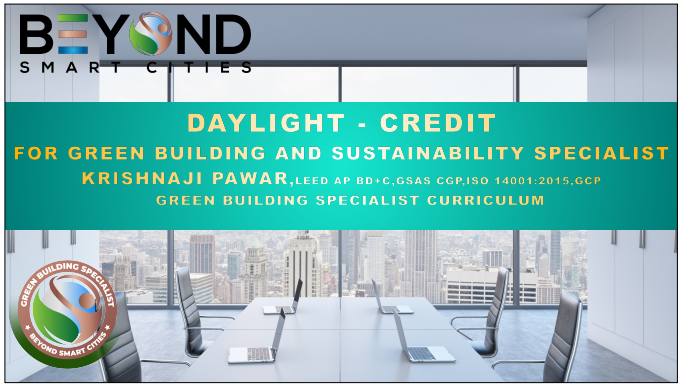
BEYOND
SMART CITIES
INDOOR ENVIRONMENTAL QUALITY - GREEN BUILDING TECHNOLOGY TRAINING PROGRAM
FOR GREEN BUILDING AND SUSTAINABILITY SPECIALISTS
KRISHNAJI PAWAR,LEED AP BD+C,GSAS CGP,ISO 14001:2015,GCP
GREEN BUILDING SPECIALIST CURRICULUM


BEYOND
SMART CITIES
DAYLIGHT - CREDIT
FOR GREEN BUILDING AND SUSTAINABILITY SPECIALIST
KRISHNAJI PAWAR,LEED AP BD+C,GSAS CGP,ISO 14001:2015,GCP
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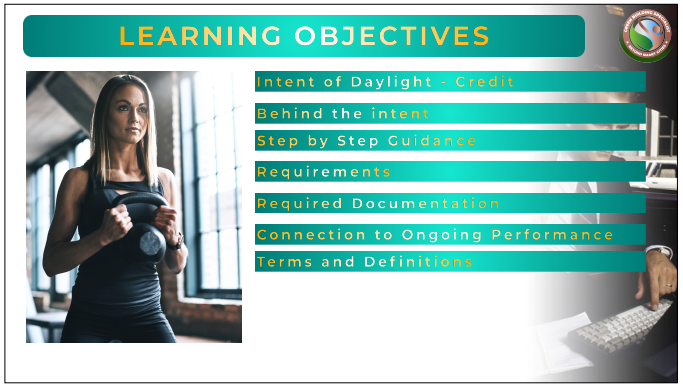

LEARNING OBJECTIVES
Intent of Daylight - Credit
Behind the intent
Step by Step Guidance
Requirements
Required Documentation
Connection to Ongoing Performance
Terms and Definitions

IEQ- CR(3) - DESIGN

Intent

To connect building occupants with the outdoors, reinforce circadian rhythms, and reduce the use of electrical lighting by introducing daylight into the space.

Potential Technologies & Strategies

☑Projects have three compliance options. The options that require more detailed design input and analysis or that demonstrate actual performance earn a correspondingly higher number of points. A good computer simulation is the best way to inform the design phase and help create a more effective daylit project. Project teams should integrate daylight concerns into the design process while taking into account such factors as heat gain and loss, glare control,

DAYLIGHT

Requirements

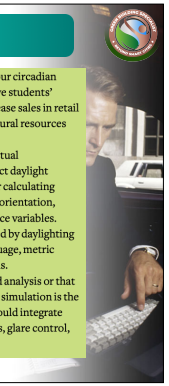
Provide manual or automatic (with manual override) glare-control devices for all regularly occupied spaces. AND Select one of the following three options.
Perform annual computer simulations for spatial daylight autonomy300/50% (sDA300/50%), and annual sunlight exposure1000,250 (ASE1000,250) as defined in IES LM-83-12 for each regularly occupied space. Healthcare projects must use each regularly occupied space located in the perimeter area determined under EQ Credit Quality Views. Additionally, calculate the average sDA300/50% value for the total regularly occupied floor area.

