

Sanuvox Saber Smart
Laboratory Testing

July 2, 2008

On July 2, 2008, irradiance testing was conducted on a Sanuvox Saber Smart (Sanuvox Technologies Inc., Quebec, Canada) UVGI fixture submitted by the manufacturer. Irradiance testing was conducted in a UV lamp testing rig in the Penn State Department of Architectural Engineering Indoor Environment Center located in State College, Pennsylvania.

The lamp testing rig allows measurement of UV lamp output as a function of ambient air velocity and temperature (Figure 1). It has the same cross-sectional area (2 feet \times 2 feet) and can produce approximately the same range of flow rates as the standard ASHRAE Standard 52.2 rig. It is made of sheet metal covered with 2 inch thick fiberglass insulation. The test rig is constructed to allow convenient component maintenance with easy access to the lamp fixture being tested. The rig is equipped with a variable speed fan controlled by a variable frequency drive, as well as an electric resistance heating coil and DX cooling coil that can be operate individually or together to maintain air temperature control. Currently, there is no control for relative humidity.

The test rig is interfaced with a data acquisition board driven by LabVIEW software (National Instruments Corporation, Austin, Texas). These controls allow air temperatures to be maintained within about 1°F in the range of approximately 40°F - 90°F. Additionally, air flows can be controlled up to 3000 ft³/min with about 3% accuracy. This provides face velocities in the test section of up to 750 ft/min. Flow and temperature are measured by an Ebtron (Ebtron Inc., Loris, South Carolina) thermal dispersion type flow station (Figure 2). Turning vanes and flow straighteners are included to create a uniform velocity across the duct at the lamp test section.

The UV lamp test section (Figure 3) is accessible to allow changing the orientation of the lamp under test. The internal portion of this section of the rig is completely covered with black felt roughly 5 feet upstream and downstream of the lamp being tested. Thus, irradiance results are essentially worst-case measurements with all reflectance inside the test rig being eliminated. The UV irradiance was measured using an IL 1700 Research Radiometer equipped with a SED033/NS254/TD Narrowband 254 nm Sensor (International Light Technologies, Peabody, Massachusetts).

The Sanuvox Saber Smart was mounted in a wooden door created specifically for testing the device (Figure 4 and Figure 5). The lamp was centered vertically in the rig and extended 12.5 inches into the rig from the interior surface of the door (not including the white end cap of the lamp). This resulted in the center of the lamp being at a point 12 inches from the top (or bottom) of the rig and 6.25 inches from the door. This point was used as the reference point for the irradiance measurements. A mounting device (Figure 6) was used to hold the IL 1700 sensor at the reference point while still allowing the sensor to be moved closer or further away from the lamp.

To test the lamp output, a bubble level and square were used to position the sensor mounting device at the appropriate distance from the lamp in the rig. The wooden door with the lamp installed was then closed to seal the test rig. The rig control system was set to maintain a temperature of 70°F and an air flow rate of 50 ft/min. This low flow rate

provides minimal air flow while still allowing temperature control in the test rig. Once the air flow and temperature inside the rig stabilized, the Sanuvox Saber Smart was powered on and was given 20 minutes to stabilize. The irradiance recorded was that measured by the IL 1700 sensor at the end of the 20 minute period. The lamp was then turned off and the rig was adjusted to maintain an air flow rate of 500 ft/min, which would approximate flows in typical air ducts. Once the rig stabilized at this new flow condition, the lamp was powered on and given another 20 minutes to stabilize. After recording the irradiance at the high flow rate, the lamp was powered off and the wooden door was opened. The sensor mounting device was repositioned at a new distance from the lamp and the testing process was repeated.

