



Life's Resources, Inc.
Lowering Risks by Innovation 

Effect of the ClearWater Tech Ozone/Ultraviolet Light Unit on the Survival of Molds in an Air Duct

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ClearWater Tech
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by

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1.0 Introduction

1.1 Purpose

The purpose of these tests was to determine the effect of the ClearWater Tech Zephyr Ozone/Germicidal Ultraviolet Light Unit on the survival of molds suspended in an air duct.

1.2 Background

Air is an important vehicle for transmitting infectious and allergenic molds. Their growth and survival in air ducts provide a contaminating source that offers the opportunity for the dispersion of spores into the air of occupied spaces. In addition, some molds produce mycotoxins that can also be dispersed into occupied spaces as gaseous contaminants that are not removed even by high-efficiency particulate air filtration. Some mycotoxins cause serious health effects in susceptible individuals, with significant long-term effects on vital organs. Reducing the levels of viable molds in air ducts can the lower exposure of susceptible persons to infectious, allergenic, and toxic airborne contaminants in occupied spaces. Levels of viable airborne molds and mycotoxins can be reduced by reducing their ability to survive in contaminated sources, such as in heating, cooling, or ventilating ducts and related equipment.

1.3 Specific Objectives

The specific objective of the tests described herein was to determine the effect the Clearwater Tech Zephyr Ozone/Germicidal Ultraviolet Light Unit on the survival of molds in an air duct.

1.4 Test Microorganisms

A mold species was selected for testing which represents a broad class of commonly encountered molds found in indoor environments. *Penicillium funiculosum* was used to determine the effect of the test unit on the survival of molds in air ducts. This mold has been used extensively in studies of effects of environmental factors on mold survival. *Penicillium funiculosum* has been used, for example, as a model organism to evaluate the effects of aerial disinfection of libraries.¹ The mold is widely used for testing the survival of molds in the environment. It is also representative of broader classes of molds that demonstrate allergenic and/or pathogenic reactions in exposed humans.

¹ Malalanirina W. Rakotonirainy et al., "Research on Fungicides for Aerial Disinfection by Thermal Fogging in Libraries and Archives," *International Biodeterioration & Biodegradation*, 1999, 44, pp. 133-139.

2.0 Test Equipment and Methods

2.1 Test Unit

The test unit was described as the ClearWater Tech Zephyr Ozone/Germicidal Ultraviolet Light Unit as shown in Figure 1. The unit was duct mounted and contained an ozone-producing light, which was shielded from a germicidal ultraviolet light.

