Ultraviolet and UV Lamps

last updated slightly 5/29/2006.

The Ultraviolet Spectrum

Ultraviolet refers to all electromagnetic radiation with wavelengths in the range of 10 to 400 nanometers, or frequencies from 7.5E14 to 3E16 Hz.

The UVA range is wavelengths from 315 to 400 nanometers. Wavelengths from about 345 to 400 nM are used for "Blacklight" effects (causing many fluorescent objects to glow) and are usually very slightly visible if isolated from more visible wavelengths. Shorter UVA wavelengths from 315 to 345 nM are used for suntanning.

UVB refers to wavelengths from 280 to 315 nanometers. These wavelengths are more hazardous than UVA wavelengths, and are largely responsible for sunburn. The ozone layer partially blocks these wavelengths.

Strangely, UVB lasers are considered less hazardous than UVA lasers, since UVB is more easily absorbed by various fluids and tissues in the eye and cannot reach the retina in significant amounts. UVB also does not penetrate as deeply in the skin as UVA. However, the deadliest types of skin cancer (malignant melanomas) start in the epidermis, an upper layer of the skin. UVB is largely blamed for these cancers, although shorter UVA wavelengths are considered possibly cancer-causing.

UVC refers to shorter UV wavelengths, usually 200 to 280 nM. Even shorter wavelengths from 10 to 200 nM are usually considered separately as "Vacuum Ultraviolet" since they are absorbed by air, although these wavelengths are also considered a shorter range of UVC. Wavelengths in the UVC range, especially from the low 200's to about 275 nM, are especially damaging to exposed cells. Such shortwave UV is often used for germ killing purposes.

Incandescent Blacklights

There are incandescent bulbs made with deep violet-blue bulbs which largely filter out visible light. Longer UVA wavelengths get through the glass and are not blocked by the dark colored filter dye. Most visible violet and some visible blue, as well as a wide range of infrared and the longest, less visible of visible red wavelengths. Some traces of other visible wavelengths get through.

These bulbs are a convenient source of some UV to cause fluorescent paints, dyes, and other substances and objects to glow. Most of such fluorescent objects (especially magenta, red, pink, orange, yellow, and green ones) also glow from visible violet and blue light.

These bulbs are quite safe, although it may not be a good idea to stare into one from short distances for long periods of time. They generally have hotter running filaments that last only about 500 hours or so.

Fluorescent Blacklights

There are fluorescent tubes that emit UV. The phosphor coating on the inner surface of the tube absorbs the UVC emitted by the low pressure mercury arc, and emits longer UV wavelengths. There are at least six different UV-emitting phosphors used in fluorescent lamps.

One common lamp is the ""BLB" fluorescent lamp. The tubing is made from a very deep violet-blue glass known as "Wood's glass". The tubing is quite transparant to medium and longer UVA wavelengths, and shorter visible violet wavelengths, and a fairly broad range of infrared and the longest, least visible red wavelengths. These tubes emit lots of UV mainly between 350 and 375 nanometers, some of the 404.7 and dimmer 407.8 nM violet mercury lines, and just enough of the blue 435.8 nM mercury line to have a basically blue color when lit.
The "BLB" lamps are used for special effects due to their ability to make fluorescent objects glow very brightly.

There is a less common deep-blue-violet lamp with no phosphor and made with special glass (maybe quartz) to transmit the 253.7 nM UVC (shortwave UV) mercury line. These lamps are generally used to make fluorescent rocks glow.

There are UV fluorescent lamps with glass not dyed to block visible light. This includes the BL and the similar 350BL. These are often used to attract insects into electric insect killers. The 350BL has a broader spectrum peaking at a slightly shorter wavelength (350 nanometers) than the BL does, and is supposedly more attractive to insects than the BL.

There are other ultraviolet lamps such as UVB medicinal lamps and UVA suntanning lamps.

