This Daylighting Guide for Commercial Office Interiors is a resource for interior architects and others when designing for daylit spaces. Daylighting offers the potential for highly productive work environments that also save energy. Designers play a critical role in ensuring the benefits are realized. This guide provides checklists, tips and information to assist.

**INTRODUCTION**

“Daylighting” refers to the use of sunlight, skylight, and overcast sky illumination to provide functional interior lighting that is appropriate to specific programmatic areas and comfortable to the occupant. The design of an office tenant improvement (TI) nearly always provides substantial opportunity to use daylight to meet these objectives.

The benefits of buildings illuminated with daylight include:

- Healthier and higher quality interior environments for occupants
- Increased individual productivity
- Increased human comfort
- Mental and visual stimulation necessary for the proper regulation of human brain chemistry

When daylight is used as part of an integrated design strategy it can provide substantial energy savings.

The contents of this guide are proposed as a process to successfully design with daylight in a commercial office space. In most areas, this means complete control of direct sunlight during all occupied time and assurance of adequate-diffuse daylight to meet ambient and/or task illumination criteria during daylight hours.

In office environments, daylighting traditionally encompasses three primary avenues of design inquiry:

- Interior surface design and selection for effective daylight harvesting
- Shading for glare control
- Shading for thermal comfort (and heat gain control)
In an office TI, we assume that window size, orientation, exterior solar control devices and overall floor plate depth are predetermined. Yet, the interior designer still has a critical role to play in creating a design that meets daylighting criteria appropriate to visual comfort. Placement of the program elements takes into consideration patterns of occupancy, times of use, and orientation of the building to determine the availability and best use of daylight in relation to the program daylight requirements.

Programming for daylight may include LEED™ criteria, however, successful daylighting is far more specific to the visual experience than any single metric. In order to determine the availability and best use of daylight in relation to the program, the designer must ask themselves a series of qualitative and quantitative questions. The column at left titled Programming Criteria For Each Program Element lists four key queries. While the first two speak of quality of light and view, the second two open up opportunities to hard wire a link between specific programmatic elements and thoughtful daylighting strategies.

An example of a program for daylight criteria might include the following:

- **Open Office** - Daylight and view desired, occupants have glare control
- **Private Offices** - Daylight and view desired, individual occupant glare control
- **Support Spaces** - Minimal daylight or view opportunities required
- **Building Core** - No daylight or view opportunities are necessary

### EXAMPLE OF A DAYLIGHTING OPPORTUNITY ANALYSIS

Legend:
- Daylight available, requires occupant control of glare
- Direct sunlight, requires occupant control of glare
- Minimal daylight penetration or view opportunities
- No daylight penetration or view opportunities
- Approximate daylight penetration (1.5x to 2x window head height)
- Zones of direct sun exposure in Northern Hemisphere

Footcandle (fc)
A unit of measurement for calculating adequate lighting levels.

It is the amount of light that actually falls on a given surface.

The footcandle is equal to one lumen (a measure of the power of light perceived by the human eye) per square foot.
The next critical step during programming is to understand the patterns of light specific to the TI space over the course of a day. Daylighting simulation software can be used to understand the distribution of diffuse daylight, while direct sunlight patterns can be understood quickly with any design software that allows for simple shadow casting. Remember that sun control performance is only critical during occupied times.

Understanding patterns of light specific to the TI space is a critical step in the programming process.

- Identify distribution of diffuse illumination and direct sunlight.
- Recognize locations of direct sunlight patterns and the time of day they occur.

Once the characteristics of each daylit TI space are better understood and documented, specific programming criteria can then be applied. The column at left titled Programming Criteria For Each Daylit Space lists six key queries to help define the lighting control strategy of each space.

**BEST PRACTICE FOOTCANDLE LEVELS**

- 5 fc: Reception area/ simple orientation for short visits.
- 10 fc: Working spaces for simple visual tasks.
- 30 fc: Performance of visual tasks of high contrast and large size.
- 50 fc: Performance of visual tasks of high contrast and small size, or visual tasks of low contrast and large size.

**TOPLIGHTING STRATEGIES**

Toplighting via diffuse skylights, or clerestories should be included wherever architecturally possible. Studies show that toplighting tends to provide the most effective daylight performance, since it typically avoids the direct sunlight and glare challenges associated with perimeter windows.

