



The University of Florida's Wayne Walker using a Steamax (Amerivap Systems) to steam-treat the sill plate to tack strip after removing baseboards and lifting carpeting in a bed bug-infested apartment. (Photo: E. Lee)

Fumigation, Steam, Dusting and Labor

A review of a successful formula for bed bug control developed by pest management professionals at the University of Florida.

By Wayne Walker, Ken Glover, Phil Koehler, Ellen Thoms and Eric Hobelmann

The bed bug, *Cimex lectularius* L., is rapidly becoming the new nemesis of the pest control industry. The bed bug can disperse widely throughout a living area to hide undetected in openings the width of a business card. It can feed on a wide variety of vertebrates, including humans and their pets. Bed bugs even have been found infesting the hollow perches of pet bird cages. Most recently, bed bug populations collected throughout the United States have demonstrated resistance to pyrethroid insecticides in laboratory trials (Romero et al. 2007). These attributes are making repeated treatments for bed bug infestations the norm and not the exception.

Wayne Walker, a pest control manager

for the Department of Housing at the University of Florida (UF) in Gainesville, Fla., can vouch for the challenges in eradicating bed bugs from residential housing. Walker has been responsible for pest control in UF campus housing for six years. Walker found the first bed bug infestation in campus housing in April 2004. Since then, one dozen units, all in family apartment housing, have been treated for bed bugs. Residents in these apartments tend to be graduate students and about 85 percent are from outside the United States. As a result, these residents tend to have few furnishings and small budgets when arriving at UF, so they rely on furnishing their apartments with pre-owned furniture.

In spite of information provided to residents on bed bugs and free pest control services by UF, Walker has observed that residents are often reluctant to contact him until bed bug infestations become severe and spread throughout the apartment.

Walker found several challenges in controlling bed bugs in campus housing. Bed bugs sometimes could not be eradicated from furniture that was overstuffed, heavily infested or complex in construction, such as box springs, sleeper sofas and recliners, even when a combination of steam and residual insecticides were applied. Residents often would not follow Walker's requests to discard these furnishings, which provide important refugia for bed bugs, because they had no money to buy replacements. Bed bugs commonly were found behind vinyl baseboards in the apartments, but furnishings often blocked access for treating these areas. Finally, residents often would not follow Walker's instructions to wash and dry all bedding (including blankets), linens

and clothing to kill bed bugs potentially infesting these items.

Fumigation with Dow AgroSciences' Vikane gas fumigant (sulfuryl fluoride) has been demonstrated to be a reliable treatment to eradicate structural infestations of bed bugs with one application. Unfortunately, whole-structure fumigation may not be a practical option for apartments, dormitories, hotels and other multi-unit dwellings in which only one to a few units (or rooms) are infested with bed bugs.

Nonetheless, Walker found the attributes of fumigation tantalizing for bed bug control. He liked the fact that Vikane could penetrate into all types of household furnishings to kill all bed bug life stages, including eggs. Vikane leaves no residues of toxicological concern after aeration. Walker was hesitant to apply residual insecticides to furnishings such as sofas and recliners, on which parents and their children often slept.

Walker now has included containerized fumigation of household furnishings as part of his Integrated Pest Management (IPM)

regime of steam treatment and low-toxicity residual insecticides for apartments extensively infested with bed bugs. Containerized fumigation eliminates the requirement of whole-structure fumigation, while utilizing the advantages of fumigation for potentially infested items that could be hard to treat using other methods. The steps of this IPM treatment regime are: preparation, apartment treatment and containerized fumigation.

Preparation

- UF finds alternative housing if the residents have no place to stay for one or more nights while their apartment is being treated.

- Walker provides the residents with a checklist similar to that developed by Dow AgroSciences on of how to pack to "leave the bed bugs behind." (See related article below.)

Apartment Treatment

- All furnishings and household items, including clothing, bedding and linens, are



Fig. 1: A truck containing furnishings and household items removed from a bed bug infested-apartment to be fumigated with Vikane gas fumigant (Dow AgroSciences). Fans pictured are used for fumigant introduction and aeration. (Photo: R. Pereira)

moved to a truck for fumigation (see Fig. 1, above). The time to move furnishings (see Table 1, page 48) depends on the amount of furnishings and location of apartment (on ground level or the second story). There are no elevators in UF family housing.

