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# Brightness

- ◆ Subjective impression of amount of light leaving a surface or point
- ◆ Based on human response
- ◆ Depends on adaptation level of the eye
- ◆ Cannot be directly measured or quantified

# Glare

❖ Excessively bright source of light in field of view

❖ Types

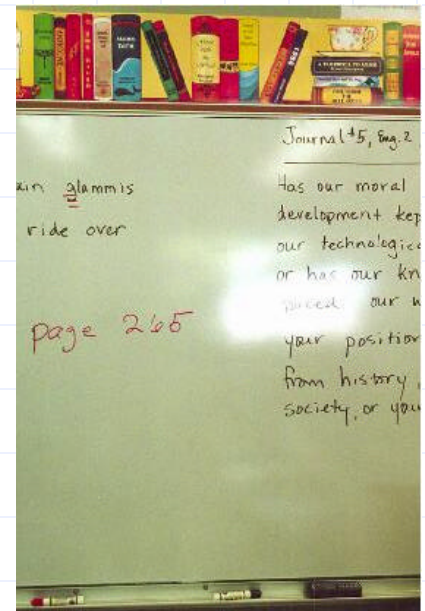
- Direct
- Reflected

❖ Degree

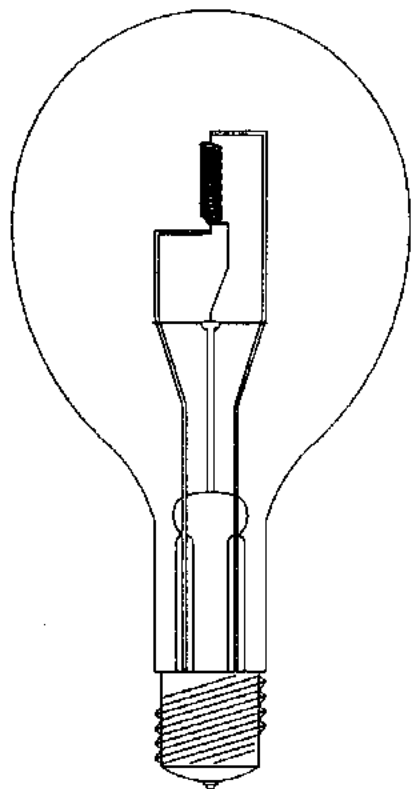
- Discomfort
- Disability

❖ Veiling Reflections

- Specific case of reflected glare

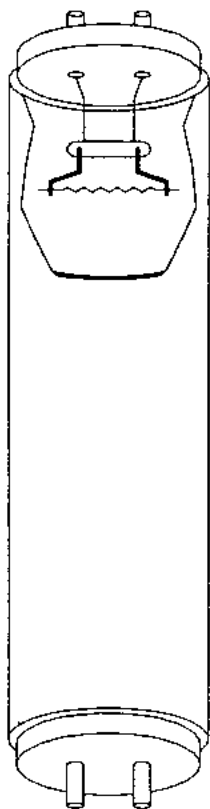


# Incandescent Lamps



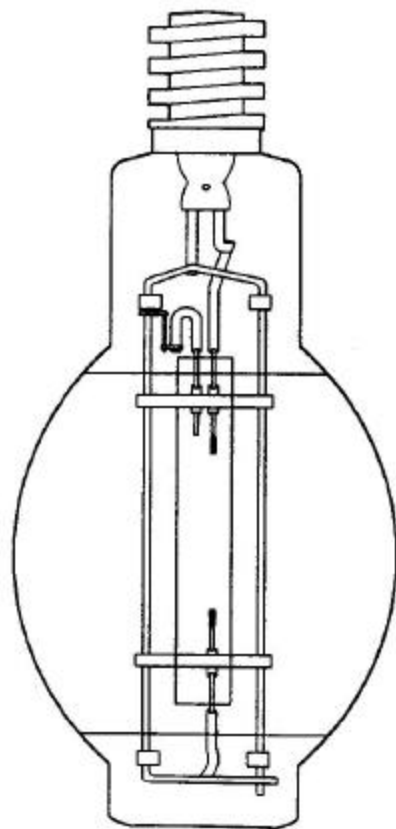
- ◆ Low efficacy ( $< 23$  lpw)
- ◆ Short lamp life (750 to 6000 hours at best)
- ◆ Good lumen maintenance
- ◆ Warm CCT
- ◆ Excellent CRI
- ◆ Dimmable

