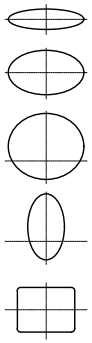
AREA LIGHTING CLASSIFICATIONS



TYPE 1 IS VERY LINEAL AND INTENDED FOR 1 OR 2 LANE ROADWAYS.

TYPE 2 IS STILL LINEAL BUT WIDER IN THE FRONT TO ACCOMMODATE 4 LANE ROADWAYS, OR WIDER DRIVE LANES.

TYPE 3 (COMMONLY KNOWN AS A "BAT-WING") IS SUITABLE FOR PERIMETERS, OFTEN WHERE OTHER INTERIOR POLE PLACEMENTS FILL THE SITE.

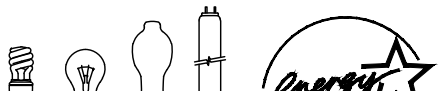
TYPE 4 (COMMONLY KNOWN AS A "FORWARD THROW" OR" ASYMMETRIC) IS BEST ALONG PERIMETERS WHERE SPILL LIGHT IS A CONCERN OR THERE ARE NO PLACE TO ADD POLES WITHIN A SITE.

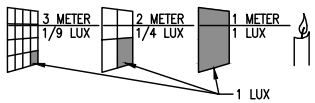
TYPE 5 – IS AVAILABLE IN A ROUND OR SQUARE PATTERN. BEST SUITED FOR INTERIOR AREAS WITHIN A SITE OR ON THE MEDIAN OF 4–6 LANE ROADWAYS.

DESPITE THESE STANDARD 5 CLASSIFICATIONS, MANUFACTURERS WILL STRETCH THOSE PARAMETERS AND DEVELOP UNIQUE DISTRIBUTIONS AND NOMENCLATURE IN SOME CASES. FOR ACUITY BRANDS LIGHTING EXTERIOR PRODUCTS, DISTRIBUTIONS ARE CLASSIFIED AS R2 THRU R5 WITH SOME SPECIALTY DISTRIBUTIONS SUCH AS R4W, R4SC, SYM, ASY, AND VFA FOR POLE MOUNTED LUMINARIES. ALL OF THESE STILL FALLS WITHIN THE 5 BASIC CLASSIFICATIONS BUT THEIR UNIQUE PATTERNS ALLOW THE PRODUCT TO SERVE FOR SPECIFIC SITE CONDITIONS.

R4W – IS A PATTERN THAT IS A WIDER PATTERN THAN A NORMAL TYPE 4. GREAT FOR PERIMETERS AND IN SOME CASES CAN BE USED ON AN INTERIOR LOCATION WITH A TWIN CONFIGURATION. GREAT FOR A ONE REFLECTOR DOES ALL OPTION.

R4SC – STILL A TYPE 4 WITH VERY SHARP CUTOFF. THIS OPTIC EXCELS WHERE THERE ARE STRICT LOCAL ORDINANCES FOR SPILL LIGHT OR SEEKING LEED CREDITS.



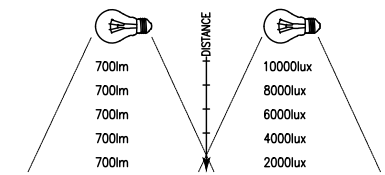




$E = \frac{I}{d^2}$

E= ILLUMINATION [1 LUMEN/FT² OR 1 FOOTCANDLE (1 LUMEN/m² OR 1 LUX OR 0.0926 FOOTCANDLE)]
I= INTENSITY OF SOURCE (1 CD OR 12.57 LUMENS)
d= DISTANCE FROM SOURCE TO OBJECT (FT OR M)

LUX (lx) = LUMENS PER SQUARE METER
1 CANDLE POWER = 12.57 LUMENS.
ONE FOOT CANDLE (fc) = 10.764lx
A COMMON CANDLE EMITS LIGHTS ROUGHLY 1 CANDELA (cd) LUMINOUS INTENSITY MEASURED AT 540 X $10^{12}$ HERTZ.
FOOT CANDLE (fc) = EQUAL THE AMOUNT OF LUMENS PER SQft OF AREA.

DIFFERENCE BETWEEN LUX AND LUMEN




LUMENS is the total number of "packets of light" (or quality of light outlet) produced by a light source. IE: A 100W incandescent lamp emits about 1300 lumens.

