Display and Conservation: The Dilema of lighting in Museums

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St Mungo's Museum, Glasgow.
Here light from large window areas was controlled by filtration and the mounting of stained glass exhibits. Working closely with the architect, David Page, particularly light sensitive exhibits are prevented from receiving direct sunlight by positioning relative to internal walls.

Light is destructive, specifically to those materials that give colour in the natural world and have been adopted by man as media to decorate or create. This phenomenon first came to the attention of the museum world in 19th Century London through studies by Russell and Abney on the rapid deterioration of watercolour paintings displayed in galleries Since then the profession of museum conservation has constantly reviewed these matters in a steady stream of publications.

Ultra-Violet (U.V.) is by far the most damaging portion of the electromagnetic spectrum and it adds little or nothing to our visual perception of objects. The exceptions are fluorescent materials such as Day-Glo paints or the Optical Brighteners added to laundry detergent which need to be treated as a special case when they form part of an exhibit. U.V. should be completely excluded from light in museums and galleries. Detailed coverage of this subject can be found in Stefan Michalski's paper "Damage to museum objects by visible radiation(light) and ultraviolet (UV)"

Guidelines for exposure from the visible portion of the spectrum are set forth in in numerous publications, however the most specific and widely cited work is by Dr. Garry Thompson at the National Gallery of London and published in his book "The Museum Environment" In general, these propose an illumination limit of 50 Lux for materials particularly susceptible to damage by light (light fugitive) and 200 lux for less fugitive materials. These guidelines,are frequently considered as absolutes and are often misunderstood by the very people who have daily responsibility for museum display and conservation.

The effects of light are a cumulative phenomenon; essentially the light level may be considered to determines the rate of deterioration but the time of exposure determines the total deterioration that occurs. In her paper "A suggested Exhibition / Exposure policy for Works of Art on Paper" Karen M. Colby proposes a policy of limiting the period of exhibition of artifacts on the assumption of lighting levels being determined by the nature of the objects. I agree with this approach which is slowly becoming standard practice in major museums such as the National Museums of Scotland and specifically, the Canadian Museums discussed in Karen Colby's paper.

From a Lighting Designer's Perspective,I would counsel a further step, that of keeping an accurate exposure record by measurement and balancing this against a predetermined exposure value, measured in lux-hours, for objects to be exhibited from collections. Gary Thompson recognised this approach in his book "The Museum Environment" and proposed cumulative exposure values in the appendix .

Accurate measurement of exposure would serve a number of causes. Firstly it would build up a body of practical data allowing for future accurate assessment of deterioration caused by light. Secondly it would allow greater flexibility of lighting levels on an object by object basis determined by the specific effects of light on the particular materials composing the object. Finally, this approach allows a more effective use of time-limiting lighting control, whether by visitor-operated switches or by comprehensive lighting control systems.

This system would also take into account the shorter duration high light levels encountered by conservators at work, curators reporting condition, or when television lights are used at exhibition openings!

In essence, the system of conservation based on limiting the illumination falling upon objects has fundamental problems in providing information to the viewer. The experience of viewing is dependent on the amount of light reaching the eye by reflection from the objects and their peripheries within a certain timeframe. The human visual system is a marvel of evolution; it can provide functional information throughout a vast range of light levels from starlight in open country to full desert sunlight. However, within this operating range it can only provide detailed information over a very much more limited range of light levels. It is therefore necessary for the Curator, Conservator, Exhibition and Lighting Designers to provide a visual environment for visitors that allows them the maximum visual access to objects on display.

2 Low Light Gallery, St. Mungo's Museum. Low light levels are accomplished by creating coffers over display cases with Durer miniatures. Bouncing the light round the coffer and down the wall provides at once an even coverage at 50 lux without dimming and a uniform visual environment allowing high visual acuity without glare or problems of the viewer self shadowing the lightsource when closely examining the exhibits.

Limits on Maximum Illumination create frequent problems in presentation of objects. The lower standard level of 50 lux in museums is not acceptable in any field where any level of visual acuity is required. Providing a maximum of 50 lux creates a series of problems. The first is simply that of the inverse square law. As the distance between the object, and the light source increases the level of illumination is reduced by the square of the distance. Imagine a typical display case with , say, a full height dressed figure extending from 200mm below the lighting diffuser in the case top and the base, 2M below the diffuser. 50 lux at the top of the figure translates to 15.4 lux at the foot of the figure, a hopelessly inadequate lighting level. Another example would be a painting spotlit from track at 3 M high and 1M from the wall using a 20W 38 dichroic lamp aiming at the centre of the picture. This results in 259 lux at the centre, 225 lux at the top and 70 lux at the bottom. This is caused by the fall off of light across the beam of the lamp. Remember that the quoted beam angle relates to the angle at which the measured intensity is half that of the maximum intensity at the centre of the beam, and the effect of greater distance and increased angle of incidence at the bottom picture.

Absolutely flat lighting is impossible to achieve, at a practical level, for even wall washers or diffuse, or reflected light will vary substantially over height. This kind of diffuse lighting is generally poor for revealing any of the texture, grain or brush work in exhibits.