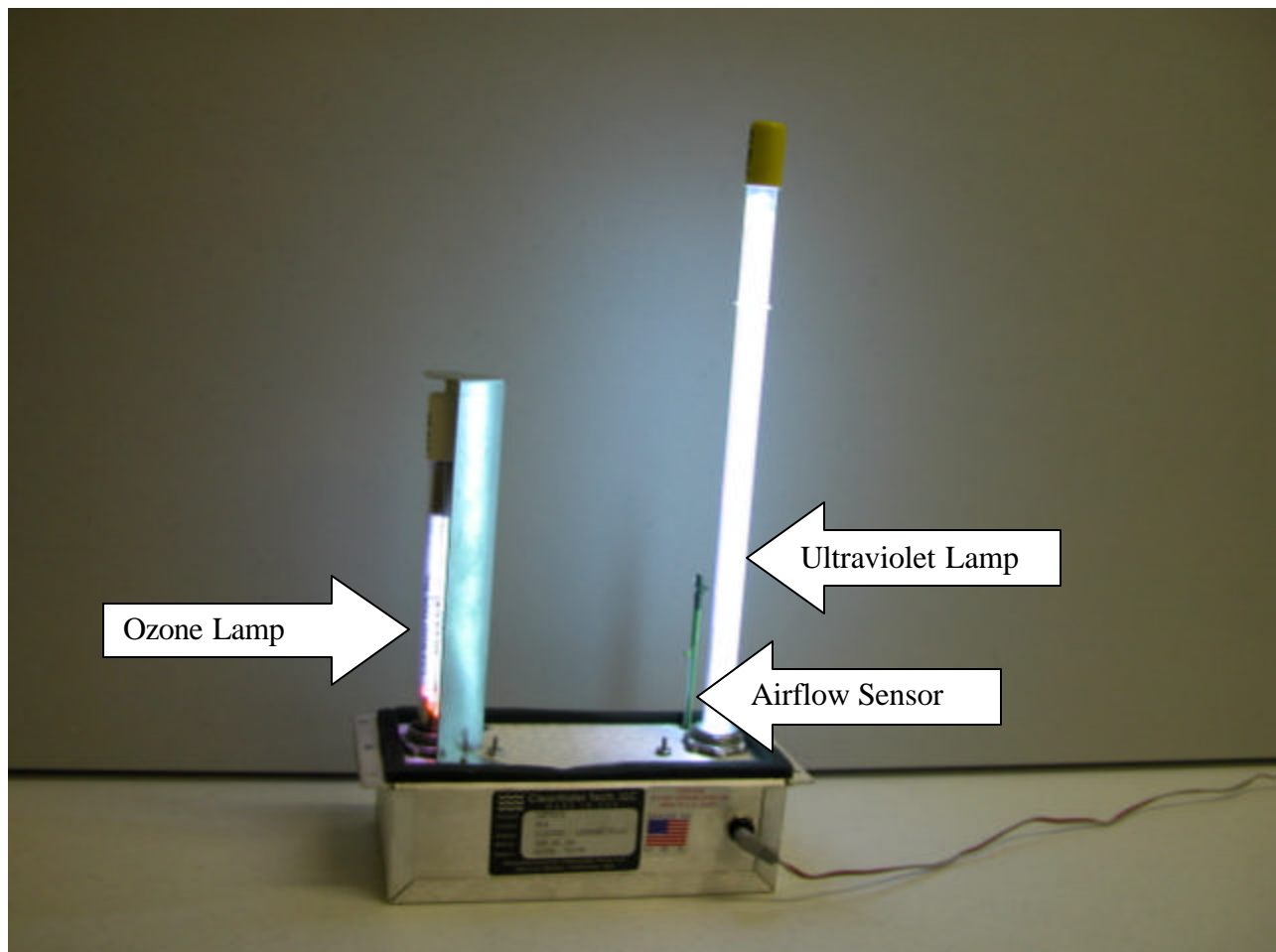


Figure 1. ClearWater Tech In-Duct Unit

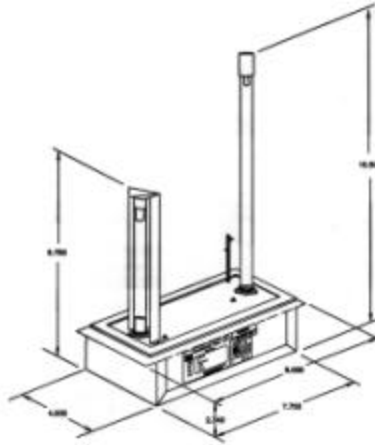


Figure 2. Illustration of Test Unit

2.2 Test Duct

The test duct is illustrated in Figures 3 and 4. It consisted of an electrically grounded galvanized steel ventilation duct with a dimension of 10-inch by 16-inch by 12 feet. The duct was attached 1 x 2 x 2.5 feet HEPA-filtered Air-Kleen™ air-moving device. Using transitional adapters the test duct was attached to approximately 21 feet x 10-inch diameter galvanized steel recirculation duct. Air was circulated through the test duct using two backward curved impellers. Air was recirculated through the test portion of the air duct at an average face velocity of approximately 240-feet per minute (fpm). The air was filtered during recirculation by sequentially passing it through a 24 x 12 x 2-inch bed of activated carbon and 24 x 12 x 5 7/8-inch HEPA filter. The activated carbon was used to reduce fugitive ozone emissions into the laboratory and the HEPA filtration system was used to prevent laboratory contamination by test mold spores.

