PROTECTION FROM LIGHT DAMAGE

Cristina Dumitra Olariu

No one needs to be told that light can change colours and rot materials, though with the fastness of modern dyes and the affluent tendency to throw away rather than repair this comon knowledge has no longer the practical importance that it once had, except in the museum.

Light can only damage what it reaches and since most objects are opaque to light its major effect is *on* surface deterioration. But the surface is the very essence of many exhibits, above all of paintings and drawings.

We can say that all organic material is at risk under light The term organic material includes all things which originated in animals or plants - for example, paper, cotton, linen, wood, parchment, leather, silk, wool, feathers, hair, dyes, glues, gums and resins - and in addition, because of similarities in chemical structure, almost all synthetic dyes and plastics.

It must he remembered that light can cause not only colour change but strength change, as in the weakening of textiles and the destruction of paint medium.

Stone, metal, glass and ceramics, with some exceptions, are not affected by light, and we need not worry too much about wood, bone or ivory if their surface colour is not important. But this section on light is concerned to a greater or lesser extent with just about every other kind of museum material.

Most of us recognize fading as a form of light damage, but this is only a superficial indication of deterioration that extends to the physical and chemical structure of collections. Light provides energy to fuel the chemical reactions that produce deterioration. While most people know that ultraviolet (UV) light is destructive, it is important to remember that all light causes damage. Light damage is cumulative and irreversible[1] .

To reduce surface deterioration to a minimum we must control the lighting. But before we deal with ways and means it will help to examine the nature of light.

The Nature of Light

Light is a form of electromagnetic energy called radiation. The radiation that we know from medicine and nuclear science is energy at wavelengths far shorter than the light spectrum; radio waves are much longer wavelengths. Visible light, the form of radiation that we can see, falls near the center of the electromagnetic spectrum. The visible spectrum runs from about 400 nanometers (nm, the

---

[1] Thomson, Garry. *The Museum Environment*. 2nd edition. London and Boston: Butterworth in association with The International Institute for Conservation of Historic and Artistic Works, 1986, pp. 2-4.

measurement applied to radiation) to about 700 nm. Ultraviolet wavelengths lie just below the short end of the visible spectrum (below 400 nm). The wavelengths of infrared light lie just above the long end but our eyes cannot see them. This type of light also damages collections.

How does light do its damage?

Light energy is absorbed by molecules within an object. This absorption of light energy can start many possible sequences of chemical reactions.

The ultimate nature of energy is not understood. But what science can do is to define and quantify physical systems and the energy changes that they undergo. Heat, light and motion are forms of energy.

A chemical reaction, which for us means deterioration, may absorb energy or may actually release some of the potential energy hold in the molecules. But in either case a certain definite quantity of energy must be supplied in order to start the reaction This is known as the *activation energy* of the reaction.

In the museum the activation energy may be brought to an object by heating it or illuminating it. To us a chemical change such as deterioration seems to be a gradual thing, but this is because many millions of molecules are involved.

Ultraviolet Light vs. Visible Light

Since UV radiation is the most energetic and destructive form of light, we might assume that if UV light is eliminated, visible light is of minimal concern. This is not true; all wavelengths of light do significant damage.

In practical terms, UV light can be easily eliminated from exhibit, reading, and storage areas, since our eyes do not perceive it and will not miss it. Visible light is far more problematic, but it should be eliminated from storage areas as much as possible and carefully controlled in other areas.

Sources of Light

Light has two sources: natural and artificial. Libraries and archives should avoid natural light. Sunlight has a high percentage of ultraviolet. Daylight is also brighter and more intense, and therefore causes more damage, than most artificial light.

The two primary artificial light sources currently in use in libraries, museums, and archives are incandescent and fluorescentlamps. (The term "lamp" is used by architects and engineers to refer to the various types of light bulbs, rather than to the fixtures containing the bulbs.) Driven by the need for energy conservation and cost savings, manufacturers continue to refine lamp technologies to produce longer-lived lamps that consume less energy and provide better light. Compact fluorescent, tungsten-halogen, high intensity discharge (HID), and electrodeless lamps have all been developed in response to these concerns.

Conventional incandescent lamps produce light when an electric current is passed through a tungsten filament, heating it to about 2700 degrees Celsius.

