

BED BUGS:



*Containerized fumigation
and heat treatment*



Edited by

Roberto Pereira

Phil Koehler

Ellen Thoms

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Bed Bugs:

Containerized Fumigation, Heat Treatment and Other Control Methods

Bed bugs are rapidly becoming one of the most important urban pests. The rapid bed bug resurgence and the predominance of insecticide-resistant strains in the U.S. have taken many pest control managers by surprise. The need for new methods for management of bed bug infestations demands urgent action by the pest management and Extension personnel all over the country and abroad.

Bed bugs infestations are found both in rooms (under carpet, behind baseboards, inside electrical outlet, etc) as well as in room contents (bed frames, mattresses, furniture, clothing, etc). While the application of residual pesticides may provide adequate control of these pests in the infested rooms, applications of chemical pesticides is not always desirable, or adequate for elimination of bed bugs from room contents. This is especially true about beds, sofas, and other furniture that have prolonged and direct contact with human users, which can potentially result in considerable transfer of chemical pesticides to people.

The purpose of this workshop is to demonstrate methods for control of bed bugs in room contents, as a separate component of the overall bed bug control strategy. Containerized fumigation with insecticidal gas and containerized heat treatment of room contents will be discussed along with other control methods that form the basis for a sound integrated management of bed bug infestations.

Bed Bugs

Biology and Control

University of Florida, Dept. of Entomology & Nematology
Urban Entomology Lab.



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Order: Hemiptera

Sub-Order: Heteroptera - Stink bugs

Scientific Name: *Cimex lectularius* L.

Common Name: Common Bed Bug

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Why are bedbugs a problem now (again) ?

1. Greater human mobility
2. Less use of any residuals – last 5-6 yrs
3. Significant switch to baits for roaches & ants
4. Many PMPs are not familiar w/ bed bugs
 - inadequate survey, wrong ID, incomplete treatment
5. Pyrethroids used in most accounts are repellent
 - bugs do not get a lethal dose (esp. in deep cracks)
 - harborages easy to miss in first survey
 - bugs may detect & avoid residual treatments
 - bug pop. often “split” or move from such treatments
6. People may call any unknown bite - “bed bugs”

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Medical Importance

- Found naturally infected w/ ≥ 28 human pathogens
- Never proven to transmit any human disease
- Several species feed on humans
(Common & Tropical Bed Bugs, Bat Bugs, & Poultry Bugs)
- Salivary proteins cause “sensitivity” to repeated bites by large numbers of bed bugs
5 stages: no reaction; delayed reaction; both immediate & delayed; immediate reaction only; & finally, no reaction
True hypersensitivity can develop (but it is reversible)
- Serious social stigma to having an infestation

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What Are They?

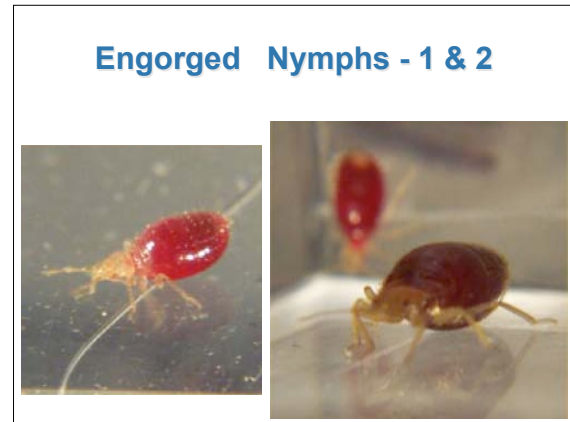
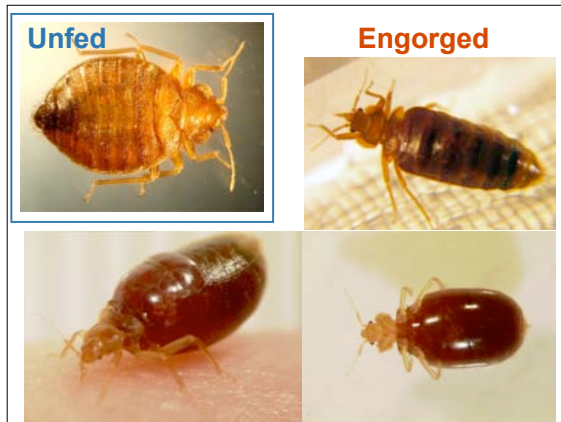
- Blood feeding parasites of Humans, birds and other animals.
- 1.5 mm – 1 cm long, flat, ovoid, with no wings*



- Brown to Dark Red (Adult)
- Tan (Newly Hatched)

Bed Bugs are Thin and Flat





Small – 3/16 inch long, oval, flat, reddish brown insects

True bugs - w/ 3-seg. beak, 4-seg. antennae

Vestigial wings & a thin coat of fine golden hairs

Give off a distinctive “musty, sweetish” odor - stink bug smell

Partly digested blood in feces causes “rusty” spots

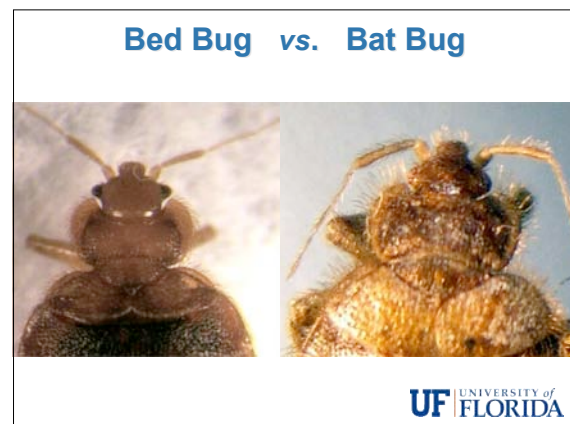
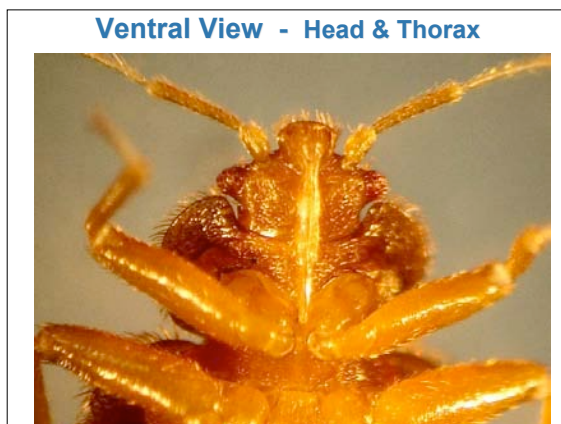
Males – pointed abdomen

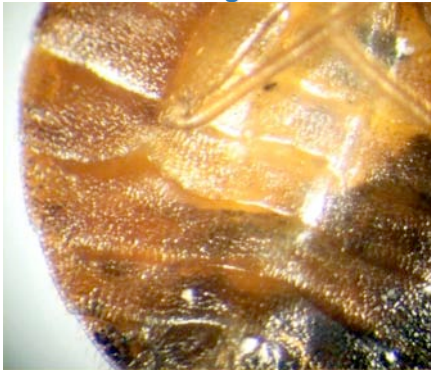
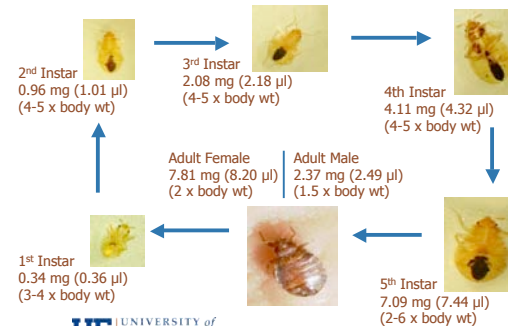
Females – rounded abdomen

cm

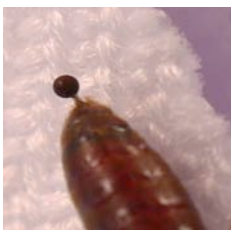
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This block contains a list of characteristics of bed bugs, including their size, color, antennae, wings, odor, and feces. It also includes a small photograph of a bed bug next to a ruler for scale, and the University of Florida logo.



Feed only on Blood**Mammals or Birds****Small (1 mm long) whitish eggs in loose clusters****Nymphal instars****Need at least 1 blood meal each instar****4-5 weeks egg-to-egg****at 75-80% RH; 83-90° F****200-500 eggs per female****Adults can survive >1 yr. w/o feeding****Nymphs 3-4 mo.****Mating – “Traumatic” Insemination****Adult Bed Bugs Mating****Male punctures female body wall****Injects sperm into the female's abdomen, outside of the reproductive tract.****Female ‘Para-genital Sinus’****How much do they eat?**

½ of the blood ingested is lost by defecation within 5 hours.

**Temperature**

- **Development Stops**
 - **Below ~55° F**
 - **Above ~99° F**



Bed Bugs Thrive



At temps between
~68° F - 80° F
(your house)

Bed bugs die at temperatures > 113°F



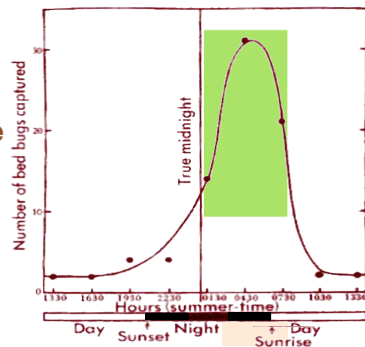
Dryer for linens,
drapes, and clothing



Pressurized steam
for surfaces, cracks
and crevices

Activity

When are
you more
susceptible
to bed
bugs?



What makes them active?

- Some aggregation pheromones
- No known attractants
- Heat and CO₂ most likely attraction to hosts
- Hunger
 - Random movement until a host is found
 - Can not detect a host outside of 5 feet

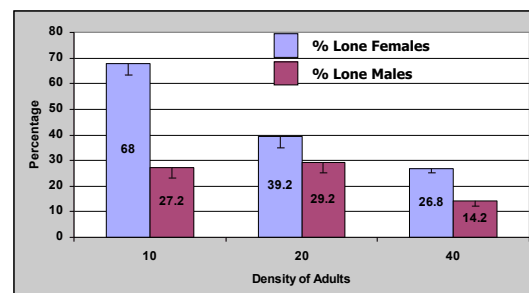
Movement

Quick movers

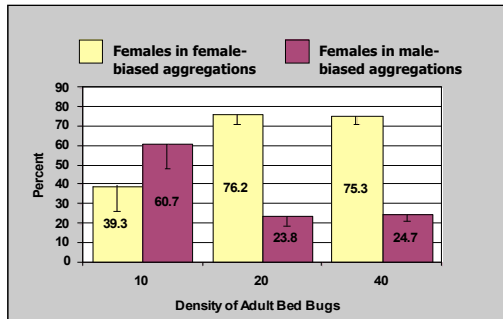
Adults can crawl about 4 ft/minute
Nymphs can crawl about 1 ft/minute



Female bed bug avoid aggregations (to avoid males and traumatic insemination)



Female bed bug seek female groups (to avoid males and traumatic insemination)



Viable Eggs



Eggs and Droppings



Feeding



Engorging Adults & N - 2



Bites

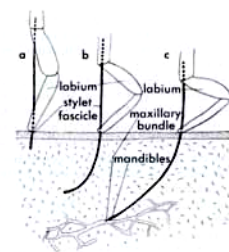


FIG. 3-1.—Diagram showing successive stages (a, b, c) in penetration of stylet fascicle through the skin and into a blood vessel (Dickerson and Lavoipierre 1959).

Reactions vary, but are generally mild

DO NOT TRANSMIT DISEASE*

Bites

Painless (?), red papules, often in groups of three, not centralized to one body part

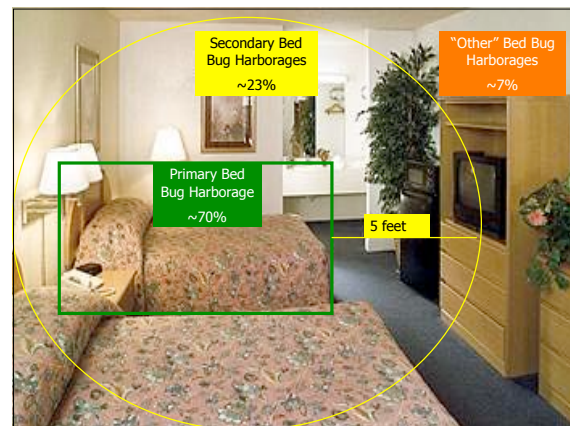


Delusory Parasitosis vs. Bed Bugs

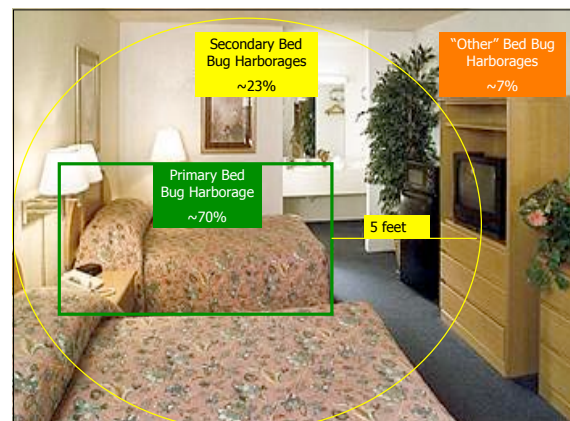
- Describe sensations that feel like bugs, worms, or mites are biting, crawling or burrowing into, under, or out of their skin.
- Complain that furniture is infested.
- Conviction that no one believes they exist except themselves.

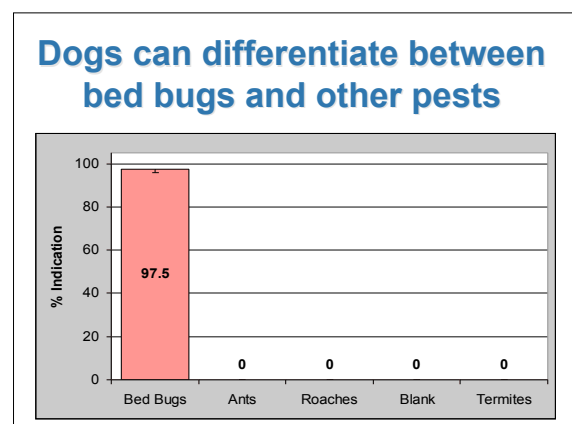
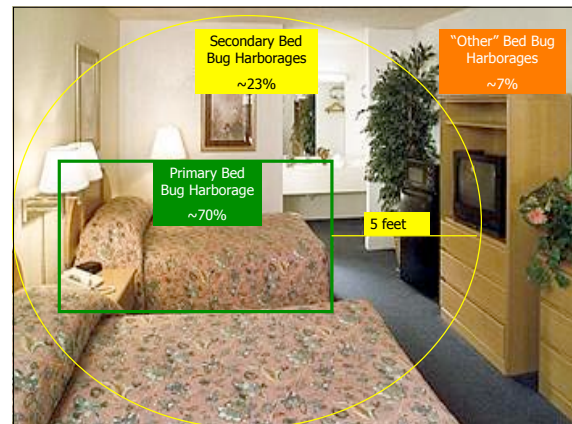


Bed Bugs & Rusty Spots on Sheet

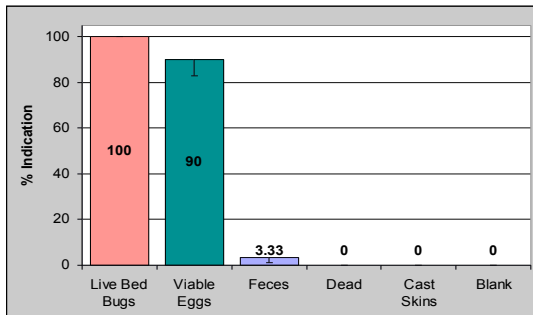


Possible Primary Harborages

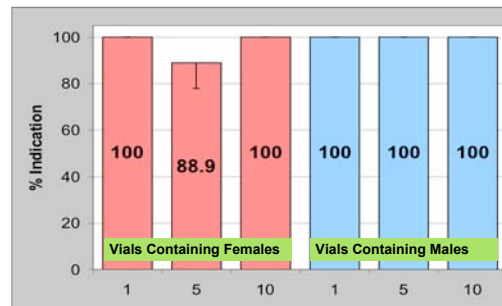




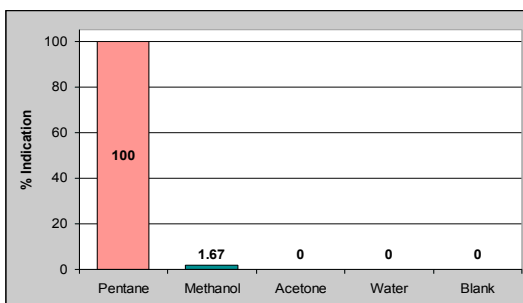
Dogs can differentiate between live and dead infestations



Dogs can detect a single male or female bed bug



Dogs can be trained with and detect artificial bed bug extracts



Some Control Strategies

- Thorough survey & accurate ID
- Educate customers
 - may take > 1 visit
- Sanitation will not eliminate bedbugs
- Initial vacuuming
 - mattresses, beds, harborages
- Treat harborages w/ properly labeled residual
 - try to not use highly repellent materials
- Dust electrical boxes, voids
 - maybe seal them shut
- Seal harborages shut
 - pref. silicone-based sealant
- Consider physical barriers if appropriate
- Sticky monitors
 - may detect continued presence
 - uncover their bottom sticky areas

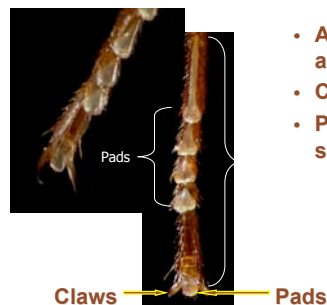
Close up of Bed Bug Leg

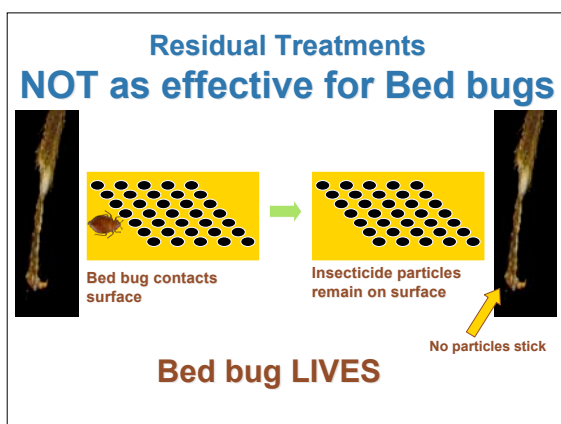
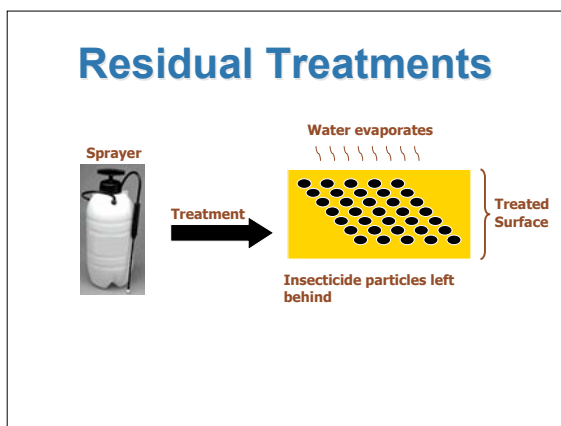
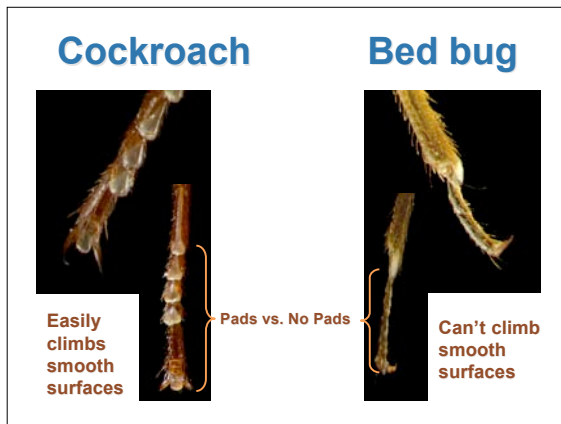
- Adapted for crawling
- Claw used for gripping rough surfaces or for gripping host to insert mouthparts



Leg of Cockroach

- Adapted for running and climbing.
- Claws for traction.
- Pads for climbing smooth surfaces.