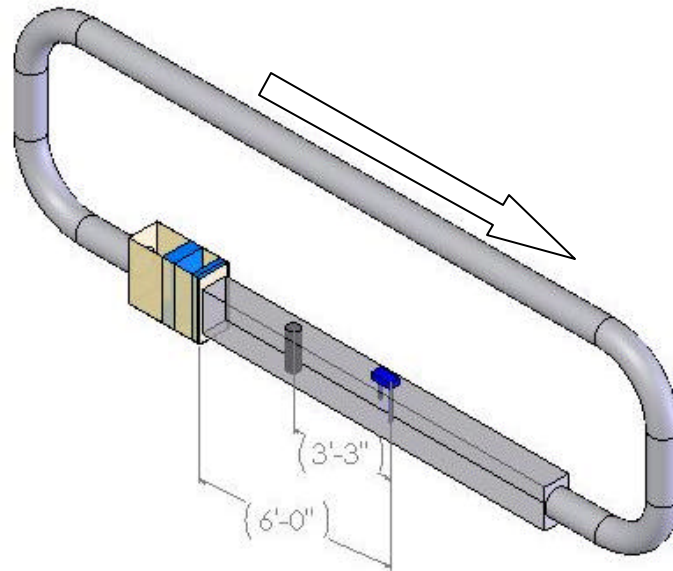


Figure 3. Test Duct Illustration Showing Air Flow Direction

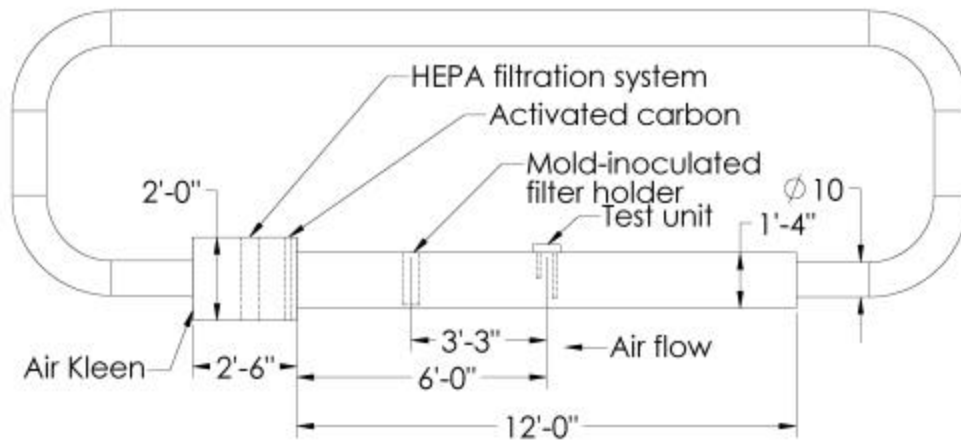


Figure 4. Test Duct Diagram

2.3 Environmental Conditions

The relative humidity and temperature were measured using a wet and dry bulb psychrometer. These experiments were performed at a relative humidity level of 64 % and a temperature of 80° F. Mold growth in indoor environments is favored by high relative humidity levels. Ozone is also generally more germicidally active at high relative humidity levels. These tests were performed under ambient conditions in an occupied commercial building.

2.4 In-Duct Microorganism-Suspending Holders

The tests were performed using sterile membrane filter (Gelman Sciences) test surfaces inoculated with the test microorganisms. The inoculated filters were placed onto aluminum in-duct suspending holders and attached using cellophane tape.

2.5 Air Velocity

Air velocity measurements were performed with a thermal anemometer Model 9870 Alnor Air Velocity Meter.

2.6 Mold Test Methods

Penicillium funiculosum (ATCC 11797) was grown on potato dextrose agar (Difco) at 24° C. Ten-fold dilutions of the organism cultures were made in phosphate buffered water. Selected dilutions of the test organisms were inoculated onto the test filters using a membrane filtration procedure and rinsed with phosphate buffered water. Inoculated filters were aseptically placed onto the surface of the mold-suspending holders and secured on one edge using adhesive tape. The air duct under controlled air velocity conditions for a specified duration of time. The control experiments were performed with the test unit suspending into the air duct, but in a non-energized condition. The test experiments were performed with the test unit in an energized condition.

Following exposure to specified conditions, the inoculated membrane filters were aseptically removed from the surface of the mold-suspending holders using sterile forceps. The inoculated membrane filters were then placed onto the surface of potato dextrose agar-containing petri dishes for assay. Colonies were counted and the cultures were photographed following four and then five days of incubation at room temperature.

3.0 Results

The results of *Penicillium funiculosum* mold survival experiments following a 4-min exposure time of a 1×10^{-2} dilution are shown in Figures 5. The control experiment, which was performed without the test unit operating, showed 75 surviving colony forming units (CFU) after the 4-min exposure time in the air. The test experiment was performed under the same conditions, but with the test unit operating. The test demonstrated 0 surviving mold CFU.

