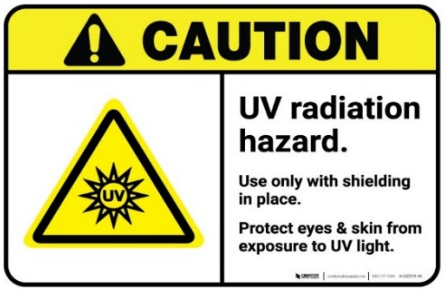
UMassAmherst | Environmental Health & Safety

Ultraviolet (UV) Protection Fact Sheet

How to protect from UV exposure?

Avoid skin or eyes exposure to UV radiation sources whenever possible. The UV radiation generated by laboratory equipment can exceed recommended exposure limits and cause injury with exposures as brief as three seconds in duration.

1. Never work in a biosafety cabinet while the germicidal lamp is on. If possible, close the sash while lamp is on. Please also note that other forms of disinfection are preferred in biosafety cabinets as UV lights must be properly maintained to provide adequate disinfection and to preclude exposure to users.
2. Never use a transilluminator without the protective shield in place. Shields must be kept clean and replaced when damaged. Use alternatives to UV transilluminators where possible.
3. Crosslinkers must not be used if the door safety interlock is not working properly.
4. To help prevent eye and skin injuries, please label any equipment that emits UV radiation.



An example of label

5. Personal protection equipment (PPE):
   1) Protective Clothing

   Wear standard laboratory attire including a fully buttoned lab coat, long pants and closed toe shoes. While working with UV radiation sources, lab workers should particularly vigilant to prevent gaps in protective clothing that commonly occur around the neck and wrist areas.

   2) Eye/Face Protection

   If there is any potential for the eyes and face to be exposed to UV radiation, a polycarbonate face shield stamped with the ANSI Z87.1-1989 UV certification must be worn to protect the eyes and face in addition to safety glasses/goggles. Ordinary prescription eyeglasses may not block UV radiation. UV certified goggles and safety glasses will protect the eyes, but it is common for lab workers to suffer facial burns in the areas not covered by the goggles or glasses.

3) Gloves

Wear disposable nitrile gloves to protect exposed skin on the hands. Please make sure wrists and forearms are covered between the tops of gloves and the bottom of the lab coat sleeves.

Are there any occupational exposure limits for UV?

There is no Occupational Safety and Health Administration (OSHA) standard regarding exposure to ultraviolet light.

The critical organs for UV exposure are the eye and skin. The thresholds for the observed effects vary significantly with wavelength. Therefore, "action spectra" have been developed to create a dose response relationship. Basically, the "action spectrum" refers to the relative spectral effectiveness of different wavelengths to elicit a biological effect. Please find the more information in *Table 1* below.

- *The most hazardous UV radiation has wavelengths between 240 nm and 300 nm*. In this wavelength range, the threshold limit value (TLV) is less than 10 mJ/cm^2, with the minimum TLV (the most hazardous radiation) being 270 nm (TLV = 3 mJ/cm^2)
- *The least hazardous UV radiation has wavelengths exceeding about 315 nm* (UV-A radiation). Above that wavelength, the TLV is always over 1,000 mJ/cm^2, and it steadily climbs above that wavelength, indicating that the radiation is less hazardous with increasing wavelength for wavelengths above 315 nm.
- Between 180 nm and 240 nm, the radiation becomes increasingly more hazardous to up to 10 mJ/cm^2 at 240 nm.

Because some biological effects to the eyes and skin vary with wavelength, the human exposure guidelines express the efficacy of the UV spectrum normalized to the most damaging wavelength range (270-280 nm for the eyes). Acceptable exposure limits (*Table 2*) are based on an action spectrum that combines the spectra for erythema of Caucasian skin with photokeratitis (i.e., a condition of the eye). The result is a smooth curve forming an acceptable criteria (*Figure 1*).

