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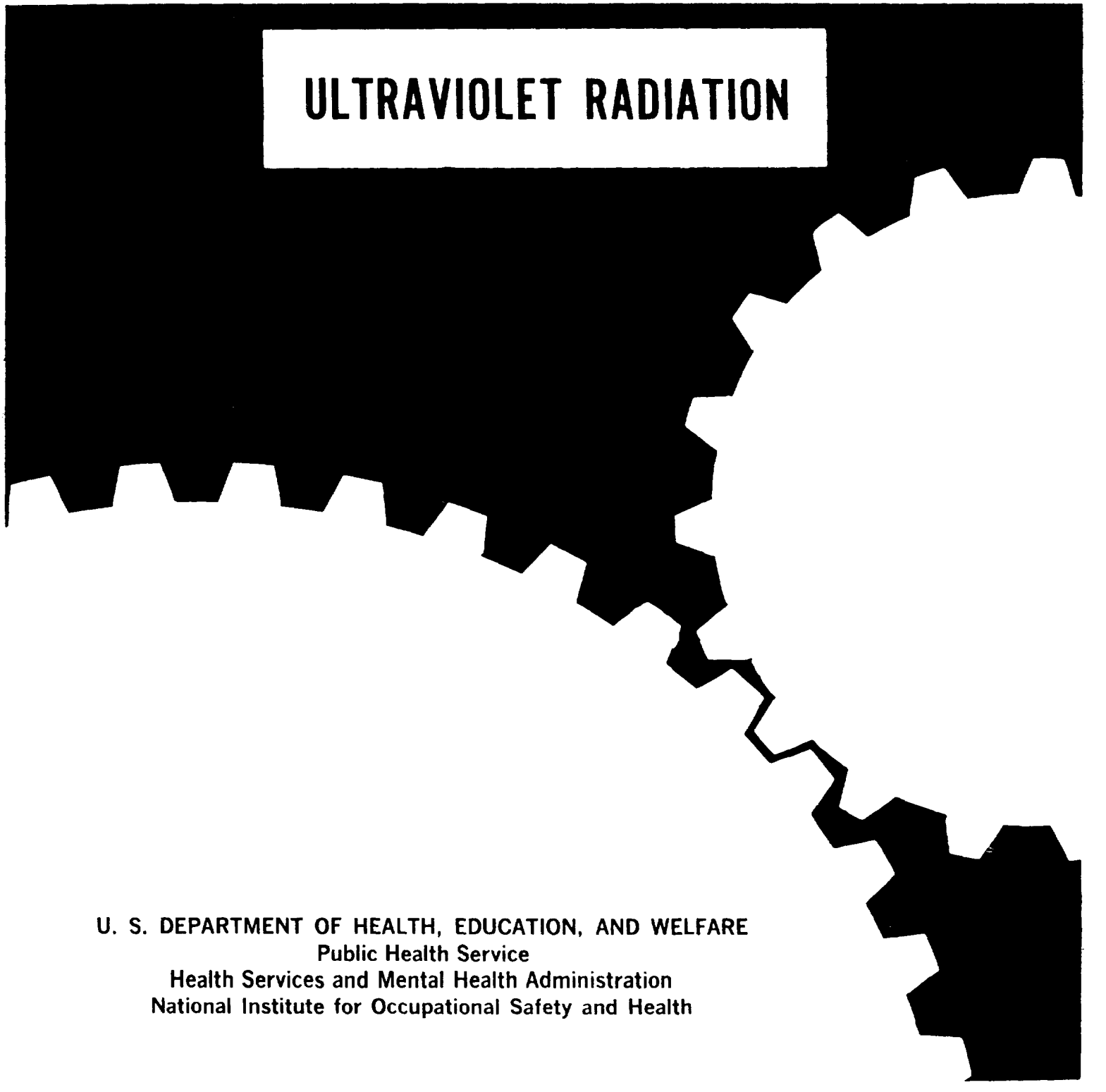

U. S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service
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OCCUPATIONAL EXPOSURE TO ULTRAVIOLET RADIATION

U. S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service
Health Services and Mental Health Administration
National Institute for Occupational Safety and Health

