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EXAMINATION OF BEETLE-INFESTED SHIPPING PACKAGE 9975-03996

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Examination of Beetle-Infested Shipping Package 9975-03996

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Summary

Package 9975-03996 was identified as being infested with drugstore beetles in April 2012. It was shipped to SRNL, where the possibility of using acoustic emission detection to detect the beetles was explored. This technology has potential for this application, although additional work would be needed to improve the sensitivity and automate signal processing to make it practical for use with a large number of packages.

In April 2014, the infested package was re-opened and examined. Compared to the regions photographed in 2012, relatively little additional damage was observed. The overall pattern, extent and rate of damage appear consistent with that observed previously in two infested packages from Hanford. It was then decided that further observations of this package be terminated. The remaining beetles were killed by freezing, and the package was rehabilitated and made available for service.

Background

Several thousand 9975 shipping packages are used as part of the approved storage configuration of special nuclear material in K-Area Complex (KAC). These packages, including the fiberboard assembly within each package, are an integral part of the safety basis for the facility. As such, the continued integrity of the packages must be assured for the duration of storage.

Drugstore beetles (*Stegobium paniceum* (L.) Coleoptera: Anobiidae) have been confirmed in three 9975 shipping packages – 2 at Hanford and 1 in KAC. The Hanford infested packages were identified in 2007, and their examination is documented in references 1-3. This report documents SRNL examinations of the beetle-infested KAC package, 9975-03996. The infestation was first noted in K-Area during annual maintenance inspection on April 9, 2012. Photographs of the package were taken by K-Area personnel, and the package was shipped to SRNL for further investigation.

Investigation Plan

After the package was moved from KAC to SRNL, the following actions occurred.

- A plan was developed to examine the package using acoustic emission detection, to determine whether that technology would be capable of identifying an infested package without opening it. This plan was executed by D. Shull (EES), and the results reported in Reference 4.
- The package was allowed to sit (relatively) undisturbed for 2 years, in accordance with a Technical Assistance Request from KAC [5], after which it was opened for visual examination.
- After examination, KAC personnel (E. Hackney and B. Eberhard) directed that further observations of the package be terminated. Subsequently, the remaining beetles were killed and the package was rehabilitated.

Results

Acoustic Emission Detection

Acoustic emission detection is a proven technology in the pest industry, with key applications in the detection of termites and other specifically targeted pests. Mr. John Rodgers of Acoustic Emission Consulting, Inc, provided a demonstration of his acoustic emission detection equipment in an attempt to detect the presence of drugstore beetles in package 9975-03996 at SRNL on July 12, 2012. An audible signal was detectable when the acoustic emission probe was in acoustic contact with the drum, and the strength of the signal varied depending on the closeness of contact between the drum and fiberboard at the probe location. However, the signal strength was very low, and did not exceed a preset threshold which would have allowed electronic recording of the detected events. This equipment was provided to D. Shull (EES) as a temporary loan to investigate ways to improve the signal strength and/or otherwise facilitate the detection process for this application. These efforts are documented in Reference 4, and led to the following conclusions:

> "Though limited, these tests have shown that this technique and acoustic emissions instrumentation are promising for detecting the presence of drugstore beetles. Additional work would be needed to improve the ease of detection, and to automate the signal processing to eliminate the need for human interpretation. Depending on the desired operational method of conducting package scans, a system could be developed to scan multiple packages in automated sequence or simply scan one package at a time. Unless scanning area background noise is sufficiently low, simple peak signal detection methods of beetle activity will not likely be successful and more advanced signal processing techniques and automated analysis will be needed. Several options have been presented to reduce operator radiation exposure during package scans. These suggested enhancements are feasible and can be achieved to develop a realistic detection capability for field use."

Package Examination after 2 Years

Following the acoustic emission testing, the package sat generally undisturbed in either 717-A or 723-A, to provide an opportunity for the infestation to progress. Approximately 2 years after the initial discovery that 9975-03996 was infested, the package was re-opened to identify the extent of damage. This work was performed on April 24, 2014, and took place outside to minimize the likelihood of escaping beetles causing a re-infestation of other packages. (Since the beetles are indigenous to South Carolina, there was no concern with the incidental escape of a few individuals into the environment.) Opening and examination of the package was performed by SRNL (W. Daugherty, C. Allen, G. Sides, D. Trapp and T. Tranh) and witnessed by NMM Engineering (E. Hackney and B. Eberhard).

