

Quality of the Visual Environment

10

LIGHTING QUALITY

Patterns of light and dark affect both our perceptions of the world and our emotional and physiological responses, and thus they are essential in gathering information about the physical world. Good-quality lighting can support visual performance and interpersonal communication and improve our feelings of well-being (Figure 10-1). Poor-quality lighting can be uncomfortable and confusing and can inhibit visual performance. This chapter defines and discusses lighting quality.

The overall purpose of lighting is to serve the needs of people. The role of the lighting designer is to match and rank the needs of the people using the space with the economic and environmental considerations and the architectural objectives, and then to translate the results into a workable design and functional installation. The human needs served by lighting are identified in Figure 10-2.

Lighting for Human Needs

The needs of people are complex. Emotions, actions, perceptions, and health are influenced by lighting. Central to human needs is visibility, because it is the detection and organization of light patterns that allow a person to analyze and evaluate the environment. Once objects and patterns are visible, one can use a pencil to write a note, learn to pronounce new words by following the facial expressions of a teacher, walk down a corridor without bumping into a vacuum cleaner on the floor, appreciate a painting, or feel relaxed in a dimly lighted restaurant. Figure 10-2 illustrates that visibility is central to a larger number of human needs: task performance; mood and atmosphere; visual comfort; aesthetic judgment; health, safety, and well-being; and social communication.

Visibility. Visibility is the ability to extract information from the field of view, whether that information is the location of a curb or of a flower arrangement. It is a necessary condition for good-quality lighting. Lighting installations exist to enable sight. For many years this fact led to a heavy emphasis on visibility over all other goals for lighting design. As a result, research was focused in this direction, and we have a good understanding of visibility and its importance. Con-

trast, luminance, time, and size are the most powerful variables influencing the visibility of objects. Age modifies this relationship; for the older viewer, the task must be larger and brighter and its contrast higher in order to achieve visibility levels equivalent to those of younger viewers. In general, high illuminances can offset visibility losses for tasks of low contrast and small size.

Task Performance. Task performance is an essential human need. The task is the user's activity, whether measuring the size of a room, washing mud off hands, reading room numbers posted in a corridor to find a doctor's office, or seeing the details in the etchings displayed in a museum. Lighting must enable users to perform the "work" they came to do. Task performance and visual performance are not synonymous; in fact, several nonvisual factors contribute significantly to task performance. Training, motor skills, motivation, and many other human factors interact with visibility to affect the level of task performance. Visual performance, on the other hand, eliminates these factors from consideration in assessing the impact of visual stimuli, including lighting variables, on a behavioral response.^{1,2} Illuminance selection, discussed in its own section below, is largely based on visual performance, not task performance.

Mood and Atmosphere. Needs for mood and atmosphere encompass the emotional response to the luminous environment.³ Preference, satisfaction, relaxation, and stimulation are influenced by lighting. These mood states can indirectly influence other behaviors, such as task performance.⁴

Visual Comfort. Visual comfort is an essential human need that can affect task performance, health and safety, and mood and atmosphere. Office workers may find themselves more fatigued in a glaring lighting installation, but flashing lights in a discotheque can temporarily excite and please that same person.

Aesthetic Judgment. Aesthetic judgment needs differ from emotional responses. Humans appear to need to make sense of what they see, so the information must be either immediately available in a scene or implied. Lighting can communicate meaning, reinforce rhythmic patterns in the architecture, and enhance color, thereby creating a hierarchy of social significance in the visual field. Lighting can also hinder understanding by introducing patterns that conflict with

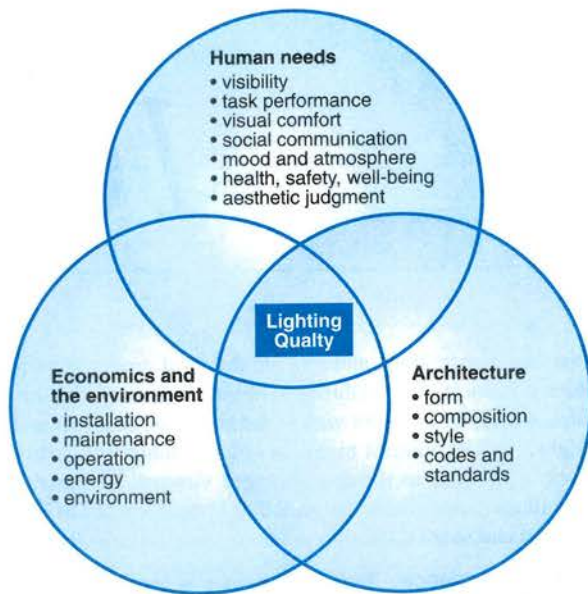


Figure 10-1. Lighting quality: the integration of human needs, architecture, and economics and the environment.

the underlying scene. One research model that attempts to quantify aesthetic judgments uses four dimensions of appraisal: coherence, legibility, mystery, and complexity.^{5,6} Another uses visual interest and visual lightness (room surface brightness).^{7,8,9} These studies conclude that preference for a scene increases when the lighting is nonuniform; however,

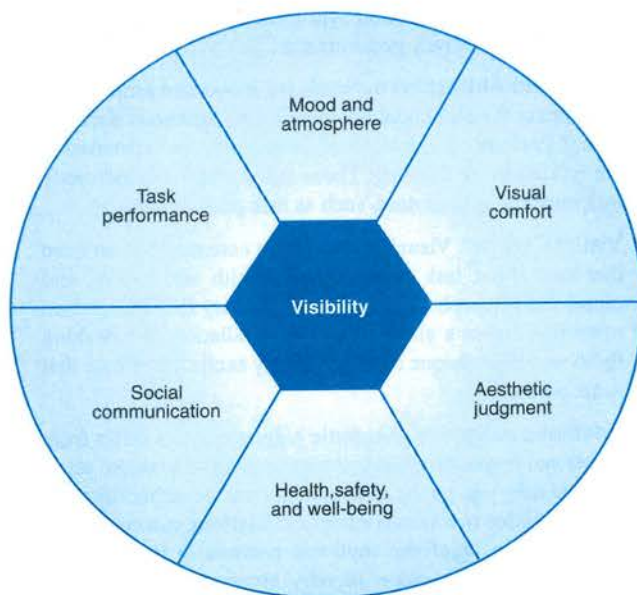


Figure 10-2. Human needs served by lighting.

high levels of one quality can reduce levels of another. For example, a scene that is complex may rank low in coherence.

Health, Safety, and Well-Being. Although they are needs of primary importance, health, safety, and well-being are often overlooked. As an example, flicker from some electric lighting can produce a stroboscopic effect with moving machinery, making the machine appear to move at a different rate. Electronic ballasts for fluorescent lamps reduce the perception of flicker, and it also appears that they reduce the incidence of headaches and eyestrain.¹⁰ Safety is an important need, but emergency lighting is only one aspect of it. Lighting also affects the visibility of curbs, stair edges, train platforms, roadway intersections, and labels of critical chemicals and pharmaceuticals.

Light also has a direct impact on wakefulness and the state of the circadian system (i.e., sleep-wake cycle) by suppression of melatonin in the brain. Recent evidence suggests that disruption of the circadian system may have long-term consequences for different types of cancer.¹¹ This is a new field of research and should be carefully monitored by the lighting designer.

The relative importance of these needs differs for each setting. In a factory, aesthetic judgments are likely to be less important than health and safety or task performance. In a restaurant, social and communication needs, aesthetic judgments, mood, and comfort are all important; however, visual tasks such as reading the menu also need to be considered. One of the challenges in lighting design is to determine which human needs are to be served. In some cases, needs conflict and require careful thought to establish priorities.

Social Communication. Social communication needs include the creation of luminous conditions conducive to such communications in a setting, especially by facial appearance. Much human communication occurs by nonverbal means, but these cues are missed if the lighting distracts from or masks the information. Facial recognition, for example, which is a critical element of security lighting, is influenced not only by the amount of light needed to detect a face, but also by the modeling of facial features created by the pattern of the light and shadow on the subject's face.

Balancing Human Needs with Architecture and Economics and the Environment

Architecture. Lighting occurs in an architectural context, whether interior or exterior. High-quality lighting is responsive to the architectural form, composition, and style.³ The integration with the architecture conveys meaning and contributes to the observer's understanding of the space.

Light that ignores architecture can violate human needs. For example, emergency lighting that is not coordinated with the building layout can slow down or prevent egress.¹²

Specifying luminaires that are too tall to fit in the plenum space could delay the completion of a construction project.

Economics and the Environment

Costs frequently influence and constrain lighting system choices. Purchasers tend to be very sensitive to first costs, but installation, operation, and maintenance costs can outweigh first costs in a complete economic analysis. Any lighting solution fails if maintenance or operating costs are higher than common practice.

In recent years, codes and standards have mandated lighting power density limits (e.g., ASHRAE/IESNA Standard 90.1).¹³ But reduced energy use should not be regarded merely as a compliance with regulation; this is a responsibility toward the ongoing environmental health of our planet and the well-being of future generations.

HOW TO USE THE IESNA LIGHTING DESIGN GUIDE

Previous editions of the *Illuminating Engineering Society of North America (IESNA) Lighting Handbook* have discussed important criteria for assessing and designing the visual environment, but a formal system for considering these criteria had never been developed by the IESNA. However, the IESNA has always recommended illuminances for specific applications or visual tasks. As a result, lighting specifiers often mistook the IESNA system of recommended illuminances as the primary or even sole criterion for lighting design. This edition of the *IESNA Lighting Handbook* introduces a new, formal system for considering a wide range of lighting design criteria. If followed, the recommended design criteria will increase the quality of the visual environment throughout North America. In engineering terms, the goal is to raise the "minimum standard of care" required of lighting designers.

This chapter, which includes the new IESNA Lighting Design Guide, focuses on criteria important for a high-quality visual environment. It should be emphasized, however, that a high-quality lighting design should also be energy-efficient, cost-effective, and require minimum maintenance. Future editions of the *IESNA Lighting Handbook* may include these other criteria. In the meantime, the lighting designer should employ information presented in this edition of the *IESNA Lighting Handbook* on energy efficiency, safety and security, and maintenance to establish the best possible lighting design for the client. The reader should also consult other IESNA publications such as the series of Recommended Practices for various lighting applications.

The IESNA Lighting Design Guide at the end of this chapter is divided into the following sections:

- I. Interior
- II. Industrial

- III. Outdoor
- IV. Sports and Recreation
- V. Transportation
- VI. Emergency, Safety, and Security

Within each section there are different headings, subheadings, and location or task listed alphabetically and presented in rows of the Design Guide. For example, in the "Interior" section, "Educational Facilities" is listed, and under this heading is a subheading called "classrooms," under which is a location called "science laboratories."

The columns in the Design Guide represent the criteria important for a high-quality visual environment, including both horizontal and vertical illuminance. There are 23 criteria defined in this chapter and discussed in other chapters of this edition of the *IESNA Lighting Handbook*.

One of four levels of "importance" is entered in the cells of the Design Guide: "very important," "important," "somewhat important," and "not important or not applicable." Each cell entry represents the relative importance of one criterion for a particular location or task. The IESNA Lighting Design Guide and the entries ranking the relative importance of the criteria for specific locations or tasks were developed through consensus by the IESNA.

A simple example of how to use the IESNA Lighting Design Guide may be helpful. Suppose a lighting designer is asked to design the lighting of an open-plan office. The designer should go to the "Interior" section in the Design Guide and look for "Offices." Within "Offices," the designer should look for the "open-plan offices" subheading. The lighting designer can learn from the Design Guide that, in offices with intensive use of visual display terminals (VDTs), in addition to vertical illuminance, factors such as source/task/eye geometry, reflected glare, direct glare, and luminances of room surfaces are "very important" and should be considered in the design.

The user of the IESNA Lighting Design Guide should read the section "Discussions of Design Issues" below for a better understanding of every design criterion. The user can consult the section "Illuminance Selection" below for a more detailed understanding of the recommended horizontal and vertical illuminances. The other chapters in this edition of the *IESNA Lighting Handbook* should also be consulted to learn more about the bases and the applications of the design criteria. Finally, the designer, with specific knowledge of the project and past experience, can deviate from any lighting design recommendations in the matrix. Factors that might lead to deviations from the recommendations include the following:

- Life, health, and safety issues
- Security
- Energy requirements
- Historical context
- Reduced visual function (e.g., macular degeneration)

- Melatonin suppression at night
- Mental dysfunction
- Unusual maintenance requirements
- Nonhuman requirements (e.g., for plants, animals, cameras)
- Material degradation
- Unusual client specifications

The lighting designer is strongly advised, however, to document and explain all deviations from the recommendations given in this edition of the *IESNA Lighting Handbook*.

