Canadian Conservation Institute
Institut canadien de conservation

CCI Notes 13/1

Textiles and the Environment

Introduction

Textiles are among the most sensitive objects in museum collections due to their organic nature. Their long-term preservation is affected by numerous agents of deterioration, including light, pests, physical forces, pollutants, incorrect relative humidity (RH), and incorrect temperature. Further information can be found in the *CCI Preservation Framework Online* (www.cci-icc.gc.ca/tools/framework/index_e.aspx).

Light

Light is essential to see and appreciate textiles, but it is one of the most damaging agents of deterioration. Light, or electromagnetic radiation, is a form of energy. Visible radiation occurs from the violet portion through to the red portion of the electromagnetic spectrum. Wavelengths beyond the violet end of the visible spectrum, i.e. ultraviolet (UV), are shorter, occur at greater frequency, and are more damaging to textiles than wavelengths beyond the red end, i.e. infrared (IR), which are longer and of low frequency. UV and visible radiation have the potential to cause photochemical damage, whereas IR radiation produces radiant heat. Damage to textiles depends on the intensity of the light, the proportion of UV radiation, and the length of exposure. The UV radiation in daylight, sunlight, and some artificial sources is a major cause of yellowing and weakening of fibres, fading, and change in colour of many natural dyes and early synthetic dyes.

Mitigating the damaging effects of light

Light damage is cumulative and irreversible. It is the total light exposure that is important. **Total exposure equals illuminance (lux) x length of exposure (hours)**. The illuminance or light intensity is measured in lux (luminous flux per square metre). The object will incur the same amount of damage from an intense light for a brief period of time as from a weak light for a lengthy period. For example, exposure at 100 lux for 400 hours will result in the same damage as exposure at 50 lux for 800 hours. Thus, light damage can be reduced by half by reducing light levels by half (i.e. from 100 lux to 50 lux) or by decreasing the duration of light exposure by half.

Ideally, textiles should not be exposed to any UV radiation from daylight or from unfiltered, UV-emitting lamps. If it is not possible to block or eliminate the UV component, levels should not exceed 75 μW/lm. Textiles should be exhibited under the lowest light intensity that allows for their aesthetic appreciation. The traditional 50 lux benchmark is adequate for viewing details on light-coloured objects, if very high light levels are not adjacent, and if viewers are able to adjust to ambient light. Depending on the sensitivity of colorants used on textiles, a higher lux level, used with caution for brief periods, would enable viewers with less visibility to better distinguish fine or low-contrast details, or dark-coloured objects (Michalski 1997). Raising the levels only when required and then reducing them will minimize cumulative light damage.

The vulnerability of textile colorants to light varies. To minimize the damaging effects of light on textiles, avoid extremes of light exposure. Eliminate natural light from windows in display and storage areas by covering the windows. Note that the clear, UV-absorbing films available for windowpanes can reduce the amount of UV radiation **without** reducing visible light. It is important to verify the performance of UV filters and films for lamps and windows before installation, and periodically thereafter.

Turn off lights in display areas during non-visiting hours, rotate textiles, and leave them on display for limited time periods, i.e. a 3-month maximum. Use visitor-activated light switches. To better control the intensity of light, use lower-wattage bulbs, place dimmers on light switches, and increase the distance between the light source and the textile. Keep a record of the time the textile is on display, the lux level, and the environmental conditions as these will assist in determining annual exposure levels.

Lights should be kept off in storage areas, but low light levels are acceptable when accessing the area for brief periods. Storing textiles in closed cabinets or drawers protects them further.

There is currently a confusing array of lamps available on the market. Each type has characteristics that may or may not be suitable for museum display. Lighting for displays is complex and choices should be considered carefully.

Types of light sources

Incandescent lighting provides many options for museum and gallery exhibits. Ceiling track lighting systems using incandescent floodlights can be fitted with dimmers or filters (see CCI Notes 2/3 *Track Lighting* for further information). Using lower-wattage lamps reduces illumination levels, but maintains the "whiteness" of the light. Dimming increases the "yellowness" of the light. Spotlights can be dimmed, filtered down, or replaced with floodlights to provide a more diffuse illumination. However, both produce the same quantity of light. Incandescent lamps have a low UV output, but emit radiant heat (IR). Thus, they should never be used inside display cases, should be used with a UV filter if lighting sensitive objects, and must be placed far enough from textiles that the heat does not cause damage.