Photographs were taken to document the extent of infestation damage, and to compare to the damage observed in 2012. Figure 1 shows the extent of "tracks" (from beetle droppings) observed on the drum and lid interior surfaces in 2014. Figure 2 shows a similar density of tracks on the air shield surfaces observed in 2012. In Figure 3, a portion of the air shield that was photographed during both inspections shows no difference in the tracks within the boxed region.

Figures 3 and 4 show one side of the upper fiberboard assembly which was photographed during both examinations (the air shield weld seam provides a common reference point). Many of the beetle penetrations observed in 2014 were also present in 2012 (the circled features in these photographs), with little additional damage observed in 2014.

No beetle-related damage was observed on the ID surfaces of either the upper or lower fiberboard assemblies (Figures 5 and 6), although some frass (a combination of uneaten fiberboard particles, beetle droppings and dead beetles) was found in the bottom interior of the lower assembly. It is assumed that this frass dropped down from the top surface of the lower assembly during handling, since some frass was observed in this area during both examinations (Figure 7). The pattern of damage limited to the outer regions is consistent with the observations of the two infested packages from Hanford, in which the damage was generally confined to the outer 2 inches or so [1, 3], although much deeper damage was observed in the bottom layers of the second Hanford package.

The remainder of the lower fiberboard assembly was not examined in 2012. The lower assembly was removed for a more complete inspection in 2014. The lower assembly did not slide out easily as is normally the case. Rather, two large hooks were used to engage the ID surface of the assembly and significant effort was required to pull it out. Figure 8 shows the lower assembly partially withdrawn, and reveals that frass had built up between the fiberboard and drum on one side, providing a very tight fit. As the lower assembly was removed into a plastic bag (to contain any live beetles), a significant amount of frass was also captured in the bag (Figures 9 and 10).

In addition to the frass, significant beetle damage was observed in the lower fiberboard assembly (Figures 10 and 11). While the degree of damage varied over the fiberboard surface, the overall extent of damage was more severe than in the upper assembly.

Primary observations and conclusions from this examination include:

- There was little visible change in the overall extent of damage during the last 2 years. Some live beetles were observed, indicating that the infestation was still active.
- The infestation was heavier in the lower assembly than in the upper assembly.
- Damage was limited to the outer regions – no damage was observed on the fiberboard ID surfaces.
- The pattern, extent and rate of damage appear generally consistent with that observed in the Hanford infested packages.

Based on the above, KAC personnel directed there was no further need to maintain the beetle population in this package for further study.

Package Rehabilitation

Based on information provided by a Clemson University entomologist (Dr. Robert Bellinger) [6], the remaining beetles were killed by exposure to low temperature. This same method was previously used with the second Hanford package. The package was moved to 786-A and placed in an environmental chamber on May 14, 2013. The chamber was cooled to 0 °F (-18 °C) for a planned hold time of 9 days. Due to the timing and personnel availability, the actual hold time

was 13 days. The package was transported to 717-A on June 12, 2014, and delivered to the Packaging Technology and Pressurized Systems group for replacement of the fiberboard and re-certification of the package. Transportation and freezing of the package were coordinated by M. Phillips (EES).

Discussion

Package 9975-03996 was originally assembled at the vendor (Joseph Oat Corp.) on October 25, 2004. It received annual maintenance in January 2006 and April 2007, and was used for moving material in K and H areas between these two dates. No discrepancies were noted during these operations. The infestation was first noted during annual maintenance in K Area in April 2012, approximately 7.5 years after initial package assembly.