Treatments

- **Dusts** – treat deeply into cracks
 - Puff duster
 - Paint brush
- **Sprays** – provide quick kill of exposed insects
- **Aerosols** – kill insects in bedding and clothing
 - Treating sensitive materials – bedding, clothing
- **Fumigation** in severe cases



Non-Chemical Controls



- **Bags** for mattresses and boxsprings
- **Vacuum** insects from harborages
- **Exclusion**
- **Wash** bedding and clothing

Necessary Customer Actions

- **Laundry** bedding with soap, borax additive
 - Sheets
 - Mattress pad
 - Blankets
 - Bed skirt
 - Bedspread
 - Clothing
- **Dry clean**
 - Pillows
 - Clothing
 - Drapery
 - Pillows



Necessary Customer Actions

- **Vacuum** thoroughly using stiff brush
 - Mattress, box springs
 - Check every seam, tuft, button, slats, ticking, and cracks
 - Bed frame
 - Upholstered furniture
 - Draperies
 - Baseboards
 - Carpet next to baseboard
 - Cracks in furniture
- **Discard** vacuum cleaner bag
 - Place in plastic bag
 - Seal and remove from premises
- **Seal** damaged mattresses and box springs in zippered bags
- **Exclusion** by caulking and barriers on bed legs



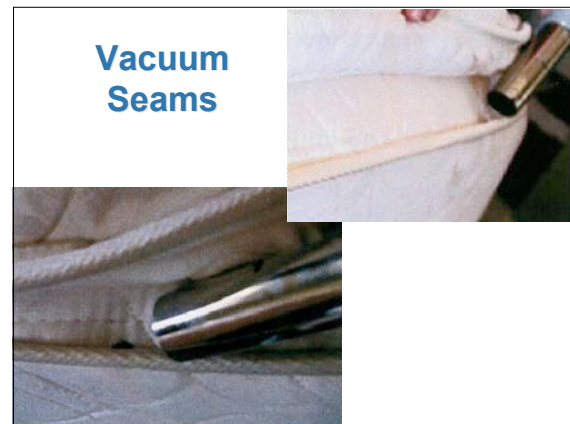
Dry Heat - Clothes Drier



“Dry” anything that can be put into drier approximately 10 minutes will do!

Plastic Bed Bags





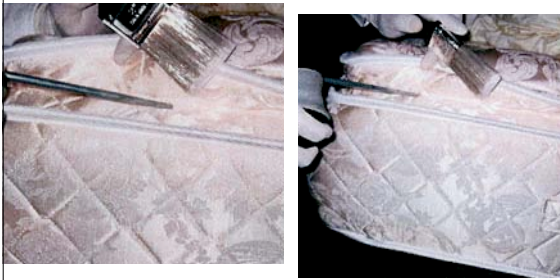
Dusting Mattresses



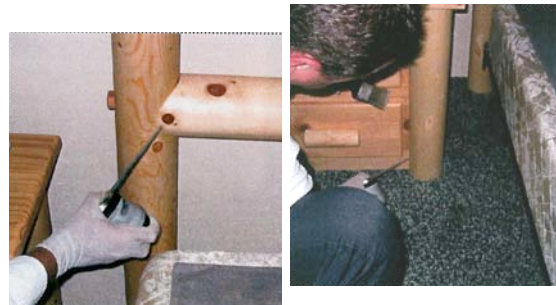
Dusting Bed Rails



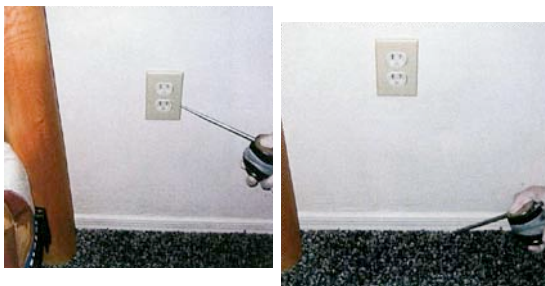
Dusting Folds in Mattresses



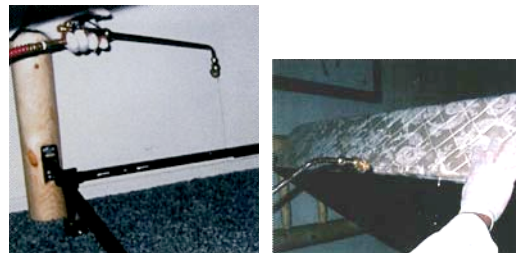
Dusting Bed



Dusting Outlets



Bed Spraying



Spray Harborage



Spray Procedures

- Remove drawers
- Turn upside down
- Spray inside
- Spray underneath side
- Check clothing and belongings in drawer



Aerosol Sensitive Items



Aerosol Bedding



When Treating “Think in 3-D”

1. **Treat along a baseboard but remember...**
Bed bugs may already be (or can go) into or through wall voids, along pipes, or through air vent passages to rooms on either side, above, or below.
2. **Consider concurrently treating the same identical “spots”**
On the other side of the common wall
Along the wall-ceiling edges of rooms below

Fumigation treatments

1. **“Whole structure” fumigation will eliminate bugs present within treated areas, but**
This may not be economically practical
There is no residual protection
2. **The same things are true for . . .**
“Batch” or “Single-Room” Fumigations
Heat treatments (Whole Bldg. or One - Room)
Cold treatments (Whole Bldg. or One - Room)
Steam treatments (mattress, box spring, etc.)

Armed Forces Pest Management Board

TECHNICAL GUIDE NO. 44

Bed Bugs - Importance, Biology, and Control Strategies



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Bed Bugs - Importance, Biology, and Control Strategies

Foreword. The common bed bug, *Cimex lectularius* L., the tropical bed bug, *C. hemipterus* (Fabricius), and a few closely related species of blood-feeding true bugs (Hemiptera: Cimicidae) have been persistent pests of humans throughout recorded history. They may have evolved as cave-dwelling nest ectoparasites of mammals (probably bats), with at least one species later switching to feed mainly on cave-dwelling humans. As humans moved from caves to tents and, ultimately, houses, bed bugs, especially the common bed bug, were probably brought along. Bed bugs appear in the literature and folklore of many cultures and countries, from the Greeks and Romans to early Jewish and Christian writings, and in the records of colonial Americans (Usinger 1966). After World War II, widespread use of synthetic insecticides led to sharp declines in bed bug populations in most industrialized countries. By 1997, they were so scarce in the U.S., Canada and Europe that it was difficult to find fresh specimens to use in teaching college entomology classes (Snetsinger 1997). Many contemporary Pest Management Professionals (PMPs) with years of experience have never seen an active bed bug infestation. During the past 8-10 years, a resurgence of bed bugs has been reported in the U.S., Canada, European countries, Australia and parts of Africa. Infestations have occurred in homes, hotels, hostels, cruise ships, trains, and long-term care facilities (Cooper and Harlan 2004, Doggett *et al.* 2004, Hwang *et al.* 2005, Johnson 2005). This Technical Guide was developed to meet the need for current information and guidance regarding bed bug control.

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Disclaimer

Trade names are used in this TG to provide specific information and do not imply endorsement of the products named or criticism of similar ones not mentioned. Mention of trade names does not constitute a guarantee or warranty of the products by the AFPMB, the Military Services, or the Department of Defense.

Introduction: In recent years, bed bugs have become much more common worldwide, especially in developed countries. The purpose of this TG is to provide general information about the main pest species of bed bugs, including their importance, key aspects of their biology and behavior that can affect control efforts, and strategies and techniques that pest management professionals (PMPs) and others may wish to implement to achieve desired levels of control. Management strategies and techniques chosen will usually be dependent on important details of the local situation, such as physical conditions (especially temperatures), the condition of the human population, military activity, and available control resources and expertise. Unless otherwise stated, the focus of this TG is the common bed bug, *Cimex lectularius* L.

Corrections or suggestions to improve this TG should be addressed to: Editor, TG # 44, Bed Bugs – Importance, Biology, and Control Strategies, Defense Pest Management Information Analysis Center (DPMIAC), Forest Glen Section – WRAMC, Washington, DC 20307-5001, Phone: (301) 295-7476, FAX: (301) 295-7473; or DSN: 295-7476.

Purpose: To provide background information on the importance, biology and behavior of bed bugs that can impact control efforts against them, and to suggest a range of current control strategies and techniques that are known to be effective, with emphasis on integrated methods, timely resolution of the pest problem, and maximum education of, and involvement by, members of the affected human population. Also, to provide additional references to assist decision makers and local PMPs in resolving and preventing bed bug infestations.

Importance

Blood feeders. Bed bugs only consume blood, usually feeding on a mammal (*e.g.*, human, bat) or bird. They need at least one blood meal of adequate volume in each active life stage (instar) to develop to the next stage and to reproduce. There are five nymphal stages, and each one may feed multiple times if hosts are readily available. Fig. 1 shows the egg and nymph stages; Fig. 2 depicts the adult stage.



Fig. 1. Bed bug eggs and nymphs. Photograph by H. J. Harlan.



Fig. 2. Adult female bed bug feeding. Photograph by G. D. Alpert.

Adult bed bugs may feed every three to five days throughout their estimated six to 12 month life span. The act of biting a host can cause both physical and psychological discomfort, and can result in local allergic skin reactions to injected salivary proteins (Feingold *et al.* 1968).

Potential to transmit human pathogens. Bed bugs have been found naturally infected with at least 28 human pathogens but have never been proved to biologically or mechanically transmit any of them (Usinger 1966, Cooper and Harlan 2004). Shedding of viral DNA fragments in bug feces and retention of hepatitis B virus through a normal molt seem to support the possibility of mechanical transmission, as when bugs are crushed onto abraded human skin (Jupp *et al.* 1991, Blow *et al.* 2001).

Bites and health effects. Bed bug bites are usually almost undetectable, but their saliva contains biologically and enzymatically active proteins that may cause a progressive, visibly detectable allergenic skin reaction to repeated bites. Depending on bite intensity and frequency, there are typically five post-bite effect stages: no reaction (no or too few antibodies developed), delayed reaction, delayed plus immediate reaction, immediate reaction only, and no visible reaction (due to excess circulating IgG antibodies). Typical symptoms include a raised, inflamed, reddish wheal at each bite site, which may itch intensely for several days (Fig. 3). “Immediate” immune reactions may appear from one to 24 hours after a given bite and may last 1-2 days (Fig. 4) (Feingold *et al.* 1968).



Fig. 3. Reaction from bed bug bites, 30 minutes after feeding. Photo by H. J. Harlan.



Fig. 4. Reaction from bed bug bites, 48 hours after feeding. Photo by H. J. Harlan.

"Delayed" immune reactions usually first appear one to three (up to 14) days after a bite and may last 2-5 days (Feingold *et al.* 1968). Humans who are frequently bitten by bed bugs may develop a sensitivity "syndrome" that can include nervousness, almost constant agitation ("jumpiness"), and sleeplessness. In such cases, either removing the bed bugs (physically or chemically) or relocating the person can cause the syndrome to disappear over time. Several additional cimicid species are known to bite humans, including tropical bed bugs, poultry bugs, various species of bat bugs, and swallow bugs. A social stigma may be associated with bed bug infestations (Usinger 1966), but there is currently no requirement to report infestations to any public health or government agency.

Importance as pests. Because they are nocturnal, use cryptic harborages, are very small and elusive, and can detect and avoid many chemicals, including cleaning agents, bed bugs are often difficult to control. Complete elimination of an established bed bug population is nearly impossible to accomplish in a single service visit by most PMPs. They are easily transported on or in luggage, furniture, boxes, and clothes. Except after a blood meal, they are very thin and can fit through, or hide in, very narrow cracks. Unfed adults can live for several months (sometimes longer than a year), while second through fifth stage nymphs can survive for at least three months without feeding. The numbers, geographic distribution, and severity of bed bug infestations are rapidly increasing in Europe, North America, Australia and other parts of the world. The public's fear of bed bugs, the effects of their bites, and their characteristic, disgusting smell are magnifying their importance as pests. Because the general public is not very knowledgeable about bed bugs, their bites nearly always lead to visits to some clinical medical facility or expert (often a physician). There are usually additional costs for diagnosis, or at least for symptomatic medical treatments. In 2004 alone, at least 17 of 65 homeless shelters in Toronto spent a mean of \$US 3,085 each to address bed bug problems (Hwang *et al.* 2005). Lawsuits have produced awards of \$US 20,000 to 382,000 plus expenses (Gooch 2005, Johnson 2005).

Dispersal of bed bugs from one structure or infestation site to another is usually passive – the bugs or their eggs are unknowingly carried in or on pieces of furniture, bedding, luggage, clothing, electronic devices or cardboard boxes. Furniture rentals and purchases of used furniture are rather common, especially in poor communities, and this probably helps rapidly and repeatedly spread bed bugs to new sites and redistribute them back into places from which they may have been eliminated earlier.

Large multi-unit buildings can be very difficult to rid of bed bugs. Once they become established, any control effort that does not include concurrent inspection of all units, together with a coordinated program of treatment and occupant education, is usually doomed to fail, because the bugs will frequently move from any partially treated, potentially repellent active site to adjacent rooms or floors. They readily move through wall voids, along utility lines, heating ducts, elevator shafts, and laundry or mail chutes.

Because of their ability to adapt and survive in any environment suitable for their human hosts, bed bugs can become established and develop significant populations even in long-

term deployment sites involving only tents as troop shelters. In more permanent military housing, they can quickly become pests wherever they are introduced.

Biology and behavior

Adult bed bugs are about 6-7 mm (3/16-1/4 inch) long, broadly oval, flat, brown to reddish-brown true bugs, with a 3-segmented beak, 4-segmented antennae, and vestigial wings. They have very thin, vertically flattened bodies covered with short, golden-colored hairs. They give off a distinctive musty, sweetish odor, due to certain chemicals that are produced by glands in their ventral thorax. The tips of their abdomens are usually pointed in males but rounded in females. They feed only on blood, usually of mammals or birds, and mate by “traumatic insemination.” It may take 3-12 minutes for one bug to feed to repletion. About 20% of the time, adult bed bugs and large nymphs will void remains of earlier blood meals while feeding. This produces the typical rusty or tarry spots seen on bed sheets or in bug hiding places (Fig. 5). They feed repeatedly, but each of the five nymphal stages must have at least one blood meal before it can develop to the next stage. As well, females must feed in order to produce eggs.



Fig. 5. Bed bug adult on sheet, showing typical fecal spots. Photo by H. J. Harlan.

Bed bugs will travel 5-20 ft. from an established harborage to feed on a host. Although they seem to prefer humans, they readily feed on birds, rodents, or other mammals. Their life cycle from egg to egg may take four to five weeks under favorable conditions [*e.g.*, 75-80% RH; 28-32°C (83-90°F)]. They can survive and remain active at temperatures as low as 7°C, if they are held at an intermediate temperature for a few hours, but their upper thermal death point is 45°C (113°F). Bed bugs are nocturnal but will seek hosts and feed in full daylight when hungry. Females attach their small (1 mm long) cylindrical (about four times as long as their diameter) pearly-white eggs to any nearby surfaces, usually in crevices (harborages), where they hide in loose groups or clusters. Each female may lay 200-500 eggs during her lifetime, which may be 6-12 months or longer. Cast bed bug skins usually accumulate in harborages.

Common bed bugs can be found all over temperate areas of the Northern and Southern Hemispheres almost anywhere that humans have established houses and cities. They thrive at temperatures and humidities that are considered comfortable by most people, who usually afford them ample blood meals and plenty of good harborage nearby. The tropical bed bug, *Cimex hemipterus* (Fabricius), is widespread at tropical and subtropical latitudes worldwide, and it accordingly requires a higher average temperature than does the common bed bug. In continental Europe, established infestations of this species are rare; in the Western Hemisphere, it is seldom found north of Mexico and Puerto Rico, or south of Peru and Brazil. Occasional limited populations have been found in Florida and Chile. Several species of bat bugs, swallow bugs, and other bird-feeding bugs occur in various north and south temperate parts of the world and may occasionally bite humans (Usinger 1966, Gold and Jones 2000).

Control Strategies and Techniques

Inspection. Detailed inspection by a qualified person is the essential first component of any effective bed bug control program. If found, the bugs must be detected, accurately identified (IDed), and their harborage sites and a rough estimate of the population size must be determined as quickly as possible. There is no device for attracting or trapping bed bugs, so a thorough visual inspection must be performed. Certain pyrethrin-based flushing agents can help stimulate the bugs to move around, making them easier to detect where populations are limited. Cimicids that feed chiefly on bats or birds can usually be controlled by removing those hosts and all their nesting materials, then treating their hosts' roosting or nesting areas.

Detection. A bed bug infestation is usually revealed through signs, such as finding live bugs, observing dark fecal deposits or lighter rusty spots on bed linens or in harborages, discovering eggs or cast skins in harborages or near feeding sites, recording where and when alleged victims have been bitten, or smelling the bugs' characteristic odor (Fig. 6). Any combination of two or more of these signs can help verify an infestation, and help determine the bugs' distribution and prevalence. Monitoring may be augmented by using sticky traps and insecticidal aerosols that produce a flushing or excitatory effect. For cimicid species that mainly feed on bats or birds, detecting and locating their usual hosts' roosts or nests is important. The presence of such hosts may signal a possibility that their removal or exclusion could trigger or facilitate an infestation of human living areas.



Fig. 6. Bed bug-infested mattress showing typical signs of infestation. Photo by B. Pannkuk.

Education. Educating the occupants of any living space infested by bed bugs is essential to ensure that they actively and voluntarily cooperate in the control program. Occupants will be expected to improve and maintain sanitation, minimize clutter, and perhaps also seal harborages to exclude or restrict the movements of the pest population. It will help if people understand bed bug biology and behavior, as well as proposed control strategies and techniques. Education may include verbal explanations, answering questions, posting notices, and broadcasting Web sites or distributing handouts in the local language. Throughout a control program, continuous communication should be maintained between occupants, housing managers, and any involved government agencies.

Physical removal. Bed bugs can be vacuumed from exposed harborages or resting sites, such as box spring edges or mattress seams, but their eggs are stuck tightly to harborage surfaces and are usually hard to remove. Using a high efficiency particulate air (HEPA) filtered vacuum, which removes >99% of all particles >0.3 micron diameter, will ensure that many allergens associated with bed bugs and their debris are also removed. Vacuuming, especially during inspections, will immediately remove a significant portion of the pest population and will usually kill some of the bugs. Bed bugs may also be removed from exposed resting sites by pressing down on them with the sticky side of a commercially available tape, hand-picking them, or brushing them into a container of rubbing alcohol or soapy water (Potter 2004, Gooch 2005).

Exclusion. Bed bugs have weak, flexible, piercing-sucking mouthparts, and weak, simple feet (tarsi) and claws. They are incapable of chewing or clawing through even a very thin coating of sealant or an unbroken layer of paper or cloth. Sealing a layer of almost any material in place, to completely cover a harborage opening, can halt bed bug movement. Once sealed inside a void or harborage, living bugs are effectively removed

from the pest population and will die in place. Sealing most of the openings between a harborage and bed bugs' usual host access site(s) will at least restrict the bugs' movements and help temporarily reduce the intensity of their feeding. Storing clothes and other items in plastic bags or tightly sealed containers can greatly reduce potential harborage sites.

Mattress covers. Commercially available plastic covers, at least 0.08 mm thick, usually with a zippered edge, can completely enclose a mattress or box spring and prevent any bed bugs harboring in them from accessing hosts. Originally developed to reduce human exposure to allergens in mattresses infested with house dust mites, such covers both seal in and exclude bed bugs. They may also be homemade using plastic sheeting that is sealed shut with durable, flexible tape (*e.g.*, nylon fiber tape, duct tape) (Cooper and Harlan 2004).

Physical killing techniques (heat, cold, controlled atmospheres, steam)

Heat. Since the early 1900s, bed bugs have been controlled by heating infested rooms or whole buildings to temperatures of at least 45°C; the thermal death point for these pests. For heat treatment to be effective, it is critical that high temperature and low relative humidity be attained for a minimum length of time. Some species of stored product beetles, which are often difficult to kill, have been eliminated by exposure to a combination of 49-52°C (120-125°F) and 20-30% relative humidity for 20-30 minutes. Heat treatment provides no residual effect, and bed bugs can re-occupy any site so treated immediately after temperatures return to suitable levels. Potential physical distortion of structures or their contents, as well as flammability risks associated with some kinds of heat sources, may be a concern in particular situations (Usinger 1966). Laundering infested linens or cloth items in hot water with detergent, followed by at least 20 minutes in a clothes dryer on low heat, should kill all life stages of bed bugs but would not prevent their reinfestation.

Cold. Exposure to low temperatures can kill bed bugs if they are kept cold enough long enough. Bed bugs can tolerate -15°C (5°F) for short periods and, if acclimated, they can survive at or below 0°C (32°F) continuously for several days (Usinger 1966). Cold treatments of rooms or buildings to control bed bugs have not been well studied or often employed, but freezing furniture or other items within containers or chambers [*e.g.*, below 0°F (-19°C) for at least four days] may be a practical alternative for limited infestations or to augment other control measures. A new commercial technology uses CO₂ from cylinders deposited as a "snow" to kill bed bugs and a variety of pests by rapid freezing.

Controlled Atmospheres. In preliminary laboratory tests by the German Federal Environmental Agency, all life stages of common bed bugs were reportedly killed by constant exposure to very high concentrations of carbon dioxide (CO₂), at ambient atmospheric pressure, within 24 hours or less; however, high concentrations of nitrogen gas (N₂) were not very effective under the same conditions (Herrmann *et al.* 2001).

Steam. Steam treatments have been used effectively by some PMPs to quickly eliminate live bugs and their eggs from the seams of mattresses and other cloth items. However, this technique requires practice and care. Manufacturer's instructions must be followed concerning the steam generating devices' operation, maintenance and safety precautions. The steam emission tip must usually be about 2.5-3.8 cm from the surface being steamed. If the tip is too far away, the steam may not be hot enough to kill all the bed bugs and eggs that it contacts. If the tip is too close, excess moisture may be injected into the treated material, which may lead to other problems (*e.g.*, facilitating dust mite population survival and increase; growth of surface molds).

Sticky Monitors. Sticky traps are a simple way to monitor many crawling insects, and have been used to augment other techniques for control of spiders and cockroaches. Although bed bugs will often get caught on such monitors, many recent reports from PMPs in North America have indicated that they are not very effective at detecting small to moderate populations of bed bugs, even when infestation signs are obvious, bugs are easily observed, and people are being bitten routinely.

