# Assessing Broadband Optical Radiation

*By James Stewart, Principal, LVR Limited, james@lvrlimited.com*

As of 27 April 2010, member states across the whole of the European Community must have in place local legislation that is designed to assess and limit the amount of *artificial optical radiation (AOR)* that employees may be exposed to in the workplace. This requirement originates from the EU's *Physical Agents Directive (AOR) 2006/25/EC*, which is part of a family of directives designed to protect workers from sources of harm such as noise, vibration, and electromagnetic fields.

The AOR directive is intended to protect workers from harmful sources of visible and invisible light, which therefore includes light across the spectrum from *UV*, through *visible*, and *IR*. Only *artificial sources* of light are considered; the effects of exposure to the sun through working outdoors does not fall under scope of the directive.

The *Exposure Limit Values (ELVs)* described in the directive are derived from the internationally accepted guidance values published by the *International Commission on Non-Ionizing Radiation Protection (ICNIRP)*. These values detail maximum exposure for different spectral bands, which correspond to the separate *hazard functions* that exist in each of these regions. There are separate ELVs for both *coherent* light sources such as lasers, and *non-coherent*, otherwise referred to as *broadband* sources, such as incandescent lamps, LEDs, welding arcs, etc.

When writing the directive it was recognised that expecting employers, especially SMEs, were, on the whole, not going to possess the expertise to undertake what can be quite a complex assessment. Therefore the directive made specific provision for a *"user guide"* to be produce to facilitate workplace evaluation. The *Non-Binding Guide to the Artificial Optical Radiation Directive 2006/25/EC* was prepared by the UK's *Health Protection Agency (HPA)* under contract the to EU. [http://www.hse.gov.uk/radiation/nonionising/aor-guide.pdf]

The *Non-Binding Guide* provides a useful background into different types of optical radiation and describes what can be regarded as a simplified approach to assessing optical radiation exposure. The premise being that the simplified approach overestimates the hazard, therefore if the evaluation satisfies this approach then no further assessment should be necessary. Only if exposure from the simplified assessment appears to be hazardous, should a more detailed evaluation be required.

**Measuring Retinal Hazards**

One tool that both ICNIRP and the Non-Binding Guide make mention of is the *lux meter*, which is useful due to being relatively low cost. This type of device is probably the more common light measuring tool that can be found in the workplace. The lux meter is normally used to measure *illuminance* (lux). However if one converts this to a figure of *luminance (candela per square metre)* by dividing the measurement provided by the meter by the angle subtended by the source, it is possible to make a quick assessment for *retinal hazards*. The requirement to be met in order to undertake this type of assessment is that the light source must only emit optical radiation within the 380nm-1400nm region, which is visible and or near infrared light. If the *luminance* from this type of source determined to be less than $10^4$ cd $m^{-2}$ then no further assessment is necessary.

In circumstances where the simplified approaches to assessment, or the lux meter approach indicate that a more thorough assessment is required, the methodology described in the *IEC 62471:2006 "Photobiological Safety of Lamps and Lamp Systems"* should be referred to. This standard is actually very closely related to a former document produced by the *International Commission on Illumination* referenced as *CIE S 009:2002*. The IEC standard has since been published as a *European Norm*, and is currently in the process of being *harmonised* into the *Low Voltage Directive*, meaning that assessment and classification through this methodology will become the accepted route to showing *product safety* and *CE compliance.*

**Risk Groups and Hazards**
*EN 62471:2008* defines a classification scheme for lamps and lamp systems, based on the amount of hazard present in the light emitted from the product. There are essentially four categories known as *Risk Groups* into which a broadband light source may fall. As the *risk group* number increases, so too does the hazard present.

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|---|---|
| Exempt Group | No optical hazard is considered reasonably foreseeable, even for continuous, unrestricted use. |
| Risk Group 1<br>Low Risk | Safe for most applications, except for very long exposures where direct viewing may be expected. |
| Risk Group 2<br>Moderate Risk | Generally do not pose a realistic optical hazard if aversion responses limit the exposure duration |
| Risk Group 3<br>High Risk | Potential hazard even for momentary exposures, and system safety requirements are generally essential. |

*Figure 1. EN 62471:2008 Risk Group Categories*

Adopting an approach, where the *risk group* information is communicated to the user, alleviates much of the difficulty that would be faced by somebody in the workplace who has to determine the risk present in the using the light source. Exposure from the lamp system shall not exceed the maximum ELV within the time limit defined by the *risk group*. The lamp safety standard characterises different parts of the optical radiation spectrum with different ELVs in a similar fashion to the distinction made in the AOR directive, which takes into the account the different *hazard functions*, (wavelengths in the spectrum that can cause specific harm).

The *risk group* category of the lamp system is determined at a specific distance of *200mm* from the source. The standard also describes the measurement procedure required at this distance, which depending upon spectral content will either be a *radiance* or *irradiance* measurement. In practice these measurements require the use of a detector, and a combination of field stops and apertures set up under controlled conditions to perform what the lamp standard warns *"poses significant challenges to the radiometrist"*.

