Integrated Lighting System Performance Specifications

Prepared by LightLouver LLC (March 2013)

In support of the design of effective daylighting systems utilizing the LightLouver Daylighting System, LightLouver LLC staff have developed the following **minimum** performance specifications for the architectural elements that are part of an integrated lighting (daylighting + electric lighting + lighting controls) design solution. Adhering to these minimum performance specifications, and the manufacturer's product application guidelines, will help ensure proper illumination, visual comfort and long-term energy savings.

Architectural and interior design products that meet these minimum performance specifications are listed as Complying Components and Products on the LightLouver Optimization Program web page. <www.lightlouver.com>

Definition of Daylighting

LightLouver LLC defines daylighting as t***he purposeful use of sunlight to meet the illumination requirements of an architectural space***.

The key words in this definition are "purposeful" and "illumination requirements". "Purposeful" indicates that the collection / admittance and distribution of sunlight into an architectural space is a conscious statement of design intent and a conscious act of design, while "illumination requirements" indicates that the quantitative (i.e. light levels) and qualitative (i.e. visual comfort) criteria of effective lighting design will be met.

Good daylighting and electric lighting design is difficult and requires that the design team simultaneously address numerous design issues and variables. Effective integrated lighting design can be complex, but if certain design challenges and design goals are kept in mind and if specific performance requirements are understood and followed, the design team can achieve an excellent integrated design solution. This performance Specification has been created to this end.

Daylighting Design Challenges

Design teams face numerous challenges when designing for the use of daylighting in buildings, including the following:

- Glare – Visual discomfort due to large amount of sunlight in the occupants' field of view, typically in combination with a high contrast ratio between the daylight entering the space and the surrounding window frame or wall surfaces.

- Poor daylight distribution – Excessive daylight levels near the windows and inadequate daylight levels deeper in the space result in non-uniform illumination levels.

- Improper selection of electric lighting fixtures and lamps – Selecting electric lighting fixtures, ballasts and lamps that will effectively integrate with the daylighting system.

- Ineffective electric lighting system "daylight harvesting" controls – Improper design or selection of the electric lighting system controls can reduce the amount of "daylight harvesting" and thus the energy savings derived from dimming or turning off electric lights.

- Ineffective interior window treatment – During periods of direct sun on fenestration, excessive daylight and sunlight patches on work surfaces, or excessive shading / blackout, due to improper selection of interior window treatment.

- Inappropriate interior design and furniture selection -- Choice of wall colors, ceiling color / reflectance, partition height and color, furniture placement, and other interior design decisions can have a detrimental impact on daylighting system performance.

Daylighting Design Goals

During the Programming Phase of the Architectural Design Process, project-specific daylighting design goals should be developed by the design team and approved by the client. We suggest the following general daylighting design goals as a starting point for establishing project-specific goals:

- Quantity

-- Daytime ambient lighting provided by daylight for the majority of the year for all daylit spaces

- Quality

-- Uniform distribution of daylight to reduce uncomfortably high brightness ratios, and increase “daylit” area
-- Elimination of direct sunlight onto work surfaces to reduce glare and visual discomfort
-- Solar heat gains utilized, when beneficial, to reduce heating loads

- Usability

  – Ensure access to adequate daylight for all occupants
  – Ensure views / visual connection to the outdoors for all occupants

- Building Integration

  – Fully integrate daylighting with the architectural design
  – Fully integrate daylighting with the electric lighting system
  – Synergistic with other building systems – mechanical, electrical, life safety, etc…

