NEMA LE 6

Procedure for Determining Target Efficacy Ratings for Commercial, Industrial, and Residential Luminaires

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Procedure for Determining Target Efficacy Ratings
for Commercial, Industrial, and Residential Luminaires

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Foreword

This standards publication was developed to assist individuals purchasing or designing lighting systems for interior or exterior applications in determining the Target Efficacy Rating (TER) of a lighting product. The TER is intended to be a metric, among many other considerations, to evaluate the energy effectiveness of a lighting installation.

This standards publication was promoted by the need of the luminaire manufacturing industry to have a uniform method of determining energy effectiveness of their products. The NEMA LE 6-2009 Standard supersedes the NEMA LE 5, LE 5A, and LE 5B Standards for Luminaire Efficacy Ratings (LER).

It is not the intent of this standards publication to inhibit luminaire design or to impose arbitrary tolerances on any luminaire manufacturer. Further, it is not the intent of this standards publication to be used to regulate luminaires since many other factors related to visibility, color, contrast, glare, uniformity, and other metrics must be considered based on application requirements.

The preparation of this standards publication was done by the Luminaire Section, in close cooperation with the Lamp and Ballast Sections of the NEMA Lighting Systems Division. Input of users and other interested parties has been sought and evaluated. Inquiries, comments, and proposed or recommended revisions should be submitted to the Indoor Lighting Section of NEMA by contacting:

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This standard was developed by the Luminaire Section. Section approval of the Standard does not necessarily imply that all section members voted for its approval or participated in its development. At the time it was approved, the Luminaire Section was composed of the following members:

Acuity Brands Lighting
Arcalux Corporation
BJB Electric
Cooper Lighting
Deco Lighting
Emerson/EGS Electrical Group
EYE Lighting International
GE Consumer & Industrial Lighting Systems
Hubbell Lighting, Inc.
Juno Lighting Group
National Cathode Corp.
Philips Lighting
RAB Lighting
Ruud Lighting Inc.
Satco Product Inc.
Schneider Electric-Square D Company
TayMac Corporation
Technical Consumer Products, Inc.
Thomas & Betts Corporation
Westinghouse Lighting Solutions

Purpose

The purpose of this standards publication is to:

a. Provide the lighting design community and procurement officials with a practical and uniform method for calculating a metric to evaluate and compare the “energy effectiveness” of luminaires.

b. Provide the ability for construction or renovations focused on sustainable design to evaluate the energy performance of luminaires.

c. Provide electrical utility companies with a method to establish performance criteria for luminaires for use with energy savings rebate programs.

d. Provide a methodology for luminaires that considers lamp and ballast components as well as the effectiveness of the luminaire optics to deliver light to an intended task.

e. Define categories for types of luminaire products based on function, physical or dimensional attributes, and optical characteristics of luminaires to enable qualified energy comparisons within a category of product.

f. Preserve for the luminaire manufacturers and the lighting industry the right to use laboratory facilities, testing methods, and completed test data that currently exist and are in accordance with approved industry standards.

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Section 1
GENERAL

1.1 SCOPE

This standards publication provides a procedure for the determination of the Target Efficacy Rating (TER) for luminaires under laboratory test conditions.

This standard describes categories or types of product used in common indoor and outdoor lighting applications.

This standard does not apply to luminaires for specialized applications, including but not limited to products intended to be aimed, accent luminaires, rough or hazardous use luminaires, or emergency lighting.

1.2 REFERENCED PUBLICATIONS

The latest editions and revisions of the following publications are adopted as indicated by reference in this Standards Publication.