LUX is a ratio of illumination (or lumens) over a distance: 1 lux = 1 lumen per square meter. ILLUMINATION ON A SURFACE

ELECTRONIC BALLAST LAMP WATTS X 10%
MAGNETIC BALLAST LAMP WATTS X 25%

FLOURESCENT LAMPS LOAD
2 LAMP F32T8 – ~65 WATTS
3 LAMP F32T8 – ~100 WATTS
4 LAMP F32T8 – ~120 WATTS

| FLUORESCENT FIXTURE |
|---|
| 1 LAMP = 32W |
| 2 LAMP = 60W |
| 3 LAMP = 100W |
| 4 LAMP = 120W |

TRACK LIGHTS – 75 WATTS PER FOOT

$LEF = \frac{\text{TOTAL LAMP LUMENS X LIGHT OUTPUT RATIO}}{\text{TOTAL CIRCUIT POWER}}$

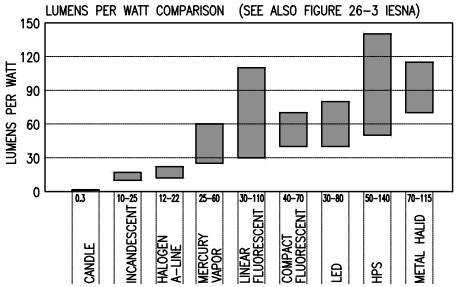
LEF = LUMINARIE EFFICIENCY FACTOR

$\text{LUMENS PER WATT} = \frac{\text{LUMENS}}{\text{WATTS}}$

| Watts | | | (Brightness) | WATTS | ~LUMENS |
|---|---|---|---|---|---|
| Incandescent | CFL | LED | Lumens | | |
| 40 | 8 – 12 | 6 – 9 | 400 – 500 | 150W | 2600lm |
| 60 | 13 – 18 | 8 – 12.5 | 650 – 900 | 100W | 1600lm |
| 75 – 100 | 18 – 22 | 13+ | 1100 – 1750 | 75W | 1100lm |
| 100 | 23 –30 | 16 – 20 | 1800+ | 60W | 800lm |
| 150 | 30 – 55 | 25 – 28 | 2780 | 40W | 450lm |

| DIMMER ⟶ BRIGHTER | | | | |
|---|---|---|---|---|
| LUMENS | 450 | 800 | 1100 | 1600 |
| STANDARD INCANDESCENT | 40W | 60W | 75W | 100W |
| HALOGEN INCANDESCENT | 29W | 43W | 53W | 72W |
| CFL | 9W | 14W | 19W | 23W |
| LED | 9W | 13W | 17W | N/A |

LUMENS PER WATT COMPARISON (SEE ALSO FIGURE 26-3 IESNA)




| LIGHT TYPE | TYPICAL LUMINOUS EFFICACY (LUMENS/WATT) |
|---|---|
| TUNGSTEN INCANDESCENT LIGHT BULB | 10–25 LM/W |
| HALOGEN LAMP | 12–22 LM/W |
| LED LAMP | 30–80 LM/W |
| FLUORESCENT LAMP | 30–110 LM/W |
| MERCURY VAPOR LAMP | 25–60 LM/W |
| METAL HALIDE LAMP | 70–115 LM/W |
| HIGH PRESSURE SODIUM VAPOR LAMP | 50–140 LM/W |
| LOW PRESSURE SODIUM VAPOR LAMP | 100–200 LM/W |

| Color | Wavelength | Frequency | Photon energy |
|---|---|---|---|
| violet | 380–450 nm | 668–789 THz | 2.75–3.26 eV |
| blue | 450–495 nm | 606–668 THz | 2.50–2.75 eV |
| green | 495–570 nm | 526–606 THz | 2.17–2.50 eV |
| yellow | 570–590 nm | 508–526 THz | 2.10–2.17 eV |
| orange | 590–620 nm | 484–508 THz | 2.00–2.10 eV |
| red | 620–750 nm | 400–484 THz | 1.65–2.00 eV |

