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USACHPPM TECHNICAL GUIDE No. 208

Procedures for Thermal Control of Cockroaches in Army Food Service Facilities

United States Army Center for Health Promotion and Preventive Medicine

Readiness Thru Health

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PROCEDURES FOR THERMAL CONTROL OF COCKROACHES IN ARMY FOOD SERVICE FACILITIES

USACHPPM TECHNICAL GUIDE NO. 208

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Chapter 1

Introduction

1-1. Purpose.

a. The purpose of this technical guide is to provide guidance to pest management specialists on the use of heat for controlling cockroaches in food service facilities. Detailed instructions and safety precautions for the conduct of a thermal control treatment are provided. It is strongly suggested that users participate in on-the-job training to further reinforce and detail the process and safety precautions. A study and economical analysis were developed to provide information for activities making decisions regarding conventional control of cockroaches and thermal control alternatives. This cost benefit analysis can be obtained from the proponent of this guide.

b. The procedures described were developed as a result of the experience gained by heat treating numerous (20) Army food service facilities. This guide cannot anticipate all possible scenarios; therefore, the pest management specialist must do an independent evaluation of each facility to be treated. The process will continue to evolve as further experience is gained and newer technology becomes available. Your comments and suggestions for improving the guide and/or the process are welcomed.

c. Chapter 2 provides a list of the necessary steps to conduct a thermal control treatment. Where additional information or safety precautions are warranted, comments follow each listed step. Sample forms used during a thermal treatment process are included in Appendix A. Abbreviated checklists, broken down by operational responsibilities, are provided in Appendix B. The content of both of these appendices is formatted so it may be photocopied and used while planning and performing the thermal control treatment.

Use of trademarked or company name does not imply endorsement by the U.S. Army, but is intended only to assist in identification of a specific product.

d. Appendix C lists the desired characteristics of equipment required and a listing of specific products meeting these characteristics. This guide provides product specific procedures to assist the user. If equipment is substituted or modifications are made to the process, it is the responsibility of the user to ensure that these changes are properly tested for all potential safety, health, and efficacy problems that may be affected by these changes.

1-2. Bibliography. A bibliography of thermal control related articles are listed in Appendix D.

1-3. Abbreviations and Special Terms. Abbreviations and special terms are explained in Appendix E.

1-4. Technical Support. Technical support can be obtained from Commander, USACHPPM, ATTN: MCHB-DC-OEN/Entomological Sciences Program, 5158 Blackhawk Road, Aberdeen Proving Ground, MD 21010-5422; or DSN 584-3613, commercial (410) 671-3613; or facsimile to DSN 584-2037 or commercial (410) 671-2037.

1-5. Safety Precautions. Due to the nature of the thermal control process, there are a few physical hazards to avoid. Less harmful hazards, such as hot stainless steel surfaces, are not discussed. Only the most severe hazards are addressed: heat exhaustion, carbon monoxide poisoning, and eye drying.

a. **Heat Injury.** The incidence and severity of heat strain will vary widely among people, even under identical heat stress conditions. Work-limiting injury/impairments can arise from the combined effects of environmental heat loading and body heat production/loss. Profuse and extended sweating produces dehydration and loss of body electrolytes, and may lead to heat-related injury. Symptoms of heat exhaustion include reddening of the skin, thirst, nausea, vomiting, shortness of breath, muscle cramps, headache, mood change, disorientation, dizziness while standing (from sweat-related blood volume loss), fever, unsteadiness, and profound fatigue. These symptoms are not specific for heat exhaustion and all of them are not always present in every case. Prolonged increases in body temperature may also be associated with adverse reproductive outcomes. Heat stroke is the most serious heat-induced disorder and is life threatening. Body temperature rises to 102 °F (40 °C) or higher. Sweating may **or may not** have ceased. The key finding is significant central nervous system impairment. Work in hot environments may lead to one of several forms of illness. Heat injury requires prompt treatment; heat stroke requires emergency treatment and hospitalization. To avoid heat injury follow the procedures outlined below:

(1) Prevent Dehydration.

(a) **Maintain adequate hydration** before working in the heated environment.

(b) **Drink cool water** instead of cold water/ice water.

(c) **Drink a cup of water** approximately **every 20 minutes** during heat exposure periods, even if not thirsty.

(2) Reduce Exposure to Heat.

(a) A variety of issues impact the choice of clothing for work in a hot environment such as the one posed by this procedure. These include protection against contact with hot surfaces, insulation against radiant and convective heat loads (forced movement of air at these ambient temperatures may lead to body heat gain), and ability to permit heat loss through evaporation of sweat. Loose-fitting cotton clothing, such as coveralls, has worked well during the 20 heating trials conducted to date. The use of cooling equipment/garment, such as commercially available cooling vests, is recommended for all or some personnel as per guidance of an onsite Industrial Hygienist.

(b) The amount of time spent in the heated area should be minimized to the maximal extent possible through job design and controls. During the 20 heat treatments conducted to date, personnel have generally limited their work time to 20 minutes per hour and no heat-related injuries have been experienced. But even this exposure duration should be reduced if at all possible. Each individual reacts differently to high temperatures; therefore, he or she must be alert for signs of heat strain and act accordingly. It is also prudent, because of the heat stresses posed, that personnel who perform this task undergo medical screening for heat intolerance and fitness to perform the essential job functions. Consult with an Industrial Hygienist on the need for physiological monitoring during heat exposure.

b. **Carbon Monoxide Poisoning.** Carbon monoxide poisoning is a potential problem whenever combustible fuels are used in a facility. **Carbon monoxide is a colorless, odorless gas and is impossible to detect by smell** and at **high concentrations may be fatal** without producing warning symptoms. It is a chemical asphyxiant that decreases the ability of blood to carry oxygen to the brain and other body tissues. However, with properly engineered equipment, it should be of minimal concern. All heaters used in these heat treatments have safety features which will stop the burning of fuel if the units should malfunction (i.e., improper fuel combustion). With the large amount of air being forced through the heating chamber, unsafe levels of carbon monoxide should never be an issue. However, in the unlikely event that carbon monoxide should exceed safe breathable levels, the symptoms of

carbon monoxide poisoning need to be recognized due to the **lethality** of this type of poisoning. **Symptoms of carbon monoxide poisoning** include **dizziness, headaches, and increased heart rate.** Personnel should be alert for symptoms, and consult an industrial hygienist and monitor the air within the facility during the process if any concerns exist.

c. **Eye Drying.** Eye drying and irritation result from exposure to hot air produced by the heaters and the reduction of relative humidity within the treatment area. The heated air can reach temperatures of 175 °F or more and is exhausted at the end of the heating ducts at approximately 19 miles per hour. These conditions can rapidly dry the eyes and the surrounding mucous membranes. To reduce eye irritation and drying, one should not work in the area being treated for more than 15 to 20 minutes at a time. Prolonged direct exposure to the hot air flow can result in damage and should be avoided. Goggles or glasses will provide additional protection to reduce eye irritations.

1-6. Propane Facts and Safety. Since the process and heater system described in this technical guide are based on a propane fuel system, a brief listing of propane facts and safety precautions follows:

a. **Propane is highly explosive, and any gas leaks** in a heat treatment process are a major concern and **must be tested for and corrected prior** to any attempt to operate the heater(s). Propane is heavier than air and if a gas leak is present, the propane will flow to the floor (or downstairs), spread like water, and slowly fill lower areas. If propane tanks are to be used inside a building, they **must be properly tested** for **leaks** by using a combustible gas leak detector or a leak detector solution and **only** used in areas that have **good ventilation**. The **pressure regulators** and **valves must meet** the **manufacturer's specifications** for the equipment being used. Do not use a wrench or pliers to close the valve; it must be closed leak-tight by hand.

b. **Propane tanks must be handled properly:**

(1) **Never refill** a smaller tank from a larger tank, such as filling a 100-pound tank from a 200-pound tank. Serious, possibly explosive, damage to the smaller tank can result.

(2) **Never use** tanks or equipment that are defective.

(3) **Move** propane tanks only when a valve protection cover is in place.

(4) **Never lift** the propane tank by the valve; it can be damaged.

(5) **Never expose** the propane tank to the direct heat of the thermal treatment; it could become over pressurized and leak propane.

(6) **Never leave** tanks in an unsecured location.

(7) **Never use** a vertical tank in a horizontal position. Liquid propane, rather than propane gas, will flow to the heater and not burn properly.

(8) **Never use** pipe-joint-compound to stop leaking connectors; it could clog the gas hoses and valves.

1-7. Background and Evolution of the Thermal Control Process.

a. The thermal cockroach control methodology was developed as an alternative to traditional insecticide applications for chronic cockroach infestations with high levels of resistance to insecticides in food service facilities. Applications of residual insecticides had failed to keep cockroach infestations at acceptable levels. To date, the thermal control program has provided unprecedented control results in the Army dining facilities treated.

b. Heat, when lethal temperatures are reached, has proven to be an effective technique for killing the various life stages of stored product pests (Shepard, 1984) and termites (Forbes and Ebeling, 1987). Heat is also being used by a few pest control companies to control cockroaches. Isothermics Inc., a training and marketing agency, licenses the patented use of sublethal temperatures (110 °F) and boric acid to control cockroaches (Quarles, 1993 and 1995). High temperatures can cause insect death by increasing the rate of desiccation. Death generally occurs slowly in this matter; for instance, cockroaches will die in 24 hours at 102 °F if there is no water present. However, acute thermal death, which occurs in minutes, is the result of rapid physiological changes. Exposure to high temperatures degrades the integrity of the cell membrane by changing the viscosity of the phospholipids. The nervous system is especially sensitive to such changes. Enzymes can also be inactivated causing biochemical imbalances. This can occur in temperatures lower than what is actually necessary to denature the enzyme. Additionally, high temperatures can cause changes in ionic activity, thus, affecting the insect's pH levels (Fields 1992).

c. What temperature is necessary to kill all stages of the German cockroach? In our laboratory tests, we found that 112 °F for 60 minutes killed 100 percent of the adults and nymphs. However, we did have some eggs hatch following that exposure. At 115 °F for 45 minutes the eggs were killed as well. At 120 °F for 30 minutes we had complete mortality. Forbes and Ebling (1987) found that at 130 °F death occurs within 7 minutes.

d. An initial attempt at thermal control of German cockroaches was conducted in June 1993 using open space heaters. One of the main problems identified during this treatment was the inability to produce adequate, uniform heat distribution throughout the facility. Large fans were placed in the facility, but this did not solve the problem. Heaters with flexible ducts which move large volumes of air are required to achieve target temperature at the lower levels.

e. Temperature profiles of a typical successful thermal treatment are presented in Appendix F. The first graph shows the average temperatures of stainless steel equipment harborages (i.e., bottom of hollow table legs, inside bottom of cabinets, ovens, food warmers), locations on the floor, and locations at the ceiling. On average, target temperature was reached within 20 minutes at the ceiling and within 2 hours in the harborages and on the floor. However, average temperatures are not important to cockroaches, since they will seek cool microhabitats. The other three graphs in Appendix F are box plots showing the variation in temperatures at 120, 180, and 240 minutes into the run. Superimposed over the individual data readings at each time is a box plot. Box plots are statistical tools that show where 75 percent of the values occurred. The median value is represented by a horizontal line within the box, and the notch covers 50 percent of the values. The first box plot shows the variation in ceiling temperature. Note that all locations were above the target temperature at 120 minutes and that they stayed there for the duration of the run. The second box plot shows the variation of stainless steel harborage temperatures. It took 240 minutes (4 hours) for all the harborages to come up to the target temperature. However, note that once the harborages came up to target temperature, they stayed there; hence, cockroaches either died due to the high temperature or fled the harborages to cooler locations at floor level. The third box plot shows the variation of floor temperatures. Note that at no time were all floor temperatures above the target temperature. As heating ducts are moved around, some areas would exceed the target temperature while the duct was in the area and then would drop below target temperature when the ducts were moved. This data illustrates why vacuuming has become an important part of the thermal process. There will always be cool spots on the floor where the cockroaches can escape the heat. Unless they are vacuumed up, they will simply run around the facility.

f. Since cockroaches can survive the heat treatment in cool spots on the floor, it was concluded that a pre- and post-thermal treatment pesticide application would further enhance the thermal control efficacy in reducing the cockroach population. As a result of confirming these observations, it is recommended that an insect growth regulator be applied the evening prior to the thermal treatment followed by a combined pesticide application of residual insecticide and insect growth regulator the night following the heat treatment. The insect growth regulator Gentrol® is heat stable to 140 °F. Normally, this high temperature is not

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® Gentrol is a registered trademark of Zoecon Corporation, A Sandoz Company, Dallas, TX.

reached at floor level in the cracks and crevices; if it does, the insects will not survive. Since it is conceivable that residual insecticides when heated could adversely affect the thermal team, they should not be applied prior to application of the heat.

1-8. What to Expect During the Days Following a Thermal Treatment.

a. It has been observed that the cockroach trap index obtained the night following a thermal treatment may be as high or higher than the pretreatment index. This observation does not necessarily mean that the thermal treatment was ineffective, but that, to a large extent, the majority of the surviving cockroaches have been displaced from their normal harborages and are actively seeking new harborage sites. As a result, a higher number of cockroaches are active at the floor level where the traps are located. Examples of three actual treatments are presented for three representative buildings in Appendix G. Figures 1 through 3 graph the number of cockroaches per trap per night and show when the pesticide applications were made before and after thermal control. A full arrow indicates a complete pesticide application using a residual insecticide and possibly dust, baits, and an insect growth regulator. A half arrow indicates that only baits and/or dust were used. Also, data for each facility are displayed, indicating the difference in the quantity of insecticide applied for equal periods of time pre- and post-thermal control.

b. In Building 2377 (Figure 1, page G-2), the trap indices, pre- and post-thermal control, were 44 and 35 cockroaches/trap, respectively. By 2 weeks post-thermal treatment, the cockroach population dropped below a trap index of 2 and remained at this level for all but 1 of the 18 months since the thermal control. Since thermal control treatment, only one application of residual insecticide was made, as opposed to 14 applications during the 18 months prior to thermal treatment. This represents a 20-gallon reduction of insecticide spray. During this period, 1 or 2 dozen bait stations (Combat®) were placed in the facility on seven separate occasions.

c. In Building 6542 (Figure 2, page G-3), the trap index reached 4.1 3 months post-thermal treatment. This was the only facility where an insect growth regulator was not used in conjunction with the thermal control. Following the application of a residual insecticide and insect growth regulator, 3- and 4-months post thermal control, the trap index decreased and remained below 1.0 until June 1996, 2 years after application of the heat. Over the next 18 months only four applications of small amounts of dust (6 ounces each), maintenance of a couple dozen bait stations, and two applications of an insect growth regulator were made. Despite these limited pesticide applications, there was still an 81-percent reduction in residual insecticide spray and a 31-percent reduction in labor hours.

® Combat is a registered trademark of U.S. Chlorox MAXFORCE Insect Control Systems, Oakland, CA.

d. In Building 2373 (Figure 3, page G-4), the trap index the morning after thermal control was over five times higher than the day before. However, within 2 weeks the trap index dropped to 0.5, reduced to 0.1 within 2 months, and has remained below that level for the last 22 months. In fact, only two cockroaches have been observed or trapped in this facility within the last year. In the 22 months since thermal control, pesticide application has been limited to only one prophylactic application of an insect growth regulator, four prophylactic applications of dust, and 1 - 2.5 dozen bait stations.

e. While some cockroaches remain in these facilities, this process has eliminated the yearly population peaks which occurred in late summer and fall. The combination of heat treatment with follow-up cockroach surveillance, selected pesticide application, and emphasis on building sanitation has resulted in long-term control.

Chapter 2

Conduct of a Thermal Control Treatment

2-1. Conducting the Preliminary Inspection and the Prebriefing.

a. **Evaluating the facility to be thermally treated.**

(1) **Determine if the building is suitable for thermal treatment.** Certain structural deficiencies, may prevent or hamper the routine thermal treatment of a facility. Some concerns that must be addressed are:

(a) **Is the building structurally sound?** Buildings with leaky roofs or walls that are not sealed and/or insulated from the outside may not contain the heat needed to thermally control the cockroach population. The only such building encountered thus far in this condition has been a World War II vintage wooden building, built on stilts.

