Understanding Artificial Optical Radiation and the EU *Directive 2006/25/EC*

BY **JAMES STEWART**

The implementation of legislation which mandates the amount of AOR, or light, that employees can be exposed to in the workplace

AS WE START THE NEW YEAR, the April 27th deadline for all European member states to put into place measures to implement the EU *Directive 2006/25/EC* relating to occupational exposure to *Artificial Optical Radiation* (AOR) seems to be that much closer. As a quick recap to those that haven't read Karl Ruling and Mike Wood's previous article in the Summer 2007 edition of *Protocol*, the new legislation sets mandatory limits on the amount of AOR, or light, that employees can be exposed to in the workplace. The directive also sets out the duty for employers to assess the risk to workers from exposure to AOR, avoid or reduce any risk, provide information and training, and, where necessary, health surveillance. The legislation details several pages of *Exposure Limit Values* (ELVs), which span the ultra-violet, visible, and infrared regions of the electromagnetic spectrum, meaning that sources of both visible and invisible light must be considered. A further distinction is made to identify both *coherent* (laser) and *non-coherent* (broadband) light sources. The ELVs that are used in the directive are drawn from the work of the International Commission on Non-Ionizing Radiation Protection (ICNIRP).

At first sight these obligations may seem to be quite onerous. Particularly as the task of measuring or calculating the exposure levels is not a trivial process to say the least. In the UK, PLASA, aware of the potential problem this could cause, has been quite active in trying to undertake an impact assessment with the assistance of the government body the Health Protection Agency (HPA). Their work in this area is ongoing at present, and will be

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published in due course. In the meantime, what do we know about the technical and practical implications of a directive designed to limit worker exposure to harmful levels of light in an industry, where illuminating people with bright light sources is a big part of what we do?

Before we delve into some of the detail surrounding assessing regular non-coherent lights sources, which include sources such as incandescent lamps, metal halide discharge, and LEDs, it is worth taking a quick look at how the hazards associated with lasers have been managed.

Laser products will, of course, fall under scope of the legislation in that they produce artificial light, but with the long-standing knowledge that such light can be harmful, a fairly mature product safety standard, *IEC 60825-1:2007*, exists. This standard uses a hazard classification scheme based on the amount of light the laser product can produce. A laser pointer would typically be Class 2 laser product, safe for accidental viewing, while laser show projectors are generally the more hazardous Class 3B and 4 products. The laser's classification not only dictates what engineering features should be present in the device, but is also used to indicate what precautions should be in place when the product is used. Again, the Class 2 laser pointer being present on site is less of an issue than a Class 4 laser show projector.

Such a classification scheme works well in being able to immediately identify any sources that can cause harm, and helping to decide what precautionary measures should be adopted. Therefore can a similar scheme be employed to assist users of non-coherent light sources?

Well, there is help at hand in the form of the IEC published standard *EN 62741:2008 Photobiological Safety of Lamps and Lamp Systems*, which details a hazard classification scheme, an outline of the measurement procedure, and describes the Exposure Limit Values. This IEC standard is actually the same as *CIE S 009:2002*, which has drawn considerably on the similar work of *ANSI/IESNA RP 27*, parts 1 to 3. The Lamp Standard is not as mature as the Laser Product Safety standard, leading to it being somewhat confusing in places, which isn't helped by the fact that the process for correct measurement and assessment is a complex subject in the first place. To help address this, the IEC has published a subsequent *Technical Report IEC/TR 62471-2 Guidance on manufacturing requirements relating to non-laser optical radiation safety.*

In **Figure 1** the lamp standard describes four groups in which a source can be classified ranging from the Exempt Group, through three further groups that increase with the hazard potential: Risk Group 1 (Low Risk), Risk Group 2 (Moderate Risk), and Risk Group 3 (High Risk).

The philosophy behind the classification scheme is that exposure to the source shall not exceed the ELV within the time limit specified by the Risk Group. Different ELVs exist for different parts of the spectrum, so it is not quite as straightforward as saying a

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

Figure 1 – Lamp Standards

lamp that does not exceed the ELV in 10 seconds is Risk Group 1. It is therefore highly dependant upon the spectral content of the light emitted from the source, and the potential hazard that this could present. EN 62471 provides the detail of the maximum exposure durations for each of the hazard functions within each of the four groups of lamp.

