# THE PRINCIPLES OF LIGHTING

## PART 2: LIGHTING FOR DISPLAY SCREEN EQUIPMENT AREAS

**Continuing the series of articles on lighting, this article examines a topic which is of growing relevance in practice today. It includes information which can be used to advise patients for whom VDU use is a significant element of their home and working life. It also provides guidance for lighting design in VDU areas in the practice.**

**Dr Alan Smith is a leading authority on lighting and its relevance to optical practice.**

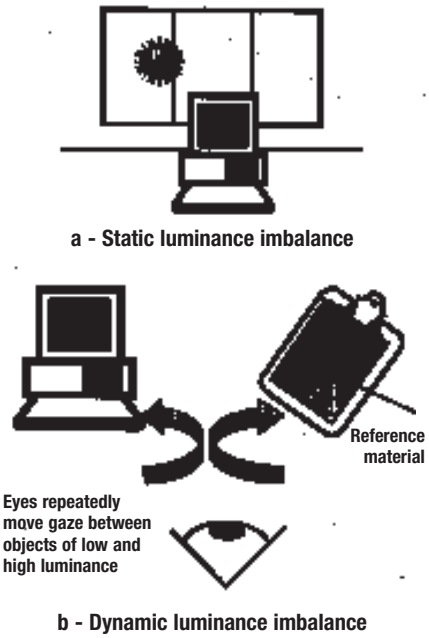
**Dr Alan Smith discusses lighting and its relevance to optical practice**

**Keywords: de-focussed images, downlighter, luminance contrast, luminance imbalance, uplighter, veiling reflections.**

The provision of optimum lighting conditions within an interior is seldom uncomplicated due to several factors which include the likelihood that occupants have differing visual characteristics, possibly influenced by age, and also that occupants will not necessarily have simultaneously identical visual needs.

When considering those interiors that contain display screen equipment, the aim is to obtain an appropriate sense of balance of all light sources, both natural daylight and artificial which with thoughtful positioning of the individual and the screen, relative to the sources of light, will present a situation in which glare and/or veiling reflections are minimised if not totally eliminated.

The Health and Safety (Display Screen Equipment) Regulations 1992[1] implements the 1990 EC Directive[2] in respect of display screen equipment and the operators of such equipment. Furthermore BS EN ISO 9241-1:1997[3] and BS EN ISO 9241 – 6: 2000[4] details the ergonomics of an operator in conjunction with a workstation. Further information is provided in CIBSE LG 3[5], AOP Handbook[6] and The Guide to the Regulations[7]. The optometrist or dispensing optician habitually has to confer with patients who use display screen equipment both




▲ **Figure 1:** Static and dynamic luminance imbalance

occupationally and domestically and it is essential therefore to acknowledge the factors involved in the provision of appropriate lighting in those locations where such equipment is used.

Consideration is given to methods of lighting an environment, in which display screen equipment is installed, which assists in the provision of a visual environment in which glare and/or veiling reflections are minimised if not totally eliminated and which is therefore agreeable to operators of the equipment.

## The display

The correct interpretation of data shown on a display screen relies upon variations in luminance and consequently the visibility of the text on the screen will be influenced by the luminance contrast. The characteristics of the immediate surround to the screen are highly influential in providing comfortable viewing conditions and it is accepted that the luminance of the visual field in the vicinity of the immediate surround is unlikely to be constant. In combination all of these factors will have a significant effect on the ultimate conditions prevailing.

Luminance imbalances, which can be conveniently sub-divided into two categories, for instance static and dynamic, often occur in areas containing display screen equipment.

Static luminance Imbalance (SLI) often develops when a display screen is incorrectly positioned against a backdrop of a very high luminance source typically a window.

In general terms it occurs when there are appreciable differences in the luminance values of objects in the line of sight of the display screen operator.

If, however, a display screen operator constantly changes gaze between scenes of low and high luminance values, the visual system will be repeatedly making changes in adaptation. In general Dynamic Luminance Imbalance (DLI) occurs when an individual views objects with markedly differing luminance values in rapid succession. **Figure 1** shows the effects of Static and Dynamic Luminance Imbalances.

Veiling Reflections occur when an out-of-focus image of a high luminance source appears in a display screen and is subsequently viewed by the operator. This has the effect of casting a covering or 'veil' of light in front of the screen. A secondary problem can occur insomuch as the out-of-focus image causes the operator to experience fluctuations in accommodation, particularly when part of the information on the screen is decipherable.

## The production of optimum lighting conditions

The likelihood that an overall visual environment is pleasant and acceptable to screen operators is heavily dependent upon the careful planning of the lighting installation. It is important however to accept that to design the lighting of a given interior solely and exclusively for the use of display screen equipment is a practice likely to be fraught with problems. It could be argued, and with some justification, that even in dedicated computer rooms, other non-screen visual tasks have to to be carried out.

