A Therma-Stor® LLC White Paper

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HEAT TREATMENT:

A FIELD STUDY IN BEDBUG CONTROL

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THE PROBLEMATIC BEDBUG

There are many theories as to why bedbugs have emerged in the last decade as one of the preeminent blood feeding insects. Opinions range from the loss through regulation of organophosphate and carbamates pesticides available to the Pest Control Operator, the increase in baiting programs for insects such as ants and cockroaches which has lead to an overall reduction in the baseboard spraying more common in the past, and an increase in world travel to and from countries where bedbugs are more accepted as a pest people are accustomed to tolerating. During a recent interview with a medical professional from an African nation about the fact that she had brought bedbugs to a client in America, she was asked 'Did you know you had bedbugs?' her response was, 'Doesn't everyone?'

Whatever the reason for their resurgence, this paper will shed some light on how to control bedbugs with heat, the successes and failures, and what the PCO needs to know before entering this potentially lucrative and challenging market.

THERMA-STOR TECHNOLOGIES

Therma-Stor LLC, located in Madison, Wisconsin, was established in 1977 to apply advanced heat transfer technologies to residential and commercial markets. Beginning with heat recovery water heaters, Therma-Stor also manufactures a line of residential and commercial dehumidifiers, air scrubbing, water extraction, and evaporative drying products. With some of the most powerful heat transfer equipment already in use worldwide, it was a small leap for the corporation to enter the field of heat treatment control for insect pests with an initial focus on the exploding bed bug market. In 2009 the decision was made to test already available technologies in the field for the control of bedbugs. Though much research has been done, and there were already a lot of opinions as to the efficacy of using heat to kill bedbugs, Therma-Stor engineers launched an extensive series of real life, field studies to prove or disprove the current facts and opinions about this specialized service. As such, it is the intent of this paper to explain basic bedbug control, and what actually worked and did not work when employing thermal remediation for bedbug control in these field studies.

PREVIOUS AND ALTERNATE OPTIONS

Resistance and cross-resistance (when pests become resistant to one class of insecticide, they soon can resist others with similar modes of action) to pesticides have been documented through university studies across the country. These small insects, barely visible in their nymphal stage, are hard to find and even harder to reach with pesticides. Most currently labeled pyrethroid products do not allow for the direct treatment on mattresses, and even when the mattress can be treated directly, the bedbug will harbor in the deep cracks and crevices of the boxspring and mattress itself. What is even more frustrating to the client with bedbugs, and the PCO is that often persons living in the dwelling will experience bites while

sleeping but no insects can be found. This presents a real problem for the IPM approach which suggests that we should first identify and locate the insect pest before making a treatment using chemicals. There are isopropyl based products that do not show resistance to date. Though effective on contact, these products have the same inherent use problem as other liquids, namely that you have to get to where the insects are and get them to come in contact with the product while it still transmits a lethal dose.

Physical barriers like the ClimbUp Insect Interceptor™ will stop the bedbugs from climbing up the legs of couches, chairs, bed posts and other furniture where people sleep. Experience tells us that bedbugs will crawl out to the center of a ceiling and drop down on the human heat source. Bedbug proof mattresses are another physical barrier that stops the insects from establishing a home in the mattress and killing the ones trapped inside over time because they cannot get a blood meal. Carbon dioxide based monitors are available that monitor bedbugs, but elimination is not the goal of this product as it is primarily a monitor that will have some effect on the overall population.

At present, there are no biological control methods for this insect. That is, we do not have another living organism we can place inside the structure that will kill the bedbug. Freezing temperatures and steam can kill bedbugs but are only effective if you can get them to where the insects are hiding.

There are some dust formulations that work more as desiccants than toxicants, e.g. boric acid and Diatomaceous earth formulations. These, too, are effective products, but only if the insects interact with them.

Prior to heat technology, the only proven method of penetrating every crack and crevice and wall void where the bedbug might harbor was sulfuryl fluoride. Though very effective in killing bedbugs, the regulations regarding transport, purchase and application of this federally restricted lethal gas are costly in both time and labor.

