Sanilume White Paper: UVC Air Disinfection Principles

There is continuing misinformation and misunderstandings with respect to claims by UVC device manufacturers on the efficacy of their devices and what their claims and terminology actually mean. Here at Sanilume, we hope to shed some light on this subject.

UVC Kills Pathogens. All living microbes will be inactivated (killed) by UVC depending on the dose (irradiance x time). This is not a theory; it has been empirically tested for over a century now. It is estimated that a dose of 40 mj/cm2 will inactivate any known microbe on earth, and about 3 mj/cm2 to inactivate Sars-Covid2, the virus which causes Covid-19.

What Matters. Sifting through all the information and claims being made, there are only two main factors that determine the ability of any UVC device to kill pathogens: UVC intensity/power, and the duration of direct contact of the UVC irradiation on the pathogens. For UVC air disinfections devices, this translates into the airflow of the aerosol pathogens through the UVC energy field. So, the greater the UVC power, the greater the kill ratio, and the greater the airflow through the UVC energy, the greater the kill ratio. **All claims and information out there can be compared and analysed against these two basic principles!**

Air Changes Per Hour (ACH). An "air change per hour" is simply the complete exchange of air in a room in one hour. A typical HVAC system may be able to provide 4-8 ACH. Assuming an ACH of 6, and no pathogens are getting recycled (unlikely unless the HVAC system uses UVC or expensive HEPA filters), the room air would be sanitised every 10 minutes in theory. In reality, much less than that.

Equivalent Air Changes Per Hour (eACH). An equivalent air change per hour does not actually replace any room air. It refers to the elimination of all pathogens in the entire room in one hour. Actual air changes replace the air with fresh sanitized air every hour (again, if a HEPA filter or UVC system is present). This is why it is called an equivalent" air change.

Air Purifiers. Air purifiers generally have very low airflow, and the intake and outflow of air is located at a single spot in the room, which makes clearing the entire room air extremely inefficient, perhaps 1-2 ACH depending on room size. Additionally, what no manufacturers of air purifiers want to advertise is that the filters need to be replaced often, and they are a repository for live pathogens. They retain water condensation and can be a literal petri dish culture of pathogens. This is the heart of the Quebec School district air purifier controversy.

Direct UVC Irradiation Devices. These devices come in a multitude of formats, but they irradiate surfaces with UVC. These devices have some merit for medical sterilization applications but are entirely ineffective for general room sterilization: 1) People cannot be present; UVC is harmful when people are exposed to it. 2) The UVC needs to directly, line-of-sight contact any pathogens. Shadows, dust, moisture etc. will negate the UVC efficacy. 3) The minute people are present, everything becomes reinfected. Save your money.

Upper Room Air UVC Devices. This is the UVC technology that Sanilume uses. Leading science bodies around the world recommend this type as by far the most efficient method of air sterilization. There is a

reason for this; **PHYSICS 101** as explained in "What Matters" above. Upper room air devices blanket a UVC energy field safely above people's heads and into the upper areas of a room. Rising room air currents (which contain the aerosol pathogens) both from natural convection current or from HVAC systems, brings the pathogens in contact with the UVC energy fields. As quoted from an ASHRAE scientific publication[1], "An optimal upper-room UV installation, therefore, has the potential of producing the equivalent of 20 ACH or more in the occupied lower room."

Standard Upper Room Air Fixtures Explained. Standard upper room air GUV fixtures such as the Cooper GAW[2] utilize a 20 watt UVC lamp and emits about .5 watts of UVC power. This low power is distributed through the cubic air volume of the space it is mounted in. The larger the square footage, and the higher the ceiling height, the proportionally lower kill power the unit will have. Units such as these have no air moving capability, so their pathogen killing power is directly dependant on their UVC output. Several of these types of units would need to be installed in a 400 sq ft room to provide high efficacy.

Sanilume Explained. Sanilume units use a 75 watt lamp and distributes about 2 watts of energy at it's lowest setting. This is about four times the power of standard fixtures. Remember that the fixture's efficacy is related to the cubic volume it is mounted in. Sanilume has adjustable apertures that can be opened up as the ceiling height is increased; up to a max of about 7 watts, which has 14 times the efficacy of standard fixtures in a room with high ceilings. And remembering that the airflow circulating the pathogens in the UVC field is the second fundamental of "what matters", Sanilume fixtures have high power low noise fans that can add the equivalent of 10 ACH in a 400 sq. ft room with 9 ft. ceilings.

Sanilume Numbers Explained. Sanilume quotes their SL36-KT-75 at 35 eACH. Why, and what does this mean exactly? Based on the cubic volume of 400 sq. ft with 9 ft ceilings and a total Sanilume UVC output of 2 watts, a conservative 25 eACH can be calculated. The Sanilume fans move about 25,000 cubic feet of air per hour both through the fixture and through the UVC field in the room. This adds an approximate 10 eACH, creating a total eACH of about 35 with 9 ft ceilings. As ceiling height increases, Sanilume's apertures can be opened to release more UVC energy and compensate for the increased ceiling height. Although Sanilume's air moving power decreases proportionally as ceiling heights rise, the increase in UVC outpaces the loss. As a result, Sanilume can confidently use an eACH of 35 regardless of ceiling heights in moderately high rooms. **Following these calculations, 35 eACH equates to a conservative equivalent air change every 1.71 minutes in a 400 sq. ft. room, independent of the ceiling height (up to approximately 31.5 ft ceilings**)

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[1] Guidelines for the Application of Upper-Room Ultraviolet Germicidal Irradiation for Preventing Transmission of Airborne Contagion—Part I: Basic Principles Melvin W. First, Sc.D., P.E. Edward A. Nardell, M.D. William Chaisson, P.E. Richard Riley, M.D. Life Member **ASHRAE**

[2] Cooper Industry's GAW Germicidal Air Wall Mount