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Effect of a HVAC Air Treatment Unit on the Survival of Bacteria

April 9, 2002

Prepared for

Clearwater Tech, LLC
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Report No. 8003-02-1

by

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1.0 Purpose

The purpose of these tests was to determine the effect of an in-duct air treatment unit on the survival of microorganisms inside HVAC air handling ducts.

2.0 Tests

2.1 Bacteria Survival Tests

2.1.1 Apparatus Tested

The test apparatus was identified as a Zephyr Ozone/Germicidal unit and was supplied by Clearwater Tech, LLC. The test unit, shown in Figure 1, consisted of a germicidal ultraviolet lamp, an ozone lamp, and an airflow sensor.

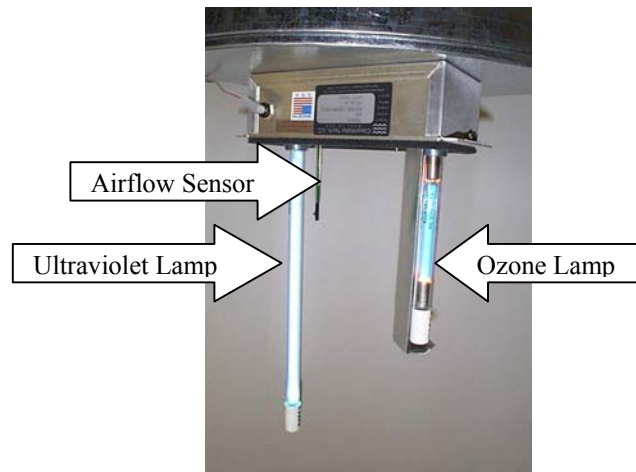


Figure 1. Zephyr Ozone/Germicidal Unit

A diagram of the test unit is shown in Figure 2.

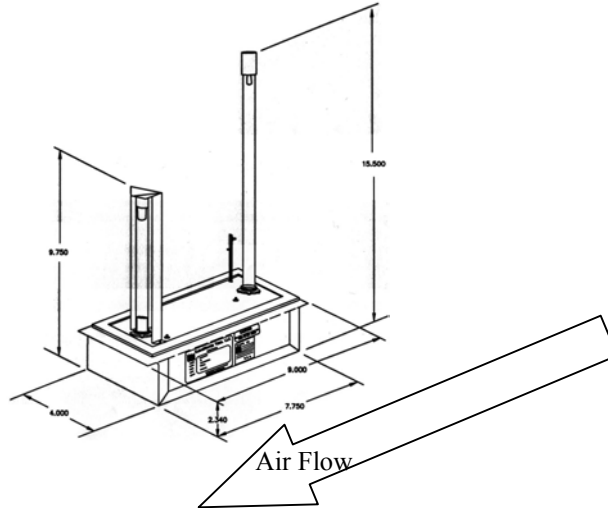


Figure 2. Test Unit Diagram

2.1.2 Test Setup and Procedures

Test Duct

Tests were performed in a 10 inch by 16 inch by 12 foot galvanized air duct with an attached HEPA-filtered air-moving device. The test unit was inserted into a rectangular hole on the top surface (narrow dimension) of the air duct, with the lamps projecting into the duct. The unit was positioned so that the airflow direction was from the germicidal ultraviolet lamp toward the ozone-producing lamp. A metal shield protected the ozone-producing lamp from direct exposure to the germicidal ultraviolet lamp. The in-duct microorganism-suspending holders were mounted on the same surface. The test unit was set at its maximum output setting.

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 specially fabricated aluminum in-duct suspending holders, as shown in Figure 3. The holders containing the inoculated filters were placed into the test duct at specified locations from the test apparatus. Prior to initiating each series of tests the test surface holders were sterilized by steam autoclaving for 15 min at 15-lbs. pressure.



Figure 3. In-Duct Microorganism Holders

Test Organism

The test organism was *Serratia marcescens* (American Type Culture Collection No.14756).

Test Procedure

Prior to each series of tests, the organisms were grown overnight at 95° F in nutrient broth (Difco). Ten-fold dilutions of the organism culture 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 in-duct filter holders. The filter holders containing filters inoculated with the test organisms were then placed into the air duct at specific distances from the test unit. In-duct tests were performed to establish control baseline conditions with the apparatus de-energized. Experimental tests were performed with the apparatus energized.

Following exposure to specified conditions, the membrane filters were aseptically removed using sterile forceps and placed onto the surface of nutrient agar-containing petri dishes for assay. Following incubation at 95° F for 24 hrs, the cultures were placed at room temperature until red pigmentation developed. Colony counts following appropriate incubation were used to determine the viability of the organisms.