# Fluorescent Lamps



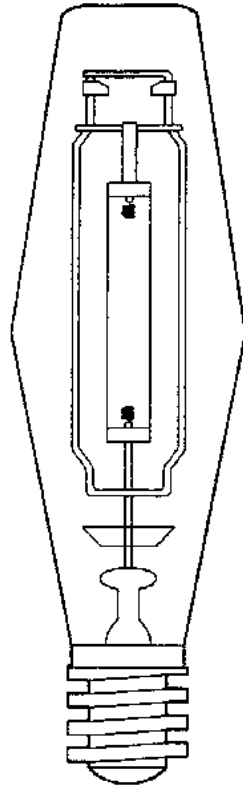
- ◆ High efficacy (up to 100 lpw)
- ◆ Long life (up to 30,000 hours)
- ◆ Good to excellent lumen maintenance
- ◆ Wide variety of CCTs
- ◆ Excellent CRI
- ◆ Dimmable with special ballasts

# Metal Halide Lamps



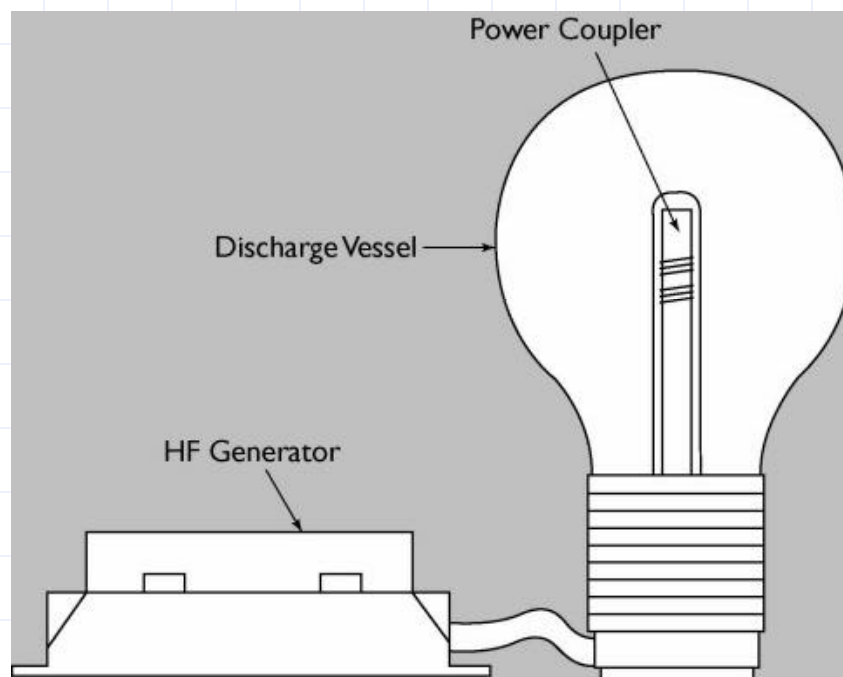
- ◆ High efficacy (up to 100 lpw)
- ◆ Medium to long lamp life (up to 30,000 hours)
- ◆ Good lumen maintenance
- ◆ Variety of CCTs
- ◆ Good to excellent CRI
- ◆ Few dimmable with difficulty

# High Pressure Sodium Lamps



- ◆ High efficacy (up to 120 lpw)
- ◆ Long life (up to 24,000 hours)
- ◆ Good lumen maintenance
- ◆ “Golden”
- ◆ Poor CRI, except with special lamps
- ◆ Few dimmable with difficulty

# Induction Lamps



- ◆ Electrodeless
- ◆ High efficacy (up to 88 lpw)
- ◆ Long life (up to 100,000 hours)
- ◆ Good lumen maintenance
- ◆ Variety of CCTs
- ◆ Excellent CRI
- ◆ Not dimmable

