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EXAMINATION OF SHIPPING PACKAGES 9975-01658, 9975-02075 AND 9975-02738

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EXAMINATION OF SHIPPING PACKAGES 9975-01658, 9975-02075 AND 9975-02738

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Summary

SRNL has assisted in the examination of three 9975 shipping packages (9975-01658, 9975-02075 and 9975-02738) following their use for storage of nuclear material in K-Area Complex (KAC). Each of these was targeted for examination because the axial gap exceeded the 1 inch maximum criterion, signaling the potential for degradation of the fiberboard overpack and drum. Each package experienced a degree of compaction of the bottom fiberboard layers, and had elevated moisture levels toward the bottom. A small amount of mold was observed on the lower fiberboard assembly in 9975-02738. However, the majority of the fiberboard in each package appeared to retain good integrity consistent with non-degraded material. Minor corrosion was observed on these drums, but is judged to have not compromised the drum integrity.

Background

Of the several 9975 shipping packages recently removed from storage in KAC for field surveillance three were sent to SRNL for more detailed examination based on the observation of several conditions of interest. The axial gap in all three packages exceeded the criterion of 1 inch maximum. Additional observations include water stains and corrosion on the drum or lid of one or more packages. These packages were opened and examined in 723-15A with assistance from High Pressure Lab personnel.

Package 9975-01658 was packaged at SRS in October 2003, and received in KAC in October 2003 with a 18.8 watt internal heat load. After field surveillance in KAC on April 5, 2016, it was received in SRNL and examined on April 14, 2016.

Package 9975-02075 was packaged at RFETS in May 2003, and received in KAC in June 2003 with a 13.1 watt internal heat load. After field surveillance in KAC on April 12, 2016, it was received in SRNL and examined on April 20, 2016.

Package 9975-02738 was packaged at RFETS in June 2003, and received in KAC in June 2003 with a 11.7 watt internal heat load. After field surveillance in KAC on April 11, 2016, it was received in SRNL and examined on April 20, 2016.

This report documents the results of examination of these three packages.

Examination Results

Measurements (dimensions and moisture content) and observations taken on the fiberboard assembly from each package are summarized, and compared to the field surveillance data collected in KAC, in Tables 1 - 3. For each package, the axial gap was slightly larger when measured in SRNL than it was in KAC. It is expected that additional compaction of the bottom fiberboard layers occurred during handling and transport.

Additional observations from 9975-01658 include:

- The bottom 1-3 layers of the lower fiberboard assembly were saturated (darkened). On the bottom surface, this saturated region extended several inches in toward the center. (Figure 1)
- Dried water spots along one side on top of the air shield * (Figure 2).

- Stains and light corrosion on the drum ID surface * (Figure 3).
- Light corrosion on the underside (interior surface) of the lid.
- Light corrosion on the bottom of the drum, along the outer corner (Figure 4).

Additional observations from 9975-02075 include:
- Water spots on the drum exterior surface * (Figure 5).
- Light corrosion on the bottom of the drum, along the outer corner (Figure 6).

Additional observations from 9975-02738 include:
- Light stains on the upper fiberboard assembly (Figure 7).
- Glue residue and light mold on the side of the lower fiberboard assembly (Figure 8).
- Light corrosion on the bottom of the drum, along the outer corner (Figure 9).
- Deposits and/or corrosion product on the underside (interior surface) of the lid * (Figure 10).
- Not noted in the SRNL examination, but the field surveillance identified small corrosion spots on the drum ID surface * (Figure 11).

The observations above marked with "*" were also noted in the field surveillance.

Discussion

Given the initial observation of an axial gap exceeding the 1 inch maximum criterion for each of these packages, the examinations focused on the fiberboard assembly and drum. An excessive axial gap is often associated with the concentration of water in regions of the fiberboard assembly, especially in the bottom layers, and with impacts on the integrity of the fiberboard and drum.

