

LIGHTING DESIGN & ENERGY CODES



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LIGHTING DESIGN & ENERGY CODES:

- ⌘ Why lighting design(er)?
- ⌘ Energy efficient regulations in the USA
- ⌘ Energy efficient regulations in Spain (HE3)
- ⌘ Application of energy efficient lighting

WHY LIGHTING DESIGN(ER):

Benefits of good architectural lighting design(er):

- ✍ Improvement of visibility
- ✍ Complementation of form, program and color
- ✍ Enhancement of the architecture
- ✍ Decreased equipment costs
- ✍ Decreased operation costs
- ✍ Decreased people costs
- ✍ Increased revenues

WHY LIGHTING DESIGN(ER):

Lighting design based on:

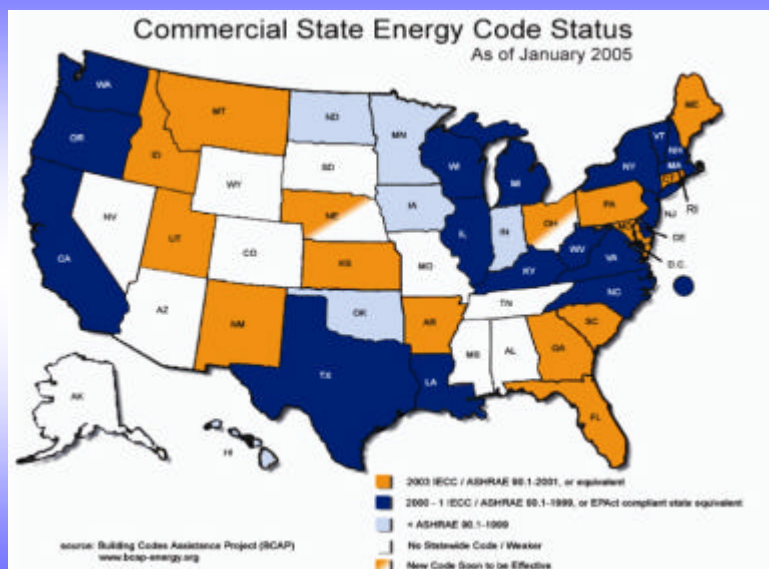
- Design intent & aesthetics
- Fixture and lamp performance
- Scaled mockups
- Maintenance
- Budget
- Lead time
- Energy efficiency & codes
 - applicable code
 - computer calculations
 - calculate watts/square feet
 - energy efficient solutions

WHY LIGHTING DESIGN(ER):

Documents prepared by lighting designer:

- Lighting Plan, showing fixture layout
- Fixture & lamp specification
- Architectural lighting details
- Control Intent Diagram
- Zone and load schedule
- Control System Specification
- Energy calculations for Electrical Engineer's reference, if requested

BUILDING CODES IN THE USA:



BUILDING CODE REGULATIONS IN THE USA:

- ASHRAE/IESNA 90.1-2004
- IECC 2004
- STATE CODES, LIKE CALIFORNIA CODE TITLE 24-2005
- LEED, Green Building Rating System

BUILDING CODE REGULATIONS IN THE USA:

ASHRAE, Lighting Power Density (LPD) is based on:

- ⌘ product performance data
- ⌘ lamp/ballast efficacy and light loss factors
- ⌘ IESNA recommendations
- ⌘ quality of lighted environments

BUILDING CODE REGULATIONS IN THE USA:

ASHRAE, mandatory provisions:

- ⌘ lighting controls
- ⌘ luminaire wattage
 - standard incandescent= labeled wattage of the luminaire
 - luminaire with ballasts=wattage of lamp/ballast combination
 - line voltage track=min 30W per foot
 - low voltage track= transformer wattage
 - all others as specified

BUILDING CODE REGULATIONS IN THE USA:

LUMINAIRE WATTAGE EXAMPLE:

- A. Eight 2'x4' Fluorescent Fixtures
 - three 4' T8 (32Watts) fluorescents per fixture
 - 1 three-lamp electronic ballast
 - Ballast Input Wattage is 90 Watts
- B. 6 Incandescent Downlights
 - specified lamp is 60 Watt
 - maximum labeled wattage of fixture is 75 Watts
- C. 16 feet of Line Voltage Track
 - specified are 5 track heads
 - 90 Watt Halogen PAR38 lamps

WRONG WAY:

- A. 8 fixtures x 3 lamps x 32 Watts per lamp = 768 Watts
- B. 6 downlights x 60 Watts = 360 Watts
- C. 5 track heads x 90 Watts/HAL PAR38 = 450 Watts

~~Total Watts = 1578 Watts~~

RIGHT WAY:

- A. 8 fixtures x 90 ballast input watts = 720 Watts
- B. 6 downlights x 75 Watts labeled fixture = 450 Watts
- C. 16' track x 30 Watts/foot = 480 Watts

Total Watts = 1650 Watts

BUILDING CODE REGULATIONS IN THE USA:

ASHRAE, mandatory provisions:

- ⌘ lighting controls
- ⌘ luminaire wattage
- ⌘ installed interior lighting power
 - space by space or building area method
 - exemptions & allowances
- ⌘ exterior building grounds lighting

Building Area Type ^a	Lighting Power Density (W/ft ²)
Museums	1.0

Building Type	Space-by-Space Method LPDs													Building Specific Space Type and LPDs (W/ft ²)				
	Common Space Types and LPDs (W/ft ²)																	
	Classrooms	Offices	Offices - Open Plan	Offices - Divided	Other - Divided	Classrooms - Natural/Artificial	Classrooms - Natural	Classrooms - Artificial	Classrooms - Mixed	Classrooms - Other	Classrooms - Other	Classrooms - Other	Classrooms - Other	Classrooms - Other	Classrooms - Other	Classrooms - Other	Classrooms - Other	Classrooms - Other
Classrooms Buildings	0.2	1.2	1.2	2.0	1.8	2.0	0.2	1.0	0.7	0.8	1.4	1.4	0.7	Classrooms	1.0			
Museums														Museums	1.0			

HE3, Eficiencia Energética de las Instalaciones de Iluminación

HE3, Eficiencia Energética de las Instalaciones de Iluminación

SCOPE:

- new construction
- rehabilitation of existing buildings
- renovation of commercial and administrative buildings

Exceptions:

- monuments and buildings with recognized historical or architectural value
- temporary constructions
- industrial facilities and workshops
- small independent buildings
- interiors of dwellings.

HE3, Eficiencia Energética de las Instalaciones de Iluminación

MANDATORY PROVISIONS:

- VEEI, value of the energy efficiency of the installation (W/m^2) for each 100 lux
 - $VEEI = \frac{P \times 100}{S \times Em}$
 - P= installed interior lighting power used by the luminaires, including lamps, ballasts etc. (W)
 - S= lighted floor area (m^2)
 - Em= average maintained horizontal illuminance (lux)

Módulo de eficiencia energética de la instalación		
grupo	Ámbito de aplicación diferenciada	VEEI (W/m ²)
1	edificios de general	5,0
	edificios de edificios de comercio	5,0
	edificios de oficinas, ...	5,0
	edificios de escuelas o centros de enseñanza	5,0
	edificios de viviendas ...	4,0
2	edificios de general	4,5
	edificios de edificios de comercio	4,5
	edificios de oficinas, ...	4,5
	edificios de escuelas o centros de enseñanza	4,5
	edificios de viviendas ...	3,5
3	edificios de general	4,0
	edificios de edificios de comercio	4,0
	edificios de oficinas, ...	4,0
	edificios de escuelas o centros de enseñanza	4,0
	edificios de viviendas ...	3,0
4	edificios de general	3,5
	edificios de edificios de comercio	3,5
	edificios de oficinas, ...	3,5
	edificios de escuelas o centros de enseñanza	3,5
	edificios de viviendas ...	2,5
5	edificios de general	3,0
	edificios de edificios de comercio	3,0
	edificios de oficinas, ...	3,0
	edificios de escuelas o centros de enseñanza	3,0
	edificios de viviendas ...	2,0

HE3, Eficiencia Energética de las Instalaciones de Iluminación

MANDATORY PROVISIONS:

- VEEI
- Control system and regulation to optimize daylight

HE3, Eficiencia Energética de las Instalaciones de Iluminación

MANDATORY PROVISIONS:

- VEEI
- Control system and regulation to optimize daylight
- Maintenance plan

HE3, Eficiencia Energética de las Instalaciones de Iluminación

REQUIRED DOCUMENTATION:

- area index
- calculation points
- light loss factor
- average maintained horizontal illuminance
- Unified Glare Rating
- Color Rendering
- VEEI
- luminaire input power
- control system

HOW TO COMPLY WITH THE CODE WITHOUT SACRIFICING THE DESIGN INTENT?