In summary, the reader should follow these six steps:

1. Go to the Design Guide and find the location or task (row) under consideration.
2. Learn about the design criteria (columns) that are very important, important, and somewhat important for that location or task.
3. Go to the section "Discussions of Design Issues" of this chapter to understand every design criterion.
4. Go to other chapters for discussions of how to apply the relevant design criteria in the location or for the task under consideration and for a better understanding of issues that are not included in the Design Guide, such as energy efficiency, economics, and maintenance.
5. Consult the section "Illuminance Selection" in this chapter regarding the recommended horizontal and vertical illuminances. Use professional judgment to determine whether a change in these values is justified given the specific situation and the relative importance of the other design issues.
6. Document the lighting design process, especially any justifications for any changes to the recommendations provided in the *IESNA Lighting Handbook*.

DISCUSSIONS OF DESIGN ISSUES

The following are brief discussions of the design issues that appear in the *IESNA Lighting Design Guide*.

Appearance of Space and Luminaires. Appearance includes both the arrangement of elements such as furnishings and luminaires in a space and their relationship to one another. These elements can provide visual cues that assist occupant orientation. It is important that the style of the luminaires coordinate with and enhance the design and architecture of the space. Lighting systems can also help create an image for the space (e.g., "corporate," "casual," "luxurious," "industrial," or "avant garde").

Another important issue is "visual clutter," that is, confusing or distracting details in the visual field. For instance, lighting equipment can interfere with the view of a natural landscape or a carefully designed visual composition. The eye is drawn to areas of greater brightness. Bright areas

should be important to the composition, and preferably they impart some visual information (e.g., identify key paths for wayfinding, define boundaries, and delineate circulation patterns). Color patterns should also lead the eye to the areas of greatest importance.

Color Appearance (and Color Contrast). Color appearance can affect visibility and aesthetics. For example, fluorescent paint can enhance visibility of an object but clash with the aesthetic composition in the space. Factors that contribute to color appearance include the spectral power distribution of the light source, the color perception abilities of the observer, and the transmission and reflection properties of objects and surfaces in the room or area. Color contrast, the difference in perceived color between a task and its background, is often an important issue for industrial tasks and for safety signage or markings.

Generally, lamps with a color rendering index (CRI) greater than 80 should be used to ensure a pleasant appearance of skin tones, food, and merchandise. For most office, educational, health care, and institutional workplaces, a CRI of 70 or above is acceptable. A CRI of 50 provides adequate color rendering for most industrial tasks. If color matching, paint mixing, or color selection is involved, a lamp with a CRI of 90 or above should be used.

Daylighting Integration and Control. A view of the outdoors is believed to be important for psychological and physiological reasons by providing cues about the time of day and weather, and by providing distant objects on which to focus, thereby allowing people to relax the muscles of their eyes. Diffusing window glass should be avoided because it obscures views of the outdoors.

Daylight and sunlight can be used to help light a space, but care should be taken to control the quantity and distribution of the light and to control heat gain. Overhangs, light shelves, window blinds, and shades are all useful. It should be noted that more illumination is sometimes needed on interior surfaces near windows to reduce the brightness contrasts between those surfaces and the windows. For example, occupants' faces and other important surfaces can appear in dark silhouette against a window unless illuminated by electric lighting. Daylighting is most effective when used as ambient illumination, but it is too variable as a reliable source for task illuminance.

Automatic photoelectric controls as well as manual dimming and switching are effective energy-saving strategies to be used with daylight. Automatic controls are often unacceptable to occupants, however, so special consideration must be given to commissioning these systems to meet both energy-saving goals and occupant satisfaction (see also the section "System Control and Flexibility" below).

Transitioning from daylight conditions to interior or enclosed spaces requires time for eyes to adapt. Visual "transition zones" are effective design features that allow occupants time to adapt comfortably as they move between areas of high and low brightness.

Direct Glare. Glare can cause discomfort and interfere with visibility. Direct glare occurs when the light travels directly from the source to the eye. This may include “disability glare,” “discomfort glare,” and “overhead glare” (see also the section “Reflected Glare” below).

Luminaires, windows, and skylights can be uncomfortable to view, but there appears to be more tolerance of window brightness than of comparable luminaire brightness. Presumably this is due to viewers’ preference for the visual information attained from windows.

Glare criteria for luminaire luminances between 50° and 90° from luminaire nadir (i.e., 0° to 40° above horizontal) have been established. Light from other angles can also produce glare if luminances exceed 10,000 cd/m². As a rule, luminaire luminances should not be more than 100 times those of surrounding surfaces to minimize glare. This can be achieved with luminaires that illuminate the ceiling as well as the task and by increasing ceiling reflectance.

Flicker (and Strobe). Flicker is the rapid variation in light source intensity, usually most noticeable in peripheral vision. Individuals vary widely in flicker sensitivity. Lamp flicker may interact with the movement of industrial machinery or with moving balls in various sports to produce a stroboscopic effect, where the machinery or ball appears to move at a rate different from its actual movement. The flashing seen in lamp startup is not considered flicker.

In industrial applications, flicker can be mitigated by using a three-phase electric distribution system with circuiting adjacent luminaires on alternate phases. High-frequency (20 to 60 kHz) electronic ballasts effectively eliminate flicker.

Illuminance (Horizontal). Horizontal illuminance is the density of luminous flux falling onto a horizontal surface, measured in lux (lumens per square meter) or footcandles (lumens per square foot). Unless otherwise indicated, the plane on which the illuminance is specified and measured is assumed to be a horizontal plane 0.76 m (30 in.) above the floor for interior and industrial locations and tasks, 0.91 m (36 in.) above the ground for sports and recreational locations and tasks, and at grade for the outdoors.

Illuminance (Vertical). Vertical illuminance is the density of luminous flux falling onto a vertical surface, measured in lux (lumens per square meter) or footcandles (lumens per square foot).

Intrinsic Material Characteristics. Visual cues about surfaces and materials, such as texture or transparency, are revealed by lighting. The ability to see these cues, like nap and grain, may be critical to evaluating the type or quality of material, or the degree of consistency.

Light Distribution on Surfaces. Patterns of light resulting from the spacing and light distribution of the luminaires, as well as from objects that can cast shadows, can affect task visibility, comfort, and perceptions. Harsh striated patterns of excessive brightness or noticeable shadow should be

avoided. Illuminance patterns should correspond with architectural features (e.g., a regular pattern of glowing sconces) or objects (e.g., lighting art on the walls). Random patterns can be confusing or distracting.

Surfaces should not have extremely different brightnesses. For example, ceiling and walls should have luminances within a 3:1 ratio. Spaces with totally uniform brightness, however, lack visual interest. “Luminance ratios” refer to the relative luminances of any two areas in the visual field (e.g., ceiling-to-wall luminance ratios or immediate-surround-to-task luminance ratios).

Light Distribution on Task Plane (Uniformity). Patterns of light on the task plane can be distracting, confusing, or beneficial. The task plane varies according to the application. In an office, the task plane is most often the desk top; in a corridor, it may be the floor; in an industrial plant, the cutting table; in a parking lot, the pavement surface. These patterns of light and shadow can affect task visibility, comfort, and perception. Task illuminance should be higher than the immediate surround. Work surface illuminances that are 1.5 to 3 times higher than those in the surrounding areas assist in directing occupants’ attention to the task. Greater luminance ratios must be avoided to minimize visual fatigue. Descriptive statistics about illuminance or luminance distributions such as maximum-to-average or average-to-minimum are used to quantify the luminous uniformity of a surface. Use photometric data and luminaire manufacturer’s guidelines to achieve the uniformity recommended for the application.

Light Pollution/Trespass. Light that is directed upward to the sky or reflected from surfaces that interferes with astronomical observations or appreciation of the night sky is termed “light pollution.” “Light trespass” is unwanted light that falls beyond the property line or area intended to be illuminated.

Luminaire Noise. Sound generated by the internal parts of a luminaire can be annoying and distracting. Electromagnetic ballasts are the usual sources of sound, but incandescent lamps operated on certain types of dimmers and air moving through air-handling luminaires can also produce noise.

Luminances of Room Surfaces. Room surface luminances influence the perception of brightness in a space. Illuminance and reflectance affect luminance. Matte surfaces of high reflectance (e.g., white-painted walls and light-colored furniture finishes) are effective materials for increasing room surface luminances. Luminaires expressly designed for lighting walls or ceilings are effective tools for increasing room surface luminances.

Average wall luminances of at least 30 to 100 cd/m² are preferred in typical office work spaces (where 300 to 1000 lx [30 to 100 fc] is provided on the workplane). Minimize dark areas at tops of walls. If there are no luminaires dedicated to illuminating the walls, locate general lighting luminaires close to walls and utilize lenses, reflectors, or louvers

to soften the pattern of light and distribute more light to the top of walls.

Spaces that deliver both direct and diffuse light to the occupant and task increase user comfort and satisfaction. This approach reduces distracting shadows from hands, desk objects, partitions, and overhead cabinets; reduces overhead glare; and improves facial modeling.

Modeling of Faces or Objects. Lighting can reveal the depth, shape, and texture of an object. Through the creation or elimination of shadows, faces and objects can have more or less contrast.

The distribution of light in a retail display is critical to attracting attention and making the merchandise look appealing. Appropriate direction and distribution depends on the type of merchandise, but generally a combination of diffuse light and directional light will enhance appearance.

In industrial applications, modeling is critical to assessing material quality, finish quality, and degree of consistency. Appropriate direction and distribution of light vary depending on material and task. Often diffuse ambient lighting is inadequate for assessing fine texture; task lighting is therefore used to provide the required direction, distribution, and intensity of light.

A high percentage of communication is nonverbal. It is important that the pattern of light on faces enables clear recognition and interpretation of expressions by enhancing contrast in certain areas around the mouth and eyes. Concentrated downlighting, which creates harsh facial shadows and accentuates blemishes and wrinkles, should be avoided because it creates too much contrast on the face. Multidirectional lighting improves facial modeling. Interreflected light from walls, partitions, ceiling, and light-colored work surfaces helps increase vertical illuminance on faces, filling in sharp shadows and rendering faces in a more pleasing way with easier-to-read facial expressions.

Peripheral Detection. The human visual system is designed to detect movement in the periphery of the visual field and to guide the fovea to that movement for inspection and interpretation.

Point(s) of Interest. A point of interest is the object or place to which attention is drawn, using movement, luminance contrast, and color contrast.

Reflected Glare. Bright reflections from polished or glossy surfaces are uncomfortable and reduce task visibility; this is known as "reflected glare." "Veiling reflections" are contrast-reducing reflections from semi-specular surfaces that reduce task visibility. The possible negative impact of reflected glare and veiling reflections can be estimated. The ratio of illuminance on the task from the mirror angle relative to the total illuminance on the task should be less than 0.3 for satisfactory results, whereas unsatisfactory results can occur if the ratio exceeds 0.7. Both reflected glare and veiling reflections can be mitigated by providing illuminance from the sides of the task or by special lumi-

naire optical designs. It should be noted, however, that reflected glare can improve visibility for some tasks such as paint inspection for defects or reading increment marks on a steel rule (see also the section "Source/Task/Eye Geometry" below). For VDT applications the most practical solution to both veiling reflections and reflected glare is to select a VDT monitor with a diffuse reflecting screen and one that provides a bright background and dark text.

Shadows. Shadows can interfere with task visibility by placing detail in darkness (e.g., a body shadow on a paper task), and they can also enhance definition of three-dimensional details (e.g., imperfections in a piece of cloth). Point sources (e.g., incandescent or high-intensity discharge [HID] lamps) can cause sharp shadows from obstructions, whereas linear or area sources (e.g., luminaires with a large upright component, fluorescent lamp luminaires with large prismatic lenses and white reflectors) produce more diffuse shadows. Local task lighting can increase illuminances to minimize shadows on machinery or under cabinets.

Source/Task/Eye Geometry. The angular relationships between the viewer, the task, and the luminaire are frequently critical to task visibility. This geometry can both enhance contrast (e.g., scribed marks on a micrometer) and reduce it (e.g., viewing a meter dial through glass).

Sparkle/Desirable Reflected Highlights. Small points of high luminance can enhance visual interest (e.g., a candle flame or decorative tree lights).

Special Considerations. Often there are special issues associated with a specific location or task (e.g., photodegradation or hazardous location requirements).

Surface Characteristics. Object characteristics such as texture, color, and specular and reflectance values of surfaces can affect the perceived brightness of walls, ceilings, exterior building facades, and pavement. Interior workspaces should have high reflectances (walls, 50 to 70%; ceiling, 75 to 90%) to increase interreflections and thus help reduce the undesirable contrast of luminaires against their background. High reflectances also allow the designer to produce an effective lighted environment with fewer watts and fewer luminaires.

Surfaces should be matte or satin finished to avoid reflected glare. Dark surfaces (20 to 50%), saturated colors, and glossy finishes can maintain visual interest and stimulation, but they should be used to a limited degree. The Finish Schedule of construction documents should include material reflectances available from manufacturers of paint, wall covering, fabrics, and ceiling tiles.