In general, higher internal heat loads will produce higher internal temperatures and higher temperature gradients across the fiberboard. The thermal gradient in turn will create a counter-gradient in the fiberboard moisture content and relative humidity, although the absolute humidity tends to remain relatively constant [1]. Field surveillance data from KAC can be used to approximate the thermal and moisture gradients. The thermal gradient across the fiberboard sidewall is approximated by the difference between the shield lid temperature and the drum OD temperature. The upper fiberboard assembly moisture gradient is approximated by the difference between the average OD moisture content and the average ID moisture content. These two gradients are compared in Figure 12 for a sampling of 26 packages with cane fiberboard.

The data in figure 12 show a degree of scatter, but an overall trend is apparent. Reasons for the scatter might include local variation in fiberboard properties, and circumferential variation in the temperature of a package due to varying heat load of adjacent packages. The three symbols in Figure 12 that are highlighted are from the packages documented in this report. These are among the most extreme outliers, although the specific reason(s) for their variation are unknown. Based on the general trend and the heat load of these packages, 9975-01658 has a lower fiberboard moisture gradient than expected for its heat load, while the other two packages have a lower thermal gradient than expected for their heat load.

Fiberboard degradation rates will increase with temperature, above a certain threshold value [1]. As the fiberboard degrades, water is produced as a byproduct. Increasing fiberboard water content can

also lead to increasing degradation rates [2]. At the same time, any moisture inside the 9975 drum is slowly changing to come into equilibrium with the environment outside of the package. Leakage paths through the drum exist between the drum flange and lid, around the caplugs, and through the rolled joint at the bottom of the drum. There may be significant variation in the "leakiness" of each package and the rate at which moisture can enter or leave. The relative leakiness of each pathway may also influence the axial distribution of moisture within the package. This combination of possible behaviors can lead to a range of moisture conditions within the 9975 packages in storage.

Each package had some degree of elevated moisture in the bottom fiberboard layers (with light mold observed on 9975-02738), but the remainder of the fiberboard assembly had typical moisture levels, and presented an appearance consistent with non-degraded fiberboard.

The water stains on the 9975-01658 air shield indicate condensate had formed on the lid at some point. Although there was no stain on the drum side corresponding to water running down to the bottom, such condensation can be an effective mechanism for concentrating water at the bottom of the drum. Condensation on the drum and lid interior surfaces may also have contributed to the corrosion noted in those locations in 9975-01658 and 9975-02738. These incidences of corrosion were only examined visually, and their exact nature has not been identified, although the corrosion on the 9975-01658 ID surface is similar in appearance to the corrosion observed on the drum exterior of other packages. It is judged that the integrity of these drums has not been significantly challenged by this corrosion.

A fine-bristle wire brush was used on local regions of corrosion: on the 9975-01658 drum interior surface, and on the 9975-02738 lid. Photographs of these regions before and after brushing (Figures 13, 14) show much of the corrosion remaining, suggesting there may be some small depth of penetration.

The presence of corrosion on the drum OD around the bottom stitch welds has been suggested as an indicator of significant moisture buildup and/or fiberboard degradation [3, 4]. No corrosion was observed at this location in these 3 drums, and the internal degradation was minor relative to other examined packages. However, each of the drums had a small amount of corrosion on the underside, along the outer corner. This has also been observed on other packages [4, 5]. Given the position of this corrosion relative to the nearest potential leak path (on the side above the rolled bottom), and the absence of corrosion on the drum side, it is judged unlikely that this corrosion resulted from anything leaking from these drums. Rather, it likely resulted from environmental conditions outside the packages, assisted by the stress state in this tight corner. Therefore, the observation of corrosion in this location on the bottom of 9975 drums, in the absence of additional corroborating evidence, should not be taken as in indication of significant degradation of the drum and fiberboard.

Drawing R-R2-F-0025 [6] recognizes that the axial gap dimension may vary over time due to variation in the fiberboard properties. This same caveat extends to all fiberboard dimensions. Most of the measured fiberboard dimensions for these three packages are in reasonable agreement with nominal drawing dimensions, but a few fall significantly outside the drawing tolerances. This includes the lower assembly overall height for all three packages (0.184 – 0.376 inch below the minimum value), and the upper assembly inside diameter for 9975-01658 (0.090 inch below the minimum value). All other dimensions were within 0.029 inch of the tolerance range. With the

overall lower assembly height reduced, but the lower assembly height above the bearing plate much closer to nominal, the majority of height reduction likely occurred in the layers below the bearing plate, where the moisture levels are highest and the fiberboard experiences the greatest compressive stress from the weight of the shield and containment vessels.