A similar pattern was noted for the two infested packages from Hanford. These two packages were assembled by a different vendor (Accurate Machine Products Corp.), although it was reported that the same subvendor fabricated the fiberboard assemblies for all three packages. Another common point is that the cane fiberboard for each of these packages was manufactured at the Knight-Celotex plant in Marrero, La. Accordingly, there are credible scenarios for either a single root cause of all 3 infested packages or for separate independent causes. Specific understanding of the root cause has not been pursued.

The Hanford packages were manufactured earlier than the 9975-03996 package, as evidenced by their lower serial numbers (-02662, -02711). Therefore, they were also assembled several years prior to the infestation being noted in 2007. In each of these packages, the rate of damage was relatively modest, although the total damage possible during a long-term storage situation is significant. Testing of the fiberboard from the Hanford packages identified that the mechanical properties of the fiberboard were degraded by the beetle damage, while density and thermal properties were not significantly changed [3]. This is due primarily to the fact that the beetle tunnels are filled with frass, which has similar density and thermal properties to the fiberboard, but does not replace the mechanical integrity that was lost. Separate testing of the fiberboard from 9975-03996 was not performed.

Conclusions

Package 9975-03996 was examined in April 2014, two years after the initial identification that it was infested with drugstore beetles. Relatively little change was noted compared to photographs taken two years earlier. Acoustic emission technology was demonstrated to be capable of detecting an active infestation of drugstore beetles, but additional work would be needed to improve the sensitivity and automate signal processing to make it practical for use with a large number of packages. After allowing the infestation to continue for 2 years, the extent of damage was characterized, and the decision made to terminate further study. The beetles were killed by freezing, and the package rehabilitated and made available for service.

References

[1] SRNL-MST-2008-00015, "Material Properties of Beetle-Infested Fiberboard from Package 9975-02662", W. L. Daugherty, January 23, 2008

[2] "Investigation of Drugstore Beetles and Their Effects within Radioactive Material Shipping Packages", B. M. Loftin and J. M. Shuler, Proceedings of the 36th Annual Waste Management Conference - WM2010, Phoenix, Arizona 2010.

[3] SRNL-L4400-2012-00011, "Material Properties of Beetle-Infested Fiberboard from Package 9975-02711", W. L. Daugherty, May 22, 2012

[4] SRNL-STI-2013-00091, "Detection of Drugstore Beetles in 9975 Packages using Acoustic Emissions", D. J. Shull, February 2013

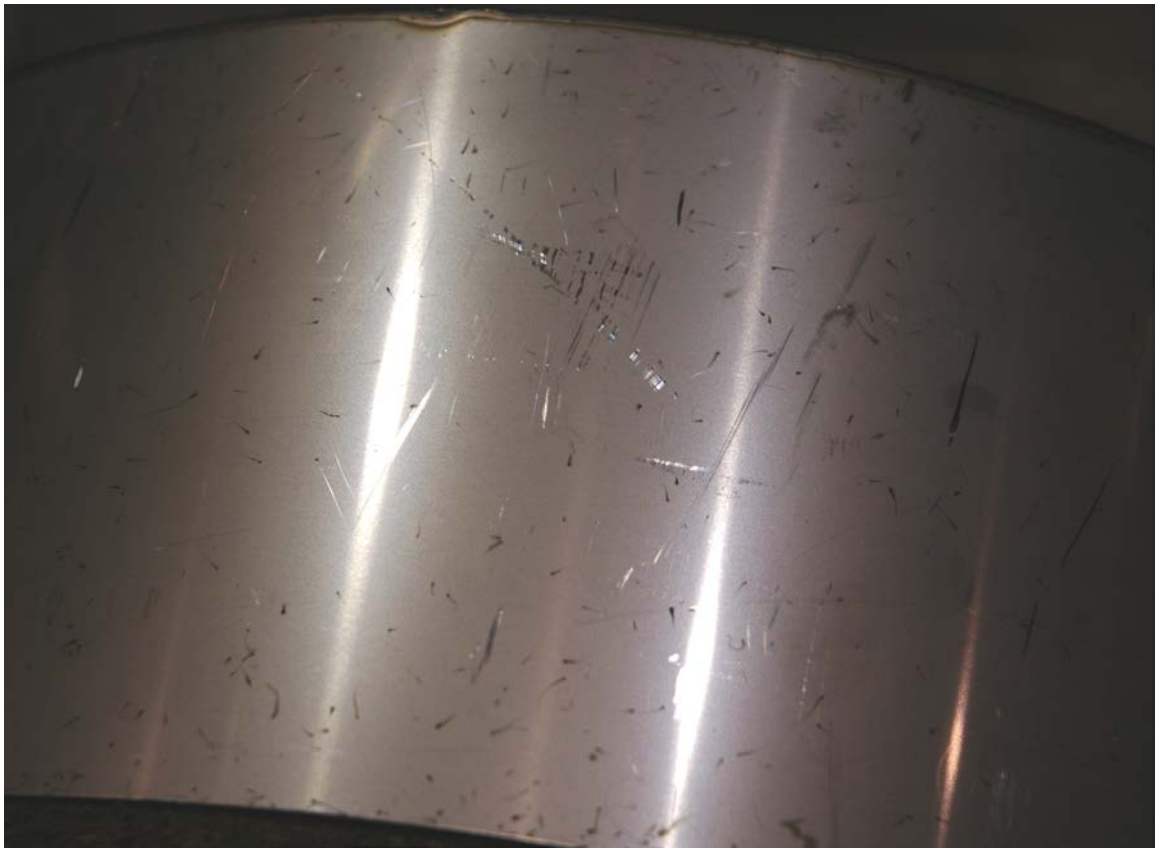
[5] M-TAR-K-00002, Technical Assistance Request "Monitoring of Beetle Infested Fiberboard in 9975-03996", E. Hackney, October 23, 2012

