Safety Tips for Using UV Lamps

Types of UV Lamps

Ultraviolet (UV) radiation occupies the portion of electromagnetic spectrum from 100 to 400 nanometers (nm). The UV spectrum consists of three regions:

UV-A (315–400 nm)
UV-B (280–315 nm)
UV-C (100–280 nm)

For most people, the main source of UV exposure is the sun. Exposure from the sun is typically limited to the UV-A region, since the earth's atmosphere protects us from the more harmful UV-C and UV-B regions. Only artificial light sources emit radiant energy within the UV-C band. UV generating devices may contain one or a combination of a couple or more artificial light sources (UV lamps) in order to achieve the desired light quality. Below are listed some of the most used types of UV generating lamps.

Xenon arc lamp

A xenon (Xe) arc lamp is a specialized type of gas-discharge lamp that produces light by passing electricity through ionized xenon gas at high pressure. The lamp generates a bright white light that closely mimics natural sunlight. Xenon arc lamps are used in movie theater projectors and searchlights, as well as in industry and research to simulate sunlight.

There are three main types of xenon arc lamps: continuous-output short-arc, continuous-output long-arc, and flash.

Example of Xe arc lamp

Xe short-arc lamps come in two distinct varieties: pure xenon, which contains only xenon gas, and xenon-mercury, which contains xenon gas and a small amount of mercury metal. Xenon-mercury short-arc lamps have a bluish white spectrum and extremely high UV output. These lamps are used primarily for UV curing applications, sterilizing objects, and generating ozone.

Xe long-arc lamps are structurally similar to short-arc lamps except that the arc-containing portion of the glass tube is greatly elongated. When mounted within an elliptical reflector, these lamps are frequently used to simulate sunlight. Typical uses include solar cell testing, solar simulation for age testing of materials, rapid thermal processing, and material inspection.

All xenon short-arc lamps generate substantial ultraviolet radiation. Xenon has strong spectral lines in the UV bands, and these readily pass through the fused quartz lamp envelope. The UV radiation released by a short-arc lamp can cause a secondary problem of ozone generation. Equipment that uses short-arc lamps as the light source must keep the UV radiation contained and prevent ozone buildup.

Many lamps have a shortwave UV-blocking coating on the envelope and are sold as "ozone-free" lamps for solar simulator applications. Some lamps have envelopes made out of ultra-pure synthetic fused silica (such as "Suprasil"), which allows them to emit useful light into the vacuum UV region. These lamps are normally operated in a pure nitrogen atmosphere.

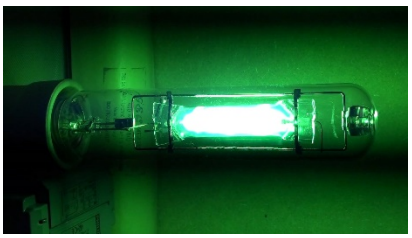
Xe flash lamps typically provide 80 flashes per second and are used in movie theater projectors and searchlights, as well as in industry and research to simulate sunlight. Other applications include air pollution analysis, biochemical analysis, blood or urine analysis, color sensing, factory automation, gas analysis, precision photometry, semiconductor inspection, shape inspection, and spectrophotometry.

Metal halide arc lamp

Example of metal halide street lamp

A metal halide lamp is an electric lamp that produces light via an electric arc through a gaseous mixture of vaporized mercury and metal halides (compounds of metals with bromine or iodine). The most common metal halide compound used is sodium iodide. Once the arc tube reaches its running temperature, the sodium dissociates from the iodine, which adds orange and red to the lamp's spectrum from the sodium D line as the metal ionizes. As a result, metal halide lamps produce an intense white light and have high luminous efficacy at approximately 75–100 lumens per watt, which is about twice that of mercury vapor lights and three to five times that of incandescent lights and. Lamp life is 6,000 to 15,000 hours. Primarily developed for use in film and television lighting, which requires a high temporal stability and daylight color match, metal halide lamps are used for wide-area overhead lighting for commercial, industrial, and public spaces, such as parking lots, sports arenas, factories, and retail stores, but also for residential security lighting. Most types are fitted with an outer glass bulb to protect the inner components and prevent heat loss. The outer bulb can also be used to block some or all of the UV light generated by the mercury vapor discharge. The metal halide lamp requires a warm-up period of as long as five minutes (depending on the lamp type). While it warms up, the lamp exhibits different colors as the various metal halides vaporize in the arc chamber.

