National Institute of
BUILDING SCIENCES

Low Vision Design Program

Design Guidelines for the Visual Environment

Funded by generous support from the
Hulda B. and Maurice L. Rothschild Foundation

Also supported by the
Jim H. McClung Lighting Research Foundation

An Authoritative Source of Innovative Solutions for the Built Environment

MAY 2015

Design Guideline for the Visual Environment May 2015

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Acknowledgements

This guideline was developed by the Low Vision Design Committee of the National Institute of Building Sciences (NIBS) through initial funding from the U.S. General Services Administration (GSA) and subsequent grants from the Hulda B. and Maurice L. Rothschild Foundation and the Jim H. McClung Lighting Research Foundation.

The Low Vision Design Committee was established by the NIBS Board of Directors in September 2011 as an outcome of the September 2010 Workshop on Improving Building Design for Persons with Low Vision. Proceedings of that workshop are available at the NIBS Low Vision Committee Website: http://www.nibs.org/?page=lvdc. That workshop was sponsored by the U.S. General Services Administration at the request of Vijay K. Gupta, who was the chief mechanical engineer at GSA until his retirement in January 2011. The committee expresses its gratitude to Vijay for his continued active participation in its activities since his retirement.

Development of the guideline began as a committee activity in September, 2012. Members of the Low Vision Design Committee are listed in Appendix 4B.

The committee thanks the Hulda B. & Maurice L. Rothschild Foundation for its early strong encouragement, endorsement, and funding, which enabled the committee to organize and to commence its work. The ongoing financial support and guidance of the foundation, and especially the active participation of its president, Robert N. Mayer, PhD, for a wide range of very significant tasks, has been instrumental in the ability of the Committee to continue to move towards its objectives.

The committee also expresses our sincere gratitude to the Jim H. McClung Lighting Research Foundation, for its generous encouragement and financial support.

Foreword

We see with our brains, not with our eyes. Light—from direct sources and surface reflections in the environment—enters the eye and impacts the retina. Signals produced by the retina's rods and cones are then transmitted to the brain, which, influenced by our psychology, translates that information into what we know as our "visual experience."

While treatment of low vision and other visual disorders are medical issues, assuring optimal access to the built environment for persons with visual impairments is a design issue. Whether we are fully sighted or have sight limitations, visual cues in the architecture and interior design of a space aid us in our interactions with our surroundings. Lack of clarity in visual cues or any defect in our interpretation or comprehension of the environment can reduce our ability to understand or to safely navigate the environment. As low vision affects an increasing percentage of the population, particularly as a consequence of aging, the need to accommodate persons with low vision in the built environment increasingly must be addressed.

Lighting design is key to the visual environment: Using natural and electric lighting to illuminate objects in a space while minimizing negative effects such as glare and low contrast is beneficial to all sighted persons. Light and contrast in the visual environment are equally important for persons with low vision to see and understand the environment around them.

To evaluate the effects of light in a design, we need to know:

- Quality of the visual environment (balanced luminances and low glare)
- Quantity of light on visual tasks providing good task contrast
- The vision (or view) expected to be perceived by the occupants
- The impact that light has on health and safety.

Glare, improper low contrast, and low illuminance levels are three of the most common visual impediments in the built environment. Many modern buildings are designed with large areas of glazing for daylight and views, and with extensive electric lighting systems. Often, people with low vision have not been considered in design; so that many existing buildings present hazards and confusion to them through such common features as:

- Glare from windows and luminaires
- Confusing reflections in polished wall and floor surfaces and stairs
- Optically misleading geometries in floor patterns and stair finishes
- Inadequate lighting on vertical surfaces, walking surfaces and stairs
- Inadequate locations and quantity of task lighting and lack of lighting adjustability
- Improper use of light source spectral distribution.

The Need for Guidelines

Low vision is characterized by vision that is no longer correctable by glasses, contact lens, surgery, or medication.[1] Low vision is severe enough to cause difficulty with the ability to complete daily living tasks. Vision impairment occurs from age; injury, such as traumatic brain injuries experienced by war veterans; or disease. Different diseases affect different parts of the visual system and cause different patterns of vision loss, which result in different functional deficits and accommodative needs.

The need to address accommodation of people with low vision in all building types increases as the population ages, and the US Census tells us that seniors are the fastest growing segment of the population, with more than 40 million people in the US over the age of 65 in 2011 (a 15% increase since 2000). As an older adult with normal vision ages, adaptation time from a glaring environment to a darker environment slows, color discrimination decreases, contrast sensitivity decreases, and visual acuity decreases in low contrast conditions. The area of visual field in which older adults with normal vision can maintain their visual attention also gets smaller as one ages.[2].

The Americans with Disabilities Act of 1990 (ADA) made access to nearly all facilities in the United States by all Americans people with disabilities a national priority and a civil right. Many of the design requirements of the ADA have been incorporated into building codes and other state or locally enforced requirements for facilities facility design by jurisdictions nationwide. The federal government, through the Architectural Barriers Act of 1968 (ABA), has mandated accessibility to federal buildings. These statutes have been translated into physical design guidance through the development of guidelines. These guidelines have had significant impact on the design of buildings in the United States, making them accessible to people with a variety of disabilities. While accommodating some needs of people who are blind, the current ADA and ABA Standards fall far short of addressing the needs of people with low vision.

This document hopes to fill that gap by proposing guidelines to encompass design for persons with low vision and other visual impairments. It is the intent of this guideline to inform the regulatory and design communities about the challenges experienced by low vision populations and to provide specific design recommendations regarding the visual environment in order to afford equal access to all facilities through universal design principles.

Purpose

With the increasing emphasis on accommodation of people with low vision within the built environment, clinicians indicate that it would be useful to quantify values of light by measurable parameters that take into account occupant perception. Likewise, designers may find it helpful to be able to quantify visual environments/occupant perceptions using the same measurable values. This guideline offers both clinicians and those accountable for building performance the means to achieve these values, based on empirical data from published laboratory and field studies, recommended design practices from technical societies, as well as from published post-occupancy evaluations of buildings occupied by both low vision and normally sighted persons.

In developing this guideline, it has become clear that there are many issues related to the visual environment that have not been studied and tested sufficiently to yield good data. Therefore, we hope that this guideline will also serve as a roadmap for future research and feedback in order to create a more robust universe of empirical data to guide the regulatory and design communities.

Scope

This design guideline addresses planning and design of a building and site, including all features used to access the building or facility, such as walkways and pathways, stairs, and ramps; interior spaces, including finish materials, and fixed and moveable furniture; and the lighting design, including the use of daylighting and electrical lighting.

This guideline is intended for use in new construction and alterations of public accommodations and commercial facilities required to be accessible by the ADA and the ABA. The Guidelines will be very useful for the design of residences, especially senior housing and care facilities to increase their independence, and safety.

Measurements

All dimensions in this document show the dimension designated by code or regulation in parentheses with the corresponding international metric designation preceding it. For example: 1.52 m (60 in) diameter clearance for navigation of a wheelchair in an accessible toilet room.

What is Low Vision?

"Low vision" has been defined as "chronic visual impairments that cause functional limitations or disability" (1) where:

- *Chronic* means that low vision cannot be corrected with medical or surgical intervention or refractive error correction
- *Visual impairment* means loss of visual acuity, loss of contrast sensitivity, loss of peripheral vision, or the occurrence of central blind spots
- *Functional limitations* means increased difficulty with reading, mobility, visual motor activities, interpreting visual information and night blindness.
- *Disability* means unable to perform usual or customary daily activities (See Chapter 4.)

Major contributors to vision impairments and their functional implications include:

- **Glaucoma**, a group of eye diseases that can lead to blindness by damaging the optic nerve. The eye continuously produces a fluid, which must drain from the eye to maintain healthy eye pressure. The pressure can cause damage to the optic nerve, which transmits information from the eye to the brain. In the most common, age-related form, there are usually no noticeable symptoms initially and a person with glaucoma may not be aware of visual changes immediately.

  Glaucoma results in peripheral vision loss initially, and the effect can be a "tunnel vision" effect that makes it difficult to navigate without bumping into objects that are off to the side, near the head, or at foot level. The brain often fills in blind spots in the visual field, which can make it difficult for the person to be aware of the extent of vision loss. Individuals with field loss from glaucoma need to identify the boundaries of their visual field loss and learn to locate objects in their environment more easily. Visual acuity may not be affected so the individual may be able to read signage; however glaucoma can cause loss of contrast sensitivity, which affects ability to distinguish curbs, edges of steps, and reading text on screens with low contrast between text and background (2).

- **Macular Degeneration (MD)** is a gradual, progressive, painless deterioration of the macula, which is the small area in the center of the retina that provides detailed vision. Older persons are most at risk of age-related macular degeneration (AMD), but MD can affect people of all ages. In adults, there are two types of MD: dry and wet. Most MD starts as the dry type and in 10-20% of individuals, it progresses to the wet type. In wet MD, abnormal blood vessels develop under the macula and break, bleed, and leak fluid. This damages the macula and if left untreated can result in rapid and severe loss of central vision. MD always occurs in both eyes, but does not necessarily progress at the same pace in both eyes; it is possible to experience the wet type in one eye and the dry type in the other (3).

People with MD may have trouble reading mail or newspapers but have no trouble spotting an object off to the side or while walking around, even in unfamiliar places. Damage to the macula reduces the clarity of what the person is looking directly at, and also reduces contrast sensitivity. Therefore, identifying faces and seeing curbs and steps may be difficult .Glare from bright direct light can wash out the peripheral receptors that the individual with MD uses to navigate the environment and filtered lenses are often very useful to reduce this effect. Also, contrast improvements can help the brain fill in the gaps in missing vision.

- **Diabetic retinopathy** is the leading cause of new blindness. “Retinopathy" is a general term that describes damage to the retina, which converts incoming light into electrical impulses. These electrical impulses are carried by the optic nerve to the brain, which interprets them as visual images. Diabetic retinopathy occurs when diabetes damages the tiny blood vessels in the retina (4) .

  Vision may change from day to day or even from morning to evening, in response to changing blood glucose levels. Some individuals have peripheral vision loss mimicking glaucoma, others have central loss similar to MD; still others experience bleeding in the vitreous that can create a glare problem like cataracts. Functional implications include:
  - Blurred or double vision; blurred central vision from macular edema can interfere with reading
  - Flashing lights, which can indicate a retinal detachment
  - A veil, cloud, or streaks of red in the field of vision, or dark or floating spots in one or both eyes, which can indicate bleeding
  - Blind or blank spots in the field of vision
  - Decreased visual acuity
  - Decreased depth perception, in combination with decreased visual acuity, can make it difficult to see curbs and steps, or walk into a public facility.

- **Retinitis pigmentosa (RP**) is part of a large group of hereditary retinal conditions involving one or several layers of the retina, causing progressive degeneration. In the most common forms of RP, it is initially the rods of the retina (which mediate night vision and which predominantly populate the peripheral retina) that are affected, with later dysfunction of the cones. The condition which involves both eyes, is inherited and is generally diagnosed later in life. (A related condition, Ushers Syndrome, may show up early in life. This is accompanied by hearing loss that might be significant.).

  People with this progressive degeneration of the retina usually retain central vision until late in the disease, as the periphery slowly constricts. Individuals with RP will start to notice an increasing difficulty in night vision with progressive constriction of the visual field to tunnel vision of 20 degrees or less in the better-seeing eye, and total blindness eventually (5).

- **Cataract** is a progressive cloudiness, hardening, and yellowing of the normally transparent lens of the eye. According to the National Eye Institute, approximately 50 percent of all Americans will either have a cataract or will have had cataract surgery by age 80 (6). Functional implications include:
  - Reduced ability to perceive lower contrast
  - Reduced ability to perceive color: The lens gradually becomes yellowish or brownish, and is no longer clear or transparent. Vision acquires a "brownish" tint, making it difficult to tell the difference between certain colors, such as navy blue, brown, and black; or blue, green and purple. This change in color can also degrade the sharpness of a person's vision.
  - Problems with depth perception: Judging distances accurately requires closer attention. In addition, shadows and shadow patterns can be incorrectly interpreted as drop-offs, level changes, steps, or obstructions.
  - Need for more light: As we get older, we generally need three to four times more light to perform everyday activities. This need for increased light occurs gradually, and most people are not aware that their lighting requirements may have changed over time.
  - Increased sensitivity to glare: Too much light can also produce glare, which can interfere with seeing surroundings clearly.
  - Overall blurring: Lack of detail makes it difficult to tell time, read, watch television, see food on a plate, and walk safely indoors and outdoors, since depth perception may also be affected. Some people with cataracts describe the effect as being similar to looking through a window that is hazy and streaked with dirt.

Prevalence of Low Vision in the Population

The low vision population is comprised of people who have disease-related or age-related vision loss as well as people with eye conditions that affect vision temporarily or permanently (7). Consequently, most of these individuals are used to having good vision and may not have adapted to reduced vision, nor have most of them had low vision services. Most have not received skills-training such as orientation to the environment, trailing or self-protective techniques, or braille. Most do not use mobility canes. If traveling with others, most are not trained in proper human guide techniques.

Approximately 89 million people in the U.S. over the age of 40 (i.e., 63%) have vision problems, according to 2010 data and statistics from the National Eye Institute of the National Institutes of Health (8). Within this population, nearly 17 million (i.e., 19%) have chronic visual impairments including:

- 2.9 million with reduced visual acuity that cannot be corrected with medical or surgical interventions or refractive error corrections, defined as Low Vision (> 20/40 in the better seeing eye)
- 1.3 million with legal blindness (≥ 20/200 in the better seeing eye)
- The sum of these two populations, 4.2 million persons, is in agreement with the estimate of 4.5 million from the clinical database of more than 1,000 patients (1)
- 2.1 million with macular diseases (e.g., age-related macular degeneration)
- 7.7 million with retinal diseases (e.g., diabetic retinopathy)
- 2.7 million with glaucoma.