Pesticide Applications

Residual applications. Currently, non-chemical products and techniques are incapable of efficiently or quickly controlling or eliminating established bed bug populations. Precise placement of a suitably labeled, registered and formulated residual chemical insecticide is still the most practically effective bed bug control. Effective control consists of applying interior sprays or dusts to surfaces that the bed bugs contact and to cracks and crevices where they rest and hide. When using residual insecticides, care should be taken to select the least-toxic active ingredients and formulations, following an IPM approach. Microencapsulated and dust formulations will have a longer residual effect than others. Synergized pyrethrins are often highly lethal and produce a flushing effect, allowing faster analysis of the infested area. If the label permits, addition of pyrethrins at 0.1-0.2% to organophosphate, or carbamate (where these active ingredients are legal and labeled for this use), or other microencapsulated insecticide formulations may increase efficacy by irritating the bugs, initiating an excitatory effect, and causing them to leave their hiding places, thus increasing their exposure to the fresh insecticide layer. Modified diatomaceous earths with hydrophobic surfaces can also be used to treat cracks and crevices. Retreatment, when needed, should be carried out after the shortest interval permitted by the label until the pest bug population has been eliminated. The choice of chemical products and specific application techniques can depend on many factors, including the physical location and structural details of the bugs' harborages, the product's labels (which can vary by political jurisdiction), the immediate environment, and local or national laws.

Crack-and-crevice applications. Because of their habit of hiding clustered together in cracks and narrow harborages, precisely applied crack-and-crevice treatments are among the most effective control techniques against bed bugs. Active ingredients change over time, and several are currently available, as well as some products that contain multiple ingredients labeled for use against bed bugs. Various formulations and devices are also

available for applying insecticides to bed bug-infested areas. For example, dust formulations should be used in electrical outlet boxes and in other places where it is desirable to employ low-risk (low volatility and toxicity), long-lasting insecticides.

IGRs. When properly applied, insect growth regulators (IGRs) have essentially no effect on vertebrate metabolism because of their mode of action and low application rates, but they can have a significant impact on bed bug fertility and egg hatching success (Takahashi and Ohtaki 1975).

Fumigation. Fumigation of furniture, clothing, or other personal items can kill all bed bug stages present. However, such treatments will not prevent reinfestation immediately after the fumigant dissipates. Fumigation of an entire building would be equally effective but, again, would not prevent reinfestation, and would seldom be necessary, practical, or affordable (WHO 1982, Snetsinger 1997, Gooch 2005).

Impregnated fabrics and bednets. Fabrics and bednets, factory- or self-impregnated with formulations of residual chemical insecticides, can help deny bed bugs access to hosts, and may kill some of the bugs that crawl on them. This can be economical because spray, dipping or coating formulations of products containing permethrin will often remain effective through many launderings, some for the life of the fabric (Lindsay *et al.* 1989). However, one West African population of tropical bed bugs was recently reported to be resistant to a particular pyrethroid used to impregnate bednets (Myamba *et al.* 2002).

ULV, aerosols, and foggers. Insecticides currently labeled for ULV, aerosols and foggers have little or no residual effects on bed bugs. Most will seldom penetrate cryptic bed bug harborages. If directly injected into harborages, these products may stimulate some of the bed bugs to become active and move out into the open, allowing them to be seen by inspectors. Otherwise, bed bugs are seldom killed, even by prolonged or repeated exposure to such products.

Follow-up. At least one follow-up inspection of infested sites should be conducted at a suitable interval (*e.g.*, 10-21 days) after each control effort or treatment in order to detect any of the typical signs of continued infestation, such as live bugs, cast skins (after those present earlier had been removed), fecal spots on bed linens or harborages, and unhatched eggs.

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Web sites offering bed bug information. Please note that web sites may sometimes contain incorrect information. Government and university web sites are usually more reliable than sites created by commercial or private interests.

National Pest Management Association, www.pestworld.org

PCT Magazine, www.pctonline.com

Pest Control Magazine, www.pestcontrolmag.com

University of Kentucky Extension Entomology,
www.uky.edu/Ag/Entomology/entfacts/struct/ef636.htm

Harvard School of Public Health, www.hsph.harvard.edu/bedbugs/

Australian Environmental Pest Managers Association, www.aepma.com.au

Appendix 1. Sample Bed Bug IPM Template

This template outlines IPM strategies for controlling bed bug infestations in many military housing situations. Additional or alternative strategies and techniques are discussed elsewhere in this TG. The following sequence of steps should facilitate control of bed bugs in troop or family housing.

1. Inspection. Prompt, careful, thorough inspection by a qualified individual of sites reported or suspected to be infested by bed bugs. Start at the site where biting was reported and work outward for at least a 5-20 ft. radius.
2. Correct identification (ID) of any pest species present. A sample of the pests present should be collected and identified (IDed) by a qualified person using suitable keys or other ID aids.
3. Education of occupants(s) and manager(s) of the infested structure(s). Occupants and managers of the infested structure(s) should be provided concise, clear information about the ID, biology, and general behavior of any pest bugs found. They should be informed of the need for their cooperation and of any self-help steps they might take to reduce or limit the infestation, or that would help prevent re-infestation. Information can be provided by direct explanation, fact sheets (handouts), reference to a Web site, or a combination of these.
4. Physical control measures.
 - a. Using a vacuum cleaner (preferably HEPA-filtered), remove the bugs and their cast skins from all observed and suspected harborage sites during the initial inspection, and periodically afterward (*e.g.*, once weekly as a self-help action). The vacuum bag should be removed immediately afterward, sealed tightly inside a larger plastic bag, and that bag incinerated or placed in the next normal trash collection.
 - b. Launder all infested cloth items in hot water [$>120^{\circ}\text{F}$ (49°C)] for >10 min., with soap or detergent, then dry in a warm or hot dryer [$>140^{\circ}\text{F}$ (60°C)] for >20 min., or dry clean to kill all bed bug life stages present.
 - c. Consider enclosing each mattress and box spring in a sealable plastic cover, such as those sold to limit exposure to house dust mites.
 - d. Place all recently laundered cloth items (*e.g.*, bed linens, clothing) in large plastic bags or tightly closed bins to prevent any bed bugs from re-infesting them.
 - e. Seal shut all cracks, crevices, and entry points to wall voids, using a high-quality silicone-based sealant, especially within a 20-ft. radius of any spot where bed bug bites have occurred.

f. Additional or alternative physical control measures against bed bugs may include: heat, cold, steam, controlled atmospheres, and sticky insect monitors.

5. Chemical control measures.

a. A residual insecticide should be applied, according to label directions, to each infested site and preferably to a small area around each site. Such applications often involve treating cracks and crevices. When planning and conducting any such treatments, consider examining, if not treating, the opposite side of any involved wall, floor or ceiling.

b. Electrical outlet boxes, and similar voids that cannot be readily sealed, should be treated with an appropriate insecticide dust.

c. Consider including some type of insect growth regulator (IGR) as a concurrent treatment (usually as a tank mix).

d. Limited use of an aerosol or ULV pyrethroid may facilitate the detection of hidden bed bugs and cause them to move around, and may also potentially increase their exposure to any previously applied residual insecticide.

e. Fumigation of batches of furniture, clothing or other items within chambers may be warranted and affordable in specific cases, but whole-structure fumigation to control bed bugs is very seldom practical or economically feasible.

6. Follow-up. Re-inspection of infested structures and sites should be done about 10-21 days after any initial treatment, and (if needed) again about 10-21 days later, to detect, and to precisely target the treatment of, any continued infestation.



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-Steam Vapor System (Therma-Kleen, www.therma-kleen.com). The Steamax is portable and is utilized when treating one or two rooms. The Therma-Steam 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

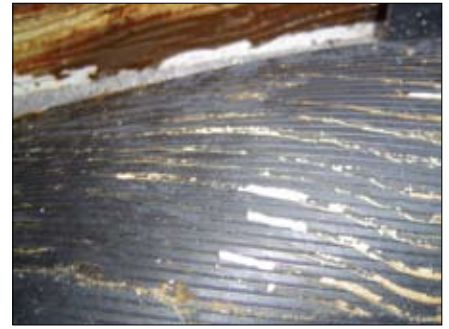


Fig. 2. Channels on the back of vinyl baseboards provide harborage for bed bugs. (Photo: W. Walker)

- 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.

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 Fumiscopes (Key Chemical and Equipment Co., www.fumiscopes.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)

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.

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.

Acknowledgements

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References

Romero, A., M. F. Potter and K. F. Haynes. 2007. Insecticide-Resistant Bed Bugs: Implications for the Industry. *Pest Control Technology* 38(7): 42, 44, 46, 48, 50, 143.



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)

Vikane[®] Gas Fumigant for Eliminating Bed Bugs

Considerations When Fumigating For Bed Bugs:

1. Give an adult occupant of the residence to be fumigated a bed bug fact sheet and check list on how to pack to leave bed bugs behind. An example is attached.
2. For multi-unit dwellings (apartments, condominiums, dormitories), consider the following:
 - **Require at least one adult occupant from each unit to attend group meeting(s)** to explain preparation procedures and answer questions. Have attendees sign a check-in sheet at each meeting.
 - **Set-up checkpoints** manned by authorized personnel to screen occupants as they are leaving before the fumigation and returning after the fumigation to ensure compliance (as much as possible) with preparation requirements for bed bug fumigations.
3. Add clauses in the fumigation contract that are specific for bed bug control. Clauses to consider could include responsibilities for reinfestation and exclusions for medical expenses and repair or replacement of items due to infestation by bed bugs. Consult NPMA's Sample Bed Bug Contract for further information.
4. Monitor bed bug fumigations using a Fumiscope to document and confirm sufficient dosage (3X the drywood termite dosage) is accumulated to kill bed bugs.
5. At this time, the veterinary community is largely unaware of the re-emergence of bed bugs. Warm-blooded pets including birds can serve as important hosts, and pet cages and bedding can be sources of infestation. The American Veterinary Medical Association currently has no guidelines or information available to veterinarians and the public on bed bugs.

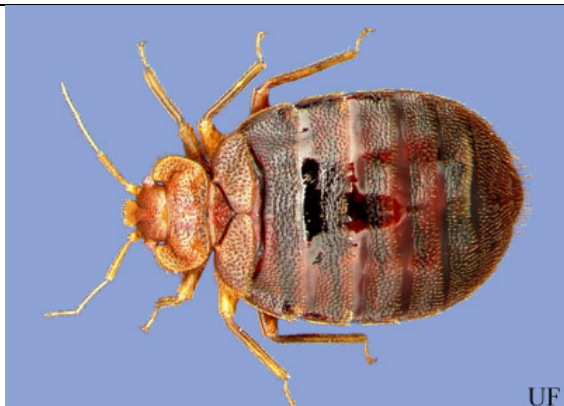
Vikane® Gas Fumigant for Eliminating Bed Bugs

Facts You Need To Know About Bed Bugs...

What do bed bugs look like?

Adults of the common bed bug (*Cimex lectularius*) are about ¼ inch long, reddish to dark brown in color with flattened bodies. They cannot fly, but can run quickly. Eggs and newly hatched nymphs are pale and very tiny – the size of a pin head.

Adult bed bug (Photo courtesy of University of Florida, IFAS)



How do bed bugs spread? Bed bugs are spread easily by “hitchhiking” on all types of household items, such as clothing, bedding, furniture, luggage, back packs, and animal cages. Although bed bugs prefer to infest wood and fabric to metal and plastic surfaces, they have been found infesting electronic devices, such as alarm clocks, and hollow perches in bird cages.

What do bed bugs feed on? The common bed bug prefers to feed on humans, but can feed on a wide range of warm-blooded animals, including cats, dogs, birds, rabbits, and rodents. Bed bugs do not stay on the host. They move from hiding places in bedding, furniture, cages, and other nearby cracks and crevices to feed briefly on people and pets at night. Adults can live more than a year without a blood meal.

What are signs of infestation by bed bugs?

Look for the following:

- Red, welt-like bites that itch and occur while sleeping (bed bugs feed at night).
- Live bed bugs, eggs, molted skins of bed bugs, and dark brown or rusty spots (excrement) are indications of infestations.
- Bed bugs hide and lay eggs in mattress seams, box springs, bedding, head boards, picture frames, sofas, furniture, carpeting, drapes, and any crack and crevice the width of a business card. (Photo courtesy of M. Potter, University of Kentucky)



Vikane[®] Gas Fumigant for Eliminating Bed Bugs

Packing Check List - How to Leave the Bed Bugs Behind

- ☐ **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 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, 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.



Procedures for Vikane[®] Gas Fumigant in Trailers

Including other containers such as cargo containers and storage pods

Sealing Methods:

- 1) Various sealing methods can effectively confine Vikane in trailers:



- a. Tarp entire trailer and seal to the ground with sand and/or water snakes.
- b. Tarp entire trailer by driving the trailer on top of the tarp and then wrap it (above).
- c. Tape gaps on trailer doors and other openings (right)
- d. Tape openings and seal trailer doors using polyethylene and tape. .



- 2) Tips on Sealing (based on research by Dow AgroSciences):
 - a. Trailers with wood flooring generally have waterproofing material applied to the underside, which limits fumigant penetration through the flooring.
 - b. A truck trailer connected to a cab, compared to one separate from the cab, can have extensive fumigant loss into the cab if the trailer is tape-and-sealed after it is loaded (e.g. sealed from the cab).
 - c. Taping all trailer door seams can be as effective as using polyethylene and tape for confining Vikane (see above, right photo).
 - d. Confinement is more variable using tape-and-seal procedures than tarping, even when repeatedly refumigating the same trailer. The exception would be for trailers that have been modified to be permanently sealed for fumigation.
 - e. For a tape-and-seal fumigation, fumigant leak testing using a TIF detector or SF-ExplorIR after fumigant introduction can identify areas requiring additional sealing and significantly improve fumigant confinement.

Security:

- 1) The fumigator should use their padlock (not one provided by the customer) to secure the trailer from unauthorized entry during fumigation.

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Procedures for Vikane[®] Gas Fumigant in trailers

Including other containers such as cargo containers and storage pods

- 2) In addition to the label requirement to post all trailer doors with warning signs during the fumigation, many states require warning signs be placed on all sides of a fumigated structure (which are visible at ground level).
- 3) Since most trailers and containers are less than 4.4M cubic feet, only a fraction of an ounce of chloropicrin will need to be applied per label-required rates.

Fumigant Introduction:

- 1) Calculate the required dose (total pounds to introduce) and introduction rate (pounds/minute) using the Vikane Fumiguide[™]
- 2) Fan use and placement:
 - a. A single fan should be sufficient for introduction. Use a fan of appropriate capacity based on the pounds of Vikane introduced per minute.
 - b. Place the fan so the fumigant is dispersed into an open area of the trailer.
 - c. Fans do not need to be operated throughout the fumigant exposure period. The fan can be operated during and for about 10 minutes following fumigant introduction, then turned off remotely by unplugging the fan.
- 3) Introduction hose:
 - a. Based on average temperature and humidity conditions, it is recommended to introduce the fumigant through at least 100 feet of 1/8" ID hose.
 - b. In conditions of high temperature and humidity, an introduction hose longer than 100 ft may be necessary to achieve the label-required introduction rate.
- 4) It is recommended to use plastic sheeting or tarps when needed to protect trailer contents from contact with the liquid fumigant during introduction.
- 5) Measure the pounds of Vikane introduced, using equipment such as weighing scales, to obtain the required dose.

Monitoring:

- 1) Monitoring is the only way to confirm that sufficient dosage was accumulated to control the target pest(s).
- 2) When monitoring, measure fumigant concentrations remotely, using a Fumiscope or similar device, after fumigant introduction and at appropriate time intervals to determine the actual Half Loss Time (HLT).
- 3) Use the Fumiguide to calculate the actual HLT and dosage accumulation and, if less than planned, to determine the amount of fumigant to add or time to extend the exposure to obtain the required dosage.

Aeration:

- 1) Once the required dosage has been obtained, aeration can be initiated.
- 2) Repositioning the fan inside the trailer and/or using an additional fan can reduce the time to aerate to 1 ppm.

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The Fumiscope™ for Measuring Concentrations of Vikane® Gas Fumigant During Fumigation

What equipment is used to measure concentration of Vikane during the fumigant exposure period?

Measurements of Vikane concentrations in a fumigated space during the fumigant exposure period can be made using equipment such as the Fumiscope. The Fumiscope can measure concentrations of sulfuryl fluoride to about 0.5 oz/1000 cubic feet (about 120 ppm) depending upon the model, so this equipment is not sensitive enough to use as a clearing device after the fumigation. The Fumiscope can be used in conjunction with the Fumiguide calculator(s) for determining actual half-loss time (HLT) and accumulated dosage.

How does the Fumiscope measure Vikane?

The Fumiscope uses a cell to compare the thermal conductivity of a mixture of Vikane and dry air to that of dry ambient air. This difference is converted into an electric current, which is displayed as oz per 1000 cu ft on the meter. The sample is drawn (by electric pump) through the drying tube, the flow rate meter, and subsequently through the thermal conductivity cell by an electric pump.

What Fumiscope models are available?

The current **Model 5.0** has lighted digital display indicates from 0 to 2999 ounces per 1000 cu. ft. Units are complete with electric pump, flow meter, flow adjustment, sensitive measuring elements, lighted digital display and power supply operating on 115 or 220 volt user selectable - all contained in a rugged Pelican case with a protective cover.

The former **Model D** has a digital readout and indicates 0 to 1000 oz per 1000 cu ft. It is normally operated on 110 volt AC, but can be adapted to operate on 220 volts AC or from a 12-volt auto battery. Older analog models (**EV or E-200**) are still found in the field. The model EV has a range of 0 to 50 oz per 1000 cu ft. The model E-200 has a range of 0 to 100 oz per 1000 cu ft.

The **RDA** (Remote Data Acquisition) Fumiscope provides essentially the same function as the standard Fumiscope. The difference is that the RDA Fumiscope can be left at the structure that is being fumigated and remotely accessed via the standard telephone system or cell phone from a remote computer. The RDA Fumiscope has four test ports for sampling four independent sample locations as compared to the single test port for the standard Fumiscope single test point. Up to 99 RDA Fumiscopes can be connected together at one location and operate together to test up to 396 sample locations.

The main advantage of the RDA Fumiscope is the ability of the fumigator to access real-time monitoring readings from a location distant from the fumigated structure. This eliminates the cost of having an employee at the job site conduct monitoring. If the structure does not have electricity and phone service, the RDA Fumiscope can use a standard 400/600 volt/amp UPS and a modem-capable cell phone. The unit can also be direct connected using an RS232 cable.

The Fumiscope™ for Measuring Concentrations of Vikane® Gas Fumigant During Fumigation

Where can Fumiscopes be purchased?

Fumiscopes can be purchased through your distributor or from the manufacturer, Key Chemical and Equipment Co:

Key Chemical and Equipment Co.
13195 49th Street N., Unit A
Clearwater, FL 34622
keychem@ij.net
Phone: (727) 572-1159
Fax: (727) 572-4595
website: www.Fumiscope.com

What are the operating procedures for Fumiscopes that use Drierite?

Model D Fumiscopes manufactured before September 2001 and Older analog models (**EV or E-200**) require the use of a drying material, such as Drierite, to remove moisture from the air sample. The equipment is operated as described below:

1. Fill drying tube with Drierite (4 to 8 mesh). Tip: Be sure cotton is in place in bottom of tube to prevent dust from being drawn into the pump and cell.
2. Turn on pump and check for leaks by blocking inlet and noting if flow rate drops to “zero.” Do the same by blocking the outlet.
3. After warm-up (approximately 10 to 15 minutes depending on the humidity), adjust the flow rate to approximately 1 cu ft per hour (CFH) and “zero” the instrument.
4. Attach sampling hose (usually 1/4” tubing) and readjust the flow rate if necessary to the same rate in Step 3.
5. Wait at least 3 minutes for a monitoring line of 100 feet or less for the sample to reach the Fumiscope and the reading to stabilize before recording the concentration.
6. Disconnect the tubing and adjust the flow rate to the original setting and check to be sure the unit returns to “zero” - if not, reset it to “zero.” Zero drift may occur during the first few minutes of operation.
7. Change Drierite when approximately 3/4 of the material has changed from blue to pink. (Spent Drierite may be regenerated by placing in a shallow pan and heating in an oven to 300 to 400 F for 20 to 30 minutes then return it to the bottle while still slightly warm.)

What is the internal drying system used for new Fumiscopes and how is it used when operating these Fumiscopes?

Model D manufactured after September 2001, Model 5.0, and RDA Fumiscopes have a new internal drying system. This new patented system makes the instrument much more accurate and convenient by eliminating the sample humidity fluctuation. This new system can be retrofitted into older model D Fumiscopes.

In these models, the external glass drying tube and the use of Drierite have been eliminated. In place of the drying tube is a filter, which is attached to the inlet fitting of

The Fumiscope™ for Measuring Concentrations of Vikane® Gas Fumigant During Fumigation

the instrument panel. The filter is designed to keep the new drying system from being damaged. The filter should last for years as long as the sample tubes are clean and moisture free. The filter should be changed if the flow meter can not be adjusted to read 1.0 CFH or moisture is present in the filter. The filter has no effect on drying or readings.

