June 19 - 20, 2025
Hollywood, FL

TRANSPORTATION SYMPOSIUM

Intro to Roadway Lighting

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Transportation Symposium Website

SCAN ME

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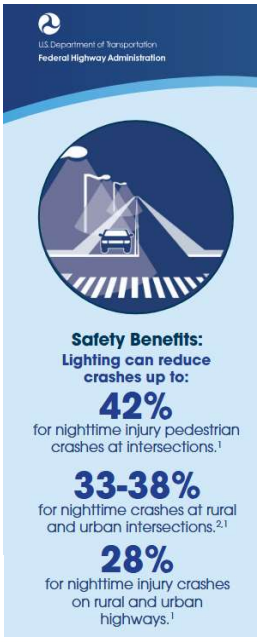
FDOT

General Lighting Introduction

Why Roadway Lighting?

- **FHWA Proven Safety Countermeasure**
  - With no lighting:
    "The nighttime fatality rate is about 3x the daytime rate."
- **AASHTO Roadway Lighting Design Guide**
- **AASHTO Solid State Roadway Lighting Design Guide**
  - *From driver studies, "increases in the light level… increased the odds of detection from a safe distance."*
- **Illuminating Engineering Society (ANSI/IES RP-8-25 Book)**
- **CMF Clearinghouse - Crash Modification Factors (CMF)**
  - Countermeasure ⇨ "Install lighting":
    Crash Reductions Range About…
    20% to 50%



Sources

1. (CMF ID: 436, 433, 192) Elvik, R. and Vaa, T., "Handbook of Road Safety Measures." Oxford, United Kingdom, Elsevier, (2004).

2. (CMF ID: 2376) Ye et al. A Simultaneous Equations Model of Crash Frequency By Collision Type for Rural Intersections, 87th Annual Meeting of the Transportation Research Board, (2008).

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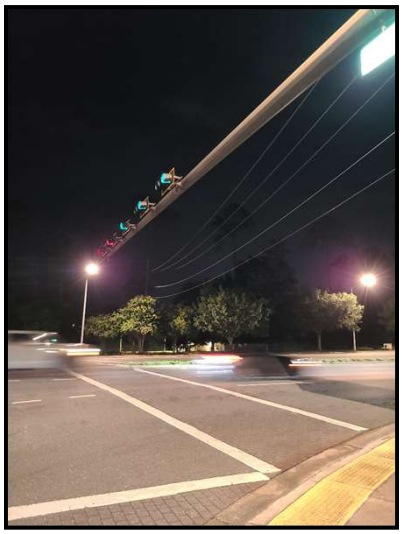
USAGE JUSTIFICATION: State Highway System

FDM 231.3.2.1

Signalized Intersections

- **Context Classifications C3 thru C6:**
  Lighting is required per Table 231.2.1 …
- **All Other Contexts:**
  Lighting usage is a District office decision based on crash history



3

USAGE JUSTIFICATION: State Highway System

FDM 231.3.2.1.2

"Isolated" Signalized Intersections

- ***"Isolated"*** means the corridors connecting to the intersection are <u>not</u> lighted…
- Lighting requirement is similar to "regular" Signalized Intersections, except that…
  lighting level requirements are lowered
  - Avoids light pollution
  - Reduces severity of light level change (glare)…
- **Lighting is required for C3 thru C6**
  - For all other contexts,
    Lighting usage is a District office decision

Blue Angel Parkway

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USAGE JUSTIFICATION: State Highway System

FDM 231.3.2.2

Unsignalized Intersections

- **All Context Classifications*:***
  Lighting is required if connecting corridors are lighted
  (corridors meet warranting requirements of 231.4)…
  - **When *Corridors are Not Lighted:***
    Lighting usage is a District office decision based on crash history

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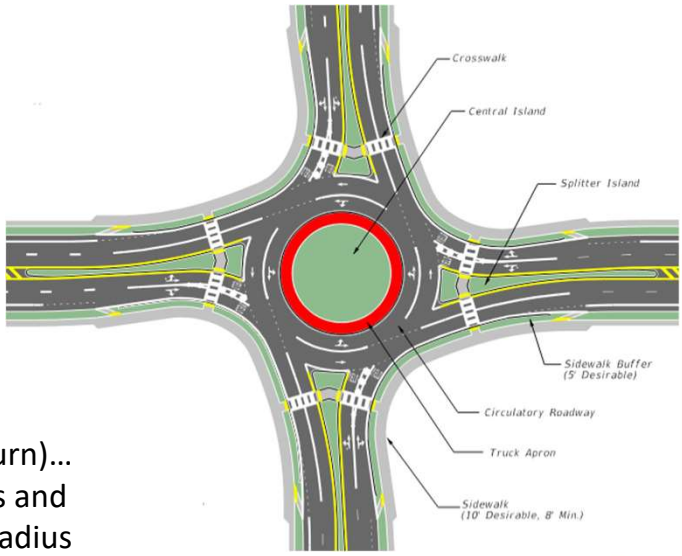
USAGE JUSTIFICATION: State Highway System

FDM 231.3.3

Roundabouts

- **All Context Classifications:**
  Lighting is required
  by default per FDM 213.11
  - Lighting is important for…
    - driver's early anticipation (approach deceleration)…
    - safe navigation of geometry around the island (headlights typically don't turn)…
    - complex vehicle movements and pedestrian visibility… tight radius



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USAGE JUSTIFICATION: State Highway System

FDM 231.3.4.2

Channelized Turn Lane Crosswalks

- **All Context Classifications**
  Lighting is required if intersection is lighted
  - Following the intersection's crosswalk criteria for right turns…
  - May also be treated as a midblock crosswalk per FDM details (if far from main intersection)

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USAGE JUSTIFICATION: State Highway System

FDM 231.3.4.1

Midblock Crosswalks & Ramp Crosswalks

- **All Context Classifications:**
  Lighting is required
  by default per FDM 222…
- That's it! Pedestrian safety is a priority. Crosswalks are installed specifically to improve safety

Tennessee Street – Near FSU

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USAGE JUSTIFICATION: State Highway System

FDM 231.4

Corridors

Limited Access Facilities, Major Arterials, Other

- **All Context Classifications:**
  Warrant analysis is needed to determine if lighting is used…
- **See FDOT Manual on Uniform Traffic Studies (MUTS), CH 14**

From FDOT MUTS:

- **Step 1 Warrant Analysis** – Spreadsheet Analysis for Step 2 Consideration – FHWA Lighting Handbook method
- **Step 2 Net Present Value Analysis** – Highway Safety Manual method

"If the crash cost reduction … is equal to or greater than (long term) cost of … the lighting project, then lighting is justified for high crash locations (HCL) as identified by the State Safety Office's annual HCL list." Otherwise, calculate NPV to rank priorities of spending in each District. Compare lighted to not-lighted condition with crash modification factors (CMF).

