THRESHOLD LIMIT VALUES FOR ULTRAVIOLET RADIATION MEASURED FOR SOURCES USED IN RESEARCH EQUIPMENT AND SOME CASES OF OVEREXPOSURE TO UV RADIATION

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ABSTRACT

The standard for occupational exposure to ultraviolet radiation is based on the Threshold Limit Values (TLV) published by the American Conference of Governmental Industrial Hygienists. These TLV are relative to a monochromatic source of radiation at 270nm. The exposure at this wavelength in 8h is 30 Jm^{-2} and the effective irradiance which will produce this exposure in 1 milliwatt m^{-2}. TLV have been measured for a range of ultraviolet sources used widely in educational establishments. Some cases are given of over exposure resulting in 5 - 35 Threshold Limit Values being received to the face and eyes.

INTRODUCTION

The Occupational Exposure Standard for protection against ultraviolet radiation adopted in the United States of America and accepted by the United Kingdom Health and Safety Executive for protection against ultraviolet radiation was produced by the American Conference of Governmental Industrial Hygienists (AGGIH).

The standard[1] which applies both to the skin and eyes is based on the threshold limit value for the eyes, and whilst it overprotects the skin of most individuals it should protect the eyes satisfactorily.

ACGIH Recommendations for the actinic region 200 - 315 nm

The TLV vary with wavelength. TLV for the actinic ultraviolet region 200-315nm are shown in Table 1.

Maximum permissible exposure for 8 hours at 270 nm = 30Jm^{-2} (Compare this with a threshold[2] for Infra Red exposure of the cornea of 6 x 10^4 Jm^{-2}

λnm	TLV Jm^{-2}	Sλ
200	1,000	0.03
220	250	0.12
240	100	0.30
260	46	0.65
270	30	1.00
280	34	0.88
290	47	0.64
300	100	0.30
310	2,000	0.015
315	10^4	0.003

The effective irradiance for the ultraviolet source is defined by the following equation

$$E_{eff} = E \quad S \quad d \quad \text{in} \quad Wm^{-2}$$

$E\lambda$ = Irradiance at wavelength
$S\lambda$ = Relative spectral effectiveness (relative to 270nm)
$d\lambda$ = Wavelength interval of
E_{eff} = Effective irradiance relative to a monochromatic source at 270nm

The effective irradiance for a period of 8 hours in l milliwatt m^{-2}. The exposure time in an eight hour period for other values of effective irradiance is given by

$$t(secs) = \frac{30}{E_{eff}(Wm^{-2})}$$

The relative spectral effectiveness $S\lambda$ is the factor which allows for the differing biological sensitivity of the skin and eyes against λ. $S\lambda$ is based on data determined for primates, rabbits and human exposure of the eye near the threshold.

ACGIH Recommendation for UVA region 315-400nm

1989-90 proposals for the TLV for the UVA region are as follows

λ nm	TLV Jm^{-2}	$S\lambda$
315	1×10^4	0.003
320	2.9×10^4	0.001
330	7.3×10^5	0.00041
340	1.1×10^5	0.00028
350	1.5×10^5	0.0002
360	2.3×10^5	0.00013
365	2.7×10^5	0.00011
370	3.2×10^5	0.000093
380	4.7×10^5	0.000064
390	6.8×10^5	0.000044
400	1×10^6	0.000030

Measurement of Effective Irradiance and Threshold Limit Values

The effective irradiance can be determined by two methods

(i) Measuring the irradiance at Wavelength λ multiplying this by $S\lambda$ and integrating this product over the spectral output of the lamp:

(ii) Measuring the effective irradiance directly using an instrument where response matches the relative spectral effectiveness curve defined by ACGIH.

The International Light Radiometer 1L730A[3] is an instrument that will, using a suitable detector, measure the effective irradiance directly for the region 200-315nm.

The detector used to undertake the measurements below was a type PT171D which is essentially a vacuum photodiode with a filter assembly. The detector response ideally should match the relative spectral effectiveness curve ($S\lambda$) of ACGIH.