IMPLEMENTATION

REQUIRED DOCUMENTATION

Documentation	All projects	Option I	Option II	Option III
Floor plan highlighting regularly occupied spaces (for healthcare, regularly occupied perimeter area)	X	X	X	X
List of glare control device for all windows with their control mechanism	X	X	X	X
List of compliant spaces with the annual summary values for sDA and ASE		X		
Geometry used from simulations		X	X	
Narrative or output file describing daylight simulation program, simulation inputs, and modeler file		X	X	
List of compliant spaces with their calculated illuminance values			X	
Floor plan or list of compliant spaces with measured illuminance values for each room				X
Calculations demonstrating percentage of compliant space between 300 lux and 3,000 lux				X

BEHIND THE INTENT



Increased access to daylight has positive human behavioral and health effects because it reinforces our circadian rhythms.[1] Access to sufficient daylight has been shown to increase healing times in hospitals, improve students' performance,[2] increase productivity in the workplace,[3] fight depression and lethargy, and even increase sales in retail environments.[4] A well-designed daylit building also uses less electric lighting energy, conserving natural resources and reducing air pollution.

This credit has evolved significantly and now focuses on using simulated daylight analysis and actual measurement to estimate daylight quality and daylight levels. These methods more accurately predict daylight access and support the design process for optimizing daylight. The previous prescriptive method for calculating daylight using window design less accurately accounted for such project-specific factors as building orientation, exterior conditions, the interaction with interior finishes, time of day and year, and other performance variables. The new simulation requirements use global metrics and performance values for daylight established by daylighting professionals. Other globally recognized standards-setting organizations are using the credit's language, metric conversions, and performance goals to create consistency in the daylighting and building professions.

Projects have three compliance options. The options that require more detailed design input and analysis or that demonstrate actual performance earn a correspondingly higher number of points. A good computer simulation is the best way to inform the design phase and help create a more effective daylit project. Project teams should integrate daylight concerns into the design process while taking into account such factors as heat gain and loss, glare control, visual quality, and variations in daylight availability.

STEP-BY-STEP GUIDANCE

STEP 1. ESTABLISH DESIGN CRITERIA

During predesign, work with the owner to understand lighting and daylighting goals. Specify daylighting performance criteria in the owner's project requirements.

STEP 2. CONSIDER SITE AND MASSING

During schematic design, determine how best to orient the building to allow for passive solar strategies, and explore ways to improve daylight penetration and distribution.

- Consider identifying and preserving existing topography and landscape features that will shade the building or minimize glare.
- Consider proximity to neighboring buildings and their effects on daylighting availability and shading.
- Evaluate the building footprint, the structural floor-to-floor height, and finished ceiling clearances to determine an adequate ratio of window to floor area.
- Consider incorporating atria, clerestories, courtyards, and shallow floor plates.
- Weigh the effects of the envelope design on energy efficiency. Incorporate exterior shading to minimize solar heat gains and glare while admitting daylight.

STEP 3. DESIGN TO MAXIMIZE DAYLIGHT

Consider how best to allocate interior space to ensure that daylight is available in all regularly occupied spaces. Enclosure design and furniture selection will affect daylight penetration. Possible design strategies include the following:

- Use transparent partitions or interior glazing to provide daylight to enclosed spaces.

STEP-BY-STEP GUIDANCE +

- In open-plan offices, select low partitions or incorporate glazed panels above 42 inches (1 070 millimeters).
- Consider using daylighting simulations early in the design process to ensure effective daylighting and to identify and minimize sources of glare.

STEP 4. IDENTIFY REGULARLY OCCUPIED SPACES

Identify all regularly occupied spaces within the project (see *EQ Overview, Regularly versus nonregularly occupied spaces*). Highlight regularly occupied spaces on the floor plan or furniture plan and create a tracking table that lists all regularly occupied spaces and their respective floor area (square footage or square meters).

Determine whether any regularly occupied spaces should be excluded from the daylight requirements (see *Further Explanation, Project Type Variations*). Spaces where tasks would be hindered by the use of daylight may be excluded. Spaces may not be excluded for security or noise concerns.

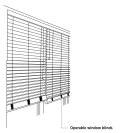
For Healthcare projects, only consider regularly occupied spaces within the perimeter area (see EQ Credit Quality Views, *Further Explanation, Perimeter Areas*).