In June of 2009, the Centers for Disease Control and Prevention (CDC) stated in a published article that *"Clusters of bedbug-infestation cases are well known in various communities, especially where living conditions are poor or in urban environments... Because this type of outbreak (dermatitis) in a medical facility can be considered healthcare associated, medicolegal implications must be considered and appropriate control measures adapted."* In other words, the bedbugs themselves do not spread disease, but in some cases cause skin lesions and the physicians and facilities rendering care to patients may be on the hook for damages. Until bedbugs are proven to spread disease and this is documented, as in the case of mosquitoes and West Nile Virus, it is unlikely that that our own Environmental Protection Agency will fast track new pesticides or reinstate unregistered products that may help control this bedbug population explosion.

THE HEAT SOLUTION

BENEFITS

It is often said that 'nature abhors a vacuum' and so does the pest control operator. It wasn't long before entrepreneurial PCOs began to experiment with the use of heat to kill bedbugs, especially with the profit draining call-backs associated with this insect. Many companies we have interviewed either refuse to take on bedbug business—a potentially lucrative source of revenue—or take it with disclaimers up to and including no guarantees that the customer's problem will be solved. A tough sell in any economic cycle, more so in the current flat economy.

If heat could be proven effective in most cases against the bedbug the benefits would include:

- A "green solution", no pesticides needed.
- No EPA or state approval.
- No concern for chemically sensitive occupants of the building, children or pets.
- Elimination of pesticide based lawsuits, regulations and licensing.
- No Personal Production Equipment associated with the handling of chemicals.
- No chemical contamination of property, internal or external environments.
- Customers will no longer be told they need to throw away mattresses and other valuable but infested furnishings.

THE PROJECT

We know that heat kills; but at what temperature and duration? Do published studies performed in a laboratory prove to be true in the field? Before Therma-Stor began marketing their brand of heat treatment to the pest control community, they knew they had to conduct their own extensive research in real life field conditions. With such a wide range of information, some seemingly contradictory, about the effectiveness of high temperatures on bedbugs, it would not be acceptable to base their strategy simply on the word and research of others. Several sites were chosen in New York, New Jersey and Pennsylvania.

Bio assays were performed where live bedbugs in various stages of development were placed in closed vials and distributed throughout the structures to be treated. Some were placed directly on top of furniture, some inside walls, and others inside furniture at various heights within the structure. Bedbugs used in the bioassays were harvested from populations in New York City and New Jersey. Some of the buildings had been previously treated with pesticides; others had never been treated. The temperatures for the bioassays were taken with a laser thermometer. Readings were taken through the glass vials and around the surface directly where the vials were placed with a Fluke Laser Distance Meter.

Adult and nymph bedbugs placed within the structure at various locations visible to the naked eye (dresser tops, dresser drawers, tables, window sills, closets) were unaffected at temperatures below 105°F. Temperatures above this level showed adult and nymph bedbugs began to move around the vial as if agitated. It is not possible to discern whether they were trying to move away from or toward a heat source. Mortality was witnessed at varying temperatures, depending on the duration of exposure to the heat source. At 110°F the insects were very active, and attempted to crawl up the vial walls. At 113°F with an exposure time of three minutes the bedbugs began to turn over, their legs curled and they appeared dead. We took them outside later to see if they would revive, but they did not. Insects at ambient external air temperature varying from 70-80 °F were brought into the buildings and placed on surfaces and in areas of the building where temperatures were recorded to be 126°F. Those insects brought from the outside and placed into the structure at this temperature died within one minute.

It appears that not all bedbugs are created equal. Some of the bedbugs placed in the building were able to withstand temperatures of only 118°F for one minute and died, while others at temperatures of 126°F were able to last just over two minutes. One adult bedbug was able to withstand 115°F for six minutes before expiring.

What about behind the walls? Can temperatures high enough to kill bedbugs be reached behind the walls? We cored a two inch hole through one side of a plaster wall, suspended a wireless data logger within the wall and resealed the opening. The data logger recorded that temperatures in the range of 135°F were reached within the wall approximately 15 minutes after the exterior of the same wall reached that temperature. If enough BTU/hr are available and sufficient number of fans to move the air, interior wall temperature should not be a problem.

