SRNL-STI-2014-00547

EXAMINATION OF SHIPPING PACKAGE 9975-05050

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Publication Date: November 2014

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This document was prepared in conjunction with work accomplished under Contract No. DE-AC09-08SR22470 with the U.S. Department of Energy.

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EXAMINATION OF SHIPPING PACKAGE 9975-05050

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Revision Log

Document No. SRNL-STI-2014-00547 **Rev. No.** 0

Document Title Examination of Shipping Package 9975-05050

Rev. #	Page #	Description of Revision	Date
0	all	Original document	11/6/2014

Summary

Shipping package 9975-05050 was examined in K-Area following its identification as a high wattage package. Elevated temperature and fiberboard moisture content are key parameters that impact the degradation rate of fiberboard within 9975 packages in a storage environment. The high wattage of this package contributes significantly to component temperatures. After examination in K-Area, the package was provided to SRNL for further examination of the fiberboard assembly. The moisture content of the fiberboard was relatively low (compared to packages examined previously), but the moisture gradient (between fiberboard ID and OD surfaces) was relatively high, as would be expected for the high heat load. The cane fiberboard appeared intact and displayed no apparent change in integrity relative to a new package.

Background

On September 4, 2014, the content of 9975-05050 was repackaged in K-Area Complex (KAC). While this package was not scheduled for surveillance activities, limited measurements were performed on the fiberboard at the request of NMM Engineering. This package contained an internal heat load of 16.3 watts, and had been in storage since July 2008 (for 6.2 years). It provided an opportunity to examine the fiberboard from a package with a heat load higher than from any previous surveillance packages. Of particular interest was the moisture condition of the fiberboard, and the degree of moisture segregation due to the internal heat load. Component temperatures, fiberboard dimensions, axial gap humidity and moisture levels were recorded in KAC.

On October 6, 2014, package 9975-05050 was transferred to SRNL and opened for additional examination. This was performed in 717-A on October 6, with the assistance of C. Allen (SRNL High Pressure Lab). Dimensional measurements, humidity and moisture levels were repeated on both the upper and lower fiberboard assemblies, as well as additional measurements that were made possible by removing the lower fiberboard assembly from the drum. The fiberboard assembly is fabricated from cane fiberboard. This report documents the observations from this package.

Examination Results

Dimensional, moisture and humidity data from both the KAC and SRNL examinations are summarized in Table 1. The only significant difference in the two data sets is in the relative humidity measured in the upper air space. The relative humidity measured in KAC is significantly higher than that measured in SRNL (94% vs 68%). The elevated measurement in KAC reflects the relocation of the package from its relatively warm storage location to a cooler room for opening and examination. During this transitional period, cooling of the drum exterior and adjacent internal air spaces will increase the relative humidity, which will then require an extended period to return to equilibrium as all package components cool to a new ambient temperature.

Dimensions are similar between the two sets of measurements. Minor differences likely result from operator bias and minor settling during transport. The axial gap is very similar for the two examinations, and meets the 1 inch maximum criterion.

The appearance of the fiberboard assemblies is consistent with undegraded fiberboard. No significant odor indicative of mold or mustiness was detected. The fiberboard was intact and solid, with no indication of significant mechanical damage.

Discussion

Most of the fiberboard dimensions are consistent with specified tolerances [1]. Those dimensions not meeting drawing tolerances include the 3 height dimensions for the lower assembly (both KAC and SRNL measurements), and the KAC measurement of the upper assembly inside diameter. However, Reference 1 identifies that the height of the lower assembly is to be adjusted as needed to meet the axial gap criterion. In addition, the package assembly drawing [2] recognizes that the axial gap dimension may vary over time due to variation in the fiberboard properties. As moisture content changes, all fiberboard dimensions are subject to change, and there are no requirements that the dimensions remain within initial tolerances.

With the high heat load in this package, a significant moisture gradient would be expected between the fiberboard ID and OD surfaces. The KAC measurements are most representative of this condition, since they were made at the time the heat load was removed. Any subsequent measurements would tend to show a decreasing moisture gradient as the fiberboard approaches a new equilibrium condition. The KAC upper assembly moisture data show a value <6 %WME (wood moisture equivalent) at 3 ID locations, and 6.2 %WME at a fourth ID location. Since the moisture meter does not register any value below 6 %WME, the average ID moisture content is very close to this threshold value. The moisture content of the upper assembly OD surface was 13.4 %WME in KAC. This gives a net gradient across the upper assembly of ~7.4 %WME.