Conclusions

SRNL has assisted in the examination of three 9975 shipping packages following storage of nuclear material in K-Area Complex (KAC). The initial observation of the axial gap exceeding the 1 inch maximum criterion signaled the potential for further degradation of the fiberboard and drum. Each package experienced a degree of compaction of the bottom fiberboard layers, and had elevated moisture levels toward the bottom, but the majority of the fiberboard appeared to retain good integrity consistent with non-degraded material. Minor corrosion was observed on these drums, but is judged to have not compromised the drum integrity.

References

1. SRNL-STI-2016-00254, "Humidity Data for 9975 Shipping Packages with Cane Fiberboard", W. L. Daugherty, May 2016

2. SRNL-STI-2015-00610, "Status Report – Cane Fiberboard Properties and Degradation Rates for Storage of the 9975 Shipping Package in KAC", W. L. Daugherty, December 2015

3. SRNL-STI-2016-00014, "Examination of Shipping Packages 9975-01641, 9975-01692, 9975-03373, 9975-02101 and 9975-02713", W. L. Daugherty, January 2016

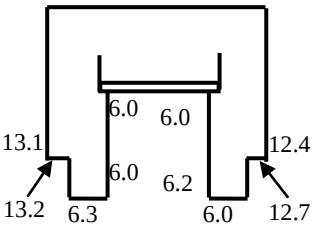
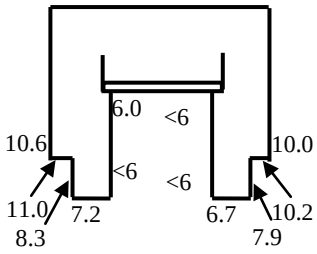
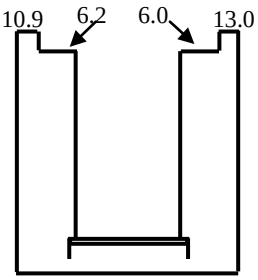
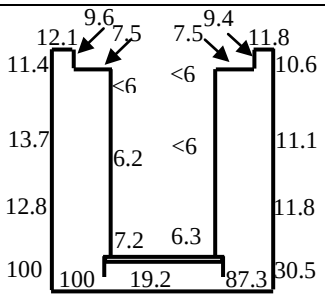
4. SRNL-STI-2016-00152, "Examination of Shipping Package 9975-02403", W. L. Daugherty, March 2016

5. SRNL-STI-2016-00209, "Destructive Examination of Shipping Package 9975-02101", W. L. Daugherty, May 2016

6. Drawing R-R2-F-0025, Rev. 2, "9975 Drum with Flange Closure Subassembly and Details", October 29, 2003

7. SRNL-L7200-2008-00007, "Correlation between Cane Fiberboard Moisture Content and Relative Humidity", W.L. Daugherty, December 10, 2008

Table 1. Detailed fiberboard data for packages 9975-01658 (18.8 watt internal heat load)

	9975-01658 (in KAC) 4/5/2016		9975-01658 (in SRNL) 4/14/2016	
Upper assembly	Dimensions (inch)	Moisture content (%WME)	Dimensions (inch)	Moisture content (%WME)
UD1	17.646		17.645	
UD2	8.510		8.450	
UR1			3.050	
UR2			1.503	
UH1			7.152	
UH2			2.092	
UH3	4.945		4.964	
Lower assembly	Dimensions (inch)	Moisture content (%WME)	Dimensions (inch)	Moisture content (%WME)
LD1			18.066	
LD2			8.480	
LR1			3.244	
LR2			1.516	
LH1			26.274	
LH2			20.362	
LH3	2.008		2.022	
Axial gap	1.248 inch		1.33 inch	
Notes	84.6 %RH in upper air space.			

