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CANTERBURY DISASTER SALVAGE TEAM

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1. Light Issues

INTRODUCTION

Light is a common cause of damage to collections. Paper, bindings, and media (inks, photographic emulsions, dyes, and pigments, and many other materials used to create words and images) are particularly sensitive to light.
Light can cause paper to bleach, yellow, or darken, and it can weaken and embrittle the cellulose fibres that make up paper. It can cause media and dyes used in documents, photographs, and art works to fade or change colour. 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 generally irreversible.

What is light?
Light is a form of electromagnetic energy called radiation.
Visible light, the form of radiation that we can see falls near the centre of the electromagnetic spectrum. The visible spectrum runs from about 400 nanometers (nm, the 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 in the form of heat build up.

The Chemistry of Light
Light energy is absorbed by molecules within an object.
The general term for this process is *photochemical deterioration*. Each molecule in an object requires a minimum amount of energy to begin a chemical reaction with other molecules. This is called its *activation energy*. Different types of molecules have different activation energies. If the light energy from natural or artificial light equals or exceeds the activation energy of a particular molecule, the molecule is "excited," or made available for chemical reactions. The excess energy may show up as heat or light; the energy may break bonds within the molecule (this will create smaller molecules and weaken the object); one of the primary photochemical reactions is oxidation, in which the "excited" molecule transfers its energy to an oxygen molecule, which then reacts with other molecules to initiate damaging chemical reactions. While the sequence of events can be extremely complex, the end result is always

deterioration.

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. All wavelengths of light do significant damage.

In practical terms, UV light can be easily eliminated from exhibits, 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. Cultural institutions should avoid natural light where collection is present. 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 cultural institutions are:
•**incandescent**
•**fluorescent lamps**.

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.

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.
1. These lamps emit significant UV light and do require filtering.
2. Filters can be expensive and special housings designed to accept the UV filters may be necessary.
3. Tungsten-halogen lamps are also used in exhibition lighting.

Fluorescent lamps
contain mercury vapour 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 vapour 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 colour than traditional fluorescents, and they can usually be used in incandescent sockets. These lamps must still be filtered as they emit UV radiation.

High Intensity Discharge
Like fluorescents, **high intensity discharge (HID)** lamps contain a vapour inside a glass lamp coated with a fluorescent powder, but they are much more intense than normal fluorescents.
There are two types.
1. Mercury or metal halide HID lamps should not be used, since they have a dangerously strong UV output and filtering can be difficult.
2. High-pressure sodium HID lamps are too intense for direct lighting (and do not provide good colour rendering), but they can be used for indirect lighting (i.e., bouncing light off the ceiling) in large storage spaces with high ceilings. Sodium HID lamps have very low UV emissions, which can be further reduced by painting the ceiling with white Titanium Dioxide paint, a UV-absorber. Sodium HID lamps generate little heat, are efficient, and have low operating costs.

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

Electrode less lamp
The **electrode less 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. Electrode less lamps produces light in other ways, including the use of radio frequencies to excite a coil or microwave energy directed at the element sulphur to produce visible light.
•Electrode less lamps produce a lot of illumination, so thus far they have only been used as sources of ambient light (the light produced by one electrode less sulphur lamp equals more than 250 standard 100 watt incandescent lamps). They are more energy efficient, and they provide excellent colour rendition, low infrared and ultraviolet light, and long life. It is expected that this technology will eventually be miniaturized for use in smaller exhibit spaces and in exhibit cases.

Control of UV
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. 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 50 lux (5 foot candles) or less and for less sensitive materials to 200 lux (15 foot candles) 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 colours 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 colours in an effort to begin developing more specific guidelines based on the International Standards Organization (ISO) Blue Wool light fading standards

Guidelines

In the absence of universal guidelines, it is recommended that each institution establish its own limits on exhibition for its collections.