American National Standards Institute (ANSI)
11 West 42nd Street, 13th Floor
New York, NY 10036

ANSI C82.2-2002	*Methods of Measurement of Fluorescent Lamp Ballasts*
ANSI C82.3-2002	*Reference Ballasts for Fluorescent Lamps*
ANSI C82.5-1990 (R1995)	*High-Intensity Discharge and Low-Pressure Sodium Lamps*
ANSI C82.6-2005	*Ballasts for High-Intensity Discharge Lamps—Methods of Measurement*
ANSI C78.81-2005	*Double-capped Fluorescent Lamps—Dimensional and Electrical Characteristics*
ANSI C78.901-2005	*Single-Based Fluorescent Lamps—Dimensional and Electrical Characteristics*

Illuminating Engineering Society of North America (IESNA)
120 Wall Street FL 17
New York, NY 10005-4001

Current versions of the following IESNA Publications apply

	IESNA Lighting Handbook
LM-66	*Single-ended Compact Fluorescent Lamps—Electrical and Photometric Measurements*
LM-45	*Incandescent Lamps—Electrical Measurements*
LM-51	*High Intensity Discharge (HID) Lamps—Electrical Measurements*
LM-46	*Photometric Testing of Indoor Luminaires using HID or Incandescent Filament Lamps*
LM-41	*Approved Method for Photometric Testing of Indoor Fluorescent Luminaires*

1.3 DEFINITIONS

ballast: An auxiliary device used with an electrical discharge lamp(s) to obtain the necessary circuit conditions (voltage, current, and wave form) for the proper starting and operation of a particular fluorescent or high-intensity discharge (HID) lamp(s) from a particular line voltage and frequency.

ballast factor: A term used to describe the percentage of light output, produced when a fluorescent or HID lamp(s) is energized from a commercially available ballast, as compared to the light output produced when energized from a reference ballast. Ballast factor tests are run in accordance with ANSI C82.2 and ANSI C82.6.

coefficient of utilization (CU): The ratio of luminous flux (lumens) calculated as received on the work plane to the total luminous flux (lumens) emitted by the lamps alone.

compact fluorescent lamp: A compact shape fluorescent lamp with a single base that performs the entire mechanical support function.

energy effectiveness factor (EEF): The percent of lamp lumens that are received by a specified typical target area for the luminaire. The methodology for calculating EEF is a function of the luminaire product category to which the luminaire is assigned.

fixture: The structural parts of a luminaire, including parts designed to distribute the light and to position and/or protect the lamp(s), to mount and support the ballast(s), and to provide a wire way or means of connecting the lamp(s) and ballast(s) to the power supply. A fixture includes the ballast(s), but does not include lamp(s).

fluorescent lamp: A low pressure mercury electric-discharge lamp in which a fluorescing coating (phosphor) transforms a portion of the ultraviolet energy generated by the arc discharge into visible light.

high-intensity discharge (HID) lamp: An electric discharge lamp in which the light producing arc is stabilized by wall temperature, and the arc tube has a bulb wall loading in excess of three watts per square centimeter. HID lamps include groups of lamps known as mercury vapor, metal halide, and high-pressure sodium.

incandescent lamp: A lamp in which light is produced by a filament heated to incandescence by an electric current.

lumen: The SI unit of luminous flux.

luminaire: A complete lighting unit consisting of a lamp or lamps and ballast(s) together with the parts designed to distribute the light, to position and protect the lamps, and to connect the lamps through the ballast(s) to the power supply.

photometric efficiency: A ratio of luminous flux (lumens) emitted by a luminaire to that emitted by the lamp or lamps used therein.

rated lamp lumens: The rated average lumen output for a typical lamp, taken from the manufacturer's catalog. These values are substantiated by tests performed in laboratories accredited by the National Voluntary Laboratory Accreditation Program.

reference ballast: A ballast especially constructed to have certain prescribed electrical characteristics for use in testing electrical discharge lamps and other ballasts in accordance with ANSI C82.3 or ANSI C82.5.

roadway coefficient of utilization (roadway CU): The ratio of luminous flux (lumens) calculated as received within a specified distance in front of the pole (0-180 degree plane) and an infinite distance to the sides of the pole (90-270 degree plane) to the total luminous flux (lumens) emitted by the lamps alone.

room cavity ratio: A number indicating room cavity proportions, calculated from the length, width, and height.

target efficacy rating (TER): The ratio of lumens emitted from a luminaire that contribute to the illumination of a target area per watt of power consumed by the luminaire.

