Section 7

LIGHTING CONSIDERATIONS

Architecture is concerned with the enclosure of space, including the elements of structure, form, color, brightness, contrast, focal areas, and spatial relationships; all of which require light. Thus lighting ***must*** be a basic, inseparable factor in the architectural analysis and overall design of the Library building. Through the use of both natural and artificial light, the architect, interior designer, electrical engineer, and lighting designer create visual moods, affect behavior, modify form, provide orientation within the library buildiing, dramatize particular building features, and provide adequate illumination for the specific needs of each library task.

For several years the lighting of libraries was planned by electrical engineers and building designers who generally used a quantitative approach. Major emphasis was given to the use of large or general area quantities of illumination, with too little consideration given to visual comfort, color rendition capabilities of the light source, aesthetics, or energy conservation of the system. Typical layouts consisted of fluorescent luminaries evenly spaced across the ceiling providing equal illumination for the majority of task positions.

Lighting for library buildings should emphasize the qualitative approach in terms of the ***quality*** of light being provided. It should offer a pleasing visual atmosphere, and operate with energy efficiency, taking into account the increased use of computer monitors for public and staff use, as well as microform reader/printers, resulting in a system that allows utilization of this equipment without accompanying eyestrain. By placing light at the point of the task where it is needed, a lesser quantity of light is required, saving energy. By allowing the user to direct the light to the task, visual comfort is enhanced.

LIGHTING SPECIFICATIONS AND THE PROTECTION OF COLLECTIONS

Light degrades paper, bookbinding materials, and other library media, reducing their service lives. Ultraviolet (UV), infrared, and visible light all cause degradation of outer surfaces. Therefore, each source of light damage needs to be addressed and controlled. Damage is directly proportional to exposure (i.e., intensity x time). The greater the exposure, the greater the damage. To the extent possible, library customers and staff should be located in areas with natural light and the collections of library materials should be housed in areas with artificial light. This will facilitate better control of light exposure to the collections.

Visible light levels recommended for preservation storage and display usually are much below the 30 – 50 foot candles recommended for task lighting for reading. Natural light, of course, almost always exceeds the recommended light levels of task lighting. Since

less light is better, light levels for the bookstacks housing the collections should be set to the minimum acceptable to enable book titles and call numbers to be read without great difficulty. Lighting types and configurations that can reduce the maximum light levels will result in reduced deterioration of the collections.

Natural and fluorescent light contains ultraviolet (UV) rays. UV rays are damaging to library materials. Collections of a non-special nature housed in areas of the building with natural light should have the bookstack ranges of shelving set perpendicular to and away from windows whenever possible to avoid direct sunlight on the spines/covers of books.

The collections storage areas should be positioned so that there is ***no natural lighting*** that shines directly onto the collections. Artificial lighting should be equipped with staff-operated local switches or motion detection so that the lights can be activated as needed. This is most desirable to the artificial lights remaining on continuously, or for extended periods, when lighting is not needed for the staff or the customers.

Fluorescent lighting should be equipped with UV shields to eliminate much of the UV light. Windows should be tinted with a UV filtering layer. These steps will substantially reduce operational expenses for rebinding and repair of otherwise exposed collection materials. Limiting the intensity of UV light as a portion of total light exposure to a maximum of 75 microwatts/lumen is recommended.

Infrared radiation damage is most noticeable when light sources are close enough to the collections to heat them. This results in local damage. This situation can be witnessed in older, over-crowded bookstacks with collections housed on the shelves near the incandescent bookstack lighting. A more common situation in newer libraries occurs in display areas that use hot, high intensity lighting. The lighting can heat up objects even if the lighting is placed some distance from the objects. When lighting is mounted in display or other cases it will raise the temperature of the case environment.

Most collections of materials receive more exposure to light when on display than at any other time during their service lives. Display lighting that is left on during all open hours cumulates very high levels of exposure and light damage. In an effort to limit damage, the visible light levels most often recommended for display of paper-based materials are 5 - 15 foot candles. This is a level often lower than surrounding ambient lighting. This level is often too low to attract visitors to the exhibit. Exhibits should be housed in a separate space with low levels of ambient lighting.[1]

LIGHTING SOURCES

Natural Light – Natural light can provide important psychological benefit to Library

[1] An alternative is to raise exhibit lighting levels at least to ambient lighting levels, making sure the lights are turned off when they not needed, and limiting the length of time that materials are on display.

customers as well as supplement lighting needs during daytime hours, providing that glare control, human factors, and integration of building systems are properly addressed. Daylight apertures typically serve two distinct purposes:

- Allowing views to the exterior; and
- Providing functional ambient light for the interior.