STEP 5. PROVIDE GLARE CONTROLS

Provide glare-control devices for all transparent glazing in regularly occupied spaces, regardless of whether the glazing receives direct sunlight or whether the space meets the illuminance requirements of this credit (Figure 1).

- All glare-control devices must be operable by the building's occupants to address unpredicted glare. Automatic devices with user override are acceptable.
- Acceptable glare-control devices include interior window blinds, shades, curtains, movable exterior louvers, movable screens, and movable awnings.
- Systems not acceptable as glare-control devices include fixed exterior overhangs, fixed fins and louvers, dark-colored glazing, and frit and other glazing treatments.
- Diffused and translucent glazing systems do not require glare-control devices.

Window with fixed louvres



Operable window blinds

Unacceptable Glare Control Devices

- Fixed exterior overhangs
- Fixed fins
- Fixed louvres
- Dark-colored glazing
- Frit glazing treatment
- Additional glazing treatments

Acceptable Glare Control Devices

- Interior window blinds
- Interior shades
- Curtains
- Movable exterior louvres
- Movable screens
- Movable awnings

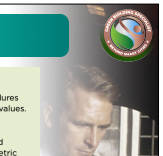
Figure 1. Glare control devices

STEP-BY-STEP GUIDANCE +

STEP 6. SELECT ONE OPTION

Determine which option the project will pursue. Options 1 and 2 involve different modeling procedures (see IES LM 83-12 and *Further Explanation, Illuminance Simulation Procedure*) and different point values. Option 3 requires no modeling.

- **Option 1** requires project teams to simulate both hourly illuminance and direct sunlight in each space over an entire year and likely necessitates engaging a daylighting consultant. The method uses a daylight simulation program that generates spatial daylight autonomy (sDA) ratios,[8] a metric that determines annual daylight performance based on annual weather data and occupancy use. This temporal analysis provides more information for design decisions than single-point-in-time calculations.[9] Only spatial daylight autonomy (and not continuous autonomy or daylight autonomy) is modeled.
- **Option 2** is similar to the simulation option in previous versions of LEED and may require the help of a daylighting consultant. This compliance method has been carried over from previous LEED versions because illuminance calculation is still used by many daylighting professionals. However, project teams are now required to use site-specific daylight illuminance values instead of the program default values for weather. This provides daylight performance data that better reflect actual site conditions, leading to better design decisions.
- **Option 3** is typically for renovations that involve minimal modifications to the building envelope and for substantiating a completed project's design strategies with a performance-based metric. Consider the schedule before selecting Option 3: the second required measurement must occur at least five months after the first measurement. Measurement compliance method is similar to the method used in previous versions and is now the only method for credit compliance that is not simulation based. This method has been revised to better address the differences in daylight experienced throughout the year by requiring measurements at two times—when the sun is high in the sky and when the sun is low in the sky.



STEP-BY-STEP GUIDANCE +

Option 1. Simulation—Spatial Daylight Autonomy

STEP 1. COLLECT SDA SIMULATION INPUTS

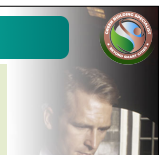
Work with the daylighting consultant to identify information needed for the daylight simulation. At a minimum, compile the following:

- Exterior building geometry and obstructions
- Site plan, location, and context
- Floor plan and furniture plan
- Interior finishes and surface reflectance (see *Further Explanation, Surface Reflectance*).
- Glazing performance specifications
- Glare-control device specifications
- Project occupancy schedule
- Local climate weather files, such as typical meteorological year (TMY2 or TMY3) data, available at nrel.gov

STEP 2. PERFORM SDA SIMULATION

Prepare the sDA model based on information collected in Step 1. Follow the modeling methodology outlined in IES LM 83 (section numbers below refer to this standard).

- See Section 2.2, sDA—Building 3D Modeling Methodology, for guidance on the period of analysis, illuminance threshold information, temporal threshold, analysis area, analysis points, operation of blinds and shades, optical properties of blinds and shades, exterior obstructions, window and skylight details, interior surface reflectances, and furniture and partitions. For building geometries, develop a complete building model.
- Ensure that the software program selected is capable of simulating the sDA model per Section 2.3.3, Modeling Parameters.