Diagram Source: Philips Lighting

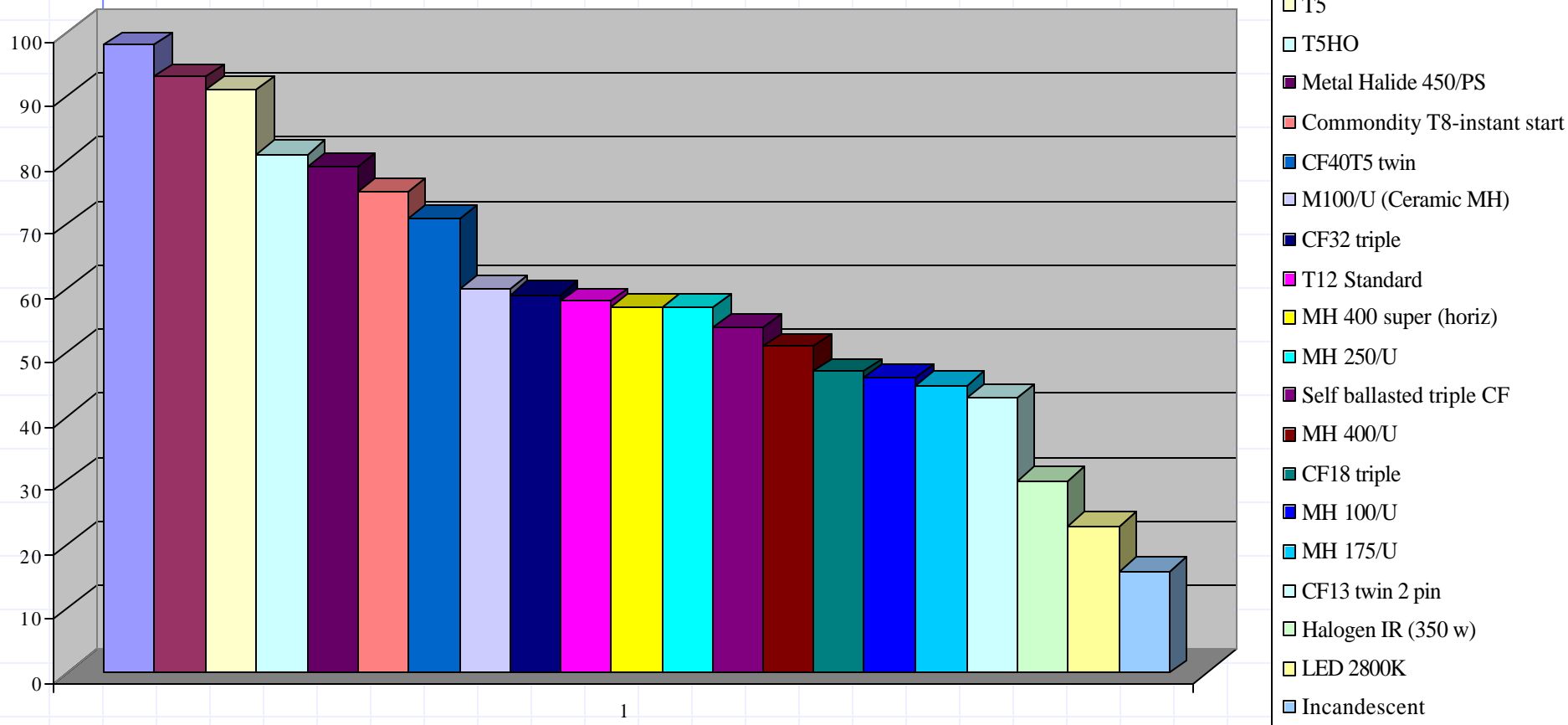
# LEDs



- ◆ Solid state light source
- ◆ Semiconductor chip
- ◆ Size depends on cluster of printed circuit board
- ◆ Efficacy varies with color
- ◆ Life up to 100,000 hours
- ◆ Color efficient
- ◆ Dimmable

Diagram Source: Osram Sylvania

# Lamp Efficacy Comparison



Source: Robert Sardinsky, LC, Rising Sun Enterprises, Inc.

# What is an Ordinance?

- ◆ Local law
- ◆ Within jurisdiction of adopting agency
- ◆ Cannot conflict or supercede state or federal law
- ◆ Generally for community specific issues

# Why have Lighting Ordinance?

- ◆ Conserve energy and resources
- ◆ Permit reasonable use of lighting
  - Safety
  - Utility
  - Security
  - Productivity
  - Enjoyment
  - Commerce
- ◆ Protect the natural environment

