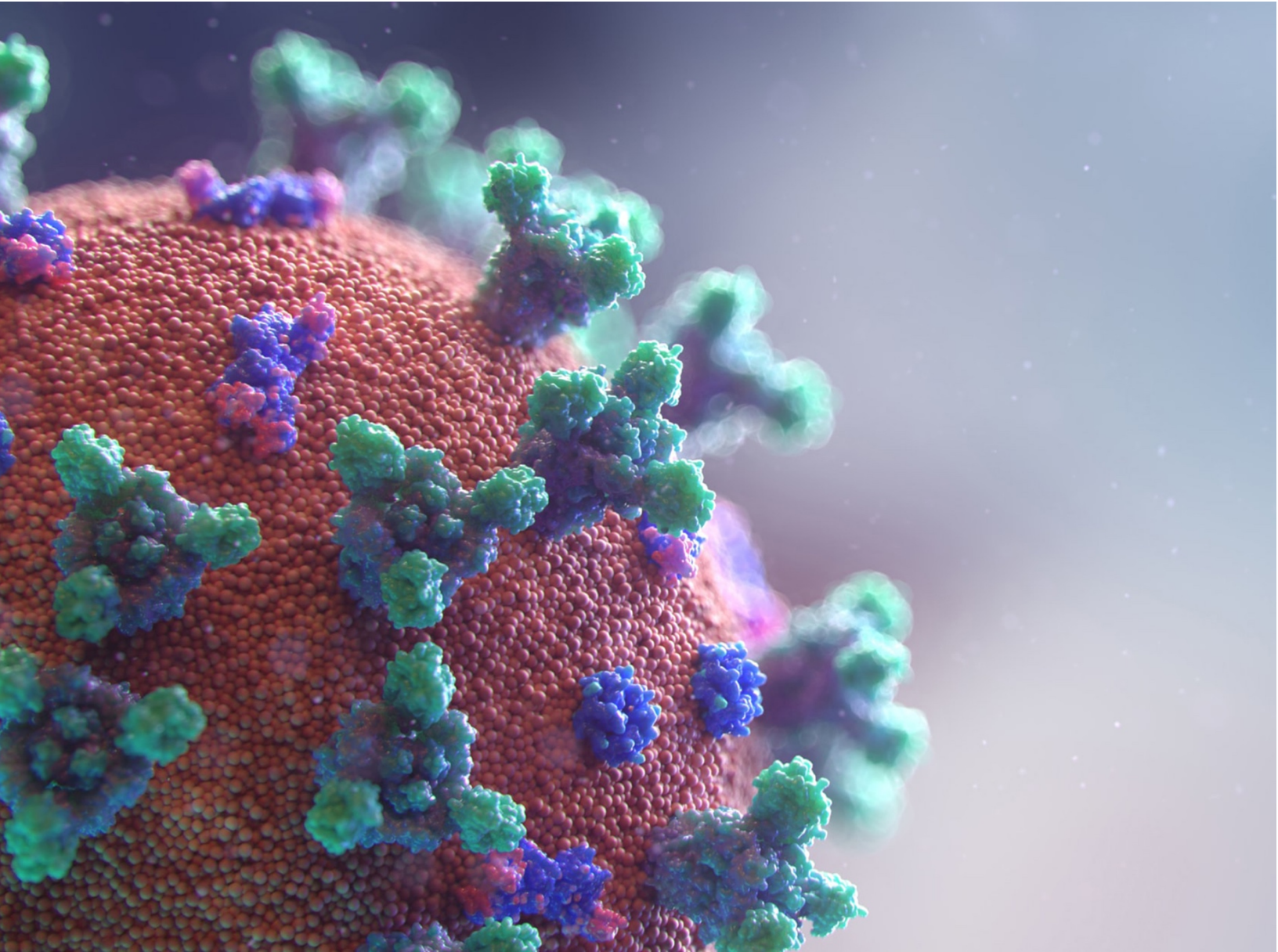


UVC SENSORS TO MONITOR ULTRAVIOLET GERMICIDAL IRRADIATION (UVGI)



A White Paper by
Solar Light Company, LLC

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1.0 SUMMARY

The ongoing COVID-19 pandemic has severely stressed the worldwide healthcare system and has created dangerous shortages of personal protective equipment (PPE), including masks, gowns and gloves. In an effort to extend inventory, healthcare institutions and emergency responder organizations have instituted decontamination procedures involving the delivery of ultraviolet germicidal irradiation (UVGI).

