



Funding for this Publication provided by The American Recovery and Reinvestments Act of 2009, U.S. Department of Energy. Administered by Battelle Memorial Institute, Pacific Northwest National Laboratory.

JULY 2011 • VOLUME 1, ISSUE 1

WHAT IS THE PURPOSE OF THIS REQUIREMENT?

To achieve the full potential for energy savings and improved lighting quality from daylight, it is important to provide automatic controls for the electric lighting system. Daylight sensing controls regulate the light output of luminaires in response to available daylight. Regulating light output is accomplished by switching and/or dimming fixtures located within the daylight zone. The change in electric light is triggered by a photocell measuring available daylight within the zone. The goal is to use electric light as a supplement to daylight and only have it turned on to the degree necessary to uniformly maintain the desired illumination level within the daylight zone.

There are numerous studies that point to the value of daylight from better student test scores in schools to higher sales per square foot in stores to more rapid recovery in hospitals. But even without those, instinctively, we all feel better with access to daylight. If those were not sufficient reasons to use daylight, it's also free and in endless supply, with no negative impact on the environment. The electric load of a building that is attributable to lighting can vary from 15-40% of the building load. If we can save 30-70% of that load by consciously bringing daylight into our buildings and tuning the electric light to balance with it, we can achieve significant energy savings in our buildings.



Photo courtesy of Multicare.

Daylighting of a patient infusion treatment room. Through research evidence daylighting has been shown to improve patient well-being and promote more rapid recovery.

Daylight must be distinguished from sunlight when we are planning our buildings. Direct sunlight brings with it disabling glare and heat that are counterproductive. Diffuse daylight brings usable light without much heat gain.

Building orientation, landscape elements and building elements can be planned to maximize diffuse daylight and minimize direct sunlight. Interior or exterior shading devices can be used where other design elements are insufficient. Once those are developed the electric lighting system, which has to be designed for non-daylight hours, can then be fine tuned to only produce the amount of light that daylight cannot deliver. It needs to be a dynamic system to achieve the greatest savings as daylight is constantly changing throughout the day and with the seasons.

Daylight zones occur under overhead glazing and adjacent to vertical glazing elements. Each have specific boundaries as defined in WSEC Chapter 2.

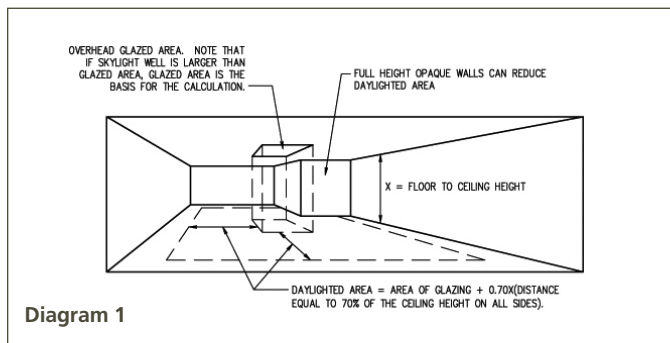
The electric load attributable to lighting can vary from 15-40% of the total building load. Architectural daylighting strategies and daylighting controls can reduce the lighting load of a building by 30-70%.



Daylit Zone Under Overhead Glazing

Diagram 1 demonstrates the boundaries of the daylight zone under overhead glazing. This daylit area is calculated by combining the area of the overhead glazing element (in square feet) plus one of the following, whichever is least:

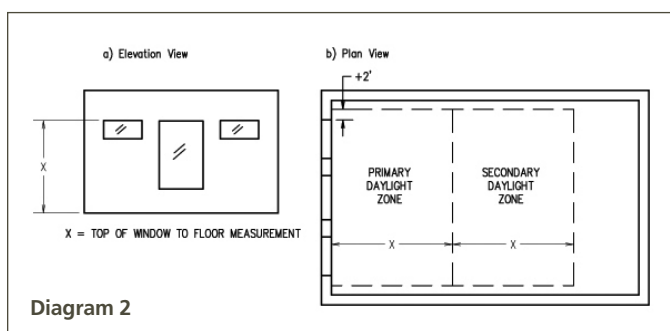
- > Distance equal to 70% of the floor to ceiling height.
- > The dimension to a ceiling height partition.
- > One-half the distance to adjacent overhead or vertical fenestration.



