

Sulfuryl Fluoride Structural Fumigation



Personal Chemical Exposure Program
Department of Entomology
University of California, Riverside

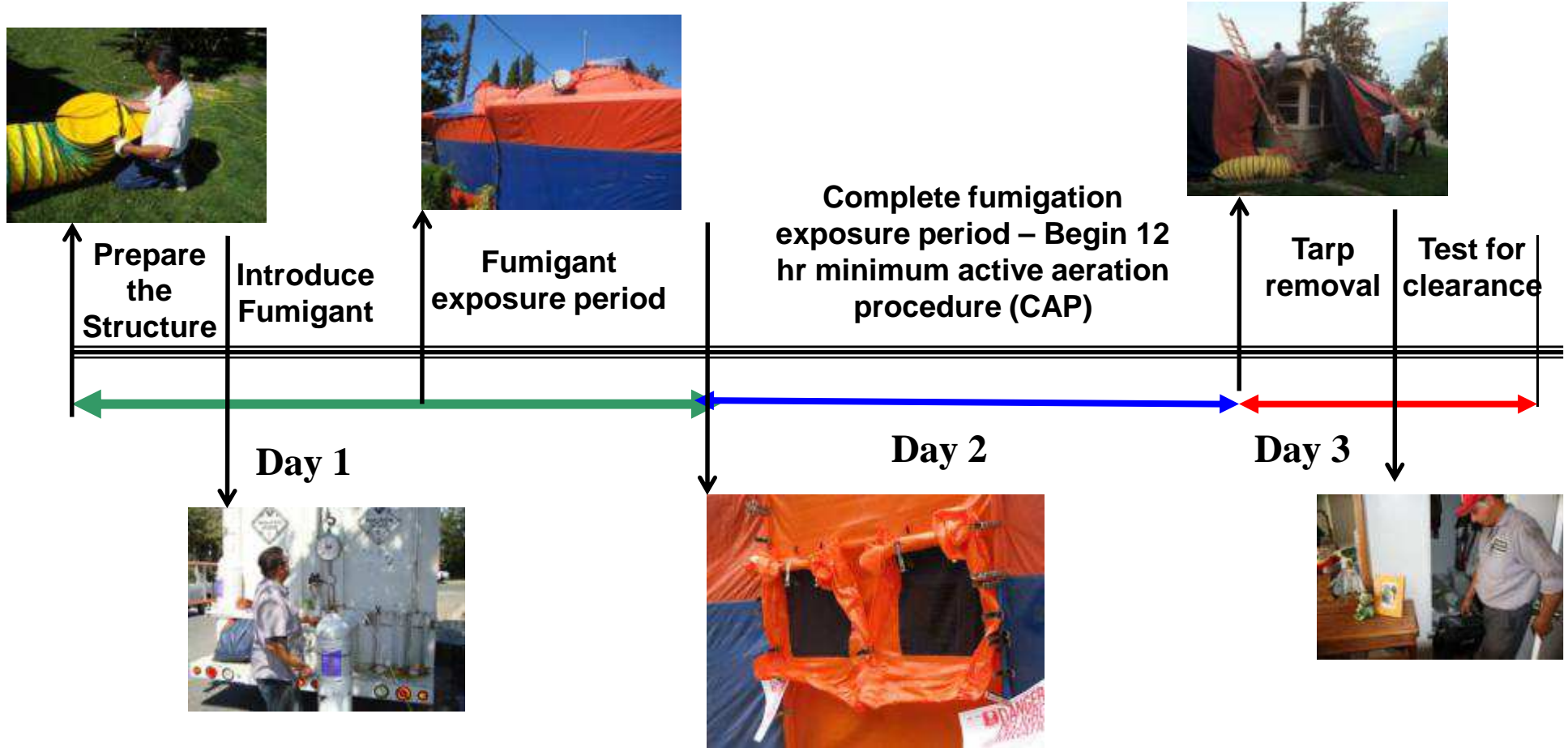
- The Personal Chemical Exposure Program in the Department of Entomology conducts human and environmental studies intended to clarify and define important chemical exposure issues.
- Concepts in chemical exposure assessment related to our research include risk assessment, mitigation, perception and regulation.