The moisture gradient across the upper fiberboard assembly sidewall is plotted in Figure 3 for 30 packages for which moisture data was recorded in KAC. KAC data provide a better correlation than SRNL data since they are taken at the time of unloading, and there has been minimal change in the equilibrium moisture gradient. There is a trend for the moisture gradient to increase as the internal heat load increases. The scatter in these data likely results from one or more of the following causes:

- Variation in total moisture content from one package to another,
- Asymmetry in temperatures of adjacent packages, and/or
- Variation in ambient temperature around the package after removal from storage and the length of time between removal and opening.

Of these causes, the total moisture content provides a strong influence. The Figure 3 data are re-plotted in Figure 4 after dividing the gradient by the average moisture content (and multiplying by 10 to retain a comparable scale). With this normalization, much of the outlying scatter has been reduced significantly. The other identified causes would be more difficult to quantify, and the degree of their influence is unknown.

Reference [2] recognizes that the axial gap dimension may vary over time due to variation in the fiberboard dimensions. Migration of moisture within the fiberboard will lead to changes in dimensions – drier regions will shrink, and moister regions will expand. In addition, if the moisture content of the bottom fiberboard layers increases, they can lose compression strength and undergo compaction from the weight of the shield and containment vessels. The lower assembly vertical dimensions (LH1, LH2 and LH3) are each below their respective lower bound drawing value. This suggests an overall vertical shrinkage throughout the assembly or local regions of compression. However, since the drawings recognize the potential for dimensional change, this condition would not be considered unacceptable.

Specific fiberboard properties were not measured for this package. However, the fiberboard displays a general overall appearance and integrity similar to that expected for undegraded material.

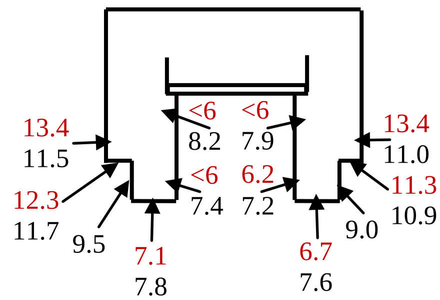
References

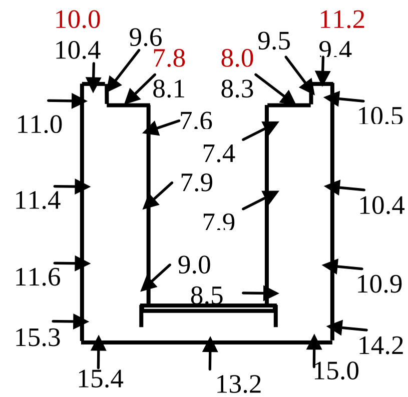
1. Drawing R-R2-F-0019, Rev. 8, "9975 Insulation Assembly, Subassemblies and Details", February 20, 2008

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

Table 1. Detailed data for package 9975-05050

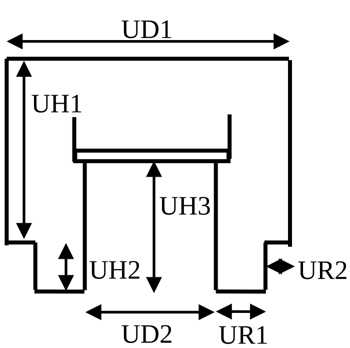
	KAC Data	SRNL Data	
Upper air space RH	93.8% at 77.2 F (25.1C)	67.6% at 24.8 C	Moisture content (%WME)
Axial gap	0.945	0.952	
Upper assembly			
Dimension UH1	- - -	7.222 inch	
Dimension UH2	- - -	2.115 inch	
Dimension UH3	4.984 inch	5.008 inch	
Dimension UD1	17.714 inch	17.686 inch	
Dimension UD2	8.498	8.552 inch	
Dimension UR1	- - -	3.053 inch	
Dimension UR2	- - -	1.518 inch	
UD2 + 2(UR1)	14.662 inch	14.658 inch	
Calculated density	- - -	0.280 g/cc	
Lower assembly			
Dimension LH1	- - -	26.546 inch	
Dimension LH2	- - -	20.298 inch	
Dimension LH3	2.094	2.084 inch	
Dimension LD1	- - -	18.058 inch	
Dimension LD2	- - -	8.475 inch	
Dimension LR1	- - -	3.275 inch	
Dimension LR2	- - -	1.510 inch	
Calculated density	- - -	0.287 g/cc	





Notes:

Each recorded dimension is an average of 2 or 4 measurements, ~90 or 180 degrees apart.
Dimension UH1 includes the air shield, which adds ~0.1 inch to the measurement.
Moisture content values in red were recorded in KAC. Values in black were recorded in SRNL.