[6] electronic mail message "Temperature control of Drugstore beetle", from Bob Bellinger to Bradley Loftin, September 14, 2007

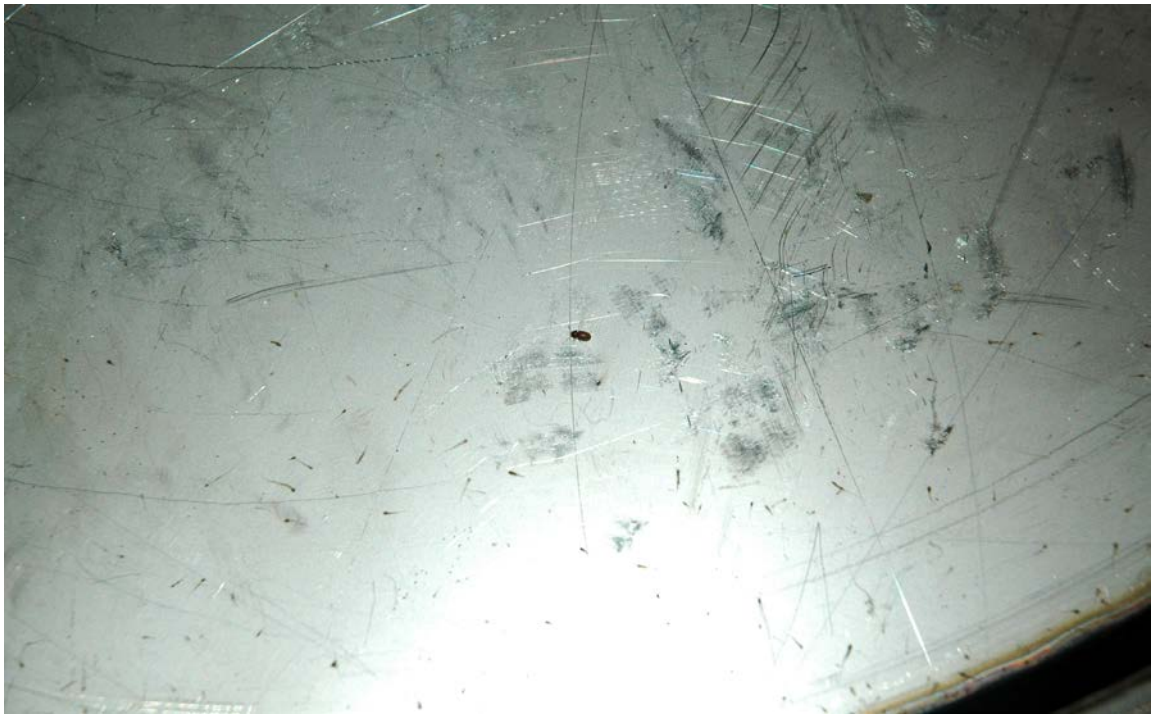
(a)

