Far-UVC Light in Healthcare Design Specifications

Client: Dr. Ernesto Brauer

Project Name: Far-UVC Light in Healthcare

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Function (a general statement of what the device is supposed to do): The PDS should begin with a brief, concise paragraph describing (in words) the overall function of the device. In the initial stages, this will be the problem statement, and will become more specific as you decide on a final design.

Germicidal ultraviolet light (254 nm), referred to as GUVC light, has been proven as an efficient source of killing pathogens with 99.9% effectiveness. Unfortunately, due to the nature of this longer wavelength, GUVC light can only be utilized in settings where no humans are present, as prolonged exposure to this light can cause temporary or permanent eye and skin damage. As an alternative, Far-UVC light (~220 nm) has been proposed to have little to no health risks due to less penetration into human skin from its shorter wavelength, while still maintaining the same effectiveness rate as GUVC light. As these results have only come from short term and limited empirical studies, our goal is to perform a meta-analysis to investigate the effectiveness of Far UVC light in preventing coronavirus strains HCoV-229E, HCov-OC43, and SARS-CoV-2 from existing on surfaces and in the air. We will determine its efficacy at different light dosages, distances, and durations by utilizing literature, probability models, and survival formulas. Based on our findings, we will design a product that will use Far-UVC light to kill airborne and surface adherent viruses in a fully furnished 10.20 m^3 clinical patient bathroom, with 99.9% effectiveness. By using probability equations and models (Beer-Lambert's Law), we will theoretically prove the product's efficacy.

Client requirements (itemize what you have learned from the client about his / her needs): Briefly describe, in bullet form, the client needs and responses to your questions.

- Design a far-UVC product that can be implemented in a clinical setting and is able to safely disinfect objects/surfaces while people are present and exposed to this light.
- Perform a meta-analysis to prove that Far-UVC light is 99.9% effective in killing microorganisms in populated spaces using light.

- Determine dosage (exposure time), distance, and intensity of light required to kill microorganisms and that can disinfect a full 320 square foot fully furnished patient room

Design requirements: This device description should be followed by a list of all relevant constraints, with the following list serving as a guideline. (Note: include only those relevant to your project):

1. Physical and Operational Characteristics

a. **Performance requirements:**

The performance demanded or likely to be demanded should be fully defined. Examples of items to be considered include: how often the device will be used; likely loading patterns; etc.

The product must be able to disinfect 99.9% of viruses in the air and on target surfaces. Ideally the light will be able to disinfect as much surface area as possible. It must not pose any safety risk to humans who could be exposed for any period of time. This light must also be able to be on constantly for periods of time on the scale of years. It must be prepared to be on 24 hours a day for 365 days a year over the course of 5.5 years.

b. **Safety:**

Understand any safety aspects, safety standards, and legislation covering the product type. This includes the need for labeling, safety warnings, etc. Consider various safety aspects relating to mechanical, chemical, electrical, thermal, etc.

Use this light in a way that won't cause cancer (melanoma), damage eyes (cataracts), or any other kind of harm to anyone that is exposed to the light for any period of time. Studies must also be done to make sure the light still keeps the "beneficial microorganisms" in our bodies intact. In theory, this will be done by ensuring that the light has wavelengths that are short enough so they can not penetrate living human cells but is long enough to penetrate and damage the DNA in viruses, thus killing them.

c. **Accuracy and Reliability:**

Establish limits for precision (repeatability) and accuracy (how close to the "true" value) and the range over which this is true of the device.

Accuracy includes ensuring that the light accurately targets the intended area(s) by covering 99% of the target area and killing, on average, 99.9% of the intended microbes in the area.

d. **Life in Service:**

Establish service requirements, including how short, how long, and against what criteria? (i.e. hours, days of operation, distance traveled, no.of revolutions, no. of cycles, etc.)

A life in service greater than other types of light sources is required so that it remains effective in its disinfectant properties. Light will be built into a normal light emitting diode

(LED) light source (3.3 forward voltage and a 120V power supply) that can be replaced with the normal light source, however, the far-UVC light should be expected to be on at all times (24/7).

e. **Shelf Life:**

Establish environmental conditions while in storage, shelf-life of components such as batteries, etc.