1972

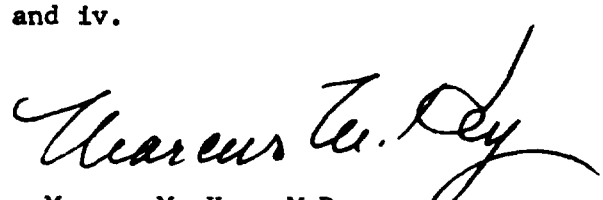
HSM 73-11009

PREFACE

The Occupational Safety and Health Act of 1970 emphasizes the need for standards to protect the health and safety of workers exposed to an ever-increasing number of potential hazards at their workplace. To provide relevant data from which valid criteria and effective standards can be deduced, the National Institute for Occupational Safety and Health has projected a formal system of research, with priorities determined on the basis of specified indices.

It is intended to present successive reports as research and epidemiologic studies are completed and sampling and analytical methods are developed. Criteria and standards will be reviewed periodically to ensure continuing protection of the workers.

I am pleased to acknowledge the contributions to this report on ultraviolet radiation by my staff and the valuable, constructive comments by the Review Consultants on Ultraviolet Radiation, an ad hoc committee of the American Industrial Hygiene Association, and the American Medical Association Committee on Occupational Toxicology. The NIOSH recommendations for standards are not necessarily a consensus of all the consultants and professional societies that reviewed this criteria document on ultraviolet radiation. A list of the NIOSH Review Committee members and of the Review Consultants appears on page iii and iv.



Marcus M. Key, M.D.
Director, National Institute
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The Office of Research and Standards Development, National Institute for Occupational Safety and Health, had primary responsibility for development of the criteria and recommended standard for ultraviolet radiation. The Franklin Institute Research Laboratories developed the basic information for consideration by NIOSH staff and consultants under contract No. HSM-049-71-36. Robert E. Seiter served as criteria manager.

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CRITERIA DOCUMENT: RECOMMENDATIONS FOR AN OCCUPATIONAL EXPOSURE STANDARD FOR ULTRAVIOLET RADIATION

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I. 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 irradiance (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.