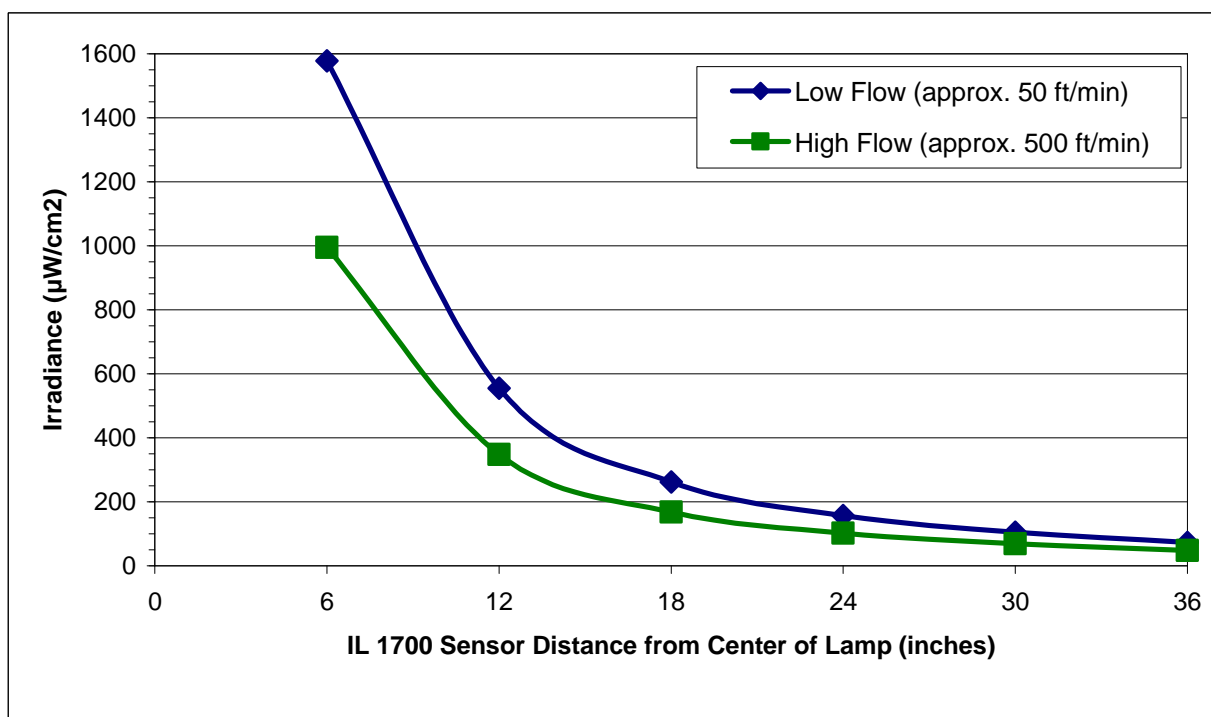
For each of the two flow rates, irradiance measurements were taken at six distances downstream from the center of the lamp: 6 inches, 12 inches, 18 inches, 24 inches, 30 inches, and 36 inches. While relative humidity was not controlled during the tests, it was monitored throughout the day using a Model 8386A VelociCalc Plus (TSI Incorporated, Shoreview, Minnesota). The relative humidity inside the test rig was between 40-50% throughout the entire day of testing.

Table 2 displays the expected deactivation of *B. Subtilis* spores immersed in a water film on a wet surface as a function of distance from the lamp center and for different air flow rates over the lamp surface. The results indicate that if the lamp is left on for a reasonable time that mold and algal growth would not be possible on surfaces within a reasonable distance of the lamp surface. These estimations are based on precise measurements of lamp UV 254 nm output and laboratory measured rates of deactivation of *B. Subtilis* spores suspended in water subjected to known UV 254 dosages and corresponding observations of similar deactivation responses of aerosolized *B. Subtilis* spores in entrained air flow air streams.

