

The Installation of *ActiveGuard*[™] Mattress Liners for the Prevention of Bed Bug (*Cimex lectularius*) Infestation in Hotel Rooms

James B. Ballard, Ballard Pest Management Consulting, LLC.



The *ActiveGuard*[™] mattress liner is an impregnated fabric containing 1.64% permethrin. The product is applied to bedding, e.g. mattress, air mattress, box spring, sofa bed, etc. and kills bed bugs and dust mites (*Dermatophagoides farinae*) by contact.

Active mattress liners represent a unique product class, of which *ActiveGuard* is a member, and are unlike anything used in the field today to control bed bugs. An innovative attribute of these liners is they are 'pre-dosed' and therefore not prone to human error associated with the application of other bed bug control products such as sprays, powders, heat, cold, steam, and encasements.

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Permethrin impregnated bed nets have been used for decades to provide mosquito protection because of the repellent nature of permethrin against mosquitoes. In contrast, Moore and Miller (2006) reported that bed bugs were not repelled by permethrin. Despite anecdotal reports suggesting otherwise, these studies are supported by numerous lab and field observations by pest managers, by hotel operators, by Allergy Technologies (the manufacturer of *ActiveGuard*) and by the author over the past three years.

For instance, an *ActiveGuard* mattress liner installed on a mattress in a major cosmopolitan hotel was found to contain six dead 2nd instar bed bugs less than 24 hours after installation in a hotel room professionally cleared of bed bugs that day. Additional observations from users have reported finding dead bed bugs on *ActiveGuard* mattress liners in the field, an observed behavior that supports the conclusion that *ActiveGuard* is not repellent to bed bugs (Ballard et al., 2011).

The *ActiveGuard* mattress liner may be used alone or in combination as part of an integrated pest management (IPM) protocol [Ballard (2010) and Ballard et al. (2011)]. As a standalone control device, the liner may be installed on mattresses and/or box springs in a preventive situation. If a few bed bugs in luggage emerge in a hotel room, these bed bugs will be killed when they come into contact with the liner as they attempt to reach and feed upon humans in the bed. When used in infested hotels, motels, residential homes and apartments, the *ActiveGuard* mattress liner is often used as part of an overall bed bug control protocol. The *ActiveGuard* mattress liner is often installed on a mattress or box spring that has already been cleared of bed bugs using another product labeled for that use. The mattress liner is then installed to kill any residual bed bugs that were overlooked or any eggs that later hatch. *ActiveGuard* also prevents the mattress or box spring from becoming infested with bed bugs for 18 to 24 months; a period of residual activity unseen in other products labeled for bed bug use.

Use as a Preventative Strategy

These studies centered upon the installation of *ActiveGuard* mattress liners on hotel beds as a preventive measure for bed bugs. In most cases, the beds selected were those in rooms that had a history of bed bug infestation, but were not known to be infested at the time the mattress liners were installed. Bed bug infestations were monitored in the various hotels over time to determine if any of the rooms containing *ActiveGuard* mattress liners became later infested with bed bugs. This data is reflective of the described hotel bed conditions as of June 30, 2011.

Hotel #1 (153 rooms) As a preventative measure, (though they did have bed bug incidents in 2 rooms in 2008 and 2009) *ActiveGuard* was installed in every room (200 beds), on both mattresses and box springs, as part of a complete hotel renovation. The hotel has had *ActiveGuard* for 15-17 months with no subsequent bed bug incidents.

Hotel #2 (1600 rooms) The hotel has 45 rooms (75 beds) that have had *ActiveGuard* installed for 9 months. No subsequent bed bug incidents in rooms that have *ActiveGuard* installed have been reported. Prior to the *ActiveGuard* installation, they had 2 bed bug incidents a week throughout the hotel.

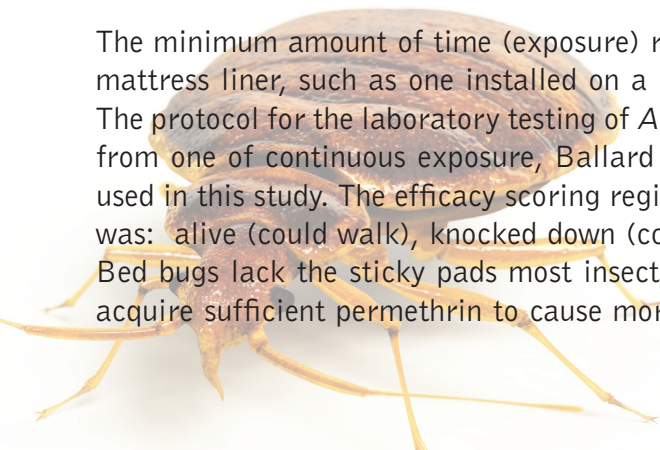
Hotel #3 (122 rooms) This hotel installed *ActiveGuard* on all 216 beds, both mattresses and box springs, primarily because of previous problems with bed bugs escaping from torn encasements. There have been no bed bug issues in any of the rooms for 6-7 months including those with previous bed bug histories. Prior to the *ActiveGuard* installation, the hotel reported 2 bed bug incidents per week.

Hotel #4 (194 rooms) The hotel installed *ActiveGuard* on the mattresses of 12 rooms (30 beds) that have had a history of bed bug problems. While they had 3 bed bug incidents earlier in 2009 prior to installation, there have been no bed bug issues for the 19 months of *ActiveGuard* use.

