HAZARD EVALUATION AND TECHNICAL ASSISTANCE REPORT
HETA 90-122-L2073
TECHNICAL ASSISTANCE TO SAN FRANCISCO
GENERAL HOSPITAL AND MEDICAL CENTER
SAN FRANCISCO, CALIFORNIA
OCTOBER 1990

Hazard Evaluation and Technical Assistance Branch
Division of Surveillance, Hazard Evaluations and Field Studies
National Institute for Occupational Safety and Health
4676 Columbia Parkway
Cincinnati, Ohio 45226

HETA 90-122-L2073
OCTOBER 1990
SAN FRANCISCO GENERAL HOSPITAL
AND MEDICAL CENTER
SAN FRANCISCO, CALIFORNIA 94110

NIOSH INVESTIGATORS:
C. Eugene Moss
Teresa Seitz, CIH

I. BACKGROUND

On January 9, 1990, the National Institute for Occupational Safety and Health (NIOSH) received a request from the Director, Environmental Health and Safety (EHS), San Francisco General Hospital and Medical Center (SFGHMC) seeking assistance in documenting occupational ultraviolet (UV) radiation levels emitted by germicidal lamps. The request also asked for information that could be used for developing guidelines for the safe use and installation of such lamps. UV radiation measurements were made on all germicidal lamps at SFGHMC by NIOSH personnel on April 3-6, 1990.

The SFGHMC uses germicidal lamps to disinfect the air in their tuberculosis (TB) and aerosolized pentamidine clinics. Since SFGHMC provides care for large numbers of patients who may be at increased risk for TB, they have installed ceiling and wall-mounted UV lamps in an attempt to further reduce transmission of TB in clinics that these patients visit.

The germicidal lamp used in these facilities is a low-pressure mercury vapor lamp which is primarily a line, rather than broad band source, and emits UV and visible radiation at specific wavelengths. Over 95 percent of the radiant energy is emitted at a wavelength of 253.7 nanometers (nm). These lamps have been used for many years to aid in the control of TB by "disinfecting" the air. This evaluation addressed only occupational exposure to UV radiation emitted by germicidal lamps. The issue of efficacy in using these lamps to "disinfect" the air was not investigated. Further discussions about the effectiveness of such lamps to "disinfect" can be found in references 1-5.

II. EVALUATION CRITERIA

There is a potential hazard resulting from exposure to the UV radiation emitted from these lamp types. The critical organs of exposure for the 254 nm radiation from these lamps are the eye and skin. At this wavelength, the radiation is absorbed by the outer surfaces of the eye, and overexposure can result in inflammation of the cornea (photokeratitis) and/or conjunctiva (conjunctivitis). Keratoconjunctivitis is a reversible injury, lasting 24-48 hours, but it is a debilitating condition while it runs its course. There is a latent period of a few hours, depending on the dose, so it is sometimes not recognized as an occupational injury by the worker. Skin exposure to UV radiation can result in the familiar sunburn effect. This is also a reversible injury and the time course depends on the severity of the burn.

In 1972, NIOSH formulated criteria for a recommended standard for occupational exposure to UV radiation [6]. Pertinent sections of this standard are enclosed as Appendix I. This recommended standard is designed to protect the worker against the aforementioned eye and skin injury. The recommended standard is wavelength-dependent in the spectral region of interest and is based on an action spectrum established in human and animal studies. Recently the American Conference of Governmental Industrial Hygienists (ACGIH), whose Threshold Limit Value (TLV) is the same as the NIOSH recommended standard, has recommended a revision for certain wavelengths [7]. A copy of that draft revision is enclosed as Appendix II [8].

III. EVALUATION DESIGN AND METHODS

The measurement system consisted of a calibrated International Light (IL) radiometer, Model 700, connected to a SED240 detector incorporating a special diffuser/filter combination that permitted the system to read UV levels directly in units of biologic effective watts per square centimeter. The system was owned by the California Department of Health Services.

