

International Municipal Signal
Association presents

IMSA Roadway Lighting Technician



Advancing the Future of Public Safety

Updated March 2026

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Intent of Refresher Presentation

- This review is not intended to cover every aspect of the exam and is not limited to the content, or questions found on the exam.
- To briefly review the required technical knowledge and understanding of a typical Roadway Lighting technician gained through job experience and previous training.
- Review the latest concepts of industry standards in an overview format designed to promote group discussion and sharing of ideas.
- Questions should be asked as the presentation is underway, and the topic is under discussion – others will benefit from any questions asked!

IMSA Program Clarification

- 1) IMSA certification programs include *ALL* of North America, mostly the United States and Canada.
- 2) Our industry lacks continuity in education, training, knowledge, and skill set across North America.
- 3) Furthermore, our certifications cover people working in all facets of public safety, such as:
 - Public Agencies, Contractors, Manufacturer's, Dealers, Tech Support Services, Design Firms, Consultants, and Education Outlets
- 4) You will see products, technologies, and other examples used in all these sectors. *So, you could see things that you may not be familiar with, or use in your local area, or fall outside your scope of work, because **it will be covered on the exams.***
- 5) These programs cover *everything* related to Roadway Lighting.

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IMSA Roadway Lighting Technician

Program Introduction



Advancing the Future of Public Safety

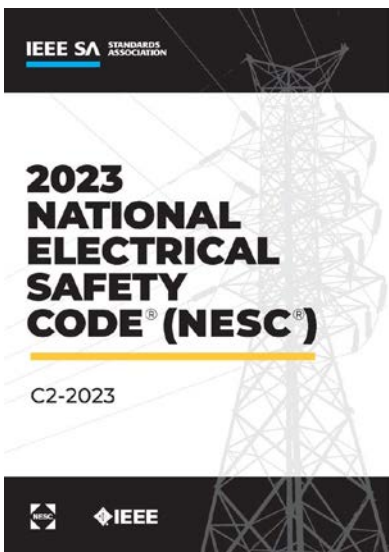
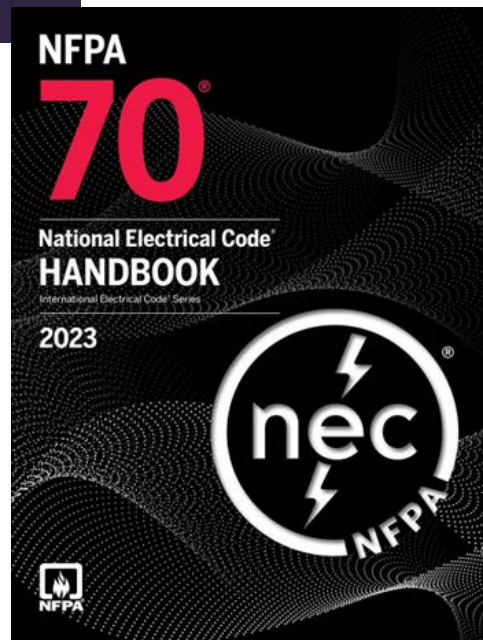
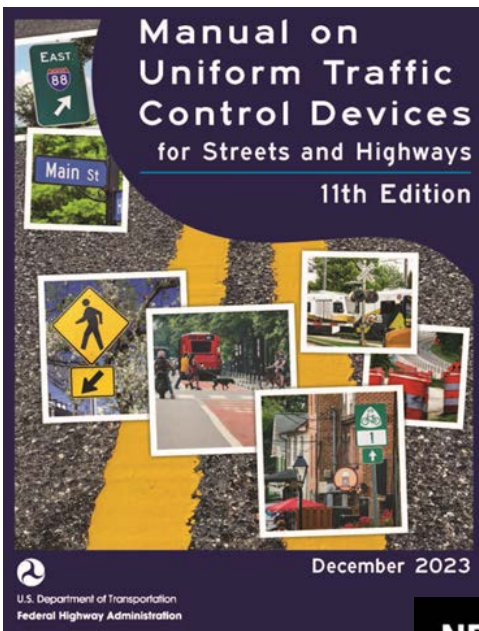
Roadway lighting plays a crucial role in enhancing public safety, increasing visibility, reducing accidents, aesthetics, and deterring crime on our streets and highways. As an integral part of urban infrastructure, roadway lighting provides illumination during nighttime and low-light conditions, ensuring clear visibility for drivers, pedestrians, and cyclists.



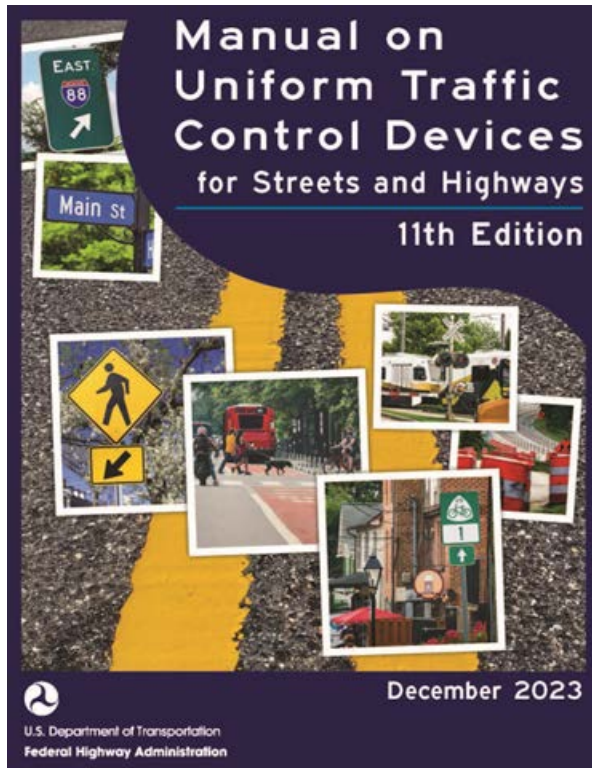
Governing Agencies and Manuals

2

- FHWA (Federal Highway Administration) publishes:
- **MUTCD** (Manual on Uniform Traffic Control Devices)
- OSHA (Occupational Safety and Health Administration)
 - Worker Safety, Standard Setting, Compliance and Enforcement, whistleblower protection.
- **NESC** (National Electrical Safety Code)
 - The National Electrical Safety Code or ANSI Standard C2 is a United States standard of the safe installation, operation, and maintenance of electric power and communication utility systems
- **NFPA** (National Fire Protection Association) publishes:
- **NEC** (National Electric Code)
 - Electrical Safety, National Standards, Electrical System Design, as well as Installation and Maintenance.
- NEMA (National Electrical Manufacturers Association)
 - Standardization, Safety and Reliability, and Technical Expertise
- IES (Illuminating Engineering Society)
 - Standards cover various aspects of lighting design and technology
- US Coast Guard covers bridge and waterway lighting

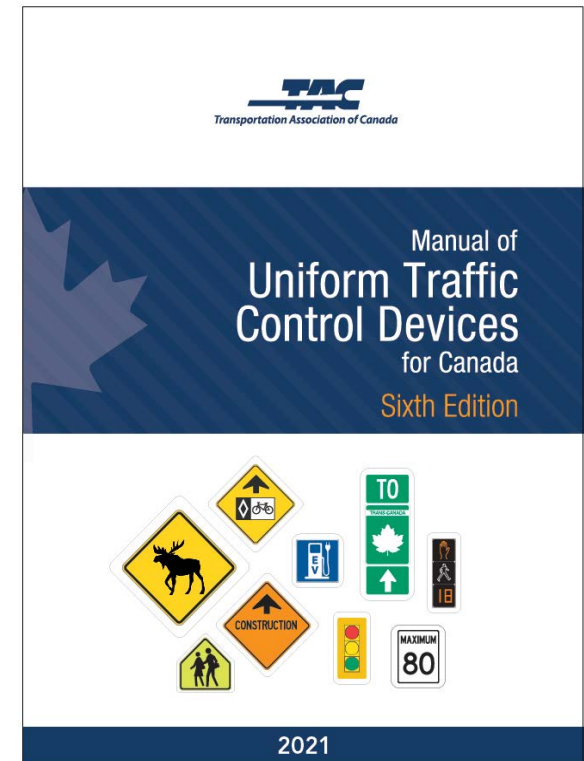


- **CCOHS** (Occupational Health and Safety)
 - In Canada, Canadian Center for Occupational Health and Safety is regulated and enforced by government at the provincial level. Minimum standards are set through the code and OHS Act.
- **(TAC)** Transportation Association of Canada / **(ATC)** Association des Transports du Canada
 - Publishes the **MUTCDC** for Canada among other transportation reference materials. The MUTCDC is often used as a guideline by government agencies and design consultants for traffic signal and sign designs for installations in Canada.
- **(CEC)** Canadian Electrical Code published by CSA, Part 1
 - Majority of provinces and municipalities have adopted CEC as the safety standard for Electrical Installations in the areas of Traffic Signals and Streetlighting.
 - Safety Standards for Electrical Installations are governed and enforced by the Provincial Safety Act.



The **MUTCD** (Manual on Uniform Traffic Control Devices) defines the standards used by road managers nationwide to install and maintain traffic control devices on all streets, highways, pedestrian and bicycle facilities, and site roadways open to public travel.

The Manual of Uniform Traffic Control Devices for Canada (**MUTCDC**) also provides standards and guidelines and promotes similar uniformity across the Canadian provinces.



Manual on Uniform Traffic Control Devices (**MUTCD**)

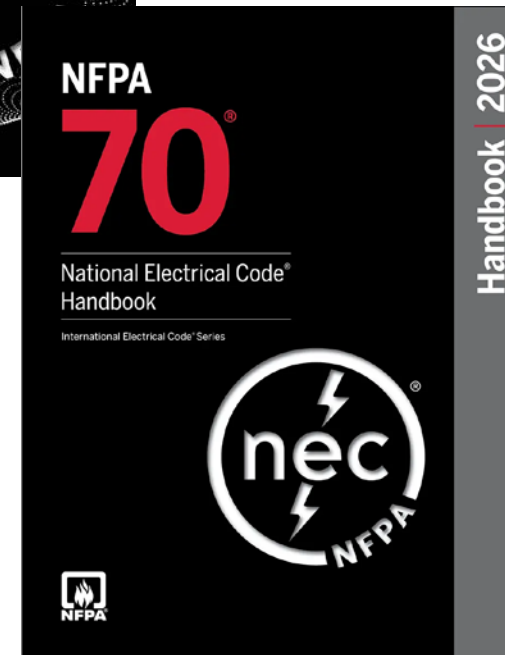
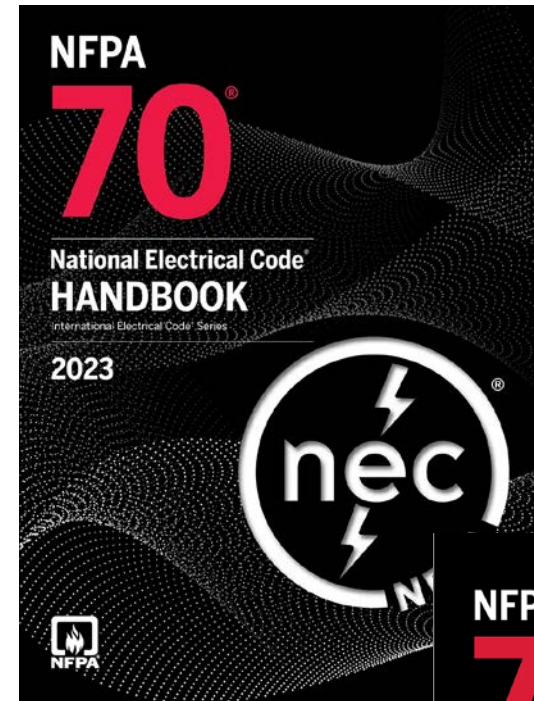
Manual of Uniform Traffic Control Devices for Canada (**MUTCDC**)

The National Electrical Code (**NEC**) Handbook provides detailed interpretations, explanations, and additional information to accompany the National Electrical Code.

- The NEC Handbook and the National Electrical Code are published by the National Fire Protection Association (NFPA)
- The NEC Handbook expands upon the NEC, which is a set of electrical standards and regulations that govern the safe installation, operation, and maintenance of electrical systems in the United States.
- It covers a wide range of topics, including electrical wiring, grounding, equipment installation, electrical calculations, and safety practices.

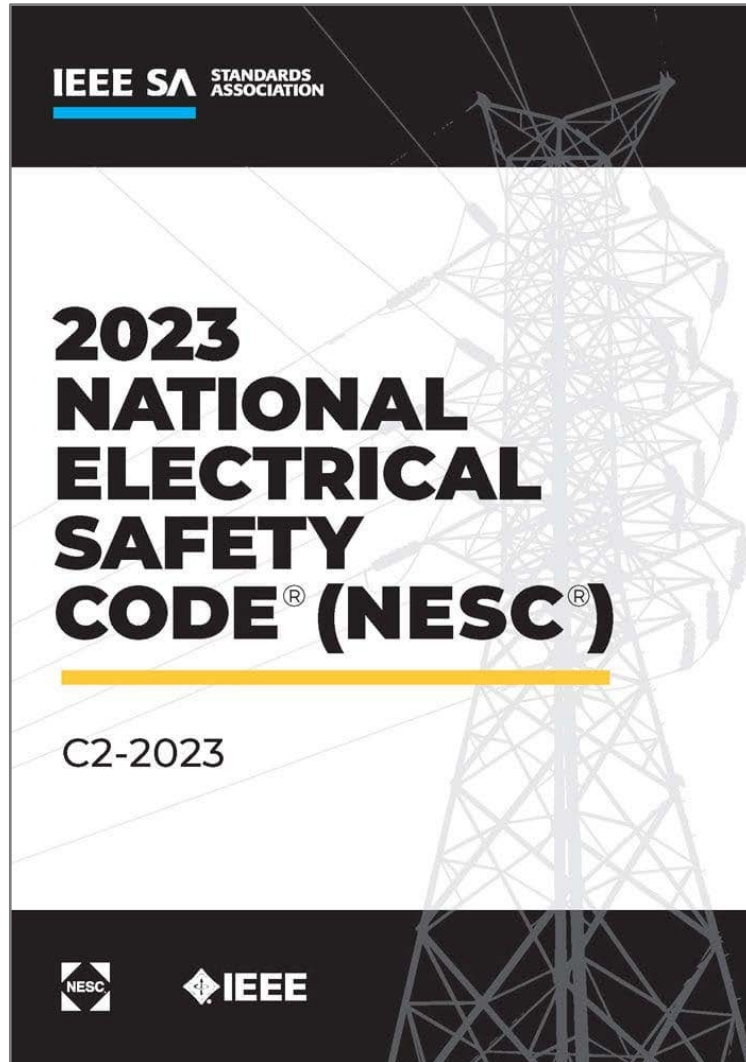
The NEC Handbook offers the following features:

1. Commentary
2. Examples and Illustrations
3. Case Studies
4. Historical Information
5. Cross-References and Index



2026 coming soon*

<https://www.nfpa.org/product/nfpa-70-national-electrical-code-nec-handbook/p0070hb>



The 2023 **NESC**[®] covers practical safeguarding of persons during the installation, operation, or maintenance of:

- Electric supply stations
- Overhead supply and communications lines
- Underground or buried supply and communication cables

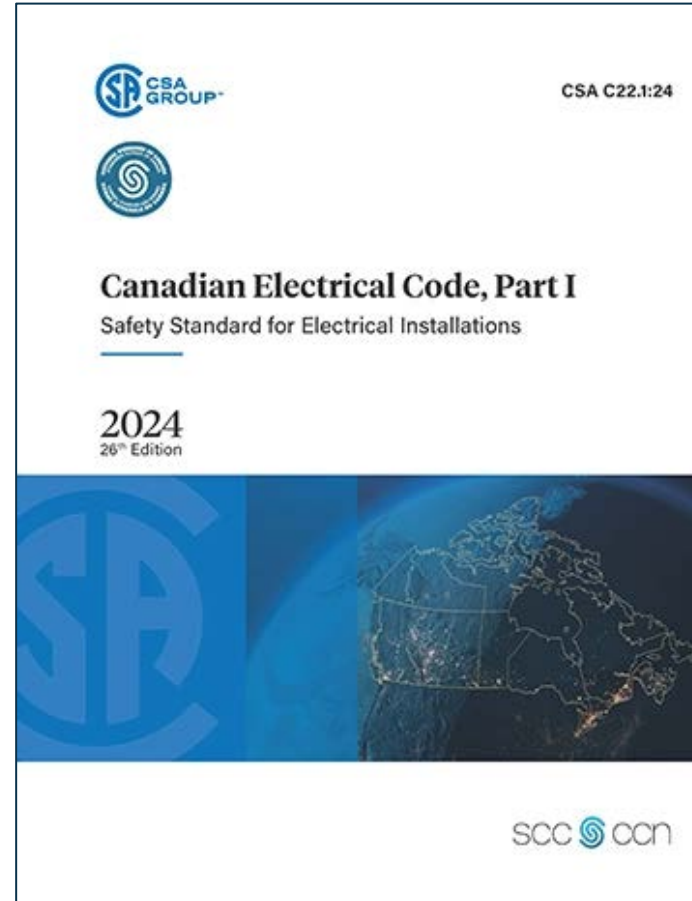
It also includes work rules for the operation of electric supply and communications lines and equipment.

This Code consists of the introduction, definitions, grounding rules, lists of referenced and bibliographic documents, and Parts 1, 2, 3, and 4 of the 2023 Edition of the National Electrical Safety Code.

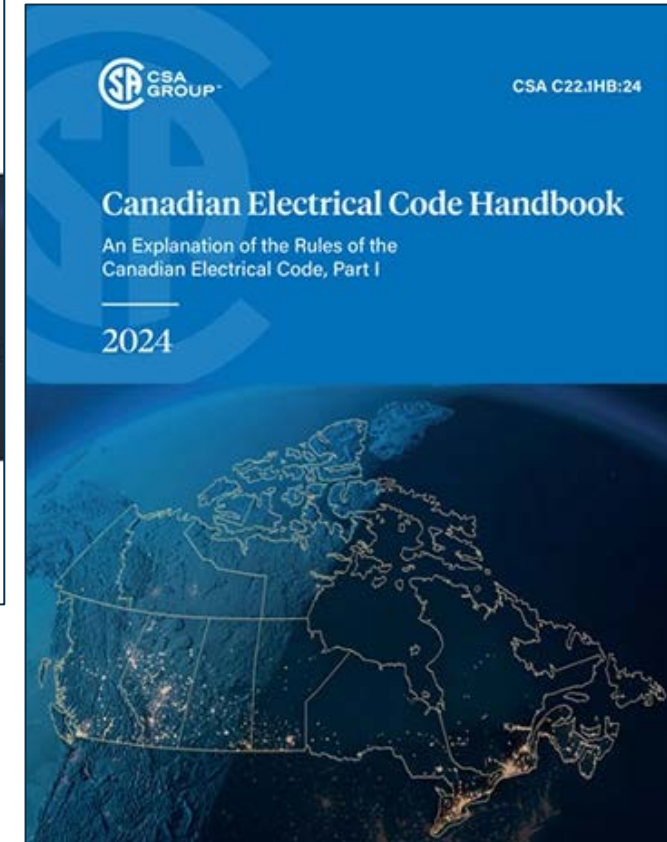
Canada's equivalent of the National Electrical Code (NEC) Handbook and the National Electrical Safety Code (NESC) is the **Canadian Electrical Code (CEC)** and the accompanying Handbook.

Published by the CSA Group (formerly the Canadian Standards Association), developed by technical specialists and following the same structure of the Code, the Handbook includes pertinent information, examples, calculations and graphics to provide guidance for implementing the Code in industrial, commercial and residential installations.

Despite the use of the term "Canadian", the CEC is not a single national law; rather it is a group of laws locally-adopted by individual provinces, territories, and municipalities in an effort to standardize their enforcement of safe electrical practices.



The CEC is available for purchase from the CSA Group.
<https://www.csagroup.org/store/Canadian-electrical-code-products/>



Provincial Utility-Specific Codes:

- In addition to the CEC, some provinces have specific codes that address the unique requirements of electrical utility systems.
- A prominent example is the "Alberta Electrical Utility Code." This code provides safety standards for the installation and maintenance of electrical utility systems specifically within Alberta.
- Therefore, in Alberta, there is the Canadian Electrical Code, and then there is also the Alberta Electrical Utility Code, that utility companies must adhere to.
- Other provinces may defer to utility companies for their own specifications and regulations.