These two seemingly linked design considerations, however, may potentially conflict. For example, view windows typically occur low in the wall at eye height, while functional daylight apertures distribute light most evenly when they are placed up high. It is important to evaluate the building's daylighting potential early in the design process, keeping in mind that glare from both direct sunlight and diffuse skylights should be controlled to the same degree as from luminaries.

Artificial Light Sources - The four main types of artificial light sources used in library interiors today are:

- Incandescent/Halogen;
- Fluorescent/Compact fluorescent;
- Ceramic Metal Halide/(Standard) Metal Halide; and
- LED.

Each has qualities that match the specific requirements of a particular area or situation. Therefore no single type of system can be recommended exclusively. The primary consideration in selecting a particular lighting system is to provide light for the Library customer to complete a specific visual task without distraction, such as minimizing the glare and brightness of lighting fixtures. In addition, the lighting system should complement the architectural and interior design of the Library while also being highly energy efficient.

These four sources vary in terms of:

- Maintenance and replacement;
- Types of lamps and ballasts required;
- Rated life of various bulbs;
- Heat and glare factors;
- Color of the light produced;
- Effect on the eyes; and
- Required warm-up time.

The primary features of each source are compared in the Lamp Characteristics Table 5 followed by a detailed analysis of each source's advantages and disadvantages.

Table 5
Lamp Characteristics

Source	*Life*	*CCT* [1]	*CRI* [2]
Incandescent	750 hrs – 2,500 hrs	2700°K	97 - 100
Halogen	3,000 hrs – 5,000 hrs	3000°K	100
Fluorescent	20,000 hrs – 24,000 hrs	3000°K - 6500°K	78 - 86
Compact Fluorescent	10,000 hrs – 12,000 hrs	2700°K - 4100°K	82
Ceramic Metal Halide	6,000 hrs – 15,000 hrs	3000°K - 4200°K	80 - 96
Metal Halide	15,000 hrs – 20,000 hrs	3000°K - 4300°K	65 - 70
LED	20,000 hrs – 25,000 hrs	2500°K - 2700°K	70 - 80

Notes:
1. CCT (Correlated Color Temperature) is a measure of the visual "warmth" or "coolness" of the light from a lamp. The higher the value (in degrees Kelvin), the whiter or "cooler" the light appears.
2. CRI (Color Rendering Index) is an indication of the ability of the lamp to render object colors in a normal, natural way. The higher the number (on a scale of 0 to 100), the better the color appearance.

Incandescent/Halogen Lighting - Incandescent lamps are inexpensive, easy to install, and do not require ballasts. They are relatively easy to control through the use of ready-manufactured dimmer systems. A wide variety of incandescent lighting fixtures and lamp types are available for special uses. Incandescent lighting has good color rendition and is particularly effective for tasks requiring exceptional optical control, such as displays, accent lighting, and art exhibits.

Traditional incandescent lights have a filament, or one "point" from which the light is produced, as opposed to the linear light of fluorescent tubes. Traditional incandescent lamps are inefficient to operate and therefore relatively expensive to maintain, given their short life. The rated life of many incandescent lamps is less than 2,000 hours. Incandescent lamps also produce considerable heat, which can adversely affect the operation of air conditioning systems. The traditional incandescent light blub is now considered non-compliant pending legal challenges.

Low-voltage halogen lighting systems compensate for the shortcomings of the traditional incandescent light, with longer lamp life and more energy efficiency, while maintaining good color rendition. Halogen lamps are easily dimmable as well. Low-voltage halogen lighting systems are recommended for highlighting special areas such as exhibits, art work, new book displays, etc. Track lighting for such areas could provide flexibility for highlighting changing displays. Consider MR-16 halogen lamps for these types of applications.

Fluorescent/Compact Fluorescent Lighting - Given its energy efficiency, long life, and the variety of luminary designs providing numerous forms of diffused light, ranging from direct to indirect as needed, fluorescent lighting is recommended as the best general lighting system. Historically, the most commonly used light source in libraries, fluorescent lamps produce about three to four times the light per watt, and can last six

to ten times longer than incandescent lamps. In contrast to the point-of-source bulbs, a fluorescent lamp emanates light along the entire length of its tube and diffuses light more effectively. Rapid gains have been made in fluorescent technology over the past few years. The introduction of compact PL fluorescent lamps has virtually replaced the use of standard incandescent lamps in commercial buildings. Thinner, one-inch diameter fluorescent (T8) tubes are now prominent in the marketplace, producing more light with less energy consumption than their one and one-half inch (T12) predecessors, which are nearly obsolete. The new 5/8-inch diameter (T5) tubes are also becoming readily available. However, the T5 tubes are unlikely to completely replace the T8's, due to their inherent source brightness. In recent comparison studies, they have proven to be slightly less efficient than their T8 counterpart when the whole "system wattage" is considered (i.e. lamp plus ballast). The new T8 lamp/ballast combinations now in the market reduce overall input wattage without sacrificing initial lumens.

