

**48-410 Acoustics and Lighting
Fall 2008**

Monday, Wednesday, 12:30-13:20
DH A310 (lectures)
Hunt Lower Level (Software Sessions)

Lecture 7: Lighting Regulations

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Office Hours: Wed 18:00-19:00

Carnegie Mellon
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Class Plan

- ASHRAE 90.1
- LEED EQ8.1 EQ8.2

References

USGBC. LEED for New Construction Version 2.2, 2006.

ASHRAE. Standard 90.1 Energy Standard for Buildings Except for Low-Rise Residential Buildings, 2004.

LEED EQ 8.1 & 8.2

Intent

Provide for the building occupants a connection between indoor spaces and the outdoors through the introduction of daylight and views into the regularly occupied areas of the building.

EQ 8.1 – Daylight Availability

75% of all regularly occupied areas achieving minimum daylight availability

OPTION 1 – Glazing Factor Calculation

75% of occupied areas achieving minimum 2% Glazing Factor

OPTION 2 – Daylight Model Simulation

75% of occupied areas achieving minimum 25fc on horizontal workplane

OPTION 3 – Daylight Measurement

75% of occupied areas achieving minimum 25fc on horizontal workplane

Exemplary Performance – 95% of occupied areas achieving daylight requirements

EQ 8.2 – Exterior Views

90% of all regularly occupied areas with view to vision glazing (exterior windows at vision levels)

Plan and section line-of-sight calculations






Exemplary Performance – Case-by-case basis

LEED EQ 8.1

Glazing Factors Calculations

Similar to average daylight factors, but accounts for window type and not reflectivity.

Table 1: Daylighting Design Criteria

Window Type	Geometry Factor	Minimum T _{vis}	Height Factor	Best Practice Glare Control
 sidelighting daylight glazing	0.1	0.7	1.4	Adjustable blinds Interior light shelves Fixed translucent exterior shading devices
 sidelighting vision glazing	0.1	0.4	0.8	Adjustable blinds Exterior shading devices
 toplighting vertical monitor	0.2	0.4	1.0	Fixed interior Adjustable exterior blinds
 toplighting sawtooth monitor	0.33	0.4	1.0	Fixed interior Exterior louvers
 toplighting horizontal skylights	0.5	0.4	1.0	Interior fins Exterior fins Louvers

Equation 1: Glazing Factor Calculation

$$\text{Glazing Factor} = \frac{\text{Window Area [SF]}}{\text{Floor Area [SF]}} \times \text{Window Geometry} \times \frac{\text{Actual } T_{vis}}{\text{Minimum } T_{vis}} \times \text{Window Height Factor}$$

LEED EQ 8.1

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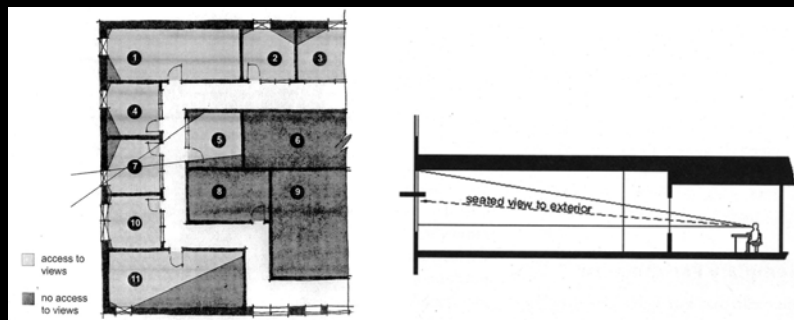
Table 2: [LEED] Glazing Factor Tabulation Spreadsheet

