

Use of UV Germicidal Lamps inside Biosafety Cabinets

BACKGROUND

Biosafety Cabinets are often equipped with germicidal ultraviolet light (UV) lamps that radiate light at a wavelength of 254nm (UV-C band) to decontaminate the interior surface. To ensure the energy output is sufficient to kill microorganisms, the lamp output intensity must be tested periodically, and the intensity should not be less than 40microwatts per square centimeter (uW/cm²) at the center of the work area. A nominal lamp power of 30 Watts typically provides a UV intensity of approximately 125uW/cm² at a distance of one meter from the lamp. In many BSCs, the distance from the lamp to the floor of the cabinet is less than one meter, so intensities at the work surface greater than 125 uW/cm² should be expected.

There have been many studies done to investigate the germicidal effect of UV light on mycotoxins, spores, bacteria, food, water, and indoor air quality. The table below details the UV-C energy dosage necessary for surface decontamination and sterilization, except of viruses, which were decontaminated in water.

Biological Agent	Type of Biological Agent	UV-C Dosage for 90% Sterilization (uW sec/cm ²)	Sterilization time (sec)*
Penicillium spp.	Fungus	224,000	1800
Aspergillus flavus	Fungus	34,900	300
Aspergillus niger	Fungus	31,500	250
Yeast	Fungus	4000	30
Influenza A	Virus	1900	15
HIV-1	Virus	28,000	220
Vaccinia	Virus	1500	10
Escherichia coli	Bacteria	2000	20
Staphylococcus aureus	Bacteria	6600	50
Bacillus subtilis	Bacteria	6800	50
Mycoplasma spp.	Bacteria	8400	70
Pseudomonas aeruginosa	Bacteria	2200	20

*Using a UV-C intensity of 125 uW/cm²

Refer to the following ebook available through the UBC Library for a more exhaustive listing: Ultraviolet Germicidal Irradiation Handbook: UVGI for Air and Surface Disinfection by Kowalski, Wladyslaw Jan

LIMITATIONS

UV lamps installed inside BSCs have limitations that all researchers and users should know before relying on them to decontaminate BSC surfaces. BSCs are usually supplied with low pressure mercury vapor lamps. These lamps emit germicidal radiation at a wavelength of 254nm for about 6000 hours. The lifetime of germicidal UV bulbs varies depending on design. After this time, the lamp does not produce enough radiation, even though it appears to be functioning properly. The material that the bulb is made of can also absorb some of the germicidal rays.

Even when producing enough radiation at 254nm, UV intensity is greatly limited by the following factors:

Penetration – UV light has limited penetrative ability. The presence of dust or any other particles on the lamp or in the path of UV radiation impedes its penetrative ability. Material left inside the cabinet will also block UV radiation from contacting the BSC surface. The BSC must be empty and wiped down prior to UV use to ensure the effectiveness of the lamp.

Relative Humidity – the germicidal effects drop significantly above 70% relative humidity.

Temperature and Air Movement – Lamp cooling under airflow (such as inside a BSC) can also lower UV output, thus care should be taken to shield lamps from direct airflow via parabolic reflector. If the BSC has a closeable sash, closing the sash and turning off the blower will eliminate airflow on the lamp.

Age – UV bulbs may continue to burn without emitting effective radiation. UV lamps should be replaced when they emit 70% or less of their rated initial output, as determined by regular testing. UV lamps installed inside BSCs must be replaced when the 254nm UV irradiation intensity on the work tray surface of the cabinets is less than 40 uW/cm².

Care and maintenance – UV lamps require annual replacement and frequent cleaning to ensure effectiveness. Lamps should be turned off and wiped with a soft pad moistened with alcohol. Cleaning is the responsibility of the personnel in charge of the laboratory.

PRECAUTIONS WHEN USING UV LIGHT

Below are various controls and personnel protection to be implemented wherever possible to minimize exposure and mitigate the risks associated with BSC germicidal UV lamps.

Engineering Controls

- Containment/Location – Limit access to those working directly with the equipment by locating equipment in a separate room or a low traffic area. Use UV-absorbing glass or plastic shields.
- Interlocks – Some equipment has built-in interlock devices that prevent operation when unsafe to do so. Never tamper with interlocks, and repair when damaged.
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- Check safety equipment to ensure that it is rated for the wavelength in use.
- Close the sash hood completely if using UV lights in a BSC.

Administrative Controls

- Training – Personnel should be trained in best practices for BSC use.
- Warning Signs – All potentially dangerous areas should be conspicuously labelled with warning signs. E.g. “UV Hazard on - Protect eyes and skin”

Personal Protective Equipment

- Limit time and distance when working with UV-producing equipment.
- Wear lab coat, long pants, and proper shoes.
- Gloves – Nitrile gloves are recommended, but other hazards also need to be considered in choosing the correct glove. Note that wrist areas are often left unprotected and need to be covered.
- Safety glasses should wrap around the face and be ANSI-Z87 rated. Normal eyeglasses/contacts offer very little or no protection.
- Face Shield is preferred to safety glasses as it protects more skin. People commonly forget to protect their chin and neck.

Maintenance

- Routine monitoring of the lamp's output is necessary.
- Bulbs should be wiped off on a monthly basis with a soft cloth dampened with ethanol.

Note that the lamp should be turned off.

- The bulb must be cool to the touch prior to wiping.
- Replace bulbs according to the manufacturer's instructions at the recommended end of life or when testing indicates intensity on the work tray surface of the cabinet is less than 40 uW/cm².

REVIEW AND RETENTION

This guidance document is reviewed regularly as deemed necessary by the responsible departmental representative within Safety & Risk Services.