The measurement system used in this evaluation was compared with two NIOSH systems (both were IL model 730 with same detector/diffuser/filter combination) and found to yield the same value of irradiance using a germicidal lamp as the source. All instruments used in this evaluation had been calibrated within 6 months of use by the manufacturer.

UV radiation measurements were made at the edge of the germicidal lamp fixture (approximately 4 inches from the lamp), at a location near the installed lamp at a distance of one foot from the ceiling (to estimate the reflected level), and at the closest table top location where it was thought an occupational exposure could occur to health care workers. The lamp fixture measurement was taken to simulate a potential maintenance worker exposure for cleaning or lamp replacement duties. The measurements at one foot from the ceiling were chosen to simulate possible top of the head exposure levels due to ceiling reflections. The table top results provided an estimate of exposure involving desk or table work.

In the process of evaluating the UV radiation from germicidal lamps at SFGHMC, the NIOSH investigators made observations on how the lamp was installed and used, presence of protective equipment and warning signs, and other safety related issues. The Director, EHS, informed the NIOSH investigators that as of the date of these measurements there had been no staff TB seroconversions.

IV. DISCUSSION AND RESULTS

Maximum irradiance levels were documented since the lamps were not stable in their radiant output, probably due to aging characteristics. The levels of direct, reflected, and table top UV radiation measured at SFGHMC, as shown in Table 1, exceed the recommended 8-hour ACGIH TLV of 0.1 effective microwatt per square centimeter (uW/cm^2). These findings, concerning the potential for overexposure from germicidal lamps, are in agreement with previously published findings [9-10]. No attempt was made to determine how long a worker was in a given location since they move quite extensively in performing their duties. UV radiation levels close to the lamp source exceeded the TLV by at least 4000 times, while table top exposure levels exceeded the TLV by at least 2 times. Permissible exposure times in seconds, for exposure to far UV incident upon the unprotected skin or eye, are shown in Table 2. Using Table 2 and the results shown in Table 1, one can estimate the length of time an unprotected worker could stay at certain places within the rooms that contained these lamps without exceeding the NIOSH recommended exposure level. The maximum permissible exposure time in seconds for exposure to far UV radiation incident upon the unprotected skin or eye may be computed by dividing 0.003 joules per square centimeter (J/cm^2) by the maximum recorded effective irradiance (E_{eff}) level in watts per square centimeter (W/cm^2). When this is done, the highest level measured of 1200 microwatts per square centimeter (Uw/cm^2) at four inches corresponds to an exposure time of 2.5 seconds. The maximum ceiling reflected value of 2.3 Uw/cm^2 at one foot from the ceiling corresponds to an exposure time of about 22 minutes. If one assumes a male health care worker is 6 feet tall, then a head top exposure from this reflected UV beam, assuming inverse square law considerations, would be about 0.29 uW/cm^2, which exceeds the maximum recommended exposure for an 8-hour day. Taller workers would of course be more at risk. The table top maximum value of 0.7 uW/cm^2, shown in Table 2, is equivalent to about 72 minutes. Obviously, the closer the table top is to the lamp fixture the higher the exposure. These types of calculations can be used to determine relative placement of people and objects in the room to minimize exposure. They also suggest the use of control measures such as goggles, ceiling louvers, and thin plastic UV absorbing materials may be of benefit to workers.

The following observations were noted in rooms containing UV lamps:

Room #1

The first exposure situation was a room used to treat TB patients with aerosolized pentamidine (AP). The room was used by 1 to 4 patients simultaneously for 30 minutes, once a week. These patients sat in chairs about 8 feet from the lamp. During the treatment one health care worker, a respiratory therapist, was stationed in the room. AP treatments were being done 4 hours per day for one day a week, but would soon be extended to 2 days per week. As far as could be determined, there was no protective eyewear available in the room.

The room had one 30 watt germicidal lamp mounted on a side wall approximately 8 feet from an open window and at a height of 87 inches above the floor. The lamp was activated by a pullcord connected to a switch. It was not obvious how long the germicidal lamp had been in the lamp fixture but the bulb surface was quite dirty and the fixture holder needed to be cleaned. There was no lamp fixture interlock on the door nor were there any warning signs posted advising occupants as to the presence of UV radiation. There was, however, a small (2 inch) label affixed to the side of the lamp fixture housing the UV source. Unfortunately, this label could only be read at an extremely close distance to the fixture while standing on a ladder.

