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Container Materials, Fabrication and Robustness

By

K.A. Dunn[1], M.R. Louthan[1], G.B. Rawls[1], R.L. Sindelar[1], P.E. Zapp[1], and J.W. McClard[2]
Savannah River National Laboratory[1]
Aiken, SC 29808
and
Savannah River Nuclear Solutions[2]
Aiken, SC 29808

Abstract:

The multi-barrier 3013 container used to package plutonium-bearing materials is robust and thereby highly resistant to identified degradation modes that might cause failure. The only viable degradation mechanisms identified by a panel of technical experts were pressurization within and corrosion of the containers. Evaluations of the container materials and the fabrication processes and resulting residual stresses suggest that the multi-layered containers will mitigate the potential for degradation of the outer container and prevent the release of the container contents to the environment. Additionally, the ongoing surveillance programs and laboratory studies should detect any incipient degradation of containers in the 3013 storage inventory before an outer container is compromised.

Introduction

The Materials Identification and Surveillance (MIS) Working Group (WG) is a selected group of technical experts from each of the participating sites within the Department of Energy (DOE) Complex. These experts are responsible for coordinating and resolving issues associated with the stabilization, packaging and storage programs for excess nuclear materials in the DOE Complex. The MIS Working Group determined that the only potentially viable degradation mechanisms for the container materials are pressurization due to gas generation and/or corrosion associated with impurities (specifically chlorides and fluorides) and moisture in the plutonium-oxides [1]. The MIS WG was instrumental in identifying critical features of a containment package system to mitigate these potential degradation mechanisms. The packaging features, for plutonium-(Pu) bearing materials, are specified in the DOE-STD-3013 [2]. These critical features include specifications that:

- The 3013 package shall consist of at least two individually welded, nested containers to isolate the stored materials from the environment.
- The use of an additional container, sometimes referred to as a convenience container, is optional. However, to date, all DOE Complex packaging sites have

used convenience containers as the innermost vessel to contain the plutonium-bearing materials.
- The minimum design pressure of the outer container shall be 4927 kPa (699 psig). This design pressure is based on the maximum viable pressure that could be reached within the 3013 system and will thus preclude any pressure induced release of the container contents to the surrounding environment.
- All containers must be fabricated of ductile, corrosion resistant materials, such as 300 series stainless steel.

In addition to the features required of each package, the outer 3013 container was standardized to facilitate compliance with shipping and storage at the different facilities in the DOE Complex. The standardization included dimensions, material type (316L SS), and fabrication method. A typical 3013 container set is shown in Figure 1 which shows an outer container, an inner container, and a convenience container. The convenience container is not a requirement of the DOE-STD-3013, however, it has been used in all cases where plutonium-bearing oxides have been packaged.

The requirements and standardizations provide a robust package designed to contain plutonium-bearing materials for a proposed 50 year system lifetime. However, to validate the assumptions related to the safety of these containers multi-pronged technical evaluations that include laboratory testing and surveillance activities are conducted.

Background

The technical conclusion that the only viable degradation mechanisms for the 3013 containers are pressurization due to gas generation and/or corrosion associated with impurities (specifically chlorides and fluorides) in the plutonium-oxides [1] was based on significant research and development The 4927 kPa (699 psig) design pressure of the outer container is based on the maximum gas pressure that could develop in a system that contained 0.5 wt% moisture, was generating 19 watts of heat and had a gas temperature of 211 C. These conditions provide an upper bound to the conditions that could exist in a properly packaged 3013 container system. Thus, the 4927 kPa (699 psig) design pressure exceeds the pressure that would develop in a container if all the moisture were converted to gas and the gas temperature was at the maximum conceivable level. Additionally, a number of experiments have been done to measure pressurization [3] as a function of gas composition, time and temperature. The resultant data convincingly demonstrate that the maximum pressure measured is only a small fraction of the design pressure. Therefore, the pressure boundaries of the 3013 package, as defined in the 3013 standard, are sufficiently robust to contain any pressure that could conceivably develop within the outer container.

Potential forms of corrosion, the second viable degradation mechanism for the 3013 package, have also been evaluated [4] and include pitting, crevice corrosion, and stress corrosion cracking (SCC). Corrosion is possible because of the impurities in the plutonium-bearing materials, mainly chlorides and fluorides, and the presence of moisture (an electrolyte) in the container. The DOE-STD-3013 moisture limit of <0.5 wt

% for the material is fairly conservative; however, the presence of chlorides and fluorides along with the very small quantity of moisture is of concern. Literature studies along with laboratory testing and surveillance activities have shown that it is unlikely for crevice corrosion or pitting to penetrate even one barrier let alone the multi-barrier 3013 package [5].