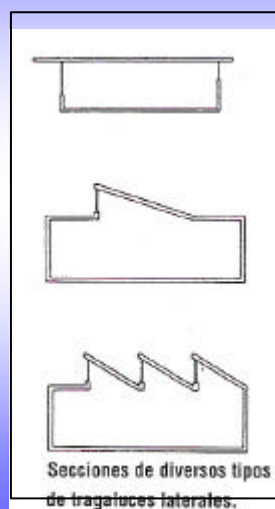
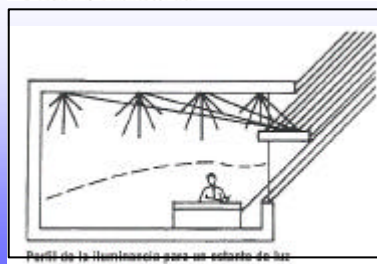
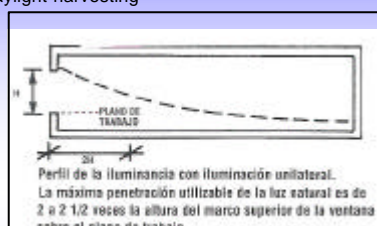
ENERGY EFFICIENT LIGHTING

- appropriate lighting

Activity Task	Illuminance (lux)	Glare Limit UGRL	Color rendering (Ra)
Office			
Filing, copy, circulation	300	19	80
Write, read, type	500	19	80
Manual technical drawing	750	19	80
Cad work station	500	19	80
Educational Buildings			
Class and study rooms	300	19	80
Lecture and adult classrooms	500	19	80
Art and drawing classrooms	750	19	80
Sport halls, swimming pools	300	22	80

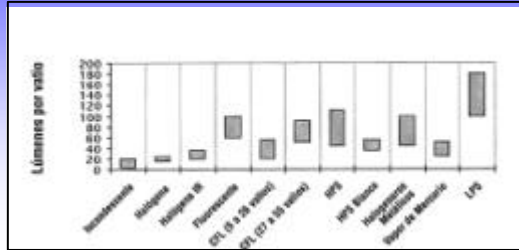
ENERGY EFFICIENT LIGHTING

- appropriate lighting
- daylight harvesting



ENERGY EFFICIENT LIGHTING

- appropriate lighting
- daylight harvesting
- use efficient lamps



Lamp	Watt	Color rendering (Ra)	Life Hours	Lumens	Average Efficacy Lumens/Watt
Incandescent					
Incandescent A lamp	75	100	750	1700	17 Lumens/Watt
Halogen MR16, 24"	50	100	3000	800	16 Lumens/Watt
Halogen MR16, 4" (infra Red, 40"	37	100	5000	800	22 Lumens/Watt
Fluorescent, 4" (1.1 ft)					
T12 (Rapid Start)	34	80	20,000	2800	80 Lumens/Watt
T8	32	80	20,000	2800	86 Lumens/Watt
T8 High Output	44	80	18,000	3600	82 Lumens/Watt
Super T8	35	80	20,000	2700	85 Lumens/Watt
T5	28	80	20,000	2700	101 Lumens/Watt
T5 High Output	44	80	20,000	4700	86 Lumens/Watt
Compact Fluorescent					
CFL, 100w ball	42	80	12,000	2700	70 W/Lumen
Metal Halide					
Q7 9" Metal Halide	35	80	12,000	1800	61 W/Lumen
PAR30 Metal Halide	35	80	8000	1300	42 W/Lumen
T6 Metal Halide	39	80	12,000	2800	67 W/Lumen
T8 Metal Halide	70	80	12,000	4800	71 W/Lumen
LED					
			50,000-100,000		20-40 W/Lumen

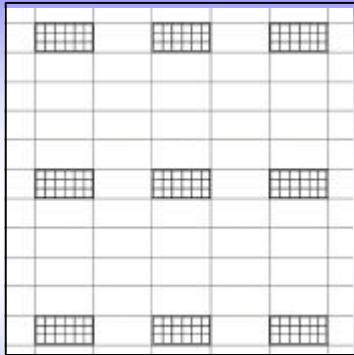
ENERGY EFFICIENT LIGHTING

- appropriate lighting
- daylight harvesting
- use efficient lamps
- use efficient electronic ballasts