System Control and Flexibility. Many spaces require different light levels for a variety of tasks. Conference rooms and auditoriums in particular need to have equipment that provides for different settings for slide shows, personnel interviews, financial meetings, presentations, and cleaning. Two or more lighting circuits can be used separately or to-

gether to achieve a wide range of appearances and light levels. One system can light walls, another can provide downlight on the workplane, and a third can provide general ambient illumination from a decorative luminaire mounted over a table. Preset scene controls can be employed with combinations of circuits. Dimming provides additional flexibility.

There are widely differing personal preferences for illuminance in work areas. User satisfaction can be enhanced through control of illuminance with switching or dimming of task or overhead lighting. Task lights can also be used so that the occupants can control the location, direction, and intensity of light. This is particularly important in spaces where both VDT and paper tasks are used.

DESIGN ISSUES APPLIED TO COMMON LIGHTING SITUATIONS

Lighting quality issues should be considered for the whole space and for every visual task within an indoor or outdoor

lighted environment. These considerations should have an impact on the design, finishes, and furniture and equipment layout of the space. Six applications are discussed in this section, illustrating how lighting design issues affect the visual environment. The lighting issues are noted on the illustrations and discussed along with design strategies and guidelines that the designer can use to satisfy the design objectives. It should be noted, however, that these illustrations are not necessarily representative of typical spaces, so the emphasis on certain design issues may not be relevant to all applications.

These guidelines were developed by lighting professionals with many years of design experience. It should be noted, however, that the same design objectives can be achieved in these examples with different lighting equipment and layouts.

Figure 10-3 is an illustration of an industrial machine shop, with open trusswork on the ceiling and suspended HID high-bay luminaires. The visual tasks are reading drawings and using lathes, drill presses, and other machinery. A series of design issues should be considered in the design of

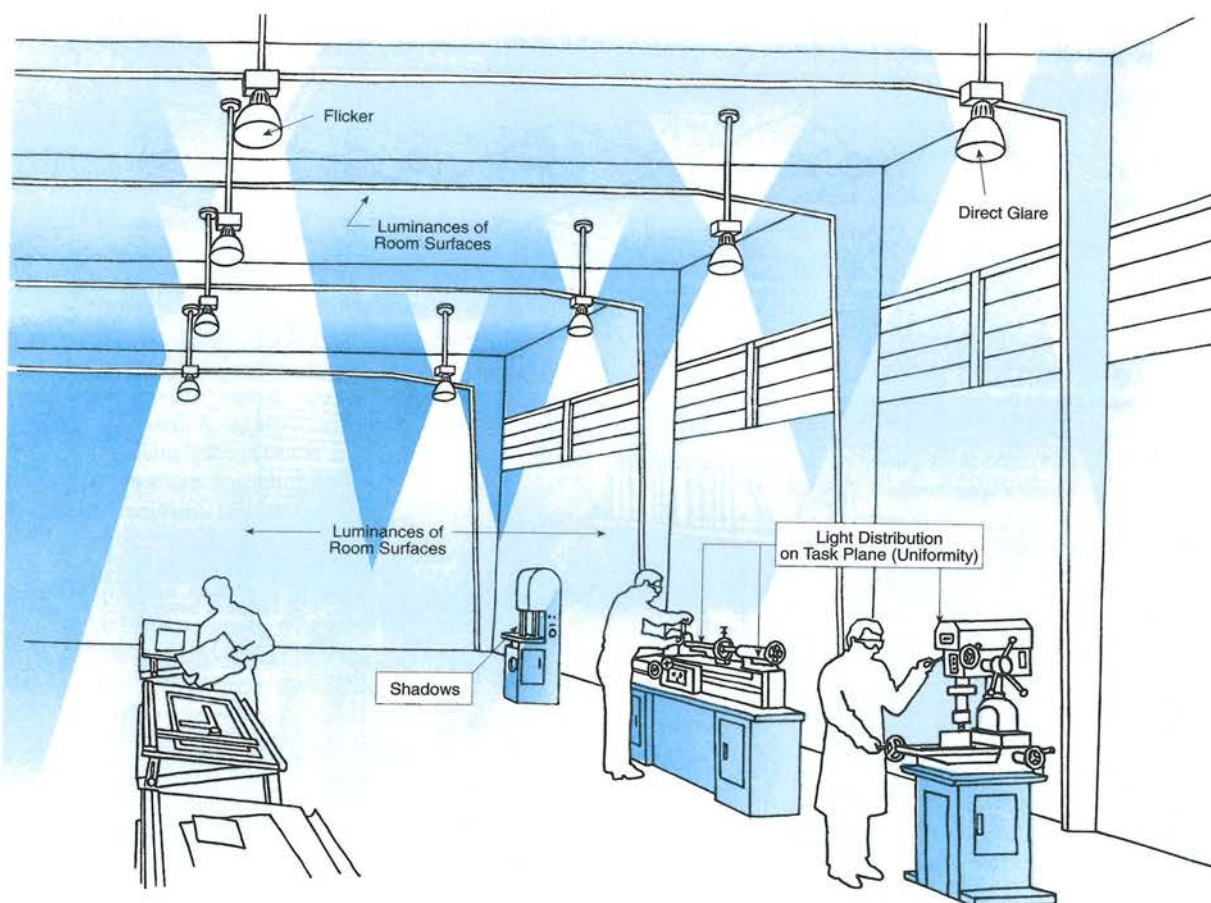


Figure 10-3. Industrial machine shop.

the lighting and the space. Several of these are noted on the illustration and also listed below, with simple guidelines for dealing with each issue:

- *Flicker (and Strobe).* Unless operated at high frequencies, HID lamps can be a source of flicker, which can be both annoying and a potential hazard for operators of moving machinery. Consider putting alternate HID luminaires on different phases of a three-phase electrical system to minimize the stroboscopic effect.
- *Luminances of Room Surfaces.* Industrial spaces can appear dark and the luminaires excessively bright if the ceilings are dark. Paint the ceiling a light color and choose luminaires that direct some light upward. This can make the space feel brighter and the luminaires appear less glaring by reducing the contrast between the lighted luminaire and the surrounding ceiling. Indirect light in an industrial space can minimize shadows. Walls painted a light color reflect more diffuse light onto task areas, mitigating shadows and increasing the general brightness of the space.
- *Light Distribution on the Task Plane (Uniformity).* Illuminances on the floor or work plane should not vary widely, or else it will be hard for workers to see details in the darker areas. Use the luminaire manufacturer's photometry and spacing recommendations, along with calculation procedures that account for tall obstructions, to ensure reasonable uniformity.
- *Direct Glare.* Glare affects both visual comfort and the viewer's ability to see. Consider using low-brightness luminaires that minimize the occupants' direct view of bright lamps from normal angles.
- *Shadows.* Industrial machinery or the operator's body can shadow the visual task from the general lighting. Consider fitting the machines with individual task lights.

Figure 10-4 shows an office space with a VDT, windows, and an acoustical lay-in ceiling. Pendant luminaires with a direct/indirect distribution provide ambient lighting. The workstation has linear fluorescent lamp undercabinet lighting. An adjustable task light provides illumination for a variety of tasks. The following design issues should be considered:

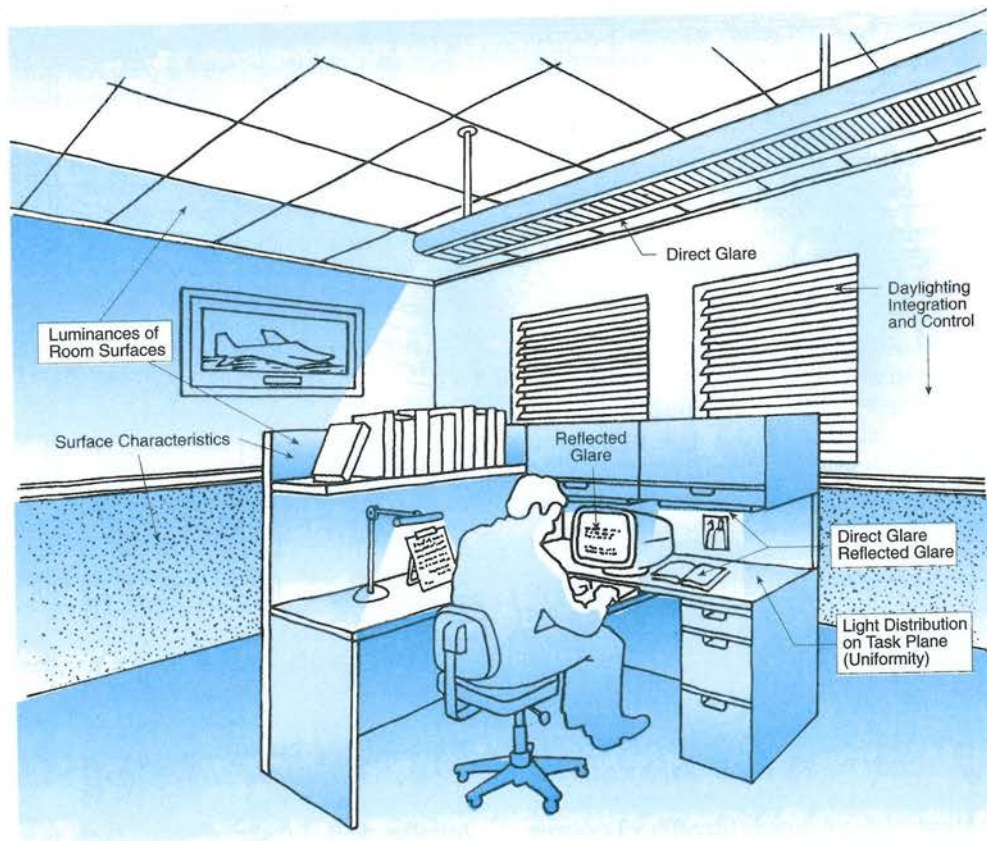


Figure 10-4. Office with work at the VDT as the primary visual task.

- *Direct Glare*
 - Ceiling. Choose a luminaire that limits glare at viewing angles the office worker would commonly experience. Semi-specular or white louvers can reduce the contrast between the lamp and the luminaire. Avoid luminaires with specular louvers where the worker's viewing angle permits seeing the lamp reflection. Luminaires that illuminate the ceiling as well as the task and higher ceiling reflectance help to reduce the contrast between the luminaire and the ceiling.
 - Undercabinet task light. Choose a luminaire that has an opaque front so that the seated worker has no direct view of the lamp or lens.
 - Adjustable task light. Choose a luminaire that is flexible enough to illuminate the visual task so that the bare source is not visible to the occupant or to adjacent workers.
- *Reflected Glare*
 - Undercabinet task light. Locate the luminaire to minimize reflected glare and veiling reflections from the desk top. A movable luminaire or special optics can help achieve this goal if luminaire location is restricted.
 - VDT screen. Computer screens with diffusing finishes, anti-reflection (AR) coatings, and high background luminances can be beneficial. The screen should not be oriented toward windows.
- *Light Distribution on Task Plane (Uniformity)*
 - Luminaire spacing. The pattern of light on the workplane is strongly affected by the photometric distribution of the luminaire. Space the luminaires so that the illuminance pattern on the workplane is within the recommended uniformity range. Luminaire spacing should be reduced if partial height furniture partitions are used. It should be noted, however, that luminaire spacing can be increased if indirect or direct/indirect lighting is used.
 - Luminaire selection. Avoid narrow-distribution luminaires, especially if the light from the luminaire produces a sharp scallop of light on the wall. This light pattern can be distracting if it serves no design purpose.
 - Workstation. Avoid extreme differences in luminance between the workplane and other surfaces in the visual field.
 - Desk top. Provide uniform illuminance on the desktop from undercabinet task lighting. Consider using a dimming electronic ballast to allow the occupant to control the location, direction, and intensity of light.
- *Luminances of Room Surfaces*. Provide uniform illuminance on the walls, ceilings, and furniture partitions to reduce contrast and achieve visual comfort in

the workplace. If there are no dedicated luminaires for illuminating the walls (wall washing), space the ceiling luminaires less than 1 m (3 ft) from the wall and use white or semi-specular louvers and reflectors. Harsh striated patterns of excessive brightness or noticeable shadow should be avoided.

- *Surface Characteristics*. Interior workspaces should have high reflectances (walls, 50 to 70%; ceiling, 75 to 90%) to increase interreflections and thus help reduce contrast of luminaires against their background. High reflectances also allow the designer to produce an effective lighted environment with fewer watts and fewer luminaires.
- *Daylighting Integration and Control*. Use blinds or shades on windows to control glare and thermal discomfort from sun and sky. Use high-reflectance walls to reduce the contrast between the bright windows and the walls.