(b)

Figure 1. Lid underside (a) and drum interior (b) showing “tracks” of beetle droppings, photographed in 2014

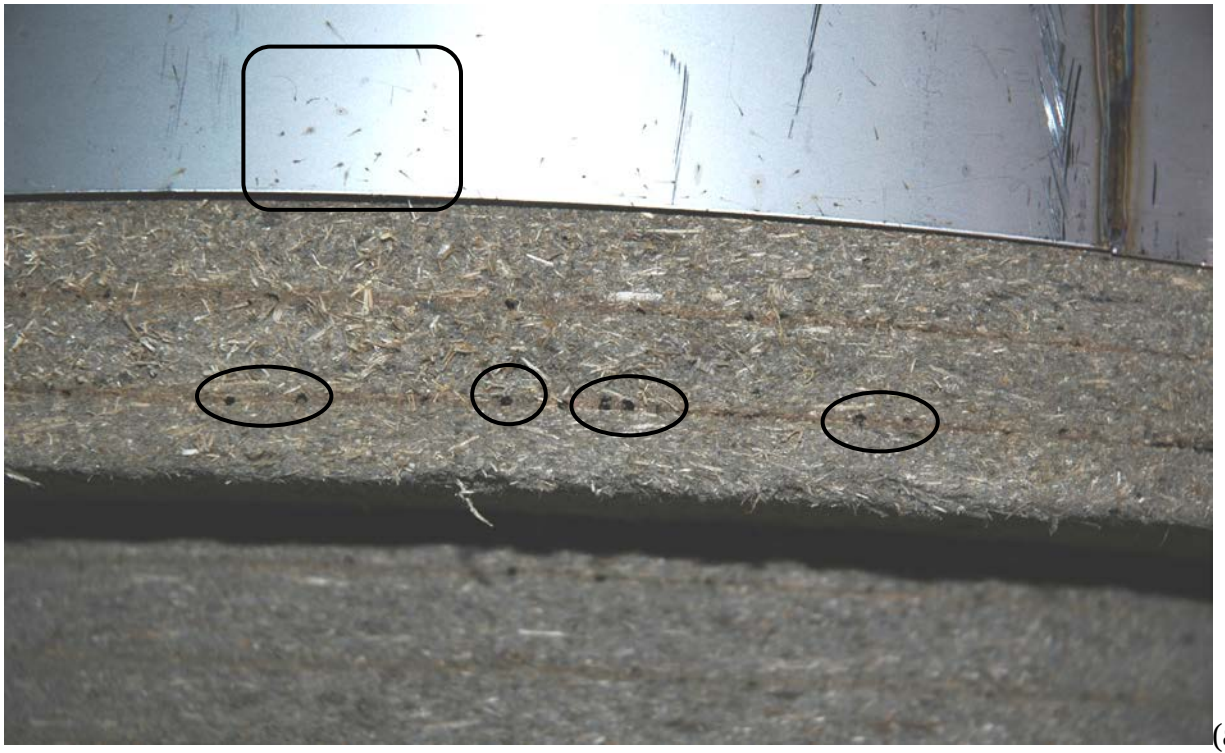


(a)