Halogen lamps are a type of incandescent lamp. However, they emit more light than other incandescent lamps, and have a much higher UV output. The quartz envelope does not filter UV radiation effectively, so it is important to monitor the UV component of these lamps. Ensure also that they are fitted with UV-filtering, heat-resistant glass lenses when planning to light highly sensitive objects such as dyed textiles. Because quartz halogen lamps have a high heat output, they should not be used inside display cases. These lamps are often used as the light source in fibre-optic applications. All incandescent lamps consume more energy than fluorescents.

Fluorescent lamps can be used for ambient lighting in display areas, but should be filtered because of the UV radiation they emit (see CCI Notes 2/1 *Ultraviolet Filters for Fluorescent Lamps* for further information on filtering UV radiation). Dimmers compatible with fluorescent lamps can also be used to better control light intensity. Lamps should be chosen with a Colour Rendering Index (CRI) of 80–100 (the CRI scale does not go higher than 100). In exhibits where lamps with a high CRI are used, viewers are better able to see colours correctly. Before purchasing fluorescent lamps, also take note of the Correlated Colour Temperature (CCT) assigned to particular bulbs. For comparison, daylight has a colour temperature of 6500 degrees Kelvin (K). Indoors, at low light levels, a "warm" light with a slightly yellow cast is often chosen, corresponding to a colour temperature of 2700–3000K. For brightly lit areas, a "cool" light with a slightly blue cast corresponding to a colour temperature of 5000K or higher can be used.

Compact fluorescent lamps may also be useful at short distances. As with traditional fluorescent lamps, these emit UV radiation and should be fitted with a UV-filtering sleeve or cover. Compact fluorescent lamps are available in several colour temperatures, and, with a CRI of 80–100, are useful for lighting objects.

High Intensity Discharge (HID) lights have a high light output, a low CRI, and variable colour performance, so they may not be appropriate for museum exhibits. However, the metal halide types are commonly used in fibre-optic applications. Another issue with HID lamps is that they emit heat. To get around this problem, the light source is typically kept in another area to dissipate the heat and, stemming from this, individually directed fibre-optic lamps are then used for lighting objects. Fibre-optic lighting systems for museum exhibits are advantageous in that very little UV reaches the objects and the IR component is eliminated.

Light Emitting Diode (LED) lamps vary greatly in terms of lamp housing, cost, reliability, lifetime, and CRI. Typically, the UV output of LED lamps is low; thus, using UV filters is unnecessary. LED lamps are considered cold light sources and, as such, could be useful for lighting objects at short distances.

Pests

Pests are living organisms such as insects, rodents, and mould, which are able to damage materials.

Textile and costume collections are often housed in undisturbed, dark environments, which can provide an ideal habitat for insects. Larvae of the clothes moth and the carpet beetle are particularly damaging because they perforate and consume keratinous protein fibre such as wool. They will attack silk, cotton, and synthetics if soils are present or if these fabrics block the way to a food source. Signs of the presence of insects include the actual larvae, their webs and casings (often containing fecal pellets, which may be the same colour as the textile), eggs, and adult insects. Silverfish may damage fabrics en route to a source of food such as the starch sizing on some cottons. Rodents and other animals will gnaw, shred, and soil textiles.

Strategies for dealing with pests in the museum include preventive measures such as good housekeeping and building maintenance. Avoid using, storing, or leaving beverages or foodstuffs in display and collection storage rooms. All new acquisitions and loans should be quarantined, examined, and monitored before being introduced into the collection. This allows staff to detect mould and insects.

Dealing with mould and insect infestations promptly will help prevent their spread. Implement an Integrated Pest Management (IPM) system. Further information on controlling infestations can be found in CCI Notes 3/1 *Preventing Infestations: Control Strategies and Detection Methods*; CCI Notes 3/2 *Detecting Infestations: Facility Inspection Procedure and Checklist*; CCI Notes 3/3 *Controlling Insect Pests with Low Temperature*; Pinniger 2001; and Pinniger and Winsor 1998.

