

# Decontamination of Personal Computers with Formaldehyde Gas

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## Abstract

*Personal computer boxes, keyboards, and monitors were placed in routine decontamination chambers and decontaminated with gaseous formaldehyde. Assessment of decontamination effectiveness by biological indicator data demonstrated that successful decontamination of internal spaces was achieved without prior dismantling of the computer components.*

## Introduction

Formaldehyde gas has been used successfully for decades to decontaminate laboratories, biosafety cabinets, laboratory equipment, and animal rooms. Since the initial report (Taylor et al., 1969), the critical values for temperature, time, relative humidity, and gas concentration have been refined (Ackland et al., 1980; Songer et al., 1972).

Lach (1990) showed that maintenance of uniform gas concentration levels within spaces to be decontaminated was essential to avoid polymerisation of the formaldehyde and to achieve uniform activity. Although formaldehyde gas has some ability to penetrate crevices and porous materials (Hoffman & Spiner, 1970; Spicher & Borchers, 1983), some reports contend that formaldehyde diffuses poorly (Cheney & Collins, 1995) and is unreliable for decontamination of surfaces that are porous or not well exposed (Phillips, 1977).

The overall reliability and effectiveness of the method for decontamination of laboratory spaces, biosafety cabinets, and filter housings were demonstrated in a long-term study by Abraham, Le Blanc Smith, and Nguyen (1997). The present study shows that formaldehyde gas is able to penetrate inside the covers of conventional personal computers, keyboards, and monitors to completely decontaminate biological indicator spore strips.

## Method

The external casings of the monitor, keyboard, and computer box of a standard desktop personal computer were removed. Strips containing  $10^4$  spores of *Geobacillus stearothermophilus* (grown from American Type Culture Collection # 7953) were placed in various positions inside the monitor, keyboard, and computer box casings prior to reassembly.

Formaldehyde gas ( $5\text{ g m}^{-3}$ ) was generated in a 27

$\text{m}^3$  airlock as described previously (Abraham et al., 1997). An electric fan was placed at one corner position of the airlock to circulate the gases but was not directed specifically at any computer component.

Decontamination proceeded for 15 hours at an ambient temperature of  $21^\circ\text{C}$ , after which the formaldehyde was neutralized by ammonia gas as described previously (Abraham et al., 1997). After purging the room, the dust covers were again removed from the computer components and the spore strips recovered and incubated in bacterial growth medium for 7 days at  $56^\circ\text{C}$ . An unexposed positive control spore strip was incubated in parallel and growth was determined by cloudiness of the medium.

## Results

Four similar experiments were done in which biological spore strip indicators (*G. stearothermophilus*) were placed in various positions inside the personal computer monitor, keyboard, and control box during a standard gaseous formaldehyde decontamination cycle. In the particular experiment shown in the Figures, 12 spore strips were placed in relatively inaccessible positions inside the casings of a computer control box and monitor. After the decontamination cycle, the external casings were removed and spore strips (#1 and #2) were recovered from beneath the power supply (Figure 1) and behind the hard drive (Figure 2).