Sulfuryl Fluoride Structural Fumigation Personal Chemical Exposure Program (PCEP)

Executive Summary

In September and October, 2010, Dr. Krieger and PCEP research assistants from the University of California, Riverside, monitored sulfuryl fluoride residential fumigations for the treatment and control of drywood termites at two typical, single-family residences in Riverside, CA. The fumigations were performed by commercial applicators. PCEP monitoring was assisted by Dow AgroSciences technicians. Concentrations of Vikane[®] gas fumigant at standard commercial rates were measured to assess potential worker, resident and bystander sulfuryl fluoride exposure. The California Aeration Plan (CAP) was evaluated.

General Fumigation Timeline



Interior and exterior fumigant concentrations of each residence were monitored during all stages of actual fumigations (fumigant introduction, exposure, and aeration). The major objectives of our monitoring study were the following: 1) to evaluate potential bystander (e.g. neighbor) exposure during the fumigation and aeration procedures, and, 2) to determine if the required California Aeration Plan (CAP) satisfies California and federal safety standards for reoccupancy following fumigation.





Two Riverside, CA residences were fumigated with sulfur hexafluoride to treat and control drywood termites in September and October 2010. The fumigations were done by trained, licensed fumigators who followed product label and California regulations. Equipment including tarps, ladders, and fumigant cylinders are shown here prior to the fumigation.

The residences were tarped, fumigated at the labeled drywood termite control rate, and aerated by a licensed fumigator following product label requirements and state regulations.



For the California Aeration Plan (CAP), sealed ducting (1, 2) attached to an aeration fan (3) inside the fumigated space and sealed inlet vents (4) were installed during the tenting process, before the fumigant was introduced.





The warning agent, chloropicrin, was introduced into the building per label directions prior to the introduction of the fumigant sulfuryl fluoride. Chloropicrin at low levels of about 0.07 ppm causes eye irritation. Chloropicrin serves to warn of the presence of the odorless and colorless sulfuryl fluoride and is a deterrent to intruders. Chloropicrin is removed from the building with the sulfuryl fluoride during aeration.

A custom amount of fumigant, based on factors such as the target pest, building size, construction and environmental conditions, was accurately determined using a custom electronic calculator required by the fumigant label.



PCEP staff confirmed the building measurements and amount of sulfuryl fluoride required at each residence before introduction of fumigant.



The fumigant was weighed to introduce the prescribed amount into the fumigated space.



Interior and exterior fumigant concentrations were continuously monitored during the fumigant introduction, exposure, and aeration periods.



Exterior fumigant concentrations were continuously monitored at eight locations that were evenly spaced and close to the tarp. At each exterior sample location, a calibrated air pump attached to a stand continuously drew air into a gas-tight bag (air sample locations circled).