Key Considerations:

- It's crucial to recognize that electrical work *must comply with both* the CEC and any applicable provincial or territorial regulations.
- Utility companies themselves may also have their own internal standards and requirements that contractors must follow.
- Most provinces and territories adopt the Canadian Electrical Code (CEC) and then may add their own amendments. This means they have their own provincial or territorial electrical regulations, but they are based on the national CEC. However, Alberta has gone further in creating a separate, dedicated utility code.

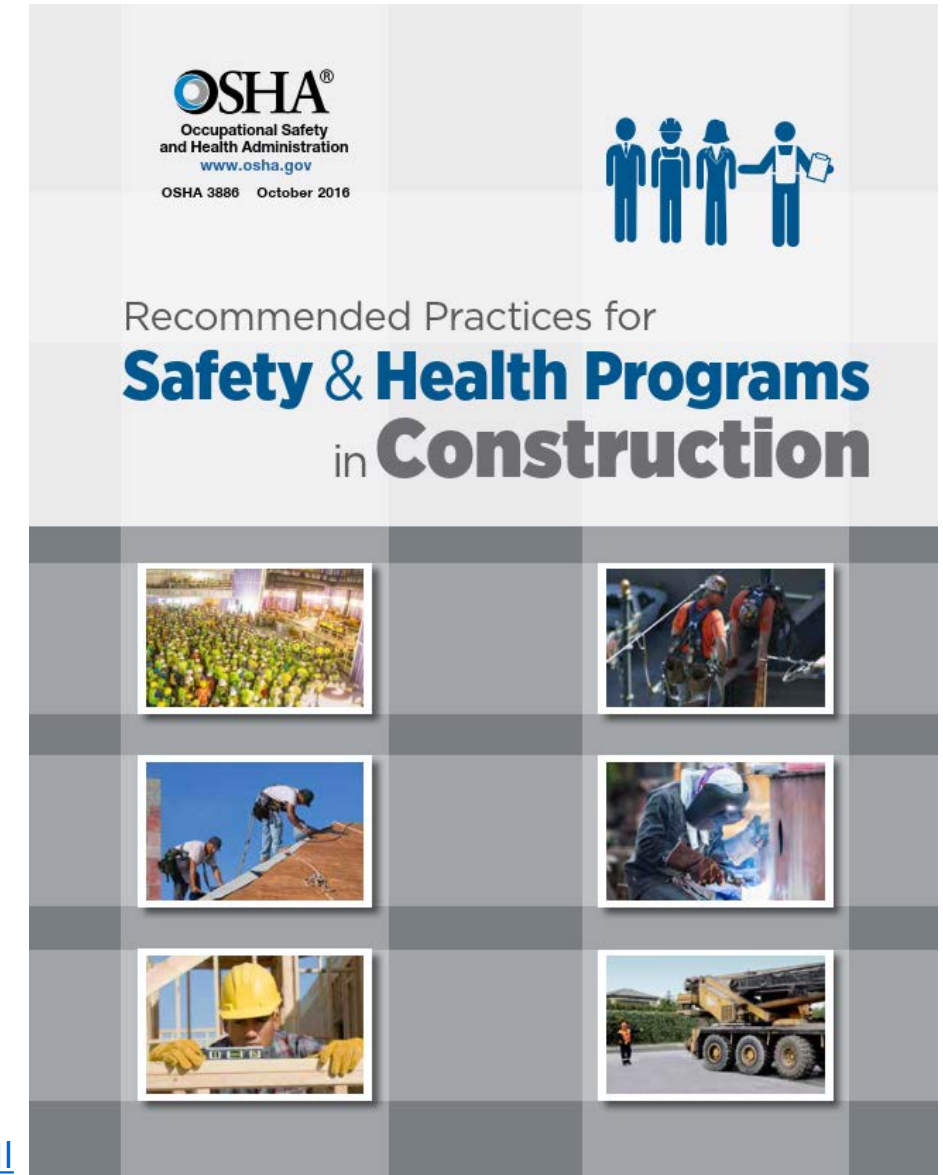
OSHA is a federal agency within the United States Department of Labor.

The mission of OSHA is to assure safe and healthful working conditions for working men and women by setting and enforcing standards and by providing training, outreach, education and assistance.

Here are some key aspects of OSHA:

1. Workplace Safety Standards
2. Inspections and Compliance
3. Training and Education
4. Recordkeeping and Reporting
5. Whistleblower Protection
6. Partnerships and Collaboration

<https://www.osha.gov/publications/all>



The Federal Highway Administration (FHWA) is an agency within the United States Department of Transportation (USDOT) responsible for ensuring the safety, efficiency, and sustainability of the nation's highway system.

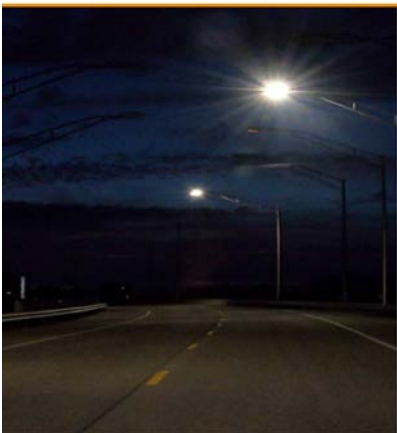
- The FHWA plays a crucial role in planning, designing, constructing, and maintaining highways and bridges across the country.

Here are some key aspects of FHWA:

- Infrastructure Development
- Safety Advocacy
- Funding and Grants
- Research and Innovation
- Policy Development
- Technical Assistance and Training

FHWA

Lighting Handbook



2023

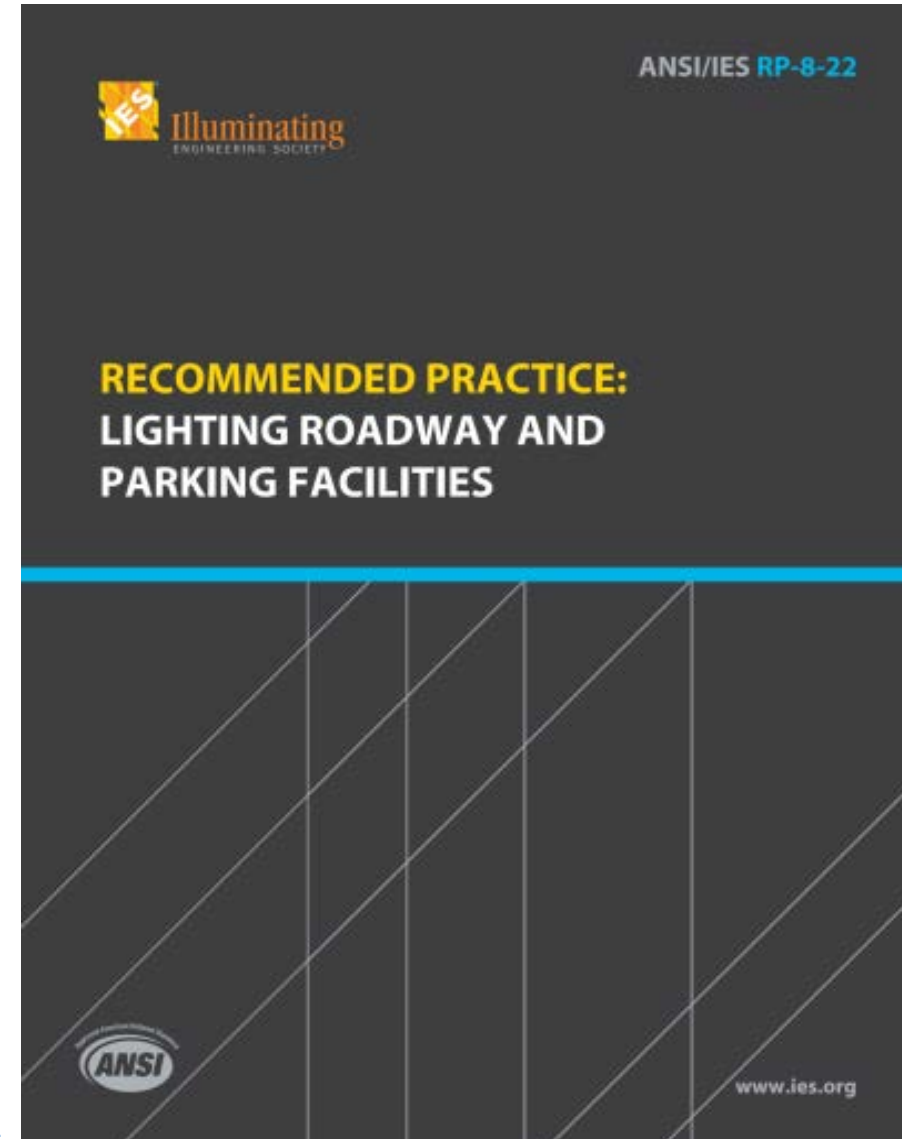
The IES is an accredited Standards Development Organization (SDO) under American National Standards Institute (ANSI) approved procedures.

- The Society publishes nearly 100 varied publications including recommended practices on a variety of applications, such as energy management and lighting measurement

IES (Illuminating Engineering Society) standards cover various aspects of lighting design and technology. These standards include:

- **Recommended Lighting Levels:** Ensure optimally lit spaces for outdoor safety, indoor comfort, and office productivity.
- **Design Guides:** Provide guidance on lighting design.
- **Lighting Measurements:** Define measurement procedures.
- **Technical Memorandums:** Address specific lighting issues.
- **ANSI/IES RP-8-22:** Focuses on motorist visual quality, hazard visibility, and energy efficiency.

www.ies.org

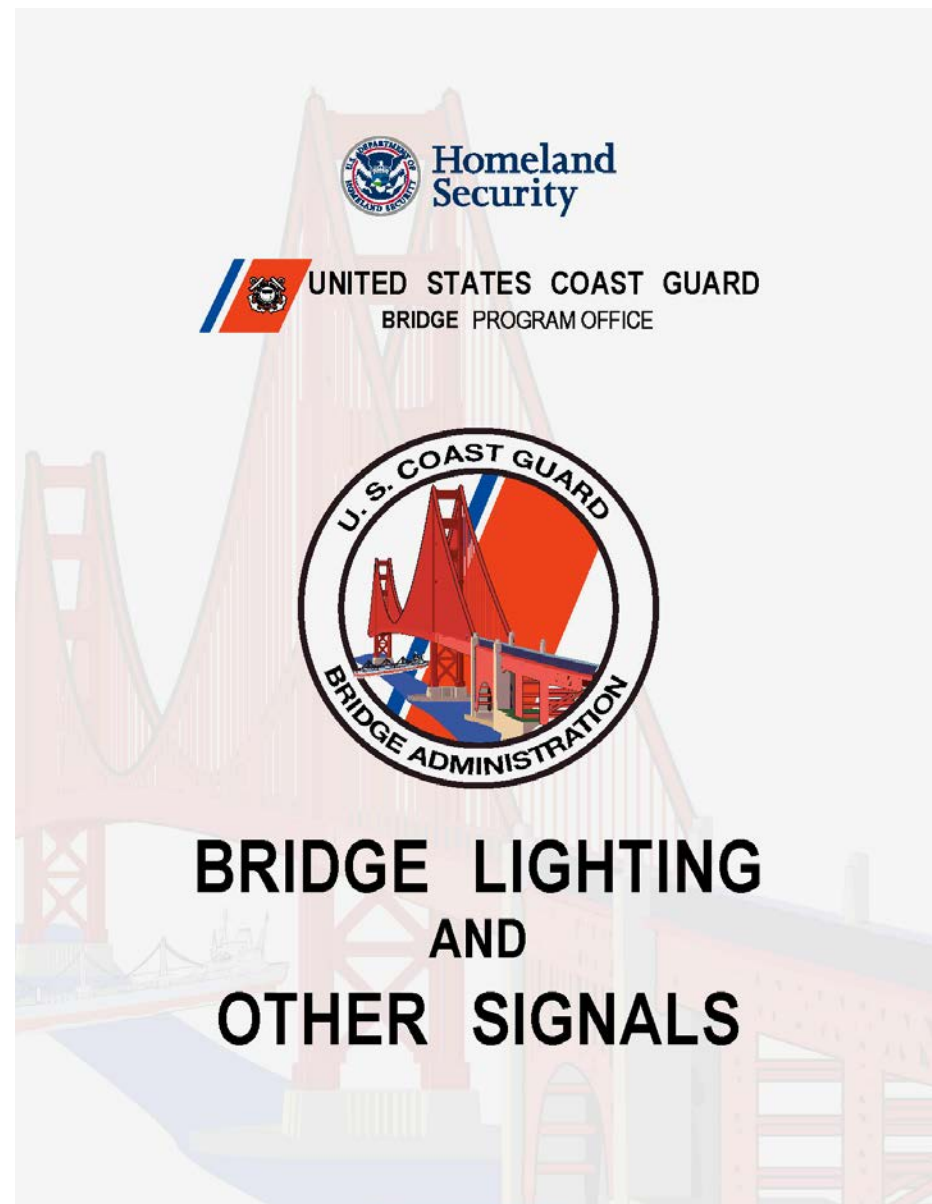


The United States Coast Guard is responsible for the safety, security, and environmental concerns of the nation's waterways. Specifically, they are responsible for:

- Maritime law enforcement
- Search & Rescue
- Port Security
- Environmental Stewardship
- Military Operations
- Marine Transportation
- Ice Operations

Specifically, to this course they are responsible for bridge and waterway lighting for navigation purposes.

- Navigation lights are often fed out of the same lighting control center that controls the bridge street lighting.

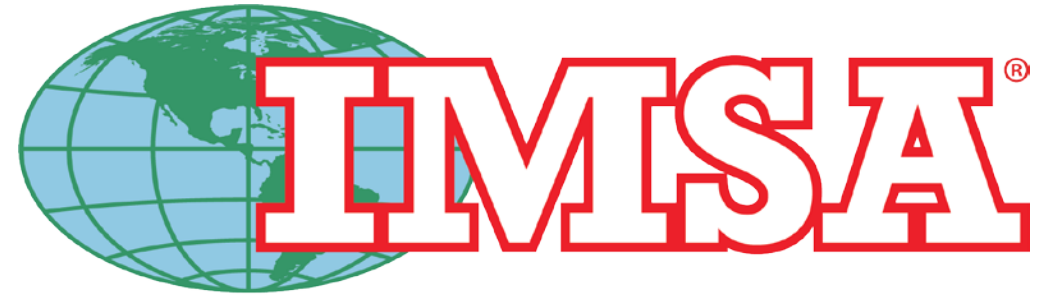


**BRIDGE LIGHTING
AND
OTHER SIGNALS**

IMSA offers several certification programs:

- Work Zone Traffic Control
- Traffic Signals
- Signs and Pavement Markings
- Roadway Lighting
- Fiber Optics

IMSA assists public agencies in lowering the likelihood of unnecessary legal action by increasing the quality of public safety personnel. It is the deep conviction of IMSA that a certification program is warranted in each area of these public safety operations.



Advancing the Future of Public Safety

IMSA Mission

Dedicated to providing quality certification programs for the safe installation, operation and maintenance of public safety systems; delivering value for members by providing the latest information and education in the industry.

When approached on the job site for public comment, please follow your jurisdictions policies and procedures for how to engage.

Respond:

- Professionally
- Non-committedly
- Carefully



IMSA Roadway Lighting Technician

Session 1: PPE, Safety and Utilities



Advancing the Future of Public Safety

Personal Protective Equipment (PPE) refers to specialized equipment and clothing worn by individuals to protect themselves from potential hazards and risks in the workplace or other environments.

The importance of Personal Protective Equipment can be summarized as follows:

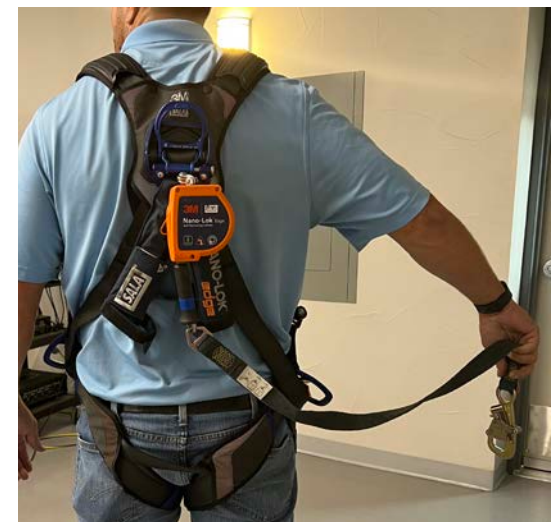
- Worker Safety
- Hazard Mitigation
- Legal and Regulatory Compliance
- Risk Reduction
- Confidence and Productivity
- Containment and Prevention of Hazard Spread
- Emergency Preparedness

Before beginning work or repairs, first make sure you have the appropriate Personal Protective Equipment.

Different PPE may be required for tasks with different voltages.

*PPE Examples:

- Hard hat
- High-Visibility Vest
- Face shield and or Eye Protection
- Insulated Gloves
- Die-electric Safety Boots
- Insulated tools
- Fall protection (Harness with lanyard)



****This is a sample list. Check your local jurisdiction and NEC standards.***

HEARING PROTECTION What Type is best for you?

PROS	Earmuffs	CONS
<ul style="list-style-type: none"> Good Protection Reusable Easy on/off Radio option allows you to listen to sports/music 		<ul style="list-style-type: none"> May not fit well over glasses Higher Initial price Facial hair may affect fit Uncomfortable in hot environments
PROS	Push-In Earplugs	CONS
<ul style="list-style-type: none"> Low Initial Price Reusable Easy on/off Use stem for quick and clean insertion 		<ul style="list-style-type: none"> Lower Protection Must have correct size Easy to loose Can become uncomfortable after long periods of time
PROS	Formable Earplugs	CONS
<ul style="list-style-type: none"> Good Protection Lowest Initial Price Comfortable Can be worn with Glasses and earrings 		<ul style="list-style-type: none"> Easy to loose Disposable More Time to insert Requires clean hands for insertion

Earplugs are cheaper than the hearing aids!

OSHA requires an employer to implement a hearing conversation program when noise exposure exceeds 85dBA as an 8-hour time-weighted average.

Choose the Hearing Protection That's Right for You

- *Canal caps – reduction of 25 dB*
- *Expandable foam plugs – reduction of 20-33 dB*
- *Pre-molded, reusable plugs – reduction up to 33dB*
- *Earmuffs – reduction of 25 - 30 dB*

Look for the NRR – Noise Reduction Rating

You can use a simple NRR de-rating formula:

$$(NRR - 7) / 2 = \text{approximant noise reduction level}$$

$$(33 - 7) / 2 = 13 \text{ dB of noise reduction}$$

Electrical safety gloves, also known as insulating gloves, are a critical piece of Personal Protective Equipment (PPE) for roadway lighting technicians and anyone working around energized electrical equipment. They protect the wearer from electrical shocks and burns by providing insulation from electrical current.

Electrical safety gloves are classified by the level of voltage protection they provide and are subject to strict standards. In the United States, these standards are set by the American Society for Testing and Materials (ASTM).

Here are the classifications:

- Class 00:** Max use voltage of 500 volts AC, 750 DC
- Class 0:** Max use voltage of 1,000 volts AC, 1500 DC
- Class 1:** Max use voltage of 7,500 volts AC, 11,250 DC
- Class 2:** Max use voltage of 17,000 volts AC, 25,500 DC
- Class 3:** Max use voltage of 26,500 volts AC, 39,750 DC
- Class 4:** Max use voltage of 36,000 volts AC, 54,000 DC

All rubber insulating gloves must be professionally tested and recertified semi-annually or quarterly.

