# American Industrial Hygiene Association
# Position Statement
# Chemical Fumigation in Healthcare Settings

## Executive Summary

Situation: In the 1960s, chemical fumigation was used as an adjunct to environmental cleaning of hospital isolation rooms and other critical areas. Over time, this approach lost favor due to questions of efficacy. Following the 2001 anthrax bioterrorism attack, there was renewed interest in using fumigants for microbial decontamination. Even more recently, researchers have proposed using chlorine dioxide or hydrogen peroxide vapor for terminal disinfection of hospitals contaminated with mold and bacteria. This white paper discusses the appropriate uses and limitations of chemical fumigants in healthcare settings.

Resolution: Fumigants have been used for many years for agriculture, horticulture, and in cargo ships to destroy plant pests and pathogens. In the case of the anthrax attacks in Washington, D.C. and New Jersey in 2001, fumigation with chloride dioxide successfully decontaminated the U.S. postal facilities and the Hart Senate Office Building. Several researchers have also successfully reduced microbial counts in hospitals using fumigants such as hydrogen peroxide vapor. However, a significant concern about the use of chemical fumigation is the potential for inadvertent occupational and public exposure.

Results: Case reports where a chemical fumigant escaped through sewer lines and caused serious illness and death are presented. This demonstrates that once released, there is a potential for the gas or vapor to escape through breaks in containment, plumbing fixtures, or ventilation ducts. Other concerns associated with the use of chemical fumigants in hospitals include damage to surfaces and equipment, and the chance for recontamination if the source is not eliminated. In the case of hospital patients shedding microorganisms, it may not be feasible to eliminate the source.

Lessons learned: Because of the potential for inadvertent exposure to people and damage to surfaces or equipment, chemical fumigants should only be used when the benefits clearly exceed the risks.

## Background

In the 1960s, the use of chemical fumigation for control of microbial contamination in hospitals was thought to be an effective adjunct to environmental cleaning of hospital isolation rooms and other critical areas.(Friedman, H., Volin, E., & Laumann, D., 1968) However, over time this approach gradually lost favor due to questions of efficacy.(Garner, J. S. & Favero, M. S., 1985; Mallison, G. F., 1980) The Centers for Disease Control and Prevention (CDC) in their *Guidelines for Environmental Infection Control in Health-Care Facilities* (CDC, 2003) does not recommend chemical fogging for general infection control in routine patient-care areas. In addition, paraformaldehyde for decontamination of biosafety cabinets is no longer registered by the Environmental Protection Agency for this purpose.

An additional concern about the use of chemical agents for fumigation or fogging is the potential for inadvertent occupational exposure. Fumigants have been used for many years for agriculture or horticulture to destroy plant pests and pathogens. In one instance, nine greenhouse workers received significant overexposure to methyl bromide when this fumigant traveled up a sewage pipe into the greenhouse.(Hustinx, W. N. et al., 1993) In another more serious incident, this same fumigant inadvertently entered a home through a sewer pipe, killing an infant and sickening the parents.(Langard, S., Rognum, T., Flotterod, O., & Skaug, V., 1996) These incidents point out one of the major concerns associated with the use of chemical fogs. Once released, there is always a potential for the gas or vapor to escape through breaks in containment, plumbing fixtures, or ventilation ducts.

Following the 2001 bioterrorism incidents involving anthrax spores,(CDC, 2001; Jernigan, D. B. et al., 2002) there was renewed interest in using fumigants for microbial decontamination.(Tearle, P., 2003) More recently, researchers have proposed using chlorine dioxide or hydrogen peroxide vapor for terminal disinfection of buildings contaminated with mold and bacteria in hospitals and animal care rooms.(French, G. L. et al., 2004; Hardy, K. J. et al., 2007; Burton, N. C., Adhikari, A., Iossifova, Y., Grinshpun, S. A., & Reponen, T., 2008; Wilson, S. C. et al., 2005; Krause, J., McDonnell, G., & Riedesel, H., 2001; Sebesteny, A., Milite, G., & Martelossi, P., 1992) As in the past, the efficacy of fumigation has been questioned.(Wilson, S. C. et al., 2005; Hardy, K. J. et al., 2007; Burton, N. C., Adhikari, A., Iossifova, Y., Grinshpun, S. A., & Reponen, T., 2008)

The use of airborne fumigation for general environmental disinfection and sterilization has been implemented in a small handful of hospitals but is being actively marketed by businesses. The process involves dispersing biologically toxic gases or vapors into the air to kill germs on surfaces in various hospital rooms. For example, there have been attempts to control methicillin-resistant *Staphylococcal aureus* (MRSA) in Great Britain by releasing a hydrogen peroxide vapor in unoccupied hospital rooms.(French, G. L. et al., 2004) The concern is that environmental surfaces routinely touched by patients and workers may play a role in the spread of these microorganisms. Fumigation techniques are being considered because it is difficult to disinfect these surfaces using conventional surface

disinfectants.(French, G. L. et al., 2004; Clark, J., Barrett, S. P., Rogers, M., & Stapleton, R., 2006; Andersen, B. M. et al., 2006) Examples of chemicals proposed for use as fumigants include vaporized hydrogen peroxide, chlorine dioxide, ozone(Berrington, A. W. & Pedler, S. J., 1998) and super oxidized water (Sterilox)(Clark, J., Barrett, S. P., Rogers, M., & Stapleton, R., 2006).