STEP-BY-STEP GUIDANCE +

- Determine how the regularly occupied spaces will be divided into analysis areas. The analysis areas must cover all regularly occupied floor area. For the annual sunlight exposure (ASE) calculations, at a minimum, each floor must be an analysis area (for Healthcare, use all regularly occupied perimeter floor area).
- Include glare-control devices in the model as described in Sections 2.2.7, Blinds/Shades Operation, and 2.2.8, Blinds/Shades Optical Properties.
- Set thresholds for the simulation to 300 lux for 50% of the hours between 8 A.M. and 6 P.M. local clock time, for a full calendar year, from January 1 to December 31. See Sections 2.2.1, Period of Analysis; 2.2.2, Illuminance Threshold Information; and 2.2.3, Temporal Threshold.
- Ensure that the model includes all permanent interior obstructions. Moveable furniture and partitions may be excluded. See Section 2.2.11 for suggestions on modeling furniture and partitions.
- Refer to Section 2.3, sDA—Climatic Modeling Methodology, for guidance on climate conditions for the project's location (see *Further Explanation, Finding Meteorological Data*).

Perform the sDA simulation.

Consult with the project team on assumptions developed for early design simulations. The assumptions should be further refined as design develops. Simulation results used for credit documentation should be based on the design that is closest to the completed construction documents for the as-built scenario.

STEP 3. EVALUATE SDA COMPLIANCE

Review the simulation output results and determine the sDA value for all regularly occupied floor area (for Healthcare, the regularly occupied perimeter floor area).

- Record the areas that are daylit (i.e., they contribute to the sDA value by meeting the threshold for the simulation).
- Confirm that the project meets or exceeds the requirements in Table 1 in the credit requirements.

STEP 4. PERFORM ANNUAL SUNLIGHT EXPOSURE SIMULATION

- Prepare the annual sunlight exposure (ASE) model based on information collected in Step 1 and the sDA model created in Step 2. The sDA model can be used for ASE analysis with a few modifications. Follow the modeling methodology outlined in IES LM-83 (section numbers below refer to this standard).
- See Section 3.2, ASE—Building 3D Modeling Details, for guidance on the period of analysis, illuminance threshold information, temporal threshold, analysis area, analysis points, operation of blinds and shades, optical properties of blinds and shades, and exterior obstructions.
- The analysis areas should be the same as those used for the sDA simulations. To align with the supporting research for ASE, small analysis areas (ideally space by space, or orientation per floor) are recommended. At a minimum, the analysis area must be for all regularly occupied floor area on a single floor (for Healthcare, the regularly occupied perimeter area on a single floor).
- Glare-control devices are not included in the analysis per Section 3.2.6, Blinds/Shade Operation.
- Set thresholds for the simulation to 1,000 lux of direct sunlight for more than 250 hours of the hours between 8 A.M. and 6 P.M. local clock time, for a full calendar year, from January 1 to December 31. See Sections 3.2.1, Period of Analysis; 3.2.2, Illuminance Threshold Information; and 3.2.3, Temporal Threshold).
- Refer to Section 3.3, ASE—Climatic Modeling Methodology, for guidance on climate conditions for the project's location. The ASE analysis does not require modeling of sky luminance or ground reflectance. If the software being used does not accommodate direct sunlight as described in Section 3.3, ASE may be identified based on illuminance compared with adjacent nodes.

For an alternative way to determine ASE, see Further Explanation, Direct Sunlight Based on Lux Differences between Adjacent Grid Points.

STEP 5. EVALUATE COMPLIANCE FOR ANNUAL SUNLIGHT EXPOSURE

Review the simulation output results and determine the ASE values for each analysis area.

- Record the ASE values for each floor area being analyzed.
- Confirm that the ASE value does not exceed 10% for each analysis area. The 10% threshold should be determined for small areas, ideally space by space or orientation per floor. At a minimum, the 10% threshold must be determined for all regularly occupied floor area (for Healthcare, the regularly occupied perimeter area) on a single floor.