There are also the similar fluorescent actinic lamps, producing long UV wavelengths and/or visible violet. These are sometimes used in some special photographic and printing processes. One of these is the 03, specializing in producing visible violet light. The 03 is also used in reef aquariums with live coral since coral utilizes violet and deep blue wavelengths. The 03 actinic will cause fluorescence of most fluorescent dyes, pigments and paints other than ones which fluoresce blue.

3 mm. Miniature Fluorescent Blacklights

There are now 3 mm. diameter cold cathode fluorescent miniature blacklight tubes. These come in lengths of 25, 50, and 100 mm. These are available at All Electronics, (800)-826-5432 or http://www.allcorp.com.

Catalog numbers are UV-325 ($8.25), UV-350 ($8.50), and UV-3100 ($10.75). These apparently require only a few mA at 200 to maybe 300 volts, but substantially higher voltage may be necessary for starting. All Electronics also sells inverters to drive these lamps and related miniature fluorescent lamps (3 to 6 mm. diameter) from 12 volts DC.

A major manufacturer of these and miniature cold cathode fluorescent lamps (CCFL) in general is JKL Lamps.

Digi-Key also sells JKL products including blacklight CCFL lamps.

"Beehive" (high pressure mercury) Blacklights

The high pressure mercury spectrum includes a strong cluster of lines in the 355-356 nanometer range. Fixtures with Wood's glass and ordinary mercury lamps are sometimes used as high power blacklights. Some of these fixtures are known as "beehive lamps" due to their appearance and the buzzing sound of their ballasts. Beehive lamps are available from some theatrical supply companies.

Fluorescent Tanning and Medical UV Lamps

Back to UV-emitting fluorescent lamps! There is a type that emits wavelengths in the short end of the UVA range, and these are used for suntanning. One brand of these lamps is "Uvalux".

There is even a UVB emitting fluorescent lamp, used for some special medical treatments of skin. These lamps are used to confine the UV's effects to outer portions of the skin, since UVB is more readily absorbed and less penetrating than UVA is.

"RS" Reflector ("floodlamp") Sunlamps

These lamps resemble ordinary "indoor" floodlamps. They contain a high pressure mercury arc tube and a tungsten filament used as a ballast. When first started, the light is mainly incandescent light, and these lamps are sometimes mistaken at first for ordinary floodlamps. When the mercury lamp warms up, the green-bluish white color of the mercury light is more apparent. The main UV spectral lines emitted are the 365-366 nanometer UVA cluster which is nearly useless for tanning and the 313 nanometer UVB cluster. Some weaker but significant shorter UVB lines are present, as well as a weak UVA line at 334.1 nM, in the tanning range.

Since these lamps rely mainly on UVB for tanning, they are more likely to cause sunburn and skin cancer than UVA suntanning lamps (which are not completely safe either). The instructions for one of these RS lamps actually states that some sunburn is necessary in order to get a tan from such lamps. UVB lamps are also particularly irritating to downright harmful to eyes.

Other Sunlamps

There are other high pressure mercury sunlamps. Many of these are of the "Sperti" brand, and most of these have a bare arc tube made of a special glass. A few have a smaller arc tube made of quartz or a glass that is nearly pure quartz. These lamps use nichrome wire, basically heating elements, as the ballast to limit current. The larger glass arc tubes often have electrodes over an inch from the ends of the arc tube, and the ends need some of the heat from the resistive elements in order for all of the arc tube to

get hot enough to fully vaporize the mercury.
Like the RS lamps, these lamps rely mainly on UVB for tanning and are quite harsh on human skin and eyes.

Germicidal and EPROM Erasing Lamps

Many of these lamps resemble fluorescent lamps, but are clear. Others resemble "neon" tubing. The ones that resemble fluorescent lamps are actually electrically compatible with fluorescent lamps and will work in fluorescent fixtures. Such lamps have part numbers beginning with a "G" instead of an "F".