PPE decontamination procedures require accurate dosing UVC energy to inactivate pathogens while maintaining the integrity of the PPE materials. The most effective UVGI methods employ UVC sensors to ensure the exposure levels of materials during sterilization are both achieved and maintained. Solar Light Company, LLC, designs and manufactures precision solar simulators, meteorological instruments, sources, sensors, and standards and provides calibration services to assess the impact of sunlight on human health and the environment. Areas of focus include: SPF measurement of sun protection products, monitoring UV disinfection systems and environmental monitoring.

This white paper provides an overview of the capabilities of Solar Light's UVC

sensors and handheld radiometers that are used to determine the accurate UVC dose and intensity to aid in the safe and effective decontamination of PPE with UVGI.

2.0 INTRODUCTION

To extend the stockpile of PPE, decontamination procedures involve the delivery of UVGI to be used on contaminated PPE. UVGI has been shown to effectively inactivate a wide range of human pathogens, including coronaviruses and other human respiratory viruses. Levels of UVGI required to inactivate human pathogens are below the level of irradiation that will affect the integrity of the PPE.

Integration of UVC meters with remote sensors enables the delivered UVGI dose to be monitored from outside the room to improve safety of personnel performing these protocols.

3.0 BACKGROUND

Ultraviolet Spectral Region

A rainbow is made when light shines through droplets of water and divides into various colors. The light just beyond the violet end of the spectrum is not visible to the naked eye and is called ultraviolet ("beyond violet"), known commonly as UV light.

There are three types of UV light, each representing a different section of the UV light spectrum: UVA (320 to 400 nm), UVB (280 to 320 nm), and UVC (200 to 280 nm). UVC is the form used for a germicidal activity. Although 10% of the sun's radiation is composed of UV light, virtually all of the sun's UVC rays are blocked by the Earth's ozone layer, so most UVC exposure is created by artificial means.

Ultraviolet Germicidal Irradiation (UVGI)

When UVC light is used for germicidal purposes, it is referred to as UVGI, ultraviolet germicidal irradiation. UVGI "deactivates" or kills microorganisms, including viruses, bacteria, molds, and other fungi by disrupting their DNA. "Deactivated" means the organism is not necessarily killed but can no longer reproduce. Some deactivate after microseconds of exposure while others require much longer exposure. The effectiveness of UVGI depends on several factors, including:

- Intensity of the lamp(s)
- Location of the UVC lamp(s)
- Length of time of exposure
- An organism's ability to withstand UVGI
- Relative humidity
- Ambient temperature

- The reflectivity of surrounding surfaces

Additionally, UVGI is used for:

- Laboratory disinfection
- Surface disinfection
- HVAC air disinfection
- Drinking water purification
- Wastewater treatment
- Food and beverage protection
- Phototherapy
- Blood products pathogen reduction

UVC Dosage and Intensity Measurements

In air and surface disinfection applications, the UV effectiveness is estimated by calculating the UV dose that will be delivered to the microbial population.

UV dose is not measured directly but is inferred based on the known or estimated inputs to the protocol: relative humidity and atmospheric contaminants (reduction in UV intensity), illumination rate (contact time), transmittance (light reaching the target), and lamp intensity.

The UV dose is calculated as follows:

$$\text{UV dose } (\mu\text{J}/\text{cm}^2) = \text{UV intensity } (\mu\text{W}/\text{cm}^2) \times \text{exposure time (seconds)}$$

The dosage, a product of UV light intensity and exposure time, is usually measured in micro joules per square centimeter. For 90% viral reduction, UV dosages of most bacteria and viruses range from 2,000 to 8,000 $\mu\text{J}/\text{cm}^2$.

4.0 UVC SENSORS FOR GERMICIDAL AND STERILIZATION APPLICATIONS

Section 3.0 highlighted the importance of the measurement of UVC intensity and the determination of UVC dosage in the application of UVGI for decontaminating PPE. That is where the UVC sensors and radiometers manufactured by Solar Light Company, LLC have a large contributing role.

