Solar UVR exposure of outdoor workers (tinsmiths) in Austria

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Abstract. To quantify solar ultraviolet radiation (UVR) exposure of a certain occupational group involved in typical outdoor work in Austria, a study was conducted using UVR-sensitive polysulphone (PS) film badges and electronic UV dosimeters. The study found that the investigated workers were exposed to high levels of UVR, in most cases without adequate sun protection.

Introduction

Outdoor workers are a group that receives regular and significant solar UVR exposures [*Gies et al.*, 1995]. Exposure to UVR is a well known risk factor in the development of UVR induced lesions of the eye (e.g. UV cataract [*Dolin*, 1995]) and the skin (e.g. skin cancer[*Altmeyer et al.*, 1997]) and solar UVR is categorized as carcinogenic by the International Agency for Research on Cancer [*IARC*, 1992]. In order to formulate protective strategies against harmful occupational solar UVR it is necessary to quantify the UVR exposure at the outdoor workplace.

To quantify the occupational solar UVR exposure of tinsmiths a study was conducted in summer 2005 (June and July) involving 14 workers in Klagenfurt and Villach (Carinthia, Austria, latitude 46 °N, altitude 500 m). Totally, 240 man day exposures were accumulated at 7 different construction sites. While conducting personal observations on site, information on the environmental, personal and work practice factors that affect personal UVR exposure was collected.

A conversion factor was calculated giving the ratio between the measured radiant exposure at different parts of the body and the global erythemal radiant exposure. With this factor it is possible to estimate the UVR exposure for the workers.

Data collection

PS film badges (thickness 26 µm) were used for UVR dosimetry and were fixed at the workers' external clothing (neck, chest and at the cap). The calibration and data interpretation of the PS films were performed by the department of dermatology of TU Dresden. The transmittance of the PS film changes on exposure to UVR and this change of transmittance (or absorbance) at the wavelength of 330 nm can be related to the biologically effective dose [*Knuschke and Barth*, 1996]. The PS film was fixed in a cardboard holder which was placed in a plastic mask with a rectangular aperture. One field of the aperture was covered with a grey filter, the second field consisted of the bare PS film. The usage of a grey filter to cover the PS film allowed longer measurement intervals as the bare PS film is saturated after accumulating about 30 standard erythemal doses (SED, 1 SED is defined as an erythemal radiant exposure of 100 J m^{-2}).

The workers were asked to wear the PS film badges the whole workday and fix it always at their external clothing. Construction sites were observed by employees of ARCS randomly but at least twice per day. In this study the PS film dosimeters were replaced on average after 3 workdays. Replacement of the PS films was carried out by the observing persons from ARCS. The exposed PS films were collected and read-out after the study thus dark reaction of PS films had to be considered.

Two electronic data logger dosimeters X2000-4 (Gigahertz-Optik) were used as additional measurement devices to measure erythemal UVR and UVA exposures in order to verify the measurement results derived with the PS films. To measure the horizontal biologically effective exposure PS film dosimeters were placed on a plane horizontal surface in a shadeless area. Additionally measurements with a solar light model 501 UV-biometer were made by the Austrian UV-index network, some 5 km from the location of one construction site.

Guidelines and threshold limit values

Table 1. Threshold limit values for the eye and the skin.

action spectrum	affected tissue	base	time	threshold limits	
				H_{eff}	E_{eff}
s_7	eye (cornea), skin	ICNIRP, ACGIH	8 h	30 J m^{-2}	
UV-A	eye (lens)	ACGIH	≤ 1000 s	10000 J m^{-2}	
			> 1000 s		10 W m^{-2}
		ICNIRP	8 h	10000 J m^{-2}	
s_{ery}□	skin	CIE	8 h	I: 200 J m^{-2} II: 250 J m^{-2} III: 350 J m^{-2} IV: 450 J m^{-2}	

To estimate the workers' risk for UVR induced lesions of the eye and the skin the measured biologically effective exposures have to be compared to threshold limit values. For this study the thresholds given in table 1 were used.