RESULTS

Table 1. Summary of Sanuvox Saber Smart Irradiance Testing Results

Low Flow (approximately 50 ft/min)			
Distance from Lamp (inches)	UV Irradiance ($\mu\text{W}/\text{cm}^2$)	Actual Flow (ft/min)	Actual Temperature ($^{\circ}\text{F}$)
6	1578.0	52.4	70.8
12	555.0	52.4	70.8
18	262.0	52.4	70.8
24	157.2	52.4	70.9
30	105.5	52.4	70.6
36	73.2	52.4	70.4
High Flow (approximately 500 ft/min)			
Distance from Lamp (inches)	UV Irradiance ($\mu\text{W}/\text{cm}^2$)	Actual Flow (ft/min)	Actual Temperature ($^{\circ}\text{F}$)
6	995.0	499.1	70.5
12	348.0	499.1	70.5
18	167.8	499.1	70.5
24	102.1	499.1	70.5
30	68.6	500.6	70.5
36	48.2	499.1	70.5



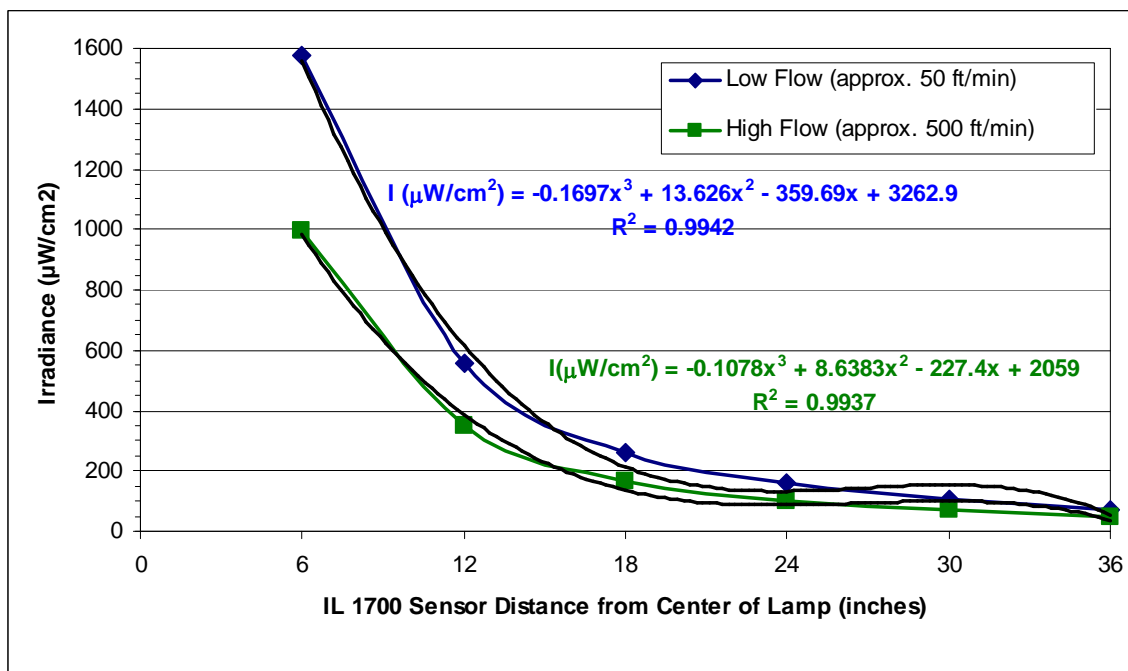


Table 2
Time to Deactivate 99% of Water Covered B. Subtilis Spores at Various Distances from Lamp Center and for Two Different Air Flow Rates