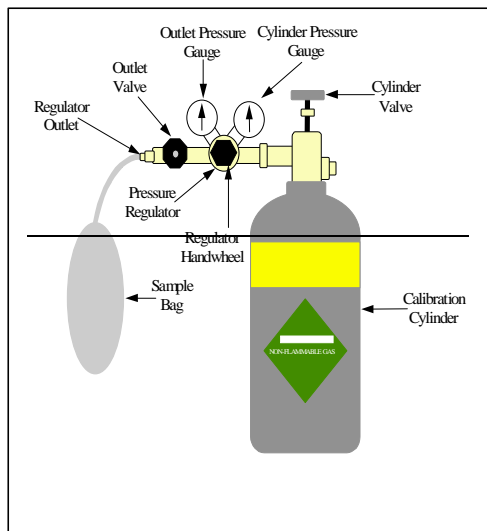
The sample line should be attached to the inlet side of the filter to obtain a reading after the instrument has been allowed to warm up (10 to 15 minutes) and the meter has zeroed.

How are Fumiscopes calibrated?

Small sample cylinders containing known concentrations of Vikane are available for calibration purposes. Specially designed plastic sample bags are used to transfer and inject the gas/air mixture to the Fumiscope. The instrument can then be adjusted to accurately measure the known concentration. This method is ideally suited for quick, easy and reliable calibration of the Fumiscope as well as confirmation of accuracy in the field.

Sample cylinders and bags are available from:

**Scott-Marrin, Inc.
6531 Box Springs Blvd.
Riverside, CA 92507-0725
Phone: (909) 653-6780
e-mail: sales@scottmarrin.com**



The procedure for testing the calibration of the Fumiscope (all models except RDA) is as follows:

1. Warm up and “zero” Fumiscope.
2. Attach regulator to calibration cylinder and tighten with a wrench (note - left-hand thread).
3. Close outlet valve and back out regulator handwheel (turn to left).
4. Open cylinder valve approximately 1/2 turn.

3

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The Fumiscope™ for Measuring Concentrations of Vikane® Gas Fumigant During Fumigation

5. Turn regulator valve clockwise until outlet pressure gauge reads 3 to 5 psi.
6. Close cylinder valve and open regulator valve to bleed regulator.
7. Repeat steps 3 through 5.
8. Attach sample bag to regulator outlet and slowly open outlet valve to fill bag approx. 90% full. Do not overfill as bag will burst.
9. Disconnect sample bag from regulator and connect to Fumiscope inlet.
10. Read Fumiscope meter for concentration of calibration of Vikane. If the concentration on the meter is more than 5% different from the actual concentration, remove the bag, re-zero the Fumiscope and repeat the measurements.

If the calibration check indicates a need for adjustment, remove the four Phillips screws in the faceplate of the Fumiscope.

1. Wait 2 to 3 minutes and then adjust the meter to the gas concentration with the appropriate “pot.”
2. Remove the bag and allow the meter to return to zero. If it does not return to zero, re-zero it and re-calibrate.

Model E-V and E-200 have two adjustment “pots” (blue disks) along the top of the circuit board. The disk on the left (when facing front of panel) adjusts the scale for Vikane. These two pots are interacting. The methyl bromide (MeBr) scale must be adjusted first if the instrument is to be calibrated for both gases. If a calibration is desired for Vikane only, the MeBr pot should not be touched and only the pot for Vikane is adjusted. Some also have a zero adjust lower on the board (adjust this first if it needs adjustment).

Model D has three pots on the top edge of the board. The outer pot is the zero adjust, the center is for Vikane, and the inner is for MeBr. The MeBr scale must be adjusted first if the instrument is to be calibrated for both gases. Some instruments have another zero adjust lower on the board near the pump (adjust this first if the zero needs adjustment).

Model D Fumiscopes manufactured after September 2001 will also have three calibration access holes in the top of the case. This will allow for calibration without the need to disassemble the instrument.

The procedure for Fumiscope Model D Calibration with access ports is as follows:

1. To calibrate the new instrument, locate the three rubber plugs on the top, outside of the case. Gently remove the rubber plugs with a small screwdriver.
2. With the instrument powered ON and warmed up (10 to 15 minutes), place the panel zero adjust knob in the center of its span. Disregard the meter reading at this point.
3. With a small screwdriver at least 2.5” long, insert the screwdriver in the hole at the right side of the instrument.
4. Turn the adjuster to make the panel meter read zero.
5. Place the screwdriver in the center adjustment hole and place the front panel switch in the Vikane position.

The Fumiscope™ for Measuring Concentrations of Vikane® Gas Fumigant During Fumigation

6. Re-zero the meter using the front panel adjustment to read zero if necessary.
7. Place the gas sample on the inlet filter and observe the panel meter. When the meter reading does not change for 15 seconds, turn the screwdriver and adjust the meter to the correct reading.
8. Remove the gas sample and the unit should return to zero.
9. Replace the rubber plugs in the top of the case. This completes the calibration.

An alternate procedure can be used to calibrate the Fumiscope. This procedure is based on comparing the concentration readings of the instrument to be calibrated with a standard instrument and adjusting the one to be calibrated to indicate exactly the same concentration as the standard.

Where do I get my Fumiscope repaired?

Contact the manufacturer, Key Chemical and Equipment Co:

Key Chemical and Equipment Co.
13195 49th Street N., Unit A
Clearwater, FL 34622
keychem@ij.net
Phone: (727) 572-1159
Fax: (727) 572-4595
website: www.Fumiscope.com

The Fumiscope™ for Measuring Concentrations of Vikane® Gas Fumigant During Fumigation

What factors can affect measurements using a Fumiscope?

The factors affecting measurements vary depending upon which Fumiscope model is being used:

Factor	EV	D	5.0	RDA
Warm-up - Allow the instrument to warm up until the readout stabilizes (usually 10 to 15 minutes depending on the humidity).	x	x	x	Automatically stabilizes readings
Zero - Frequently re-align meter to zero.	x	x	x	Automatically re-zeros
Flow rate - Keep flow rate at 1 cu ft/hour. Check for each sample.	x	x	x	Automatically checks flow rate
To save time, charge sampling hoses with a hand squeeze bulb or vacuum pump ¹ before connecting them to Fumiscope.	x	x	x	Pump continuously operates
Monitoring line - For accurate readings do not draw samples through fumigant introduction hose, which could cause erroneously high readings.	x	x	x	x
Other gases - Fumiscope will detect other gases and vapors, including paints, varnishes, propane and natural gas, sewer gases and auto exhaust.	x	x	x	x
Temperature - Avoid rapid changes in temperature. Avoid moving the instrument from shade to sun or from a hot car to cool shade.	x	x	x	Unit remains in fumigated space
Moisture - Water can cause the TC cell to rust. Check sampling tube for condensation. (Use fresh and adequate drying medium such as Drierite in Fumiscopes that do not have an internal drying system.)	x	x	x	x
Interference – Nearby cordless phones, cell phones, cell towers, and flickering fluorescent light ballasts will interfere with Fumiscope measurements. Use extension cords with grounds.	x	x	x	
Dust from Drierite (in Fumiscopes that do not have an internal drying system) - Dust can damage the pump and TC cell. Regularly replace cotton in bottom of drying tube. Clean inside of drying tube with glass window cleaner when dusty.	x	x (pre-9/01)		

¹ The “Fumi-Purge” vacuum pump is available for purchase from Key Chemical

How using a 5 ppm calibration standard affects the accuracy of legacy Interscan GF-1900 sulfuryl fluoride monitors

Defining Our Terms

As defined in the ANSI/ISA-51.1-1979 (R1993) standard entitled *Process Instrumentation Terminology*,

“Accuracy” is the degree of conformity of an indicated value to a recognized accepted standard value, or ideal value.

“Accuracy rating” is a number or quantity that defines a limit that errors will not exceed when a device is used under specified operating conditions. Accuracy rating includes the combined effects of conformity, hysteresis, dead band, and repeatability errors.

Expressing Accuracy Rating

Common methods of expressing accuracy rating are

- Percent of scale length (percent of full scale)
- Percent of actual output reading

Traditionally, expressing accuracy rating with percent of full scale has been used with analog instruments. On legacy Interscan Vikane[®] monitors, accuracy rating is $\pm 2\%$ of full scale. Since the full scale range is 0-50 ppm, any reading is accurate ± 1 ppm.

With digital instruments, it is more common to express accuracy rating with percent of reading, often adding the inherent error of the least significant digit. Thus, one might encounter the specification of $\pm 2\%$ of reading ± 1 least significant digit. [The least significant digit is the lowest digit in a number, located at the far right of a string.]

In such a case, if the digital range were 0-50 ppm, at a reading of 1 ppm, the accuracy would be $1 \text{ ppm} \pm 0.02 \text{ ppm} \pm 1 \text{ ppm}$ (meaning that the true value could be between 0 - 2.02 ppm).

If the digital range were 0-50.0 ppm, at a reading of 1 ppm, the accuracy would be $1 \text{ ppm} \pm 0.02 \text{ ppm} \pm 0.1 \text{ ppm}$ (meaning that the true value could be between 0.88 - 1.12 ppm).

The Influence of the Calibration Standard

However, in gas detection, most instruments, including all instruments used to detect Vikane[®], must be calibrated against a known standard. Thus, these instruments are reference methods, rather than absolute methods.

By all rights, the accuracy of the calibration standard should be taken into account when discussing the accuracy of a gas detection instrument, but in practice, this is done more by implication than directly. An instrument manufacturer may reveal in some footnote that measurement accuracy is limited to the accuracy of the calibration standard, but then proceed as if this does not really matter.

In other words, although a disclaimer may be presented, all accuracy specs will deal with inherent matters of the instrument only. In fact, the error in calibration standard accuracy would be additive, and it is likely that this would add another ± 2 percent to the mix. Fortunately, with the mandated 5 ppm calibration standard, this yields an additional error of only 0.1 ppm.

But, the 5 ppm calibration standard improves accuracy in one other way:

All other things being equal (but, we will find that they are NOT) it is considered best practice to calibrate a gas analyzer at somewhere between 50-85% of the full-scale value. That is why a 40 ppm standard was long used for the Vikane[®] monitor.

However, it is also considered best practice to calibrate at a value reasonably close to the levels at which

How using a 5 ppm calibration standard affects the accuracy of legacy Interscan GF-1900 sulfuryl fluoride monitors

you will be measuring. Hence, the introduction of the 5 ppm calibration standard. Note that even if a 1 ppm standard were available, it would be unwise to calibrate an instrument so close to the bottom of its range.

Consider that the ± 1 ppm accuracy spec was based on a full scale range of 0-50 ppm. Arguably, since the majority of clearance measurements will be made in the range of 0-5 ppm, and the unit will be calibrated with a 5 ppm standard, some allowance should be made for this compression of scale.

By conventional reasoning, a true 0-5 ppm range instrument would have an accuracy of ± 0.1 ppm. And while one cannot hold that our 0-50 ppm unit, pressed into service as a quasi 0-5 ppm unit—by virtue of the new calibration standard—is a true 0-5 ppm instrument, some accuracy benefit should still ensue in this very special case.

It All Comes Down To This

A very conservative approach would be to average the two ranges, giving a “virtual” measuring range of 0-27.5 ppm. As such, the accuracy would be ± 0.55 ppm—a significant improvement.

It is stipulated that some analytical purists may take issue with our “virtual” measuring range argument, but then analytical purists—happily ensconced in their laboratories—do not have to clear structures, subject to extremely demanding environmental regulations.

Reading 1 ppm on legacy Interscan sulfuryl fluoride monitors [Model GF-1900]

1.0 Background

1.1 Historical

In the mid-1980's, Interscan developed an instrument to be used in the clearance of structures treated with Vikane[®] gas fumigant. At the time, the reentry level was set at 10 ppm (parts-per-million). The measuring range of the instrument was 0-50 ppm, with an integral analog meter. The units were usually calibrated with span gas at a target level of 40 ppm.

Some years later, the reentry level was lowered to 5 ppm. To accommodate this change, operation of the integral pyrolyzer (or furnace) was modified to produce better conversion of the SO_2F_2 to SO_2 , and thus, improved sensitivity of the instrument. A procedure was subsequently introduced calling for more frequent calibration, within 30 days of use.

Recent federal re-registration of this pesticide by the US EPA has once again lowered the reentry level—this time to 1 ppm. About one year prior to this label change, the span gas was lowered to a target level of 5 ppm.

1.2 Purpose of this document and technical scope

Although the Interscan was originally designed to detect levels of 10 ppm and subsequently modified to detect at 5 ppm, increased care in operation and maintenance of this instrument will effectively achieve satisfactory performance to the first division on the meter, 1 ppm.

This document will focus on methods that will optimize instrument performance under these new operating conditions. Certain of these methods are subject to change as modifications (including digital meter kits) are made to your Interscan unit, and revisions to this document will be issued at that time. Detailed discussion of accuracy, resolution, and calibration is beyond the scope of this document.

2.0 New Instrument Operating Procedures

2.1 Zeroing the instrument

2.1.1 Current procedures, as outlined in the GF-1900 instruction manual, call for zeroing the unit with ambient air, which is being drawn in by the integral sample pump. Whether one was operating in the 10 ppm or 5 ppm era, prudence would always dictate that this zeroing be done only in an environment that would be free from contamination with sulfuryl fluoride gas.

2.1.2 Now, however, the slightest contamination might be enough to compromise the zero, and therefore the fumigant clearance reading.

2.1.3 Best practice shall now be to use the following procedures to assure that only clean air, free from any sulfuryl fluoride gas, be utilized to zero the instrument. It is recommended to zero the instrument a minimum of 10 feet **upwind** from the fumigated structure and outside of carports, porches, or other areas with overhanging roofs attached to the fumigated structure.

2.1.4 Current procedures, as outlined in the GF-1900 instruction manual, call for waiting until the READY light illuminates before zeroing the instrument. In addition, the user is cautioned to wait until the meter stops moving, before attempting to zero the instrument. Given the critical nature of the zero setting, initial meter stability must be especially emphasized, even if stating this instruction is technically nothing new. Thus, best practice shall now be as follows:

As before, wait until the READY light illuminates, but after this occurs, check that the meter is stable (needle steady and not moving) before attempting to zero the instrument. Depending on when the instrument was last used, this could take an extra few minutes.

Reading 1 ppm on legacy Interscan sulfuryl fluoride monitors [Model GF-1900]

2.1.5 The new zeroing method, described in 2.1.3 and 2.1.4 shall be performed just before each clearance.

2.2 Taking readings in the structure to be cleared

2.2.1 Random motion imparted to the instrument, from walking around while holding it, could cause the meter to bounce around mechanically, rendering a reading of one division difficult. In addition, holding the instrument at odd angles may affect meter movement.

2.2.2 Best practice shall now be to stop walking, hold the monitor parallel to the ground, and stand still while taking a reading.

2.3 Interpreting a one ppm reading

2.3.1 Users of the GF-1900 are well familiar with the difference between artificially induced spikes (often caused by excessive radio frequency interference) and true instrument response. A true instrument response is characterized by a smooth, steady rise of the meter needle.

2.3.2 As such, best practice shall be to define a one ppm reading as a smooth, steady rise of the meter needle to a point coincidental with, or beyond the first meter division. To distinguish this from possible noise, this reading must persist for at least 5 seconds.

3.0 Conclusions

The move to a 1 ppm clearance level has put increased burdens on all of us: The fumigant manufacturer, the fumigator, the instrument company, and the regulators. Even the most sophisticated analyzers are pressed to the maximum to read 1 ppm, and these are priced at a point nearly ten times higher than the GF-1900.

This Best Practices document, as well as subsequent mod kits and newer models of the Interscan sulfuryl fluoride monitor, will help our valued customers in their continuing efforts to provide safe and effective pest control by effectively achieving the 1 ppm clearance standard.

Contact Interscan Corporation:

PO Box 2496

Chatsworth CA 91313

Phone: 818-882-2331

FAX: 818-341-0642

<http://www.gasdetection.com/>

VIKANE® FUMIGATION LOG FORM

Date: / /

Fumigation Company

Site Address:

Cert. Operator in Charge: _____ # _____ Cert. Applicator: _____ # _____

Crew Members:

<i>Put Up Information</i>					
Type of Structure	Frame Crawl	Masonry Crawl	Garage Attached		
	Frame Slab	Masonry Slab	Garage Detached		
Fumiguide Used:	Fumiguide™ B	Fumiguide Y	Fumiguide Calculator		
Cylinder Number	W V - _____ Lot # _____				
Dosage Factor		Relative Humidity		Pic Range (oz)	
Tarp Condition		Amp per fan		No. Pic Intro Sites	
Seal Condition		Monitor Job	Yes No		
Wind (mph)		Estimated HLT		Pounds Vik Applied	
Volume (MCF)		Dosage (oz/MCF)		Introduction Time:	_____ AM\ PM
Underseal		Gas Required (Lb)			
Temperature (F)		OZ-HR Required			
Hours Exposure		Max Release Rate	_____ Lb/Min		

Monitor Readings:	Readings in oz/1000 ft ³				
	Equilibrium Readings ¹	Interim Readings ²	Terminal Readings	Hours Elapsed Between Readings ³	Actual HLT (hr)
Locations:	_____ AM/PM	_____ AM/PM	_____ AM\ PM		
1)					
2)					
3)					
4)					
5)					
6)					
<i>Average:</i>					

¹ Use Funtion 1 if your first readings are not at equilibrium ² Recommended 3-6 hr after equilibrium ³ Hr between equilibrium and terminal readings

Corrected information from Calculator:

Cert. Operator in Charge _____ # _____		Cert. Applicator: _____ # _____	
<i>Tear Down Information</i>		Date: / /	Aeration Complete
Seal Broken	_____ AM\ PM		Date: / /
Active 1-Hour Aeration	Start: _____ AM\ PM		_____ AM\ PM
	Finish: _____ AM\ PM		Cleared by: _____

Detector used: _____ Last calibration date: _____

Tear Down Comments:

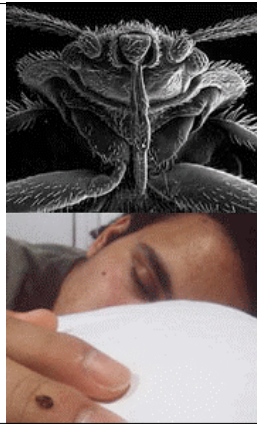
©™Trademark of Dow AgroSciences LLC

Vikane is a federally Restricted Use Pesticide

Always read and follow label directions

Economical Heat Treatment for Bedbugs

Philip G. Koehler
& Roberto M. Pereira
Urban Entomology Building
352-392-2484
pgk@ufl.edu

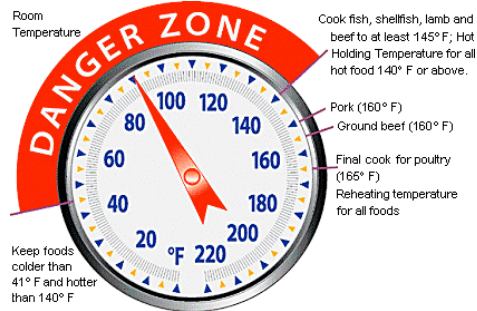


Thermal Death Point for Bed Bugs

- 111-113 degrees Fahrenheit
- 44-45 degrees Celsius



Killing Bed Bugs Bed bugs at least 113 F



First attempt at heat treatment



First attempt at heat treatment



First attempt at heat treatment Started at 9 AM

- Never reached 113 F



Second attempt at heat treatment



Poly sheeting covered with blankets

Second attempt at heat treatment

- 4 heaters blew circuit breakers
 - Each heater draws 12 amps



Final Setup for Heat Treatment



- Moved bed to center of room
- Placed nightstand and other items on top or next to it