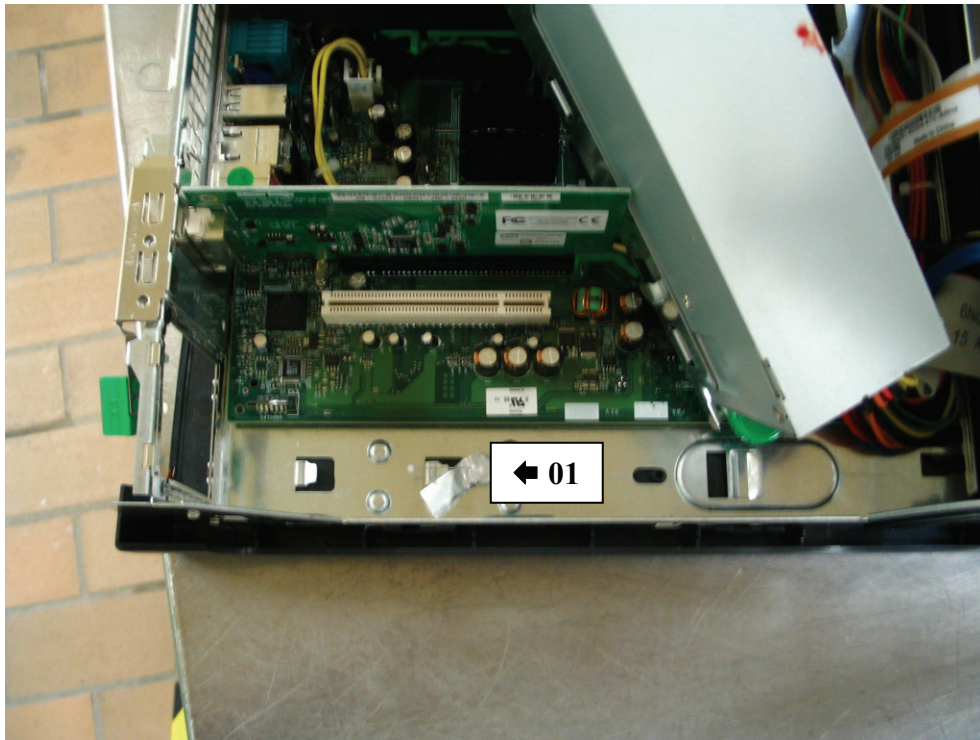
Spore strips #7 and #8 were recovered from inside the LCD screen inner cover of the monitor (Figure 3). The 12 indicator spore strips were placed in separate culture tubes and incubated at  $56^\circ\text{C}$  for 7 days. None of the test culture tubes contained any viable spores, determined by lack of bacterial growth in the indicator medium. As expected, the control tube showed bacterial growth after 24 hours. Three other experiments where spore strips were placed in other positions within computer components including the keyboard produced identical results.

## Discussion

Formaldehyde gas is known to be a very effective decontaminant for clean surfaces and room spaces (Abraham et al., 1997; Ackland et al., 1980; Taylor et al., 1969). Hoffman & Spiner (1970) and Spicher & Borchers (1983) showed formaldehyde gas had a reasonable ability to penetrate materials and crevices and

