

UV exposure from sunlight compared with industrial sources: Implications for the development of Australia/NZ standards for UV protection

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Abstract. The Ultraviolet Radiation (UVR) Section at ARPANSA provides advice on and assessments of the levels of UVR emitted from various sources. Accurately assessing such sources requires either time consuming and expensive spectral measurements or a radiometer capable of measuring the relevant UVR wavelengths. Often all that is required is an initial approximate measurement to assess the magnitude of the UVR present. To this end, polysulphone (PS) badges can be placed in the vicinity of the UVR source and then evaluated subsequently at ARPANSA. This process is relatively inexpensive but provides a first estimate of the potential UVR hazard. If the PS badges show significant UVR exposure, then a more detailed and accurate follow-up measurement can be undertaken. The assessments for a range of different situations are described:

- a welding bay at an automobile manufacturing plant:
- an assessment of the UVR hazard in a compensation claim in a printing works:
- solar UVR levels at a new open cut mining enterprise
- solar UVR levels affecting the exhibits at a museum
- A range of welding bays in a factory.

Interestingly, for the exposures assessments, the solar UVR exposures were larger than those due to the artificial sources by a factor of 10, reinforcing the fact that solar UVR is the most important source of UVR to which the world's population is exposed. Use of UVR protection and changing behaviour can help reduce UVR exposures. Currently Standards on Sunscreens and Sun Protective Clothing are joint Australian and New Zealand Standards. As Australian Standards are revised they are reviewed jointly and as a result Sunglasses and Solaria are set to become joint Australian/New Zealand standards shortly. While there is a global push to have uniform standards worldwide, there may be cases where standards need to differ on a regional basis, and this applies in particular to UVR protection standards in Australian and New Zealand, given the high solar UVR levels in the region.

Introduction

Artificial sources of UVR have hazards that are unfamiliar and unknown to most people whereas sunlight is familiar and something they feel comfortable with. Guidelines on exposure to UVR have been issued by ICNIRP (1999) and cover exposure to both the skin and the eyes. ICNIRP limits the accumulated exposure in an 8 hour working day to less than 30 J/m² effective, when the output from a UVR source is weighted with the ICNIRP spectral response. The hazards from artificial sources can

vary markedly, from non hazardous with allowed exposure times of greater than 8 hours to extremely hazardous with allowed exposure times of less than a minute (Table 1).

Table 1. Time to exceed ICNIRP exposure limit for some typical UVR sources

| Category | Time (minutes) |
|------------------------------------|----------------|
| Quartz halogen lamp | ~10 |
| UVA lamp | ~17 |
| Germicidal (UVC) lamp | 1 - 3 |
| Arc welding | 1 - 5 |
| Solaria | 3 - 20 |
| Solar radiation ^a | |
| Darwin 12.4°S, summer/winter | 5 - 12 |
| Melbourne 37.8°S, summer/winter | 7 - 70 |
| Christchurch 43.6°S, summer/winter | 8 - 85 |

^aSolar noon on cloud-free day.

Results and Discussion

The ICNIRP weighted hazard is relevant to both the skin and the eyes. Also relevant is the erythemally effective dose to the skin. The CIE introduced the concept of the Standard Erythral Dose or SED (CIE 1997), where 1 SED is 100 J/m² effective, when the output from a UVR source is weighted with the CIE erythral response (CIE 1987). The SED is thus a useful measure of the biologically effective UVR for quantifying the hazard to the skin of UVR sources, many of which ARPANSA has assessed.

UVR Hazard Assessments

The employees at a car manufacturing plant were concerned about UVR exposure in the vicinity of a MIG welding robot. The employees wore eye protection, however there were no protective screens in place. A number of PS badges were placed around the worksite at a range of positions within 2 to 7 metres of the welder for 6 hours. While there was some UVR present, the cumulative doses recorded were less than 0.2 SEDs (Table 2). One PS badge in direct line of sight to the welder received 1.4 SEDs in 6 hours.

An employee of an industrial printing company claimed eye damage from accidental exposure to UVR from a printing lamp, which were in a dedicated printing room with interlocks. Personnel were not present when the lamps were in use. The exposure durations of the PS badges were much longer than any employee would achieve, yet the maximum UVR measured was ~ 0.15

SEDs (Table 2).