Mercury vapor lamp



Example of mercury vapor lamp

A mercury vapor lamp is a gas-discharge lamp that produces light via an electric arc through vaporized mercury. The arc discharge is generally confined to a small fused quartz arc tube mounted within a larger borosilicate glass bulb.

In low-pressure mercury vapor lamps, only the lines at 184 and 253 nanometers (nm) are present. Only the light at 253 nm is usable. Synthetic quartz can be used in the manufacturing to keep the 184 nm light from being absorbed. In medium-pressure mercury vapor lamps, the lines from 200–600 nm are present. The lamps can be constructed to emit primarily in the UV-A (around 400 nm) or UV-C (around 250 nm). High-pressure mercury vapor lamps are those lamp commonly used for general lighting purposes. They emit primarily in the blue and green.

Some mercury vapor lamps (including metal halide lamps) must contain a feature that prevents ultraviolet radiation from escaping. Even with these methods, some UV radiation can still pass through the outer bulb of the lamp. This accelerates the aging process of some plastics, leaving them significantly discolored after only a few years' service. Polycarbonate suffers particularly

from this problem, and it is not uncommon to see fairly new polycarbonate surfaces positioned near the lamp that have turned a dull yellowish brown color after only a short time.

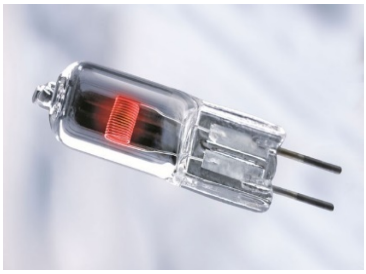
Deuterium arc lamp

Example of deuterium arc lamp

A deuterium arc lamp (or simply deuterium lamp) is a low-pressure gas-discharge light source often used in spectroscopy when a continuous spectrum in the ultraviolet region is needed. This kind of lamp emits radiation extending from 112 to 900 nm, although its continuous spectrum is only from only 180 to 370 nm. Deuterium lamps are often used with a tungsten halogen lamp to allow measurements to be performed in both the UV and visible regions.

Lamp life is typically approximately 2,000 hours (most manufacturers guarantee 2,000 hours, but newer lamps are consistently performing well out to 5,000 hours or longer).

Halogen Lamps



Example of halogen lamp

A halogen lamp, also known as a tungsten halogen, quartz halogen, or quartz iodine lamp, is an incandescent lamp that has a small amount of a halogen such as iodine or bromine added.

Like all incandescent light bulbs, a halogen lamp produces a continuous spectrum of light, from near ultraviolet to deep into the infrared. Since the lamp filament can operate at a higher temperature than a non-halogen lamp, the spectrum is shifted toward blue, producing light with a higher effective color temperature and higher power efficiency. This makes halogen lamps the only light source that produces black-body radiation spectrum similar to that of the sun and most suitable for the eyes.

High-temperature filaments emit some energy in the UV region. Small amounts of other elements can be mixed into the quartz, so that the doped quartz blocks harmful UV radiation. Because the halogen lamp operates at very high temperatures, it can pose fire and burn hazards. To reduce unintentional UV exposure, and to contain hot bulb fragments in the event of explosive bulb failure, general-purpose lamps usually have a UV-absorbing glass filter over or around the bulb. Alternatively, lamp bulbs may be doped to filter out the UV radiation. With adequate filtering, a halogen lamp exposes users to less UV than a standard incandescent lamp producing the same effective level of illumination without filtering.

Fluorescent lamp

Fluorescent lamps are used for UV curing in a number of applications. In particular, these are used where the excessive heat of mercury vapor is undesirable, or when an item needs more than a single source of light and instead the item needs to be surrounded by light, such as musical instruments. Fluorescent lamps that produce UV anywhere within the UV-A/UV-B spectrum can be created.

Light-emitting diodes (LEDs) have recently been used in research laboratories to construct solar simulators. They offer promise in the future for energy-efficient production of spectrally tailored artificial sunlight.

