

Challenge

Access to a steady supply of N95 respirator masks is inadequate due to the COVID-19 pandemic

Solution

Irradiation and reuse of existing N95 respirator masks using the UVP XX-Series Lamps

Ultraviolet-based Disinfection of N95 Respirator Masks Using the UVP XX-Series Lamps

Introduction

According to an FDA commissioned report, a dose of 1 J/cm^2 is sufficient to result in no detectable virus on N95 mask material after UVGI treatment, corresponding to a $3.9\text{-}4.5 \log_{10}$ reduction for MERS-CoV and $4.0\text{-}4.8 \log_{10}$ reduction for SARS-CoV-1, between experimental and control groups¹. Below, we describe how to use the UVP XX-series lamps to achieve the same irradiation level of 1 J/cm^2 . HCWs should inspect masks for wear and tear after each disinfection cycle¹⁻⁴.

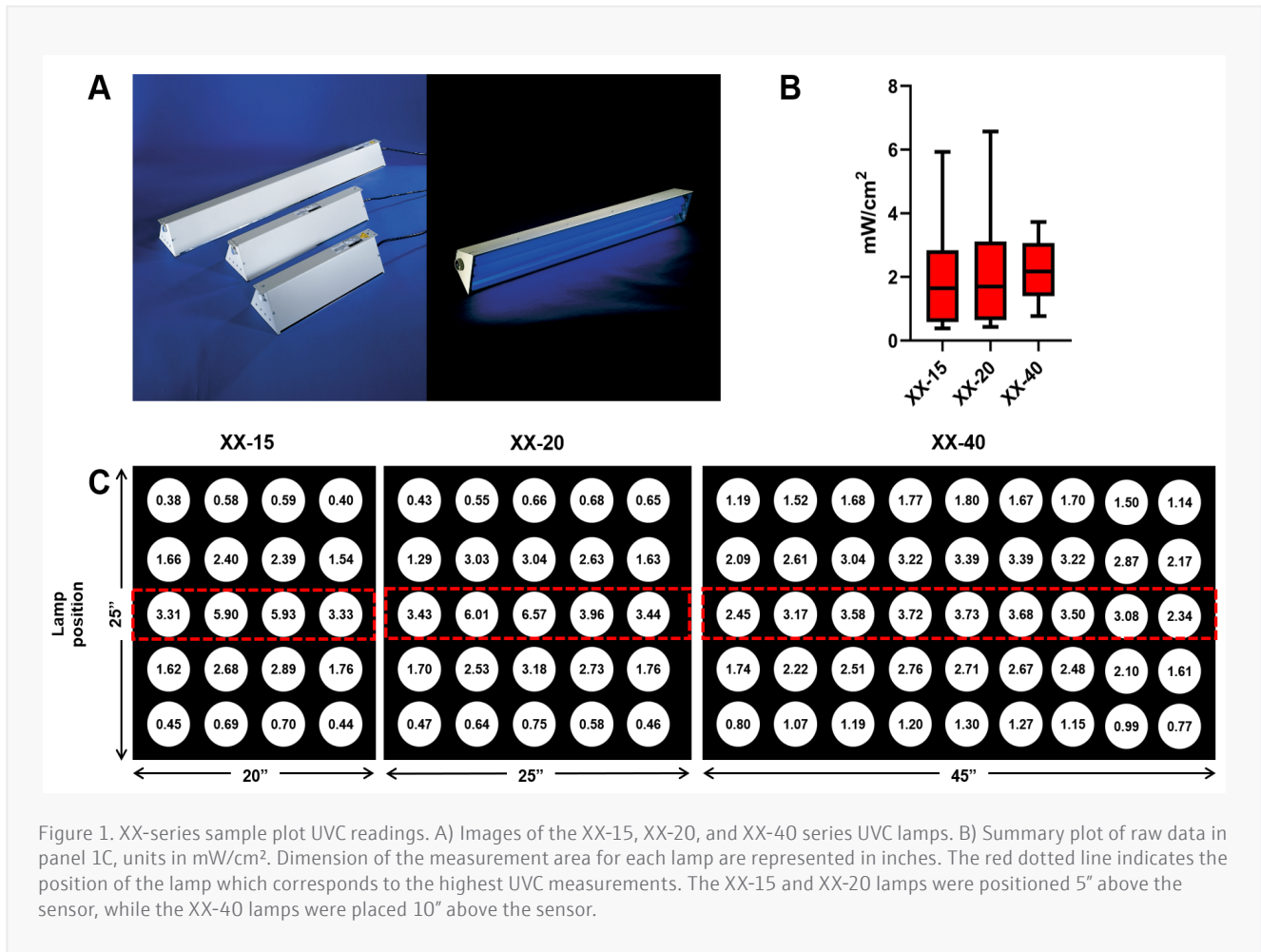
Protocol for the XX-series Lamps

This protocol is only intended for the disinfection of N95 respirators and should not be used to disinfect other medical equipment. It is up to each operator to determine how this protocol fits within their organization's decontamination process. To operate the UVP XX-series lamps, follow the instructions below.

Note: users will need to purchase a UVC radiometer (P/N 97-0016-01) and UVX-25 sensor (P/N 97-0016-01) from Analytik Jena to determine the run time for UVGI.

Determining Run Time

Users should perform a run time calibration on the day a disinfection workflow is performed. If performing a calibration and disinfection on separate days, reevaluate run time. If performing disinfection on the same day as a run time calibration, warm up for >5 minutes if the instrument has been idle.