Equipment for Heat Treatment



6 polystyrene sheets

Equipment for Heat Treatment



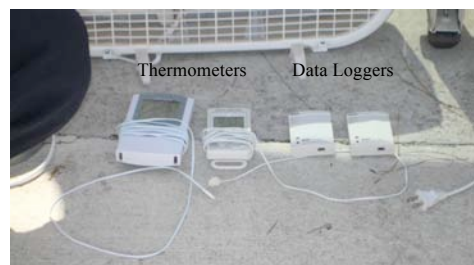
Extension cords and power strip

2 heaters

2 box fans

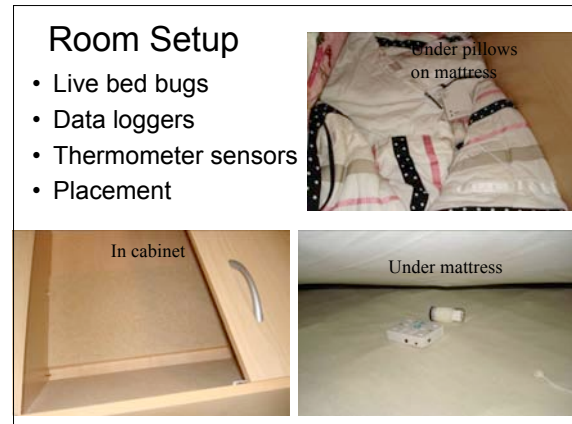
1 oscillating fan

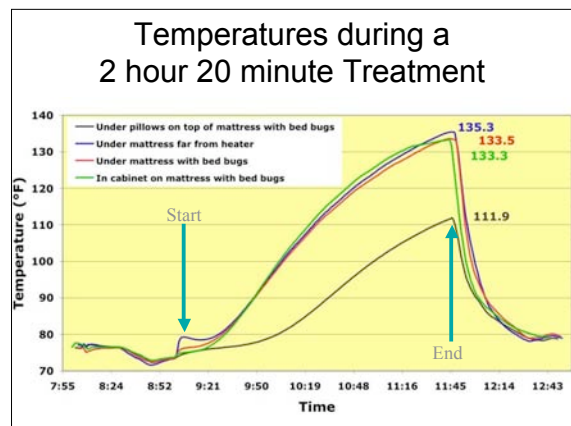
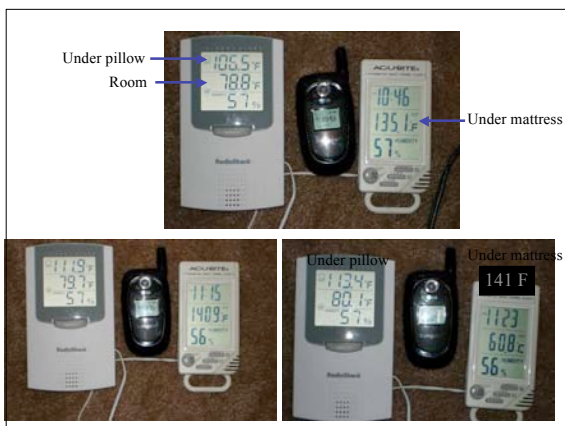
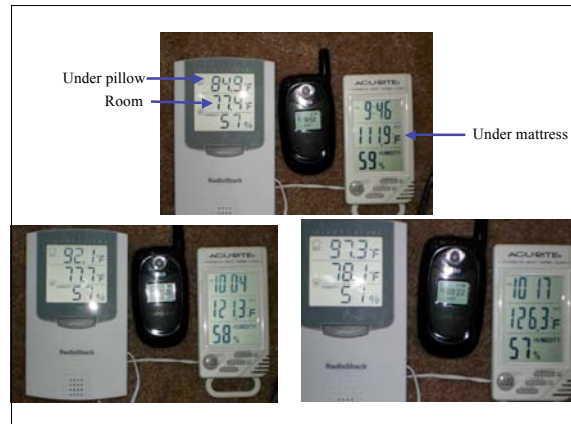
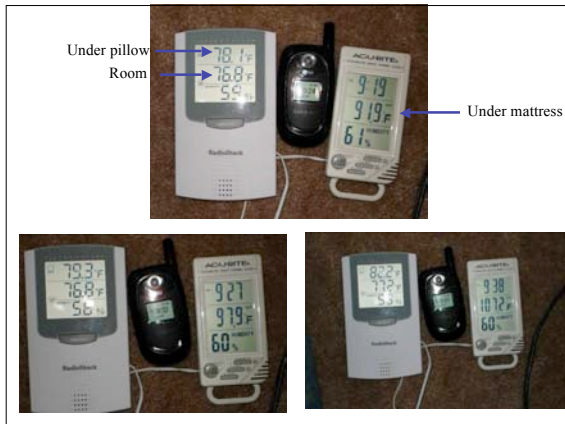
Temperature Monitoring

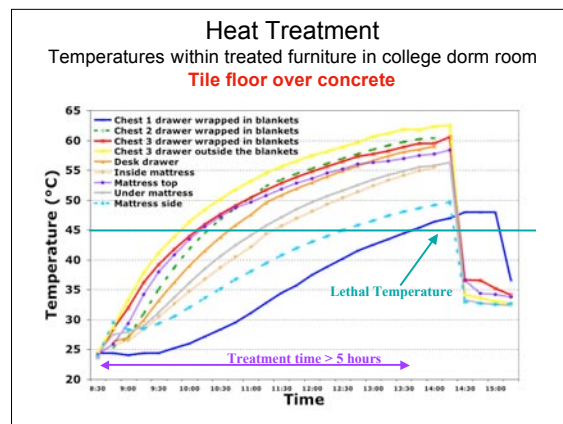
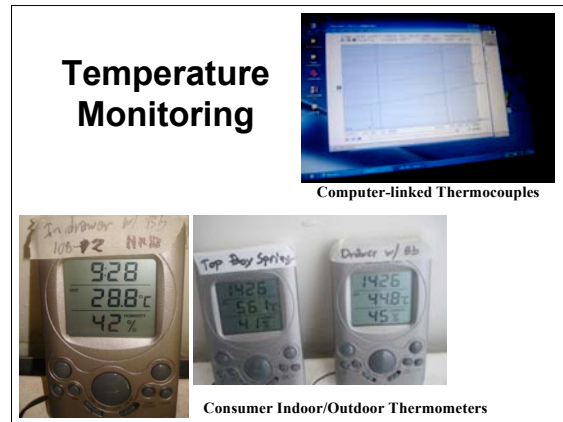


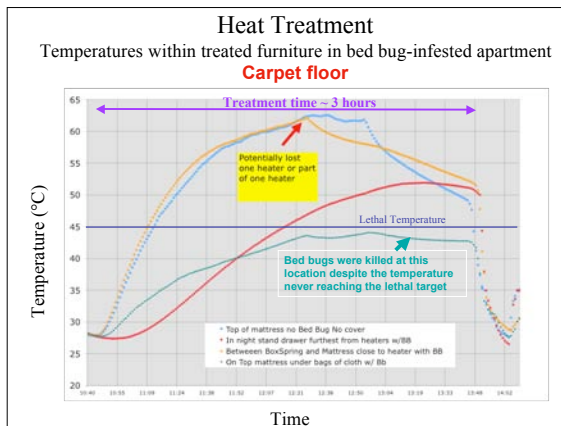
Thermometers

Data Loggers









Equipment


- 2 Space heaters
- \$99.90



DeLonghi EW7707CM Oil-filled Radiator with ComforTemp Technology
 Buy new: ~~\$79.99~~ **\$49.95**
 12 Used & new from \$25.00

Equipment

- 6 Polystyrene sheets (4 by 8 ft)
- \$137.76



Insulfoam
2" x 4' x 8' R-Tech Expanded Polystyrene R-7.8

Item #: 15357 Model: 15357

\$22.96

Product Availability:

Online Shipping Options include

- Lowe's Home Delivery

Equipment

- 2 Box fans
- \$27.34



Lasko 20" Box Fan

Item #: 95021 Model: 37

\$13.67

[Add to Cart](#)

[Click to Enlarge](#)

Image displayed may not be representative of actual product color or finish.

Equipment

- 1 Oscillating fan
- \$29.95



Lasko 2506 Oscillating Fan
 Buy new: ~~\$38.94~~ **\$29.95**

In stock. Processing takes an additional 2 to 3 days.

★★★★★ (1)

Equipment

- 2 Thermometers
- \$17.94



Garden Treasures Digital Indoor/Outdoor Thermometer

Item #: 79632 Model: 00586GTSB

\$8.97

[Add to Cart](#)

[Click to Enlarge](#)

Product Avail

Because prod

enter your lo

Zip Code: []

Already have

Description

3-5/8"D x 1/2"L x 2-3/8"H

Indoor/outdoor use

Lasko 2506 Oscillating Fan

10' long weather-proof sensor cord

Customer Ratings

Equipment Costs \$312.89

- 2 Space heaters
- 6 Polystyrene sheets
- 2 Box fans
- 1 Oscillating fan
- 2 Thermometers
- 2 Extension cords; power strip
- Duct or packing tape

- Bed bugs die at 113 F
- Room Temperature
 - 76.8 F at 9:20 AM
 - 80.1 F at 11:23 AM
- Under mattress
 - 91.9 F at 9:20 AM
 - 141.3 F at 11:23 AM
- Under pillow on mattress
 - 78.1 at 9:20 AM
 - 113.4 F at 11:23 AM



Trie-Die Application to harborages

Treat perimeter of room during heat treatment

Economical, Localized Heat Treatment for Control of Bed Bugs infestations

Roberto M. Pereira, Philip G. Koehler, Margie Pfiester and Wayne A. Walker

University of Florida

Equipment

- Oil-filled electrical space heaters
- Box fans (50.8 cm diam., Lasko, West Chester, PA)
- Small desktop fans
- Tape
- Electrical extension cords
- Polystyrene sheathing board insulation (4 ft x 8 ft x 2 in, Perma “R”)
- Temperature monitoring equipment
 - outdoor/indoor consumer digital thermometers (Acu-rite, Chaney Co.)
 - temperature recorders (Hobo, Onset)
 - thermocouple probes (Onset) connected to laptop computer

General Procedures.

- Room furniture grouped at the center of the room.
- Oil-filled heaters placed on the floor around the furniture.
- Box fans positioned so that air will blow through the heater radiator.
- Small desk fans (or other fans) placed on top of the furniture to assist with the air circulation around the treated furniture
- 6 polystyrene sheathing boards placed forming a box around furniture:
 - 4 forming the sides of a box surrounding the furniture;
 - 2 boards used to form a top to the insulating box.
- Temperatures monitored at various locations within the treated furniture.
- Place live bed bug vials at some locations within the treated furniture.
- Terminate treatment temperature in all monitoring locations reach 113°F (45°C), the expected lethal temperature for bed bugs.
- Remove insulating box or cover.
- Recovered any bed bug vials and verify mortality of bed bugs.

Room	Bed Bug IPM		Insulation	Trial	Treatment Duration	Room Temperature (°C) ^a		Lowest maximum temperature (°C)	Time to reach	Highest maximum temperature (°C)	Time to reach (h)	% Bed Bug Vials Killed (# insects used)
	Floor	Heaters				Start	Max					
D	Tile	2	Plastic Tarp	1	7.3	21.0	27.9	37.9	6.9	41.5	6.3	0 ^b (30)
		4	Plastic Tarp + Blankets	2	5.2	24.1	29.4	51.8	5.1	55.0	5.2	100 (30)
M	Carpet	2	Styro Boards	1	2.8	22.9	26.7	44.4	2.8	60.8	2.4	100 (30)
Ya (111)	Tile	2	Styro Boards	1	5.9	26.4	- ^c	44.4	6.0 ^d	67.4	5.4	100 (15)
		2	Styro Boards	2	6.0	24.3	- ^c	44.8	5.9	59.5	5.7	100 (15)
		2	Styro Boards	3	5.2	21.6	- ^c	44.3	5.3 ^d	58.1	5.1	100 (15)
Yb (108)	Tile	2	Styro Boards	1 ^e	5.4	26.6	- ^c	38.1	5.3	62.7	5.4	67 (15)
		2	Styro Boards	2	5.5	24.0	- ^c	48.0	5.6 ^d	62.7	5.3	100 (15)
		2	Styro Boards	3	4.9	23.8	27.7	48.1	5.8	57.4	5.9 ^d	100 (15)
G	Carpet	2 ^f	Styro Boards	1	2.2/3.1 ^g	27.4	- ^c	44.1	2.3	62.5	1.9	100 (30)
A	Carpet	2	Styro Boards	1	2.4	26.6	31.7 ^h	51.8	2.4	55.4	2.4	100 (30)

^a During treatment

^b Some dead bed bugs in vial placed between mattress and boxspring where highest maximum was recorded.

^c Room temperature not recorded.

^d Temperature continued to rise after application of heat had been terminated.

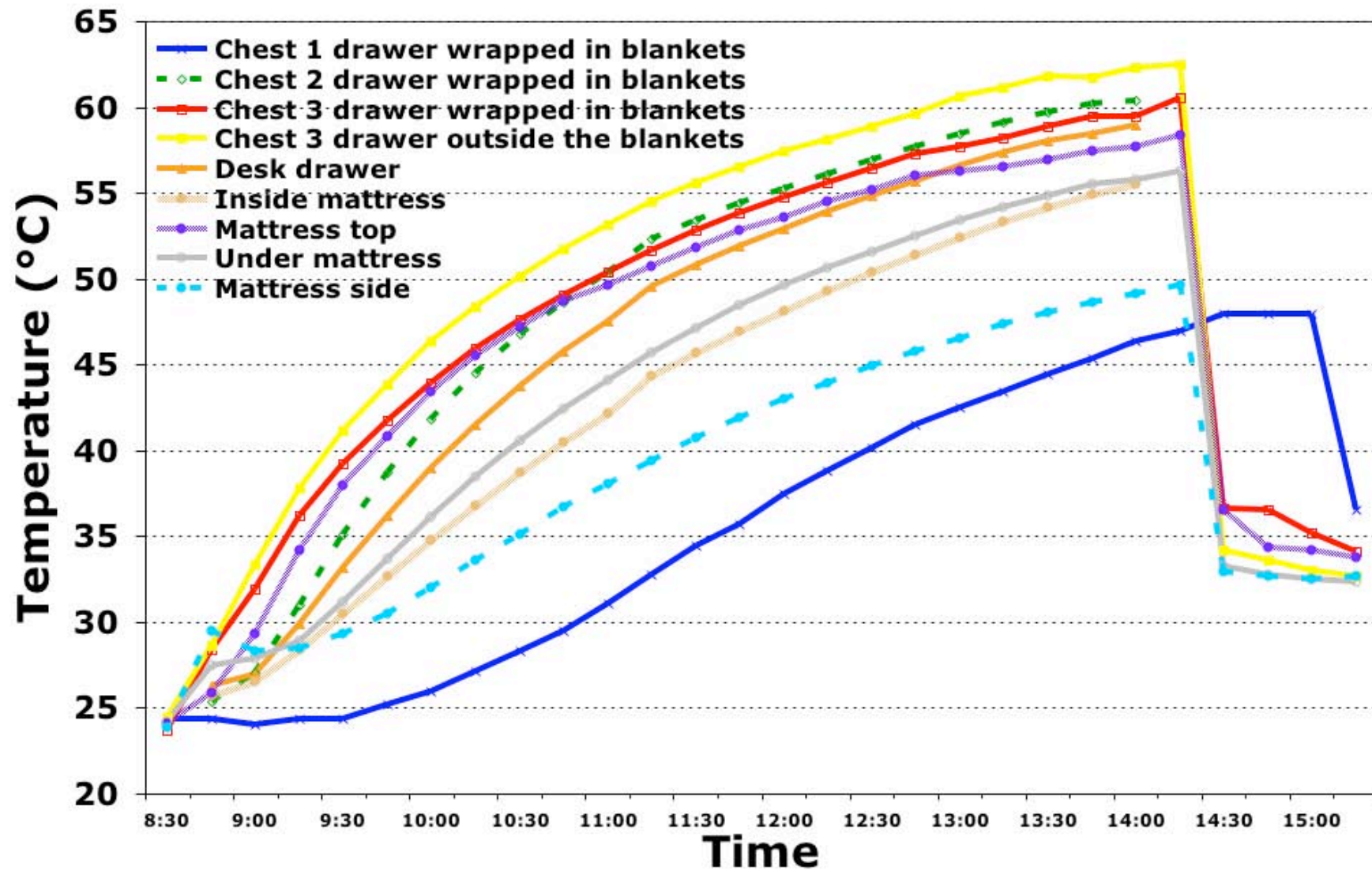
^e Power interrupted twice during treatment

^f Out put from ne of the

^g Insulating box was opened approximately 1 h after power to heaters and fans had been cut off.

^h Measured right on top of insulation box.

Fig. 1. Temperature at different locations within the heat-treated furniture during trial 2 in room Yb.



Bed Bugs "a terror in the dark"

Mallis, 1954



Herman Giraldo & John Loesch
Whitmore Micro-Glen Research
Laboratories

How to "think" about Bed Bugs

- As "blood sucking" cockroaches.
 - Nocturnal
 - Live in cracks, crevices, voids.
 - Form pheromone induced clusters.
 - Can spread from room to room.
 - Can be carried in luggage and boxes.
 - Best treated by targeting their harborage.

How do structures become infested with bed bugs?

- Hitchhike on furniture, clothing, beds.
- Introduced in travelers suitcases or wheelchairs.
- Secondhand furniture

Bed Bugs can be found in:

- Single family homes
- Apartments
- Public housing and shelters
- Hotels and Motels (\$29.⁹⁵ to \$499.⁰⁰/night)
- Movie theaters
- Vivaria (animal housing, zoos)
- Poultry & Rabbit housing
- Public transportation (buses, trains)

Bed Bug harborage sites include:

- Tufts, seams, buttons & folds of mattresses
- Box springs, bed frames and covers
- Couches, chairs, lamps, telephones, radio's
- Window and door moldings, curtains
- Behind wallpaper, pictures, book bindings
- Cracks in hardwood flooring
- Under carpet along walls (tack strip)
- Wall voids (outlets & switch plates)
- Luggage, wheelchairs, boxes

Historical Bed Bug Control

- Hot water poured in cracks
- Sticky bean leaves under beds
- Sulfur fumes
- Kerosene, benzene
- Pyrethrum powder between the sheets
- Hydrocyanic acid gas
- 5.0% DDT
- 0.5% Lindane
- Linseed + hempseed + train oil = BBB

BBB= Bed Bug Bursting

Bed Bug Control

1. Inspect, Inspect, Inspect!
2. Verify species of insect.
3. Educate your customer.
4. Chemical and non-chemical treatment techniques
5. Follow up on all treatments.

Step 1:

Inspecting for Bed Bugs

- You must be *very* thorough
- Always use a flashlight
- Sticky traps are *rarely* helpful
- Must be willing to move and disassemble items (beds, nightstands, chairs, carpets)
- Be alert for Bed Bug odor
- Look for piles of cast nymphal skins
- Blood spots on sheets (linear) ● ● ●
- They live in clusters like German cockroaches

Step 3:

Customer Education

- The What, Where & How of bed bugs
- Provide fact sheets
- Explain treatment preparation instructions
- Tell the customer what *not* to do.
 - No bug bombs
 - No do-it-yourself products

Crack and Crevice®



Crack and Crevice®

Crack is defined as 3/16" or smaller



Crack and Crevice®

EPA Defined Crack & Crevice in 1973 .

Application of small amount insecticide into cracks & crevices in which insects hide or through which they may enter a building. Such openings commonly occur at expansion joints, between different elements of construction and between equipment and floors. These openings may lead to voids such as hollow walls, equipment legs and bases, conduits, motor housings, junction or switch boxes. The crack and crevice treatment includes the use of sprays, dusts, or baits. It permits the use of insecticides in food areas as long as the insecticide is placed only in cracks & crevices. It does not allow the treatment of surface areas.



Crack and Crevice®

The logic of Crack & Crevice treatment:

- Places the insecticides where the insect spends majority of its time.
- Places the insecticide where people and pets will not come in contact with it.
- Places the insecticide where it has the ability to remain active for a longer period of time.



Crack and Crevice® Application



Light Infestations

Move the injector tip three linear feet per second of application.

**Step 4.****Bed Bug Control**

- Contact Insecticides
 - **Pyrethrin**
 - 565 Plus XLO®
 - P.I.®
 - ULD® BP-100 PLUS with Hydroprene
- Crack & Crevice Insecticides
 - **cyfluthrin** - Cy-Kick® CS
 - **silica + pyrethrin dust** - Tri-Die®
- Spot Treatment Insecticides
 - **Cyfluthrin** - Cy-Kick® CS

Pressurized Contact Insecticides**565 Plus XLO®**

Pressurized Contact Insecticide (Formula 2)

- Contains
 - 0.5% natural pyrethrum
 - 1% PBO
 - 1% MGK-264
- Quick flush and knockdown
- Broad spectrum control for flying and crawling insects
- System III® compatible
- Very economical choice

**Pressurized Contact Insecticides****P.I.®**

Contact Insecticide

- Contains
 - 0.5% natural pyrethrum
 - 4% PBO
- Quick flush and knockdown with low odor
- Broad spectrum control for flying and crawling insects
- System III® compatible
- Labeled for use in food handling areas
- Premium contact insecticide

**Specialty Pressurized Insecticides****MotherEarth™ 2% Py Contact Insecticide**

- Contains
 - 2% pyrethrins with no synergists
- Delivers quick kill of crawling and flying insects
- Active ingredient is a botanical insecticide derived from chrysanthemum flowers
- Great for sensitive accounts
- Not System III® Compatible

**ULD® Volumetric Insecticides****ULD® BP-50**

Contact Insecticide

- Synergized insecticide containing
 - 0.5% natural pyrethrum
 - 5% PBO
- ULV, void, Crack & Crevice® and other uses
- Cost effective formulation
- Labeled for use in food handling areas
- Broad use label



ULD® Volumetric Insecticides

ULD® BP-100 Plus

Hydroprene IGR

- Contains:
 - 0.706% hydroprene - 2% PBO
 - 1% pyrethrins - 3% MGK-264
- Optimized ratio of hydroprene to pyrethrin for maximum results
- Pre-mixed for convenience - simple rate of one ounce per 1,000 cubic feet of treatment space
- Broadest space treatment IGR label
 - 112 pests (including bed bugs)
 - 119 sites listed (including indoor, outdoor and on-animal)

ULD® Volumetric Insecticides

ULD® BP-300

Contact Insecticide

- Dual synergized insecticide containing
 - 3% natural pyrethrum
 - 6% PBO
 - 10% MGK-264
- Space, Crack & Crevice®, ULV and void injection applications
- Indoor/outdoor use
- Labeled for use in food handling areas
- Broad use label



Pressurized Residual Insecticides

FastOut™ CS Foam

Ready-To-Use Insecticide

- Contains
 - 0.1% controlled release cyfluthrin
- FastOut CS is the only microencapsulated, ready-to-use foam
- Microencapsulated-Extends residual in voids
- Non-Repellant-Ants and termites don't detect it
- Broad Spectrum-The foam product for any situation/Insect
- Convenience-No mixing, spills, or calibration



Residual Dust Insecticides

Tri-Die®

Pressurized Silica + Pyrethrin Dust

- Contains
 - 0.6% pyrethrins
 - 4.8% PBO
 - 8.0% amorphous silica dioxide
- Fast acting residual insecticide dust
- Desiccant/repellent
- Electro-statically charged for great dispersion
- Micro-Pro™ technology



Residual Dust Insecticides

Tri-Die®

Silica & Pyrethrum Dust

- Contains
 - 1% pyrethrins
 - 10% PBO
 - 40% amorphous silica dioxide
- Fast acting residual insecticide dust
- Desiccant/repellent
- Flows better than competitive dust (lower bulk density)
- Formulated for extended residual activity



Residual Dust Insecticides

MotherEarth™ D

Pest Control Dust

- Contains
 - 100% high purity freshwater diatomaceous earth
- Highly absorptive desiccant dust
- Long-lasting dust provides continuous protection from pests
- Easily covers cracks, crevices and voids
- Mined straight from Mother Earth
- OMRI Listed



Microencapsulated Residual Concentrates

Cy-Kick® CS

Controlled Release Cyfluthrin

- Contains
 - 6% microencapsulated cyfluthrin
- Very quick knockdown and long residual
- Better surface coverage with SmartCap™ microencapsulation technology
- No visible residue and very low odor
- Labeled for use in food handling areas
- Broad label including mosquitoes and bed bugs
- Economical cost per mixed gallon



Microencapsulated Residual Concentrates

Microcare® 3% CS

Controlled Release Pyrethrins

- Contains
 - 3% Pyrethrins
 - 15% PBO
- Quick knockdown with excellent residual activity
- Indoor and perimeter protection
- Excellent for sensitive environments



CRACK & CREVICE® III Phenothrin

Bed Bug and Spider Killer

- Active: 1% phenothrin
- Label: Indoors and outdoors for crawling and flying insects (not for use in food handling areas)
- Size: 6 x 14 oz
- Target Insects: bed bugs and spiders (and 38 other insects)



* Registration pending in CA, CO & NY

Specimen Label

RESTRICTED USE PESTICIDE DUE TO INHALATION TOXICITY
For sale to and use only by Certified Applicators or persons under their direct supervision and only for those uses covered by the Certified Applicator's certification.