Another UVR hazard assessment of an industrial welding company involved measurements in multiple welding bays and of the doses received by the welders and their assistants. Most exposures were low, less than 0.1 SEDs. However, some operators had exposures of 0.5, 1.1 and 0.8 SEDs (Table 2). These were too high and also in excess of the ICNIRP limits unless these employees were wearing adequate UVR protection.

Table 2. Measured industrial UVR exposures.

| Location | Duration | Distance | Exposure SEDs |
|-------------|----------|-----------|---------------|
| Automobile | 6 hrs | 2 m | < 0.14 |
| Welding bay | 6 hrs | 4 - 7 m | < 0.04 |
| Near Welder | 6 hrs | 3 m | 1.4 |
| Industrial | 1 hr | 1 m | < 0.15 |
| Printing | 1-10 min | 0.1 - 1 m | < 0.06 |
| Near Welder | 1 min | 1 m | 1.26 |
| Industrial | ~ 6 hrs | - | < 0.1 |
| Welding | ~ 4 hrs | - | 1.1 |
| | ~ 6 hrs | - | 0.5 - 0.8 |

PS badges were used to address management and employee concerns over solar UVR exposures in an open cut mining operation at high altitude near the equator. PS badges are often used in personal exposure studies and are therefore calibrated for solar UVR. The employees wore PS badges and the measured exposures were substantial, of the order of 2-8 SEDs, equivalent to 20 to 50% of ambient UVR (Table 3). A recent study in collaboration with Queensland Health using PS badges to measure the UVR exposures of outdoor workers in the construction industry also found exposures were a significant fraction of ambient and were therefore in excess of the limit unless adequate and essential protection was provided for all workers.

Table 3. UVR exposures of outdoor workers.

| Location | Duration | Ambient UVR | Exposure SEDs |
|--------------|----------|-------------|---------------|
| Open Cut | ~ 8 hrs | 30 | 2 - 5 |
| Mining | ~ 8 hrs | 16 | 3 - 8 |
| | ~ 8 hrs | 18 | 3 - 6 |
| Building | | | |
| Construction | < 6 hrs | 10 - 14 | 4 - 6 |

Other assessments involved the UVR exposures of the exhibits in a Museum, in order to confirm the exhibits were safely housed for insurance and funding purposes and the calibration of a number of medical phototherapy cabinets in Sydney and Melbourne to ensure the doses delivered were correct.

Comparing the UVR doses in Tables 2 and 3 shows that

it is the outdoor workers that have more substantial exposures than employees working with artificial sources, the possible exception being welders and their assistants. This is because there are numerous control measures for artificial sources that are unfortunately not possible with sunlight. These are administrative control measures such as hazard awareness, limitation of access, hazard warning lights and signs and limitation of exposure time. Engineering control measures such as containment, sealed housings, screened areas, use of interlocks and elimination of reflected UVR also play a role.

The solar UVR for a typical mid-latitude location (in this case Sydney) is shown in Figure 1. At solar noon, with a UV Index of 12 (equivalent to 10.8 SEDs/hr), the ICNIRP guidelines are exceeded in 6.6 mins and erythema or sunburn would be achieved in 11 mins for people with skin type I. ARPANSA has experience with personal UVR exposure studies with various population groups which indicate that the range of exposures within any group can be very large and are generally log-normally distributed. Some subjects had consistently high or low exposures depending upon the individual's behaviour.

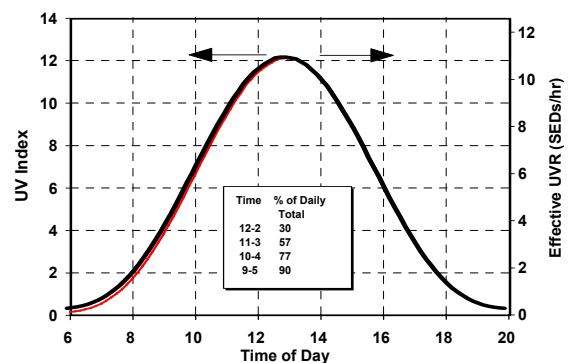


Figure 1. The variation of solar UVR with time of day, showing the relationship between UVR in SEDs/hr (right axis) and the UV Index (left axis).