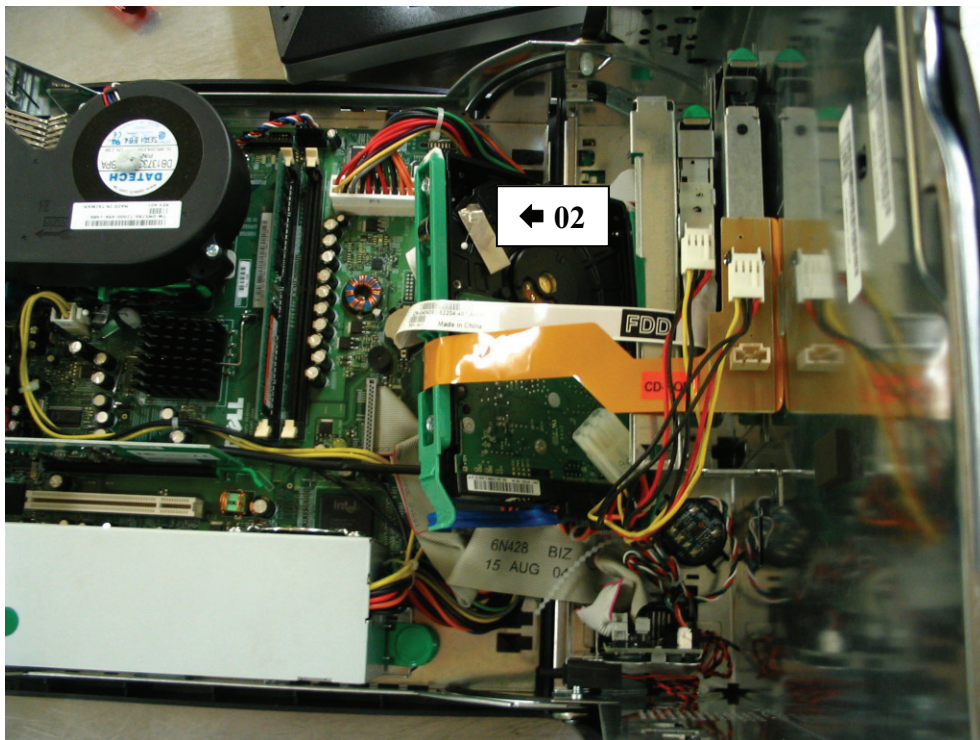
**Figure 1**

The position of a test spore strip under the power supply of a computer control box prior to reassembly and formaldehyde decontamination.



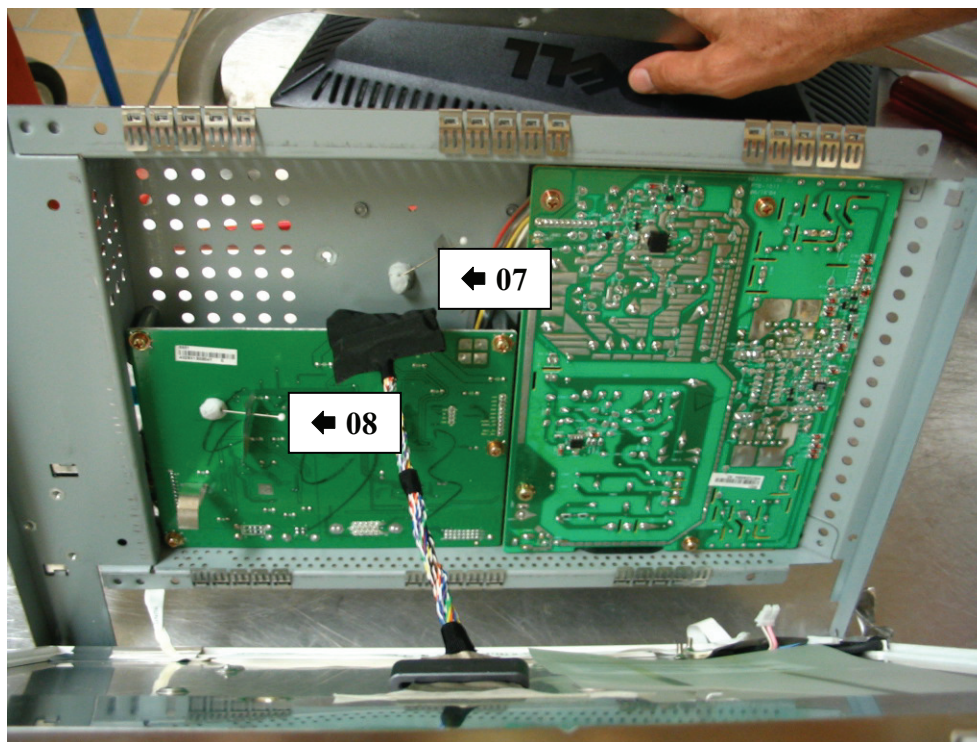
**Figure 2**

The position of a test spore strip behind the hard drive of a computer control box prior to reassembly and formaldehyde decontamination.



### Figure 3

Positions #7 and #8 of spore strips on the outside of the LCD inner screen cover of a computer monitor prior to reassembly and formaldehyde decontamination. The spore strips are held in position by pins in this photograph.



to decontaminate such surfaces. In contrast, the need to disperse formaldehyde gas thoroughly to establish uniform concentrations and to avoid condensation problems (Lach, 1990) has been reported.