The room door was open and was reported by the hospital staff to remain so all the time. An open window provided the major source of ventilation when the weather was good. When the weather did not permit the use of the windows, then UV radiation was used to "disinfect" the room air. There is presently no exhaust air diffuser in the treatment room. It was reported that the UV lamp was never on when people were in the room, yet while the NIOSH investigators were there, the lamp remained on and patients were being treated.

Room #2

The second exposure situation was a room used for sputum induction. In this room a patient was given saline solutions to induce coughing for approximately 30 minutes total time. The health care worker, a nurse, set up the procedure for the patient and then left the room. The patient sat in a chair about 4 feet from a 30 watt germicidal lamp. As far as could be determined, there was no protective eyewear available in the room.

There was one 30 watt germicidal lamp mounted in a fixture on a side wall approximately 5 feet from an open window at a height of 93 inches above the floor. The lamp was activated by a wall switch located near the door. Unfortunately, there were three switches located in the same area which created confusion. The switches controlled the room light, the germicidal lamp, and the room exhaust fan. The fan was affixed over an opening in the only window in the room. There was no mechanical source of supply air in this room. When the fan was on, and the door closed, there was exhaust ventilation through this setup. However, when evaluated with smoke tubes, the exhaust ventilation was shown to be minimal at distances beyond three feet from the fan. It was not apparent whether or not the fan was turned on for every treated patient.

The hospital staff did not know how long the germicidal lamp had been in the lamp fixture, but it was obvious that it had been installed quite a long time since the bulb surface had darkened and the fixture holder needed to be cleaned. In addition, there was no lamp fixture interlock on the door and no warning sign posted advising as to the presence of UV radiation, nor was there any label affixed to the side of the lamp fixture housing the UV source.

Room #3

The third exposure situation was also a room used for sputum induction. This room was located on the same floor as Room #2 but also doubled as a men's bathroom. The patient sat on the commode that was located about 4 feet from a wall-mounted 30 watt germicidal lamp that was used during the treatment period. As with the prior situation, the nurse began the procedure and then left the room. As far as we could tell there was no Zprotective eyewear available.

The lamp fixture was mounted on a wall at a height of 86 inches above the floor. The lamp was activated by a wall switch located next to the door. The germicidal lamp and room light were activated by the same switch. No one knew how long the germicidal lamp had been in the lamp fixture but the bulb surface was quite dirty and the fixture holder needed to be cleaned. There was no lamp fixture interlock on the door nor were there any warning signs posted advising as to the presence of UV radiation.

There was an exhaust fan in the ceiling which was operational. When the bathroom door was closed, the room was under negative pressure with respect to the hallway. For reasons not fully understood, the wall area above the commode was covered with aluminum foil. The presence of the foil on the wall permitted increased reflectance of UV radiation.

Room #4

This area was used as an interview room for refugees. It was reported to the NIOSH investigators that about 50% of the refugees entering SFGHMC were TB positive. At least three or four immigration workers were stationed in the room at the same time. The refugees sat in chairs about 6 feet from the lamp. While no actual medical treatments were delivered to these people, the UV lamp was on during the interview process.

The interview room had one 30 watt germicidal lamp mounted in a fixture suspended from and aimed at the ceiling located 93 inches from the floor. This indirect lamp was always on, as there was no way to turn it off. No one knew how long the germicidal lamp had been in the lamp fixture, and there were no warning signs posted advising as to the presence of UV radiation.

As far as could be determined, there was no protective eyewear used in the room. The room door was open and remained so all the time. There were two exhaust diffusers in the ceiling that appeared to be operating but no air was being supplied to the room from the mechanical ventilation system. With the door opened, the room was under positive pressure with respect to the hall.