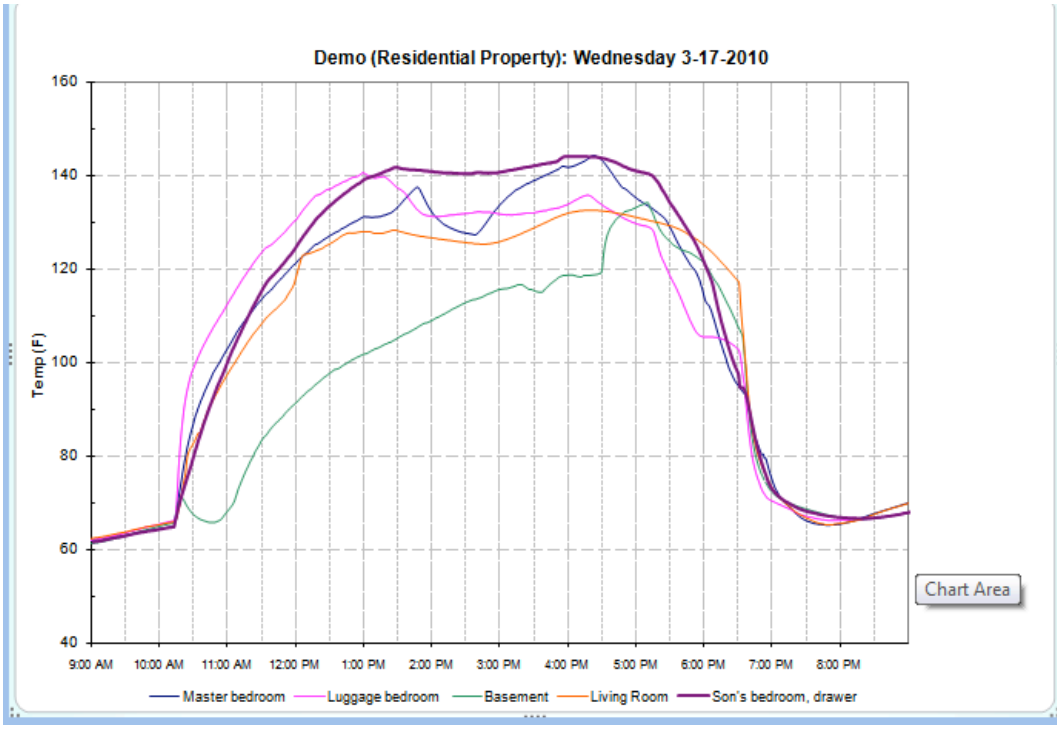
So we have learned that temperature in itself is important, but the duration of exposure (as with conventional liquid pesticide and fumigants) must be taken into consideration. Field studies show us that if you can reach the critical temperatures throughout the structure in excess of 126°F for several minutes, mortality will be assured.

RESOURCES NEEDED

This will vary with the size and location of the area to be treated. You can approximate the amount of heat units you will need based on square footage, though cubic footage is most important. Assuming an average ceiling height of eight feet, three 30,000 BTU/hr units and at least five fans with a capacity of 3,000 cubic feet per minute (CFM) will be needed to treat a typical 1,000 square foot apartment. Take into consideration set-up time, performing a pre-treatment checklist, the unexpected, and tear down time; two reasonably athletic employees will take a full 8 hour day to complete the task.

By performing these field studies in single family homes, multi-level apartment buildings and single level apartments, we have learned that a square foot is not a square foot when it comes to heat dispersal. For instance, the amount of heat needed to raise the temperature in a below ground basement can be twice that required to heat the same space on the second floor. Heat rises, and basements are cooled by the average ground temperature of about 50-55°F. In the example below (Figure 1) you can see that most rooms in the house exceeded 120F° at approximately 11:30 AM on the morning of the heat treatment. It took the basement (indicated by the green line) until 4:30, and even then the basement did not reach the higher temperature levels of the other rooms. Bringing below grade basements up to the proper temperature to kill bedbugs is a major consideration when employing a heat treatment and should be considered when pricing the job as the PCO will need more BTUs and time in this section of the structure.

Figure 1.



Once you have enough units to generate the desired heat, and the fans to move them, it is imperative that you monitor the structure with data loggers that can detect cool spots or hot spots in the treatment area and make adjustments as needed.

