[Consultation Draft - June 2003]

Radiation Protection Standard

Occupational Exposure to Ultraviolet Radiation

Radiation Protection Series Publication No. #

AUSTRALIAN RADIATION PROTECTION AND NUCLEAR SAFETY AGENCY

ARPANSA

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.

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Occupational Exposure to Ultraviolet Radiation

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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.

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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

Foreword

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

This publication replaces the previous standard issued by the National Health and Medical Research Council as RADIATION HEALTH SERIES No.29 *Occupational standard for exposure to ultraviolet radiation (1989)*, without changing the exposure limits set out in the previous standard.

This Radiation Protection Standard provides guidance on the maximum limits of occupational exposure to ultraviolet radiation for conditions where it is believed that nearly all workers may be repeatedly exposed without adverse effect.

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

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

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

[signature]

John Loy
CEO of ARPANSA

Contents

1. Introduction

1.1 Citation

This Radiation Protection Standard may be cited as the *Radiation Protection Standard for Occupational Exposure to Ultraviolet Radiation (2003).*

1.2 Background

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) and at the annual meeting in 1996, ICNIRP concluded that recent data did not suggest that the exposure limit (EL) values needed to be amended (ICNIRP Health Physics 1996). This standard replaces the National Health and Medical Research Council's Radiation Health Series No 29 (RHS 29), 1989.

1.3 Purpose

The purpose of this document is to provide guidance on maximum limits of exposure to ultraviolet radiation (UVR) in the spectral region between 180 and 400 nm. The exposure limits specified represent conditions under which it is believed that nearly all workers may be repeatedly exposed without adverse effect.

1.4 Scope

These exposure limit (EL) values for exposure of the eye or the skin may be used to evaluate potentially hazardous exposure from UVR. The limits do not apply to ultraviolet lasers. The values should be used as guides in the control of exposure to both pulsed and continuous sources of UVR where the exposure duration is not less than 0.1 μsec. The ELs are below levels used for UV exposures of patients as a part of medical treatment or for elective cosmetic purposes. They are intended as upper limits for non-therapeutic and non-cosmetic exposure. These ELs are typically exceeded by noonday solar radiation overhead at 0° to 40° latitude within 5 to 10 minutes in summer. These ELs apply to unprotected skin and eyes and the implications of this standard for outdoor workers are that they will need to be protected against solar UVR.

These ELs should be considered as absolute limits for ocular exposure but occasional exposure of conditioned skin may not result in adverse effects.

1.5 STRUCTURE

This Radiation Protection Standard is structured as follows:

Section 2 and Schedules 1 and 2 provide 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 advise on protection from UVR is available, and
- Annex 6 lists the Regulatory Authorities for occupational exposure to UVR.

2. Exposure Limits (EL)

2.1 The EL for both occupational exposure to UVR incident upon the skin or eye where irradiance values are known and the exposure duration is controlled are as below.

2.2 Ultraviolet radiant exposure in the spectral region 180 to 400 nm incident upon the unprotected skin and unprotected eye(s) must not exceed 30 $J.m^{-2}$ effective spectrally weighted using the relative spectral effectiveness contained in Schedule 1.

2.3 The total unweighted ultraviolet radiant exposure in the spectral region 315 to 400 nm must not exceed 10 $kJ .m^{-2}$.

2.4 For determination of 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:

$$E_{eff} = \sum E_\lambda . S_\lambda . \Delta_\lambda$$

where:

E_{eff} = Effective irradiance in $W.m^{-2}$ ($J.s^{-1}.m^{-2}$) normalised to a monochromatic source at 270 nm

E_λ = Spectral irradiance in $W.m^{-2}.nm$

S_λ = Relative spectral effectiveness (unitless)

Δ_λ = Bandwidth in nanometres of the calculated or measurement intervals

2.5 Permissible exposure time in seconds for exposure to actinic UVR incident upon the unprotected skin or eye may be computed by dividing 30 $J.m^{-2}$ by E_{eff} in $W.m^{-2}$. The maximum exposure duration may also be determined using Schedule 2 which provides representative exposure durations corresponding to effective irradiances in $W.m^{-2}$ (and $\mu W.cm^{-2}$).