Low Flow (approx. 50 fpm)			Water Immersed B. Subtilis spores		
Distance from Lamp (in.)	Irradiance ($\mu\text{W}/\text{cm}^2$)	Flow (fpm)	Temperature ($^{\circ}\text{F}$)	t(sec) to 99% Reduction	t(min) to 99% Reduction
6	1578.0	52.4	70.8	20.84	0.35
12	555.0	52.4	70.8	59.27	0.99
18	262.0	52.4	70.8	125.55	2.09
24	157.2	52.4	70.9	209.24	3.49
30	105.5	52.4	70.6	311.78	5.20
36	73.2	52.4	70.4	449.36	7.49
High Flow (approx. 500 fpm)			Water Immersed B. Subtilis spores		
Distance from Lamp (in.)	Irradiance ($\mu\text{W}/\text{cm}^2$)	Flow (fpm)	Temperature ($^{\circ}\text{F}$)	t(sec) to 99% Reduction	t(min) to 99% Reduction
6	995.0	499.1	70.5	33.06	0.55
12	348.0	499.1	70.5	94.52	1.58
18	167.8	499.1	70.5	196.03	3.27
24	102.1	499.1	70.5	322.16	5.37
30	68.6	500.6	70.5	479.49	7.99
36	48.2	499.1	70.5	682.43	11.37

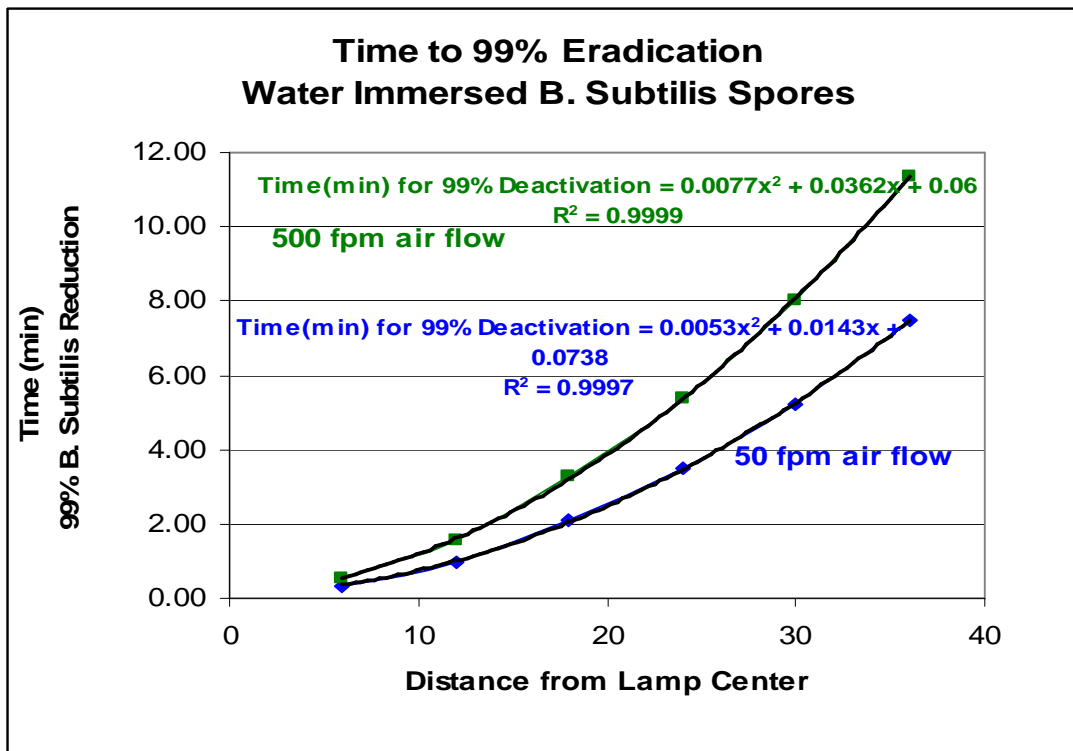
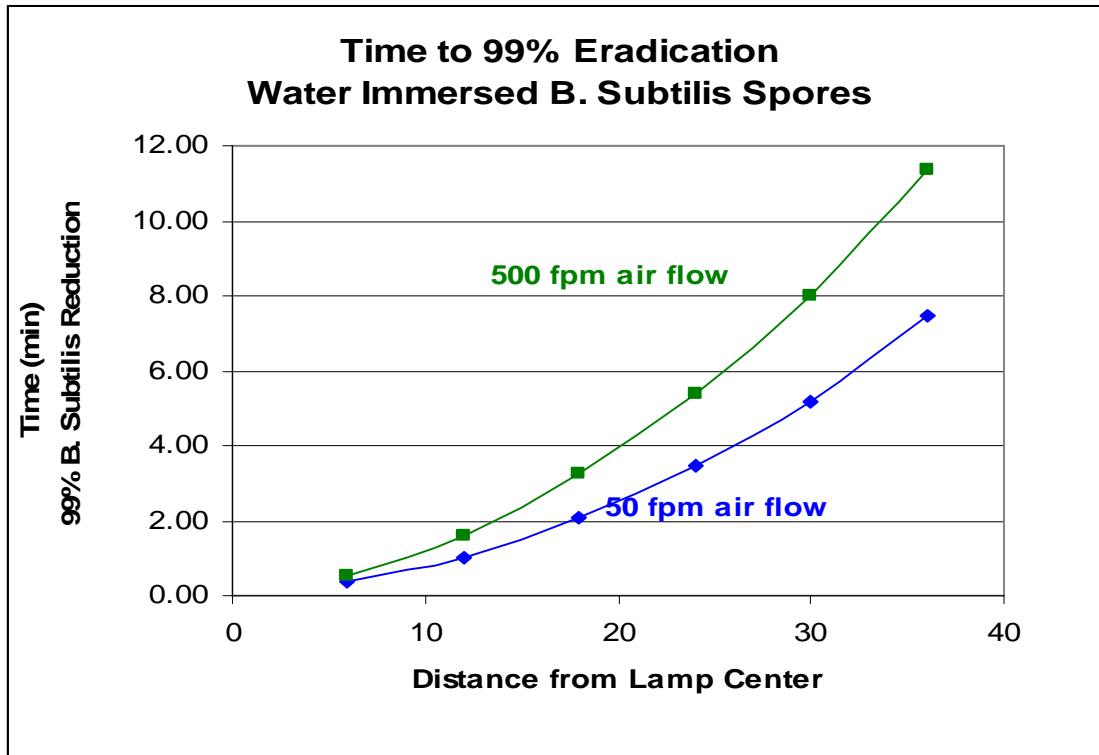