Section 2
SELECTION OF COMPONENTS

2.1 TEST SPECIMEN—LIGHTING FIXTURE

The luminaire selected for test shall be clean and representative of the manufacturer's current and regular production.

2.2 TEST SPECIMEN(S)—BALLASTS

Ballast(s) chosen for the test shall be typical of current production.

Ballasts shall be tested and certified as having ballast factors that are within +/- 0.025 of established average ballast factors or the manufacturer's published ballast factor, for the particular ballast when tested in accordance with ANSI C82.2 or ANSI C82.6.

2.3 TEST SPECIMEN(S)—LAMPS

Lamps of stable output should be used. They should be constant in light output for constant line voltage and repeated operation.

Lamps selected for tests should be typical of current production and should be selected for uniform luminance, consistent with their geometry.

Lamps shall conform to the requirements for reference lamps in accordance with ANSI C78.81 and ANSI C78.901. Where American National Standards do not exist for a given lamp type, values published by the lamp manufacturers shall apply. Lamps shall be burned for at least 100 hours in order to ensure stable electrical characteristics.

Section 3
TESTING FACILITIES AND EQUIPMENT

3.1 FACILITIES

Because of the importance of obtaining accurate and repeatable measurements, a National Voluntary Laboratory Accreditation Program (NVLAP) accredited photometric laboratory or a laboratory with a quality management system is recommended for testing.

The photometric laboratory shall have facilities for performing tests in accordance with all applicable sections of the IESNA LM-41, LM-46, and LM-66.

3.2 GENERAL CRITERIA

Because of the sensitivity of linear and compact fluorescent and to a lesser degree, low wattage HID lamp light output to air flows, all testing should be conducted in a simulated "draft free" environment. Although air movement is necessary to avoid thermal stratification, care should be taken to minimize any draft or air flow within the immediate vicinity of the test lamps or luminaire, or both.

Ambient temperature should be controlled to 25°C (77°F) within a tolerance of ± 1°C (1.8°F) for fluorescent products, and ± 5°C (9°F) for incandescent and HID products. (Reference: IESNA LM-41 and 46.)

Lamp pin or base contact connections should remain the same throughout the tests both for the calibration and for the luminaire test.

Section 4
CALCULATIONS

4.1 TARGET EFFICACY RATING

The Target Efficacy Rating (TER) shall be specified by the following formula:

TER = EEF x TLL x BF / Input Watts

Where:

TER = Target Efficacy Rating, expressed in rated lumens per watt. This value shall be expressed as a whole number rounding up (≥ 0.5) or down (< 0.5) as required.

EEF = Energy Effectiveness Factor and is calculated based on the class of products in section 4.2 and calculations in section 4.5. EEF shall be expressed as a two-place decimal, rounding up (≥ 0.005) or down (<0.005) as required.

TLL = Total initial lamp lumens, total number of lamps in the test luminaire multiplied by the published rated initial lamp lumens.

BF = Ballast factor of test ballast or the average ballast factor of test ballasts used in the photometric test.

INPUT WATTS = Total wattage of the luminaire as measured during the photometric test, or calculated based on the ballast manufacturers' published data for that lamp/ballast combination if photometric test data is not available.