Figure 1. The 3013 container used by Savannah River Site (SRS) for oxides. The outer container is consistent for all packaging sites in the DOE Complex.

However, in small-scale laboratory experiments designed to bound the aggressive exposure conditions possible in actual 3013 containers packaged across the DOE Complex, stress corrosion cracks developed in two Type 304L stainless steel test specimens [6,7]. The significance of these tests is that the cracking occurred at room temperature after only 166 days of exposure. The cracks developed at the plutonium-oxide stainless steel interface and only occurred in test samples exposed in actual plutonium-oxide. Similar samples exposed to surrogate non-radioactive oxides did not crack. Such cracking illustrates the importance of environment-specific testing. The cracking of these laboratory samples was not anticipated and the results suggest that the potential effects of stress corrosion of the convenience can and the inner container must be evaluated to assure that the multi barrier design provides a robust package that maintains its integrity, even if the inner container should experience stress corrosion cracking.

Stress Corrosion Cracking

Stress-corrosion cracking is caused by the simultaneous presence of a susceptible alloy, sustained tensile stresses, and a particular environment [8] as shown in a Venn diagram in Figure 2. Remove any one of these parameters and SCC will not occur. A discussion of the 3013 package relative to stress, material and environment is developed below.

Stress

In the 3013 containers, the primary stresses are the residual stresses induced by the forming operations used to fabricate the containers and the residual weld stresses developed by the weld closure operations. Experience has shown that gas pressures that develop in the containers are well below the design pressure and therefore the pressure induced tensile stress imparted to the container is insignificant relative to the residual stresses. The residual fabrication stresses from the forming operation are not well defined but should approach the yield strength of the container material as will the residual weld stresses. Taken together, these residual stresses will provide sufficient stress in any 3013 container to support stress corrosion cracking should the other two conditions for cracking be achieved.

Material

Austenitic stainless steels, such as the 300 series stainless steels used for the 3013 containers, are often chosen for applications that require a corrosion resistant material that is, fabricable and weldable. Although generally a good option, the 300 series steels are susceptible to chloride-induced stress corrosion cracking and sensitization. Sensitization is a metallurgical change that can occur when austenitic stainless steels are heated under conditions that promote the grain boundary precipitation of chromium rich carbides. This precipitation reduces the resistance of the steel to corrosion and can lead to intergranular corrosion and stress corrosion cracking in specific environments. Type 316L SS was chosen as the material of construction for the outer container and either 304L or 316L SS was chosen as the material of construction for the inner and convenience containers. The "L" indicates a low carbon content and was selected to minimize the tendency for sensitization, however, it is possible for sensitization to occur in the L grade steels. The heat-affected-zones in welded 300 series austenitic stainless steels are often sensitized and, even without sensitization, are often susceptible to stress corrosion cracking. Additionally, annealed microstructures and the microstructures associated with wrought processes such as flow forming are also susceptible to SCC. Therefore, several regions in the 3013 containers are susceptible to chloride induced SCC. These regions include the closure welds in both the inner and outer containers and the heavily deformed regions of the inner and outer containers as well as the convenience containers. There is also a container fabrication weld in the outer container.

The evaluations of the 3013 container stresses and materials demonstrate that both of these factors place the containers under conditions where SCC is possible if the environment will support the cracking process. Such evaluations provide one of the reasons that the moisture content of the packages is controlled to such a low level and illustrate the significance of the cracking observations in the small scale test specimens.

Environment

Environmental parameters in the 3013 package include temperature, moisture, radiation and plutonium-oxide/salt composition. The small scale test results suggest that SCC is possible in a 3013 container. However, to date, SCC has not been observed in any packaged container. Stress corrosion cracking has only been observed in a laboratory test that exposed highly stressed, welded coupons to plutonium-oxide/salt mixtures at bounding moisture contents. In this focused laboratory setting, only one composition of plutonium-oxide/salt at bounding moisture levels resulted in stress corrosion cracking. The cracking occurred near the weld interface which was in contact with the plutonium-oxide/salt material. No evidence of SCC was seen in similar laboratory samples exposed in the headspace gas region.