Figure 1. UV lamp testing rig.

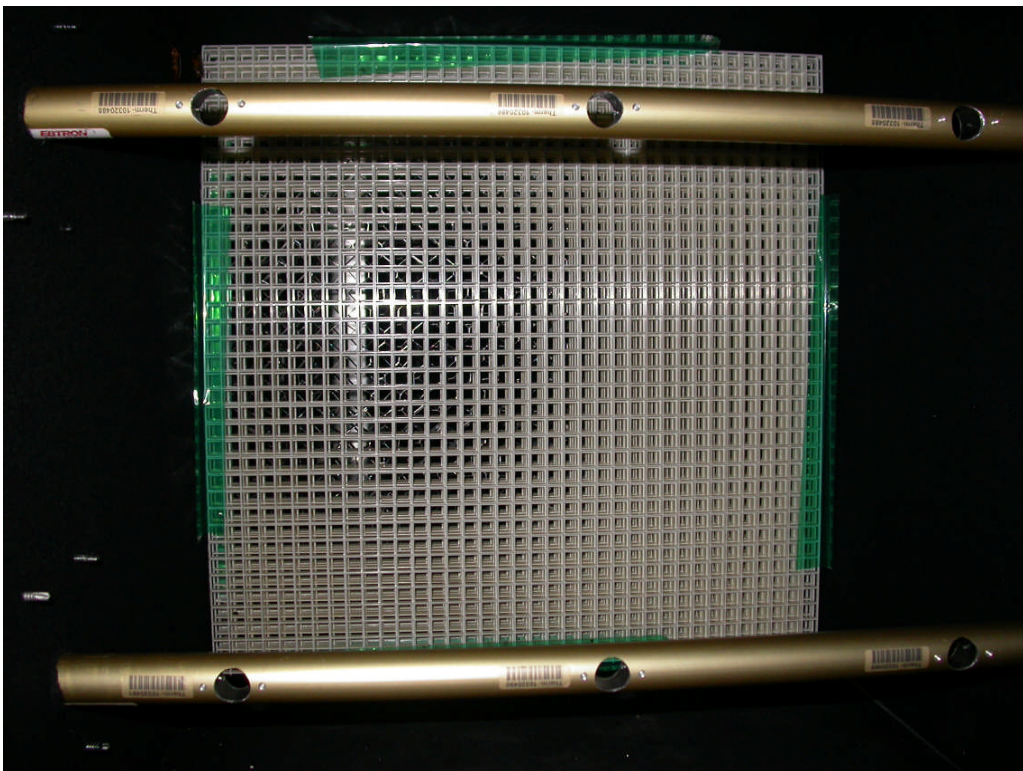


Figure 2. Flow station inside UV lamp testing rig.

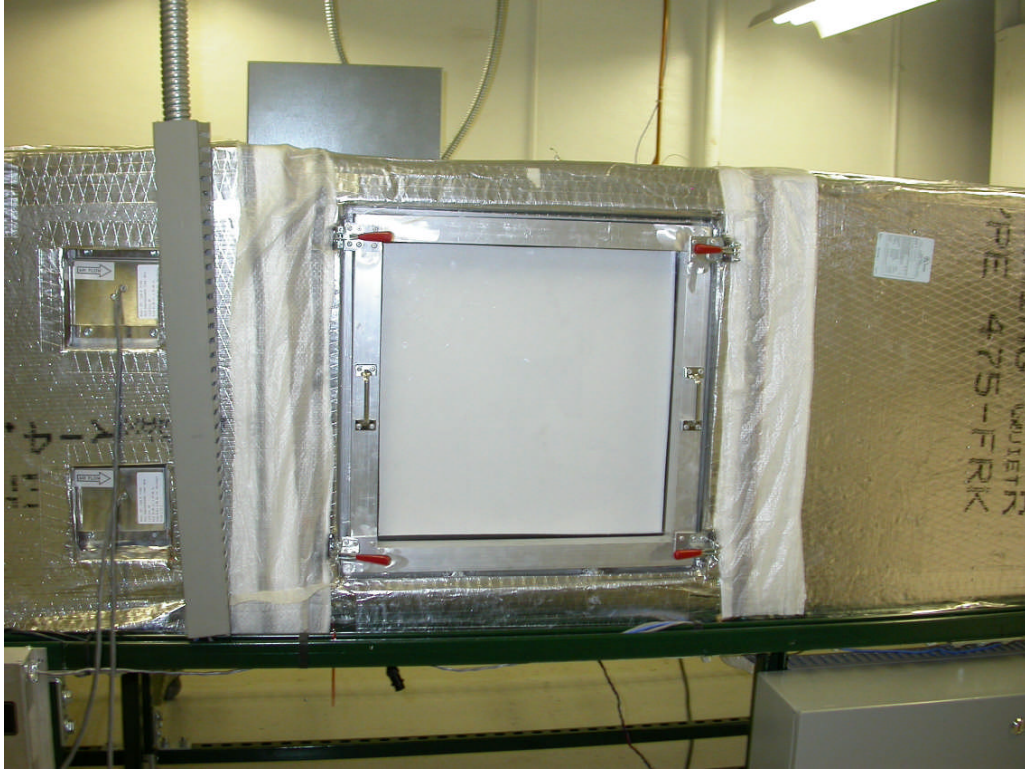


Figure 3. UV lamp test section.