- In the unfurnished apartment, vinyl baseboards are easily accessed for removal. Walker finds the parallel channels on the back of the baseboards create suitable harborage for bed bugs (see Fig. 2, page 44). These channels are difficult to treat without removing the baseboards. Infested vinyl baseboards are replaced if deteriorated or fumigated with furnishings and reinstalled if still reusable. Baseboards are removed in bedrooms, living room, closets and hallways. Walker does not typically remove baseboards in the kitchen, bathroom or dining area unless his inspection reveals signs of bed bugs infesting those areas. Walker notes baseboards that are well sealed to the wall along the upper edge, which is frequently found with wood trim, would not need to be removed. These baseboards can be treated by steam and crack-and-crevice insecticide treatment as described next.

- Steam is used to treat all cracks and crevices in rooms where baseboards are removed, including shelves in closets. In carpeted rooms, the carpet is lifted off the perimeter tack strip to treat this area and the sill plate. Walker utilizes two different steam application devices: the Steamax (Amerivap Systems, www.amerivap.com) and Therma-Steem Vapor System (Therma-Kleen, www.therma-kleen.com). The Steamax is portable and is utilized when treating one or two rooms. The Therma-Steem Vapor System was initially purchased by UF for carpet and upholstery cleaning. Walker later found that it adapted well for the steam treatment of bed bugs and uses it when treating entire apartments.

How to Leave the Bed Bugs Behind

A packing checklist for residents temporarily leaving their dwelling to be fumigated.

- **Bring as few items as possible when leaving the residence for the fumigation.** Remember, bed bugs hitchhiking in suitcases, back packs, boxes, clothing, bedding and pet cages is a common way for these insects to be introduced into buildings. Bed bugs have been found infesting small electronic devices, such as alarm clocks.
- **For all fabric items that will be taken out of the residence during the fumigation, wash in hot water and dry in high heat in a dryer (140°F) before returning them to the fumigated residence.** This includes clothing, blankets, pillows, stuffed toys and pet bedding.
- **Do not use boxes, suitcases, back packs, gym bags or any similar items from the infested residence to pack belongings.** These items should remain in the residence to be fumigated. Pack belongings needed during the fumigation in light colored or clear plastic bags or plastic containers, such as sweater boxes or new luggage not previously stored in the infested residence.
- **Do not place washed or packed items on furniture (beds, sofas, dressers, tables, etc.) or flooring (carpets or rugs) that may be infested with bed bugs.** Immediately remove packed items from the infested residence or place them on a clean, hard surface (kitchen or bathroom floor, in a bath tub or shower) until they can be removed from the residence.
- **Mattresses completely enveloped in plastic covers that cannot be removed or opened, such as infant mattresses, cannot be fumigated.** These mattresses must be removed prior to fumigation. If there is any evidence that such a mattress is infested with bed bugs or the individual sleeping on the mattress has been bitten by bed bugs, it is advised that a new mattress be purchased.
- **Pet cages and pet bedding should be fumigated.** Pet cages with any small gaps, seams or hollow spaces that could harbor bed bugs should be left in the residence to be fumigated. Food in the cages should be removed prior to the fumigation. The pets should be transferred to new travel cages or housing known not to be infested with bed bugs to remove them from the residence prior to the fumigation. Pet bedding/blankets should not be removed from the residence before the fumigation unless they can be washed, dried and packed as described above.

Source: Dow AgroSciences

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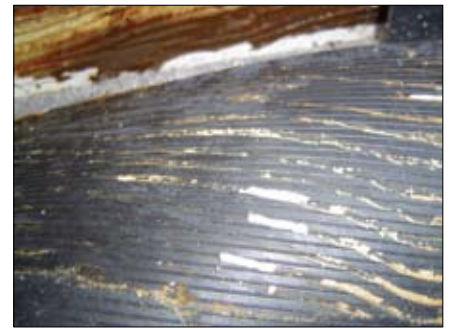


Fig. 2. Channels on the back of vinyl baseboards provide harborage for bed bugs. (Photo: W. Walker)

- All switch and outlet plates are removed. Wall cavities around the electrical components are treated with Tri-Die (8 percent silica gel powder with 0.6 percent synergized pyrethrin, Whitmire Micro-Gen) before wall plates are reinstalled. The sill plate and space between the sheet rock and tacking strip is also treated with Tri-Die before reattaching carpeting and baseboards (see Fig. 3, page 45). Walker has observed that areas treated with Tri-Die are not reinfested with bed bugs, even in units in which bed bugs infest adjacent furniture that was not previously fumigated. Tri-Die does leave a visible residue, but this is covered by baseboards, carpeting and wall plates when reattached.