See FDOT MUTS for actual detailed requirements

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USAGE JUSTIFICATION: State Highway System

FDM 231.3.6.1

Nighttime Underdeck Lighting:

Bridge Underpasses

- **Lighting is required** (through underpass) if connecting corridor is lighted…
- **Also, light at the District office's discretion:**
  - where pedestrians are expected
  - to help avoid loitering

District 4

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USAGE JUSTIFICATION: State Highway System

FDM 231.4

Interchanges
On Interstate Highway System

- **Lighting is required** by default per FDM 222

Image Credit: HNTB

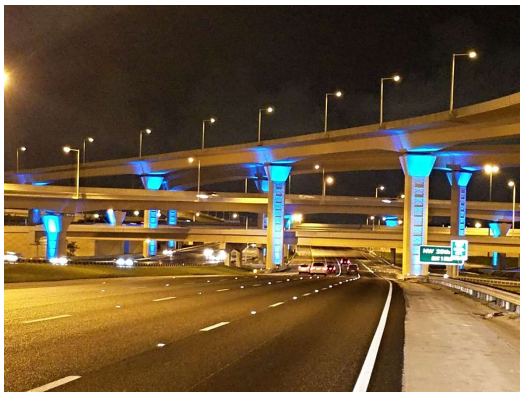
I-4 Ultimate

USAGE JUSTIFICATION: State Highway System

FDM 231.4

Interchanges
Off Interstate Highway System

- **Warrant analysis** is needed to determine if lighting is used…
  - Similar to "Corridor" warranting described on previous slide…
  - See FDOT Manual on Uniform Traffic Studies (MUTS), CH 14



Dolphin-Palmetto Interchange

Photo Credit: *RobertHolmesPhoto.com; The de Moya Group*

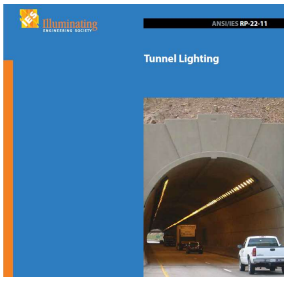
USAGE JUSTIFICATION: State Highway System

FDM 231.3.6.2

Daytime Underdeck Lighting:

***Long** Bridge Underpasses, like "Tunnels"*

- **Underpasses > 150 Ft**
  Use lighting analysis to determine need…
- ***This is a complex design process following:***
  ANSI/IES RP-22-11:
- ***Consider expert Consultants for these "rare" cases***
- ***See FDM 231.3.6.2 for all requirements***



District 2 – Before Daytime Lighting Added, "Black Hole Effect"

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Design Introduction — *FDOT Design Manual 231*

General Placement

Topic #625-000-002
FDOT Design Manual — January 1, 2025

231 Lighting

231.1 General

Roadway lighting benefits the traveling public by improving nighttime visibility of roadway geometry, vehicles, pedestrians, and obstructions. The design and layout of lighting should complement the basic highway design and must comply with the requirements of ***FDM 215*** for roadside safety.

Locate light poles between the right of way line and the outside edge of curbs or shoulders as applicable. Light poles are permitted in the median only when lighting from the outside cannot meet the criteria shown in ***Table 231.2.1*** without being supplemented by median lighting. Additionally, light poles placed in medians must be mounted on or behind barriers per the requirements in ***FDM 215.2.9*** and ***Standard Plans, Index 715-002***.

- ***See Standard Plans Index 715 Series for light pole and foundation options***
  …we'll review this with the Lighting Design Table!

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Luminaire Selection

Topic #625-000-002
FDOT Design Manual — January 1, 2025

231 Lighting

231.1.1 Design Luminaires

Use only luminaires listed on the Department's ***Approved Products List*** (*APL*) for the corresponding usage cases. Obtain photometric information from manufacturers to use in the lighting design and resulting design luminaire selection. Include the design luminaire information with the Lighting Plans per the requirements of ***FDM 943***.

- **Obtain "IES File" from the manufacturer for lighting analysis in AGi32 or similar software… We'll discuss in upcoming slides!**
- **Include Luminaire information in Lighting Design Table per FDM 943… We'll discuss in upcoming slides!**

What is Color Temperature?

Correlated Color Temperature (CCT) is a way to describe the color of light produced by lamp options:

- **Lower color temperature is "warmer" or "softer", and is more amber or orange (candlelight)**
- **Higher color temperature is "cooler", and is whiter with increasing blue content**

LUMINAIRE OPTIONS — *Photometric Design Intro*

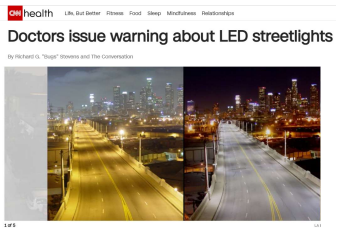
Considerations for FDOT's Color Temperature Policy:

- **Environmental Needs –**
  - Blue Light Reduction…
  - Sky Glow Reduction
  - Less Wildlife Effects
  - ***IDA Recommendations***

IDA INTERNATIONAL DARK-SKY ASSOCIATION

Recommends 3000K Max.

- **Aesthetic Needs –**
  - Preferences Near Homes & Businesses
  - News Articles, Widespread Public Feedback
  - Aesthetic Downtown Districts & Tourist Areas
  - Parks & Campuses



- **Health Impacts –**
  - Discomfort Glare (blue light)
  - Mental Health / Mood
  - ***AMA Recommendations***

AMA AMERICAN MEDICAL ASSOCIATION

Recommends 3000K Max.

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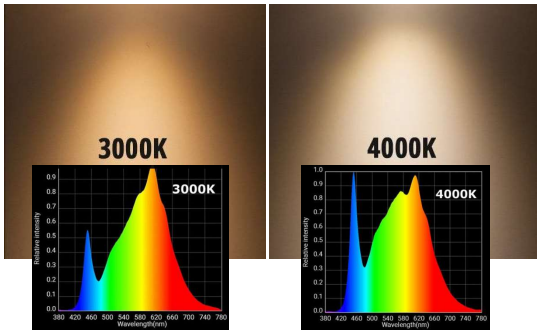
LUMINAIRE OPTIONS — *Photometric Design Intro*

Color Temperature Options

FDM 231.2 ***Color Temperature***

- ***Color Temperature policy was released in RDB 22-02 back in 2022.***

Information on this topic is available at:
https://www.fdot.gov/roadway/training/trainweb.shtm



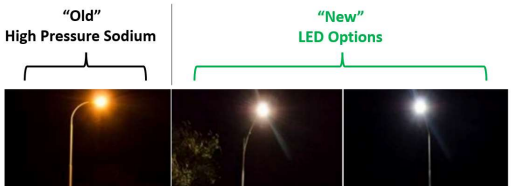


Table 231.2.3 Correlated Color Temperature (CCT)

Design Speed	Context Classification	CCT
Arterials and Collectors		
≤ 35 mph	All	2700K[1] or 3000K
≤ 50mph	All	3000K
≥ 55mph	C1 & C2	3000K
≥ 55mph	C3[2]	4000K
Limited Access Facilities		
All	All	3000K

Notes:
(1) Consider use of 2700K per the description above
(2) Higher number context classifications may apply

FDOT TRANSPORTATION SYMPOSIUM

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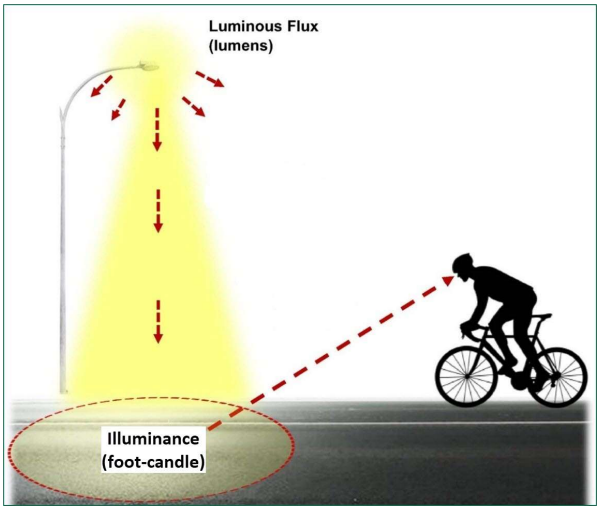
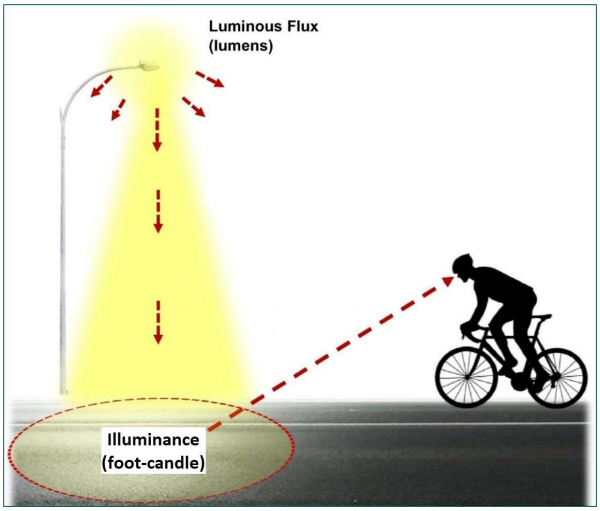
Lighting Analysis