Such lamps are used in EPROM erasers. To build your own EPROM eraser, all you need is a germicidal bulb and a fluorescent fixture. The bulbs can be purchased from some hardware stores and some electrical supply stores. There may be a substantial minimum order at some of these places if they don't stock these lamps. You may have slightly better luck trying places that order lamps from General Electric, a main supplier of these lamps and other less common lamps.

If you are building your own fixture, you may want to use the 15 watt lamp since ballasts for these lamps are widely available. You may even be able to trashpick a 15 watt ballast, or one compatible with 14, 15, and 20 watt lamps. The 15 watt germicidal lamp which mechanically and electrically resembles a 15 watt fluorescent lamp is known as the G15T8. I have heard that EPROMs could be erased by a G15T8 in 3 minutes (from Mark Zenier, mzenier@eskimo.com).
Please note that germicidal lamps are intended to be dangerous to living cells. THESE THINGS ARE HAZARDOUS, especially to the conjunctiva of the eye. Any fixture should be made to block the shortwave UV. Such fixtures are often built with interlock switches that prevent operation with the lamp exposed. Ordinary glass does stop this dangerous UV, as well as all other UVC and UVB wavelengths. One dangerous aspect of UV exposure is the delay from exposure to appearance of symptoms. Symptoms usually don't begin until a few minutes after exposure, and typically reach their peak more than a half hour (maybe a few hours) after exposure. In the event of exposure, prompt emergency medical treatment may reduce any damage.

Apparently Incandescent Ozone Lamps

These look like incandescent bulbs. These bulbs are roughly of ping pong ball size, about 1-3/8 inch (about 35 mm.) in diameter. They have an intermediate screw base, or sometimes a bayonet base like that of an auto taillight bulb. The filament is roughly V-shaped or a sharpish U-shape, with one support at the tip. These bulbs are sometimes labeled "Puritron" or "Odorout" and may also be labeled "protect eyes" and also "4 watts". In the past, these bulbs were used in some dryers to kill germs and oxidize odors.

In these bulbs, an arc forms across the ends of the filament. These bulbs need a current-limited (or high resistance) power supply that delivers about .33 to .4 amp to the bulb with about 10.5-12 volts across the bulb. Do not connect these bulbs to voltage-regulated power supplies; either little/no arc will form or the arc will "blow up" and melt one or both ends of the filament.

A 14, 15, or 20 watt fluorescent lamp "choke" ballast in series with one of these bulbs will permit the bulb to operate from AC line/mains voltage. However, the ballast is likely to overheat after a few minutes. A capacitor of 8 uF will work as a ballast at 120V, 60 Hz if it is rated for continuous use with such AC voltage. (I have tried this, it works!) Use 10 uF for 50 Hz. Use 55 percent as much capacitance for 220V, or 50 percent as much capacitance for 240V. Another ballast that works with 120 volts is an ordinary 40 watt bulb. An alternative is to use a lower AC voltage like 18 to 40 volts AC with an appropriate dropping resistor. I do not recommend DC because the negative end of the filament will receive the brunt of the heat of the arc.

The arc is rather diffuse and has the characteristic light blue color of low pressure mercury vapor. An inert gas, probably argon, is also present to adjust the electrical characteristics. The arc emits substantial amounts of the 253.7 nanometer shortwave UV line of mercury, which is harmful to living cells such as bacteria and the cells in the conjunctivas of human eyes. Appearance of damage is often delayed for several minutes or longer after exposure. This radiation is harmful to other life forms, and is sometimes hazardous to human skin, depending on the thickness of the dead outermost layer of the epidermis.

Lesser amounts of the 184.9 nM shortwave UV line are also emitted. This wavelength forms ozone. Ozone oxidizes some odors, but is corrosive to some types of rubber and to human lungs. Luckily, ozone largely reverts to ordinary oxygen in a manner of minutes after the lamp is shut off (unless the air temperature and pressure are like those of the ozone layer, in which case the ozone lasts longer). The 184.9 nM radiation will only travel several feet (a few meters) through air before it is absorbed.

