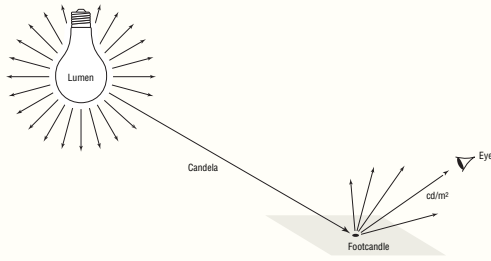


Cooper Lighting: How To Read Photometrics

HOW TO READ PHOTOMETRICS



PHOTOMETRIC TERMS

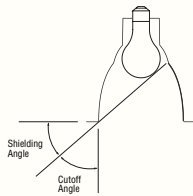
Lumens: Luminous flux, measured in lumens (lm), is the total amount of light produced by a source without regard to direction. The luminous flux is provided by lamp manufacturers and common lumen values are included in the lamp matrix.

Candela: Luminous intensity, measured in candela (cd), is the amount of light produced in a specific direction. Graphically, this information is compiled into polar formatted charts that indicate the intensity of light at each angle away from 0° lamp axis (nadir). The numeric information is also available in tabular form.

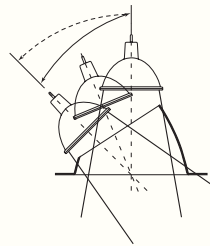
Footcandles: Illuminance, measured in footcandles (fc), is the measure of the quantity of light that arrives on a surface. Three factors that affect illuminance are the intensity of the luminaire in the direction of the surface, the distance from the luminaire to the surface, and the angle of incidence of the arriving light. Although illuminance cannot be detected by our eyes, it is a common criterion used in specifying designs.

Candelas/meter²: Luminance measured in candelas/meter² (cd/m²) is the quantity of light that leaves a surface. It is what the eye perceives. Luminance will reveal more about the quality and comfort of a design than illuminance alone.

Cutoff: The cutoff angle of a luminaire is the angle between the vertical axis (nadir) and the line of sight when the brightness of the source or its reflected image is no longer visible. This is the deciding factor for visual comfort in a lighting system. Deep cutoff optics provide low brightness luminaires, allowing the eye to see more effectively. The shielding angle is the complementary angle to the cutoff angle.



Translating Center Beam Optics: Adjustable accent fixtures historically have been inefficient luminaires. As lamps were aimed away from the vertical axis, light from the lamp was wasted—either trapped within the luminaires or re-reflected away from the intended target because the lamp aimed into the reflector cone or baffle. IRIS products solve this problem of well-shielded fixtures with its translating center beam optics design. As the lamp is tilted, its axis pivots about the center of the aperture at the ceiling plane. Light from the center beam does not aim into the reflector. In addition, the lamp translates towards the aperture to maximize more light to exit through the opening. Translating center beam optics increases the amount of light from an adjustable accent, allowing incandescent sources to be used with increased efficiency.



PHOTOMETRIC INFORMATION

Photometric information is provided with each fixture to assist in the lighting layout.

Test Number: The photometric test number identifies the specific lamp and luminaire combination tested.

Lamp Information: Identifies the lamp designation and initial lumen output.

Beam Spread: Lamp beam spread to 50% maximum candlepower.

Center Beam Candle Power (CBCP): Maximum candlepower of lamp at nadir.

Cutoff: Cutoff of lamp and lamp image angle as given from nadir.

Spacing Criterion (SC): Mathematically classifies the maximum spacing allowed in order to maintain reasonably even illumination.

$$\text{Luminaire Spacing} = \text{SC} \times \text{Height to Illuminated Plane}$$

Efficiency: Compares how much light is emitted from a luminaire; however, efficiency does not indicate the quality of light or visual comfort of a luminaire.

$$\text{Efficiency \%} = \frac{\text{Luminaire Lumens}}{\text{Lamp Lumens}}$$

Unit LPW: Indicates total system efficacy; however, unit LPW provides no indication of the light's direction or quality. Some luminaires with a lower LPW may produce a more desirable lighting effect than a luminaire with a higher LPW.

$$\text{LPW} = \frac{\text{Lamp Lumens} \times \text{Luminaire Efficiency}}{\text{Luminaire Watts}}$$

Candelas: Polar candela diagrams graphically illustrate the light intensity at specific directions from nadir. Intensity is on the vertical axis, and radial lines indicate elevation angles at 30°, 60° and 90° from nadir. For symmetrical downlights, only one half of a plane of data is shown; for wall washers, both wall and downlight data are shown. Consult specification sheets for full diagrams of non-rotationally symmetric units.