The Human Eye and Brain will tend to average out variations in lighting levels. In display conditions this gives rise to perception problems when areas of radically different brightness are simultaneously within the field of view. Experimentally this is demonstrated in "Fechner's Paradox" which demonstrates that if a second low level light source impinging on one part of the retina is added to a primary brighter source the eye responds by the iris opening to an average position between the two levels of light as the total light entering the eye increases This effectively makes bright sources brighter in the field-of-view, making less bright areas more difficult to see. This is called "disabling glare" and frequently occurs in museum exhibitions where lights are reflected in picture glasses or where poorly shielded lights are in the same field of view as pictures or objects.

Suitable types of illuminant for museum displays

Fluorescent lamps are often proposed as they are energy efficient and provide reasonable colour rendering, in fact the best can offer colour rendering indices in the 90's. The quality of fluorescent lamps is discussed in David Saunders' paper "Fluorescent Lamps: a Practical Assessment" This light source can be considered suitable where a general wash of light is required however they do have some technical disadvantages particularly where dimming is required. Dimming is complex simply because of the way these lamps work. Also, as these lamps are dimmed there are perceptible shifts in colour rendition. Manufacturers assure us that these are slight, however as the level is reducing so is the perceived colour rendition which is simultaneously being compromised by the lower light level.

The most common illuminant for display lighting is Tungsten Halogen (TH);and , these days, specifically low voltage TH. This has the advantage of a continuous colour spectrum and therefore a colour rendering index of 100. Technically it is easy to dim and it is easy to design well optically controlled light fittings as the source of light is relatively small. Practically, dimming reduces not only the lighting level but also the apparent colour temperature and therefore the ability to render colours at the blue end of the spectrum. The result is the familiar feeling of gloom engendered by the yellowing of light when heavily dimmed. In practice, dimming more than 15 to 20% will create this effect. In our previous example we demonstrated the levels achieved from a 20W lamp at 3 M high and 1 M from a wall are in the region of 250 lux. Should we need to achieve 50 Lux from this lamp by dimming , we would encounter poor viewing conditions due to the consequent yellowing of the light.

Practicalities

I believe that good quality presentation can be achieved without compromising the conservation of objects. It is now time to reconsider the setting of maximum lighting levels as the main method of preserving objects from light damage. Limiting the time of exposure by rotation of objects between archive storage and exhibition, by providing systems that reduce light level when objects are not being viewed; and by limiting high level exposure for condition reports, presentation work and research will combine to provide acceptable life of objects.

Ongoing research will allow individual objects to be categorised more accurately for their light fugitivity and this information can be reflected in permissible exposure on an object by object basis.

With an exposure recording system in place, the next step is to asses the appropriate lighting level for particular objects and exhibitions. Basic requirements for exhibition need to include the following:

1 There should be no direct sunlight in the exhibition space
2 Daylight must be filtered to exclude UV
3 Maximum daylight levels to be controlled, however, keep in mind that level variation should be allowed to reinforce the connection between the illuminated space and the natural world.
4 Artificial light sources to be selected to provide optimum colour rendition
5 Artificial light sources to be filtered to exclude UV as far as practicable

Now we have a foundation to set lighting levels appropriate to the viewing conditions. These will depend on the nature of the exhibition space, the exhibition design and colouring of wall, floor and ceiling surfaces. It will become a design decision at this stage as to how to approach the lighting; will it be by washes of light or spotlighting or a combination of these techniques? How will it interact with the viewer? How will it be controlled?

The individual objects can then be addressed with reference to the allowable exposure and the curatorial and exhibition requirements for juxtaposition. Decisions can then be made as to the average illumination to be received by each object to allow for maximum visibility in the context of the exhibition. This is not an argument to light all exhibits at uniform high levels; however , as previously discussed, the visual experience is determined by the amount of light reflected back from an object in the visual context within which it lies, so average levels of 40 lux may be adequate for a watercolour exhibited against a mid-tone wall in an otherwise dark area. However the same picture exhibited in a partially daylit gallery with pale walls may need to receive an average of 100-150 lux to be equally viewable, in the context of a total recorded exposure policy both situations would be acceptable within the life of the object providing suitable times of archival storage were allowed between periods of exhibition.

Measurement

I have witnessed numerous situations in which erroneous measurement and inappropriate measurement devices have resulted in devastation of a museum's visual environment. Occasionally, my work requires me to make investigations into perceived lighting problems brought about by poor understanding of light measurement. The proposed conservation methodology relies on a uniform and comprehensive approach to measuring and recording lighting levels. In this context we are interested in three measurement parameters:

1 Average illumination at the object
2 Ultraviolet radiation as a proportion of the illuminant
3 Exposure over time

I will outline the methodology we use for these measurements as a proposal for discussion for a uniform system.

1 Average Illumination at the object: This basic measurement needs to be made with a meter equipped with an integrating sensor; typically these will have a slightly domed opaque cover over the measuring cell. This should be fully Cosine corrected, meaning that it accepts light from many different angles and accurately integrates it in the indicated measurement. It should also conform

to the CIE curve for spectral response which matches that of the human eye. Most modern general purpose light meters meet these criteria.