The optical properties of low pressure mercury lamps are different for the two shortwave UV mercury lines than at other wavelengths. Low pressure mercury vapor looks like dense fog at these two wavelengths, making the lamp even more diffuse as a shortwave UV source than it is as a visible light source.

UPDATE 5/22/2006: The "S11" (roughly pingpong ball size) ones have been discontinued for many years, but a fan of this site has pointed out a replacement! These are the "GTL3" lamps! They have the same base, similar electrical characteristics (although they may want a little less current - they are specified to take .333 amp), and they have the same base style! They will work with 120VAC in series with a 40 watt incandescent lamp. The main difference is the shape and size of the bulb, and I have not heard that they produce the 184.9 nm ozone-forming wavelength. But they are germicidal lamps and they produce the 253.7 nm wavelength.

When web-searching, be aware that GTL3 is also the bulb shape/size specification for some penlight bulbs - meaning "tube-on-globe with lens tip" and 3/8 inch in diameter. The germicidal GTL3 does not have a GTL3 shape/size bulb.

Other Sources and Inadvertent Sources

Halogen bulbs are made of quartz or sometimes a form of "hard glass", both of which usually let through most UVB wavelengths. Undoped quartz passes all UVB and most UVC (not including most "vacuum UV"). Although halogen lamps rated to last 2,000 hours or more have filaments not hot enough to produce much of these wavelengths, it is usually recommended to use a glass shield. In addition to UV hazards, the more compact quartz halogen bulbs operate under great stress and have a slight risk of exploding.
Shorter life photographic and projection halogen lamps have substantially higher filament temperatures and emit significant amounts of UVB. It is important to block this, usually with a glass shield appropriate for the amount of heat encounteded.

Daylight (including sunlight) is actually the number one source of ill effects of UV, including sunburn, skin cancers, and UV related eye injuries and eye aging.
Ordinary fluorescent lamps emit some UV, but less than is found in a comparable amount of daylight.

Most xenon strobes using glass flashtubes emit a spectrum similar to that of sunlight at high noon in tropical areas. There is a fair amount of UVA and sometimes a bit of UVB. Quartz flashtubes emit all this as well as substantial amounts of shorter wave UVB, UVC, and a bit of the longest vacuum UV wavelengths. (Some special quartz tubing has UV-absorbing dopants.)

Carbon arcs and welding arcs usually radiate substantial amounts of UVA, usually substantial amounts of UVB, and moderate to sometimes substantial amounts of UVC.

TV screens and computer monitor screens emit very little UV.

Using Alternate UV Sources to Erase EPROMS

EPROMs are normally erased by UV in the UVC range. Longer UV wavelengths don't work as well, although UVB can be reasonably effective. Lamps used to erase EPROMs are normally germicidal fluorescent-style lamps. Many people run into a need to erase EPROMs and don't have such lamps, and don't want to pay often-high prices for lamps made to erase EPROMs. Here is the approximate effectiveness of each of other various UV sources. Much of this may not be much better than simple educated guesses of mine. Anyone with better knowledge of EPROM erasing is encouraged to send me the real scoop!

Ordinary incandescent bulbs and incandescent blacklight bulbs will not erase EPROMS within the bulb's lifetime at any voltage.

Fluorescent blacklights are very slow at best. An EPROM sitting face-down on top of a blacklight tube can be erased in 3.5 days, according to feedback sent to me from Mark Zenier (mzenier@eskimo.com). Blacklight tubes may vary, and your mileage probably will.

Halogen lamps may work, if any glass shield is removed. However, beware that quartz halogen bulbs are not guaranteed to not explode, and it is recommended to operate such bulbs only in some sort of protective housing. You should allow lots of time, since halogen lamps are not particularly effecient at producing shorter wavelengths of UV.