Walker also advises it is important to understand the lifestyles of the residents in bed bug-infested dwellings. He has found residents sleep on sofas, recliners and even the carpeted floors as their normal sleeping location and then they move blankets, pillows and bedding to other parts of the apartment during the day. This can rapidly spread bed bugs throughout an apartment and make a complete treatment regime that includes fumigation necessary to eradicate the infestation.

Containerized Fumigation

- The fumigation is conducted by Ken Glover, a certified fumigator and Environmental Health and Safety Coordinator for UF. The truck is fumigated in the secured and fenced UF Hazardous Materials Yard. The truck is driven over 6-mil polyethylene sheeting, in which the truck is completely wrapped (see Fig. 4, page 46). The polyethylene sheeting is aligned so the tarp seams can be rolled and clamped without use of a ladder.

- All label safety precautions are followed, including posting of warning signs (see Fig. 5, page 48) and use of chloropicrin (a warning agent) and secondary locking using padlocks.

- The amount of Vikane to introduce is determined using the Fumiguide calculator.



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The dosage of Vikane is determined by the target pest, its life stage and temperature at the site of the target pest. Bed bugs require threefold the drywood termite dosage to control all life stages. The amount of Vikane to introduce into the tarped truck is determined by the exposure time (typically 21 hours), dosage to be accumulated, volume of the fumigated space (2,500 cubic feet) and fumigant confinement, described by half-loss time (HLT). The Fumiguide uses five factors to estimate HLT: tarp and seal condition (excellent for the new polyethylene and wrapping method); wind speed (typically 5 mph); volume; and underseal (slab). The estimated HLT for a tarped truck is 15.3 hours based on these factors. Based on a temperature of 75°F and the fumigation parameters listed previously, about 3 pounds of Vikane are required to fumigate the furnishings in the truck for a monitored fumigation.

- The Vikane gas fumigant cylinder is weighed to accurately measure the pounds to introduce. Vikane is introduced inside the truck storage compartment using 1/8 inch inner diameter (ID), 100-foot-long, nylon braided hose that is attached to a 3.2 amp fan (Lakewood). This introduction method ensures compliance with label requirements to "direct the fumigant into the blast of air from a fan(s) having a capacity of at least 1,000 cubic feet per minute (cfm) for each pound of Vikane released per minute." The fan is positioned to prevent applying the fumigant directly to the surfaces of furnishings. The introduction fan is unplugged when monitoring indicates that equilibrium is obtained.

- Monitoring lines are set up to measure fumigant concentrations in two locations: 1) inside the truck storage compartment, and 2) between the truck and polyethylene tarp. A digital Fumiscope (Key Chemical and Equipment Co., www.fumiscope.com) is used to take readings immediately after introduction until the fumigant reaches equilibrium and prior to aeration to de-



Fig. 3. Treating sill plate to tack strip with Tri-Die (Whitmire Micro-Gen) after removing baseboards and lifting carpeting in a bed bug-infested apartment. (Photo: W. Walker)



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termine the actual HLT and confirm the necessary dosage has accumulated. During a fumigation conducted July 27-28, 2007, the measured HLT of the tarped truck was 65 hours, equivalent to a fumigation chamber. Fumigant loss from the compartment indicates this area would have a 0.3 h HLT if not sealed. Monitoring bed bug fumigations is recommended to document that sufficient dosage is accumulated.

- To aerate the tarped truck, a large fan is attached to the tarp in the front to exhaust air out of the fumigated space (see Figs. 6 and 7, page 50). A second smaller fan is attached to the rear of the truck for fresh air intake. This method enables efficient fresh air exchange of the fumigated space and controlled discharge of the fumigant. Using this method, the time required to aerate the contents of the truck to non-detectable fumigant concentrations is about one hour. An approved clearance detector, such as an Interscan gas analyzer (Interscan Corp., www.gasdetection.com) or SF ExplorIR (Spectros Instruments, www.spectrosinstruments.com), is used to verify the truck and its contents are aerated to label-required re-entry concentrations before the truck is

driven and contents are removed.