Regularly Occupied Space ID	Regularly Occupied Space Name	Regularly Occupied Space Area (sf)	Sidelighting - Vision Glazing		Sidelighting - Daylight Glazing		Toplighting Sawtooth Monitor		Toplighting Vertical Monitor		Toplighting Horizontal Skylight		Glazing Factor
			Area (sf)	T _{vis}	Area (sf)	T _{vis}	Area (sf)	T _{vis}	Area (sf)	T _{vis}	Area (sf)	T _{vis}	
101	Office	820	120	0.9	40	0.7	0	N/A	0	N/A	0	N/A	3.3
102	Office	330	30	0.9	5	0.7	0	N/A	0	N/A	0	N/A	1.8
103	Open Office (Daylit Area)	2250	330	0.9	110	0.7	0	N/A	0	N/A	0	N/A	3.3
103	Open Office (Non-Daylit Area)	685	0	0.9	0	0.7	0	N/A	0	N/A	0	N/A	0
104	Office	250	25	0.9	5	0.7	0	N/A	0	N/A	0	N/A	2.1
105	Office	250	25	0.9	5	0.7	0	N/A	0	N/A	0	N/A	2.1
Total Regularly Occupied Space Area (sf)			Total Regularly Occupied Space Area with a Minimum 2% Glazing Factor		Percentage of Regularly Occupied Space with a 2% Glazing								
		4585	3570		78%								

LEED EQ 8.2

Line-of-sight calculations

Vision Glazing – (Sections of) Exterior windows between 2'6" to 7'6" above FFL



LEED EQ 8.2

Line-of-sight calculations

Figure 2: Horizontal View at 42°, used to confirm access to views

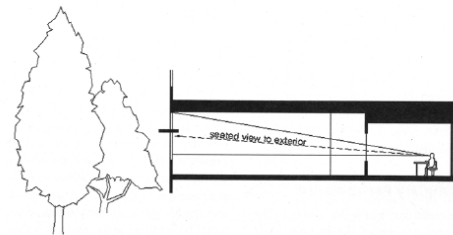


Table 1: Determination of Compliance

Room	Regularly Occupied Floor Area [SF]	Plan Area of Direct Line of Sight to Perimeter Vision Glazing [SF]	Calculated Area of Direct Line of Sight to Perimeter Vision Glazing [SF]	Horizontal View at 42° [Yes/No]	Compliant Area [SF]
101 Office	820	790	820	Yes	820
102 Conference	330	280	330	Yes	330
103 Open Office	4,935	4,641	2,641	Yes	4,641
104 Office	250	201	250	No	0
105 Office	250	175	175	Yes	175
Total	6,585				5,966
Percent Access to Views [5,966/6,585] 90.5% Credit Earned					

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ASHRAE 90.1

Chapter 9 – Lighting

Scope:

- Interior Spaces of Buildings
- Exterior Building Features (Facades, illuminated roofs, architectural features, exits, etc.)
- Exterior Building Grounds Lighting

Compliance with:

- General scope and definitions
- Mandatory Provisions
- Lighting Power Density (Building Area Method OR Space-by-Space Method)

Mandatory Provisions

- Lighting Control – Automatic shutoffs, space control, and additional controls
- Tandem Wiring – Shared ballasts
- Exit Signs – Internal illuminated exit signs no more than 5 watts per face
- Exterior Building Grounds Lighting – Luminaires of more than 100 watts to have minimum efficacy of 60 lm/W
- Exterior Building Lighting Power – Total allowable power for exterior building features lighting

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Interior Lighting Power Allowance (Building Method & Space-by-Space Method)

Prescription of total allowable power for electric lighting in buildings
 Based on "typical" spatial conditions, lamp layout, and lighting technology
 Choice of method depending on type of project / level of design detail

- Building method budgets according to *building type*
- Space-by-space budgets by considering *areas of specific functions*

Flexibility in design – budget can be allocated at designers' discretion

Exemptions – additional power allowance for:

- Decorative lighting
- Additional lighting to satisfy visual display terminals (VDT) needs
- Retail display lighting