# Motivations for Ordinances

## ◆ Nuisance

- Pole height limits
- Setback requirements

## ◆ Safety/security

- Footcandle requirements

## ◆ Astronomer

- Cut off requirements
- LPS required
- Lumens per acre limits

## ◆ Dark Sky

- Lumen-based cut off requirements

# Issues w/ Existing Ordinances

- ◆ Footcandle requirements different from IESNA recommendations
- ◆ No differentiation between residential and commercial areas
- ◆ Technical errors
- ◆ May not address entire community
  - Flag lighting
  - Building floodlighting
  - Landscape lighting
  - Sports lighting
  - Outdoor sales

# Elements of Good Ordinance

- ◆ Preamble
- ◆ Definitions
- ◆ Applicability
- ◆ Enforcement
- ◆ Specific Requirements

# What is a Code?

- ◆ Set of “model requirements” of regional or national nature, adopted into law by an ordinance or bylaw
- ◆ Example: the National Electrical Code
  - Developed by the National Fire Protection Agency
  - Adopted with modifications as state Electrical Code, e.g. California Electrical Code
  - Adopted with modifications as local Electrical Code, e.g. San Francisco Electrical Code

# What are Standards?

- ◆ Recommendations and guidelines
- ◆ Establishes the standards of professional practice in the industry
- ◆ Developed by consensus
- ◆ For lighting in the US - IESNA

# Applicable IESNA Standards

- ◆ RP-2-01 Lighting Merchandising Areas
- ◆ RP-6-01 Sports and Recreational Area Lighting
- ◆ RP-8-00 Roadway Lighting
- ◆ RP-17-87 Lighting for Airport Road and Automobile Parking Areas
- ◆ RP-19-01 Roadway Sign Areas
- ◆ RP-20-98 Lighting for Parking Facilities
- ◆ RP-22-96 Tunnel Lighting
- ◆ RP-33-99 Lighting for Exterior Environments

# Applicable IESNA Standards

- ◆ DG-4-03 Roadway Lighting Maintenance
- ◆ DG-5-94 Recommended Lighting for Walkways and Class I Bikeways
- ◆ DG-13-98 Selection of Photocontrols for Outdoor Lighting Equipment
- ◆ G-1-03 Guideline on Security Lighting for People, Property, and Public Spaces

# Applicable IESNA Standards

- ❖ TM-3-95 Classification of Luminaire Light Distribution
- ❖ TM-10-00 Addressing Obtrusive Light (Urban Sky Glow and Light Trespass) in Conjunction with Roadway Lighting
- ❖ TM-11-00 Light Trespass: Research, Results and Recommendations

# Applicable IESNA Standards

- ◆ LM-52-03 Photometric Measurements of Roadway Sign Installations
- ◆ LM-64-01 Photometric Measurement of Parking Areas
- ◆ LM-69-95 Guide for Interpretation of Roadway Luminaire Photometric Data (reaffirmed 2002)
- ◆ LM-71-96 Photometric Measurements of Tunnel Lighting Installations (reaffirmed 2001)

# Applicable IESNA Standards

## ❖ IESNA Lighting Handbook, 9<sup>th</sup> Edition

- Chapter 20 – Sports and Recreational Area Lighting
- Chapter 21 – Exterior Lighting
- Chapter 22 – Roadway Lighting
- Chapter 29 – Emergency, Safety, and Security Lighting

# Conflicts in Existing Standards

Example	Park Walkways		
	G-1-03 (Security)	DG-5-94 (Walkways & Class I Bikeways)	Handbook, Ch. 22 (Roadway)
Maint Horiz Illuminance	0.6 fc (ave)	0.5 fc (ave)	0.5 fc (ave)
Horizontal Uniformity	4:1 (ave to min)	10:1 (ave to min)	NA
Maint Vert Illuminance	0.5 to 0.8 fc (min)	0.5 fc (min)	NA
Vertical Uniformity	4:1 (ave to min)	5:1 (ave to min)	NA

# Conflicts in Existing Standards

Example	Major Retail Parking Lot		
	G-1-03 (Security)	RP-20-98 (Parking)	RP-2-01 (Merchandise)
Maint Horiz Illuminance	3 fc (ave)	0.5 fc (min)	10/7/5 fc (ave)
Horizontal Uniformity	4:1 (ave to min)	15:1 (max to min)	NA
Maint Vert Illuminance	0.5 to 0.8 fc (min)	0.5 fc (min)	NA
Vertical Uniformity	4:1 (ave to min)	NA	NA

# General Design Criteria

## ◆ Illuminance (maintained values)

- Horizontal
- Vertical
  - ◆ Positive ID 30 feet from viewer
  - ◆ 4:1 luminance ratio background-to-face – avoid silhouette