OBSTACLES TO SUCCESS

- Experience show us that what can go wrong will go wrong. The process always starts with the applicator and the initial sale of the service. Customer expectations are set very high, and the need for preparation is not stressed enough. Case in point: After treating one unit in Manhattan, and confirming with bio-assays that we reached the correct temperature and duration to kill the bedbugs, within minutes of the tenants returning, bedbugs were found crawling across the floors and bed in one apartment. After some detective work, two problems were evident. This tenant had stowed away compressed clothes inside a laundry bag (the heat cannot penetrate through compressed clothing), and the tenant had returned with infested clothing she took with her to stay at a friend's during the thermal remediation, and immediately unpacked, dispersing bedbugs into the apartment.
- Customers are given a checklist of all items that must be removed from the unit and/or stored in the refrigerator. These include common household items like corked wine bottles, chocolates, and candles. Though our team always completed a pre-treatment checklist to confirm the extent of the customer's preparation, we missed a candle that was molded and colored to look like a setting of artificial flowers. After the treatment, it was found on the floor in a much flatter form than the artist originally planned. Cardinal rule: clutter kills. If the treatment area is stacked with clutter, clothes, books, etc., heat penetration will be severely impacted.
- The importance of "fluffing" or flipping the clothes during the application cannot be overstressed. Heat readings were taken in one apartment where the walls were at 140°F, but the interior temperature of a compressed pile of clothing was only in the 90°F range. These readings were taken after several hours of sustained heat within the structure at temperatures that would kill bedbugs. Clearly, any insects inside clothes piles would not have died had we not flipped the pile.
- Hot and cool spots from within the rooms: the more heating units and the more fans to move the air around, the better. Therma-Stor uses stackable electric fans that move 3,000 CFM of hot air around the room, in conjunction with the fans in the heating units themselves. During the treatment, these fans should be moved around and redirected as temperature readings require. These insects are going to try to survive, and if they can find a cool spot before fatal temperatures are reached, they may hide there.

WORKER/PUBLIC SAFETY

It should be clearly stated that any PCO considering entering the heat treatment marketplace be prepared to train their employees in safe handling of electricity, lifting, and walking working surfaces. If you are using high voltage—such as 440V or more—necessary precautions must be taken to keep the public away from this electrical hazard.

Inspect for pesticide dusts that may have been placed by the tenant or previous pesticide applicator. When the unit is heated, and the fans turned on, these dusts will become airborne and the area should not be entered without the proper respiratory protection. Any pesticide or others chemical dusts not in wall voids should be removed manually or with a HEPA rated vacuum prior to thermal remediation.

THE THERMA-STOR MODEL

All heat kills, but we only want to kill the bedbugs. Heat systems currently range from small off-the-shelf propane and electric units to larger, multi-component models that produce their own electricity through a diesel or a propane fired generator. Heat and electricity create their own safety problems and are inherently hazardous to use if the proper safety precautions are not taken.

Prior to Therma-Stor, major competitors in the bedbug heat treatment arena based their programs on electric powered heaters running from a main generator that requires 480-600 volts of electricity. Each separate unit could weigh as much as 225 pounds, and put out about 25,000 BTU/hr, depending on the model. Some of the units measure 29 inches wide, and will fit through modern building doors and hallways, but often have to have the wheels removed to get into more narrow hallways and doors of older architecture.

Therma-Stor's product has solved these problems by using a uniquely patented glycol heat transfer unit that runs on 110V and puts out 300,000 BTU/hr. Because the liquid based (hydronic) heat source is generated from a burner outside the structure, the heating units inside the building can be much smaller, weighing only 80 pounds and measuring only 20 inches wide. Large wheels allow a single person to install these units with no problems getting into narrow hallways and doors of older buildings as well as up and down stairs.

EXPECTED RESULTS

If you bring enough BTUs to the site, the customer prepares the structure properly, you have enough fans to move the air, proper monitoring of heat stratification is performed, and the necessary labor force is in place, you can expect a one hundred percent kill if the temperature is held for the necessary duration.

But what about reinfestation? This will depend on your customer type. If it is a patient oriented property, such as a psychiatric center, procedures can be put in place to stop bedbugs from being reintroduced. One location in New York requires all new clients to go through a check-in procedure that includes: laundering and drying of clothes, a shower, and inspection of all personal items. In one field study the homeowner likely picked up the bedbugs through travel. Their house was uncluttered and well kept. No bedbugs or bites were detected several months after the treatment.

Multiple dwelling units present other problems such as reinfestation from a neighbor. Depending on your business model and propensity toward the use of pesticides, a void treatment with pesticide dust and/or liquid residuals may be appropriate. There are EPA exempt products on the market that will still allow the PCO to market their bedbug control program as a green alternative.

Heat treatment is an excellent tool in the growing business of bedbug control, and is another means by which the PCO can give their customer back the peaceful sleep they desire.