Diametral dimensions were measured twice, ~180 degrees apart, other dimensions were measured 4 times, ~90 degrees apart. Average values are reported.
Dimension UH1 includes the air shield.
Fiberboard moisture content is measured with a GE Protimeter Surveymaster wood moisture meter. Conversion of its results (%WME) to wt% water has been described for cane fiberboard in Reference 7.

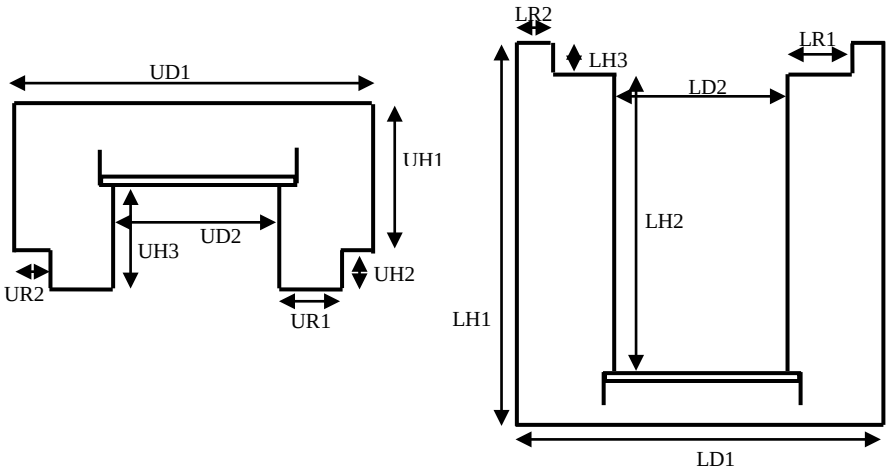
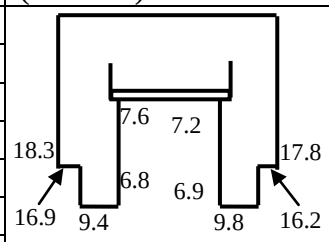
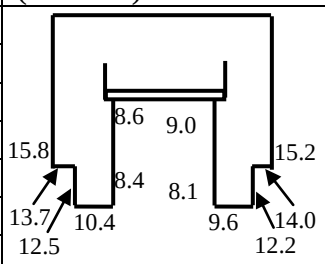
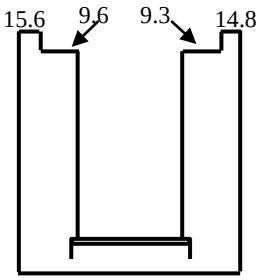
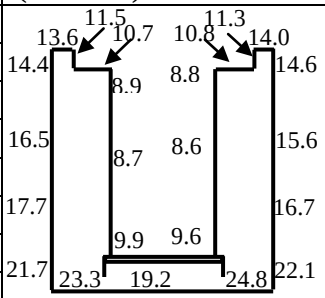


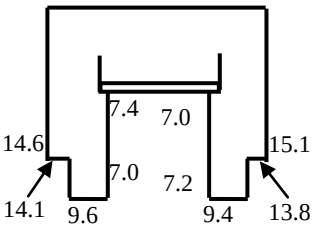
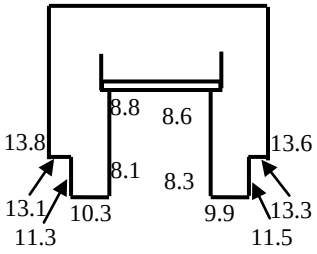
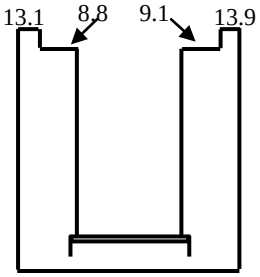
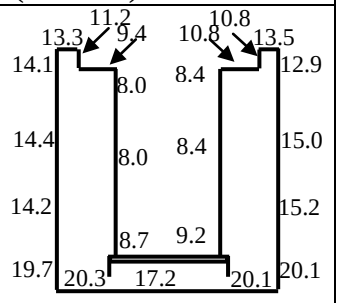
Table 2. Detailed fiberboard data for package 9975-02075 (13.1 watt internal heat load)