These numbers are growing with the general population, but with acceleration in the age groups above 75 years old

Empirical data from five studies (1) reveal that the prevalence rate for those with low vision, defined in these studies as visual acuity worse than 20/70 in the better eye, is relatively flat at approximately 1% for ages less than 55 to 60 but then accelerates and becomes very steep at age 75. At the age of 80, the prevalence rate is about 10% of the general population at that age (1). From five carefully controlled and published studies, prevalence is projected to increase linearly by approximately 33% during the next 15 years. (1).

These studies also reveal that two-thirds of the people with low vision are women, primarily because women live longer (1), but the age distribution among women with low vision is similar to the age distribution among men with low vision.

CHAPTER 1 – General Design Principles

Design for the built environment has multiple components: successful accommodation of functional requirements, safe and durable construction, and aesthetic quality. We react to these components through all of our senses, and a design may be considered successful if building users perceive through their senses that all of the building components are safe and acceptable. If building users experience a shortfall in these perceptions, their safety, performance, and independence in the environment may be compromised. As one of the more common shortcomings of design is the inability of persons with low vision to be able to fully engage with their environment, it is the purpose of these guidelines to help designers more fully accommodate this population.

Light that enters the eye is characterized and measured both indirectly and directly. Signals from this light impingement are emitted from receptors in the retina. These signals are transmitted to two different parts of the brain where: 1) perception and vision occur (1) and 2) circadian rhythms are regulated. (See Appendix 5A).

A visual environment is comprised of interrelated components:

- Sources of light (intensity, distribution, brightness, color)
- Materials and surfaces that reflect light from the sources (reflectance and specularity)
- Luminance balance throughout the visual scene.

This chapter defines the characteristics of these components in terms to design and evaluate visual environments. Where possible, these characteristics are expressed as measurable parameters and values based on empirical evidence obtained in laboratory tests or from verifiable field data.

1.1 What do we "see?"

When we "see" a surface, we are really seeing the light reflected from it back to our eyes. *Surface luminance* is how we measure that reflected, directional light, and is affected by light striking the surface (illuminance), the size of the surface, and the surface reflective characteristics.

1.1.1 What are surface reflective characteristics?

Surfaces have light reflective characteristics typically expressed in terms of the percentage of light falling on it that is reflected away, identified as the Light Reflectance Value (LRV). A typical default example is 80% for ceilings, 50% for walls, and 20% for floors.

Surfaces also vary from being diffuse to specular. Diffuse reflection assumes that light is reflected off the surface in a “Lambertian” manner. This means that the luminance is uniform in all directions, regardless of the direction of light falling on the surface, which can be simply calculated and is why typical lighting calculations assume all surfaces are diffuse. Specular surfaces are like mirrors where the light is reflected perfectly geometrically, which is also a simple geometric calculation. Semi-specular surfaces combine diffuse and specular reflections, and require bidirectional reflectance distribution function (BRDF) to model. Most architectural interiors have a mixture of surface characteristics, from specular marble floors to diffuse drywall to semi-specular semi-gloss paint.

Spectral reflectance characteristics of the surface equates to the color of the surface. The spectral distribution function of the light source plays an important role in how we perceive surface colors.

1.2 Lighting Design Methods (Illuminance and Luminance)

There are two general lighting design methods—illuminance and luminance—used to calculate and evaluate the lighting design. Illuminance by far is the method most commonly used by designers; luminance is more complex, but more accurately describes the visual scene from one fixed point of view. Readers are referred to the Illuminating Engineering Society’s *The Lighting Handbook, 10th Edition* [http://www.ies.org/handbook/} for current calculation methods.

1.2.1 Illuminance

Illuminance-based design predicts the amount of incident light on a surface. Incident light is a combination of light coming directly from the light source (electric or natural) and reflected light from other surfaces. The electric light source illuminance is derived from the photometric characteristics of the light source and the relative location (distance and angle). Reflected illuminance is typically assumed to be from diffuse, gray surfaces.

1.2.2 Luminance

Luminance-based design predicts the amount of reflected light off a surface in a particular direction. Reflected light is a combination of illuminance and surface reflectance characteristics. In order to perform luminance-based design, we need to know the defining surface characteristics of all surfaces within the visual field. (If the surfaces are semi-specular, surface BRDFs are required.) An ideal model would also take into account spatial spectral distribution characteristics in order to predict perceived colors and color contrast.

1.2.3 Illuminance is today's standard design method; luminance is tomorrow's

Illuminance is the most commonly used design method and is understood by all lighting designers. It is a first step towards design and, combined with uniformity ratios and limiting photometric distribution in glare zones, should predict quality designs.

While luminance better represents what we see, it is extremely challenging in predicting and concisely reporting. Viewer location, viewing angles, and surface characteristics are all required for this modeling, while typically during the lighting design phase specific surfaces have yet not been selected. Luminance-based design is not well understood by designers, partly because there are few computer programs that model luminance in a way that is practical for use as a design tool. Except for roadway lighting, there is to date no luminance criteria established by the Illuminating Engineering Society (IES), the source of industry-standard criteria.

Luminance calculations can be used today to supplement illuminance calculations by spot-checking for high luminance contrast ratios. Eventually, as better data and design tools become available, luminance design will likely become the method of choice for lighting design, particularly if after further research, IES establishes luminance criteria and publishes technical guidance, especially for populations with low vision. Designer education will be crucial at that juncture. As of this writing, however, illuminance-based design is the practical choice for most applications.

Table 1. Comparison of illuminance and luminance design methods

Design Method Comparison	Illuminance Based Design	Luminance Based Design
Units	Lux	Candela/meter^2
Amount of light	Yes	Yes
Reflected light	No	Yes
Light source brightness	No	Yes
Contrast	No	Yes
Glare potential	Maybe (vertical illuminance)	Yes
Circadian Rhythm	No	Yes
Calculation Method Available	Yes—Simple	Yes—More Difficult
Measurements and Verification	Yes	Yes

Design Method Comparison	Illuminance Based Design	Luminance Based Design
What we "see"	No	Yes
Calculations Methods Available	Yes	Yes
Calculations Dependent on:		
--Photometric Data	Yes	Yes
--Viewing Location	No	Yes
--Surface Reflectance Characteristics	Diffuse and gray for inter-reflections	Yes
Complexity	Low	High
Daylight Modeling	Yes	Yes
Field Measurements		
--Illuminance Meter	Yes	
--Luminance Meter		Yes
--HDR Camera		Yes
Repeatable	Yes	Maybe
Criteria Available	Yes	Only for roadway lighting
Designer Knowledge	High	Low to none

1.2.4 Light Source Spectral Distribution and Material Colors

The ability to see and to differentiate between surfaces and objects in the visual environment are dependent on the spectral distribution characteristics of the light source, color of objects/materials, and the combination of these characteristics. Circadian rhythms may also be affected by these light sources. (See Appendix 5A.) Procedures for calculating values of color and value are described in Appendices 5B and 5C. Product information on CCT and CRI values is available from the manufacturers.

Light source spectral distribution is described in two different ways, Correlated Color Temperature (CCT) and Color Rendering Index (CRI).

Light in the "blue" range (460 – 480 nm), similar to what is found in daylight or light from the blue sky during the middle of the day, has a positive biological impact, but this same wavelength in the evening and at night from electric light sources may have a negative impact on circadian rhythm entrainment and melatonin secretion.

Color Rendering Index (CRI) is an indicator on how well material colors are represented under a specific light source (scale of 0 to 100). The higher the CRI (above 70), the better the color appearance. (See Appendix 5C).

1.3 Additional Considerations

1.3.1 Architectural Controls

Architectural treatments of the site, building, and façade offer a primary means to achieve control of luminance contrast and glare from daylighting. Building orientation, possible shade from trees and other buildings, exterior controls (reveals, louvers, and light shelves), glazing systems, and interior light shelves and shading all should be considered, especially during the conceptual design phase.

1.3.2 Building Systems and Controls

Because every individual has unique vision capabilities and personal tolerances, flexibility in controlling environmental quality is very important, especially when trying to accommodate the range of low vision disorders. (See Appendix 5D.)

CHAPTER 2 – Site and Landscape Design

Site planning must be integrated with the design of the building and respect the surrounding context and orientation. The following are typical site design considerations that can affect older adults and persons with low vision. As each site is unique, it is recommended that a site analysis devoted to vision issues and safety issues be performed before design begins.

The designer should be alerted to the importance of surface characteristics of exterior design elements, which can play a crucial role in the comfort and safety of older adults and other persons with low vision. The designer should also be alert to possible impacts of the site planning and design that could result in glare, which is both distracting and uncomfortable to vision and a potential safety hazard for trips and falls. For instance, the intensity of sunlight when striking a walking surface makes the selection of the light reflectance value and sheen of the paving material an important consideration. At night, elements with a high value contrast help to define a change of level, vertical and horizontal surfaces, and objects from their background—all important considerations when designing for older adults and persons with low vision. (For more information on site planning related to building design, see Chapter 3: Architecture, Lighting and Interior Design.)

2.1 Approaches to the Site and Building(s)

It is recommended that, wherever possible, all approaches to a building or facility be considered accessible routes as defined in the U.S. Department of Justice 2010 ADA Standards for Accessible Design (ADA Standards) (24; 30), or be accessible for persons with low vision with features recommended in this Section 2.1, or without steps or stairs. (If some approaches cannot be made accessible for persons with low vision, it is recommended that visual or other directions be provided to direct persons to the accessible route.)

- Where bollards and other barriers are used in sidewalks and other pedestrian pathways, they should be a minimum of 1 m (48 in.) (20). It is recommended that the color, form, and other features of the bollards and other barriers contrast with the surroundings so that they do not present a hazard that could cause pedestrians to collide with the barriers either in daylight and darkness (see Table 4D-2)).
- It is recommended that paving be of medium-dark color value and not glaringly reflective, especially in plazas, outdoor eating areas, and other open spaces where reflections of sunlight into the building could add to glare (see Table 4D-2.)
- It is recommended that curbs, wheelstops, and other changes to the level of paving be of contrasting color and value. Bollards that have horizontal ornamental projections, or are linked by chain or rope are a hazardous falls risk to many persons, including those with low vision.

Where bollards with linking chains are used as barriers to prevent pedestrians from stepping into traffic, the chains must be visually prominent in dimensions and color so people with low vision do not miss seeing them. However, caution should be used in selection of use of varying colors and patterns in paving that might obscure actual steps or other changes in paving levels or, conversely, may become false suggestions of level changes.

See Table 4D-2.

2.2 Building Orientation, Location, and Form

Building orientation will affect the amount of direct and reflected solar penetration of interior spaces, and the need for controls to mitigate or prevent consequent glare. Buildings with natural landscape and views will benefit from reduced reflected solar load and glare and provide better occupant comfort. Narrow footprint shapes favoring the south and north façade exposures will enhance daylight exposure opportunities from more than one direction. Wherever possible under site and location conditions, the following are recommended:

- Direct east- and west-facing exposures should be avoided for building occupancies such as offices and other workspaces to avoid the direct low angle light from the rising or setting sun.
- Design buildings to maximize daylight penetrations without direct sunlight
- Locate buildings with views of landscape when possible.

2.3 Site Circulation

It is recommended that walkways in the public right-of-way comply with the following, in addition to the standards of the Authority Having Jurisdiction:

- Walkways must not present hazards of tripping and falling due to uneven surfaces or from steps, curbs, and edging that are not clearly visible with change of color, value, and texture. Curbs and other walkway edges should be raised above the walkway pavement a minimum of 100 mm (4 in.) (20), and be of contrasting color or value sufficient to be clearly visible to the pedestrian as a pavement boundary. Pavement edge curbs are generally not needed where there are handrails. (See Table 4D-2.)
- The approach pathways to public entrances must be easily identified with signs or visual clues such as architectural or landscape features so that approaching persons will be able to locate the entrance.
- Stairs and steps should be designed with leading edges (i.e., nosings) that clearly contrast in color and value with treads and risers (24). Where steps cross grades, tapered risers to meet grade may be hazardous to the unwary pedestrian who may be unable to see the edge of the step and/or detect them visually or who may have balance issues. Where possible, tapering should be avoided or, in addition to contrasting leading edges, use

handrails to lead or guide the pedestrian to the full step and riser section of the stair/steps.

- Pavement patterns and color changes that could be mistaken for steps should be avoided where they cross paths of pedestrian travel.
- Drains and gratings should be placed to the sides rather than in the pathways in paved pedestrian areas. Gratings bars should run perpendicular to the path of travel and be spaced not more than 13 mm (1/2 in.) apart (20).
- Avoid lighting placement that shines directly into pedestrians' eyes.
- Walkway lighting should be provided to minimize glare. For example, bollard lighting should be directionally downward and overhead, and post lighting should be baffled from view by walkers looking at the pathway.
- Lighting directed toward the facades and other vertical surfaces of a building or facility is preferable to fixtures directed outward from eaves, as often is done for security. Careful coordination of lighting is needed to avoid "blinding" closed circuit televisions (CCTV security cameras) on one hand and building occupants on the other, while providing desired building and landscaping lighting for aesthetic purposes.

2.4 Courtyards and Plazas

In general, courtyards and plazas are subject to many of the same recommendations as other paved areas, with the following additional considerations:

- Older adults and those with low vision have longer adaptation times when moving from areas of bright to dim lighting and vice versa. Therefore, where courtyards and plazas are accessed from the building or are part of the entrance design, transition from the bright light of an outdoor space to an indoor space should be made with a vestibule in which the daylight level is reduced by the design or with glazing or shading devices.
- Where courtyards are adjacent to the building walls, large glass areas such as windows in the building perimeter could be mistaken for openings by the person with low vision. Therefore, clearly visible barriers to prevent accidental collision are recommended, such as horizontal rails, mullions, or muntins. Doorways must be clearly identified.
- Fixed seating, tables, containers, etc., should comply with Section 2.5 below.
- Landscaping within the courtyard or plaza should comply with Section 2.6 below.
- Sculpture placed within paved areas of a courtyard or plaza if not of a size, form, and/or color that is readily visible in contrast to the surroundings, should be placed or mounted to avoid accidental collision by pedestrians with low vision, such as providing a contrasting pedestal or highlighted by a contrasting outline of the base that is flush with the surrounding walkway to avoid a trip hazard.
- Lighting in courtyards and plazas should be provided to minimize glare. Bollard lighting should be directionally downward.