The MED as given in table 1 for different skin types should not be seen as strict threshold but rather as an orientating value. In recent years the CIE has introduced the concept of the SED [*CIE*, 1997]. As the MED varies considerably among individuals of the same skin type, the SED should be used for an objective evaluation of the hazard for the skin as the SED is independent of the skin type.

Factor Anatomical to Horizontal (ATH) Exposure

One aim of the study was to compare the erythemal radiant exposures at certain body parts of the workers to the horizontally measured erythemal radiant exposures. If there was a good correlation between the anatomical and horizontal exposure a factor ATH (anatomical to horizontal) could be derived according to equation 1.

$$\mathrm{ATH} = \frac{\text{effective anatomical exposure}[\mathrm{J\,m^{-2}}]}{\text{effective horizontal exposure}[\mathrm{J\,m^{-2}}]} \qquad (1)$$

With this factor the UV-exposure of a certain body part can be calculated by knowledge of the effective horizontal exposure (this data is daily provided by the UV-index network).

Results

Table 2. Average of the measured effective daily occupational exposures.

	neck	chest	cap (back of the head)
erythemal UVR $s_{ery}(\lambda)$	1690 J m^{-2}	480 J m^{-2}	1360 J m^{-2}
actinic UVR s (λ)	434 J m^{-2}	123 J m^{-2}	350 J m^{-2}
UVA	473000 J m^{-2}	134000 J m^{-2}	381000 J m^{-2}

The measurement results in table 2 show that the workers accumulate effective UVR doses which exceed the threshold limit values given in table 1 by far. At the neck of the workers erythemal radiant exposures up to 2700 J m^{-2} per workday were measured and consequently the MED for skin type I (200 J m^{-2}) was exceeded by more than a factor of 10.

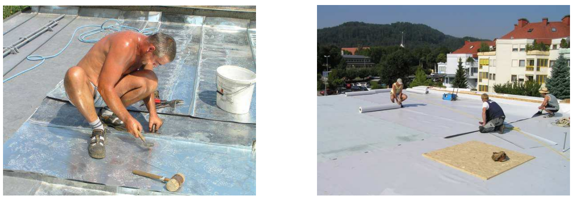

Figure 1. Typical workplace situations for tinsmiths: working with reflective materials.

As the investigated occupational group is often working at highly reflective surfaces (e.g. copper and aluminum roofs, see figure 1) even the workers' eyes accumulate high doses of UVR. If the average UVA exposure and the average actinic UVR exposure of the chest are taken into account to estimate the UVR exposure of the eye the corresponding threshold limit values are exceeded by a factor of 4 for the actinic UVR and by a factor 13 for the ICNIRP UVA threshold limit value (this threshold is quite discussable from the authors point of view).

For the neck and the chest the factor ATH was calculated according to equation 1. For the erythemal radiant exposures the following factors and standard deviations were derived:

- neck: 0,50 ± 19 %
- chest: 0,12 ± 5 %

Conclusions

The measured results indicate that there might be an increased risk for the investigated occupational group for UVR induced lesions of the eye and the skin. To a certain extent the skin can adapt to frequent UVR exposures by thickening of the outermost layers of the skin (stratum corneum) and increased production of melanins (tanning). However, the measured effective UVR dose rates seem to be too high even for melano-competent workers (skin types III and IV) as sunburns were visually noticeable in spite of their tanned skin. The highest risk exists for melano-compromised workers (skin types I and II) since their skin adaptation to frequent UVR exposures is less pronounced.

As the eye cannot adapt to UVR all workers seem to have the same risk for UVR induced lesions of the eye despite of their skin type. During the UV-monitoring workers often complained of typical symptoms of photokeratoconjunctivitis. Personal protection against solar UVR is highly recommendable for both the eye and the skin for the investigated occupational group.

In a following study personal protection against solar UVR (sunscreens, textiles, sunglasses, and headwear) will be tested in practice in order to evaluate their effectiveness of protection and their acceptability among the workers.

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