Specialty Gas Fumigant
®Trademark of Dow AgroSciences LLC

For control of: Existing infestations of insects and related pests such as drywood termites, Formosan termites, powder post beetles, death watch beetles, old house borers, bedbugs, cockroaches, clothes moths, rodents (rats, mice), and the larvae and adults of carpet beetles (except egg stage), oriental, American, and brown-banded cockroaches.

For use in: Dwellings (including mobile homes), buildings, construction materials, furnishings (household effects), shipping containers and vehicles including automobiles, buses, surface ships, passenger railcars, and recreational vehicles (but not including aircraft).

When fumigating, observe local, state, and federal rules and regulations including such things as use of chloropicrin, clearing devices, positive-pressure self-contained breathing apparatus, security requirements, and placement of warning signs.

Active Ingredient	
sulfuryl fluoride.....	99.8%
Inert Ingredients.....	0.2%
Total	100.00%

EPA Reg. No. 62719-4

Keep Out of Reach of Children

DANGER  **POISON**
PELIGRO

Precaucion al usuario: Si usted no lee inglés, no use este producto hasta que la etiqueta le haya sido explicada ampliamente.

Precautionary Statements
Hazards to Humans and Domestic Animals

Extremely Hazardous Liquid And Vapor Under Pressure • Fatal If Inhaled • May Be Fatal If Swallowed • Liquid May Cause Freeze Burns of Exposed Skin

Do not get in eyes, on skin, or on clothing. Vikane® specialty gas fumigant is odorless. Exposure to toxic levels may occur without warning or detection by the user.

First Aid

In all cases of overexposure, such as nausea, difficulty in breathing, abdominal pain, slowing of movements and speech, numbness in extremities, get medical attention immediately. Take person to a doctor or emergency treatment facility.

If inhaled: Get exposed person to fresh air. Keep warm and at rest. Make sure person can breathe freely. If breathing has stopped, give artificial respiration. Do not put anything in the mouth of an unconscious person. Call a poison control center or doctor for further treatment advice.

If liquid is on skin or on clothing: Immediately apply water to contaminated area of clothing before removing. Once area has thawed, remove contaminated clothing, shoes, and other items covering skin. Wash contaminated skin area thoroughly or shower. Call a poison control center or doctor for further treatment advice.

If liquid is in eyes: Hold eye open and rinse slowly and gently with water for 15-20 minutes. Remove contact lenses, if present, after the first 5 minutes, then continue rinsing eye. Call a poison control center or doctor for treatment advice.

Note to Physician: Vikane is a gas which has no warning properties such as odor or eye irritation. (However, chloropicrin is used as a warning agent and is a known lachrymator). Early symptoms of exposure to Vikane are respiratory irritation and central nervous system depression. Excitation may follow. Slowed movement, reduced awareness, and slow or garbled speech may be noted. Prolonged exposure can produce lung irritation, pulmonary edema, nausea, and abdominal pain. Repeated exposure to high concentrations can result in significant lung and kidney damage. Single exposures at high concentrations have resulted in death. Treat symptomatically.

Liquid Vikane in the eye may cause damage due to refrigeration or freezing.

Notice: Read the entire label. Use only according to label directions. **Before using this product, read Warranty Disclaimer, Inherent Risks of Use, and Limitation of Remedies elsewhere on this label. If terms are unacceptable, return at once unopened.**

In case of emergency endangering health or the environment involving this product, call 1-800-992-5994. If you wish to obtain additional product information, visit our web site at www.dowagro.com.

Agricultural Chemical: Do not ship or store with food, feeds, drugs or clothing.

Directions for Use

It is a violation of Federal law to use this product in a manner inconsistent with its labeling.

Read all Directions for Use carefully before applying.

Storage and Handling

Store in dry, cool, well ventilated area under lock and key. Post as a pesticide storage area. If the storage area is in an occupied building, the storage area must have either 1) a forced air ventilation system that meets required local ordinances for the storage of hazardous materials and operates continuously; or 2) be equipped with a permanently mounted and properly maintained and functioning sulfuryl fluoride monitoring device designed to alert occupants of the building if sulfuryl fluoride in the air of the storage area is greater than 1 ppm. Store cylinders upright, secured to a rack or wall to prevent tipping. Do not contaminate water, food, or feed by storage.

Cylinders should not be subjected to rough handling or mechanical shock such as dropping, bumping, dragging, or sliding. Do not transport any cylinders in closed vehicles where they occupy the same common airspace as personnel. Transport securely only in an upright position.

Do not remove valve protection bonnet and safety cap until immediately before use. Replace safety cap and valve protection bonnet when cylinder is not in use.

When cylinder is empty, close valve, screw safety cap onto valve outlet, and replace protection bonnet before returning to supplier. Only the registrant is authorized to refill cylinders. Do not use cylinder for any other purpose. Follow registrant's instructions for return of empty or partially empty cylinders.

Leak Procedures: Evacuate immediate area of leak. Use a NIOSH or MSHA approved positive pressure self-contained breathing apparatus (SCBA, not SCUBA) or combination air-supplied/SCBA respirator, such as manufactured by Ranger, Survivair, Scott, or MSA, for entry into affected areas to correct problem. Move leaking or damaged cylinder outdoors or to an isolated location, observing strict safety precautions. Work upwind if possible. Do not permit entry into leakage area by unprotected persons until concentration of fumigant in the breathing zone is determined to be 1 part per million (ppm) or less, as determined by a detection device with sufficient sensitivity such as an INTERSCAN, MIRAN [SapphiRe] or Spectros ExplorIR gas analyzers. For more detailed information on the source and use of air monitoring devices or respirators, consult the Vikane Gas Fumigant Structural Fumigation Manual.

Cylinder and Product Disposal: Promptly return all empty cylinders to your distributor of Vikane. Follow proper cylinder handling directions above.

Pesticide wastes are acutely hazardous. Improper disposal of excess pesticide is a violation of Federal law. If these wastes cannot be disposed of by use according to label instructions, consult your State Pesticide or Environmental Control Agency, or the Hazardous Waste Representative at the nearest EPA Regional Office for guidance.

General Information

Before using, read and follow all label precautions and directions. Prior to the parties entering into a fumigation agreement, the Fact Sheet for Vikane must be provided to an adult occupant of the structure to be fumigated.

Vikane is a highly hazardous material and should be used only by individuals knowledgeable of the hazards of this chemical and trained in the use of required respiratory equipment, fumigant detection devices, emergency procedures, and in the proper use of this fumigant.

When used for fumigation of enclosed spaces, such as houses and other structures, warehouses, vaults, chambers, trucks, vans, boxcars, ships, and other transport vehicles, 2 persons trained in the use of this product, at least one being an applicator who is licensed/certified by the state, must be present during introduction of fumigant, reentry prior to aeration, and during the initiation of the initial aeration procedure when exposure exceeds 1 ppm. **Two persons need not be present if monitoring is conducted remotely (outside the area being fumigated) and no one enters the fumigated structure.**

If fumigating for insect pests, do not apply when temperature at site of pest activity is below 40°F. This temperature may be measured at the slab foundation, sub-floor soil, or wherever the coolest part of the structure may be. This restriction does not apply when fumigating for rodents.

When fumigating a single unit/room within or connected to a larger structure (such as town houses, apartments, condominiums), all units of the entire structure must be vacated during the fumigation and aeration periods.

Remove food, feed, drugs, and medicinals from the structure before the fumigation if they cannot be adequately sealed to prevent exposure to Vikane. Chloropicrin must be used as described on the label to warn of an ongoing fumigation.

Preparation for Fumigation

Structural Fumigation

Remove from the structure to be fumigated all persons, domestic animals, pets, and desirable growing plants. Remove mattresses (**except waterbeds**) and pillows completely enveloped in waterproof covers or remove covers (or open seal of waterproof covers). Food, feed, drugs (including tobacco products), and medicinals (including those items in refrigerators and freezers) can remain in the structure if they are in plastic, glass, or metal bottles, cans, or jars with the original manufacturer's air-tight seal intact. Food, feed, drugs (including tobacco products), and medicinals (including those items in refrigerators and freezers) not in plastic, glass, or metal bottles, cans, or jars with the original manufacturer's air-tight seal intact, need to be removed from the fumigation site, or double bagged in Nylofume* bags, which are available from distributors of Vikane.

Note: Extinguish all flames, including pilot lights of water heaters, gas refrigerators, ranges, ovens, broilers, dryers, gas fireplaces, etc. Turn off or unplug all electrical heating elements such as those in heaters, pianos, organs, etc. Shut off automatic switch controls for appliances and lighting systems which will be included in the space to be fumigated.

Open operable internal doors, internal openings to attics and sub areas, storage chests, cabinets, drawers, closets, and appliances (such as washers, dishwashers, dryers, microwave or conventional ovens, etc.). Using electric fan(s) will help provide for forced distribution and aeration of basements and other dead air spaces to facilitate rapid dispersion of gas. Refrigerator and freezer doors may be left open if the units are turned off or disconnected and all food items have been removed. If the applicator chooses to leave sealed food items in closed refrigerators and freezers during the fumigation, the appliances must be opened when clearing the structure until the concentration of Vikane in them is 1 ppm or less.

Multi-Unit Structures: When fumigating a single unit/room within a larger structure (such as townhouses, apartments, condominiums), all units of the entire structure must be prepared as a fumigated structure, and all applicable rules, regulations and label instructions apply, such as occupant notification, structure preparation, posting, securing, and aeration. An adult occupant of each currently-occupied unit must be provided with the Fact Sheet for Vikane. Ensure that all exterior entranceways and exterior doors providing access to individual units are secured with secondary locks (see Securing Structure Entrances) so that only the state licensed applicator in charge can gain access. Chloropicrin need only be used in the fumigated space where Vikane is introduced. During Step (3) of Aeration Procedure 1 or 2, check all units within the fumigated structure for concentrations of Vikane with an approved clearance device. If the concentration of Vikane is greater than 1 ppm in the breathing zone (i.e., areas within the structure where individuals typically stand, sit or lie down) in a unit, ventilate the unit with operable doors and windows open and continue to measure the concentration of Vikane until it is 1 ppm or less. Structure may be reoccupied when concentrations in the breathing zones in all units is 1 ppm or less.

Connected Structures: A connected structure is defined as any structure connected with the structure to be fumigated by construction elements (e.g., pipes, conduits, ducts, etc.) which may allow passage of fumigant between the structures. If state rules and regulations do not describe or permit a process to isolate and seal a connected structure to prevent passage of fumigant from the fumigated structure, then the connected structure must be vacated during the fumigation. When it is necessary to vacate any connected structure, that structure shall be considered as a fumigated structure and all applicable rules, regulations and label instructions apply, such as occupant notification, structure preparation, posting, securing, and aeration. Chloropicrin need only be used in structures where Vikane is introduced. Concentration levels of Vikane must be measured in the breathing zones (see Aeration and Reentry) in any connected space or structure to confirm concentrations are 1 ppm or less before structure can be reoccupied.

Tarpaulin Fumigation

Open operable windows as permitted by local and state regulations. When tarping, use a highly resistant material such as a vinyl coated nylon, or polyethylene sheeting of at least 4 mil thickness. Seal all seams. Seal the bottom edges of the cover to the ground using materials such as soil, sand, or weighted "snakes." To minimize escape of gas through the soil and to avoid injury to nearby plants, wet soil outward from foundation to the cover if not sufficiently moist to act as a barrier for the gas.

Taped Fumigation

For fumigation sites that can be sealed with plastic, paper, or tape, seal adequately around doors, windows, vents, and other openings.

Chamber Fumigation

For chamber fumigation use a tightly-sealed chamber with adequate circulation.

Construction Materials, Furnishings (Household Effects), Vehicles, and Shipping Containers

Follow preparations as appropriate in above paragraphs for chamber, taped fumigation, or tarpaulin fumigation to assure good confinement of the gas for the recommended period of exposure.

Fumigation of Surface Ships in Port

Surface ships in size up to and including large ocean-going ships may be fumigated with Vikane to control the various pests listed. The professional fumigator and the ship's captain (or owner) shall follow all applicable regulations including those listed in the Coast Guard, DOT, Title 46, Shipping section, Parts 147A.1-147A.43. Except for those persons involved in fumigation, no people, plants, or pets may be on board during fumigation.

The person responsible for the fumigation must notify the master of the vessel, or his representative, of the requirements relating to personal protection equipment and detection equipment. Emergency procedures, cargo ventilation, periodic monitoring and inspections, and first aid measures must be discussed with and understood by the master of the vessel or his representative.

If leakage of the fumigant is detected, the person in charge of the fumigation shall take action to correct the leakage, or shall inform the master of the vessel, or his representative, of the leakage so that corrective action can be taken.

Food, feed, drugs, and medicinals shall not be exposed to the fumigant. If not removed from the vessel they shall be protected from exposure. The vessel must not be moved during the fumigation and aeration periods. If reentry is necessary before aeration is completed, positive pressure self-contained respiratory protection must be worn.

Warning Agent

Chloropicrin is a warning agent introduced into the structure during fumigation. In order to avoid direct exposure to the fumigant being released, chloropicrin must be released within the structure at least 5 to 10 minutes prior to introduction of the fumigant. Place a handful of wicking agent, (e.g., cotton) in a chloropicrin evaporation container(s). Do not use chloropicrin evaporation containers or application equipment made of magnesium, aluminum, or their alloys as chloropicrin may be severely corrosive to such metals. To enhance the distribution of chloropicrin throughout the structure, place the chloropicrin evaporation container in the air stream of a fan. Pour chloropicrin over the wicking agent. When adding chloropicrin to evaporation containers, dispense no more than 3 fl oz per container. Use 1 fl oz/10,000 to 15,000 cubic feet (30 ml/283 to 425 cubic meters) of space to be fumigated or follow dosage rate calculated by the electronic Fumiguide™ system. Establish at least one chloropicrin introduction site for each 45,000 cubic feet of space to be fumigated. Removal of all chloropicrin evaporation containers from the fumigated space during the initial phase of aeration after tarp removal will aid in the dissipation of the warning agent from the structure.

Chloropicrin need not be used when fumigating passenger railcars; however, a thorough walk-through inspection must be performed of each railcar with doors being immediately locked upon leaving each car, and a guard must be posted during fumigant introduction, exposure period, and aeration.

Chloropicrin is a warning agent which causes smarting of the eyes, tears, and discomfort, and has a very disagreeable pungent odor at very low concentrations. Chloropicrin must be used by persons certified to apply Vikane or under their supervision. Fumigators must observe the precautionary statements and safety recommendations appearing on the chloropicrin label.

Protective Clothing

Wear splash-resistant goggles or full face shield for eye protection during introduction of the fumigant. Do not wear gloves or rubber boots. Do not reuse clothing or shoes that have become contaminated with liquid Vikane until thoroughly aerated and cleaned.

Respiratory Protection

If the concentration of Vikane in the breathing zone of the fumigated area (as measured by a detector device with sufficient sensitivity such as an INTERSCAN, MIRAN [SapphIRe] or Spectros ExplorIR gas analyzers) does not exceed 1 ppm (4 mg/cubic meter), no respiratory protection is required. When this concentration is exceeded, all persons in the exposed area must wear a NIOSH or MSHA approved positive pressure self-contained breathing apparatus (SCBA, not SCUBA) or combination air-supplied/SCBA respirator such as manufactured by Ranger, Survivair, Scott, or MSA. Before using any make or brand of SCBA, learn how to use it correctly. Determine that it has an adequate air supply for the job at hand, that it fits properly, providing an adequate seal around the face, and that it is in good working order. For more detailed information on the source and use of air monitoring devices and respirators, consult the Vikane Gas Fumigant Structural Fumigation Manual.

Prefumigation Check: Check for potential leaks.

Securing Structure Entrances

To secure the structure against unauthorized entry during the fumigation exposure period and Step 2 of Aeration Procedure 1 or 2, use a locking device or barricade on all exterior doors or doorways. A locking device or barricade must be demonstratively effective in preventing an exterior door or doorway from being opened using normal opening or entering processes by anyone other than the certified applicator in charge of the fumigation or persons in his/her on-site direct supervision. Consult state and local regulations for any supplementary instructions and restrictions on securing against entry.

Dosage and Exposure Time

For fumigation to control drywood termites and non-egg stages of other insect and related structural and household pests, the Fumiguide calculator(s) is to be used for the coordination of fumigant rates with soil or slab temperature, exposure period, and fumigant loss rate measured as half-loss-time (HLT). When control of the egg stage is desired or when fumigating for Formosan termites, use the indicated multiple factor of the drywood termite dosage (as determined by Fumiguide calculator(s)) for pests listed in the following table:

Pest	Dosage Factor (as a multiple of drywood termite dosage)
rodents [†]	1/2X
carpet beetles ^{††} and cockroaches ^{††}	1X
furniture carpet beetles ^{††} and bedbugs	3X
old house borers and Formosan termites	4X
clothes moths	6X
powder post beetles and death watch beetles	10X

These dosages apply to dwellings, buildings, construction materials, furnishings, and vehicles.

[†]To determine the proper dose for rodent control, use 80°F as the calculating temperature. Unlike insects, rodents are warm blooded and do not require increased dosages at lower temperatures.

^{††}More than one fumigation may be needed to control the infestation after egg hatch.

For fumigation to control rodents, use sufficient gas to accumulate at least 36 ounce-hours following equilibrium, regardless of ambient air temperature. Refer to the Vikane Gas Fumigant Structural Fumigation Manual.

The Fumiguide B Calculator is to be used for unmonitored structures to coordinate fumigant rates with temperatures, a 20- to 24-hour exposure period, and an estimated HLT.

The Fumiguide Y Calculator is used in conjunction with Fumiguide B when fumigant concentrations are monitored and/or there are measured variations in exposure time.

The Fumiguide Calculator is a hand-held microprocessor which performs the functions of both the Fumiguide B and Y calculators and includes relative humidity as a calculating factor.

These calculators, Directions for Use, and referenced literature may be obtained from Dow AgroSciences.

Introducing the Fumigant

Release the fumigant from outside the structure, tarp, or vehicle. The release point(s) should be into a large open space(s) in the fumigation site(s). Release the fumigant through a suitable leak-proof tube with a minimum burst pressure of 500 pounds per square inch (psi). 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. Damage to household materials can occur if insufficient fan capacity is used for the rate of Vikane released. It is recommended that protective sheeting, such as polyethylene plastic under the shooting stand, shooting hose, and shooting fan be used to further protect floors during application. **To prevent damage, do not apply fumigant directly to any surface.**

Posting of Fumigated Areas

The applicator must post all entrances to the fumigated areas with signs bearing, in English and Spanish:

1. The signal word DANGER/PELIGRO and the SKULL and CROSSBONES symbol.
2. The statement, "Area under fumigation, DO NOT ENTER/ NO ENTRE."
3. The date of fumigation.
4. Name of fumigant used.
5. Name, address, and telephone number of the applicator.

Only a certified applicator may authorize removal of placards, and only when the concentration of Vikane in the breathing zones of the treated site is 1 ppm or less.

Aeration and Reentry

No one should be in treated areas if the level of Vikane is above 1 ppm unless provided with a NIOSH or MSHA approved positive pressure self-contained breathing apparatus (SCBA, not SCUBA) or combination air supplied/SCBA respirator such as manufactured by Ranger, Survivair, Scott, or MSA. **Note: During the initial one hour aeration procedure, approved respiratory protection must be worn until the concentration of Vikane is confirmed not to exceed 1 ppm with an approved detection device.** Since the INTERSCAN, MIRAN [SaphIRe] and Spectros ExplorIR gas analyzers give immediate readings, respiratory protection is not required when clearing with these instruments after having completed the initial one hour aeration procedure. If a reading indicates levels in excess of 1 ppm, leave the affected area immediately.

