UVP

Application Note
AN A114

Determining Occupational Exposure to Ultraviolet Radiation

INTRODUCTION

Exposure to excessive amounts of ultraviolet radiation can cause injury to the skin and eyes. To assist the operator in assuring that his UV exposure does not exceed tolerable limits, UVP, Inc. has developed a technique using the UVX Radiometer System. This technique is a two-step process:

1. The operator measures the ultraviolet intensity at the distance his exposed skin or eyes will be from the source.
2. He converts this measurement to an exposure time limit using a conversion factor.

The relative danger varies greatly for the different lamp types and, for this reason, several factors are required. These are listed in Figure 1 for the most common UV sources.
In this bulletin these factors will be derived and examples given so that the operator can be sure he is working in a safe environment.

DEFINITIONS

To derive the conversion factors it is necessary to define some terms:

1. Radiant incidence/milliWatt per square centimeter (mW/cm^2) - Electromagnetic power incident per unit area, a measure of the amount of light striking a unit area.
2. Nanometer (nm) - Measure of wavelength, one billionth of a meter.
3. Watt (w) - Unit of power.
4. milliWatt (mW) - One thousandth of a Watt.

STANDARDS

The National Institute for Occupational Safety and Health (NIOSH) has recommended standards for exposure to ultraviolet radiation. In this recommendation the UV spectrum is divided into two regions, the 315 to 400 nm or long wave region and the 200 to 315 nm or short and middle wave region. The division is made at 315 nm because the difference in the potential hazard is so great for the two regions. We shall also treat them separately.
For the 315 to 400 nm region it is recommended that the total radiant incidence on unprotected skin and eyes should not exceed 1.0 milliWatt per square centimeter (mW/cm^2) for periods longer that 1000 seconds. If the incidence is less than 1.0 mW/cm^2 there is no time limit, and if it is more the time should be reduced so that the total dose does not exceed 1000 $mW\text{-}sec/cm^2$.
For the 200 to 315 nm region the NIOSH recommendations are more complicated. The recommended Ultraviolet Radiation Exposure Standard is shown in Figure 2. The vertical axis represents the allowable dose the operator may receive in a 24 hour period. The horizontal axis is the wavelength of the light incident on the skin or eyes.

To apply this curve the operator needs to know both the wavelength distribution and the intensities of these wavelengths for his particular UV source. He must then fold these curves together to determine his allowable exposure time. UVP, Inc. has developed a technique using the UVX Radiometer System that eliminates the need for these tedious calculations for the most common situations.

EXPOSURE DETERMINATIONS FOR 315 to 400 nm RADIATION

In this region the most common emitter types are 365 nm line sources, phosphor coated lamps, and continuum emitters. For each of these a factor (K) can be defined which takes into account the spectral characteristics of both the emitter and the UVX Radiometer sensor. The factor can be used to determine exposure times.

First we can determine the meter reading that represents the maximum level a person can withstand without requiring any time limit. The formula for this is:

$$\text{Maximum Reading (MR)} = \frac{1.0\ \text{mW/cm2}}{K}$$

Also the permissible exposure time in seconds for greater incident levels can be computed from the formula:

$$\text{Permissible Exposure Time (PET)} = \frac{1000}{\text{KH}}$$

Where R is the reading from the UVX Digital Radiometer in mW/cm^2.

Applying these formulae to the most common cases, we have: 365 nm LINE EMITTERS. The factor K for these equals 1.0 since the UVX is calibrated to measure this type of discharge. MR then becomes 1.0 mW/cm^2 and PET = 1000/R sec.

Example 1: A UVX reading of 1.2 mW/cm^2 from a mercury discharge lamp would indicate a permissible exposure time of

$$1000/1.2 \text{ sec} = 830 \text{ sec. or about 13 min.}$$

PHOSPHOR-COATED ULTRAVIOLET EMITTERS

For this group a reasonable value for K is 1.5, so:

$$MR = \frac{1.0 \text{ mW/cm}^2}{1.5} = 0.66 \text{ mW/cm}^2 \qquad \text{and} \qquad PET = 666/R \text{ seconds}$$

Example 2: A reading of 0.6 mW/cm^2. This reading is less than the MR for this lamp type, so there would be no exposure time limit.