Once a clear description of the daylight performance is in hand, the designer must synthesize the spatial needs of the program elements with the specific patterns of sunlight and diffuse daylight relative to the daylighting design criteria set forth.
**DAYLIGHTING GUIDE**

**FOR OFFICE INTERIORS**

**Tip:** Practical Depth – For conceptual planning, the practical depth of the daylight zone is limited to 1.5 to 2 times the window height.

**RESOURCES ▼**

Daylighting Collaborative  
http://www.daylighting.org

**GLOSSARY ▼**

**Toplighting**  
Daylight that enters the space through skylights or clerestories.

**Diffuse**  
Refers to the natural light entering the space through indirect sources, be it obscured by trees, reflected off adjacent buildings or transmitted through translucent materials.

**Clerestory**  
Windows set above eye-level on a wall allowing daylight to enter higher within the space.

**SPACE PLANNING**

**RELATIVE TO PATTERNS OF DAYLIGHT & TIMES OF OCCUPANCY**

When space planning for daylight, the designer can synthesize what they know about the patterns of diffuse and direct sun in the space with each program element’s needs, priorities and occupancy patterns.

For example, it is well known that open office environments tend to be occupied by someone nearly continuously during the work day, yet private offices are often unoccupied as much as two-thirds of the time. Occupants in private offices are likely to adjust their blinds frequently, since the “ownership” of their space is clear. In order to ensure an equitable distribution of light and views, the following is recommended:

- Locate open office areas within 18’-20’ of the perimeter zone and at areas where direct sun penetration is limited (North) or less variable (South).
- Position individual offices where low angle direct sun may otherwise be problematic (East and West).

![Diagram of office layout](image)

The exact alignment of all program element daylighting criteria and the type of space available to the occupants is not always achievable. However, the visual comfort of building occupants must remain paramount in any performance equation, thus reiterating the importance of an integrated design approach where all strategies in this guide work together to create the most appropriate solution.
## FACTS

**Fabric Window Shades:**
- Generally reduces diffuse daylight levels by 90% or greater when deployed.
- Does not completely block disc of the sun unless blackout shades.
- Requires user to continuously adjust blind position for optimum daylight performance.
- Easy to use.

**Horizontal Blinds:**
- Blocks direct sunlight.
- Requires users to continuously adjust blind slat angles for optimum daylight performance.
- Redirect to create diffuse light.

## WINDOW COVERING OPERATION

### Manual Operation:
- Proper use can achieve maximum daylight performance.
- Requires frequent user attention to maintain daylight performance.

### Automated Operation:
- Deployed and retracted only when needed.
- No user interface required therefore maximizing daylight effectiveness.
- Up to four times as expensive as manual.

## WINDOW COVERING DESIGN FOR GLARE & THERMAL CONTROL

The selection of blinds, window coverings, or the lack thereof is likely the most crucial choice a designer will make when seeking to ensure visual comfort while maintaining daylight performance over time.

We have all seen buildings where blinds are down continuously. Typically, this is associated with visual discomfort (glare). The most common source of glare issues in daylighting is a line of sight to the disk of the sun. Selecting a window covering that is opaque enough to block the sun, such as fabric window shades with 3% or less openness or horizontal blinds, can control this phenomena.

Manually operated blind systems can be very effective if properly used. More specifically, a 2" horizontal blind with a white finish can function as a series of mini light shelves casting indirect light into the space when desired. However, they rely on and require constant user attention to maintain complete glare control while achieving maximum daylight performance. For this reason, blinds or shades are often permanently deployed at the “worst case scenario” position to maintain visual comfort throughout the day and year. This typically results in poor daylight performance and the elimination of views to the exterior.

Automated glare control has the distinct advantage of being deployed only when needed and retracting without user intervention when direct sunlight is no longer present to allow for unimpeded diffuse daylight. In most cases, this will deliver longer periods of effective daylight contribution, increased electric lighting power savings, and longer durations of unobstructed views to the exterior. Automation of glare control may provide the most persistent daylight performance where low angle direct sun is present during extended periods of occupancy.

### Shading and Exposure Tips:
- **North** – Shading may only be needed in early morning or late afternoon.
- **South** – Good access to strong illumination but varies throughout the year. Shading is easier than East/West.
- **East/West** – Shading is difficult but critical for comfort.