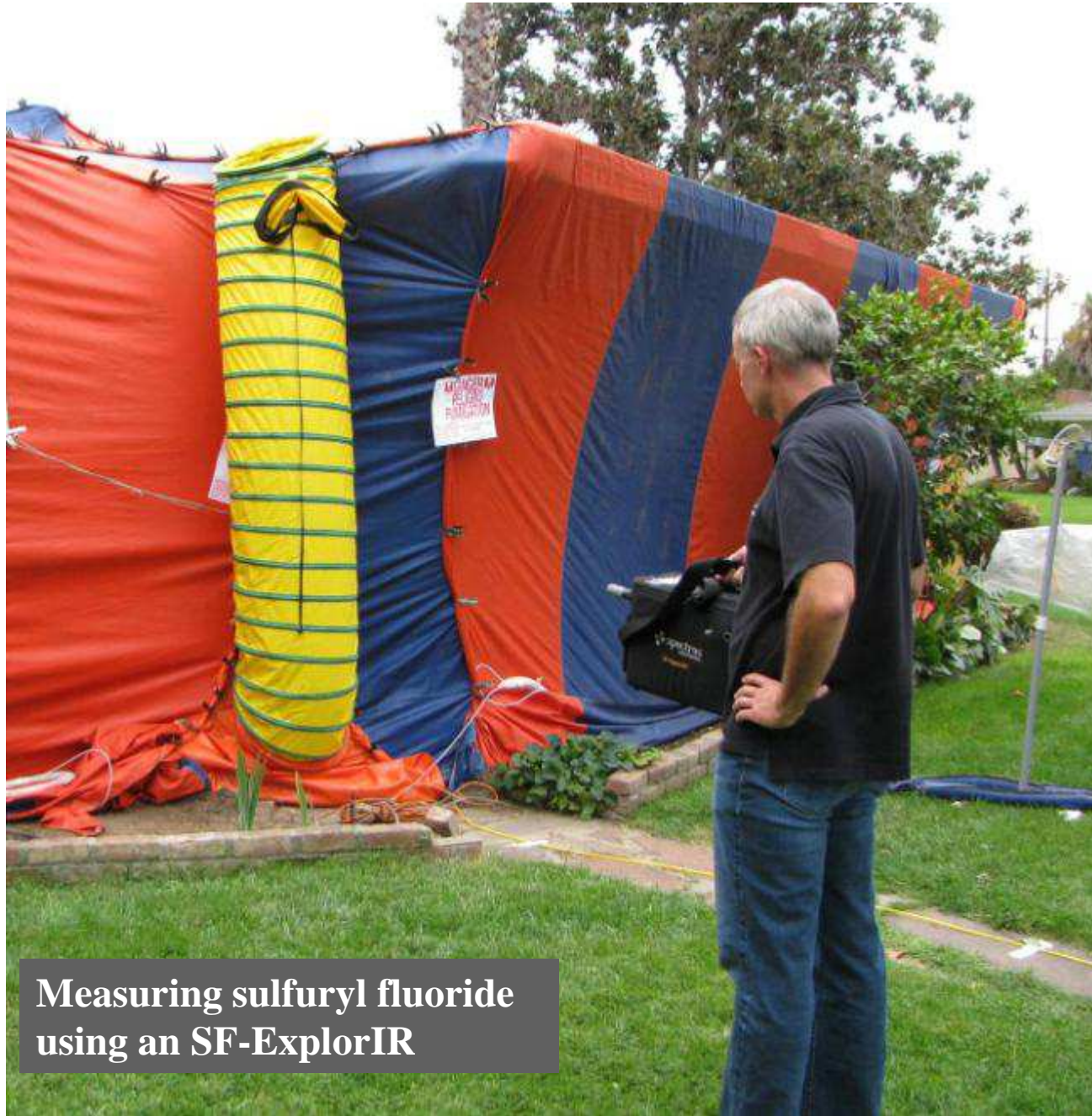
At timed intervals, the air bags were removed from the pumps and immediately replaced with clean, empty, gas-tight bags attached to the pumps to continue with uninterrupted air sampling.



Fumigant concentration in each removed bag was measured using a sensitive gas monitor, the SF-ExplorIR, which can accurately measure sulfuryl fluoride concentrations to 1 part per million (1 ppm).



The exterior fumigant concentrations of air sample intervals were used to determine the potential exposure of bystanders, such as neighbors, to the fumigant throughout the fumigation process. The potential acute exposure is called a “Time Weighted Average,” or TWA, and is based on a 24-hour exposure period.



**Measuring sulfuryl fluoride
using an SF-ExplorIR**

Interior fumigation concentrations were measured by drawing air samples through hoses placed at three locations indoors using the following validated testing procedures.



An SF-ReportIR was used to measure interior fumigant concentrations during fumigation and initial aeration





An RDA Fumiscope was also used to measure interior fumigant concentrations during fumigation and initial aeration

For the California Aeration Plan (CAP), aeration was initiated by unsealing the ducting (1) and screened inlet vents (2, 3). The airflow created by the aeration fan draws fresh air into screened inlet vents (4). Tarps remained on the houses during aeration as required by the CAP.



After aerating for at least 12 hours, as required by the California Aeration Plan, the tarpaulins were removed and the houses were tested for clearance .



