NIOSH

A Recommended Standard for Occupational Exposure to.....

Ultraviolet Radiation

A criteria document for protection against ultraviolet radiation has been prepared in accordance with sections 6 (b) (7) and 20 (a) (3) of the Occupational Safety and Health Act was transmitted to the Occupational Safety and Health Administration, U.S. Department of Labor, December 20, 1972, for review and consideration in the Standard setting process.

The standard is based on criteria developed from the results of numerous investigations of the effects of ultraviolet energy on the exposed eye and skin. In the development of the proposed standard the eye was selected as the organ for protection because the eye is much more sensitive than the skin to ultraviolet radiation. A significant safety factor for the skin is thereby provided. The proposed standard represents a complete criteria document, but recognizes present difficulties in the measurement of broadband ultraviolet energy. Evaluation for compliance is based on three different approaches depending upon the wavelength of the ultraviolet energy; these are:

1. Utilization of available instrumentation whenever applicable with recognition of instrument shortcomings.
2. Utilization of data on energy output from a specific source such as lamps.
3. Utilization of work practices when suitable instrumentation or energy output data are not available.

Exposure to ultraviolet radiation occurs in welding, metal cutting, plasma torch operation, glass manufacture, furnace and foundry operations and in bacteriologic control. Outdoor workers who are exposed to sunlight may also receive significant ultraviolet radiation, and the problem of non-occupational exposure to sunlight is recognized. An estimated 320,000 industrial workers are potentially exposed to artificial sources of ultraviolet energy, and approximately 4.8 million outdoor workers are potentially exposed to sunlight.

The recommendations for an occupational exposure standard for ultraviolet radiation take into consideration available information on health effects and limited data on technical feasibility of achieving various levels of exposure.

The criteria document was reviewed by four knowledgeable consultants, two professional societies, and government agencies with interest and responsibility in occupational safety and health. No response was obtained from the solicitation in the *Federal Register*.

It was the feeling of the reviewers that the ultraviolet radiation standard as proposed in this document, which has been adapted from the American Conference of Governmental Industrial Hygienists, is appropriate and that no additional information that would affect the standard is available at this time.

The substantial changes incorporated into the criteria document as a result of the reviewers' comments involved recognition of the limited use of present measuring devices and the need for use of work practices and protective clothing and goggles.

The following is the first chapter of the criteria document. It contains the NIOSH recommendations for controlling worker exposure to Ultraviolet Radiation.

U. S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service
Center for Disease Control
National Institute for Occupational Safety and Health

1. RECOMMENDATIONS FOR AN ULTRAVIOLET RADIATION STANDARD

The National Institute for Occupational Safety and Health (NIOSH) recommends that occupational exposure to ultraviolet energy in the workplace be controlled by compliance with the following sections. Ultraviolet radiation (ultraviolet energy) is defined as that portion of the electromagnetic spectrum described by wavelengths from 200 to 400 nm. (For additional definitions and conversion factors, see Appendix II.) Adherence to the recommended standards will, it is believed, prevent occupational injury from ultraviolet radiation, that is, will prevent adverse acute and chronic cutaneous and ocular changes precipitated or aggravated by occupational exposure to ultraviolet radiation.

Sufficient technology exists to prevent adverse effects on workers, but technology to measure ultraviolet energy for compliance with the recommended standard is not now adequate, so work practices are recommended for control of exposure in cases where sufficient measurement or emission data are not available.

These criteria and the recommended standard will be reviewed and revised when relevant information warrants.

Section 1 — Exposure Standards

(a) For the ultraviolet spectral region of 315 to 400 nm, total irradiance incident on unprotected skin or eyes, based on either measurement data or on output data, shall not exceed 1.0 mW/cm^2 for periods greater than 1000 seconds, and for exposure times of 1000 seconds or less the total radiant energy shall not exceed 1000 $mW \cdot sec/cm^2$ (1.0 J/cm^2).

(b) For the ultraviolet spectral region of 200 to 315 nm, total irradiance incident on unprotected skin or eyes, based on either measurement data or on output data, shall not exceed levels described below. Measurement techniques are discussed in Appendix I.

(1) If the ultraviolet energy is from a narrow-band or monochromatic source, permissible dose levels for a daily 8-hour period can be read directly from Figure I-1, or, for selected wavelengths, from Table I-1.