Schedule 1

ULTRAVIOLET RADIATION EXPOSURE LIMITS AND RELATIVE SPECTRAL EFFECTIVENESS

Wavelength[a] (nm)	Exposure Limit ($J.m^{-2}$)	Exposure Limit ($mJ.cm^{-2}$)	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[b]	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[b]	34	3.4	0.880
285	39	3.9	0.770
290	47	4.7	0.640
295	56	5.6	0.540
297[b]	65	6.5	0.460
300	100	10	0.300
303[b]	250	25	0.120
305	500	50	0.060
308	1,200	120	0.026
310	2,000	200	0.015
313[b]	5,000	500	0.006

ULTRAVIOLET RADIATION EXPOSURE LIMITS AND RELATIVE SPECTRAL EFFECTIVENESS (CONTINUED)

Wavelength[a] (nm)	Exposure Limit ($J.m^{-2}$)	Exposure Limit ($mJ.cm^{-2}$)	Relative Spectral Effectiveness S_λ
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
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[b]	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

[a] Wavelengths chosen are representative; other values should be interpolated at intermediate wavelengths.

[b] Emission lines of a mercury discharge spectrum.

Schedule 2

LIMITING UV EXPOSURE DURATIONS BASED ON EL

Duration of Exposure Per Day	Effective Irradiance E_{eff} ($W.m^{-2}$)	Effective Irradiance E_{eff} ($\mu W.cm^{-2}$)
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

References

1. IRPA/INIRC 1985, 'Guidelines on limits of exposure to ultraviolet radiation of wavelengths between 180 nm and 400 nm (incoherent radiation)', *Health Physics* 1985, 49(2): 331-340.

2. IRPA/INIRC 1989. 'Proposed change to the IRPA 1985 guidelines on limits of exposure to ultraviolet radiation', *Health Physics* 1989, 56(6): 971-972.

3. International Commission on Non-Ionizing Radiation Protection 1996, 'Guidelines on UV Radiation Exposure Limits', *Health Physics* 1996, 71: 978.

4. National Health and Medical Research Council 1989, 'Occupational standard for exposure to ultraviolet radiation', *Radiation Health Series* No.29. Canberra: NHMRC.

5. JH Bernhardt and R Matthes 1997, 'Recent and Future Activities of the ICNIRP', *Radiation Protection Dosimetry*, 72; 167-176.

6. UNEP/ICNIRP/WHO 1994, 'Environmental Health Criteria 160, Health and environmental effects of ultraviolet radiation, Geneva'.

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 the Limits for 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. The exposure limits of this standard (first published by IRPA[1] in 1985) are derived from numerous scientific studies (both human and animal) of the acute effects of ultraviolet irradiation of skin and eyes. The exposure limits are set below the threshold limit value of 30 $J.m^{-2}$ 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)[2] in 1989 updated the previous limits on ultraviolet radiation which it had published in Health Physics[1] 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[4] RHS 29.

At its 1996 annual meeting, ICNIRP[3] 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[5] published in Radiation Protection Dosimetry. Thus the original ELs still apply as does the original IRPA/INIRC rationale for their development, which can be found in Health Physics[2].

Annex 2

Health effects of UVR

Background

A comprehensive review of UVR effects has been published by IRPA/INIRC[2] in 1985 and UNEP/WHO/ ICNIRP[6] in 1994 and the interested reader is referred to those documents. The following discussion is a brief summary of the health effects of UVR.

General biological effects

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

Acute Effects

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

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

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

Chronic Effects

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

A fuller and more detailed discussion of health effects of UVR can be found in the IRPA/INIRC[2] rationale and the UNEP/WHO/ICNIRP[6] Environmental Health Criteria, which also has a chapter on UVR protective measures.

Annex 3

Limiting Excessive Exposure to Ultraviolet Radiation (UVR) in the Workplace

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

Australians are predominantly a fair skinned population and enjoy an outdoor lifestyle and each year there are approximately 270,000 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.

UVR exposure also places our eyes at risk of photokeratitis, photoconjunctivitus 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 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 from UVR.

Employer's Legal Requirements Concerning Exposure To UVR.

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

Worker's Obligations Concerning UVR Exposure.

Workers or any other person at a workplace have an obligation to comply with the instructions given for workplace health and safety by the employer. If the employer provides personal protective equipment (PPE) for protection against UVR and instructs the employee in its use (3), the worker has an obligation to use the PPE. The worker also has an obligation not to wilfully or recklessly interfere with or misuse anything provided for workplace health and safety and to not wilfully put anyone else or themselves at risk.