2.5 Street and Site Furniture –Signs, Benches, Containers, etc.

- Site furniture (and pole-mounted lighting, signs, etc.) should be placed out of the path of pedestrian travel and be designed and located so as to be visible to pedestrians at all times and under natural and electric lighting.
- Benches and other seating should be a contrasting color value to the surroundings to be clearly visible and be placed offset from the pedestrian route in order not to present a collision or tripping hazard.
- Trash and recycling containers should be clearly visible in form, color, and value contrast with the surroundings and adjacent glazed areas at a height of not less than 1 m (40 in.) (20), and be placed offset from the pedestrian route in order not to present a collision or falls hazard.
- Security barriers, such as bollards, low fences, or walls, should be designed to pose no hazard to the pedestrian with low vision, who may not be able to see these barriers when they occur in unexpected places in the pedestrian access path.

2.6 Landscaping

- Trees should be selected to avoid low-hanging branches projecting into paved walkways and plazas such that they might present a hazard to pedestrians.
- Trees that drop fruit, nuts, or cones seasonally should be avoided next to paved walkways to minimize falls risk from objects on the path.
- Landscaping can be used to help guide pedestrians in large, open paved spaces as “landmarks” along with bollards and site furniture to assist in wayfinding.
- Select hardscaping and plant borders with easily identifiable edges.

2.7 Water Features

Water features such as fountains, ponds, etc. should be ringed with seating or otherwise placed to avoid falls risk.

- Raised perimeters such as walls, seating, etc. of 600 mm (24 in.) (20) height above adjacent walkways or other paving can provide safe barriers from accidents.

2.8 Wayfinding

Buildings and complexes such as campuses that are accessible to the public should be provided with wayfinding aids to assist in locating destinations with signs, maps, and other visual and auditory aids. These are especially useful to first-time visitors and should be designed to be used by people with low vision as well as people with normal vision. The following recommendations supplement Section 703 of the Americans with Disability Act Accessibility Guidelines for Buildings and Facilities (30).

- Viewing distance for various types of wayfinding should be considered to be at least 2 m (7 ft.) (28). However in some circumstances (e.g. where areas at signs are congested or where information needs to be conveyed at greater distances to allow appropriate reaction and response), it may be appropriate to allow for considerably greater viewing distances.

- Wayfinding aids should be located in prominent positions perpendicular to the flow of traffic, where possible, for easy discovery from vehicles—where appropriate—and foot traffic.
- Wayfinding aids mounted on posts are vulnerable to damage and may be hazardous if too close or protruding into the path of travel. Wayfinding aids suspended overhead may be difficult for low-vision users to see and may be missed since such users frequently concentrate downward to avoid stumbling hazards. However, if overhead wayfinding aids are used, they should be mounted at a minimum of 2100 mm (84 in) above the path of travel. (Signs on walls may be preferable, and should be mounted at between 1400 mm and 1700 mm (55 – 67 in.) for standing persons and between 1000 mm and 1100 mm (40 – 43 in.) for wheelchair users (28).
- Tactile wayfinding aids (braille) are generally not familiar to older adults and persons with low vision, but all wayfinding aids should comply with the following:
- Information displays, lettering styles, spacing and other features should comply with ADA Standards 703.2 (30), and as follows:
    - Signs are more legible for people with low vision when characters contrast with their background with a Light Reflectance Value (LRV) as recommended in Table 4D-2.
    - Lettering and other graphics should be monochromatic white information on black field because many persons with low vision have some degree of color blindness and difficulty with low contrast. See also Table 4D-2.
    - Raised or incised lettering not contrasting in color or value with the surrounding field is not recommended for use by persons with low vision. Shadows may confuse rather than enhance visibility.
  - Wayfinding surface illumination should be uniform and as recommended in Table 5C-1, Ref. 4, in daylight and after dark and the sign surfaces should be shielded from the light source to avoid reflected glare.
  - Internally illuminated or backlit signs may be difficult for persons with low vision due to glare.
  - Variable message signs may be suitable with the following recommendations (28):
    - Use left-justified text a minimum of 22 mm (7/8 in.) high but not less than 1 percent of the distance at which the sign is to be read.
    - Use sans-serif fonts with upper and lower-case in simple sentences without abbreviations.
    - Space characters about ¼ of the font width, and space words more than characters.
    - Space lines apart 50 percent of text height where multiple lines are needed, but avoid fewer than 3 lines.
    - Do not use multiple colors or flashing messages.

  - Liquid crystal displays may be difficult for persons with low vision, especially where they may be subject to direct sunlight or strong shadows. LED and other internally illuminated displays are preferable.

2.9 Other Design Issues

The following additional design recommendations will benefit both people who are fully sighted as well as those with low-vision:

- Curbs and other steps or changes in level in any pedestrian route should be painted with a reflective paint material to be more visible in the dark.
- Card or proximity door lock systems are preferable to numeric keypads because combination numbers may be forgotten, and keypads are more difficult to use. Card operated or proximity systems that can be programmed to invalidate lost cards or key fobs and issue replacements are available.
- When necessary to use them, keypads and instructions for entrance lock, parking meters, and ticket machines should be illuminated at all times and be designed with the features recommended below:
  - The telephone layout (rather than the calculator layout) is recommended for keypads, with a single raised dot on the 5 for keypads on public access terminals.
  - The font for numeric keypads should have an open shape and be at least 4mm high (a closed shape makes it more difficult to distinguish numbers such as 3 and 8). Ensure a good contrast between the typeface and the color of the keys.
  - All keys should be a non-reflective finish, tactually discernible and raised by at least 2mm (±.07 in.). Recessed keys can be difficult for people with arthritic conditions and others with poor manual dexterity. Edges of key buttons should be 2.5 mm (±0.1 in.) apart.
  - Where possible, use equipment that provides tactile and/or audible feedback when buttons are depressed or the lock is disengaged.
  - Color-coded keys may not be discernible to some persons with low vision, but if used, use red for cancel; yellow for clear; and green for enter, proceed, accept, etc. If possible, use different shapes for these keys.
- Door hardware and lighting at entrances should be coordinated to ensure that lock keyways, intercom devices, doorbell buttons, etc., are illuminated after daylight hours.
- Spill light or light trespass (especially non-shielded security flood lighting) from adjacent buildings and sites and from on-site fixtures onto sidewalks, parking areas, and pathways, etc., is a common glare problem. Non-shielded exterior lighting viewed from the inside of buildings can also be a source of glare—even outside security (or building façade lighting) directed into windows of occupied spaces. Light trespass—spills onto other properties and rights-of-way—may be regulated by ordinances.
- For transitions between outdoors and indoors, provisions should be made for adjusting the lighting to suit various day and night lighting conditions and to avoid backlighting.

CHAPTER 3 – Architecture, Lighting, and Interior Design

Designs that accommodate persons with low vision require more than usual attention to surface characteristics of the built environment and to the need for continuity between the site and building or other facility. This is especially so with respect to transitions from the bright daylight of outdoors to the lower light conditions of the interior, known as “Dark Adaptation”. , “Light Adaptation” occurs when the eye changes from a dark environment to a brighter environment. Light adaptation occurs very rapidly, whereas, dark adaption happens slowly. After dark, attention to the transition from interior lighting is critical because older adults and persons with low vision have longer adaptation times when moving from areas of brighter light to lower levels of lighting and darkness. Many persons with low vision as well as seniors also experience a loss of contrast sensitivity.

Environments that utilize a distinct value contrast to define the elements of the space provide valuable information for people to negotiate their environment safely. Value contrast is particularly critical in areas of circulation to define changes of level, vertical and horizontal surfaces, and objects from their background. Surface characteristics, including value, sheen, texture and pattern, are all important considerations when designing for persons with low vision. (See Tables 4D-2, and Appendix 5C, Surface Characteristics).

3.1 Overall Building Concern: Daylighting Control

Windows, skylights, and other openings to the outdoors bring important spatial and psychological benefits to the rooms they serve. They entice people to go outside. They allow occupants to view the outdoors, sense the time of day (affecting circadian rhythms), note weather changes, and feel less confined in an artificial interior environment. The daylight, especially direct sunlight, admitted by windows and skylights continuously changes and often must be controlled to achieve an optimal safe visual environment, free of glare and shadows. Architectural treatments of the site, building, glazing, shading, and façade treatments offer a primary means to achieve control of luminance contrast and glare from daylighting.

The amount of daylight admitted to a building may affect building energy consumption. Energy codes, regulations, and standards require a Daylight Factor of 2% for as much as 75% of the building area. Meeting this daylight factor may require controls to achieve acceptable contrast and glare values. Similarly, compliance with energy codes, regulations, and standards should be reviewed for maximum allowable Lighting Power Density (LPD) values for indoor and many outdoor areas. The limits for LPDs have been increased in common areas for facilities used primarily by persons who are visually impaired (16), due to the understanding that this population group requires higher levels of light.

The following items should be considered, especially during the conceptual design phase:

3.1.1 Building Orientation

- The basics of architectural design reveal that north and south exposures of a building are the most uniform in terms of light and the easiest to control. The east and west exposures tend to produce the most glare penetration into a building because of the severe angles of sun at sunrise and sunset.
- An Aspect Ratio (i.e., length of main axis compared to minor axis) of greater than 3.0 will enhance the penetration of daylight into the center of the building (31).
- A practical depth of daylight penetration is approximately 15 m (45 ft.) without skylights or light shelves (31).

3.1.2 Windows and Other Openings

- Control glare. If daylight is not properly regulated, glare results and may interfere with visual comfort, wayfinding, safe ambulation, and performing tasks particularly in today's computer environment.
- Avoid a single source of daylight: Daylighting from more than one direction in a space may be beneficial in balancing the light throughout the room during the day. The shape of the ceilings can significantly affect how ambient daylight can be provided throughout a room.
- Windows and other glazed openings that occur directly ahead of a path of travel, for example, at the end of a corridor, may present strong glare unless diffused or mitigated with curtains, window shades, or other means. Placement of such openings to the side of the path of travel may be a better solution.
- Multiple sources of penetration (e.g., windows in adjacent walls) may prove difficult to provide in some spaces - particularly those with relatively low ceiling heights. Higher ceiling heights are encouraged to help balance and increase penetration of the daylight. Interplay with electric ambient light to balance the light levels becomes an option.
- Spaces reliant solely on daylighting can become too dark for a person with low vision to navigate without supplemental electric lighting. Luminance contrast for wayfinding in daylighted spaces should be considered both with and without the contribution of the daylighting to maximize the navigational assistance provided for older adults and persons with low vision, when daylight is not present..

3.1.3 Reveals, Exterior Louvers, and Exterior Light Shelves

- Exterior controls, such as reveals, louvers and intercept the visual brightness of daylight, which can thus reduce glare.

- Exterior louvers may be vertical or horizontal. Orientation of the louvers may be fixed, adjusted manually, or adjusted automatically with photo-sensors and motors.

- Exterior light shelves, which are horizontal elements that can be built into the building façade, redirect light to illuminate ceilings where it is reflected to interior spaces and helps provide luminance balance. The horizontal projection also blocks the view of sky from viewers inside. The brightness of the sky is also a source of glare.

3.1.4 Glazing Systems

Glazing systems include windows, curtain walls, doors, skylights, and other fenestrations through which visible light is transmitted. Treatments of the glazing materials can reduce glare, which helps persons with some vision disorders. These treatments include:

- Exterior shading
- Interior shading.

3.1.5 Interior Light Shelves and Shading

Interior devices such as the following may also reduce glare:

- Interior light shelves
- Woven or Horizontal or Vertical Blinds, depending on the orientation of the glazing and the color/value density of the material
- Drapes, depending on the orientation of the glazing and the color/value density of the drapery material.

3.1.6 Lighting Calculations:

The following procedures for lighting calculations are recommended for all regularly occupied spaces:

- Spatial Daylight Autonomy (sDA) and Annual Sun Exposure (ASE) (32).
- Point- by- point Illuminance calculations for each area. Refer to Appendix 5B for procedures.
- Calculate task surface Illuminance.
- Calculate values for appropriate luminance contrast parameters

The following procedures for lighting calculations are recommended for intermittently occupied spaces:

- Calculate circulation surface Illuminance such as the floor or stairs. Point-by-point, area-by-point, or utilization factor methods may be used to estimate Illuminance values.

The following procedures for lighting calculations are recommended for select/critical areas (e.g., regularly occupied spaces, locations where wayfinding is the primary task, where potential hazards exist):

- Calculate values for appropriate luminance contrast parameters

- For areas where view to the outside is important or where the light spectrum is important for color rendering or circadian patterns (see Appendix 5A), determine values

3.2 Building Entrances

3.2.1 Doors

All stairs and steps leading to building entrances should be designed with handrails and nosings that clearly contrast in color and value with treads and risers. Where steps cross grades, tapered risers to meet grade may be a trip hazard to the unwary pedestrian. Where possible, avoid tapering or use high-contrast handrails to guide the pedestrian to the full step and riser section of the stair/steps.

- Public entrances must be easily identified as such from the street, by their design, architectural setting and location in the building facade, or signage must be provided at the street to direct people to the public entrance. Other doors, such as restricted use doors for employees-only and egress-only doors, could be misconstrued as entrances by the unwary unless they are placed in less conspicuous locations, have less commanding design or have large-print signage to inform the approaching persons.
- Doors must be visually distinguishable from sidelights and other adjacent features, i.e. mirrored panels, to avoid confusing approaching users. This is most simply accomplished by designing stiles and rails to make transparent areas different from adjacent sidelights.
- Power-operated and power-assisted doors should be easily identified visually, such as with decals on the doors or with high-contrast push plates or other operating switches placed and lighted to be visible on the approach. Power sliding doors are preferable to swinging doors. Power-operated out-swinging doors should be provided with sensors far enough away from the door on the approach side to prevent collisions between door swings and entering users.
- Glazed doors and side panels should have decorative features , i.e. signs, logos, or emblems at eye level (between 1400 and 1600 mm (54 and 62 in.) above floor level and repeated at a lower level 1m (39 in.). The size of the features should be larger than 150 mm (6 in.) and visible from both inside and outside the building (20).
- Because some persons with severe sight limitations may be escorted by another person, consideration should be given to providing at least one door wide enough (e.g., 1200 mm (48 in.) for two persons to pass. This should include revolving doors if no swinging doors are used.