The design of the tear drop laboratory test coupons used in the small scale tests includes a highly stressed region with a weld interface and a potentially sensitized microstructure in the heat affected zone (HAZ) of the weld. There are two significant factors associated with the small scale test results: 1) cracking did not occur in the non-welded regions of the stressed test samples, even though those regions were in contact with the plutonium-oxide/salt mixtures and the stresses in those regions were high enough to support stress corrosion, and 2) no cracking was observed in samples that were not in contact with the plutonium-oxide/salt mixtures The microstructures in the laboratory coupons correlate to microstructures in the nested 3013 containers. However, no welds in the 3013 container configuration are in direct contact with the plutonium-oxide/salt mixture because they are only located in the headspace gas region.

The occurrence of SCC in the small scale test specimens exposed to the plutonium-oxide/salt mixtures at the bounding environmental conditions (except for temperature) was not anticipated. This observation suggests that the environment in the 3013 containers may support SCC under certain circumstances.

The evaluation of the three factors shown in the Venn diagram demonstrates that under conditions that closely correspond to conditions anticipated in some 3013 container systems, stress corrosion cracking may occur in areas where the plutonium-oxide/salt mixtures contact the container surface. Cracking in the headspace gas regions and other regions where contact is not achieved has not been demonstrated but cannot be entirely discounted at this time. However, because of the nested arrangement of the container system, cracking of the outer container will require the presence of an appropriate environment to crack the convenience container, movement of the environment through the cracks in the convenience container into the inner container and the development of new cracks in the inner container which propagate through the inner container wall. After the inner container cracks, the environment must reform inside the outer container and another set of new cracks must initiate and propagate. Experimental observations, outlined in the following sections of this report, suggest that this will not occur.