Described within this paper are four (4) products by Solar Light used to evaluate dosage and intensity, specifically aiding in the decontamination of PPE worn by front-line workers. The products are:

1. PMA 2100 Handheld, Dual-Input, Data Logging Radiometer
2. PMA 2200 Handheld, Single-Input Radiometer
3. Solarmeter® Model 8.0 Handheld UVC Intensity Meter
4. Solarmeter® Model 8.0-RP Handheld UVC Intensity Meter with Remote Probe

PMA2100 Handheld, Dual-Input, Data Logging Radiometer



Solar Light's versatile NIST-Traceable Model PMA2100 Handheld, Dual Input, Data-logging Radiometer is designed for scientific professionals, offering unparalleled accuracy and flexible data management. The unit accepts over 85 different PMA-Series Digital Sensors. It functions as a light meter, photometer, and UV meter measuring UVA, UVB, UVC, Visible, and IR light. Solar Light's patented Intelligent Detector Technology allows users to interchange sensors without losing the functionality of a single purpose meter, while the Automatic Sensor Recognition feature eliminates the need to match meters and sensors. As a result, any PMA Sensor can interface with any PMA Meter, which is especially useful when multiple radiometers and sensors are being utilized in PPE decontamination procedures. The PMA2100 can store 1024 records with full traceability, each including time, date, and sensor calibration status. Data logging can be

triggered automatically or manually, in 1 minute to 2-hour intervals, and is stored in embedded memory that can be downloaded to a computer via USB.

The sensor output algorithm provides precision readings, user selectable units of measure such as foot-candles, lux or intensity), and date of calibration.

Intensity ($\mu\text{W}/\text{cm}^2$) measurements can be time-integrated to yield real-time accumulated dose ($\mu\text{J}/\text{cm}^2$) information. Set-points, such as Min., Max., and Average, can be displayed and used to set programmable audible alarms when continuous observation of the radiometer is not possible.

Features

- High Sensitivity
- Dynamic Range 2×10^5
- Excellent Long-term Stability
- Automatic or Manual Data Logging
- Automatic Sensor Recognition
- Intelligent Detector Technology
- NIST Traceable Calibration
- UVC Dose and Intensity Measurements
- Made in the USA

Healthcare Applications

- Skin and SPF Testing
- Clinical Studies
- Phototherapy

For more details on the PMA2100 handheld, dual input, datalogging radiometer:

<https://solarlight.com/product/datalogging-radiometer-pma2100/>

For a technical user guide on the PMA2100 handheld, dual input, datalogging radiometer:

<https://solarlight.com/wp-content/uploads/pma2100-quick-start-guide-1.pdf>

PMA2200 Handheld, Single-Input Radiometer



Like the PMA2100, the Model PMA2200 Handheld, Single-Input Radiometer accepts over 85 different PMA-Series sensors measuring UV, Visible and IR wavelengths. Its patented Intelligent Detector Technology combined with Automated Sensor Recognition enables seamless interchange between radiometers and sensors. As with the PMA2100 handheld radiometer, the PMA2200 allows all functions to be operated directly from the keypad with unit of measurement selection, set-points and audible alarms.

Features

- High Sensitivity
- Dynamic Range (6.5 Digital Display)
- Automatic Sensor Recognition
- Intelligent Detector Technology
- NIST Traceable Calibration
- UVC Dose and Intensity Measurements
- Made in the USA

Healthcare Applications

- Skin and SPF Testing
- Clinical Studies
- Phototherapy

For more details on this PMA2200 handheld, single input radiometer:

<https://solarlight.com/product/pma2200-single-input-radiometer/>

For a technical user guide on the PMA2200 handheld radiometer usage:

<https://solarlight.com/wp-content/uploads/pma2200-quick-start-guide.pdf>

PMA2122 Digital Germicidal UVC Sensor (UVGI)



Solar Light's Model PMA2122 Digital Germicidal UVC Sensor provides fast and accurate intensity measurements of the effective UVGI from 249-259 nm.

PMA2122 sensor detects UVC from 0 - 2000 $\mu\text{W}/\text{cm}^2$ with a resolution of 0.01 $\mu\text{W}/\text{cm}^2$ and is utilized for measurements protocols where UVC intensity < 1500 $\mu\text{W}/\text{cm}^2$. PMA2122G sensor detects UVC from 0 – 20,000 $\mu\text{W}/\text{cm}^2$ with a resolution of 0.1 $\mu\text{W}/\text{cm}^2$ and is used for measurement protocols where UVC intensity > 1500 $\mu\text{W}/\text{cm}^2$. Standard sensor packaging meets IP60 requirements, and optional weatherproof (IP68) sensor packaging is available. An embedded memory module retains all calibration data, name, type and serial number of the sensor for rapid interchange between handheld radiometers with efficient document control and traceability.