- FDOT primarily uses the **illuminance** method for meeting roadway and crosswalk requirements (FDM 231.2) …
- **Illuminance** measures the quantity of light falling upon a surface…
- **Illuminance** is the simplest calculation method that provides the most flexibility with lighting complex road geometries, intersections, and crosswalks



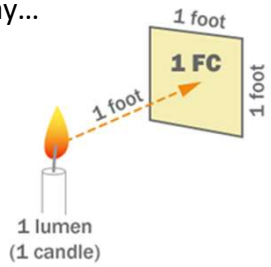
Lighting Analysis

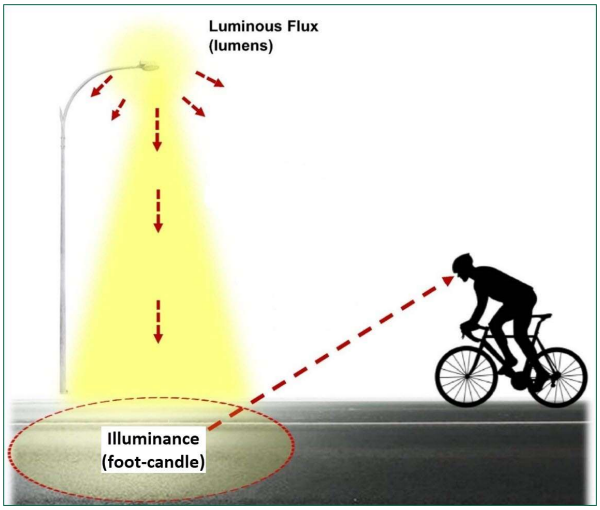
- Note that FDOT does **not** use reflectivity to calculate general roadway lighting (a.k.a. "~~luminance~~" method):
  - Florida pavement tends to significantly change color
  - The goal is visibility of other items besides pavement (vehicles, pedestrians, markings, etc.)
  - Dense traffic changes reflectivity
  - Software doesn't accommodate curved roads and crosswalk needs when using reflectivity methods
  - ***RESULT: Illuminance*** method is most practical to meet all needs!



Lighting Analysis

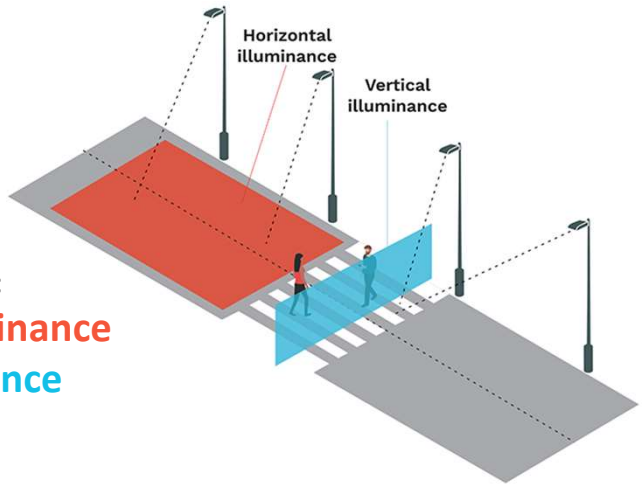
- **Illuminance** uses the unit of "**foot-candle (F.C.)**"
  - **One F.C.** equals the amount of light falling on a 1Ft. x 1Ft. flat square surface, produced by a candle that's 1Ft. away…





Above Image Credit: ENERGETIQ

Lighting Analysis



- **FDOT primarily uses two types of illuminance:**
  - **Horizontal illuminance**
  - **Vertical illuminance**

Above Image Credit: Schréder
https://www.schreder.com

Horizontal Illuminance

- Measures light falling on horizontal surface (e.g., pavement)…
- Light is measured…
  - at data points that simulate light sensors in software… perpendicular to the surface using…
    horizontal foot-candles (H.F.C.)…
    - H.F.C. has widespread usage:
      - **Corridors**
      - **Intersections**
      - **Interchanges**

      (See ***FDM 231.3*** for boundaries and data point layout needs)

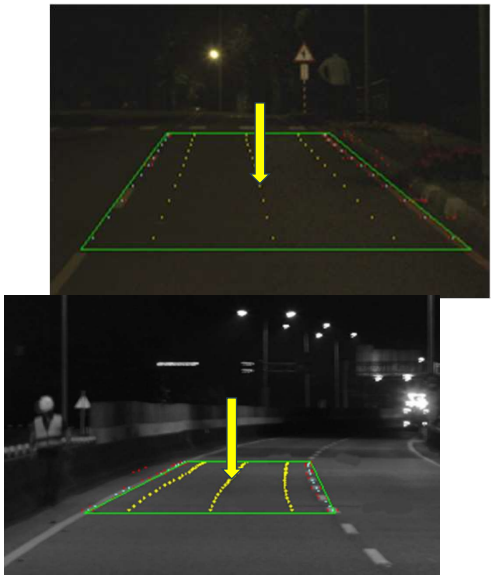
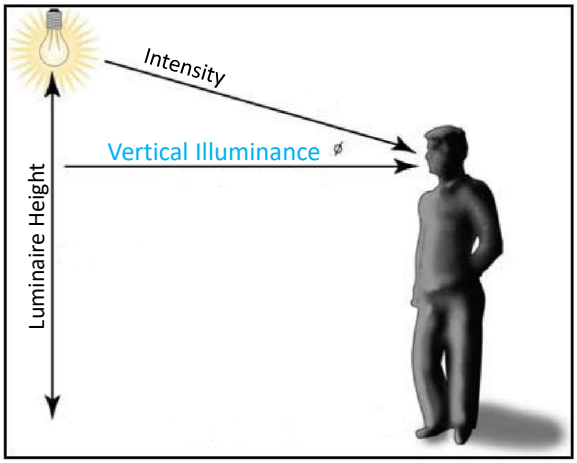


Image Credit: MDPI Article - Cheng-Hsien Chen, Shau-Wei Hsu, Tsung-Hsun Yang, and Ching-Cherng Sun

Vertical Illuminance

- Measures light falling on vertical surface (e.g., pedestrian)
- Light is measured…
  - at data points that simulate light sensors in software… **in the direction of approaching vehicles (drivers)** using…
    vertical foot-candles (V.F.C.)…
    - V.F.C. has widespread usage, particularly at **Crosswalks**

      (See ***FDM 231.3*** for boundaries and data point layout needs)



Above Image Credit: *FHWA Information Report on Lighting Design for Midblock Crosswalks*