(2) If the ultraviolet energy is from a broad-band source, the effective erradiance (I_{eff}) relative to a 270-nm monochromatic source shall be calculated from the formula below. From I_{eff}, the permissible exposure time in seconds for unprotected skin or eyes shall be computed by dividing 0.003 J/cm^2, the permissible dose of 270-nm radiation, by I_{eff} in W/cm^2.

$$I_{eff} = \sum I_\lambda S_\lambda \Delta_\lambda$$

where I_{eff} = effective irradiance relative to a monochromatic source at 270 nm.

I_λ = spectral irradiance in $W/cm^2/nm$.

S_λ = relative spectral effectiveness (unitless); see Table I-1 for values of S_λ at different wavelengths.

Δ_λ = band width in nm.

Table I-2 lists permissible exposure times corresponding to selected values of I_{eff} in $\mu W/cm^2$.

If radiation intensity from a point source is known at some distance from the worker, for example, from measurement at another point or from output data at a known distance from the ultraviolet source, attenuation of radiation from that point to the worker can be calculated from the principle that radiation decreases with the square of the distance it must travel. For example, an object 3 feet away from a radiation source receives 1/9 the energy of an object 1 foot away. This assumption is conservative in some instances, since ultraviolet radiation, especially at very low wavelengths, may be absorbed by some components of the atmosphere. Where information on atmospheric absorption of ultraviolet radiation is known, further correction may be applied. The calculation of intensity of radiation at any given point by use of the inverse square formula explained above does not take into consideration reflected energy.

The recommended standard is not proposed for application as a standard to lasers. It should be recognized that significant non-occupational exposure to ultraviolet radiation can occur from exposure to sunlight, particularly during the summer months.