Candelas

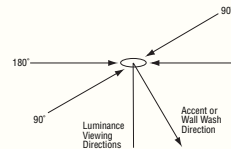
Vertical Angle	cd
90°	0
85°	0
75°	0
65°	0
55°	0
45°	112
35°	413
25°	547
15°	583
5°	566
0°	562

Luminance

Degree	cd/m²
85°	0
75°	0
65°	0
55°	0
45°	11286

Luminance: Average luminance numerically indicates the brightness of the aperture.

Luminance is provided for various viewing directions, the 0° direction being where the wall wash or accent light is aimed. To convert the preferred cd/m² measure to the older footlamberts, multiply by 3.462. Typically, luminance reveals more about the quality and comfort of a lighting system than illuminance alone.



HOW TO READ PHOTOMETRICS (continued)

BARE LAMP VS REAL WORLD DATA

Accent (a.k.a. projector) lamp photometrics, based upon published bare lamp data, vastly overstate the performance of recessed low voltage adjustable accent fixtures; and require lighting designers to estimate losses within the fixture. Additional losses, from actual operating voltage and actual vs. designed filament position within the reflector, will further reduce light output.

e.g. GE Q50MR16/C/NSP15 tilted 30° and aimed on a wall 2' from the fixture

	Voltage (v)	Footcandles (fc)
Published Bare Lamp Data:	12.0	361
Off the shelf Bare Lamp	12.0	320
Off the shelf lamp as tested in P3MR-E3AAC	12.0	252
Corrected for Truvolt™ xfr. on switch or dimmer	11.8	237
Corrected for laminated xfr. on switch	11.5	217
Corrected for laminated xfr. on dimmer	10.6	161

While the published bare lamp data produces 361 fc, the off the shelf lamp tested bare produces 320fc (11% less). Once this lamp is tested in the Iris fixture, the same off the shelf lamp produces 252 fc (21% less).

Worse still is the additional loss from the industry standard laminated transformer on a dimmer, which produces a total loss of 55% from the published bare lamp data.

Recognizing these tremendous losses, IRIS publishes "real world photometrics" for our low voltage fixtures using off the shelf lamps installed in fixtures using a clear lens and operated at 12.0 volts.

CONE OF LIGHT

Useful tools for rapid lighting comparisons and calculations, cones of light calculate initial footcandle levels for a single unit based upon point calculation techniques. Beam diameters are rounded to the nearest half-foot.

Cone of Light

Distance to Illuminated Plane	Initial Nadir Footcandles	Beam Diameter
4.5	27	5.0
5.5	18	6.5
6.5	13	7.5
8.0	8	9.5
10.0	5	11.5
12.0	4	14.0

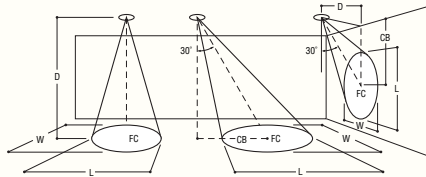
Beam diameter is to 50% of maximum footcandles.

Downlight: These cones of light provide single-unit performance with no inter-reflections from surfaces. Data listed is for mounting height, footcandle values at nadir, and resulting beam diameter. Please note:

1. Mounting heights are from the fixture plane to the illuminated work plane (task).
2. Footcandle values are at nadir (0°).
3. Beam diameter is defined as 50% maximum footcandle values. This allows rapid spacing of units for uniform illumination, allowing overlapping of 50% levels.
4. Maximum footcandle values may not always occur at nadir; batwing distributions produce maximum values surrounding nadir.
5. Proration factors are provided for other reflector finishes.