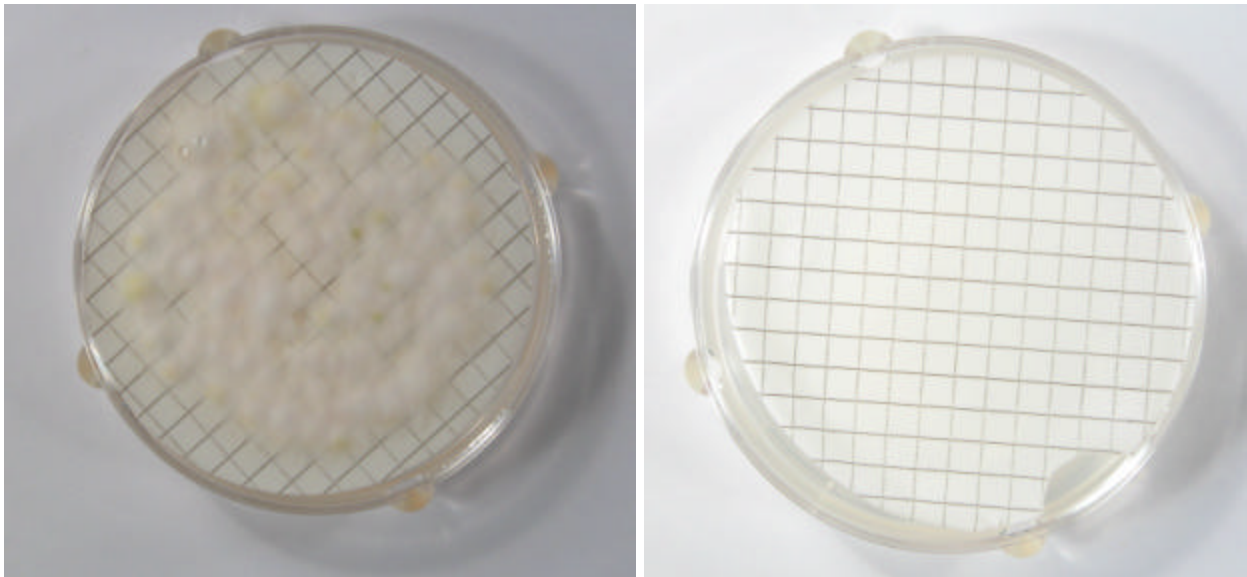


Figure 5. *Penicillium funiculosum* Colonies: Control vs. Test
(1×10^{-2} dilution; 4-min exposure in duct)

Figure 6 shows the results of the test performed under the same conditions as the above experiments, but using a 10-fold lower dilution of the same culture (1×10^{-1}). After 4-min exposure under the control condition, the *Penicillium funiculosum* CFU were too numerous to count. (The culture also showed evidence of the presence of other contaminating molds in the test duct.) Based on counts obtained in other dilutions, the number of CFU was calculated to be 750 CFU. The culture obtained following the same in-duct exposure, but with the test unit operating showed the presence of a sparse number of CFU.