4.2 LUMINAIRE TYPES AND CLASSIFICATIONS

Interior Luminaires:

a) Cylinder
b) Downlight, Commercial
c) Downlight, Residential
d) Highbay, linear
e) Highbay, non-linear
f) Linear industrial
g) Lowbay
h) Parking Garage
i) Recessed linear
j) Striplight
k) Surface mount, linear
l) Surface mount, non-linear
m) Surface mount, residential
n) Suspended, linear
o) Suspended, non-linear
p) Suspended, residential

Exterior Luminaires:

a) Area and Site
b) Bollard
c) Border
d) Canopy
e) Decorative, post top
f) Roadway

4.3 CALCULATION OF BALLAST FACTOR FOR LINEAR AND COMPACT FLUORESCENT LAMPS

Ballast factor (BF) should be calculated in the following comparative method:

$$BF_T = BF_B \times (CF_T / CF_B)$$

Where:

BF_T = Ballast factor of the ballast being tested (unknown ballast factor)

BF_B = Ballast factor of base test ballast for lamp type being tested (known ballast factor)

CF_T = Calibration Flux with ballast being tested

CF_B = Calibration flux using same lamps as being used in test for which ballast factor is being calculated (same as used for CF_T) and operated on base ballast(s) used for BF_B.

4.4 CALCULATION OF BALLAST FACTOR FOR HID BALLASTS

HID luminaire photometric testing is based on IESNA LM-46, and, in accordance with this test method, ballast performance is based on nominal wattage delivered to the test lamp. Accordingly, the ballast factor will be shown as 1.0.

4.5 CALCULATION OF ENERGY EFFECTIVENESS FACTOR

4.5.1 Interior Luminaires

Table 4-1
Interior Luminaires EEF Calculations

Luminaire Type	EEF Calculation
Cylinder	= average CU for a space with 80/50/20 reflectances using the CUs for RCRs 3 and 7
Downlight, Commercial	= average CU for a space with 80/50/20 reflectances using the CUs for RCRs 1 and 5
Downlight, Residential	= average CU for a space with 80/50/20 reflectances using the CUs for RCRs 1 and 5
Highbay, linear	= average CU for a space with 50/30/20 reflectances using the CUs for RCRs 4 and 8
Highbay, non-linear	= average CU for a space with 50/30/20 reflectances using the CUs for RCRs 4 and 8
Linear industrial	= average CU for a space with 50/30/20 reflectances using the CUs for RCRs 1 and 8
Lowbay	= average CU for a space with 50/30/20 reflectances using the CUs for RCRs 1 and 4
Parking Garage	= average CU for a space with 30/0/20 reflectances using the CUs for RCRs 2 and 3
Recessed, Linear	= average CU for a space with 80/50/20 reflectances using the CUs for RCRs 1 and 4
Striplight	= average CU for a space with 50/30/20 reflectances using the CUs for RCRs 1 and 8
Surface Mount, Linear	= average CU for a space with 80/50/20 reflectances using the CUs for RCRs 1 and 4
Surface Mount, Nonlinear	= average CU for a space with 80/50/20 reflectances using the CUs for RCRs 1 and 5
Surface Mount, Residential	= average CU for a space with 80/50/20 reflectances using the CUs for RCRs 1 and 4
Suspended, Linear	= average CU for a space with 80/50/20 reflectances using the CUs for RCRs 1 and 4
Suspended, Nonlinear	= average CU for a space with 80/50/20 reflectances using the CUs for RCRs 1 and 5
Suspended, Residential	= average CU for a space with 80/50/20 reflectances using the CUs for RCRs 1 and 5