Daylit Zone At Vertical Glazing

Diagram 2 demonstrates the boundaries of the daylit zone adjacent to vertical glazing. Note that there are primary and secondary daylight zones. The primary daylight zone is calculated by multiplying the window head height by one of the following, whichever is least:

- > Width of the window plus an additional two-feet on either side.
- > Width of the window plus one-half the distance to adjacent overhead or vertical glazing.



Even if the vertical glazing is only a clerestory, the head height determines the depth of the daylight zone.

The secondary daylight zone extends further into the space from the edge of the primary zone. It is calculated by multiplying the window width as described above, by one of the following for depth, whichever is least:

- > An area equal in size to the primary zone located immediately adjacent to it.
- > The area immediately adjacent to the primary zone up to the nearest ceiling height opaque partition.

WHAT DOES THE WSEC REQUIRE?

All daylight zones, as described above, shall be provided with the means of controlling electric lighting within these zones independent of general area lighting. In general, all permanent luminaires located within daylight zones shall be controlled by automatic daylight sensing controls. There are a few exceptions where occupancy sensors or individual lighting controls may be used in lieu of daylight sensing controls. These exceptions are defined in WSEC 1512 and 1513.3.

Automatic Daylight Sensing Controls

There are three primary requirements for automatic daylight sensing controls (must comply with all three).

- > They must be capable of regulating the power input to the electric lighting fixtures to reduce their light output while maintaining a uniform level of illuminance within the space.
- > They must have time-delay circuits that prevent light level adjustments from occurring in less than three-minute intervals (also referred to as short cycling).
- > They only control luminaires within the daylight area. This includes primary and secondary daylight zones adjacent to vertical glazing and daylight zones under overhead glazing. All daylight zone areas (primary, secondary, overhead) shall be controlled separately from each other.

Note that contiguous daylight zones adjacent to vertical glazing are allowed to be controlled by a single controlling device provided that they do not include zones facing more than two adjacent cardinal orientations (i.e. north, south, east, west).

Approved methods of regulating lighting fixture power input and therefore light output include:

- > **Continuous dimming** down to at least 20% light output.
- > **Step switching** of each individual lamp in multiple lamp fixtures. This requires multiple ballasts within the fixtures and more complex wiring. Switching of alternate fixtures within the zone is only allowed with single lamp fixtures.
- > **Step dimming** by reducing the output of all of the lamps in individual luminaires by at least 50% and provide an automatic OFF control.



Photo courtesy of Paccar Hall.

Daylighting in education buildings reduces energy use for lighting and makes more lively, desirable spaces.

over time so the change in light level is not perceived by the occupants. For longest lasting results, dimming is the preferred technology.

Exceptions to Daylighting Controls Requirements

The Energy Code identifies a variety of exceptions in WSEC 1512 and 1513.3. The purpose of these exceptions is to address situations where daylighting controls:

- > *impact the performance of special purpose lighting (such as for food warming or indoor plant growth)*
- > *counter the purpose of special purpose lighting (such as for theatrical production or video-conferencing)*
- > *could cause a safety risk (such as lighting integral to medical equipment and machinery, or high risk security areas)*
- > *are redundant to other lighting controls requirements (such as lighting controlled by occupancy sensors)*

Note that most exceptions are independent of general area lighting. Daylighting control exceptions that do apply to general area lighting have either requirements for occupancy sensor controls or automatic shut-off controls, or are located in safety risk areas.

Commissioning of Lighting Systems

Commissioning provides a means of verifying that lighting and daylighting control systems and equipment are calibrated, adjusted and operate as defined in the approved plans and specifications, thus ensuring the expected energy savings. This includes functional testing of the lighting control system based on a sequence of operations document and training of facilities personnel. Lighting system commissioning is required for all lighting and daylighting controls.

Both stepped switching and stepped dimming are very noticeable by building occupants and can be disturbing to work flow. As such, the control devices are often disabled by occupants. Dimming can be done slowly

There is not a minimum system size threshold for this requirement.

Existing Lighting System Additions or Alterations

If new wiring is being installed to serve added fixtures and/or fixtures are being relocated to a new circuit, all control requirements defined in WSEC 1513.1 through 1513.5, which includes daylight controls, shall be provided. These requirements also apply when a new lighting panel (or a moved lighting panel) with all new raceway and conductor wiring from the panel to the fixtures is installed. In an addition, alteration or retrofit project, all lighting controls are required to be commissioned regardless of the size of the project.