3.2.2 Vestibules

All entrance doorways shall have thresholds compliant with ADA Standards and shall not have steps or stairways closer than 1 m from the doorways. It is recommended that vestibules be provided for all exterior entrances—especially at the main public entrance to a facility. The vestibule should be not less than 2,400 mm (96 in.) (20) between doors to provide room for people to pause for visual adjustment to changing light between the two sets of doors without obstructing the door swings. Greater distances may be needed for power-operated out-swinging doors with approach sensors. In addition:

- Thresholds, gratings, and floor mats can become tripping hazards if not designed to be flush with the adjacent floor finishes.
- Because vestibules are relatively compact spaces, surface finishes that are highly reflective can be visually confusing and should be avoided.
- Transparent door areas are desirable to allow users to see other people approaching on the opposite side. Since fully-glazed doors may confuse some persons with reflections of themselves seen as another approaching person, smaller glazed areas are preferable. Large, transparent door areas can be a hazard if not protected with divisions or mullions to prevent accidental collisions. Glazed sidelights should be similarly protected.
- The vestibule can serve as a transitional space between indoor and outdoor lighting levels. Provisions should be made for adjusting the lighting to suit various day and night lighting conditions and to avoid backlighting. A place to sit should be provided within the vestibule that is out of the pathway where the users can allow their eyes to adapt to the change of light levels from interior to exterior.

3.3 Lobbies

Traditional building lobbies are typically large, high-ceilinged open spaces designed to serve as reception, orientation, wayfinding, and security screening spaces, which are consequently well-populated and visually confusing at peak periods. They are the transitional spaces from the outside world to the building's interior circulation, and often include monumental stairs, elevators, escalators, and other circulation features:

- Planning of the entrance area should provide for the first-time visitor, without a guide companion, who may need assistance finding information about navigating the building. This might suggest placing reception personnel as close to and directly visible from the point of entry as possible. In buildings with security screening, security personnel should be sensitized to the needs of persons with low vision to assist them through the screening process and direct them to the reception and building information directory.
- Touchscreens for building directory and wayfinding information should provide fonts and graphics that persons with low vision can read, and be augmented with sound. Placement of the device should be such that it is easily seen from the entry door and activation of the screen should be obvious such as by a large, visible button. Dynamic tactile systems (electro-mechanical arrays for changeable braille characters) for Braille users might be located adjacent the touch screens. Position the touchscreen to avoid glare from windows and lighting for people standing and sitting.
- The use of electronic audio communications as audio guidance assistance in buildings may not be adequate if visitors cannot be assumed to be equipped with the necessary receiving devices before they enter the building. However, audible announcement systems are useful for emergency announcements.

- Personal audio assistance receivers using triggering key fobs, smart phones, or similar handheld devices may be useful for populations who frequent facilities such as schools and places of employment where the system can be designed to serve that population and devices can be made available for regular use. Careful design of the audio assistance system's speech quality, message length and clarity, and coordination with other audible systems is crucial to avoiding confusion and misunderstandings.

3.3.1 Atriums

- Many modern public buildings are designed with lobbies and other interior areas that are multi-story glazed spaces, often referred to as an "atrium." These spaces may serve as lobbies, or as interior courtyards used for many purposes, such as circulation, dining and assembly. These spaces are often challenging to the person with low vision because of the amount of daylight introduced to them by wall glazing and skylights, and because they are adjacent to interior, electrically illuminated rooms, corridors, and other areas. Transitional spaces between the atrium and adjoining corridors, elevator lobbies and other circulation spaces to permit adjustment to changes in lighting level are strongly recommended. Lighting levels at the floor level should not change suddenly such as where accent downlighting is used.
- Atrium travel for guidance to important destinations such as emergency exits, information/registration desks, elevators, etc. may be enhanced by the use of high-contrast signage, tactile flooring, changes in lighting level, and visual contrasts of floor surfaces.

3.3.2 Wayfinding Aids

Directional and wayfinding graphic aids are important for all buildings used by the public, especially for people visiting for the first time. In addition to the guidance provided for signs in ADA Standards 703 (30), the following is recommended to accommodate persons with low vision:

- Persons with low vision may not be proficient in interpreting braille. Therefore, visual aids are more appropriate, and should be placed as close to the main entrance doors as possible to be readable before entering the lobby without having to search for the reception desk, security facilities, etc.
- All graphics must be adequately illuminated at all hours, and should have high-contrasts between figures or text and background field. See introductory discussion to this chapter and Table 4D-2.

3.3.3 Reception

Where a lobby reception is provided, the location must be easily identified and coordinated with any security procedures located in the lobby. Such reception facilities should be provided with seating if visitors are required to wait to be escorted by facility personnel. Furniture must be positioned out of the walkway and have a color/value contrast to their background, making the furniture easily seen by persons with low vision in order to avoid the risk of accidental collisions and falls. Chairs with arm rests should be included. See Table 4D-2.

3.3.4 Vertical Circulation

Stairs in lobby areas should be designed with contrasts between treads and risers as required for all other stairs (see below). As for unenclosed stairs, the design must prevent collision with the underside of the stair by means that do not also create a tripping or collision hazard (such as curbs or low planters).

- Escalators and moving walkways should be designed with the following, in addition to all code and regulatory requirements:
  - Tread nosing edges in yellow or other highly visible color with permanent solid materials rather than painted.
  - Underside protections as recommended for monumental freestanding stairs above.
- Under-step demarcation lighting and yellow combs at the entry to and exit from the escalator to make the access safe and visible.
- Elevators should be designed with the following, in addition to all code and accessibility requirements:
  - Elevators should be placed in separate alcoves off the main lobbies that are well-defined by lighting and other visual cues to provide, where applicable, lighting transition between low-level elevator cab lighting and high-level lobby lighting.
  - Elevators that are softly lit inside should not open directly to a day lit atrium, but should open to a transitionally brighter lobby.
  - Elevator buttons should have contrasting, easy-to-read fonts that are internally lighted for better visibility.

3.3.5 Surface Finishes

- Highly polished floor finishes are potentially difficult for persons with low vision due to glare and reflections, especially where floor-to-ceiling windows are in use. It is recommended that floors be a matte finish with textured coating rather than polished. Sheen and contrast should be as recommended in Table 4D-2.
- Avoid flooring patterns that could be mistaken for steps or changes in floor surface, such as stripes, or geometric patterns. These can also be confusing, especially where the design is perpendicular to the direction of travel. These can be especially hazardous in broad steps leading to changes in floor level. See also Table 4D-2.
- Vertical surfaces that are reflective also may be confusing to those with low vision, and “full height” mirrors should not be used in contact with the floor where the reflection could be mistaken for a doorway or extension of the space.

3.3.6 Lighting

Electric lighting should generally be uniform along the length of corridors. The use of task lighting such as at room entrance doors facilitates reading the room number and use of an entrance device, such as a key or card key. Higher lighting levels at elevators help to locate the elevator as a wayfinding device. Lighting should be even; avoiding pools of light in an overall dim environment. See Table 4D-2.

3.3.7 Fenestration

Allowing daylight and outdoor views in lobby spaces should be balanced against energy and security considerations, but the impact of glare should also be given consideration. Glare is a concern especially when one is entering a lobby space with daylighting where there may be more muted electric lighting from an interior corridor or elevator lobby.

3.4 Lounges and Waiting Areas

The purpose of the lounge or waiting area must be considered, whether it is for short-term holding or longer term activities, including reading, break and relaxation needs.

3.4.1 Surface Finishes

- Flooring: If the lounge or waiting space is a part of a circulation space such as a lobby or corridor, a change in flooring may be desired for aesthetic, acoustic, or other reasons. Care should be taken to avoid tripping hazards such as rugs and low tables.
- Wall finishes: Consideration should be given to reducing contrast between wall finish colors and values with adjacent windows. Where it is useful or important to distinguish one wall element from another such as door frames, increasing contrast can be helpful to the person with low vision.
- See Table 4D-2 for further guidance.

3.4.2 Furniture

Lobby waiting and lounge furniture should be selected to be clearly visible in form, color and value against the flooring and other surrounding surfaces so that they don't become collision hazards. Low ottomans and coffee tables can be particularly hazardous when "floated" in open lobby and other circulation areas. Provide some chairs with arm rests.

- Arrangement of seating should allow users to choose a location that is facing toward a view or away from the daylight.
- Daylight can be used as task lighting for reading the newspaper or a book.
- Seating arranged for conversation should be flexible and movable. Avoiding placement of heavy furniture pieces, i.e. sofas and love seats, in front of windows, due to the luminance contrast of the daylight and light falling on the face of a seated person.

- Many people who are hearing impaired rely on lip reading to augment their understanding of verbal communication. Facing toward a window will make it impossible to see the fine details of the other person's face and lips.

3.4.3 Lighting

- Generally, high-intensity down lighting may be unsuitable in lounge seating areas where people may sit to read, because the down lighting may create difficult shadows on reading matter. Table lamps or similar task lighting offer more control and may be more appropriate.

3.4.4 Fenestration

- Fenestration placement and design for a lounge or waiting space should consider potential impact of glare for those in the seating area.
- Arrangement of seating should allow users to choose a location that is facing toward a view or away from the source of glare.

3.5 Interior Circulation Spaces

3.5.1 Corridors

Generally, circulation corridors should maintain constant width. Columns, furnishings, and other objects should be placed outside the paths of circulation and be clearly visible by contrasting color and value to avoid obstructing free and safe movement.

3.5.2 Ramps

Ramps and steps are hazardous if they cannot be easily seen such as by change in color, value or texture, at the beginning and end of the ramp and by contrasting color and value between treads and risers. Patterns in the flooring material may obscure the edge of a step and are not recommended. See Sections 1.2, 1.3 and Appendix 5C for additional guidance.

3.5.3 Railings

Railings may be useful in many circulation areas, and when in contrasting color and value persons with low vision more easily locate the railings, especially at interruptions such as for doors.

3.5.4 Doorways

Doorways should contrast with the surrounding walls in material, color, and value to make them more easily identifiable. Hardware such as locks, latches, and pulls should be contrasting in color and value with the door, and room numbers and other graphics must be placed and illuminated in order to be easily read. If a door has the same finish on both sides, a contrasting color and value should be provided on the leading edge of the door. This allows a person with low vision to identify that the door is open and prevents them from running into the edge of the door. See Sections 1.2, 1.3 and Appendix 5C for additional guidance.

3.5.5 Elevator lobbies

- Contrasting colors and textures are recommended between elevator doors, frames, and walls of the elevator alcove.
- Elevator lobbies or alcoves should be varied in design, finishes, and other features from floor to floor to help elevator users identify the specific floor, including large-type floor numbers or names.
- See Section 3.3.4 for additional guidance.

3.5.6 Surface Finishes

In some buildings where corridor systems may be complex or potentially confusing to the user, it may be helpful to vary the wall treatments, colors, patterns, artwork or materials to help orient the user.

3.5.7 Lighting

Electric lighting should generally be uniform along the length of corridors. The use of task lighting, such as at hotel room entrance doors, facilitates visibility of the room number and use of an entrance device such as a key or card key. Higher lighting levels at elevators provide a wayfinding device to help locate the elevator. Lighting levels should be even; avoiding pools of light on the floor or scalloped patterns on the walls in an overall dim environment.

3.5.8 Fenestration

Fenestration may be introduced to circulation areas such as side walls of the corridors for aesthetic purposes,, to improve security and to help in orientation by maintaining views of the outdoors. Light levels must be even, avoid high luminance contrast created from windows, especially at the end of corridors.

3.5.9 Wayfinding Aids

Wherever possible, wayfinding aids should be placed facing the direction of travel rather than on walls and doors along the corridor sides. Signage placed across corridors at the ceilings may be difficult to see for some people with low vision to see and may be difficult to illuminate properly.

- All wayfinding aids must be in high contrast with the surrounding fields in color and value. See Table 4D-2.
- All wayfinding aids require electric lighting illumination that does not result in glare from reflections off the signage or adjacent surfaces[3] (34).

3.6 Stairways

3.6.1 Surface Finishes

- Stair risers should contrast with treads to aid in visibility to persons ascending the stairs.
- Stair tread nosings should be in high contrast colors and values from stair treads and should be 50 mm (2 in.) wide so that the edge of each tread is highly visible to the user descending.
- Stringers or skirting should have a strong value contrast with treads and risers to enhance their visibility.
- Highly figured or patterned materials should be avoided, as they may be confusing to those with low vision. Continuous carpeted stair runners with such designs may camouflage the edge of the tread and create a fall hazard.
- The sloping undersides of stairs and escalators could become a head-bumping hazard, so spaces under the stairs or escalators must be enclosed or otherwise protected to prevent access below a height of 2030 mm (80 in) See also ADA Standards 307.4 (30).
- See Table 4D-2.

3.6.2 Hand rails

In addition to code and regulatory requirements, the following is recommended:

- Hand rails should contrast with wall surfaces in color and value.
- Where handrails turn corners, it is preferable that they be continuous rather than interrupted.

3.6.3 Undersides

The sloping undersides of stairs could become a head-bumping hazard, so spaces under the stairs should be enclosed or otherwise protected to prevent access below a height of 2030 mm (80 in).

3.6.4 Lighting

In addition to requirements of life safety codes, electric lighting of stairways must be designed to make the step edges clearly visible, especially in the direction of egress— usually in the downward direction. Uniform, diffused lighting which does not produce soft shadows on the treads is desirable.

3.6.5 Fenestration

Fenestration with glare control may be introduced to stairways to improve aesthetics, to improve security, increase light levels, and to help in orientation by maintaining views of the outdoors.

3.7 Elevators

The following are recommended in addition to requirements of applicable codes and regulations:

3.7.1 Surface Finishes

Include car handrails on three sides using tubular in preference to flat rails. See Table 4D-2.