The shelf life must be for 50,000 hours or about 5.5 years if the light is on 24 hours a day for 365 days. This is comparable to a normal LED light.

f. **Operating Environment:**

Establish the conditions that the device could be exposed to during operation (or at any other time, such as storage or idle time), including temperature range, pressure range, humidity, shock loading, dirt or dust, corrosion from fluids, noise levels, insects, vibration, persons who will use or handle, any unforeseen hazards, etc.

This device is meant for use in a fully furnished typical patient clinical setting, such as a 320 square foot patient room or a 40 square foot bathroom, lead to very sterile environments. It will exist at room temperature (20-22 degrees Celsisus), low and stable humidity (40-50% relative humidity), will not encounter significant shock loading, dirt or dust. Must be resistant to other sterilizing chemicals used in the area. The housing must maintain stability when being built into/used in the operating environment (likely metal housing similar to those used in other lighting fixtures).

g. **Ergonomics:**

Establish restrictions on the interaction of the product with man (animal), including heights, reach, forces, acceptable operation torques, etc..

Far-UVC light emission is safe for contact on human skin and eyes. People should not touch or bend lights otherwise they may break, however, the light will be in close proximity to humans and specialized equipment so it should not emit heat that could be damaging. Significant amounts of water should not be in contact with the lights as they can potentially explode.

h. **Size:**

Establish restrictions on the size of the product, including maximum size, portability, space available, access for maintenance, etc.

A strip light overhead design should have dimensions of about 5ft in length x 2.5ft in width x 1ft depth* to ensure variable placement in clinical environments while not being bothersome. As an overhead light, one section of this rectangular housing will be exposed for emission to the rest of the room and access for maintenance.

i. **Weight:**

Establish restrictions on maximum, minimum, and/or optimum weight; weight is important when it comes to handling the product by the user, by the distributor, handling on the shop floor, during installation, etc.

The weight of this product should be less than 10lbs* to ensure it can be easily installed with regard to installation hardware and wall supports.

j. **Materials:**

Establish restrictions if certain materials should be used and if certain materials should NOT be used (for example ferrous materials in MRI machine).

Materials should be safe and consistent with other materials that would be considered safe and usable in a hospital setting.

k. **Aesthetics, Appearance, and Finish:**

Color, shape, form, texture of finish should be specified where possible (get opinions from as many sources as possible).

A clean, smooth, simplistic finish and uniform shape are required in clinical settings to not interfere with procedures and movements occurring below/around.

2. **Production Characteristics**

a. **Quantity:** number of units needed

There is a current issue with the rate of production. This design needs to be able to be mass produced for uses in clinical settings around the world.

b. **Target Product Cost:** manufacturing costs; costs as compared to existing or like products

Existing products range from about $500 to multiple thousands of dollars depending on the design. Manufacturing costs for simple products such as ours should be limited to $500.

3. **Miscellaneous**

a. **Standards and Specifications:** international and /or national standards, etc. (e.g., Is FDA approval required?)

FDA approval would be required. Once approved by FDA, international standards would likely be met. As of March 2020 there is an specific document for “Sterilizers, Disinfectant devices, and Air Purifiers” during the Covid-19 Pandemic. (https://www.fda.gov/media/136533/download)

- Current regulatory exposure limit of 222 nm light to the public is ~3 mJ/cm2/hour with a maximum regulatory limit of 23 mJ/cm2 per 8-hour exposure
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b. **Customer:** specific information on customer likes, dislikes, preferences, and prejudices should be understood and written down.

Customers prefer simple, efficient products and lights that are easy to install and control. The light would be able to sterilize the area within a reasonable time and work consistently.

c. **Patient-related concerns:** If appropriate, consider issues which may be specific to patients or research subjects, such as: Will the device need to be sterilized between uses?; Is there any storage of patient data which must be safeguarded for confidentiality?

Those sensitive to light may experience discomfort when using far-UVC. Those with other conditions that might be more sensitive to light such as:

-Being pregnant
-The elderly
-People with cancer
-People with large open wounds
-Babies / toddlers
-Animals

d. **Competition:** Are there similar items which exist (perform comprehensive literature search and patents search)?

- Air filters with Far-UVC light
- Portable wand design
- Vertical light lamps
- Architectural sanitation lights
- Overhead doorway
- Medical equipment with built in lights on high contact areas
- Sanitation boxes
- Mounted track/swivel
- UVC lights in general that are used to disinfect objects after put in a container for a few minutes