



**Australian Government**

**Australian Radiation Protection and Nuclear Safety Agency**

**[Consultation Draft – August 2005]**

## **Radiation Protection Standard**

# Occupational Exposure to Ultraviolet Radiation

Radiation Protection Series Publication No. #

## Radiation Protection Series

The *Radiation Protection Series* is published by the Australian Radiation Protection and Nuclear Safety Agency (ARPANSA) to promote practices that protect human health and the environment from the possible harmful effects of radiation. ARPANSA is assisted in this task by its Radiation Health and Safety Advisory Council, which reviews the publication program for the *Series* and endorses documents at the Radiation Protection Standards level, and by its Radiation Health Committee, which oversees the preparation of draft documents and recommends publication.

There are four categories of publication in the *Series*:

**Radiation Protection Standards** set fundamental requirements for safety. They are prescriptive in style and may be referenced by regulatory instruments in State, Territory or Commonwealth jurisdictions. They may contain key procedural requirements regarded as essential for best international practice in radiation protection, and fundamental quantitative requirements, such as exposure limits.

**Codes of Practice** are also prescriptive in style and may be referenced by regulations or conditions of licence. They contain practice-specific requirements that must be satisfied to ensure an acceptable level of safety in dealings involving exposure to radiation. Requirements are expressed in ‘must’ statements.

**Recommendations** provide guidance on fundamental principles for radiation protection. They are written in an explanatory and non-regulatory style and describe the basic concepts and objectives of best international practice. Where there are related **Radiation Protection Standards** and **Codes of Practice**, they are based on the fundamental principles in the **Recommendations**.

**Safety Guides** provide practice-specific guidance on achieving the requirements set out in **Radiation Protection Standards** and **Codes of Practice**. They are non-prescriptive in style, but may recommend good practices. Guidance is expressed in ‘should’ statements, indicating that the measures recommended, or equivalent alternatives, are normally necessary in order to comply with the requirements of the **Radiation Protection Standards** and **Codes of Practice**.

In many cases, for practical convenience, prescriptive and guidance documents which are related to each other may be published together. A **Code of Practice** and a corresponding **Safety Guide** may be published within a single set of covers.

All publications in the *Radiation Protection Series* are informed by public comment during drafting, and **Radiation Protection Standards** and **Codes of Practice**, which may serve a regulatory function, are subject to a process of regulatory review. Further information on these consultation processes may be obtained by contacting ARPANSA.



**Australian Government**

**Australian Radiation Protection and Nuclear Safety Agency**

## **Radiation Protection Standard**

# Occupational Exposure to Ultraviolet Radiation

Radiation Protection Series Publication No. #

This publication was approved by the Radiation Health Committee on dd mmmm yyyy, and the Radiation Health & Safety Advisory Council, at its meeting on dd mmmm yyyy, advised the CEO to adopt the Standard.

## NOTICE

© Commonwealth of Australia 2005

This work is copyright. Apart from any use as permitted under the *Copyright Act 1968*, no part may be reproduced by any process without prior written permission from the Commonwealth available from the Attorney-General's Department. Requests and inquiries concerning reproduction and rights should be addressed to:

Commonwealth Copyright Administration  
Attorney-General's Department  
Robert Garran Offices  
National Circuit  
Barton ACT 2600

URL: [www.ag.gov.au/cca](http://www.ag.gov.au/cca)

Email: [commonwealth.copyright@ag.gov.au](mailto:commonwealth.copyright@ag.gov.au)

Requests for information about the content of this publication should be addressed to the Secretariat, ARPANSA, 619 Lower Plenty Road, Yallambie, Victoria, 3085 or by e-mail to [secretariat@arpansa.gov.au](mailto:secretariat@arpansa.gov.au).

ISBN ???????

ISSN 1445-9760

The mission of ARPANSA is to provide the scientific expertise and infrastructure necessary to support the objective of the ARPANS Act — to protect the health and safety of people, and to protect the environment, from the harmful effects of radiation.

Published by the Chief Executive officer of ARPANSA in MMM YYYY

## 1 **Foreword**

2  
3 This document was drafted after a review of the UVR guidelines issued by the  
4 International Non-Ionizing Radiation Committee of the International  
5 Radiation Protection Association (IRPA) and its successor the International  
6 Committee on Non-Ionizing Radiation Protection (ICNIRP), which recently  
7 reassessed the original UVR exposure limits. First drafts of the document  
8 were circulated to the Radiation Health Committee for comment and  
9 discussed by the full committee at their meetings during 2000.

10  
11 This publication replaces the previous standard issued by the National Health  
12 and Medical Research Council as RADIATION HEALTH SERIES No.29  
13 *Occupational standard for exposure to ultraviolet radiation (1989)*.

14  
15 This Radiation Protection Standard limits the occupational exposure to  
16 ultraviolet radiation for artificial sources in the workplace, considered to be a  
17 controlled environment and provides guidance on minimizing a person's  
18 exposure to uncontrollable sources of UVR, such as the sun. While mandatory  
19 application of the limits for exposure to solar ultraviolet radiation to outdoor  
20 workers is difficult in practice, it is important to limit UVR exposures by using  
21 engineering and administrative controls as well as personal protection. The  
22 UVR exposure limits are set to levels where it is believed that nearly all  
23 workers may be repeatedly exposed without adverse effect.

24  
25 The Standard was developed by a Working Group of the Radiation Health  
26 Committee after a comprehensive review of existing international standards  
27 and guidelines and their associated scientific literature. The document was  
28 reviewed by the Radiation Health Committee and then circulated for public  
29 comment from June–August 2003.

30  
31 The comments received were reviewed by the working group, and the final  
32 Standard was adopted by the Radiation Health Committee on (date). The  
33 Radiation Health and Safety Advisory Council advised the CEO to adopt the  
34 Standard on (date).

35  
36 The Standard will be reviewed from time to time to ensure that it continues to  
37 provide the highest standards of protection.

38  
39  
40  
41 **[signature]**

42  
43  
44 John Loy  
45 CEO of ARPANSA  
46  
47

48  
49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60  
61  
62  
63  
64  
65  
66  
67  
68  
69  
70  
71  
72  
73  
74  
75  
76  
77  
78  
79  
80  
81

# Contents

<b>Foreword .....</b>	<b>iii</b>
<b>1. Introduction.....</b>	<b>1</b>
1.1 CITATION.....	1
1.2 BACKGROUND .....	1
1.3 PURPOSE .....	2
1.4 SCOPE .....	2
1.5 STRUCTURE .....	3
1.6 INTERPRETATION.....	3
<b>2. Duties and Responsibilities .....</b>	<b>4</b>
2.1 EMPLOYERS’ DUTIES .....	4
2.2 EMPLOYEES’ DUTIES.....	4
<b>3. Protection from occupational exposure to UVR sources.....</b>	<b>5</b>
3.1 MANAGING RISK IN OCCUPATIONAL UVR EXPOSURE.....	5
3.2 PROVISION OF INFORMATION TO EMPLOYEES.....	6
3.3 POST INCIDENT EXPOSURE MANAGEMENT .....	7
3.4 ADDITIONAL REQUIREMENTS FOR OCCUPATIONAL EXPOSURE TO ARTIFICIAL SOURCES OF UVR .....	7
3.5 ADDITIONAL REQUIREMENTS FOR OCCUPATIONAL EXPOSURE TO SOLAR UVR .....	8
<b>Schedule 1 Exposure Limits (EL).....</b>	<b>9</b>
<b>References.. .....</b>	<b>13</b>
<b>Glossary..... .....</b>	<b>15</b>
<b>Annex 1 Rationale for Limiting Exposure to UVR.....</b>	<b>16</b>
<b>Annex 2 Health effects of UVR .....</b>	<b>17</b>
<b>Annex 3 Limiting Excessive Exposure to Ultraviolet Radiation (UVR) in the Workplace .....</b>	<b>20</b>
<b>Annex 4 ARPANSA Radiation Protection Series Publications..</b>	<b>25</b>
<b>Annex 5 Radiation Protection Authorities.....</b>	<b>27</b>
<b>Annex 6 Regulatory Authorities .....</b>	<b>28</b>
<b>Contributors to Drafting and Review .....</b>	<b>29</b>
<b>Index..... .....</b>	<b>30</b>

# 1. Introduction

## 1.1 CITATION

This Radiation Protection Standard may be cited as the *Radiation Protection Standard for Occupational Exposure to Ultraviolet Radiation (2005)*.

## 1.2 BACKGROUND

Australians are predominantly a fair skinned population and enjoy an outdoor lifestyle and each year there are approximately 370,000 new cases of skin cancer diagnosed in Australia. Although some types of skin cancers are relatively easy to treat if detected early, there are over 1200 fatal cases of skin cancer each year. Avoidance of sun exposure, wearing clothing with good body coverage, a broad brimmed hat, wrap around sunglasses and sunscreen are all major factors in preventing UVR exposure and skin cancer.