(b) **Are there adequate access ways for heaters and personnel?** There must be adequate access openings for heater ducts into the treated area, to "bleed air" out of the area, and for easy access for personnel to move into and out of the area, particularly during the treatment. If doors are blocked and personnel are unable to easily leave the facility, serious injury can occur should they become overwhelmed by the heat or other types of emergencies develop. In large facilities or rooms, a number of openings is essential for the proper positioning of heaters for adequate heat distribution. To maximize the heat treatment, heaters must have a short, straight access to the heated area for optimum placement of the 18-inch-wide duct work. Each heater duct run should not exceed 25 feet from the direct-fired heater. For every two heaters used in the facility, there must be at least one "bleed air" window or door area to permit the escape of cooler air forced out from the facility.

(c) **Is there excessive standing water or a plumbing problem?** If floor drains do not function properly and pipes leak continuously, standing water and/or very wet conditions can reduce the effectiveness of the thermal cockroach control efforts. Excess water frequently causes structural damages which can provide deep harborage areas for cockroaches. As a result of water continually seeping between and under ceramic floor tiles, the floor tiles become loose and can buckle and break when heat is applied. Excessive standing water on the floor can also cool adjacent areas below lethal temperatures.

(d) **Are there sufficient properly grounded electrical outlets?** Electrical outlets that will be used during the thermal treatment must be properly wired and grounded for safe propane heater operation. In many of the older facilities, the electrical supply and distribution are inadequate to support two 7-amp heaters on one circuit. Therefore, it is critical that the electrical system be evaluated during the initial planning phase for the thermal treatment.

(2) **Check for accessibility and placement of propane tanks.** Ensure that an adequate number of propane tanks are available for the number of heaters and size of the building to be treated. Propane tanks should **never** be placed in the heated area of the facility being thermally treated or stored in the building before or after use. Accommodations will have to be made to secure the number of tanks used during the treatment process. The number of propane tanks required may need to be adjusted depending on the weather conditions at the time of treatment. If temperatures below 50 °F are expected, **two tanks per heater are absolutely necessary** to supply sufficient gas pressure for a 4- to 6-hour treatment. Thermal treatment should not be considered if temperatures below 40 F are predicted, unless all propane tanks will be used inside an area of the building not being superheated [see paragraph 1-6b(5)].

(3) **Check to see if Jordan® brand refrigerators are present in the areas to be thermally treated.** During heat treatments, older models of the Jordan refrigerators have experienced door and seal damage due to heat exposure of 110 to 120 F. The types of damage observed were warping and separating of the pressure-fitted door assembly due to foam insulation expansion. If this type of refrigerator is present in the treatment area, it should be either removed from the area or insulated with a thermal blanket and the doors kept closed.

(4) **Check for areas where the ceramic floor tiles may be loose.** In most military kitchens and dining areas, the floors are constructed of ceramic tile overlaying a poured concrete subfloor. In older facilities, the floor tile sometimes becomes loose from the sub-flooring. By tapping a rubber mallet or wooden rod every 1 or 2 feet on the tile floor within the areas to be heated, loose tiles and hollow areas can be identified by the hollow sound they make when hit. This information can be used to minimize floor damage due to lifting or cracking floor tile created by high temperatures generated by the heater duct lying directly in contact with the tile or the blowing of hot air over the tile. Two procedures that need to be

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employed to reduce floor damage are moving heater ducts frequently (hourly) to reduce the time hot air is blowing on a particular section of the floor and drilling a hole through the grout in each hollow area to allow heated air and moisture to escape without lifting the tile. If many tiles are loose the sounding of the floor, drilling holes in the grout, and filling the holes after treatment can add several additional hours to the process. Facility managers should be warned that despite conscientious efforts to drill the grout in all necessary areas, it is possible that small sections of tile will be damaged. In the 14 facilities treated where sounding and drilling of the grout was implemented, only two small (less than 10 square-foot) areas of tile were damaged.

(5) **Measure the cubic footage of the area to be heated.** In order to determine the number of heaters required for a heat treatment, the total volume (cubic feet) of the areas to be heated needs to be calculated. For planning purposes, at least one 400,000 Btu heater is required for each 6,000-8,000 cubic feet of building space to be heated. A 45,000 to 50,000 cubic-foot building will require approximately seven 400,000 Btu heaters. This will inject enough heated air into the facility to exchange the air volume approximately every 4 minutes.

(6) **Check for potential cockroach harborages.** A joint survey of the facility to be treated should be conducted with the facility manager or his representative prior to the thermal treatment to identify potential cockroach harborages; i.e., cracks, crevices, equipment, shelving, hanging pictures, etc. As many as possible of the harborage sites identified need to be eliminated or corrected (caulking cracks or crevices) by the facility support personnel or the contractor prior to any thermal treatment. Areas to be checked include:

(a) The wall-floor interface, particularly in frequently traveled areas and where standing water is common (i.e., in the dish washing area, behind sinks, at floor drains).

(b) Missing or broken tile grout in heavily used areas (i.e., in dishwasher areas or near stoves).

(c) Bulletin boards and pictures that are attached or hung on the wall.

(d) Decorative wooden paneling in the serving and dining areas.

(e) The areas behind, surrounding, and inside circuit breaker boxes.

(f) Anchor holes in the wall, formerly used for securing items.

(g) Broken or improperly placed light switches or electrical outlets and their covers.

(h) Passage holes in walls/floors for electrical wires or pipes or air vents. In the heating process, the area within walls does not reach lethal temperatures; therefore, it is critical that the walls be properly sealed.

(i) Interstitial spaces above a drop ceiling and the metal support system for the ceiling tiles.

(j) Insulation around steam and water pipes and air handling systems.

(k) Gaps around and behind wooden shelving in areas such as dry storage, laundry, bars and waitress stations.

(7) **Initiate cockroach surveillance in the facility to be treated at least 1 month prior to the thermal treatment to get the baseline sticky trap index.** A baseline sticky trap (Mr. Sticky®) index must be determined to establish the cockroach population levels present in the building. Two or more trap nights should be conducted prior to a thermal treatment. The baseline data will determine how effective current pest control measures are and indicate the need for thermal control. Place at least 20 to 30 sticky traps throughout a 5,000-square-foot facility. To be most effective, the traps must remain dry and be placed against the wall in areas where they will not be damaged or removed. For further guidance on effective sticky trap procedures, refer to TB MED 561, Occupational and Environmental Health Pest Surveillance. Traps should not be located where they will be disturbed by the normal daily activities of dining facility personnel, but placed in areas where cockroach activity is most likely to occur (i.e., underneath soda machines, refrigerators, stoves). Since cockroaches commonly travel along the wall-floor interface area, survey sticky traps should be placed parallel and next to the wall-floor junction to sample the cockroach population foraging for food. Once this trapping phase is complete, record the findings and stop all further chemical control applications unless otherwise directed by the thermal control team.

(8) **Determine if a fire suppression sprinkler system is installed.** If a fire suppression sprinkler system is not present, the thermal treatment can proceed with little concern of what the maximum ceiling temperature will be. Generally a maximum temperature of 150 °F should not be exceeded. If a fire suppression sprinkler system is present, an additional level of concern is added to the thermal treatment. During this phase a number of questions must be answered to allow for proper planning of the treatment. Read the safety information on the system and consult with a fire suppression system expert. Only those trained and certified in these systems should remove and reinstall them. Areas of concern are:

® Mr. Sticky is a registered trademark of LoTox Products International, Mount Vernon, NY.

(a) **What type of system is present?** The most common types of fire suppression systems installed in food preparation areas are the dry-chemical system, dry-water system and wet-water system. These systems differ in the types of sprinkler heads and the areas where the fire suppression material is stored.

i. A dry-chemical system is typically used as a range-fire suppression system. Since the heat-sensitive fusible elements for this system have a high temperature rating (265 °F), the fusible elements are not damaged during the heating process. However, the cylinders which store the fire suppression chemical for this system **must be** either **removed** from the heated area or **insulated** with a thermal blanket and **monitored** with a thermocouple, so excessive temperatures are not reached. Some systems have a pressurized carbon dioxide cylinder with no high pressure release valve. **Such cylinders must be removed.**

ii. A dry-water system has the water stored in a tank usually outside the area to be protected. Only pressurized air is in the pipes to each sprinkler head and holds a check valve against the water. When the sprinkler head is activated, the air pressure is released and the water follows immediately thereafter. The dry-water system's head can be the **most costly to repair**. Manager's should weigh the potential cost of replacing these heads against the benefits of the thermal control.

iii. A standard wet-water system has water in the distribution pipes and is held in check until the sprinkler head is activated. This system is generally the **least expensive of the three systems** and any damage to it, as a result of heat treatment, would be the least expensive to repair. However, it is in the best interest of the facility to evaluate the concerns of this treatment and ensure protection of the sprinkler system to avoid unnecessary repair costs.

(b) **What is the maximum temperature threshold for each type sprinkler head present?** The sprinkler head temperatures for the various fire suppression systems can vary between **125 to 265 °F**. The dry-chemical system used for gas ranges has heat-sensitive fusible elements rated at 265 °F. Since temperatures generated during thermal treatments remain well below this level, one does not need to be concerned about heat damaging these elements. The most common threshold temperatures for sprinkler systems in the buildings treated thus far are **155 to 165 °F**. These temperature thresholds are acceptable for a proper thermal treatment. In certain cases where the sprinkler system is quite old, the fusible elements may become weaker due to small amounts of corrosion and **can be activated at temperatures 10 °F below the manufactured sprinkler head rating**. Whenever possible, the **fire suppression system should be deactivated to prevent accidental flooding of the premises.**

(c) **Can the sprinkler heads be insulated?** The decision to insulate the sprinkler heads of the fire suppression system depends largely upon the installation and design of the system. If the water distribution pipes are fully exposed to the heat, it would be impractical to insulate the sprinkler heads since the heat would be conducted through the exposed portion of the steel pipes into the sprinkler head insulators. However, if the water distribution pipes lie above a drop ceiling, it may be practical to consider insulating the sprinkler heads from the higher ceiling temperatures. Depending on the number of sprinkler heads located in the area to be heated, this could be the most time-consuming activity during setup. If the ceiling height is approximately 8 feet, a mobile platform could be used to speed up the installation of sprinkler insulators. If, however, the ceiling height is 10 to 12 feet, a ladder will need to be used. In any case, this procedure will require two team members. The most effective insulator material evaluated under field conditions has been a ceramic fiber (Temp Mat®). A sprinkler head insulator was developed by cutting the Temp Mat into 18- by 12-inch sections and covered with plastic to contain the ceramic fibers. The narrow part of the sprinkler in Figure 1 was covered with a section of foam pipe insulation and the Temp Mat wrapped around it. The foam pipe insulation makes it easier for the Temp Mat to be secured to the sprinkler head with nylon electrical cable ties. In order to closely monitor the levels of temperatures within the insulators, thermocouples were placed inside a few insulators next to the sprinkler head to safeguard against overheating the sprinklers. Another alternative to insulating the sprinkler heads would be to lower the heater output temperature to within the sprinkler head threshold temperatures and extend the thermal treatment time. In most cases, insulation of the sprinkler heads is recommended as an added precaution.

(9) **Determine if the facility's walk-in refrigerator can remain on or must be turned off.** In the pretreatment survey of the facility, all walk-in refrigerating equipment should be checked to see if the refrigerator's compressors are located in the area to be heated. **If the compressor is going to be exposed to the thermal temperatures**, the walk-in refrigerator **must be turned off.** However, if the compressor is out of the heated area, it can remain on. Walk-in refrigerators are excellent locations to store perishable products that have been removed from smaller refrigerators scheduled to be turned off during the thermal treatment. To date, there has been no damage or decline in the internal temperatures of operating walk-in refrigerators due to heat treatments.

b. **Brief DPW, Preventive Medicine, Food Service, Fire Department, Safety Manager, and Pest Management personnel on the process and what their roles will be.** At least 1 month prior to the scheduled thermal treatment, arrange an information briefing for members of each of the offices involved concerning the thermal treatment process, identifying

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organization responsibilities, and scheduling the time for the treatment. The briefing can be accomplished most effectively by using an informational slide presentation. During the presentation, emphasize all of the procedures that must be accomplished before, during, and after the thermal treatment. In particular, show where mortar and grout work must be accomplished, how drains are to be flushed and sealed, and how door and window inserts are prepared and installed. In addition, emphasize that all gas to any equipment within the heated area must be shut off prior to thermal treatments, the air handling system to the treatment area will also need to be turned off during the treatment phase; and air vents in the ceiling and roof must be covered to prevent unwanted air exchange.

Figure 1. Wrapping Temp Mat Insulation Around Sprinkler Head. (Insert shows wrapped sprinkler head with external temperature-sensing thermocouple.)

c. **Distribute checklists (Appendix B) to DPW, Preventive Medicine, Food Service, and Pest Management personnel.** The checklist is a listing of specific tasks that must be accomplished by the various organizations involved before and after the cockroach thermal treatment. The checklist should be provided to supporting organizations prior to or at the information briefing.

2-2. Activities to be Completed the Day Before the Treatment is Planned.

a. **Conduct a sticky trap survey to establish a "current cockroach trap index."** A pretreatment cockroach survey performed the night before a thermal treatment is beneficial in identifying infested areas and measuring the effects of a thermal treatment. If a routine cockroach survey has been performed within 15 days of the thermal treatment, a pretreatment cockroach survey is not necessary. The number and location of sticky survey traps to be placed in a facility predominately depends on the size, equipment, and design of a building. Normally, bathrooms, offices, closets, and dry food storage areas require no more than two or three sticky traps placed on the floor in protected areas next to a wall. The number and location of traps for kitchens and dishwasher room are more variable. In the kitchen area, a sticky trap should be placed under or near stoves, refrigerators, steam kettles, deep-fat fryers, and garbage disposals. In dishwasher rooms, at least three to eight traps need to be set depending on the size of the area.

b. **Seal unnecessary windows and air vents.** Determine which windows will be used for heater input ducts and which will be used for "bleed air" ducts. If the remaining windows leak significant amounts of air, they should be covered with plastic. In addition, any air ducts which are not needed for bleed air should be sealed with plastic sheeting or plywood. During the thermal treatment, the heat produced may cause the duct tape's adhesive to come loose. However, taping around the entire sheet of plastic and using tacked wooden strips to attach the plastic will resolve this problem. Another alternative to duct tape would be to use high-temperature tape (see Appendix C for source) which has an adhesive that will secure items even at high temperatures and leaves no adhesive residue when removed.

c. **Install sprinkler head insulators**. Due to the amount of time required for this process, it is recommended that insulators be installed the evening or day prior to the thermal treatment. Obtain permission to do this from the fire department. Installing the sprinkler head insulators will require the use of a step ladder. This task can be more efficiently and safely accomplished if the workers don't have to work around the thermocouple wiring laying along the floor. Nevertheless, a few thermocouple wires should be installed next to the sprinkler heads inside the insulators to monitor the temperature of the sprinkler heads.

d. **Apply insect growth regulator to cracks, crevices, and equipment "touch points."** Application of an insect growth regulator (Gentrol), in accordance with label directions, prior to thermal treatment produces a band of chemical sterilant for those cockroach nymphs which contact it after leaving their harborages during the heat treatment. Thorough application of Gentrol to "touch points" where any piece of equipment comes into contact with the floor is important, since these are the areas where nymphs typically survive the thermal treatment. Gentrol is stable to 140 °F and, therefore, a good choice for this process. It must be applied

early enough in advance so that it can dry thoroughly prior to application of the heat, otherwise the heat will cause it to dissipate into the air. Thus far, there has been no evidence of insect growth regulator resistance identified in cockroaches.

e. **Ensure mortar and grout work has been completed.** Using the checklist prepared during the pretreatment inspection, ensure that all recommended work has been completed. Also, conduct an inspection of the facility using the points identified in paragraph 2-1a to determine if any oversights were made during the initial inspection or if any additional problems have developed. If necessary, make on-the-spot improvements to problem areas using a silicone-based caulk. Be aware that many caulks will run and sag if applied the same day as the heat. It may be better to tape the area shut and apply caulk after the heat treatment.