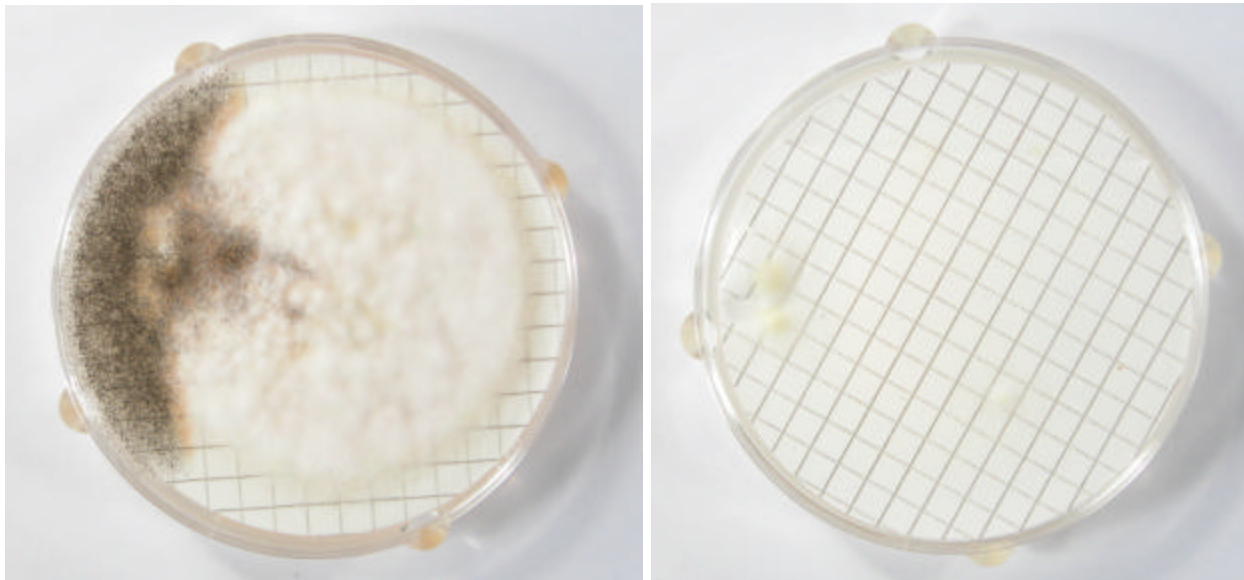


Figure 6. *Penicillium funiculosum* Colonies: Control vs. Test
(1×10^{-1} dilution; 4-min exposure in duct)

To further enumerate the surviving mold CFU in the tests, the cultures were incubated for a total of five days. The photos of results of this further incubation, presented in Figure 7, showed no CFU in the 1×10^{-2} culture. The 1×10^{-1} culture showed a total growth of 6 CFU. These results show that 6 CFU out of 750 CFU of *Penicillium funiculosum* survived a 4-min exposure to the test unit in the air duct. Based on these results the mold CFU reduction caused by the test unit exceeded 99.99 per cent under the conditions of these tests.

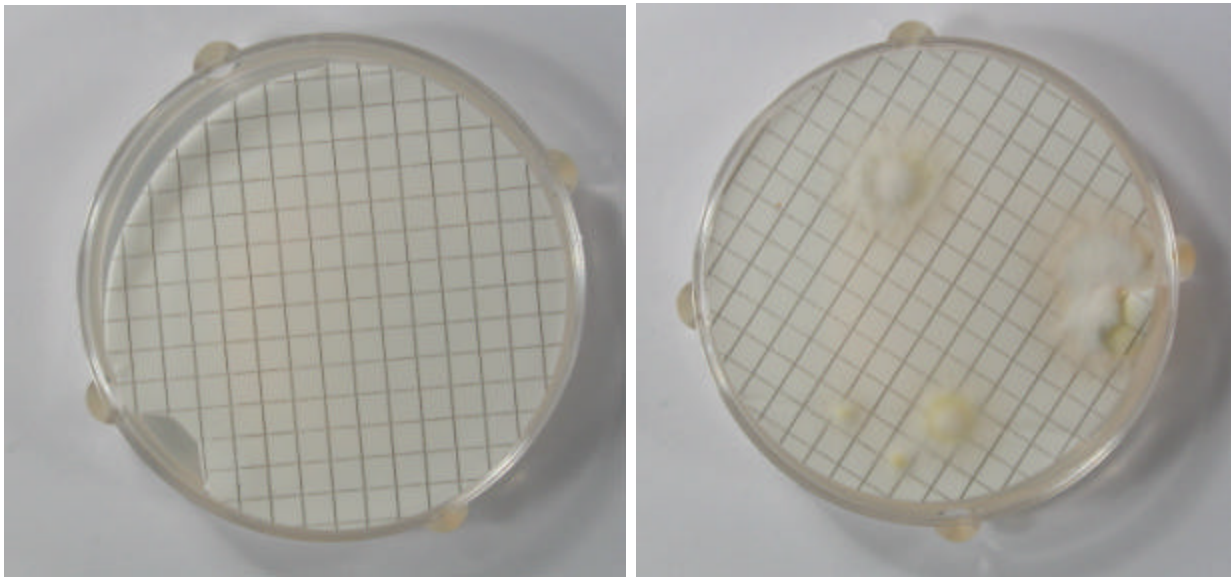


Figure 7. *Penicillium funiculosum* Colonies: 1×10^{-2} vs. 1×10^{-1} Dilution
(4-min exposure in duct; 5-day incubation)

4.0 Summary and Conclusions

A series of tests were performed on a HVAC duct-mounted ClearWater Tech Zephyr Ozone/Germicidal unit, referred to as the test unit. The test mold used for these tests, *Penicillium funiculosum*, was a penicillin mold that was representative of common mold contaminants in indoor environments. The survival of the molds in the air duct is likely to be affected by the specific environmental conditions and the duration of exposure. Under the conditions of these experiments, which represented the indoor conditions in an occupied building, the test unit was found to reduce the survival of *Penicillium funiculosum* molds by 99.99 percent following exposure in an air duct at a distance of 39 inches for 4-min.