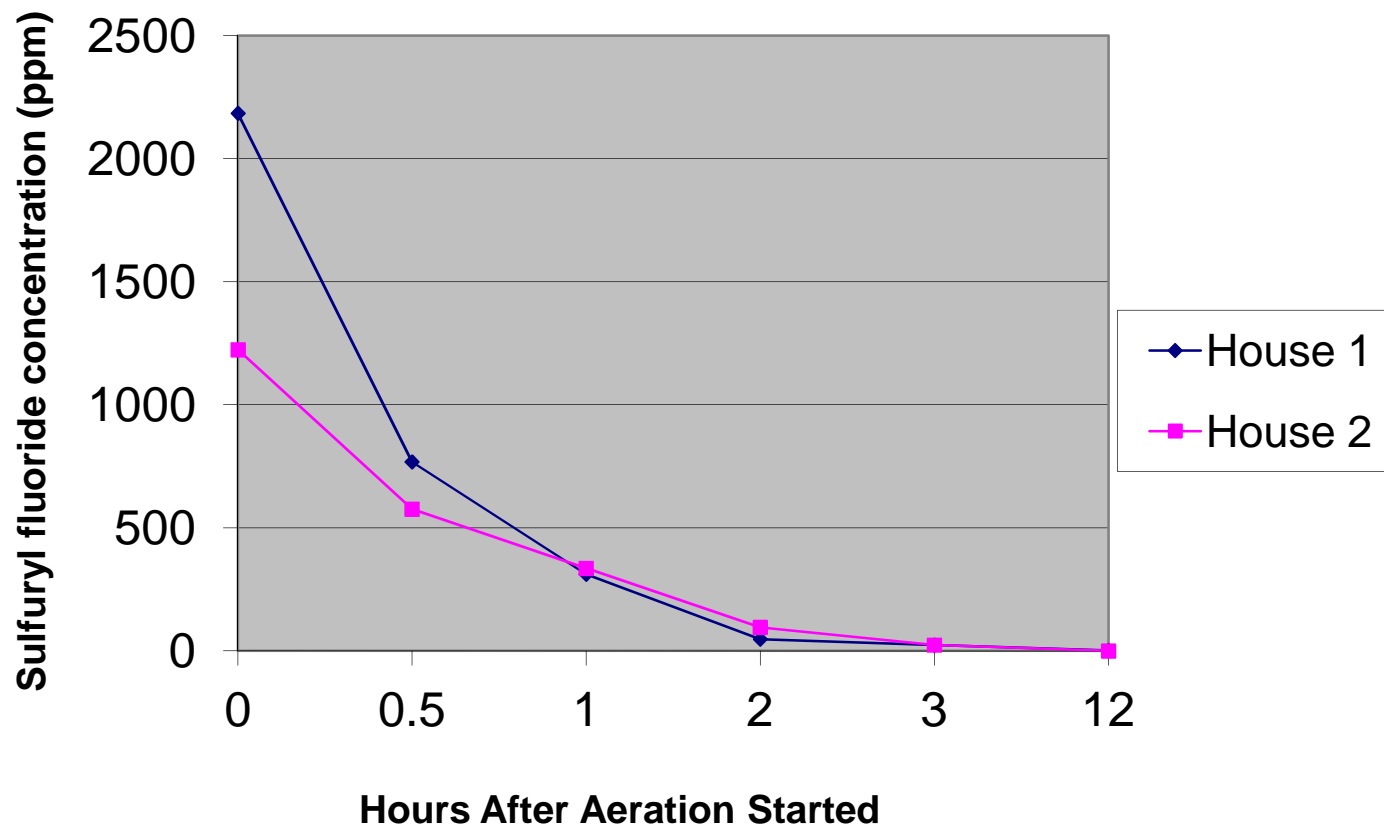
Conclusion 1: Air sampling showed that sulfuryl fluoride concentrations outside the fumigated residences were negligible throughout the fumigation and aeration periods. Possible worker and bystander exposures were well below the NOAEL (No Observed Adverse Effect Level) of the US EPA and California Department of Pesticide Regulation (Air sample locations adjacent to the house are circled)



Fumigant levels decline rapidly during aeration

Conclusion 2: Interior air sampling (Graph 1) showed that sulfuryl fluoride concentrations declined very rapidly during aeration using the California Aeration Plan (CAP). Fumigant concentrations were at or below the permissible exposure limit for occupants of 1 ppm established by the US EPA and California Department of Pesticide Regulation following the aeration time (minimum 12 hours) required by the CAP.