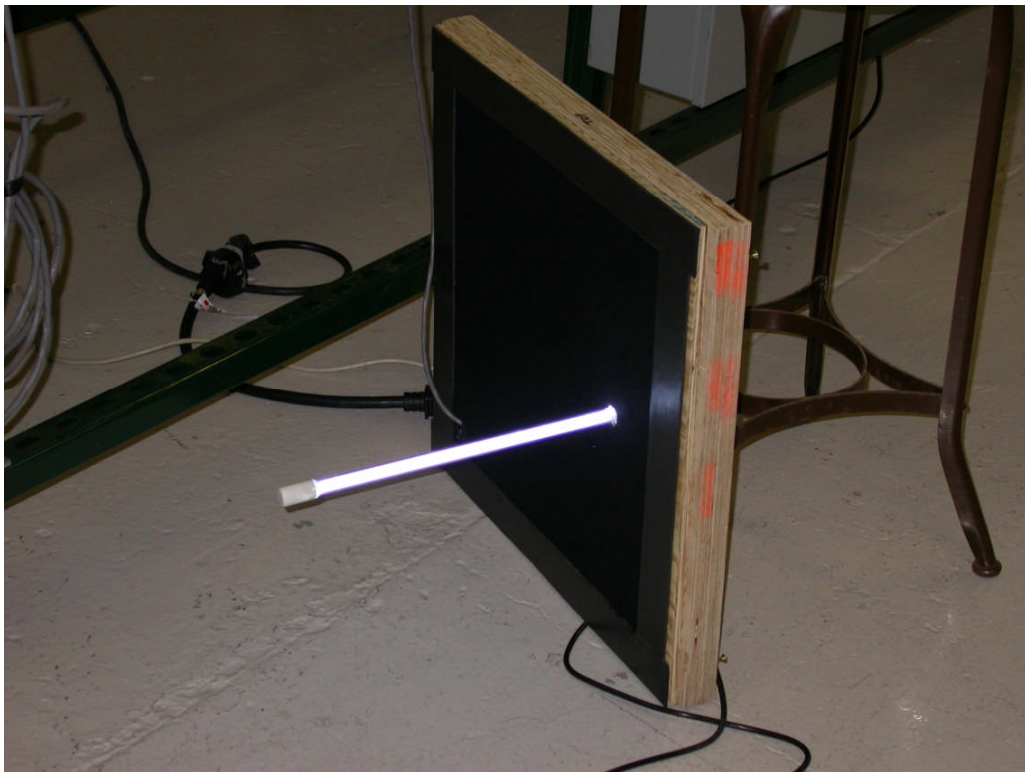


Figure 4. Sanuvox Saber Smart mounted in wooden door for testing.