ASHRAE 90.1

Building Method

TABLE 9.5.1 Lighting Power Densities Using the Building Area Method

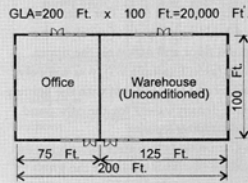
Lighting Power Density		Lighting Power Density	
Building Area Type ^a	(W/m ²)	Building Area Type ^a	(W/m ²)
Automotive Facility	10	Multi-Family	8
Convention Center	13	Museum	12
Court House	13	Office	11
Dining: Bar Lounge/Leisure	14	Parking Garage	3
Dining: Cafeteria/Fast Food	15	Penitentiary	11
Dining: Family	17	Performing Arts Theater	17
Dormitory	11	Police/Fire Station	11
Exercise Center	11	Post Office	12
Gymnasium	12	Religious Building	14
Healthcare-Clinic	11	Retail	16
Hospital	13	School/University	13
Hotel	11	Sports Arena	12
Library	14	Town Hall	12
Manufacturing Facility	14	Transportation	11
Motel	11	Warehouse	9
Motion Picture Theater	13	Workshop	15

^a In cases where both general building area type and a specific building area type are listed, the specific building area type shall apply.

Example 9-H – Interior Lighting Power Allowance, Building Area Method

Q

A one-story building measures 200 ft by 100 ft and consists of an office and a conditioned warehouse. The building has 12 in.-thick exterior walls. The partition that separates the office and the warehouse is 8 in. thick. The office area is 75 ft by 100 ft measured from the outside edge of the exterior walls to the center of the partition wall. The warehouse is 125 ft by 100 ft measured from the outside edge of the exterior walls to the center of the partition wall. What is the gross lighted area? What is the interior lighting power allowance using the building area method?



A

Gross lighted area is measured to the outside surface of exterior walls and to the centerline of interior partitions. The gross lighted area of the entire building is 100 ft x 200 ft = 20,000 ft². The gross lighted area of the office portion is 7500 ft² and for the warehouse is 12,500 ft². The interior lighting power density for the office portion of the building is 1.3 W/ft² and the density for the warehouse portion is 1.2 W/ft².

Lighting Power Allowance = $1.3 \times 7500 + 1.2 \times 12500 = 24,800 \text{ W}$

Provided the interior lighting system for the entire building is included under the same permit application, the designer can use more lighting power in the office and less in the warehouse, as long as the overall interior lighting power is less than 24,800 W.

ASHRAE 90.1

Space-by-space Method

TABLE 9.6.1 Lighting Power Densities Using the Space-by-Space Method

Common Space Types*	LPD (W/m²)	Building Specific Space Types (Continued)	LPD (W/m²)
Offices/checkout	12	For Bar Lounge/Entire Dining	13
Office-open plan	12	For Family Dining	23
Conference/ Meeting/ Multipurpose	14	Food Preparation	13
Classrooms/ Lectures/ Training	15	Laboratory	15
For Penitentiary	14	Restrooms	10
Lobby	14	Dressing Locker/Fitting Room	6
For Hotel	12	Corridor/Transition	5
For Performing Arts Theater	36	For Hospital	11
For Motion Picture Theater	12	For Manufacturing Facility	5
Audience/ Seating Area	10	Stairs – active	6
For Gymnasium	4	Active Storage	9
For Exercise Center	3	For Hospital	10
For Convention Center	8	Inactive storage	3
For Penitentiary	8	For Museum	9
For Religious Buildings	18	Fire Stations	
For Sports Arena	4	Fire Station Engine room	9
For Performing Arts Theater	28	Sleeping Quarters	3
For Motion Picture Theatre	13	For Office – Seating Area	13
For Transportation	5	Convention Center – Exhibit Space	14
Atrium-first three floors	6	Library	
Atrium-each additional floor	2	Card File & Cataloging	12
Lounge/Recreation	13	Snacks	18
For Hospital	9	Reading Area	13
Dining area	10	Hospital	
For Penitentiary	14	Emergency	29
For Hotel	14	Recovery	9
For Motel	13	Nurse station	11