Figure 10-5 shows the produce department of a supermarket, with wet produce cases, grocery shelves, produce bins, and a feature display. The grocery shelves and wet cases utilize valance lighting, and track-mounted accent lights illuminate the bins. There is additional uplighting from above the grocery shelves and wet cases. The following are some relevant design issues:

- *Direct Glare*
 - Accent lights. Use narrow-beam track lights and careful aiming to illuminate the produce but reduce glare for shoppers. Use louvers if necessary.
 - Valance lighting. For visual comfort and improved visibility of produce, conceal the lamps mounted in wet cases.
- *Light Distribution on Task Plane (Uniformity)*. The ratio of illuminances between merchandise and aisle should not exceed 3:1, so that shoppers can alternatively see the merchandise in their baskets and on the shelves.
- *Luminances of Room Surfaces*. Uplights on top of perimeter cases and on top of grocery gondolas help reduce shadows and make the space appear uniformly illuminated.
- *Color Appearance (and Color Contrast)*. Use high-color-rendering lamps (CRI > 80) to make produce look appealing and help shoppers evaluate the freshness of the produce.
- *Illuminance (Vertical)*. Vertical illuminance is important for grocery shelves.
- *Point(s) of Interest*. The feature display should have at least 3 to 5 times higher illuminance than the surrounding areas to attract the shopper's attention.

Figure 10-6 shows a building exterior with a canopied restaurant entrance and parking lot. There are shrubs and



Figure 10-5. Supermarket produce section.

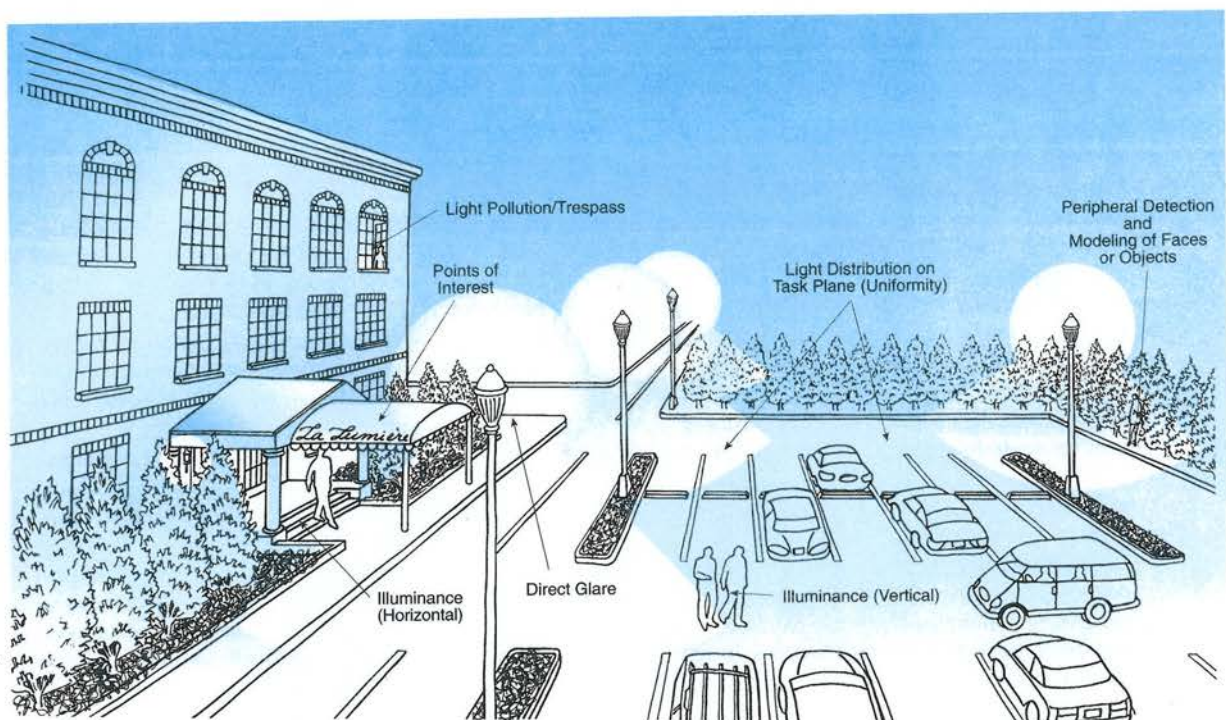


Figure 10-6. Restaurant entry/parking lot.

trees around the perimeter of the parking lot, wall sconces illuminating the entry stairs, uplights on specimen trees next to the building, and decorative post-top luminaires in the parking lot. The following design issues are important:

- **Direct Glare.** Use cutoff optics or a semi-cutoff optical system to control glare. Avoid using luminaires where the bare lamp can be seen.
- **Light Distribution on Task Plane (Uniformity).** Make sure parking lot is uniformly illuminated (usually a 4:1 average-to-minimum illuminance ratio is preferred).
- **Peripheral Detection.** Illuminate the perimeter of the area so that pedestrians and motorists can see potential danger in their peripheral vision.
- **Modeling of Faces or Objects.**¹⁴ If it is important to identify faces, provide adequate vertical as well as horizontal illuminance. Diffuse illumination from luminaires and from surface reflections is helpful.
- **Illuminance (Vertical).** This helps motorists see obstacles and pedestrians in their path more quickly.
- **Light Pollution/Trespass.** Avoid using luminaires that emit light above the horizontal plane. Minimize direct light onto nearby windows and illumination onto adjacent properties.
- **Illuminance (Horizontal).** Follow guidelines for illuminance on steps and entry areas, including provisions for transitional illuminances from dark spaces to light spaces and vice versa.
- **Point(s) of Interest.** Make sure signs, special landscaping, and other points of interest are clearly visible to attract attention.

Figure 10-7 illustrates the passenger cabin of an airplane. The lighting must enable many activities that can occur day or night, such as boarding the aircraft and stowing luggage, reading and handwriting, viewing television or projection screens, and sleeping. The following are important design issues:

- **System Control and Flexibility.** General illumination required for stowing luggage could be too bright for comfortable television viewing or sleeping, so it is essential that there be a flexible control system that allows the crew to reduce ambient illumination throughout the cabin. Also, individual control of reading lights accommodates different activities, including sleeping.
- **Daylighting Integration and Control.** The cabin windows provide a view and, during the day, light onto surfaces inside the cabin, but blackout shades should be provided to minimize brightness.
- **Source/Task/Eye Geometry.** The passenger reading light needs to be carefully located with the user and task locations in mind. A good reading light posi-



Figure 10-7. Aircraft passenger cabin.

tion, distribution, and aiming angle helps avoid veiling reflections and shadows on reading and writing surfaces.

- **Direct Glare.** For comfort and visibility, brightness should be minimized at normal viewing angles for the cabin attendants and the passengers. Solutions include aiming luminaires away from passengers' eyes, lensing or louvers luminaires, and using indirect lighting.
- **Luminances of Room Surfaces.** An airplane cabin is a confined space. Consider light colored, matte finishes and washing light across ceiling, wall, and overhead bin surfaces to effect a perception of spaciousness.
- **Color Appearance (and Color Contrast).** Choose light sources that deliver good color rendering of skin tones and interior finishes.
- **Modeling of Faces or Objects.**¹⁴ Good facial modeling assists communication between crew and passengers. For general lighting, use some indirect illumination reflected from light-colored surfaces to help wash out harsh shadows on faces.

Figure 10-8 shows an indoor tennis court. It is important that the players see their opponents and team members clearly, see the ball in motion, and not be confused by glare or shad-

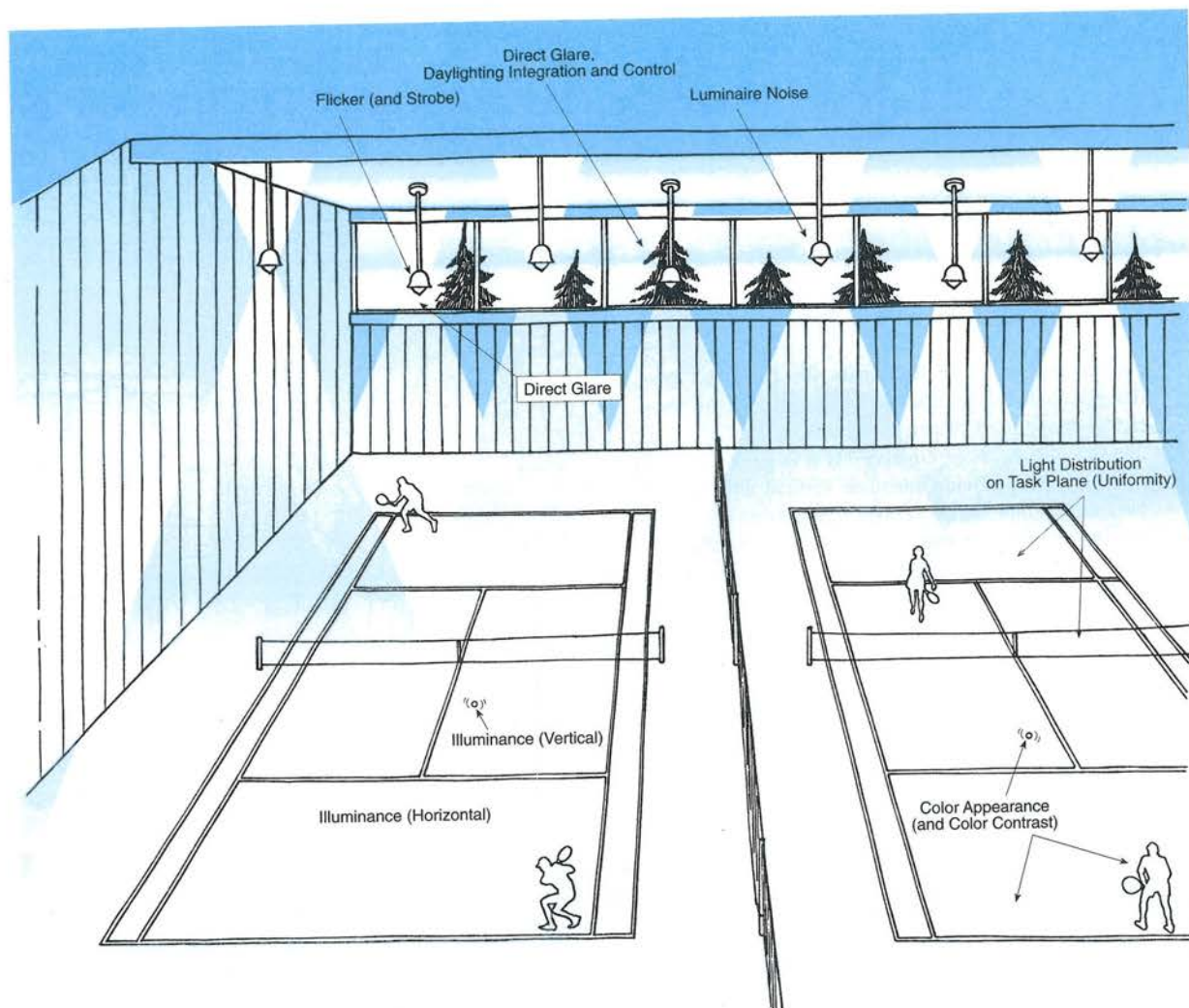


Figure 10-8. Indoor tennis court.

ows. The following design issues are common to many interior sports facilities.

- *Light Distribution on Task Plane (Uniformity)*. It is important to keep the illuminance on the tennis court within the uniformity ratios suggested in Chapter 20, Sports and Recreational Area Lighting.
- *Illuminance*. Illuminances, both horizontal and vertical, are important for observing player action and ball movement. Vertical illuminance above the court is important so that the ball trajectory can be seen.
- *Direct Glare*. Bright luminaires, especially those with exposed lamps, can produce glare and after-image that can severely limit a player's ability to track the ball. Consider using indirect lighting or control lamp brightness with lenses or louvers.
- *Color Appearance (or Color Contrast)*. Use light sources that render skin tones well. Also, color contrast between the ball and the surrounding surfaces can help make the ball easier to see.
- *Flicker (and Strobe)*. In order to avoid the stroboscopic effect with the ball, use light sources with high-frequency ballasts, or put adjacent luminaires on alternate phases of a three-phase electrical system.
- *Daylighting Integration and Control*. If daylight is admitted to the sports facility, ensure that glare from windows and skylights does not interfere with the visual comfort of the players or the visibility of the ball.
- *Luminaire Noise*. The noise from ballasted luminaires can be very distracting to players and spectators. Use remote-mounted ballasts, "potted" ballasts

in enclosures that isolate ballast vibrations, or electronic ballasts.

ILLUMINANCE SELECTION

In 1979, the IESNA established an illuminance selection procedure, which was published in the 6th, 7th, and 8th editions of its *Lighting Handbook*. The philosophy of that procedure was to enable the lighting designer to select illuminances based on a knowledge of space and occupant characteristics as well as the task and worker characteristics.

The philosophy of that procedure has been embraced again in this edition, but the procedure has been modified and simplified to place visual performance and therefore illuminance selection more in balance with the other important lighting design criteria presented in this chapter and discussed throughout this edition of the *IESNA Lighting Handbook*. Specifically, the recommended illuminances provided in the Design Guide are based on the Society's judgment of best practice for "typical" applications. Every situation is unique so, naturally, typical conditions may not be appropriate for a specific application. As a professional, the lighting designer should have a better understanding of the particular space and the needs of the occupants and clients than what can be presented in a recommended illuminance value for a typical space.