Interior concentrations* of sulfuryl fluoride measured in two houses during 12 hours of aeration



Graph 1:

*** Average of measurements at three interior locations for each sample interval (hours after aeration started)**

Other information about sulfuryl fluoride fumigation...

Personal Chemical Exposure Program staff periodically respond to questions from the public about fumigation. We are pleased to respond or to help you get information you need. Some common questions are included here. Fumigation technology is well-studied--answers to questions about specific work practices and safe fumigant use may be obtained from the trained professionals who work as sulfuryl fluoride fumigators, pesticide registrants, and state regulators.

Q. How many fumigations with sulfuryl fluoride are conducted each year in California?

A. About 100,000 fumigations with sulfuryl fluoride are conducted each year in California. Costs for control and repair of damage from drywood termites in California exceeds \$300 million annually and are projected to increase. <http://nature.berkeley.edu/upmc/publications.php>

Q. What sulfuryl fluoride products are registered for structural fumigation of residences and other buildings in California?

A. There are three sulfuryl fluoride products registered for structural fumigation of residences and other buildings in California.

Sulfuryl Fluoride Products Registered for Structural Fumigation in California

Registrant	Brand Name	U.S. EPA Reg. No.
Dow AgroSciences LLC	Vikane®	62719-4-ZA
Ensystem II, Inc.	Zythor®	81824-1-AA
Drexel Chemical Company	Master Fume®	19713-596-AA

Q. Why are buildings fumigated with sulfuryl fluoride?

A. Sulfuryl fluoride is the most important structural fumigant in the United States for the treatment and control of structure-infesting pests. About 100,000 fumigations are conducted in California each year. University scientists have shown that fumigation is the most reliable and complete method for elimination of infestations of drywood termites and other pests such as wood-destroying beetles and bed bugs, in buildings. In California drywood termites and other wood-destroying pests do more than \$300 million damage every year to homes and other buildings. Research from the University California, Berkeley, evaluating treatments for control of drywood termites can be viewed at:

<http://nature.berkeley.edu/upmc/publications.php>

Whole-structure fumigation using sulfuryl fluoride is a very important tool to protect buildings, their contents, and occupants from ongoing adverse effects from pest infestations. No alternative treatments have been identified to date that have the same consistency, completeness, and degree of efficacy as sulfuryl fluoride fumigation for pest elimination.

Q. What is a toxic air contaminant?

A. Toxic Air Contaminant: As defined by California Health and Safety Code, Section 39655 (a): an air pollutant which may cause or contribute to an increase in mortality or in serious illness, or which may pose a present or potential hazard to human health. Substances which have been identified by the U.S. EPA as hazardous air pollutants (e.g. benzene, asbestos) shall be identified by the Board as toxic air contaminants.

Of course, an air contaminant is *toxic* only if air concentrations are high enough to cause adverse effects (toxicity) in persons who are exposed.

Q. Sulfuryl fluoride and chloropicrin are listed as a California Toxic Air Contaminant (TAC). Does this affect their use as a fumigant and warning agent, respectively, in homes and other buildings?

A. No, listing of sulfuryl fluoride and chloropicrin as TAC's does not affect their label use directions. The regulatory standards for air levels have been reduced based upon scientific review of data from structural fumigation during application and aeration.

The TAC listing process is an additional step required by State law in California to identify materials that may be found in air. It is in addition to the actual risk characterization analysis done by California Department of Pesticide Regulation (DPR) and includes a separate review. Some other common chemicals listed as TACs include chlorine, formaldehyde, methanol, naphthalene, and toluene.