Threshold Limit Values

The most hazardous UV radiation emitted by the UV lamps is that with wavelengths between 240 and 315 nm. In this range the threshold limit value (TLV) is less than 10 millijoules per square centimeter, and the most restrictive TLV is the UV-C at 270 nm, which is set at 3 millijoules per square centimeter. This is the maximum safe level one may receive in an 8-hour period. To compare the radiant exposure TLV to the irradiance of the unit, a conservative estimate of potential exposure time must be used. If one is potentially exposed for the entire 8 hours, the effective irradiance TLV is 0.1 microwatts per square centimeter.

Hazard and Risks from UV Lamps

UV lamps produce light radiation from ultraviolet through visible to infrared radiation. The biggest hazard comes from the UVR. UVR cannot be seen and is not felt immediately, but it is harmful to both the eyes and skin. The user may not realize the danger until after the exposure has caused damage. Symptoms can occur 4 to 24 hours after exposure.

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 UVR is redness of the skin called erythema (similar to sunburn). Chronic effects include accelerated skin aging and skin cancer.

UV radiation is absorbed in the outer layers of the eye – the cornea and conjunctiva. Acute overexposure leads to a painful temporary inflammation, mainly of the cornea, known as photokeratitis. Repeat overexposure to the UV is unlikely because of the pain involved. Chronic exposure leads to an increased risk of certain types of ocular cataracts.

Working unprotected for even a few minutes can cause injury. It is possible to calculate acute threshold for acute effects and to set exposure limits. It is not possible, however, to calculate threshold for chronic effects; therefore, because no exposure level is safe, exposure should be reduced as much as possible.

Other Hazards Related to Use of UV Lamps

Lamp explosion

Arc lamps used with solar simulators contain high-pressure gas and may explode if not handled properly. Avoid touching or scratching the glass section of the lamp. Fingerprints should be wiped off with isopropyl alcohol and a clean soft tissue; otherwise they will weaken the lamp envelope. Use cotton gloves for handling the lamp.

Cotton Gloves

Install the lamp with proper polarity of electrical connections. Do not stress the glass parts when tightening electrical connections. Replace the lamp when it reaches its lifetime limit. An old lamp having a darkened glass envelope has a high likelihood of exploding and should be replaced.

Mercury (Hg)

Some of the solar simulators use mercury-based arc lamps (Hg or HgXe). Mercury contamination can occur if a lamp breaks or explodes. Consult with the industrial hygienist on proper handling of mercury contamination.

Ozone

Short-wavelength UV light converts oxygen into ozone. Ozone produced by lamps with high UV output can be a major irritant to the user. Even ozone-free lamps can produce enough ozone to be uncomfortable for someone who is particularly sensitive. Proper ventilation should be considered before the system is in use.

Electrical shock

During normal operation, the user is protected from contact with any energized electrical connections. However, electrical shock danger will occur if interlocks are defeated or the power supply section is opened with the unit still plugged in. Unplug the unit before replacing the lamp or servicing the power supply section.

Heat

An arc lamp envelope reaches very high temperatures during normal operation and can cause severe burns if touched. Let the lamp cool at least 15 minutes before opening the lamp compartment door.

Controls

There are three types of control measures: engineering, administrative (procedural), and personal protective equipment (PPE).

Engineering Controls

Location

Having UV generating devices located in a separate room, alcove, or low-traffic area of a lab is ideal. To avoid exposure to other personnel, avoid placing UV generating devices in the vicinity of desk areas or other equipment.

Enclosure

The use of light-tight cabinets and enclosures is the preferred means of preventing exposure. Where it is not practicable to fully enclose the UV source, use screens, shields, and barriers.

Interlocks

Some solar simulator enclosures come with interlocks; alternatively, interlock devices can be installed. Interlocks should not be tampered with and should be replaced or repaired when defective.

Administrative Controls

Typical administrative controls include limiting access, ensuring that people are aware of the potential hazards, and providing training and safe working instructions for users.

Training

Personnel should be trained in using the UV-generating devices safely. The manufacturer's manuals provide specific safety-related information (type of eye/skin protection needed, ventilation requirements, etc.) that must be completely understood before using the equipment. If any uncertainty or concern exists regarding the safe use of UV-generating devices, contact the manufacturer for clarification.