Sunlight sometimes works somewhat, taking maybe a week or two if weather and haze conditions are good and you are in a tropical area, or in a subtropical area during summer. If you don't have all of this working in your favor, it can take months for the sun to erase your EPROM.
(Effectiveness of sunlight according to most Usenet posts on the subject.)

UVA tanning fluorescent lamps are better than blacklights, but may still take somewhat long periods of time. (Mark Zenier says 45 minutes. I suspect this may be when everything is going well at very short range.) Besides, if you don't already own these lamps or work for a tanning salon, you will probably find EPROM erasing lamps less expensive and more easily available.

UVB fluorescent lamps probably work almost reasonably well, but are not common. They are found mainly in a small minority of dermatology medical facilities and their suppliers.

High pressure mercury sunlamps, including "RS" or "floodlamp-style" sunlamps, work somewhat, much better than real sunlight. At shorter range, the RS floodlamps deliver a concentration of shorter wave UV similar to that of EPROM erasing lamps. Since the sunlamps deliver UVB rather than UVC, they probably take much longer than the 20 minutes typical of the lamps made to erase EPROMs. Non-UVB-emitting high pressure mercury lamps are probably about as good as blacklights - ineffective to awfully slow.

Xenon flashtubes have been mentioned as sources of UV to erase EPROMs. Some are made with "hard glass", some forms of which let through some UVB. These have sometimes been reported to work - but take lots of time. Quartz flashtubes should be much faster, since UVC passes through quartz. NOTE - wavelengths much shorter than normally used for EPROM erasing are present, and may have some damaging effect.

The spherical 4 watt bulbs emit the ozone-producing vacuum UV wavelength, as well as the usual UVC eprom-erasing wavelength. These will erase EPROMs, but again, EPROMs may not like the extra-short wavelength. If anyone out there actually knows how safe or unsafe really short wave UV such as 184.9 nM is to EPROMs, please let me know!

Some feedback I already got on using these 4 watt "dryer bulbs":

Isaac Winfield (isw@hvds.com) and Mark Zenier (mzenier@eskimo.com) mention the use of one of these bulbs in a fat "tin" can, such as a coffee can or a "Crisco" can (when Crisco came in metal cans, not foil-coated cardboard ones). Some magazines mentioned constructing such an EPROM eraser in the 70's. Erasing time was 30-40 minutes. A 40 watt incandescent bulb can be mounted on top of the can for use as a ballast and as an "on" indicator. (Use a different bulb for voltages other than 120.) Simply put the EPROMs on a table, put the can over them, and turn the light on!

WARNING - Those 4 watt bulbs are very hard to get now. I advise to use anything else!

If you have an odd low pressure mercury lamp requirement, you may want to contact UVP Inc. and ask them about their "PEN RAY" line of low pressure mercury lamps. They have a variety of standard lamps and make custom ones.

UVP Inc.
2066 W 11th St.
Upland, Ca. 91786-9908
909-946-3197
909-946-3597 FAX
WEB http://www.uvp.com

Hazards and Precautions

UV has all kinds of hazards.

SKIN HAZARDS

Longer UVA wavelengths emitted by blacklights and general purpose high pressure mercury lamps are basically harmless. Although the hazard is not quite zero, it is generally quite negligible. The same is generally true of any UV-containing light that has passed through ordinary glass.

There is an exception: Some drugs photosensitize skin to ordinarily harmless quantities and wavelengths of UV. Ask your doctor or pharmacist.

Shorter UVA wavelengths cause suntanning. It is widely believed that UV suntanning is not completely safe no matter what you do. Possible ill effects include skin cancers and accelerated aging of the skin.

UVB is much worse, inherently irritating. The skin is designed to take small amounts of UVB and recover, but nothing is perfect here. You probably want to avoid any significant UVB exposure unless a physician recommends UVB exposure for medical purposes.