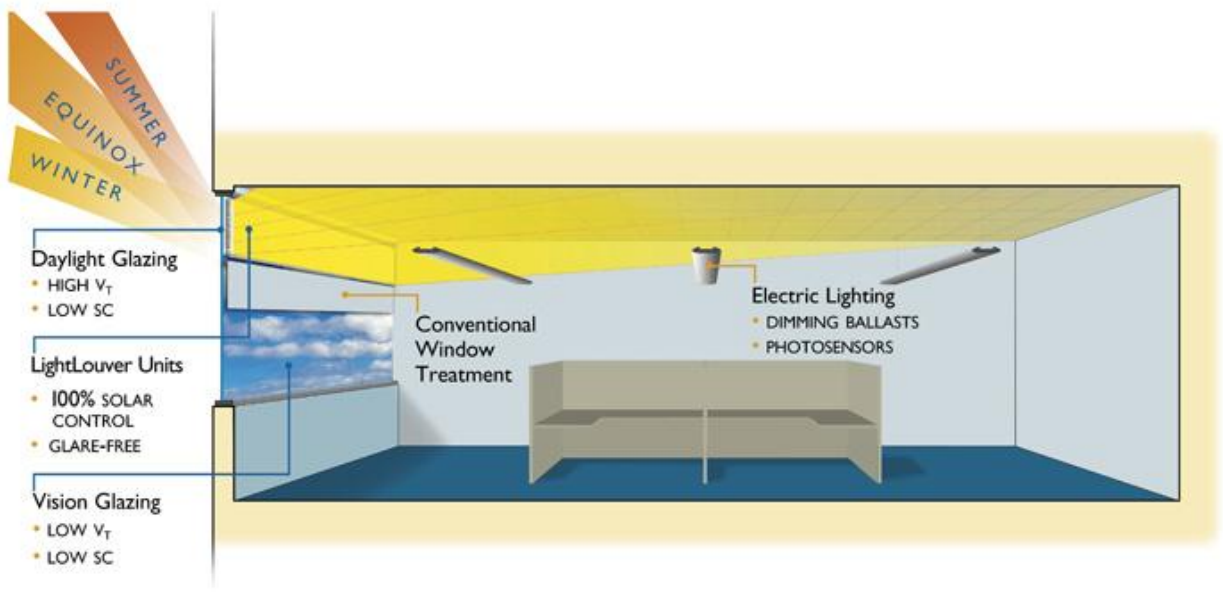
- Economics

  – Integrate with daylight responsive electric lighting controls to maximize “daylight harvesting” and energy savings
  – Minimize first costs to reduce payback period from energy savings

Daylighting Performance Specifications

The following integrated lighting system performance specifications have been developed with the daylighting design challenges and the daylighting design goals in mind.

To achieve an effective, integrated daylighting design solution in new and existing commercial / institutional buildings, design teams must consider numerous site and building-related factors. A few of these factors are addressed in the following minimum material / product performance specifications. Selecting components and products that meet these minimum performance specifications will not guarantee optimal performance, but will put the design team on the path to an effective, integrated daylighting design solution.



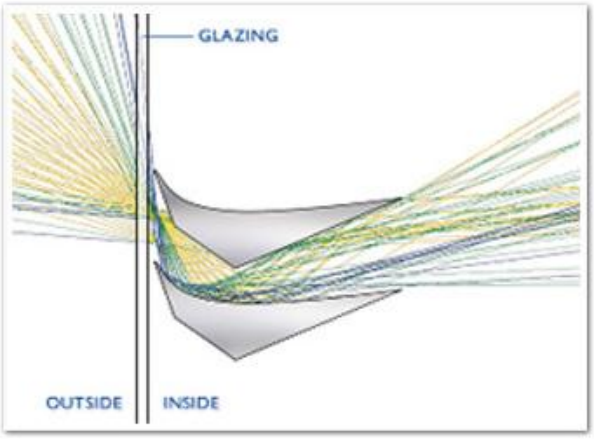
Access to Sunlight

"Daylight windows" (windows where the LightLouver units are to be located) should ideally have unobstructed access to sunlight throughout the day. Exterior overhangs or other architectural features **must not** shade these "daylight windows", and any exterior window shading devices should be located below the "daylight windows", and designed to shade the "view windows".

Fenestration Specifications

Most commercial buildings in various climates benefit from windows with a low U-value (low heat conduction) and a low Solar Heat Gain Coefficient (reduced solar heat gain). This essentially translates to an insulated glazing unit (IGU) with a low-emissivity coating.

As an optical daylighting and solar control product, LightLouver units are recommended for east, south and west facing facades (in northern latitudes, >20^{o}N) to redirect incident sunlight deep in the space to provide ambient lighting while eliminating glare and direct sunlight on work surfaces.



The patented LightLouver reflective slat design redirects all sunlight above a 5 degree altitude angle upward onto the ceiling of the daylit space, providing ambient lighting and eliminating direct sunlight on work surfaces. LightLouver units are a perfect solution for East, West and South facing windows.

When using LightLouver units, the "daylight windows" (windows where the LightLouver units are to be located) should also have a high visible light transmittance and a low exterior reflectance to maximize daylight collection. Obviously, glazing design conditions will vary for the design of a new commercial building versus the redesign of an existing commercial building. The ideal glazing performance specifications for "daylight window" and "view window" fenestration glazing in **new construction** are as follows:

Daylight Window Glazing -- New Construction
Visible Light Transmission (VLT, Tvis) > 65% (75% Tvis recommended)
Solar Heat Gain Coefficient (SHGC) < 0.40
Light to Solar Heat (LSG) Gain Ratio > 1.8
Exterior Reflectance < 13%
U-Value < 0.31

NOTE: Scenarios/design conditions in cold climates may benefit by a higher SHGC (lower LSG).