- Every glove should be field tested before each use:**
 - Roll the cuff shut and inflate the glove with trapped air.
 - Check for any air leaks.
 - If leaking air is found, **DO NOT USE THE GLOVE!!!**



A fall arrest system consists of:

- A full body harness
- A shock absorbing lanyard or a self-retracting lifeline
- An anchorage point rated at 5,000 pounds

BUT you must consider the total distance of a free fall



<https://hsseworld.com/photo-of-the-day-8-basic-steps-to-wear-a-safety-harness/>

8 BASIC STEPS

To Wear Safety Harness



 <p>STEP-01</p> <p>Always Lift the harness with the help of Dorsal D-ring</p>	 <p>STEP-05</p> <p>Make sure to pass the excess straps through the loops. The loose ends of the strap may expose the wearer to unnecessary risks.</p>
 <p>STEP-02</p> <p>Slip the shoulder straps over both the shoulders. Allow the Dorsal D-ring to lie just between your shoulder-blades at the back</p>	 <p>STEP-06</p> <p>Make sure that the dorsal D-Ring is easily accessible to your hand.</p>
 <p>STEP-03</p> <p>Connect the Chest Strap</p>	 <p>STEP-07</p> <p>Finally, you may check the fit of the Harness by sliding your 4 fingers under the Thigh strap.</p>
 <p>STEP-04</p> <p>Pull the leg strap between the legs and connect to the opposite end using the special buckles. Repeat for the other leg. All other connections are made similarly</p>	 <p>STEP-08</p> <p>This ensures that although the Harness has fitted tightly, it still allows full range of m movement</p>

 Learn More at <https://hsseworld.com>

Considering the total distance of a free fall

- Length of the lanyard/self-retracting lifeline – 6' +/-
- OSHA's maximum deceleration distance – 3.5'
- Harness stretch – 1' +/-
- Height of worker - 6' +/-
- Distance to workers D-ring from feet – 5'
- Safety factor – 3'

Total fall distance = 18.5' +/-

Now consider what height you work at in a bucket truck?

- ***Are you going to hit the ground?***

You MUST consider all these criteria BEFORE assembling a fall arrest system





ANSI Z87.1: OSHA-Approved Safety Glasses

On every pair of safety glasses, you will see the marking "Z87+" or "Z87.1."
This marking on safety glasses validate that the eye protection has been tested to the ANSI Z87.1 standard.



Safety toe protective footwear must be worn at all times regardless of the presence of a hazard; and the safety toe protective footwear must meet the following requirements:

- leather uppers,
- oil resistant and non-skid soles, and
- American Society for Testing and Materials (ASTM) F2413-05 with an impact resistance rating.
- While working in the electrical industry, your safety work boots should have a dielectric sole (optional) for better protection against electric shock.

Performance Class Requirements:



Type 2 Class Vest

ANSI standards specify that the retroreflective material must have a reflectivity rating that allows the worker to be visible from at least **1,000 feet** (305 meters) when illuminated by vehicle headlights.

Class 2 Apparel: Suitable for workers in environments where traffic speed is **between 25 and 50 mph (40 to 80 km/h)** or in areas where greater visibility is required in complex backgrounds.

Class 2 vests provide a higher level of visibility through increased fluorescent background fabric and a **minimum of 201 square inches (0.13 meters²) of retroreflective material.**

Type 3 Class Vest

Class 3 Apparel: Required for high-risk work zones, such as areas with traffic moving **over 50 mph (80 km/h)** or environments where workers are close to high-speed vehicles, in low-light conditions, or against complex visual backgrounds. Class 3 garments provide the maximum visibility with additional fluorescent and retroreflective material, including long sleeves or full-body coverage for 360-degree visibility. A **minimum of 310 square inches (0.20 meters²) of retroreflective material** is required for Class 3 apparel.



OSHA requires that the chemical manufacturer, distributor, or importer provide **Safety Data Sheets** (SDSs) *(formerly MSDSs or Material Safety Data Sheets)* for each hazardous chemical to downstream users to communicate information on these hazards.

In 2003, the UN adopted the Globally Harmonized System of Classification & Labeling of Chemicals (GHS).

An internationally agreed upon system of standardized chemical hazard classification & communications.

SDSs offer safety information for chemicals you may use in your work environment. Technicians are required to maintain a file of SDS sheets for chemicals and hazardous substances that they use.



Safety Data Sheet California CARB Compliant

1 - Identification

Product Name: WD-40 Multi-Use Product Aerosol

Product Use: Lubricant, Penetrant, Drives Out Moisture, Removes and Protects Surfaces From Corrosion

Restrictions on Use: None identified

SDS Date Of Preparation: August 2, 2021

Manufacturer: WD-40 Company
Address: 9715 Businesspark Avenue
San Diego, California, USA
92131

Telephone:
Emergency: 1-888-324-7596
Information: 1-888-324-7596
Chemical Spills: 1-800-424-9300 (Chemtrec)
1-703-527-3887 (International Calls)

2 - Hazards Identification

Hazcom 2012/GHS Classification:

Flammable Aerosol Category 1

Gas Under Pressure: Compressed Gas

Aspiration Toxicity Category 1

Specific Target Organ Toxicity Single Exposure Category 3 (nervous system effects)

Note: This product is a consumer product and is labeled in accordance with the US Consumer Product Safety Commission regulations which take precedence over OSHA Hazard Communication labeling. The actual container label will not include the label elements below. The labeling below applies to industrial/professional products.

Label Elements:



DANGER!

Extremely Flammable Aerosol.

- In Canada, hazardous products are regulated by Canada's Hazardous Products Regulations (**HPR**), and Canada's national hazard communication standard, the Workplace Hazardous Materials Information System (**WHMIS**). These regulations are enforced through provincial or territorial government departments responsible for health and safety, or the federal labor program for federally regulated workplaces.
- In both Canada and the USA, the Globally Harmonized System (GHS) provides a standardized approach to classifying chemical substances and mixtures based on their inherent hazards.

SDS are called MSDS (Material Safety Data Sheet)

There are nine (9) categories of information that must be present on an MSDS in Canada. These categories are specified in the Controlled Products Regulations and include:

1 - **Product Information:** product identifier (name), manufacturer and suppliers' names, addresses, and emergency phone numbers

2 - **Hazardous Ingredients**

3 - **Physical Data**

4 - **Fire or Explosion Hazard Data**

5 - **Reactivity Data:** information on the chemical instability of a product and the substances it may react with

6 - **Toxicological Properties:** Health Effects

7 - **Preventive Measures**

8 - **First Aid Measures**

9 - **Preparation Information:** who is responsible for preparation and date of preparation of MSDS

Work zones are areas where roadwork takes place and usually involve lane closures, detours, or reduced speeds for safety purposes. They are marked by signs, traffic cones, barrier walls, and other safety devices. The type of work zone typically determines its duration, which can be found in the MUTCD.

Below are the types of work zones and their average durations:

1. **Long-term Stationary**: These are established work areas that **occupy a location more than 3 days**. In these zones, traffic patterns can be significantly affected for an extended period. These zones **can last several months to several years**. Examples include major highway construction or expansion, significant bridge reconstruction, or large-scale infrastructure improvements.
2. **Intermediate Stationary**: These zones are set up for work that occupies a location **more than one daylight period up to 3 days, or nighttime work lasting more than 1 hour**.
3. **Short-term Stationary**: These are established for **daytime work** that occupies a location **for more than 1 hour** within a single daylight period. Examples include minor road repairs, utility work, or tree trimming near the roadway.
4. **Short Duration**: This is work that occupies a location for **up to 1 hour**.

Please note that the durations provided above are general estimates and can vary significantly depending on the complexity of the project, unforeseen challenges, and other factors.
In many cases, work is done during off-peak hours or overnight to minimize disruption to traffic, so even for longer-term work zones, motorists may not encounter them at all times.

The Electrical Safety Foundation International (ESFI) uses the U.S. Bureau of Labor Statistics (BLS) Census of Fatal Occupational Injuries (CFOI) and Survey of Occupational Injuries (SOII) to distill information specifically pertaining to fatal and nonfatal occupational electrical injuries. Each year the ESFI publishes electrical injury information in tabular and graphical form on our website. The most recent data covers electrical injuries from 1992 – 2020 and fatalities from 2003 – 2020 but mainly focuses on 2011 – 2020 data.

Fatal Electrical Injuries

There were 126 electrical fatalities in 2020. A 24% decrease over 2019 and the lowest number of electrical fatalities recorded (recording started in 2003).

In 2020, 5.3% of all electrical incidents were fatal.

The number of electrical fatalities varies between ages

- 7% of electrical fatalities occurred in workers aged 20 – 24
- **33%** of electrical fatalities occurred in workers aged 25 – 34
- **21%** of electrical fatalities occurred in workers aged 34 – 44
- 18% of electrical fatalities occurred in workers aged 45 – 54
- 17% of electrical fatalities occurred in workers aged 55 – 64

Non-fatal Electrical Injuries

There were 2,220 non-fatal electrical injuries involving days away from work. This was a 17% increase over 2019 and a return to the same levels as 2017.

Age of worker involved in non-fatal electrical injury:

- 16 – 19 years old: 2%
- 20 – 24 years old: 22%
- 25 – 34 years old: 24%
- 35 – 44 years old: 22%
- 45 – 54 years old: 16%
- 55 – 64 years old: 7%
- 65 years and over: 1%

Length of service with employer when injury occurred:

- Less than 3 Months: 26%
- 3 Months to 11 Months: 10%
- 1 year to 5 Years: 32%
- More Than 5 Years: 31%

“*Look up and live*” is a saying for a reason:

- Overhead power lines can be deadly; therefore, care must be taken when working near these lines.
- OSHA mandates that you **MUST maintain a MINIMUM of 10 foot of clearance** from overhead power lines (table “A”)

<https://www.osha.gov/laws-regs/regulations/standardnumber/1926/1926.1408>

Understand how power poles are constructed:

- The highest voltage lines will be at the top of the pole
- Potential voltages on lines reduce as you come down the pole
- Communications lines will be the lowest lines on the pole, if present
- Look for “*risers*” on poles as overhead utilities may transition to become underground utilities



The regulation of clearance from overhead power lines in Canada involves a combination of national, provincial/territorial, and utility-specific oversight.

Here's a breakdown:

- The **CEC (CSA C22.1)** provides fundamental safety standards for electrical installations, including clearances. It establishes minimum requirements to prevent electrical hazards.
- **Provincial/Territorial Authorities:**
 - Each province and territory is responsible for adopting and enforcing the CEC. They may also introduce their own supplementary regulations or amendments to address local conditions.
 - Electrical utility companies often have their own internal standards and requirements that contractors and others must follow when working near their infrastructure. These standards may exceed the minimum requirements set out in the CEC and provincial/territorial regulations.
 - Provincial and territorial occupational health and safety regulations, such as those enforced by WorkSafe BC in British Columbia, also play a crucial role.



As a Roadway Lighting Technician, you may be required to locate underground wiring before others dig.

Before excavation, 811 must be contacted.

Most State laws defines excavation as “any operation in which earth is moved or removed by means of any tools, equipment, or explosives and includes auguring, backfilling, boring, ditching, drilling, grading, plowing-in, pulling-in, ripping, scraping, trenching, hydro excavating, post holing, and tunneling”.

Safety – Underground Utilities

1 - 18

When digging or excavating is required there is potential for hazard. Hazard to yourself, and in exposing or damaging underground utilities. It is necessary to call or contact the utility locating service in your area. The locate identification colors are as follows:

Locate Color	Utility
Red	Electric Power Lines
Yellow	Natural Gas, Steam, Petroleum, & Oil Lines
Blue	Potable Water Lines
Green	Sanitary Sewer & Storm Drain Lines
Orange	Communications Lines - Phone, Cable TV, Fiber Optic
Pink	Temporary Surveying Markings
Purple	Chilled Water, Reclaimed Water, Irrigation & Slurry Lines
White	Proposed Excavation
Not Specified	Military & Private Underground Facilities



**SAFETY IS IN YOUR HANDS.
EVERY DIG. EVERY TIME.**

The 811 Logo is a registered trademark of the Common Ground Alliance.



- In Canada, the "Call Before You Dig" process is handled through provincial one-call centers, like Ontario One Call or BC 1 Call, Alberta First Call...
- These centers act as a communication link between individuals planning to dig and the owners of underground infrastructure.
- When you call or click to request a locate, the one-call center notifies the relevant utility companies, who then locate and mark their underground lines on your property.

Here's a more detailed breakdown:

1. Contact the One-Call Center:

In most provinces, you can either call 811 or visit the one-call center's website to submit a locate request. Visit www.clickbeforeyoudig.com to find information on the notification service in your area.

2. Provide Project Details:

You'll need to provide information about your digging project, such as the location, the type of work, and the depth of excavation.

3. Notification:

The one-call center notifies the relevant utility companies (e.g., gas, electricity, water, telecommunications) about your planned dig.

4. Locating and Marking:

The utility companies then send out locators to mark the approximate location of their underground infrastructure with paint or flags.

5. Safe Digging:

Once the utilities are marked, you can dig safely, respecting the marked areas.

Key points to remember:

- **It's free and the law:** In many jurisdictions, it's required by law to contact the one-call center before any digging.
- **Allow sufficient time:** Give the one-call center and the utility companies ample time to respond, typically a few business days.
- **Respect the marks:** Carefully dig around the marked areas to avoid damaging underground utilities.

True or False:

Safety toe protective footwear only needs to be worn when a hazard is present?

What color paint should you mark proposed excavations with?

- A) Yellow
- B) Green
- C) White
- D) Black

Red Utility Markings represent what?

- A) Proposed Excavation
- B) Electric
- C) Communication
- D) Water
- E) Gas

Blue Utility Markings represent what?

- A) Proposed Excavation
- B) Electric
- C) Communication
- D) Water
- E) Gas

Orange Utility Markings represent what?

- A) Proposed Excavation
- B) Electric
- C) Communication
- D) Water
- E) Gas

Yellow Utility Markings represent what?

- A) Proposed Excavation
- B) Electric
- C) Communication
- D) Water
- E) Gas

What documentation does OSHA require for each hazardous chemical in the workplace?

- A) Safety Data Sheet (SDS)
- B) Safety Alignment Sheet (SAS)
- C) Manual on Controlled Chemicals Sheet (MCCS)
- D) Chemical Hazardous Sheet (CHS)

True or False:

If a utility marking is absent, it means the site is safe for excavation.

True or False:

Different PPE may be required for tasks with different voltages.

IMSA Roadway Lighting Technician

Session 2: Tools and Equipment



Advancing the Future of Public Safety

Wire Strippers & Cutters



Wire strippers and cutters are essential tools for electrical work. They are used to remove the insulation from wires, make clean cuts, and prepare the cables for proper connections during installation or repairs.

These may be part of a **Dielectric (Insulated) Tool Set** that includes screwdrivers, pliers, and other tools with insulated handles. They are designed to protect the user from electric shock when working with live circuits or components.

- Make sure you know what voltage the insulated tools are rated for.
- Inspect the insulated handles for any cracks, cuts, nicks, or damage that may compromise electrical safety.



Cable Crimping Tool



A cable crimping tool is used to create secure and reliable connections between wires and connectors per the manufacture's recommendations. It compresses the metal terminal onto the cable, ensuring a tight and durable connection.



A digital or analog multimeter is a versatile tool used for electrical troubleshooting and maintenance. It can measure voltage, current, and resistance, allowing technicians to test and diagnose electrical issues in roadway lighting systems.

When using a multimeter for troubleshooting, you can measure the following:

- AC and DC voltages \tilde{V} and $\overline{\overline{V}}$
- Fuse and wire continuity
- Transformer primary (only qualified persons) and secondary voltages
- Diode and Transistor lead voltages (meter dependent)
- Integrated Circuit supply pin voltages
- Component resistance





To use a multimeter, you need to turn it on and select the mode you want to use,

- connect one meter lead to the circuit you want to test,
 - touch the other lead to opposite end of circuit, and
 - read the display on the multimeter.
-
- Voltage measured in a **DC circuit** is dependent on positive (+ **Red**) and negative (- **Black**) polarities.
 - Therefore, it is important to match the meter leads to the positive and negative terminals of a DC power source to get a correct reading.
 - Voltage measured in an **AC circuit** is not as dependent on polarities since the current constantly changes direction.

Testing of the Multimeter accuracy is ideal before each use.

Always exercise caution and follow safety procedures when working with cables, especially if they are connected to live power sources.



Continuity testing of Multimeter:

- Set your multimeter to the proper continuity or resistance mode. **Damage to your meter could result if incorrect.** The exact setting may vary depending on the model of your multimeter.
- Connect one probe of the multimeter to the item to be tested.
- Connect the other probe to the opposite end of the item.
- Observe the multimeter reading. If the item tested is continuous and intact, the multimeter will typically emit a beep sound or display a low resistance reading (close to zero ohms). This indicates that there is a complete electrical path between the two ends of the item.

Testing of the Multimeter accuracy is ideal before each use.

Always exercise caution and follow safety procedures when working with cables, especially if they are connected to live power sources.



A light meter is a sensitive electronic device that measures the intensity of light or illumination of a given area. It is used to assess and monitor the illumination levels and uniformity of roadway lighting, ensuring compliance with standards and regulations.

The housing protects the actual light **sensor** inside the light meter. The sensor can be built-in or an external attachment. Most light meters can measure brightness in lux (lx), foot candle (fc) or candela per square meter (cd/m^2) units. Some light meter devices are equipped with an internal memory or data logger to record and save measurements.

<http://highways.dot.gov/safety/other/visibility/nighttime-visibility>

“Adequately maintained retroreflective signs, pavement markings, and **roadway lighting** improve nighttime highway visibility and reduce the risk of crashes by increasing visibility for drivers and other roadway users.”

“Adequate lighting (i.e., at or above minimum acceptable standards) is based on research recommending horizontal and vertical illuminance levels to provide safety benefits to all users of the roadway environment.”

Insulation resistance testers (Megohmmeters or “meggers”) are used to check the integrity of and measure the electrical resistance of different insulators of electrical cables and connections. It helps identify any faults or weaknesses in the wiring of roadway lighting circuits.

NEVER meg a conductor that is connected in a circuit with any equipment attached.

When using a megger:

- Connect the Megger to the conductor you want to test.
- Connect one lead to the conductor and the other lead to ground.
- Turn on the megger and select the lowest voltage possible. You can always increase the voltage if you do not get the proper readings.
- A reading of “**infinity**” indicates good conductor insulation.
- A reading of “**zero**” indicates a direct short to ground through the insulation.
- A reading of some megohm value **in between zero and infinity** indicates a compromised conductor insulation.



A bucket truck, also known as an aerial work platform or cherry picker, is a vehicle equipped with a hydraulic lift that allows workers to reach elevated areas safely. It is commonly used for installing or repairing overhead lighting fixtures on poles.

The most effective way of communication between the technician and equipment operator is through hand signals.

Make sure you conduct a pre-trip inspection of the vehicle per the manufacturer's recommendations and CDL as appropriate to include all fluid levels, tires, lighting, vehicle accessories, boom and bucket inspection, and stowing mechanisms before each shift. Document and report any defects, damage, or irregularities according to your agency's procedures, which may include removing the vehicle from service.



Digger Derrick



A digger derrick is a specialized type of truck-mounted equipment commonly used in construction, utility, and telecommunications industries. It combines the functionalities of a digger, a crane, and an auger to perform various tasks related to digging, lifting, and setting utility poles, as well as other similar applications.

A pre-trip inspection is required for this vehicle as well.

What is one critical component to check during a bucket truck's pre-trip inspection?

- A) Fluid levels
- B) Radio functionality
- C) Interior upholstery
- D) Paint condition

A Light Meter Measures?

- A) Voltage
- B) Color of light
- C) Temperature of light
- D) Intensity of light or Illumination

What Vehicle is equipped with a hydraulic lift that allows workers to reach elevated areas?

- A) Forklift
- B) Service Truck
- C) Bucket Truck
- D) Utility Truck
- E) Digger Derrick

True or False:

Wire Strippers and cutters are not essential tools for electrical work?

True or False:

A Digger Derrick combines the functionalities of a crane, digger, and auger

True or False:

Fleet vehicle inspections should take place before each shift.

IMSA Roadway Lighting Technician

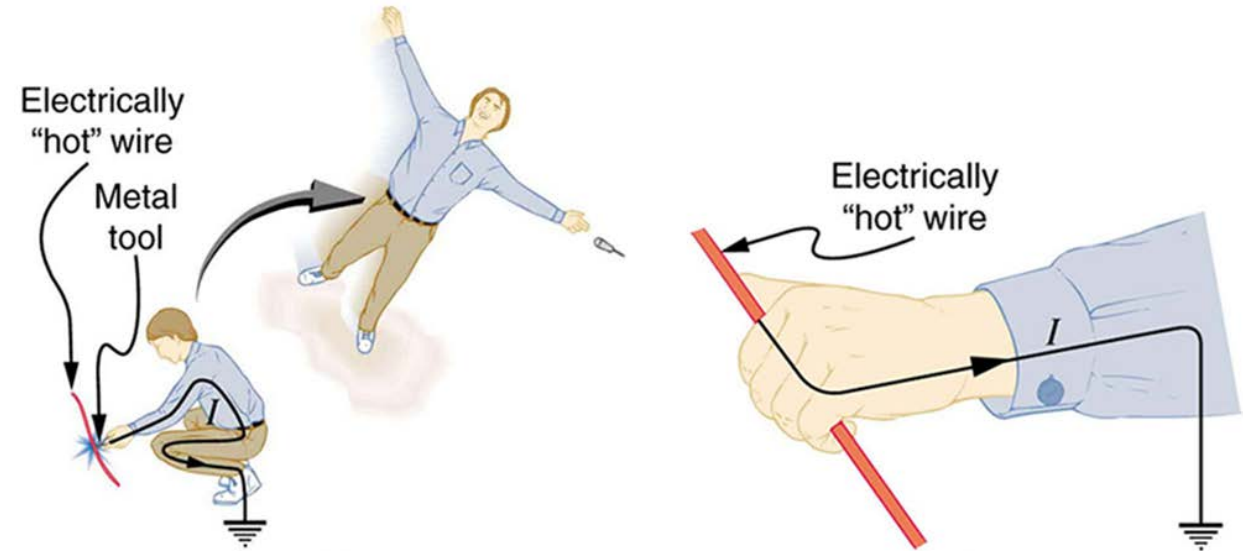
Session 3: Basic Electrical Theory



Advancing the Future of Public Safety

Electricity is Dangerous!!!