LUX AND LOW LIGHTING CHART

| CONDITION | ILLUMINATION | | DETAILS |
|---|---|---|---|
| | fc | LUX | |
| SUNLIGHT | 10,000 | 107,527 | DAYLIGHT RANGE |
| FULL DAYLIGHT | 1,000 | 10,752 | |
| OVERCAST DAY | 100 | 1,075 | |
| VERY DARK DAY | 10 | 107 | |
| TWILIGHT | 1 | 10 | |
| DEEP TWILIGHT | .1 | 1 | |
| FULL MOON | .01 | .108 | LOW LIGHT LEVEL RANGE |
| QUARTER MOON | .001 | .0108 | |
| STARLIGHT | .0001 | .0011 | |
| OVERCAST NIGHT | .00001 | .0001 | |

| LIGHT SPECTRUM | | |
|---|---|---|
| COLOR | WAVELENGTH | FREQUENCY |
| VIOLET | ~380–440nm | ~790–680THz |
| BLUE | ~440–485nm | ~680–620THz |
| CYAN | ~485–500nm | ~620–600THz |
| GREEN | ~500–565nm | ~600–530THz |
| YELLOW | ~565–590nm | ~530–510THz |
| ORANGE | ~590–625nm | ~510–480THz |
| RED | ~625–740nm | ~480–405THz |
| PEACH | ~ | ~ |
| BROWN | ~ | ~ |
| BLACK | ~ | ~ |

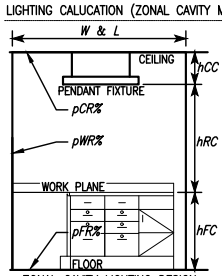
| BULB COMPARISON | | | | | | |
|---|---|---|---|---|---|---|
| FEATURES | Incandescent | CFL | HID | LED | Halogen | Fluorescent |
| Rated Avg. Life | 755–1200 | 10,000 | 20,000 | 50,000 | 3,000 | 3,000 |
| Life Span | Low | Long | Very Long | Very Long | Medium | Medium |
| Watts | 3 – 500 | 3 – 120 | 35 – 1500 | 2.5 – 16 | 5 – 500 | 5 – 500 |
| Cost per bulb | 1.25 | 3.95 | | 39.95 | | |
| Cost to Operate | High | Low | Lowest | Low | Medium | Medium |
| Price to Product | Low | Medium | High | High | Medium | Medium |
| Lumens per Watt (LPW) | 15LPW | 60LPW | Up to 120LPW | 45LPW | 25LPW | 25LPW |
| Color Temperature (in Kelvin) | 2700K | 2700K – 6500K | 1700K – 6500K | 2700K – 6500K | 3000K | 4000K |

| REFLECTANCE TABLE | | | |
|---|---|---|---|
| COLORS | % | MATERIALS | % |
| WHITE | 70–80 | PLASTER – WHITE | 80 |
| LIGHT CREAM | 70–80 | WHITE PORCELAIN | 65–75 |
| LIGHT YELLOW | 55–65 | GLAZED WHITE TILE | 60–75 |
| LIGHT GREEN | 45–50 | LIMESTONE | 35–70 |
| PINK | 45–50 | MARBLE | 30–70 |
| SKY–BLUE | 40–50 | SANDSTONE | 20–40 |
| LIGHT GRAY | 40–45 | BRICK – RED | 10–20 |
| BEIGE | 25–35 | CARBON – BLACK | 2–10 |
| YELLOW OCHER | 25–35 | | |
| LIGHT BROWN | 25–35 | MIRROR | 95 |
| OLIVE GREEN | 25–35 | CLEAR GLASS | 6–8 |
| ORANGE | 20–25 | | |
| VERMILLION RED | 20–25 | MAPLE (NATURAL) | 60 |
| MEDIUM GRAY | 20–25 | BIRCH (NATURAL) | 35–50 |
| | | OAK – LIGHT | 15–35 |
| DARK GREEN | 10–15 | CHERRY (NATURAL) | 15–30 |
| DARK BLUE | 10–15 | OAK – DARK | 10–15 |
| DARK RED | 10–15 | MAHOGANY | 6–12 |
| DARK GRAY | 10–15 | WALNUT – DARK | 5–10 |
| | | | |
| IDEAL CEILING | 60–90 | TIN | 67–72 |
| IDEAL WALLS | 35–60 | STAINLESS STEEL | 50–60 |
| IDEAL COUNTERTOPS | 30–50 | ALUMINUM | 55–58 |
| DEFAULT: CEILING = 80, WALL = 50, FLOOR = 20 | | | |

