

GUIDELINE: USE OF UV GERMICIDAL LAMPS INSIDE BIOLOGICAL SAFETY CABINETS

Introduction

Biological Safety Cabinets are equipped with germicidal ultraviolet light (UV) lamps that radiate light at a wavelength of 254 nm (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 40 microwatts 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 for 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)*
<i>Penicillium</i> spp.	Fungus	224,000	1800
<i>Aspergillus flavus</i>	Fungus/grains and legumes	34,900	300
<i>Aspergillus niger</i>	Fungus/fruits and vegetables	31,500	250
Yeast	Fungus	4,000	30
<i>Influenza A</i>	Virus	1,900	15
<i>HIV-1</i>	Virus	28,000	220
<i>Vaccinia</i>	Virus	1,500	10
<i>Escherichia coli</i>	Bacteria	2,000	20
<i>Staphylococcus aureus</i>	Bacteria	6,600	50
<i>Bacillus subtilis</i>	Bacteria	6,800	50
<i>Mycoplasma</i>	Bacteria	8,400	70
<i>Pseudomonas aeruginosa</i>	Bacteria	2,200	20

* Using a UV-C intensity of $125 \mu\text{W}/\text{cm}^2$

For a more exhaustive listing refer to: **Ultraviolet Germicidal Irradiation Handbook: UVGI for Air and Surface Disinfection** by Kowalski, Wladyslaw Jan) available on the UV Germicidal Light web page ([uOttawa Electronic Link to Germicidal Handbook](#)). See the *Back Matter PDF* to access the following appendices:

Appendix A	UV Rate Constants for Bacteria
Appendix B	UV Rate Constants for Viruses
Appendix C	UV Rate Constants for Fungi and other Microbes
Appendix D	UVGI Lamp Data and Ratings
Appendix E	C++ Source Code for Lamp UV Field Average Irradiance
Appendix F	Ultraviolet Material Reflectivities
Appendix G	UVGI Rating Values (URV)

It should be noted that UV lamps installed inside Biosafety Cabinets 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 biological safety cabinets, emit germicidal radiation at a wavelength of 254 nanometers 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. 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 extremely above 70% relative humidity.
- **Temperature and Air Movement** – Lamp cooling under airflow (such as inside a Biological Safety Cabinet) can also lower UV output, thus care should be taken to shield lamps from direct airflow via parabolic reflector.
- **Age** – UV germicidal lights inside Biosafety Cabinets 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 percent or less of their rated initial output. UV lamps installed inside biological safety cabinets must be replaced when the 254 nm UV irradiation intensity on the work tray surface of the cabinet is less than 40 microwatts per square centimeter.
- **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.

Biological safety cabinets listed by the National Sanitation Foundation (NSF) after 1992 may not have lamps installed because there is no longer a NSF secondary test standard for UV lamps. The NSF-49 standard for Biohazard cabinetry does not provide any performance criteria for UV lighting and does not recommend the use of UV lights inside biological safety cabinets. In addition, the new Canadian Biosafety Guidelines also states that the use of UV irradiation germicidal lamps is strongly discouraged due to their limited effectiveness at disinfecting the inside of Biological Safety Cabinets.

Precautions to be taken when using UV light

The Ontario Ministry of Labour has recommended engineering controls and personal protection to protect oneself from common sources of Ultraviolet Radiation in the workplace. Below are various controls that have been implemented wherever possible to minimize exposure and mitigate the risks associated with germicidal lamps inside Biological Safety Cabinets.

- **Engineering Controls**

- i. 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.
- ii. Interlocks – Some equipment has built-in interlock devices that prevent operation when safety may be compromised. Never tamper with interlocks, and repair when damaged.
- iii. Eliminate Reflection – Many surfaces, especially shiny ones, reflect UV rays. If possible, paint such surfaces with non-UV-reflecting material.
- iv. Check safety equipment to ensure that it is rated for the wavelength in use.
- v. Close the sash hood completely if using UV lights in a BSC.