	9975-02075 (in KAC) 4/12/2016		9975-02075 (in SRNL) 4/20/2016	
Upper assembly	Dimensions (inch)	Moisture content (%WME)	Dimensions (inch)	Moisture content (%WME)
UD1	17.643		17.654	
UD2	8.516		8.554	
UR1			3.048	
UR2			1.502	
UH1			7.076	
UH2			2.066	
UH3	4.931		4.944	
Lower assembly	Dimensions (inch)	Moisture content (%WME)	Dimensions (inch)	Moisture content (%WME)
LD1			18.038	
LD2			8.478	
LR1			3.246	
LR2			1.524	
LH1			26.412	
LH2			20.328	
LH3	2.038		2.028	
Axial gap		1.208 inch		1.25 inch
Notes	83.8 % RH in upper air space			

Diametral dimensions were measured twice, ~180 degrees apart, other dimensions were measured 4 times, ~90 degrees apart. Average values are reported.

Refer to Table 1 to identify dimensions. Dimension UH1 includes the air shield.

Table 3. Detailed fiberboard data for package 9975-02738 (11.7 watt internal heat load)

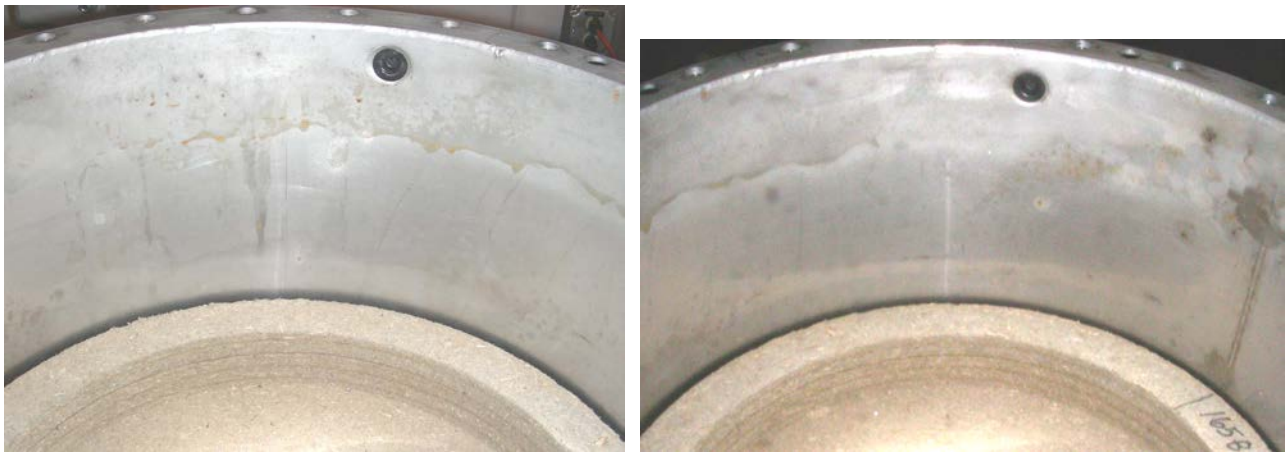
	9975-02738 (in KAC) 4/11/2016		9975-02738 (in SRNL) 4/20/2016	
Upper assembly	Dimensions (inch)	Moisture content (%WME)	Dimensions (inch)	Moisture content (%WME)
UD1	17.667		17.579	
UD2	8.520		8.580	
UR1			3.024	
UR2			1.491	
UH1			7.034	
UH2			2.156	
UH3	4.944		4.962	
Lower assembly	Dimensions (inch)	Moisture content (%WME)	Dimensions (inch)	Moisture content (%WME)
LD1			18.076	
LD2			8.479	
LR1			3.254	
LR2			1.517	
LH1			26.466	
LH2			20.348	
LH3	1.996		2.006	
Axial gap		1.115 inch		1.19 inch
Notes	77 %RH in upper air space			

Diametral dimensions were measured twice, ~180 degrees apart, other dimensions were measured 4 times, ~90 degrees apart. Average values are reported.

Refer to Table 1 to identify dimensions. Dimension UH1 includes the air shield.