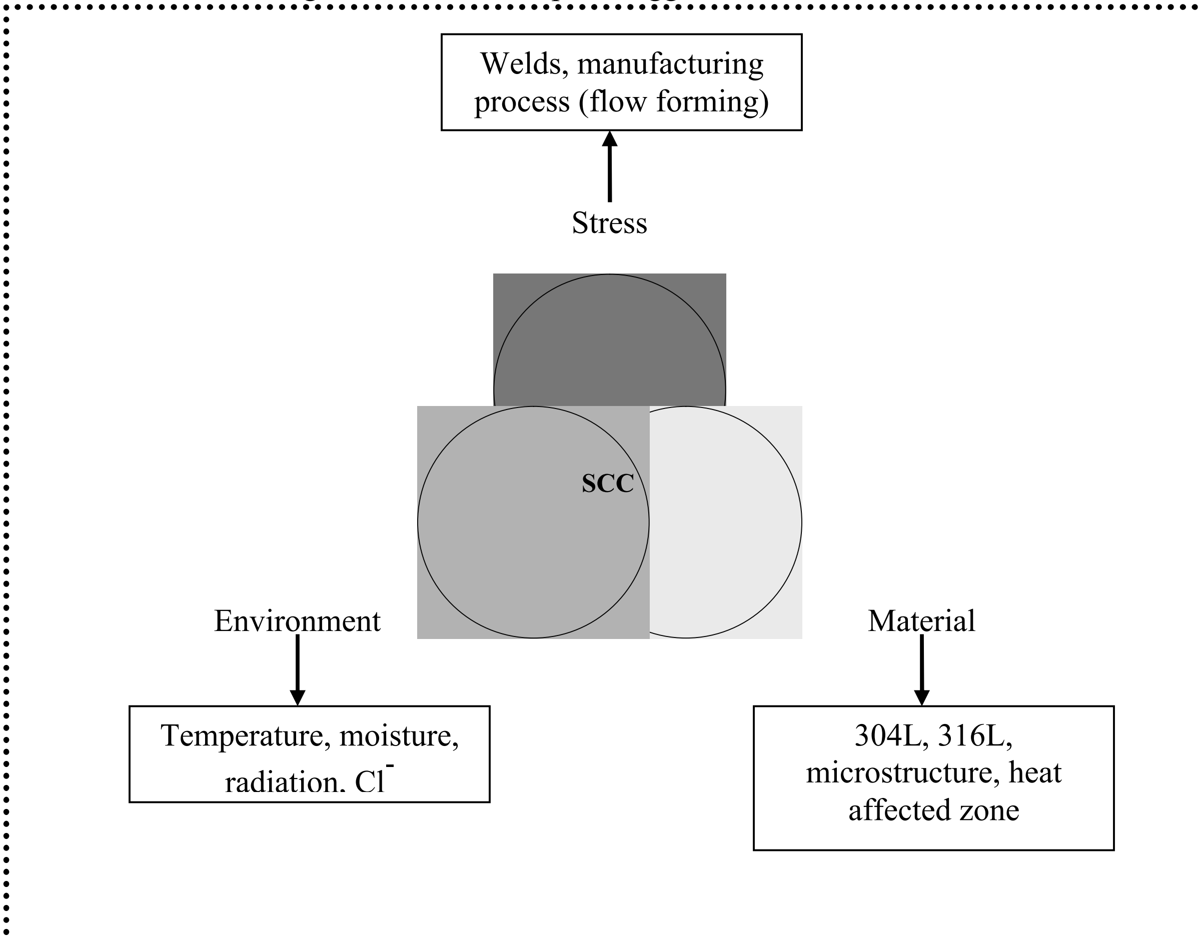

Figure 2. Venn Diagram showing relationship of stress, environment and material on stress corrosion cracking.

Cracking Observations

Stress corrosion cracking in the two 304L stainless steel tear drop coupons only initiated in regions where the samples contacted a plutonium-oxide / 2% chloride salt mixture (with 0.2 % calcium chloride) loaded with approximately 0.6% water [6,7]. The cracking occurred mainly along the interface between a transverse autogenous weld at the center of curvature of the coupon and the parent metal. The depth of the weld was about half the parent metal thickness. Metallography showed that the highly branched cracks propagated along the parent metal/weld interface, across the weld itself, and finally through the weld into the underlying parent metal. The cracks within the parent metal were transgranular and consistent in appearance with aqueous chloride-induced stress corrosion cracking of 304L stainless steel.

The teardrop coupons were chosen as a screening test for stress corrosion cracking because of their compact size, the elimination of a need for hardware or fixturing to maintain a stressed condition and the ability to simulate the metallurgical conditions and stresses in the containers. The stresses in the sample are a combination of tensile stress developed by clamping and welding the specimen ends to form a teardrop and other residual stresses developed during sample fabrication. A transverse autogenous weld was placed on the metal strip before the strip was bent into the teardrop shape. This weld was used to simulate the microstructure of the closure weld in the 3013. Testing of similar teardrop samples in boiling $MgCl_2$ solutions demonstrated that numerous regions contained stresses sufficient to support stress corrosion. These regions included the autogenous weld, the machined edges of the coupons, the weld made to produce the teardrop shape and the stresses in the U-bend region of the sample. As previously stated, the only area to crack in the plutonium-oxide/salt tests was associated with the autogenous weld where the weld interface contacted the plutonium-oxide/salt mixture. The lack of cracking in the other, very SCC susceptible areas of the teardrop samples demonstrates the critical role that plutonium-oxide/salt mixture contact plays in the cracking process and suggests that the only regions of the 3013 container system that may be susceptible to SCC in the packaging environments are the regions where such contact exists. This observation demonstrates that the potential regions for SCC may be limited, even though the residual stresses in the 3013 containers are sufficient to support cracking in numerous regions.

The stress in the teardrop coupon is above the yield stress of the non-bent steel [9], and should be approximately equal to the residual stresses in the 3013 containers because of the severe deformation that accompanies the container fabrication processes. The applied stress from the pressure loading of the containers is at levels much below the yield stress of the material. The pressure boundary on the outer container was built to ASME Code [5] allowable stresses which are limited to 2/3 the material yield strength. After the first five years of the Integrated Surveillance Program [1], 43 destructive examinations have been performed. The ages of the containers examined ranged from three to six years and all pressures observed have been below 20 psig. This data shows that the pressure levels in the 3013 containers are well below the design pressure further assuring that the applied stress is significantly below the yield strength.

Therefore the main driving force for the stress corrosion cracking in the 3013 package is the residual stress from fabrication just as the main driving force for cracking of the teardrop samples was residual stresses created by fabricating the tear drop. Sources of residual stress in the containers include the welding operations and the forming operations used to fabricate the containers. The inner containers also include through wall closure welds that attach the top to the containers. The outer container has two welds. The bottom head is attached to the outer container with a single groove full penetration circumferential butt weld and the lid of the outer container is attached with a full penetration circumferential corner joint weld that seals the container during packaging. The residual stresses created by the container fabrication and welding processes establish numerous regions where the residual stresses are sufficient to support SCC and to determine the "most SCC susceptible" locations in the 3013 containers, a series of tests were conducted in boiling $MgCl_2$ solutions.