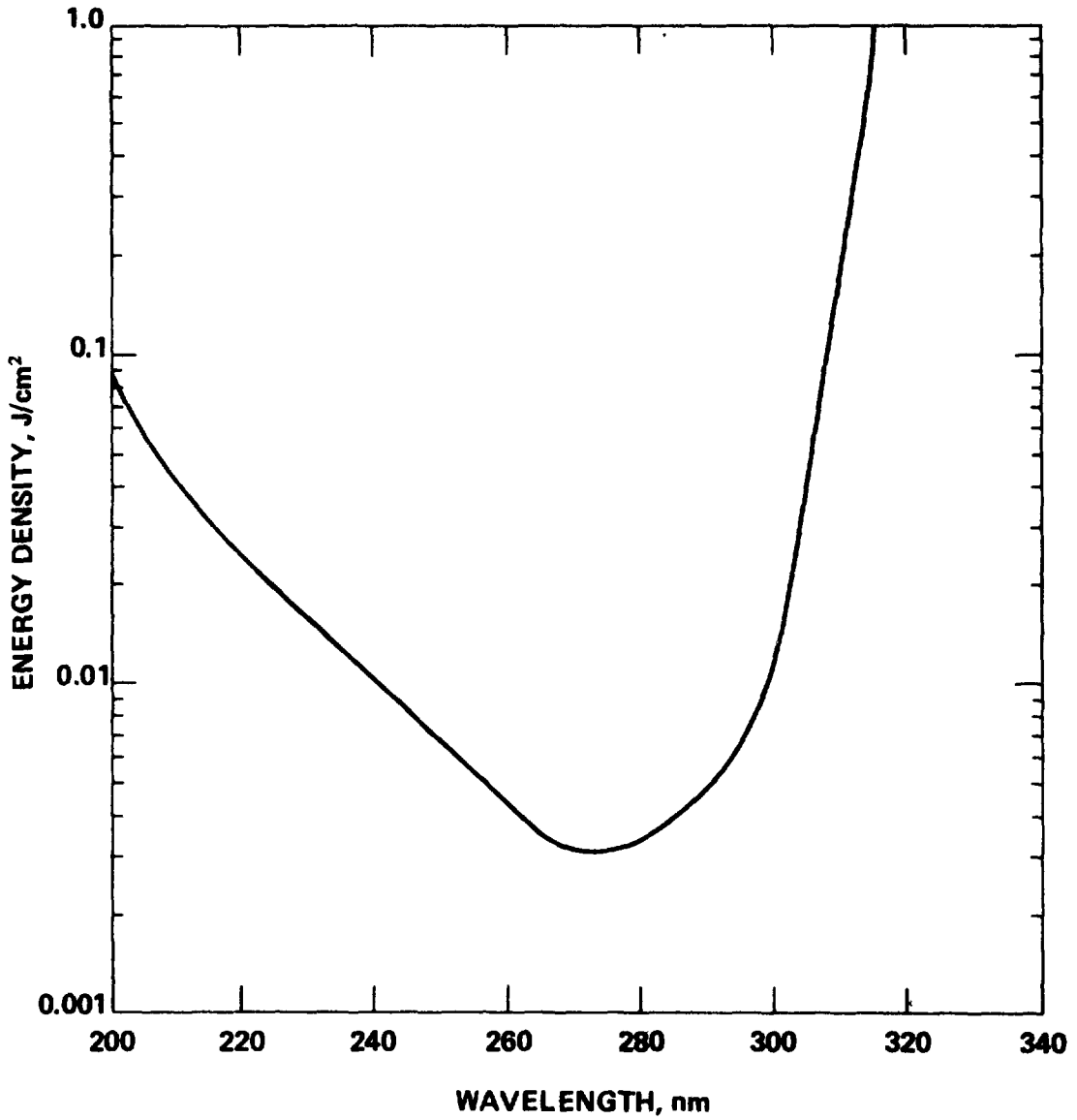

Figure I-1. Recommended Ultraviolet Radiation Exposure Standard
This figure was adapted from a figure developed and published by the American Conference of Governmental Industrial Hygienists in "Threshold Limit Values for Chemical Substances and Physical Agents in the Workroom Environment with Intended 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/cm^2)	Relative spectral effectiveness ($S\lambda$)
200	100.0	0.03
210	40.0	0.075
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.	5.0
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

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.

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 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 light-weight 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-intensity 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.

II. INTRODUCTION

This report presents the criteria and recommended standard based thereon which were prepared to meet the need for preventing impairment of health from occupational exposure to ultraviolet radiation. The criteria document fulfills the responsibility of the Secretary of Health, Education, and Welfare, under Section 20(a)(3) of the Occupational Safety and Health Act of 1970 to ". . . develop criteria dealing with toxic materials and harmful physical agents and substances which will describe . . . exposure levels at which no employee will suffer impaired health or functional capacities or diminished life expectancy as a result of his work experience."

The National Institute for Occupational Safety and Health formalized a system for the development of criteria upon which standards can be established to protect the health and safety of workers from exposure to hazardous chemical and physical agents. It should be pointed out that any criteria for a recommended standard should enable management and labor to develop better engineering controls and more healthful work practices and should not be used as a final goal.

The standard proposed is based on the results of numerous investigations of the effects of ultraviolet energy on skin and eyes, and is based on the eye as the most sensitive organ, so that protection of the eyes should result in a significant safety factor for the skin. Additionally, because of variations in pigmentation, skin thickness, normal clothing styles, and,

in the case of outdoor exposures, in insolation, an additional safety factor for skin protection is afforded many workers.

Prevention of the acute effects of ultraviolet radiation on skin and eyes should provide protection from chronic effects such as cataracts or skin cancer. However, it is believed more research into chronic effects of ultraviolet energy on skin and eyes is needed.

Because of the present difficulties in measurement of broadband ultraviolet energy pointed out in this document, evaluation for compliance is based on three different approaches: (1) utilization of available instrumentation wherever applicable with recognition of instrument shortcomings; (2) utilization of data on energy output from a specific source, such as lamps; and (3) utilization of the work practices when suitable instrumentation or energy output data are not available.

These criteria and recommended standard will be subject to review and will be revised when appropriate.