Lamp		Volts	Input Watts	Nominal Line Amps	Power Factor	Ballast Factor	Ballast Efficacy Factor	Harmonic Total	Crest Factor
F32T8	1	120	25	0.22	> .98	.77	3.08	< 10%	< 1.7
F32T8	1	277	25	0.11	> .95	.77	3.08	< 10%	< 1.7
F32T8ES	1	120	23	0.20	> .98	.77	3.35	< 10%	< 1.7
F32T8ES	1	277	23	0.10	> .95	.77	3.35	< 10%	< 1.7
F28T8	1	120	21	0.20	> .98	.77	3.67	< 10%	< 1.7
F28T8	1	277	21	0.10	> .95	.77	3.67	< 10%	< 1.7
F25T8	1	120	19	0.18	> .98	.78	4.11	< 10%	< 1.7
F25T8	1	277	19	0.09	> .90	.78	4.11	< 10%	< 1.7
F17T8	1	120	14	0.12	> .98	.78	5.57	< 15%	< 1.7
F17T8	1	277	14	0.06	> .90	.78	5.57	< 15%	< 1.7
F40T8	1	120	32	0.25	> .98	.76	2.38	< 10%	< 1.7
F40T8	1	277	32	0.13	> .95	.76	2.38	< 10%	< 1.7

ENERGY EFFICIENT LIGHTING

☞ efficient electronic lamp & ballasts, example:



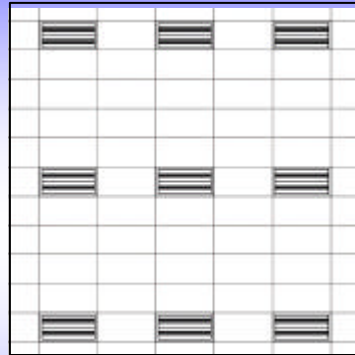
standard spacing 8'X10'

GENERIC PARABOLIC T8 SYSTEM;

3 LAMP T8 SYSTEM

51 FOOTCANDLES AT 1.125 W/SF

45 FOOTCANDLES PER 1 W/SF



standard spacing 8'X10'

HIGH PERFORMANCE T5 SYSTEM;

2 LAMP T5 SYSTEM

48 FOOTCANDLES AT 0.75 W/SF

64 FOOTCANDLES PER 1 W/SF

ENERGY EFFICIENT LIGHTING

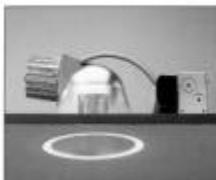
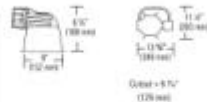
- appropriate lighting
- daylight harvesting
- use efficient lamps
- use efficient electronic ballasts
- use efficient luminaires

ENERGY EFFICIENT LIGHTING

- efficient luminaires, example:

Compact Fluorescent Luminaires
Horizontal Downlights (1-Lamp)

6" 26 Watt

Color = 9 T_v (120 mcd)

How to Specify:

Reflector: **None to Kit** Single Tube Lamping

8021 (23W) 84120W (2) 11 (20W)


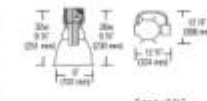
Other options are listed below left.
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Reference Data		Coefficients of Utilization	
Cat. No.	802123W	Working	80 (80% Foot)
TTC Lumens	11200	Beam	30 35 40
Lamp Lumens	1000	1	60 65 70
Watts (23/27W)	23/27	2	65 70 75
Power Factor	0.95	3	70 75 80
Color	9 T _v	4	75 80 85
Lamp Life (hrs)	10000	5	80 85 90
Startup Time	1.2	6	85 90 95
Color Shift	30*	7	90 95 100
Color	30*	8	95 100 105

Application Data		Coefficient Curves	
Spacing	Match luminaire	Beam	80 (80% Foot)
at	Foot	Beam	30 35 40
Center	center	1	60 65 70
0	60	2	65 70 75
10	65	3	70 75 80
20	70	4	75 80 85
30	75	5	80 85 90
40	80	6	85 90 95
50	85	7	90 95 100
60	90	8	95 100 105

Compact Fluorescent Luminaires
Vertical Open Downlights

6" 26/32 Watt

Color = 9 T_v (120 mcd)

How to Specify:

Reflector: **None to Kit** Single Tube Lamping

8021 (23W) 84120W (2) 11 (20W)

