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Use of UV Germicidal Lamps inside Biosafety Cabinets

1. 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's output intensity must be tested periodically, and the intensity should not be less than 40microwatts per square centimeter ($\mu\text{W}/\text{cm}^2$) at the center of the work area. A nominal lamp power of 30 Watts typically provides a UV intensity of approximately $125\mu\text{W}/\text{cm}^2$ 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 $125\mu\text{W}/\text{cm}^2$ 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 ($\mu\text{W sec}/\text{cm}^2$) for 90% Sterilization | 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 $125\mu\text{W}/\text{cm}^2$



For a more exhaustive listing please refer to the following ebook that is available through the UBC Library:

Ultraviolet Germicidal Irradiation Handbook: UVGI for Air and Surface Disinfection

By Kowalski, Wladyslaw Jan

2. LIMITATIONS

It should be noted that UV lamps installed inside BSCs have limitations that all researchers and users should know about before relying on them for protection against contamination and exposure to personnel. Low pressure mercury vapor lamps, usually supplied with BSCs, emit germicidal radiation at a wavelength of 254nm for about 6000 hours. After this time, the lamp does not produce enough radiation, even though it appears to be functioning properly.

In addition, **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. In addition, material inside the cabinet while UV is still on will block UV radiation from contacting the surface by shading. If a sliding sash is present, it should be closed while the UV light is in operation. Regular cleanliness is necessary 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.
- **Age** – UV germicidal lights inside BSCs for decontamination should be checked because 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. 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.
- **Cleanliness** – UV lamps should be cleaned often. UV lamps require annual replacement and scheduled cleaning to ensure its effectiveness. The lifetime of germicidal UV bulbs varies depending on design. Also the material that the bulb is made of can absorb some of the germicidal rays. Lamps should be turned off and wiped with a soft pad moistened with alcohol. Cleansing is the responsibility of the personnel in charge of the laboratory.

3. PRECAUTIONS WHEN USING UV LIGHT

Below are various controls and person protection that are to be implemented wherever possible to minimize exposure and mitigate the risks associated with germicidal lamps inside BSCs.



- **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 safety may be compromised. Never tamper with interlocks, and repair when damaged.
 - Eliminate Reflection – Many surfaces, especially shiny ones, reflect UV rays. If possible, paint such surfaces with non-UV reflecting material.
 - 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 correct and safe procedure of preparing, start-up, working inside, and post-working inside BSCs.
 - 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.
 - Glasses should wrap around the face and be ANSI-Z87 rated. Normal eyeglasses/contacts offer very little or no protection.
 - Face Shield – is preferred as it protects more skin/ People commonly forget to protect their chin and neck. A face shield is **required** when working with UV lamps outside of protective shielding (e.g cutting DNA bands from an agarose gel on a transilluminator).
- **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 not be operating and must be cool to the touch prior to wiping.
 - Bulb replace should proceed according to the manufacturer’s instructions based on the amount of use.

4. REVIEW AND RETENTION

This guidance document is reviewed annually or whenever deemed necessary by the responsible departmental representative, the Occupational and Research Safety Group within Risk Management Services.