V. SUMMARY

Several items of interest were quite apparent from the room observations made at SFGHMC. First, there was no protective eyewear available in the rooms and none had been purchased by the safety department for use by workers exposed to UV radiation. Second, all rooms used a 30 watt germicidal lamp. A lower wattage bulb in these small rooms could have reduced the occupational UV exposure level. Third, bulb changers need to be aware of the need for protective clothing and gloves from both the UV radiation levels as well as possible glass breakage. As mentioned earlier, the levels of UV near the surface of the bulb will exceed the permissible exposure limit in as little as 2-3 seconds. Fourth, reflectance levels of UV radiation can be quite high and varied as shown in Table 1. While high reflectance may be desired for increasing the UV dose to air contaminants, it is not desirable from a unprotected worker skin and eye viewpoint. As shown in Table 3 different materials reflect UV at different levels (11). Fifth, worker exposure to germicidal lamp UV levels is dependent on many factors; however, some of the most important ones are position of the bulb in the room, age of the bulb, obstruction of the UV radiation by objects near the bulb, and height of the workers. Sixth, while no ozone measurements were made in this evaluation, it should be noted that some germicidal lamps do generate a small amount of 185 nm radiation, a wavelength that is responsible for producing ozone. Provisions may need to be made to ventilate this generated ozone. Seventh, information is not presently available regarding optimum ventilation conditions which allow good air mixing between the irradiated upper room air and the breathing zone of occupants in the lower room air zone, while at the same time providing a sufficient dose of UV radiation for effective killing of infectious droplet nuclei. While there are no consensus guidelines on ventilation systems designed for areas where germicidal lamps are used, the provision of good room air distribution and mixing is recommended to prevent stagnant air conditions or short-circuiting of supply air within the room. Additionally, the use of local exhaust ventilation (booths, hoods) may be appropriate in some situations to contain contaminants generated during certain procedures such as aerosolized drug treatments and sputum induction procedures.

It should also be noted that since the UV radiation produced by these lamps can represent an occupational exposure situation while disinfecting the air at the same time, care must be taken in the selection of the instrumentation used to quantify the energy of the source. This means that whatever instrumentation is used must have the correct spectral range to match the unique source output. In addition, awareness of the solarization and aging properties of lenses, tube envelopes, and detector components must be given. Often high concentrations of water vapor in the atmosphere may cause absorption of the UV energy.

Finally, it should be recognized that numerous epidemiological studies (6) have indicated chronic exposure to UV radiation (at wavelengths less than 290 nm) is associated with the induction of skin cancer. In view of health care workers exposed to high levels of UV radiation (at 254 nm) from germicidal lamps, it is recommended that indiscriminate use of these lamps be stopped. Exposure to health care workers from these sources should be reduced to the lowest feasible level using appropriate engineering controls and work practices.

VI. RECOMMENDATIONS

As stated earlier, this evaluation addresses only occupational exposure concerns from germicidal lamps at SFGHMC and does not deal with the effectiveness or use of such lamps. If the lamps are used, then, the following specific recommendations are offered to reduce potentially significant occupational exposure to UV radiation:

1. There should be a uniform policy as to when germicidal lamps are to be replaced. This could be determined from either a time/use log or a system based on cumulative time.

2. A training course should be provided to lamp replacers to insure awareness of the potential health hazards.

3. Under no conditions should germicidal lamps be used as replacement lamps for conventional fluorescent lamps. If this were to happen, there could be widespread public and/or occupational problems [12].

4. There should be a policy on how to label these UV lamps, including the use of warning signs on doors.

5. The possible use of door interlocks as a control measure to minimize health care worker exposure should be considered. In particular, if the UV lamps were connected to a door switch, then they could only become activated when the door was closed. If the door was opened, the lights would go off. If such a system was also put on a timer, then minimum exposure to personnel would occur.

6. The importance of ventilation as a combined control measure should not be underestimated. This includes the provision of good air distribution and mixing. The rooms evaluated during this survey were not optimal from a ventilation design standpoint, as doors and windows were used as supplemental ventilation, and supply or exhaust air diffusers were not always present.