Table 1. Ultraviolet Radiation Exposure TLV and Spectral Weighting Function

Wavelength (nm)*	Threshold Limit Value (TLV®) (J/m^2)**	TLV® (mJ/cm^2)**	Relative Spectral Effectiveness, S(λ)
180	2.5 x 10^3	2.5 x 10^2	0.012
190	1.6 x 10^3	1.6 x 10^2	0.019
200	1.0 x 10^3	1.0 x 10^2	0.030
205	5.9 x 10^2	5.9 x 10^1	0.051
210	4.0 x 10^2	4.0 x 10^1	0.075
215	3.2 x 10^2	3.2 x 10^1	0.095

220	2.5×10^2	2.5×10^1	0.120
225	2.0×10^2	2.0×10^1	0.150
230	1.6×10^2	1.6×10^1	0.190
235	1.3×10^2	1.3×10^1	0.240
240	1.0×10^2	1.0×10^1	0.300
245	8.3×10^1	8.3	0.360
250	7.0×10^1	7.0	0.430
254***	6.0×10^1	6.0	0.500
255	5.8×10^1	5.8	0.520
260	4.6×10^1	4.6	0.650
265	3.7×10^1	3.7	0.810
270	3.0×10^1	3.0	1.000
275	3.1×10^1	3.1	0.960
280***	3.4×10^1	3.4	0.880
285	3.9×10^1	3.9	0.770
290	4.7×10^1	4.7	0.640
295	5.6×10^1	5.6	0.540
297***	6.5×10^1	6.5	0.460
300	1.0×10^2	1.0×10^1	0.300
303***	2.5×10^2	2.5×10^1	0.120
305	5.0×10^2	5.0×10^1	0.060
308	1.2×10^3	1.2×10^2	0.026
310	2.0×10^3	2.0×10^2	0.015
313***	5.0×10^3	5.0×10^2	0.006
315	1.0×10^4	1.0×10^3	0.003
316	1.3×10^4	1.3×10^3	0.0024
317	0.5×10^4	1.5×10^3	0.0020
318	1.9×10^4	1.9×10^3	0.0016
319	2.5×10^4	2.5×10^3	0.0012
320	2.9×10^4	2.9×10^3	0.0010
322	4.5×10^4	4.5×10^3	0.00067
323	5.6×10^4	5.6×10^3	0.00054
325	6.0×10^4	6.0×10^3	0.00050
328	6.8×10^4	6.8×10^3	0.00044
330	7.3×10^4	7.3×10^3	0.00041
333	8.1×10^4	8.1×10^3	0.00037
335	8.8×10^4	8.8×10^3	0.00034
340	1.1×10^5	1.1×10^4	0.00028
345	1.3×10^5	1.3×10^4	0.00024
350	1.5×10^5	1.5×10^4	0.00020
355	1.9×10^5	1.9×10^4	0.00016
360	2.3×10^5	2.3×10^4	0.00013
365***	2.7×10^5	2.7×10^4	0.00011
370	3.2×10^5	3.2×10^4	0.000093

375	3.9×10^5	3.9×10^4	0.000077
380	4.7×10^5	4.7×10^4	0.000064
385	5.7×10^5	5.7×10^4	0.000053
390	6.8×10^5	6.8×10^4	0.000044
395	8.3×10^5	8.3×10^4	0.000036
400	1.0×10^6	1.0×10^5	0.000030

Source: American Conference of Governmental Industrial Hygienists (ACGIH®), 2022 TLVs® and BEIs® Book.