4.5.2 Exterior Luminaires

Table 4-2
Exterior Luminaires EEF Calculations

Luminaire Type	EEF Calculation
Area and Site Type I Distribution	= roadway CU over a target area that is +/- 1 MH in the 0-180 plane
Area and Site Type II Distribution	= roadway CU over a target area that is -1 MH -to- +1.75 MH in the 0-180 plane
Area and Site Type III Distribution	= roadway CU over a target area that is -1 MH -to- +2.75 MH in the 0-180 plane
Area and Site Type IV Distribution	= roadway CU over a target area that is -1 MH -to- +4 MH in the 0-180
Area and Site Type V Distribution	= % lamp lumens over a square target area +/- 4 MH in the 0-180 and 90-270 planes
Bollard	= % lumens over a square target area +/- 4 MH in the 0-180 and 90-270 planes
Border	= Photometric Efficiency
Canopy	= % lamp lumens over a square target area +/- 4 MH the 0-180 and 90-270 planes
Decorative, post top	= CU over a target area +/- 4 MH in both directions
Roadway Type I Distribution	= roadway CU over a target area that is +/- 1 MH in 0-180 plane
Roadway Type II Distribution	= roadway CU over a target area that is -1 -to- +1.75 MH in 0-180 plane
Roadway Type III Distribution	= roadway CU over a target area that is -1 -to- +2.75 MH in 0-180 plane
Roadway Type IV Distribution	= roadway CU over a target area that is -1 -to- +4 MH in 0-180 plane
Roadway Type V Distribution	= % lamp lumens over a square target area +/- 4 MH in the 0-180 and 90-270 planes

4.6 SAMPLE CALCULATION OF TARGET EFFICACY RATING

4.6.1 Interior Luminaire

Product information:

2-lamp recessed troffer with electronic ballast
Lamp type: F28T5 rated at 2730 lumens
Luminaire wattage: 60 watts
Ballast factor: 0.95

Determine luminaire type and classification

A recessed troffer is a recessed luminaire with linear lamps, therefore it is a *"Recessed Linear"* classification

Determine Energy Effectiveness Factor (EEF)

For the recessed linear classification:

EEF = average CU for an 80/50/20 space using the CUs for RCRs 1 and 4

Using a photometric software tool or photometric report provided by the luminaire manufacturer or independent laboratory, identify the Coefficient of Utilization (CU) for ceiling reflectance of 80%, wall reflectance of 50%, and floor reflectance of 20% for Room Cavity Ratios 1 and 4.

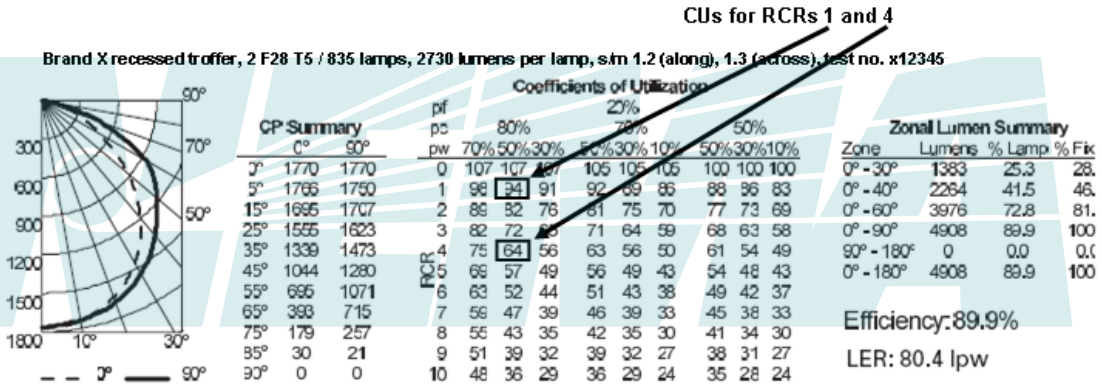


Figure 4-1
Interior Luminaire TER Calculation,
CU Determination

Room Cavity Ratio (RCR)	Coefficient of Utilization (CU)
1	0.94
4	0.64
EEF (Average)	**0.79**

Determine Total Lamp Lumens (TLL)

= lumens per lamp x number of lamps
= 2730 x 2 = 5460 lumens

TER = EEF x TLL x BF / Input Watts
= 0.79 x 5460 x 0.95 / 60 = **68 lumens / watt**

4.6.2 Exterior Luminaire

Product information:

Architectural shoebox – Type III distribution
Lamp type: 250w MH, 20500 lumens
Luminaire wattage: 297 watts
Ballast factor: 1.00