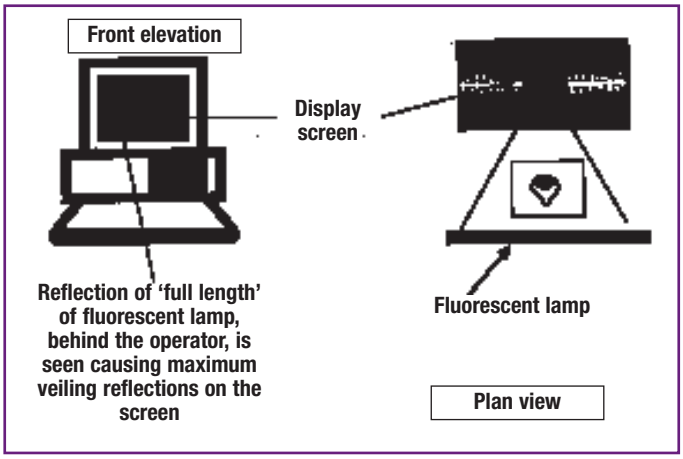
Changes in adaptation take place when an operator is viewing the screen as a result of other parts of the interior being simultaneously visible. It is probable that in certain circumstances light scattered in the eye will diminish the contrast of the image formed on the retina, causing some vision impairment. Furthermore transient changes in adaptation will occur if the display screen equipment operator glances away from the screen, which may also cause vision impairment.

Many visual problems caused in an interior where display screens are used can be remedied by a simple re-positioning of the light source, the display screen, or the operator. It will be evident that relocation of the luminaire can be impractical not to mention the associated expense and there is often a much simpler remedy, involving the ergonomics of the operator. **Figure 2** shows that the largest possible projected area of the offending luminaire produces the largest out-of-focus image in the screen. If however the screen is rotated through 90°, the projected area of the offending luminaire, seen in the screen, will be reduced significantly to that of the end elevation only, as shown in **Figure 3**. Such a move may regrettably cause the operator's line of sight to be at right angles to a window, a move that would in interiors with only one window wall, contravene recommendations. In such situations the relocation of the offending luminaire(s) through 90° may, be contemplated as a prima facie option. Unfortunately such a remedy is often impractical if not totally impossible.

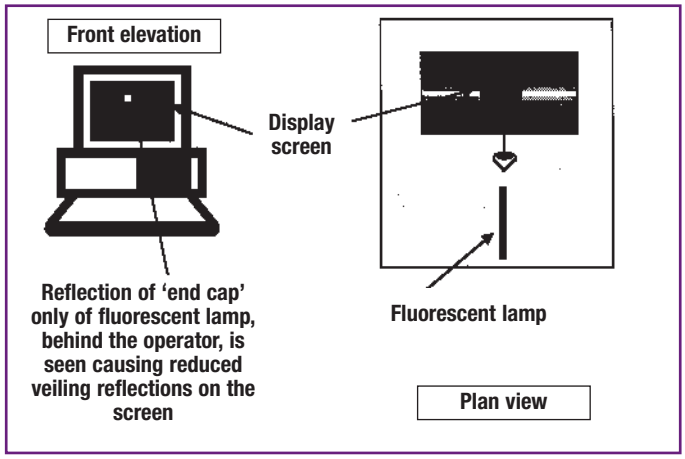
## Uplighters

The discussion thus far has been centred on the use of ceiling-mounted or ceiling-suspended luminaires i.e. those luminaires that emit the greater proportion of their light output in the downward direction. By contrast the use of uplighters is becoming more

▼ **Figure 2:** Orientation of luminaire causes maximum veiling reflections




▼ **Figure 3:** Relocation of luminaire causes reduced veiling reflections



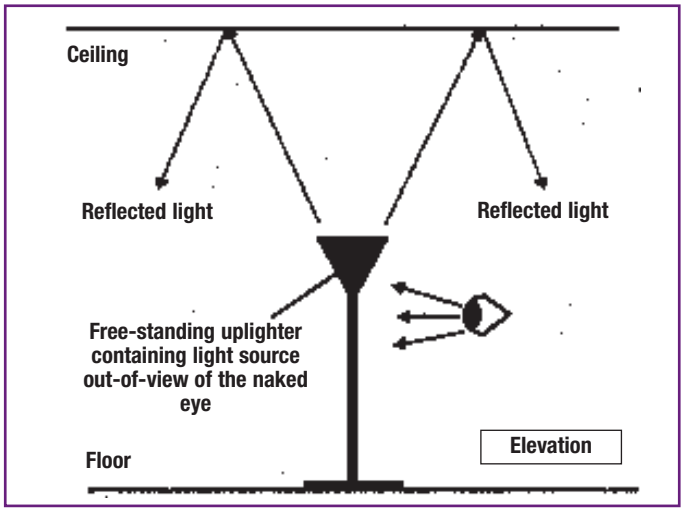
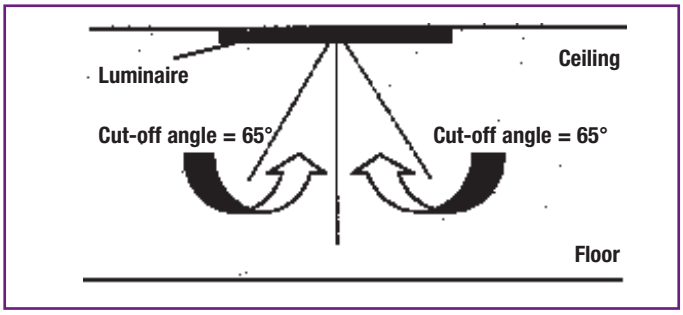