Air Velocity

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

Ozone

Ozone was monitored using an Analytical Technology PortaSens II Model C16 Gas Leak Detector with an ozone sensor module having a minimum range of 0-5 ppm and a resolution of 0.1 ppm.

Ultraviolet Light

Ultraviolet light intensity was measured using a Cole-Parmer Instrument Co. Series 9811 Radiometer in the 254 nm band.

3.0 Results

3.1 Test Duct Characteristics

The average air velocity was approximately 250 fpm. The ultraviolet light intensity at 39 in downstream from the test unit was measured at $45 \mu\text{W}/\text{cm}^2$. The ozone concentration at 39 in downstream from the test unit was detected by smelling but was measured at <0.1 ppm, which was undetectable with the instrument used.

3.2 Effect of Energized Unit on Bacteria Survival

The tests on the effect of the test unit on the survival of *Serratia marcescens* bacteria were performed at room temperature. Bacteria suspended in the air duct 39 in. upstream from the test unit were compared with those suspended in the air duct 39 in. downstream from the test unit. Various dilutions of the microorganisms were used in order to obtain countable numbers of bacterial colonies. The concentration of organisms in the upstream test, shown in Figure 4, was 1.04×10^9 .

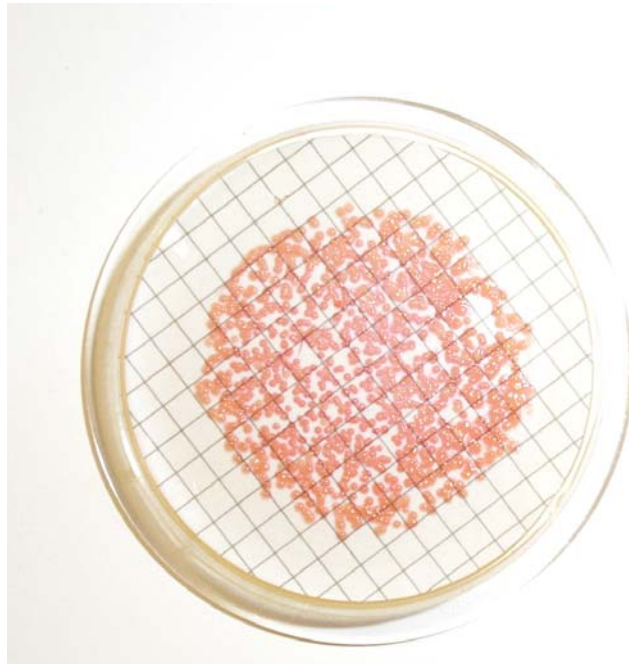


Figure 4. Growth of Bacteria Upstream from Test Unit
Dilution 1×10^{-6}
(2 min exposure in air duct)

The concentration of organisms in the downstream test, shown in Figure 5, was 1.20×10^{-7} .

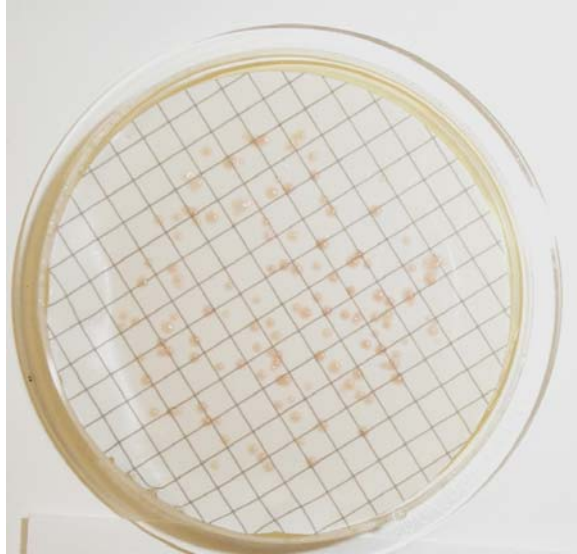


Figure 5. Growth of Bacteria Downstream from Test Unit
Dilution 1×10^{-5}
(2 min exposure in air duct)

Table 1 shows that within two minutes of exposure, the survival of the bacteria was reduced by 99% at a distance of 39 inches downstream from the test unit.

Table 1. Effect of Test Unit Exposure at 39 Inch Distance

	Count	Percent Reduction Upstream vs. Downstream
Upstream from Test Unit	1.04×10^{-9}	0
Downstream from Test Unit	1.20×10^{-7}	99

4.0 Summary and Conclusions

A series of tests were performed on a HVAC duct-mounted Zepher Ozone/Germicidal unit, referred to as the test unit. The test produces ultraviolet light in the germicidal wavelength of 254 nm and also produces ozone.

The test unit was found to reduce the survival of *Serratia marcescens* bacteria in the air duct by 99 per cent within two minutes of exposure at a distance of 39 inches.