Illuminance Recommendations

In 1979, the IESNA established nine illuminance categories, "A," the lowest set of recommended illuminances, through "I," the highest set. Each of the nine categories had general descriptions of the visual task, irrespective of the application. Generally, the same approach has been employed in this edition of the *IESNA Lighting Handbook* to help lighting designers establish the best task illuminance. However, four important modifications have been adopted.

- The recommended illuminances are no longer provided without reference to a specific application. Every application in the Design Guide has a specific recommended illuminance (horizontal, vertical, or both) representing best practice for a typical application.
- The nine illuminance selection categories established earlier by the IESNA have been reduced to seven categories and organized into three sets of visual tasks (orientation and simple, common, and special). These groupings provide additional clarity to the category descriptions (Figure 10-9).
- Additional precision has been given to the task descriptions in each category. In the previous three editions it was impossible for the lighting designer to unambiguously ascertain what constituted, for example, "low contrast" or "small size." Specific

Figure 10-9. Determination of Illuminance Categories*

Orientation and simple visual tasks. Visual performance is largely unimportant. These tasks are found in public spaces where reading and visual inspection are only occasionally performed. Higher levels are recommended for tasks where visual performance is occasionally important.

A	Public spaces	30 lx (3 fc)
B	Simple orientation for short visits	50 lx (5 fc)
C	Working spaces where simple visual tasks are performed	100 lx (10 fc)

Common visual tasks. Visual performance is important. These tasks are found in commercial, industrial and residential applications. Recommended illuminance levels differ because of the characteristics of the visual task being illuminated. Higher levels are recommended for visual tasks with critical elements of low contrast or small size.

D	Performance of visual tasks of high contrast and large size	300 lx (30 fc)
E	Performance of visual tasks of high contrast and small size, or visual tasks of low contrast and large size	500 lx (50 fc)
F	Performance of visual tasks of low contrast and small size	1000 lx (100 fc)

Special visual tasks. Visual performance is of critical importance. These tasks are very specialized, including those with very small or very low contrast critical elements. Recommended illuminance levels should be achieved with supplementary task lighting. Higher recommended levels are often achieved by moving the light source closer to the task.

G	Performance of visual tasks near threshold	3000 to 10,000 lx (300 to 1000 fc)
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* Expected accuracy in illuminance calculations are given in Chapter 9, Lighting Calculations. To account for both uncertainty in photometric measurements and uncertainty in space reflections, measured illuminances should be with $\pm 10\%$ of the recommended value. It should be noted, however, that the final illuminance may deviate from these recommended values due to other lighting design criteria.

ranges of contrast and size have been established for this edition (Figures 10-10 and 10-11).

- Recommended illuminances increase roughly logarithmically with increasing task difficulty by combined changes in task contrast and task size, as defined in Figure 10-10. These recommendations are guided by both the scientific literature and practical experience.

High illuminances can partially compensate for small size and low contrast to maintain high levels of visual performance. Changes in visual performance as a function of task contrast and size, background reflectance, and observer age can be calculated precisely.¹⁵ For well-controlled situations, this procedure can be a useful predictive tool. However, performance at a visual task depends on many uncontrolled vi-

Figure 10-10. Determination of Visual Task Parameters**CONTRAST**

How to calculate: $|L_b - L_t|/L_b$ or $|\rho_b - \rho_t|/\rho_b$
 where L is luminance (L_b and L_t must use same units),
 ρ is reflectance,
 b refers to the background, and
 t refers to the target.

Definition of contrast using reflectance requires equal illuminance on target and background.

How to interpret:

Low contrast: 0.3 or lower, but not near threshold*

High contrast: above 0.3

This division is based on the plateau-escarpment nature of visual performance.^{15,21}

SIZE (see also Figure 10-11)*How to calculate:*

Solid angle (sr): $(w \times h \times \cos \theta)/d^2$
 where w and h are the dimensions (width and height) of the critical detail of the target,
 θ is the viewing angle, and
 d is the viewing distance
 (w , h , and d must use the same units).

Visual angle (deg): $\arctan(w \times \cos \theta)/d$
 where w is the dimension (width) of the critical detail of the target,
 θ is the viewing angle, and
 d is the viewing distance (w and d must use the same units).

Note: Visual performance for two different targets subtending the same area will be the same, even if the targets have different aspect ratios (e.g., a square-shaped target versus a long, rectangular-shaped target).^{15,21}

How to interpret:

Small size: 4.0×10^{-6} sr or smaller (solid angle), but not near the acuity limit*

Large size: larger than 4.0×10^{-6} sr

This division, like that of contrast, is based on the plateau-escarpment nature of visual performance.^{15,21}

Note: $1^\circ = 0.01745$ radians = 60 minarc; $1 \text{ sr} = 66^\circ$ visual angle for a circular target. For a cone where θ is the half-cone angle, solid angle = $2\pi(1 - \cos \theta)$.

* It should be noted that contrast threshold and the acuity limit are dependent on background luminance, duration of presentation, color, surround conditions, and in general, any number of factors that affect visibility, including those idiosyncratic to the viewer. Above a contrast of 0.3 and a size of 4.0×10^{-6} sr, these factors are not very important to visual performance.

sual and nonvisual factors that are highly variable and largely indeterminable by the lighting designer. For example, it is often difficult or impossible to know the age, retinal health, and optical refraction of the worker. Moreover, worker motivation, education, manual dexterity, posture, stature, and level of fatigue are highly variable and usually unmeasurable. Therefore, a precise calculation method for visual performance cannot be justified for typical areas or activities. For this reason, the IESNA currently believes that the recommended illuminances in the Design Guide and in

Figure 10-11. Examples of Common Visual Angles and Solid Angles

Printed reading task from 19 in. (50 cm)

Typeface size	Visual angle ($^\circ$)*	Solid angle (sr) [†]
6 point	0.03	1.7×10^{-6}
8 point	0.04	3.1×10^{-6}
10 point	0.05	4.8×10^{-6}
12 point	0.06	6.9×10^{-6}
14 point	0.07	9.4×10^{-6}
24 point	0.12	2.8×10^{-5}
36 point	0.18	6.2×10^{-5}

Viewing a square-shaped object from 100 ft (30 m)

Object size	Visual angle ($^\circ$)*	Solid angle (sr) [†]
3 × 3 in. (7.5 × 7.5 cm)	0.14	6.3×10^{-6}
6 × 6 in. (15 × 15 cm)	0.29	2.5×10^{-5}
12 × 12 in. (30 × 30 cm)	0.57	1.0×10^{-4}

Wire sizes (diameter in cross section) viewed from 15 in. (40 cm)

Wire size	Visual angle ($^\circ$)*	Solid angle (sr) [†]
American Wire Gauge (AWG)		
30 (0.25 mm diameter)	0.04	3.4×10^{-7}
AWG 24 (0.51 mm diameter)	0.07	1.4×10^{-6}
AWG 20 (0.81 mm diameter)	0.12	3.5×10^{-6}
AWG 16 (1.29 mm diameter)	0.19	9.0×10^{-6}
AWG 12 (2.05 mm diameter)	0.31	2.3×10^{-5}
AWG 8 (3.28 mm diameter)	0.49	5.8×10^{-5}

Circular drilled holes viewed from 15 in. (40 cm)

Hole diameter	Visual angle ($^\circ$)*	Solid angle (sr) [†]
0.01 in. (0.25 mm)	0.04	3.4×10^{-7}
0.02 in. (0.51 mm)	0.07	1.4×10^{-6}
0.03 in. (0.76 mm)	0.11	3.1×10^{-6}
0.04 in. (1.02 mm)	0.15	5.6×10^{-6}

* Angular width of single character stroke (vertical stroke, Times typeface).

[†] Average solid angle of total printed area of character for numerical digits (see reference 15).

Figure 10-9 are adequate and appropriate guidelines for lighting design.

The Basis for Deviating from the Recommended Illuminances

Every visual task identified in the Design Guide has provisions for horizontal and vertical illuminance recommendations. Depending on the task, one or both illuminance recommendations are provided. Occasionally, the Guide refers the reader to an application chapter for recommended illuminances. The recommended values throughout the Design Guide represent consensus values formally obtained by the appropriate application committee.

Occasionally the visual task in a specific space is not typical, and Figures 10-10 and 10-11 should be used to adjust

the illuminance for that task. Indeed, it is extremely important that the lighting designer have a clear understanding of the visual task being illuminated and then determine whether, in fact, the recommended illuminance is appropriate. It is also possible that more than one visual task is performed in a space. The lighting designer should make provisions to illuminate these tasks to the recommended levels unless other design criteria supercede illuminance as a design criterion.

The IESNA recognizes that illuminance is not the sole lighting design criterion. Other criteria in the design guide may be more important than illuminance; to address the primary design criteria, the lighting designer can deviate from the recommended illuminance. Further, and as listed in the section "How to Use the IESNA Lighting Design Guide" above, there are many other factors that might lead to deviation from the recommendations made in the Design Guide. Given the complexity and diversity of design goals for a specific application, it is impossible to formulate a formal, precise method for deviating from the recommended illuminances in the Design Guide. However, some guidance, based on descriptive statistics, is offered by the IESNA with regard to what might be considered "dramatic" deviations from a recommended illuminance.

Consider a hypothetical example. A survey of task illuminances was obtained for a large sample of open-plan offices where the primary visual task is reading 8- and 10-point print, and the recommended illuminance is 300 lx. Figure 10-12 illustrates the results of the survey. Illuminances ranged from 150 lx to 450 lx with a peak frequency of 300 lx. Roughly two-thirds of the illuminances (i.e., one standard deviation) were between 250 and 350 lx, and approximately 95% (i.e., two standard deviations) of the illuminances were between 200 and 400 lx. Dramatic deviations were those illuminances below 200 or above 400 lx and, in total, represented less than 5% of all illuminances surveyed.

In general, the IESNA believes that a dramatic difference between an actual and a recommended illuminance (i.e., a

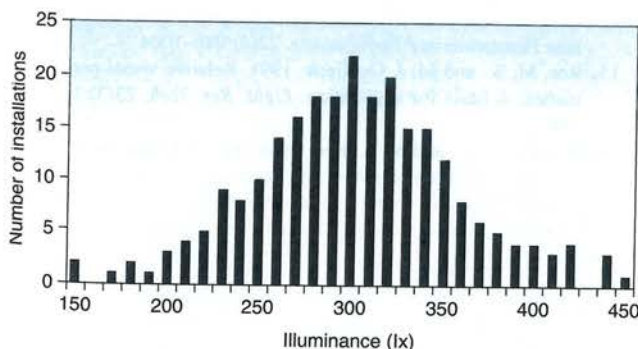


Figure 10-12. Hypothetical distribution of surveyed illuminances.

difference of two standard deviations or more) would be 1/3 more or 1/3 less than the recommended value. It should be noted again that an experienced lighting designer can produce a satisfactory illuminance outside this range, but it would be an exceptional achievement. As already noted above, the IESNA believes that any dramatic deviations from the recommended value should be carefully documented by the lighting designer, not only because documentation is good professional practice, but it is also good to have in case the design illuminance is ever challenged.

Age

Finally it should be noted that the recommendations for illuminances provided in the Design Guide are not made with respect to the age of the occupants. Generally, the visual requirements of older persons are significantly different from those of younger persons in the two ways^{16,17}: (1) there is a thickening of the yellow crystalline lens, which decreases the amount of light reaching the retina, increases scatter within the eye, and reduces the range of distances that can be properly focused (presbyopia); and (2) there is a reduction of pupil size, decreasing the amount of light reaching the retina.

The retinal illuminance of a typical 60-year-old person is only about one-third of the retinal illuminance of a typical 20-year-old person due to smaller pupil sizes and thicker lenses (Figure 10-13).¹⁸ Additionally, the near point of a typical 20-year-old person is 10 cm (4 in.), compared to more than 1 m (3 ft) for a typical 60-year-old person (Figure 10-

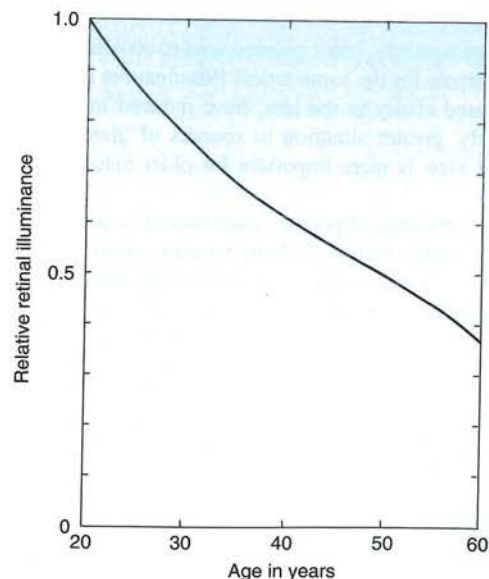


Figure 10-13. An estimate of relative decline in retinal illuminance with age.