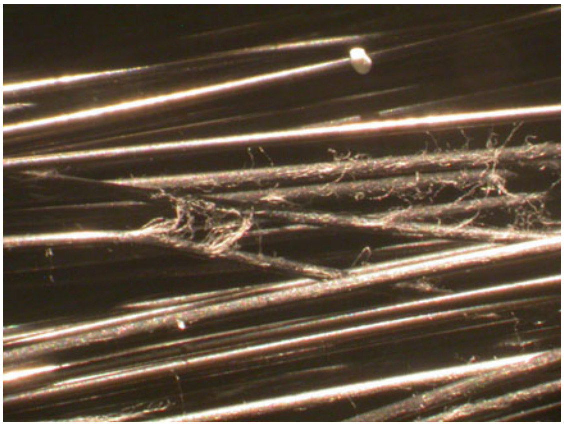
Factors to consider include:

1. 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);
2. 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.
3. 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.

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.

Light and UV meters

A light meter measures only the level of illumination; a UV meter must be used to measure the UV component of light. UV light is measured in microwatts per lumen (SYMBOL -µW/ l). The most common UV meter is the Crawford monitor, but all UV meters will measure the proportion of



ultraviolet in visible light. Again, this should not exceed 75 µW/l. A word of caution regarding UV meters: some older UV meters (costing from $500 to $1500) may not be adequately sensitive to UV light; they may indicate that levels are safe when in reality they are not. Newer more expensive ($3000 to $5000) meters are designed to measure UV levels more accurately.

CONTROLLING ULTRAVIOLET LIGHT

UV light can be filtered by passing the light through a material that is transparent to visible light but opaque to ultraviolet. The ideal filter would prevent all wavelengths of UV below 400 nm from passing through, but this is difficult to achieve. There are many products available that do the job adequately. In setting priorities, it is usually important to deal with natural light first, and then fluorescent light.

Ultraviolet-filtering plastic is available to cover windows and skylights. It must cover the surface completely so that all light passes through it. This plastic is available either in self-supporting sheets of acrylic or in thin film (usually acetate) that is cut to shape with a knife or scissors and adhered to the glass. The acrylic panels can be used in place of window glass (if fire regulations allow), mounted as secondary glazing on existing windows, or hung inside the window from hooks (the panel must be cut larger than the window glass, so that all light passes through it). Tinted panels are also available, to reduce overall light.

Varnishes

Varnishes that absorb ultraviolet light are also available. A supplier applies these coatings on window glass with a special tool. Currently, varnish is not recommended; it is very difficult to apply uniformly, and it deteriorates over time. Plastic is more convenient, lasts longer, and does the job better.

UV filters are normally needed on fluorescent lamps. Filters are available in the form of soft, thin plastic sleeves and hard plastic tubes. The tubes are generally several times more expensive, and do not provide any more protection than thin sleeves. If hard tubes do not fit the lamp exactly, unfiltered light can slip by at uncovered ends. The thin plastic sleeves should also be properly sized for the lamp. If necessary, two sleeves can be overlapped to extend the length of a single sleeve. Whatever type of filter is used, maintenance staff must be trained to transfer the filter when they change lamps.

UV Sleeves

If the fluorescent lights are housed in recesses that are completely covered by a plastic shield, however, UV light levels should be tested before an institution spends money on UV-filtering sleeves. Experience has shown that these plastic shields often provide UV filtering, reducing UV levels to 10-20 μW/l. Some fluorescent lamps produce significantly less UV than others. To insure maximum protection, one suggestion is to use lamps that produce relatively low UV in combination with UV filters. This will further reduce UV levels, reduce damage caused by improper installation or failure to replace filters, and extend the lives of the filters themselves. Some manufacturers now make fluorescent lamps with UV-filtering glass, but these can be much more expensive than standard lamps. Replacements must be kept on hand, and care must be taken not to replace a custom UV-filtering lamp with an ordinary one.

Titanium Dioxide

Another option available for protecting against UV light is the use of white paint containing titanium dioxide. While this method is not as effective, it will cut down on UV light significantly. Titanium dioxide paint absorbs ultraviolet light, and can be painted directly on windows or skylights, if they do not provide the only source of light.

HOW LONG UV DO FILTERS LAST?