Overall performance of a lamp over its life

| LAMP LUMEN DEPRECIATION (LLD) | | |
|---|---|---|
| | GROUP REPLACEMENT | REPLACEMENT OR BURNOUT |
| INCANDESCENT | 0.94 | 0.88 |
| TUNGSTON–HALOGEN | 0.98 | 0.94 |
| FLUORESCENT | 0.90 | 0.85 |
| MERCURY | 0.82 | 0.74 |
| METAL–HALID | 0.87 | 0.80 |
| HPS | 0.94 | 0.88 |

LIGHTING CALUCATION (ZONAL CAVITY METHOD) DOE




ZONAL CAVITY LIGHTING DESIGN

$RCR = 5 \times hRC \times \left(\frac{L + W}{L \times W}\right)$

$APL = \frac{lum \times CU \times MF}{Mfc}$

$FIX = \frac{A}{APL}$

$Afc = \frac{FIX \times lum \times CU \times MF}{A}$

WATTS/FIXTURE = _____

WATTS/ROOM = _____

WATTS/Sqft = _____

| CALCULATION TERMS | |
|---|---|
| APL | AREA PER LUMINAIRE (Sqft) |
| FIX | NUMBER OF FIXTURES REQD. |
| LF | LAMPS PER FIXTURE |
| lum | LUMENS PER LUMINAIRE |
| CU | COEFFICIENT OF UTILIZATION (FOUND WITH FIXTURE CUT SHEET) |
| LLF | LIGHT LOSS FACTOR |
| BF | BALLAST FACTOR |
| MF | MAINTENANCE FACTOR (CLEANLINESS OF SPACE, .9) |
| LLD | LAMP LUMEN DEPRECIATION |
| LU | LUMENS PER FIXTURE |
| Mfc | MAINTAINED FOOTCANDLES DESIRED |
| Afc | AVERAGE MAINTAINED ILLUMINATION (FOOTCANDLES) |
| hCC | FIXTURE TO CEILING (ft) |
| hRC | WORK PLANE TO FIXTURE (ft) |
| hFC | FLOOR TO WORK PLANE (ft) |
| CCR | CEILING CAVITY RATIO |
| RCR | ROOM CAVITY RATIO |
| FCR | FLOOR CAVITY RATIO |
| pCR | CEILING REFLECTANCE VALUE (80) |
| pWR | WALL REFLECTANCE VALUE (50) |
| pFR | FLOOR REFLECTANCE VALUE (20) |
| L | LENGTH OF ROOM (ft) |
| W | WIDTH OF ROOM (ft) |
| A = L X W | |

COST OF LIGHT (CHAPTER 25 IESNA)

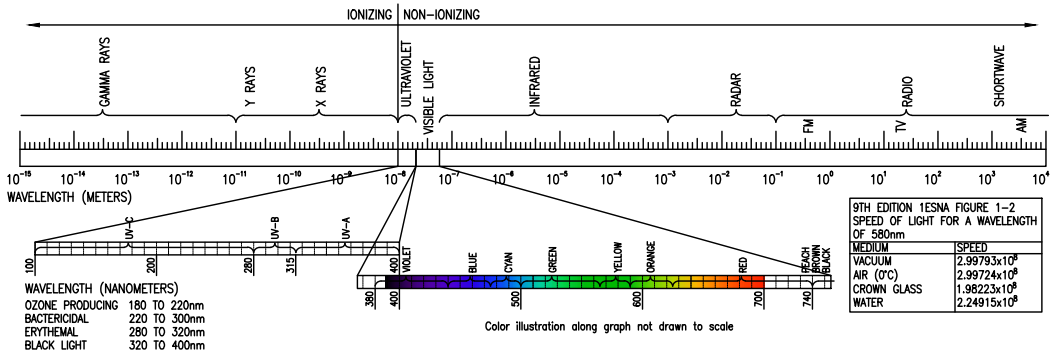
$U = \frac{10}{Q}\left(\frac{P + h}{L} + WR\right)$

U = UNIT COST OF LIGHT FOR A LAMP (DOLLARS/$10^6$ lm x h)
Q = MEAN LAMP FLUX (LUMENS)
P = LAMP PRICE (CENTS)
h = LABOR COST TO REPLACE ONE LAMP (CENTS)
L = AVERAGE RATED LAMP LIFE (THOUSANDS OF HOURS)
W = MEAN INPUT POWER PER LAMP (LAMP AND LOSSES) (WATTS)
R = ENERGY COST (CENTS/KILOWATT-HOUR)