In 2002 [10], a stress corrosion cracking test was performed for the outer container and more recently in 2009 for the inner and convenience containers [11]. The testing was performed to ASTM G 36 using boiling $MgCl_2$ solutions. Several of the tests were terminated after 48 hours. Severe cracking was observed in the container walls, however, no leakage of the $MgCl_2$ was observed through the container. The metallurgical evaluations following the tests confirmed that through wall cracks were present in the containers. Although these branching, primarily transgranular cracks penetrated the container walls, the crack system was so torturous and the crack openings so small that the $MgCl_2$ solution did not leak through the crack system. The residual stresses in the container components were the driving force for cracking and the occurrence of cracking illustrates that residual tensile stresses were in excess of 10 ksi [8]. The top closure weld in the outer container has been evaluated using finite element techniques and shown to have residual stress levels as high as yield [12]. This evaluation is consistent with upper bound welding residual stresses at yield levels being used in the pressure vessel and piping industry for the evaluation of crack like flaws. Additionally, when weld heat input is high, the stress distribution can be at yield levels through the wall [13, 14]. These observations demonstrate that although the residual stresses in the 3013 containers are high, these fixed displacement stresses do not cause significant crack openings and therefore do not create an easy path for the migration of the plutonium-oxide/salt mixtures.

The residual stress levels resulting from the forming of the convenience and inner container have not been fully evaluated. A literature review, however, indicates the residual stress level resulting from deep draw forming processes can be significant in both the axial and circumferential directions [15, 16]. Additional evaluations would be required to quantify the forming residual level in the convenience and inner containers. Analysis of the metallurgical data that is currently available from the destructive examination being performed as part of the 3013 Surveillance Program will provide qualitative evidence of the presence of forming residual stress. A review of the fabrication procedures could provide a qualitative assessment of forming residual stress in the convenience and inner container. However, regardless of the outcome of these evaluations, the $MgCl_2$ tests have demonstrated that residual stress driven cracks in the containers will provide relatively tight, tortuous paths, even if they should penetrate the container wall

Quantifying the residual stress magnitude in the 3013 package remains a priority because such quantification would allow direct comparisons with stress corrosion testing as performed in the tear drop test [9] and better define the potential for crack openings as the residual stress fields redistribute during the cracking process. The stress analysis of the teardrop coupon showed that the Mises stress at the location of the crack was approximately 70,000 psi. This stress is slightly above the yield stress of the parent metal, which was assumed in this analysis to be 66,000 psi, before the metal is deformed into the tear dropshape. The stress analysis showed further that the maximum Mises stress in the coupon was not found at the center of curvature, but rather was found to be about 93,000 psi at the "shoulders" of the coupon, due to the cold working operation as the metal is bent into the tear drop shape. The observation that the cracks in the teardrop samples exposed to plutonium-oxide/salt environments developed near the weld, rather than in the highest stress regions suggests that the welding process increased the material susceptibility to cracking. Increases in SCC susceptibility have been observed in SCC situations where weld induced alterations in the microstructure of the material are present.

The experimental observations of cracking in the teardrop samples and the 3013 container sections provide a technical basis to conclude that if stress corrosion cracking does occur in the 3013 container system, the cracking will:

1) Occur in regions where the container material is in contact with the plutonium-oxide/salt mixtures, and
2) Produce a torturous crack path with minimal crack openings, even if the container wall is breached.

These conclusions, as will be further discussed in the next section, demonstrate that the nested, multi-barrier 3013 container design virtually precludes the initiation of SCC in the outer container.

Multi-Barrier Container Arrangement, Welds and Stress Corrosion Cracking

A detailed summary of each of the DOE Complex packaging site's 3013 container configuration and its corresponding weld regions are provided in Table 1. A subset of Hanford and SRS containers is expected to represent those containers with the highest potential for SCC due to relative humidity conditions at loading. The 3013 container configuration is a robust package because of the multiple barriers that contain plutonium-oxide against release to the environment. Although the mechanism by which the observed SCC occurred is not fully understood, current data from the experimental program supports the conclusion that SCC of the containers requires that the plutonium-oxide material to be in contact with a high stress region of the 304L and 316L stainless steel materials [6, 7]. This conclusion is further supported by the fact that SCC has not been observed in the headspace gas region with any of the numerous 3013 corrosion tests conducted at SRNL or LANL [17].

