ULTRAVIOLET RADIATION
QUICK REFERENCE SHEET

This document was developed by the AIHA NIR Committee. The intent is to provide general information to practicing Industrial Hygienists on NIR topics and to determine next steps for assessing and controlling NIR hazards. For additional, detailed information please refer to the reference section.

Characteristics – Ultraviolet radiation (UV) is a type of optical radiation, which means its physical behavior is similar to that of light. The UV spectrum is divided into three main wavelength bands: UV-A or "blacklight" (315-400 nm); UV-B or "erythemal" (280-315 nm); and UV-C or "germicidal" (100-280 nm). Wavelengths shorter than about 190 nm are strongly absorbed by air. UV is not visible to the human eye, but many broadband UV sources also emit visible light.

Units of Measure – The irradiance, or power per unit area received at a surface, is typically measured in W/m^2 or mW/cm^2. The radiant exposure, a measure of dose, is the energy received per unit area of irradiated surface, expressed as J/m^2 or mJ/cm^2. Wavelength of the radiation is expressed in nm. (W=watt; J=joule, m=meter, cm= centimeter, nm=nanometer.)

Significant Sources – Sunlight, welding and plasma arcs, xenon lights, mercury vapor lights, germicidal lamps, curing lamps, sunlamps, tanning lamps, and ultraviolet light-emitting diodes (ULEDs), UV photolithography.

Biological Effects – UV is strongly absorbed by proteins and DNA. Because UV does not penetrate deeply into tissue, the target organs are the skin and eye. Acute overexposure may cause erythema (redness or burning) of the skin and photo keratitis (inflammation of the cornea), also called "snow blindness" or "welder's flash". Chronic overexposure can cause cataracts, skin aging, and immunosuppression. The International Agency for Research on Cancer (IARC) has classified UV, including the UV-A, UV-B, and UV-C bands, as a Group 1 human carcinogen. Specifically, UV exposure can cause malignant melanoma, non-melanoma skin cancers, and possibly eye cancer. Although dark pigmentation can reduce the risks of UV exposure, all skin types are at risk. UV can also interact with a number of naturally occurring and synthetic photosensitizers, including some drugs, to increase the potency of UV radiation in causing skin burns or cancer. Interaction of drugs with UV radiation will be documented in the information provided by the drug manufacturer or Physicians' Desk Reference.

Exposure Guidelines – The effectiveness of UV at causing skin burns or corneal inflammation depends on the wavelength. Maximum effectiveness for photo keratitis occurs around 270 nm. The ACGIH threshold limit value (TLV®) for UV is harmonized with the International Commission on Non-Ionizing Radiation Protection (ICNIRP) guidelines. Under these guidelines for broadband sources, the UV incident on the eye must be weighted by a relative spectral effectiveness function to obtain the "effective irradiance". The tabulated values for this weighting function can be found in the ACGIH TLV booklet or the ICNIRP guideline for UV. The integral of the effective irradiance over time (or, For constant irradiance, the product of effective irradiance and exposure time) shall not exceed 3 mJ/cm^2 in a day. If the effective irradiance varies over time, the 3 mJ/cm^2 limit should be applied to the effective radiant exposure, which can be measured using an integrating UV radiometer. This guideline for the corneal hazard is also believed to be protective of nearly all skin types in the absence of photosensitizers. To prevent damage to the lens and retina from UV-A, the unweighted UV-A radiant exposure should not exceed 1 J/cm^2 if the daily cumulative exposure time is less than 17 minutes, and the unweighted

ULTRAVIOLET RADIATION
QUICK REFERENCE SHEET

UV-A irradiance should not exceed 1 mW/cm^2 for daily cumulative exposure times greater than 17 minutes.

Exposure Assessment – Field measurement of UV radiation should be performed with broadband detectors that have a spectral response that is well matched to the relevant effectiveness function over the entire spectral range of the UV source. Integrating meters can be used to obtain measurements of cumulative UV dose in J/cm^2. For solar UV exposure, the Global Solar UV Index, which is widely available as part of local weather forecasts, is a good awareness tool for assessing the risk of outdoor work or recreational activities.

Ancillary Hazards – UV-C radiation at wavelengths less than 242 nm reacts with oxygen to form ozone, which in some cases could reach lethal concentrations if not removed by local exhaust ventilation. Sources of ozone-generating UV-C include gas-shielded arc welding, xenon lamps, mercury lamps, and germicidal lamps. Short-arc UV lamps contain gas under elevated pressure, posing a potential explosion hazard even when cold.

Control Measures –Enclose or orient UV sources so that direct or reflected radiation does not fall on skin or eyes. Limit duration of exposure so that effective UV dose does not exceed 3 mJ/cm^2 in a day. Cover skin with tightly woven fabrics or leather; nitrile or latex gloves are recommended if a barrier to fluids is also needed. Choose eyewear that is specifically rated for UV absorption. It should be noted that many transparent materials such as glass and polycarbonate absorb UV-B and UV-C but transmit significant fractions of UV-A. Sunscreens of SPF 15 or higher should be used on skin that cannot be covered by clothing, and as a back-up for protective clothing.

References and Additional Information

ACGIH: Ultraviolet Radiation TLV Documentation, 2012.

V.J. Cogliano et al.: Preventable exposures associated with human cancers. Journal of the National Cancer Institute 103:1-13, 2011.

R.T. Hitchcock, C.E. Moss, W.E. Murray, R.M. Patterson, and R. James Rockwell: Chapter 22, Nonionizing Radiation in The Occupational Environment: Its Evaluation, Control, and Management, 2nd Edition. Fairfax, VA: AIHA, 2003.

International Commission on Non-Ionizing Radiation Protection (ICNIRP). Guidelines on limits of exposure to ultraviolet radiation of wavelengths between 180 nm and 400 nm (incoherent optical radiation). Health Physics 87:171-186, 2004.

M.L. Phillips and A. Butler: Chapter 31, Nonionizing Radiation: Broadband Optical, in Patty's Industrial Hygiene, 6th Edition. Hoboken, NJ: John Wiley & Sons, 2011.

U.S. Environmental Protection Agency. UV Index. Available at http://www.epa.gov/sunwise/uvindex.html.

WHO International Agency for Research on Cancer Monograph Working Group: A review of human carcinogens–Part D: radiation. The Lancet Oncology 10:751-752, 2009.