Personal computers and laptops are critical tools in biocontainment laboratories, and their removal for repair or replacement is a frequent requirement. An effective method for decontamination without damage to electronic equipment is highly desirable. To our knowledge, no reports demonstrating the efficacy of formaldehyde gas for the decontamination of personal computers currently exist. The validity of the procedure is important in view of the contrasting reports that the gas must be effectively dispersed (Lach, 1990) and that formaldehyde can penetrate crevices (Spicher & Borchers, 1983). In addition, it is important to know if effective decontamination can be achieved without removal of external dust casings from various components of personal computers.

To provide greater decontamination certainty, the outer covers of personal computer components were removed and spore strips placed specifically in places where complete formaldehyde gas penetration was considered less likely. The results show that effective decontamination, measured by inactivation of very resistant *G. stearothermophilus* spores, was achieved in all experiments. The biological indicator chosen for this work was  $10^4$  spores/strip as the internal spaces of electronic equipment were not expected to be heavily contami-

nated with pathogens. While a 6-log decontamination is considered usual to prove sterilization, a 4-log decontamination of the very resistant thermophile was considered adequate for this particular application, as pathogens of concern are known to be very much less resistant to decontamination by formaldehyde (Abraham et al., 1997).

This general procedure has been used perhaps hundreds of times for more than 10 years to decontaminate personal computers at this institute without any detectable damage or interference with the electronic function of the computers. However, biological monitoring of the effectiveness of the decontamination was usually done only in the decontamination chamber itself and not within each computer component; therefore, such data are less detailed than those described here.

This work demonstrates that gaseous fumigation with formaldehyde using the conditions described allows personal computers to be completely decontaminated prior to removal from microbiological containment laboratories without the need to disassemble the components.

### Acknowledgements

Phil McCabe, Neil Slater, and Peter Le Blanc Smith contributed to the development of the procedures and the collection of data over many years.

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## Review of the Emory University Applied Laboratory Emergency Response Training (ALERT) Program

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### Abstract

*With an increased number of newly constructed high-containment laboratories and staff working in these facilities, the risk for emergency situations has increased, as has the need for systematic training of the emergency responders who assist during an emergency at a high-containment laboratory. With support from the National Institutes of Allergy and Infectious Diseases (NIAID) and the Southeast Regional Center of Excellence for Emerging Infections and Biodefense (SERCEB), Emory University developed the Applied Laboratory Emergency Response Training (ALERT) Program. In close collaboration with the City of Atlanta Department of Fire Rescue, Emergency Medical Service (EMS), and other emergency medicine professionals, staff at the Rollins School of Public Health developed a comprehensive training program aimed at bridging the gap between high-containment laboratory staff and emergency responders. Since March 2006, over 750 emergency responders have participated in the ALERT Program. Over 95% of ALERT Program participants demonstrated an increase in knowledge, with the average excellence rating for the ALERT Program at 4.45 (on a scale of 1=Poor and 5=Excellent). Additionally, the perception of risk that high-containment*

*laboratories bring to the public, staff working in the laboratory, staff working outside the laboratory, and emergency responders was individually evaluated, with significant reductions in the ratings of risk occurring among individuals who had attended the ALERT Program. Long-term evaluation of the participants' knowledge retention, risk perception, as well as implementation in other locations outside of Atlanta, Georgia, is still needed.*

### Background

The safety of high-containment biological laboratories is garnering increased public scrutiny and professional attention, particularly with respect to emergency response in these laboratories. In October 2007, the United States Government Accountability Office released a report titled, "High-Containment Biosafety Laboratories: Preliminary Observations on the Oversight of Proliferation of BSL-3 and BSL-4 Laboratories in the United States" (U.S. Government Accountability Office, 2007). Several findings were discussed in this report, including the increased number of high-containment laboratories and the need for strategic planning with emergency responders. Also released in 2007, the fifth edition of the National Institutes of Health/Centers for Disease Control