STEP-BY-STEP GUIDANCE +

Option 2. Simulation—Illuminance Calculations

STEP 1. COLLECT ILLUMINANCE SIMULATION INPUTS

Work with the daylighting consultant or modeler to identify information needed for the daylight simulation. At a minimum, compile the following:

- Exterior building geometry and obstructions
- Site plan, location, and context
- Floor plan and furniture plan
- Interior finishes and surface reflectance (see *Further Explanation, Surface Reflectance*)
- Glazing performance specifications
- Local climate weather files, such as typical meteorological year (TMY2 or TMY3) data, available at nrel.gov

STEP 2. PERFORM ILLUMINANCE SIMULATION

Prepare the illuminance model based on information collected in Step 1.

- Follow the modeling methodology outlined and illustrated in *Further Explanation, Illuminance Simulation Procedure*.
- Perform the point-in-time simulations.
- Consult with the project team on assumptions developed for early design simulations. The assumptions should be further refined as design develops. Simulation results used for credit documentation should be based on the design that is closest to the completed construction documents for the as-built scenario.
- Perform one illuminance simulation at 9 A.M. on the equinox (September 21 or March 21).
- Perform a second illuminance simulation at 3 P.M. on the equinox (September 21 or March 21).

STEP 3. EVALUATE ILLUMINANCE COMPLIANCE

Review the simulation output results and determine the illuminance values for all regularly occupied floor area (for Healthcare, the regularly occupied perimeter floor area).

- Record the areas that are daylit (have illuminance levels between 300 lux and 3,000 lux for both 9 A.M. and 3 P.M.) and the associated floor area.
- Confirm that the project meets or exceeds the values in Table 2 in the credit requirements.

Option 3. Measurement

STEP 1. PREPARE FOR MEASUREMENTS

Determine when the first and second measurements will be taken.

- Schedule the first day of measurement after the project construction is complete, all furniture is moved in, window shades are installed, and people have occupied the space.
- Review Table 4 in the credit requirements to determine timing of the second measurement. Both measurements must occur during regularly occupied months. For example, measurements for a school may not be taken during school breaks.
- Review the regularly occupied space floor area (for Healthcare, all regularly occupied perimeter floor area) to determine the required measurement grid. Draw the measurement grid and the measurement nodes (usually located at the center of each grid space) on a floor plan.

STEP 2. PERFORM MEASUREMENTS

Use a light meter to take a daylight illuminance measurement at workplane height (30 inches [760 millimeters] above finished floor, unless otherwise defined) between 9 A.M. and 3 P.M. (see *Further Explanation, Solar Time or Local Time*).

- Refer to the Illuminating Engineering Society (IES) Lighting Handbook, 10th edition, Section 9.7, for more information on light meters.
- Identify the location of each measurement node in the actual space.
- Record the measured illuminance at each node on the floor plan or in a tracking table.
- If measurements cannot be completed for the entire project in one day, continue the following day between 9 A.M. and 3 P.M.

STEP-BY-STEP GUIDANCE +

- Repeat the process using the same nodes for the second measurement (see *Further Explanation, Examples, Option 3*).

STEP 3. EVALUATE ILLUMINANCE COMPLIANCE

Review the measurement results and determine the illuminance values for all regularly occupied floor area (for Healthcare, the perimeter floor area).

- Record the areas that are daylit (have illuminance levels between 300 lux and 3,000 lux for both measurements) and the associated floor area.
- Confirm that the project meets or exceeds the values in Table 3 in the credit requirements.

REQUIREMENTS

Provide manual or automatic (with manual override) glare-control devices for all regularly occupied spaces.

AND

Select one of the following three options.

Option 1. Simulation: Spatial Daylight Autonomy and Annual Sunlight Exposure (1–3 points, 1-2 points Healthcare)

Perform annual computer simulations for spatial daylight autonomy$_{300/50\%}$ (sDA$_{300/50\%}$), and annual sunlight exposure$_{1000,250}$ (ASE$_{1000,250}$) as defined in IES LM-83-12 for each regularly occupied space. Healthcare projects must use each regularly occupied space located in the perimeter area determined under EQ Credit Quality Views. Additionally, calculate the average sDA$_{300/50\%}$ value for the total regularly occupied floor area.