7. All highly UV reflecting material (i.e. aluminum foil) used in the various rooms with these lamps should be removed or replaced with non-UV reflecting materials

8. If personnel are to work in rooms having activated germicidal lamps, then wearing of UV protective eyewear and equipment is necessary.

9. Equipment used to measure germicidal UV radiation should be maintained and calibrated on a regular schedule.

10. Ozone measurements may be necessary to perform when multiple lamps are used within a restricted area.

VII. REFERENCES

1. Riley, R. L. and Nardell, E. A. Clearing the air: The theory and application of ultraviolet air disinfection. Am. Rev. Respir. Dis. 139: 1286-1294, 1989.

2. Hart, D. Bactericidal Ultraviolet Radiation in the Operating Room. Twenty-nine year study for Control of Infections. JAMA 172(10): 109-118/1019-1028, 1960.

3. Hart, D. and Nicks, J. Ultraviolet Radiation in the Operating Room-Intensities Used and Bactericidal Effects. Archs.Surgery 82:449-465, 1961.

4. Wulf, H. C. Work in Ultraviolet Radiation. Contact Dermatitis 6(1):72-76, 1980.

5. Berg, M. and Cederblad, A. Ultraviolet Radiation in Operating Rooms. Human Exposure to Ultraviolet Radiation. Risks and Regulations, W. F. Passchier and B. F. M. Bosnjakovic, Editors; Excerpta Medica, Amsterdam, International Congress Series 744: 359-363, 1987.

6. National Institute for Occupational Safety and Health. Criteria for a recommended standard occupational exposure to ultraviolet radiation. Cincinnati, OH. NIOSH, 1972.

7. American Conference of Governmental Industrial Hygienists. Documentation of the threshold limit values, 4th ed. Cincinnati, OH. ACGIH, 1984.

8. American Conference of Governmental Industrial Hygienists. Threshold limit values and biological exposure indices for 1989-1990. Cincinnati, OH. ACGIH, 1989.

9. Murray, W. E. Ultraviolet radiation exposures in a mycobacteriology laboratory. Health Physics 58 (4):507-510, 1990.

10. Gulvady, N. U. UV Keratoconjunctivitis Vs. Established Dose Effect Relationship. J. Occ. Medicine 18(8):573, 1976.

11. Ullrich, O.A. and Evans, R. M. Ultraviolet Reflectance of Paints. A special study done by Battelle in Columbus, Ohio for the American Welding Society, August, 1976.

12. Rose, R.C. and Parker, R.L. Erythema and conjunctivitis. Outbreak caused by inadvertent exposure to ultraviolet light. JAMA 242(11):1155-1156, September 1979.

TABLE I

Maximum Readings Obtained in
Medical Center Rooms

SFGHMC
San Francisco, CA
HETA 90-122
April 3-6, 1990

Location	Room Size (ft^2)	No. of Lamps*	Distance from Floor (inches)	Distance from Ceiling (inches)	UV irradiance (uW/cm^2) 4" from lamp	UV irradiance (uW/cm^2) ceiling reflected	UV irradiance (uW/cm^2) table top
Room 1	150	1	87	19	1200	2.3	0.5
Room 2	76	1	93	25	500	0.9	0.2
Room 3	40	1	86	30	400	1.0	0.7
Room 4	120	1	93	22	z	0.7	0.3

* All lamps in fixtures were rated 30 watts
+ Values expressed in effective biological units
x Reflected ceiling level acquired at one foot from ceiling
y Table top levels measured where health care workers would sit.
z Could not measure

TABLE II

Permissible exposure time to
far UV Radiation

SFGHMC
San Francisco, CA
HETA 90-122
April 3-6, 1990

Duration of Exposure Per Day	Effective Irradiance (uW/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
5 min	10
1 min	50
30 sec	100
10 sec	300
1 sec	3,000
0.5 sec	6,000
0.1 sec	30,000

TABLE III

Reflectance of 253.7 nm Radiation from Selected Surfaces at Normal Incidence

SFGHMC
San Francisco, CA
HETA 90-122
April 3-6, 1990

Material	Percent Reflectance(%)
Aluminum foil	73
Chromium	45
Nickel	38
Stainless Steel	20-30
Silver	22
White wall plaster	40-60
White paper	25
White cotton	30
Glass	4
Water paints	10-30
Titanium oxide	6

Data for this reference taken from References 3 and 6.

