Ultraviolet Radiation Emissions from Blacklight Torches

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ABSTRACT

Ultraviolet radiation emissions from three model 0410-UV365 UV torches have been measured under contract to JNE Marketing Ltd. The torches are intended for use by Police Authorities and Forensic Science personnel to detect fluorescent substances such as Smartwater™, and by professional Public Health and NDT personnel.

The results of the measurements are presented and a hazard assessment carried out by comparison with exposure limits published by the International Commission on Non-Ionizing Radiation Protection.

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1 INTRODUCTION

Ultraviolet radiation (UVR) emissions from three model 0410-UV365 UV torches incorporating light emitting diodes (LEDs) have been measured, under contract to JNE Marketing Ltd, in order to identify potential optical radiation hazards to persons exposed to the beam from the torches. Each torch incorporates a single LED and rear reflector protected by a transparent front cover (see figures 1-3).

Figure 1 General view of torches

Figure 2 Side view of torch

Figure 3 End view of illuminated torch

The torches are intended for professional use by, for example, police/forensic/environmental health officers, in tasks such as non-destructive testing, locating fluorescent dyes which may be on stolen property or on persons who are being questioned under suspicion, etc. Therefore, exposure of persons to UVR emissions from the torches is sometimes intended, although JNE Marketing do not intend to make the torches available to the general public or through retail.

A hazard assessment of the UVR emissions has been carried out on the basis of exposure to UVR emissions at distances of approximately 100 and 20 cm. The assessment has been carried out by referring to exposure limit values (ELVs) for UVR published by the International Commission on Non-Ionizing Radiation Protection (ICNIRP) (ICNIRP 2004). These ELVs have been recommended for use in the UK by the former National Radiological Protection Board (NRPB - in April 2005 NRPB was incorporated into the Health Protection Agency (HPA) as the HPA Radiation Protection Division) (NRPB, 2002). These ELVs have also been adopted as the basis for risk assessment for exposure of employees to artificially generated optical radiation in a recent European Directive (EU, 2006). This report may be used as information bearing on a risk assessment carried out for UVR emissions from these torches.

Measurement data have also been used to estimate the classification of these torches under an International standard for lamps and lamp systems (IEC, 2006).

2 EXPOSURE LIMIT VALUES

When assessing the potential for hazardous exposures from artificial UVR sources, HPA recommends (NRPB, 2002) that:

a. needless exposure to UVR be avoided,

b. unavoidable exposure to UVR should be kept below exposure limit values (ELVs),

c. repetitive exposures up to the ELVs should be avoided,

d. a balanced, cautionary approach should be adopted to reduce exposure to UVR wherever possible.

The ELVs which HPA recommends for use are those published by the International Commission on Non-Ionizing Radiation Protection (ICNIRP, 2004).

The ICNIRP ELVs for the eye and skin are as follows:

a. To protect the lens, a maximum radiant UVA (315 – 400 nm) exposure for the eyes within an 8 hour working day = 10 kJ m^{-2}

b. To protect the cornea, conjunctiva and skin, a maximum effective radiant UVR (180 – 400 nm) exposure for the eyes and skin within an 8 hour working day = 30 J m^{-2} (eff)*

*Weighted with relative biological spectral effectiveness values published by the International Commission on Non-Ionizing Radiation Protection.

These ELVs represent levels at which ICNIRP considers most of the working population can be repeatedly exposed without suffering any acute adverse health effects and without noticeable risk of long term effects. Some persons may be unusually photosensitive or may be exposed to photosensitising agents; these ELVs may not adequately protect these persons. The ELVs are not intended to avoid chronic skin effects: the incidence of these effects will be reduced by virtue of prevention of acute effects and reduction in lifelong exposure.

It should be noted that the Council of the European Union published a Directive on 27 April 2006 which is aimed at protecting workers from the adverse effects of exposure to artificial optical radiation. The Directive gives priority to reducing risks at source, through preventative measures related to workstation design, work equipment design, procedure and methods. It places a responsibility on employers to assess exposure levels, adopt preventative measures and arrange for the provision of information and training for their workers. The Directive incorporates Exposure Limit Values that are based on the ICNIRP guideline values. The Directive requires the UK to implement appropriate regulations by 27 April 2010. More information on this subject may be obtained from the HSE web site at:

http://www.hse.gov.uk/radiation/nonionising/optical.htm

3 RADIOMETRIC MEASUREMENT EQUIPMENT

All measurements were made using an ISA Jobin-Yvon Spex scanning spectroradiometer, consisting of integrating sphere input optics, fibre optic light guide, double grating monochromator and photomultiplier tube detector.