Features

- High Sensitivity
- Cosine Corrected
- NIST-Traceable Calibration
- Made in the USA

For more details on the PMA2122 sensors:

<https://solarlight.com/product/pma-2122-germicidal-uvc-detectors/>

Solarmeter®

Handheld UVC Intensity Meters

Solarmeter® Model 8.0 and Model 8.0-RP are used to determine the UVC intensity reaching the PPE. UVC dose is determined through manual calculation.

Solarmeter® Model 8.0 UVC Meter



Solarmeter® Model 8.0 is a handheld, single button UVC Intensity Meter with a UVC range of 0 – 2,000 $\mu\text{W}/\text{cm}^2$ with 1 $\mu\text{W}/\text{cm}^2$ resolution. To use the point-and-click Solarmeter® Model 8.0, simply aim the sensor located on the top panel directly at the source. Press and hold the push-button switch on the face of the meter. Solarmeter® Model 8.0 detects UVC from 246-262 nm and reproducible measurements requires repeatable and accurate placement of the meter from UVC source.

For more details on Solarmeter® Model 8.0 Handheld UVC Intensity Meter:

<https://www.solarmeter.com/model8.html>

Solarmeter® Model 8.0-RP

Handheld UVC Intensity Meter with Remote Probe



Solarmeter® 8.0-RP is also a handheld, single-button UVC intensity meter with a range of 0 – 2,000 $\mu\text{W}/\text{cm}^2$ and 1 $\mu\text{W}/\text{cm}^2$ resolution that comes with an additional feature: the Remote Probe allowing ease for directional measurements.

Features

- Remote Probe with 3-foot / 0.91 meter Cable (Model 8.0-RP Only)
- Compact, Handheld, and Durable
- Simple Single-Button Operation
- NIST Traceable Accuracy
- LCD Display
- Made In USA







Healthcare Applications

- Monitoring UVC Germicidal Lamp Intensity & Aging
- Testing Eyewear UVC Blocking Capabilities
- Measuring Germicidal Lamp Fixture Leakage

For more details Solarmeter® Model 8.0-RP Handheld UVC Intensity Meter:

<https://www.solarmeter.com/model8rp.html>

5.0 PRODUCT COMPARISON - UVC SENSORS AND RADIOMETERS BY SOLAR LIGHT COMPANY, LLC, FOR DECONTAMINATION OF PPE WITH UVGI

| SOLAR LIGHT PRODUCT | GOOD | | BETTER | | BEST | |
|--|---|---|--|--|---|--|
| | Solarmeter® 8.0 | Solarmeter® 8.0-RP | PK2222-10-10 | PK2222-1G-10 | PK2122-20-10 | PK2122-2G-10 |
| |  |  |  |  |  |  |
| DESCRIPTION | Handheld, Single Button UVC Meter | Handheld, Single Button UVC Meter with Remote Probe | Handheld Radiometer, 1 UVC Germicidal Sensor, 10 m Cable | Handheld Radiometer, 1 UVC (Extended Range) Germicidal Sensor, 10 m Cable | Handheld, Data Logging Radiometer, 2 UVC Germicidal Sensors, 10 m Cable | Handheld, Data Logging Radiometer, 2 UVC (Extended Range) Germicidal Sensors, 10 m Cable |
| DELIVERY (HRS) | 48 | 48 | 72 | 72 | 72 | 72 |
| INTENSITY | X | X | X | X | X | X |
| DOSE | | | X | X | X | X |
| REMOTE MEASUREMENT (3 FT) | | X | | | | |
| REMOTE MEASUREMENT (10 M) | | | X | X | X | X |
| SINGLE SENSOR | | X | X | X | | |
| DUAL SENSORS | | | | | X | X |
| UVC RANGE: 0 - 2,000 uW/cm ² | X | X | X | | X | |
| UVC RANGE: 0 - 20,000 uW/cm ² | | | | X | | X |
| DATA LOGGING | | | | | X | X |
| NIST CALIBRATED | X | X | X | X | X | X |