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/cm² for periods greater than 1000 seconds, and for exposure times of 1000 seconds or less the total radiant energy shall not exceed 1000 mW·sec/cm² (1.0 J/cm²).

(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 broadband 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/cm², the permissible dose of 270-nm radiation, by I_{eff} in W/cm².

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

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

I_λ = spectral irradiance in W/cm²/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 μW/cm².

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.

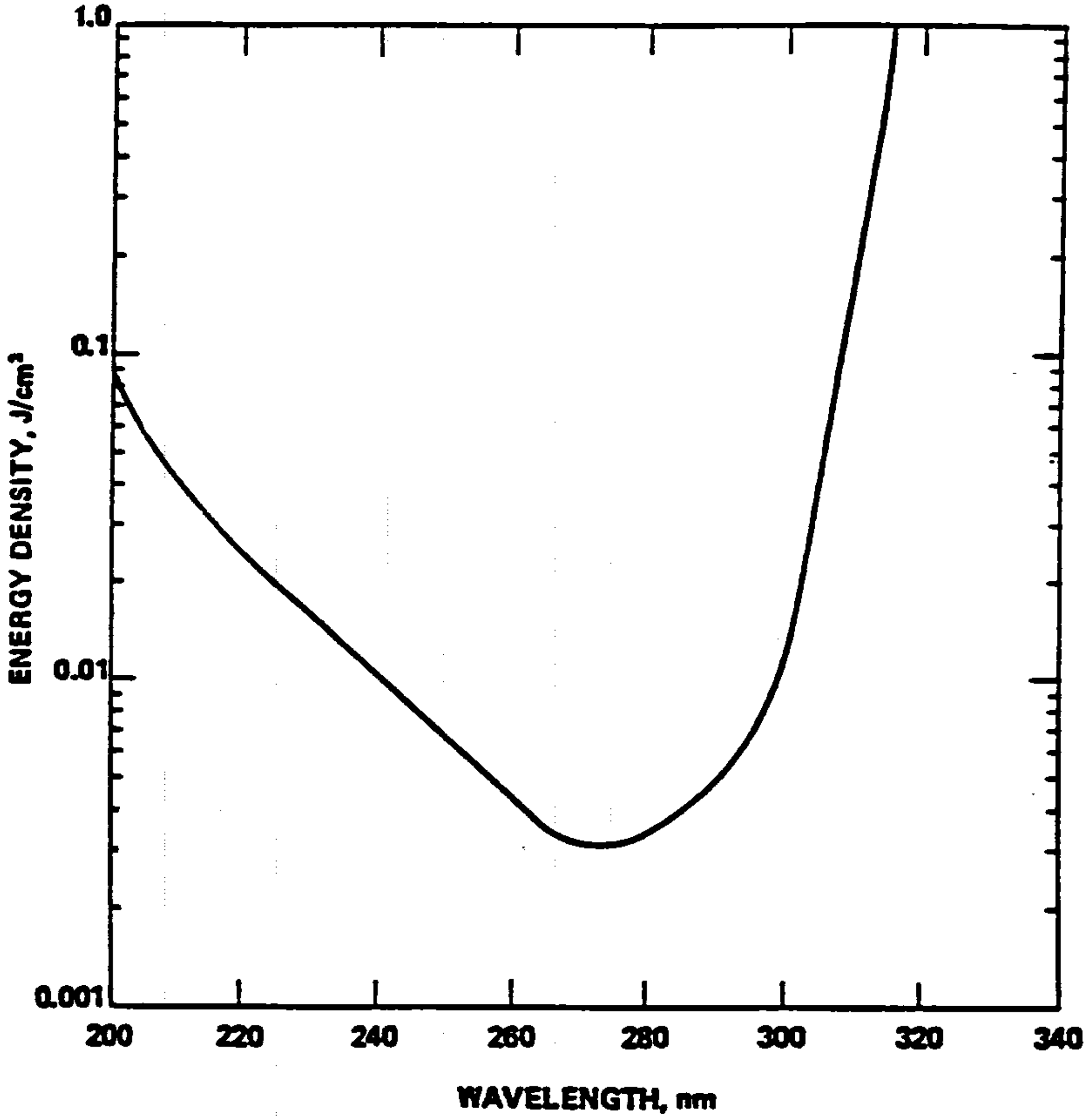

Figure I-1. Recommended Ultraviolet Radiation Exposure Standard
This figure was adapted from a figure developed and published by the American Conference of Governmental Industrial Hygienists in "Threshold Limit Values for Chemical Substances and Physical Agents in the Workroom Environment with Intended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

NOTICE OF INTENDED CHANGES (for 1989-90)

These physical agents, with their corresponding values, comprise those for which either a limit has been proposed for the first time, or for which a change in the "Adopted" listing has been proposed. In both cases, the proposed limits should be considered trial limits that will remain in the listing for a period of at least one year. If after one year no evidence comes to light that questions the appropriateness of the values herein, the values will be reconsidered for the the "Adopted" list.

ULTRAVIOLET RADIATION

The Committee voted to recommend a revision to the TLV for ultraviolet radiation (UV) in the UV-A band (315–400 nm) to more accurately reflect current biological data. This revision relaxes the limits for longer wavelengths and reduces the limits for the shorter UV-B wavelengths for lengthly exposures. The revision is as follows:

These Threshold Limit Values (TLVs) refer to ultraviolet radiation in the spectral region between 180 and 400 nm and represent conditions under which it is believed that nearly all workers may be repeatedly exposed without adverse effect. These values for exposure of the eye or the skin apply to ultraviolet radiation from arcs, gas and vapor discharges, fluorescent and incandescent sources, and solar radiation, but they do not apply to ultraviolet lasers (see the TLVs for Lasers). These values do not apply to ultraviolet radiation exposure of photosensitive individuals or of individuals concomitantly exposed to photosensitizing agents.[1] These exposures to the eye do not apply to aphakics. These values should be used as guides in the control of exposure to continuous sources where the exposure durations shall not be less than 0.1 sec.