FDOT Illuminance Method *Photometric Design Intro*

Vertical Illuminance

- REMEMBER: Data points are placed to measure street lighting using design software
- Data points are oriented in the direction facing oncoming drivers…

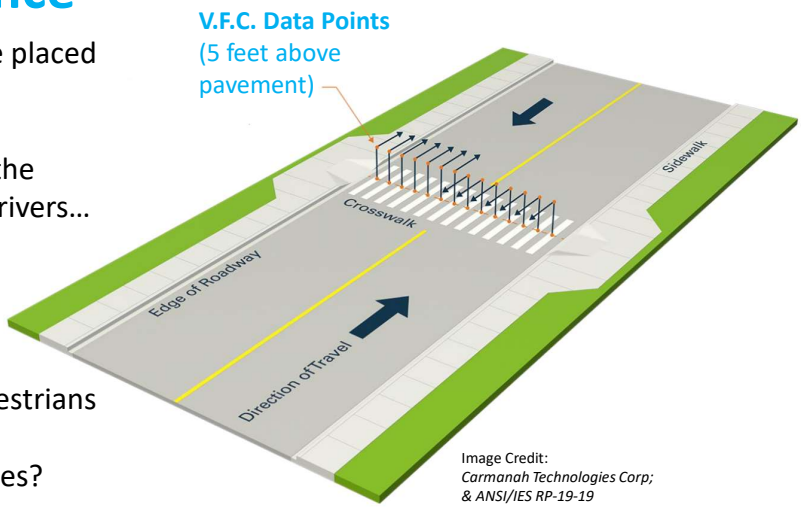


Image Credit:
Carmanah Technologies Corp; & ANSI/IES RP-19-19

- This helps to illuminate pedestrians from the view of drivers…
- Where do we place light poles?

FDOT TRANSPORTATION SYMPOSIUM

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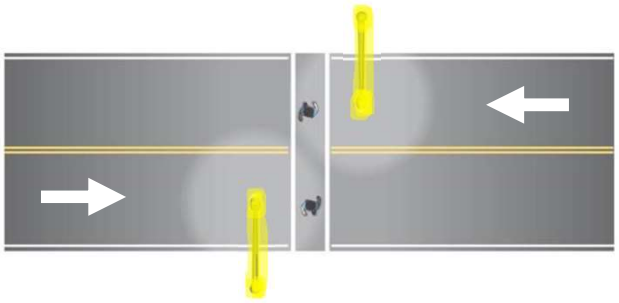
FDOT Illuminance Method *Photometric Design Intro*

Vertical Illuminance

- Place **light poles** between crosswalk and approaching drivers…



- The goal is positive contrast…

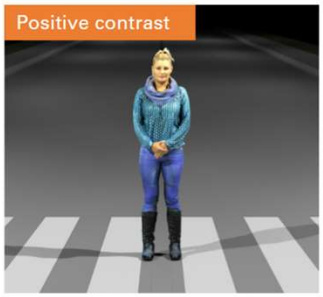


Image Credit:
Carmanah Technologies Corp; & ANSI/IES RP-8-18

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Vertical Illuminance

- **Positive Contrast** helps drivers to more easily identify pedestrians among visual clutter…
- For crosswalks, place light poles in a location to… supplement vehicle headlights
- Notice that bright color clothing helps in all cases

Negative Contrast

Positive Contrast

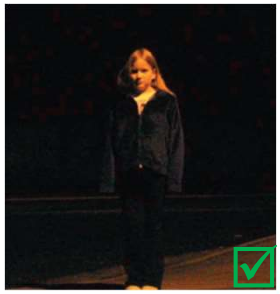

Image Credit:
ANSI/IES RP-8-18

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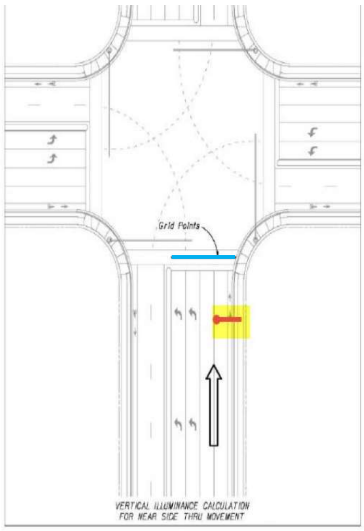
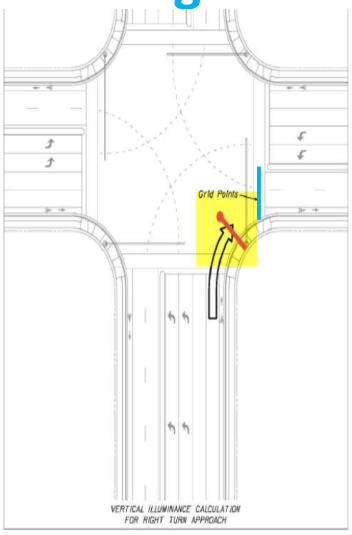
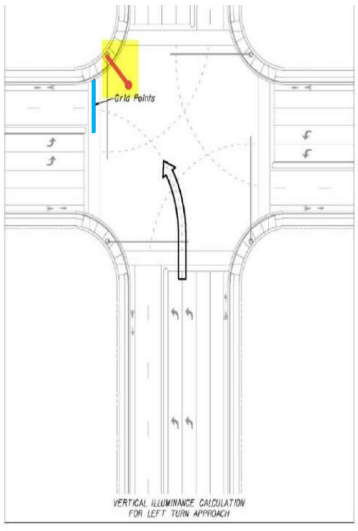
Vertical Illuminance – Signalized Intersections







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FDOT Lighting Values

- **FDM Table 231.2.1** provides horizontal and vertical foot-candle requirements as previously introduced…
- Per ***FDM 231***, the lighting designer…
  - Obtains "IES file" for each luminaire being considered…
  - Designs streetlighting in CADD software such as AGi32 or similar

https://lightinganalysts.com/learn/live-online-training-classes/

Table 231.2.1 Lighting Values

Roadway Classification	Illumination Level Average Foot Candle		Illumination Uniformity Ratios		Veiling Luminance Ratio
Or Location Type	Horizontal (H.F.C.)	Vertical (V.F.C.)	Avg./Min.	Max./Min.	$L_{V(MAX)}/L_{AVG}$
Corridor Lighting					
Limited Access Facilities	1.5	N/A	4:1 or Less	10:1 or Less	0.3:1 or Less
Major Arterials	1.5				
Arterial Lighting Retrofit	1.0-1.5				
Other Roadways	1.0				
High Mast Lighting					
All Roadway Classifications	0.8-1.0	N/A	3:1 or Less	10:1 or Less	N/A
Signalized Intersection and Roundabout Lighting					
New or Reconstruction	3.0 Std. 1.5 Min.	1.5 Std. 1.2 Min.	4:1 or Less	10:1 or Less	N/A
Intersection Lighting Retrofit	1.5 Std. 1.0 Min.	1.5 Std. 1.0 Min.			
Isolated Lighting	1.0-1.5	1.0-1.5			
Unsignalized Intersection Lighting					
All Project Types	1.0-1.5	1.0-1.5	4:1 or Less	10:1 or Less	N/A