The spectroradiometer was calibrated using a Cathodeon model R16 deuterium discharge lamp. This lamp had been calibrated for spectral irradiance at the National Physical Laboratory (NPL, 2005).

4 MEASUREMENT METHODS

The spectroradiometer described above was calibrated to measure *spectral irradiance*. Irradiance is defined as the rate at which energy arrives per unit surface area (at a stated measurement location), and has the unit W m^{-2}. Spectral irradiance is the irradiance at discrete wavelength intervals (in this case, 1 nm). For comparison with the ELV for exposure of unprotected eyes and skin to UVR, it is necessary to spectrally weight the irradiance data to take account of varying biological effectiveness. Such weighted data are referred to as *spectral effective irradiance*. The spectral effective irradiance is summed across all wavelengths to give a single figure, the *effective irradiance*. Irradiance data (effective or unweighted) can be integrated across time to give *radiant exposure* data, which can be compared directly with ELVs. Alternatively, an ELV can be divided by irradiance data to calculate the time required for exposure to reach the ELV.

Before measurements were made, each torch was fully charged up using the battery chargers provided. Measurements of irradiance were then made with the scanning spectroradiometer at two locations relative to the torches:

a 100 centimetres directly in front of each torch (chosen as a convenient and realistic exposure distance), for comparison with ELVs (NRPB, 2002; ICNIRP, 2004; EU, 2006). These measurements were repeated 10 times to investigate fall-off in emissions as the torches' batteries discharged.

b 20 centimetres directly in front of the brightest torch (which had been fully re-charged), for comparison with the International Standard on lamps and lighting systems (IEC, 2006). This measurement was made once only, as this assessment should be made under conditions which will maximise any emissions.

During all measurements, the spectroradiometer input aperture was located within the brightest visible portion of the emitted beam.

5 RESULTS AND HAZARD ASSESSMENT

The UVR irradiances (200 – 400 nm), UVA irradiances (315 – 400 nm) and effective UVR irradiances (200 – 400 nm) measured at each location for each torch are presented in table 1. Results of measurements made at 100 cm are quoted as an average of 10 measurements ± the sample standard deviation on those measurements: the mean spectral irradiance data for torch A are illustrated in figure 1. The times required to reach the ICNIRP ELVs have been calculated: where statistical data are available these calculations were carried out for an irradiance equal to the mean + 2 standard deviations. The results, presented in table 2, can be taken to represent maximum permissible daily exposure (MPE) times.

Figure 1. Mean spectral irradiance of Torch A at 100 cm (mW m^{-2} nm^{-1})