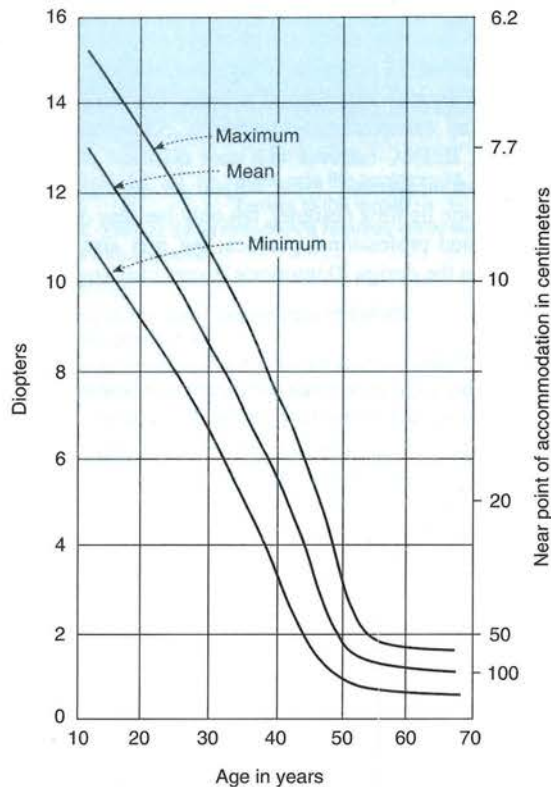


Figure 10-14. The decrease of the amplitude of accommodation with age.

14). Consequently, older persons tend to require higher task illuminances for the same retinal illuminances and, because of reduced clarity in the lens, have reduced image quality. Similarly, greater attention to sources of glare within the field of view is more important for older than for younger persons.

The population of persons older than 60 years is growing, and this means that the lighting specifier must consider the possibility of increasing the recommended illuminances and take measures to avoid glare and excessive luminance ratios in the field of view (see the sections "Direct Glare" and "Reflected Glare" above for additional information about glare). It should be noted too that after age 65, neurological factors (e.g., macular degeneration, diabetic retinopathy) become increasingly problematic. These changes demand even more sophisticated lighting design. It is recommended that other resources be consulted for guidance on the effects of age on the quantity and quality of illumination, and that this information, like that for other lighting design criteria, be factored into the final design.¹⁹⁻²¹

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IESNA Lighting Design Guide

I. INTERIOR LOCATIONS AND TASKS	Blank = Not important or not applicable																
	Very Important	Important	Somewhat important	Special Considerations	Notes on Special Considerations	Illuminance (Horizontal)	Category or Value (lux)	Illuminance (Vertical)	Category or Value (lux)	Notes on Illuminance - see end of section	Reference Chapter(s)						
Design Issues	Appearance of Space and Luminaires	Color Appearance (and Color Contrast)	Daylighting Integration and Control	Direct Glare	Flicker (and Strobe)	Light Distribution on Surfaces	Light Distribution on Task Plane (Uniformity)	Luminances of Room Surfaces	Modeling of Faces or Objects	Point(s) of Interest	Reflected Glare	Shadows	Source/Task/Eye Geometry	Sparkle/Desirable Reflected Highlights	Surface Characteristics	System Control and Flexibility	Special Considerations
Accounting (see Offices)																	Ch. 11
Air Terminals (see Transportation Terminals in Section V, Transportation)																	Ch. 23
Armories																A	
Art Galleries (see Museums)																	Ch. 14
Auditoriums																	
Assembly																	
Social activity																A	
Banks (see Reading)																	Ch. 11
Lobby																	
General																A	
Writing area																A	
Tellers' stations																A	
ATM facilities — keypad																C	
ATM facilities — display screen																A	
ATM facilities — writing surface																B	(2)
ATM facilities — surrounding area																A	(3)

IESNA Lighting Design Guide

Interior-3

I. INTERIOR LOCATIONS AND TASKS	Very Important																	Important	Somewhat important	Blank = Not important or not applicable					
	Appearance of Space and Luminaires	Color Appearance (and Color Contrast)	Daylighting Integration and Control	Direct Glare	Flicker (and Strobe)	Light Distribution on Surfaces	Light Distribution on Task Plane (Uniformity)	Luminances of Room Surfaces	Modeling of Faces or Objects	Point(s) of Interest	Reflected Glare	Shadows	Source/Task/Eye Geometry	Sparkle/Desirable Reflected Highlights	Surface Characteristics	System Control and Flexibility	Special Considerations	Notes on Special Considerations	Illuminance (Horizontal)	Category or Value (lux)	Illuminance (Vertical)	Category or Value (lux)	Notes on Illuminance - see end of section	Reference Chapter(s)	
Design Issues	Correctional Facilities																								Ch. 14
	Cells																			D	B	B	B (4)		
	Day rooms																			D	B	B			
	Corridors (see Service Spaces)																								
	Court Rooms (see Reading)																								
	Seating area (spectators)																	(1)	C	E	A	C (5)		Ch. 14	
	Judge and clerk																	(1)	E	E	C	C (6)			
	Litigant's table																	(1)	E	E	C	C (5)			
	Podium																	(1)	D	D	B				
	Witness chair																								
Dance Halls/Discotheques																									
Dance halls/discotheques																			A	A	A				
Ballrooms/social events																			B	B					
Depots, Terminals, Stations (see Transportation Terminals in Section V, Transportation)																								Ch. 23	
Drafting/Graphic Arts																									
CAD stations only																									
Mixed CAD and paper task																			C	D	A	A			

IESNA Lighting Design Guide

Interior-5

I. INTERIOR LOCATIONS AND TASKS	Very Important																		Important				Somewhat important				Blank = Not important or not applicable			
	Appearance of Space and Luminaires	Color Appearance (and Color Contrast)	Daylighting Integration and Control	Direct Glare	Flicker (and Strobe)	Light Distribution on Surfaces	Light Distribution on Task Plane (Uniformity)	Luminances of Room Surfaces	Modeling of Faces or Objects	Point(s) of Interest	Reflected Glare	Shadows	Source/Task/Eye Geometry	Sparkle/Desirable Reflected Highlights	Surface Characteristics	System Control and Flexibility	Special Considerations	Notes on Special Considerations	Illuminance (Horizontal)	Category or Value (lux)	Illuminance (Vertical)	Category or Value (lux)	Notes on Illuminance - see end of section	Reference Chapter(s)						
Design Issues																								Ch. 11						
																								Ch. 11						
																								Ch. 11						
																								Ch. 13						

IESNA Lighting Design Guide

Interior-7

I. INTERIOR LOCATIONS AND TASKS	Very Important																	Important			Somewhat important				Blank = Not important or not applicable				
	Appearance of Space and Luminaires	Color Appearance (and Color Contrast)	Daylighting Integration and Control	Direct Glare	Flicker (and Strobe)	Light Distribution on Surfaces	Light Distribution on Task Plane (Uniformity)	Luminances of Room Surfaces	Modeling of Faces or Objects	Point(s) of Interest	Reflected Glare	Shadows	Source/Task/Eye Geometry	Sparkle/Desirable Reflected Highlights	Surface Characteristics	System Control and Flexibility	Special Considerations	Notes on Special Considerations	Illuminance (Horizontal)	Category or Value (lux)	Illuminance (Vertical)	Category or Value (lux)	Notes on Illuminance - see end of section	Reference Chapter(s)					
Design Issues	Recovery room																												
	General																												
	Dialysis unit, medical																												
	Elevators																												
	EKG and specimen room																												
	General																	(10)											
	Emergency outpatient																												
	General																	(10)											
	Endoscopy rooms																												
	General																												
	Peritoneoscopy																		(10)										
	Culdoscopy																		(10)										
	Eye surgery																		(10)										
	Fracture room																		(10)										
	General																		(10)										
	Local																		(10)										
	Inhalation therapy																		(10)										
	Laboratories																		(10)										
	Specimen collecting																		(10)										
	Linen																												
	Sorting soiled linen																												
	Central (clean) linen room																												
	Sewing room, general																		(10)										
Linen closet																													
Lobby																		(10)											
Locker rooms																													
Medical illustration studio																		(10)											
Medical records																		(10)											

IESNA Lighting Design Guide

Interior-9

I. INTERIOR LOCATIONS AND TASKS	Very Important																	Important			Somewhat important			Blank = Not important or not applicable		
	Appearance of Space and Luminaires	Color Appearance (and Color Contrast)	Daylighting Integration and Control	Direct Glare	Flicker (and Strobe)	Light Distribution on Surfaces	Light Distribution on Task Plane (Uniformity)	Luminances of Room Surfaces	Modeling of Faces or Objects	Point(s) of Interest	Reflected Glare	Shadows	Source/Task/Eye Geometry	Sparkle/Desirable Reflected Highlights	Surface Characteristics	System Control and Flexibility	Special Considerations	Notes on Special Considerations	Illuminance (Horizontal)	Category or Value (lux)	Illuminance (Vertical)	Category or Value (lux)	Notes on Illuminance - see end of section	Reference Chapter(s)		
Design Issues	Radiation therapy section																									
	General																	(10)		B	A					
	Solarium																	(10)		C	A					
	General																	(10)		D	B					
	Local for reading																	(10)		C	A					
	Stairways																									
	Surgical suite																									
	Operating room, general																	(10)		G	E					
	Operating table																	(10)		G	E					
	Scrub room																			F	D					
	Instruments and sterile supply room																									
	Clean-up room, instruments																									
	Anesthesia storage																									
	Substerilizing room																									
	Surgical induction room																									
	Surgical holding area																									
	Toilets																									
Utility room																										
Waiting areas																										
General																		(10)		C	A					
Local for reading																		(10)		D	B					
Homes (see Residences)																								Ch. 18		

IESNA Lighting Design Guide

I. INTERIOR LOCATIONS AND TASKS	Blank = Not important or not applicable														
	Very Important	Important	Somewhat important	System Control and Flexibility	Special Considerations	Notes on Special Considerations	Illuminance (Horizontal)	Category or Value (lux)	Illuminance (Vertical)	Category or Value (lux)	Notes on Illuminance - see end of section	Reference Chapter(s)			
Design Issues	Appearance of Space and Luminaires							C		A		Ch. 12, 20			
	Color Appearance (and Color Contrast)											Ch. 17			
	Daylighting Integration and Control														
	Direct Glare														
	Flicker (and Strobe)														
	Light Distribution on Surfaces														
	Light Distribution on Task Plane (Uniformity)														
	Luminances of Room Surfaces														
	Modeling of Faces or Objects														
	Point(s) of Interest														
	Reflected Glare														
	Shadows														
	Source/Task/Eye Geometry														
	Sparkle/Desirable Reflected Highlights														
	Surface Characteristics														
Locker Rooms															
Merchandising Spaces															
Retail store areas															
Alteration room															
Fitting room															
Dressing areas															
Fitting areas															
Locker rooms															
Stock rooms, wrapping and packaging															
Sales transaction area															
Circulation															
General merchandise display															
Feature display															
Show windows															

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Interior-13

I. INTERIOR LOCATIONS AND TASKS	Very Important	Important	Somewhat important	Blank = Not important or not applicable																					
	Appearance of Space and Luminaires	Color Appearance (and Color Contrast)	Daylighting Integration and Control	Direct Glare	Flicker (and Strobe)	Light Distribution on Surfaces	Light Distribution on Task Plane (Uniformity)	Luminances of Room Surfaces	Modeling of Faces or Objects	Point(s) of Interest	Reflected Glare	Shadows	Source/Task/Eye Geometry	Sparkle/Desirable Reflected Highlights	Surface Characteristics	System Control and Flexibility	Special Considerations	Notes on Special Considerations	Illuminance (Horizontal)	Category or Value (lux)	Illuminance (Vertical)	Category or Value (lux)	Notes on Illuminance - see end of section	Reference Chapter(s)	
Design Issues	Offices (13)																							Ch. 11	
	Filing (see Reading)																								
	General and private offices (see Reading)																								
	Open plan office																								
	Intensive VDT use																(14, 15)								
	Open plan office																	(14, 15)							
	Intermittent VDT use																								
	Private office																								
	Libraries (see Libraries)																								
	Lobbies, lounges, and reception areas																								
	Mail sorting																								
	Copy rooms																								
	Parking Facilities (see Section III, Outdoor)																								Ch. 22
Post Offices																								Ch. 11	
Lobby																		(1)							
Customer service counter																		(1)							
Mail processing, general																		(1)							

Reading (16)	Ch. 11, 12											
Copied tasks												
Microfiche reader												
Photograph, moderate detail												
Thermal copy, poor												
Photocopies												
Photocopies, 3 rd generation												
Data processing tasks												
VDT screens												
Impact printer												
good ribbon												
2 nd carbon and greater												
ink jet/laser printer												
keyboard reading												
Machine rooms												
Active operations												
Tape storage												
Machine area												
Equipment service												
Thermal print												
Handwritten tasks												
#2 pencil and softer leads												
#3 pencil												
#4 pencil and harder leads												
Ball-point pen												
Felt-tip pen												
Handwritten carbon copy												
White boards												
Chalk boards												
Printed tasks												
6-point type												
8- and 10-point type												
Glossy magazines												
Maps												
Newsprint												
Typed originals												
Telephone books												
Residences												
General lighting												
Conversation, relaxation, and entertainment												
Passage areas (circulation)												