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*Images courtesy of WAREMA Renkhoff GmbH*
The selection and design of open office furniture, especially workstation panels, requires a continued commitment to the preservation of daylight and views. Workstation panels must be kept low (42” or less) and parallel to the direction of the daylight distribution to ensure the maintenance of views. Where higher panels (48” or greater) are required for privacy or to create a sense of enclosure, they should be oriented perpendicular to the perimeter glazing. Sixty-five inch high panels that are perpendicular to the direction of daylight distribution can enable privacy and allow for ample storage without compromising views or creating dark shadows.

Workstations should be designed whenever possible so that the direction most occupants face while performing visual tasks (i.e. looking at a computer) is perpendicular to daylight openings. This helps avoid the visual discomfort occupants experience when looking into their shadow, or worse, from the excessive contrast occurring when a visual task area is immediately surrounded by the brightness of a view to the exterior.

**WORKSTATION PANELS**

![Perpendicular orientation of user to window](Image)

Daylight performance maximized with this panel layout

![Perpendicular orientation of user to window](Image)

Daylight essentially blocked with this panel layout

**Glossary**

**Visual Discomfort**

Can be caused by glare on a computer screen, direct line of sight to the disk of the sun, or excessive contrast of two items within a person’s visual field. Often occupants will resort to shutting the blinds or shades if the daylight is causing the visual discomfort. If a space then becomes too dark, users will turn on the electric lighting, thus negating the anticipated energy savings of using daylight.
The light reflectance is based on a scale of 0 (total light absorption) to 100 (total light reflection), where 0 is black and 100 is white.

Light reflectance values (LRV) traditionally have been calculated by lighting designers as follows:

- 80 for ceiling
- 50 for walls
- 20 for floors

When estimated LRVs do not match the actual design, the lighting solution may not be appropriate to the space.

It is difficult to achieve maximum energy efficiency, as estimated above, when interior finish selections are dark in tone.

Interior surface finishes can be a powerful tool in shaping the perception of brightness within interior spaces. Physiologically, our eyes tend to adjust to the brightest location within an interior space. This means that if the perimeter zone is substantially brighter than the interior zone, the space will tend to be perceived as dark. This is often referred to as the "cave effect."

With typical office ceiling heights and core depths in excess of 25'-0", it is very difficult to achieve balanced illumination from one side to the other. The balance of daylight distribution within a given volume is crucial to visual comfort and the perception of brightness. Furthermore, structure, beams, ductwork, and other equipment should be positioned so that they do not cast shadows on surfaces that are crucial for daylight inter-reflection. This is especially true with the ceiling plane.

The placement of bright surfaces opposite or around daylight apertures can help to reduce contrast and balance the luminosity in the space. The strategic placement of darker surfaces adjacent to planes that are designed to be perceived as bright can, by contrast, enhance the perception of brightness and uniformity where desired.
Implicit in the discussion of daylighting design is the desire to reduce energy waste. This requires that automated controls be superimposed on the electric lighting equipment.

Within the context of office tenant improvements, any discussion of daylighting design implies that the electric lighting in areas with daylight will be under photocell control. When applied effectively, photocell lighting controls can save substantial lighting power by reducing/extinguishing electric light output when available daylight meets workplane illuminance needs.

A crucial step in integrating electric lighting design and controls with a daylighting strategy is the identification of user expectations with respect to their role in operating the lighting system and their tolerance for automated transitions in electric light output when daylight conditions change.

We know that the human eye adapts to a wide range of light levels. However, jarring and unexpected transitions in light distribution and intensity have caused numerous photocell lighting controls systems to be disabled via occupant intervention. This type of occupant annoyance is what gives lighting control systems a bad name. Feedback about this behavior has provided guidance for designers: choose the correct style of control for each space (dual-switching, step-dimming or continuous dimming) and ensure post-occupancy commissioning of the system for user satisfaction.

**ORGANIZING LIGHTING CONTROL ZONES**

A daylighting “control zone” is a group of fixtures in locations of similar daylight availability. These luminaires are controlled together via a photocell to reduce electric light output when daylight is present. Automated lighting controls should be prioritized to areas where daylight performance is expected to be high over time, and where individual occupant control of lighting is not realistic.