Exposure to solar ultraviolet radiation is the predominant cause of skin cancer in populations of European origin, particularly when the sun is highest in the sky, such as in summer during the middle of the day and limiting UVR exposures at these times has the greatest potential for reducing skin cancer incidence (IARC 92, Hill, Elwood & English 2004). The best approach to implementing successful strategies in reducing skin cancer will be to encourage sun protection policies and practices that reduce sun exposure in both occupational and recreational activities (IARC 92, Hill, Elwood & English 2004). An exposure standard that encourages UVR exposures to be less than that required to obtain observable biological effects is a key to reducing occupational exposures.

UVR exposure also places our eyes at risk of photokeratitis, photoconjunctivitis and cataracts. Prolonged exposure to UVR can have serious consequences for the eyes. Wearing wrap around sunglasses and a broad brimmed hat can prevent most of the UVR from reaching the eyes.

UVR can be produced by various artificial sources but for most people the sun is the predominant source of exposure to UVR. For outdoor workers without adequate protection or control measures the levels of solar UVR exposure may exceed the exposure limits set out in this Standard. Many workers, in particular those exposed to solar UVR, may not be using adequate protection against UVR.

This Standard is based on the recommendations of the International Non-Ionizing Radiation Committee of the International Radiation Protection Association (IRPA/INIRC 1989), which were a modification to their original guidelines proposed in 1985 (IRPA/INIRC 1985). These IRPA/INIRC guidelines were reviewed by the International Commission on Non-Ionizing Radiation Protection (ICNIRP) at the annual meeting in 1996 and again in 2004. ICNIRP concluded that recent data did not suggest that the exposure limit (EL) values needed to be amended (ICNIRP 2004). This standard

131 replaces the National Health and Medical Research Council's Radiation  
132 Health Series No 29 (RHS 29), 1989.  
133

### 134 **1.3 PURPOSE**

135

136 This Radiation Protection Standard sets out to protect workers by

137

138 1 limiting the occupational exposure to ultraviolet radiation for artificial  
139 sources in the workplace, considered to be a controlled environment

140

141 2 setting requirements for minimizing a person's exposure to uncontrollable  
142 sources of UVR, such as the sun. While mandatory application of the  
143 limits for exposure to solar ultraviolet radiation to outdoor workers is  
144 difficult in practice, it is important to limit UVR exposures by using  
145 engineering and administrative controls as well as personal protection.

146

147 This *Standard* sets common essential requirements for the control of  
148 exposure to ultraviolet radiation, including the specification of employer's  
149 duties and employee's duties. It also provides practical strategies for  
150 protection of workers from ultraviolet radiation.

151

### 152 **1.4 SCOPE**

153

154 This Standard covers exposure to ultraviolet radiation incurred as part of a  
155 worker's occupation and includes both solar UVR and artificial sources of  
156 UVR. The document covers exposures to incoherent sources of UVR in the  
157 spectral region between 180 and 400 nm.

158

159 The Standard establishes threshold exposure levels for occupational exposure  
160 of the eye or the skin during an 8 hour working day. The Standard does not  
161 apply to UVR exposures of patients as a part of medical treatment or for  
162 elective cosmetic purposes. These threshold levels are intended as upper  
163 limits for non-therapeutic and non-cosmetic exposure and should be  
164 considered as absolute limits for ocular exposure but occasional exposure of  
165 conditioned skin above these levels may not result in adverse effects.

166

167 (a) The exposure limits of Schedule 1 apply to artificial sources of UVR in the  
168 workplace, a controlled environment, but do not apply to ultraviolet lasers  
169 (exposures to lasers are covered by laser standards (reference?) –  
170 difficulties with lasers due to dose rate/intensity and non linearity?). The  
171 values should be used as guides in the control of exposure to both pulsed  
172 and continuous sources of UVR where the exposure duration is not less  
173 than 0.1  $\mu$ sec.

174

175 (b) Given the variability in exposures to solar UVR due to highly variable  
176 ambient solar UVR levels as well as behavioural effects and different  
177 exposure geometry, application of the exposure limits of Schedule 1 is not  
178 practical and limiting UVR exposures to as low as possible is the most  
179 effective approach. The exposure limits of Schedule 1 are typically  
180 exceeded within 5 to 10 minutes in summer by solar radiation for 2 to 3  
181 hours either side of noon at 0° to 40° latitude (see Annex 3).

## 1.5 STRUCTURE

This Radiation Protection Standard is structured as follows:

Section 2 specifies duties and responsibilities of employers and employees.

Section 3 sets out a risk management approach to reducing exposure to UVR in the workplace.

Schedule 1 provides the limits for occupational exposure to UVR.

The meanings of terms used in the Standard are defined in the Glossary.

Annexes to the Standard provide information that will assist users of the Standard.

- Annex 1 provides the rationale for the limits,
- Annex 2 provides a description of the health effects of UVR,
- Annex 3 provides guidance on limiting exposure to UVR in the workplace,
- Annex 4 lists other publications in the Radiation Protection Series,
- Annex 5 lists the authorities where advice on protection from UVR is available, and
- Annex 6 lists the Regulatory Authorities for occupational exposure to UVR.

## 1.6 INTERPRETATION

This *Standard* is based on the principles described in the ‘Guidelines on limits of exposure to ultraviolet radiation of wavelengths between 180 nm and 400nm (incoherent optical radiation)’, (ICNIRP 2004). Terms used in this *Standard* have the meaning given in the *Glossary*. In addition, the words ‘must’ and ‘should’ have a special meaning. ‘Must’ indicates that the requirement to which it refers is considered to be mandatory. ‘Should’ indicates a recommendation - that is, a requirement that is to be applied as far as is practicable in the interests of reducing risk.

## 2. Duties and Responsibilities

### 2.1 EMPLOYERS' DUTIES

Where there are sources of ultraviolet radiation present in the workplace, an employer must ensure that a program of ultraviolet radiation protection is devised and implemented. In fulfilling this requirement, the employer must:

- (a) provide information to and appropriate induction and on-going training for employees who may be exposed to ultraviolet radiation in their work;
- (b) ensure that a plan for the control of exposure to ultraviolet radiation is developed, approved, implemented and regularly reviewed, and that the workforce is consulted in the planning and review process (examples of such a plan are given on the ARPANSA web site) ;
- (c) ensure that all necessary resources for implementing the plan for the control of exposure are provided, including personal protective equipment;
- (d) endeavour to ensure that exposure to ultraviolet radiation in the workplace is kept to a minimum.
- (e) when an employee reports a matter which may compromise ultraviolet radiation protection, ensure that appropriate action is taken to investigate and, if necessary, rectify the problem;
- (f) inform the appropriate authority without delay of the occurrence of an incident or accident and, as soon as practicable, of its cause and consequences and of the steps taken to remedy the situation and to prevent a recurrence;
- (g) The employer may seek an exemption from some of these requirements, where they are not all appropriate in a particular circumstance, by making application to the appropriate authority.

### 2.2 EMPLOYEES' DUTIES

Employees who may be exposed to ultraviolet radiation in the workplace must, to the extent that they are capable, comply with all reasonable measures to control and assess exposure to ultraviolet radiation in the workplace, including:

- (a) following the ultraviolet radiation protection practices specified in the plan for the control of exposure to ultraviolet radiation;
- (b) participating in training related to ultraviolet radiation protection, as required;
- (c) making proper use of the training received to ensure their own health and safety and that of other persons;
- (d) making proper use of protective equipment provided by the employer;
- (e) reporting to the employer, any matter of which they are aware which may compromise ultraviolet radiation protection.

## **3. Protection from occupational exposure to UVR sources**

### **3.1 MANAGING RISK IN OCCUPATIONAL UVR EXPOSURE**

The following people must ensure that the hazards associated with exposure to ultraviolet radiation are managed: employers; operators of ultraviolet radiation sources; people in control of workplaces; designers, manufacturers and suppliers of ultraviolet radiation sources; self-employed persons.

The persons listed above are to ensure that the hazards associated with exposure to ultraviolet radiation and ultraviolet radiation sources are managed by a risk management process as listed below in 3.1.2.

#### **3.1.1 Workplace Policy**

A risk management process for ultraviolet radiation exposure must be implemented and should be clearly documented in a written workplace policy that expresses the commitment of all parties. This policy must identify the risks, specify the procedures that must be implemented to control and manage them, and identify those responsible for that implementation.

#### **3.1.2 Risk Management Process**

The risk management process must include:

- (a) Identification of the hazards. This step should include identification of the sources of ultraviolet radiation;
- (b) Assessment of the risk. This step includes estimation of exposure levels, comparison to the relevant limits and consideration of both the likelihood and severity of the consequence(s) of the hazard ;
- (c) Choice of the most appropriate control measures to prevent or minimise the level of risk. The control/s chosen must not cause other hazards ;
- (d) Implementation of the chosen control measures. This step must include maintenance requirements to ensure the ongoing effectiveness of the control/s and training on the control measures for workers potentially exposed to ultraviolet radiation;
- (e) Monitoring and reviewing the effectiveness of the control measures. The monitoring and review process must assess whether the chosen controls have been implemented as planned, that the control measures are effective and that the control measures have not introduced new hazards or worsened existing hazards.