Accent: Patterns of light from adjustable accent luminaires are dependent upon the lamp type, wattage, lamp tilt and location of illuminated plane. Single-unit performance data is provided for horizontal and vertical planes, with the lamp tilted at either 0°, 30°, or 45° aiming. Please note:

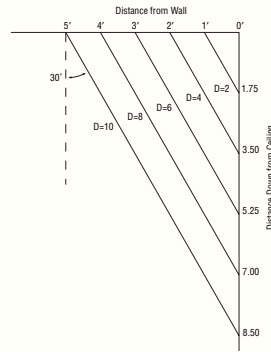
1. Aiming angle is measured from nadir.
2. D is distance from the floor or wall.
3. Footcandle values are maximum values.
4. Effective Visual Beam (EVB) is determined by 50% of the maximum footcandle level.
5. Beam length and width based upon the EVB.
6. CB is the distance at which center beam of the lamp occurs either from the ceiling or nadir.



Beam Aiming: Beam aiming diagrams allow a designer to easily select the proper distance from a wall to locate a luminaire and get the center beam of the lamp where desired.

For lighting art objects on a wall, the 30° aiming is preferred. At this angle, 1/3 of the beam's length will be above the CB point, and 2/3 will be below it. Thus, if a painting is three feet tall, plan for the CB to be aimed 1 foot below the top of the painting.

For increased modeling of three-dimensional objects, two lights are typically used, a key light and fill light. Both are aimed at least 30° elevation and are located 45° off axis.

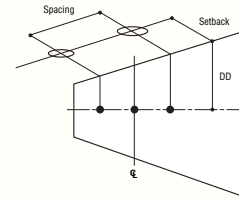


WALL WASH DATA

Asymmetric wall wash distributions are provided with two types of performance charts. A single-unit performance chart plots the illuminance levels at one-foot increments along and down a wall.

Multiple-unit performance charts report the performance of the middle units computed from a four unit layout. Illuminance values are plotted centerline of unit and centered between units.

1. Illuminance values are cosine-corrected initial values.
2. No room surface inter-reflections contribute to illuminance values.
3. Changing unit spacing will affect the illumination level.



$$\text{New FC} = \frac{\text{Existing Spacing} \times \text{Average Table FC Level}}{\text{New Spacing}}$$

LIGHT LOSS FACTORS

Many variables affect the illumination level after installation. Two of the greatest factors are Lamp Lumen Depreciation (LLD) and Luminaire Dirt Depreciation (LDD). Additional light loss factors affect the illumination level over time. It is the designer's responsibility to understand and apply the appropriate factors.

Lamp lumen depreciation accounts for the reduction in lumen output that all lamps experience as they age. Typical factors are listed in the following chart.

Source	LLD
Standard Incandescent	0.87
Quartz Halogen Incandescent	0.95
Compact Fluorescent	0.95

Luminaire dirt depreciation accounts for the reduction in light output of a fixture due to accumulation of dirt on the surfaces of the fixture. The three factors that determine the luminaire dirt depreciation are the optical distribution, cleanliness of the environment and its cleaning cycle.

Environment	LDD Open Unit	LDD Lensed Unit
Very Clean	0.97	0.85
Clean	0.85	0.79

EFFECTS OF LOWER OPERATING VOLTAGE ON LUMEN OUTPUT

Any incandescent (including halogen) lamp operating at less than its designed voltage will produce less lumens and a lower color temperature than stated. This effect can be of great magnitude with low voltage lamps.

The formulas below will create the multipliers to apply to photometric calculations and predictably plan the light levels of a given space. The table summarizes the more common voltages experienced.

Formula to correct output for lower secondary voltage
 (Actual Xfr Output/Lamp Voltage)^{1.8} = % of published output
 e.g. (10.6 / 12.0)^{1.8} = 64%
 Note: If using Excel simply enter =POWER((10.6/12.0),3.6)

Formula to correct color temp for lower secondary voltage:
 (Volts Running / Volts Rated)^{0.42} = % of rated color temp
 e.g. (10.6 / 12.0)^{0.42} = .95%
 Note: If using Excel simply enter =POWER((10.6/12.0),.42)

	Output %	Color Temp. %
IRIS with	100%	100%
Truvolt™ Xfr.	97%	100%
	94%	99%
Laminated Xfr.	86%	98%
Laminated Xfr.	68%	96%
on a dimmer	64%	95%

CONE COLOR FINISH MULTIPLIERS

The finish of a reflector has a greater effect on non-directional lamps like the A-lamp as compared to a directional lamp like the MR16. IRIS has tested all of our finishes with both lamp types for better accuracy. These finish multipliers are listed below each finish and should be used to modify the published photometrics for our Clear Alzak reflectors to another finish.