The labor and materials to seal the truck could be reduced if only the compartment door was sealed by taping. This also would result in a smaller space — just the storage compartment of the truck — to be fumigated. Nonetheless, more fumigant would need to be introduced to compensate for a more rapid HLT, about 1½ to 2 hours based on other fumigations. A total of about 9 pounds of Vikane would be required for a monitored fumigation of the tape-sealed truck with equivalent temperature, wind and exposure time. Fumigators who repeatedly use the same truck or trailer for fumigation can permanently seal it to obtain a better half-loss time.

DISCUSSION AND CONCLUSIONS. Bed bugs can evade detection and treatment and take advantage of human behavior to move extensively between and within dwellings. Bed bug populations can potentially develop resistance to pyrethroids when repeatedly treated with these insecticides. These attributes often require pest management professionals to creatively integrate a combination of tools to effectively eradicate

bed bug infestations, as exemplified by the IPM treatment program developed by Walker at UF.

A total of about 15 hours in labor is required to treat a heavily infested two-bedroom apartment for bed bugs using the UF treatment program (see Table 1, page 48). According to Rick Cooper, technical director, Cooper Pest Solutions, Lawrenceville,



Fig. 4. A truck completely wrapped in 6-mil polyethylene for fumigation of bed bug-infested contents with Vikane gas fumigant. (Photo: E. Hobelmann)

N.J., it is not uncommon for treatments to take 8 to 12 hours for a heavily infested two-bedroom apartment. This includes the initial treatment and two or three follow-up visits, but doesn't include travel time. Cooper also reported his company eliminated bed bugs 81 percent of the time in two to three visits for sites with low infestation rates, but the success rate dropped for heavily infested sites (PCT Bed Bug Seminar, New York, Aug. 2007).



Fig. 5. Posting warning signs on a truck bed containing bug-infested contents to be fumigated with Vikane gas fumigant. (Photo: R. Pereira)

Table 1

Labor and Materials Budget for Treating a Two-Bedroom Apartment for Bed Bugs¹

Labor	Hours	Materials	Amount
Moving furniture out of and back into apartment	6	Tri-Die (8-ounce container)	4 containers
Removing baseboards and wall plates, steaming and treating with Tri-Die	3		
Replacing baseboards and wall plates	2	Glue containers (reattach 100 linear feet of baseboard)	2.5 containers
Fumigation (sealing and preparing truck, fumigant introduction, monitoring, aerating and clearance testing)	4	Vikane gas fumigant	3 lb ²
		chloropicrin	0.2 ounce
		6-mil polyethylene sheeting	40 x 50 feet

¹Second story apartment; treating living room, study, two bedrooms, three closets and hallway; ca. 250 linear feet of baseboards removed and sill plate treated.

²Monitored fumigation, 2,500 cubic feet fumigated volume, excellent seal and tarp condition, wind 5 mph, slab underseal, 21 hour exposure time, 75°F.

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The advantage of the UF treatment program is that bed bugs are eliminated in heavily infested apartments using a one-time treatment regime that eliminates callbacks and follow-up treatments. This increases the resident's satisfaction and reduces the potential of bed bugs spreading through wall voids to adjacent apartments. In addition, residual pesticide application is limited to wall void and crack-and-crevice treatments. Fumigation is used to effectively treat furnishings, bedding, textiles and other household items to minimize occupant exposure to residual pesticides.

Walker has given presentations on control of bed bugs for the Association of College and Housing Officers International and the Southeastern Association of Housing Officers. Through discussions with members of these associations, he has observed that containerized fumigation using Vikane is currently underutilized as an important component of IPM programs for bed bug control. The treatment methods developed at UF could readily be implemented for bed bug control in residential and commercial facilities with entrenched bed bug infestations. 

Walker, Glover and Koehler are with the University of Florida, Gainesville. Thoms and Hobelmann are with Dow AgroSciences in Florida. Thoms can be reached at ethoms@giemedia.com.

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Fig. 6 and Fig. 7. A large fan used by University of Florida officials to efficiently ventilate Vikane from tarped truck during the initial aeration period. (Photos: E. Hobelmann)

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