Determine luminaire type and classification

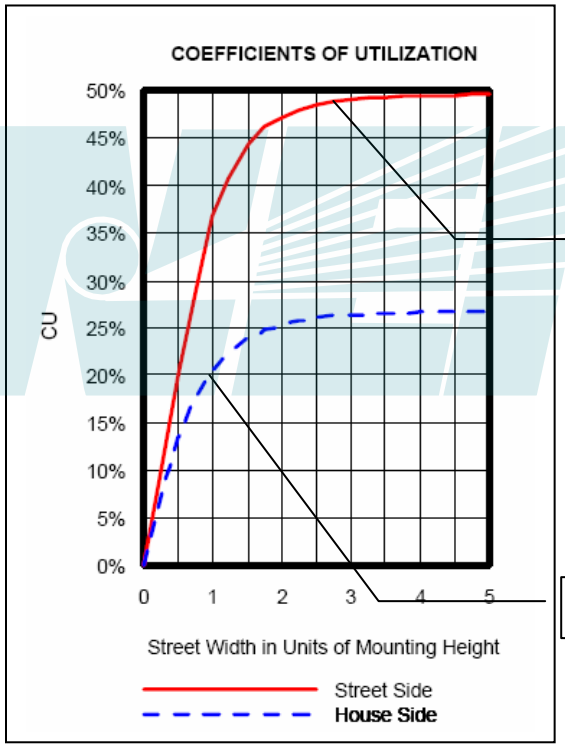
An architectural shoebox is an *"Area and Site—Type III Distribution"* classification

Determine Energy Effectiveness Factor (EEF)

For the Area and Site Type III distribution classification:

EEF = roadway CU over a target area that is -1 MH-to-+2.75 MH in 0-180 plane

Using a photometric software tool or photometric report provided by the luminaire manufacturer or independent laboratory, identify the roadway CU over a target area that is -1 MH-to-+2.75 MH in front of the luminaire and an infinite direction to the sides of the luminaire.



$EEF_{(STREET\ SIDE)} = 0.48$

$EEF_{(HOUSE\ SIDE)} = 0.20$

$EEF = EEF_{(STREET\ SIDE)} + EEF_{(HOUSE\ SIDE)}$

$= 0.48 + 0.20 = 0.68$

Figure 4-2
Exterior Luminaire TER Calculation, EEF Determination

Determine Total Lamp Lumens (TLL)

= lumens per lamp x number of lamps
= 20500 x 1 = 20500 lumens

TER = EEF x TLL x BF / Input Watts
= 0.68 x 20500 x 1.00 / 297 = **47 lumens / watt**

Section 5
RECOMMENDED REPORTING FORMAT
(Example Only)

5.1 INTERIOR LUMINAIRE

Luminaire Catalog #	Luminaire Category	Lamp Type	Ballast Type	EEF	Luminaire Watt Input	Ballast Factor	TER
Cat. No.	Recessed Linear	2-28 W T5 2,750 Lu/Lamp	Elect-ronic	0.78	60	0.95	67

5.2 EXTERIOR LUMINAIRE

Luminaire Catalog #	Luminaire Category	Lamp Type	Ballast Type	EEF	Luminaire Watt Input	Ballast Factor	TER
Cat. No.	Area and Site – Type III	250 W MH 20,500 Lu/Lamp	Elect-ronic	0.68	297	1.00	47

Appendix A
DEFINITIONS OF LUMINAIRE TYPES AND CLASSIFICATIONS

A.1 Interior Luminaires:

a) Cylinder
A wall- or surface-mounted luminaire (which may be direct or direct-indirect) in the shape of a long cylinder (whose shape is generally cylindrical form including square cross section).
Typical uses: Lobbies, conference halls, stairwells, building facades mounted at a mid-to-high mounting height.