3.7.2 Controls and Signals

- Locate high-contrast call buttons and other controls to be readable by persons seated in wheelchairs in the car as well as standing persons..
- Select car controls and floor position signals so that floor number buttons and other graphic information are internally illuminated and not obscured by glare from the cab lighting.

3.7.3 Lighting

Lighting from the elevator car ceiling should be diffused and uniform rather than strong downlights, which create pools of high-contrast light and glare.

3.8 Toilet and Bath Rooms

Public toilets and baths are problematic for persons with low vision because often the spaces are small relative to the number and size of objects typically in them—fixtures, compartments, accessories, etc. Monochromatic color schemes may have the effect of confusing the viewer with low vision.

Entrance doorways and screening entrance vestibules are often difficult for a person with an escort to use. Therefore, wherever space permits, entries without doors and with extra width is desirable (such as is common for high volume use in airports).

The following recommendations are offered to improve the definitions of these objects in order to make them easier to see and use.

3.8.1 Surface Finishes

- Matte finishes on architectural surfaces are preferable to highly polished ones.
- Colors and values of wall and floor surfaces should contrast with those of the plumbing fixtures.
- Partitions arranged to baffle views into the toilet room from the public areas outside can be confusing to the person with low vision. It may help to vary the colors and values of the baffle wall to make it stand out by providing contrast with other walls.
- Lavatory bowls should contrast in color and value from the countertop in which the bowl is set.
- Toilet partitions should differ in color and value from the walls of the toilet room.

3.8.2 Plumbing Fixtures

In many public buildings, white plumbing fixtures are the most practical to maintain, clean, and replace, so these may be the brightest objects in the room. This is appropriate since they will be most discernible when set against darker finishes surrounding them.

3.8.3 Plumbing Trim and Accessories

- Plumbing trim (such as faucets and flush valves) may be seen more easily if specified finishes are darker and less mirror-like such as brushed or satin chrome or nickel, pewter, or oil-rubbed bronze rather than polished chrome,.
- Everyone easily uses electronically activated faucets and flush valves, and they are especially convenient for people with low vision .
- Accessories such as paper towel and other dispensers may be used more easily when their finishes contrast with the walls and countertops on which they are mounted.. The operating devices for paper towel dispensers should be of high contrast.
- Liquid and foam soap dispensers should be placed so that spillage falls into lavatory basins or on a countertop rather than on the wall or floor. Designs that have larger spaces under the dispensing nozzle are easier for everyone to use.
- Full-length mirrors may be mistaken for doorways by persons with low vision, if the mirrors are located where a door might be expected such as at the entrance to a public toilet room. Many building owners prefer not to place mirrors over the lavatories to reduce hair grooming over the lavatories. However, these can be placed on other walls at

an appropriate height for grooming without being full height. They should be placed to allow lighting from the sides rather than from directly above.

- A shallow counter or shelf below the mirror provides a place for cosmetics and other grooming aids and helps to define the mirror as a grooming area.

3.8.4 Lighting

- To avoid shadows and dark areas, ambient lighting for restrooms should cover all areas evenly, including toilet stalls and entrance vestibules. Shadows and dark areas often occur in the entrance areas, and create discomfort and confusion because of the decrease in visual functioning.
- Vanity lighting at mirrors should be selected to avoid glare while illuminating the vanity surface and the face of the user. Lighting should be placed on each side of the mirror in addition to ambient lighting from above.

3.8.5 Fenestration

- Most public restroom do not have windows with a view, others may have clerestory windows to provide daylight. Where windows do occur, glare from daylight may be exacerbated by the light colors and polished surfaces often used in these spaces. Window position and treatment to control the amount of daylight entering should be considered.
- Windows facing the user upon entering a toilet room are especially challenging to persons with low vision. It is recommended that the room entrance be placed, if possible, to avoid opening directly opposite a window.

3.9 Offices and other Workspaces

3.9.1 Layout

Daylighting conditions and the associated view connections are key factors influencing an occupant's choice of workspace layout. Shared workspace will result in different layouts than individual spaces due to privacy needs, individual work preferences, and co-worker relationships that likely will result in very different luminance distributions:

- Circulation patterns should be clearly recognizable, and wayfinding must be user friendly. Proceeding through the office should be simple and intuitive for the users.
- Glazed partitions with glare control fronting the open area add to a feeling of spaciousness and should be used extensively where appropriate, but must not present a hazard by being dangerously less visible in circulation pathways.
- In laying out workstations, avoid long rows of cubicles, but do not create mazes or confusing paths of travel among workstations.

3.9.2 Furniture and Workstations

Furniture for private offices may be selected to suit the tastes of the occupant, but in open offices with modular workstations, the following are recommended:

- Vertical surfaces of cubicle panels and upholstery for seating should contrast with flooring and main walls in hue and value or be trimmed with contrasting material to make these forms visible for individuals with low vision.
- Persons with low vision can find their way more easily through modular workstations when they are arranged with clearly visible aisles of generally constant clear widths. Flooring texture and color may be used to define the aisles more clearly.
- Modular office cubicle panels may provide screening from glare from windows, but controls should be used to avoid glare when cubicle panels are omitted or are transparent on sides facing windows.

3.9.3 Surface Finishes

- High gloss finishes should be avoided on horizontal and vertical surfaces to avoid reflected glare.
- Highly figured or patterned floor and wall surfaces in a space with many workstations and other furniture can be visually disorienting and should be avoided.
- See Table 4D-2 for further guidance.

3.9.4 Lighting

Electric lighting of office and other work areas must be designed to coordinate with the fenestration and natural daylighting:

- Lighting controls that react to fluctuations in daylight levels can assist in maintaining comfortable lighting levels for general illumination while maximizing energy savings, but always of high enough illumination intensity to allow persons with low vision to clearly see their surroundings.

  Individual task illumination levels may need to be higher for particular tasks than is justified for circulation and other areas to suit individual preferences. For optimal positioning and flexibility, task lighting that is movable and adjustable in brightness is usually desirable. Luminaires should be selected with non-glare producing, direct/indirect ambient illumination, or with cutoff angles for lenses and baffles that reduce visibility of lamps to the occupants at their tasks.

3.9.5 Fenestration

For daylighting design, the most critical luminance relationships are those between the daylight opening, its immediately adjacent surfaces and the surfaces surrounding the work tasks. Electric lighting on surfaces adjacent to fenestration may reduce high luminance contrast and the glare effect from daylight.

3.10 Dining Areas

3.10.1 Layout

In situations where the dining facility is specifically for populations in which low vision is common, self-service cafeterias may need to be staffed to provide assistance in guiding patrons to food, condiment, and beverage stations and to carry trays and locate seating.

- Scatter-type cafeteria serveries can be confusing for persons with low vision, and lighting levels should be maintained throughout the space rather than concentrated at each service island.
- In general, a dining space has relatively simple circulation needs that may confuse the person with low vision if the circulation routes are not intuitively designed, clearly visible and with easily read and lighted wayfinding. The circulation routes also need to be augmented with color and texture changes in flooring as wayfinding guidance. Some of the destinations needing clear guidance and definition include:
    - Entrances to destinations such as cafeteria line or captain (for seating assistance), menu and notice boards, and empty tables
    - Scatter-type cafeteria food and beverage stations
    - Cafeteria line to condiment and tableware stations and to cashier
    - Dining tables to self-help tables, such as salad and dessert bars
    - Dining table area to restrooms
    - Dining table area to exits
    - Layouts.

3.10.2 Furniture

To avoid a sterile, institutional appearance, dining tables are typically grouped non-orthogonally where possible. This, however, makes wayfinding more difficult where patrons self-seat, such as in cafeterias. Use of distinctive visual landmarks such as columns, sculpture, and planters can assist in visually locating a table in a large dining space. Variation in furniture upholstery colors and value contrasts may also help, although some types of low vision involve difficulty in color perception.

3.10.3 Surface Finishes

- Reflective or highly polished floors and walls can be visually challenging, so these types of surface finishes should be avoided.
- Table and chair colors and patterns that contrast in color, value and texture with wall and floors are easier to see and less likely to cause collisions.

3.10.4 Lighting

Generally, the following provisions are recommended:

- Lighting at cafeteria lines and steam tables should be placed so as to avoid glare on such surfaces as glass separators, as well as stainless steel and other polished surfaces.
- Menu boards and other information must be easily visible and illuminated without glare.
- See Tables 2 and 3 for further guidance.

3.10.5 Fenestration

- Skylights or top lighting fenestration should be diffused or designed to prevent direct sunlight penetration, glare, and shadows on floors and table surfaces.
- Window areas facing direction of travel from the entrance and cafeteria serving area may present glare and interfere with the diner's ability to navigate the space. Outdoor landscaping and/or window shading can mitigate this problem.

3.10.6 Other Design Considerations

Menus may be a reading challenge for many people with low vision due to small font size. Menu boards mounted on the wall behind preparation areas of cafeteria stations and short order counters may be difficult for many people to read, especially when the menu selection is large and restrictive space dictates using small font size. At tables in dining areas with wait staff, printed menus may be hard to read due to low lighting. Some options to be considered to address this issue follow (28):

- If space is available at the beginning of the cafeteria line or short order counters, task-lit menu boards and other information may be located there. Labels of food and beverage selections located at the place of display or point of sale such as at the steam table or dessert case may also be helpful.
- Hand-out paper menus in large font size, with contrasting print on a matte finish, at the beginning of the cafeteria line or short-order counter may be a simple way to accommodate low-vision customers.
- Task lighting luminaires at tables can help diners read traditional menus, review the bill and see their food and dishes in otherwise low ambient light.
- Video and touchscreens may also be useful tools for presenting menus and other information.

3.11 Assembly and Conference Areas

3.11.1 Layout

In general, an assembly space has relatively simple circulation needs, which may confuse the person with low vision if the main paths for travel are not clearly visible and provided with easily read and lighted wayfinding as guidance in varying ambient lighting conditions:

- In fixed seating auditoriums, aisles leading to seats should have lighting from row ends and on any steps.
- In flexible-seating spaces, the way to seats, tables, etc. will be facilitated when the arrangements are in simple geometries with clear pathways to and from entrances, restrooms, refreshment tables and exhibits.
- In conference rooms, seating that faces directly into windows is problematic due to glare. Window shading may help mitigate this glare.
- Speakers' rostrum, screens, etc. must be placed to avoid receiving direct sunlight or being backlit by sunlight or daylight from windows or skylights. Provide contrast to define the edge of the stage and steps leading to the stage. A handrail at the steps will not only call attention to the location of the steps, but will also provide stability to all users.

3.11.2 Furniture

- Rectangular conference tables should be arranged perpendicular to windows so that neither long side faces the glare of the windows, which may also obscure the view of a person silhouetted by the window. Window shade material which is dark will control the brightness from the window, but may also retain some of the view, depending upon the opacity of the material.
- Round conference tables allow a variety of choices of seating with respect to windows and glare.
- Glass-topped or other reflective table surfaces may reflect glare into the eyes of those seated at the table. Clear glass table tops are not recommended, due to the loss of depth perception.
- In conference rooms with fixed seats in auditorium-style arrangements, light-colored seating fabrics can make finding seats easier in the dark.

3.11.3 Surface Finishes

- Polished floors and walls may confuse the person with low vision for whom flat or low-luster finishes are more comfortable. Polished floors may create glare and potentially be a safety issue.
- Seating upholstery colors and textures that contrast with surrounding walls and floors make it easier to negotiate the space and to locate and identify seats.
- See Table 4D-2..

3.11.4 Lighting

Electric lighting requirements for assembly spaces are complex and vary widely with the type of assembly function. In spaces where darkened audience seating areas may be needed, the following special recommendations should be considered:

- Aisles must always be visible even when seating is not fixed.
  - Transition lighting levels at entrances can lessen the impact of entering and leaving the assembly space when the space is darkened.
  - Provide a strong value contrast between the floor, walls and seating. .In addition to ambient lighting, provide supplemental light at the floor level.

3.11.5 Fenestration

- All fenestration can produce glare, and may need shading of some type.
- Most assembly functions will need to have lower lighting levels during some presentations, so wayfinding must be visible under all daylight or darkened conditions.
- Where tables are set aside for refreshments, information materials, etc. during conferences, dedicated lighting of these areas is recommended when the main space has a lower ambient lighting level.

3.12 Dwellings, Resident and Patient Rooms

The most intimate spaces for human occupancy are also the most Important for day-to-day living and are therefore most subject to differences in occupant preference. Because the spaces become so familiar to the occupant, many features that could be hazardous or problematic for the occasional user (as in a public facility) will be more easily remedied . Following are recommendations that can be helpful to persons with low vision.

3.12.1 Layout

- Since residents will become very familiar with their dwelling or room layout, the need for signage or other aids may be minimal, but the placement of doors and passages connecting rooms should be coordinated with potential furniture arrangements to keep paths of travel simple, direct and unencumbered.
- Recommended design minimum dimensions for persons with low vision are as follows except as provided in applicable codes and regulations:

Widths of Pathways (20)	
Person with cane or walker	750 mm (30 in.)
Person with guide dog	1100 mm (44 in.)
Person with escort	1200 mm (48 in)
Doorways (clear opening)	900 mm (36 in.)
Corridors	1200 mm (48 in.)

- Light switches and power outlets should contrast in color and value with wall surfaces and have an indicator light when turned off. Light switches should be mounted at 1300 mm (52 in.) and power outlets located at 500 mm (20 in.) above the finish floor (20).

- All doors should be able to be held mechanically completely closed or completely open with predictability.
- Double-acting doors can be hazardous unless they are recessed or otherwise protected from opening into a path of travel.
- Raised thresholds may present a tripping hazard, so should be avoided.
- Corridors, passageways, and other spaces used for circulation may be made safer by providing handrails along the path of travel in a contrasting color and value to the walls.
- Wiring for power, data, phone, and cable TV can be tripping hazards if room arrangements and furniture require long wires to reach outlets. Placement of convenience outlets should be such that no wire from an appliance crosses any path of travel.

3.12.2 Furniture

Wherever possible, familiar furniture owned or selected by the occupant is important to retain. Coffee tables and other furniture with transparent glass tops and without opaque edges can be hazardous even to the occupant with normal vision, and should be avoided.