Microorganisms that damage textiles include mould and bacteria. Mould often appears as a white-coloured velvety growth and is sometimes accompanied by a musty odour. Both cellulosic and proteinaceous textiles are at risk. Soils, stains, or fabric finishes, such as starch, are attractive as sustenance for microorganisms. The growth of microorganisms causes coloured staining that is often impossible to remove and weakens textile fibres, sometimes to the point of disintegration.

A controlled environment will help prevent mould from developing. For methods of dealing with mould, consult the following CCI publications: Technical Bulletin No. 26 *Mould Prevention and Collection Recovery: Guidelines for Heritage Collections*; CCI Notes 13/15 *Mould Growth on Textiles*; and Technical Bulletin No. 12 *Controlling Museum Fungal Problems*.

Physical Forces

Tears, losses, splits, and wear can result from previous use, internal stresses inherent in the object, and handling. Sharp creases along fold lines have the potential to become splits because the fibres in these areas are under considerable stress.

Some damage to textiles can be prevented. Historic textiles often appear deceptively strong and resistant, but they are vulnerable not only from their history — age, fragility, or composition, including combinations of heavy with lightweight materials — but also because they are familiar objects. Handling increases the potential for damage to costumes and textiles. Limit handling textiles and, whenever possible, handle the support or mount rather than the object itself (see Robinson and Pardoe 2000 for more detailed information).

Textiles and costumes on display or in storage without adequate support may become distorted by gravity. Custom mannequins for displaying costumes, or padded mounts for storing costumes, help prevent damage from physical forces (see Barclay et al. 2002 and Brunn and White 2002 for further information). Ensure that mannequins are stable by providing an adequate base or one that can be secured to the display surface. Oversized textiles, such as tapestries, may require custom supports for display and storage, and two or more people to transport or install them.

In transit and shipping, physical forces such as vibration, impact, pressure, abrasion, or shocks can result in damage. Ensure that textiles are cushioned and secured to their mounts, and provide proper packaging (see Robinson and Pardoe 2000).

Pollutants

Gases resulting from industrial, vehicle, and other emissions cause degradative chemical reactions, which affect fibre properties. Some products within the museum such as wood, coatings, acidic tissue paper, and other historic objects can emit harmful gases (see Tétreault 2003). Acidity of fibres can also result from the deterioration of the fibre itself and from manufacturing and finishing processes.

Solid particles, such as dust from clothing and soil from the immediate environment, are harmful because they can become trapped in the spaces within and between threads, and on irregular fibre surfaces. Sharp, gritty particles of silica, commonly found in dust, can cut through fibres when handled during storage, display, or transit. At higher temperatures and RH, fine dust will cement itself to fibres within a short period and become very difficult to remove. Some particulates absorb pollutants from the environment, which may lead to a harmful chemical reaction to the fibre or the dye under high humidity. Some soils are food sources for mould, insects, and other damaging biological activity. Oils deposited from improper handling, water and food stains, and soils from use can oxidize and become set over time, causing disfigurement, weakening, and breakage.

Keep windows and doors closed to minimize problems due to atmospheric pollutants. Any openings to the exterior should be properly sealed. Atmospheric pollutants within the museum can be controlled to some extent by using recommended products, e.g. stable paints on walls and carpeting that does not emit harmful gases, and by instituting a non-smoking policy. Chemicals such as paints and cleaning agents should be stored in a space away from collection storage or display.

Good housekeeping cannot be overstressed in preventive conservation. Every museum should practice a routine of thorough, methodical inspection and meticulous cleaning. The cleaner the storage and display area, the less chance there is of mould, insects, chemical damage, and abrasion occurring. Mounts used to support artifacts in storage and on display should be constructed from stable materials. Objects can be protected from light and dust by covering them temporarily when they are not being used.