- Roadway Lighting technicians may be required to work on components or wiring while energized or “hot”.
- Using insulated tools, non-conductive tools and wearing gloves can reduce the chances of getting shocked by isolating you from the circuit.
- Also, your freehand should not be touching the pole, cabinets, or any other grounded device.



Don't Complete the Circuit!

What can happen if electrical safety isn't followed and power is not turned off?

An Arc Flash is an electrical explosion with a tremendous amount of pressure and heat.

Always disconnect the power before working on fuses or breakers!

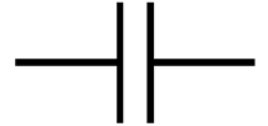


Occupational Safety and Health Administration (OSHA), U.S. Department of Labor. "Electric-Arc Flash Hazards".
Published on OSHA website, embed at: <https://www.youtube.com/watch?v=GyNqmcqKZ-8>.
Public domain (U.S. government work), with some third-party testing footage courtesy of
KEMA Laboratories & Partnership for Electrical Safety.

Common Schematic Symbols



- **Diode**



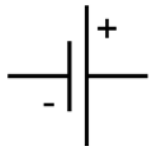
- **Capacitor**



- **Inductor**



- **Resistor**



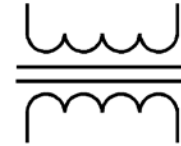
- **DC voltage source**



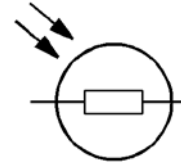
- **AC voltage source**



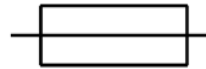
- **Ballast**



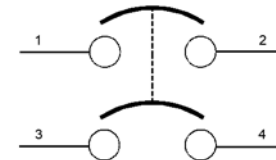
- **Transformer**



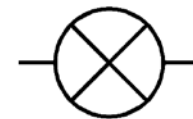
- **Photocell**



- **Fuse**



- **2-Pole Breaker**



- **Bulb/Lamp**

A **Conductor** is a material that allows the free flow of electrons with very little resistance.

- It is defined as an element having a valence shell that has one to three electrons
- Good conductors are Gold, Silver, **Copper**, Aluminum, Nickel, Mercury, and Zinc

An **Insulator** is a material that has a high resistance and does not allow for the free flow of electrons

- It is defined as an element having a valence shell that has five to eight electrons
- Good insulators are dry air, glass, dry wood, porcelain, rubber, Bakelite, and PVC

Understanding electricity

Electricity flowing through wires (conductors) is similar as water flowing through pipes.

- **Voltage** is like Water Pressure
- **Current** is like the amount of water flowing at that moment
 - **Resistance** is like the size of the pipe
- **Power** is the amount of water consumed and the amount of time it took to consume it

Voltage (E) – The amount of electrical pressure in a circuit as measured in Volts.

Current (I) – The amount of electrical flow in a circuit as measured in Amps.

Resistance (R) – The opposition to current flow as measured in Ohms.

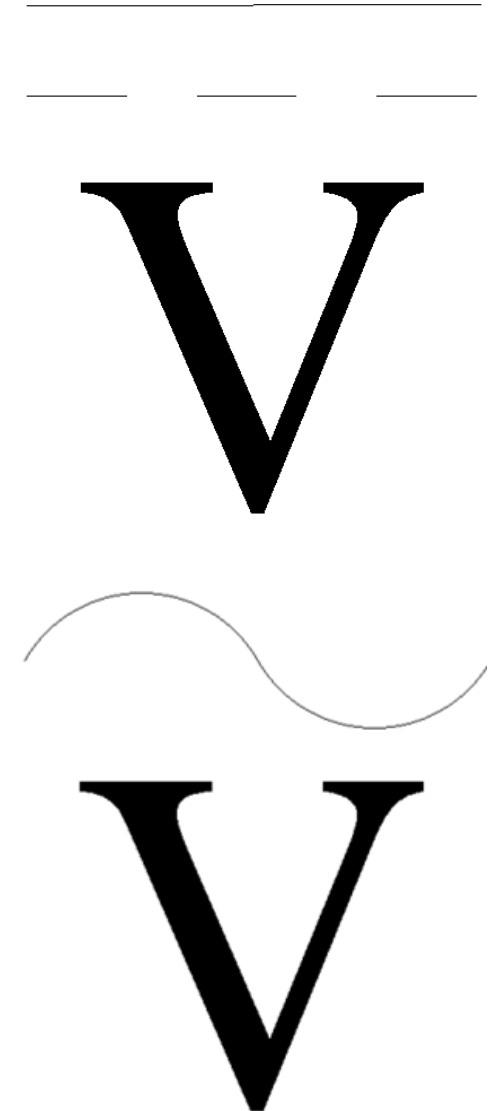
Power (P) – The amount of electrical energy in a circuit as measured in Watts.

DC – Direct Current

Direct Current is produced by batteries or power supplies and only travels in one direction. Electronic circuits and control devices typically run on DC. Typical voltages used in electronic devices are 3-5 VDC, 12 VDC, and 24 VDC.

AC – Alternating Current

Alternating current is the type of electricity that powers our homes, businesses, factories, and our Roadway Lighting. It is generated by various types of generators and distributed through the power grid. Typical voltages are 120/240 VAC, 208 VAC, and 277/480 VAC. AC current in North America alternates at 60 cycles per second and is measured in Hertz.



Current – DC and AC currents are very different.

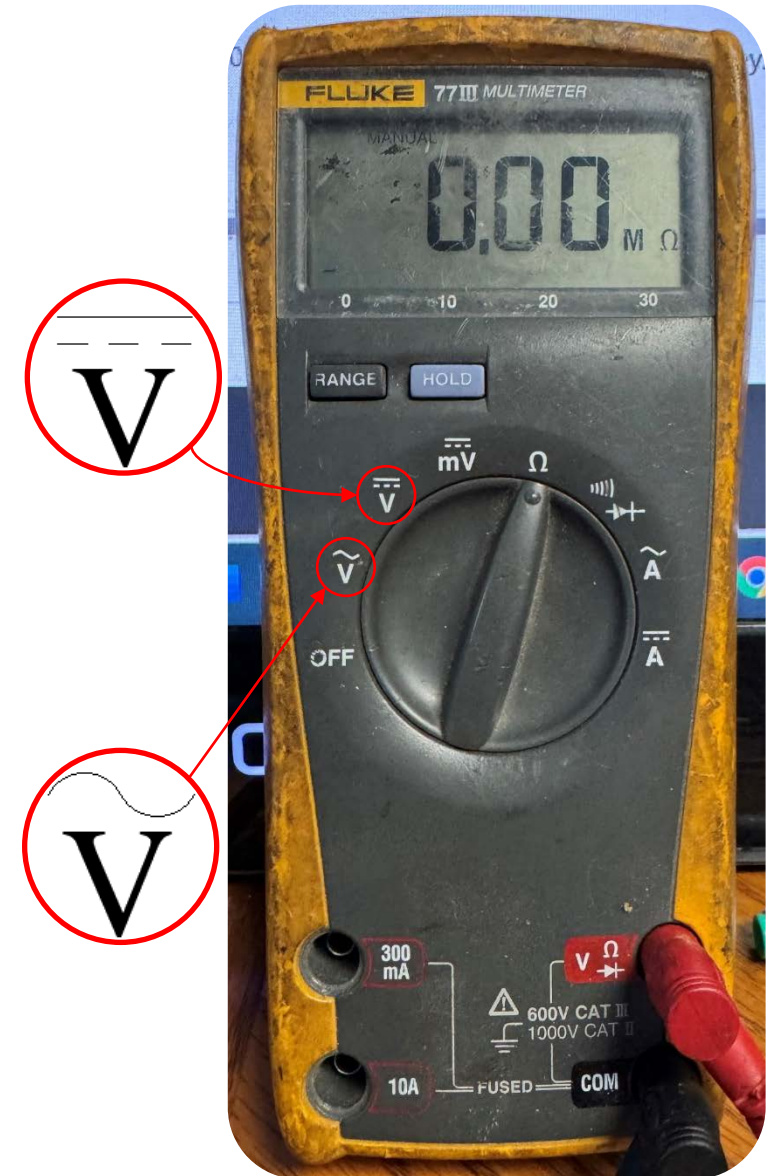
- **DC current** from the source (such as a battery) is constant and only flows in one direction; hence "Direct Current"
 - Current flows from the positive pole (**red**) to the negative pole (black)
- **AC current** from the source constantly varies and flows back and forth in two directions; hence "Alternating Current"
- The byproduct of any current flowing in a circuit is *heat*.



Voltage is the electrical pressure behind moving current in a circuit.

Because DC and AC currents are so different, so too are the voltages with respect to polarities.

- Voltage measured in a **DC circuit** is dependent on positive (**Red**) and negative (**Black**) polarities.
 - Therefore, it is important to match the meter leads to the positive and negative terminals of a DC power source to get the correct reading.
- Voltage measured in an **AC circuit** is not as dependent on polarities since the current constantly changes direction.
 - However, to maintain the idea of positive and negative in a circuit, the **red** lead is used on the positive side of the circuit (**black conductor**), and the **black** lead is used on the negative side of the circuit (**white conductor**).



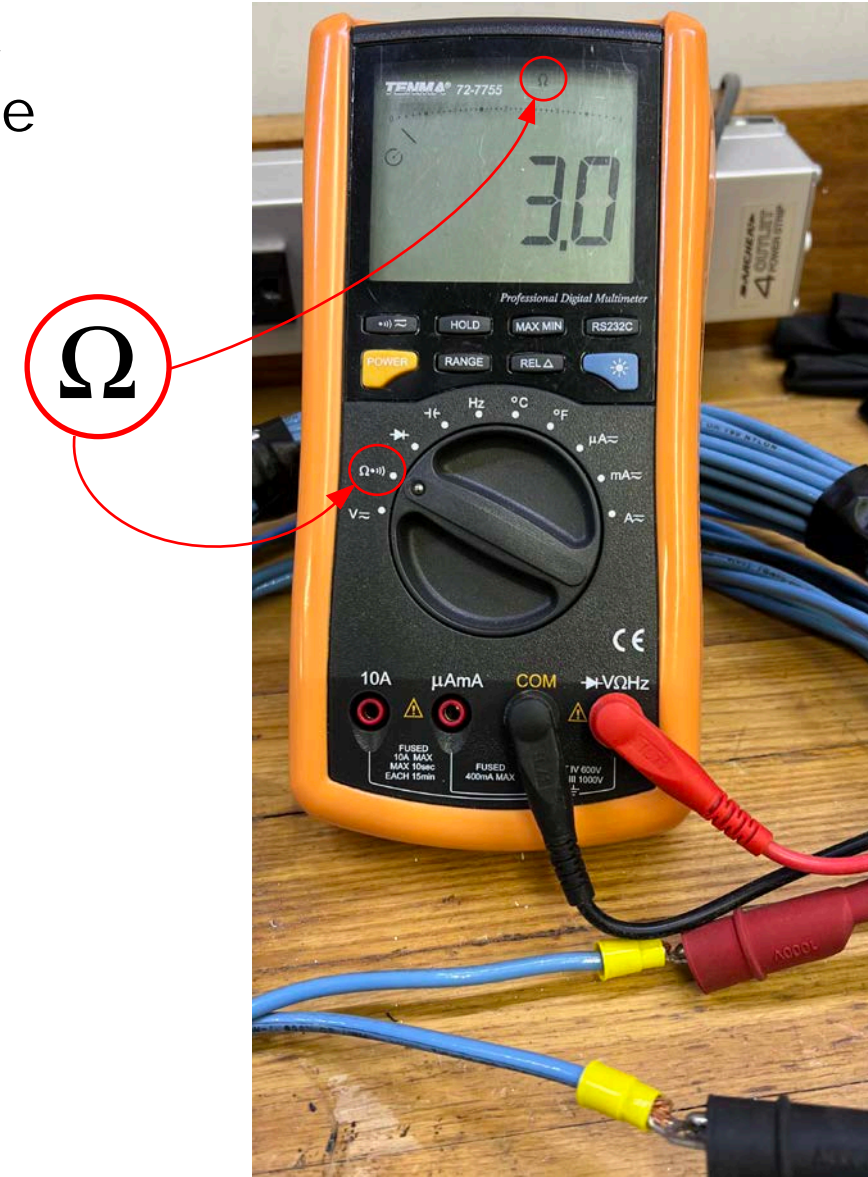
Resistance is the opposition to current flow in a DC circuit and is measured in Ohms, symbolized with the Omega symbol (Ω) and identified by the letter "R".

Resistance is a product of:

- The Voltage on a circuit
- Type of conductive material
- Length of the conductor
- Cross-sectional area of the conductor
- Amount of load on the circuit

The byproduct of resistance is heat, which adds to the opposition of current flow

Impedance is the opposition to current flow in AC circuits. It too is measured in ohms (Ω) and is identified with the letter "Z".



Fuses are overcurrent protection devices used in electrical circuits.

- Overcurrent is a result of a *short circuit* – an unintended path to ground or too much load on a circuit.
- Both situations cause an excessive amount of heat within the circuit

Fuses cannot interfere with the normal operation of a circuit but must sense when something is electrically wrong with a circuit to protect it from damage.

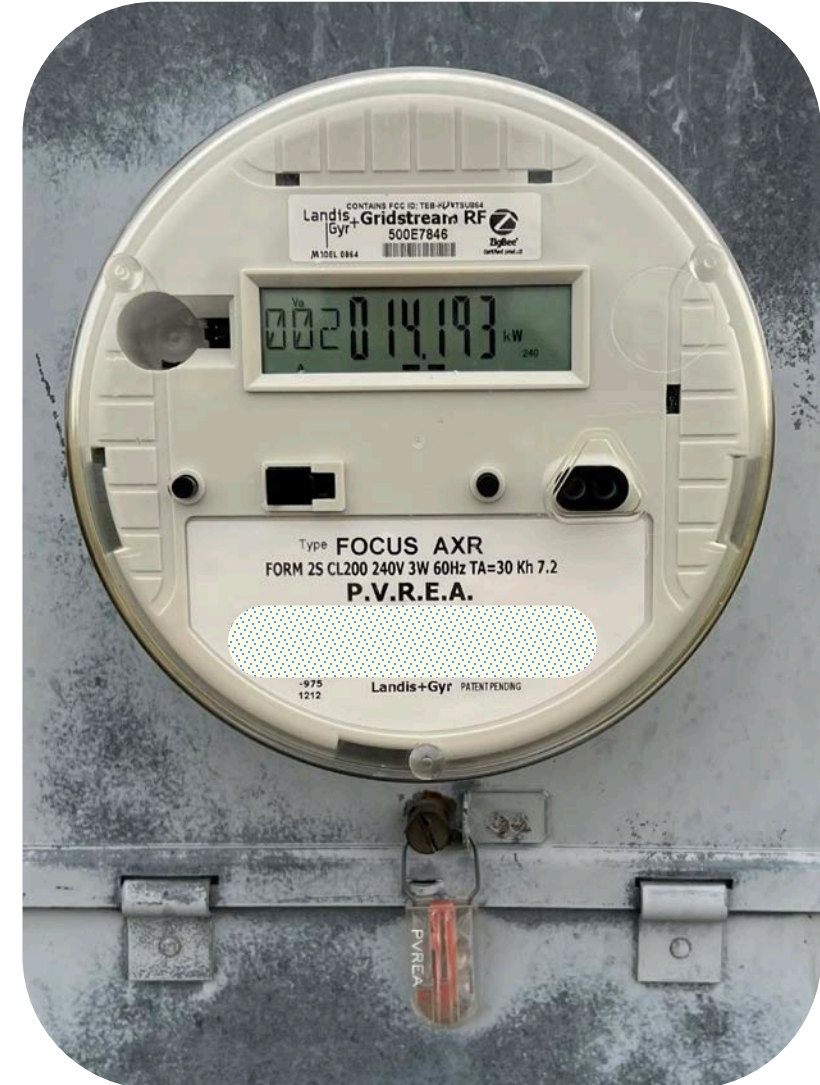
- Fuses are made with a soft metal element connected to two metal terminals, which offers very little resistance and has a low melting point
- Fuses function because of the I^2R heating effect. Excessive current creates a lot of heat, which melts the fuse element, thereby opening the circuit.



Cartridge and Blade fuses

Power is the amount of electrical energy consumed by a circuit.

- In other words, how much work was accomplished and how much energy did it take?
- Power is a product of Voltage x Current and is measured in Watts
- Power must be calculated by measuring the voltage times the current or measured with a watt meter
- ***Everything in the electrical world is based on power***



Ohm's Law

$$E = I \times R$$

$$I = E / R$$

$$R = E / I$$

Power Formulas

$$P = I \times E$$

$$I = P / E$$

$$E = P / I$$

There are multiple voltages typically used in streetlight circuits; **120/240 VAC, 208 VAC, 277/480 VAC.**

If impedance goes up, current & voltage goes down.

If impedance goes down, current & voltage goes up.

The amount of **power consumed** by a circuit is a function of **Voltage** times **Current (ExI)**.

All electrical equipment and circuits are based on how much power will be consumed.

Ohm's Law

$$E = I \times R$$

$$I = E / R$$

$$R = E / I$$

Power Formulas

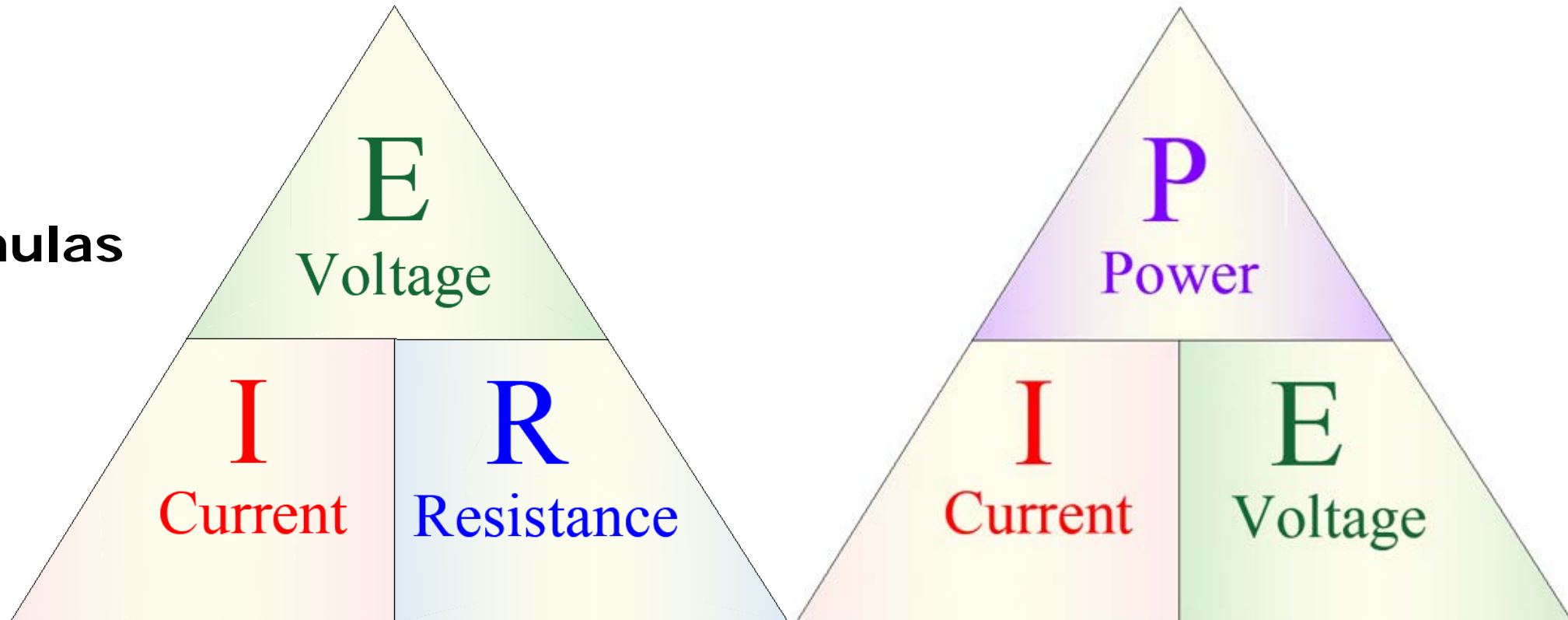
$$P = I \times E$$

$$I = P / E$$

$$E = P / I$$

A good method for keeping the Ohm's Law and power formulas straight is to use the diagrams below:

- Cover up the value you're looking for
- What's left over is the formula you use to find your answer



In a Series circuit current only has one path to follow.