Figure 4: Principal of the uplighter




▲ Figure 5: Cut-off angle for downlighter luminaires

widespread in areas where display screen equipment is located. Within the uplighter luminaire the light source is positioned so that it is not visible to the naked eye, as shown in **Figure 4** from which it will be evident that the creation of veiling reflections is eliminated.

Of necessity uplighters direct their light initially onto the fabric of an interior, for instance walls and the ceiling, and as a result their operation is less efficient when compared with ceiling-mounted luminaires. However since the use of uplighters is a successful technique in avoiding veiling reflections, this associated loss in luminaire efficiency is often tolerated.

Whilst the use of uplighters in interiors is unquestionably beneficial in eliminating veiling reflections, it must be emphasised that there are disadvantages, some of which are not insignificant, associated with their installation that must be taken into account.

The effectiveness of an uplighting installation in providing a pleasing and acceptable lighting installation is influenced by:

- Fabric reflectances
- Fabric specularity (a specular surface is a mirror-like surface)
- Fabric colour finishes
- Luminance values
- Room geometry
- Colour output properties of light sources used
- Light source flicker

In an uplighter installation the colour output characteristics of the lamps and the colour finish of the ceiling must be considered as an indivisible combination. The perceptible colour of the ceiling is heavily influenced by:

- The colour output properties of the light emitted by the lamps
- The spectral reflectance properties of the ceiling fabric

Flickering is an annoying condition and those light sources that are prone to producing flicker should not be used in uplighters where the situation is likely to be aggravated. The flickering output from a lamp will be reproduced, and very often magnified, in the ceiling space over which it is projected. Additionally with some discharge lamps there is a strongly perceived variation in the light output in sympathy with the repeated oscillations in the electrical mains supply. This can in certain circumstances be reproduced and magnified in the ceiling.

It is recommended that for optimum visual conditions the average luminance of the ceiling must not be greater than 500 candelas per metre$^2$. The corresponding maximum value of luminance on the same surface should be not greater than 1500 candelas per metre$^2$.

There are certain situations where the use of an uplighter installation is totally impractical and one such restriction is imposed by the physical height of the room. For those interiors where the floor-to-ceiling height is less than 2.5 metres or greater than 3.5 metres, the interior is not likely to benefit from the installation of uplighters.

Due to the reliance on reflected light for their modus operandi, uplighter installations usually produce a reversal of the spatial distribution of light within an interior, when compared to that to which room occupants are generally accustomed. In certain circumstances this could induce lacklustre feelings within occupants, produced as a direct outcome of their workplace surroundings.

## Downlighters

Downlighters can be used in interiors containing display screen equipment where uplighters are unsuitable or inappropriate but it has to be appreciated that there are restrictions on the output characteristics of downlighter luminaires. To limit luminance reflections appearing on a display screen to an acceptable value, it is essential to use luminaires with a luminous intensity distribution specifically designed for the purpose to which it will be put.

The screen luminance subsequently produced by a downlighter luminaire is a pivotal characteristic to be considered when selecting appropriate equipment for use in an area containing display screens. It follows that the design of such luminaires must incorporate provision enabling the luminance of the luminaire to be stringently controlled.