This sensor should be held parallel with the principal plane of the object. Measurements should be taken at no less than 5 points, close to the centre to determine the point of peak illuminance and close to the four corners, one reading being taken at the point of minimum illumination. In the case of objects having more than one principal plane, sculptures etc., measurements should be repeated on each plane. These readings provide a guide to the actual spread of illumination across the object, in general the maximum and minimum readings should not exceed the ratio of 1:3 to provide perceived evenness of illumination unless there is a positive reason for highlighting a particular portion of the object When averaged they will give a realistic light exposure for the object. The light meter should not be pointed directly at the light source unless this is normal to a principal plane as this will give a false high reading. Similarly a directional sensor on the light meter will give a false low reading when parallel to the object plane and a false high reading when pointed at the light source. It should also be remembered that even high quality light meters are only accurate to 3% even when newly calibrated, therefore two meters can be expected to show variation of up to 6 lux an a measurement of around 100 lux.

2 Ultraviolet Radiation: As this is expressed as a proportion of the light emitted from a light source, a number of devices have been manufactured to give either a direct reading or a "hit and miss" reading by way of light-emitting diode indicators. Theoretically these devices are independent of light level and should be able to give a rapid and accurate assessment. In practice, they have severe shortcomings. At low light levels they are less accurate than is desirable, the type with an LED readout is even more limited in terms of the information it provides. Our preferred method is to use a direct reading UV radiometer and calculate a result from a simultaneous light measurement. In this case both instruments should be pointed directly at the light source and the result directly calculated.

I propose the formulation of a set of absolute levels of UV radiation. As UV is acknowledged to be the most damaging part of the spectrum, its exclusion will provide the greatest benefit in terms of conservation. UV is inevitably present in any light source, so essentially we are measuring the effectiveness of some filter medium in reducing or eliminating it. This subject is extensively covered in David Saunder's article on filtration of UV. The 75 microwatt per lumen standard derived from Garry Thomson's work is based on the unfiltered output from a standard incandescent lamp. This book also specifies an ideal UV filter. Current dichroic coating technology has provided us with such a filter. David Saunders proposes a maximum UV level of 10 microwatts per lumen which is only achievable through the use of these filters. His article also points out the shortcomings of many other commercial UV filters. Using these simpler filter media and through careful manufacturer selection of lamps it is easy to achieve levels of 35-50 microwatts per lumen. From the above I would propose the following absolute limits of UV as practically achievable within the majority of museums and galleries.

	milliwatts per m sq.	Lux	microwatts per Lumen
Old Standard	3.75	50	75
Old Standard	18.75	200	75
Sensitive	1	100	10
Normal	8	200	40

The table above indicates the original standards in Thompson for comparison.
These figures are offered for discussion and are not to be considered as prescriptive.

3 Exposure over time: This is the key measurement for this proposed method of conservation lighting. The methodology will vary according to a range of factors, depending on the particular object and exhibition conditions. At the simplest, if we consider the example of an exhibition with a single set lighting state, the measurements required above will be recorded and it is simply a matter of recording the length of time the lighting is switched on in an exhibition log. At the end of the exhibition the exposure, determined by measurement, is simply multiplied by the number of hours recorded in the log.

More complex situations include visitor controlled lights. In this situation a time recording device should be attached to the visitor controlled circuit and readings logged. Daylighting creates an even more complex situation. This is a significant variable and monitoring must be undertaken in a systematic way. It is technically possible to provide a data logging device for each object which can be downloaded into a computer for record keeping and analysis; I suggest a data logging device be mounted on each wall which receives natural light and exposures for each artwork be based on the initial measurements taken compared to the logged data for the time the measurement was taken and pro-rated according to the recorded lighting level data over the period of exhibition. Over the course of two or three years the recorded data can be used to determine annual exposures for each wall with variations over the year and this data can be used to assist in organising future hangs to keep most sensitive exhibits from the walls receiving most light.

Conclusion:

In closing I must reiterate that the existing system of conservation based on limiting the maximum illumination of objects is fundamentally flawed and requires a more sensitive and flexible approach to providing optimum display conditions for museum exhibits without compromising conservation efforts. In the end though this fundamental change of approach depends on a reasonable, aesthetically aware and open minded team of conservation and design professionals, willing to forego the comfort of established conservative methodology in pursuit of common clarity.

Kevan Shaw 19th of February 1996

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Footnotes

clicking on the underlined title of the footnote will return you to your place in the text.

1 .Russell and Abney: Bromelle 1964

2. "Damage to museum objects by visible radiation(light) and ultraviolet (UV)" : Stefan Michalski. Preprints of the Bristol Conference on Lighting in Museums Galleries and Historic Houses, The Museums Association (1987)

3. ...The Museum Environment...: Gary Thompson, 1978, The Museum Environment, London, Butterworth-Heinemann.

4. A "suggested Exhibition / Exposure policy for Works of Art on Paper"Karen M. Colby Montreal Museum of Fine Art 1991, Internet: http://www.webcom.com/litesrc/

"5. Fluorescent Lamps: a Practical Assessment" : David Saunders; National Gallery Technical Bulletin 11 (1987)