When considering the potential for plutonium-oxide material to transfer from one container to the surrounding container, each Site's storage configuration and container design, including welds, need to be considered. There are no welds in several of the convenience containers used for packaging the plutonium-bearing material. These convenience containers provide a barrier to material contact with the 3013 inner container. The Hanford convenience container lid contains a filter for venting. The filter is attached to the container using a seam fusion weld. The SRS convenience container lids contain notches for venting purposes. The seam weld on the Hanford convenience container filter is initiated on the external side of the convenience container lid, is not through wall, and therefore, it is not in direct contact with plutonium-oxide powder. In the SRS convenience containers the notch may allow for some small amount of plutonium-oxide material to transfer into the inner container. It is expected that this material will settle at the bottom the inner container away from the closure weld region that is considered to have the most SCC susceptible microstructure in the container. Basically, however, the transfer of significant quantities of plutonium-oxide into the inner container of either the Hanford or SRS packages requires a breach of the convenience container.

The residual stresses in the convenience containers [11] are sufficient to support SCC in boiling $MgCl_2$ solutions, however a susceptibility to cracking in relevant plutonium-oxide/salt/moisture environments has not been demonstrated. The only plutonium-oxide induced cracking that has been observed has occurred in near weld regions, even when these regions contained lower stresses than were present in non-cracked regions of the same samples. This observation suggests that the stress level is less significant than the metallurgical condition of the material that results from a welding operation. Therefore, the 3013 packaging process results in the plutonium-bearing materials being in direct contact with low susceptibility regions of the convenience containers and stress corrosion cracking of the convenience containers is not expected. However, in order to conservatively assess the robustness of the 3013 package, a through-wall crack due to stress corrosion cracking of a 3013 convenience container is postulated. Intuitively, a through-wall crack may provide a path for potential material transport through the container. However, because of the tight, torturous path created by the stress corrosion crack, the transport of oxide and salt particulates through a SCC in a 3013 container is not considered credible.

Stress corrosion cracks have occurred in stainless steel piping in aqueous systems and in laboratory experiments. As a result, models have been developed to evaluate water leakage through such cracks in leak-before-break demonstrations [18]. Although not directly applicable to the analysis of particulate transport, the mechanistic description of water flow through a stress corrosion crack with an area controlled by crack length, pressure loading, and material compliance, with flow rates directly related to stress-corrosion-crack tortuosity and the fluid velocity regime, is relevant to an assessment of particulate transport.

A through-wall crack in a material is opened (crack opening displacement) under membrane and bending stresses. The amount of opening is depending on the crack length and stress level [19]. That is, a crack that has grown under a residual stress field can not be opened unless a sustained pressure loading is present or the residual stress is not significantly relieved by crack propagation. Furthermore, the channel traversing the section of steel is not smooth - the morphology of stress corrosion cracks in stainless steel show crack paths to be comprised of numerous turns and branches along the crack channel as observed in the SRNL results [18]. Particles of plutonium-oxide at sizes even well below the typical stainless steel container material grain sizes of 25-50 μm could not be expected to pass though the crack channel. In addition, a driving force would be needed to move a particle through the crack channel. Only entrainment in a fluid flow (e.g. water or high velocity gas) could provide a driving force on the particle.

This case is not credible in any of the containers in the 3013 system, first because high gas pressures have not been observed and second because any gas pressure loading on a crack would be expected to be quickly relieved without any significant transport of material from one nested container into the next. Additionally, because of the Hanford filter and the SRS notches, neither of those convenience containers is capable of pressurization which means that entrainment of particulates through stress corrosion cracks in those containers is not credible. Therefore, bulk transport of oxide and salt particulate material through a stress corrosion crack without wide openings due to high membrane stresses and sustained flow is not feasible. As discussed earlier, the applied stress due to pressure is much below the yield stress of the material and even if high pressures did develop those pressures would dissipate as soon as the container wall was breached. Additionally, a sustained pressure would be needed to keep the crack open. This conclusion is supported, in part, by the observations in the $MgCl_2$ test of the outer container that showed that a high viscosity solution ($MgCl_2$) did not leak through a container [6].