View Window – New Construction
Visible Light Transmission (VLT, Tvis) No minimum performance specification for "view window" glazing Tvis is specified, as the SHGC and LSG ratio requirements will be the governing factors in "view / vision" glazing selection.

Solar Heat Gain Coefficient < 0.30
Light to Solar Heat Gain > 1.8
Exterior Reflectance < 20% (As appropriate, match the "daylight" glazing exterior reflectance, or contrast the "daylight" glazing with a higher exterior reflectance glazing.)
U-Value < 0.31

For **existing buildings**, when the windows will not be replaced, the fenestration design (window setbacks, overhangs, orientation, and self-shading) and window glazing properties will determine the viability of incorporating the LightLouver Daylighting System. Special conditions, such as the need for added solar control, may suggest the use of LightLouver units even if the glazing does not meet the minimum performance specification. Additionally, the layout of the spaces to be daylit will influence the applicability of the LightLouver Daylighting System. The new construction fenestration performance specifications presented above represent the preferred conditions for the use of the LightLouver Daylighting System in existing buildings; however, glazing replacement in a renovation project is not always a feasible or viable option, and thus other design conditions may be acceptable.

Daylight Window Glazing -- Existing Buildings
Visible Light Transmission (VLT, Tvis) > 50% (65% Tvis preferred)
Solar Heat Gain Coefficient < 0.45
Light to Solar Heat (LSG) Gain Ratio > 1.2
Exterior Reflectance < 13%

Ceiling Reflectance Specifications

Reflectance > 80% (> 90% preferred)
Specular Reflectance < 2%
Surface Finish - A smooth, matte finish with no heavy patterns, texture or protrusions that would act as a “light dam,” blocking daylight distribution across the ceiling surface

Wall / Partition Reflective Specifications

Wall Diffuse Reflectance > 40% below 7’ 0” or > 70% above 7' 0"
Partition Height < 60 inches

Fenestration Shading Specifications

Effectively shade the "view window” during the spring, summer and fall months without shading any portion of the “daylight window”

Interior Shading Specifications

Effectively blocks the direct sunlight entering the “view window” and not allowing more then 3 % of this direct sunlight to strike critical work surfaces

Electric Lighting Fixture Specifications

Source Efficacy > 60 lumens / Watt
Luminaire Efficiency > 80%
Indirect Component 10 - 30 %
Electronic Programmed Start Ballasts

Zoning / Circuiting -- Ability to control (dim or turn off) electric lights in daylit spaces in response to daylight. Typically locate rows of lighting fixtures parallel to the “daylight windows”.

Daylight Compatible Electric Lamp Specification

The quality of light, as defined by color temperature, is very important when integrating electric lighting with daylighting. Daylight has a color temperature of approximately 5,600 degrees Kelvin (5600K). Thus, when daylight and electric light will be combined (seen) on the same surface, such as a ceiling with reflected daylight from LightLouver units and with electric light from pendent lighting fixtures, the color temperature of each light source needs close to the same. Most warm light fluorescent lamps have a color temperature of 3300K, while cool white fluorescent lamps have a color temperature of 5000K.

The recommended performance specification for electric lamps is as follows:

Color Temperature: > 4000K, and preferably >5000K

Daylight Responsive Controls Specifications

Any photosensor control based system – open or closed loop acceptable
Known spatial sensitivity with a broad symmetrical sensitivity curve
Known spectral response with minimal sensitivity in the Infra-Red (IR) and Ultra- Violet wavelengths

Open Loop

- Sensitive from 50 – 8,000 footcandles
- Durable, UV stable and resistant to yellowing and cracking, etc...
- Programmable control algorithm
- Photometrically calibrated sensor preferred

Closed Loop

- Sensitive from 0.5 – 500 footcandles
- Sensor shielded from seeing any LightLouver units
- Programmable sliding setpoint control algorithm

Lighting Power Density Specifications

Building energy codes and standards specify the maximum lighting power density (LPD) that the electric lighting system can have by building / space type. These LPDs have been developed in cooperation with the Illuminating Engineering Society to ensure that quality lighting that meets the illumination requirements of the occupants and space can be provided within the code / standard specified LPD. The International Energy Conservation Code (IECC), California Title 24, ASHRAE Standard 90.1 and other Model Codes will specify the maximum building / space LPDs that are allowed to be in compliance with the code. You will need to consult the applicable building energy code in the project location to determine the maximum allowable LPD.

Typically, an allowance is made when daylight dimming controls will be integrated into the design.