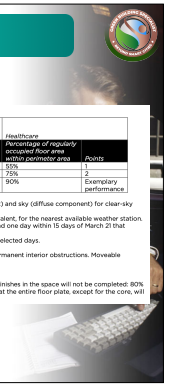
For any regularly occupied spaces with ASE$_{1000,250}$ greater than 10%, identify how the space is designed to address glare.

Points are awarded according to Table 1.

Table 1. Points for Option 1

	New Construction, Core and Shell, Schools, Retail, Data Centers, Warehouses and Distribution Centers, Hospitality	Healthcare
The average sDA$_{300/50\%}$ value for the regularly occupied floor area is at least **40%**	1 point	1 point
The average sDA$_{300/50\%}$ value for the regularly occupied floor area is at least **55%**	2 points	2 points
The average sDA$_{300/50\%}$ value for the regularly occupied floor area is at least **75%**	3 points	Exemplary performance

REQUIREMENTS



Each regularly occupied space achieves sDA$_{300/50\%}$ value of at least **55%**	Exemplary performance or 1 additional point if only 1 or 2 points achieved above	Exemplary performance or 1 additional point if only 1 point achieved above

The sDA and ASE calculation grids should be no more than 2 feet (600 millimeters) square and laid out across the regularly occupied area at a work plane height of 30 inches (76 millimeters) above finished floor (unless otherwise defined). Use an hourly time-step analysis based on typical meteorological year data, or an equivalent, for the nearest available weather station. Include any permanent interior obstructions. Moveable furniture and partitions may be excluded.

CS only
If the finishes in the space will not be completed, use the following default surface reflectances: 80% for ceilings, 20% for floors, and 50% for walls. Assume that the entire floor plate, except for the core, will be regularly occupied space.

OR

Option 2. Simulation: Illuminance Calculations (1–3 points, 1-2 points Healthcare)

Perform computer simulations for illuminance at 9 a.m. and 3 p.m. on a clear-sky day at the equinox for each regularly occupied space. Healthcare projects should use the regularly occupied spaces located in the perimeter area determined under EQ Credit Quality Views.

Demonstrate illuminance levels are between 300 lux and 3,000 lux at both 9 a.m. and 3 p.m. Spaces with view-preserving automatic (with manual override) glare-control devices may demonstrate compliance for only the minimum 300 lux illuminance level.

Points are awarded according to Table 2.

Table 2. Points for Option 2

New Construction, Core and Shell, Schools, Retail, Data Centers, Warehouses and Distribution Centers, Hospitality		*Healthcare*	
Percentage of regularly occupied floor area	*Points*	*Percentage of regularly occupied floor area within perimeter area*	*Points*
55%	1	55%	1
75%	2	75%	2
90%	3	90%	Exemplary performance

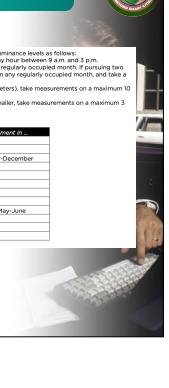
Calculate illuminance intensity for sun (direct component) and sky (diffuse component) for clear-sky conditions as follows:

- Use typical meteorological year data, or an equivalent, for the nearest available weather station.
- Select one day within 15 days of September 21 and one day within 15 days of March 21 that represent the clearest sky condition.
- Use the average of the hourly value for the two selected days.

Exclude blinds or shades from the model. Include any permanent interior obstructions. Moveable furniture and partitions may be excluded.

Core and Shell only
Assume the following default surface reflectances if the finishes in the space will not be completed: 80% for ceilings, 20% for floors, and 50% for walls. Assume that the entire floor plate, except for the core, will be regularly occupied space.

REQUIREMENTS



Option 3. Measurement (1-3 points, 1-2 points Healthcare)

Measure illuminance in each regularly occupied space. Healthcare projects should use the regularly occupied spaces located in the perimeter area determined under EQ Credit Quality Views.