Other options are listed below left.
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Reference Data		Coefficients of Utilization	
Cat. No.	802123W	Working	80 (80% Foot)
TTC Lumens	10200	Beam	30 35 40
Lamp Lumens	2500	1	60 65 70
Watts (23/27W)	23/27	2	65 70 75
Power Factor	0.95	3	70 75 80
Color	9 T _v	4	75 80 85
Lamp Life (hrs)	10000	5	80 85 90
Startup Time	1.2	6	85 90 95
Color Shift	30*	7	90 95 100
Color	30*	8	95 100 105

Application Data (23W)		Coefficient Curves	
Spacing	Match luminaire	Beam	80 (80% Foot)
at	Foot	Beam	30 35 40
Center	center	1	60 65 70
0	60	2	65 70 75
10	65	3	70 75 80
20	70	4	75 80 85
30	75	5	80 85 90
40	80	6	85 90 95
50	85	7	90 95 100
60	90	8	95 100 105

ENERGY EFFICIENT LIGHTING

- appropriate lighting
- daylight harvesting
- use efficient lamps
- use efficient electronic ballasts
- use efficient luminaires
- materials & room proportions

ENERGY EFFICIENT LIGHTING

Maintenance:

$$\approx \text{Light Loss Factor (LLF)} = \text{Lamp Lumen Depreciation (LLD)} \times \text{Luminaire Dirt Depreciation (LDD)}$$

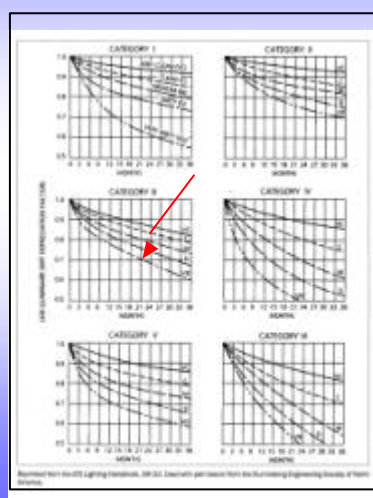
Item No.	Part No.	Symbol	Ordering Code	Qty	Notes	Item Length	Base Length (mm)	Base Dia (mm)	Approx. Total Lumens (lm)	Design Lumens (lm)	
Universal T8 Fluorescent Lamps 10 Pin Base Type											
17	34791-0	1	FITF72L835ALTO	25	71,890,3000	34	14000	25000	4400	1300	
	34791-0	1	FITF72L835ALTO	25	71,890,3000	34	14000	25000	4400	1300	
	34791-0	1	FITF72L835ALTO	25	71,890,3000	34	14000	25000	4400	1300	
	34824-0	1	FITF72L835ALTO	25	71,890,3000	34	14000	25000	4400	1300	
	34824-0	1	FITF72L835ALTO	25	71,890,3000	34	14000	25000	4400	1300	
	34824-0	1	FITF72L835ALTO	25	71,890,3000	34	14000	25000	4400	1300	
	34824-0	1	FITF72L835ALTO	25	71,890,3000	34	14000	25000	4400	1300	
	34824-0	1	FITF72L835ALTO	25	71,890,3000	34	14000	25000	4400	1300	
18	34813-0	1	FITF72L835ALTO	25	71,890,3000	34	14000	25000	4400	1300	
	34813-0	1	FITF72L835ALTO	25	71,890,3000	34	14000	25000	4400	1300	
	34824-0	1	FITF72L835ALTO	25	71,890,3000	34	14000	25000	4400	1300	
	14124-1	1	FITF72L835ALTO	25	71,890,3000	34	14000	25000	4400	1300	
	34824-0	1	FITF72L835ALTO	25	71,890,3000	34	14000	25000	4400	1300	
	34824-0	1	FITF72L835ALTO	25	71,890,3000	34	14000	25000	4400	1300	
	34824-0	1	FITF72L835ALTO	25	71,890,3000	34	14000	25000	4400	1300	
	34824-0	1	FITF72L835ALTO	25	71,890,3000	34	14000	25000	4400	1300	
19	24671-0	1	FITF72L835ALTO	25	71,890,3000	34	14000	25000	4400	1300	
	27136-0	1	FITF72L835ALTO PLZ	150	1,430,3000	40	20000	25000	2950	1800	
	24670-0	1	FITF72L835ALTO	25	71,890,3000	34	14000	25000	4400	1300	
	27134-0	1	FITF72L835ALTO PLZ	150	1,430,3000	40	20000	25000	2950	1800	
	24671-0	1	FITF72L835ALTO	25	71,890,3000	34	14000	25000	4400	1300	
	27135-1	1	FITF72L835ALTO PLZ	150	1,430,3000	40	20000	25000	2950	1800	
	27135-4	1	FITF72L835ALTO	25	71,890,3000	34	14000	25000	4400	1300	
	27135-6	1	FITF72L835ALTO	25	71,890,3000	34	14000	25000	4400	1300	
	27181-0	1	FITF72L835ALTO PLZ	150	1,430,3000	40	20000	25000	2950	1800	
	27181-3	1	FITF72L835ALTO	25	71,890,3000	34	14000	25000	4400	1300	
	27181-4	1	FITF72L835ALTO	25	71,890,3000	34	14000	25000	4400	1300	
	27181-5	1	FITF72L835ALTO PLZ	150	1,430,3000	40	20000	25000	2950	1800	
	27181-6	1	FITF72L835ALTO	25	71,890,3000	34	14000	25000	4400	1300	
	27181-9	1	FITF72L835ALTO PLZ	150	1,430,3000	40	20000	25000	2950	1800	
	27181-3	1	FITF72L835ALTO	25	71,890,3000	34	14000	25000	4400	1300	