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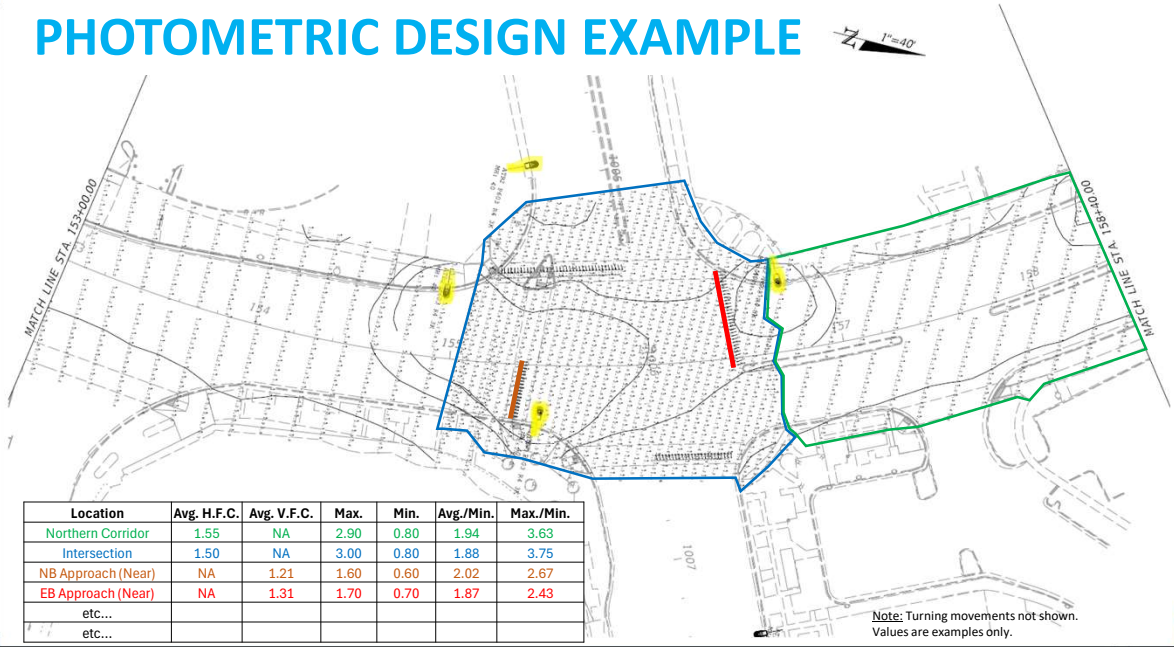
PHOTOMETRIC DESIGN EXAMPLE



Location	Avg. H.F.C.	Avg. V.F.C.	Max.	Min.	Avg./Min.	Max./Min.
Northern Corridor	1.55	NA	2.90	0.80	1.94	3.63
Intersection	1.50	NA	3.00	0.80	1.88	3.75
NB Approach (Near)	NA	1.21	1.60	0.60	2.02	2.67
EB Approach (Near)	NA	1.31	1.70	0.70	1.87	2.43
etc…						
etc…						

Note: Turning movements not shown.
Values are examples only.

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Light Spill

FDM 231.2.2 Light Spill

- ***Give attention to reducing light projection into surrounding areas***
- ***If wildlife areas or residential properties are within 100 feet of luminaire, then select a luminaire model with manufacturer's light shielding options available for potential future install***
- ***Call for immediate light shielding for severe cases (such as pictured)***

Light Shielding

Light Trespass Shield:
Pre-install provided (4) #8 hex washer head screws in holes in luminaire optical plate. Do not fully tighten. Align keyhole slots in shield base to screws. Rotate shield slightly to engage keyhole slots onto screw heads. Tighten screws until snug.
Light Trespass Shield can be installed in 4 different positions; 0°, 90°, 180°, 270°.

Figure 1 – Light Trespass Shield

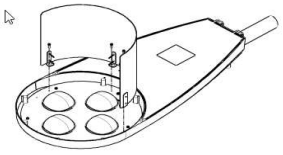
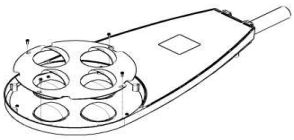


Figure 2 – House Side Shield



- Prior to selecting luminaires for AGi32 illuminance calculations…

  check manufacturer's shieling options!

- Specify in Lighting Plans

Environmental Lighting

- ***FDM 231.2.1*** provides detailed instructions…
- Designers should "consult with District's environmental managers or permit coordinators on a project-specific basis" (as early as Phase 1 submittal)…
- Meet ordinances and permit requirements of local agencies, including direction from **FDEP** and **FWC**.

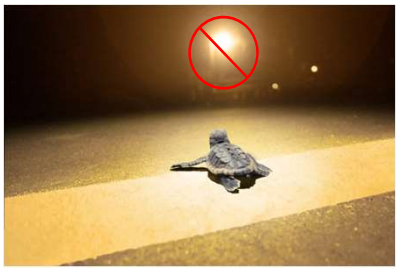


Photo credit:
Blair Witherington

Special Considerations | Photometric Design Intro

Environmental Lighting

- ***FDM 231.2.1*** provides detailed instructions
- Where required, oriented lights away from "wildlife-sensitive" areas, including beaches for ***sea turtles***…
  - Use "Wildlife-sensitive" luminaires on the APL
  - Deep amber color is less visible to wildlife (less disorienting to turtle hatchlings)
  - Use light shielding as previously discussed…
- **FDOT's Office of Environmental Management** "Protected Species and Habitat" website is a great resource

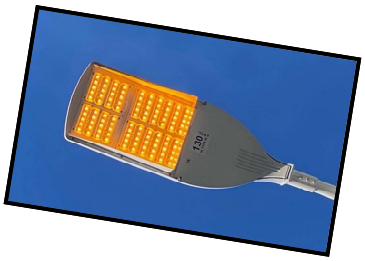


Image Credits:
Duke Energy (Top)
Sea Turtle Conservancy (Bottom)

Plans Inclusion

Design Intro

NEW Lighting Data Table

Lighting Data Table

Pole No.	Easting	Northing	Baseline	Station	Offset	Foundation	Arm Length	Arm Rise	Mount Height	Quantity Luminaires	Type	Make\Model	Lumens	IES Dist Type	CCT(K)	Tilt (deg)	Luminaire Watts	Luminaire Volts	Load Center No.	Circuit No.	Maint. Agency	Pay Item
1																						
2																						
3																						
4																						
5																						

- ***Table is included with FDOT CADD load***
  - ***Released with Open Roads Design (ORD)***
- Corresponds to ***FDM 943 Lighting Plans***
- *Adds new information as requested by Districts*
- *Offers drop-down selections matching Standard Plans options*

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Plans Inclusion

Design Intro

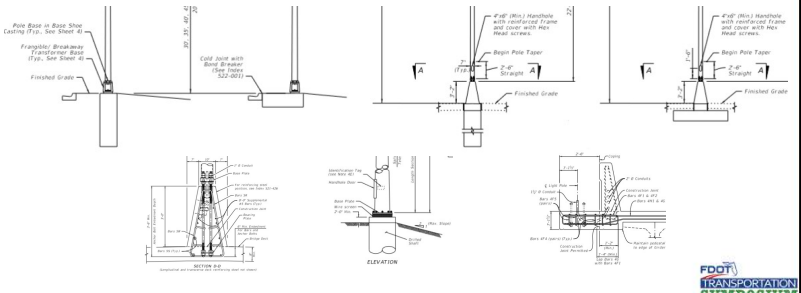
NEW Lighting Data Table

Lighting Data Table

Pole No.	Easting	Northing	Baseline	Station	Offset	Foundation	Arm Length	Arm Rise	Mount Height	Quantity Luminaires	Type	Make\Model	Lumens	IES Dist Type	CCT(K)	Tilt (deg)	Luminaire Watts	Luminaire Volts	Load Center No.	Circuit No.	Maint. Agency	Pay Item
1																						
2																						
3																						
4																						
5																						

- ***New:* *"Foundation" Entry***
- Drop-down selection has all Standard Plans options, including…