## ◆ Uniformity

## ◆ Glare

## ◆ Shadows / Obstructions

Source: IESNA G-1-03 Guidelines for Security Lighting for People, Property, and Public Spaces

# General Design Criteria

## ◆ Site divisions

- Total site
- Pedestrian
- Pedestrian path
- Building
- Building perimeter

Source: IESNA G-1-03 Guidelines for Security Lighting for People, Property, and Public Spaces

# Unoccupied Spaces

- ◆ Ave horiz illuminance
  - 0.5 to 2 fc (1 fc *if security is an issue*)
- ◆ Ave to min uniformity
  - 8:1 (6:1 *if security is an issue*)
- ◆ Disability glare for secure areas
  - Use in extreme situations only

Source: IESNA G-1-03 Guidelines for Security Lighting for People, Property, and Public Spaces

# Offices/Commercial Buildings

## ◆ Building façade

- 0.5 to 2 fc ave horiz illuminance
- 8:1 ave to min uniformity - (6:1 *if security is an issue*)

## ◆ Building interiors

- 1 fc ave horiz illuminance
- 6:1 ave to min uniformity
- Carry flashlights
- IR motion sensors or IR cameras – keep areas dark when secure / illuminate when trespassed

Source: IESNA G-1-03 Guidelines for Security Lighting for People, Property, and Public Spaces

# Offices/Commercial Buildings

- ◆ Perimeter fences and walls
  - Solid barrier – light both sides
  - View barrier – keep luminance outside fence lower
- ◆ Guarded entrances
  - 10 fc ave horiz illuminance - or twice immediate surround
  - 3:1 ave to min uniformity
  - Vertical illuminance 25% of horizontal at driver
  - Multiple, redundant luminaires
  - Consider back-up power

Source: IESNA G-1-03 Guidelines for Security Lighting for People, Property, and Public Spaces

# Offices/Commercial Buildings

## ◆ Gate House

- Dimmable lights
- Glass – specular-reflecting, low transmission, installed at tilted angle
- Well-shielded task lighting to avoid reflectance on surveillance monitors

Source: IESNA G-1-03 Guidelines for Security Lighting for People, Property, and Public Spaces

# ATMs

## ◆ Illuminance recommendations

- 15 fc min at face of machine
- 10 fc min on all horizontal surfaces within 10'
- 2 fc ave horiz within 50'
- 2 fc ave in supporting parking areas within 60'
- 2 fc ave extending 40' on side of building if ATM within 10' of corner

## ◆ Uniformity recommendations

- 3:1 ave to min between zones above

Source: IESNA G-1-03 Guidelines for Security Lighting for People, Property, and Public Spaces

# ATMs

## ◆ Other recommendations

- Use redundant lighting
- Avoid glare and light trespass
- Ensure facial identification at a distance of 30'
- Support CCTV operations
- Provide unobstructed view 50' in all approachable directions

Source: IESNA G-1-03 Guidelines for Security Lighting for People, Property, and Public Spaces

# Parking Lots

- ◆ General requirements previously discussed
- ◆ In area of main entrance
  - 5 fc ave horiz illuminance
  - 4:1 ave to min uniformity

Source: IESNA G-1-03 Guidelines for Security Lighting for People, Property, and Public Spaces

# Parking Garages

## ◆ General parking area

- 6 fc ave horiz illuminance
- 4:1 ave to min uniformity

## ◆ Elevators and stairs

- 10 fc ave horiz illuminance in 30' radius
- 4:1 ave to min uniformity

Source: IESNA G-1-03 Guidelines for Security Lighting for People, Property, and Public Spaces

# Fast Food Restaurants

## ◆ Drive-up window

- Use setback from window to rear of building
- 6 fc ave horiz illuminance within 30'
- 3:1 ave to min uniformity

## ◆ General parking and other areas

- 3 fc ave horiz illuminance
- 4:1 ave to min uniformity

## ◆ Use enclosed refuse area

Source: IESNA G-1-03 Guidelines for Security Lighting for People, Property, and Public Spaces

# Convenience Stores (Gas, too)

## ◆ Customer use areas

- 6 fc ave horiz illuminance
- 3:1 ave to min uniformity

## ◆ Other areas

- 3 fc ave horiz illuminance
- 4:1 ave to min uniformity

## ◆ Inside store

- 30 fc ave horiz illuminance
- Provide clear view to outside (avoid reflections in glass)