These values should be used as guides in the control of exposure to ultraviolet sources and should not be regarded as a fine line between safe and dangerous levels.

Recommended Values

The threshold limit values for occupational exposure to ultraviolet radiation incident upon skin or eye where irradiance values are known and exposure time is controlled are as follows:

1. For the near ultraviolet spectral region (320 to 400 nm), total irradiance incident upon the unprotected skin or eye should not exceed 1.0 mW/cm² for periods greater than 10^3 seconds (approximately 16 minutes) and for exposure times less than 10^3 seconds should not exceed 1.0 J/cm².

2. The ultraviolet radiant exposure incident upon the unprotected skin or eye should not exceed the values given in Table 16 or Figure 11 within an 8-hour period.
3. To determine the effective irradiance of a broadband source weighted against the peak of the spectral effectiveness curve (270 nm), the following weighting formula should be used:

$$E_{eff} = \Sigma E_\lambda S_\lambda \Delta\lambda$$

where:

E_{eff} = effective irradiance relative to a monochromatic source at 270 nm in W/cm² (J/s/cm²)

E_λ = spectral irradiance in W/cm²/nm

S_λ = relative spectral effectiveness (unitless)

$\Delta\lambda$ = band width in nanometers

4. For most white-light sources and all open arcs, the weighting of spectral irradiance between 200 and 315 nm should suffice to determine the effective irradiance. Only specialized UV sources designed to emit UV-A radiation would normally require spectral weighting from 315 to 400 nm.
5. Permissible exposure time in seconds for exposure to actinic ultraviolet radiation incident upon the unprotected skin or eye may be computed by dividing 0.003 J/cm² by E_{eff} in W/cm². The exposure time may also be determined using Table 17 which provides exposure times corresponding to effective irradiances in μW/cm².
6. All the preceding TLVs for ultraviolet energy apply to sources which subtend an angle less than 80°. Sources which subtend a greater angle need to be measured only over an angle of 80°.