Dropdown Options:	Index or Use:
Shaft	715-002, 003, 010
SpreadFooting	715-002
Barrier-SpreadFoot	715-002
Barrier-Cylindrical	715-002
Barrier-BridgeDeck	715-002
PedestalMount	521-650 & 660
N/A	Underdeck Lights
ProjectSpecific	Plans Details



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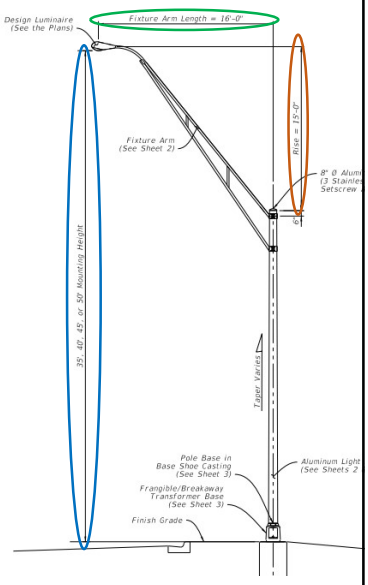
Plans Inclusion

Design Intro

NEW Lighting Data Table

Lighting Data Table

Pole No.	Easting	Northing	Baseline	Station	Offset	Foundation	Arm Length	Arm Rise	Mount Height	Quantity Luminaires	Type	Make\Model	Lumens	IES Dist Type	CCT(K
1															
2															
3															
4															
5															



- ***New:* "Arm Length", "Arm Rise", and "Mount Height" inputs**
- Drop-down selection has all *Standard Plans options*, including…

Arm Length (Standard Plans)
0'
8'
10'
12'
15'
16'
N/A

Arm Rise (Standard Plans)
0'
3'
5'-6"
15'
N/A

Mounting Height (Standard Plans)
20'
25'
30'
35'
40'
45'
50'

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Plans Inclusion

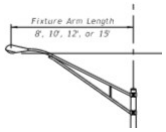
Design Intro

NEW Lighting Data Table

Lighting Data Table

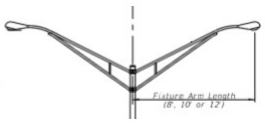
Pole No.	Easting	Northing	Baseline	Station	Offset	Foundation	Arm Length	Arm Rise	Mount Height	Quantity Luminaires	Type	Make\Model	Lumens	IES Dist Type	CCT(K)	Tilt (deg)	Luminaire Watts	Luminaire Volts	Load Center No.	Circuit No.	Maint. Agency	Pay Item
1																						
2																						
3																						
4																						
5																						

- ***New:* "Quantity Luminaires" per Location**
- *Standard Plans 715 Series Options below…*

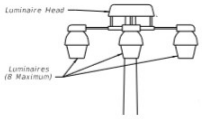


Single Arm:
1 Luminaire

Pole Top:
1 Luminaire



Double Arm:
2 Luminaires



High Mast:
4 to 8 Luminaires

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Plans Inclusion

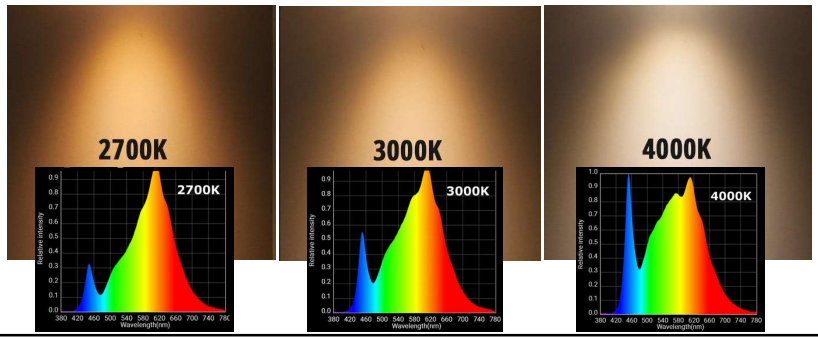
Design Intro

NEW Lighting Data Table

Lighting Data Table

Pole No.	Easting	Northing	Baseline	Station	Offset	Foundation	Arm Length	Arm Rise	Mount Height	Quantity Luminaires	Type	Make\Model	Lumens	IES Dist Type	CCT(K)	Tilt (deg)	Luminaire Watts	Luminaire Volts	Load Center No.	Circuit No.	Maint. Agency	Pay Item
1																						
2																						
3																						
4																						
5																						

- *"Correlated Color Temperature – CCT(K)" per Location*
- *FDM Table 231.2.3 Options…*



For additional Information,
See the RDO Training Website (March 2022)…
https://www.fdot.gov/roadway/training/trainweb.shtm

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Plans Inclusion

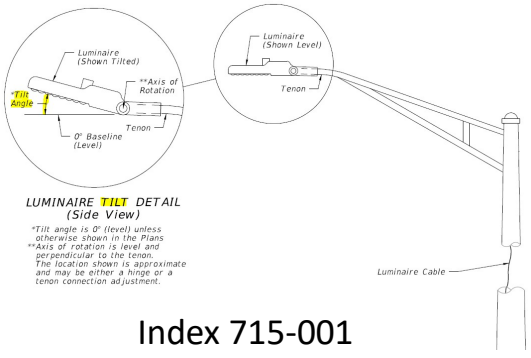
Design Intro

NEW Lighting Data Table

Lighting Data Table

Pole No.	Easting	Northing	Baseline	Station	Offset	Foundation	Arm Length	Arm Rise	Mount Height	Quantity Luminaires	Type	Make\Model	Lumens	IES Dist Type	CCT(K)	Tilt (deg)	Luminaire Watts	Luminaire Volts	Load Center No.	Circuit No.	Maint. Agency	Pay Item
1																						
2																						
3																						
4																						
5																						

- *New Luminaire "Tilt" Angle Input*
- *FDM 231.2 Options:*
  0, 5, or 15 degrees…



LUMINAIRE TILT DETAIL
(Side View)

*Tilt angle is 0° (level) unless otherwise shown in the Plans
**Axis of rotation is level and perpendicular to the tenon. The location shown is approximate and may be either a hinge or a tenon connection adjustment.

Index 715-001
(*New* Detail)

FDOT TRANSPORTATION SYMPOSIUM

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Plans Inclusion

Design Intro

***NEW* Lighting Data Table**

Lighting Data Table

Pole No.	Easting	Northing	Baseline	Station	Offset	Foundation	Arm Length	Arm Rise	Mount Height	Quantity Luminaires	Type	Make\Model	Lumens	IES Dist Type	CCT(K)	Tilt (deg)	Luminaire Watts	Luminaire Volts	Load Center No.	Circuit No.	Maint. Agency	Pay Item
1																						
2																						
3																						
4																						
5																						

- ***Also Added…***
  - ***"Type" of Lighting (Conventional, High Mast, Underdeck, Wildlife, Sign, etc.)***
  - ***Design Luminaire:***
    - ***"Make and Model"***
    - ***"Lumens"***
    - ***"IES Distribution Type" (No.'s 1 thru 5)***
    - ***"Watts"***
    - ***"Volts"***
  - ***"Load Center No."***
  - ***"Circuit No."***
  - ***"Maintaining Agency"***

District 6: SR826/SR836 Credit: americastransportationawards.org

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June 19 - 20, 2025
Hollywood, FL

TRANSPORTATION SYMPOSIUM

Intro to Lighting Design *Part 2*
Circuit Design Intro – Voltage Drop

Ayman Mohamed (D5), PhD., P.E.