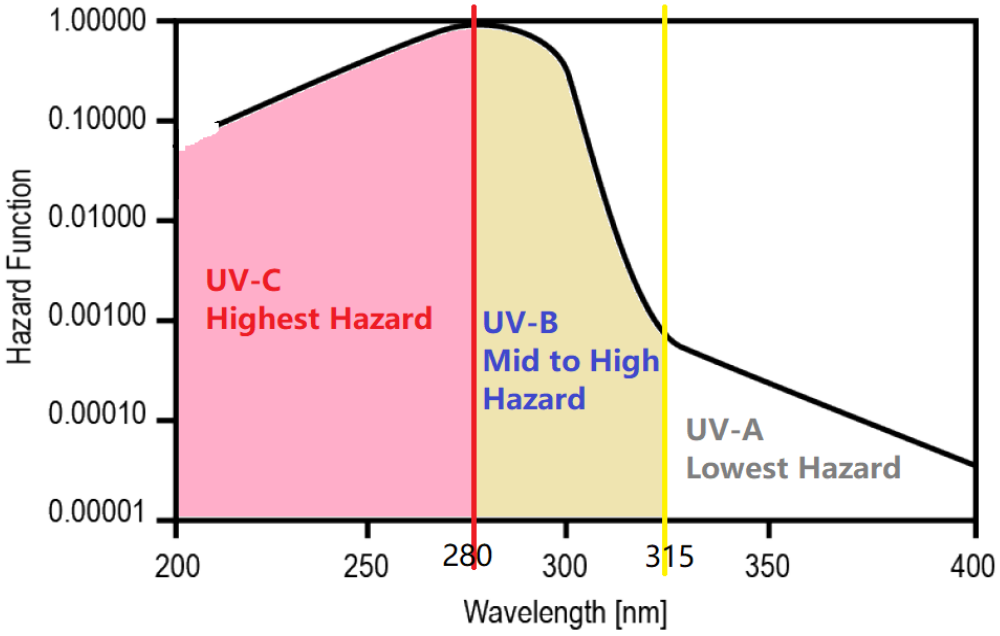
* Wavelengths chosen are representative; other values can be interpolated at intermediate wavelengths.
** 1 mJ/cm^2 = 10 J/m^2
*** Emission lines of a mercury discharge spectrum.

Table 2. Exposure Durations for Given Actinic UV Radiation Effective Irradiances

Exposure duration	Effective Irradiance (*m*W/cm^2)
8 hours	0.0001
4 hours	0.0002
2 hours	0.0004
1 hour	0.0008
30 minutes	0.0017
15 min.	0.0033
10 min.	0.005
5 min.	0.01
1 min.	0.05
30 seconds	0.1
10 s	0.3
1 s	3
0.5 s	6
0.1 s	30

Source: American Conference of Governmental Industrial Hygienists (ACGIH®), 2022 TLVs® and BEIs® Book.

Figure 1. Hazard Function (relative spectral effectiveness, S(λ) for UV



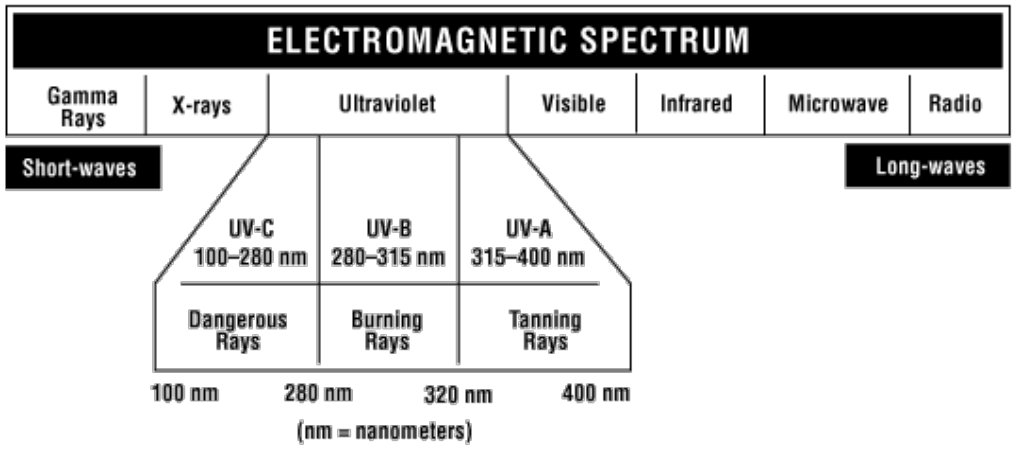
Source: American Conference of Governmental Industrial Hygienists (ACGIH®), 2022 TLVs® and BEIs® Book.