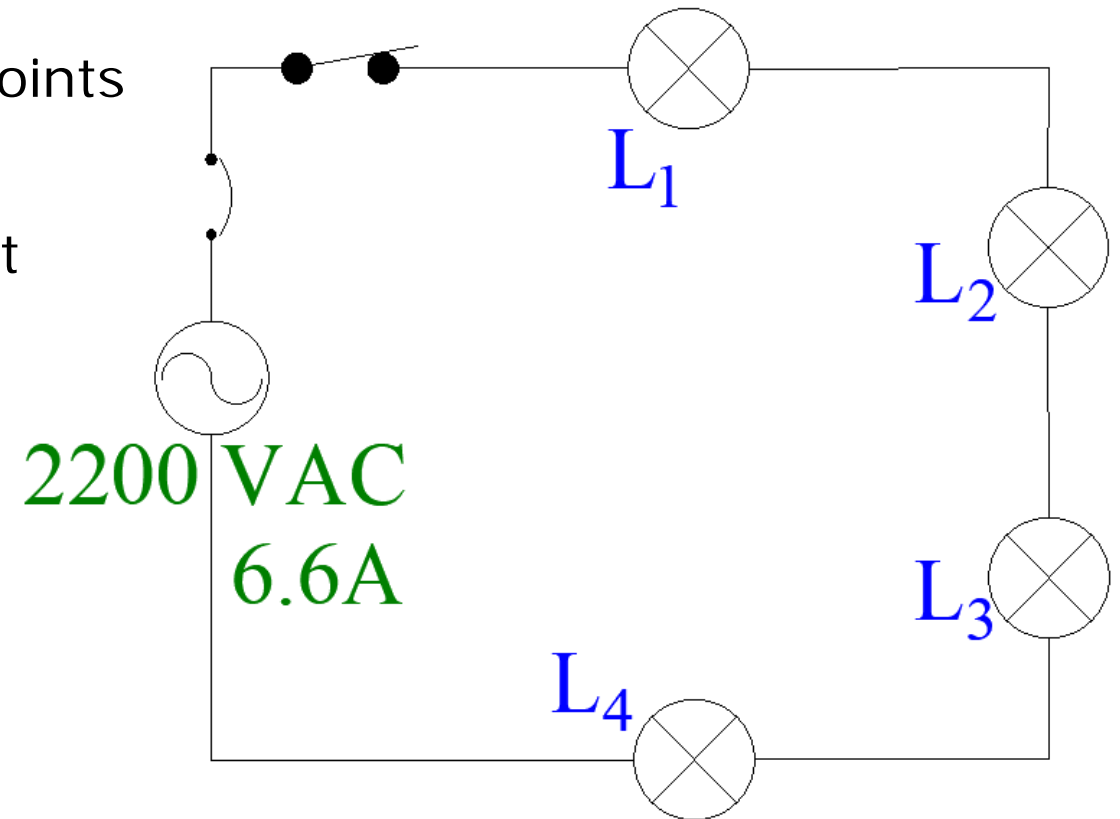
Therefore, the current remains constant at all points within the circuit.

Voltage drops across each load in a series circuit

Think about a string of Christmas tree lights;
If one lamp burns out the entire string of lamps
will be out.

There are still some series streetlight circuits
operating in the United States.

EXTREME CAUTION must be used if you ever
encounter a series streetlight system due to the high
voltage used.



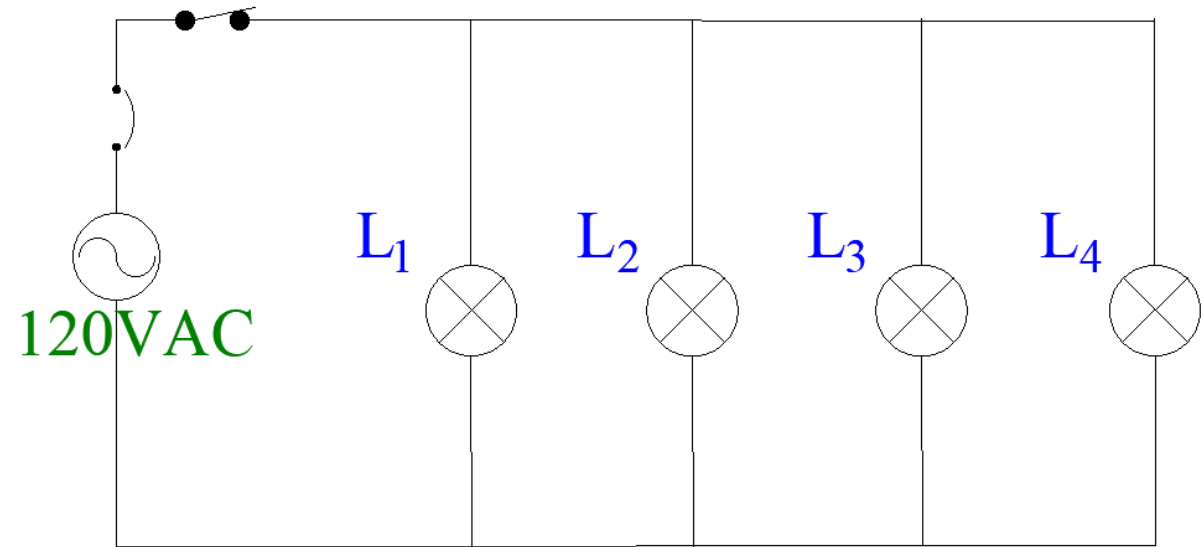
Series Connection

In a Parallel circuit current drops across each branch of the circuit

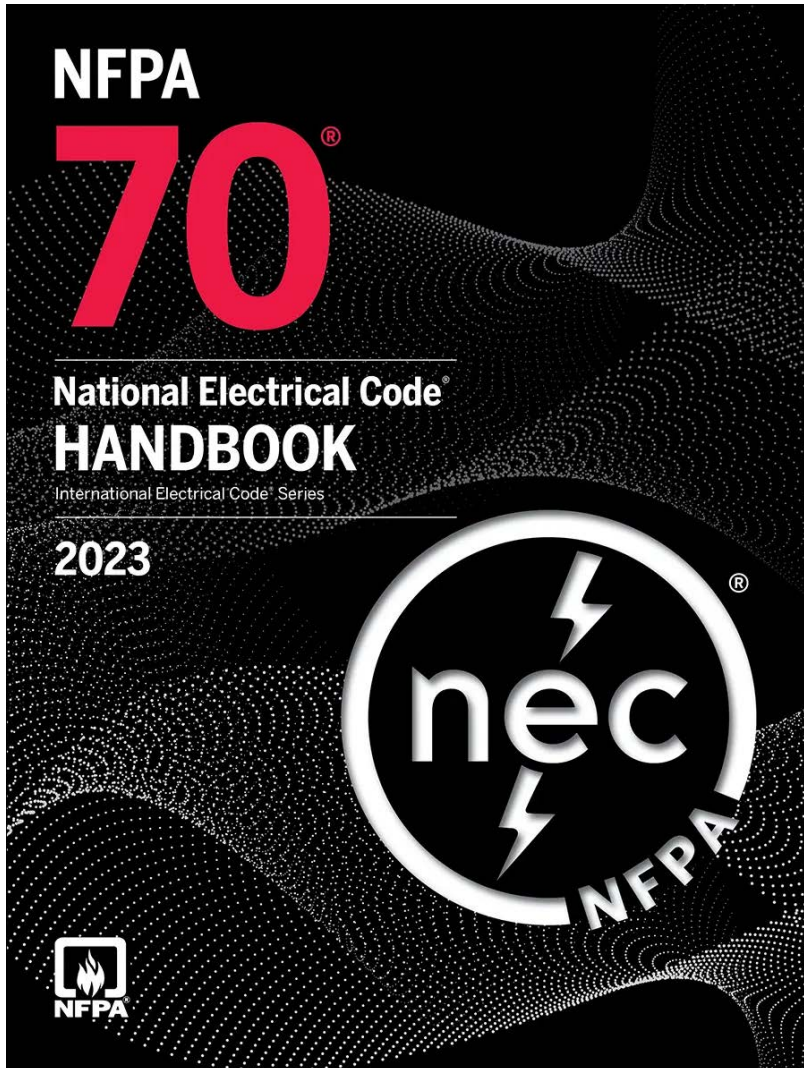
Voltage on the other hand remains constant at all points within the circuit.

- Each branch is connected directly to the power source

Think about the string of Christmas lights you put on the outside of the house; If one lamp burns out the entire string of lamps will continue to operate minus the bad lamp.



Parallel Connection



Grounding and Bonding

Section 250.4 of the NEC states the general requirements for grounding and bonding of electrical systems for both grounded and ungrounded systems.

For grounded systems, the NEC requires you to perform all of the following: electrical system grounding, electrical equipment grounding, electrical equipment bonding, and bonding of electrically conductive materials.

In ungrounded systems, the same actions are required except for electrical system grounding. When these NEC requirements are implemented, an **effective ground-fault current path** (EGFCP) is created, which is your desired end goal.

The EGFCP helps operate devices such as circuit breakers and fuses or ground-fault detectors in ungrounded systems.

Grounding and bonding are fundamental aspects of electrical safety in Canada, and they are meticulously addressed within the **Canadian Electrical Code (CEC) Section 10**.

This section is dedicated to grounding and bonding requirements. It provides detailed rules and guidelines for ensuring safe electrical installations. It defines essential terminology and outlines the objectives of grounding and bonding.

Here's a breakdown of the key requirements:

Grounding:

This involves connecting electrical systems and equipment to the earth, providing a path for fault currents to safely dissipate. The purpose is to minimize the risk of electrical shock and prevent damage to equipment.

Bonding:

This involves connecting conductive parts of electrical systems and equipment together to create an electrically continuous path. The goal is to equalize electrical potential, reducing the risk of voltage differences that could cause electrical shock.

Grounding

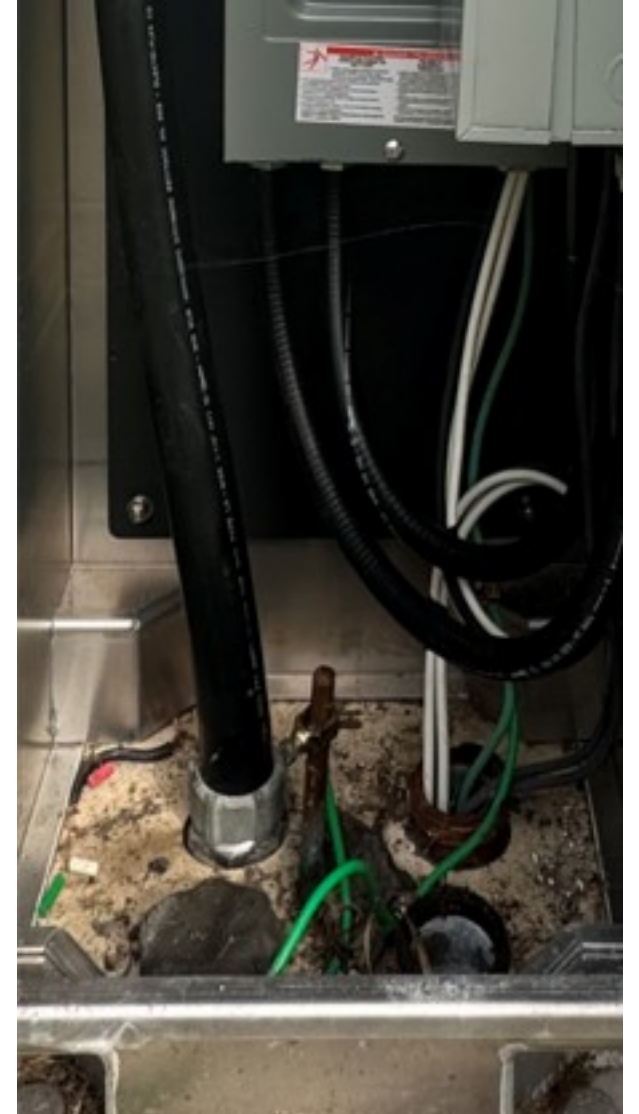
The NEC defines ground as “the earth.” Grounding is a conductive connection, intentional or accidental, between a circuit or electrical equipment and the ground or some conductive object acting as the ground. In an airplane, for example, the fuselage acts as the ground.



Grounding

Per NEC Section 250, the resistance/impedance to ground should be less than 25 ohms*, as measured with a multimeter.

- Additional ground rods are required if the resistance is greater.
- Per the NEC, only one grounding conductor is allowed under a single ground rod clamp
- Additional grounding conductors may be bonded together



Bonding

Article 100 of the NEC defines bonded (bonding) as “connected to establish electrical continuity and conductivity.”

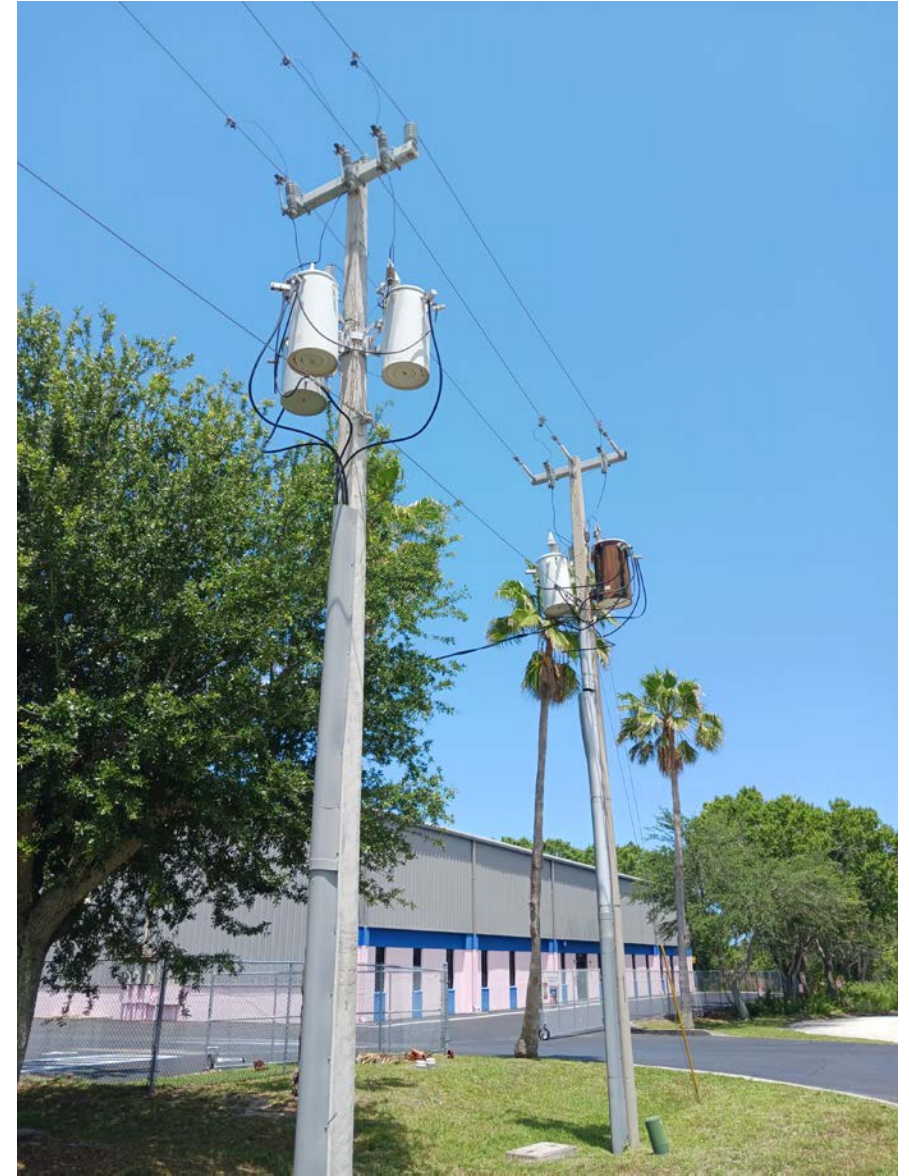
Bonding metal parts, such as enclosures and raceways, ensures that they are all continuous on an **effective ground-fault current path** (EGFCP) that references back to ground (earth).

The EGFCP helps operate devices such as circuit breakers and fuses or ground-fault detectors in ungrounded systems.

In grounded systems, it is important to bond the equipment grounding conductors to the system grounded conductor to complete the EGFCP back to the source of electricity. The conductivity of the EGFCP is critical for protective devices to work properly. This speaks to why we scrape the paint from contact surfaces of metallic enclosures to make our electrical system bonding connections. Removing the paint, as required in Section 250.12, provides for a better connection and conductivity path.

Voltage drop is a common phenomenon that occurs in electrical systems, including roadway lighting. When electrical current flows through a conductor, there is a natural resistance to the flow of electricity, causing a drop in voltage along the length of the conductor.

Generally, the longer the cable and the smaller the circular mil area, the greater the voltage drop. Hence, voltage drop is particularly a problem with long cable runs found in larger buildings, farms, transmission and distribution lines, and of course, roadway lighting.



Voltage Drop can occur in roadway lighting systems due to several factors:

Cable Length: The longer the cable length between the power source and the roadway lights, the greater the voltage drop. This is because the resistance of the cable increases with length.

Cable Size: The circular mil area (CMA) of the conductor used in the system also affects voltage drop. Smaller circular mil conductors have higher resistance and, therefore, result in greater voltage drop compared to larger circular mil conductors.

Load: The electrical load connected to the roadway lighting system affects voltage drop. If the load is heavy or there are multiple lights connected, it can lead to a higher voltage drop.

Type of Conductor: The material of the conductor can impact voltage drop. Different materials have different resistivities, and conductors with higher resistivities will result in more significant voltage drops.

Connections: Poorly made or loose connections in the roadway lighting system can contribute to voltage drop. Loose connections have higher resistance, leading to higher voltage drop.

Voltage drop can have various consequences for roadway lighting systems, including reduced light output and increased power consumption. Insufficient voltage reaching the lights can result in dimmer illumination and decreased visibility. It can also lead to premature failure of the lighting fixtures and increased maintenance costs.

To mitigate Voltage Drop in roadway lighting, several measures can be taken:

Proper Cable Sizing: Using conductors with larger circular mil areas will reduce resistance and minimize voltage drop in longer runs.

Voltage Regulation: Implementing voltage regulation devices, such as voltage regulators or stabilizers, can help maintain a stable voltage level, compensating for voltage drop.