#### **3.1.3 Control Prioritization**

307 Where there is potential for exposure above the limits, the hazard should be  
308 managed through application of the most appropriate control priorities as  
309 indicated below. The measures higher in the control priorities are usually  
310 more effective than those lower, and should be given greater consideration  
311 accordingly. In order of priority, the Control Priorities are:

- 312
- 313 (a) **Elimination** of the hazard. If this is not practical, exposure to the risk  
314 should be prevented or minimised by one or a combination of the  
315 following control measures ;
- 316
- 317 (b) **Substitution** of a less hazardous (and more manageable) process or  
318 less hazardous plant; and
- 319
- 320 (c) **Engineering controls** including redesign of equipment or work  
321 processes and/or isolation and containment of the hazard. Examples  
322 include: installing shielding or enclosing the source either in a container  
323 or in a dedicated room, fail-safe interlocks, built-in UVR detectors and  
324 alarms, elimination of reflected UVR and ventilation to remove any  
325 ozone produced;
- 326
- 327 (d) Introduction of **administrative** controls such as signage restricting  
328 access, hazard signs or warning lights or if necessary, the need for  
329 personal protection. Due care during any maintenance and service on  
330 the UVR source, particularly if safety shielding is removed.  
331 Administrative controls may be used in combination with higher level  
332 controls;
- 333
- 334 (e) Use of appropriate **personal protective equipment (PPE)**. All users  
335 of PPE must be provided with the appropriate PPE and trained and  
336 supervised in its use to ensure that they have a clear understanding of its  
337 correct usage and limitations and they must use it accordingly. In  
338 addition, the PPE must be maintained and replaced as specified by the  
339 manufacturer to ensure it is kept in good condition so that its  
340 effectiveness as a control is not compromised.

### 341 342 **3.1.4 Training and Supervision**

343  
344 Workers who may be exposed to ultraviolet radiation must be trained in safe  
345 work practices regarding ultraviolet radiation and supervised when  
346 appropriate. They must also be trained about the controls in place to manage  
347 the potential ultraviolet radiation hazard. There must be appropriate  
348 procedures in place to ensure that the safe systems of work to prevent  
349 ultraviolet radiation exposure are utilised.

### 350 351 **3.1.5 Assessment of UVR Levels**

352  
353 Advice on measurement or estimation of UVR exposures is covered in  
354 Annex 3.

## 355 356 **3.2 PROVISION OF INFORMATION TO EMPLOYEES**

358 Employees must be advised about the following:

359

360 (a) The known biological effects of overexposure to ultraviolet radiation.  
361 These are summarised in a number of publications by international  
362 agencies (WHO 1992, NRPB 2002, ICNIRP 2004). \* Editorial Note: It is  
363 planned to produce an ARPANSA Safety Guide Statement of the health  
364 effects and general information in easy to understand plain language for  
365 distribution to outdoor workers and the general public.

366

367 (b) The procedures to be followed in the event of any over-exposure,  
368 including a contact point.

369

### 370 **3.3 POST INCIDENT EXPOSURE MANAGEMENT**

371

372 A plan for medical management of any case of severe over-exposure must be  
373 developed in advance.

374

375 The following plan of action is suggested as appropriate in the event of  
376 ultraviolet radiation over-exposure of the eye:

377

378 (a) First Aid treatment should be obtained from the nearest first aider,  
379 doctor or hospital as required for burns or other injuries.

380 (b) Employers should arrange for employees suspected or confirmed as  
381 over-exposed to ultraviolet radiation is to be medically assessed as soon  
382 as possible after the over-exposure.

383 (c) In the event that medical assessment of the eye is required then referral  
384 to an ophthalmologist is recommended.

385 (d) The employer must ensure the employee is fully advised and  
386 understands the nature of the over-exposure incident and the nature and  
387 reasons for the post incident management of it.

388 (e) The over-exposure or incident must be investigated to determine the  
389 level and extent of exposure to ultraviolet radiation. This information  
390 should be recorded as specified in (d) above. Appropriate corrective  
391 action or changes to procedures need to be instituted as soon as is  
392 reasonably practicable, with regard to preventing future over-exposures  
393 to any employees working in similar situations.

394

395 (f) The overexposure or incident must be reported to the relevant authority.

396

### 397 **3.4 ADDITIONAL REQUIREMENTS FOR OCCUPATIONAL** 398 **EXPOSURE TO ARTIFICIAL SOURCES OF UVR**

399

400 3.4.1 The exposure limits of Schedule 1 apply to artificial sources of UVR in  
401 the workplace, a controlled environment, but do not apply to  
402 ultraviolet lasers.

403

404 The values should be used as guides in the control of exposure to both  
405 pulsed and continuous sources of UVR where the exposure duration is  
406 not less than 0.1  $\mu$ sec.  
407

408 3.4.2 All the requirements outlined in Sections 3.1.2 and 3.1.3 must be  
409 employed for artificial sources of UVR.  
410

411 3.4.3 The responsible person must ensure that no person is occupationally  
412 exposed to ultraviolet radiation from artificial sources at levels that  
413 exceed the occupational exposure limits specified in Schedule 1.  
414

### 415 **3.5 ADDITIONAL REQUIREMENTS FOR OCCUPATIONAL** 416 **EXPOSURE TO SOLAR UVR** 417

418 3.5.1 Given that exposures to solar UVR can vary greatly due to the highly  
419 variable ambient solar UVR levels as well as behavioural effects and  
420 different exposure geometry, mandatory application of the exposure  
421 limits of Schedule 1 is not practical. However, it is important that the  
422 exposures to solar UVR are kept to a minimum by using appropriate  
423 protective measures (see Annex 3). The exposure limits of Schedule 1  
424 are typically exceeded within 5 to 10 minutes in summer by solar  
425 radiation for 2 to 3 hours either side of noon at 0° to 40° latitude (see  
426 Annex 3).  
427

428 3.5.2 For outdoor workers, all the requirements as outlined in Sections 3.1.2  
429 and 3.1.3 must be employed.  
430

431 While it may not be possible to limit exposure of outdoor workers to  
432 below the exposure limits of Schedule 1, it is important that the  
433 exposures to solar UVR are kept to a minimum by using appropriate  
434 protective measures.  
435

# Schedule 1

## EXPOSURE LIMITS (EL)

S1.1 The EL for occupational exposure to UVR incident upon the skin or eye where irradiance values are known and the exposure duration is controlled are as below. Note that S1.2 and S1.3 must both be satisfied independently.

S1.2 For the UV-A spectral region 315 to 400 nm, the total radiant exposure on the unprotected eye must not exceed 10 kJ .m<sup>-2</sup> within an 8 hour period and the total 8 hour radiant exposure incident on the unprotected skin must not exceed the values given in Table 1. Values for the relative spectral effectiveness are given up to 400 nm to expand the action spectrum into the UV-A for determining the EL for skin exposure.

S1.3 In addition, the ultraviolet radiant exposure in the actinic UV spectral region (UV-B and UV-C from 180 to 315 nm) incident upon the unprotected skin and unprotected eye(s) within an 8 hour period must not exceed the values given in Table 1.

S1.4 For broadband sources emitting a range of wavelengths in the ultraviolet region (ie most UVR sources), determination of the effective irradiance of such a broadband source is done by weighting all wavelengths present in the emission with their corresponding spectral effectiveness by using the following weighting formula :

$$E_{\text{eff}} = \sum E_{\lambda} \cdot S_{\lambda} \cdot \Delta\lambda$$

where:

$E_{\text{eff}}$  = Effective irradiance in W.m<sup>-2</sup> (J.s<sup>-1</sup>.m<sup>-2</sup>) normalised to a monochromatic source at 270 nm

$E_{\lambda}$  = Spectral irradiance in W.m<sup>-2</sup>.nm

$S_{\lambda}$  = Relative spectral effectiveness (unitless)

$\Delta\lambda$  = Bandwidth in nanometres of the calculated or measurement intervals

S1.5 Permissible exposure time in seconds for exposure to actinic UVR incident upon the unprotected skin or eye may be computed by dividing 30 J.m<sup>-2</sup> by  $E_{\text{eff}}$  in W.m<sup>-2</sup>. The maximum exposure duration may also be determined using Table 2 of this Schedule which provides representative exposure durations corresponding to effective irradiances in W.m<sup>-2</sup> (and μW.cm<sup>-2</sup>).