Responsibility for photo-control design and integration occurs at the nexus of the interior designer, the lighting designer, and the electrical engineer. Critical considerations are as follows:

- What type of work area is this; what tasks are performed?
- What are the maintained illumination levels?
- Is the photocell placed in a location where what it “sees” is representative of the luminous experience of the space or zone during typical daylight conditions?
- Will other light sources interfere with the ability of the photocell to control a particular zone or layer of light?
- What will the transition between electric light levels feel like?
- What is the reference location for calibration and commissioning of each zone?
- Who is responsible for doing this work?

**Tip:** Generally, due to lack of obstructions and therefore better interreflectivity, shared open office areas rather than private offices provide the best opportunity for automated photocell control of electric lighting in an office TI.
Continuous dimming is achieved by using a single ballast/single circuit that continuously lowers the light output of its lamps from a maximum 100% output to a low end of 50%, 20%, 10%, 5% or 1% depending on the ballast type. Ballast cost typically goes up as the low end dimming range goes down. Controlling for a slow fade-rate maintains occupant satisfaction.

Step-dimming is a confusing term. It is achieved by using a single circuit that "dims" all its lamps by reducing light output (and power consumption) by one or more steps between full ON and OFF (i.e. 100/50/off). Since all lamps in the luminaire are affected equally this control choice maintains the photometric distribution and the aesthetic of the luminaire and is therefore referenced as a form of "dimming." It is designed to be a low-cost, easy-to-install system which simply uses an additional input lead for the switching circuit.

Dual- or Multi-level switching was conceptualized using 3-lamp luminaires. By using 2 ballasts, the center lamp is controlled separately from the outside 2 lamps (commonly referred to as "inboard-outboard"). This method of lowering output and saving energy is achieved by then switching 1 or 2 lamps OFF, providing up to 3 levels of illumination. This requires multiple circuits to each luminaire and produces a shift in photometric distribution and the aesthetic of the luminaire. As energy code restrictions have increased, the use of 3-lamp luminaires has plummeted because they do not meet code and illuminance uniformity requirements.

For most traditional shared open office environments continuous dimming is the appropriate choice. This is because the transition in light level is gradual enough that it is not noticeable, and therefore not disruptive, to most occupants. The unexpected and sudden change in light levels associated with step-dimming or dual-switching should be relegated to the general service areas such as the break room, copy room, corridors, stairwells, etc. It also helps if these spaces are not visible from seated work areas. Another common source of dissatisfaction is that occupants see fixtures that are obviously de-energized (OFF) and perceive that something is "wrong." This speaks to the need for educating occupants so that they understand the systems and why they are used. To overcome this perception, it is imperative that the lighting designer provide light using sources such as balanced vertical illumination, sconces, or task lights for work surfaces.
Daylighting design goals and aspirations vary widely among program elements and the visual tasks they support. However, there is a common linkage between design relationships that connect the sky and its patterns of illumination at the macro scale with an individual workstation and the specific needs of a person who will use that space to accomplish necessary tasks. This set of relationships includes:

- The site and sky as a light source
- The massing and orientation of the building (or space within the building)
- The depth of the floor plate
- Building aperture sizes and locations
- Architectural elements and window coverings for glare and thermal control
- The interior surfaces and their luminous properties
- Interior furnishings including workstation panel layout
- And ultimately the orientation of the occupant within his/her workstation or office; the direction one faces when performing visual tasks

The interior designer, in partnership with others on an integrated design team, has significant influence in realizing the daylighting potential in any tenant improvement project.

**CHECKLIST ITEMS**

- Determine daylighting and view criteria for each program element.
- Do a site visit to understand the existing conditions during the hours of occupancy: where and when the daylighting enters the space, potential reflection off of or shading created by adjacent buildings.
- Diagram out the daylighting and view opportunities on the floor plan.
- Align the program criteria for each space with the most desirable location on the floor plan.
- Select the appropriate window covering for the space to diffuse light or glare when and where required. Privacy needs are also a consideration with window covering selection.
- Choose interior finishes that will support the maximum efficiency of electric lighting and daylighting but also support balanced luminosity in the space.
- Plan for open office workstation panels to be 42" or lower where they are parallel to the perimeter window.
- Integrate a lighting control system into the space. To help reduce electrical light output, zone areas with similar daylight performance together.