Achieve illuminance levels between 300 lux and 3,000 lux. Spaces with view-preserving automatic (with manual override) glare-control devices may demonstrate compliance for only the minimum 300 lux illuminance level.

Points are awarded according to Table 3.

Table 3. Points for Option 3

New Construction, Core and Schools, Schools, Retail, Data Centers, Warehouses and Distribution Centers, Hospitality		*Healthcare*	
Percentage of regularly occupied floor area	*Points*	*Percentage of regularly occupied floor area within perimeter area*	
55%, at one time in the year	1	55%, at one time in the year	1
75% at two times in the year	2	75% at two times in the year	2
90% at two times in the year	3	90% at two times in the year	exemplary performance

With furniture, fixtures, and equipment in place, measure illuminance levels as follows:

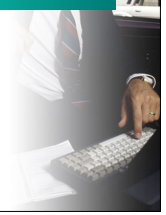
- Measure at appropriate work plane height during any hour between 9 a.m. and 3 p.m.
- If pursuing one point, take one measurement in any regularly occupied month. If pursuing two points, take two measurements: one measurement in any regularly occupied month, and take a second as indicated in Table 4.
- For spaces larger than 150 square feet (14 square meters), take measurements on a maximum 10 foot (3 meter) square grid.
- For spaces 150 square feet (14 square meters) or smaller, take measurements on a maximum 3 foot (900 millimeters) square grid.

Table 4. Timing of measurements for illuminance

If first measurement is taken in ...	*take second measurement in ...*
January	May-September
February	June-October
March	June-July, November-December
April	August-December
May	September–January
June	October-February
July	November-March
August	December-April
September	December-January, May-June
October	February–June
November	March–July
December	April-August

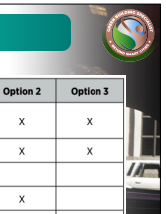
CONNECTION TO ONGOING PERFORMANCE

LEED O+M EQ prerequisite Indoor Environmental Quality Performance: Strategies to promote connection of building occupants with the outdoors and reinforce circadian rhythms by introducing an appropriate amount of daylight into newly constructed spaces via measurement and simulation approaches can contribute to better indoor environmental quality and overall occupant satisfaction during the operations phase.



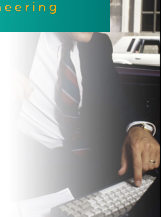
REQUIRED DOCUMENTATION

Documentation	All projects	Option 1	Option 2	Option 3
Floor plans highlighting regularly occupied spaces (for Healthcare, regularly occupied perimeter area)	X	X	X	X
List of glare-control devices for all windows with their control mechanism	X	X	X	X
List of compliant spaces with their annual summary values for sDA and ASE		X		
Geometric plots from simulations.		X	X	
Narrative or output file describing daylight simulation program, simulation inputs, and weather file		X	X	
List of compliant spaces with their calculated illuminance values			X	
Floor plans or list of compliant spaces with measured illuminance values for each node				X
Calculations demonstrating percentage of compliant space between 300 lux and 3,000 lux				X



REFERENCED STANDARDS

- REFERENCED STANDARDS IES Lighting Measurements (LM) 83-12, Approved Method: IES Spatial Daylight Autonomy (sDA) and Annual Sunlight Exposure (ASE): webstore.ansi.org
- The Lighting Handbook, 10th edition, Illuminating Engineering Society: ies.org



TERMS AND DEFINITIONS

Direct sunlight is an interior horizontal measurement of 1,000 lux or more of direct beam sunlight that accounts for window transmittance and angular effects and excludes the effect of any operable blinds, with no contribution from reflected light (i.e., a zero bounce analysis) and no contribution from the diffuse sky component. (Adapted from "Illuminating Engineering Society")

Items of movable furniture and partitions that can be moved by users without the use of tools or the assistance of special trades or facility management

Permanent interior obstruction: a structure that cannot be moved by the user without tools or assistance from special trades and facilities management. Examples include lab hoods, ixed partitions, demountable opaque full- or partial-height partitions, some displays, and equipment.

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