Note : When applying the EL to the skin for the case when there is continuous exposure for a period longer than 8 hours (such as a double shift for indoor workers) special care needs to be taken. This is because the EL is based on a normal 24 hours cycle of light and dark where cellular repair takes place mainly when the exposure is discontinued.

485  
486  
487  
488

**TABLE 1 ULTRAVIOLET RADIATION EXPOSURE LIMITS AND  
RELATIVE SPECTRAL EFFECTIVENESS**

Wavelength <sup>a</sup> (nm)	Exposure Limit (J.m <sup>-2</sup> )	Exposure Limit (mJ.cm <sup>-2</sup> )	Relative Spectral Effectiveness S <sub>λ</sub>
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 <sup>b</sup>	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 <sup>b</sup>	34	3.4	0.880
285	39	3.9	0.770
290	47	4.7	0.640
295	56	5.6	0.540
297 <sup>b</sup>	65	6.5	0.460
300	100	10	0.300
303 <sup>b</sup>	250	25	0.120
305	500	50	0.060
308	1,200	120	0.026
310	2,000	200	0.015
313 <sup>b</sup>	5,000	500	0.006

489

490  
491  
492  
493

**TABLE 1 ULTRAVIOLET RADIATION EXPOSURE LIMITS AND  
RELATIVE SPECTRAL EFFECTIVENESS (CONTINUED)**

Wavelength <sup>a</sup> (nm)	Exposure Limit (J.m <sup>-2</sup> )	Exposure Limit (mJ.cm <sup>-2</sup> )	Relative Spectral Effectiveness S <sub>λ</sub>
315	1.0 × 10 <sup>4</sup>	1.0 × 10 <sup>3</sup>	0.003
316	1.3 × 10 <sup>4</sup>	1.3 × 10 <sup>3</sup>	0.0024
317	1.5 × 10 <sup>4</sup>	1.5 × 10 <sup>3</sup>	0.0020
318	1.9 × 10 <sup>4</sup>	1.9 × 10 <sup>3</sup>	0.0016
319	2.5 × 10 <sup>4</sup>	2.5 × 10 <sup>3</sup>	0.0012
320	2.9 × 10 <sup>4</sup>	2.9 × 10 <sup>3</sup>	0.0010
322	4.5 × 10 <sup>4</sup>	4.5 × 10 <sup>3</sup>	0.00067
323	5.6 × 10 <sup>4</sup>	5.6 × 10 <sup>3</sup>	0.00054
325	6.0 × 10 <sup>4</sup>	6.0 × 10 <sup>3</sup>	0.00050
328	6.8 × 10 <sup>4</sup>	6.8 × 10 <sup>3</sup>	0.00044
330	7.3 × 10 <sup>4</sup>	7.3 × 10 <sup>3</sup>	0.00041
333	8.1 × 10 <sup>4</sup>	8.1 × 10 <sup>3</sup>	0.00037
335	8.8 × 10 <sup>4</sup>	8.8 × 10 <sup>3</sup>	0.00034
340	1.1 × 10 <sup>5</sup>	1.1 × 10 <sup>4</sup>	0.00028
345	1.3 × 10 <sup>5</sup>	1.3 × 10 <sup>4</sup>	0.00024
350	1.5 × 10 <sup>5</sup>	1.5 × 10 <sup>4</sup>	0.00020
355	1.9 × 10 <sup>5</sup>	1.9 × 10 <sup>4</sup>	0.00016
360	2.3 × 10 <sup>5</sup>	2.3 × 10 <sup>4</sup>	0.00013
365 <sup>b</sup>	2.7 × 10 <sup>5</sup>	2.7 × 10 <sup>4</sup>	0.00011
370	3.2 × 10 <sup>5</sup>	3.2 × 10 <sup>4</sup>	0.000093
375	3.9 × 10 <sup>5</sup>	3.9 × 10 <sup>4</sup>	0.000077
380	4.7 × 10 <sup>5</sup>	4.7 × 10 <sup>4</sup>	0.000064
385	5.7 × 10 <sup>5</sup>	5.7 × 10 <sup>4</sup>	0.000053
390	6.8 × 10 <sup>5</sup>	6.8 × 10 <sup>4</sup>	0.000044
395	8.3 × 10 <sup>5</sup>	8.3 × 10 <sup>4</sup>	0.000036
400	1.0 × 10 <sup>6</sup>	1.0 × 10 <sup>5</sup>	0.000030

494  
495  
496  
497  
498  
499  
500

<sup>a</sup> Wavelengths chosen are representative; other values should be interpolated at intermediate wavelengths.

<sup>b</sup> Emission lines of a mercury discharge spectrum.

501  
502

**TABLE 2    LIMITING UV EXPOSURE DURATIONS BASED ON EL**

---

Duration of Exposure Per Day		Effective Irradiance	
		$E_{\text{eff}}$ ( $\text{W}\cdot\text{m}^{-2}$ )	$E_{\text{eff}}$ ( $\mu\text{W}\cdot\text{cm}^{-2}$ )
8	Hr	0.001	0.1
4	Hr	0.002	0.2
2	Hr	0.004	0.4
1	Hr	0.008	0.8
30	Min	0.017	1.7
15	Min	0.033	3.3
10	Min	0.05	5
5	Min	0.1	10
1	Min	0.5	50
30	Sec	1.0	100
10	Sec	3.0	300
1	Sec	30	3,000
0.5	Sec	60	6,000
0.1	Sec	300	30,000

503  
504

## References

- 505  
506  
507 Bech-Thomsen, N. and Wulf, H.C. (1992) Sunbathers' application of sunscreen is  
508 probably inadequate to obtain the Sun Protection Factor assigned to the  
509 preparation. *Photodermatol. Photoimmunol. Photomed.* 9:242-244.
- 510 Bernhardt, J.H. and Matthes, R. (1997) 'Recent and Future Activities of the ICNIRP',  
511 *Radiation Protection Dosimetry*, 72; 167-176.
- 512 Diffey, B.L. and Cheeseman, J. (1992) 'Sun protection with hats'. *Br. J Dermatology*  
513 127:10-12.
- 514 Gies, P. and Wright, J (2003) 'Measured Solar Ultraviolet Radiation Exposures of  
515 Outdoor Workers in Queensland in the Building and Construction Industry'.  
516 *Photochem. Photobiol.* 78:342-348.
- 517 Gies, P., Roy, C., Javorniczky, J., Henderson, S., Lemus-Deschamps, L. and Driscoll,  
518 C. (2004) Global Solar UV Index: Australian Measurements, Forecasts and  
519 Comparison with the UK. *Photochem. Photobiol.* 79:32-39.
- 520 Hill, D, Elwood, J.M. and English, D.R. (2004) 'Prevention of Skin Cancer', *Cancer*  
521 *Prevention – Cancer Causes Vol.3*, Kluwer Academic Publishers, Dordrecht,  
522 The Netherlands.
- 523 International Agency for Research on Cancer (IARC) 1992, 'Solar and Ultraviolet  
524 Radiation' Volume 55 of the IARC Monographs on the Evaluation of  
525 Carcinogenic Risks to Humans Volume, IARC/ WHO.
- 526 International Commission on Non-Ionizing Radiation Protection (ICNIRP) 2004,  
527 'Guidelines on limits of exposure to ultraviolet radiation of wavelengths  
528 between 180 nm and 400 nm (incoherent optical radiation)', *Health Physics*  
529 2004, 87(2): 171-186.
- 530 IRPA/INIRC 1985, 'Guidelines on limits of exposure to ultraviolet radiation of  
531 wavelengths between 180 nm and 400 nm (incoherent radiation)', *Health*  
532 *Physics* 1985, 49(2): 331-340.
- 533 IRPA/INIRC 1989. 'Proposed change to the IRPA 1985 guidelines on limits of  
534 exposure to ultraviolet radiation', *Health Physics* 1989, 56(6): 971-972.
- 535 International Commission on Non-Ionizing Radiation Protection (ICNIRP) 1996,  
536 'Guidelines on UV Radiation Exposure Limits', *Health Physics* 1996, 71: 978.
- 537 National Health and Medical Research Council 1989, 'Occupational standard for  
538 exposure to ultraviolet radiation', *Radiation Health Series* No.29. Canberra:  
539 NHMRC.
- 540 National Health and Occupational Safety Commission (NOHSC) Guidance note for  
541 the Protection of Workers from the Ultraviolet Radiation in Sunlight. NOHSC :  
542 3012(1991).
- 543 National Radiological Protection Board (2002) "Advice on Protection Against  
544 Ultraviolet Radiation", *Documents of the NRPB* 13; No.2.
- 545 Queensland Government (1995) *Workplace Health and Safety Act* Goprint Brisbane.
- 546 Queensland Government Workplace Health and Safety (2001) 'Controlling Excessive  
547 Exposure to Ultraviolet Radiation'. *Safety Link* No.7, November.