A category rating system of classification of downlighter luminaires has previously been used whereby an interior was placed into one of three categories dependent upon the number of screens, the frequency of use and the likely consequences of misreading information on the screen if the lighting is inappropriate. This system is not now recommended and where lighting designers are not able to ascertain information about the screens in use in a

## Glossary of terms

**Colour rendering:** the ability of a light source to reveal the "real" or "expected" colour of an object. The Colour Rendering Index has a maximum value of 100. A value of 20 would be poor.
**Dichroic filter:** consists of a glass base plus thin layers of varying refractive index. Interference causes absorption of some wavelengths and transmission of others.
**Hygroscopic:** tending to absorb moisture.
**Lumen:** the measurement of luminous flux.
**Luminaire:** the 'housing' for a lamp, or lamp fitting. The luminaire includes the equipment containing the lamp, the control gear, the component controlling the appearance of the lamp and the protection of the lamp.
**Luminous efficacy:** the ratio of light output to the input power (lumens/watt).
**Photopic vision:** vision mediated largely by cone receptors. The maximum sensitivity is at a wavelength of 555nm.
**Black body:** a theoretical 'perfect' absorber and emitter of radiation. The quantity and colour of emitted radiation depends on the black body temperature.

given interior they will need to select a luminaire with a luminance limit of 200 candelas per square metre at an angle of 65 degrees to the downward vertical through the lamp centre. This angle may be reduced to 55 degrees in special circumstances.

Light distribution at acute angles tends to create a high luminance contrast between the room walls/ceiling and the working plane. The introduction of an indirect lighting component will therefore help prevent an otherwise gloomy room appearance.

The Health & Safety (Display Screen Equipment) Regulations 1992[1], under the overall auspices of the Health & Safety at Work Act 1974[8], describe minimum health requirements in relation to work with display screen equipment including VDUs. It is the responsibility of all employers to ensure that all VDU workstations under their command meet the provisions of the Regulations. In general the 1992 Regulations require:

**a** satisfactory lighting conditions

**b** provision of an appropriate contrast between any VDU and the background environment, and

**c** workstations be designed so that any glare or distracting screen reflections will be eliminated.

## Light sources used in display screen equipment areas

Due to their high heat output, GLS (general lighting service) lamps and tungsten halogen lamps are generally unsuitable for use in uplighters. Some discharge lamps take a seemingly inordinate time to reach luminous stability after switch on which would, in many circumstances, preclude their use in uplighter installations. Furthermore the restrike capabilities of some discharge lamps prevents their use in installations where the lamps are expected to respond almost instantaneously to switching actions.

Not surprisingly compact fluorescent lamps have enjoyed a sizeable share of the market for use in modern offices. Metal halide lamps, typically the 70Watt version, are finding an ever-increasing use in uplighters for use in areas containing display screens although the limitations of their re-strike capabilities limits their use to installations which are not continually being switched on and off. Notwithstanding this restriction, metal halide lamps with a Correlated Colour Temperature (CCT) value of typically 3000 Kelvin and a Colour Rendering Index (CRI) value of between 80 and 90 are ideal for use in uplighters. It will be recalled that the CCT value of a discharge lamp is the temperature of a theoretical black body that emits the same colour as the light source under consideration. The metal halide lamp described will therefore emit the same colour output as that of a black body at a temperature of 3000 Kelvin.

## Conclusions

When used incorrectly, daylight can be a chief source of annoyance for occupants of an interior in which display screens are used. The sensation of well being that typically occurs when windows provide a link with the outside world must not be overlooked. The obvious benefits of daylight have to be balanced against the likelihood that an over-abundance of daylight, entering an interior in an uncontrolled manner, will give rise to glare and veiling reflections. In turn the situation described can deter the use of display screen equipment.

A lighting installation that provides both direct and indirect light is an effective technique for producing a balanced luminance variation between the room fabrics and the working plane. The relationship between direct and indirect lighting is of paramount importance and requires careful planning as any significant mismatch is likely to produce disturbing consequences.

## References


**1.** Health & Safety *(Display Screen Equipment)* Regulations 1992, Statutory Instrument SI 2792.

**2.** EC Directive 90/270/EEC: *the minimum safety and health requirements for work with display screen equipment.*

**3.** BS EN ISO 9241-1:1997, *Ergonomic requirements for office work with visual display terminals.*

**4.** BS EN ISO 9241-6: 2000, *Ergonomics requirements for office work with visual display terminals (VDTs)*, Guidance on the work environment.

**5.** CIBSE LG3: *Lighting Guide, The Visual Environment for Display Screen Use,* Chartered Institution of Building Services Engineers, London, 2001, ISBN 0 900953 71 3.

**6.** AOP Handbook, *Guidance on Visual Standards for VDU/DSE Users,* Association of Optometrists, London.

**7.** Display screen equipment work: Health and Safety *(Display Screen Equipment)* Regulations 1992, Guidance on Regulations (L26), ISBN 0 7176 0410 1.

**8.** Health and Safety at Work etc Act 1974



**Dr Alan Smith is an Honorary Research Fellow at the Institute of Occupational Health, University of Birmingham. He is a consultant, lecturer and technical author in lighting having written nationally and internationally on the subject. He is an Examiner for The College of Optometrists in Occupational Optometry and a member of the Editorial Board for Optometry in Practice with responsibility for Environmental Optometry. He is a member of the Lighting Group Committee of RNIB and recently took up the appointment of Secretary to the Sports Vision Association.** ■