Conditioned (tanned) individuals can tolerate skin exposure in excess of the TLV without erythemal effects. However, such conditioning may not protect persons against skin cancer.

Reference

1. *Sunlight and Man.* Fitzpatrick *et al*, Eds. Univ. of Tokyo Press, Tokyo, Japan (1974).

Table 17 and Figure 11 remain the same as they appear on pages 113 and 114, respectively

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 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-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.

TABLE 16
Ultraviolet Radiation Exposure TLV and
Spectral Weighting Function

Wavelength* (nm)	TLV (J/m²)	TLV (mJ/cm²)	Relative Spectral Effectiveness S_λ
180	2,500	250	0.012
190	1,600	160	0.019
200	1,000	100	0.030
205	590	59	0.051
210	400	40	0.075
215	320	32	0.095
220	250	25	0.120
225	200	20	0.150
230	160	16	0.190
235	130	13	0.240
240	100	10	0.300
245	83	8.3	0.360
250	70	7.0	0.430
254#	60	6.0	0.500
255	58	5.8	0.520
260	46	4.6	0.650
265	37	3.7	0.810
270	30	3.0	1.000
275	31	3.1	0.960
280#	34	3.4	0.880
285	39	3.9	0.770
290	47	4.7	0.640
295	56	5.6	0.540
297#	65	6.5	0.460
300	100	10	0.300
303#	250	25	0.190
305	500	50	0.060
308	1,200	120	0.026
310	2,000	200	0.015
313#	5,000	500	0.006
315	1.0×10^4	1.0×10^3	0.003
316	1.3×10^4	1.3×10^3	0.0024
317	1.5×10^4	1.5×10^3	0.0020
318	1.9×10^4	1.9×10^3	0.0016
319	2.5×10^4	2.5×10^3	0.0012
320	2.9×10^4	2.9×10^3	0.0010
322	4.5×10^4	4.5×10^3	0.00067

TABLE 16 (con't)
Ultraviolet Radiation Exposure TLV and
Spectral Weighting Function

Wavelength* (nm)	TLV (J/m²)	TLV (mJ/cm²)	Relative Spectral Effectiveness S_λ
323	5.6×10^4	5.6×10^3	0.00054
325	6.0×10^4	6.0×10^3	0.00050
328	6.8×10^4	6.8×10^3	0.00044
330	7.3×10^4	7.3×10^3	0.00041
333	8.1×10^4	8.1×10^3	0.00037
335	8.8×10^4	8.8×10^3	0.00034
340	1.1×10^5	1.1×10^4	0.00028
345	1.3×10^5	1.3×10^4	0.00024
350	1.5×10^5	1.5×10^4	0.00020
355	1.9×10^5	1.9×10^4	0.00016
360	2.3×10^5	2.3×10^4	0.00013
365#	2.7×10^5	2.7×10^4	0.00011
370	3.2×10^5	3.2×10^4	0.000093
375	3.9×10^5	3.9×10^4	0.000077
380	4.7×10^5	4.7×10^4	0.000064
385	5.7×10^5	5.7×10^4	0.000053
390	6.8×10^5	6.8×10^4	0.000044
395	8.3×10^5	8.3×10^4	0.000036
400	1.0×10^6	1.0×10^5	0.000030

* Wavelengths chosen are representative; other values should be interpolated at intermediate wavelengths.

\# Emission lines of a mercury discharge spectrum

NOTICE OF INTENT TO ESTABLISH THRESHOLD LIMIT VALUES

LIGHT AND NEAR-INFRARED RADIATION

These Threshold Limit Values (TLVs) refer to visible and near-infrared radiation in the wavelength range of 400 nm to 1400 nm and represent conditions under which it is believed that nearly all workers may be exposed without adverse effect. These values should be used as guides in the control of exposure to light and should not be regarded as a fine line between safe and dangerous levels.