Only an approved detection device of sufficient sensitivity, such as the INTERSCAN, MIRAN [SaphIRe] or Spectros ExplorIR gas analyzer, can be used to confirm a concentration of Vikane of 1 ppm or less. The INTERSCAN must be calibrated according to manufacturer recommendations within one month prior to use as a clearance device. All other approved detection devices must be calibrated according to manufacturer recommendations. The concentration of Vikane must be monitored in breathing zones. Structure must remain posted for fumigation until cleared for reentry.

Open all operable attic doors and accesses and direct a fan into the attic. If the structure has an attached garage, the door between the garage and structure should be open. If the structure has a central air handling system, the fan (or blower) should be activated for each unit if operational. As an alternative, a fan may be placed in front of a furnace inlet to blow air into central heating and cooling ducts.

Select the appropriate procedure based on the fumigation rate:

All structures fumigated at 16 oz/MCF or less may be aerated using procedures 1 or 2.

All structures fumigated at concentrations greater than 16 oz/MCF must be aerated using procedure 2.

Aeration Procedure 1

These steps must be completed in sequence.

Step (1): Aerate structure with all operable windows and doors open, aided by the use of one or more fans, for a minimum of 1 hour. Total fan capacity, using one or more fans, shall be capable of displacing a total of 5,000 cfm.

Step (2): Secure structure and do not allow reentry for a minimum of 6 hours from the start of aeration (first opening of the seal). During this time structures must remain posted.

Step (3): After the minimum 6-hour waiting period, measure the concentration of Vikane in breathing zones of each room. If the concentration of Vikane is greater than 1 ppm, ventilate structure with operable doors and windows open and confirm concentrations are 1 ppm or less before the structure is reoccupied.

Aeration Procedure 2

These steps must be completed in sequence.

Step (1): Aerate structure with all operable windows and doors open, aided by the use of one or more fans, for a minimum of 1 hour. Total fan capacity, using one or more fans, shall be capable of displacing a total of 5,000 cfm.

Step (2): Secure the structure and do not allow reentry for a minimum of 8 hours from the start of aeration (first opening of the seal). During this time the structure must remain posted.

Step (3): After the minimum 8-hour waiting period, measure the concentrations of Vikane in breathing zones of each room. If the concentration of Vikane is greater than 1 ppm, ventilate structure with operable doors and windows open and confirm concentrations are 1 ppm or less before the structure is reoccupied.

For more detailed information on the source and use of air monitoring devices or respirators, consult the Vikane Gas Fumigant Structural Fumigation Manual. Do not reoccupy fumigation site, i.e., building, ship, vehicle or chamber, or move vehicle until aeration is complete. Warning signs must remain posted until aeration is determined to be complete.

Terms and Conditions of Use

If terms of the following Warranty Disclaimer, Inherent Risks of Use, and Limitation of Remedies are not acceptable, return unopened package at once to the seller for a full refund of purchase price paid. Otherwise, use by the buyer or any other user constitutes acceptance of the terms under Warranty Disclaimer, Inherent Risks of Use and Limitation of Remedies.

Warranty Disclaimer

Dow AgroSciences warrants that this product conforms to the chemical description on the label and is reasonably fit for the purposes stated on the label when used in strict accordance with the directions, subject to the inherent risks set forth below. Dow AgroSciences MAKES NO OTHER EXPRESS OR IMPLIED WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE OR ANY OTHER EXPRESS OR IMPLIED WARRANTY.

Inherent Risks of Use

It is impossible to eliminate all risks associated with use of this product. Plant injury, lack of performance, or other unintended consequences may result because of such factors as use of the product contrary to label instructions (including conditions noted on the label, such as unfavorable temperature, soil conditions, etc.), abnormal conditions (such as excessive rainfall, drought, tornadoes, hurricanes), presence of other materials, the manner of application, or other factors, all of which are beyond the control of Dow AgroSciences or the seller. All such risks shall be assumed by buyer.

Limitation of Remedies

To the extent permitted by law, the exclusive remedy for losses or damages resulting from this product (including claims based on contract, negligence, strict liability, or other legal theories), shall be limited to, at Dow AgroSciences' election, one of the following:

1. Refund of purchase price paid by buyer or user for product bought, or
2. Replacement of amount of product used.

Dow AgroSciences shall not be liable for losses or damages resulting from handling or use of this product unless Dow AgroSciences is promptly notified of such loss or damage in writing. In no case shall Dow AgroSciences be liable for consequential or incidental damages or losses.

The terms of the Warranty Disclaimer, Inherent Risks of Use, and this Limitation of Remedies cannot be varied by any written or verbal statements or agreements. No employee or sales agent of Dow AgroSciences or the seller is authorized to vary or exceed the terms of the Warranty Disclaimer or this Limitation of Remedies in any manner.

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Label Code: D02-069-015

Replaces Label: D02-069-014

LOES Number: 010-02064

EPA-Accepted 04/13/06

Revisions:

1. Added shipping containers as a place where Vikane may be used.
2. Clarified railcars as passenger railcars.
3. Added requirements for storing Vikane in an occupied building.
4. Added tobacco products to those items that should be removed for a structural fumigation.
5. Added instructions for fumigating multi-unit structures and connected structures.

MATERIAL SAFETY DATA SHEET



VIKANE* GAS FUMIGANT

Emergency Phone: 800-992-5994
Dow AgroSciences LLC
Indianapolis, IN 46268

Effective Date: 10/7/03
Product Code: 91503
MSDS: 000506

1. PRODUCT AND COMPANY IDENTIFICATION:

PRODUCT: Vikane* Gas Fumigant

COMPANY IDENTIFICATION:

Dow AgroSciences
9330 Zionsville Road
Indianapolis, IN 46268-1189

2. COMPOSITION/INFORMATION ON INGREDIENTS:

Sulfuryl fluoride	CAS# 002699-79-8	99.8%
Impurities Associated with the Active Ingredient		0.2%

This document is prepared pursuant to the OSHA Hazard Communication Standard (29 CFR 1910.1200). In addition, other substances not 'Hazardous' per this OSHA Standard may be listed. Where proprietary ingredient shows, the identity may be made available as provided in this standard.

3. HAZARDOUS IDENTIFICATIONS:

EMERGENCY OVERVIEW

Hazardous Chemical. Colorless, odorless compressed gas. Evacuate immediate area if leak occurs. Excessive vapor concentrations are attainable and a single exposure may cause death. Toxic to pets, fish, wildlife, and avian.

EMERGENCY PHONE NUMBER: 800-992-5994

POTENTIAL HEALTH EFFECTS: This section includes possible adverse effects, which could occur if this material is not handled in the recommended manner.

EYE: Essentially non-irritating to eyes. Liquid may cause frostbite.

SKIN: Essentially non-irritating to skin. Liquid may cause frostbite. No adverse effects anticipated by skin absorption.

INGESTION: Moderate toxicity if swallowed. The oral LD₅₀ for rats is 100 mg/kg. Swallowing is unlikely because of the physical state.

INHALATION: Vapor concentrations are attainable which may be fatal with single exposure. Excessive exposure may cause severe irritation to upper respiratory tract (nose and throat) and lungs. The LC₅₀ for a 4-hour exposure for rats is 991-1122 ppm.

SYSTEMIC (OTHER TARGET ORGAN) EFFECTS: In animals, effects have been reported on the following organs: brain, central nervous system, kidney, lung, respiratory tract and thyroid gland. Observations in animals include convulsions and tremors. May cause fluorosis of teeth and bones.

CANCER INFORMATION: Did not cause cancer in laboratory animals.

TERATOLOGY (BIRTH DEFECTS): Birth defects are unlikely. Exposures having no effect on the mother should have no effect on the fetus. Did not cause birth defects in animals; other effects were seen in the fetus only at doses which caused toxic effects to the mother.

REPRODUCTIVE EFFECTS: In animal studies, did not interfere with reproduction.

4. FIRST AID:

EYES: In case of frostbite, immediately flush eyes with water; remove contact lenses, if present, after the first 5 minutes, then continue flushing eyes for at least 15 minutes. Obtain medical attention promptly preferably from an ophthalmologist.

SKIN: If shoes, gloves, or clothing covering skin become wet with sulfuryl fluoride, immediately apply water to contaminated clothing before removing. Once area has thawed, remove contaminated items covering skin. Wash thoroughly or shower.

INGESTION: If swallowed, induce vomiting immediately as directed by medical personnel. Never give anything by mouth to an unconscious person. Seek medical attention.

INHALATION: Remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, oxygen should be administered by qualified personnel. Call a physician or transport to a medical facility.

MATERIAL SAFETY DATA SHEET



VIKANE* GAS FUMIGANT

Emergency Phone: 800-992-5994
Dow AgroSciences LLC
Indianapolis, IN 46268

Effective Date: 10/7/03
Product Code: 91503
MSDS: 000506

NOTE TO PHYSICIAN: Treatment of exposure should be directed at the control of symptoms and the clinical condition of the patient. Sulfuryl fluoride is a gas, which has no warning properties such as odor or eye irritation (however, chloropicrin is used as a warning agent and is a known lachrymator). The prediction of possible human effects is based in part on observations made on laboratory animals. It is predicted that persons exposed to sulfuryl fluoride will show little evidence of intoxication at first, unless the concentration is very high (>400 ppm). Early symptoms of exposure to sulfuryl fluoride are respiratory irritation and central nervous system depression. Excitation may follow. Slowed movement, reduced awareness, and slow or garbled speech may be noted. It is essential to keep such an individual at bed rest for at least 24 hours. Clinical observations should be directed at the pulmonary, hepatic, and renal systems. Prolonged exposure can produce lung irritation, pulmonary edema, nausea, and abdominal pain. Repeated exposure to high concentrations can result in significant lung and kidney damage. Convulsions may ensue with respiratory arrest being the terminal event. Assisted respiration may be necessary. Clinical observation is essential. There is no known antidote for over-exposure to sulfuryl fluoride.

5. FIRE FIGHTING MEASURES:

FLASH POINT: Not applicable
METHOD USED: Not applicable

FLAMMABLE LIMITS

LFL: Not combustible
UFL: Not combustible

EXTINGUISHING MEDIA: Sulfuryl fluoride is not combustible. However, if cylinders are in a fire area, water can be used to keep them cool to help prevent discharge of product caused by melted fusible plugs on the cylinders. Use of water will also help to scrub out part of any hydrofluoric acid and sulfur dioxide, which may be formed by decomposition of the product in a fire.

FIRE & EXPLOSION HAZARDS: Cylinders exposed to fire may vent and release toxic gas through melted fusible plugs on cylinders. Although sulfuryl fluoride is not combustible, in temperatures exceeding 400°C (752°F), it will degrade to form hydrogen fluoride and sulfur dioxide.

FIRE-FIGHTING EQUIPMENT: Wear positive-pressure, self-contained breathing apparatus and full protective clothing. When fighting fires in atmospheres containing potentially high concentrations of sulfuryl fluoride, encapsulating protective suits should be worn due to possible formation of hydrofluoric acid. Protective suit material should be compatible with exposure to hydrofluoric acid.

6. ACCIDENTAL RELEASE MEASURES:

ACTION TO TAKE FOR SPILLS/LEAKS: Evacuate immediate area if cylinder begins to leak. Use a NIOSH or MSHA approved positive-pressure, self-contained breathing apparatus (SCBA) or combination air-supplied/SCBA respirator, such as manufactured by Ranger, Survivair, Scott, or MSA, for entry into affected areas to correct problem. For leaking cylinders occurring near structure being fumigated, place the cylinder inside the designated structure if it can be done safely. If leaking cylinder occurs elsewhere, move leaking or damaged cylinder outdoors or to an isolated location, observing strict safety precautions. Work upwind if possible. Do not permit entry into leakage area by unprotected persons until concentration of fumigant is determined to be 5 ppm or less, as determined by a detection device with sufficient sensitivity such as an INTERSCAN or MIRAN gas analyzer. For detailed information on the source and use of air monitoring devices or respirators, consult Dow AgroSciences at 800-992-5994.

7. HANDLING AND STORAGE:

PRECAUTIONS TO BE TAKEN IN HANDLING AND STORAGE: Handling: Keep out of reach of children. Do not breathe gas. Keep all unnecessary people and pets out of area containing sulfuryl fluoride gas. Storage: Store in original container and away from heat and dwellings.

MATERIAL SAFETY DATA SHEET



VIKANE* GAS FUMIGANT

Emergency Phone: 800-992-5994
Dow AgroSciences LLC
Indianapolis, IN 46268

Effective Date: 10/7/03
Product Code: 91503
MSDS: 000506

8. EXPOSURE CONTROLS/PERSONAL PROTECTION:

These precautions are suggested for conditions where a potential for exposure exists. Emergency conditions may require additional precautions.

EXPOSURE GUIDELINE: Sulfuryl fluoride: ACGIH TLV is 5 ppm TWA, 10 ppm STEL. OSHA PEL is 5 ppm TWA.

ENGINEERING CONTROLS: Provide general and/or local exhaust ventilation to control airborne levels below the exposure guidelines. Lethal concentrations may exist in areas with poor ventilation.

RECOMMENDATIONS FOR MANUFACTURING, COMMERCIAL BLENDING, AND PACKAGING WORKERS:

RESPIRATORY PROTECTION: Atmospheric levels should be maintained below exposure guideline. When respiratory protection is required, use a NIOSH approved self-contained breathing apparatus or positive-pressure airline with auxiliary self-contained air supply. For emergency and other conditions where the exposure guideline may be exceeded, use a NIOSH approved positive-pressure self-contained breathing apparatus or positive pressure airline with auxiliary self-contained air supply. In confined or poorly ventilated areas, use a NIOSH approved self-contained breathing apparatus or positive pressure airline with auxiliary self-contained air supply.

SKIN PROTECTION: No special skin protection should be needed. Skin contact with the liquid may cause freeze damage if the liquid is confined to the skin; do not wear gloves or rubber boots.

EYE PROTECTION: Use chemical goggles.

APPLICATORS AND ALL OTHER HANDLERS: Refer to the product label for personal protective clothing and equipment.

9. PHYSICAL AND CHEMICAL PROPERTIES:

BOILING POINT: -67°F (-55°C)
VAPOR PRESSURE: 15.2 atmospheres @ 20°C
VAPOR DENSITY: 4.3 g/L @ 20°C
SOLUBILITY IN WATER: Practically insoluble
SPECIFIC GRAVITY: 1.35 @ 20°C
APPEARANCE: Colorless
ODOR: Odorless compressed gas

10. STABILITY AND REACTIVITY:

STABILITY: (CONDITIONS TO AVOID) Cylinders may leak or rupture in a fire.

INCOMPATIBILITY: (SPECIFIC MATERIALS TO AVOID) Strong base.

HAZARDOUS DECOMPOSITION PRODUCTS: Sulfur dioxide and hydrogen fluoride under fire conditions with hydrocarbons.

HAZARDOUS POLYMERIZATION: Not known to occur.

11. TOXICOLOGICAL INFORMATION:

MUTAGENICITY: In-vitro and animal genetic toxicity studies were negative.

12. ECOLOGICAL INFORMATION:

ENVIRONMENTAL FATE:

MOVEMENT & PARTITIONING:

Bioconcentration potential is low (BCF <100 or Log Pow <3).

Potential for mobility in soil is very high (Koc between 0 and 50).

Log octanol/water partition coefficient (Log Pow) is estimated using a structural fragment method to be 0.41. Soil organic carbon/water partition coefficient (Koc) is estimated to be 6.124.

Henry's Law Constant (H) is estimated to be 3.28E-02 atm-M³/mole.

DEGRADATION & PERSISTENCE:

The hydrolysis half-life is 18 minutes to 3 days.

MATERIAL SAFETY DATA SHEET



VIKANE* GAS FUMIGANT

Emergency Phone: 800-992-5994
Dow AgroSciences LLC
Indianapolis, IN 46268

Effective Date: 10/7/03
Product Code: 91503
MSDS: 000506

ECOTOXICOLOGY:

Material is highly toxic to aquatic invertebrates on an acute basis (LC₅₀ or EC₅₀ is between 0.1 and 1 mg/L.

Acute immobilization EC₅₀ in water flea (*Daphnia magna*) is 0.62 mg/L.

Growth inhibition EC₅₀ in green alga (*Selenastrum capricornutum*) is 3.05 mg/L.

Growth inhibition EC₅₀ in green alga (*Selenastrum capricornutum*) is 0.83 mg/L.

13. DISPOSAL CONSIDERATIONS:

DISPOSAL METHOD: Promptly return all empty cylinders to Dow AgroSciences. Wastes are toxic. Improper disposal of excess waste is a violation of federal law. If these wastes can not be disposed of by use according to label instruction, consult your state pesticide or the hazardous waste representative at the nearest EPA regional office for guidance.

14. TRANSPORT INFORMATION:

U.S. DEPARTMENT OF TRANSPORTATION (DOT) INFORMATION:

Do not ship this material by air.

For all other modes of transportation:
SULFURYL FLUORIDE/2.3/UN/2191/POISON
INHALATION HAZARD/ZONE D

15. REGULATORY INFORMATION:

NOTICE: The information herein is presented in good faith and believed to be accurate as of the effective date shown above. However, no warranty, express or implied, is given. Regulatory requirements are subject to change and may differ from one location to another; it is the buyer's responsibility to ensure that its activities comply with federal, state or provincial, and local laws. The following specific information is made for the purpose of complying with numerous federal, state or provincial, and local laws and regulations.

U.S. REGULATIONS

SARA 313 INFORMATION: This product contains the following substances subject to the reporting requirements of Section 313 of Title III of the Superfund Amendments and Reauthorization Act of 1986 and 40 CFR Part 372:

CHEMICAL NAME	CAS NUMBER	CONCENTRATION
Sulfuryl Fluoride	002699-79-8	99.8%

SARA HAZARD CATEGORY: This product has been reviewed according to the EPA "Hazard Categories" promulgated under Sections 311 and 312 of the Superfund Amendment and Reauthorization Act of 1986 (SARA Title III) and is considered, under applicable definitions, to meet the following categories:

An immediate health hazard
A delayed health hazard
A sudden release of pressure hazard
A reactive hazard

TOXIC SUBSTANCES CONTROL ACT (TSCA): All ingredients are on the TSCA inventory or are not required to be listed on the TSCA inventory.

MATERIAL SAFETY DATA SHEET



VIKANE* GAS FUMIGANT

Emergency Phone: 800-992-5994
Dow AgroSciences LLC
Indianapolis, IN 46268

Effective Date: 10/7/03
Product Code: 91503
MSDS: 000506

STATE RIGHT-TO-KNOW: The following product components are cited on certain state lists as mentioned. Non-listed components may be shown in the composition section of the MSDS.

CHEMICAL NAME	CAS NUMBER	LIST
Sulfuryl Fluoride	002699-79-8	NJ3 PA1

NJ3=New Jersey Workplace Hazardous Substance (present at > or = to 1.0%).
PA1=Pennsylvania Hazardous Substance (present at > or = to 1.0%).

OSHA HAZARD COMMUNICATION STANDARD: This product is a "Hazardous Chemical" as defined by the OSHA Hazard Communication Standard, 29 CFR 1910.1200.

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA) RATINGS:

Category	Rating
Health	3
Flammability	0
Reactivity	1

COMPREHENSIVE ENVIRONMENTAL RESPONSE COMPENSATION AND LIABILITY ACT (CERCLA, or SUPERFUND): To the best of our knowledge, this product contains no chemical subject to reporting under CERCLA.

16. OTHER INFORMATION:

MSDS STATUS: Revised Section: 2, 3, 4, 8, 11, 12 & 14
Reference: DR-0015-5588
Replaces MSDS dated: 5/22/01
Document Code: D03-069-447
Replaces Document Code: D03-069-446

The Information Herein Is Given In Good Faith, But No Warranty, Express or Implied, Is Made. Consult Dow AgroSciences for Further Information.

Specimen Label



Chloropicrin

Warning Agent

For Non-Pesticidal Use Only

For use only with Vikane® specialty gas fumigant.
Not for use with any other structural gas fumigant.

NOTE: Chloropicrin Warning Agent is a highly hazardous material and must be handled only by individuals trained in its proper use. Consult Dow AgroSciences for correct procedure before using.

Active Ingredient:	
chloropicrin	96%
Inert Ingredients	4%
Total	100%

Contains 13.7 lb of chloropicrin per gallon.

Keep Out of Reach of Children

**DANGER
PELIGRO**



POISON

Si usted no entiende la etiqueta, busque a alguien para que se la explique a usted en detalle. (If you do not understand the label, find someone to explain it to you in detail.)

IN ALL CASES OF OVEREXPOSURE, GET MEDICAL ATTENTION IMMEDIATELY BY TRANSPORTING TO AN EMERGENCY TREATMENT FACILITY.

First Aid

If inhaled: Remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. Get medical attention immediately.

If case of skin contact: Immediately flush skin with plenty of water for at least 30 minutes while removing contaminated clothing or other items covering the skin and shoes. Get medical attention. Wash clothing before reuse. Properly dispose of leather items such as shoes, belts, and watch bands.

If case of eye contact: Immediately flush eyes with plenty of water for at least 30 minutes. Remove contact lenses after the first 5 minutes and continue washing. Get medical attention immediately.

