AUVS
ADVANCED ULTRA-VIOLET SYSTEMS

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QUESTIONS AND ANSWERS ABOUT UV

1. Introduction
    1. Dr. Clarks background, education, past positions, patents, UV development.

        - Ph.D. in electrical engineering with specialization in controlled nuclear fusion and plasma physics research
        - Currently, President, CEO Novatron, Inc. Previously, President, PurePulse Technologies, Inc. (1988 – 1998). Numerous executive and research positions at Maxwell Laboratories, Inc. (1973 – 1988). Research Scientist, Los Alamos National Laboratory 1973. Research Scientist University of Texas and Cornell University 1972 (joint appointment).
        - 30 years' experience developing intense UV sources and applying UV energy for antimicrobial applications
        - More than 25 technical articles published and inventor on 18 patents

    2. Very brief discussion of the development of Advanced UV System technology and why.

        - The Advanced UV System (AUVS) technology was developed with Department of Defense (DoD) funding to protect people in buildings against bio agent attacks. Large systems were installed by Novatron, Inc. at the Pentagon in Washington DC as part of a protection system there.

2. UV General
    1. What is UV?

        - UV light is similar to ordinary visible light. The wavelengths of UV light are slightly shorter than those of violet light, but longer than those of x-rays. UV wavelengths are not visible to the human eye.

    2. How does UV energy cause germicidal effect?

        - The wavelengths in certain parts of the UV spectrum are such that they can efficiently break apart molecular bonds in strands of nucleic acid (DNA) in microorganisms such as bacteria, viruses and other microorganisms. Once these bonds are broken, the microorganisms cease to survive and function.

3. What are the most effective wavelengths for UV germicidal effect? Why is this called (UVC)

    - The UV spectrum is divided into several parts depending on wavelength. The shorter wavelengths, those further from the visible spectrum and nearer the x-ray spectrum are labeled UVC. The longer wavelengths nearer the visible spectrum are labeled UVB and UVA, with UVA being closest to the visible spectrum. The wavelengths in the UVC portion of the UV spectrum match the energy of the molecular bonds in microbial DNA more closely and are orders of magnitude more effective in destroying those bonds and rendering the microbes incapable of surviving.

4. What is the measurement for UV energy?

    - UV energy is typically measured in terms of the amount of energy per unit area reaching a surface. Common units of measurement are: Joules per square centimeter (J/cm2) or milliJoules per square centimeter (mJ/cm^2). A milliJoule is one - one thousandth of a Joule (1 mJ = 0.001 J).
    - The UV power reaching a surface is typically measured in units of Watts per square centimeter. It is a measure of the instantaneous intensity of a UV source.
    - One watt of power applied for one second (1Watt-second, or 1W-s) results in an accumulation of one Joule of energy. Thus, $1\ W\text{-}s/cm^2 = 1\ J/cm^2$. The units of J/cm^2 and $W\text{-}s/cm^2$ are used interchangeably as a measure of UV dose.

5. Is the same amount of energy used to kill any microorganism?

    - No, different organisms require different amounts of energy to achieve a given amount of kill.

6. What is a log of kill?

    - Each log of kill is a reduction by a factor of 10 in the number of viable organisms. For example, if a surface has 1000 microbes per square centimeter, a 3 log kill would reduce the number of surviving organisms to 1 per square centimeter.

7. What influences the kill rate for UV, time, distance. and type of organism.

    - For a UV source of a given power, the amount of exposure time determines the total amount of UV energy accumulated. The amount of accumulated energy determines the kill achieved for a particular microbe. Some microbes are more resistant than others. However, with an appropriately designed system, it is possible to very effectively kill typical pathogenic microorganisms with high intensity UV applied for times of a minute or less.

8. Which organisms are the toughest to kill and why?

   - Many bacteria exist only in what is called a vegetative state, where they are continually metabolizing, growing and multiplying. These are generally relatively easily killed by UV.
   - A factor that determines how easily a bacteria is killed is the size of the organism and the thickness of any protective layer such as the cell wall.
   - Some bacteria can form spores which are a dormant form of the bacteria. Bacterial spores are much more resistant to most antimicrobial processes such as heat, UV, x-rays, drying, etc., since they generally have a tough protein shell that protects them.
   - Viruses are typically rather easily killed by UV because they are composed largely of nucleic acids and generally are small and easily penetrated by the UV wavelengths.