Transportation Symposium Website

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DEFINITIONS:

Power (Watts): is the amount of current times the voltage level at a given point.

Voltage (Volt): is the difference in electrical potential between two points in a circuit. It's the pressure or push behind current flow through a circuit.

Current (Amps): is what flows on a wire or conductor like water flowing down a stream. Current flows from points of high voltage to points of low voltage on the surface of a conductor.

Resistance (ohm): determines how much current will flow through a component. Resistors are used to control voltage and current levels. A very high resistance allows a small amount of current to flow. A very low resistance allows a large amount of current to flow.

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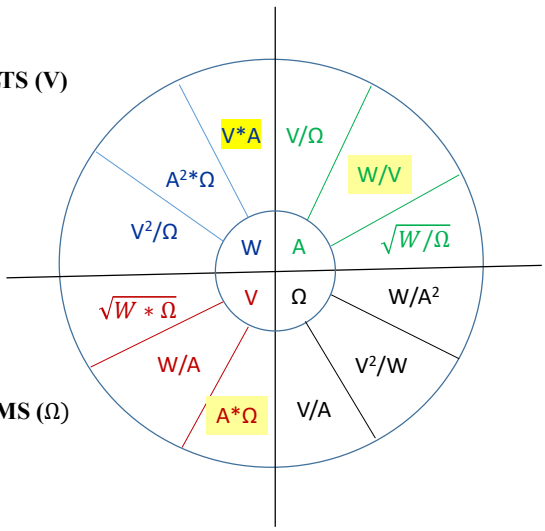
OHM'S LAW:

AMPERES (A) =WATTS (W) / VOLTS (V)

$A=W/V$

Use to Get Circuit Breaker Size



VOLTS (V) = AMPERES (A) X OHMS (Ω)

$V=A*\Omega$

Use to Get Voltage Drop

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120V Versus 480V

Circuit Design Intro

Example 1

How many 60W light fixtures can I install on a 20A breaker at home (120V)?

Voltage (V) = 120V
Current (A)= 20 A

WATTS (W) = AMPERES (A) X VOLTS (V)

Total Watts = 20A x120V =2400W
# of bulbs = 2400W / 60W = 40 fixtures

20A breaker does not accommodate exactly 20A. Per NEC, you can't push the current over 80% of its specified ampacity. Typically we use 75% of the 20A.

Breaker = 20A X 0.75 = 15A
Total Watts = 120V x 15A =1800W
# of bulbs = 1800W / 60W = 30 fixtures

How about if the bulbs are 274W?

# of bulbs = 1800W / 274W = 6.6 fixtures use 6 fixtures ***May be OK for intersection lighting***

Example 2

How many 274W luminaires can I install on a 20A breaker with 480V service?

Voltage (V) = 480V
Current (A)= 20A
Breaker = 20A X 0.75 = 15A
Total Watts = 480V x 15A = 7200W
# of Luminaires = 7200W / 274W = 26.27 use 26 Luminaires

Needed for interchange and corridor lighting

FDOT TRANSPORTATION SYMPOSIUM

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What is Voltage Drop?

Circuit Design Intro

- Voltage drop is the accumulated reduction in voltage resulting from conductors' resistance from the electrical service point to the last luminaire.
- If you have too much voltage drop on a circuit, the last luminaire(s) you are trying to power may not work.
- Inefficiency means using more power and receiving less output.
- Make sure you have enough capacity for future expansion.

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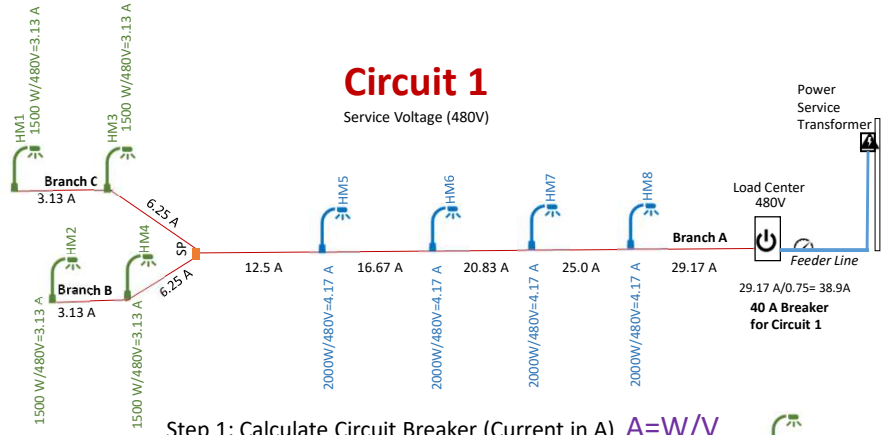
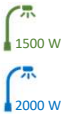
STEP 1: Calculating Circuit Breaker

EXAMPLE



Step 1: Calculate Circuit Breaker (Current in A) A=W/V

1- Get fixtures wattages
2- Start from last fixture and calculate current needed for each fixture toward the load center using Ohm Law A=W/V.
3- Accumulate the required current in Amps from last fixture toward the load center
4- Select circuit breaker size based on the accumulated Amperes and a safety factor of at least 75% (Accumulated Amps/0.75)



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Conductor Resistance

EXAMPLE

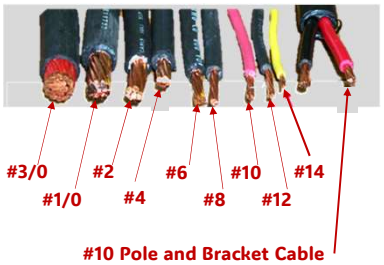
AWG #	CM	RESISTANCE PER 1000' AT 75 DEGREES C FOR UNCOATED COPPER
1	83690	0.154
2	66360	0.194
3	52620	0.245
4	41740	0.308
6	26240	0.491
8	16510	0.778
10	10380	1.24
12	6530	1.98
14	4110	3.14
1/0	105600	0.122
2/0	133100	0.0967
3/0	167800	0.0766
4/0	211600	0.0608
250	250000	0.0515
300	300000	0.0429
350	350000	0.0367

Lower Resistance

Minimum AWG per FDOT Specs

Inside pole

Source: NEC 2017 Handbook - Table 8 Chapter 9



SECTION 992
HIGHWAY LIGHTING MATERIALS

992-1.3 Conductors: All conductors shall be color-coded stranded copper meeting the requirements of NEMA WC 70. All conductors shall be tested and listed by a NRTL.
Service and circuit conductors shall be single-conductor cable Type THWN-2 and shall not be smaller than No. 6 AWG.

992-2.5 Luminaire Cable: Pole and bracket cable shall be multi-conductor Type XHHW-2 XLP TC with three No. 10 AWG.