As an employee these obligations can be met by following safe working procedures established by the employer. Employees should not intentionally expose themselves or others to levels of UVR that may exceed the exposure limits of this Standard. They should never operate equipment that emits UVR with the shielding or protective devices removed.

Managing Exposure to UVR in the Workplace

The process for managing workplace health and safety risks, both generally and for UVR risks, is:

(a) Identification of the hazards. This step should include identification of the primary sources of UVR exposure in the workplace;

(b) Assessment of the risk. This step includes assessment 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 minimize the level of risk. There is a need to ensure that the control(s) chosen do 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 UVR;

(e) Monitoring and reviewing the effectiveness of the control measures. The monitoring and review process assesses whether the chosen measures are effective and that the control measures have not introduced new hazards or worsened existing hazards.

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

(a) **Elimination** of the hazard. If this is not practical, exposure to the risk should be prevented or minimised by one or a combination of the following control measures;

(b) **Substitution** of a less hazardous (and more manageable) process or less hazardous plant; and

(c) **Engineering controls** including redesign of equipment or work processes and/or isolation of the hazard. Examples include shielding and fail-safe interlocks;

(d) Introduction of **administrative** controls such as signage restricting access or defining exposure limit boundaries, safe work systems. Administrative controls may be used in combination with higher level controls;

(e) Use of appropriate **personal protective equipment** (PPE). All users of PPE must be provided with the appropriate PPE and trained and supervised in its use to ensure that they have a clear understanding of its correct usage and limitations and they must use it accordingly. In addition, the PPE must be maintained and replaced as specified by the manufacturer to ensure it is kept in good condition so that its effectiveness as a control is not compromised.

SOLAR UVR IN THE WORKPLACE

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

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

- Directly from the sun,
- Scattered from the open sky,
- Reflected from the environment

This means that even if a person is shaded from the direct sun they can still receive substantial UVR exposure from the open sky and reflective ground surfaces. If a person is in the shade but can view blue sky they are still exposed to solar UVR from the sky. A highly reflective environment can also increase UVR levels and can reduce the effect of protective measures. Some ground and building surfaces are quite reflective to UVR and can reflect UVR onto the skin and eyes and these include white paint, light coloured concrete and metallic surfaces (4).

Workers who spend a significant amount of time during the day in a motor vehicle can also receive high levels of solar UVR, however, laminated front windscreens and tinting of the side and rear windows can greatly reduce the amount of UVR entering the vehicle. Most automotive tints provide excellent protection against solar UVR (5).

<u>The Occupational UVR Exposure Limits and Solar UVR</u>

The exposure limit in this Standard for both general and occupational exposure to UVR incident upon the skin or eye is 30 Jm^{-2} in an 8 hour working day.

UVR levels are reported by the media as a Solar UV-Index (6), which is a measure of the maximum daily UVR. The UV Index allows for cloud cover and other environmental factors and is used worldwide for reporting UVR levels. The UV Index provides the public with a numerical indication of the maximum potential solar UVR level during the day. The higher the number the higher the solar UVR hazard.

The following table shows that the duration required to exceed the exposure limits varies with the intensity of solar UVR. During summer when the UV Index value may be 12 for a typical Melbourne clear sky day the time it takes for an individual with unprotected fair skin to redden (sunburn) is approximately 7 minutes, which would exceed the 8 hour limit.

UV Index	Tmax (mins)
2	40
4	20
6	13
8	10
10	8
12	7
14	6
16	4

Protection measures for solar UVR

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

A number of personal protection measures can help to reduce the exposure from solar UVR. The use of appropriate clothing that covers as much of the unprotected skin as possible is a simple method of reducing exposure to solar UVR. An ultraviolet protection factor (UPF) was developed by ARPANSA to assist the public and workers in choosing clothing that offers suitable UVR protection. The higher the UPF rating the greater the UVR protection offered by the clothing. UPF ratings of 50+ provide excellent protection against solar UVR. Wearing a hat can provide significant protection to the face, neck, ears and eyes. The measure of protection provided by a hat is determined by the design (7); broad brimmed (>7cm) hats provide the best protection for the face, neck and ears. Where hard hats are required brim or neck flaps should be worn.