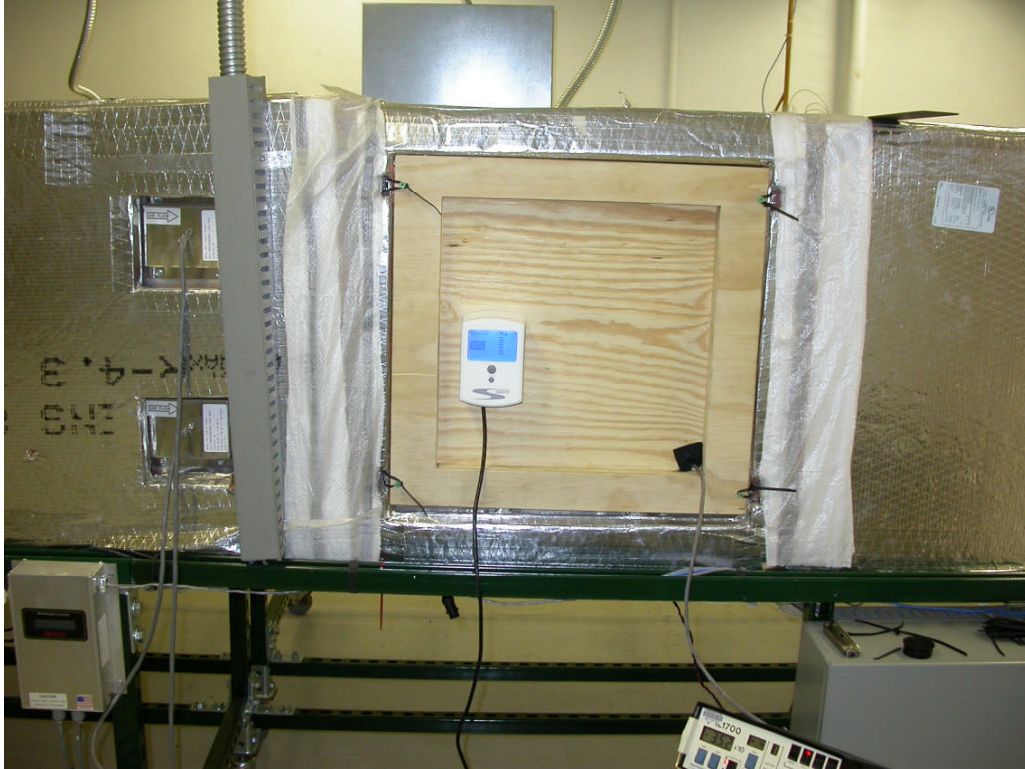


Figure 5. Sanuvox Saber Smart installed inside test rig.

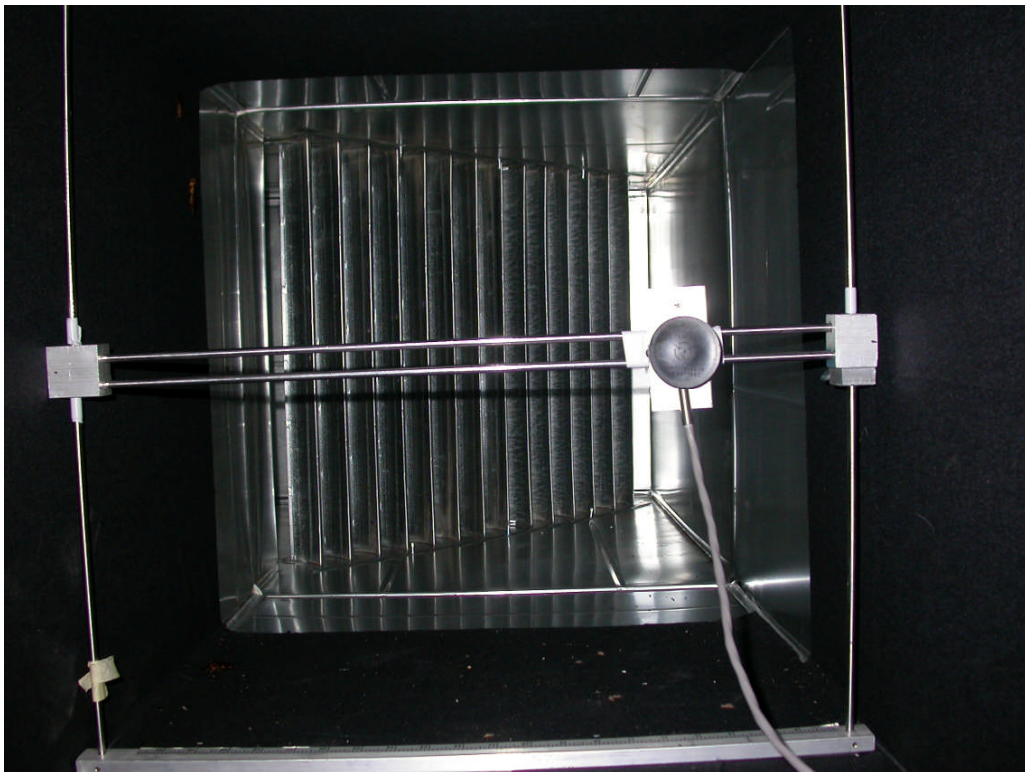


Figure 6. Mounting device to maintain IL 1700 sensor at center of lamp.