Standards and UVR Protection

It is now useful to briefly review the current status of standards covering UVR and protection in Australia and New Zealand.

With sunscreens and the standard (AS/NZS 2604), one current major area of concern is the UVA protection provided by sunscreens because of concerns about the roles of UVA in immune suppression and cancer. There is currently a review by the Australian Cancer Society of the UVA testing for sunscreens in an attempt to improve their broad spectrum protection. There is also the problem of sunscreen application rate when used by the public, which many studies have shown is always too low in comparison to when tested. Suggestions have been made that the tests use thinner layers or alternatively test as currently required and scale the SPF to more realistic values appropriate to the lower application rates used by the public.

The sunglass standard AS1067 is currently under review and should become a joint Australian and New Zealand

standard this year. Australia was the first country to introduce a standard on sunglasses (1971) and is the only country in the world with a mandatory standard, which means that all sunglasses sold in Australia **must** comply with the standard. While the majority of proposed changes to the standard are technical, as far as consumers are concerned, the changes will be largely deal with the labelling requirements of sunglasses.

The Sun Protective Clothing standard AS/NZS 4399 is a joint standard issued in 1996 and was the first in the world covering sun protective clothing. Other overseas standards now exist (British, US, CEN draft) and these have generally adopted much of AS/NZS 4399. However, due to the difficulties involved there are still no wet or stretch tests in any of the standards. Unlike with sunscreens, protection provided by clothing in real wear situations is higher than that obtained in tests (Ravishankar and Diffey 1997).

The standard on solarium (AS2635) is an Australian standard and is currently under review and should become a joint AS/NZS standard this year. The current draft is the first anywhere to impose an upper limit on the maximum intensity of solarium, something strongly resisted by solarium operators. The proposed upper limits restrict the power of solarium to less than 5 times that of the sun! The solarium standard is not mandatory and currently relies on self regulation, although the competence of the operators is very variable. Recent studies in the US have linked solarium use to skin cancer. The question is why some people still want to increase exposure when so much effort goes into reducing UVR exposure.

Figure 2 shows ground based measurements of yearly total solar UVR from a number of locations around the world versus latitude. The levels for Australia and New Zealand are amongst the highest and suggest that no further increases due to ozone depletion are required to add to what is already a significant problem. It also means that the UVR protection standards in place in this region need to be rigorous and comprehensive.

Conclusions

Australia and New Zealand already have high levels of solar UVR and consequently have very high skin cancer rates. Any increase in solar UVR from ozone depletion will only add to the problem. Behavioural changes offer the possibility of significantly reducing UVR exposures (by factors of 10 or more), by changing the way people act when outside or whether they use UVR protection. Rigorous standards for UVR protection provided by sunscreens, sunglasses and clothing ensure that the public is properly protected when they choose to use them.

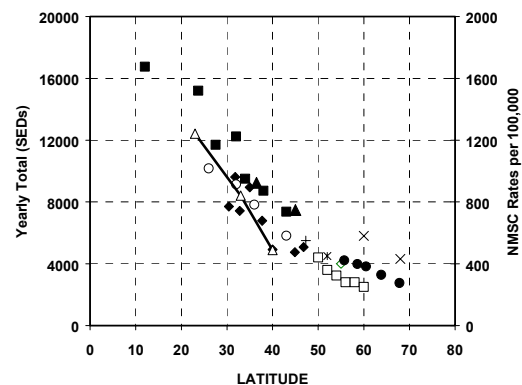
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Figure 2. Latitude gradient of solar UVR_{eff} in SEDs per year from Gies et al (2000) showing measurements from a



number of countries around the world (■ Australia, ▲ NZ, the UK(1) ◇ and UK(2) □, × Finland, ◆ USA, ○ Japan, + Germany, ◇ Holland and ● Sweden). Also shown for comparison are the non melanoma skin cancer rates for Australia (NMSCR - △ right axis).