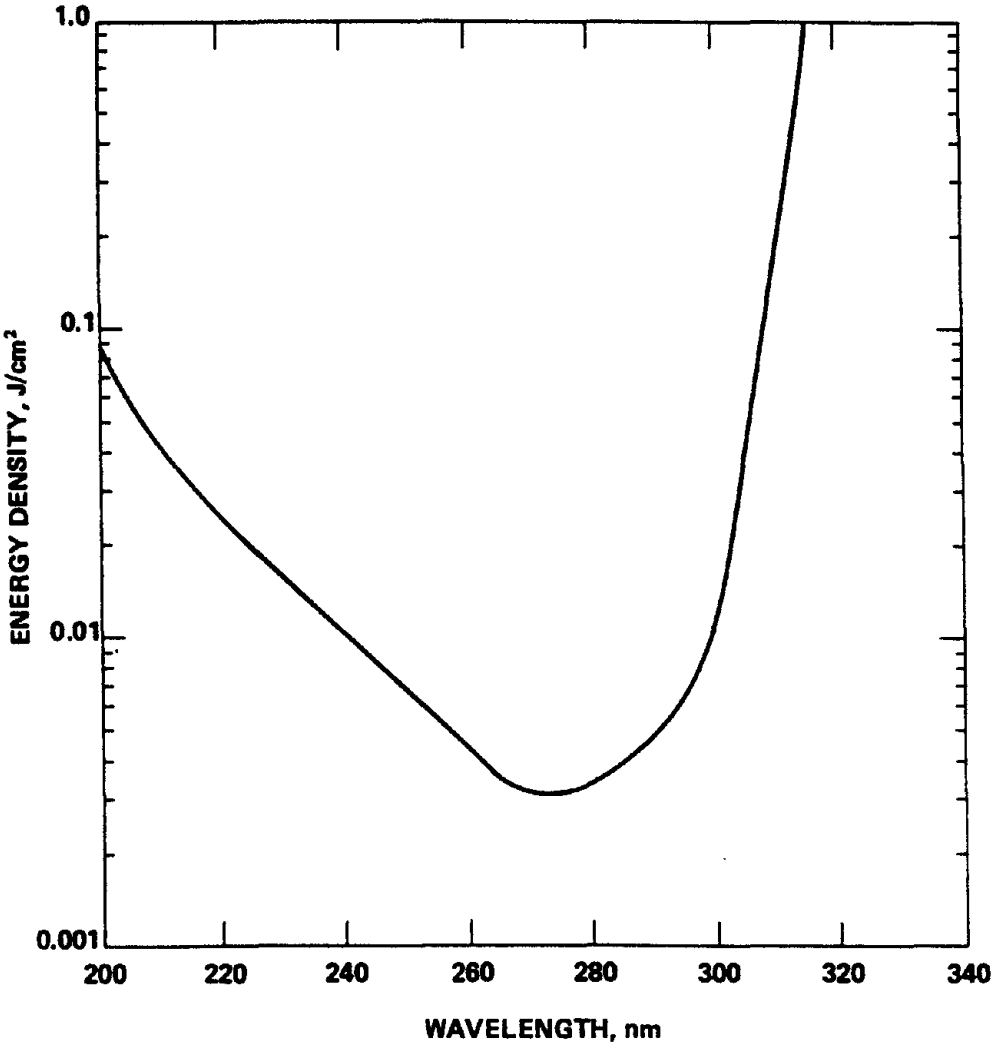

Figure I-1. Recommended Ultraviolet Radiation Exposure Standard
This figure was adapted from a figure developed and published by the American Conference of Governmental Industrial Hygienists in "Threshold Limit Values for Chemical Substances and Physical Agents in the Workroom Environment with Intended Changes for 1972".

Table I-1

Total Permissible 8-Hour Doses and
Relative Spectral Effectiveness of Some
Selected Monochromatic Wavelengths

Wavelength (nm)	Permissible 8-hour dose (mJ/cm2)	Relative spectral effectiveness (S_λ)
200	100.0	0.03
210	40.0	0.075
220	25.0	0.12
220	25.0	0.12
230	16.0	0.19
240	10.0	0.30
250	7.0	0.43
254	6.0	0.50
260	4.6	0.65
270	3.0	1.00
280	3.4	0.88
290	4.7	0.64
300	10.0	0.30
305	50.0	0.06
310	200.0	0.015
315	1000.0	0.003

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

Table I-2

Maximum Permissible Exposure Times
for Selected Values of I_{eff}

Duration of exposure per day	Effective irradiance, I_{eff} ($\mu W/cm^2$)
8 hrs	0.1
4 hrs	0.2
2 hrs	0.4
1 hr	0.8
30 min	1.7
15 min	3.3
10 min	4.0
5 min	10.0
1 min	50.0
30 sec	100.0

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

Section 2 — Medical Recommendations

(a) The worker's past medical history should be obtained to determine if the worker suffers from any condition that is exacerbated or aggravated by exposure to sunlight.

(b) A worker who gives a history of such a condition should not be permitted to work in an area exposed to ultraviolet radiation.

(c) The worker should be advised that any blemish that appears on skin exposed to long term ultraviolet radiation should be examined by a physician.

Section 3 — Apprisal of Employees of Hazards From Exposure to Ultraviolet Energy.

(a) Each employee who may be exposed to high intensity artificial sources of ultraviolet energy shall be apprised of all hazards, relevant symptoms and precautions concerning exposure. This apprisal of hazards shall include:

(1) Information as to the proper eye protection and protective clothing to be used.

(2) Instruction on how to recognize the symptoms of eye and skin damage due to ultraviolet radiation.

(3) Information as to special caution that shall be exercised in situations where employees are exposed to toxic agents and/or other stressful physical agents which may be present in addition to and simultaneously with ultraviolet radiation.

(b) Highly susceptible (i.e. light skinned, easily sunburned) employees who regularly work out of doors and are exposed to sunlight should be apprised of possible long term effects of sun exposure and of the desirability of preventing these effects by use of protective clothing or sunscreens.

Section 4 — Labeling

All sources, work areas, and housings specified in Table I-3 shall carry the following warning:

CAUTION

HIGH INTENSITY ULTRAVIOLET ENERGY

PROTECT EYES AND SKIN

Section 5 — Work Practices

Worker exposure to ultraviolet energy from 200 to 400 nm shall be controlled by adherence to the standard set forth in Section 1 or the preventive procedures described in this Section, as applicable. Compliance with the standard, based on measurement data or emission data, or adherence to the work practice procedures will protect against injury from ultraviolet energy.