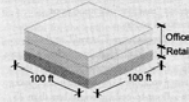
Common Space Types*	LPD (W/m²)	Building Specific Space Types (Continued)	LPD (W/m²)
Exam/Treatment	16	Retail (For accent lighting see 9.3.1.2.1.a.c)	
Pharmacy	13	Sales area	18
Patent Room	8	Mall Concourse	18
Operating Room	24	Electrical/mechanical	16
Nursery	6	Workshop	20
Medical Supply	15		
Physical Therapy	10	Building Specific Space Types	
Radiology	4	Gymnasium/ Exercise Center	
Laundry/Washing	6	Playing Area	15
Automotive – Service/Repair	8	Exercise Area	10
Manufacturing		Courthouse/ Police Station/ Penitentiary	
Low Bay (<7.6 m Floor to Ceiling Height)	13	Courtroom	20
High Bay (>7.6 m Floor to Ceiling Height)	18	Confinement Cells	10
Detailed Manufacturing	23	Judges Chambers	14
Equipment rooms	13	Sports Arena	
Control room	5	Ring Sports Area	29
Hotel/Motel Guest Rooms	12	Court Sports Area	25
Dormitory – Living Quarters	12	Indoor Playing Field Area	15
Museum		Warehouse	
General Exhibition	11	Fine Material Storage	15
Restoration	18	Medium/Bulky Material Storage	10
Bank Office – Banking Activity Area	16	Parking Garage – Garage Area	2
Religious Buildings		Transportation	
Worship/pulpit, choir	26	Airport – Concourse	6
Fellowship Hall	10	Air/Train/Bus – Baggage Area	11
		Terminal – Ticket counter	16

* In cases where both a common space type and a building specific space type are listed, the building specific space type shall apply.

Example 9-1 – Interior Lighting Power Allowance, Space-by-Space Method

Q

Use the space-by-space method to determine the interior lighting power allowance for a three-story building with retail on the ground level and office space on levels two and three. The building measures 100 ft x 100 ft and has a total area of 30,000 ft². (This example is the same as Example 9-G, except in this case, more detail is provided to enable the space-by-space calculations.)



A

Make a list of the spaces types for each building type and indicate the floor area for each space type (see the table below). For each space type, look up the lighting power density (LPD) from Table 9.3.1.2. The total allowance for each space type is the W/ft² density multiplied by the area of each space type. The total allowance for the 20,000 ft² of office space is 26,520 W or 1.33 W/ft². The total allowance for the 10,000 ft² of retail space is 19,080 W or 1.91 W/ft². These allowances are very similar to the allowances given by the building area method (1.3 and 1.9, respectively). The lighting power allowance for the whole building is 45,600 W divided by 30,000 ft² or an average of 1.52 W/ft². Compare this to the 1.50 W/ft² determined for the same building in Example 9-G.

Building Type	Space Type	LPD (W/ft ²)	Area (ft ²)	Allowance (W)
Office	Offices, enclosed	1.5	4,100	6,150
	Offices, open	1.3	12,000	15,600
	Meeting rooms	1.5	800	1,200
	Lobby	1.8	800	1,440
	Dining area	1.4	200	280
	Food preparation	2.2	100	220
	Restrooms	1.0	300	300
	Corridors	0.7	1,000	700
	Active storage	1.1	400	440
	Inactive storage	0.3	200	60
	Electrical/mechanical	1.3	100	130
		Total/Weighted Average	1.33	20,000
Retail	General sales area	2.1	8,000	16,800
	Offices, enclosed	1.5	200	300
	Lounge	1.4	150	210
	Restrooms	1.0	50	50
	Corridors	0.7	100	70
	Active storage	1.1	1,500	1,650
		Total/Weighted Average	1.91	10,000