UVC is even worse, but less penetrating since it is easily absorbed. The outermost portion of human skin is made of dead cells. This layer sometimes gives partial protection from UVC, especially shorter wavelengths. However, don't count on this. UVC is quite damaging to living cells and has nasty burning effects.

EYE HAZARDS

UVA has one nasty effect on eyes, known as "nuclear cataracts". This is a permanent "tanning" of the lens of the eye. "Nuclear" refers to this occuring mainly in the center of the lens of the eye. You need lots of heavy exposure to get this. Nuclear cataracts occur mainly among people who work outdoors. Although incandescent blacklights emit wavelengths that cause nuclear cataracts, they are largely safe since you typically get less UV exposure from these than from sunlight. Even considering the fact that your pupils are wider under blacklight than under sunlight, there is so much less UV that it is safe to stare into the bulb from a few feet away for large amounts of time. (No warranty, so I don't recommend this.)
Fluorescent blacklights are worse, but are usually comparable to sunlight when you are a couple feet away. Although I have yet to hear of eye damage blamed on reasonable use of blacklights, those who are around them a lot may want UV blocking eyewear.

Persons who have had cataract surgery need extra protection, since the lens of the eye largely absorbs UV. The retina does not like strong exposure to UV.

It should be noted that UVA-related eye damage involves a process with at least two steps. The first step (excitation of tryptophan or related molecules) normally reverses itself. Damage requires excited molecules to receive additional UV before they de-excite. This means that UVA eye damage is not linearly proportional to the intensity of exposure, although it may be proportional to the duration of exposure of a given intensity.

I have yet to see data indicating clearly what is and is not safe. However, nuclear cataracts are most common in people who work outdoors in sunny areas. In case of doubt, use UV blocking eyewear. Cheaper amber and yellow sunglasses do actually work - I have tested them. Sunglass lenses made of real glass and green in color attenuate UV a fair amount. Clear, blue, purple, or pink glasses may not work, even if they are claimed to work. I saw one pair of clear glasses with a sticker claiming "100 percent UV blocking" which let through more UV than window glass did.

UVB is worse on eyes than UVA, and can burn the cornea and the conjunctiva. UVC is especially burning to the conjunctiva. Please beware that symptoms are delayed considerably from exposure. Symptoms typically begin a few minutes after exposure and gradually increase for at least a half hour, often an hour to a few hours after exposure. If you have been exposed and any symptoms begin, promptly seek emergency medical care to minimize damage. NOTE - a doctor has e-mailed me advising that modern medical science can't do that much for UV burns to the eyes.

SOME OTHER HAZARDS

(Not complete)

Prolonged, heavy UV exposure causes some plastics to turn a brownish yellow color. A few of these plastics are also affected (to a lesser extent) by shorter visible violet wavelengths such as mercury's 404.7 nM deep violet line.

SOME WAYS TO REDUCE UV HAZARDS

UVB and UVC, as well as the shortest UVA wavelengths, do not go through ordinary glass. Even Pyrex and other more ordinary forms of heat-resistant glass can be used as shields to block UVB and UVC.

Another option is to contain all light from the suspect source. For example, EPROM erasers often have an interlock switch to prevent operation with the lamp exposed.

In the event you need something transparant to visible light (and most infrared) but which blocks all UVC, UVB, and well over 95 percent of UVA, use a GAM ("Great American Market") number 1510 (UV shield) filter gel or Rosco UV filter (03114). This is available from some theatrical supply shops. If very severe exposure is anticipated, the filter gel should be preceded by glass.

Other Web Sites and Pages on UV lamps

Ultra Violet Products (http://www.uvp.com)
has an impressive web site and sells quite a variety of ultraviolet lamps.

My hack to defeat the 1 minute auto shutoff of the Derma Spec 4 watt blacklight.

Where to get these

I keep this info in a different file, http://www.misty.com/~don/lsrc.html.

Written by Don Klipstein.

Back up to my lighting index page.
Back up to my home page.