Like incandescent lamps, fluorescent lighting can be controlled via ready-manufactured dimmer systems. The color rendition of fluorescent lamps has improved dramatically over recent years with the utilization of tri-phosphors, resulting in the development of higher CRI lamps. Fluorescent lamps should be T8, tri-phosphor energy saving type, within the color temperature range of 3000°K to 4100°K (3500°K preferred). Regardless of the color temperature chosen, a mock-up of the selected lamps, along with the library's interior finishes and adjacent light sources used should be done in order to ensure color compatibility. Fluorescent ballasts should be electronic, high power factor, energy saving type with less than 10 percent THD (total harmonic distortion), to prevent interference with the book detection system.

Metal Halide Lighting – The only HID (high intensity discharge) source that should be considered for use in library interiors is metal halide, primarily because of its (comparatively) superior color rendition. Color can vary from a bright yellow in the sodium-vapor HID's to a blue-violet in some mercury-vapor HID's. Metal halide lamps are typically higher in wattage, more energy efficient, and have longer life spans than either fluorescent or incandescent sources. Metal halide lighting is suggested particularly for use in high ceilings to provide both direct and indirect lighting. It should rarely be used in a library as a visible source, as it provides light from only one point rather than diffusing the light, as do fluorescents. Although metal halide lamps can be successfully utilized for general lighting of high ceiling areas, they should not be used for individual rooms, due to several limitations such as the intensity and required warm-up time. Metal halide lighting is energy efficient, and with the advent of effective high-temperature, color-corrected metal halide lamps, metal halide lamps are suitable for general interior use.

Limited dimming capability for metal halide lamps is available, but the controls require sophisticated systems, compared to the ready-manufactured systems available for incandescent and fluorescent lighting. Like other HID sources, metal halides are sensitive to variations in electrical current and may go off if the variation is too great. HID's require warm-up time before reaching full output after being turned off or knocked

off by a power variation. Some HID's require time to cool down before lighting up again, and this could pose a safety problem if no other lighting is available. Power surge controllers are recommended to minimize this problem. Metal halide ballasts should be electronic, high power factor, energy saving type.

LED Lighting -- Consideration should be given to LED lighting for possible use with displays, signage, and others elements of the building that might be highlighted by this type of lighting.

ILLUMINATION MEASUREMENTS

While the most commonly known measurement of illumination levels is the foot-candle (fc), it is only a two-dimensional unit and needs to be viewed in relation to other terms. The lumen is the fundamental unit for measuring light energy. In physical terms, a lumen is defined as the amount of energy radiating from one square foot of surface area of an imaginary sphere, two feet in diameter, surrounding the light source. In essence, the lumen measures light at the source.

A foot-candle is a measurement of luminous energy at a surface upon which it falls and is defined as one lumen of light energy incident upon one square foot of surface area. Hence, a foot-candle measures the density of light. Light is a radiant form of energy; the further it travels, the more area it covers and the less density it has. The foot-candle measures only ambient lighting levels on a surface and does not take into consideration factors such as glare, shadowing, contrasts, or other factors that affect task visibility or the ability to see. The recommended light levels (Table 6) are the accepted standard, to be used as a guideline along with input from library staff.

In designing the lighting the designer must calculate the quantity of illumination for each particular space and its various functions. Visibility, for example, which affects the ease of performing a visual task, is dependent upon contrast and background luminance. More specifically, the designer must take into consideration all factors in the immediate lighting environment that affect the ability to see task visibility, such as glare, reflection, absorption, shadowing, and contrast, and evaluate the quality as well as the quantity of illumination.

Table 6 on the following page is the recommended levels of illumination.

LIGHTING EFFICIENCY

The efficiency of a light source is determined by the quantity of light per unit of energy that it takes to produce that light. Lighting efficiency is measured in lumens per watt, or the number of lumens produced by one watt of electricity. Artificial light sources now on the market vary in efficiency from seven to over 180 lumens per watt. Incandescent light sources are the least efficient and metal halide the most efficient.