Example 3: A reading of 2.2 mW/cm^2. This is larger than the MR, so we would have:

$$PET = \frac{666}{2.2} = 303 \text{ seconds}$$

CONTINUUM EMITTERS

Welding arcs and incandescent lamps emit light over a broad spectrum in a continuous fashion and not in discrete wavelengths like a line emitter. For that portion of the continuum between 315 and 400 nm, K = 2.0 should be used. This implies:

$$MR = \frac{1.0 \text{ mW/cm2}}{2.0} = 0.5 \text{ mW/cm}^2 \qquad \text{and} \qquad PET = 500/R \text{ Seconds}$$

These values are summarized in Figure 1.

Spectral Region (nm)	Emitter Type	Radiometer System	Maximum Radiometer Reading for Unlimited Exposure Time (MR)(mW/cm)	Formula for Permissible Exposure Time PET (sec)
315-400	365 nm Line	UVX	1.0	1000/R
	Phosphor Coated Ultraviolet	UVX	0.66	666/R
	Continuum	UVX	0.50	500/R
200-315	254 nm Line	UVX	N/A	6/R
	Continuum	UVX	N/A	6/R

FIGURE 1 - EXPOSURE DETERMINATIONS

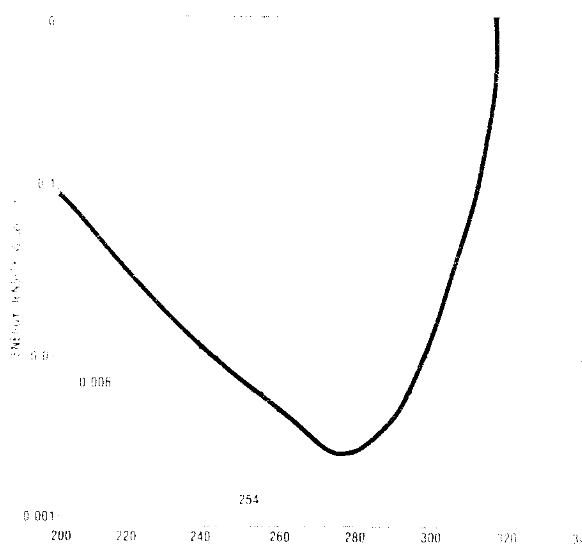

FIGURE 2 - RECOMMENDED ULTRAVIOLET RADIATION EXPOSURE STANDARD

This figure was adapted from a figure developed and published by the American Conference of Governmental Industrial Hygienists — Threshold Limit Values for Chemical Substances and Physical Agents in the Workroom Environment with Intended Changes for 1972

EXPOSURE DETERMINATIONS FOR 200 to 315 nm RADIATION

In this region it is, again, necessary to consider the type of emitter being measured. The most common types are 254 nm line sources and continuum emitters.

254 nm LINE EMITTERS

This category includes the low pressure mercury discharge lamp which is the most used short wave lamp. The published permissible dose for this type (see Figure 2) is 6.0 mW-sec/cm^2. Since the UVX is calibrated to measure this type of source, the PET can be computed from the formula:

$$PET = 6.0/R \text{ seconds}$$

Where R is the UVX reading in mW/cm^2 and PET is in seconds.

Example 4: A UVX radiometer reading at 0.05 mW/cm^2. Here we would have:

$$PET = \frac{6.0}{0.05} = 120 \text{ seconds}$$

CONTINUUM EMITTERS

For incandescent lamps and welding arcs the situation is more complicated. Here the spectral characteristics of the source, the sensor, and the response of the skin must be taken into account. Calculations involving all of these factors have produced the following formula: <u>PET = 6.0/R seconds</u>

where R is the UVX reading in mW/cm^2. It is a coincidence that this formula matches the one given for a 254 nm line emitter.

This data is summarized in Figure 1.

More general information can be found in the UVX radiometer operators' manual.

NOTE: The in-house safety policy of UVP, Inc. requires employees to use eye and skin protection whenever the UVX indicates the presence of any measurable 200-315 nm radiation.

UVP

UVP, Inc. 2066 W. 11th Street, Upland, CA 91786
(800) 452-6788 * (909) 946-3197 * Fax: (909) 946-3597 * E-Mail: uvp@uvp.com

Ultra-Violet Products Ltd., Unit 1, Trinity Hall Farm Estate, Nuffield Rd., Cambridge CB4 1TG UK
+44(0)1223-420022 * Fax: +44 (0)1223-420561 * E-Mail: uvp@uvp.com

Internet: www.uvp.com