Figure 1. Lower fiberboard assembly from 9975-01658 (upside down) showing bottom layers and outer portion of the bottom darkened from moisture. This photograph was taken in SRNL on April 14, 2016, 9 days after the package was unloaded in KAC.

Figure 2. Dried water spots on the 9975-01658 air shield



(a) (b)

(c) (d)

Figure 3. Stains and light corrosion on 9975-01658 drum ID surface.

Figure 4. Light corrosion on the bottom of the 9975-01658 drum.

Figure 5. Water spots on the side of 9975-02075 drum.

Figure 6. Light corrosion on the bottom of 9975-02075 drum.

Figure 7. Slightly darkened areas on the 9975-02738 upper fiberboard assembly. This photograph was taken in SRNL on April 20, 2016, 9 days after the package was unloaded in KAC.

Figure 8. Glue residue (1) and light mold (2) on the 9975-02738 lower fiberboard assembly. This photograph was taken in SRNL on April 20, 2016, 9 days after the package was unloaded in KAC.

Figure 9. Light corrosion on the bottom of 9975-02738 drum.

(a)

(b)

Figure 10. Deposits and/or corrosion product on the underside of the 9975-02738 lid (a), with a detail of the central spot in (b).

(a)

(b)

Figure 11. Corrosion on the 9975-03728 drum interior. Photos taken in KAC by NMM personnel.

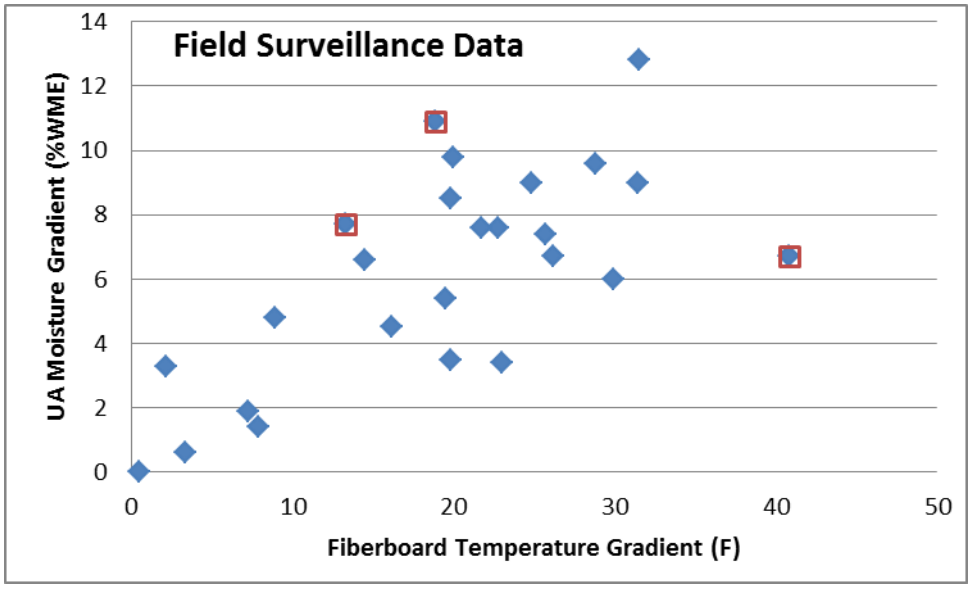


Figure 12. Comparison of moisture gradient across the upper fiberboard assembly to the temperature gradient based on KAC field surveillance data of packages with cane fiberboard. The highlighted data are from 9975-01658, 9975-02075 and 9975-02738.