More information on UV:

What is UV?

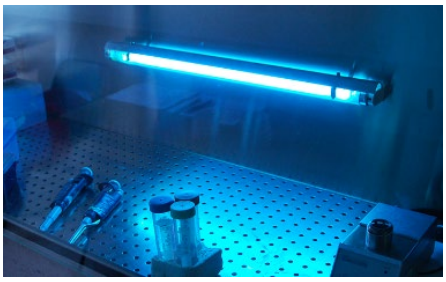
Ultraviolet radiation is non-ionizing radiation and is a part of electromagnetic spectrum. The ultraviolet spectrum is commonly divided into the following three regions:

Region	Region Name	Wavelength (nm)	Hazard Rating
UV-A	Black Light	315-400	Lowest
UV-B	Erythermal	280-315	Mid to High
UV-C	Germicidal	100-280	Highest



Source: https://www.ccohs.ca/oshanswers/phys_agents/ultravioletradiation.html

Devices emitting UV in research labs include, but are not limited to: bactericidal lamps (such as the germicidal lamps in biosafety cabinets), transilluminators, crosslinkers, black light lamps, carbon, xenon and other arcs, fluorescence equipment, hydrogen and deuterium lamps, metal halide lamps, mercury lamps, plasma torches, phototherapy lamps, printing ink polymerizing equipment, welding equipment, etc.



Germicidal lamp

Crosslinker

Printing ink polymerizing equipment

Plasma torch

What are the potential health effects of UV?

Some UV exposure is essential for good health. It stimulates vitamin D production in the body. In medical practice, one example is UV lamps can be used for treating psoriasis.

UV radiation is harmful to both skin and eyes. The effects on skin are of two types: acute and chronic. Acute effects appear within a few hours of exposure, while chronic effects are long-lasting and cumulative and may not appear for years. An acute effect of UV is redness of the skin (called erythema), similar to sunburn. Chronic effects include accelerated skin aging and skin cancer.

The eyes are very sensitive to UV radiation. Prolonged direct exposure to UV-B and UV-C light can cause serious effects such as conjunctivitis and photokeratitis. (*Conjunctivitis* is an inflammation of the membranes lining the insides of the eyelids and covering the cornea. *Photokeratitis* manifests as an aversion to bright light.) The severity of these conditions depends on the duration, intensity, and wavelength. Symptoms may appear 6 to 12 hours after exposure and may subside after 24 to 36 hours with no permanent damage. Chronic exposures to acute high-energy UV radiation can lead to the formation of cataracts.

References:

1. American Conference of Governmental Industrial Hygienists (ACGIH®), 2022 TLVs® and BEIs® Book
2. University of Rochester, Ultraviolet light safety guidelines. https://www.safety.rochester.edu/ih/uvlight.html
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4. University of Pennsylvania, Ultraviolet radiation fact sheet. https://ehrs.upenn.edu/health-safety/lab-safety/chemical-hygiene-plan/fact-sheets/fact-sheet-ultraviolet-radiation
5. Canadian Centre for Occupational Health and Safety, Ultraviolet radiation. https://www.ccohs.ca/oshanswers/phys_agents/ultravioletradiation.html
6. NAVY Medicine, Industrial Hygiene Field Operations Manual, Technical Manual NMCPHC-TM6290.91-2. https://www.med.navy.mil/Portals/62/Documents/NMFA/NMCPHC/root/Industrial%20Hygiene/13IHFOM_CH11.pdf?ver=ox1CbJ6ptBOANp9OK7YCGQ%3D%3D