2-3. Setup for Thermal Treatment. On the day of the thermal treatment, setup can be greatly facilitated using the checklists provided in Appendix B. The thermal control team supervisor should confirm that all items on the checklists have been accomplished prior to thermal treatment.

a. **Placement of Thermocouples.**

(1) Placing and retrieving thermocouple wires is labor intensive, and multichannel temperature recorders are expensive. Therefore, the following guidelines are presented to reduce the number of sampling locations required. The purpose of temperature sampling is to ensure that no area of the facility gets too hot and that lethal temperatures are reached in all potential harborages.

(a) The hottest area in the facilities has been at the ceiling in the center of the room, with temperatures being cooler toward the walls. Therefore, at least one thermocouple should be used to monitor the central ceiling temperature of each room or major subdivision of a room.

(b) The coolest harborage areas are going to be those closest to the floor. Therefore, from 10 to 20 thermocouples should be used to monitor the temperatures in the lowest available harborages (LAH) throughout the facility. Examples of good locations are the bottom of cabinets, hollow table legs, the inside bottom of ovens, and wheels of carts. These sites should be within a foot of the floor. The harborage closest to the walls and in dead air spaces will be the slowest to heat and should be sampled. Refer to Appendix H for guidance in placement of thermocouples.

(2) The location of the Data logger® to monitor temperatures will be determined by the length of the thermocouple wires being used, location of electrical sockets, and the requirement that the **Data logger must be located outside the areas being heated.** In addition, it should be easily accessible to monitor temperature results. The following procedures will facilitate the placement and handling of thermocouple wires.

(3) **Begin placing thermocouples in the areas farthest from the control and monitoring equipment, using the longest wires.** As more and more wires are placed in a facility, the problem of wire tangling becomes greater, unless they are run using as many different routes as possible. When fewer wires are run through each area, tear-down time is dramatically reduced.

(4) **Keep a log of all thermocouple locations and wire identification numbers.** A log which identifies wire location and wire identification number is invaluable when thermocouple wires are accidentally and inevitably pulled from the monitoring equipment. Appendix A contains a log sheet form. Separating the recordings between heaters, ceiling, and lowest available harborage makes it easier to monitor the process.

(5) The form in Appendix A has several columns: The first is for the channel number of the Data logger. The second is for the wire number of the multipair extension bundle. The third is for the sensor number. The fourth has boxes to check whether it is at ceiling level or at the level of the lowest available harborage. The fifth column is for a brief description of the sensor location.

(6) **Secure the far end of each thermocouple.** To keep the thermocouple in place, it is also advisable to wrap the wire around any immovable object available. Ceiling temperature thermocouples can most easily be secured in place by wrapping the thermocouple wires around the top end of a 2- by 2-inch piece of wood cut to the length of the ceiling height. The wire will remain in place if it is wrapped in the form of a clove hitch knot at the top end of the wooden pole and then wrapped around the wooden pole to about the mid-point.

b. **Setup of Heaters, Ducts, and Propane Tanks.**

(1) **Heater Setup.**

(a) Initially, strategically place all of the heaters where they will be operating.

® Data logger is a registered trademark of Omega Engineering, Inc., Stamford, CT.

(b) Plug the heavy-duty extension cords for each heater into the predetermined, properly grounded, 20-amp circuits. A circuit tester can be used to determine that the electrical sockets are grounded. To prevent possible overload of any circuit during the thermal treatment, use no more than two heaters per circuit.

(c) With the propane lines not connected to the heater, and the heater start button in the "off" position, turn on the heater fan to ensure it is operational. If it works, turn the fan off again.

(d) Ensure the duct-heater connector ring is securely attached to the heater and place the 18-inch duct on the connector ring. Using duct tape, make two to three wraps around the duct/connector ring interface area, thus securing them together.

(e) **Ensure the gas pressure control knob is not turned to the maximum setting,** because it would cause output temperatures as high as 400-500 °F. It should be turned to approximately half of its range or below. As propane is used during the thermal treatment, the tank pressure decreases; therefore, the pressure drop must be compensated for by turning up the heater gas pressure control knob. If this knob is not reset at the end of the treatment, it will result in extremely high heater output temperatures when the heater is used again with a full propane tank.

(2) **Placement of Ducts and Carpenter-supplied Door and Window Inserts.**

(a) The door and window inserts should be cut and installed. Proper construction and placement of a door insert is shown in Figure 2. Once the door and window inserts are in place, the thermal control team can begin running the 18-inch heater ducts to the general areas to be heated.

(b) Heater duct runs need to be as straight and as short as possible to minimize duct air pressure on the heater's static pressure sensor. The longer the duct run, the more "back" pressure is placed on the heater. For the same reason, the more bends in the duct, the shorter it should be. If this pressure becomes too high, the heater's static pressure sensor "senses" an increased static pressure and will shut off the propane supply. The heaters used to date will not operate with more than a duct run of 25 feet or one and a half pieces of manufacturer-supplied duct work.

(c) To guard against damage to equipment and its wiring, do not blow heat directly on any equipment with plastic, rubber, or electrical components (i.e., refrigerators, freezers, soda machines, and food coolers). If these types of equipment are in the area to be heated, maintain at least 6 feet between the duct outlet and heat-sensitive equipment. Following this guideline and a maximum outlet temperature of 150-185 °F, the only brand of equipment that has been damaged has been the Jordan refrigerators referred to in paragraph 2-1a(3).

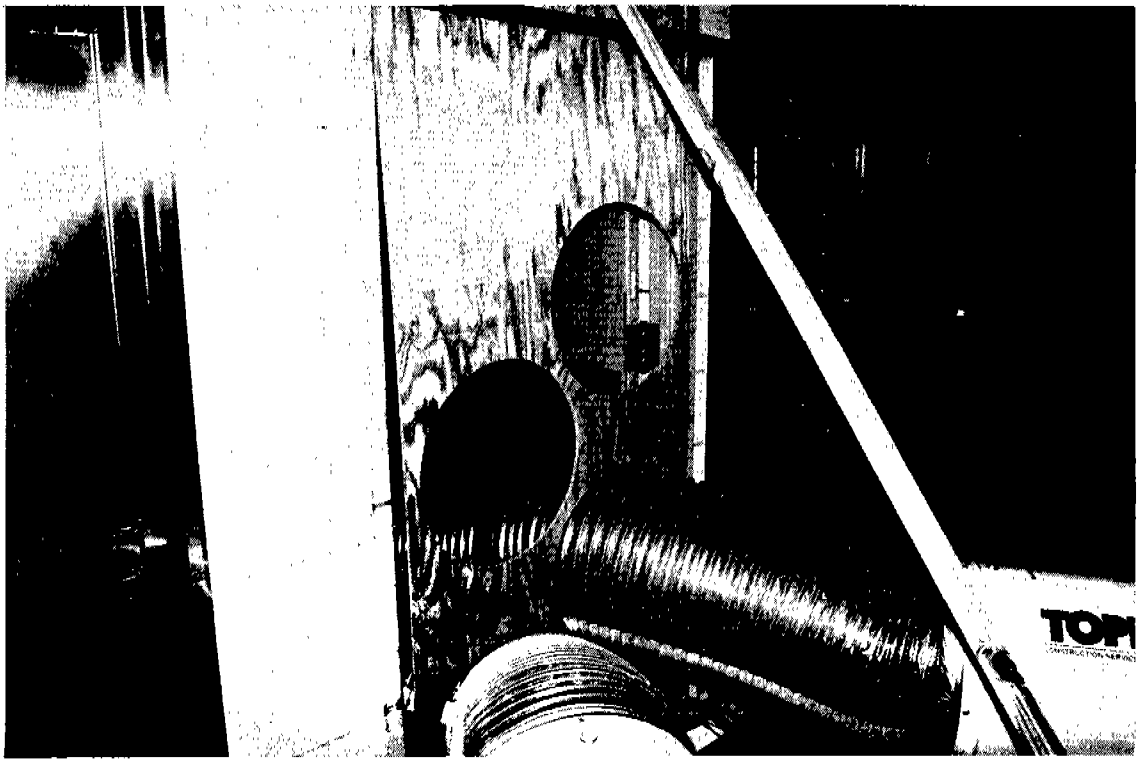

Figure 2. Example of a Door Insert.

(d) If heater ducts are to be run into windows several feet off of the ground, they must be supported to prevent kinking or bending of the duct, thus increasing static pressure. An increase in back pressure will cause the heaters to automatically shut off. Two 2- by 4-inch pieces of wood placed under the duct and extending from the heater to the window sill will provide good support for the heating ducts. This configuration can be seen in Figure 3. Occasionally, the heater must be tilted upward with support blocks to reduce kinking of the duct.

(e) If two sections of heater duct are required to be joined to extend the length of the run, this can best be accomplished by inserting one of the ducts into the other. The duct section closest to the heater should be compressed into an oval shape and inserted into the duct piece that will be furthermost from the heater. This process can be troublesome and should be accomplished before heating begins to avoid uncomfortable and exhausting exposure to the heated air exiting the duct. Single heater duct runs should not exceed 25 feet, since excess heat loss will occur and/or the back pressure will cause the heater to shut off.

(f) Heating ducts need to be run to the areas most likely infested with high populations of cockroaches: dish washing, food preparation, serving lines, and garbage disposal. Dry-food storage areas and latrines have not routinely had high cockroach populations. However, each facility is different, and the placement of ducts is dependent upon sticky trap findings and observations made during the heat treatment.

(3) **Connection of Propane Tanks to Heaters.**

(a) **If the ambient air temperatures are below 50 °F, two 100-pound propane tanks** will need to be joined or "**pigtailed**" together. To ensure this process can be accomplished, the top of the tanks must be open and accessible for the "pigtails" or the proper brass compressed gas fittings to make the necessary connections.

(b) Place the propane tanks as far from the heaters as the gas connector hoses and building design will allow. The **propane tanks** should be **secured** to prevent accidental knocking over. **Do not block** the **air intake area** for the heaters or **expose** the **propane tanks to direct heated air** from the heaters. However, indirect bleed air from the building may help to prevent the propane bottles from icing in temperatures from 40 to 50 °F. Tank icing reduces the operational capabilities of a propane tank.

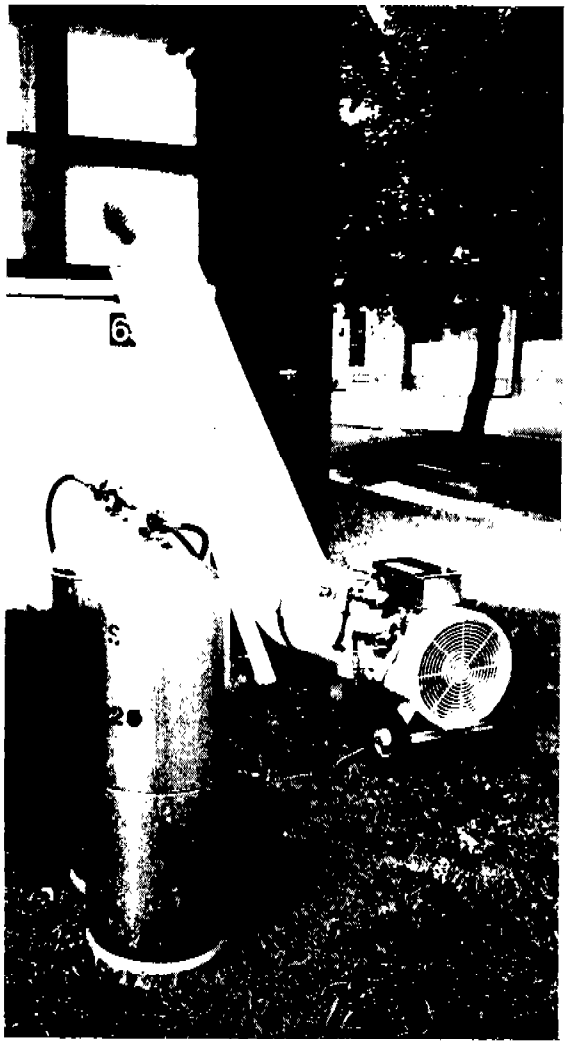

Figure 3. Support of Heating Duct.

(c) **Threads on the propane tanks** and **fittings** are **"reverse threads."** This means that to tighten fittings, they must be turned the direction normally used to loosen (**counter clockwise**), and to loosen fittings they must be turned the direction normally used to tighten (**clockwise**). Use at least a 10-inch adjustable crescent wrench for a proper grip on the brass fittings. If the crescent wrench is not adjusted properly, it will slip and eventually destroy the soft brass fittings.

(d) If a pigtail connector is used, connect the T-valve first, ensuring that it is parallel to the ground. Then connect the hose to the other tank and the hose to the heater. When tightening hoses into the T-valve of the propane tank pigtail, a second 10-inch adjustable crescent wrench is needed to hold the T-valve steady. Once again, the proper grip and gap is needed to prolong the useful life of the brass fittings.

(e) **Ensure the gas control lever on the heater is in the "off" position**. When the lever is parallel to the gas line it is "on." When it is perpendicular to the gas line it is "off."

(f) Once the hoses are connected to the propane tanks, connect the quick-disconnect fitting to the proper fitting on the heater. A pigtailed setup is pictured in Figure 4.

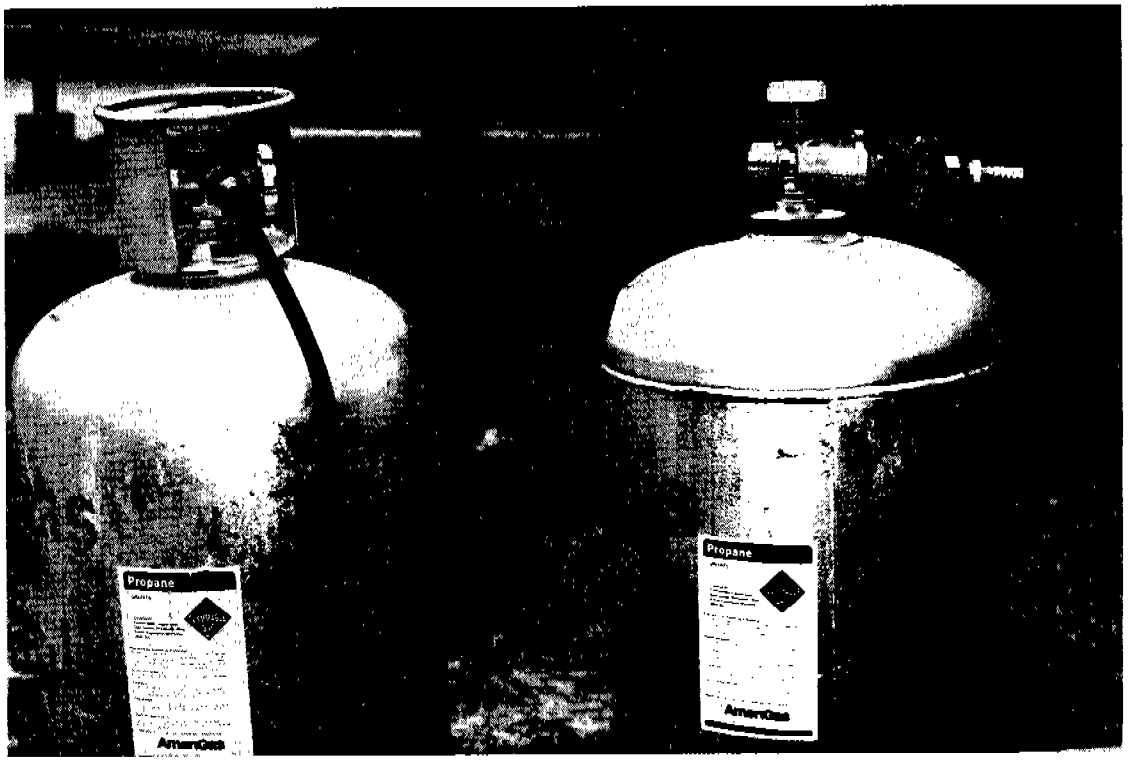

Figure 4. Pigtail Connectors.