3. UV Lamps
   1. General UV lamps
      1. Please explain continuous wave mercury lamps.
      2. Halogen pulsed UV
      3. What is the difference in terms of their effect on pathogens, cost difference and energy usage.

      - Continuous wave mercury lamps emit a large fraction of their energy in the UV. Approximately 90% of the UV emission is radiated in the 253.7 nanometer wavelength atomic mercury radiation line. This makes these lamps ideal for germicidal use, since this it is near the optimum wavelength for destroying DNA in microorganisms. These lamps are energized by continuous electrical power.
      - Halogen pulsed lamps produce a broad emission spectrum that includes visible light, infrared emission and a relatively small amount of energy in the UV. These lamps are energized by pulses of electrical power. Drawbacks to these lamps are that the electrical systems used to excite them are much more expensive and their efficiency in producing UV in the correct wavelength region to accomplish antimicrobial effects is low.

- Continuous wave mercury lamps are lower cost than pulsed halogen lamps. Continuous wave mercury lamps also require significantly less electrical energy since they are considerably more efficient at producing UV at the appropriate wavelength for antimicrobial effects.

2. What is the relationship between UV energy and distance?

   - Near a cylindrical UV lamp, the intensity decreases linearly as distance from the lamp increases. Further from the lamp the intensity decreases as the square of the distance from the lamp.

3. What about uniformity of exposure?

   - It is very important that all areas of any surface being sanitized receive enough energy to disinfect the surface. The exposure pattern must be uniform enough to assure that all areas receive the appropriate UV energy.

4. Advanced UV System technology.
   1. Do all surfaces reflect UV the same way?
   2. UV reflection and impact on UV energy.
   3. What is Advanced UV technology that was developed for the department of defense?
   4. What is the cavity effect?
   5. What are the benefits of the cavity effect for germicidal UV?
   6. Show an example (KR615) and how it works.

      - Many surfaces and materials reflect UV poorly, but some are good reflectors.
      - Surfaces that reflect UV well can significantly increase the amount of UV energy available.
      - Advanced UV System (AUVS) technology was developed by Novatron, Inc. for the department of defense for use in protecting people in buildings and enclosed spaces against biological warfare agents by killing bacterial agents in air. The AUVS technology uses reflective cavity techniques to significantly increase antimicrobial effects in air.
      - By using reflective technology, it is possible to significantly increase the intensity and uniformity of UV in a cavity.
      - Increasing the UV intensity and uniformity using the cavity effect significantly multiplies antimicrobial effects.
      - Placing an object to be disinfected in a reflective cavity such that used in the KR615 sanitizer results in a major increase in

kill of pathogenic organisms on the surface of the object because both the intensity and uniformity of the UV are greatly enhanced.

5. Hospital infection control with germicidal UV
    1. How do you test to see if the UV system works?
    2. Good and bad of UV.

- The amount of UV being produced in a system such as the KR615 sanitizer can be measured using devices such as a UV photodiode, a UV radiometer, or a filtered calorimeter. A quick and simple test to verify that the UV dose is in the appropriate range can be performed with UV photo sensitive strips that show a color change at a given dose level.
- Antimicrobial effects can be measured by exposing surfaces that have been inoculated with bacteria or pathogens of interest to the UV produced by a device such as the KR615 and using microbiology techniques to recover and determine the numbers of any surviving microorganisms.
- UV energy is a well-known, well documented and reliable means for killing microorganisms and disinfecting surfaces. The sanitizing effects are rapid and repeatable. The disinfection results also are generally independent of individual user technique, as opposed to other methods such the use of wipes. The level of sanitization achieved is much higher than can be achieved with typical techniques such as manual wiping with chemically impregnated wipes. In addition, the use of UV avoids corrosive chemicals that can damage objects and result in disposal problems for both chemicals and chemically impregnated wipes.
- A key issue with UV that must be addressed properly is preventing exposure of personnel to UV. This can be handled, however, as it has been in the KR615 sanitizer, by designing the unit such that UV is entirely contained in the UV cavity and assuring that the UV sources can't be energized if the door to the unit isn't securely closed.

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