ENERGY EFFICIENT LIGHTING

Maintenance:

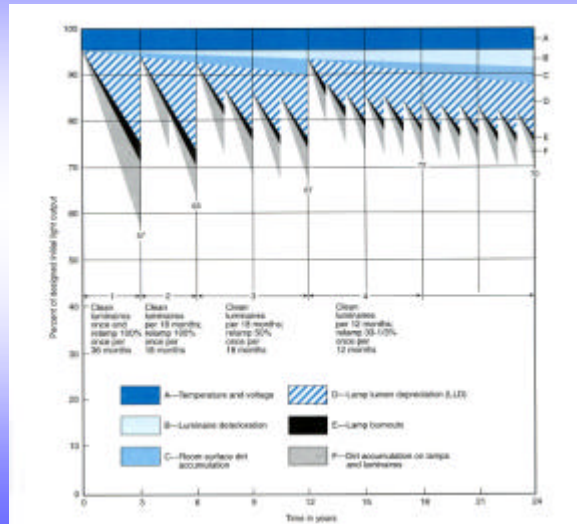
$$\approx \text{Light Loss Factor (LLF)} = \text{Lamp Lumen Depreciation (LLD)} \times \text{Luminaire Dirt Depreciation (LDD)}$$

Maintenance Category	Top Enclosure	Bottom Enclosure
I	1. None	1. None
II	1. None	1. None
	2. Translucent with 10% or more length through openings	2. Laminar or baffles
	3. Translucent with 20% or more length through openings	
	4. Translucent with 30% or more length through openings	
III	1. Translucent with less than 10% length through openings	1. None
	2. Translucent with less than 10% length through openings	2. Laminar or baffles
	3. Translucent with less than 10% length through openings	
	4. Translucent with less than 10% length through openings	
IV	1. Translucent unperforated	1. None
	2. Translucent unperforated	2. Laminar or baffles
	3. Translucent unperforated	
V	1. Translucent unperforated	1. Translucent unperforated
	2. Translucent unperforated	2. Translucent unperforated
	3. Translucent unperforated	3. Translucent unperforated
VI	1. None	1. Translucent unperforated
	2. Translucent unperforated	2. Translucent unperforated
	3. Translucent unperforated	3. Translucent unperforated
	4. Translucent unperforated	4. Translucent unperforated



ENERGY EFFICIENT LIGHTING

Maintenance example:



LIGHTING DESIGN IS MORE THAN DESIGN BY NUMBERS!

Useful sources:

- the Illuminating Engineering Society North America, "the Lighting Handbook"
- Gary Gordon "Interior Lighting for Designers"
- J. Benya "Ultra-Efficient lighting for workspaces"
- S. Graf, "Importance of using a lighting designer"
- Architectural Lighting, "Design Focus Report: Offices at 1 Watt per square foot"
- Architectural Lighting, "Codes: The good, the bad and the ugly"
- www.ashrae.org
- www.energycodes.gov
- www.usgbc.org



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