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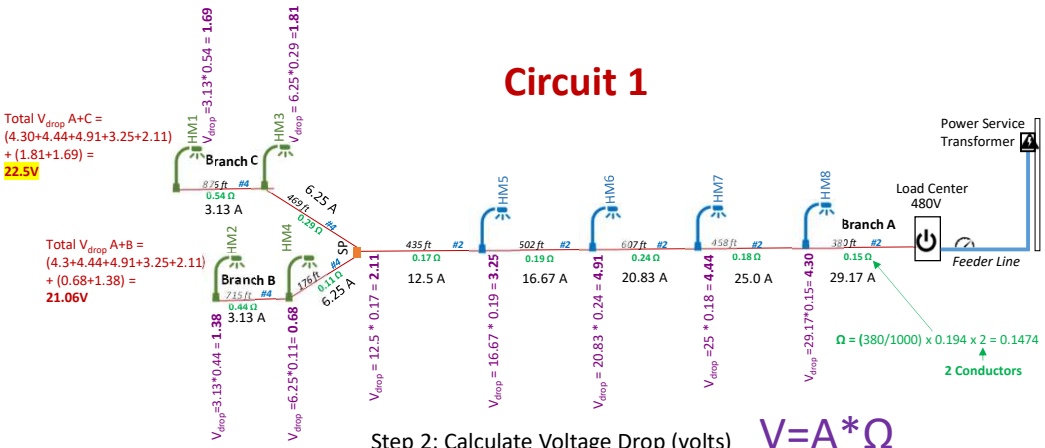
STEP 2: Voltage Drop Calculations

EXAMPLE



Step 2: Calculate Voltage Drop (volts) $V=A*\Omega$

1- Get conductor length
2- Assign conductor sizes
3- Calculate resistance (Ω=length/1000ft)*Resistance value from NEC table)
4- Calculate voltage drop (V=A*Ω)
5- Accumulate voltage drop at the last fixture in the circuit)

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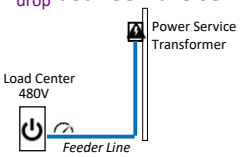
STEP 2: Voltage Drop Calculations

EXAMPLE

How to calculate the V_{drop} between the service point and the load center?



V_{drop} =A*Ω

Total Amperage for all breakers in the load center
(Need to design all circuits first and get total amperage needed at load center)

Example:

Circuit 1	*29.17 A*
Circuit 2	*8.58 A*
Circuit 3	*0.57 A*
Circuit 4	*6.13 A*
Circuit 5	*7.52 A*
Circuit 6	*7.11 A*
Total	*59.06 A*

Conductor resistance from the transformer to the load center.
(Need conductor size and length)
Example: 500 ft of #2/0 provides Ω= (500/1000) x 0.0967 x 2 = 0.0967 ohms

V_{drop} =59.06*0.0967 =**5.71 V** ← This is a fixed value to be added to all circuits

Largest from Previous Slide

Total Voltage Drop in Circuit 1 = 22.5 + 5.71 =**28.21V**

Voltage drop % for Circuit 1 = 28.21V / 480V = 5.88% ← Exceeds 5%

FDOT TRANSPORTATION SYMPOSIUM

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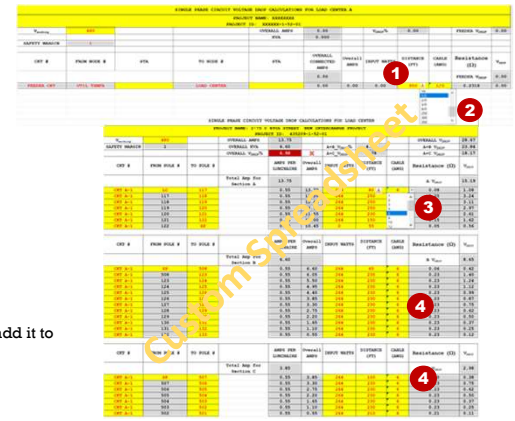
What is Circuit Voltage Drop Exceeds 5%?

The target is to ensure that non of the circuits exceed a voltage drop of 5%. If any of the circuits exceeds 5%, take the following steps and check at every step if your circuit voltage drop is reduced to below 5%

1. Decrease feeder length by moving the proposed load center as close as possible to power source.
2. Upgrade the feeder cable size to the next larger size.
3. Upgrade the entire circuit main section cable size to the next larger size.
4. Upgrade the circuit branches cable size to the next larger size.
5. Repeat step 2 or steps 3 &4
6. Remove one luminaire from this circuit and add it to the adjacent circuit.
7. Repeat step 6 until you reach below 5%



- Steps 1 & 2 will improve voltage drops for all circuits, not only the one exceeds the 5%
- If you reach steps 6 and 7 you may go back and reduce cable sizes back in steps 3 and 4 (not lower than #6), this may be obtained through several iterations.
- **Try to go below 5% to be covered for any construction adjustment of future fixtures. Aim for not more than 4.5% voltage drop in any circuit.**

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June 19 - 20, 2025
Hollywood, FL

TRANSPORTATION SYMPOSIUM

Please be sure to **certify your attendance** before leaving this event or no later than **Monday, June 30**, in order to receive PDH/CEC. Detailed instructions are available on the Transportation Symposium website.

Transportation Symposium Website

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Safety Message

TRANSPORTATION SYMPOSIUM

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Contact Us

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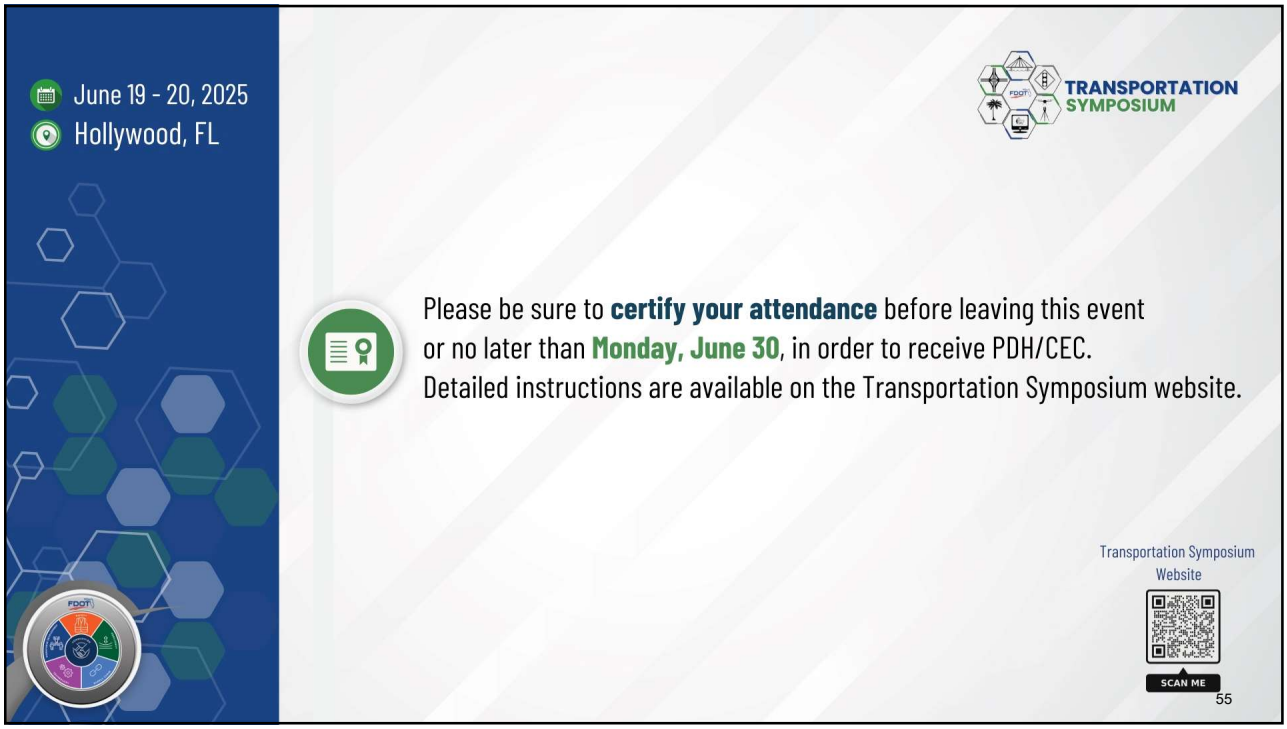
June 19 - 20, 2025
Hollywood, FL
TRANSPORTATION SYMPOSIUM
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