1. Setup grid below UVP XX-series lamp to measure UVC output. In Figure 1C, we measured 20, 25, and 45 point for the XX-15, XX-20, and XX-40 respectively. This will help identify the "Lowest Reading" that should be used to calculate run time. Note: users can also quickly sweep the sensor in the illumination area for the lowest reading and use this value as an approximation for the "Lowest Reading" in the calculations below.
2. Warm up bulbs for 5 minutes.
3. Using our radiometer (P/N 97-0016-01) and UVX-25 sensor (P/N 97-0016-01), set the units switch to the top position and the other two switches to READ, and ON/TEST.
4. Place the sensor in each position and record the UVC fluence in mW/cm². Note: let the reading stabilize before recording.
5. After measuring all points, identify the lowest reading e.g. XX-15 = 0.38 mW/cm²; XX-20 = 0.43 mW/cm²; XX-40 = 0.80 mW/cm² from Figure 1C, and calculate the disinfection run time. See example calculations below. Note: we recommend users overestimate the disinfection cycle to account for any variability in bulb fluence (e.g. in our example below for the XX-15, 2631 seconds + 5% = 2762 seconds).

Example calculations

$$\text{Lowest Reading (mW/cm}^2\text{)} \times \text{Time (seconds)} = \text{Target Dose (mJ/cm}^2\text{)}$$

$$\text{XX-15} \rightarrow \text{Time (seconds)} = \frac{1000 \text{ mJ/cm}^2}{0.38 \text{ mW/cm}^2} = 2631 \text{ seconds}$$

$$\text{XX-20} \rightarrow \text{Time (seconds)} = \frac{1000 \text{ mJ/cm}^2}{0.43 \text{ mW/cm}^2} = 2325 \text{ seconds}$$

$$\text{XX-40} \rightarrow \text{Time (seconds)} = \frac{1000 \text{ mJ/cm}^2}{0.80 \text{ mW/cm}^2} = 1250 \text{ seconds}$$

Mask Placement for UVGI

6. Place masks into position beneath the lamps.
7. Turn on lamps.
8. After calculated time has elapsed, shut off UV and flip masks over and repeat disinfection cycle.
9. After the second side has been disinfected, remove the masks and continue following the UVGI protocol approved by your hospital/institution.

Disclaimer: This protocol is intended only for UVP XX-series lamps equipped with 254 nm bulbs. If you have any model other than what is listed here, then this protocol will not work.

This protocol is intended to fit within the context of an institution-approved UV germicidal irradiation (UVGI) mask disinfection procedure^{2,3}. For example, it is expected that an operator is wearing appropriate PPE while handling contaminated masks and placing them under UVP XX-series lamps; users should keep contaminated and disinfected masks separate. It is expected that each operator consults their organization for proper infection/isolation control procedures prior to operating UVP XX-series lamps.

It is also important to note that UVC irradiation with the UVP XX-series lamps does not provide a "sterile" environment. While the UVP XX-series lamps can provide high levels of UV light, bacterial spores and types of UV resistant microorganisms may not be inactivated after running a full disinfection cycle. In addition, other factors, such as shadows, do affect the germicidal efficacy of the UV light. Therefore, improperly placing a mask or having masks overlap to where shadows are created will affect the performance of the UVC irradiation.

Prior to use, it is advised that operators contact the manufacturer of their particular mask because UVC is known to damage or degrade materials over time^{4,5}. For example, some mask/N95 respirator manufacturers do not recommend using UVC disinfection with their mask. In addition, operators should consult with their organization on the material compatibility of their masks with UVC irradiation.

Technical Data

Technical Specifications	XX-15	XX-20	XX-40	Adjustable Exposure Stand
Dimensions	19.75L x 6W x 4.25H in. (502 x 152 x 108 mm)	24L x 6W x 4.25H in. (610 x 152 x 108 mm)	49.6L x 6W x 4.25H in. (1260 x 152 x 108 mm)	20W x 6D x 13H in.
Weight	5 lb (2.3 kg)	10 lb (4.5 kg)	20 lb (9.0 kg)	8 lb (3.6 kg)

Part Numbers and Description

Part Number		Description - XX Series Lamps
115V	230V	
95-0042-05	95-0042-09	15 Watt, XX-15S Bench Lamp, 254 nm
95-0045-07	95-0047-08	20 Watt, XX-20S Bench Lamp, 254 nm
95-0043-07	95-0043-08	40 Watt, XX-40S Bench Lamp, 254 nm
Part Number		Description - Replacement Parts & Accessories
18-0062-01		Adjustable Exposure Stand
38-0172-02		Filter (for XX-15S)
34-0008-01		Tube, 15 Watt, 254 nm
34-0067-01		Tube, 20 Watt, 254 nm
34-0067-02		Tube, 40 Watt, 254 nm

Part Numbers and Description

Part Number	Description - UVX Radiometer and Sensor
97-0015-02	UVX Radiometer
97-0016-01	UVX-25, Calibration Point 254 nm

References

1. Heimbuch, B. & Harnish, D. Research to mitigate a shortage of respiratory protection devices during public health emergencies. (2019).
2. Lowe, J. et al. N95 Filtering Facemask Respirator Ultraviolet Germicidal Irradiation (UVGI) Process for Decontamination and Reuse. <https://www.nebraskamed.com/sites/default/files/documents/covid-19/n-95-decon-process.pdf> (2020).
3. Price, A. & Chu, L. COVID-19 Evidence Service - Addressing COVI-19 Face Mask Shortages [v1.2]. <https://aim.stanford.edu/covid-19-evidence-service/> (2020).
4. Lindsley, W. G. et al. Effects of Ultraviolet Germicidal Irradiation (UVGI) on N95 Respirator Filtration Performance and Structural Integrity. *Journal of Occupational and Environmental Hygiene* 12, 509–517 (2015).
5. Fisher, E. M. & Shaffer, R. E. A method to determine the available UV-C dose for the decontamination of filtering facepiece respirators. *Journal of Applied Microbiology* 110, 287–295 (2011).

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