3.12.3 Surface Finishes

- Rugs and carpets may present tripping hazards unless well secured to the floor and with edges firmly attached to avoid entangling feet, cane or crutches.
- Doors and frames may be easier to identify when they contrast with the surrounding walls in color and value. If a door has the same finish on both sides, a contrasting color and value should be provided on the leading edge of the door. This allows a person with low vision to identify that the door is open and limits them from running into the edge of the door.
- Full-length mirrors may be mistaken for openings if the mirror extends to the floor, so the bottom of the mirror should be kept above the baseboard.
- Floors and walls should be of contrasting colors or values so the person with low vision can know where the floor and wall meet. This may also be enhanced with a baseboard or border that contrasts with both surfaces.
- Ramps and steps are hazardous if they cannot be easily seen such as by change in color, value or texture, at the beginning and end of the ramp and by contrasting color and value between treads and risers. Patterns in the flooring material may obscure the edge of a step and are not recommended.
- Floor patterns in carpeting, tile, and other materials may be visually confusing to the person with low vision, and it may become especially difficult to retrieve dropped items. Solid colors may make this less of a challenge.
- Highly polished flooring may be a visual and slipping hazard; matte finishes may be more appropriate.
- See Table 4D-2.

3.12.4 Toilet and Bath Fixtures

- Wall and floor colors and finishes that too closely match the plumbing fixtures and fittings such as light switches, power outlets, robe hooks, towel bars, toilet paper holders, and soap dishes can make those items harder for the person with low vision to locate and use properly, so contrasting colors and values are recommended.
- Towel bars may be used accidentally as grab bars by their placement in or near tubs and showers and adjacent water closets, so they should be designed to support the same loads as grab bars as required by code. Grab bars should be mounted horizontally or vertically and not on a diagonal
- Shelving for bathroom items such as lotions, gels, etc. may be accidentally used for support when in or adjacent tub/shower and lavatory areas, so shelving should be designed to support the same loads as grab bars or they should be constructed as ledges or in wall recesses. .
- The wall to be seen reflected in a mirror should be painted in a medium value to provide the most contrast for the user's head and hair that is either light or dark.
- Vanity tops for lavatories that are highly polished may reflect glare from lighting if the angles of reflection are not carefully calculated to avoid direct reflections. It is recommended that matte finishes be used when possible.
- Highly patterned or textured finishes on floor and countertop surfaces (including granular materials) may make retrieval of small dropped items very difficult for persons with low vision, Untextured and unpatterned surfaces with a matte finish are recommended. See Table 4C-2 for further guidance.

3.12.5 Kitchens and Kitchenettes

- Floor and wall colors that contrast with base and wall cabinets and with countertops are recommended to assist in visual orientation. The edge of the countertop should contrast in value to the counter surface to clearly define the horizontal from vertical.
- Highly patterned or textured finishes on floor and countertop surfaces (including granular materials) may make retrieval of small dropped items very difficult for persons with low vision, so untextured and unpatterned surfaces with a matte finish are recommended.
- Countertops for kitchens that are highly polished may reflect glare from overhead or under-cabinet lighting if the angles of reflection are not carefully calculated to avoid direct reflections. It is recommended that matte finishes, for example, honed granite or marble and synthetic solid materials, be used when possible. Some countertop surface areas might be provided that are dark while others are light to facilitate working with objects such as foods that are of the opposite values. Two cutting boards, one white and one dark, will also provide the desired contrast. The countertop horizontal surface should be clearly defined.
- Cabinet drawer and door pulls are more easily seen and used when they contrast with the cabinets in texture, hue, and value When cooking appliances such stoves and cook-

tops are provided, controls must be easy to read and located so that the user does not need to reach across hot burners or pans.

- Select appliances that clearly identify the burners and distinguish whether the burners

See Table 4D-2.

3.12.6 Lighting

Placement of overhead or under-cabinet lighting should avoid reflections and glare at the work surfaces.

- In any case, diffuse lighting is preferable to “spotlighting” from visible point sources or downlights, which can leave stark contrasts and annoying reflections.
- Lighting for signage and artwork, where appropriate, should comply with ADA Standards. Also see Table 4D-2.

3.12.7 Fenestration

- Sliding glass doors and fixed adjacent sections may be hazardous when mistaken for an opening. This can be mitigated by horizontal rails, mullions, or decals on the glass.
- Glass doors in a window wall may require solid surfaces, visible characters/marking, or other architectural features to distinguish the door from the window wall, even for the fully-sighted user.

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4A. Background on this Guideline

In September 2010, the National Institute of Building Sciences (NIBS) hosted a workshop in Washington, D.C., with participants from the fields of medicine (specialists in optometry and low vision), architecture, engineering, interior design, lighting design, professional associations, government, academia, advocacy, and research and development.

A concept paper was developed based on the findings and recommendations from that Workshop: "Improving Building Design for Persons with Low Vision." Proceedings of the Workshop, the concept paper, and related material, are available at the website: http://www.nibs.org/?page=lvdc. .

The participants of that interdisciplinary workshop expressed four major learning outcomes:

- Clinicians need a better understanding of lighting and accessibility exposures that "low vision" patients experience while in "built environments"
- Designers need a better understanding of the lighting and accessibility needs of "low vision" persons while in "built environments"
- A common vocabulary is needed for clinicians, design practitioners (e.g., architects, interior designers, lighting designers, engineers), building owners and managers, and policy makers for all built environments
- There is a need to balance federal and other mandates for reduced energy consumption against the needs of all building occupants, including people with low vision, to have adequate illumination.

The objective of the concept paper was to address these learning outcomes by: 1) analyzing the issues and knowledge gaps that were identified during the workshop; and 2) proposing the development of plans for addressing these issues and knowledge gaps through evidence-based improvements in designs and operational procedures for new and existing buildings.

This guideline is a product of the workshop and concept paper, and will need further research to confirm and improve it.

In 2012, the General Services Administration (GSA) undertook to revise its publication, P-100 Facilities Standards for the Public Buildings Service, with modifications to be performance-base, and to include recommendations for design for persons with low vision. This revision has not yet been published. However, recommendations from the drafts have been considered in this guideline.

In 1995, the Royal National Institute for the Blind (RNIB) in Great Britain published: *Building Sight*, "a handbook of building and interior design solutions to include the needs of visually impaired people" (20). This document was not made mandatory by code or regulation, and remains a voluntary guideline. Many of the recommendations in the British publication are included in this guideline.

In 2001, the British Standards Institute (BSI) first published and in 2009 *updated BS 8300-: Design of buildings and their approaches to meet the needs of disabled people – Code of practice* (29). Practices described in BS 8300-2009 and Evaluating access statements requirements in Part M of the building regulations and minor technical amendments to Part M of the building regulations – Impact Statement, 2012 have been considered in drafting this guideline.

At this writing, the publication, ANSI/IES RP 28-2007 (2013): *Recommended Practice for Lighting and the Visual Environment for Seniors and the Low Vision Population* is undergoing major revisions, including its title, and will include provisions related to design for low vision (38). Recommendations in the drafts of RP 28have been considered in drafting this guideline. Correspondingly, information from this guideline is being included in the update of RP 28.

Also at this writing, the publication, *FGI 2014: Guidelines for Design and Construction of Residential Health, Care, and Support Facilities* is in development and will also include provisions for low vision in the building types it governs. Recommendations in the draft of *FGI 2014* have been considered in drafting this guideline. Correspondingly, information from this guideline is being referenced in the FGI 2014 publication.

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4D: Summary Review of Literature for Criteria

Very few references were available with original experimental data upon which to rely, especially for the "Low Vision" and "Senior" populations. Therefore preliminary literature searches were conducted in February 2013, primarily using Google, with sets of key words including: 1) Illumination, Low Vision, and Lighting Criteria; 2) Luminance and Low Vision Design; 3) Luminance, Contrast, and Low Vision Design; 4) Experimental Data on Luminous Contrast for Low Vision Persons; and 5) Experimental Data on CCT, CRI, and Low Vision.

From these searches (i.e., in excess of 500 Google "hits"), less than 50 published papers were identified that have original experimental data pertaining to buildings (i.e., many of the references address graphic design, webpage design, and highway lighting). Less than 15 published papers were identified that have original experimental data on lighting exposures and human responses from Low Vision "subjects." Of these, findings from 9 references have been summarized in Table 4C-1: Summary of Literature. A tenth reference, which was subsequently found, shows impact of peak wavelengths on perceived brightness for younger and older subjects. The blank cells represent "gaps" in evidence-based information. In trying to develop a rational basis that includes all of the listed attributes; each paper was found to address only 2 or 3 of the attributes.

It is reassuring to find that some of the Illuminance values from the experimental data are compatible with the recommended values in IES RP-28. This summary review also revealed that some visually impaired persons are adversely affected by the upper end of the values in this table while others are adversely affected by the lower end, so "flexibility" and "control" are important factors. It is also reassuring that some of the studies provided data on Luminance values that are appropriate for Low Vision persons. But, how Luminance was measured is not consistent among the papers: some measured Luminance at the plane of the eye, some measured Luminance from specific material surfaces, and some approximated Luminance with Vertical Illuminance values. Two references were found with experimental data on Contrast for signage (refs 4 and 5 in the Table, Column1) for Low Vision persons. No references were found with experimental data on glare indices for low vision persons, but Reference 8 may provide some guidance for the "no view" condition.

Table 4D-1. Ten referenced publications of data collected in controlled studies.

Ref	Type of Study	Number of Subjects	Type of Space	Values or Ranges					
				Illuminance (lm/m^2)/ Location/ Uniformity	Luminance (cd/m^2)/ Location	Contrast	CCT	CRI	Glare or Glare Index
1.	Laboratory – reading rate	20 with AMD	Living/ reading room	Optimum: 3500 lm/m^2					
2.	Field – reading efficiency (not defined)	Numbers NA: Normal, Cataracts, AMD (see cited reference 3 - 8)	Reading (task) areas	Normal: 750 lm/m^2 at the task	Normal: 70 cd/m^2 at the eye of reader				
				Cataracts: 1500-2500 lm/m^2 at the task	Cataracts: 477-795 cd/m^2 at the eye of reader				
				AMD: 400 – 4000 lm/m^2 at the task	AMD: 127-1270 cd/m^2 at the eye (implied)				
3	Field study in senior living facilities	NA: Prospective study; in seniors facility	Living areas and corridors	Living areas: 750 – 1000 lm/m^2, horizontal, at 0.6 and 0.9 m above floor	Living areas: 750 – 1000 lm/m^2, vertical, in gazing direction at 1.6 m above floor (measured as illuminance)		5000 – 6000 K (for daylight)		
				Corridors: 200 lm/m^2, horizontal, at 0.6 and 0.9 m above floor	Corridors 200 lm/m^2, vertical, in gazing direction at 1.6 m above floor (measured as illuminance)		5000 – 6000 K (for daylight)		
4.	Clinical	42 persons	Simulated		75 cd/m^2 from	Signs for			

Ref	Type of Study	Number of Subjects	Type of Space	Values or Ranges					
				Illuminance (lm/m²)/ Location/ Uniformity	Luminance (cd/m²)/ Location	Contrast	CCT	CRI	Glare or Glare Index
	Functional Tests and Laboratory Experiments	with low vision and 2 control persons with normal vision	indoor and outdoor spaces for signs and signage		patterns on signs and 150 cd/m² from background of the white board	optimal performance should be at least 5% of the reading distance and have a luminance contrast intensity (i.e., Weber contrast ratio) of 75% on white-black axis			
5.	Field Study with simulated concrete colors and textures	50 visually impaired participants, 24-92 years old	Intersections of sidewalks and streets	Daylight 18,000 – 115,000 lm/m²		Weber contrast ratio between warning material and sidewalk > 70% at tactile detection distance of 2.44 m (8ft)			
	General Reference Table 34.2	NA	Clear sky in summer – northern temperate zones	150,000 on horizontal surface	2,900 from grass				
			Overcast sky in	16,000 on	300 from grass				

Ref	Type of Study	Number of Subjects	Type of Space	Values or Ranges					
				Illuminance (lm/m^2)/ Location/ Uniformity	Luminance (cd/m^2)/ Location	Contrast	CCT	CRI	Glare or Glare Index
			summer – northern temperate zones	horizontal surface					
			Textile inspection	1,500 on horizontal surface	140 from light gray cloth				
6.			Office work	500 on horizontal surface	120 from white paper				
			Heavy engineering	300 on horizontal surface	20 from steel surface				
			Good street lighting	10 on horizontal surface	1.0 from concrete road surface				
			Moonlight	0.5 on horizontal surface	0.01 from asphalt road surface				
	Laboratory	50 normal vision – 20-30 years	Reading (task) areas	Median: 900 Range (10-90%): 329-2,072			White fluorescen t lamps		
				Median: 1,000 Range (10-90%): 600-2,127			Warm-white fluorescen t lamps		
				Median 1,055 Range (10-90%): 75426-2,090			Daylight fluorescen t lamps		
		50 normal vision – 40-79	Reading (task) areas	Median: 268 Range (10-90%):			White fluorescen		

Ref	Type of Study	Number of Subjects	Type of Space	Values or Ranges					
				Illuminance (lm/m²)/ Location/ Uniformity	Luminance (cd/m²)/ Location	Contrast	CCT	CRI	Glare or Glare Index
6, 7.		years		75-817			t lamps		
				Median: 260 Range (10-90%): 105-1,527			Warm-white fluorescen t lamps		
				Median: 315 Range (10-90%): 162-1,753			Daylight fluorescen t lamps		
		75 Cataract – preoperative – 40 – 80 years	Reading (task) areas	Median: 325 Range (10-90%): 98-1,800			White fluorescen t lamps		
				Median: 300 Range (10-90%): 45-1,416			Warm-white fluorescen t lamps		
				Median: 448 Range (10-90%): 52-1,460			Daylight fluorescen t lamps		
		50 postoperative with intraocular lens	Reading (task) areas	Median: 121 Range (10-90%): 70-1,162			White fluorescen t lamps		
				Median: 123 Range (10-90%): 50-939			Warm-white fluorescen t lamps		
				Median: 140 Range (10-90%): 60-1,197			Daylight fluorescen t lamps		
		25 postoperative	Reading (task) areas	Median: 119 Range (10-90%):			White fluorescen		