If swallowed: Do not induce vomiting. Give one cup (8 fl oz or 240 mL) of water or milk. Do not give anything by mouth to an unconscious person. Get medical attention immediately.

Note to Physician: Chloropicrin is a volatile liquid that is an active ingredient in tear gas. As a gas it is a powerful lacrymator. Symptoms of overexposure are profuse lacrymation, respiratory distress and vomiting. Pulmonary edema may develop later.

Precautionary Statements

Hazards to Humans and Domestic Animals

Causes Severe Burns Of Eye Or Skin. May Be Fatal If Absorbed Through The Skin. Causes Severe Burns of Mouth And Throat If Swallowed. May Be Fatal If Inhaled. May Cause Severe Allergic Respiratory Reaction. High Concentration Can Cause Lung Injury.

Do not get in eyes, on skin or on clothing. Avoid breathing gas/vapor. Do not take internally. Avoid prolonged or repeated respiratory contact. Use only with adequate ventilation. Wash thoroughly after handling.

Personal Protective Equipment

The following Personal Protective Equipment must be worn when handling and dispensing chloropicrin:

- Chemical-resistant gloves (such as neoprene)
- Full face shield or chemical goggles
- Respiratory Protection: When air concentrations exceed a level of 0.1 ppm, wear NIOSH or MSHA approved positive pressure self-contained breathing apparatus (SCBA, not SCUBA) or combination air-supplied/SCBA respirator such as manufactured by Ranger, Survivair, Scott, or MSA.

Chemical Hazard

Chloropicrin is severely corrosive of metal containers made of magnesium, aluminum, or their alloys.

Notice: Read the entire label before using. Use only according to label directions. **Before using this product, read Warranty Disclaimer, Inherent Risks of Use, and Limitation of Remedies elsewhere on this label. If terms are unacceptable, return at once unopened.**

In case of emergency endangering health or the environment involving this product, call 1-800-992-5994.

If you wish to obtain additional product information, visit our web site at www.dowagro.com.

Directions for Use

Storage and Handling

Storage: Store upright in a cool, dry, well-ventilated area under lock and key. Store only in original container. Do not contaminate water, food or feed by storage or disposal.

Spill and Leak Procedures: Evacuate immediate area of spill or leak. Use a self-contained breathing apparatus (SCBA) for entry into affected area to correct the problem. Move the leaking or damaged containers outdoors or to an isolated location, observing strict safety precautions. Work upwind if possible. Allow spilled material to evaporate, or absorb onto vermiculite, dry sand, earth, or similar absorbent material. Thoroughly aerate absorbent materials outdoors prior to disposing on site or at an approved disposal facility. Do not permit entry into spill area or cleanup area by unprotected persons until the concentration of chloropicrin is determined to be less than 0.1 ppm.

Disposal: Allow empty container to aerate with cap off within the fumigated space during fumigation. The location should be close to a fan and/or Chloropicrin introduction site. Replace cap. Dispose of container, after it has been aerated inside of the fumigated space, in a sanitary landfill or by other approved state and local procedures.

Chloropicrin is a warning agent introduced into the structure prior to fumigation with Vikane® specialty gas fumigant. In order to avoid direct exposure to the fumigant being released, chloropicrin must be released within the structure at least 5 to 10 minutes prior to introduction of the fumigant.

Place a handful of wicking agent (e.g., cotton) in a shallow chloropicrin evaporation container. Do not use containers or application equipment made of magnesium, aluminum, or their alloys, as chloropicrin may be severely corrosive to such metals. To enhance the distribution of chloropicrin throughout the structure, place the shallow chloropicrin evaporation container in the air stream of a fan. Pour chloropicrin over the wicking agent. When adding chloropicrin to evaporation containers, dispense no more than 3 fl oz per container. Use 1 fl oz per 10,000 to 15,000 cu ft (30 mL per 283 to 425 cubic meters) of space to be fumigated or follow dosage rate calculated by the electronic Fumiguide™ system. Use one introduction site per 20,000 to 45,000 cu ft.

Removal of all chloropicrin evaporation containers from the fumigated space during initial phase of aeration after tarp removal will aid in the dissipation of the warning agent from the structure.

Terms and Conditions of Use

If terms of the following Warranty Disclaimer, Inherent Risks of Use, and Limitation of Remedies are not acceptable, return unopened package at once to the seller for a full refund of purchase price paid. Otherwise, use by the buyer or any other user constitutes acceptance of the terms under Warranty Disclaimer, Inherent Risks of Use and Limitations of Remedies.

Warranty Disclaimer

Dow AgroSciences warrants that this product conforms to the chemical description on the label and is reasonably fit for the purposes stated on the label when used in strict accordance with the directions, subject to the inherent risks set forth below. Dow AgroSciences MAKES NO OTHER EXPRESS OR IMPLIED WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE OR ANY OTHER EXPRESS OR IMPLIED WARRANTY.

Inherent Risks of Use

It is impossible to eliminate all risks associated with use of this product. Personal injury (possibly including death), property (including plant) damage, lack of performance, or other unintended consequences may result because of such factors as use of the product contrary to label instructions, abnormal conditions (such as excessive wind or aeration), the manner of application, or other factors, all of which are beyond the control of Dow AgroSciences. All such risks shall be assumed by buyer.

Limitation of Remedies

To the extent permitted by law, the exclusive remedy for losses or damages resulting from this product (including claims based on contract, negligence, strict liability, or other legal theories), shall be limited to replacement of amount of product used.

Dow AgroSciences shall not be liable for losses or damages resulting from handling or use of this product unless Dow AgroSciences is promptly notified of such loss or damage in writing. In no case shall Dow AgroSciences be liable for consequential or incidental damages or losses.

The terms of the Warranty Disclaimer, Inherent Risks of Use, and Limitation of Remedies cannot be varied by any written or verbal statements or agreements. No employee or sales agent of Dow AgroSciences is authorized to vary or exceed the terms of the Warranty Disclaimer or this Limitation of Remedies in any manner.

®Trademark of Dow AgroSciences LLC

Dow AgroSciences LLC • Indianapolis, IN 46268 USA

Label Code: D02-152-004

Replaces Label: D02-152-003

LOES Number: 010-00009

Revisions:

1. Revised First Aid statements and Personal Protective Equipment requirements.
2. Revised dosage rates.

MATERIAL SAFETY DATA SHEET



CHLOROPICRIN

Emergency Phone: 800-992-5994
Dow AgroSciences LLC
Indianapolis, IN 46268

Effective Date: 16-Dec-05
Product Code: 16651
MSDS: 006416

1. PRODUCT AND COMPANY IDENTIFICATION:

PRODUCT: Chloropicrin

COMPANY IDENTIFICATION:

Dow AgroSciences LLC
9330 Zionsville Road
Indianapolis, IN 46268-1189

2. HAZARDOUS IDENTIFICATIONS:

EMERGENCY OVERVIEW

Hazardous. Colorless liquid with intensely irritating tear gas odor. May cause severe eye irritation with corneal injury which may result in permanent impairment of vision, even blindness. Painful irritation of the eyes at 1 ppm or less; a concentration of 15 ppm for longer than 1 minute is intolerable to humans. May cause severe skin burns. Classified as corrosive to skin according to DOT guidelines. Toxic to fish and aquatic organisms. DOT Classification is **CHLOROPICRIN, 6.1, UN1580, I, POISON-INHALATION HAZARD, HAZARD ZONE B.**

EMERGENCY PHONE NUMBER: 800-992-5994

3. COMPOSITION/INFORMATION ON INGREDIENTS:

Chloropicrin	CAS # 000076-06-2	96%
Trace quantities of water and HCl		4%

4. FIRST AID:

EYES: Wash Immediately and continuously with flowing water for at least 30 minutes. Remove contact lenses after the first 5 minutes and continue washing. Obtain prompt medical consultation, preferably from an ophthalmologist.

SKIN: Immediate continued and thorough washing in flowing water for at least 30 minutes is imperative while removing contaminated clothing. Prompt medical consultation is essential. Wash clothing before reuse. Properly dispose of leather items such as shoes, belts, and watchbands.

INGESTION: Do not induce vomiting. Give one cup (8 ounces or 240 ml) of water or milk if available and transport to a medical facility. Do not give anything by mouth to an unconscious person.

INHALATION: Move person to fresh air. If not breathing, give artificial respiration; if by mouth to mouth use rescuer protection (pocket mask, etc.) If breathing is difficult, oxygen should be administered by qualified personnel. Call a physician or transport to a medical facility.

NOTE TO PHYSICIAN: If methemoglobin is >10-20% consider Methylene blue 1-2 mg/kg body weight as 1% solution intravenously over 5 minutes followed by 15-30 cc flush (Price D, Methemoglobinemia, Goldfrank Toxicologic Emergencies, 5th Ed., 1994). If burn is present, treat as any thermal burn, after decontamination. Due to irritant properties, swallowing may result in burns/ulceration of mouth, stomach and lower gastrointestinal tract with subsequent stricture. Aspiration of vomitus may cause lung injury. Suggest endotracheal/esophageal control if lavage is done. Respiratory symptoms, including pulmonary edema, may be delayed. Persons receiving significant exposure should be observed 24-48 hours for signs of respiratory distress. Treatment of exposure should be directed at the control of symptoms and the clinical condition of the patient.

5. FIRE FIGHTING MEASURES:

FLASH POINT: Not combustible

METHOD USED: Not applicable

FLAMMABLE LIMITS

LFL: Not applicable

UFL: Not applicable

EXTINGUISHING MEDIA: All conventional extinguishing media are suitable.

FIRE & EXPLOSION HAZARDS: Not a combustible. Heated material decomposes violently at 233°F (112°C) especially when in contact with metals. Toxic and irritating gases will emit.

FIRE-FIGHTING EQUIPMENT: Wear self-contained breathing apparatus and protective clothing, evaluate area, cool containers with water spray from remote location.

MATERIAL SAFETY DATA SHEET



CHLOROPICRIN

Emergency Phone: 800-992-5994
Dow AgroSciences LLC
Indianapolis, IN 46268

Effective Date: 16-Dec-05
Product Code: 16651
MSDS: 006416

6. ACCIDENTAL RELEASE MEASURES:

ACTION TO TAKE FOR SPILLS/LEAKS: Evacuate immediate area of spill or leak. Use an approved air purifying respirator approved for organic vapors, self contained breathing apparatus, or an air supplied respirator. Move leaking or damaged containers outdoors or to an isolated location. Allow spilled material to evaporate into dry sand, earth or similar absorbent material, which may be disposed on site, or at an approved disposal facility. Do not permit entry into spill area or clean-up area by unprotected persons until concentration of chloropicrin is determined to be less than 0.1 ppm. Contact Dow AgroSciences at 800-992-5994 for large spills.

7. HANDLING AND STORAGE:

PRECAUTIONS TO BE TAKEN IN HANDLING AND STORAGE: Avoid any possible contact with liquid or vapor. Measure chloropicrin concentration with a Matheson-Kitagawa detection device using tube 172. Store upright in a cool, dry, well ventilated area under lock and key. Post as a pesticide storage area. Do not contaminate water, food, or feed by storage or disposal. Persons moving or handling containers should wear protective clothing. Open container only in a well ventilated area wearing protective clothing and respiratory protection if necessary.

8. EXPOSURE CONTROLS/PERSONAL PROTECTION:

These precautions are suggested for conditions where the potential for exposure exists. Emergency conditions may require additional precautions.

EXPOSURE GUIDELINE(S):

Chloropicrin: ACGIH TLV and OSHA PEL are 0.1 ppm. ACGIH classification is A4.

ENGINEERING CONTROLS: Provide general and/or local exhaust ventilation to control airborne levels below the exposure guidelines. Lethal concentrations may exist in areas with poor ventilation.

RECOMMENDATIONS FOR MANUFACTURING, COMMERCIAL BLENDING, AND PACKAGING WORKERS:

RESPIRATORY PROTECTION: Atmospheric levels should be maintained below the exposure guideline. When respiratory protection is required, use an approved self-contained breathing apparatus or positive pressure air line with auxiliary self-contained air supply.

SKIN PROTECTION: Use protective clothing chemically resistant to this material. Selection of specific items such as face shield, gloves, boots, apron, or full body suit will depend on operation. Use gloves chemically resistant to this material, at all times. Safety shower should be located in immediate work area. Remove contaminated clothing immediately, wash skin area with soap and water, and launder clothing before reuse. Items which cannot be decontaminated, such as shoes, belts and watchbands, should be removed and disposed of properly.

EYE/FACE PROTECTION: Use chemical goggles. Wear a face-shield which allows use of chemical goggles, or wear a full-face respirator to protect face and eyes when there is any likelihood of splashes. Eye wash fountain should be located in immediate work area.

APPLICATORS AND ALL OTHER HANDLERS: Please refer to the product label for personal protective clothing and equipment.

9. PHYSICAL AND CHEMICAL PROPERTIES:

BOILING POINT: 233°F (112°C)

VAPOR PRESSURE: 18.3 @ 20°C

VAPOR DENSITY: Approximately 5.7 (Air = 1.0)

SOLUBILITY IN WATER: 0.2 g/100 g

SPECIFIC GRAVITY: 1.66

APPEARANCE: Colorless liquid

ODOR: Intensely irritating tear gas odor

MATERIAL SAFETY DATA SHEET



CHLOROPICRIN

Emergency Phone: 800-992-5994
Dow AgroSciences LLC
Indianapolis, IN 46268

Effective Date: 16-Dec-05
Product Code: 16651
MSDS: 006416

10. STABILITY AND REACTIVITY:

STABILITY: (CONDITIONS TO AVOID) Unstable under fire conditions. Avoid temperatures above 140°F (60°C)

INCOMPATIBILITY: (SPECIFIC MATERIALS TO AVOID)
Organic amines, reducing agents and sulfuric acid.
Incompatible with containers or equipment made of aluminum, magnesium or their alloys.

HAZARDOUS DECOMPOSITION PRODUCTS: Highly toxic phosgene and toxic nitrogen oxide.

HAZARDOUS POLYMERIZATION: Not known to occur.

11. TOXICOLOGICAL INFORMATION:

POTENTIAL HEALTH EFFECTS: This section includes possible adverse effects which could occur if this material is not handled in the recommended manner.

EYE: May cause pain disproportionate to the level of irritation to eye tissues. May cause severe eye irritation with corneal injury, which may result in permanent impairment of vision even blindness. Chemical burns may occur. Vapors cause lacrimation, and painful irritation of the eyes at 1 ppm or less; a concentration of 15 ppm for longer than 1 minute is intolerable to humans because of the intense irritation produced.

SKIN: Brief contact may cause severe skin burns. Symptoms may include pain, severe local redness and tissue damage. Classified as corrosive to skin according to DOT guidelines. Vapor may cause skin irritation. May cause more severe response if skin is abraded (scratched or cut). Prolonged or widespread skin contact may result in absorption of amounts which could cause death. The LD₅₀ for skin absorption in rabbits is 62 mg/kg.

INGESTION: Moderate toxicity if swallowed. The oral LD₅₀ for male rats is 250 mg/kg. Swallowing may result in burns of the mouth and throat. Swallowing may result in gastrointestinal irritation or ulceration. In animals, effects have been reported on the following organs: liver. Aspiration into the lungs may occur during ingestion or vomiting, causing tissue damage or lung injury.

INHALATION: Initial symptoms due to low-level exposure may not seem severe but death may ensue due to delayed effects of lung injury and/or infection. Brief exposure (minutes) to easily attainable concentrations may cause serious adverse effects, even death. Excessive exposure may cause lung injury. May cause methemoglobinemia, thereby impairing the blood's ability to transport oxygen. In humans, effects have been reported on the following organs: heart, kidney, and liver. In humans, symptoms may include: blue lips and fingernails, nausea and/or vomiting, diarrhea, abdominal discomfort. May cause central nervous system effects. DOT Classification is **CHLOROPICRIN, 6.1, UN1580, I, POISON-INHALATION HAZARD, HAZARD ZONE B.**

SYSTEMIC (OTHER TARGET ORGAN) EFFECTS: Effects have been reported on the following organ: gastrointestinal tract.

CANCER INFORMATION: Available data are inadequate to evaluate carcinogenicity.

TERATOLOGY (BIRTH DEFECTS): Did not cause birth defects in laboratory animals. Has been toxic to the fetus in laboratory animals at doses toxic to the mother.

REPRODUCTIVE EFFECTS: Did not interfere with reproduction in laboratory animal studies.

MUTAGENICITY: Has been shown to have mutagenic activity in bacteria. Animal genetic toxicity studies were inconclusive.

MATERIAL SAFETY DATA SHEET



CHLOROPICRIN

Emergency Phone: 800-992-5994
Dow AgroSciences LLC
Indianapolis, IN 46268

Effective Date: 16-Dec-05
Product Code: 16651
MSDS: 006416

12. ECOLOGICAL INFORMATION:

ENVIRONMENTAL FATE

MOVEMENT & PARTITIONING:

Bioconcentration potential is low (BCF <100 or Log Pow <3).
Potential for mobility in soil is high (Koc between 50 and 150).

Measured log octanol/water partition coefficient (Log Pow) is 2.09.

Log octanol/water partition coefficient (Log Pow) is estimated using a structural fragment method to be 1.32.

Soil organic carbon/water partition coefficient (Koc) is estimated to be 36.05-62.

Log air/water partition coefficient (Log Kaw) is -1.15.
Henry's Law Constant (H) is estimated to be 2.15E-03 atm-M3 mole.

DEGRADATION & PERSISTENCE:

Tropospheric half-life is estimated to be 4.8 hours.

Theoretical oxygen demand (ThOD) is calculated to be 0.10 p/p.

ECOTOXICOLOGY:

Material is very highly toxic to fish on an acute basis (LC₅₀ is <0.1 mg/L in most sensitive species).

13. DISPOSAL CONSIDERATIONS:

DISPOSAL METHOD: If wastes and/or containers cannot be disposed of according to the product label directions, disposal of this material must be in accordance with your local or area regulatory authorities.

This information presented below only applies to the material as supplied. The identification based on characteristic(s) or listing may not apply if the material has been used or otherwise contaminated. It is the responsibility of the waste generator to determine the toxicity and physical properties of the material generated to determine the proper waste identification and disposal methods in compliance with applicable regulations.

If the material as supplied becomes a waste, follow all applicable regional, national and local laws and regulations.

14. TRANSPORT INFORMATION:

U.S. DEPARTMENT OF TRANSPORTATION (DOT) INFORMATION:

For non-bulk package sizes by land or rail:
CHLOROPICRIN/6.1/UN1580/PG I/POISON
INHALATION HAZARD//ZONE B

For bulk packages and all shipments by vessel:
CHLOROPICRIN/6.1/UN1580/PG I/MARINE
POLLUTANT/POISON INHALATION HAZARD//ZONE B

15. REGULATORY INFORMATION:

NOTICE: The information herein is presented in good faith and believed to be accurate as of the effective date shown above. However, no warranty, express or implied, is given. Regulatory requirements are subject to change and may differ from one location to another; it is the buyer's responsibility to ensure that its activities comply with federal, state or provincial, and local laws. The following specific information is made for the purpose of complying with numerous federal, state or provincial, and local laws and regulations.

U.S. REGULATIONS

SARA 313 INFORMATION: This product contains the following substances subject to the reporting requirements of Section 313 of Title III of the Superfund Amendments and Reauthorization Act of 1986 and 40 CFR Part 372:

CHEMICAL NAME	CAS NUMBER	CONCENTRATION
Chloropicrin	000076-06-2	96%

SARA HAZARD CATEGORY: This product has been reviewed according to the EPA "Hazard Categories" promulgated under Sections 311 and 312 of the Superfund Amendment and Reauthorization Act of 1986 (SARA Title III) and is considered, under applicable definitions, to meet the following categories:

An immediate health hazard
A delayed health hazard

MATERIAL SAFETY DATA SHEET



Emergency Phone: 800-992-5994
Dow AgroSciences LLC
Indianapolis, IN 46268

Effective Date: 16-Dec-05
Product Code: 16651
MSDS: 006416

CHLOROPICRIN

TOXIC SUBSTANCES CONTROL ACT (TSCA): All ingredients are on the TSCA inventory or are not required to be listed on the TSCA inventory.

STATE RIGHT-TO-KNOW: The following product components are cited on certain state lists as mentioned. Non-listed components may be shown in the composition section of the MSDS.

CHEMICAL NAME	CAS NUMBER	LIST
Chloropicrin	000076-06-2	NJ2 NJ3

NJ2=New Jersey Environmental Hazardous Substance (present at greater than or equal to 1.0%).

NJ3=New Jersey Workplace Hazardous Substance (present at greater than or equal to 1.0%).

OSHA HAZARD COMMUNICATION STANDARD: This product is a "Hazardous Chemical" as defined by the OSHA Hazard Communication Standard, 29 CFR 1910.1200.

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA) RATINGS:

Health	4
Flammability	0
Reactivity	3

COMPREHENSIVE ENVIRONMENTAL RESPONSE COMPENSATION AND LIABILITY ACT (CERCLA, or SUPERFUND): To the best of our knowledge, this product contains no chemical subject to reporting under CERCLA.

16. OTHER INFORMATION:

MSDS STATUS: Revised Sections: 2, 3, 4, 8, 11, 12 & 14
Reference: DR-0001-6375
Replaces MSDS Dated: 7/22/99
Document Code: D03-000-003
Replaces Document Code: D03-000-002

The Information Herein Is Given In Good Faith, But No Warranty, Express Or Implied, Is Made. Consult Dow AgroSciences For Further Information.