- 548 Radiation Protection Standard (1989) 'Occupational Standard for Exposure to  
549 Ultraviolet Radiation', *Radiation Protection Series* Publication No: 29.
- 550 Sliney, D.H. (1986) 'Physical factors in catarctogenesis: ambient ultraviolet radiation  
551 and temperature'. *Investigative Ophthalmology and Visual Science* 27:781-  
552 790.
- 553 UNEP/ICNIRP/WHO (1994) 'Health and environmental effects of ultraviolet  
554 radiation', *Environmental Health Criteria 160*, Geneva'.
- 555 World Health Organization (2002) *Global Solar UV Index: A Practical Guide*. Geneva,  
556 Switzerland, WHO.
- 557

558  
559  
560  
561  
562  
563  
564  
565  
566  
567  
568  
569  
570  
571  
572  
573  
574  
575  
576  
577  
578  
579  
580  
581  
582  
583  
584  
585  
586  
587  
588  
589  
590  
591  
592  
593  
594  
595  
596  
597  
598  
599  
600  
601  
602  
603  
604  
605  
606  
607  
608  
609

## **Glossary**

### **Action spectra**

A term often used for the spectral weighting functions which attempt to take the varying biological effects of different wavelengths of ultraviolet radiation into account.

### **Aphakic**

A person no longer having a natural ocular lens, for example after cataract surgery.

### **Erythema**

Reddening of the skin due to exposure to UVR.

### **Irradiance**

The rate of energy arriving at a surface per unit time and per unit area. The units are  $W.m^{-2}$  and the wavelength range the intensity is integrated over is generally stated.

### **Spectral irradiance**

The irradiance within a specific wavelength band. The units are  $W.m^{-2}.nm^{-1}$ .

### **Effective irradiance**

The effect that a UVR irradiance will have on a biological system such as the skin or eyes when the spectral effectiveness of each of the component wavelengths comprising the incident UVR is weighted and added into the total. The units are  $W.m^{-2}$ .

### **UVR**

Ultraviolet radiation of wavelengths between 100 to 400 nm.

### **UVA**

UVR of wavelengths between 315 to 400 nm.

### **UVB**

UVR of wavelengths between 280 to 315 nm.

### **UVC**

UVR of wavelengths between 100 to 280 nm.

### **Visible radiation**

Radiation of wavelengths between 400 nm and 770 nm.

## Annex 1

### RATIONALE FOR LIMITING EXPOSURE TO UVR

The organs at risk from exposure to UVR are the skin and the eyes, since the penetration depth of UVR through biological tissue is very short. In 1985 IRPA produced guidelines with exposure limits that are derived from numerous scientific studies (both human and animal) of the acute effects of ultraviolet irradiation of skin and eyes. These exposure limits are set below the threshold limit value of  $30 \text{ J.m}^{-2}$  effective for induction of observable effects and as such includes safety margins. While the guidelines relate primarily to acute effects of ultraviolet radiation exposure, they should also provide sufficient protection against chronic effects.

The International Non-Ionizing Radiation Committee of the International Radiation Protection Association (IRPA/INIRC) in 1989 updated the previous limits on ultraviolet radiation which it had published in Health Physics in 1985. These 1985 limits assumed a constant spectral effectiveness across the UVA region (315 to 400 nm). By 1989 research had shown that the spectral effectiveness in the UVA declined significantly as the wavelength approached the boundary with the visible portion of the spectrum at 400 nm and the limits were changed to take this into account. The National Health and Medical Research Council (NHMRC) adopted these 1989 IRPA limits for its occupational exposure standard (RHS 29).

At its 1996 annual meeting, ICNIRP concluded that, while significant clarification had occurred with respect to health risk assessment from exposure to UV, recent data had not provided results suggesting the exposure limit values of the 1989 guidelines need to be amended. This was also stated in an overview document of recent and future ICNIRP activities (Bernhardt & Matthes 1997) published in Radiation Protection Dosimetry. Thus the original ELs still apply as does the original IRPA/INIRC rationale for their development. The 2004 update of guidelines on limits of exposure to ultraviolet radiation (ICNIRP 2004) evaluated and reviewed recent research on biological effects of UVR exposure and made no significant changes in the exposure limit values.

The exposure limits of Schedule 1 apply for the use of artificial sources of UVR in the workplace, as in a controlled environment the UVR exposures can be limited. However, given the variability in exposures to solar UVR due to highly variable ambient solar UVR levels as well as behavioural effects and different exposure geometry, application of the exposure limits is not practical and limiting UVR exposures to as low as possible is the most effective approach.

## 651 **Annex 2**

### 652 **HEALTH EFFECTS OF UVR**

#### 654 **Background**

656 Comprehensive reviews of UVR effects have been published (UNEP/WHO/ICNIRP  
657 1994, NRPB 2002, ICNIRP 2004,) and the interested reader is referred to those  
658 documents. The following discussion is a brief summary of the health effects of  
659 UVR.

#### 660 **General biological effects**

662 Photons of UVR are sufficient to break chemical bonds in the molecules which make  
663 up the skin and eyes, such as DNA, and are therefore capable of inducing significant  
664 biological damage. The magnitude of these biological effects varies markedly with  
665 wavelength. The most significant adverse effects of exposure to UVR have been  
666 reported at wavelengths below 315 nm. This standard has been limited to UVR of  
667 wavelengths greater than 180 nm, which are transmitted through air. In regards to  
668 solar radiation very little radiation below 290 nm reaches the earth's surface.

#### 669 **Acute Effects**

671 The most common acute effect of UVR on the skin is erythema (or sunburn), which  
672 results in redness and blistering within 8 to 24 hours after exposure. The severity of  
673 the erythema depends upon the duration of the exposure and the intensity of UVR as  
674 well as the skin type of the subject.

675 UVR has also been shown to suppress the immune response in humans and thus  
676 may enhance the risk of infection and decrease the effectiveness of the body's  
677 defence mechanisms.

679 The acute effects of UVR on the eyes are photokeratitis and photoconjunctivitis,  
680 which generally last for short time periods (24 to 48 hours) before they are reversed  
681 by the body's repair processes. Other effects of UVR on the eye may be acute retinal  
682 injury to aphakics and possible lens damage to individuals exposed to  
683 photosensitizing agents.

#### 684 **Chronic Effects**

685 Chronic exposure to solar radiation accelerates the skin aging process (or solar  
686 elastosis) and increases the risk of developing skin cancer, both melanoma and  
687 non-melanoma. Chronic effects on the eye are cataracts and the development of  
688 pterygium and squamous cell cancer of the conjunctiva.

691 A fuller and more detailed discussion of health effects of UVR can be found in the  
692 ICNIRP 1996 rationale and the UNEP/WHO/ICNIRP 1994 Environmental Health  
693 Criteria 160, which also has a chapter on UVR protective measures.

#### 694 **Photosensitizers**

697 Some substances can increase the sensitivity of human skin to UVR. These  
698 substances or chemicals are called photosensitizers and they can occur naturally and  
699 may be found in working environments ranging from domestic to outdoor and  
700 industrial workplaces. Photosensitizers may also be present in medications and  
701 workers need to be made aware that if they are exposed to UVR (most notably, UV-  
702 A) and are on certain medications they may suffer a phototoxic reaction.

704 Certain occupations may encounter specific photosensitizers. For example, dyes are  
 705 encountered in the textile industry, photosensitizing plants are encountered in  
 706 agriculture and some inks found in the printing industry may contain a  
 707 photosensitizer (e.g., amyldimethylaminobenzoate). Roofers and road workers  
 708 encounter coal tars that are photosensitizers.

709  
 710  
 711

**TABLE 3 List of Photosensitizers**

Sources	Active Ingredients
<b>Photosensitizers in the domestic work environment</b>	
Bacteriostats in soaps	Halogenated salicyclanilides;
Wood preservative	
Vegetables	Psoralens in celery and parsnips
<b>Photosensitizers and the outdoor work environment</b>	
<i>Garden and countryside</i>	
Plants:	
Umbelliferae:	giant hogweed ( <i>Heracleum mantegazzianum</i> ) cow parsnip ( <i>Heracleum sphondylium</i> ) wild parsnip ( <i>Pastinaca sativa</i> ) tromso palm ( <i>Heracleum laciniatum</i> )
Rutaceae:	common rue ( <i>Ruta graveolens</i> ) gas plant ( <i>Dictamnus alba</i> ) Bergamot orange ( <i>Citrus bergamia</i> )
Moraceae:	fig ( <i>Ficus carica</i> )
Furocoumarins:	psoralen, 8-methoxypsoralen, 5-methoxypsoralen, pimpinellin, sphondin, angelicin.
<i>General</i>	
Perfumes and cosmetics:	5-methoxypsoralen (Bergapten) in oil of Bergamot, musk ambrette, 6-ethylcoumarin.
Sunscreens:	p-aminobenzoic acid (PABA), ethoxyethyl-p-methoxycinnamate, isopropylidibenzoylmethane, butylmethoxydibenzoylmethane.
Disinfectants and Antiseptics:	Methylene blue, eosin and rose bengal
Tattoos:	cadmium sulphide.
<b>Photosensitizers in the industrial working environment</b>	
Anthraquinone based dyes:	Benzanthrone; Disperse Blue 35
Polycyclic hydrocarbons:	pitch, coal tar, wood preservatives, anthracene, fluoranthene
Drugs:	chlorpromazine, amiodarone,
Plants:	giant hogweed, psoralens
Printing ink:	amyl-o-dimethylaminobenzoic acid
Animal feed supplement:	quinoxaline-n-dioxide