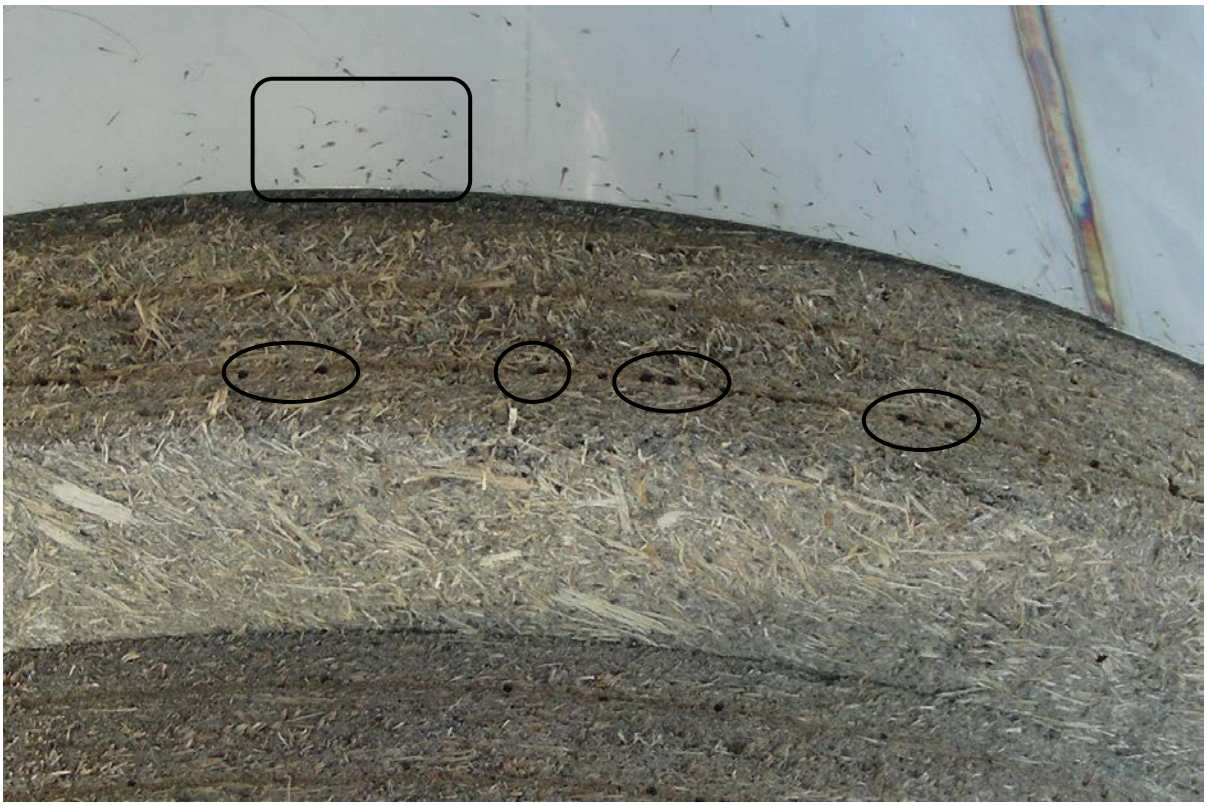


(b)

Figure 2. Air shield side (a) and top (b) surfaces showing tracks of beetle droppings, photographed in 2012 in K Area