(g) Turn on each propane tank individually. After turning on a propane tank, use a combustible gas detector or gas leak bubble solution to confirm that no gas is leaking from the gas connections or gas lines. The **combustible gas detector** is the **most sensitive** and recommended method for detecting gas leaks. If gas leaks are detected and cannot be stopped by tightening the connectors, the defective parts must be replaced. In some instances, one hose may not seat properly on one propane tank but fit properly on another, do not discard a hose once it fails on a single fitting. After trying two or three gas hoses, consider switching cylinders.

(h) Once all fittings are tight, turn on the heater's gas line control lever. A momentary hiss will be heard as propane enters the heater precombustion area. Check for gas leaks in the heater's pipe train prior to starting the heater. The system is now ready to start.

c. **Setup of Monitoring Equipment.** Ensure Data loggers and gas monitoring devices, if used, are centrally located and secured so they will not be pulled off a table by people accidentally tripping over thermocouple wires. As with the Data logger, the **gas monitor must be placed outside the area being heated**. Plastic cable ties are very effective at holding all wires together and should be secured to a table leg or other object approximately 2 feet from the wire connections to the Data logger.

(1) Ensure all Data logger channels are operational. If any problems are observed with the functioning of the Data logger or thermocouple wires, repairs should only be attempted when the equipment is nonoperational. Some of the most common malfunction problems encountered with the temperature equipment are: the male and female connectors are not properly connected, the wires in the male or female connectors are loose allowing for a faulty contact, a break has occurred along the thermocouple wiring, loose wire connections in the Data logger's channel register area, and the wires at the end of the thermocouple wiring have separated. These problems can normally be resolved on the spot with little delay; however, problems that occur with the electronics of the Data logger must be repaired by the manufacturer (if under warranty) or by certified electrician. The "trouble shooting" section of the Data logger's manual describes several of these problems and explains how they can be identified and repaired.

(2) The TOPP SAFE HEAT® Model 400 is designed to produce air that is safe to breath. If there is any indication that the heater is malfunctioning (production of smoke, a predominance of orange flaming, or indications of carbon monoxide poisoning, see paragraph 1-5b) the heater manufacturer and an industrial hygienist should be contacted. Should atmospheric gas measurements be taken, the critical measurements include:

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(a) Carbon monoxide - less than 200 ppm - is acceptable for short exposures, although 25 ppm is the acceptable American Conference of Governmental Industrial Hygienist standard for 8-hour exposure, less than 25 ppm has been the normal level experienced during our heat treatments. This level is well within the standards for healthy air quality. Since the work force will only be exposed to the heated air within a facility for short periods of time (20 minutes or less for each exposure), the potential for carbon monoxide poisoning is greatly reduced.

(b) Oxygen - at or above 21.5 percent, **below 19.5 percent is life threatening**.

(c) Combustibles - **None should be detected**. If any are detected using the atmospheric gas measuring device stop the heaters, vent the building and check all heaters, propane tanks, and the natural gas source for the building.

d. **Vent Holes for Hollow Points in Floor.** Where hollow sounds are noted in the floor during the preliminary inspection, drill ⅛-inch holes through the grout joint into the air space between the tile and floor every 2 feet. This will allow the hot air or trapped moisture to escape as it expands from the heat so that tiles are not damaged by cracking and/or breaking. If a drill stop isn't available on the drill, wrap masking tape on the drill bit so that the edge of the tape is ½-inch from the tip of the drill bit. Then drill the hole until the tape touches the floor or ½-inch deep. After the heat treatment, **all holes drilled must be filled with grout or caulking material** to prevent water from entering into the open spaces when the floor is cleaned and to prevent cockroaches from using the space as harborage.

e. **Removal or Insulation of Jordan Brand Refrigerators.** [See paragraph 2-1a(3)] Thus far, refrigerator removal has been the easiest solution to preventing heat damage, but this also allows for a possible escape for cockroaches harboring in the refrigerator or its legs. Insulating the refrigerator doors with thermal blankets may provide an alternative to equipment removal from the treatment area provided the insulation protects the insulating foam from the high temperatures.

f. **Construction of Temporary Wall Partitions.** If the cubic footage of the area to be treated exceeds the area that can be adequately heated by the number of heaters on hand, or an area such as a dining room that does not need heat treatment, a "plastic" wall partition may have to be constructed. For example: four heaters can adequately heat an area of 32,000 cubic feet. If the area to be heated is 40,000 cubic feet, a wall petition will be needed to reduce the area to be heated. To accomplish this, DPW carpenters or pest control contractors must construct a 4-mil plastic wall running from the ceiling to the floor and from wall to wall between the dining area and the kitchen/serving areas. The plastic wall must be high enough to seal the area between the floor and ceiling, but it is not necessary that it be tightly sealed at

the ceiling. To prevent cockroaches from escaping the heated area, the plastic sheeting should be duct taped to the floor and side walls as flat as possible. A single entry/exit point should be made in this wall. The entry/exit point should have the plastic overlapped about 3 feet to minimize excess air loss. Mr. Sticky Trap tape should be applied to the floor inside, next to the petition, to prevent cockroaches from escaping from the heat through the entry/exit openings. Carpenters will normally be required to construct the petition(s). One technique that has proven successful is to construct a temporary support frame from standard 2- by 4-inch pine lumber. A single 2- by 4-inch board is nailed to the top of a few upright support 2- by 4-inch boards, plastic is draped over the top, and the partition is set in place to separate the treated and nontreated areas. See Figure 5.

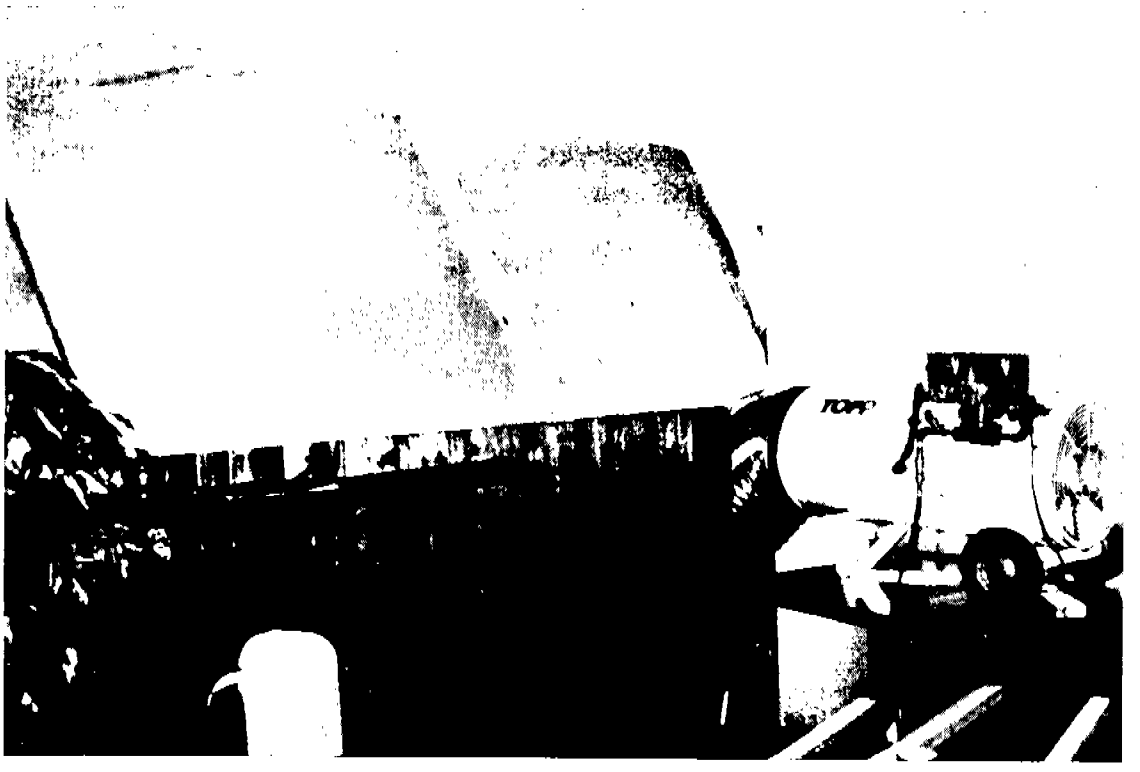

Figure 5. Completed Plastic Wall.

g. **Removal of Potentially Infested Materials.** If an area, such as a dining room, is not treated, all potentially infested materials, like salad bars and dessert cabinets, should be moved into the heated area. Tables and chairs are not generally infested. If they are, the dining room should be heat treated.

h. **Bleed Air Ducts.** One 18-inch bleed air duct is required for every two heater input ducts used.

(1) Ensure window openings that are to be used can be opened and closed easily. Bleed air duct holes can also be cut into the temporary door panels where heater input duct holes are located.

(2) Place one bleed air duct for every two heater input ducts, and adjust this ratio as necessary. With too few bleed air ports, the facility will be over pressurized and heat slowly. However, with too many bleed air ports, too much heat may be lost from the facility. Since air is being forced into the facility at 2,000 cfm for each heater used, the overpressurization of the area must be vented to the outside through bleed airways. Initially, the goal of this process is to remove as much cool air as possible. Since the air coming in is hot, it will naturally rise and fill the upper portion of the room and then gradually force the cooler, heavier air out from the bottom of the facility. As the cooler floor air is replaced with hotter air, it begins to produce the effects necessary for the thermal treatment. Once the facility is up to temperature, the number of bleed air ducts can be reduced.

i. **Checklists.** Ensure all DPW, Preventive Medicine, and Food Service workers complete the tasks listed in the checklists at Appendix B. Critical tasks are as follows:

(1) **Carpenters (if this service is not provided by the installation, the contractor will provide the necessary items).**

(a) Cut and install door and window inserts. If sized properly, these only need a friction fit and duct tape to keep them in place. They do not need to be airtight.

(b) Erect plastic wall partitions, if necessary, as described in paragraph 2-3f.

(c) Provide door stops, chock blocks, and other wood items as needed, such as 2- by 2-inch wooden poles for suspending thermocouple wires.

(2) **Food Service Personnel.**

(a) Ensure all equipment and other movable items are elevated off the floor. Some equipment may be tilted and/or blocked to allow the heated air to flow easily underneath.

(b) Ensure that all perishable foods in refrigerators/freezers have been removed or transferred into the walk-in refrigerators or other cold storage areas that have not been turned off. Some of the food items that need to be removed are chocolate, spices, coffee and tea, plastic condiment packages, fresh fruits, and brown sugar.

(c) Remove cardboard cartons containing soft drink syrup. Seal the ends of soda fountain hoses with plastic wrap and a rubber band so that cockroaches do not enter the open disconnected hoses. If removal of these containers is not practical, the thermal control personnel must vacuum any cockroaches which congregate in this refuge. Due to the mass of the syrup containers, they will be very slow to reach the temperatures necessary to kill the cockroaches.

(d) Remove computers and any equipment that has computer chips, such as radios, and televisions. Previous experience indicates that ice machine circuit boards are not affected by temperatures up to 150 °F.

(e) Remove ice from all ice machines; otherwise, the cool drain water from the melting ice will help some cockroaches survive the heat.

(f) Clean out all floor drains. Use either a steam cleaner or very hot soapy water and bleach. A lot of hot water is necessary to kill or remove cockroaches harboring in the drains.

(3) **Fire Department.**

(a) Determine the impact of the heating process on the facility's fire alarm systems and deactivate them as necessary.

(b) Evaluate the facility for flammable hazards (i.e., cleaning fluids).

(c) Deactivate or remove any fire suppression/alarm systems which may be activated or damaged by exposure to 160-170 °F, particularly the pressurized cylinders for the range hood fire suppression systems. If the air temperature approaches the upper limits of any equipment or items within the heated area, the heater output temperatures will have to be lowered. In most cases these fire suppression systems are rated at a fairly high temperature and should not activate below that temperature. If these systems cannot be removed, they will require insulation to keep the temperature of the sealed containers below their stated tolerance. Foam or fiberglass insulation sheets should be wrapped around the containers and tied in place. The thermal control team must know if the stated tolerance of the containers has been reached. Therefore, at least one thermocouple should be wrapped within each sheet of insulation and placed against the pressurized container.

(d) Ensure that the fire safety personnel on duty the day of the treatment have been informed and briefed of the thermal activities.

(4) **Heating and Refrigeration Personnel.**

(a) **Shut off all mechanical equipment** (refrigerators, freezers, soda machines, ice machines, steam kettles, exhaust vents, air handling system). Equipment may be damaged by overheating if allowed to operate during the process.

(b) **Shut off gas to the building** at the outside valve and bleed the lines dry by allowing the pilot lights to burn off any remaining gas. (Stoves and all gas handling systems within the building need to be tested with a combustible gas leak detector prior to any heater operation.)

(c) **Check refrigerator seals** to see if they are rubber and mounted onto the refrigerator door using a hard plastic strip. This type of door seal construction may be damaged by the thermal control process if the doors are left open; therefore, keep the refrigerator doors closed throughout the heating process.

(d) Tape a plastic sheet, cardboard, or paper to the ventilation ducts where they exit the building. See Figure 6.

Figure 6. A Sealed Building Exhaust System.

(e) Ensure that all windows close and seal properly.

(f) Ensure that **all equipment and fluorescent ceiling lights** are **turned off**. Fluorescent ceiling lights are shut off to protect the ballast from overheating.

(g) Find and identify to the thermal team a properly grounded 20-amp circuit for every two heaters. Additional electrical equipment should not be connected to a circuit operating two heaters. With a circuit tester, the thermal team can easily accomplish this task.

(5) **Pest Management Personnel and/or Contractors. Flush drains** with **hot water** from the dining facility sinks (water at 160 °F or above is optimal) and seal drains with plastic wrap or aluminum foil so as to prevent cockroaches from finding harborage in the cooler drains.

(6) **Preventive Medicine Personnel.** Turn in the prior night's Mr. Sticky Trap count to the thermal team. The contractor may elect to perform the cockroach surveys if the installation's preventive medicine staff cannot preform this service.

j. **Installation of Fire Suppression Sprinkler System Insulators.** If fire suppression sprinkler insulators are to be used, they should be installed prior to placing thermocouple wiring to other areas. This will reduce the possibility of accidentally disconnecting other wires due to ladder relocation. A thermocouple should be placed in at least one sprinkler insulator in each area to be heated, preferably in the middle of the room since this will ultimately be the hottest area. If any thermocouple registers a dramatic rise in temperature or comes to within 15 degrees of their activation temperature, the heater output should be reduced to prevent further temperature increases.

2-4. Conduct of Treatment. Although many people have supported the thermal team up to this point, it is now the thermal team personnel's responsibility to check everything and to ensure that the thermal treatment is successful.

a. **Review DPW, Preventive Medicine, and Food Service workers' checklists for completion.**

b. **Apply Mr. Sticky double-sided tape to trap cockroaches at escape points.**

(1) As the temperature in a facility rises, cockroach movement increases to escape the rising temperatures. Normally there are areas which cannot be heated adequately or are slower to reach lethal temperatures, such as small rooms, the plastic-floor interface (when a plastic wall is erected), and walkways between heated and nonheated areas. Small rooms

connecting to large areas are particularly difficult to heat due to poor circulation of heated air within these areas. Therefore, sticky tape should be applied along the door sill and about 2 feet up the door jams of small storage rooms or office space to prevent cockroaches from leaving the hotter areas of the facility and taking harborage in the cooler areas.