757 **TABLE 3 List of Photosensitizers** (continued)

758

Sources	Active Ingredients
<b>Major Photosensitizers administered for medical purposes</b>	
<i>Drugs</i>	
Antibacterial:	tetracyclines, sulphonamides, nalidixic acid, 4-quinolones
Tranquilizer:	phenothiazines (chloromazine)
Antidepressant:	protryptiline
Diuretic:	chlorthiazides, frusemide
Antiarrhythmic:	amiodarone, methyldopa, quindine, propranolol
Anti-inflammatory:	ibuprofen, azapropazone, naproxen,
Antifungal:	grizeofulvin
Bacteriostat:	halogenated salycilanilides, bithionol, buclosamide
Topical antifungal:	fentichlor, hexachlorophene
Antimalaric:	quinine
<i>Therapies</i>	
Photochemotherapy:	8-methoxysporalen, 5-methoxysporalen, trimethylsporalen, khellin
Photodynamic therapy:	Photofrin II

783

784  
785 Adapted from WHO/ICNIRP Draft Guide on “Protecting Workers from Ultraviolet  
786 Radiation”

787

788 For further reading see NOHSC : 3012(1991) Guidance note for the Protection of  
789 Workers from the Ultraviolet Radiation in Sunlight. This is available on  
790 [www.nohsc.gov.au/PDF/standards/GuidanceNotes/UVRadiationSunlight.pdf](http://www.nohsc.gov.au/PDF/standards/GuidanceNotes/UVRadiationSunlight.pdf)

791

792

793

## 794 **Annex 3**

### 795 **LIMITING EXCESSIVE EXPOSURE TO ULTRAVIOLET RADIATION** 796 **(UVR) IN THE WORKPLACE**

797  
798  
799 This annex covers occupational exposure to ultraviolet radiation (UVR). Exposure to  
800 UVR from the sun occurs during both leisure and various work activities, and  
801 excessive exposure to UVR can lead to sunburn, skin and eye damage, immune  
802 suppression, premature skin aging and skin cancer. Skin cancers can affect people of  
803 all skin types and can also develop on people who do not have a history of severe  
804 sunburn. Cumulative exposure to UVR and severe sunburns increase the risk of  
805 developing skin cancer.

#### 806 **Employer's Obligations Concerning UVR Exposure**

807  
808  
809 Under workplace health and safety legislation and radiation protection legislation,  
810 employers and self-employed persons have an obligation to ensure workplace health  
811 and safety. Such legislation usually provides that workplace health and safety can  
812 generally be managed by identifying hazards, assessing risks from the hazards,  
813 implementing control measures and monitoring and reviewing the effectiveness of  
814 the measures. This includes protecting employees and persons from exposure to  
815 levels of UVR that can cause adverse health effects or may exceed the exposure  
816 limits contained in this Standard. These limits do not apply to the use of UVR for  
817 medical and therapeutic purposes (e.g. phototherapy) or for cosmetic purposes (e.g.  
818 solaria), which are not covered by the standard.

#### 819 **Worker's Obligations Concerning UVR Exposure**

820  
821  
822 Workers or any other person at a workplace have an obligation to comply with the  
823 instructions given for workplace health and safety by the employer. If the employer  
824 provides personal protective equipment (PPE) for protection against UVR and  
825 instructs the employee in its use, the worker has an obligation to use the PPE. The  
826 worker also has an obligation not to wilfully or recklessly interfere with or misuse  
827 anything provided for workplace health and safety and to not wilfully put anyone  
828 else or themselves at risk. As an employee these obligations can be met by following  
829 safe working procedures established by the employer. Employees should not  
830 intentionally expose themselves or others to levels of UVR that may exceed the  
831 exposure limits of this Standard. They should never operate equipment that emits  
832 UVR with the shielding or protective devices removed.

#### 833 **Solar UVR in the Workplace**

834  
835  
836 For most outdoor workers the sun is the primary sources of UVR exposure.  
837 Construction workers, landscape gardeners, lifeguards and rural workers for  
838 example, have potentially high-risk workplaces and may receive much greater solar  
839 UVR exposures than indoor workers and this places them at greater risk.

840  
841 Solar UVR can reach a worker on the ground from three sources:

- 842 • Directly from the sun,
- 843 • Scattered from the open sky,
- 844 • Reflected from the environment

845  
846 This means that even if a person is shaded from the direct sun they can still receive  
847 substantial UVR exposure from the open sky and reflective ground surfaces. If a  
848 person is in the shade but can view blue sky they are still exposed to solar UVR from

849 the sky. A highly reflective environment can also increase UVR levels and can reduce  
850 the effect of protective measures. Some ground and building surfaces are quite  
851 reflective to UVR and can reflect UVR onto the skin and eyes and these include white  
852 paint, light coloured concrete and metallic surfaces (Slaney 1986).

853

854 Workers who spend a significant amount of time during the day in a motor vehicle  
855 can also receive high levels of solar UVR, however, laminated front windscreens and  
856 tinting of the side and rear windows can greatly reduce the amount of UVR entering  
857 the vehicle. Most automotive tints provide excellent protection against solar UVR.

858

#### 859 *The Occupational UVR Exposure Limits and Solar UVR*

860

861 The exposure limit in this Standard for both general and occupational exposure to  
862 UVR incident upon the skin or eye is 30 Jm<sup>-2</sup> in an 8 hour working day.

863

864 UVR levels are reported by the media as a Solar UV-Index (WHO 2002), which is a  
865 measure of the maximum daily UVR. The UV Index allows for cloud cover and other  
866 environmental factors and is used worldwide for reporting UVR levels. The UV  
867 Index provides the public with a numerical indication of the maximum potential  
868 solar UVR level during the day. The higher the number the higher the solar UVR  
869 hazard. Measurements of typical UV Index for most Australian Capital cities are  
870 available (Gies et al 2004).

871

872 The following table shows that the duration required to exceed the exposure limits  
873 varies with the intensity of solar UVR. During summer when the UV Index value  
874 may be 12 for a typical clear sky day around solar noon, the time it takes for an  
875 individual with unprotected fair skin to exceed the exposure limit T<sub>max</sub> is 7 minutes,  
876 while the time to achieve erythema (sunburn) is approximately 11 minutes (Gies and  
877 Wright 2003). Unprotected workers would therefore easily exceed the EL within the  
878 8 hour limit.

879

880 **TABLE 4:** A comparison between the WHO UV Index relating the sun's UVR  
881 intensity to the time taken to exceed the EL's of Schedule 1. The higher  
882 the UV Index the shorter the time to exceed the EL.

883

<b>UV Index</b>	<b>T<sub>max</sub> (mins)</b>
2	40
4	20
6	13
8	10
10	8
12	7
14	6
16	4

884

885

## 886 **Protective measures against solar UVR**

887

### 888 ***Scheduling***

889 Approximately two thirds of the daily UVR is received in the two hours before and  
890 after solar noon, when UVR levels are at their highest. If possible workers should  
891 avoid exposure to the sun during these times. Even on a cloudy day a worker may  
892 still receive high levels of solar UVR due to scattering and reflected UVR reaching  
893 the earth's surface.

894

895 ***Shade Provision***

896 Shade structures can also provide protection from solar UVR, however, the level of  
897 personal protection depends on the UPF rating of the material and the amount of  
898 scattered and reflected solar UVR from the environment, which can significantly  
899 reduce its effectiveness. If the shade structure offers only partial protection then  
900 additional measures will be required.

901  
902 ***Personal Protection***

903 A number of personal protection measures can help to reduce the exposure from  
904 solar UVR. Personal protection should be considered as the last line of defence  
905 against solar UVR. A combination of various items of personal protection against  
906 solar UVR, such as hats, clothing, sunscreen and sunglasses provides the best  
907 protection strategy rather than relying on just one form of protection.

908  
909 ***Clothing***

910 The use of appropriate clothing that covers as much of the unprotected skin as  
911 possible is a simple method of reducing exposure to solar UVR. An ultraviolet  
912 protection factor (UPF) was developed by ARPANSA and adopted into AS/NZS  
913 4399:1996 Sun Protective Clothing. The UPF ratings assist the public and workers  
914 in choosing clothing that offers suitable UVR protection. The higher the UPF rating,  
915 the greater the UVR protection offered by the clothing. UPF ratings of 50+ provide  
916 excellent protection against solar UVR.