IESNA Lighting Design Guide

Interior-15

I. INTERIOR LOCATIONS AND TASKS	Very Important																			Important			Somewhat important			Blank = Not important or not applicable		
	Appearance of Space and Luminaires	Color Appearance (and Color Contrast)	Daylighting Integration and Control	Direct Glare	Flicker (and Strobe)	Light Distribution on Surfaces	Light Distribution on Task Plane (Uniformity)	Luminances of Room Surfaces	Modeling of Faces or Objects	Point(s) of Interest	Reflected Glare	Shadows	Source/Task/Eye Geometry	Sparkle/Desirable Reflected Highlights	Surface Characteristics	System Control and Flexibility	Special Considerations	Notes on Special Considerations	Illuminance (Horizontal)	Category or Value (lux)	Illuminance (Vertical)	Category or Value (lux)	Notes on Illuminance - see end of section	Reference Chapter(s)				
Design Issues	Specific visual tasks																											
	Dining																											
	Grooming																											
	Makeup and shaving																											
	Dressing evaluation (mirror)																											
	Handcrafts and hobbies																											
	Ordinary tasks (e.g., crafts)																											
	Difficult tasks (e.g., sewing)																											
	Critical tasks (e.g., workbench)																											
	Easel hobbies																											
	Ironing																											
	Kitchen counter																											
	Critical seeing (e.g., cutting)																											
	General																											
	Kitchen range																											
	Difficult seeing (e.g., cooking)																											
	Kitchen sink																											
	Difficult seeing																											
	Noncritical (clean up)																											
	Laundry																											
Music study (piano, organ)																												
Reading																												
In a chair (casual)																												
In a chair (serious)																												
In bed (casual)																												

IESNA Lighting Design Guide

Interior-17

I. INTERIOR LOCATIONS AND TASKS		Very Important	Important	Somewhat important	Blank = Not important or not applicable																				
Design Issues	Notes:	Appearance of Space and Luminaires	Color Appearance (and Color Contrast)	Daylighting Integration and Control	Direct Glare	Flicker (and Strobe)	Light Distribution on Surfaces	Light Distribution on Task Plane (Uniformity)	Luminances of Room Surfaces	Modeling of Faces or Objects	Point(s) of Interest	Reflected Glare	Shadows	Source/Task/Eye Geometry	Sparkle/Desirable Reflected Highlights	Surface Characteristics	System Control and Flexibility	Special Considerations	Notes on Special Considerations	Illuminance (Horizontal)	Category or Value (lux)	Illuminance (Vertical)	Category or Value (lux)	Notes on Illuminance - see end of section	Reference Chapter(s)
(1) Consider lighting for video cameras. (2) Maximum illuminance. (3) At ground level. (4) The minimum illuminance in a prison cell is 200 lx (20 fc); 300 lx (30 fc) should be provided for reading at the head of the bed. (5) Adjustable task lighting recommended. (6) Task lighting recommended, possibly located in ceiling. (7) Degradation factors important to consider. (8) In the display plane. (9) Special lighting for signage or banners may be required. (10) See Chapter for special considerations. (11) Refer to Chapter 16, Health Care Facility Lighting, for specific recommendations for surgical task lighting. (12) At 30" above floor. (13) Design issues, including illuminances, can be listed for room or space. Refer to specific task under "Reading" or "Graphic Design and Materials", for example. (14) Lighting should be flexible to accommodate changes in office furniture. (15) Acoustical aspects of luminaires need to be considered. (16) Design issues and illuminances listed for the task. See "Offices" or "Educational Facilities", for example, for additional considerations for the room.																									

II. INDUSTRIAL LOCATIONS AND TASKS ^(a)		Very Important Important Somewhat important Blank = Not important or not applicable																		
		Appearance of Space and Luminaires	Color Appearance (and Color Contrast)	Daylighting Integration and Control	Direct Glare	Flicker (and Strobe)	Intrinsic Material Characteristics	Light Distribution on Surfaces	Light Distribution on Task Plane (Uniformity)	Luminances of Room Surfaces	Modeling of Faces or Objects	Reflected Glare	Shadows	Source/Task/Eye Geometry	Special Considerations	Notes on Special Considerations	Illuminance on Task Plane ^(b)	Category or Value (lux)	Notes — see end of section	Reference Chapter(s)
Design Issues	Basic Industrial Tasks																			
	Raw material processing (cleaning, cutting, crushing, sorting, grading)																			
	Coarse																			
	Medium																			
	Fine																			
	Very fine																			
	Materials handling																			
	Wrapping, packing, and labeling																			
	Picking stock, classifying																			
	Loading, inside trucks and freight cars																			
	Component manufacturing																			
	Large																			
	Medium																			
	Fine																			
	Machining																			
	Rough bench or machine work																			
	Medium bench or machine work (ordinary automatic machines, rough grinding, medium buffing, and polishing)																			
	Fine bench or machine work (fine automatic machines, medium grinding, fine buffing, and polishing)																			
Extra-fine bench or machine work (fine grinding)																				

IESNA Lighting Design Guide

II. INDUSTRIAL LOCATIONS AND TASKS ^(a)																			Very Important				Important				Somewhat important				Blank = Not important or not applicable																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																			
Design Issues																			Appearance of Space and Luminaires	Color Appearance (and Color Contrast)	Daylighting Integration and Control	Direct Glare	Flicker (and Strobe)	Intrinsic Material Characteristics	Light Distribution on Surfaces	Light Distribution on Task Plane (Uniformity)	Luminances of Room Surfaces	Modeling of Faces or Objects	Reflected Glare	Shadows	Source/Task/Eye Geometry	Special Considerations	Notes on Special Considerations	Illuminance on Task Plane ^(b)	Category or Value (lux)	Notes — see end of section	Reference Chapter(s)																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																													
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III. OUTDOOR LOCATIONS AND TASKS		Very Important	Important	Somewhat important	Blank = Not important or not applicable																	
Design Issues		Appearance of Space and Luminaires	Color Appearance (and Color Contrast)	Direct Glare	Light Distribution on Surfaces	Light Pollution/Trespass	Modeling of Faces or Objects	Peripheral Detection	Point(s) of Interest	Reflected Glare	Shadows	Source/Task/Eye Geometry	Sparkle/Desirable Reflected Highlights	Surface Characteristics	Special Considerations	Notes on Special Considerations	Illuminance (Horizontal)	Category or Value (lux) ^(a, b)	Illuminance (Vertical)	Category or Value (lux) ^(a, b)	Notes on Illuminance — see end of section	Reference Chapter(s)
Advertising Signs and Poster Boards (see Bulletin and Poster Boards, or Signs)																						
	Bikeways																					Ch. 21, 22, 29
	Alongside roadways — commercial areas																					
	Distant from roadways																					
Building																						
	General construction																					
	Excavation work																					
Building Exteriors																						
	Entrances																					Ch. 21, 29
	Active (pedestrian/conveyance)																					
	Inactive (normally locked, infrequent use)																					
	Prominent structures																					
Building and Grounds Security (see Section VI, Emergency, Safety, and Security)																						
Buildings and Monuments, Floodlighted																						Ch. 21
	Bright surrounding																					
	Light surfaces																					
	Medium light surfaces																					
	Medium dark surfaces																					
	Dark surfaces																					

IESNA Lighting Design Guide

III. OUTDOOR LOCATIONS AND TASKS		Very Important										Important		Somewhat important		Blank = Not important or not applicable						
		Appearance of Space and Luminaires	Color Appearance (and Color Contrast)	Direct Glare	Light Distribution on Surfaces	Light Pollution/Trespass	Modeling of Faces or Objects	Peripheral Detection	Point(s) of Interest	Reflected Glare	Shadows	Source/Task/Eye Geometry	Sparkle/Desirable Reflected Highlights	Surface Characteristics	Special Considerations	Notes on Special Considerations	Illuminance (Horizontal)	Category or Value (lux) (a, b)	Illuminance (Vertical)	Category or Value (lux) (a, b)	Notes on Illuminance — see end of section	Reference Chapter(s)
Design Issues	Logging																					Ch. 19
	Yarding																					
	Log loading and unloading																					
	Log stowing (water)																					
	Active log storage area (land)																					
	Log booming area (water) — foot traffic																					
	Active log handling area — (water)																					
	Log grading — water or land																					
	Log bins (land)																					
	Lumber Yards																					Ch. 19
	Marinas																					Ch. 21, 23
	Parks, Plazas, and Pedestrian Malls																					Ch. 21
	Parking Areas																				(4)	Ch. 22, 29
Piers																					Ch. 23	
Freight																						
Active shipping area															(3)							
Active shipping — surrounds															(3)							
Passenger																						
Prison Yards																						Ch. 14

Railroad Yards										Ch. 19, 23
Retarder classification yards										
Receiving yard										
Switch points									5	
Body of yard									3	
Hump area									A	
Control tower and retarder area										
Head end									A	
Body									A	
Pull-out end									10	
Dispatch or forwarding yard									20	
Hump and car rider classification yard									10	
Receiving yard									20	
Switch points									5	
Body of yard									20	
Hump area									10	
Flat switching yards									A	
Side of cars									A	
Switch points									A	
Trailer-on flatcars									20	
Horizontal surface of flatcar									A	
Hold-down points									A	
Container-on flatcars									A	
Retail Spaces - Outdoor										Ch. 13, 17, 21, 29
Fast food restaurants									C	
Car dealerships — business district									C	
Front row — adjacent to roadway									A	
Car dealerships — small towns									A	
Front row — adjacent to roadway									B	
Convenience stores									A	
Pedestrian mall									A	
Service station									A	
Dark surrounding									A	
Approach									15	
Driveway									15	
Pump island area									A	
Building faces (exclusive of glass)									20	
Service areas									20	
Landscape highlights									10	
Light surrounding									3	
Approach									20	
Driveway									20	
Pump island area									B	
Building faces (exclusive of glass)									A	
Service areas									A	
Landscape highlights									20	
5									5	

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III. OUTDOOR LOCATIONS AND TASKS		Very Important	Important	Somewhat important	Blank = Not important or not applicable																	
		Appearance of Space and Luminaires	Color Appearance (and Color Contrast)	Direct Glare	Light Distribution on Surfaces	Light Pollution/Trespass	Modeling of Faces or Objects	Peripheral Detection	Point(s) of Interest	Reflected Glare	Shadows	Source/Task/Eye Geometry	Sparkle/Desirable Reflected Highlights	Surface Characteristics	Special Considerations	Notes on Special Considerations	Illuminance (Horizontal)	Category or Value (lux) (a, b)	Illuminance (Vertical)	Category or Value (lux) (a, b)	Notes on Illuminance — see end of section	Reference Chapter(s)
Design Issues																					(5)	Ch. 22
Roadways																					(6)	Ch. 22
Roadway Rest Areas																						Ch. 21
Sculptures																	A	B				Ch. 19, 23
Ship Yards																						
General Ways																	A	A				
Fabrication areas																	B	B				
Shopping Centers (see Parking and Building Exterior, Entrances)																						
Signs																						Ch. 21, 22
Advertising															(2)		A	C				
Externally lighted roadway															(2)		A	C				
Smokestacks with Advertising Messages (see Bulletin and Poster Boards)																						
Storage Yards																						Ch. 19
Active																	C	A				
Inactive																	10	3				
Streets (See Roadways)																						Ch. 22
Tunnels																					(7)	Ch. 22

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IV. SPORTS AND RECREATION LOCATIONS AND TASKS ^(a)	Very Important													Important		Somewhat important		Blank = Not important or not applicable	
	Color Appearance (and Color Contrast)	Daylighting Integration and Control	Direct Glare	Flicker (and Strobe)	Light Distribution on Task Plane (Uniformity)	Light Pollution/Trespass	Luminaire Noise	Modeling of Faces or Objects	Reflected Glare	Shadows	Special Considerations	Notes on Special Considerations	Illuminance (Horizontal)	Category or Value (lux) ^(b)	Illuminance (Vertical)	Category or Value (lux) ^(b)	Notes on Illuminance — see end of section	Reference Chapter(s)	
Archery (Indoor) Target at 18.3m Shooting line																	(1)		
																	(1)		
Archery (Outdoor) Target at 30.4m Shooting line																			
Badminton (Indoor)																			
Baseball Professional (Outdoor) Recreational																	(2)		
																	(2)		
Basketball Indoor Outdoor																			
Billiards																			