(2) A technique that will greatly facilitate the placement of Mr. Sticky tape to the floor areas is to apply a high-temperature tape to a 3- or 4-foot piece of vinyl cove molding (3-4 inches wide) and then apply the Mr. Sticky tape over the high-temperature tape. Then the cove molding is placed on the floor at the door entrance to catch those cockroaches trying to escape to a cooler area. This technique will prevent the need to apply Mr. Sticky tape directly to the floor. After being heated, Mr. Sticky tape will leave the adhesive material on the surface of the items taped; therefore, high-temperature tape should be applied to the door jams and Mr. Sticky placed on top of it. The top protective layer of the sticky tape should not be removed until just before turning on the heaters. This will prevent workers from being "caught" on the sticky tape and pulling it up from the areas to be sealed. **All Mr. Sticky tape (or duct tape, if used) should be applied to the areas prior to heating**. Once heating begins, the double-sided tape warms very rapidly and becomes very difficult to handle.

c. **Turn off all electrical appliances, including the lights.** Most appliances used in dining facilities are designed to operate at normal building temperatures (70 to 80 °F). If operated in the temperatures produced during thermal treatments (130 to 160 °F), serious damage to the equipment can occur.

d. **Start each heater and ensure it is operating between 150 and 180 °F.**

(1) The heater startup procedures begin with a quick visual check of the heater to ensure that no debris or structure is obstructing the fan intake area and that the duct connector ring and duct are properly attached. Ensure that a thermocouple is attached to the end of the output duct and is secure. Check to see how the electrical cables have been laid, and ensure that they are not directly under any duct work within 20 feet from the heater. The heater fan switch can now be turned on. Once the fan is working properly, the heater burner can be turned on. Ignition of the gas burner should produce a deep roar if working properly. If the duct work does not immediately get hot and the roar of the flame burning can not be heard, a number of items need to be checked, but do not spend more than a few minutes with any single heater. At this time the goal of the treatment is to begin heating the building. It is very unlikely that all of the heaters will experience problems, so start all of the heaters as soon as possible. Stay with each operational heater only long enough to check the heater output temperature and to make any adjustments to the propane flow valves needed to provide a steady output of 150 to 180 °F.

(2) If the heater(s) being used does not come factory equipped with a thermometer to measure the heater's output temperatures, a digital, hand-held temperature monitor or a thermocouple inserted into the heating duct next to the heater can be used to measure the start-up temperature and subsequent temperature readings. Most heaters can be modified to accept a permanently mounted thermometer in the heater's burning chamber to measure air output temperatures. However, do not make any modifications to the heater without consulting the manufacturer first. The heater's gas regulator valves should be preset so that the initial air temperatures do not exceed the 150 to 180 °F range. Depending upon the length of the heating ducts, the actual temperature of the air being blown into the facility can be approximately 15 to 20 degrees cooler than the temperature being recorded at the heater. It is recommended that the temperatures at the heater and heating duct be monitored simultaneously at regular intervals to prevent over or under heating of the areas being treated. As the heat treatment proceeds, the level of propane in each propane tank will decrease. This reduction of propane in turn reduces the gas pressure to the heater, which necessitates an adjustment in the gas flow regulator of each heater. Depending on where each propane tank is, this adjustment may be larger or smaller. If the propane tank is inside a building or outside in the direct sunlight, it may require little adjustment. If it is outside and in the shade, it may require frequent adjustment. As the day goes on, the outside tanks may be exposed to varying degrees of sunlight and will require more or less adjustment. Regardless of whether the propane tanks are used inside or out, ensure that the safety precautions listed in Chapter 1, paragraph 1-6, are known and followed. If all of the adjusted gas flow regulators are not returned to their original starting positions at the end of each thermal treatment, the initial heater output temperatures may exceed 350 °F at the beginning of the next thermal treatment. **Always return these gas flow regulators to the starting position** at the end of the treatment and check them as each treatment begins. Heat in excess of 180 °F may cause damage to unprotected equipment.

(3) Some problems that may occur during startup and their probable causes are as follows:

(a) Improper grounding of the electrical outlet will result in the heater not working when the fan does.

(b) Inadequate circuit amperage or overloading a circuit will cause circuit breakers to trip.

(c) Air restrictive bends in the heater duct or a duct length that is too long will prevent the heater's burner from firing even though the fan is running.

(d) Too little or no propane supply will prevent the heater from firing even though the fan is running.

If you have checked all of the above problem areas and the heater system still does not run, consult the manufacturer's manual.

e. **Ensure the safety of everyone associated with the thermal treatment.**

(1) The hazards while in the heated area include a multitude of thermocouple wires spread over the floor that can be easily tripped over, wires tied to unsecured poles that can be easily knocked over, extremely hot surfaces throughout the area, and the extreme heat itself.

(2) See paragraph 1-5a for information on protecting personnel against heat injury.

(3) The thermal control team should designate an individual to keep track of who is in the heated area and must check on them if they fail to exit within an agreed time. If someone is in the area that is not accustomed to the heated environment, then they must be accompanied by an experienced team member. Casual onlookers should be discouraged from entering, or enter as a group at a predetermined time. The fewer people that enter and exit the area being treated the better. Each opening of the heated area affects the distribution of heat and more importantly adversely affects the accumulation of cockroaches in the cool spots.

f. **Investigate the heated area for cockroaches accumulating in cool areas.**

(1) One hour after beginning the treatment, walk through and investigate the entire heated area to locate the cool spots identified by the accumulation of cockroaches. **Do not readjust** the **ducts** at **this point**. Also check for floor tiles lifting and signs of any stress or damage to the equipment and other room fixtures (e.g., light fixtures, vinyl wall coverings and furniture, wall paneling) in the building.

(2) Approximately 90 minutes after beginning the treatment return to the previously identified cool spots with the lil' Hummer® and vacuum the cockroaches found. Check the wall-floor interface, the room's corners, behind any pictures on the wall, the wall-ceiling interface, under and behind refrigerators and equipment, depressions in the floor, behind doors, and around floor drains. Once these cockroaches have been vacuumed, ducts can be readjusted.

(3) Since the concrete and tile floor is very slow to heat, vacuuming is critical to this process; therefore, the thermal team should have two vacuum cleaners available for use.

® lil' Hummer is a registered trademark of Miracle Marketing Corp., Salt Lake City, UT.

(4) Since cool spots at floor level are created each time the ducts in the heated area are moved, steps (1) and (2) should be repeated throughout the thermal treatment.

g. **Ensure optimum heat is maintained throughout the facility.** Through the use of the monitoring equipment and by adjusting and readjusting the ducts and heater gas flow controls, the temperature should be maintained at or above 115 °F for 45 minutes.

h. **Watch equipment for signs of damage.** Watch for buckling floors particularly in the areas where ducts are blowing hot air.

i. **Add or remove bleed air ducts, depending on how quickly the temperature has risen at the ceiling.** Refer to paragraph 2-3h for more information on the placement, moving, and removal of bleed air ducts.

j. **Approximately 4 or 5 hours after beginning the thermal treatment, check the Data logger printout to ensure the temperature has reached at least 115 °F for 45 minutes in all of the lower harborages.** The "run time" for thermally treating a dining facility is dependent on a number of factors: the number and size of heaters, the size of the area being treated, insulation and air tightness of the building, and the infestation level of cockroaches in the facility. Normally, the target temperature of 115 °F for 45 minutes or more should be reached throughout the designated treatment areas in approximately 4 to 5 hours. If the number of active cockroaches has been reduced to a very low level and no further grouping of cockroaches is observed, then the thermal control effort can be terminated. There is no predetermined effective treatment time. It can be as short as 4 hours or as long as 7 hours. Longer treatment times do not always result in a higher level of control. Success is more dependent upon proper distribution of heat for the necessary length of time. If the heat has not reached the critical harborages, there may be a huge population of cockroaches unaffected by the thermal treatment. Towards the end of the run, temperatures in the building may activate the lil' Hummer's high-temperature switch. If this occurs, the machine must be placed in a cool area until the switch resets. Therefore, it is important for each thermal team to have at least two vacuum cleaners. Diligent vacuuming of cockroaches from the cool spots on the floor is vital to the success of the thermal treatment.

2-5. Conducting a Two-phase Cockroach Thermal Control Treatment in a Large Facility. In certain cases, it may be necessary to heat a facility in two phases, depending on the size and design of the facility and/or the number of heaters available for conducting the thermal treatment. A two-phase treatment as described in this technical guide is one in which parts of a facility are heated at separate times in order to achieve a complete building treatment. Ideally, the second treatment should be conducted immediately following the first phase to take advantage of the increase in temperatures created by the bleed air of the first phase. In

addition, the heat treatment is much more effective in controlling the total cockroach population when treated on the same day. A two-phase treatment is approached in the same way as a single-phase operation, except that additional materials and planning are normally required. However, extra precautions have to be taken to prevent cockroaches from escaping the area being treated to adjoining nontreated areas. For example, the doorways where heaters are located must be properly lined with double-sided tape (Mr. Sticky) and all other interconnecting passageways for cockroaches must be sealed and/or taped.

a. In a large facility with numerous interconnecting rooms/spaces and an insufficient number of heaters, it is necessary to heat part of the building in phase 1 and the remaining portion in phase 2. Appendix H shows how a large Army troop dining facility of approximately 90,000 cubic feet was heated with eight heaters.

(1) In Phase 1, four heaters were setup to heat the kitchen area (30,000 cubic feet), while two heaters were used to heat the dishwasher room (5,000 cubic feet). It is critical to note that both of these areas could be heated at the same time, because neither the propane tanks nor the heaters were located in the areas being heated. Based on the requirement of one heater for each 8,000 cubic feet, four heaters were required to heat the kitchen area, while only two heaters were used to heat the dishwasher room. In the kitchen area, the heaters were strategically placed to allow maximum distribution of the heat and still allow personnel access into the heated area to monitor any potential problems and to vacuum the cockroaches. Similarly, two heaters were needed to heat the dishwasher room, allowing two doors for entrance. Two of the limiting factors which affect heater placement in any situation are available building entrances for the heating ducts and the limited length of the heating duct runs.

(2) In Phase 2, eight heaters were used to heat the remaining areas of the troop dining facility -- serving areas, and dining areas (Figure H-2). Note again, that the heaters were placed at various sites around the building in order to achieve heat distribution as evenly as possible. In the two opposite dining areas, heating ducts were passed through window units to the interior of the building. All other heaters were positioned to allow the heating ducts to pass through doors to the heating areas. However, easy access to all heating areas was maintained for personnel movement.

b. There were some important reasons for heating the dishwasher room at the same time as the kitchen area. First, only eight heaters were available, an insufficient number to heat the entire area at one time, and secondly, because the dishwasher room was located in the middle of the building the heating ducts would have to be extended to reach the room. As previously stated, the heating duct runs can not exceed 25 feet from the heater before the heaters shut off automatically. In addition, the cockroach surveys indicated that the dishwasher room was

heavily infested, with a majority of cockroaches finding harborage in the dish-washing equipment. It was concluded that the dishwasher room needed to be heated directly for 3 to 4 hrs during the first phase of the treatment.

2-6. Thermal Treatment Completion and Teardown.

a. **Continue to vacuum cockroaches.** Once thermal treatment is terminated, a concerted effort should be made to vacuum as many cockroaches as possible before they relocate to new harborage sites. Cockroaches that survive the heat treatment normally are severely stressed and are more accessible to collection by vacuuming and the effects of residual insecticides.

b. **Shut down the heaters.** The **first step** in this process is to **turn off the propane flow at the tank to the heater**. When all propane within the system has been burned, the heater's burner will automatically shut off. Then turn off the heater's burner switch. Immediately disconnect the duct connector ring from the heater to prevent the injection of cool air into the heated space. This will make the task of vacuuming cockroaches easier since they will tend to stay in the cooler spots. As the room temperature cools, the clustered cockroaches will begin to disperse. Be sure to reset the gas flow regulator back to where it was initially set to provide a 150 to 180 °F output. Allow the fan to blow cool air through the heater for a few minutes, until the heater burner cools, then turn off the fan.

c. **Retrieve the thermocouples.** Thermocouples should be retrieved in the opposite order in which they were laid. The last thermocouples laid will normally be at the top, where many wires cross. Using cables which have multiple wires will greatly facilitate the laying and retrieval of thermocouples. (See Appendix C, page C-3, for a possible source.) Extreme care should be taken while retrieving the thermocouples. Too much tugging on any single wire can cause the Data logger to be pulled off of its support and/or loosen the wire's connections in the Data logger.

d. **Save the monitoring data, if any analysis is to be done of the data.** It is wise to save the monitoring data as soon as possible after the completion of the thermal treatment. Data saved on a computer can be analyzed and used to improve the thermal treatment process or for technical presentations. Moreover, a permanent record of the temperature data is critical if any liability questions develop which could be related to equipment or building damages produced during the thermal process. Follow the procedures given by the manufacturer for equipment- or software-specific instructions.

e. **Restore power to the facility.** Power can be restored to the facility once the vacuuming of cockroaches is complete. If the lights are turned on immediately following heater shut down, the cockroaches will instinctively run for cover and darkness. The

vacuuming phase may require an additional person to act as "spotter" for the person with the vacuum sweeper. During this phase, it is desirable that the lights remain off in order to collect as many surviving cockroaches as possible.

f. **Return the facility to its original condition.** All of the actions carried out during the setup phase must now be reversed.

(1) Carpenters (or Contract Personnel).

(a) Remove door and window inserts.

(b) Take down plastic walls, if they were used.

(2) Food Service Personnel.

(a) Reposition any equipment that was moved.

(b) Wait for refrigerators and freezers to stabilize before placing food in them.

(c) Return cardboard cartons containing soft drink syrup, and unseal the end of the soda fountain hoses.

(d) Return computers and/or any other equipment that have computer chips in them.

(e) Reconnect all ice machines.

(3) Fire Department Personnel.

(a) Reactivate the heat and smoke detectors and the fire alarms.

(b) Reactivate or reinstall any fire suppression/alarm systems that were deactivated, especially the range hood fire suppression systems. Remove insulation from sprinkler heads if it was used.

(c) Inform the crew on-duty that the thermal treatment is over.

(4) Heating and Refrigeration Personnel.

(a) Place in operational order all mechanical equipment (refrigerators, freezers, soda machines, ice machines, steam kettles, exhaust vents, air handling systems).

(b) Turn on gas to the building and relight the pilot lights.

(c) Once the refrigeration equipment has cooled, check refrigerator seals to see if any were damaged.

(d) Remove any covering that was used to block the ventilation ducts.

(e) Turn on all circuits at the breaker box that were turned off.

(5) Pest Management Personnel. Unseal the floor drains that were sealed.

(6) Preventive Medicine Personnel. Lay out Mr. Sticky Traps in the locations that were used for the cockroach survey conducted the night before the thermal treatment.

2-7. Posttreatment.

a. **Apply a tank mix of adulticide and insect growth regulator in accordance with the label instructions to kill any cockroaches that survived the thermal treatment.** The application of insecticide and insect growth regulator following a thermal treatment is a good supplement to this process, since the heat forces a majority of the cockroaches to become active and leave their normal daytime harborages. Those that survive the thermal treatment process will be actively searching for another harborage thus increasing the likelihood that the remaining population will come in contact with the residual pesticides.

b. **Place baits in area of incoming supplies.** Cockroach bait stations (Combat) placed in receiving storage areas will help to reduce the number of new cockroaches being introduced into the dining facility. It is also recommended that several cockroach bait stations be placed in the heat-treated areas to further help control any surviving cockroaches.

c. **Conduct sticky trap surveillance for at least 1 year following the thermal treatment.** To determine the efficacy of a thermal treatment, it is recommended that the facility be surveyed for cockroaches using the following trapping schedule: the night immediately following treatment, 1 week posttreatment, and monthly thereafter for up to 1 year. Not only will the trapping provide verification of the process, but it will indicate the areas that are becoming reinfested so that pest management practices can be employed and the population controlled before it gets well established and difficult to control.

Appendix A

FORMS

THERMAL CONTROL
OXYGEN, CARBON MONOXIDE, COMBUSTIBLE GASES LEVELS
(For use of this form see USACHPPM TG 208)

INSTALLATION: _____
BUILDING NO.: _____
DATE: _____
EMPLOYEE NAME: _____

TIME	OXYGEN	CARBON MONOXIDE	COMBUSTIBLES

INSTRUMENT NAME: _____
MODEL: _____
SERIAL NO. _____

CHPPM Form 381 (R), 1 Oct 96 (MCHB-DC-OEN)

THERMOCOUPLE SENSOR LOCATIONS

(For use of this form see USACHPPM TG 208)

BUILDING _____ INSTALLATION_____ DATE___/___/___

CHANNEL #	BUNDLE #	SENSOR #	ALTITUDE C[a]	ALTITUDE LAH[b]	LOCATION
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					
13					
14					
15					
16					
17					
18					
19					
20					

a = ceiling b = Lowest Available Harborage

CHPPM Form 381-1 (R), 1 Oct 96 (MCHB-DC-OEN)

Appendix B

CHECKLISTS

1. The following checklists are designed to be given to the DPW, Preventive Medicine, Fire Department, Food Service, and Pest Management representatives during the pre-briefing and preliminary inspection 1 month prior to a planned thermal control treatment. The checklists will be used during the preparation and conduct of the actual thermal treatment to assist the thermal control team leader and other support personnel identify specific tasks which must be accomplished prior to, during, and after a thermal control treatment.