Incandescent lamps convert only a small percentage of this electricity into light; the rest becomes heat. Conventional incandescent lamps emit very little ultraviolet light and do not require UV filtering. Examples of conventional incandescent lamps include the ordinary household light bulb and a variety of lamps used for exhibition lighting, such as the Reflectorized (R), Ellipsoidal Reflectorized (ER), and Parabolic Aluminized Reflector (PAR) lamps.

Tungsten-halogen lamps (also called quartz lamps) are a variation on the traditional incandescent lamp; they contain halogen gas inside a quartz bulb, which allows the light to burn brighter and longer. These lamps emit significant UV light and do require filtering. Filters can be expensive and special housings designed to accept the UV filters may be necessary. Tungsten-halogen lamps are also used in exhibition lighting; examples include the Halogen PAR and the Mirrored-Reflector (MR) lamp. Fluorescent lampscontain mercury vapor inside a glass lamp whose inside surface is painted with white fluorescent powder. When electricity is passed through the lamp (via a filament), the mercury vapor emits UV radiation which is absorbed by the fluorescent powder and re-emitted as visible light. Some UV light passes through most fluorescent lamps, however, so they are more damaging than incandescent lamps. The newest type of fluorescent is the compact fluorescent lamp; these are smaller, last longer, and have a more pleasant color than traditional fluorescents, and they can usually be used in incandescent sockets[2]. These lamps must still be filtered, however.

Fiber optic lighting is an energy-efficient means of providing display lighting, particularly in exhibition cases. In a fiber optic system, light is transmitted from a light source through glass or acrylic fibers. The fibers do not conduct infrared or ultraviolet light, and unlike fluorescent lamps, fiber optic lighting does not cause buildup of heat within the case (provided the light source is mounted outside the case).

The electrodeless lamp is the newest type of light source. A normal incandescent lamp is subject to the eventual failure ("burn out") of its electrode, which is a piece of metal (usually tungsten) that is heated until it produces light. Electrodeless lamps produce light in other ways, including the use of radio frequencies to excite a coil or microwave energy directed at the element sulfur to produce visible light. Electrodeless lamps produce a lot of illumination, so thus far they have only been used as sources of ambient light (the light produced by one electrodeless sulfur lamp equals more than 250 standard 100 watt incandescent lamps). They are more energy efficient than HID lamps, and they provide excellent color rendition, low infrared and ultraviolet light, and long life. It is expected that

[2] William P. Lull, with the assistance of Paul N. Banks, *Conservation Environment Guidelines for Libraries and Archives* (Ottawa, ON: Canadian Council of Archives, 1995), pp. 44-45.

this technology will eventually be miniaturized for use in smaller exhibit spaces and in exhibit cases[3].

How Much Light Is Too Much?

Do we have to eliminate all UV light? Since all visible light cannot be eliminated, particularly in exhibition areas, how low should the levels be?

Control of ultraviolet light is relatively straightforward. The standard limit for UV for preservation is 75 µW/l (international system). Any light source with a higher UV emission must be filtered. Control of visible light is obviously more problematic. It is essential to understand that light damage is cumulative, and that lower levels of illumination will mean less damage over the long term. Another important concept in controlling visible light is the law of reciprocity. This says that limited exposure to a high-intensity light will produce the same amount of damage as long exposure to a low-intensity light. For example, exposure to 100 lux for 5 hours would cause the same amount of damage as exposure to 50 lux for 10 hours.

For many years, generally accepted recommendations in the preservation community have limited visible light levels for light-sensitive materials (including paper) to 55 lux (5 footcandles) or less and for less sensitive materials to 165 lux (15 footcandles) or less. In recent years, however, there has been some debate about these recommendations. Some have argued the importance of aesthetic concerns: older visitors need more light to see exhibited objects well, and any visitor will find that more fine detail is apparent and colors appear brighter as light levels increase. In addition, the assumption that all paper objects are equally sensitive to light has been challenged[4]. Scientists at the Canadian Conservation Institute (CCI) and others have begun to gather data on rates of light fading for specific media and colors in an effort to begin developing more specific guidelines based on the International Standards Organization (ISO) Blue Wool light fading standards.