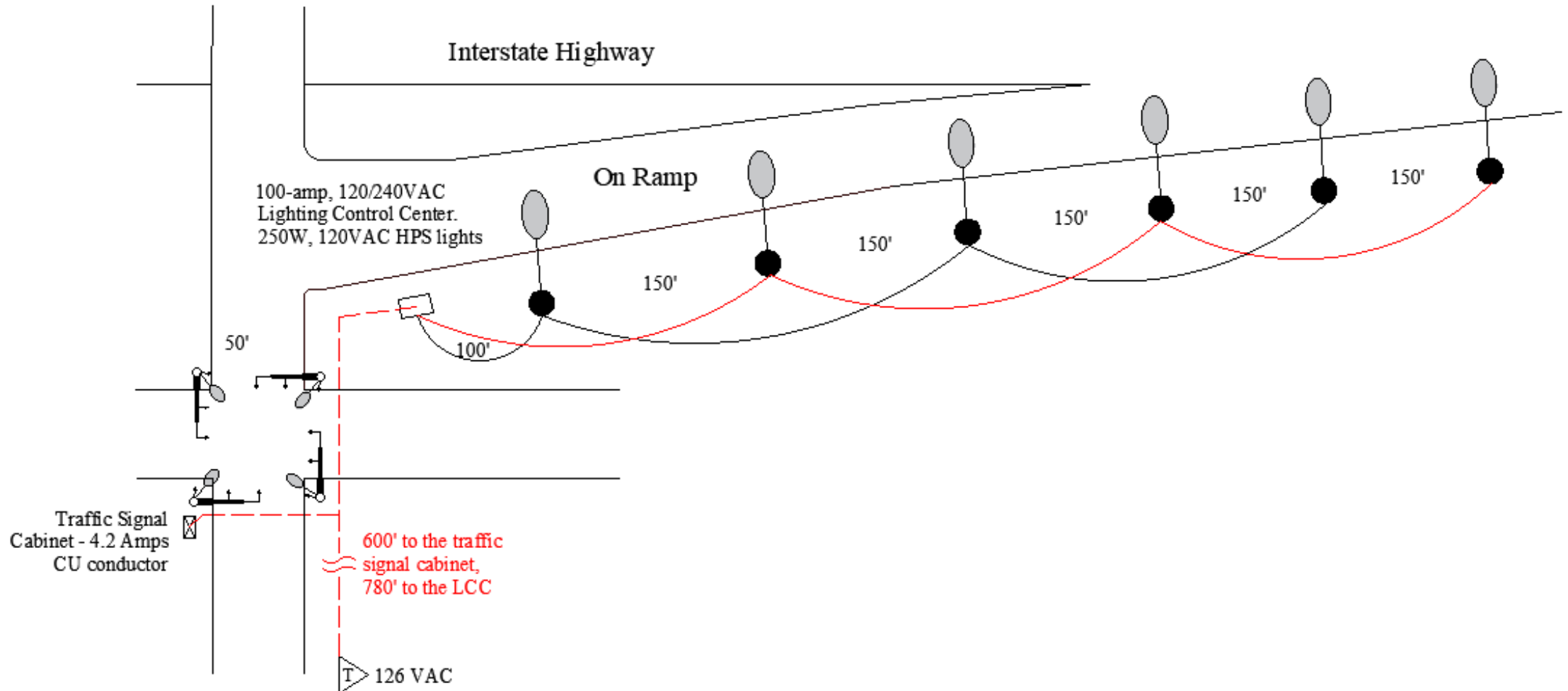
Efficient Design: Ensuring that the design of the lighting system accounts for the cable length, load requirements, and expected voltage drop can help optimize performance.

Balance the load: Balance the load(s) between multiple circuits as best as possible. By evenly distributing the loads between circuits, you'll reduce the effects of voltage drop by not overloading any one circuit.

Regular Maintenance: Regular inspections and maintenance of the roadway lighting system, including checking connections and cable integrity, can help identify and address any issues that contribute to voltage drop.

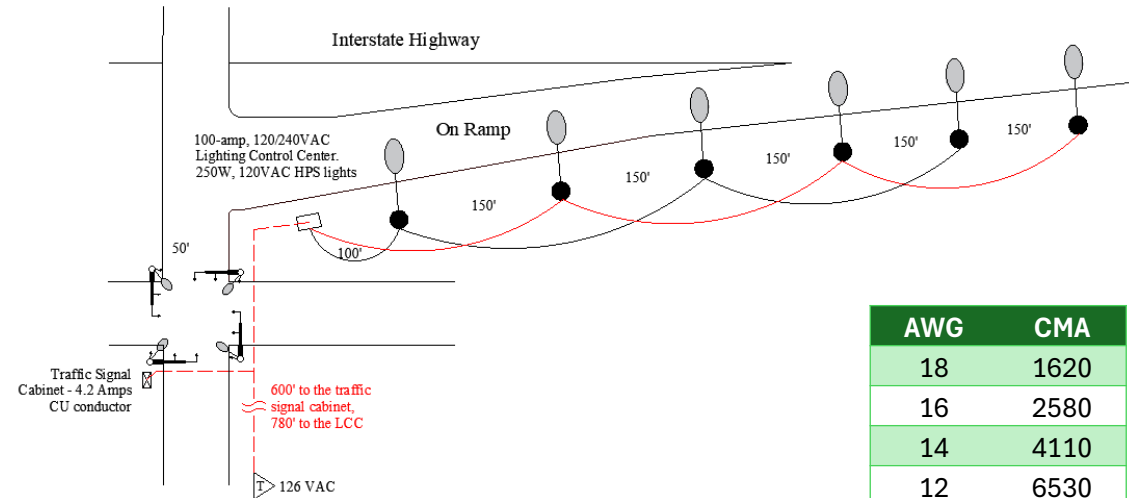
By considering these factors and implementing appropriate measures, voltage drop in roadway lighting systems can be minimized, ensuring optimal performance and visibility on the roads.

These are your lighting circuits; one “Lighting Control Center” (LCC) on an onramp to an interstate. What do you do to prevent voltage drop?



- Voltage drop is calculated with the following formula:
- $VD = \frac{2kIL}{CMA}$ where:
 - VD = Voltage Drop = (3% per the NEC)
 - 2 = the total distance current flows in a complete circuit
 - k = a constant for the type of conductor at **60° C** operating temperature
 - **10.8** for Copper conductor (@75° C = 12.9)
 - **17** for Aluminum conductor (@ 75° C = 21.6)
 - L = the length of the furthest point of the circuit
 - CMA = the circular mill area of the conductor (table at the right)

The transformer is 780' away from the Lighting Control Center. What size conductor do you need to run the on-ramp lights?



AWG	CMA
18	1620
16	2580
14	4110
12	6530
10	10380
8	16510
6	26240
4	41740
3	52620
2	66360
1	83690
1/0	105600
2/0	133100
3/0	167800
4/0	211600

- $$VD = \frac{2kIL}{CMA} \quad \text{or} \quad CMA = \frac{2kIL}{VD}$$

Per the NEC, you are allowed 3% voltage drop

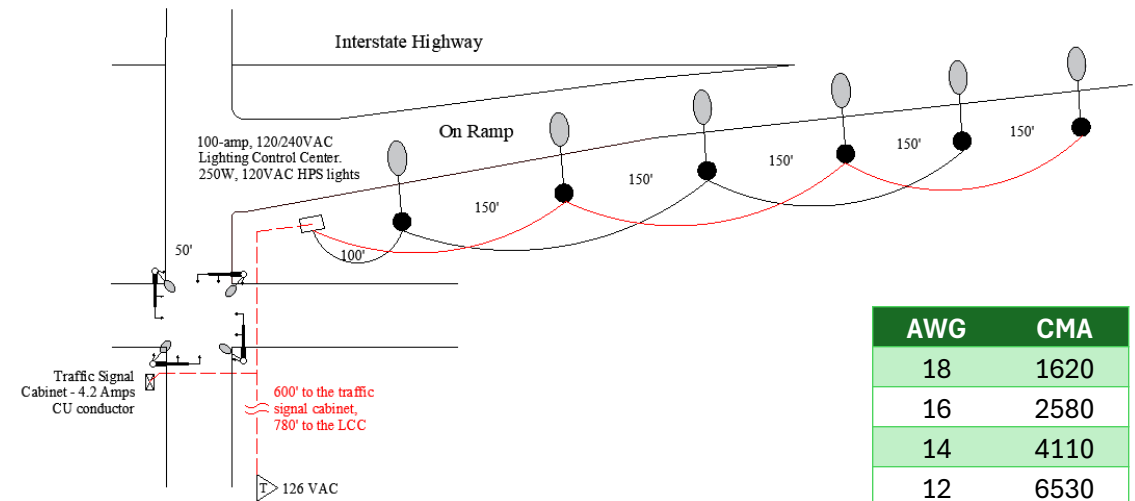
- The voltage at this transformer is 126 VAC
- The expected load at the cabinet is 30 amps
- Use copper conductor in underground conduit

$$CMA = \frac{2 * 10.8 * 30 * 780}{3.78 (VD)} = 133,714$$

133,714 cma to feed the LCC.

As per the NEC, you must use the next *largest* size conductor which is 167,800 cma or 3/0 conductor

The transformer is 780' away from the Lighting Control Center. What size conductor do you need to run the on-ramp lights?



AWG	CMA
18	1620
16	2580
14	4110
12	6530
10	10380
8	16510
6	26240
4	41740
3	52620
2	66360
1	83690
1/0	105600
2/0	133100
3/0	167800
4/0	211600

And that's just the LCC. What about the streetlights?

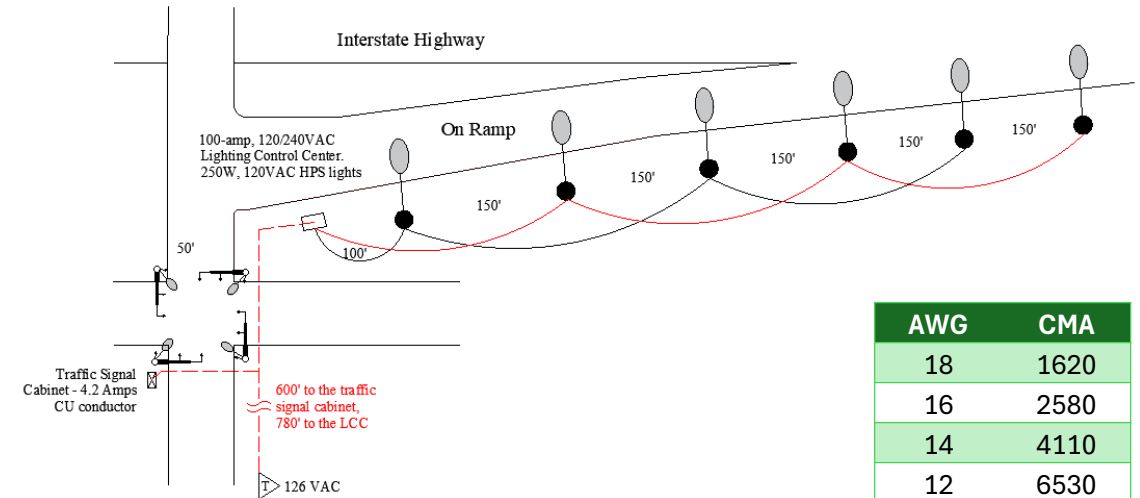
1. You can calculate the entire load on a circuit using the furthest distance:

For the **RED** circuit only:

- 3, 250W lights at 122.2 VAC = 6.14 A (2.05a) EA.
- Furthest distance from LCC = 850'
- Copper conductors fed underground

$$VD = \frac{2kIL}{CMA}$$

$$CMA = \frac{2 * 10.8 * 6.14 * 850}{3.6 (VD)} = 31,314 \text{ CM}$$



AWG	CMA
18	1620
16	2580
14	4110
12	6530
10	10380
8	16510
6	26240
4	41740
3	52620
2	66360
1	83690
1/0	105600
2/0	133100
3/0	167800
4/0	211600

You can run #4 conductor for the entire circuit and cover the voltage drop, *BUT* you'll spend a lot of money...

2. You can drop the remaining load from downstream lights once you feed upstream lights and calculate each leg individually.

For the **RED** circuit only:

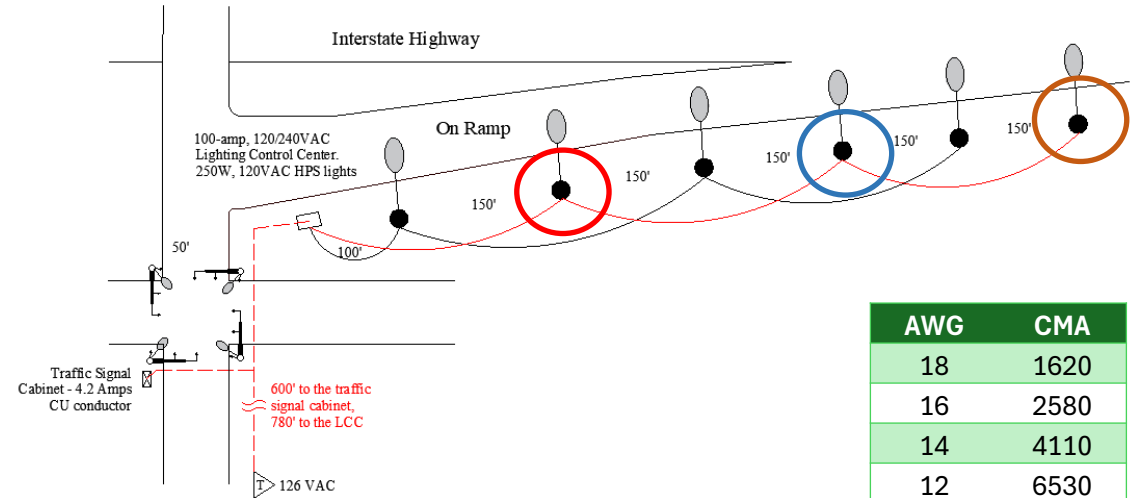
- 3, 250W lights at 122.2 VAC = 2.05 A each
- 1.2 volts dropped at each light
- First distance from LCC = 250'
- Copper conductors fed underground

$$VD = \frac{2kIL}{CMA}$$

$$\#1 \text{ CMA} = \frac{2 * 10.8 * 6.15 * 250}{1.2 (VD)} = 27,675 \text{ CM} = \#4$$

$$\#2 \text{ CMA} = \frac{2 * 10.8 * 4.10 * 300}{1.2 (VD)} = 22,140 \text{ CM} = \#6$$

$$\#3 \text{ CMA} = \frac{2 * 10.8 * 2.05 * 300}{1.2 (VD)} = 11,070 \text{ CM} = \#8$$



AWG	CMA
18	1620
16	2580
14	4110
12	6530
10	10380
8	16510
6	26240
4	41740
3	52620
2	66360
1	83690
1/0	105600
2/0	133100
3/0	167800
4/0	211600

You can calculate the load remaining at each leg and save money!!!

The left column shows electrical component. The right column shows the water equivalent of those components.

Match each component with the water equivalent.

a) Voltage

b) Current

c) Resistance

d) Power

1) Size of the pipe

2) Water pressure

3) Water consumed

4) Water flow

Knowledge Check

The left column shows electrical component. The right column shows the unit of measure for those components.

Match each component with the correct measurement.

a) Electrical pressure

b) Current

c) Resistance

d) Power

1) Amps

2) Watts

3) Volts

4) Ohms

The right column shows electrical circuit. The left column shows the rule to be true in those circuits. Match each circuit with the correct rule.

a) Voltage remains the same

b) Current remains the same

c) Resistance adds up

d) Power adds up

1) Series Circuit

2) Parallel Circuit

3) Combination Circuit

Ohm's law is based on the following formula:

- a) $E \text{ (Volts)} = I \text{ (Current)} \times P \text{ (Power)}$
- b) $E \text{ (Volts)} = I \text{ (Current)} \times R \text{ (Resistance)}$
- c) $E \text{ (Volts)} = R \text{ (Resistance)} \times P \text{ (Power)}$
- d) $I \text{ (Current)} = E \text{ (Volts)} \times P \text{ (Power)}$

What is the source voltage in a series street lighting circuit that carries 6 - 6.6 amp, 1200-watt light fixtures?

- a) 181.82 Volts
- b) 1,090 Volts
- c) 2,200 volts
- d) 7,920 volts

How much current will flow in a 120 VAC, parallel lighting circuit that has 6 - 250-watt light fixtures?

- a) .08 amps
- b) 2.08 amps
- c) 12.5 amps
- d) 15.6 amps

How much current will flow in a 120 VAC, parallel lighting circuit that has 6 - 250-watt light fixtures?

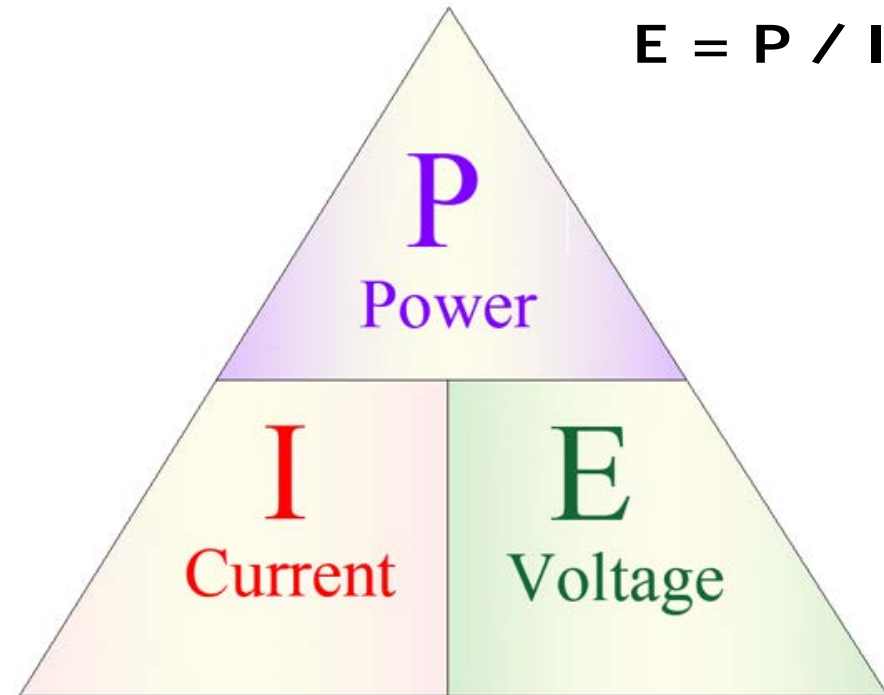
- a) .08 amps
- b) 2.08 amps
- c) 12.5 amps
- d) 15.6 amps

Power Formulas

$$P = I \times E$$

$$I = P / E$$

$$E = P / I$$



Bonding & grounding means to:

- a) Bond everything to ground
- b) Bond everything to a difference of electrical potential and then ground it
- c) Bond everything to the same electrical potential and then ground it
- d) Bond everything to each other

What is the most common material used in electrical wiring?

- a) Aluminum
- b) Gold
- c) Silver
- d) Copper

What size conductor would you need for a 4-amp load, 700 feet away from the transformer supplying 126 VAC and wanting to use aluminum conductor for a 3% voltage drop?

- a) #10
- b) #8
- c) #6
- d) #4

What size conductor would you need for a 4-amp load, 700 feet away from the transformer supplying 126 VAC and wanting to use aluminum conductor for a 3% voltage drop?

- a) #10
- b) #8
- c) #6
- d) #4

$$\text{CMA} = \frac{2 \times 17 \times 4 \times 700}{3.78} = 25,185 \text{ CM or \#6 al.}$$

AWG	CMA
18	1620
16	2580
14	4110
12	6530
10	10380
8	16510
6	26240
4	41740
3	52620
2	66360
1	83690
1/0	105600
2/0	133100
3/0	167800
4/0	211600

A 20-amp load is fed with #2 copper conductor 625 feet away from the transformer supplying 117 VAC. How much voltage drop will this cause?

- Does this meet the 3% criteria? **NO**

a) 6.4 Volts

b) 4.07 Volts

c) 3.51 Volts

d) 2.03 Volts

A 20-amp load is fed with #2 copper conductor 625 feet away from the transformer supplying 117 VAC. How much voltage drop will this cause?

- Does this meet the 3% criteria? **NO**

a) 6.4 Volts

b) 4.07 Volts

c) 3.51 Volts

d) 2.03 Volts

$$VD = \frac{2 \times 10.8 \times 20 \times 625}{66360} = 4.0687 \text{ volts}$$

AWG	CMA
18	1620
16	2580
14	4110
12	6530
10	10380
8	16510
6	26240
4	41740
3	52620
2	66360
1	83690
1/0	105600
2/0	133100
3/0	167800
4/0	211600

IMSA Roadway Lighting Technician

Session 4: Types of Lighting – Structures & Fixtures



Advancing the Future of Public Safety

TYPES OF ROADWAY LIGHTING POLES

- Steel Poles
- Aluminum Poles
- Wooden Poles
- Concrete Poles
- Fiberglass Poles
- Composite Poles

It's important to note that the type of pole used can depend on several factors, including the location, local weather conditions, aesthetic preferences, budget, and the specific requirements of the lighting fixtures to be used.