At this time there is no definitive data to indicate how long UV filtering products retain their effectiveness. In a CCI Note published in 1984, the Canadian Conservation Institute reported that both soft plastic filtering sleeves and hard plastic filtering tubes retain their UV-absorbing properties for at least 10 years. UV-filtering window films may also have limited life-spans; some manufacturers quote a life of 5-15 years for these films. In climates with intense sunlight these filters may not last as long.

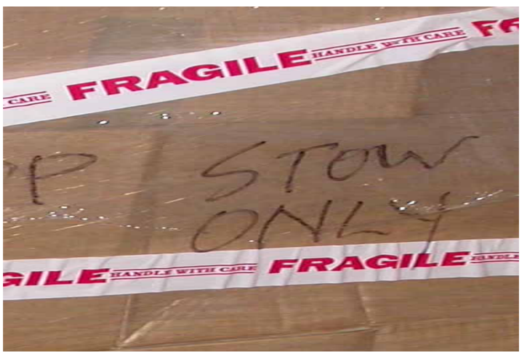
The only conclusive way to determine the continued effectiveness of UV-filtering products is to measure the UV levels emitted using a UV monitor (see cautions on UV monitor accuracy given above). Since these monitors are expensive, smaller institutions should make arrangements to borrow one every few years from a nearby large museum or other institution.

Controlling Visible Light

It would be ideal to keep collections sheltered from all light, but this is clearly impractical. Even collections stored away from light must sometimes be used. Often, in fact, storage and research areas cannot be separated. Materials must be exhibited, particularly in a museum setting. A balance must be maintained between the desire to protect materials and the need to make them accessible. Any reduction of visible light reduces long-term damage. Storage areas that are not routinely occupied by staff or researchers should be kept dark; they should be windowless, or the windows should be blocked. Lights should be turned off in such areas except when needed. This can be done with timers, but at the very least staff should be trained to turn off the lights when the space is unoccupied. Occupancy sensors can also be installed that turn off lights when no movement is sensed in the area. Lighting should be incandescent (tungsten) rather than fluorescent wherever possible.

Keep the light from reaching the object. Boxes from archival suppliers made by professional box-makers to fit the exact dimensions of individual objects are useful. While boxes will prevent damage from direct light exposure, it is uncertain whether they will protect objects from the fluctuations in temperature and humidity that may be caused by solar heating.

All windows in exhibit areas should be covered with drapes, shades, or blinds, in addition to being filtered for UV. Skylights should be covered to block the sun. Light levels should be low, and materials should never be exposed to direct sunlight. Never display objects permanently unless they are expendable.



Fragile Material

Exceptionally fragile and vulnerable objects should not be displayed fore long periods of time, and research use should be limited. If materials must be exhibited, great care must be taken to minimize damage such as:

1. Books that are opened for display should have the pages turned weekly so that one page is not constantly exposed.
2. Photographic and photocopy facsimiles of objects should be used whenever possible for display and research.
3. Spotlights should never be trained directly on an object. Indirect and low lighting will spare the object, and it will also require less adjustment of the eye from areas of intense light to those of relative darkness, allowing the use of lamps with a lower wattage throughout exhibit spaces.
4. A gradual diminution of light levels through a series of rooms may accustom viewers' eyes to lower exhibition light levels. Strategic placement of labels explaining the reason for low light levels can be used to educate patrons.

In Conclusion

All light contributes to the deterioration of collections by providing energy to fuel destructive chemical reactions within the paper. Institutions should follow the guidelines given above for measurement of light levels and control of light exposure.

All sources of ultraviolet light illuminating collections should be filtered, and the exposure of collections to visible light should be strictly controlled.

Technical information courtesy NEDCC

(North East Document Centre of Conservation)

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2. CDST News

July 20th 2009

From the Canterbury Disaster Salvage Team

How Safe is Your Hard Copy?

July 2009

The workshop will focus on printers, photocopiers and types of digital media that are archivally sound. We hope to have a varied selection of experts talking on subjects including the best equipment and materials to use to safeguard your collections.

For further information contact Lynn Campbell on 03 9804972 or lynn.campbell@ccc.govt.nz

VENUE: CHRISTCHURCH ART GALLERY TE PUNA O WAIWHETU

Maximum participants 30