Lighting designers knowledgebase edited: APR 2016



LIGHTING OVERALL DESIGNERS GUIDE




Color illustration along graph not drawn to scale

| 9TH EDITION 1ESNA FIGURE 1-2 SPEED OF LIGHT FOR A WAVELENGTH OF 580nm | |
|---|---|
| MEDIUM | SPEED |
| VACUUM | $2.99793 \times 10^8$ |
| AIR (0°C) | $2.99724 \times 10^8$ |
| CROWN GLASS | $1.98223 \times 10^8$ |
| WATER | $2.24915 \times 10^8$ |

| COLOR TEMPERATURE SPECTRUM | |
|---|---|
| DEGREES KELVIN | TYPE OF LIGHT SOURCE |
| 1700–1800K | MATCH FLAME |
| 1850–1930K | CANDLE FLAME |
| 2000–3000K | SUN: AT SUNRISE/SUNSET |
| 2500–2900K | HOUSEHOLD TUNGSTEN BULBS |
| 3000K | TUNGSTEN LAMP |
| 3200–3500K | QUARTZ LIGHTS |
| 3200–7500K | FLUORESCENT LIGHTS |
| 3275K | TUNGSTEN LAMP |
| 3380K | TUNGSTEN LAMP |
| 5000–5400K | SUN: DIRECT AT NOON |
| 5500–6500K | DAYLIGHT (SUN & SKY) |
| 5500–6500K | SUN: THROUGH CLUDS/HAZE |
| 6000–7500K | SKY: OVERCAST |
| 6500K | RGB MONITOR (WHITE PT.) |
| 7000–8000K | OUTDOOR SHADE AREAS |
| 8000–10000K | SKY: PARTLY CLOUDY |

COLOR TEMPERATURE IS A MEASUREMENT IN DEGREES KELVIN THAT INDICATES THE HUE OF A SPECIFIC TYPE OF LIGHT SOURCE. YOU CAN USE A COLOR TEMPERATURE (AS SHOWN IN THE COLOR TEMPERATURE CHART) TO SUGGEST REALISTIC COLORS FOR THE LIGHTS IN A 3D SCENE.

VISIBLE COLORS ARE RELATIVE TO THE COLOR BALANCE (OR WHITE BALANCE) OF A FILM STOCK OR VIDEO CAMERA, WITH THE TWO MOST COMMON FIXED SETTINGS BEING 3200K INDOOR COLOR BALANCE, AND 5500K OUTDOOR (DAYLIGHT) COLOR BALANCE. TO PICK AN RGB VALUE FROM THE CHART BELOW, FIRST CHOOSE WHETHER YOUR SCENE WOULD BE SHOT WITH INDOOR OR OUTDOOR FILM (USUALLY CHOSEN BASED ON THE DOMINANT LIGHTING), THEN FIND THE COLOR CORRESPONDING TO THE TYPE OF LIGHT SOURCE AT THAT COLOR TEMPERATURE.

SO, WHY DO WE MEASURE THE HUE OF THE LIGHT AS A "TEMPERATURE"? THIS WAS STARTED IN THE LATE 1800S, WHEN THE BRITISH PHYSICIST WILLIAM KELVIN HEATED A BLOCK OF CARBON. IT GLOWED IN THE HEAT, PRODUCING A RANGE OF DIFFERENT COLORS AT DIFFERENT TEMPERATURES. THE BLACK CUBE FIRST PRODUCED A DIM RED LIGHT, INCREASING TO A BRIGHTER YELLOW AS THE TEMPERATURE WENT UP, AND EVENTUALLY PRODUCED A BRIGHT BLUE–WHITE GLOW AT THE HIGHEST TEMPERATURES. IN HIS HONOR, COLOR TEMPERATURES ARE MEASURED IN DEGREES KELVIN, WHICH ARE A VARIATION ON CENTIGRADE DEGREES. INSTEAD OF STARTING AT THE TEMPERATURE WATER FREEZES, THE KELVIN SCALE STARTS AT "ABSOLUTE ZERO," WHICH IS –273 CENTIGRADE. (SUBTRACT 273 FROM A KELVIN TEMPERATURE, AND YOU GET THE EQUIVALENT IN CENTIGRADE.) HOWEVER, THE COLOR TEMPERATURES ATTRIBUTED TO DIFFERENT TYPES OF LIGHTS ARE CORRELATED BASED ON VISIBLE COLORS MATCHING A STANDARD BLACK BODY, AND ARE NOT THE ACTUAL TEMPERATURE AT WHICH A FILAMENT BURNS.