917  
918 ***Hats***

919 Wearing a hat can provide significant protection to the face, neck, ears and eyes.  
920 The measure of protection provided by a hat is determined by the design (Diffey and  
921 Cheeseman 1992); broad brimmed (>7cm) hats provide the best protection for the  
922 face, neck and ears. Where hard hats are required brim or neck flaps should be  
923 worn.

924  
925 ***Sunglasses***

926 For the eyes, sunglasses tested to the Australian and New Zealand Standard  
927 AS/NZS 1067: 2003 'Sunglasses and fashion spectacles' and some prescription  
928 spectacles provide excellent protection from exposure to solar UVR. The design of  
929 the sunglasses frames is very important. Wrap-around style sunglasses reduce the  
930 amount of scattered and reflected solar UVR reaching the eyes.

931  
932 ***Sunscreens***

933 For skin not protected by other means, broad-spectrum sunscreen with a SPF rating  
934 of at least 15+ or preferably 30+ applied correctly is an effective means of personal  
935 protection against solar UVR. The major concern is the inconsistent application of  
936 sunscreen on unprotected skin. Studies have consistently shown that people  
937 generally apply sunscreens at approximately half the required thickness and only  
938 achieve a third to half of the sunscreen rating (Bech-Thomsen, N. and Wulf, H.C.  
939 1992). Factors such as thickness, absorption into the skin, sweating and contact with  
940 water must be taken into consideration as they can reduce the effectiveness of the  
941 sunscreen. The sunscreen must also be reapplied frequently.

942  
943 ***Personal Behaviour and Training***

944 Personal behaviour of workers is an important factor in limiting the exposure to  
945 solar UVR. If personal protection measures are not used or used inappropriately  
946 then workplace education programs may be required to educate the workers and  
947 improve the manner in which they perceive solar UVR protection.

948

949 Employees with photosensitivity reactions to UVR require additional protective  
950 measures.

951

## 952 **Sources of Artificial UVR in the Workplace**

953

954 There are many types of artificial UVR sources used in industry, some emit high  
955 levels of UVR in industrial processes whilst others are common sources of visible  
956 light but may also emit UVR. Arc welders used in industry produce an intense UVR  
957 emission and workers or persons exposed to welding radiation may suffer similar  
958 health effects to workers with over exposure to solar UVR. There are many other  
959 forms of artificial UVR sources such as fluorescent lamps, mercury vapour and metal  
960 halide lamps and quartz halogen lights used in industry. Germicidal lamps used in  
961 hospitals are also a strong source of hazardous UVR. The UVR hazard of a potential  
962 source cannot be based on the level of visible light emissions, some UVR sources  
963 radiate only a faint visible light but they also emit high levels of UVR.

964

965 The hazards from artificial sources can vary markedly, from non-hazardous with  
966 allowed exposure time of greater than 8 hours to extremely hazardous with allowed  
967 exposure times of less than a minute as shown in following table.

968

969 **TABLE 5:** Some artificial sources of UVTR and the times taken to exceed the  
970 Exposure limits of Schedule 1

971

<b>Category</b>	<b>Time</b>
Fluorescent lamp	> 8hrs
Quartz halogen lamp	~ 10 mins
UVA lamp	~ 17 mins
Germicidal (UVC) lamp	1 – 3 mins
Arc Welder	1 – 5 mins

972

973

## 974 **Protection Measures for Artificial UVR**

975

976 The employer can provide protection of workers from exposure to artificial UVR via  
977 a combination of administrative, workplace and personal protective equipment  
978 measures.

979

980 **Engineering controls** including redesign of equipment or work processes and/or  
981 isolation and containment of the hazard. Examples include:

982

- 983 • installing shielding
- 984 • enclosing the source either in a container or in a dedicated room
- 985 • fail-safe interlocks
- 986 • built-in UVR detectors and alarms
- 987 • elimination of reflected UVR
- 988 • ventilation to remove any ozone produced;

989

990 Introduction of **administrative** controls such as

991

- 992 • signage restricting access
- 993 • hazard signs or warning lights
- 994 • if necessary, the need for personal protection
- 995 • due care during any maintenance and service on the UVR source, particularly  
996 if safety shielding is removed.

997  
998 Administrative management requires the identification of potential UVR hazards  
999 associated with the workplace and equipment and then restricting all unauthorized  
1000 workers and people from close proximity to the equipment or work area. The  
1001 workers operating the equipment need adequate training to understand the hazards  
1002 involved and to carry out their work safely. For worker safety the distance they  
1003 operate the equipment from has to be assessed as well as the duration of any  
1004 exposure. Finally warning signs, lights and labelling of potential equipment that  
1005 emit UVR are additional measures to aid in protection of workers. Employees with  
1006 photosensitivity reactions to UVR require additional protective measures.

1007

### 1008 **Assessment of UVR Levels and Potential Hazards**

1009

1010 Assessment of the UVR hazards from artificial sources of UVR can be achieved in a  
1011 number of ways.

1012

1013 **1.** Knowledge of the source emissions and power allows an initial assessment of  
1014 potential hazards. Such information can be obtained from the manufacturer's  
1015 data sheets on the source, which can list the spectral output or the amounts of  
1016 UVA, UVB and UVC.

1017 **2.** Dosimetric assessment using UVR sensitive polysulphone film can give an  
1018 indication of the presence of hazardous UVR. If the source spectrum is known,  
1019 then the hazard can be accurately assessed.

1020 **3.** Radiometric or spectral assessment of the source output can provide the  
1021 information to accurately quantify the amount and type of UVR emitted and  
1022 thus allow calculation of the hazard.

1023

1024

1025

1026 **Annex 4**

1027

1028 **ARPANSA RADIATION PROTECTION SERIES PUBLICATIONS**

1029

1030 ARPANSA has taken over responsibility for the administration of the former  
1031 NHMRC Radiation Health Series of publications and for the codes developed under  
1032 the *Environment Protection (Nuclear Codes) Act 1978*. The publications are being  
1033 progressively reviewed and republished as part of the *Radiation Protection Series*.  
1034 Current publications in the *Radiation Protection Series* are:

1035

1036 RPS 1 Recommendations for Limiting Exposure to Ionizing Radiation (1995)  
1037 and National Standard for Limiting Occupational Exposure to Ionizing  
1038 Radiation (republished 2002)

1039 RPS 2 Code of Practice for the Safe Transport of Radioactive Material (2001)

1040 RPS 3 Radiation Protection Standard for Maximum Exposure Levels to  
1041 Radiofrequency Fields – 3 kHz to 300 GHz (2002)

1042 RPS 4 Recommendations for the Discharge of Patients Undergoing Treatment  
1043 with Radioactive Substances (2002)

1044 RPS 5 Code of Practice and Safety Guide for Portable Density/Moisture Gauges  
1045 Containing Radioactive Sources (2004)

1046 RPS 6 National Directory for Radiation Protection, Edition 1 (2004)

1047 RPS 7 Recommendations for Intervention in Emergency Situations Involving  
1048 Radiation Exposure (2004)

1049 RPS 8 Code of Practice for the Exposure of Humans to Ionizing Radiation for  
1050 Medical Research Purposes (2005)

1051 RPS # Radiation Protection Standard for Occupational Exposure to Ultraviolet  
1052 Radiation (2005)

1053

1054 Those publications from the NHMRC Radiation Health Series and the Environment  
1055 Protection (Nuclear Codes) Act Series that are still current are:

1056

1057 **RADIATION HEALTH SERIES**

1058

1059 RHS 2. Code of practice for the design of laboratories using radioactive  
1060 substances for medical purposes (1980)

1061 RHS 3. Code of practice for the safe use of ionizing radiation in veterinary  
1062 radiology: Parts 1 and 2 (1982)

1063 RHS 4. Code of practice for the safe use of radiation gauges (1982)

1064 RHS 8. Code of nursing practice for staff exposed to ionizing radiation (1984)

1065 RHS 9. Code of practice for protection against ionizing radiation emitted from X-  
1066 ray analysis equipment (1984)

1067 RHS 10. Code of practice for safe use of ionizing radiation in veterinary radiology:  
1068 part 3-radiotherapy (1984)