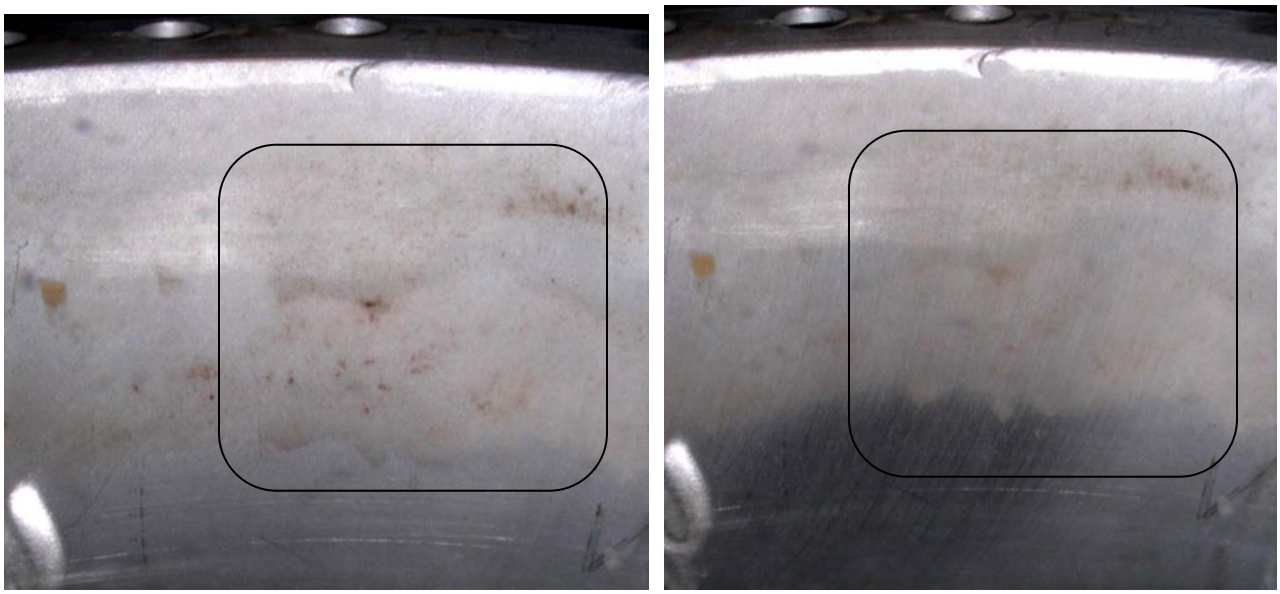


Figure 13. Corrosion on 9975-01658 drum interior before and after light brushing of the indicated area.

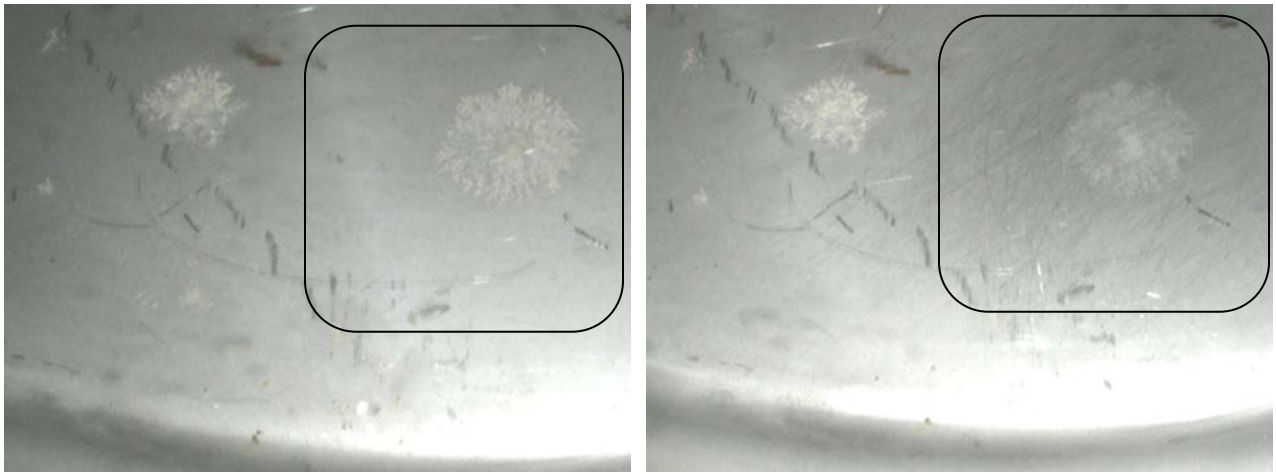


Figure 14. Corrosion on 9975-02738 lid underside before and after light brushing of the indicated area.

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