Exposure to ultraviolet energy can be controlled by enclosures, shields, protective clothing, skin creams, gloves, goggles, or face shields. Workers shall be protected from eye or skin exposure to ultraviolet radiation.

Specific protective measures to be used for various types of ultraviolet exposure are noted below.

(a) **Sunlight.** Susceptible persons working outside in strong sunlight should be protected. Protective clothing, such as long-sleeved shirts, trousers or skirt, and face and neck protection will normally be adequate. Face and neck protection can be afforded by a broad-brimmed hat, by a billed hat or cap, or by a neck shield (if the neck is not protected by hair). Hard hats may have bills or face shields to protect the face, and may have neck shields. Alternatively, face and eye

Table I-3

Radiation Source	Lamp or Instrument	Housing	Work Area	Container (Shipping or Storage)
1. Low Pressure Mercury	Yes	Yes	No	Yes
2. Sunlamp	Yes	No	No	Yes
3. Black light lamp	No	No	No	No
4. Pressure Type Arc lamps*	No	Yes	Yes	Yes
5. Open Arcs* and Incandescent Sources	No	Yes	Yes	Yes
6. Welding	Yes	—	Yes	Yes
7. Plasma Torches	Yes	Yes	Yes	Yes
8. Other artificial UV generating sources	Yes	Yes	Yes	Yes

*Lamps cannot be labeled because of their high operating temperatures.

protection can be achieved by barrier creams and goggles or spectacles.

(b) Low-intensity ultraviolet sources. Examples of sources of low-intensity ultraviolet sources are low-pressure mercury vapor lamps, sunlamps, and black-light lamps.

Glass or plastic (1/8-inch thickness or greater) spectacles, goggles or shields provide adequate eye protection. Skin can be protected by lightweight clothing, by absorbing skin creams containing benzophenones or p-aminobenzoic acid, or by barrier creams containing titanium dioxide or zinc oxide.

(c) High-intensity ultraviolet sources. Examples of high-instensity ultraviolet sources are high-pressure mercury vapor lamps, high-pressure xenon arcs, xenon-mercury arcs, carbon arcs, plasma torches, and welding arcs.

For eye protection, workers shall wear goggles, face shields or masks. For shade required for this eye protection, consult Section 7 of American National Standards Institute Z49.1-1967 (ANSI Z49.1). However, in some welding operations such as gas-shielded arc welding, workers with inadequate visual acuity may have to wear a shade of less absorbance (greater transmission) to facilitate their locating the electrodes and prevent starting the arc before putting their masks or goggles in place; eye protection must be used at all times while the arc is operating, and, if necessary in order to see the operation, shade 8 may be used in place of a shade of greater absorbance.

Skin must also be protected. Clothing of densely woven flannelette, poplin, or synthetic fabric will give sufficient protection. Facial skin can be protected by face shields of shades specified in ANSI Z49.1 or by barrier creams containing titanium dioxide or zinc oxide.

Because many synthetic clothing fibers can melt or catch fire and thereby cause severe thermal burns, clothing of synthetic fibers should be flame-resistant if operations involve great heat, sparks, or flame.

Welders' helpers and others working nearby may also require protection. Shielding such as the welder's booth guard against accidental exposure of other people. Reflection from lamp housings, walls, ceilings, and other possible reflective surfaces should be kept to a minimum by coating such surfaces with a pigment-based paint of low ultraviolet reflectance. Where such shielding and non-reflective surfaces are not used, welders-helpers and others near the welding operation should wear protective clothing, skin creams, gloves, goggles, or face shields.

Additional hazards. There are other hazards from some ultraviolet sources that must also be prevented. There is a shock hazard in some operations involving arcs, because of the high starting voltages required; wiring and connections must be adequately insulated, and persons handling the equipment must wear gloves and face shields. There must be adequate ventilation to prevent build-up of ozone and oxides of nitrogen. There may also be an explosion hazard from some ultraviolet operations, and the wearing of gloves and face shields will reduce the consequences of an explosion.

Arc welding on plates wet with unsaturated chlorinated hydrocarbons (perchloroethylene and trichloroethylene) must be avoided unless well vented, because of possible production of phosgene and hydrogen chloride.

Section 6 — Recordkeeping

Because measurement of exposure of workers to ultraviolet energy is not required, records are not required.

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