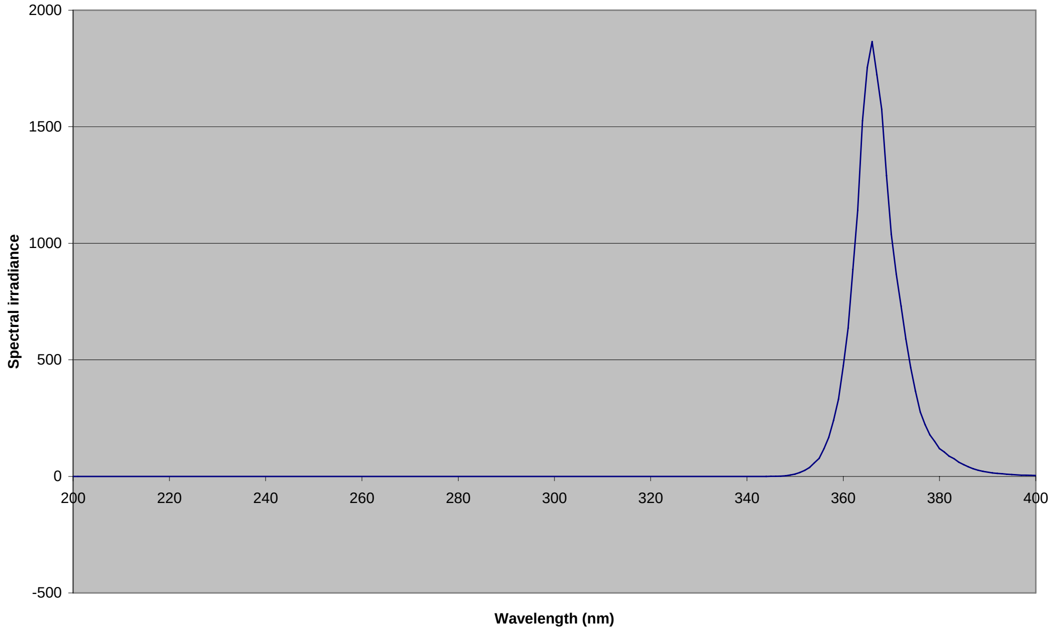

Table 1. Irradiance data for torches (mW m^{-2})

Location	UVR irradiance (unweighted)	UVA irradiance (unweighted)	UVR effective irradiance
100 cm from torch *A*	19600 ± 206	19600 ± 206	2.0 ± 0.2
100 cm from torch *B*	7340 ± 113	7340 ± 113	0.7 ±0.1
100 cm from torch *C*	11500 ± 350	11500 ± 350	1.1 ± 0.2
20 cm from torch *A*	104000	104000	10.8

Table 2. Maximum permissible exposure time

Location	UVA MPE (eyes)	Effective UVR MPE (eyes and skin)
100 cm from torch *A*	8 minutes 20 seconds	3 hours 35 minutes
100 cm from torch *B*	22 minutes	> 8 hours
100 cm from torch *C*	13 minutes 35 seconds	5 hours 35 minutes
20 cm from torch *A*	1 minute 35 seconds	46 minutes 10 seconds

6 DISCUSSION

The MPE times presented in table 2 suggest that persons exposed to these torches at distances of about 1 metre are only likely to exceed the ICNIRP ELV for the lenses of the eyes if the eyes are illuminated for longer than about 8 minutes in any 8 hour period. It is not likely that there would be any practical reason to illuminate the eyes with these torches, and such exposure should be avoided where possible and in any case kept below the ELV.

The ELV for protection of the skin and cornea will only be exceeded after lengthy exposures (3 hours 35 minutes in any 8 hours). Such long exposures are unlikely to occur accidentally.

It is recognised that JNE Marketing do not intend that these torches be sold to the general public. If the torches are used by responsible persons who are conversant with the strictures on exposure outlined above, then the use of these torches should not lead to UV exposures in excess of the ICNIRP ELVs.

The International Standard IEC 62471 (IEC,2006) contains a classification system intended for use with lamps and lamp systems. This classification system places lamps and lamp systems into one of four groups, depending on (for UV emissions) the UVA and ICNIRP-weighted UVR irradiances at 20 cm. The intention is to allow approximate risk assessment to be carried out by persons lacking radiometric data on the lamps. Although HPA does not offer an accredited test house service, the results of the measurement made at 20 cm can usefully be compared with IEC's classification system.

Under the classification system of IEC 62471, the most powerful torch examined here (torch A) produces irradiances, at 20 cm, sufficient to place the torch in IEC Risk Group 2 for effective UVR and Risk Group 3 for UVA. These Risk Groups imply that the torches pose a risk to the skin and cornea in 1000 to 10000 seconds, and to the lens in less than 100 seconds. Overall classification of the torches should be based on the strictest Risk Group to which they might be assigned (Group 3).

7 CONCLUSIONS

The model 0410-UV365 UV torches examined here must be classed as belonging to IEC Risk Group 3 (high risk), on account of the high UVA irradiance measured at 20 cm. This classification indicates that eye exposures at distances greater than 20 cm, totalling less than 100 seconds per 8-hour period, *might* be excessive for normally sensitive adults. Whether such exposures actually exceed the exposure limits or not would depend on the precise exposure geometry and duration.

The actual maximum permissible eye exposure time at 20 cm is 95 seconds, by reference to the ICNIRP exposure limit values. At 1 metre, this maximum permissible eye exposure time has extended to about 8 minutes. Eye exposure is not likely to be necessary during normal use of these torches, and should be avoided where possible.

The maximum exposure times recommended above will also allow compliance with the exposure limits published in the Artificial Optical Radiation Directive of 2006.

The torches should only be used by persons who are aware of these exposure time limits and are trained to observe them.

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