Description	Cat #	Non-Directional Lamps	Directional Lamps
Clear	C	100%	100%
Black	B	24%	93%
Blush	BU	85%	99%
Blush Haze	BUH	74%	98%
Chocolate	CC	38%	94%
Chocolate Haze	CCH	31%	93%
Cognac	K	58%	95%
Cognac Haze	KH	44%	95%
Gold	G	99%	100%
Graphite	GP	46%	95%
Graphite Haze	GPH	44%	94%
Haze	H	96%	99%
Pine	PN	42%	94%
Pine Haze	PNH	38%	93%
Sky	SK	67%	99%
Sky Haze	SKH	63%	96%
Warm Haze	WMH	90%	98%
White	W	92%	99%

LENS, LOUVER & COLOR FILTER MULTIPLIERS

Please see page 24 for the appropriate multiplier to apply with each type of media upon the photometric footcandle charts.

PITCH TO DEGREE CONVERSION

2/12	3/12	4/12	5/12	6/12	7/12	8/12	9/12	10/12	11/12	12/12
10°	14°	18.5°	22.5°	26.5°	30°	33.5°	36.8°	39.8°	42.5°	45°

POINT-TO-POINT CALCULATIONS

The calculation of footcandles at a point, no matter if it is on a horizontal, vertical or tilted surface, can be accomplished with the inverse square law. The law states that the illuminance is proportional to the candlepower of the source in the given direction and inversely proportional to the square of the distance from the source. In addition, as a surface is tilted away from the source, illuminance will decrease in a ratio equal to the cosine of the angle of incidence.

The inverse square law formula can be expressed in various ways; the two most useful follow. Version 1 is ideal for the complexities of three-dimensional space—no trigonometry (cosine) is needed, just the simple X, Y and Z coordinates of the layout. It is also very useful in calculating footcandles from the CBCP of accent lights. Version 2 is useful for calculations that can be laid out in two dimensions, and when it is easy to find the cosine of the aiming angle. Insert your data into either easy-to-use formula to calculate the initial footcandle level at a point.

Version 1: $FC = \frac{I \times N}{D^3}$

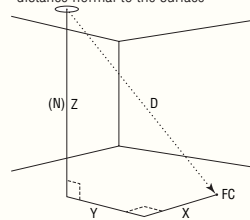
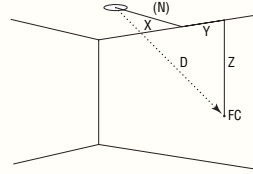
Where:

I = cd towards point

D = distance to point

(the square root of X² + Y² + Z²)

N = distance normal to the surface



Version 2: $FC = \frac{I \times \cos \theta}{D^2}$

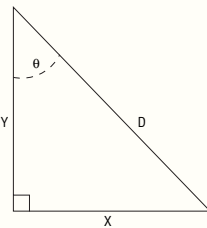
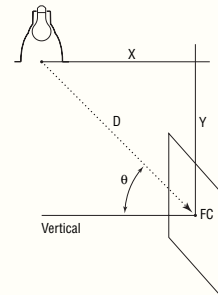
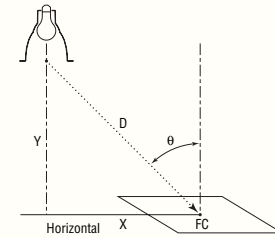
Where:

I = cd towards point

D = distance to point

(the square root of X² + Y²)

θ = angle between incident light ray and normal to the surface



θ	cos θ	TAN θ
0°	1.0	0.0
5°	.996	.087
10°	.985	.176
15°	.966	.268
20°	.940	.364
25°	.906	.466
30°	.866	.577
35°	.819	.700
40°	.766	.839
45°	.707	1.0

To find distance D: $D = \sqrt{X^2 + Y^2}$ or $D = \frac{Y}{\cos \theta}$

To find aiming angle θ: $TAN \theta = \frac{X}{Y}$ or $\cos \theta = \frac{Y}{D}$