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

For skin not protected by other means, broad-spectrum sunscreen with a SPF rating of at least 15+ or preferably 30+ applied correctly is an effective means of personal protection against solar UVR. The major concern is the inconsistent application of sunscreen on unprotected skin. Studies have consistently shown that people generally apply sunscreens at approximately half the required thickness and only achieve a third to half of the sunscreen rating (8). Factors such as thickness, absorption into the skin, sweating and contact with water must be taken into consideration as they can reduce the effectiveness of the sunscreen. The sunscreen must also be reapplied frequently.

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

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

Employees with photosensitivity reactions to UVR require additional protective measures.

SOURCES OF ARTIFICIAL UVR IN THE WORKPLACE

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

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

Category	Time (mins)
Fluorescent lamp	> 8hrs
Quartz halogen lamp	~10
UVA lamp	~17
Germicidal (UVC) lamp	1 – 3
Arc Welder	1- 5
Solaria fluorescent lamp	3 - 20

Protection Measures for Artificial UVR

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

An area that contains sources of UVR can be managed by isolating or providing approved safety guards on equipment, the use of non-UVR reflective material in these areas and interlocks to reduce accidental exposure to UVR.

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

Personal protective equipment for the skin and eyes should be provided by the employer to all employees working on equipment that utilizes a UVR source. The personal protective equipment would be clothing with excellent protection against UVR and adequate coverage of unprotected skin, and safety goggles or glasses designed to minimize UVR to the eyes. The level of protection will depend on the UVR source; for example, workers using an arc welder would require full body, hand and eye protection.

Monitoring the effectiveness of the measures requires periodic review of the control procedures that have been implemented to determine if they are working or require implementation of further measures to reduce the exposure of workers to potential UVR.

References

1. Radiation Protection Standard - Occupational Exposure to Ultraviolet Radiation Protection. Radiation Protection Series Publication No: 3.
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Annex 4

ARPANSA Radiation Protection Series Publications

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

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

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

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

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

RPS # Radiation Protection Standard for Occupational Exposure to Ultraviolet Radiation (2003)

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

RADIATION HEALTH SERIES

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

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

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

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

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

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

RHS 11. Code of practice for the safe use of soil density and moisture gauges containing radioactive sources (1984)

RHS 12. Administration of ionizing radiation to human subjects in medical research (1984)

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

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

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

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

RHS 17. Procedure for testing microwave leakage from microwave ovens (1985)

RHS 18. Code of practice for the safe handling of corpses containing radioactive materials (1986)

RHS 19. Code of practice for the safe use of ionizing radiation in secondary schools (1986)

RHS 20. Code of practice for radiation protection in dentistry (1987)

RHS 21. Revised statement on cabinet X-ray equipment for examination of letters, packages, baggage, freight and other articles for security, quality control and other purposes (1987)

RHS 22. Statement on enclosed X-ray equipment for special applications (1987)

RHS 23. Code of practice for the control and safe handling of radioactive sources used for therapeutic purposes (1988)

RHS 24. Code of practice for the design and safe operation of non-medical irradiation facilities (1988)

RHS 25. Recommendations for ionization chamber smoke detectors for commercial and industrial fire protection systems (1988)

RHS 26. Policy on stable iodine prophylaxis following nuclear reactor accidents (1989)

RHS 28. Code of practice for the safe use of sealed radioactive sources in bore-hole logging (1989)

RHS 30. Interim guidelines on limits of exposure to 50/60Hz electric and magnetic fields (1989)

RHS 31. Code of practice for the safe use of industrial radiography equipment (1989)

RHS 32. Intervention in emergency situations involving radiation exposure (1990)

RHS 34. Safety guidelines for magnetic resonance diagnostic facilities (1991)

RHS 35. Code of practice for the near-surface disposal of radioactive waste in Australia (1992)

RHS 36. Code of practice for the safe use of lasers in schools (1995)

RHS 37. Code of practice for the safe use of lasers in the entertainment industry (1995)

RHS 38. Recommended limits on radioactive contamination on surfaces in laboratories (1995)

ENVIRONMENT PROTECTION (NUCLEAR CODES) ACT SERIES

Code of Practice on the Management of Radioactive Wastes from the Mining and Milling of Radioactive Ores 1982