Personnel should carefully study the manufacturer's manuals for the UV-generating devices and be familiar with its use. It is important never to deviate from the instructions for safe operation without first contacting the manufacturer.

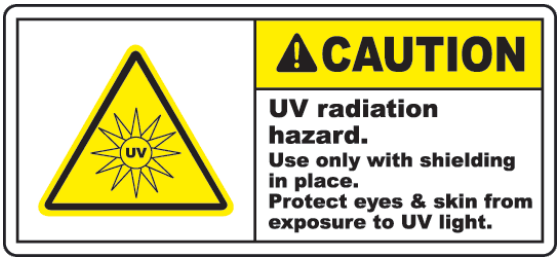
At a minimum, lab personnel should be familiar with the following when working with or around UV light:

- UV light–producing equipment
- Warning signs
- Protective equipment
- Symptoms of UV exposure

Minimizing exposure

- Never view the UV lamp directly. Although the inverse square law applies to non-laser-beam UV radiation, it is not advisable to look directly at any UV source (e.g., an arc lamp) – at any distance.
- Keep exposure time to a minimum, and where the source is not enclosed or shielded, keep as far away from it as practicable.
- Restrict access to those personnel who are directly concerned with the operation of the UV source.

Hazard warning signs



Warning signs are necessary to inform about the risk of exposure during use and maintenance. Warning signs should be used where applicable to indicate the presence of potential UVR hazards, to restrict access, and to specify PPE.

Personal Protective Equipment

Appropriate PPE includes eyewear, face shields, gloves, and lab coats.

UV Protective Eyewear

Eyewear

Use eyewear that is appropriate for the work. Special safety glasses are available for the different UV ranges. For best UV protection, the eyewear should be compliant with ANSI Z87.1 and should have a UV filter marking, *U*, followed by a number on a scale from 2 to 6.

Face shield

UV-absorbing full face shields should be worn in addition to safety glasses or goggles (goggles may not provide sufficient face protection). Severe skin burns can happen in a very short time, especially under the chin (which is often left exposed).

UV Protective Face Shields

Gloves

Wear nitrile, latex, or tightly woven fabric gloves to protect against the significant amounts of UV-A and UV-B that may pass through to the skin; these types of gloves have a low transmission of UV compared to vinyl gloves. Gloves should protect personnel from UV light, as well as from the hazard of the activity being performed.

UV Protective Gloves

Lab coat

Personnel should wear lab coats that fasten securely at the wrists and up the neck so that no skin is exposed. Burns to wrists and the neck are not uncommon.

Lab Coat

UV Neck Gaiter

UV Face Mask

PPE must be either readily available and cleaned between users or personally allocated to each user. Eye and face protection must be inspected either regularly or before each use for damage or defects such as cracks, crazing, or bleaching, and replaced when necessary. Note that PPE may need to serve multiple purposes, such as protecting against both UV and chemical splashes.

Take-Away Safety Tips

- ALWAYS use appropriate PPE for the hazard: UV face shield, goggles, gloves, buttoned-up lab coat.
- Enclose the light generated by the lamp to the extent possible.
- Avoid touching or scratching the glass section of the lamp. Fingerprints weaken the lamp envelope, and this may lead to lamp explosion.
- Do not touch the lamp while working. Let the lamp cool at least 15 minutes before opening the lamp compartment door. The arc lamp envelope reaches very high temperatures during normal operation and can cause severe burns if touched.
- Use proper ventilation with lamps that are not ozone free.
- Do not use lamp near paper, cloth, or other combustible material.
- Do not overcool the lamp. Air should never be directly forced on the bulb because it will result in uneven cooling. Recommended cooling methods are air flow, nitrogen gas flow, and use of a heat sink or an exhaust duct.
- ALWAYS keep the lamp in the provided protective case or cover until installation.
- Save the protective case or cover and packaging materials (box) for lamps that have been used to their rated service life. Use the protective case when disposing of the lamps. Firmly attach tape around the original cardboard box to seal the lamp securely.
- Xenon arc lamps should not be used beyond their rated service life. Operation beyond the rated service life may cause the lamp to burst.

The Environment, Health & Safety Division can provide assistance in measuring UV emissions and selecting the appropriate PPE to wear.

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