Source: IESNA G-1-03 Guidelines for Security Lighting for People, Property, and Public Spaces

# Single Family Residences

## ◆ Exterior doors

- 0.8 fc vert illuminance out to radius of 10'
- 4:1 ave to min uniformity background-to-face
- Use motion sensors
- Consider use of disability glare

## ◆ Landscaping

- Use upright to eliminate shadows

## ◆ Automatic controls to replicate lighting use patterns

Source: IESNA G-1-03 Guidelines for Security Lighting for People, Property, and Public Spaces

# Multi-family Residences

## ◆ Common areas

- 3 fc ave horiz illuminance
- 4:1 ave to min uniformity

## ◆ Mailbox area

- 10 fc ave horiz illuminance
- 3:1 ave to min uniformity

## ◆ Entrances to individual residence

- Same as single family

Source: IESNA G-1-03 Guidelines for Security Lighting for People, Property, and Public Spaces

# Senior Residences

- ◆ All spaces
  - Special attention to glare and shadows
- ◆ Parking garages
  - 50 fc ave horiz illuminance
- ◆ Exterior walkways
  - 5 fc ave horiz illuminance
- ◆ Interior corridors
  - 30 fc ave horiz illuminance

Source: IESNA G-1-03 Guidelines for Security Lighting for People, Property, and Public Spaces

# Hotels and Motels

## ◆ Parking areas

- 3 fc ave horiz illuminance
- 4:1 ave to min uniformity

## ◆ Sidewalks, footpaths, and grounds

- 1 fc ave horiz illuminance
- 3:1 ave to min uniformity

Source: IESNA G-1-03 Guidelines for Security Lighting for People, Property, and Public Spaces

# Schools and Institutions

## ◆ Parking lots

- 3 fc ave horiz illuminance
- 4:1 ave to min uniformity

## ◆ Sidewalks and footpaths

- 1 fc ave horiz illuminance
- 4:1 ave to min uniformity

## ◆ Periods of inactivity

- Consider black-out method for suburban and rural locations

Source: IESNA G-1-03 Guidelines for Security Lighting for People, Property, and Public Spaces

# Law Enforcement

## ◆ Entrances, interior, holding areas

- 8 fc ave horiz illuminance within 60' of all emergency vehicles and pedestrian movement areas
- 3:1 ave to min uniformity

## ◆ Parking and other walking surfaces

- 3 fc ave horiz illuminance
- 4:1 ave to min uniformity

Source: IESNA G-1-03 Guidelines for Security Lighting for People, Property, and Public Spaces

# General

- ◆ Ensure compliance with local ordinances
- ◆ Consider back-up power supply
- ◆ Additional conflicts with corporate design standards may occur
- ◆ Use rational approach based on ambient lighting conditions

# Security Cameras

- ◆ Follow manufacturer recommendations
- ◆ Typical requirements
  - Minimum illumination
  - Spectral ranges
- ◆ Automatic features of newer cameras
  - Day/night mode and IR capable
  - White balance
  - Automatic gain to keep subject in view under low illumination
  - Adjustment for backlight compensation to make subject more visible

# 2005 Title 24 – Lighting Zones

<u>Zone</u>	<u>Ambient Illumination</u>	<u>State wide Default Location</u>	<u>Moving Up to Higher Zones*</u>	<u>Moving Down to Lower Zones</u>
<u>LZ1</u>	<u>Dark</u>	<u>Government designated parks, recreation areas, and wildlife preserves. Those that are wholly contained within a higher lighting zone may be considered by the local government as part of that lighting zone.</u>	<u>A government designated park, recreation area, wildlife preserve, or portions thereof can be designated as LZ2 or LZ3 if they are contained within such a zone.</u>	<u>Not applicable.</u>
<u>LZ2</u>	<u>Low</u>	<u>Rural areas, as defined by the 2000 U.S. Census.</u>	<u>Special districts within a default LZ2 zone may be designated as LZ3 by a local jurisdiction. Examples include special commercial or industrial districts or areas with special security considerations located within a rural area.</u>	<u>Special districts and government designated parks within a default LZ2 zone may be designated as LZ1 by the local jurisdiction for lower illumination standards, without any size limits.</u>
<u>LZ3</u>	<u>Medium</u>	<u>Urban areas, as defined by the 2000 U.S. Census.</u>	<u>Special districts within a default LZ3 may be designated as a LZ4 by local jurisdiction for high intensity nighttime use, such as adult entertainment or commercial districts or areas with special security considerations requiring very high light levels.</u>	<u>Special districts and government designated parks within a default LZ3 zone may be designated as LZ1 or LZ2 by the local jurisdiction, without any size limits.</u>
<u>LZ4</u>	<u>High</u>	<u>None.</u>	<u>Not applicable.</u>	<u>Not applicable.</u>