Sources of ultraviolet radiation and their outputs.

The equipment has been grouped into categories.

Low output (1 - 100) x TLV

Hilger Atomic absorption spectrometer		2 x TLV
Hilger DC Spectrograph with carbon-graphite electrodes		40 x TLV
Hilger DC Spectrograph with carbon-graphite electrodes		17 x TLV
Aminco Colorimeter Hg lamp F4T4 BL		6 x TLV
Desaga UVIS Chromatogram Viewer Sylvania F85T/BLB lamp(10cm)		80 x TLV

Medium Output 100 - 1000 TLV

Isco UV flow monitor		168 x TLV
Philips Hg Type MB/U 400W	(25cm)	800 x TLV
Philips Hg Type MLU 300W	(25cm)	600 x TLV
Pen-ray UV Mineralight Hg lamp	(20cm)	160 x TLV

High Output > 1,000 TLV

Hanovia Portable Chromatolite Hg lamp		
with filter in place at (4cm)		2,500 TLV
with filter removed at (4cm)		26,000 TLV
Hilger Spectrograph Fe electrodes		2,600 TLV
Camag Universal Lamp (Sylvania G8T5)		
with filter (4cm)		3,400 TLV
no filter (4cm)		15,000 TLV
Desaga UVIS Chromatogram Viewer G8T5 (Germicidal lamp) 254		1,400 TLV
Hanovia Alpine Sun Lamp	(50cm)	8,000 TLV
Parker Printing Plate Machine		3,500 TLV
Sterilising Cabinet Philips TUV 30w Germicidal lamp	(25cm)	6,000 TLV
Philips TUV 15w lamp	(25cm)	1,600 TLV
Sterilisation Cabinet Sylvania G15T8	(25cm)	3,300 TLV

UV Microscopes

The output from UV microscope depends on the lamp and its power. The lamps are enclosed but leakage of UV may take place from the lamp housing. The leakage is usually low in intensity or is inaccessible and hence the hazard is small.

Occupational Over Exposure of Ultraviolet Radiation

Case 1

This involved a worker using a high intensity Hg/Xenon lamp.
The lamp was housed inside an apparatus at about 2 metres from the floor some leakage took place. No estimate of the worker exposure could be made he sustained a small erythema on his forehead.

Case 2

An electrician was asked to replace a fluorescent tube in a sterilisation cabinet. The cabinet contained a visible light fluorescent tube and a germicidal UV lamp TUV 30W. The electrician worked for a period of about 15 minutes unaware that the UV lamp was switched on. Later the same day he suffered severe photophobia and photokeratitis. Subsequently it was estimated that the effective irradiance was 1.2 W m^{-2} which corresponds to an exposure time of 25 seconds in an 8 hour period. The electrician thus received about 35 x TLV.

Case 3

A research technician was working with a clean air cabinet containing a UV germicidal lamp (TUV 30w). The technician worked for a period of about 20 minutes during which time her eyes were probably about 170 mm from the lamp and it was estimated that the effective irradiance was 1.4×10^{-1} Wm^{-2}. The technician suffered slight erythema of the skin of the face and mild irritation of the eyes. It was estimated the worker received about 5 x TLV.

Conclusions

Some equipment measured doses have a potentially hazardous high level output of UV radiation. Control of such sources of radiation is needed. The cases of over exposure considered suggests that the threshold limit values given by ACGIH are set at a reasonable value.

References

1. Threshold Limit Values and Biological Exposure Indices for 1989-1990 published by the American Conference of Governmental Industrial Hygienist Cincinnati, Ohio, ISBN 0 - 936712 - 81- 3.

2. Evaluation of Ocular Hazards Due to Electric Arc Flash at an in-line switch B.R. Chou and A.P. Cullen. Health Physics Vol. 61 No. 4 p473-479, 1991.

3. International Light. Incorporated Newburyport, Maryland, MA 01950USA.