The standard specifies that the hazard values shall be reported at a distance of 200 mm from the apparent source of the lamp. Depending upon what part of the spectrum is being assessed either a radiance or an irradiance measurement will be taken at this point. EN 62471 outlines a quite detailed procedure to obtain these measurements, highlighting the fact that they are often difficult to make. Due to the rather challenging assessment process, it probably means that such testing is beyond the scope of many manufacturers, therefore outside expertise will more than likely have to be employed.

Ideally the obligation for carrying out the assessment and classification should in the first instance be placed with the lamp supplier. The manufacturer then using the lamp as part of a lamp system, with such data in hand, is then much better equipped to decide if how they are using the lamp in their product is going to affect its original Risk Group rating. The potential problem here, of course, is that the supplier of the lamp will not always know how the lamp is going to be used by the lamp system manufacturer.

In turn, if the manufacturer is able to supply data stating the Risk Group of their product, it makes the risk assessment process for the end user far more practical, and immediately communicates what likely optical hazard potential exists in the product. Many manufacturers already carry out a similar process with photometric data to assist the end user, so therefore suppliers will hopefully see the benefits in providing the radiometric data as well. When April comes, end users are likely to become more interested in knowing if any optical hazards are present in the light sources they are using.

Presently the provision of such data is best practice, but at some point in the not too distant future EN 62471 will likely be harmonized into the European *Low Voltage Directive*, in the same way that the Laser Safety Standard presently is, and will therefore become an accepted route to showing product safety and CE compliance.

The measurement and classification process described in EN 62471 is useful in that it provides a defined method of specifying a product's Risk Group, but with the hazard being considered at a fixed distance of 200 mm, the real world viewer-related risk may be significantly different to the lamp system's risk classification. For example, it is quite likely that a product classified as a Risk Group 2 device at 200 mm will rapidly loose its potential to cause harm with the increased separation distance that would be used in real life.

To address this, IEC's *Technical Report 62471-2*, provides further guidance for manufacturers on the supply of additional safety information to the user for any lamp system that is in excess of the Exempt Risk Group. It suggests a clear statement should be provided to tell the user that the viewer-related risk is dependant upon how the product is installed and used. Additionally, to assist the user in determining the risk, information should also include data on the Hazard Distance and Exposure Hazard Values (EHVs), with an optional graphical representation of distance-dependant EHV.

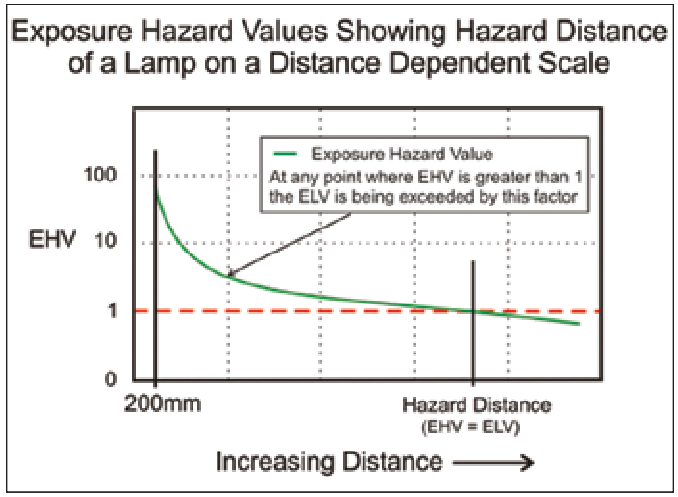

Figure 2 – Hazard Distance Values

The Hazard Distance is the point at which the actual exposure level (EL) is equal to the exposure limit value (ELV). The Exposure Hazard Value (EHV) is a useful term to indicate by what factor the ELV is being exceeded. If the EHV is greater than 1 the exposure level it is exceeding the ELV.

For employers to have access to light sources with Risk Group classification data, warning labels, and information on the hazard distances for viewer-related risk, sounds wonderful to help in identifying possible hazards, and deciding upon if any appropriate control measures are necessary. But even the more optimistic among us probably accept that this is likely to take some time to get in place, especially with the user information guidance in 62471-2, for the time being at least, not being a strict regulatory requirement.

Then of course there is also the issue of all the legacy equipment that is currently in use in the field. So how can this be addressed?

Part of the original AOR Directive detailed a specific requirement to prepare a practical guide to help facilitate determination of exposure and assessment of risk. Subsequently, the UK's Health Protection Agency was awarded the contract to produce what has become a freely downloadable document called, *A Non-Binding Guide to the Artificial Optical Radiation Directive 2006/25/EC*. The 168-page guide provides a good background to the fundamentals of optical radiation and the ELVs, along with an overview of a simplified approach for assessing occupational exposure to AOR. The second half of the guide concentrates on a wide range of worked examples, which is useful in demonstrating the methodology, but unfortunately there are no entertainment industry sources detailed, which is a pity. Nevertheless, the guide provides a good reference to somebody considering undertaking the assessments, although even the simplified approach is still quite challenging.