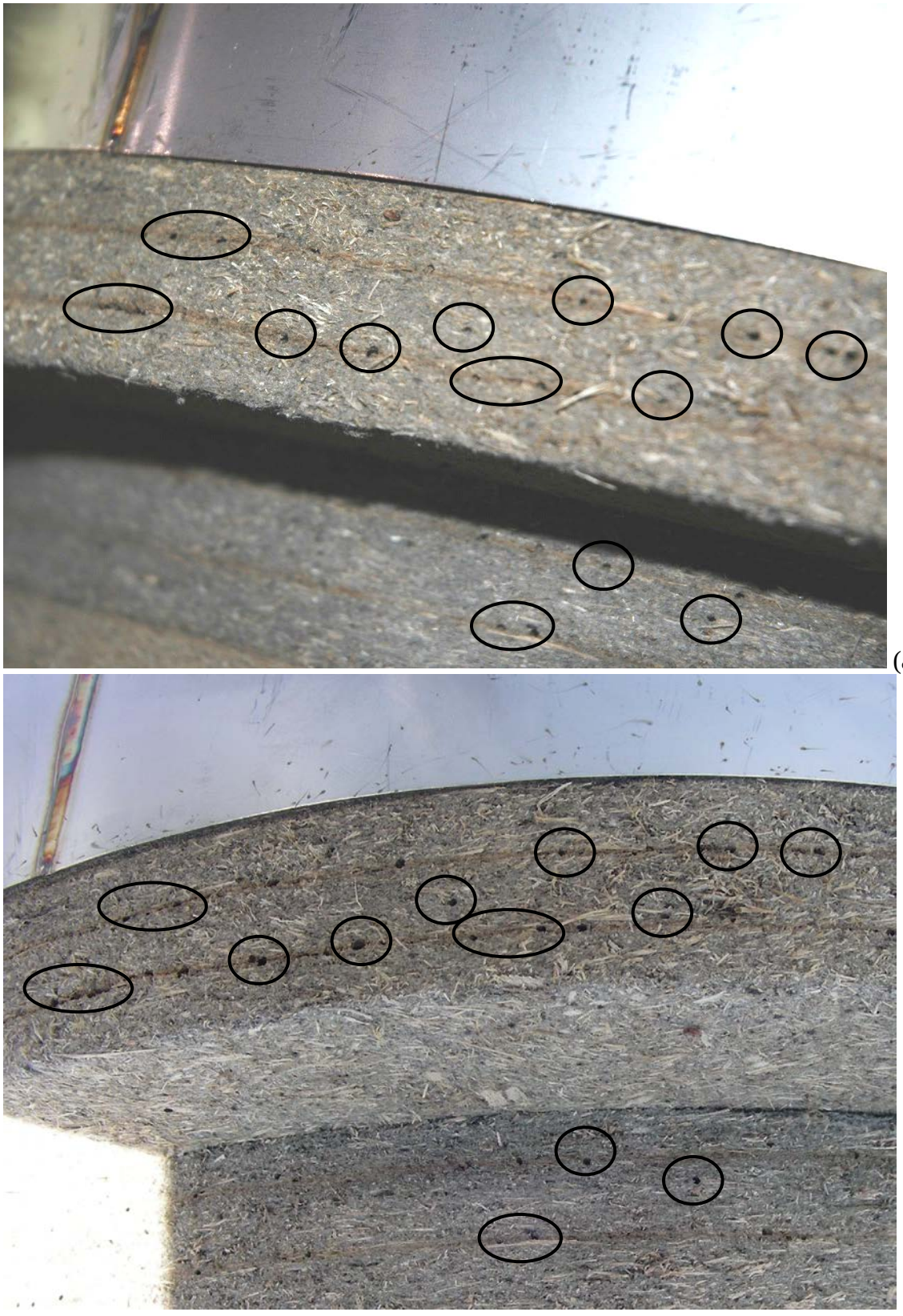


(a)



(b)

Figure 3. Side of upper fiberboard assembly comparing damage from 2012 (a) and 2014 (b). The circles highlight some of the damage observed both times. The tracks within the boxes are essentially unchanged over the 2 year period.



(a)

(b)

Figure 4. Side of upper fiberboard assembly comparing damage from 2012 (a) and 2014 (b). The circles highlight some of the damage observed both times.

Figure 5. Upper fiberboard assembly ID surface, showing no beetle damage.

Figure 6. Interior of lower fiberboard assembly showing no beetle damage, but a modest amount of frass has fallen to the bottom.

(a)

(b)

Figure 7. Top surface of lower fiberboard assembly from 2012 (a) and 2014 (b). A modest amount of frass (brown powder) has collected on these horizontal surfaces. Note the dead beetle adjacent to the drum (circled).

(a)

(b)

(c)

Figure 8. Lower fiberboard assembly partially withdrawn from drum. The view in (a), and the detail in (c) show the extent of frass buildup on one side which made the fiberboard very difficult to remove.

Figure 9. Some of the frass found after removing the lower fiberboard assembly from the drum.

Figure 10. Bottom and side of the upside-down lower fiberboard assembly, showing frass and beetle damage.

(a)

(b)

Figure 11. Additional photographs of the side (a) and bottom (b) of the upside-down lower fiberboard assembly.

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