2. These checklists are based on the distribution of labor at the installations treated to date. Assignment of specific tasks will differ with each installation, and an experienced thermal team will assume more of these responsibilities themselves. For instance, a well-equipped experienced thermal team most likely will not require assistance from the carpenter shop or the pest control shop.

3. Since each facility that receives a thermal treatment is different, these checklists may not address all issues for a specific facility. Comments or suggested changes to them should be given to the Technical Support office listed in paragraph 1-4 of this technical guide.

CHECKLIST FOR THERMAL COCKROACH CONTROL

INSTALLATION CARPENTER SHOP PERSONNEL OR PEST CONTROL CONTRACTOR

1. Pretreatment Activities.

a. ___ Cut plywood panel insert(s) (1/4-inch thickness), with circular hole(s) to allow for the injection of heat through heating duct(s). The panel insert(s) must be removable and the hole(s) large enough to pass an 18-inch duct(s) through easily. If needed, the bottom of each door panel should have a 6-inch wide opening to allow cooler bleed air to exit the building. Plywood panel inserts are most commonly used for door and window openings.

b. ___ Provide wooden poles 8 and 10 feet long for the attachment of thermocouple wires which will be used to measure temperatures at ceiling level. The cross-section dimensions of these can be small (1.5 inches square) since they only need to support lightweight wire. These must be provided as soon as facility preparation begins because running thermocouple wires is one of the most time-consuming aspects of facility preparation.

c. ___ Seal off any adjoining rooms or hallways that are not going to be heated. Plastic sheeting or thin plywood (1/4-inch) may be used.

2. Posttreatment Activities.

a. ___ Unseal any rooms or areas that were blocked off.

b. ___ Collect and store lumber for future thermal requirements.

CHECKLIST FOR THERMAL COCKROACH CONTROL

FIRE DEPARTMENT*

1. Pretreatment Activities.

a. ___ Shortly before treatment, deactivate or remove any fire suppression and alarm systems that may be activated or damaged by prolonged exposure to 150 °F or brief exposure to 175 °F.

b. ___ Deactivate any heat or smoke alarm systems.

c. ___ Deactivate the sprinkler system.

d. ___ Remove any pressurized gas cylinders associated with the fire suppression system for gas ranges.

2. Posttreatment Activities.

___ Reactivate or replace any systems that were deactivated before treatment or damaged during the treatment.

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* On some military installations many of the fire support requirements are contracted out; therefore, the thermal control coordinator must contact the installation's Fire Department Chief to determine what tasks it can support or who they have contracted to support the Fire Department's needs.

CHECKLIST FOR THERMAL COCKROACH CONTROL

FOOD SERVICE PERSONNEL

1. Pretreatment Activities.

a. ___ Remove all food items from the refrigerators/freezers. If the walk-in refrigerator's compressor is insulated from the area to be heated, it can be left on.

b. ___ Remove all food stuffs located in the area that will be damaged by exposure to 150 °F; for example, fresh fruits and vegetables, spices, or items that may melt such as chocolate and candles. Temperature-sensitive items may be stored in refrigerators or freezers that are not scheduled to be turned off.

c. ___ Leave those materials that will not be damaged, as well as paper goods, in place. This is done to ensure that cockroaches do not return with these materials. The doors of disconnected refrigeration equipment should be keep closed to prevent door and seal damage. With the doors kept closed, temperatures within this equipment should not exceed 105 °F.

d. ___ Remove all carbon dioxide tanks, portable fire extinguishers, and aerosol containers. If left, they may accidentally vent under the increased pressure caused by the rise in temperature. These items may also be placed in the walk-in refrigerator.

e. ___ Remove any potentially flammable items such as paints, charcoal lighter fluid, and paint thinners from the facility (including latrines).

f. ___ Remove computers, computer disks, and any equipment that has computer chips in them. Previous experience indicates that ice machine circuit boards are not affected by temperatures of 150 °F.

g. ___ Remove ice from ice machines.

h. ___ Clean floor drains. Use either a steam cleaner or very hot soapy water and scrub brush to ensure that organic matter is washed from the sides of the drains. High temperatures and a lot of water are necessary to kill cockroaches harboring in the drains.

i. ___ Remove any movable items (flower pots, cleaning supplies, detergent boxes, plastic milk crates) from the floor and placed on table tops or counters in the kitchen. This is done because the kill rate increases with height in the facility, it allows for better air circulation along the floor, and it reduces the number of relatively cool micro habitats that cockroaches can harbor in.

j. ___ Tilt metal cabinets or large fan bases off the floor so cockroaches cannot harbor under them.

k. ___ Remove thermometers from areas to be heated since these may be ruined by the 150 °F temperature.

2. Posttreatment Activities.

a. ___ Return all items to their condition prior to preparation for the thermal treatment.

b. ___ Refrain from washing floors until after service of the first meal. Use a broom or vacuum to remove dead roaches. Depriving cockroaches of water at this time will make the treatment more effective, since the survivors are in critical need of water following the heat treatment.

CHECKLIST FOR THERMAL COCKROACH CONTROL

HEATING AND REFRIGERATION SHOP

1. Pretreatment Activities.

a. ___ Shut off all mechanical equipment.
- ___ refrigerators
- ___ freezers (unless compressor is out of heated area)
- ___ ice machines
- ___ steam kettles
- ___ soda machines
- ___ milk dispensers

b. ___ Close all refrigerator and freezer doors to protect the door seals.

c. ___ Remove or insulate refrigerators or freezers manufactured by Jordan. The material used to insulate the doors and cabinets expands at high temperatures and causes door panels to enlarge and warp.

d. ___ Shut off all air-handling and air-conditioning units.

e. ___ Close off all ventilation ducts in those areas being heated where they exit the building. If this is impractical, seal the interior openings with a plastic sheet, cardboard, or aluminum foil. Where grease filters exist, the filter can be removed and plastic sheeting placed behind it.

f. ___ Ensure that enough live circuits of sufficient capacity are remaining to operate the heaters and miscellaneous monitoring equipment after all equipment and fluorescent ceiling lights (fluorescent ceiling lights are shut off to protect the ballast from overheating) are shut off.

g. ___ Shut off gas to the building and let pilot lights burn off any remaining gas.

2. Posttreatment Activities.

a. ___ Unblock all ventilation ducts.

b. ___ Reactivate air-conditioning and air-handling equipment.

c. ___ Reactivate all equipment which was disconnected.

CHECKLIST FOR THERMAL COCKROACH CONTROL

INSTALLATION PEST MANAGEMENT PERSONNEL
OR
PEST CONTROL CONTRACTOR

1. Pretreatment Activities.

a. ___ Prior to thermal treatment, thoroughly flush any cockroaches from the drains with hot water from a hose. Seal the drains by covering the grate with cellophane or aluminum foil. If a grate is missing, clean all grease from the floor, dry the floor, and then seal the opening with duct tape. Alternatively, wrap a wad of toweling larger than the drain in cellophane and plug the opening with it.

b. ___ Caulk any holes found in walls or floors.

c. ___ Apply an insect growth regulator in accordance with label directions.

2. Posttreatment Activities.

a. ___ Vacuum any cockroaches that have congregated in cool spots.

b. ___ Following cool down of the facility, do a residual pesticide application with an insect growth regulator and place Combat bait stations surrounding the area where supplies are brought into the facility. This is done to decrease the rate at which the facility is reinfested. A high concentration of bait stations should surround this area and be replaced as directed on the label.

c. ___ Monitor the cockroach population after treatment and spot treat any areas where reinfestation is evident.

CHECKLIST FOR THERMAL COCKROACH CONTROL

PREVENTIVE MEDICINE SERVICE

1. Pretreatment Activities.

a. ___ Select building for treatment.

b. ___ Provide preplanning coordination and notification of all military organizations responsible for the facility. Identify thermal control team members.

c. ___ Conduct pretreatment sticky trap survey 1 month before treatment.

d. ___ Ensure all required equipment and supplies are available.

2. Treatment Activities.

___ Coordinate with or task personnel to solve any other issues that may develop.

3. Posttreatment Activities.

a. ___ Provide coordination of teams during clean up and ensure that facility is returned to operating condition.

b. ___ Do posttreatment sticky trap surveillance 1 day after treatment, 1 week after treatment, and monthly thereafter for at least 1 year to determine the effectiveness of the thermal treatment. Conduct posttreatment surveillance in the same manner as the pretreatment surveillance.

CHECKLIST FOR THERMAL COCKROACH CONTROL

THERMAL CONTROL TEAM

1. Pretreatment Activities.

a. ___ Order propane. One 100-pound propane tank for each heater will be needed when outdoor temperatures are above 50 °F, and two will be needed when temperatures are lower. Specify delivery for the day prior to heat treatment. The tanks must be stored in a secure area until they are used.

b. ___ Place heaters around outside of building to maximize heating and heat distribution. Plan on having one heater for each 6,000-8,000 cubic feet of air space.

c. ___ Remove or insulate any fire extinguishers to prevent them from being exposed to temperatures exceeding 120 °F or less if so stated on the label.

d. ___ Run thermocouple wires to representative areas of the facility and to sensitive areas such as fire extinguishers.

e. ___ Set up atmosphere probe to monitor levels of carbon monoxide, oxygen, and combustibles.

2. Treatment Activities.

a. ___ Provide adequate means for air to escape during treatment. This is best done by running bleed ducts (18-inch ducts lead from a dead-air space near the floor, such as in a corner) through windows and doors to the outside.

b. ___ Position and reposition ducts throughout. Concentrate ducts in areas of the facility with the greatest infestation, typically the kitchen and dishwashing room. Keep the duct opening several feet from any equipment that may be stressed by high temperatures (such as refrigerator doors and equipment with electrical components and plastic or rubber parts) to allow the heated air to cool before it contacts the equipment.

c. ___ Adjust heater output temperature to the 150-180 °F range.

d. ___ Monitor temperature in the building at least every 10 minutes. The goal is to have all areas of the facility reach 115 °F for at least 45 minutes.

e. ___ Do not let any part of the building exceed 150-155 °F. If a fire suppression sprinkler system is present, it may be necessary to lower this temperature.

f. ___ Enter the building every half hour to look for possible damage to the building or its contents. Carefully observe nonceramic tile for discoloration, softening, or bubbling. Make sure refrigerator and freezer doors remain closed. Check plastic components of equipment for signs of heat damage.

g. ___ Enter the building periodically to check on movement of cockroaches and where they are congregating. Once temperature throughout the building has raised considerably (most locations 110-120 °F) and cockroaches have been flushed from harborage areas, vacuum them and then move ducts to cool areas.

h. ___ Monitor atmosphere for oxygen content, combustibles, and carbon monoxide.

i. ___ At termination of necessary time and temperature requirements (115 °F in all areas for 45 minutes) turn off heaters and continue to vacuum. When vacuuming is complete, open a few windows.

3. **Posttreatment Activities.**

___ Collect and pack equipment.

Appendix C

EQUIPMENT CHARACTERISTICS AND A LISTING OF THERMAL EQUIPMENT

The following equipment descriptions are taken from each manufacturer's description of their products. The list of thermal equipment is to serve as a guide when purchasing equipment, other equipment with similar characteristics may be used.

TOPP SAFE HEAT Model 400 or 500

TOPP Construction Services, Inc.
P.O. Box 504
Media, PA 19063

Telephone (610) 459-5515
Fax: (610) 459-3822

Heater Specifications:

Electrical:	
Voltage	120 VAC
Phase	1
Frequency	60 HZ
Amperage	7 Amp
Gas Type	Propane
Heat Output	400,000 Btu/Hr

Heater output temperature is adjustable and the unit is light weight and portable from 150 to 350 °F. Both of these features are critical.

lil' Hummer Backpack Vacuum

Miracle Marketing Corp.
P.O. Box 520125
Salt Lake City, UT 84152-0125
Telephone 1-800-634-6102

Motor Specifications:	
Maximum AMPS (running)	9.6
Maximum Watts (running)	1057
Maximum Airflow (Cubic Feet Minute-CFM)	92
Maximum Water Lift (sealed suction), inches	96
Maximum Horse Power (running)	1.5

Vacuum Cleaner Specification:	
Height (inches)	22.5
Width (inches)	10.5
Depth (inches)	7.5

Filtration efficiency down to 0.3 microns is possible with the Absolute Electrostatic filter. At this level, the filter will remove most insecticidal dusts, pollens, and common dust particles. The lil' Hummer will allow the user to vacuum virtually any cockroach that can be seen and kill them as they enter into the vacuum without any dispersal of the multitude of different materials vacuumed-up. It must be ordered with the heavy duty hose (to prevent kinking at high temperatures) and the higher temperature high limit switch.

Omega OM 5140 Programmable Data logger

Omega Engineering, Inc.
One Omega Drive, P.O. Box 4047
Stamford, CT 06907-0047
Telephone (203) 359-1660

The OM-5140 is a bench top model. It is completely self-contained and equipped with a built-in 24-column thermal printer, which makes it easy to monitor the heating process. It includes a data cache memory that temporarily stores logged data for reviewing or uploading to a remote computer. The OM-5140 can record and store information from up to 40 channels. Its programmable functions include: date and time; log interval, sensor type, number of channels scanned; alarm points, and unit of temperature. To facilitate attachment of thermocouples a female subminiature connector should be attached to 2-foot leads coming from the Data logger.

While the OM-5140 is an excellent piece of equipment, it is expensive. Cole Parmer offers a 12-channel scanning thermometer for $845.00. While it lacks a printer, it can be attached to a printer, it has data storage and recall features that may make it adequate for conducting thermal control.

COST INFORMATION FOR THERMAL EQUIPMENT AND MATERIALS

Item	Model/Brand	Cost[1] $	Quantity	Total Cost $	Investment Cost/ Recurring Cost
Propane Heater w/gas connector	SAFE HEAT Model 400 LP, Direct Fired Portable, w/gas metering valve	2,450	8	19,600	IC
Heating Ducts	HT-Duct-18", Mylar	31.25	20	625	IC
Heater Sleeves	N/A	56	8	448	IC
Data logger, Omega	OM-5110, Bench top, 40 channels	3,640	1	3,640	IC
Carrying case	OM-5000-CC	142	1	142	IC
Printer paper	OM-5000-RP	32	1	32	RC
Computer cable	OCAT-F-10, RS-232 cable for IBM PC,10'	56	1	56	IC
Thermocouple wire, 60', multi-pair extension cable	Cat.No.8TX20PP Copper/Constantan ANSI type TX	168	2	336	IC
Thermocouple wire, 80', multi-pair extension cable	Cat.No.8TX20PP Copper/Constantan ANSI type TX	224	2	448	IC
Thermocouple wire, 1000' roll	Cat. No. TT-T-24S SLE, Stranded 24 ga. Teflon wire	365	2	730	IC
Electrical wire connectors	SMPW-T-F, Subminiature Connectors	2.75	80	220	IC
Electrical wire connectors	SMPW-T-M, Subminiature Connectors	2.25	80	180	IC
Vacuum sweeper	lil' Hummer, back pack w/harness	320	2	640	IC

COST INFORMATION FOR THERMAL EQUIPMENT AND MATERIALS (Cont'd)

Item	Model/Brand	Cost[1] $	Quantity	Total Cost $	Investment Cost/ Recurring Cost
Vacuum accessories	hose/w plastic bent hand/cuffs; crevice tool; absolute electrostatic filter; ultra stat paper bags	40	2	80	IC
Extension cords, high temp.	N/A, 50'	66	5	330	IC
Extension cords, high temp.	N/A, 10'	39	4	156	IC
Gas connectors	pig tail, + connector	55	4	220	IC
Tape, high temp. 3" wide	PATCO tape no. 6033,	9.75	10	98	RC
Tape, high temp. 2"	PATCO tape no. 6033	6.75	10	65	RC
Duct tape	N/A	5	10	50	RC
Flash lite	Mag lite, 3 cell	17	3	51	IC
Batteries	D-cell	0.5	12	6	RC
Gas (com-mercial)	Propane (gas=$50@ Delivery ($10.50)	50	10	500	RC
Miscellaneous[2]				1,000	IC/RC

[1] Denotes the cost of each item.