The lack of bed bug incidents is not absolute proof that *ActiveGuard* prevented bed bug infestations in hotel rooms. However, due to the size of the studies and the length of time rooms with these mattress liners installed have been incident-free, the results do strongly suggest that *ActiveGuard* affords a significant level of protection against bed bug incidence. Further, these data support the development of a carefully designed confirmatory study to be conducted by a university.

Laboratory Testing

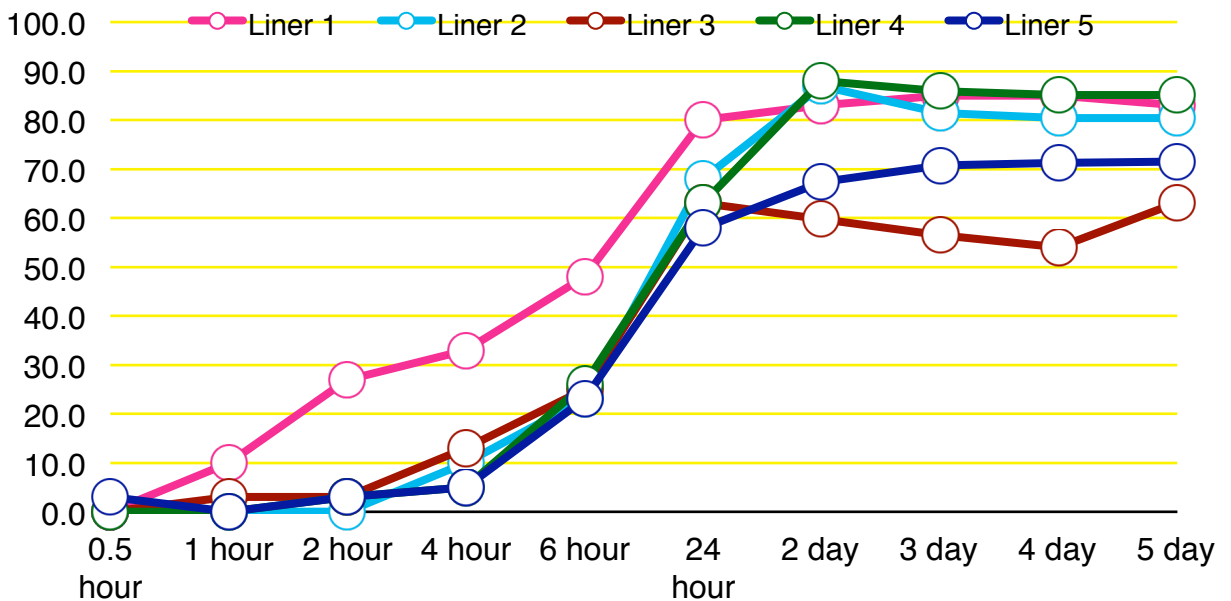
The minimum amount of time (exposure) required to kill bed bugs exposed to an *ActiveGuard* mattress liner, such as one installed on a hotel room bed mattress, has not been determined. The protocol for the laboratory testing of *ActiveGuard* for bed bug control has evolved over time from one of continuous exposure, Ballard (2008) and Russell (2006) to the 6 hour exposure used in this study. The efficacy scoring regimen for the bed bugs in this study with *ActiveGuard* was: alive (could walk), knocked down (could not stand), or dead (no movement of any kind). Bed bugs lack the sticky pads most insects have on their tarsi, and therefore require time to acquire sufficient permethrin to cause mortality. The testing protocol for this product has not



yet been optimized. Much of the earlier testing followed the protocols used for assessing residual sprays, which are not congruous with the testing of a long-lasting impregnated fabric. Furthermore, the use of recently fed bed bugs in most testing result in bed bugs that typically stay in one place with little mobility while they digest their meal. The permethrin uptake from actual bed bug search behavior for 6 hours at night in and around a hotel bed fitted with an *ActiveGuard* mattress liner would be better mimic field use than the uptake of stationary bed bugs in a Petri dish.

This study was initiated in 2011 (Snell et al. 2011). The packaged liner product was stored for 11 to 12 months prior to use. The 5 liners in this study were installed on bed mattresses for 19 months in hotel #4 listed above under "standalone use" before they were removed for testing in this study. The protocol consisted of a 6 hour exposure of mixed adult bed bugs of the Cooper 2 field strain. A six-hour exposure was chosen to represent a 6 hour night of sleeping during which time bed bugs would be actively searching for a host. It should be noted that the Cooper 2 field strain of bed bugs was found to be 49X times more resistant to the pyrethroid deltamethrin than a susceptible strain of bed bugs. Four replications containing 10 bed bugs each were confined on each of 5 aged *ActiveGuard* mattress liner fabrics and mortality recorded at 1/2 hour, 1, 2, 4, 6, and 24 hours and then at 2, 3, 4, and 5 days. Mortality from the untreated mattress liner control was used to adjust the bioassay mortality using Abbott's Correction.

Mean % Mortality



In this study the average % mortality across the 5 aged liners was 77% at day 5 though 66% mortality was achieved within the first 24 hours. The mortality of bed bugs actively searching for a host on a bed would have been higher.

Additional studies are planned for testing at the university level to better understand the critical relationship between exposure, bed bug mortality and level of pyrethroid resistance in various characterized bed bug strains.

Conclusions

ActiveGuard mattress liners appear to have great potential in killing bed bugs that come into contact with the liner when installed on mattresses or box springs in a standalone preventive situation.

The *ActiveGuard* mattress liners continued to be efficacious after 11-12 months of storage on the shelf prior to 19 months in field use.

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