IESNA Lighting Design Guide

IV. SPORTS AND RECREATION LOCATIONS AND TASKS ^(a)	Very Important												Important		Somewhat important		Blank = Not important or not applicable	
	Color Appearance (and Color Contrast)	Daylighting Integration and Control	Direct Glare	Flicker (and Strobe)	Light Distribution on Task Plane (Uniformity)	Light Pollution/Trespass	Luminaire Noise	Modeling of Faces or Objects	Reflected Glare	Shadows	Special Considerations	Notes on Special Considerations	Illuminance (Horizontal)	Category or Value (lux) ^(b)	Illuminance (Vertical)	Category or Value (lux) ^(b)	Notes on Illuminance — see end of section	Reference Chapter(s)
Design Issues																		
Horse Shows																		
Lacrosse																		
Playgrounds																		
Quoits																		
Racing (Outdoor)																		
Motor — Track																	(3)	
Bicycle — Track																	(3)	
Dog																	(3)	
Dragstrip																		
Racquetball																		
Indoor																		
Rodeo and Animal Shows																		
Roque (see Croquet)																		
Shooting, Indoor																		
Target																		
Shooting line																		

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V. TRANSPORTATION ^(a) LOCATIONS AND TASKS	Very Important																			Important			Somewhat important			Blank = Not important or not applicable		
	Appearance of Space and Luminaires	Color Appearance (and Color Contrast)	Daylighting Integration and Control	Direct Glare	Flicker (and Strobe)	Light Distribution on Surfaces	Light Distribution on Task Plane (Uniformity)	Luminances of Room Surfaces	Modeling of Faces or Objects	Point(s) of Interest	Reflected Glare	Shadows	Source/Task/Eye Geometry	Sparkle/Desirable Reflected Highlights	Surface Characteristics	System Control and Flexibility	Special Considerations	Notes on Special Considerations	Illuminance (Horizontal)	Category or Value (lux) ^(b)	Illuminance (Vertical)	Category or Value (lux) ^(b)	Notes on Illuminance — see end of section	Reference Chapter(s)				
Aircraft																								Ch. 23				
Passenger compartment																												
General																												
Reading (at seat)																												
Airports																								Ch. 23				
Hangar apron																												
Terminal building apron																												
Parking area																												
Loading area																												
Buses (See Road Conveyances)																								Ch. 23				
Rail Conveyances																								Ch. 23				
Boarding or exiting																												
Fare box (rapid transit train)																												
Vestibule (commuter and intercity trains)																												
Aisles																												
Advertising cards (rapid transit and commuter trains)																												
Back-lighted advertising cards (rapid transit and commuter trains)																												
860 cd/m ² (80 cd/ft ²) average maximum.																												

IESNA Lighting Design Guide

V. TRANSPORTATION ^(a) LOCATIONS AND TASKS	Very Important										Important			Somewhat important			Blank = Not important or not applicable							
	Appearance of Space and Luminaires	Color Appearance (and Color Contrast)	Daylighting Integration and Control	Direct Glare	Flicker (and Strobe)	Light Distribution on Surfaces	Light Distribution on Task Plane (Uniformity)	Luminances of Room Surfaces	Modeling of Faces or Objects	Point(s) of Interest	Reflected Glare	Shadows	Source/Task/Eye Geometry	Sparkle/Desirable Reflected Highlights	Surface Characteristics	System Control and Flexibility	Special Considerations	Notes on Special Considerations	Illuminance (Horizontal)	Category or Value (lux) ^(b)	Illuminance (Vertical)	Category or Value (lux) ^(b)	Notes on Illuminance — see end of section	Reference Chapter(s)
Design Issues																								
Reading (at seat)																			D	B				
Rest rooms (intercity train)																			D	B				
Dining area (intercity train)																			D	D				
Food preparation (intercity train)																			E	E			(1)	
Lounge (intercity train)																								
General lighting																			B	B		A		
Table games																			D	D				
Sleeping car																								
General lighting																			A	A				
Normal reading																			D	D				
Prolonged reading																			E	E				
Road Conveyances																								Ch. 23
Step well and adjacent ground area																			A	A				
Fare box																			B	B		A		
General lighting																			A	A				
City/intercity buses at city stop																			A	A				
Intercity bus at country stop																			A	A				
School bus while moving																			B	B		A		
School bus at stops																			D	D		A		
Advertising cards																						D		
Back-lighted advertising cards (see Rail Conveyances)																								
Reading (at seat)																			D	D				
Emergency exit (school bus)																			A	A				

IESNA Lighting Design Guide

V. TRANSPORTATION ^(a) LOCATIONS AND TASKS	Very Important														Important				Somewhat important				Blank = Not important or not applicable				Reference Chapter(s)
	Appearance of Space and Luminaires	Color Appearance (and Color Contrast)	Daylighting Integration and Control	Direct Glare	Flicker (and Strobe)	Light Distribution on Surfaces	Light Distribution on Task Plane (Uniformity)	Luminances of Room Surfaces	Modeling of Faces or Objects	Point(s) of Interest	Reflected Glare	Shadows	Source/Task/Eye Geometry	Sparkle/Desirable Reflected Highlights	Surface Characteristics	System Control and Flexibility	Special Considerations	Notes on Special Considerations	Illuminance (Horizontal)	Category or Value (lux) ^(b)	Illuminance (Vertical)	Category or Value (lux) ^(b)	Notes on Illuminance — see end of section				
Design Issues	Workshops																										
	(see Machining in Section II, Industrial)																										
	General																	(6)	D	B							
	On bench top																	(6)	E	C							
	Machine shop																		G	E							
	Cargo holds																										
	Safety																		A	A							
	During cargo handling																		D	B							
	Passageways and trunks																		A	A							
Transportation Terminals	Waiting room and lounge																		B	A					Ch. 23		
	Ticket counters																		E	D							
	Baggage checking																		D	B							
	Rest rooms																		B	D							
	Concourse																		A	A							
	Boarding area																		B	B							
Notes:																											
(a) Design issues are listed for room or space. Refer to specific task under Reading or Graphic Design and Materials, for example, for task design issues and illuminance																											
(b) Low illuminances (less than 30 lux) are given in lux; values greater than 30 lux are given in letter categories.																											



Plate 1. The magnificence of the architecture has been redefined by a new lighting system in this cathedral. Lanterns from 1929 were refurbished, 1949 downlights were retrofitted with tungsten-halogen lamps, a new indirect lighting system was installed to emphasize the ceiling vault and dome, and a television lighting system was added, all controlled to allow lighting level flexibility from 0 to 100%.

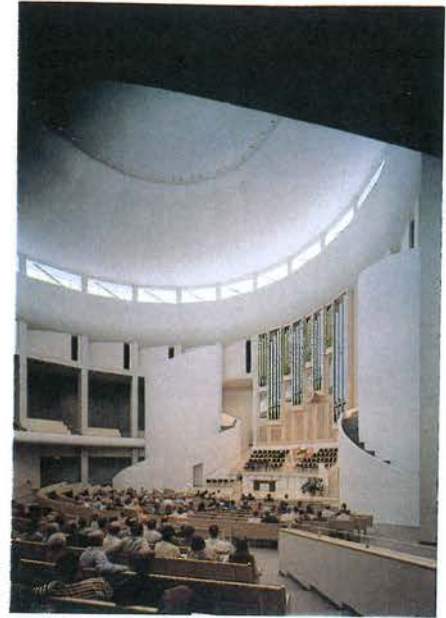


Plate 2. This sanctuary features a spiral ceiling, a centrum (altar), an organ, and a clerestory. The space is lighted for general assembly, with the organ and centrum serving as illuminated focal points. Floodlights provide ambient illumination. Warm white cold cathode lamps, concealed in a continuous architectural cove, uplight the spiral to its 200 ft peak.

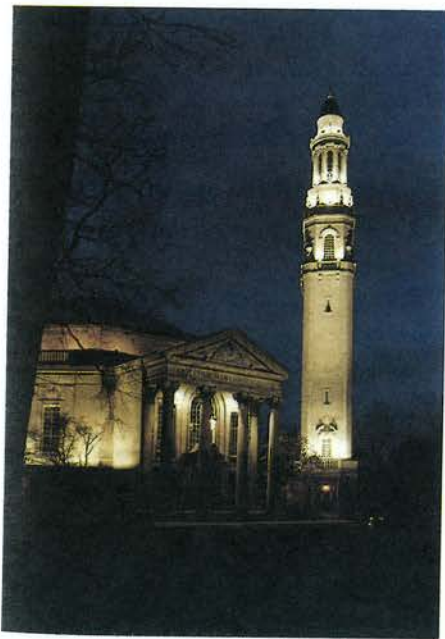


Plate 3. Lighting the exterior of this historic church and bell tower emphasizes the structure's uniqueness and significance, highlights their graceful architectural features, and provides drama to a nighttime view.



Plate 4. The lighting on vertical surfaces in the pulpit area can be raised to 70 fc, sufficient for color television broadcasting. The surrounding ambient light is then raised to about one-third of the broadcast level to mitigate any unpleasant glare from the television lighting for either the clergy or the congregation.



Plate 5. A festive, yet elegant mood was created for an entrance to a hotel and casino. The main lighting features include strings of low-wattage incandescent lights inserted into column slots, translucent alabaster column capitals that conceal fluorescent striplights, halogen wall sconces, blue neon cove uplight, incandescent bowl pendants, and PAR38 halogen downlights.



Plate 6. Main Concourse and restored Sky Ceiling, Grand Central Terminal, New York, New York. The new lighting scheme for this renowned architectural jewel incorporates new lighting technologies with classical structural elements. Beneath the decorative lunettes and cornice, a row of more than two hundred 25-W compact fluorescent lamps, set in custom cylindrical containers, spans the perimeter of the vast concourse. A fiber-optic system illuminates the constellations in the vaulted-ceiling firmament. The ceiling was painted a blue-green to simulate the night sky.

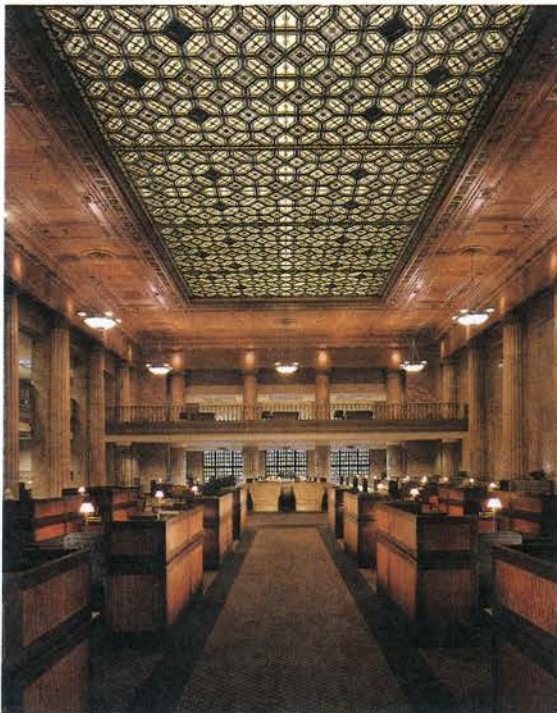


Plate 7. The main banking hall of a landmark bank building features a stained-glass ceiling, decorative multi-arm bowl pendants, and task lights on the desks. In the main traffic areas and at the teller's station, fluorescent lamp luminaires with parabolic louvers provide general illumination.



Plate 8. Shoppers use mall areas to rest and congregate. Lighting must address a variety of purposes: provide general ambient lighting; add emphasis where appropriate, yet not compete with individual store windows and entrances; and be flexible to accommodate special displays and attractions. Landscape lighting adds aesthetic beauty and serenity, and contributes to a desired image.



Plate 9. Metal halide lighting in industrial luminaires installed over this skating rink provides good general illumination for skaters and a glare-free ice surface. The uplight contribution creates a feeling of spaciousness and pleasantness in the space.

Plate 10. This sports facility features a multi-purpose gymnasium surrounded by an indoor track. Metal halide lighting is used for ambient illumination.



Plate 11. The outdoor lighting of this shopping mall not only emphasizes the architecture, but it serves to attract customers to the mall's stores and restaurants.



a



b



c

Plate 12 a, b, c, and d. Paintings, sculptures, and art objects are effectively lighted with track lights, which can be aimed to provide an even wash of light over an object (a) or to emphasize certain features, such as color or texture (b). In (c) light from several directions models the sculpture and provides a dramatic background of shadows that are as interesting to look at as the sculpture itself. In (d) daylight is admitted into this gallery through a translucent skylight, and the amount of light transmitted is carefully controlled. Track lighting provides both supplementary general illumination and accent lighting for the ornamental objects (hand-painted screens) in this exhibit.



d

Lighting Applications

IV

11. Office Lighting
12. Educational Facility Lighting
13. Hospitality Facilities and Entertainment Lighting
14. Lighting for Public Places and Institutions
15. Theatre, Television, and Photographic Lighting
16. Health Care Facility Lighting
17. Retail Lighting
18. Residential Lighting
19. Industrial Lighting
20. Sports and Recreational Area Lighting
21. Exterior Lighting
22. Roadway Lighting
23. Transportation Lighting
24. Underwater Lighting