**Determining Radiance Using a Thermal Detector**

If the spectral content can be determined from either the manufacturer's existing data, or, ideally, from taking a spectral measurement using a *spectroradiometer*, a flat response, high sensitivity thermal detector can be employed in the measurement set up to determine radiance or irradiance as required by the standard.

In work carried out by *LVR Limited* at the UK's *National Physical Laboratory (NPL)* the **Ophir 3A-P-FS**, chosen for its *high sensitivity* and *spectrally flat* detector response characteristics was used to perform *EN 62471* type assessments on a number of entertainment luminaires. The integrated glass window in front of the detector's absorber on the detector helps to reduce the effect of air currents, which can impact accurate measurement at such low powers using a thermal detector.

Having determined the *radiance* or *irradiance* of the source, the risk group can be determined by first converting to *spectral radiance* or *spectral irradiance* values respectively. These *measured spectrum* values are obtained by simply integrating the *relative spectral response* (obtained from the spectroradiometer) with the *radiance* or *irradiance* values.

Each *photobiological hazard* has its own *action spectrum* that describes how *effective* each wavelength is at causing the harm. To determine the hazard level, the *measured spectrum* is multiplied with the *action spectrum* to produce what is known as the *effective spectral radiance* or *effective spectral irradiance*. This result is compared with the *exposure limits* (ELVs) detailed in the standard allowing the *risk group* to be determined.

One limitation of the standard risk group assessment approach is that risk groups reported at the standard distance of *200mm* may be significantly higher than that which would be reported at a distance where the lamp would realistically be used in practice. A separate *Technical Report* subsequently published by IEC exists in the form of *IEC/TR 62471-2 "Guidance on manufacturing requirements relating to non-laser optical radiation safety."* [http://www.diamond-congress.hu/cie2009/03menu/binx/37_Werner_Halbritter.pdf] The Technical Report provides guidance to manufacturers on labelling issues, but also describes the need to provide *hazard distance* and *exposure hazard values* to users.

**Entertainment Industry Applications**

Over the past several months *LVR Limited* have been employing the techniques described in the standard using a *spectroradiometer* and the *high sensitivity Ophir thermal detector* to assess a range of common light sources utilised in the entertainment industry. So far the work has found that many sources fall into the *RG1* category in addition to there being a few RG2 luminaires. The latter may pose an increased risk, because under normal application of the *risk group*, the *aversion response* is intended to provide sufficient protection. But this may not always be the case when employees such as technicians as part their work have learned to override the natural aversion response. Furthermore, evolving types of high intensity sources that often create strong afterimages may be an area to be concerned with, particularly with the cumulative nature of the *Blue Light Hazard*, which is often the dominant *retinal hazard* in some of these types of sources. Work to help understand more about these risks is ongoing. In the meantime LVR are continuing to research the levels of AOR that exist with high intensity sources, and assessing light sources following the approach of the standards for *product classification* and provision of *user information*.

At first sight, the implications of the new AOR Directive can seem quite daunting and overbearing on organisations, given that, taken literally, there is the general requirement to assess all sources of AOR in the workplace. The reality is that even though people are being exposed to a more artificial light than at any time in the past, the vast majority of this light does not pose any health hazard. Most sources would be regarded as *trivial* sources, and not require any further action. It is likely that when the new legislation comes into force only a small number of new light sources will have to be more effectively managed. The majority of harmful sources of light are already known about, and are being sufficiently controlled. The important issue is that sources where the risk and hence exposure levels are unknown, sufficient evaluation is provided so as not put workers at unnecessary risk, which essentially underpins the purpose of the directive.

**Further Reading**

"Physical Agents (Artificial Optical Radiation) Directive 2006/25/EC"
http://eur-lex.europa.eu/LexUriServ/site/en/oj/2006/l_114/l_11420060427en00380059.pdf

ICNIRP International Commission on Non-Ionizing Radiation Protection
http://www.icnirp.org/

"IEC 62471:2006 (EN 62471:2008) and IEC/TR 62471-2 Standards"
http://webstore.iec.ch/

"A Non-Binding Guide to the Artificial Optical Radiation Directive 2006/25/EC"
http://www.hse.gov.uk/radiation/nonionising/aor-guide.pdf

**About the Author**

James Stewart is a qualified health and safety practitioner based in the UK, who has a strong specialism in optical radiation hazard assessment. His skills in laser safety assessment originated from display safety applications where James still has a keen interest in advising major venue operators and productions alike on laser safety issues. More recently, work James has undertaken with the assistance of leading optical radiation experts and the UK's National Physical Laboratory, has helped to hone his knowledge of broadband optical radiation assessment. Combining this technical ability with more general knowledge on UK and EU Health and Safety legislation and practice, James is able to provide a valuable skill-set to clients wanting optical radiation safety advice, assessment, training or product testing.