1069 RHS 13. Code of practice for the disposal of radioactive wastes by the user (1985)

1070 RHS 14. Recommendations for minimising radiological hazards to patients (1985)

1071 RHS 15. Code of practice for the safe use of microwave diathermy units (1985)

1072 RHS 16. Code of practice for the safe use of short wave (radiofrequency) diathermy  
1073 units (1985)

- 1074 RHS 18. Code of practice for the safe handling of corpses containing radioactive  
1075 materials (1986)
- 1076 RHS 19. Code of practice for the safe use of ionizing radiation in secondary schools  
1077 (1986)
- 1078 RHS 20. Code of practice for radiation protection in dentistry (1987)
- 1079 RHS 21. Revised statement on cabinet X-ray equipment for examination of letters,  
1080 packages, baggage, freight and other articles for security, quality control  
1081 and other purposes (1987)
- 1082 RHS 22. Statement on enclosed X-ray equipment for special applications (1987)
- 1083 RHS 23. Code of practice for the control and safe handling of radioactive sources  
1084 used for therapeutic purposes (1988)
- 1085 RHS 24. Code of practice for the design and safe operation of non-medical  
1086 irradiation facilities (1988)
- 1087 RHS 25. Recommendations for ionization chamber smoke detectors for  
1088 commercial and industrial fire protection systems (1988)
- 1089 RHS 28. Code of practice for the safe use of sealed radioactive sources in bore-hole  
1090 logging (1989)
- 1091 RHS 30. Interim guidelines on limits of exposure to 50/60Hz electric and magnetic  
1092 fields (1989)
- 1093 RHS 31. Code of practice for the safe use of industrial radiography equipment  
1094 (1989)
- 1095 RHS 34. Safety guidelines for magnetic resonance diagnostic facilities (1991)
- 1096 RHS 35. Code of practice for the near-surface disposal of radioactive waste in  
1097 Australia (1992)
- 1098 RHS 36. Code of practice for the safe use of lasers in schools (1995)
- 1099 RHS 37. Code of practice for the safe use of lasers in the entertainment industry  
1100 (1995)
- 1101 RHS 38. Recommended limits on radioactive contamination on surfaces in  
1102 laboratories (1995)  
1103

**ENVIRONMENT PROTECTION (NUCLEAR CODES) ACT SERIES**

- 1104 Code of Practice on the Management of Radioactive Wastes from the Mining and  
1105 Milling of Radioactive Ores 1982
- 1106 Code of Practice on Radiation Protection in the Mining and Milling of Radioactive  
1107 Ores 1987
- 1108  
1109  
1110

1111  
1112  
1113  
1114  
1115  
1116  
1117

## Annex 5

### RADIATION PROTECTION AUTHORITIES

Where advice or assistance is required from the relevant radiation protection authority, it may be obtained from the following officers:

COMMONWEALTH, STATE / TERRITORY	CONTACT
Commonwealth	Director, Regulatory Branch ARPANSA PO Box 655 Miranda NSW 1490 Email: info@arpansa.gov.au Tel: (02) 9541 8333 Fax: (02) 9541 8348
Australian Capital Territory	Manager Radiation Safety Radiation Safety Section ACT Health Locked Bag 5 Weston Creek ACT 2611 Email: radiation.safety@act.gov.au Tel: (02) 6207 6946 Fax: (02) 6207 6966
New South Wales	Director Radiation Control Department of Environment and Conservation PO Box A290 Sydney South NSW 1232 Email: radiation@environment.nsw.gov.au Tel: (02) 9995 5000 Fax: (02) 9995 6603
Northern Territory	Manager Radiation Protection Radiation Protection Section Department of Health and Community Services GPO Box 40596 Casuarina NT 0811 Email: envirohealth@nt.gov.au Tel: (08) 8922 7152 Fax: (08) 8922 7334
Queensland	Director, Radiation Health Department of Health 450 Gregory Terrace Fortitude Valley QLD 4006 Email: radiation_health@health.qld.gov.au Tel: (07) 3406 8000 Fax: (07) 3406 8030
South Australia	Director, Radiation Protection Division Environment Protection Authority PO Box 721 Kent Town SA 5071 Email: radiationprotection@state.sa.gov.au Tel: (08) 8130 0700 Fax: (08) 8130 0777
Tasmania	Senior Health Physicist Health Physics Branch Department of Health and Human Services GPO Box 125B Hobart TAS 7001 Email: health.physics@dhhs.tas.gov.au Tel: (03) 6222 7256 Fax: (03) 6222 7257
Victoria	Manager, Radiation Safety Program Department of Human Services GPO Box 4057 Melbourne VIC 3001 Email: radiation.safety@dhs.vic.gov.au Tel: (03) 9637 4167 Fax: (03) 9637 4508
Western Australia	Secretary, Radiological Council Locked Bag 2006 PO Nedlands WA 6009 Email: radiation.health@health.wa.gov.au Tel: (08) 9346 2260 Fax: (08) 9381 1423

1118  
1119  
1120  
1121  
1122

**Please note:** This table was correct at the time of printing but is subject to change from time to time. For the most up-to-date list, the reader is advised to consult the ARPANSA web site ([www.arpansa.gov.au](http://www.arpansa.gov.au)). For after hours emergencies only, the police will provide the appropriate emergency contact number.

1123  
1124  
1125  
1126  
1127  
1128  
1129

## Annex 6

### REGULATORY AUTHORITIES

The following organisations regulate various aspects of the occupational use of ultraviolet radiation.

COMMONWEALTH, STATE / TERRITORY	CONTACT
Commonwealth	Director, Regulatory Branch ARPANSA PO Box 655 Miranda NSW 1490 Email: info@arpansa.gov.au Web: www.arpansa.gov.au Tel: (02) 9541 8333 Fax: (02) 9541 8348
New South Wales	Director Radiation Control Section Department of Environment and Conservation PO Box A290 Sydney South NSW 1232 Email: radiation@environment.nsw.gov.au Web: www.environment.nsw.gov.au Tel: (02) 9995 5000 Fax: (02) 9995 6603
Queensland	Division of Workplace Health & Safety, Department of Industrial Relations GPO Box 69, Brisbane, Qld, 4001 Web: www.whs.qld.gov.au Ph: (07) 3225 2000 Fax: (07) 3247 4519
South Australia	Director, Radiation Protection Division Environment Protection Authority PO Box 721 Kent Town SA 5071 Email: radiationprotection.branch@state.sa.gov.au Tel: (08) 8130 0700 Fax: (08) 8130 0777
Tasmania	Workplace Standards Tasmania Department of Infrastructure Energy and Resources 30 Gordons Hill Road (PO Box 56) Rosny Park, Tas, 7018 email: wstinfo@dier.tas.gov.au web: www.wsa.tas.gov.au Tel: 1300 366 322 (inside Tas) 03 6233 7657 (outside Tas)
Victoria	[No regulator]
Western Australia	Secretary Radiological Council of Western Australia Locked Bag 2006 PO Nedlands WA 6009 Email: radiation.health@health.wa.gov.au Tel: (08) 9346 2260 Fax: (08) 9381 1423
Australian Capital Territory	ACT Workcover PO Box 224 CIVIC SQUARE ACT 2608 Email: workcover@act.gov.au Web: www.workcover.act.gov.au Ph: 02 6205 0200 Fax: (02) 6205 0797
Northern Territory	[No regulator]

1130  
1131

1132 **Contributors to Drafting and Review**

1133

1134

1135 **WORKING GROUP**

1136

1137

1138 Dr Peter Gies (ARPANSA, Non-ionizing Radiation Branch)

1139 Dr Colin Roy (ARPANSA, Non-ionizing Radiation Branch)

1140 Mr Alan Melbourne (ARPANSA, Standards Development & Committee Support Section)

1141 Ms Jill Wright (QLD Workplace Health and Safety)

1142

1143

1144	<b>Index</b>	1147
1145	(Page numbers to be added)	
1146		
1148	Actinic UVR	1187 Ocular exposure
1149	Action spectra	1188
1150	Acute effects	1189 Permissible exposure time
1151	Administrative controls	1190 Personal Protective Equipment PPE
1152	Aphakic	1191 Photoconjunctivitis
1153	Artificial	1192 Photokeratitis
1154		1193 Photosensitizers
1155	Bandwidth	1194 Pterygium
1156	Broadband source	1195
1157		1196 Radiant exposure
1158	Cataracts	1197 Rationale
1159	Chronic effects	1198 Retinal injury
1160	Clothing	1199
1161	Cosmetic	1200 Shade
1162		1201 Skin aging
1163	DNA	1202 Skin Cancer
1164		1203 Solar elastosis
1165	Emission lines	1204 Spectral effectiveness
1166	Engineering controls	1205 Spectral irradiance
1167	Erythema	1206 Sunburn
1168	Exposure limits	1207 Sunglasses
1169	Effective irradiance	1208 Sunscreens
1170	Eyes	1209 Supervision
1171		1210
1172	Hats	1211
1173	Health effects	1212
1174		1213 Therapeutic
1175	Irradiance	1214 Training
1176	Lasers	1215
1177	Lens damage	1216 UVA
1178		1217 UVB
1179	Immune response	1218 UVC
1180		1219 UVR
1181	Maximum exposure duration	1220
1182	Medical treatment	1221 Visible radiation
1183	Melanoma	1222
1184	Mercury discharge	1223 Workers
1185		1224
1186	Non-melanoma	1225
		1226
		1227
		1228