Q. Will fumigation with sulfuryl fluoride adversely affect water and soil?

A. Our research and the chemical properties of sulfuryl fluoride demonstrate that this fumigant will not adversely affect water or soil when used according to the label directions.

Sulfuryl fluoride has very low solubility in water (e.g. compared to sugar, salt or other soluble chemicals). This beneficial feature of the product is why the product label recommends watering the perimeter of the foundation prior to tarped fumigations. Water acts as a barrier to minimize movement of sulfuryl fluoride into the soil between tarps and the building, improving confinement of fumigant during the fumigation.

Q. Will occupants returning to buildings following fumigation with sulfuryl fluoride be exposed to toxic concentrations of the fumigant by off-gassing?

A. No. Due to the physical properties of sulfuryl fluoride, this fumigant does not accumulate inside a building following label-directed fumigation and aeration procedures. For fumigation the release of sulfuryl fluoride into the indoor air creates the natural force that drives sulfuryl fluoride gas into the depths of wood where drywood termites thrive. The driving force during fumigation is a concentration gradient---sulfuryl fluoride moves from the indoor air through the wood and other materials to the microscopic air spaces where no fumigant gas previously existed. The process is very rapid. During aeration the process is reversed when the fumigant concentration is rapidly reduced in the indoor air. The higher concentrations within wood and other materials is rapidly reduced as sulfuryl fluoride comes out of the air spaces in the wood, the structure, and its contents during the aeration process after the fumigation seals to outside air are opened. (*Continued on next page*)

Q. *continued.* Will occupants returning to buildings following fumigation with sulfuryl fluoride be exposed to toxic concentrations of the fumigant by off-gassing?

A. (*Continued from previous page*) Toxic concentrations of sulfuryl fluoride are maintained indoors during fumigation by tarping to seal fumigant inside the structure. The fumigant penetrates materials readily—and it is very important that the process works *both* ways (fumigant going in *and* coming out)! When aeration begins and the structure is ventilated, the off-gassing also occurs very rapidly (Graph 1 above). Following the California Aeration Plan, the residence is tested using sensitive detection equipment to confirm fumigant concentrations are 1 ppm or less, and is ready for reoccupancy.