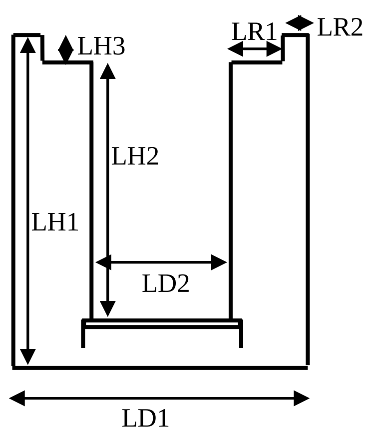



Figure 1. 9975-05050 upper fiberboard assembly


Figure 2. 9975-05050 lower fiberboard assembly

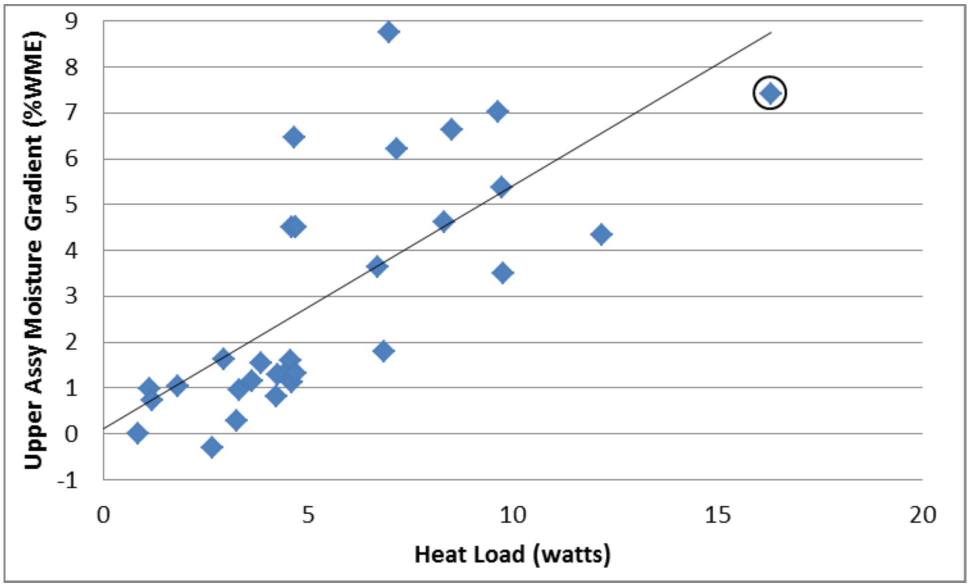


Figure 3. Moisture gradient across the upper fiberboard assembly side wall as a function of internal heat load for packages measured in KAC. The value for 9975-05050 is circled.

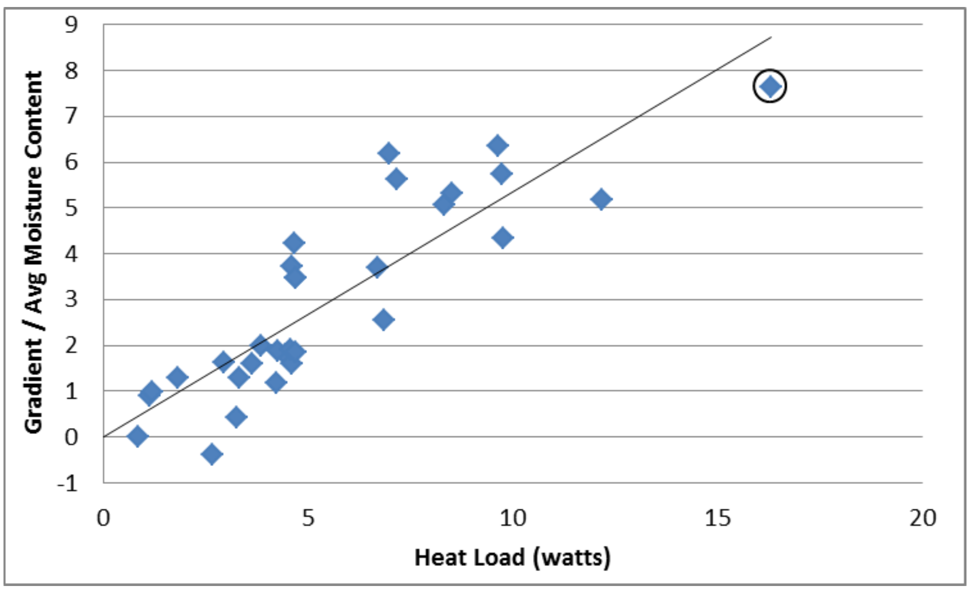


Figure 4. Moisture gradient data from Figure 3, normalized by the average upper assembly moisture content. The resulting values were multiplied by 10 to retain a comparable scale to Figure 3. The reduced degree of scatter compared to Figure 3 indicates the influence of total moisture content on the gradient.

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