Photo courtesy of Paccar Hall.



Daylighting in central spine of building brings daylight into adjacent offices and shared study spaces.

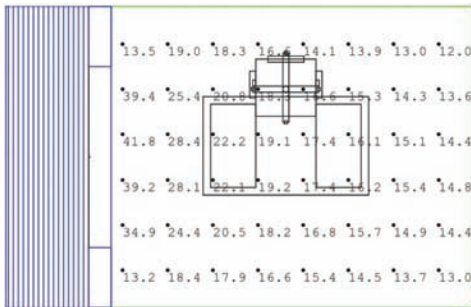
Additional Resources

- > **Lawrence Berkeley Labs – Tips for Daylighting with Windows** – <http://btech.lbl.gov/pub/designguide>
- > **National Institute of Building Sciences, Whole Building Design Guide** – http://www.wbdg.org/references/mou_daylight.php and <http://www.wbdg.org/resources/daylighting.php>
- > **Energy Design Resources - Design Briefs – Daylighting, Understanding Daylight Metrics, Lighting Controls** - <http://www.energydesignresources.com/resources/publications/design-briefs.aspx>
- > **The Integrated Design Lab** <http://www.integrateddesignlab.com/Seattle/>

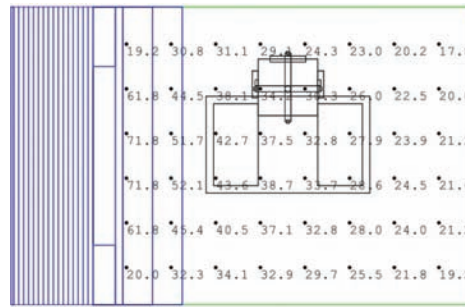
DAYLIGHTING STUDY

Comparing different shading devices over representative times of day and days of the year will show which technologies have the potential to be most effective for daylighting. It is likely that the solution for each facade of the building will be different. The images below provide a comparison between an exterior light louver and exterior/interior light shelves for an office space. Solar information is based on a clear day in mid-March in the late afternoon in Anchorage, Alaska..

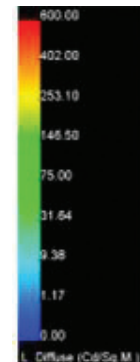
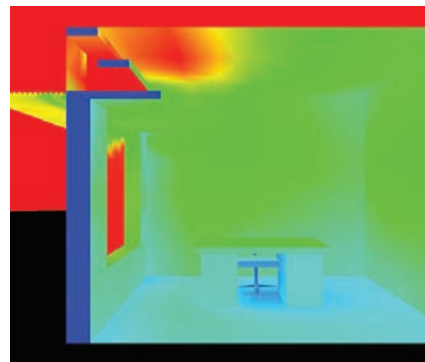
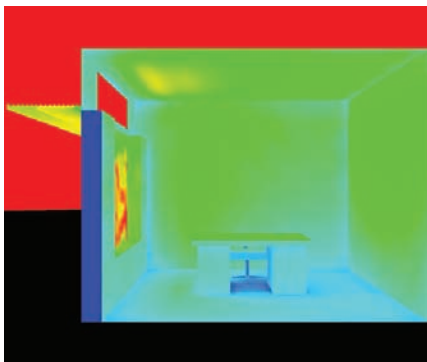
Exterior Light Louver



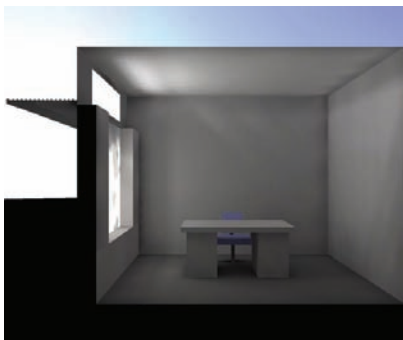
Interior and Exterior Light Shelves



The illuminance plan shows the actual light levels (measured in footcandles).



A Pseudo color rendering associates colors with numbers that describe luminance (measured in candelas per square foot).



Gray scale images show the relative differences in brightness based on what the eye sees.

Technical content contributed by:

CANDELA

SPARKLING

WORK TOGETHER | STAND APART