There was only one study that evaluated the efficacy of super oxidized water fog, and it reported a $10^4$ fold reduction in MRSA counts.(Clark, J., Barrett, S. P., Rogers, M., & Stapleton, R., 2006) The study used an ozone generator-produced concentration of 0.15 ppm to 0.10 ppm.(Berrington, A. W. & Pedler, S. J., 1998) While the authors found significant reductions of MRSA in air near the generator, the technique was less effective at greater distances and even less so on surfaces. In addition, the intent was to allow patients and workers to be present during fumigation; this could be a concern since the concentrations of ozone were high enough to be toxic to certain individuals. The authors concluded this fumigation method did not appear to be suitable for decontamination of hospital rooms. The two agents used most often for chemical decontamination are vaporized hydrogen peroxide and chlorine dioxide.

## Risk-benefit associated with the use of chemical fumigants

A. Efficacy:
   i. A significant reduction in microbial contamination was demonstrated in all studies after the application of hydrogen peroxide or chlorine dioxide fumigant.
   ii. While all studies demonstrated a reduction in bacterial counts, some reported rapid recontamination of surfaces with the same bacteria.(Hardy, K. J. et al., 2007; Otter, J. A., Cummins, M., Ahmad, F., van, Tonder C., & Drabu, Y. J., 2007) This is a problem because in the case of bacterial contamination, it is often not possible to identify the human carrier. In moldy buildings, the culprit is most often water infiltration or pipe leaks. Unless the source is identified and corrected, recontamination will continue. A related question is how often must facilities be decontaminated to keep viable microorganisms at a safe level?
   iii. Fumigation appears to have little effect on non-viable mold, micotoxins or endotoxins.(Burton, N. C., Adhikari, A., Iossifova, Y., Grinshpun, S. A., & Reponen, T., 2008) This is of concern because the health effect most commonly associated with exposure to moldy buildings is an allergic reaction. Fumigation may not be effective in preventing these allergic reactions.

B. Risks
   i. A significant concern is that when using any chemical fumigant, exposure levels to building occupants must be maintained at safe levels. This requires the treated rooms to be completely sealed to prevent any fugitive emissions. Locating and sealing all potential escape routes may be a significant challenge.

ii. Damage to decorations, furnishings and medical equipment, as well as the cost of down time should be included in cost estimates when considering a fumigation procedure. If a significant portion of a hospital is closed for fumigation, will other medical facilities be able to handle the excess patient load?

C. Selection of the "ideal" fumigant
   i. The ideal fumigation agent provides maximum dispersal within the contained area, is not corrosive to surfaces or equipment, and quickly degrades, leaving no toxic residue.(Krause, J., McDonnell, G., & Riedesel, H., 2001; Wilson, S. C. et al., 2005) Chlorine dioxide gas would be expected to disperse more efficiently; however, hydrogen peroxide should be less toxic and would not leave toxic residues. Both could be corrosive to surfaces and equipment.

## Conclusion

The use of chemical fumigation in healthcare settings should be limited to those instances where the benefits clearly exceed the risks. For example, in the case of an anthrax bioterrorism attack of a hospital, some people may consider the risks associated with fumigation of a completely sealed, unoccupied building to be acceptable in exchange for the benefit of permanently eliminating the extreme hazard of anthrax. On-the-other-hand, some people may consider routine use of chemical fumigation techniques unacceptable in situations where rapid recontamination is expected and the benefit is short-lived. Either way, assistance from a certified industrial hygienist or other qualified occupational health professional should be obtained to ensure that the risks of the fumigation process are assessed and appropriately managed.

## Reference List

Andersen, B. M., Rasch, M., Hochlin, K., Jensen, F. H., Wismar, P., & Fredriksen, J. E. (2006). Decontamination of rooms, medical equipment and ambulances using an aerosol of hydrogen peroxide disinfectant. *J Hosp.Infect., 62,* 149-155.

Berrington, A. W. & Pedler, S. J. (1998). Investigation of gaseous ozone for MRSA decontamination of hospital side-rooms. *J Hosp.Infect., 40,* 61-65.

Burton, N. C., Adhikari, A., Iossifova, Y., Grinshpun, S. A., & Reponen, T. (2008). Effect of gaseous chlorine dioxide on indoor microbial contaminants. *J Air Waste Manag.Assoc., 58,* 647-656.