Source: 2005 Building Energy Efficiency Standards for Residential and Nonresidential Buildings, Express Terms – 15-Day Language, October 2003

# 2005 Title 24 – Cutoff Req.

- ❖ Lamps  $> 175$  W in hardscape areas shall be designated Cutoff for light distribution
- ❖ Cutoff means that candela per 1000 lamp lumens does not exceed 25 at 90 degrees above nadir, and 100 at or above 80 degrees above nadir

Source: 2005 Building Energy Efficiency Standards for Residential and Nonresidential Buildings, Express Terms – 15-Day Language, October 2003

# 2005 Title 24 – W/sf Allowed

<u>Lighting Application</u>	<u>Allowed Area</u>	<u>Lighting Zone 1</u>	<u>Lighting Zone 2</u>	<u>Lighting Zone 3</u>	<u>Lighting Zone 4</u>
<u>Hardscape for automotive vehicular use, including parking lots driveways and site roads</u>	<u>Method (i.) Actual paved area plus 5' perimeter of adjacent unpaved land. Includes planters and landscaped areas less than 10' wide that are enclosed by hardscape on at least three sides.</u>	<u>0.05</u>	<u>0.08</u>	<u>0.15</u> <del>0.10</del>	<u>0.19</u>
<u>Hardscape for pedestrian use, including plazas, sidewalks, walkways and bikeways</u>	<u>Method (i.) Actual paved area plus 5 feet of unpaved land on either side of path of travel. Shall include all continuous paved area before including adjacent grounds.</u>	<u>0.06</u>	<u>0.09</u>	<u>0.17</u> <del>0.10</del>	<u>0.21</u>
<u>Hardscape for driveways, site roads, sidewalks, walkways and bikeways</u>	<u>Method (ii.) 25' wide path incorporating as much of the paved area of the site roadway, driveway, sidewalk, walkway or bikeway as possible.</u>	<u>1.0 w/lf</u>	<u>1.5 w/lf</u>	<u>4.0</u> <del>2.5</del> w/lf	<u>5.0 w/lf</u>
<u>Building Entrances (without canopy)</u>	<u>Width of doors plus 3 ft on either side times a distance of 18 feet outward.</u>	<u>0.35</u>	<u>0.50</u>	<u>.70</u>	<u>1.00</u>
<u>Outdoor Sales Lot</u>	<u>Actual portion of uncovered outdoor sales lot used exclusively for display of vehicles or other merchandise for sale. All adjacent access drives, walkway areas, customer parking areas, vehicle service or storage areas that are not surrounded on at least three sides by sales area shall be considered hardscape.</u>	<u>0.35</u>	<u>0.70</u>	<u>1.25</u>	<u>2.00</u>

Source: 2005 Building Energy Efficiency Standards for Residential and Nonresidential Buildings, Express Terms – 15-Day Language, October 2003

# 2005 Title 24 – W/sf Allowed

<u>Lighting Application</u>	<u>Lighting Zone 1</u>	<u>Lighting Zone 2</u>	<u>Lighting Zone 3</u>	<u>Lighting Zone 4</u>
<u>Building Facades</u>	<u>Not allowed</u>	<u>0.18</u>	<u>0.35</u>	<u>0.50</u>
<u>Outdoor Sales Frontage (Frontage in linear feet)</u>	<u>Not allowed</u>	<u>22.5 w/lf</u>	<u>38.5 w/lf</u>	<u>55 w/lf</u>
<u>Vehicle Service Station with or without Canopies</u>	<u>0.70</u>	<u>1.15</u> <del>1.00</del>	<u>1.45</u> <del>1.25</del>	<u>2.40</u> <del>2.00</del>
<u>Vehicle Service Station Hardscape</u>	<u>0.05</u>	<u>0.20</u>	<u>0.40</u>	<u>0.60</u>
<u>All Other Sales Canopies</u>	<u>Not allowed</u>	<u>0.70</u>	<u>1.00</u>	<u>1.25</u>
<u>Non-sales canopies</u>	<u>0.12</u>	<u>0.25</u>	<u>0.50</u>	<u>0.70</u>
<u>Ornamental Lighting</u>	<u>Not allowed</u>	<u>0.01</u>	<u>0.02</u>	<u>0.04</u>
<u>Drive Up Windows</u>	<u>0.12</u>	<u>0.25</u>	<u>0.50</u>	<u>0.70</u>
<u>Guarded Facilities</u>	<u>0.19</u>	<u>0.40</u>	<u>0.80</u>	<u>1.10</u>
<u>Outdoor Dining</u>	<u>0.05</u>	<u>0.18</u>	<u>0.35</u>	<u>0.55</u>