In the absence of universal guidelines, it is recommended that each institution establish its own limits on exhibition for its collections. Factors to consider include: the amount of time the lights are turned on in the exhibit space (this may be more than first thought, since lights are often turned on for housekeeping or other purposes when the exhibit is closed to the public); the sensitivity of the items or groups of items being exhibited; the desired lifespan of these items or groups of items; and the importance of aesthetic concerns in exhibition. Ultimately, every institution should decide on an acceptable upper limit of exposure (i.e., a certain number of lux hours per year), which may differ for different parts of an institution's collection. Publications by CCI and the exhibition

[3] See Frank Florentine, *The Next Generation of Lights: Electrodeless*, in WAAC Newsletter 17:3, (September 1995), for more information and details on the use of electrodeless lamps at the Smithsonian Institution's Air and Space Museum.

[4] Stefan Michalski, *Towards Specific Lighting Guidelines*, in proceedings of "Museum Exhibit Lighting - Beyond Edison: Lighting for the Next Century," a workshop presented by the National Park Service and the Washington Conservation Guild, March 6-8, 1996.

policy developed by the Montreal Museum of Fine Arts for works of art on paper may be helpful in estimating the sensitivity of various types of paper-based collections[5].

Using the law of reciprocity, an exhibition limit can be achieved in different ways; for example, a limit of 50,000 lux hours per year could be achieved by keeping the lights on for 10 hours per day, either at 100 lux for 50 days or at 50 lux for 100 days.

It is important to remember that even with such guidelines, some fading will occur. The goal is to achieve a workable compromise between exhibition and preservation.

PROTECTION FROM LIGHT DAMAGE

- Abstract -

Light is an agent of deterioration that can cause damage to museum objects. Light causes fading, darkening, yellowing, embrittlement, stiffening, and a host of other chemical and physical changes.

Light is a form of energy that stimulates our sense of vision. This energy has both electrical and magnetic properties, so it known as electromagnetic radiation. The energy in light reacts with the molecules in objects causing physical and chemical changes. Because humans only need the visible portion of the spectrum to see, you can limit the amount of energy that contacts objects by excluding UV and IR radiation that reaches objects from light sources. All types of lighting in museums (daylight, fluorescent lamps, incandescent (tungsten), and tungsten-halogen lamps) emit varying degrees of UV radiation. This radiation (which has the most energy) is the most damaging to museum objects. Equipment, materials, and techniques now exist to block all UV. No UV should be allowed in museum exhibit and storage spaces.

Control of ultraviolet light is relatively straightforward. The standard limit for UV for preservation is 75 µW/ l (international system). Any light source with a higher UV emission must be filtered. Control of visible light is more problematic. It is essential to understand that light damage is cumulative, and that lower levels of illumination will mean less damage over the long term. Another important concept in controlling visible light is the law of reciprocity. This says that limited exposure to a high-intensity light will produce the same amount of damage as long

[5] See Stefan Michalski, *Towards Specific Lighting Guidelines*; *A Light Damage Slide Rule*, CCI Notes 2/ 6, Canadian Conservation Institute, Ottawa (1989); and Karen M. Colby, "A Suggested Exhibition/ Exposure Policy for Works of Art on Paper" (available at The Lighting Resource website: http:// www.lightresource.com/).

exposure to a low-intensity light. For example, exposure to 100 lux for 5 hours would cause the same amount of damage as exposure to 50 lux for 10 hours.

For many years, generally accepted recommendations in the preservation community have limited visible light levels for light-sensitive materials (including paper) to 55 lux (5 footcandles) or less and for less sensitive materials to 165 lux (15 footcandles) or less. In recent years, however, there has been some debate about these recommendations. Some have argued the importance of aesthetic concerns: older visitors need more light to see exhibited objects well, and any visitor will find that more fine detail is apparent and colors appear brighter as light levels increase. In addition, the assumption that all paper objects are equally sensitive to light has been challenged. Scientists at the Canadian Conservation Institute (CCI) and others have begun to gather data on rates of light fading for specific media and colors in an effort to begin developing more specific guidelines based on the International Standards Organization (ISO) Blue Wool light fading standards.

It is important to remember that even with such guidelines, some fading will occur. The goal is to achieve a workable compromise between exhibition and preservation.