b) Downlight, Commercial
Recessed luminaire, where the maximum aperture dimension is less than 12", used in commercial installations.
Typical uses: Lobbies, conference rooms, hallways, private offices, retail, restaurants

c) Downlight, Residential
Recessed luminaire, where the maximum aperture dimension is less than 12", used in single or multi-family housing units.
Typical uses: Kitchen, bath, foyer, halls

d) Highbay, linear
A luminaire used at a mounting height over 25 feet that utilizes linear lamps and a reflector.
Typical uses: Manufacturing, warehouses, retail, gymnasiums, industrial plants

e) Highbay, non-linear
A luminaire used at a mounting height over 25 feet that utilizes non-linear lamps and a reflector.
Typical uses: Manufacturing, warehouses, retail, gymnasiums, industrial plants

f) Linear industrial
A luminaire used at a mounting height less than or equal to 25 feet that utilizes linear lamps and a reflector.
Typical uses: Manufacturing, warehouses, retail, storage rooms, garages, workrooms

g) Lowbay
A luminaire used at a mounting height less than or equal to 25 feet that utilizes non-linear lamps and a reflector.
Typical uses: Manufacturing, warehouses, retail

h) Parking Garage
A luminaire used to light parking spaces and drive lanes in a garage.
Typical uses: Parking garage

i) Recessed linear
A luminaire recessed above the ceiling utilizing linear lamps and a reflector. Product is typically larger than 12". This class of product may include a flat lens, louvers, or other materials to diffuse or distribute the light.
Typical uses: Offices, schools, conference rooms, lobbies, hallways, retail, healthcare

j) Striplight
A surface- or pendant-mounted linear bare lamp with no reflector.
Typical uses: Manufacturing, warehouses, industrial plants, storage rooms, garages, workrooms, coves

k) Surface mount, linear
A surface-mounted luminaire utilizing linear lamps and a reflector. Product is typically larger than 12". This class of product may include a flat or wraparound lens, louvers, or other materials to diffuse or distribute the light.
Typical uses: Offices, schools, conference rooms, lobbies, hallways, retail, healthcare

l) Surface mount, non-linear
A decorative surface-mounted luminaire utilizing non-linear lamps.
Typical uses: Lobbies, conference halls, restaurants

m) Surface mount, residential
A luminaire utilizing linear or non-linear lamps mounted to the ceiling used to light a large area. May include a flat or wrap around lens.
Typical uses: Kitchen, closets

n) Suspended, linear
A luminaire utilizing linear lamps that is suspended from the ceiling and typically distributes light upward and downward. May utilize a solid, translucent, or opaque bottom.
Typical uses: Offices, schools, conference rooms, lobbies, retail, healthcare

o) Suspended, non-linear
A decorative light utilizing non-linear lamps hung from a pendant.
Typical uses: Lobbies, conference halls, restaurants

p) Suspended, residential
A decorative light utilizing linear or non-linear lamps designed for use in homes that is hung from a pendant.
Typical uses: Kitchen, dining areas

A.2 Exterior Luminaires:

a) Area and Site
An outdoor luminaire used for general lighting of a large open area, typically mounted on a pole with an arm or on top of a post. This class is categorized by the IESNA roadway classification as a Type I, Type II, Type III, Type IV, or Type V distribution.
Typical uses: Parking lots, walkways, plazas

b) Bollard
An outdoor luminaire with a height lower than pedestrian level used to light an area in close proximity.
Typical uses: Walkways

c) Border
An outdoor luminaire used to light an area in close proximity and ranges in height from less than 20" down with lower rim flush with the ground/concrete and the light emitting opening is above grade.
Typical uses: Sidewalks, promenades, drive-over applications and landscaped areas

d) Canopy
Surface or recessed luminaire installed under a canopy or overhang.
Typical uses: Drive-throughs, building entrances, gas stations

e) Decorative, post top
An outdoor luminaire designed for daytime and nighttime aesthetics.
Typical uses: Walkways, plazas, streetscapes, building entrances

f) Roadway
An outdoor luminaire used to light streets or roadways, typically mounted on a pole with an arm. This class is categorized by the IESNA roadway classification as a Type I, Type II, Type III, Type IV, or Type V distribution.
Typical uses: Streets, roadways

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