Ref	Type of Study	Number of Subjects	Type of Space	Values or Ranges: Illuminance (lm/m^2)/ Location/ Uniformity	Luminance (cd/m^2)/ Location	Contrast	CCT	CRI	Glare or Glare Index
		with spectacle correction		75-439			t lamps		
				Median: 128 Range (10-90%): 39-629			Warm-white fluorescen t lamps		
				Median: 195 Range (10-90%): 54-656			Daylight fluorescen t lamps		
		50 Glaucoma 40-82 years	Reading (task) areas	Median: 596 Range (10-90%): 100-1,071			White fluorescen t lamps		
				Median: 480 Range (10-90%): 85-1,278			Warm-white fluorescen t lamps		
				Median: 675 Range (10-90%): 67-1,886			Daylight fluorescen t lamps		
8.	Field Studies with Simulated Environment s in 3m x 4m x 3m rooms in 20 story	Experiment 1: 72 university students with normal vision	Most interesting view		"The mean luminance of the background was derived from the difference between the total vertical illuminance at the subjects' eye and the illuminance				(Fig. 5): For Glare Response Vote (GRV)= 20 (just acceptable), DGI = 26 (N – 24)
			Least interesting view						For GRV = 20, DGI = 22 (N = 24)
			No view						For GRV = 20, DGI = 18 (N = 24) [may be

Ref	Type of Study	Number of Subjects	Type of Space	Values or Ranges					
				Illuminance (lm/m^2)/ Location/ Uniformity	Luminance (cd/m^2)/ Location	Contrast	CCT	CRI	Glare or Glare Index
	Arts Tower Building				from the masked cell" (i.e., measuring instrument).				appropriate for low vision persons]
9	Laboratory – color discrimination tests	12 with normal color vision and VA corrected to 20/20 or better	Experiment 1: Testing Lab At Warm (low)-CCTs	50		FM Score for Hue Tests: 55-70 [lower scores are better]	< 4000 K	CRI: 80-95	
						FM Score: 68-60		New Gamut Area Index (GAI): 70 60	
				500 [Better predictor of Hue]		FM Score: 30-40		CRI: 80-95	
						FM Score: 40-30		GAI: 55-95 [GAI is better predictor of Hue]	
		12 with normal color vision and VA corrected to 20/20 or better	Experiment 2: Testing Lab at Cool (high) CCTs	50		FM Score: 60-58	> 6000 K	CRI: 72-95	
						FM Score: 70-50		GAI: 65-95	
				500 [Better predictor of Hue]		FM Score: 45-40		CRI: 70-94 [CRI is better predictor of Hue]	
						FM Score: 45-40		GAI: 65-975	

Ref	Type of Study	Number of Subjects	Type of Space	Values or Ranges					
				Illuminance (lm/m^2)/ Location/ Uniformity	Luminance (cd/m^2)/ Location	Contrast	CCT	CRI	Glare or Glare Index
		10 with normal color vision and VA corrected to 20/20 or better	Experiment 3: Testing Lab at mix between Warm and Cool CCTs	50		FM Score: 25-42	4000 – 5000 K	CRI: 75-95	
						FM Score: 42-25		GAI: 52-95	
				500 [Better predictor of Hue]		FM Score: 15-20		CRI: 75-95	
						FM Score: 20 15		GAI: 55-95 [GAI is better predictor of Hue]	
10	Laboratory Study on Perceived Brightness and Trichromic Stimuli	40 subjects: 20 @ < 25 years; 20 @ >50 year; Normal Vision	Experimental: Two sets (i.e., “red” and “blue”) of four spectral power distributions (SPDs) were created by varying the peak wavelength of either the blue or the red primary of a red, green, blue (RGB) light-emitting diode (LED) source.	Ranged from 550 to 850		FM Score Gamut Area: 51 - 97	Controlled at 3500 K	27 - 84	

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Table 4D-2. Performance Criteria for Surfaces and Materials.

PLEASE NOTE:

The following table is designed to be used in conjunction with recommendations in the texts of chapters 2 and 3. Designers must use their professional skills in applying the recommended values in this table to fully support the objectives of chapters 2 and 3.

Awareness of the needs of people with low vision in design is relatively recent. There are some areas of concern that have not yet been researched or documented to provide credible data. Therefore, portions of the following table are either incomplete or controversial for lack of applied experience with the recommended criteria. The committee hopes that future research will resolve these shortcomings.

Table 4D-2. Performance Criteria for Surfaces and Materials. (SEE NOTE ABOVE.) References [ ] are listed at the end of this Table.

Specific Area	General Light Reflectance Value Range [1,2,10] (See note 1)	Minimum Value Contrast at Edge (%) [2,3,4,8,10, 11] (See note 2)	Minimum Value Contrast to Adjacent or Background Surfaces [2,3,4, 11] (See note 2)	Maximum Sheen (Gloss Units GU) [2,4,5,6,10] (See note 3)	Change of Texture [2,4] (See note 4)	Pattern Restriction [2,4] (See note 5)	Comment [2,5,9]
Exterior Spaces for Pedestrians							
Horizontal Surfaces							
Roadway	<35	N/A (Not Applicable)--	N/A	<10	N/A	N/A	
Curbs	<35	30	30	<10	N/A	- N/A -	
Sidewalks/Paving	<35	30	30	<10	- N/A -	YES	
Crosswalks	<35	50	50	<10	YES	N/A	
Ramps	<35	50	50	<10	YES	YES	
Steps/Stairs	<35	50	50	<10	YES	YES	
Vertical Surfaces & Objects in Circulation Pathway							
Poles/Post/Bollards	N/A	N/A	50	<70	N/A	N/A	
Drinking Fountains	N/A	N/A	50	<70	N/A	N/A	
Sculpture	N/A	N/A	50	<70	N/A	N/A	
Seating	N/A	N/A	50	<70	N/A	N/A	
Trash/Recycling	N/A	N/A	50	<70	N/A	N/A	
Gates	N/A	N/A	50	<70	N/A	N/A	
Turnstiles	N/A	N/A	50	<70	N/A	N/A	
Directional Signage	N/A	N/A	50	< 19	N/A	N/A	Signs Character: 70% Contrast
Directory	N/A	N/A	50	<19	N/A	N/A	Signs Character: 70% Contrast

Specific Area	General Light Reflectance Value Range [1,2,10] (See note 1)	Minimum Value Contrast at Edge (%) [2,3,4,8,10, 11 (See note 2)]	Minimum Value Contrast to Adjacent or Background Surfaces [2,3,4,11] (See note 2)	Maximum Sheen (Gloss Units GU) [2,4,5,6,10] (See note 3)	Change of Texture [2,4] (See note 4)	Pattern Restriction [2,4](See note 5)	Comment [2,5,9]
Building Entry							
Floor	<50	50	50	<40	YES	YES	
Solid Doors	N/A-	N/A	50	<40	--	--	
Glazed Doors	N/A-	N/A	50*	N/A	N/A	N/A	*Visible Characters @ 4'6" 5'3"
Door Frames	N/A	N/A	50	<40	N/A	N/A	
Interior Spaces							
Building Lobby							
Floors	20 – 50	50	50	<25	YES	YES	
Walls	50 - 80	N/A	30	<40	N/A	N/A	
Public Doors/Frames	N/A	N/A	30	< 40	N/A	N/A	
Non-Public Doors	N/A	N/A	0	< 40	N/A	N/A	
Directory	N/A	N/A	50	<19	N/A	N/A	
Directional Signage	N/A	N/A	50	< 19	N/A	N/A	
Furniture	N/A	N/A	30	< 70	N/A	N/A	
Vertical Circulation							
Approach to Stairs and Escalators	N/A	50	50	<25	YES	YES	
Stair Treads/Landing	30 – 60	50	30	< 40	YES	YES	
Stairway Walls	60 – 80	N/A	50	<40	N/A	N/A	
Stairway Handrails	N/A	N/A	50	< 40	N/A	N/A	
Elevator Doors	N/A	N/A	30	< 70	N/A	N/A	
Elevator Floors	30 - 60	N/A	50	<25	YES	YES	

Specific Area	General Light Reflectance Value Range [1,2,10] (See note 1)	Minimum Value Contrast at Edge (%) [2,3,4,8,10, 11] (See note 2)	Minimum Value Contrast to Adjacent or Background Surfaces [2,3,4,11] (See note 2)	Maximum Sheen (Gloss Units GU) [2,4,5,6,10] (See note 3)	Change of Texture [2,4] (See note 4)	Pattern Restriction [2,4](See note 5)	Comment [2,5,9]
Elevator Walls	40 - 80	N/A	30	< 40	N/A	N/A	
Elevator Buttons	N/A-	N/A	50	<10	N/A	N/A	
Escalator Steps	N/A	50	50	<25	N/A	N/A	
Escalator Landing	N/A	50	50	<25	YES	YES	
Horizontal Circulation							
Floor Surfaces	30 – 50	50	30	<25	YES	YES	
Walls	50 -80	N/A	30	< 40	N/A	N/A	
Public Doors/Frames	N/A	N/A	30	<40	N/A	N/A	
Non-Public Doors	N/A	N/A	< 10	<40	N/A	N/A	
Signage	N/A	N/A	50	11 - 19	N/A	YES	Signs Character: 70% Contrast
Interior Spaces							
Restrooms							
Signage	N/A	N/A	50	<19	N/A	N/A	
Doors/Frames	N/A	N/A	30	<40	N/A	N/A	
Floors	30 – 50	30	30	<25	YES	YES	
Walls	60 – 80	N/A	30	<40	N/A	N/A	
Partitions	60 -80	N/A	30	<40	N/A	N/A	
Countertop	30 – 60	30	30	<25	N/A	N/A	
Sinks	N/A	N/A	30	N/A	N/A	N/A	
Toilet/Urinal	N/A	N/A	50	N/A	N/A	N/A	
Fixture Controls	N/A	N/A	50	N/A	N/A	N/A	

Specific Area	General Light Reflectance Value Range [1,2,10] (See note 1)	Minimum Value Contrast at Edge (%) [2,3,4,8,10, 11] (See note 2)	Minimum Value Contrast to Adjacent or Background Surfaces [2,3,4,11] (See note 2)	Maximum Sheen (Gloss Units GU) [2,4,5,6,10] (See note 3)	Change of Texture [2,4] (See note 4)	Pattern Restriction [2,4](See note 5)	Comment [2,5,9]
Theatre							
Theater Aisle	20 - 40	50	30	<25	YES	YES	
Theater Steps	20 - 40	50	30	<25	YES	YES	
Theater Seating	N/A	N/A	30	N/A	N/A	N/A	
Seating Numbers	N/A	N/A	50	N/A	N/A	N/A	
Meeting Rooms							
Floors	30 - 50	30	30	<25	YES	YES	
Walls	60 -80	N/A	30	<40	N/A	N/A	
Display Walls	N/A	N/A	30	<40	N/A	N/A	
Seating	N/A	50	30	N/A	N/A	N/A	
Table Tops/Counters	30 - 60	30	30	< 25	N/A	N/A	
Window Covering	?	N/A	N/A	N/A	N/A	N/A	
Offices & Class Rooms							
Floors	20 – 50	30	30	1 – 25	YES	YES	
Walls	60 – 80	N/A	30	25 – 40	N/A	N/A	
Display Walls	N/A	N/A	30	25 – 40	N/A	N/A	
Seating	N/A	N/A	30	N/A	N/A	N/A	
Table Tops/Counters	30 – 60	30	30	10 - 25	N/A	N/A	
Window Covering	?	N/A	N/A	N/A	N/A	N/A	

Specific Area	General Light Reflectance Value Range [1,2,10] (See note 1)	Minimum Value Contrast at Edge (%) [2,3,4,8,10, 11] (See note 2)	Minimum Value Contrast to Adjacent or Background Surfaces [2,3,4,11] (See note 2)	Maximum Sheen (Gloss Units GU) [2,4,5,6,10] (See note 3)	Change of Texture [2,4] (See note 4)	Pattern Restriction [2,4](See note 5)	Comment [2,5,9]
Food Service							
Residential Kitchens	20 – 50	N/A	30	1 – 25	N/A	N/A	
Institutional Kitchens	60 – 80	N/A	30	1 – 40	N/A	N/A	
Cafeteria Serveries	60 - 80	N/A	30	1- 40	N/A	N/A	
Dining Areas							
Floors	20 - 50	30	30	<25	YES	YES	
Walls	60 – 80	N/A	30	<40	N/A	N/A	
Door/Door Frames	N/A --	N/A	30	<40	N/A	N/A	
Dining Tables	30 - 60	30	30	<25	N/A	N/A	
Dining Counters	30 - 60	30	30	<25	N/A	N/A	
Seating	N/A	- N/A -	30	N/A	N/A	N/A	

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11 (29) British Standards Institute (BSI) 2001 and in 2009 updated BS 8300-: Design of buildings and their approaches to meet the needs of disabled people – Code of practice. Practices described in BS 8300-2009 and Evaluating access statements requirements in Part M of the building regulations and minor technical

amendments to Part M of the building regulations – Impact Statement, 2012

Notes regarding values in columns:

1. The maximum values for the parameters of LRV, shown in Column 2, represent the most reflection from exterior and interior surfaces that would be acceptable to populations including persons with low vision to minimize glare. Otherwise, ranges of LRVs represent reflections from interior surfaces that would enhance luminance and be acceptable to populations including persons with low vision and would provide flexibility in meeting the minimum value contrasts in Columns 3 and 4.

2. The minimum Value Contrasts, shown in Columns 3 and 4, represent the lowest contrast that would be acceptable to populations including persons with low vision while viewing the edge of a step, a change in level, or adjacent surfaces or objects and their backgrounds. See Appendix 5C for the method of calculating Value Contrast.

3. The maximum Sheen for surfaces, shown in Column 5, represents the most specular reflection that would be acceptable to populations including persons with low vision for reducing reflected glare.