Table 6
Recommended Illumination Levels [2]

Area or Task	*Horizontal Illuminance*	*Vertical Illuminance*
Active bookstacks	30 fc	30 fc (at 30" above floor)
Inactive (closed) bookstacks	30 fc	5 fc (at 30" above floor)
Reader seating	30-50 fc	5–50 fc
Carrels and individual study desks[1]	30 fc	-
Community room[2]	5-50 fc	30 fc
Seminar/classrooms[2]	30-50 fc	5 fc–50 fc
Computer room	3-30 fc	3 fc
Word processing	3-30 fc	3 fc
Microform areas[3]	30 fc	-
Audiovisual areas	30 fc	-
Audio listening areas	30 fc	-
Local history and documents	50 fc	5 fc
Circulation Desk	30 fc	-
Admin/Offices	30-50 fc	5 fc
Cataloguing	30 fc	-
Card files (paper)	30 fc	5 fc
Conference rooms[2]	30 fc	5 fc
Staff room[4]	10 fc	3 fc
Corridors	5 fc	10 fc
Restrooms	5 fc	3 fc
Storage	5 fc	-

Notes:
1. Carrels w/shelves cause shadows and require task lighting. Consider under-shelf light, which would need to be detailed into the furniture piece.
2. Consider local dimming control system and/or switching similar types of fixtures together, in order to achieve multiple lighting levels and scenes.
3. Machines should have hoods and screens treated to reduce reflections. Consider a different lighting environment/technique for the Staff Room in order to provide a break from the work environment.
4. Individual rooms should be provided with three 15 amp and one 20 amp specification grade receptacles. Light switches should be specification grade, toggle type, rated 20 amperes, 120/277 volts. Wiring devices, in addition to those referenced above should be provided in all specialty areas and as otherwise required by library standards.

ELECTRICAL SYSTEM REQUIREMENTS

Fluorescent lighting should be on a one pole 15 ampere, 120 volt circuit, average of 1200 watts, maximum 1380 volt-amperes in accordance with National Electrical Code requirements, or a maximum of ten fixtures in accordance with Library requirements. Multi-level switching should be specified in accordance with Library staff requirements.

Lighting panel boards should be of the circuit breaker type. Panels shall consist of 70-ampere frame, 15-70 ampere trip, 10,000 A.I.C., bolt-on single pole circuit breakers.

[2] The recommended levels are based on the *IESNA Lighting Handbook*.

Where short circuit requirements dictate, 3-pole main fused switches with current limiting fuses should be provided. All panels should be provided with main molded case switches. Emergency lighting throughout the Library facility, to safely guide users and staff to exits during power failures, should be coordinated with the project's electrical engineer.

CONTROLS

Lighting in all reading areas, staff offices and workrooms, and gathering spaces should have their own on/off switches for lights in addition to centralized override switches located in the main administration area. If daylighting can be used to replace some of the electric lighting during substantial periods of the day, lighting in those areas should be dimmed or switched off via daylighting sensors.

CODES

Prior to designing the lighting system the designer should consult local authorities having jurisdiction regarding the various codes and standards this project must adhere to.

LIBRARY LIGHTING CHECKLIST

1. Is the Library located in an area where seismic bracing of light fixtures is required?
2. Is the configuration of bookstacks/furniture likely to change? If so, will the lighting design accommodate the level of adaptability that may be required?
3. Has the number of lamp types been minimized?
4. Has every effort been made to specify sources/fixtures in locations that can be easily maintained by the Library staff?

For additional information on related library lighting consult the sources in Table 7, found on the next page.

The design team and the library staff should have discussions regarding lighting control strategy (dimming, switching, control locations, etc.) early and often throughout the design period.

Table 7
Other Lighting Sources for Reference

Organization	*Website*	*Topic*
IESNA - Illumination Engineering Society of North America	www.iesna.org	Lighting
IALD - International Association of Lighting Designers	www.iald.org	Lighting
CIE - International Commission on Illumination, United States National Committee	www.cie-usnc.org	Lighting
CEC - California Energy Commission (Title 24)	www.energy.ca.gov/title24	Energy Codes
ASHRAE - American Society of Heating, Refrigeration a Conditioning Engineers, Inc.	www.ashrae.org	Energy Codes
LEED – Leadership in Energy & Environmental Design	www.usgbc.org/LEED/LEED_main.asp	Environment
IDA - International Dark-Sky Association	www.darksky.org	Environment
ALA - American Library Association	www.ala.org	Libraries
GE Lighting	www.gelighting.com	Lamps
Philips Lighting Company	www.lighting.philips.com/nam	Lamps
Osram **Sylvania**	www.sylvania.com	Lamps
Venture Lighting International	www.venturelighting.com	Lamps