Incorrect Relative Humidity and Incorrect Temperature

Relative humidity (RH) and temperature become important agents of deterioration in preventive conservation when they are incorrect. Extremes in RH, as well as large fluctuations in RH within short periods, can damage textile collections. Fluctuations in RH occur seasonally, daily, and within buildings when air vents, radiators, and heating ducts are in use. In response to these fluctuations in the environment, fibres will swell or shrink as they absorb or release water vapour. Aged, embrittled fibres may be incapable of withstanding such movement, resulting in damage such as splits in the fabric. How the object is made, and whether some components are free to expand and contract with changes in RH, complicates matters further.

During winter months, the heat produced by heating systems can dry the air, resulting in low RH levels. In low RH conditions (below 20%), textiles desiccate, becoming more brittle and fragile to handle. Another extreme to avoid is damp (75% RH and higher). It accelerates some deterioration reactions in organic materials, in addition to providing an ideal environment for mould.

For textiles, it is important that the RH level remain as constant as possible in storage, display, and transit, providing that it is a correct setpoint for the collection. Because of the extremes of the Canadian climate, this can be very difficult. If a change in RH is unavoidable, do this as gradually as possible. Keeping higher RH levels in winter may cause problems with the structure of a heated building. One should, however, attempt to maintain the RH at a setpoint within the range of 40–60% RH or the annual average for the collection. Seasonal and short-term variations of ±10% RH can be tolerated with only a small risk to most textiles. Because textiles are usually only one of several types of materials in a collection, often the challenge is to find the RH that will cause the least damage to the entire collection over time. There may be no one correct value.

In the absence of the full environmental control provided by a purpose-designed building, it is possible to achieve some measure of protection using portable humidifiers/dehumidifiers and fans; however, this requires in-depth knowledge of seasonal levels and variations within each room in a building, as well as meticulous attention to equipment maintenance and continuous monitoring of conditions. Measures such as keeping doors and windows closed and avoiding display or storage near air vents, radiators, or the perimeter walls of a building will provide some protection against RH fluctuations. National and international consensus has favoured a constant RH of 50% for the sake of uniformity between lending institutions. Remember that a change in temperature will cause the RH to fluctuate. In winter months, in order to moderate the drying effect associated with indoor heating, the temperature can be lowered to maintain RH within acceptable norms.

As with the other agents, examining temperature in isolation is too simplistic. It has now been demonstrated that a combination of factors such as exposure to pollution, incorrect temperature, and incorrect RH render unstable or acidic textiles more prone to degradation. And, as is the case for RH, it may not be possible to determine a single temperature at which the collection will be at zero or minimum risk, but one can approach the issue by looking at environmental trends over a period of time in various parts of the building. This said, textile collections are at less risk if kept at a temperature between 15 and 25°C, allowing 5°C up or down for seasonal changes. Seasonal changes should be made gradually. Textiles benefit from cooler temperatures in storage. Textiles displayed too close to a source of heat (lamps, direct sunlight, radiators, and vents) will desiccate and weaken. Some chemically unstable objects can become more vulnerable to deterioration; thus, extreme caution must be taken when handling them. Temperatures that are too low can cause physical damage as fibres become stiff and brittle. Fluctuations can also be problematic for textile collections.

This Note presents ideals towards which an institution can strive, with some guidelines for improving the environmental conditions of storage and display areas containing textiles. Even small efforts to control the most damaging agents of deterioration to textiles, notably light, pests, physical forces, pollutants, incorrect RH, and incorrect temperature, will have positive long-term effects on a collection.

Monitoring Equipment

The only way to be certain of the environmental conditions in a display or storage area is to measure them using instruments. Equipment for monitoring light, temperature, and humidity can be borrowed from the Canadian Conservation Institute (see CCI Notes 2/4 *Environmental Monitoring Kit*). A hygrothermograph or datalogger is recommended for continuous recording of RH and temperature fluctuations throughout seasonal cycles.

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Acknowledgements

Special thanks to Sandy Buchanan (Buchanan Lighting, Ottawa, ON) and Christine Fagan (Lighting Technician, National Gallery of Canada, Ottawa, ON) for reviewing the sections on light.

by the staff of the CCI Textile Lab

Originally published 1986
Revised 1992, 2008

Copies are also available in French.
Texte également publié en version française.

Cat. No. NM-95-57/13-1-2008E
ISSN 0714-6221