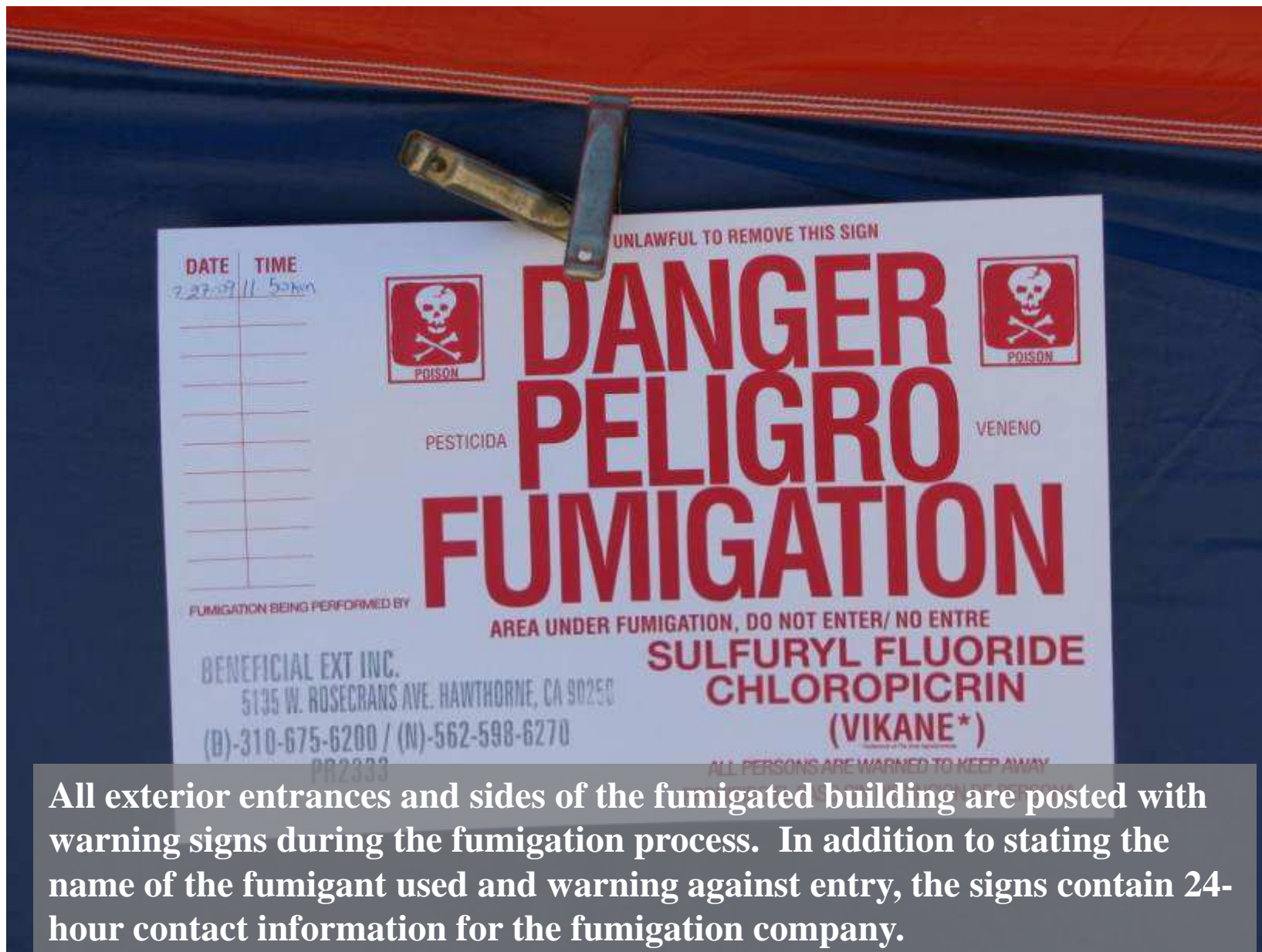
The driving force continues to be low air levels going to still lower ones down a concentration gradient. If buildings and materials retained sulfuryl fluoride, then fumigators would not need to use elaborate procedures, including tarpaulins, polyethylene sheeting, and tape, to seal structures to keep sulfuryl fluoride inside during the fumigation. Sulfuryl fluoride concentrations continue to decline to non-detectable levels following aeration even without the aid of circulation fans and with closed windows and exterior doors.

Q. What procedures do fumigators follow to protect the safety of neighbors and building occupants during fumigation with sulfuryl fluoride?

A. There are many procedures that minimize the potential exposure of fumigators and other people to sulfuryl fluoride during structural fumigation. Some of these are illustrated in the final series of photos from the fumigations PCEP researchers have monitored.



The warning agent, chloropicrin, was introduced into the building per label directions prior to the introduction of the fumigant sulfuryl fluoride. Chloropicrin serves to warn of the presence of the odorless and colorless sulfuryl fluoride and is a deterrent to intruders. Chloropicrin is ventilated from the building with the sulfuryl fluoride during aeration.



All exterior entrances and sides of the fumigated building are posted with warning signs during the fumigation process. In addition to stating the name of the fumigant used and warning against entry, the signs contain 24-hour contact information for the fumigation company.



All exterior entrances are barricaded or locked with special locking devices. This procedure prevents residents from using their keys to re-enter during the fumigation process.

Fumigators must wear respiratory protection (SCBA-Self Contained Breathing Apparatus) if they enter the fumigated space before it is aerated. NOTE: The new California Aeration Plan was developed so fumigators would not need to enter the fumigated space to initiate aeration.



Fumigators must follow detailed, validated procedures during the California Aeration Plan (CAP). These procedures specify the type of ventilation equipment used, such as ducting and fans with required capacity to move air, and the duration of ventilation period using fans.



After completion of aeration, the fumigator must test the air in each room using the Interscan or SF-ExplorIR to confirm aeration of the fumigant before allowing reoccupancy of the building.



Personal Chemical Exposure Program, Department of Entomology, UC Riverside

