This would be expected to reduce the number and frequency of contamination releases in the future.

2. For existing glovebox installations, it would appear to be advisable to develop a conversion scheme to allow the replacement of zippered gaskets with the bolted alternative.