Additionally, because of the ductile nature of 304L and 316L stainless steels, the container will not fall apart or crumble, even if a crack is present in the 3013 containers. This is a common and well known metallurgical phenomenon. The integrity of the convenience container, because it is austenitic stainless steel, is adequate to maintain the containment of the plutonium-oxide material, except for contamination levels and the inner container provided yet another barrier to reaching the outer container. Therefore, it is not likely that the quantities of plutonium-oxide/salt mixtures necessary to initiate SCC will reach the inside of an outer 3013 container packaged at any of the packaging or storage sites. To reach the outer container the plutonium-oxide must transfer from the convenience container into the inner container in sufficient quantities to create a through wall SCC then transfer enough material to the outer container to create another SCC. A single crack initiation-material transfer process is, for reasons described in this report, unlikely, and the possibility that the initiation/transfer event will occur multiple times in a 3013 container system is not considered credible.

Conclusion

Evaluations of the container materials, fabrication, and residual stresses in the 3013 package suggest that the multi-barriers and robust nature of the system will mitigate the potential for degradation of the outer container even though stress corrosion cracking was observed in small scale laboratory coupons. The technical basis for this conclusion is focused on the following:

- The robust, multi-barrier nature of the 3013 container system, monitored through the surveillance program, should preclude breach of the outer container.
- Transport of oxide and salt particulates through a stress corrosion crack in a 3013 container is not credible.
- Regardless of whether a crack is present in any of the 3013 containers, the ductile nature of 304L and 316L stainless steels prevents the container from falling apart or crumbling.
- Welds, which are known to contribute high residual stresses and potentially stress corrosion cracking susceptible microstructures, are not present in the convenience container.
- Plutonium-oxide material is not in contact with welded region of inner container, the area most susceptible to stress corrosion cracking.

This technical basis is also supported by other observations, including the facts that:

- The cracks were observed in Type 304L stainless steel which is more susceptible to stress corrosion cracking than the Type 316L stainless steel used to fabricate the outer 3013 containers.
- Cracking was observed in the oxide/coupon contact region for only one composition of oxide salt. In previous corrosion studies, many other samples have been exposed to salt bearing, plutonium-oxide materials and no evidence of stress corrosion cracking was found.

However, an evaluation of the SCC behavior and the potential for SCC within the 3013 package headspace is continuing because of the importance of the conclusion that, under 3013 relevant conditions, contact with salt material in an aqueous solution is necessary for cracking to occur.

Table 1. 3013 container assemblies used at RFETS, SRS and Hanford. The containers are nested in the following order: CC - convenience container, IC - inner container, OC - outer container. A short description of each container is given along with the welds.

RFETS and LLNL configuration.		
	Container description	**Weld Description**
CC	BNFL convenience container body 316 SS sheet with container threads that are 316SS bar. The threads are silver plated threads to mitigate galling. Threaded lid is fabricated from Type 416 SS bar to permit remote handling via magnetic mechanism.	Smooth (on external surface) and continuous full penetration weld on the container body ~6.5" from bottom of container. No closure weld.
IC	BNFL inner container ASTM A240 316 SS. IC lid also ASTM A240 316 SS.	Hollow plug press fit into inner container to allow for laser closure weld. No container fabrication welds.
SRS configuration.		
	Container description	**Weld Description**
CC	SRS convenience container 304L SS with threads. Threaded 304L SS lid with slots in screw threads to facilitate venting.	Fabrication method for container was flow-forming method. Threads of the container were machined once the container was formed. There are no welds in either the container or lid.
IC	Bagless transfer inner container 304L SS with low sulfur content fabrication using precision flowforming, IC lid also 304L SS	No fabrication welds in the container. GTAW closure welded only.
Hanford configuration.		
	Container description	**Weld Description**
CC	Hanford convenience container. Very similar to the SRS convenience container. Lid material is 304/304L and contains vent filter.	Lid has vent filter welded in place via a seam fusion weld. Seam weld on exterior of lid and does not penetrate through wall. No welds in container.
IC	Bagless transfer inner container 304L SS with low sulfur content. Container body fabrication using precision flowforming. IC lid also 304L SS	No fabrication welds in the container. GTAW closure welded only.
Outer container description		
OC	BNFL outer container body 316L SS seamless pipe, base is 316L SS plate and lid 316L SS plate.	Smooth and continuous full penetration autogenous weld ~0.5" from bottom of container to connect container body to base cap. Lid press fit into body and laser (RFETS & LLNL) or GTAW (SRS & Hanford) closure welded.

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