Full assessment requires determining the spectral content of the source, and either its radiance or irradiance, depending upon the wavelength region. A spectroradiometer and thermal detector can be used to obtain these measurements, using various limiting apertures and field stops as described in the lamp standard. Once this has been established, the actual spectrally weighted exposure level (EL) is checked against the relevant limit (ELV). Which in practice means performing some number crunching and analysis on a spreadsheet.

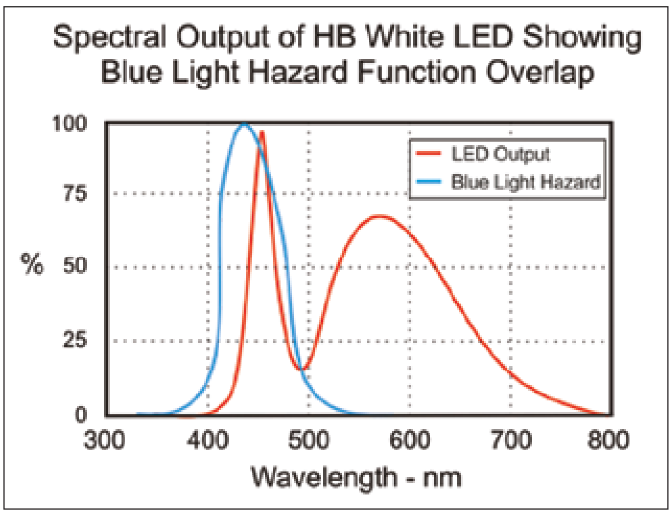

Figure 3 – Spectral Output

For preliminary assessment of retinal hazards, that is optical radiation within the 380 nm to 1400 nm region, it is possible to use just a humble Lux meter to determine if it is necessary to fully assess the emissions from a light source that is known to only emit visible and/or near infrared light. If the luminance is less than 10^4 cd m^{-2} (candela per square meter), then no further assessment is necessary. Luminance can be determined from the illuminance (Lux) measurement provided by the meter divided by angle subtended by the source.

In practice what does this all mean for the lighting industry? Well, until more work is carried out, such as that currently being undertaken by PLASA, and manufacturers start supplying the recommended radiometric user information, it is difficult to say for sure. Last summer I spent some time assessing a few sources at the National Physical Laboratory in England, and didn't come across any nasty surprises. Most turned out to be Risk Group 1 sources, and there was a Risk Group 2 source also. But even this device dropped down to Risk Group 1 when viewed a few meters away, which would probably be more representative of the viewer-related risk of the performer. A technician working closer to the lamp during focusing would be at a greater risk, but such work offers more scope for control.

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In general, infrared and ultraviolet hazards in the entertainment sector tend to be well known and managed. In the visible part of the spectrum, there is potential for thermal and photochemical retinal hazards. Realistically though someone is unlikely to receive a retinal burn unless they were staring directly into an arc lamp. The more dominant hazard in the visible spectrum is therefore *photochemical*. Prolonged exposure to sources that output strong emissions centering around the 445 nm wavelength region (blue light), can pose a photochemical, or as it otherwise known, *Blue Light Hazard* to the retina. It is believed that excessive exposure to this type of light can accelerate age-related macular degeneration. The nature of this type of hazard is that exposure is cumulative throughout the working day. This could be one to watch as sources that emit a lot of light in this region get brighter year on year.

So in rounding up this whistle-stop overview of what can undoubtedly appear to be a complex topic, we have seen that the requirement to assess and limit exposure to harmful levels of light is coming into force across Europe in late April. Manufacturers hold the key to simplifying the assessment process by stating the risk group of their products, and providing additional information on the hazard distance and exposure hazard values to users. Guidance on performing occupational exposure assessments is available in the *Non-Binding Guide* that the EU commissioned to assist the directive's implementation.

The next few months will be interesting to see how these things work out in practice, and which manufactures take the lead in supplying the user information. ■

Further Reading:

Physical Agents (Artificial Optical Radiation) Directive 2006/25/EC
http://eur-lex.europa.eu/LexUriServ/site/en/oj/2006/1_114/1_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/nonionsing/aor-guide.pdf

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