ADVICE SHEET

Conservation and Lighting

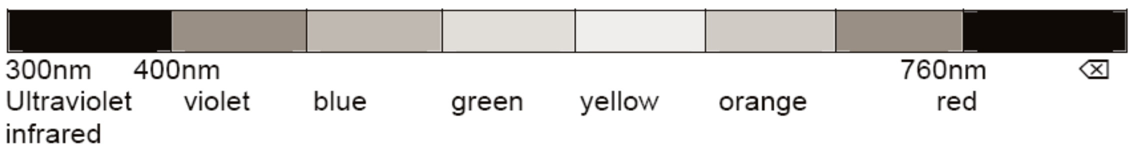
Museums Galleries Scotland

Introduction

Light is essential for the examination and enjoyment of collection items. But in a museum light also means damage: dyes and pigments fade or change appearance and the materials from which the objects are made deteriorate. Damage occurs even at low light levels, and the effects of light are cumulative. Items with organic components are particularly susceptible to damage by light. The only materials not affected are stone, ceramic, glass, and metal.

Light is a form of energy. It is expressed in wavelengths. Natural light starts at a wavelength of 300 nanometres (wavelengths shorter than 300nm cannot penetrate the atmosphere). The light spectrum can be divided into three main groups:

1. The band between 400 and 760nm is called **visible light**. We see it as the colours of the rainbow.
2. Wavelengths shorter than 400nm are called **ultraviolet radiation**. They cannot be seen by the human eye. Ultraviolet radiation has the shortest wavelengths and therefore the most damaging effect.
3. Wavelengths longer than 760nm are called **infrared radiation.** This radiation is also invisible, but it is felt as heat.



Nearly all types of light contain all three components, but the amounts per component can vary: daylight contains much ultraviolet radiation, tungsten light contains little ultraviolet but emits much infrared radiation.

There is no light level below which damage does not occur. The risk of light damage cannot be entirely eliminated unless all light is eliminated, but it can be reduced by:

- Reducing the amount of visible light an object receives (the *illuminance* or *light intensity*).

- Reducing the time an object is exposed to visible light (the *cumulative effect*).
- Eliminating all unnecessary invisible radiation.

Reducing the Amount of Visible Light

The intensity of visible light is measured with a light meter, which gives a reading in lux (1 lux = 1 lumen per square metre). It has been shown that 50 lux is the minimum amount of light needed to see the shape and colour of an object adequately. Therefore **50 lux** has been accepted as the **maximum recommended level for very sensitive items**, such as costumes and other textiles, fur and feathers, dyed leather, prints, drawings, watercolours, stamps, manuscripts, coloured and many types of old photographs, miniatures, transparencies, and unprimed thinly coloured paintings on canvas.

For items which are moderately sensitive, such as oil and tempera paintings, lacquer ware, plastics, wood, furniture, horn, bone, ivory, undyed leather, minerals and modern black and white photographs, the **maximum recommended level** is **200 lux**.

Stone, ceramic, glass, and metal are **insensitive to light**, but it is **recommended that 300 lux not be exceeded**, as it will become more difficult for the human eye to adapt when there are large differences between light levels from one space to another.

The harmful effects of **daylight** can be reduced by:

- Eliminating all direct sunlight.
- Keeping light-sensitive objects away from unblocked windows.
- Applying solar control film to windows and skylights (this is a light-reducing transparent film, which allows a view from the inside, but looks dark from the outside).
- Using net curtains, Venetian blinds or calico blinds (these give a more natural look from the outside, which may be important for historic houses and other listed buildings, but they do not allow a view from the inside).
- Blocking off the light entirely with black-out blinds.

The harmful effects of **artificial light** can be kept to a minimum by:

- Using low wattage lights.
- Reducing the number of lamps.
- Diffusing the light.
- Using dimmer switches.

It may be difficult to control daylight, as its intensity is not constant. At low light levels it can also give a rather gloomy appearance. In these situations (additional) artificial light will give a more satisfactory result. With artificial light sources the light can be made up to suit the situation: intensity; UV-content; direction; diffusion; and colour rendering (the "coolness" or "warmth" of the colour of the light) can be fully controlled to meet museum specifications.

Reducing the Time of Exposure

The damage that results from light exposure is a combination of the intensity of the light and the length of time an item is exposed to that light. An item exposed to a light intensity of 100 lux for six months will suffer the same amount of damage as an object exposed to twice the intensity for half the time (i.e. 200 lux for three months).

It is therefore important to control the time museum objects are exposed to light. If a light sensitive item has been displayed under moderately low levels for extensive periods, the total exposure level may be very high, though spot readings may be around the recommended limit. To keep the total amount of light to a minimum, **annual light exposure levels** are used.

Annual light exposure hours are based on the average number of opening hours per year for a standard museum. They are found by multiplying an average of 7 hours per day by an average of 6 days per week and an average of 52 weeks per year. This gives a figure of 2,184 exposure hours per year.