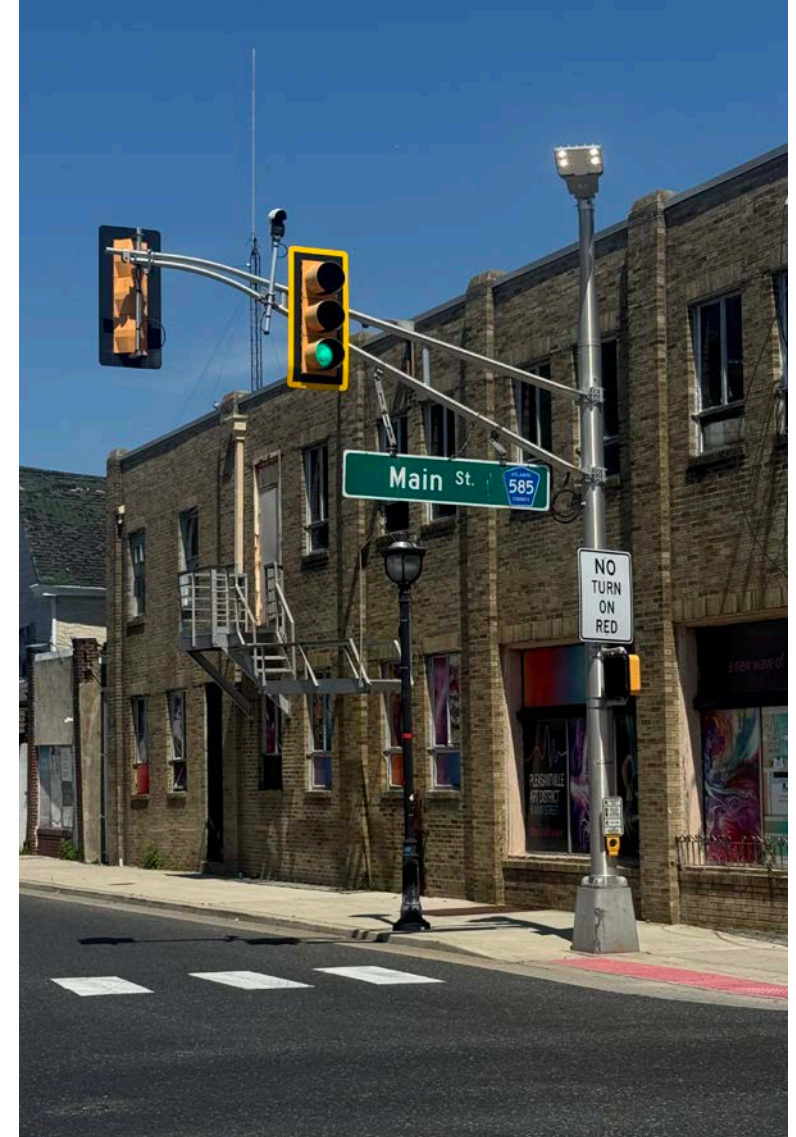
Steel Poles: These are the *most common* type of pole structures in roadway lighting. They are durable, relatively inexpensive, and can handle a wide range of fixture types and light loads.



Aluminum Poles: Lighter than steel or concrete, aluminum poles are easier to transport and install. They are also resistant to rust, which can be an advantage in certain climates.



Aluminum Arm on Concrete pole





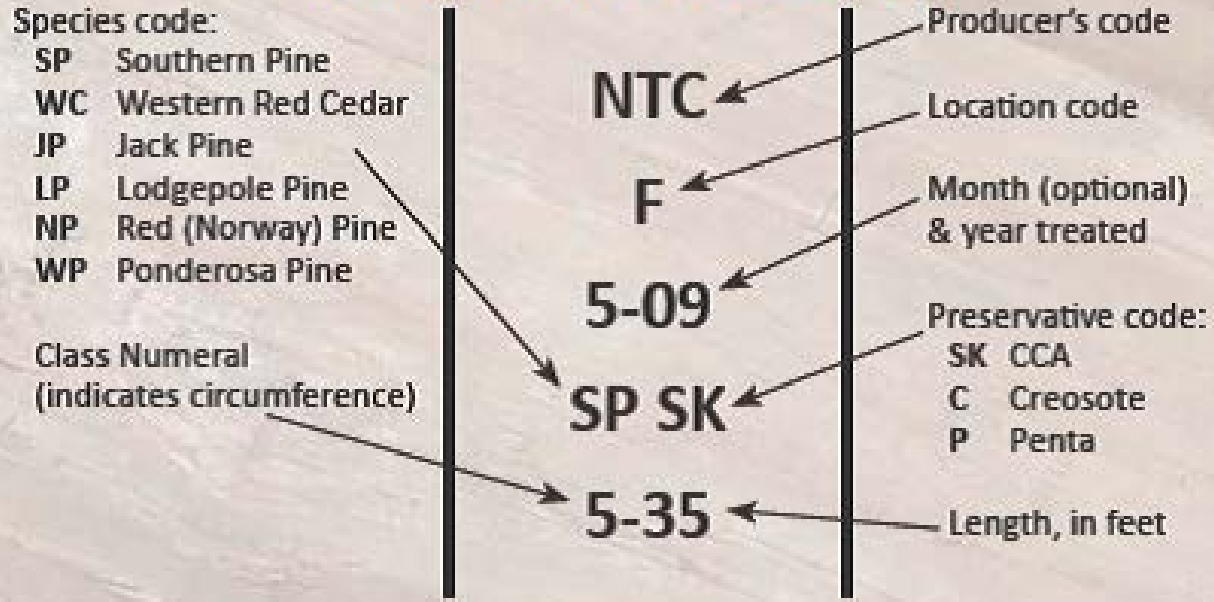
Wooden Poles: Wooden poles are made from treated timber and are used in some roadway lighting scenarios. While they don't have the same level of durability as steel or concrete, they can be more economical and fit better in natural or rural settings.

- Wood pole specifications are identified by “class” (table below)
- To determine the **depth** of the pole for installation: take 10% of the pole length and add 2 feet.
 - 45' pole = 4.5' + 2' = 6.5' depth
- Make sure the pole is plumb (straight) when you're finished

Wood Pole Class	Horizontal Load (lb.)	Length Range (ft)	Minimum Tip Circumference (inch)
H6	11,400	45-125	39
H5	10,000	45-125	37
H4	8,700	40-125	35
H3	7,500	40-125	33
H2	6,400	35-125	31
H1	5,400	35-125	29
1	4,500	35-125	27
2	3,700	20-125	25
3	3,000	20-90	23
4	2,400	20-70	21
5	1,900	20-50	19
6	1,500	20-45	17
7	1,200	20-35	15
9	740	20-30	15
10	370	20-25	12

Wooden Poles: Wooden poles may often have a brand indicating specific information about the pole.

Reading a Utility Pole Brand





Concrete Poles: Concrete poles are durable and resistant to the elements, making them a good choice for areas with severe weather conditions. They're often used in highway or large roadway settings.





Fiberglass Poles: Fiberglass poles are becoming a better option, because they're durable, light weight, and resistant to corrosion. They can also be designed to match a wide variety of aesthetic styles.

Composite Poles: These are made from a blend of materials, often fiberglass and resin, to combine the benefits of different pole types. They can be both lightweight and highly durable.



Height of Poles:

The height of the pole is a critical factor in roadway lighting. It must be high enough to provide adequate illumination to the roadway and pedestrian pathways. The height of the pole can vary depending on the type of roadway, the type of light fixture used, the level of illumination required, and local regulations. However, typical heights for street lighting poles are between 4m to 12m (about 13 to 40 feet).

Spacing of the Poles:

The spacing between poles is another important consideration. The spacing depends on the intensity of the lights, the height of the poles, the type of roadway, and the specific illumination requirements. On average, the spacing could be anywhere between 100 to 150 feet for residential areas, but this can be much greater for highways or rural roads. The spacing is usually designed to prevent dark spots between the light poles while also avoiding excessive overlapping of the light.

Standards:

The design and installation of roadway lighting systems must comply with various local, national, and international standards. In the U.S., the Illuminating Engineering Society (IES) and the American National Standards Institute (ANSI) provide guidelines for roadway lighting. These standards address issues like minimum illumination levels, uniformity ratios, glare control, and energy efficiency.

- In the early days of street lighting, the transformer for the light fixture was held in the base of the pole; i.e., a transformer base.
- Most transformers are no longer held in the base of the pole; however, transformer bases serve another purpose. They easily break away upon impact, thereby reducing the force of the impact.
- By detaching upon impact, breakaway bases reduce the risk of secondary accidents, electrical shock, and injuries.



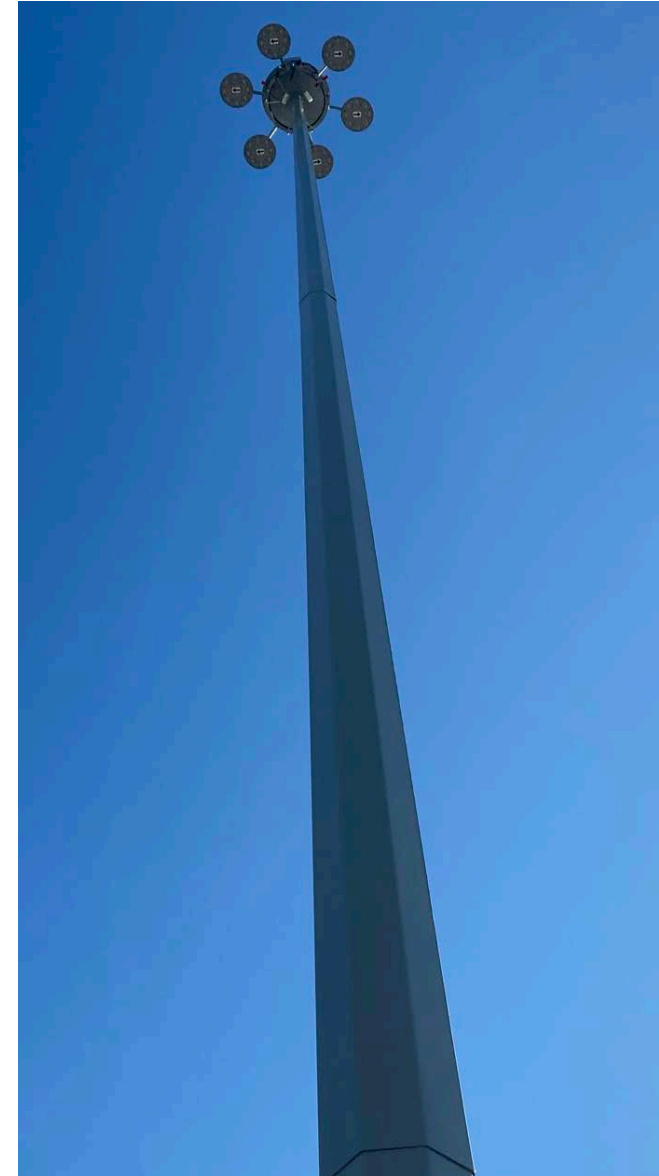
Here are some key features and benefits of high mast lighting:

Height: The height can vary but is generally in the range of 30 to 150 feet (9 to 46 meters). The increased height allows for a wider coverage area and better visibility, especially over large expanses of land.

Multiple lighting fixtures: High mast lighting installations include several lighting fixtures mounted at the top of the pole. The number of fixtures can vary depending on the specific requirements and lighting design. These fixtures are often equipped with powerful lamps, such as high-intensity discharge (HID) lamps or light-emitting diodes (LEDs), to provide bright and efficient illumination.

Wide coverage area: High mast lighting is designed to provide broad and uniform lighting coverage over a large area. This makes it suitable for applications such as highways, interchanges, parking lots, airports, and sports stadiums, where consistent illumination is crucial for safety, visibility, and security.

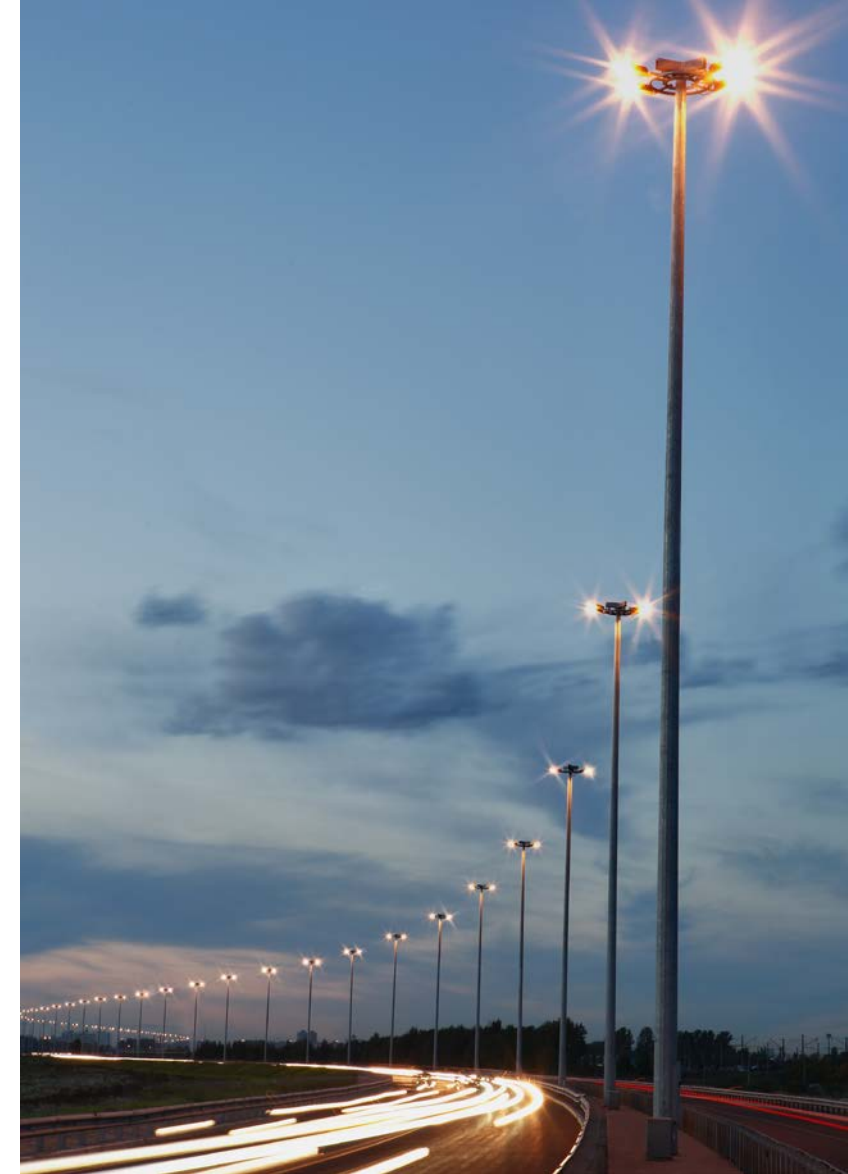
Maintenance and accessibility: High mast lighting systems are designed with ease of maintenance in mind. The fixtures are typically installed at a height that prevents easy access for maintenance and repair, therefore high mast lighting systems utilize a lowering device or winch system to bring the fixtures down to ground level for servicing.



Energy efficiency: With the advancement of LED lighting technology, high mast lighting has become more energy-efficient. LED fixtures offer significant energy savings compared to traditional lighting technologies, reducing operating costs and environmental impact.

Lighting control and automation: High mast lighting systems can incorporate advanced lighting control and automation features. This includes the ability to adjust brightness levels, schedule lighting patterns, and integrate with sensors or intelligent systems for energy optimization and adaptive lighting based on ambient conditions.

High mast lighting plays a vital role in providing safe and effective illumination for various outdoor applications, ensuring visibility, security, and comfort in large areas that require high-quality lighting.



Roadway lighting fixtures are designed to provide illumination along streets, roads, highways, and other transportation routes. These fixtures ensure visibility and safety for drivers, pedestrians, and cyclists during nighttime or low-light conditions. Roadway lighting fixtures come in various types, each with its own characteristics and purpose, such as:

- **Gas Lighting** – The first type of street lighting
- **Incandescent Lighting** – The first electric street lighting
- **Fluorescent Lighting** – An energy efficient replacement for incandescent lighting
- **Mercury Vapor Lighting** – The first real improvement in street lighting in size & light output
- **High-Pressure Sodium (HPS) Fixtures** – Replacement for the MV lighting
- **Induction Lighting** – An efficient light fixture with more natural light output
- **Metal Halide (MH) Fixtures** – A true white light output
- **Light-Emitting Diode (LED) Fixtures** – Efficiency with multiple color temperatures

Roadway lighting fixtures are chosen for the type of road, traffic volume, desired light distribution, energy efficiency, maintenance requirements, and local regulations.

Proper installation, aiming, and spacing of fixtures are also crucial to ensure uniform lighting and maximize visibility on the roadways.

Gas Street Lighting: first showed up in the United States in the early 1800's and yes, someone had to go out each night and light the lamp fixtures.



Incandescent Street Lighting: first showed up in the United States in Cleveland, Oh. In April of 1879 the electric streetlight made its debut on Americas streets.



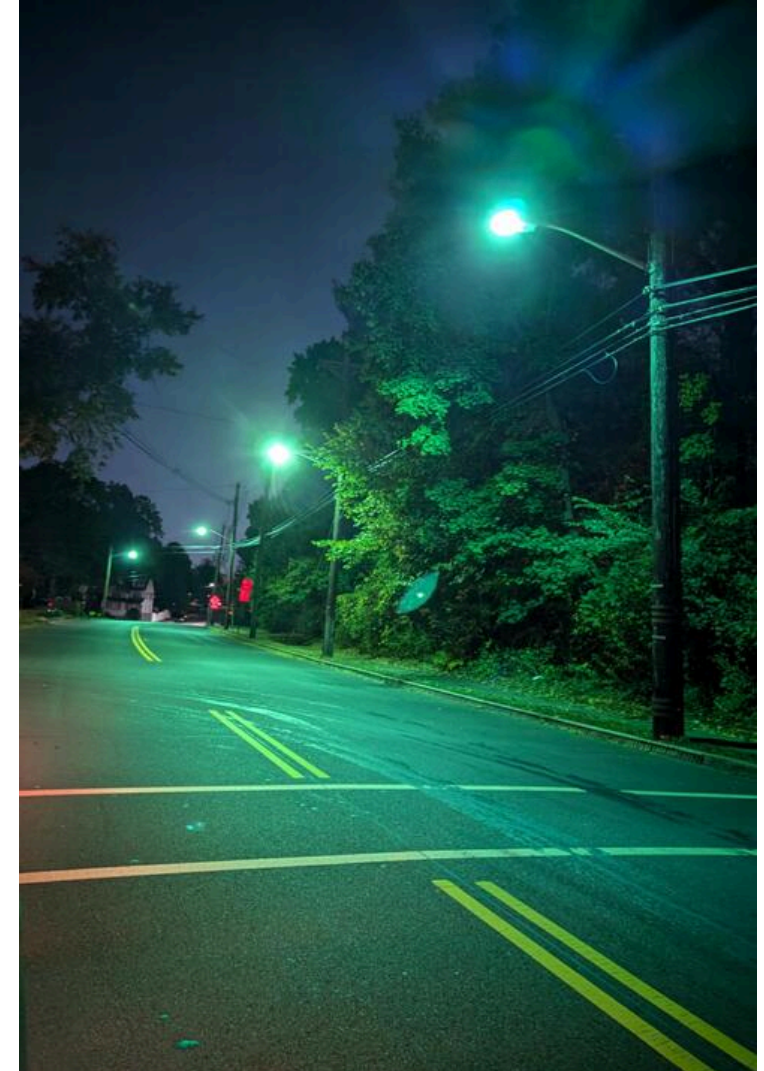
Fluorescent Street Lighting:

is an efficient light source as compared to incandescent lighting. Fluorescent tubes do not have a filament but instead has two electrodes that excite the mercury atoms thus causing them to glow.

One problem though is that fluorescent lighting gets real dim in cold temperatures.



Mercury Vapor Street Lighting: was the first gas-discharge lamp that overcame the problems with fluorescent lighting. First introduced in the mid-1930's, mercury vapor lights provide far more light output than fluorescent lighting and does not dim in cold temperatures. MV lighting produces a blueish-white light.



High-Pressure Sodium (HPS) Fixtures: Introduced in the late 1960's, HPS fixtures produce a yellowish-white light and have been widely used in roadway lighting for many years. They are known for their energy efficiency and long lifespan, making them a popular choice for street lighting.



Induction Lighting: works much like fluorescent lighting with the main difference being that induction lamps do not have any electrodes inside. Instead, the lamp utilizes an electromagnetic field to activate the mercury atoms to produce light.