Source: 2005 Building Energy Efficiency Standards for Residential and Nonresidential Buildings, Express Terms – 15-Day Language, October 2003

# 2005 Title 24 – W/sf Allowed

TABLE 147-C ALTERNATIVE POWER ALLOWANCE FOR ORDINANCE REQUIREMENTS

<u>Required light levels by law through a local ordinance (horizontal foot-candles, average)</u>	<u>Allowed Lighting Power Density (W/ft<sup>2</sup>)</u>
<u>0.5</u>	<u>0.05</u>
<u>1.0</u>	<u>0.07</u>
<u>1.5</u>	<u>0.10</u>
<u>2.0</u>	<u>0.12</u>
<u>3.0</u>	<u>0.19</u>
<u>4.0 or greater</u>	<u>0.25</u>

TABLE 147-D. MULTIPLIERS FOR SPECIAL SECURITY REQUIREMENTS

<u>Function</u>	<u>Multiplier</u>
<u>Retail parking lots in lighting zones 1, 2 and 3</u>	<u>1.25</u>
<u>Hardscape areas within 100 feet of the entrance of senior housing facilities in lighting zones 1, 2, and 3</u>	<u>1.25</u>
<u>Parking lots and walkways within 60 feet of entrances to the building for law enforcement, fire, ambulance and emergency vehicle facilities</u>	<u>2.00</u>

Source: 2005 Building Energy Efficiency Standards for Residential and Nonresidential Buildings, Express Terms – 15-Day Language, October 2003

# What is Vandal Resistant?

- ◆ Resists penetration and contraband concealment
- ◆ Impact resistant and close-fitting lenses
- ◆ Lamps & ballasts positioned away from impact zones
- ◆ Shielded lamps
- ◆ Concealed or tamper resistant hardware
- ◆ 4-point mounting to junction box

# What is Vandal Resistant?

- ◆ Gasketing
- ◆ Marine grade housing materials
- ◆ Vibration absorbing sockets for HID lamps
- ◆ Suitable IP Rating

# IP Rating System

- ◆ Ingress protection against foreign objects and water
- ◆ Developed by International Electrotechnical Commission (IEC)
- ◆ There are several different uses of IP Codes, as described in IEC 529. IP Codes can have the following arrangement:
  - First character only, such as IP 3X
  - Second character only, such as IP X4
  - Both characters, such as IP 34

# IP Rating System

## ◆ First number – Foreign object

0 - Non-protected

1 - Protected against solid foreign objects of 50 mm diameter and greater

2 - Protected against solid foreign objects of 12.5 mm diameter and greater

3 - Protected against solid foreign objects of 2.5 mm diameter and greater

4 - Protected against solid foreign objects of 1.0 mm diameter and greater

5 - Dust-protected

6 - Dust-tight

# IP Rating System

## ◆ Second number - Water

0 - Non-protected

1 - Protected against vertically falling water drops

2 - Protected against vertically falling water drops as the enclosure is tilted 15 degrees

3 - Protected against spraying water

4 - Protected against splashing water

5 - Protected against water jetting

6 - Protected against powerful water jetting

7 - Protected against temporary immersion

8 - Protected against continuous immersion

# In Addition to Luminaires

## ◆ Controls

- Time Switch
- Photocell
- Dimmer
- Motion Detector

## ◆ Maintenance

## ◆ Lamp Replacement

## ◆ Cleaning

## ◆ Pruning

Source: IESNA G-1-03 Guidelines for Security Lighting for People, Property, and Public Spaces

# Questions?

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[www.pge.com/pec](http://www.pge.com/pec)

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