The annual exposure hours multiplied by the times the recommended maximum for spot readings gives a figure for **the recommended maximum number of lux hours of exposure over the whole year**. The following suggested annual exposure levels are based on the typical exposure hours given above:

- 100,000 lux hours for very sensitive items (normally lit at 50 lux)
- 450,000 lux hours for moderately sensitive items (normally lit at 200 lux)

Annual light exposure levels can also be a useful guide when the light level cannot be reduced sufficiently. In such a case a shorter display period will ensure that the total light exposure remains within the annual maximum. Once the recommended annual exposure level has been reached, objects should be removed from display and placed into dark storage.

To reduce the exposure time, the following measures can be taken:

- Change the displays regularly, temporary displays allow objects to be rotated with items in storage.
- Turn pages of books and illuminated manuscripts regularly.
- Fit curtains to display cases.
- Fit time-switches on room or display case lighting.
- Install sensors that switch on the lights only when a movement is sensed.
- Exclude all light when the museum is closed, by using curtains or black-out blinds.

Light is only needed during opening hours, which usually are from 10am to 5pm (this is 7 hours per day). During the summer months daylight can enter an unprotected museum building from 5am to 10pm (17 hours per day). This is more than twice as long as is necessary.

Eliminating Non Visible Radiation

Ultraviolet (UV) radiation is measured with a UV monitor, and is expressed in **microwatts per lumen**: it gives the amount of the UV component within one lumen of light. To eliminate UV radiation a filter is needed that reduces the UV component in the light.

Because UV radiation does not contribute to the visual appearance of items, the aim should be to reduce it to as low as possible. Until recently the recommended maximum was **75 microwatts per lumen**. However, recent improvements in UV absorbing materials have made it possible to reduce the UV radiation to even lower levels. The aim should be to reduce it to as low as **10 microwatts per lumen wherever possible**, if zero levels cannot be achieved.

Daylight and artificial light, particularly fluorescent light, emit large amounts of UV radiation. Tungsten-halogen lamps (tungsten lamps with halogen gas added for a more efficient, slightly whiter light) emit a small amount of UV radiation with a very short wavelength. This radiation is very powerful and therefore damaging, but can be filtered out with a glass filter.

To reduce the amount of UV radiation that reaches museum objects, the following UV-absorbing materials can be used:

- Laminated glass, self adhesive film, UV-absorbing acrylic or polycarbonate sheet or UV-absorbing varnish for windows, skylights and display cases.
- UV-absorbing sleeves and filters for artificial light sources.

Other materials that can be used are:

- Lamps and tubes with a low ultraviolet emission.
- White paints, based on titanium dioxide, or zinc oxide. Light reflected by a white painted wall contains less than 20% of its original amount of UV radiation. Whitewash (chalk) is **not** effective.

Laminated glass has a long life expectancy. All other UV absorbing materials have a limited life expectancy of 5 to 10 years. The effectiveness of UV absorbing materials and white painted walls should therefore be checked on installation (for reference) and then at regular intervals. UV absorbing film and filters for use in museums should meet certain specifications; check with the supplier that they do.

Infrared radiation is that form of energy we feel as heat. All light sources produce heat to some extent: in a 100 watt tungsten bulb 94% of the electricity passing through it is converted into heat. Heat affects the relative humidity of the air and the moisture content of objects. The heat emitted by lamps will cause drying even when the RH of the room or display case is kept constant, and a rise in temperature will speed up deterioration processes. It is therefore important to avoid local "hot spots" on objects caused by lamps.

This can be done by:

- Mounting lights at a safe distance from museum objects, preferably outside display cases.
- Using `cool-beam' lamps (in which a reflector reflects visible light forwards, but allows infrared radiation to pass through the back of the lamp; these lamps should therefore always be mounted outside display cases).
- Installing a fibre optic light system, whereby the light source is separated from the light head by a flexible glass fibre or acrylic cable. In fibre optic light systems, both ultraviolet and infrared radiation are filtered out automatically.

It is beyond the scope of this advice sheet to give information about types of bulbs, lamps, and fittings currently available. A professional museum designer or museum lighting designer, and suppliers of museum standard display equipment will be able to offer further information on designing lighting systems for specific museum situations. However, curators and collection care staff should always ensure that specifications for lighting systems meet museum standards, especially if new and perhaps relatively unfamiliar lighting systems are under consideration.

Recent developments include LED lamps, and energy-saving compact fluorescent lamps which are replacing conventional tungsten lamps. While these new lamp types can have advantages in that they reduce energy consumption and produce less heat in the museum environment, not all are ideal for museum use. For instance, LED lamps can produce both heat and UV light, and their colour rendering is not yet as good as tungsten and tungsten-halogen lamps. Compact fluorescent lamps can produce significant levels of UV light (especially those with unshielded tubes) and if dimmer systems are in use, the correct version of the lamp must be specified.

Further information and advice

This is one of a series of advice sheets produced by Museums Galleries Scotland on common collections care and preventive conservation issues. For more details, signposting to further sources of advice or information on how to contact a conservator, see our website at: www.museumsgalleriesscotland.org.uk.

Further reading

Cassar, M.
Environmental Management – Guidelines for Museums and Galleries
1995, Museums & Galleries Commission / Routledge
ISBN 0-415-10559-5

Thomson, G.
The Museum Environment, 2nd edition
1986, Butterworth

The National Trust Manual of Housekeeping
Butterworth-Heinemann, 2006
ISBN 0750655291

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