[2] Includes: Tempmat (thermal insulation for sprinkler system), caulking materials, tools, gloves, expansion foam, refrigerant packs, door/window inserts, plastic for constructing wall petitions, pilot strips, detectors for electricity.

Appendix D

THERMAL CONTROL REFERENCES AND BIBLIOGRAPHY

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TB MED 561, Occupational and Environmental Health Pest Surveillance.

Appendix E

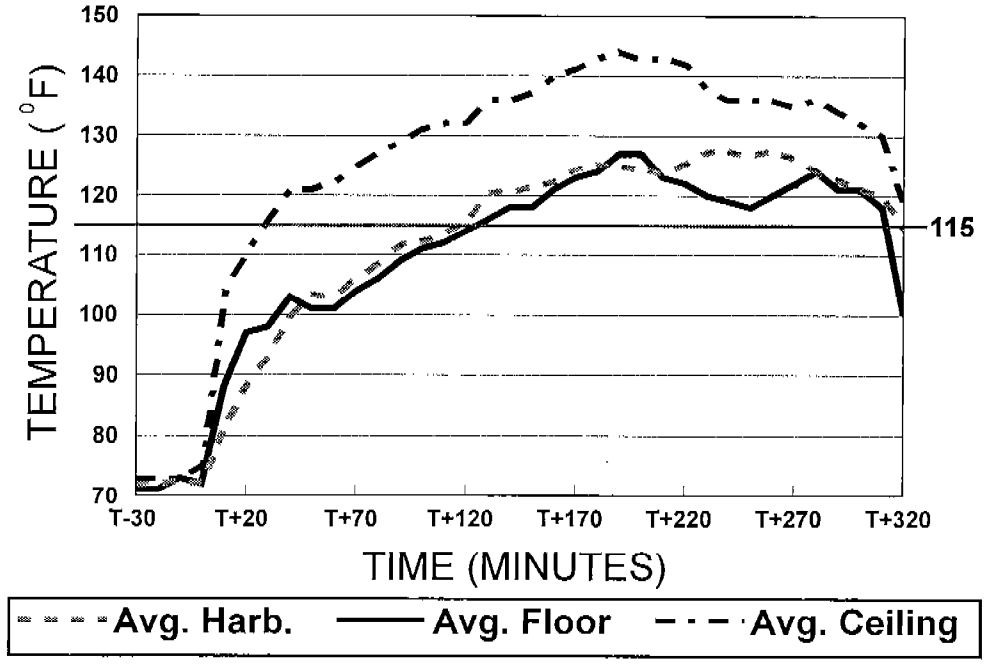
GLOSSARY

bleed air	Heated air is being forced into the facility at 2,000 cubic feet per minute for each heater used. The injected hot air displaces the cool air that is already in the facility. Bleed air is that cooler air that is forced out of the facility through pre-planned, specific window or door vent areas.
cfm	cubic feet per minute
DPW	Department of Public Works
harborage	any area in which a cockroach may live or "hide." This may be in equipment, under boxes, behind wall paneling, etc.
LAH	lowest available harborage; that harborage which is closest to the floor and will be the slowest to heat
micro habitats	small areas of cooler temperature that occur throughout the treated facility that are a result of air being deflected around, over, or under a given point or piece of equipment in the facility
OSHA	Occupational Safety and Health Administration
ppm	parts per million
thermocouple	the temperature sensor
thermocouple-bundle	a single cable composed of eight thermocouple wires bound together
Data logger	an electrically powered piece of equipment which is capable of recording multiple temperature readings at programmable time intervals. Temperatures can be read directly on the Data logger's digital display or printed out on a paper tape. Stored data can also be downloaded to a computer for permanent storage and data analysis.

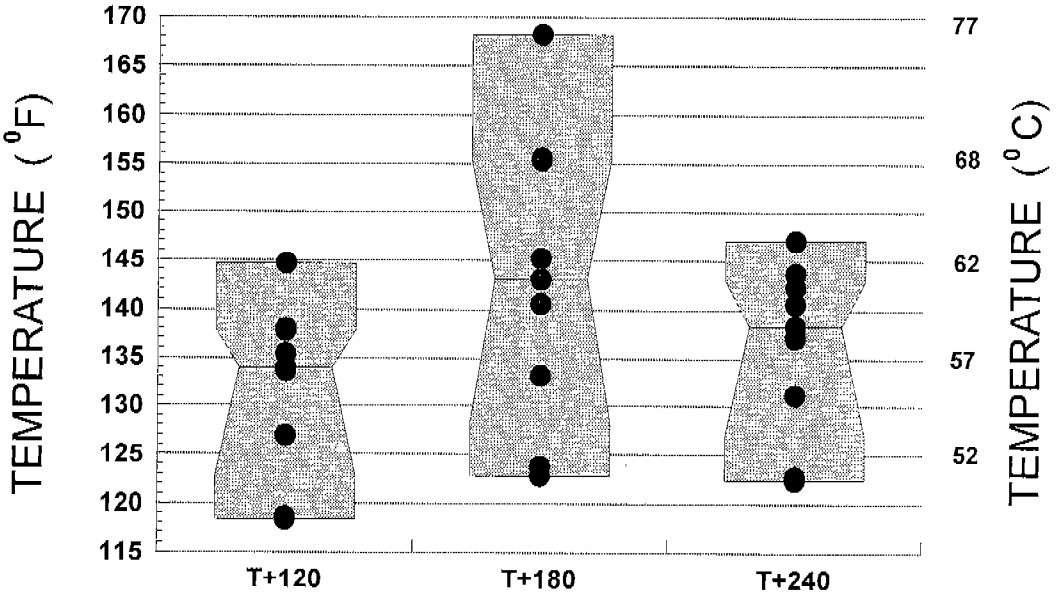
Appendix F

TEMPERATURE CURVES

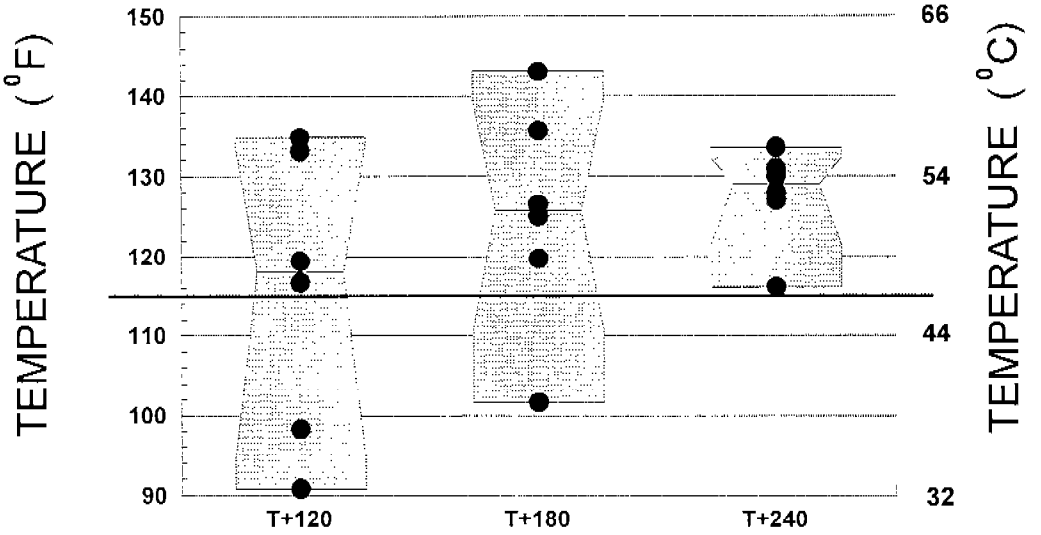
AVERAGE OF STAINLESS STEEL HARBORAGE, CEILING AND FLOOR TEMPERATURES



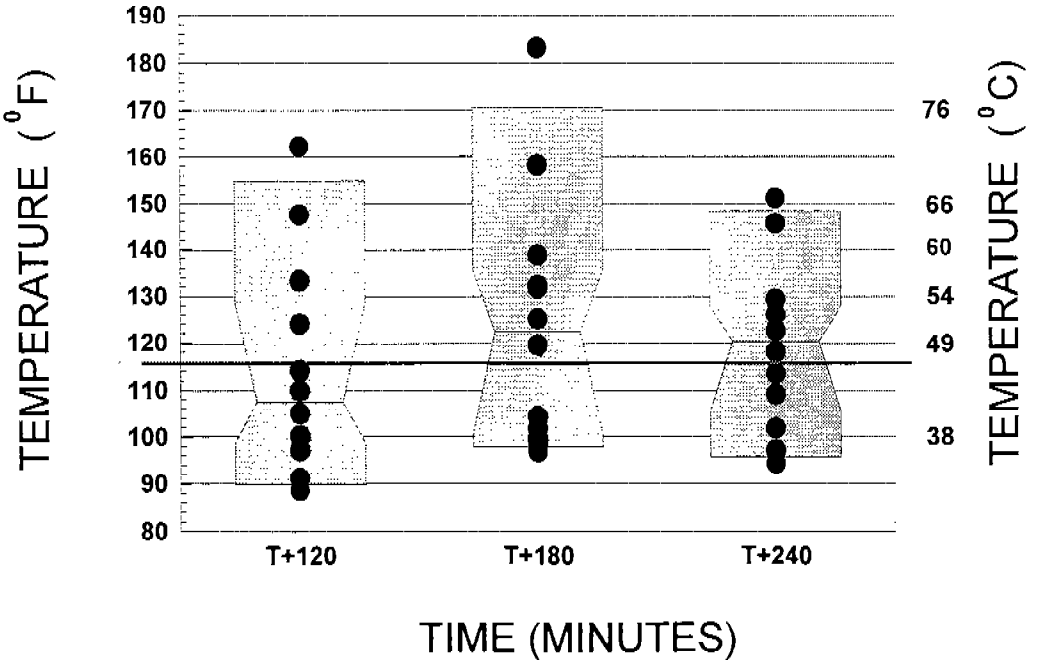
VARIATION OF CEILING TEMPERATURES



VARIATION OF HARBORAGE TEMPERATURES



VARIATION OF FLOOR TEMPERATURES



Appendix G

THERMAL CONTROL TRAP INDEX

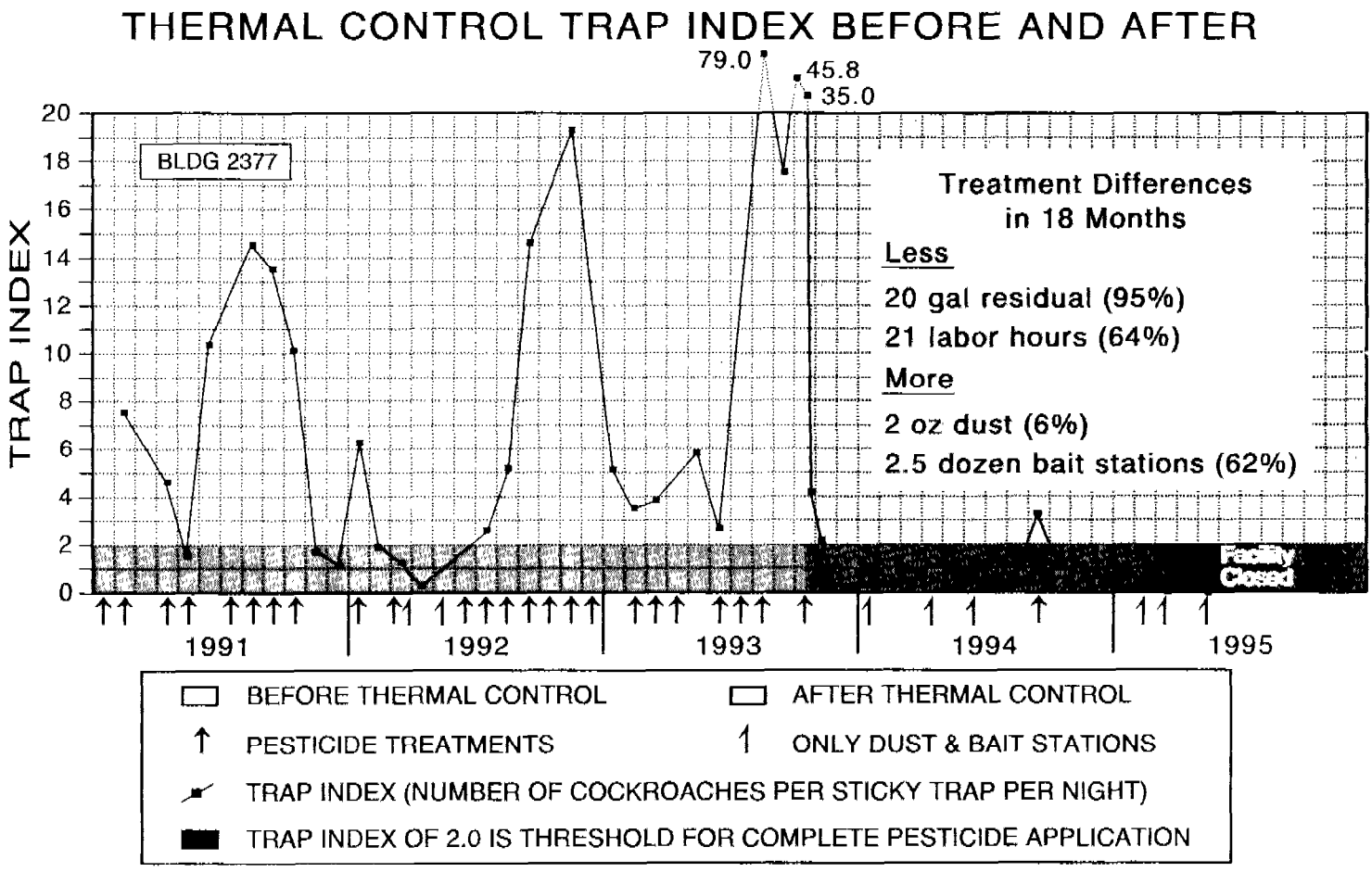

THERMAL CONTROL TRAP INDEX BEFORE AND AFTER
79.0
45.8
35.0
TRAP INDEX
20
18
16
14
12
10
8
6
4
2
0
BLDG 2377
Treatment Differences
in 18 Months
Less
20 gal residual (95%)
21 labor hours (64%)
More
2 oz dust (6%)
2.5 dozen bait stations (62%)
Facility Closed
1991
1992
1993
1994
1995
BEFORE THERMAL CONTROL
AFTER THERMAL CONTROL
PESTICIDE TREATMENTS
ONLY DUST & BAIT STATIONS
TRAP INDEX (NUMBER OF COCKROACHES PER STICKY TRAP PER NIGHT)
TRAP INDEX OF 2.0 IS THRESHOLD FOR COMPLETE PESTICIDE APPLICATION
09G023B1