- **Administrative Controls**

- i. Training – Personnel should be trained in correct and safe procedures of preparing, start-up, working inside and post-working inside Biological Safety Cabinets.
- ii. Warning Signs – All potentially dangerous areas should be conspicuously labelled with warning signs e.g. “UV HAZARD-PROTECT EYES AND SKIN”

- **Personal Protection**

- i. Limit time and distance when working with UV-producing equipment.
- ii. Wear lab coat and long pants.
- iii. 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.
- iv. Glasses should wrap around and be ANSI-Z87 rated. Normal eyeglasses/contacts offer very little protection!
- v. Face Shield – is preferred as it protects more skin area. People commonly forget to protect their chin and neck.

- **Maintenance**

- i. Routine monitoring of the lamp’s output is necessary.
- ii. Bulbs should be wiped off on a monthly basis with a soft cloth dampened with ethanol.
- iii. The bulb must not be operating and must be cool to the touch prior to wiping.
- iv. Bulb replacement should proceed according to manufacturer’s instructions based on the amount of use.

Biological effects of UV, exposure limits and photosensitivity information is available on the ORM webpage on the UV Radiation Exposure www.uottawa.ca/services/ehss/UV.html

REFERENCES

- *Ultraviolet Germicidal Irradiation Handbook: UVGI for Air and Surface Disinfection*, Kowalski, Wladyslaw Jan
- *Reduction of feed-contaminating mycotoxins by ultraviolet irradiation: an in vitro study*. Murata H, Mitsumatsu M, Shimada N. Food Addit Contam Part A Chem Anal Control Expo Risk Assess. 2008 Sep;25(9):1107-10
- *Applications of ultraviolet germicidal irradiation disinfection in health care facilities: effective adjunct, but not stand-alone technology*. Memarzadeh F, Olmsted RN, Bartley JM. Am J Infect Control. 2010 Jun;38(5 Suppl 1):S13-24
- *UV air cleaners and upper-room air ultraviolet germicidal irradiation for controlling airborne bacteria and fungal spores*. Kujundzic E, Matalkah F, Howard CJ, Hernandez M, Miller SL. J Occup Environ Hyg. 2006 Oct; 3 (10):536-46.
- *Effects of ultraviolet germicidal irradiation and swirling motion on airborne Staphylococcus aureus, Pseudomonas aeruginosa and Legionella pneumophila under various relative humidities*. Chang CW, Li SY, Huang SH, Huang CK, Chen YY, Chen CC. Indoor Air. 2013 Feb; 23 (1):74-84.
- *Position Paper on the Use of Ultraviolet Lights in Biological Safety Cabinets*. (ABSA). - Applied Biosafety, 11(2) pp. 81-87 © American Biological Safety Association 2006
- *Use of Ultraviolet Lights in Biological Safety Cabinets: A Contrarian View*. Applied Biosafety, 11(4) pp. 222-227 © American Biological Safety Association 2006
- *Accidental exposure to UV radiation produced by germicidal lamp: case report and risk assessment*. Zaffina S, Camisa V, Lembo M, Vinci MR, Tucci MG, Borra M, Napolitano A, Cannatà V. Photochem Photobiol. 2012 Jul-Aug;88(4):1001-4
- *Ultraviolet Radiation in the Workplace*. Ontario Ministry of Labour Publication, 2009.
- *The New Canadian Biosafety Guidelines, First Edition (2013)*, Chapter 11.
- *Class II/Type A2 (Formally Designated as A/B3) Biological Safety Cabinet Ordering Criteria for the National Institutes of Health (2010)* - http://www.ors.od.nih.gov/sr/dohs/Documents/A2_BSC_Specifications.pdf
- *Lawrence Berkeley National Laboratory*. (2010). Biosafety Manual - Appendix F: Decontamination and Antimicrobials.
- *Biosafety In Microbiological Laboratories*, 5th Edition, Appendix A - http://www.cdc.gov/biosafety/publications/bmbl5/BMBL5_appendixA.pdf
- *Germicidal and Short Wave UV Radiation*, Sylvania-Engineering Bulletin, #0-342 - <http://www.scribd.com/doc/81261178/Sylvania-Engineering-Bulletin-Germicidal-amp-Short-Wave-UV>
- *Johns Hopkins Medical Laboratories Safety Manual, Section VI - Electrical and Mechanical Safety*.
- *Facts about UV lights* - <http://www.himnrbehs.com/himnrbehs/pdf/Facts.About.Ultra.Violet.pdf>