Code of Practice on Radiation Protection in the Mining and Milling of Radioactive Ores 1987

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 Tel: (02) 9545 8333 Miranda NSW 1490 Fax: (02) 9545 8348 Email: arpansa@health.gov.au
New South Wales	Director, Radiation Control Section Environment Protection Authority P.O. Box A290 Tel: (02) 9995 5000 Sydney South NSW 1232 Fax: (02) 9995 5925 Email: info@epa.nsw.gov.au
Queensland	Director, Radiation Health Department of Health 450 Gregory Terrace Tel: (07) 3406 8000 Fortitude Valley QLD 4006 Fax: (07) 3406 8030 Email: radiation_health@health.qld.gov.au
South Australia	Director, Radiation Protection Branch Environment Protection Authority PO Box 721 Tel: (08) 8130 0700 Kent Town SA 5071 Fax: (08) 8130 0777 Email: radiationprotection.branch@state.sa.gov.au
Tasmania	Senior Health Physicist Department of Health & Human Services GPO Box 125B Tel: (03) 6222 7256 Hobart TAS 7001 Fax: (03) 6222 7257 Email: health.physics@dhhs.tas.gov.au
Victoria	Manager, Radiation Safety Program Department of Human Services GPO Box 4057 Tel: (03) 9637 4167 Melbourne VIC 3001 Fax: (03) 9637 4508 Email: radiation.safety@dhs.vic.gov.au
Western Australia	Secretary Radiological Council of Western Australia Locked Bag 2006 PO Tel: (08) 9346 2260 Nedlands WA 6009 Fax: (08) 9381 1423 Email: radiation.health@health.wa.gov.au
Australian Capital Territory	Director, Radiation Safety Section Department of Health, Housing and Community Care GPO Box 825 Tel: (02) 6207 6946 Canberra ACT 2601 Fax: (02) 6207 6966 Email: radiation.safety@act.gov.au
Northern Territory	Manager – Radiation Health Radiation Health Branch Department of Health and Community Services GPO Box 40596 Tel: (08) 8999 2983 Casuarina NT 0811 Fax: (08) 8999 2700 Email: envirohealth@nt.gov.au

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 Tel: (02) 9545 8333 Miranda NSW 1490 Fax: (02) 9545 8348 Email: arpansa@health.gov.au Web: www.arpansa.gov.au
New South Wales	Director, Radiation Control Section Environment Protection Authority P.O. Box A290 Tel: (02) 9995 5000 Sydney South NSW 1232 Fax: (02) 9995 5925 Email: info@epa.nsw.gov.au Web: www.epa.nsw.gov.au
Queensland	Division of Workplace Health & Safety, Department of Industrial Relations GPO Box 69, Ph: (07) 3225 2000 Brisbane, Qld, 4001 Fax: (07) 3247 4519 Web: www.whs.qld.gov.au
South Australia	Director, Radiation Protection Branch Environment Protection Authority PO Box 721 Tel: (08) 8130 0700 Kent Town SA 5071 Fax: (08) 8130 0777 Email: radiationprotection.branch@state.sa.gov.au
Tasmania	Workplace Standards Tasmania Department of Infrastructure Energy and Resources 30 Gordons Hill Road (PO Box 56) Rosny Park, Tas, 7018 Tel: 1300 366 322 (inside Tas) 03 6233 7657 (outside Tas) email: wstinfo@dier.tas.gov.au web: www.wsa.tas.gov.au
Victoria	[No regulator]
Western Australia	Secretary Radiological Council of Western Australia Locked Bag 2006 Tel: (08) 9346 2260 Nedlands WA 6009 Fax: (08) 9381 1423 Email: radiation.health@health.wa.gov.au
Australian Capital Territory	ACT Workcover PO Box 224 CIVIC SQUARE ACT 2608 Ph: 02 6205 0200 Email: workcover@act.gov.au Fax: (02) 6205 0797 Web: www.workcover.act.gov.au
Northern Territory	[No regulator]

Contributors to Drafting and Review

WORKING GROUP

Dr Peter Gies (ARPANSA, Non-ionizing Radiation Branch)
Dr Colin Roy (ARPANSA, Non-ionizing Radiation Branch)
Mr Alan Melbourne (ARPANSA, Standards Development & Committee Support Section)

Index

(Page numbers to be added)