CDC (2001). Update: Investigation of bioterrorism-related anthrax and interim guidelines for exposure management and antimicrobial therapy, October 2001. *MMWR Morb.Mortal.Wkly.Rep., 50,* 909-919.

CDC (2003). *Guidelines for Environmental Infection Control in Health-Care Facilities: Recommendations of the CDC and the Healthcare Infection Control Practices Advisory Committee (HICPAC)* (Rep. No. MMWR 2003; 52 (No. RR-10)). Atlanta: Centers for Disease Control and Prevention.

Clark, J., Barrett, S. P., Rogers, M., & Stapleton, R. (2006). Efficacy of super-oxidized water fogging in environmental decontamination. *J Hosp.Infect., 64,* 386-390.

French, G. L., Otter, J. A., Shannon, K. P., Adams, N. M., Watling, D., & Parks, M. J. (2004). Tackling contamination of the hospital environment by methicillin-resistant Staphylococcus aureus (MRSA): a comparison between conventional terminal cleaning and hydrogen peroxide vapour decontamination. *J Hosp.Infect., 57,* 31-37.

Friedman, H., Volin, E., & Laumann, D. (1968). Terminal disinfection in hospitals with quaternary ammonium compounds by use of a spray-fog technique. *Appl.Microbiol., 16,* 223-227.

Garner, J. S. & Favero, M. S. (1985). *Guideline for handwashing and hospital environmental control* (Rep. No. 99-1117). CDC.

Hardy, K. J., Gossain, S., Henderson, N., Drugan, C., Oppenheim, B. A., Gao, F., & Hawkey, P. M. (2007). Rapid recontamination with MRSA of the environment of an intensive care unit after decontamination with hydrogen peroxide vapour. *J Hosp.Infect., 66,* 360-368.

Hustinx, W. N., van de Laar, R. T., van Huffelen, A. C., Verwey, J. C., Meulenbelt, J., & Savelkoul, T. J. (1993). Systemic effects of inhalational methyl bromide poisoning: a study of nine cases occupationally exposed due to inadvertent spread during fumigation. *Br.J Ind.Med., 50,* 155-159.

Jernigan, D. B., Raghunathan, P. L., Bell, B. P., Brechner, R., Bresnitz, E. A., Butler, J. C., Cetron, M., Cohen, M., Doyle, T., Fischer, M., Greene, C., Griffith, K. S., Guarner, J., Hadler, J. L., Hayslett, J. A., Meyer, R., Petersen, L. R., Phillips, M., Pinner, R., Popovic, T., Quinn, C. P., Reefhuis, J., Reissman, D., Rosenstein, N., Schuchat, A., Shieh, W. J., Siegal, L., Swerdlow, D. L., Tenover, F. C., Traeger, M., Ward, J. W., Weisfuse, I., Wiersma, S., Yeskey, K., Zaki, S., Ashford, D. A., Perkins, B. A., Ostroff, S., Hughes, J., Fleming, D., Koplan, J. P., & Gerberding, J. L. (2002). Investigation of bioterrorism-related anthrax, United States, 2001: epidemiologic findings. *Emerg.Infect.Dis., 8,* 1019-1028.

Krause, J., McDonnell, G., & Riedesel, H. (2001). Biodecontamination of animal rooms and heat-sensitive equipment with vaporized hydrogen peroxide. *Contemp.Top.Lab Anim Sci., 40,* 18-21.

Langard, S., Rognum, T., Flotterod, O., & Skaug, V. (1996). Fatal accident resulting from methyl bromide poisoning after fumigation of a neighboring house; leakage through sewage pipes. *J Appl.Toxicol., 16,* 445-448.

Mallison, G. F. (1980). Decontamination, disinfection, and sterilization. *Nurs.Clin.North Am., 15,* 757-767.

Otter, J. A., Cummins, M., Ahmad, F., van, T. C., & Drabu, Y. J. (2007). Assessing the biological efficacy and rate of recontamination following hydrogen peroxide vapour decontamination. *J Hosp.Infect., 67,* 182-188.

Sebesteny, A., Milite, G., & Martelossi, P. (1992). Microbiologically monitored fumigation of a newly built SPF laboratory rodent facility. *Lab Anim., 26,* 132-139.

Tearle, P. (2003). Decontamination by fumigation. *Commun.Dis.Public Health., 6,* 166-168.

Wilson, S. C., Wu, C., Andriychuk, L. A., Martin, J. M., Brasel, T. L., Jumper, C. A., & Straus, D. C. (2005). Effect of chlorine dioxide gas on fungi and mycotoxins associated with sick building syndrome. *Appl.Environ Microbiol., 71,* 5399-5403.

Approved
AIHA Board of Directors
12/14/09