FIGURE 1

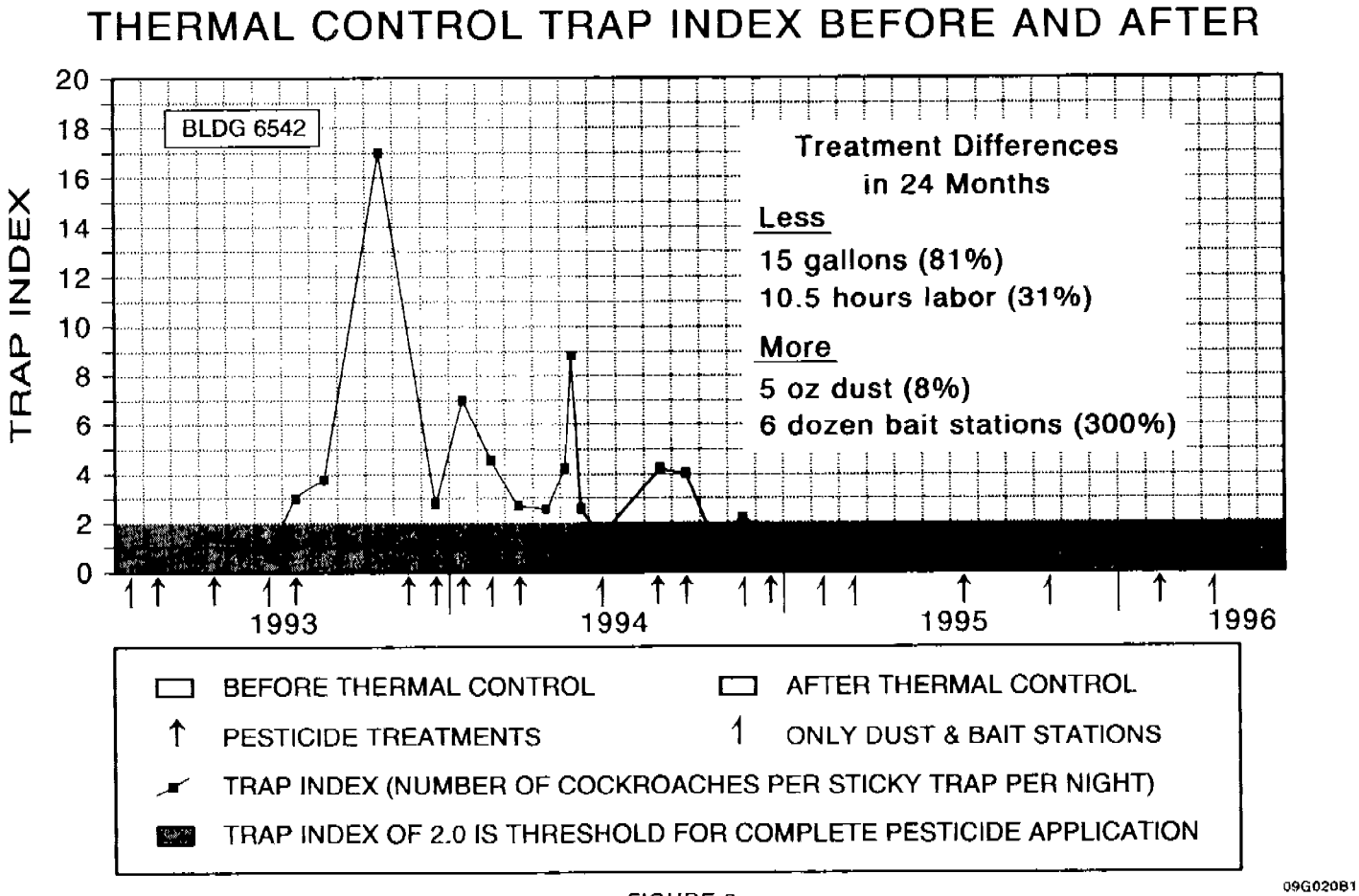

THERMAL CONTROL TRAP INDEX BEFORE AND AFTER
TRAP INDEX
20
18
16
14
12
10
8
6
4
2
0
BLDG 6542
Treatment Differences
in 24 Months
Less
15 gallons (81%)
10.5 hours labor (31%)
More
5 oz dust (8%)
6 dozen bait stations (300%)
1993
1994
1995
1996
BEFORE THERMAL CONTROL
AFTER THERMAL CONTROL
PESTICIDE TREATMENTS
ONLY DUST & BAIT STATIONS
TRAP INDEX (NUMBER OF COCKROACHES PER STICKY TRAP PER NIGHT)
TRAP INDEX OF 2.0 IS THRESHOLD FOR COMPLETE PESTICIDE APPLICATION
09G020B1

FIGURE 2

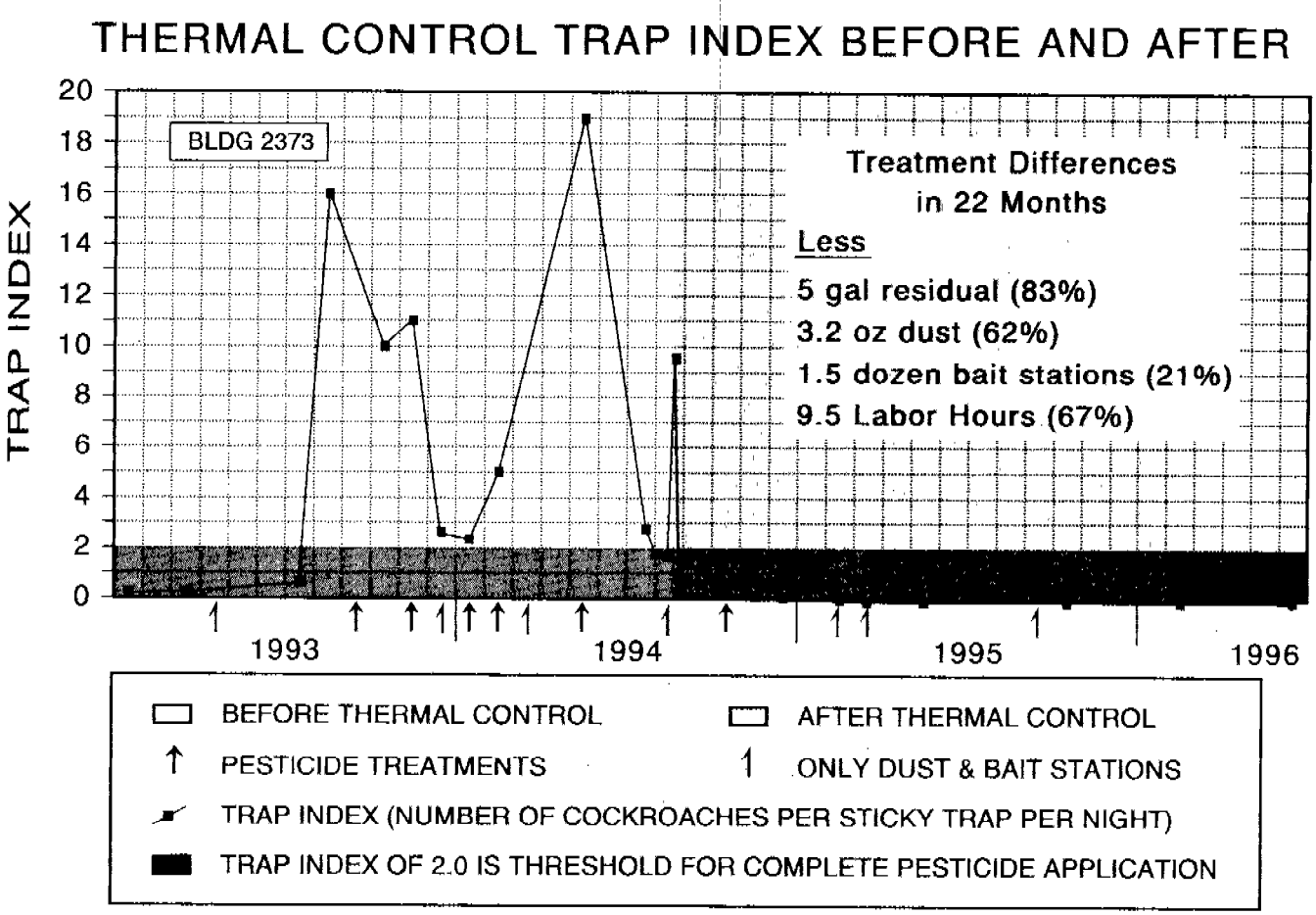


FIGURE 3

09G022B1

Appendix H

EQUIPMENT PLACEMENT

Figure 1

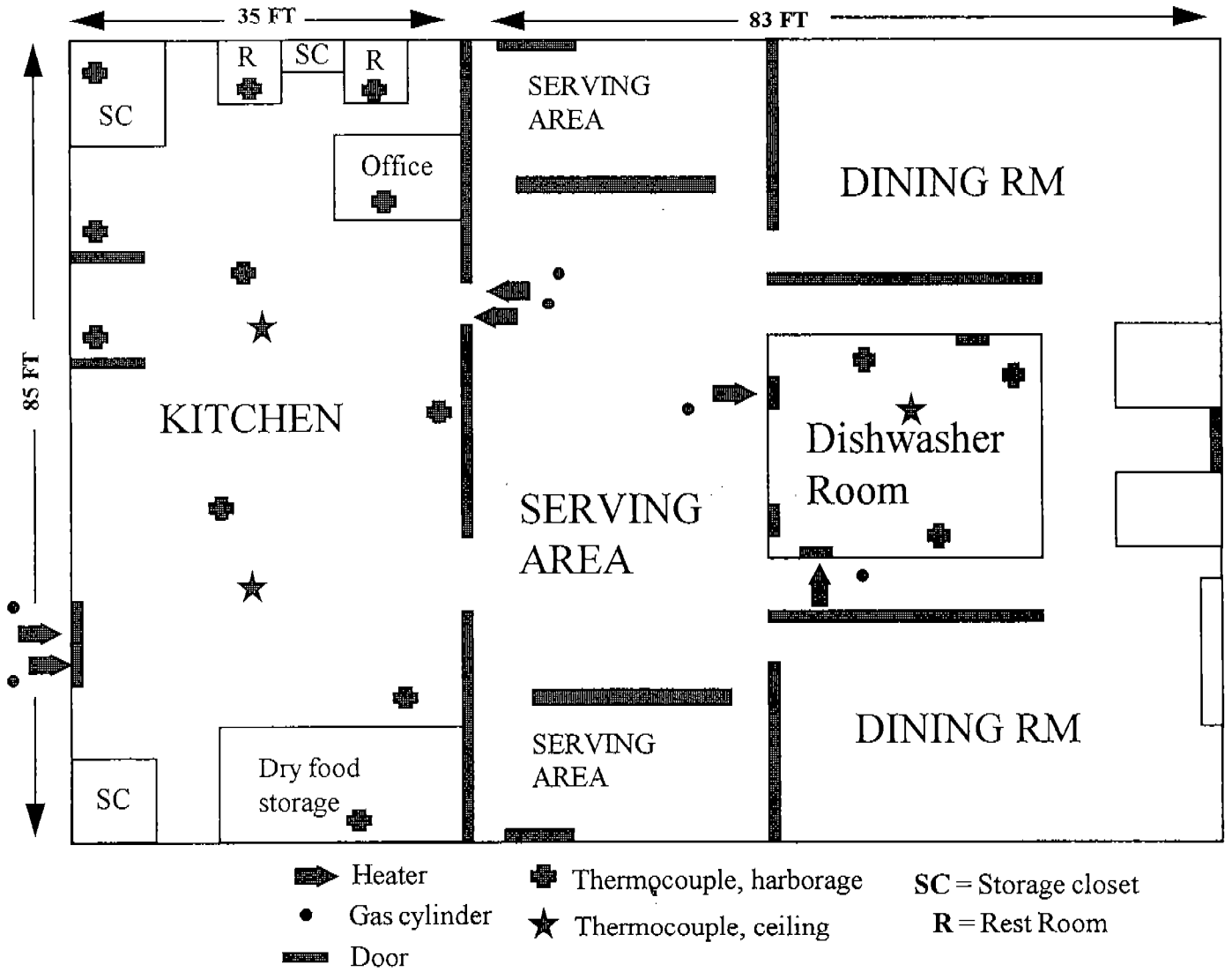
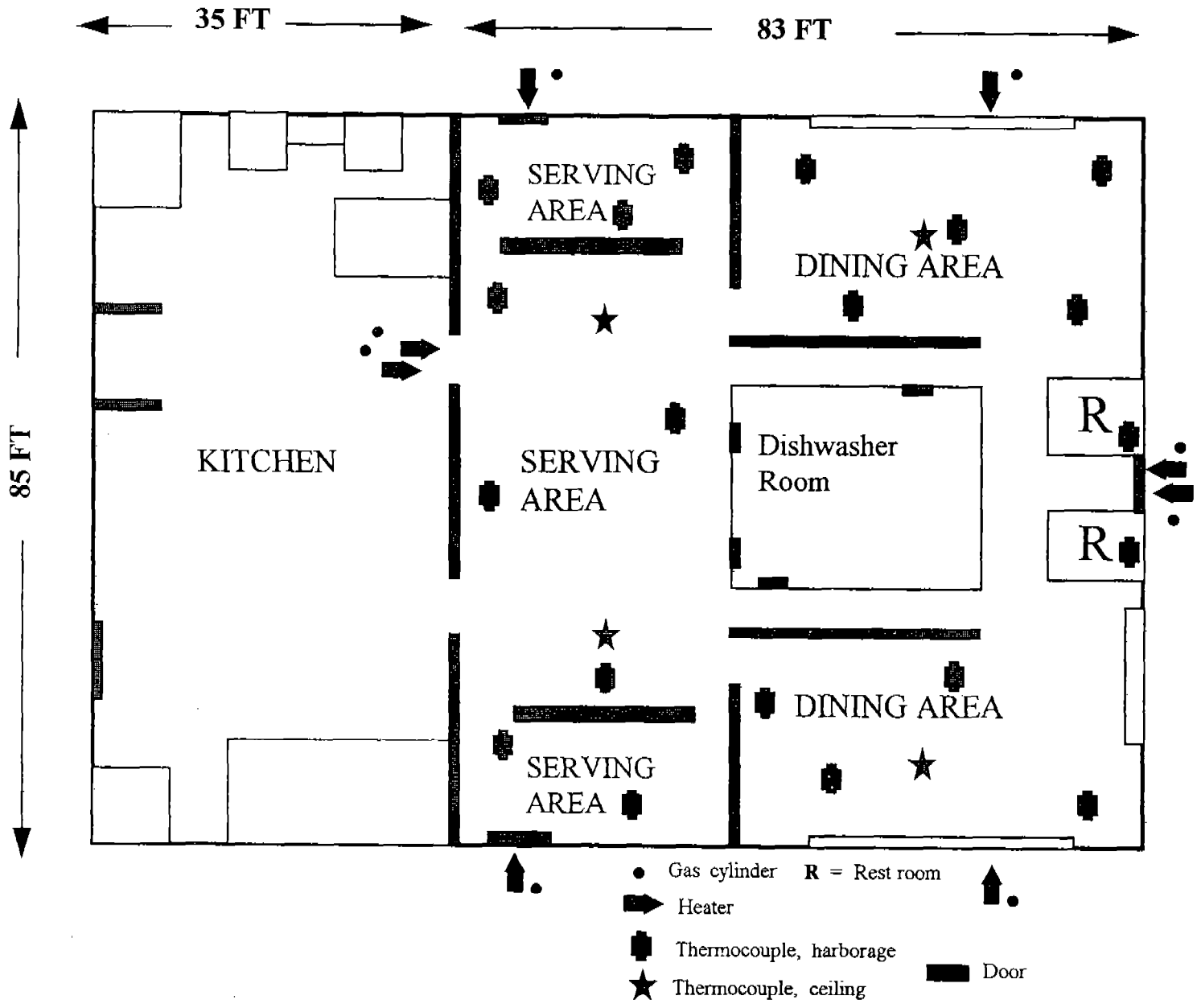

35 FT
83 FT
85 FT
SC
R
SC
R
SERVING AREA
Office
DINING RM
KITCHEN
Dishwasher Room
SERVING AREA
SERVING AREA
DINING RM
SC
Dry food storage
Heater
Gas cylinder
Door
Thermocouple, harborage
Thermocouple, ceiling
SC = Storage closet
R = Rest Room

Figure 2


35 FT
83 FT
85 FT
KITCHEN
SERVING AREA
SERVING AREA
SERVING AREA
DINING AREA
Dishwasher Room
DINING AREA
R
R
Gas cylinder
R = Rest room
Heater
Thermocouple, harborage
Thermocouple, ceiling
Door

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