4. Sheen of a surface in measured in Gloss Units (GU). See Appendix 5C for additional information.

5. A Change of Texture on a walking surface. where shown in Column 6, provides useful sensory information for a person with low vision as a subtle cueing or a warning. See Appendix 5C for additional information.

6. Patterns should be restricted to plain uniform surfaces where shown in Column 7, See Appendix 5C for additional information.

5 TECHNICAL APPENDICES

5A. Health Effects

Non-Visual Health Effects of Light Sources

There are two ways that light sources impact health: 1) vitamin D synthesis is activated when ultraviolet-B light strikes the skin; 2) circadian rhythm is a process where light enters the eye and travels the same pathway until it reaches the retina where it activates intrinsically photo sensitive retinal ganglion cells (ipRGC), which send signals to the body clock (i.e., circadian pacemaker). Vitamin D is important for everyone and does not impact those with low vision differently than normally sighted individuals therefore control of Vitamin D is not addressed in this Guideline. However, a significant percentage of those with low vision retain light perception and exhibit normal circadian patterns. (39; 40), therefore, this guideline includes circadian rhythm.

Circadian rhythm: The body clock controls the timing of most 24-hour behavioral and physiological elements, including the sleep-wake cycle, alertness and performance rhythms, hormone production, temperature regulation and metabolism.

- Light is the most powerful stimulus for entrainment of the body clock and keeping our bodies synchronized with the 24-hour light /dark cycle. The impact of light stimulus will depend on its intensity, timing, pattern of exposure, light history, and wavelength.
- The light-sensitive retinal ganglion cells (ipRGC) send signals via the optic nerve to the suprachiasmatic nucleus (SCN),the "circadian pacemaker," in the brain (14). Compared to the rods and cones, the ipRGC respond more slowly and signal the presence of light over the long term. Their functional roles are non-image-forming and fundamentally different from those of pattern vision; they provide a stable representation of ambient light intensity and wavelength content.
- Unlike the rods and cones, the ipRGC contains the photopigment, melanopsin, which is excited by light mainly in the blue portion of the visible spectrum (14) Those with low vision and many who are blind, including those with degenerated rod and cone photoreceptors, such as people with retinitis pigmentosa, still have functioning ipRGC as demonstrated by their circadian responses (41).
- The ipRGC respond to light is in the blue range of 460 – 480 nanometers (nm), (42), while the spectrum of visible light that stimulates rods and cones peaks at 550 nm. Light sources indoors should mimic the natural color rhythm of light outside. Exposure to cool light (like the blue sky) is important in the morning or during the day, but should be avoided in the evening and at night. Exposure to cool (blue-white) light at night suppresses melatonin during the time of its heaviest flow, thereby disrupting the circadian system.

- Color vision-deficient individuals can maintain a normal circadian response to light as stimulation of rods and cones is not required (39; 40). If light can be seen by a low vision person, then the circadian system should still be functional.

The impact of light stimulus will depend on its intensity, timing, pattern of exposure, light history (43), and wavelength. Circadian light, measured in luminance (amount of light entering the eye), needs to be significantly higher than light for vision.

To maintain a health circadian rhythm, daylight should be used in interior spaces that are occupied by the same people for long periods of time. The color of electric light for spaces used in the evening and night should be warm in color, avoiding the cool light found during the day; nightlight use should be limited.

5B. Interaction of Lighting with Audio and other Sensory Systems

While the subject of this guideline is design that accommodates low vision occupants, the role of the body's other senses is important to keep in mind. When we respond to the environment, all our senses are employed to enrich and inform our comprehension of the space and our movement in it.

Acoustic and kinesthetic changes are familiar experiences for everyone as contributors to our understanding of where we are. The loss of acuity in vision may heighten sensitivity in other senses and this may suggest the introduction of non-visual sensory cues to the design. For example, a change in lighting might be accompanied by a change in floor texture and sound absorption from one space to another. People with vision loss learn to use auditory and tactile cues to assist with wayfinding.

5C. Color: Light Source Color and Object Color

Light for Vision

The ability to see and differentiate between surfaces and objects in the visual environment is dependent on the various characteristics of the light source color, the object or material color and the combination of these characteristics. In addition, the light source color shining on a surface will affect the color perception of that material and the space. The color of objects or material in the space is addressed below and in Section 1.3 and Table 3.

Non-Visual aspects of Light:

- Circadian Patterns: The color of the light source will also impact circadian patterns. To maintain healthy circadian rhythms, the color temperature (wavelengths) of light must change to mimic the changing color of light in the sky from warm at dawn, cool like the blue sky at mid-day, back to warm at dusk, and darkness at night.
- Vitamin D_3 synthesis: Ultraviolet-B (UVB) light that is needed for vitamin D synthesis is out of the visible range (range of 280 - 315 nm) (51). Vitamin D_3 is required for bones and tissues to absorb calcium.
- Circadian Rhythms and Vitamin D Synthesis are addressed in greater detail in Appendix 5A.

Light Source Characteristics

Color. The spectrum of the visible light is 380 – 760 nanometers (nm). However, light below 340 nm may cause damage to the retinas of people over the age of 50 (52). Sources of visible light affect how humans perceive the colors that they see in the environment. There are two metrics to describe color quality used in architectural applications: correlated color temperature (CCT) and color rendering index (CRI) (53).

- A color temperature is expressed in degrees Kelvin (K), describing the light source and the light it emits. Lower number represent warm light (3000K or lower), i.e. dawn and dusk; mid-range is white light (3500K), i.e. one hour after sunrise; and higher numbers represent cool, bluish-white light (4000K or higher), i.e. two hours after sunrise and upward to the color of the blue sky. Warm light will enhance the warm colors and cool light will enhance cool colors. Cool light, like the blue sky, stimulates the circadian system during the day; warm light at night will not disrupt the circadian system. (See Appendix 5A for further information).
- Color rendering refers to how natural the color of an object appears with a given light source. According to IES nomenclature (45):
    - Color rendering is the "effect of an illuminant on the color appearance of objects by conscious or subconscious comparison with their color appearance under a reference illuminant."
    - Color Rendering Index (CRI) is a "measure of the degree of color shift objects undergo when illuminated by the light source as compared with the color of the same objects when illuminated by a reference source of comparable color temperature." The CRI is

a scale of 1 to 100. Light sources with a high CRI make colors appear more colorful and natural. Three variations of CRI are defined by IES:

- General: Measure of the average shift of eight standardized colors chosen to be of intermediate saturation and spread throughout the range of hues (if the CRI is not qualified as to color samples used, the general CRI is assumed).
- Special: Measure of color shift of various standardized special colors, including saturated colors, typical foliage, and Caucasian skin.
- Color Preference Index: Measure appraising the light source for enhancing the appearance of an object or objects by making their colors tend toward people's preferences.

- Color Intensity is a subset of luminance and provides information on the intensity of emitted light within a range of wavelength in a given direction.
- Uniformity refers to the even distribution of light within a space or across a plane. The plane may be horizontal, vertical or slanted. The uniformity is stated as a maximum-to-minimum ratio.
  - Older eyes adapt much more slowly to changes in light levels and function better when lighting is even and consistent.
  - A 3:1 ratio is recommended for those with low vision to minimize the fluctuation of light in a space or on a plane (38). Dark areas can obscure objects, steps and curbs.

Surface Characteristics

- Hue is the term used to describe how we perceive an object's color, i.e. red, green, blue.
  - Colors are sensed by the cones in the retina of the eye. Those who have lost their central vision may not see color, only black and white.
  - Contrasting hues are not visible to those who are color blind. Contrasting colors of the same value may not be visible to those with impaired vision.
  - The color of the light source will impact the hue of the material.
- Saturation (Intensity) refers to the brightness or dullness of the color. Saturation contrast may be too subtle for those with low vision to differentiate.
- Value (also see Eqn [5]) is the lightness or darkness of the surface color rated on a scale of 0 (black – total absorption) to 100 (white – total reflectance). The location of the surface material and interaction with the light source are important. For example, values in the higher range are recommended for ceilings and walls to distribute light throughout an interior space.
- Light Reflectance Value (LRV) is quantified numerically from 0–100 to indicate the percentage of light striking the surfaces that will be reflected back from the surface (54). The recommendations in Table 3 depend upon the location, exterior or interior, and vertical or horizontal surfaces. LRVs are used in lighting calculations and to determine value contrast. Lighting calculations for interior spaces factor in the LRV on ceilings, walls and floors to determine the illuminance (quantity of light) at a given point in a space. The LRVs in Table 3 represent a range to optimize light levels and allow for contrast in the visual environment. LRVs for materials are available from the material manufacturers. Or they can be estimated in the field using a paint fan deck under similar lighting conditions to find approximate color and sheen similar to the material (55).

- The illuminance of the light source striking the surface is an important factor. The strength of bright sunlight striking a light-value walking surface will be reflected into the eyes and may be sensed as glare.
- Outdoor walking paths and paved surfaces should be med-dark in value, below 35 LRV. Concrete darkens as it ages and will take years to reach 35 LRV without adding pigment to the mix or an acid-etch finish.

- Value Contrast, which is the ratio of between light to dark, enhances vision, especially for persons with low vision (29). Comparison of light reflectance values determines the amount of value contrast between adjacent surfaces or objects and their background to increase visibility. A minimum value difference of 30 points is required of critical elements. Steps and level changes require a greater difference of 50 points as an alert to the potential hazard. Contrast in percent is determined by: Contrast = [(B1 - B2)/B1] x 100.4 B1 = light reflectance value (LRV) of the lighter area and B2 = light reflectance value (LRV) of the darker area. Note that in any application both white and black are never absolute; thus, B1 never equals 100 and B2 is always greater than 0 (24).
  - Materials should have minimum differences in LRV for items (see Table 3):
    - LRV difference of 30 between objects and their background.
    - LRV difference of 30 between floors and walls or base molding to define the space.
    - LRV difference of 30 between doors, door frames, and walls.
    - LRV difference of 50 as an alert to level changes and on stair nosing.
  - Loss of contrast sensitivity is common among those with low vision.
  - Contrasting values should be used to define elements within a space, i.e. an edge of a step, level change or an object in the pathway.
  - Value contrast is not light dependent and benefits everyone in low-light conditions.
- Surface Sheen or Gloss: The sheen of a material is determined by shining a light on the surface at different testing angles. Black glass is used as the standard for high gloss. Material testing is conducted in a controlled laboratory condition measured by a glossmeter (25). The measurement results of a glossmeter are relative to the amount of reflected light from the black glass standard with a defined refractive index. The ratio of reflected to incident light for the specimen, compared to the ratio for the glass standard, is recorded as gloss units (GU).
  - Common terms to describe gloss include matte or flat (< 10 GU, measured at 85 degree angle), medium gloss (10 – 70 GU, measured at 60 degree angle) and specular or high gloss (>70 GU measured at 20 degree angle.
  - Light shining on a matte surface is diffusely scattered in all directions and the image forming qualities are diminished. High gloss surfaces reflect images distinctly. The incident light is directly reflected on the surface in the direction of reflection. The angle of incidence is equal to the angle of reflection, producing reflected glare.
  - Matte finishes are recommended for interior floors or exterior walking surfaces to avoid reflected glare and optical illusions created by specular reflections. High gloss floors are reported to be very detrimental to safe navigation (23). The intensity of the sun striking large vertical surfaces with a specular finish will create similar reflections and glare.

  - The combination of the gloss of the material, location, direction and intensity of the light source will determine the user's sensation of luminance, contrast and glare.
  - Recommended values are given in Table 3, in terms of Gloss Units (GU).
  - Recommended values are given in Section 1.3 Table 3, in terms of Gloss Units (GU).
- Texture: Table 3 does not recommend specific textures, but rather recommends where a change of texture provides sensory information that may be beneficial to persons who are visually impaired as a subtle cueing or a warning.
  - Patterns (also see Appendix 5C on Michelson Contrast): Table 3 indicates where patterns on the walking surface should not be used. The uniformity of walking and transition surfaces is a safety issue. Stairways and walking surfaces are the most critical areas and should not have patterns.
  - A uniform walking surface, free of visual clutter, allows the important visual information to be perceived, i.e. steps, curbs and objects.
    - The scale of the pattern and the value contrast of the pattern will determine its impact.
    - Surfaces with large scale swirling or geometric patterns are confusing, masking important visual cues, i.e. the edge of a step or objects in the pathway.
    - A pattern with a strong value contrast will be more problematic than one with a low value contrast.

5D. Dimming and other Control Strategies

Occupancy sensor placement is very important to successful implementation of lighting controls by persons with low vision. Sensors should be placed to activate as soon as a person enters the space so he or she is not forced to grope about for a switch or to avoid collisions. To avoid entrance into a completely dark room, such as public toilets with no spill light from adjacent spaces, a minimum illuminance should be provided that activates when the occupancy sensor deactivates. For ease of identification, a minimum Light Reflective Value (LRV) difference of 20 should be provided between all switches, dimmers, button controls and covers and the mounted surface, and illuminated indicator light (pilot light). Additional strategies might include:

- An Illuminated pilot light with a large button slide bar dimmer with on/off switch may provide easy control.
- Automatic-On, Automatic-Off Occupancy Sensors set lights to come on when motion is detected; lights turn off when there is no movement in the room for a (programmable) pre-set time period. To avoid entrance into a completely dark room, such as public toilets with no spill light from adjacent spaces, a minimum illuminance should be provided that activates with the occupancy sensor deactivates,
- In areas such as stairwells, occupancy sensors can be used to switch between the minimum code required light levels during unoccupied periods and full light when occupied. Automated window shades and controls can be used for glare and contrast control by adjusting the daylight penetration into a space. Easily accessible controls and manual overrides with illuminated buttons should be provided.

Endnotes

[1] (Orr & Rogers, 2006; Warren, 2008).

[2] (Haegerstrom-Portnoy, 1999)

[3] Further guidance for wayfinding and other services for persons with low vision can be found at an ADA website: http://www.ada.gov/lodblind.htm. Requirements for Braille, however, do not help persons with low vision – most of whom are not trained in Braille reading.

[4] This is a form of Equation [8] for Weber Contrast in Appendix 5C, but the denominator is more limited in this equation.