Induction lighting produces a very white light, are very efficient and have a long-life span up to 100,000 hours



Metal Halide (MH) Fixtures:

Also introduced in the 1960's, Metal halide fixtures produce a bright white light and are commonly used in large parking lots, sports fields, and highways. They provide good color rendering but are less energy-efficient compared to LED fixtures.



Gas discharge lighting fixtures are typically constructed with the same components. Here is a description of those parts:

Housing: This is the outer casing that encloses and protects the internal components of the fixture. It is usually made of durable materials such as aluminum or steel.

Reflector: The reflector is a reflective surface located inside the housing. Its purpose is to direct and distribute the light emitted by the gas discharge lamp. It enhances the fixture's light output.

Lamp Socket: The lamp socket is the component that holds the gas discharge lamp in place. It provides electrical contact with the lamp and ensures a secure connection.

Gas Discharge Lamp: The lamps are the light source in the fixture. It consists of a translucent ceramic arc tube containing a mixture of gases to include mercury, sodium, metal halides in combination with phosphors. When the lamp is energized, the gas vaporizes and produces light of various color temperatures, depending on the gas used inside the tube.

It is very important that the type of lamp match the ballast or else the light will not work.

Ballast: gas discharge lamps require a ballast to regulate the electrical current flowing through them. The ballast provides the necessary voltage and limits the current to start and maintain the lamp's operation. Again, the ballast must match the lamp type.

Ignitor/Starter: The ignitor is responsible for providing a high voltage pulse to initiate the gas discharge lamp's ignition process. It helps establish the electric arc within the lamp, enabling it to produce light.

Capacitor: gas discharge lamps often require a capacitor to help stabilize and improve the power factor, filter out electrical noise, and regulate the voltage. The capacitor assists in compensating for the lamp's inductive load and optimizing the overall efficiency of the lighting system. The capacitor was also used to ignite the lamp in older HID lighting fixtures.

Lens or Glass/Polycarbonate Cover: This component is located at the front of the fixture, protecting the lamp and other internal parts from external elements such as dust, moisture, and debris. It also shapes the light distribution pattern. Polycarbonate covers may be subject to yellowing due to heat and UV light.

Wiring and Connectors: Various wires and connectors are used to connect the internal components, including the lamp socket, ballast, ignitor, and capacitor. These enable the electrical circuitry to function properly and supply power to the lamp.

Access Panel or Cover: Some fixtures may feature an access panel or cover that allows for convenient maintenance and replacement of internal components. It provides easy access to the lamp, ballast, and other parts when needed.

Mounting Bracket: The mounting bracket is used to secure the fixture to a pole or other supporting structure. It provides stability and ensures proper alignment of the lighting fixture.

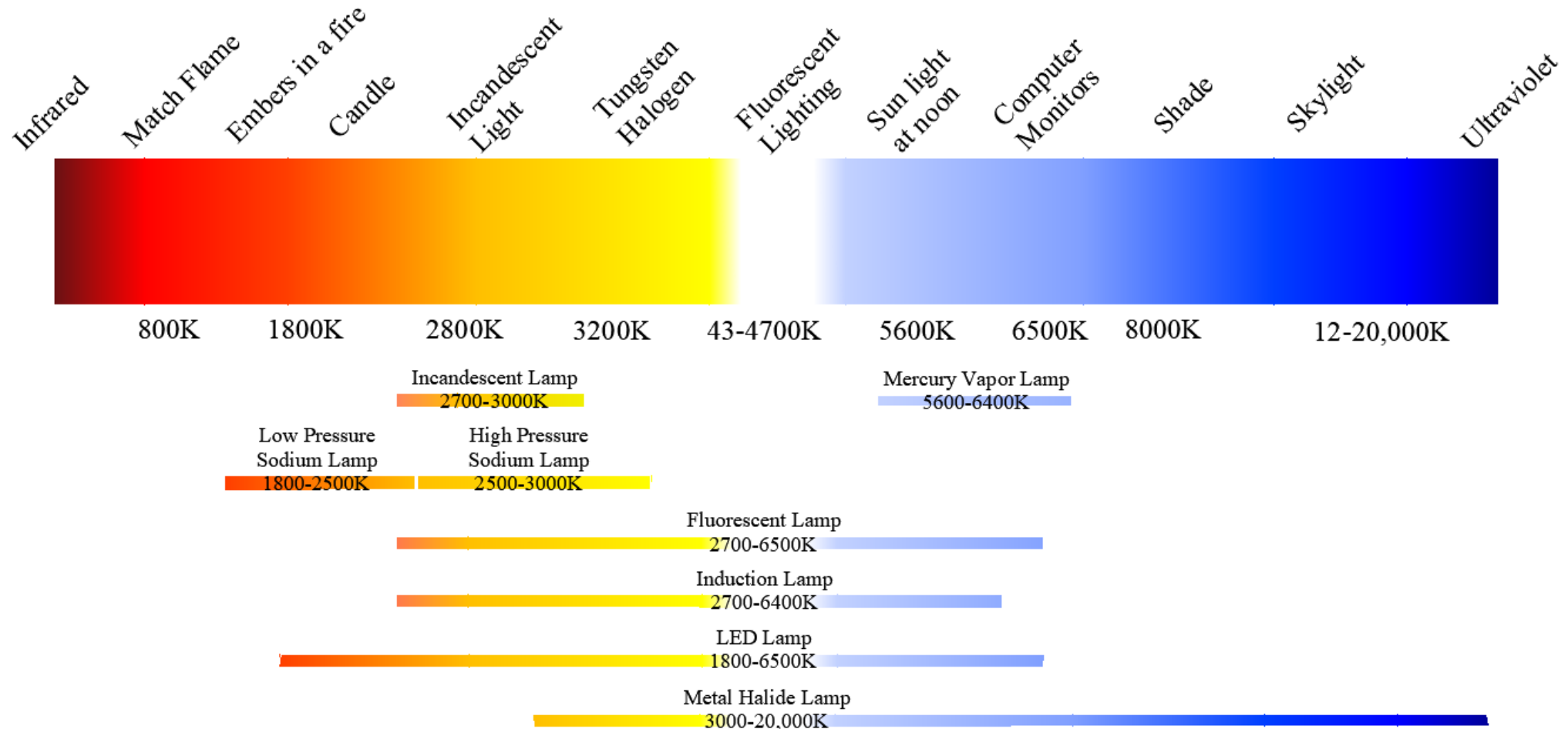
Photocell (*optional*): Some roadway lighting fixtures may include a photocell, also known as a dusk-to-dawn sensor. This sensor detects ambient light levels and automatically turns the fixture on at dusk and off at dawn, providing energy savings and convenience.

- It is most important that the photocell is matched to the proper voltage of the light fixture

It's worth noting that the specific design and configuration of a gas discharge roadway lighting fixture can vary depending on the manufacturer and model.

Streetlights are identified by their color temperature, which determines the hue of the light output.

- Temperature is measured in degrees Kelvin.
- The lower the temperature the redder the light. The higher the temperature the bluer the light.



Lamp Basics:

- **Wattage** – the amount of rated power the lamp consumes = Energy
 - Wattage was a term used for incandescent lights as a measure of how bright the light was.
 - That's how they were branded and sold.
- **Lumens** – the measurement of light output from a source over the entire area. For example:
 - A 60-watt incandescent lamp outputs 750-850 lumens
 - A 200-watt incandescent lamp outputs 3880 lumens

As you can see, the higher the wattage the brighter the lamp output.



A 69W, 660 lumen incandescent traffic signal lamp

Lamp Basics:

- However, that wattage / lumens correlation doesn't hold true with HID lamps. For example:
 - A 250-watt HID metal halide lamp outputs 22,000 lumens
 - A 250-watt HID high pressure sodium lamp outputs 33,000 lumens
 - A 250-watt HID mercury vapor lamp outputs 12,500 lumens
 - A 250-watt HID Induction lamp outputs 21,000 lumens
- HID lamps have a sealed gas tube, which is what provides the light
 - Different gasses determine the color temperature of the light
 - There is no filament. Current flows through the ionized gas inside the tube.
 - HID lamps contain hazardous materials and must be disposed of properly

*If you see an HID lamp cycling, it may be due to a failing lamp.
This is the second most likely failure point.*



A 250W, 22,000 Lumen, HID metal halide lamp – 4,000K

Lamp Basics:

- **Incandescent** lamps operate with a ***positive temperature coefficient***
 - Which means as the lamp heats up, the resistance increases
- **HID** lamps, however, operate with a ***negative temperature coefficient***
 - Which means as the lamp heats up, the resistance decreases
 - The lower the resistance, the more current flows
 - Which means all HID lamps would explode, but you don't see that happening. WHY?



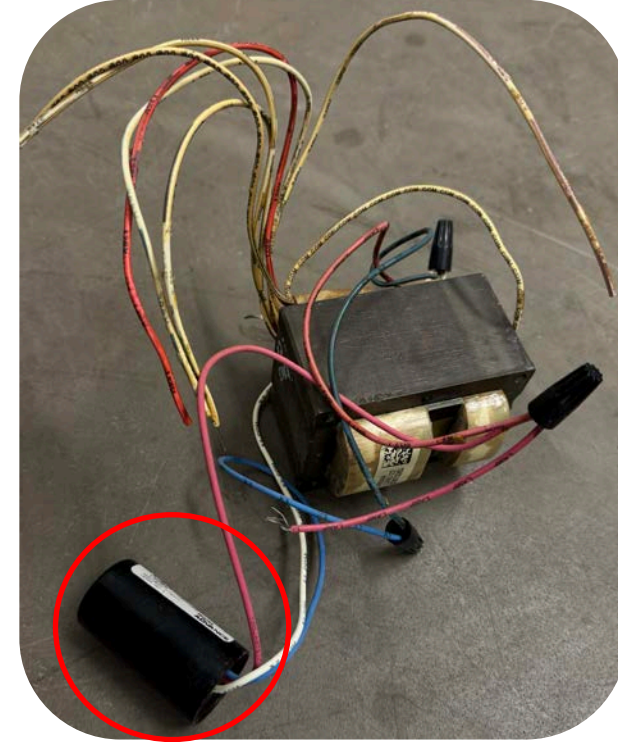
A 250W, 22,000 Lumen, HID metal halide lamp – 4,000K

Ballast Basics:

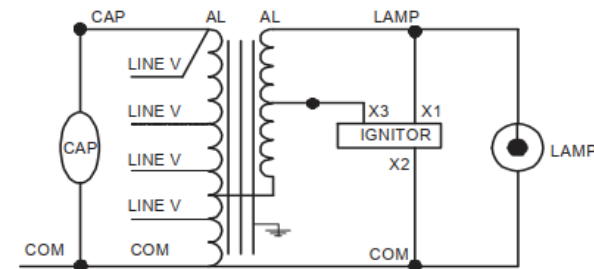
HID lamps don't explode because of the ballast.

- The ballast is a transformer that limits the amount of current flowing through the lamp.
- The ballast must be matched to the specific type of lamp and the incoming line voltage.
- Many ballasts are "multi-tapped", which means they can be used with different line voltages such as 120/208/240/277 VAC.
- The load voltage from the ballast feeds the capacitor and/or the ignitor.
- HID lamps need an Ignitor (red circle) to begin ionizing the gas atoms so that current can flow.
- The **ignitor** provides a large amount of voltage to ignite the gas. Large capacitors were also used to ignite the gas in older HID light fixtures.

If you see an HID lamp cycling, it may be due to a failing ballast (third most likely cause).



A 35W - 450W HID metal halide, multi-tap ballast



Photocell Control:

Most streetlights are controlled by a photocell

- Photocells act as the switch to turn on/off the light based on the ambient light.
- Photocells in North America should be aimed to the **North**.
 - The northern sky gets darker sooner and lighter later, thereby ensuring the streetlight remains “on” for the longest period of time
- Photocells must be matched to the type of lamp and the line voltage.
- Photocell housings can be rated for environments prone to hail

If you see an HID lamp cycling, it may be due to a failing photocell. This is the first most likely failure point.



A 120-277 VAC HID,
Incandescent Photocontrol

Light-Emitting Diode (LED) Fixtures: LED fixtures have gained significant popularity in recent years due to their energy efficiency, long lifespan, and ability to provide high-quality, directional lighting. LEDs offer various color temperatures and can be programmed for dimming or adaptive lighting systems.

LEDs offer numerous advantages, including longer lifespan, lower energy consumption, reduced maintenance costs, and the ability to adjust lighting levels and colors to meet specific requirements.



LED roadway lighting fixtures are constructed a little different from their gas discharge cousins. Here are the main components typically found in LED roadway lighting fixtures:

LED Chips: The heart of the LED roadway lighting fixture is the light-emitting diode (LED) chips. These semiconductor devices produce light when an electric current passes through them. LED chips are known for their energy efficiency, durability, and long lifespan. LEDs have a phosphorous coating on the inside to render a proper temperature. When the phosphorous coating fails, the LED color leans toward a blue color.

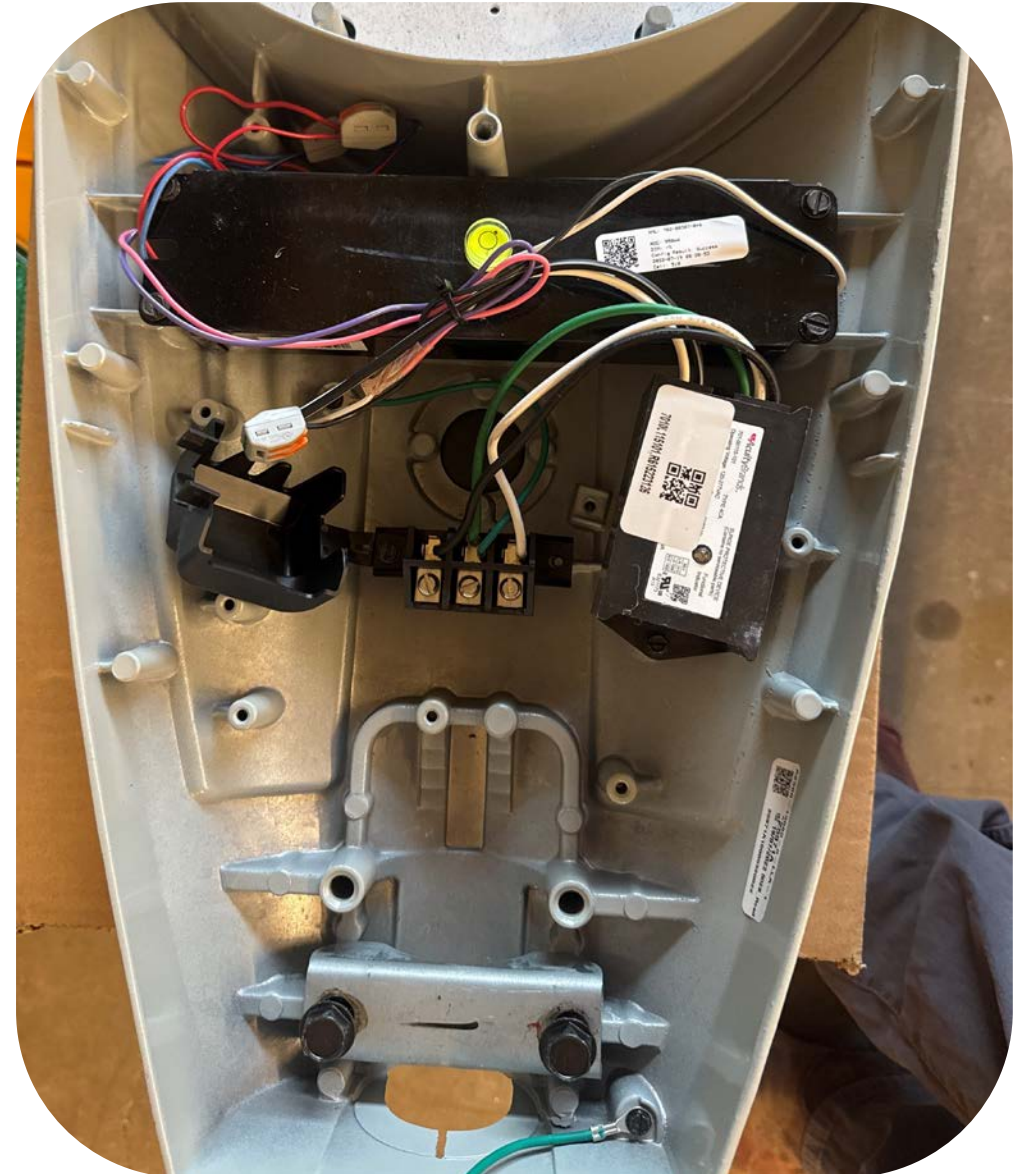
Optics: LED roadway lighting fixtures are equipped with optics, such as lenses or reflectors, to control the direction and spread of light. Optics help direct the light emitted by the LED chips onto the roadway, minimizing light pollution and maximizing illumination efficiency.

Heat Sink: LEDs generate a lot of heat while producing light, so roadway lighting fixtures include heat sinks to dissipate this heat and prevent the LED chips from overheating. Heat sinks are typically made of aluminum or other materials with excellent thermal conductivity to enhance heat dissipation.

Housing: The housing or fixture body encloses and protects the internal components of the LED roadway lighting fixture. It is usually made of durable materials like aluminum or stainless steel to withstand harsh environmental conditions.

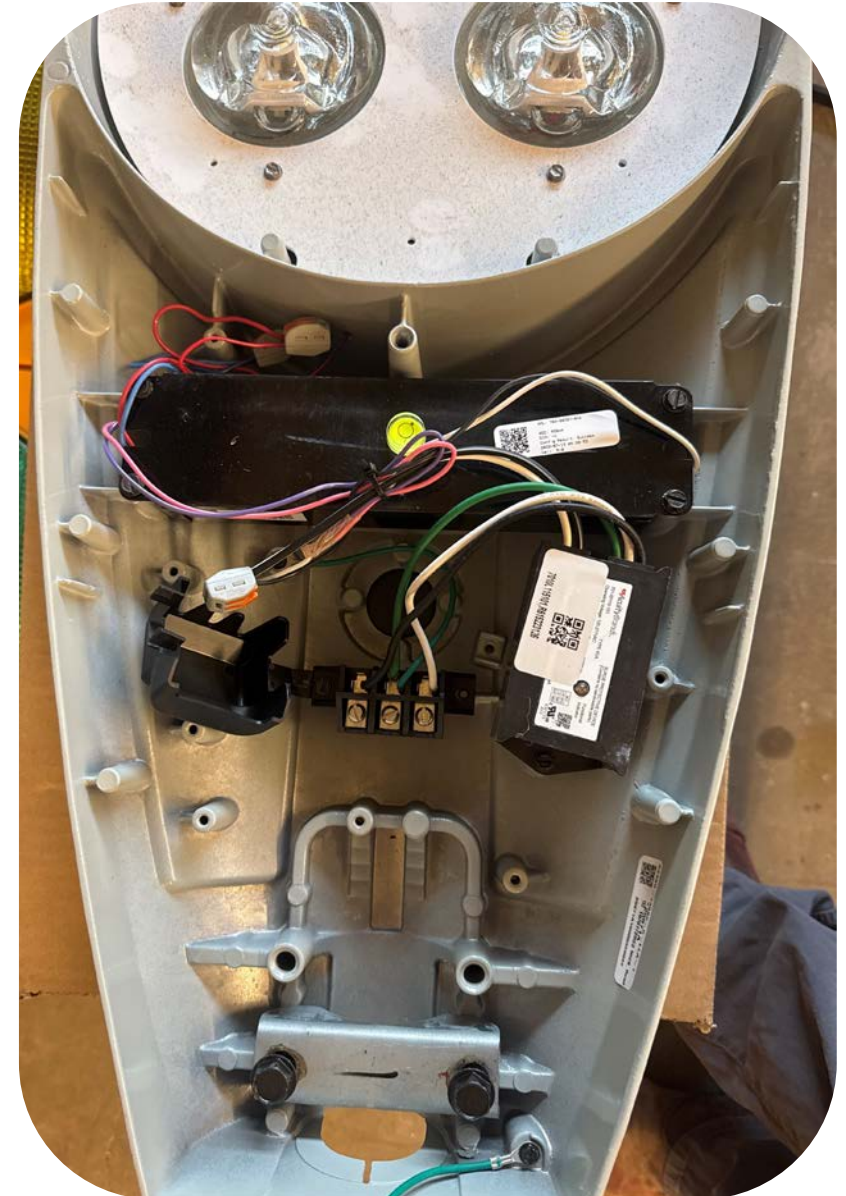
Driver: LED roadway lighting fixtures require a driver to regulate the electrical current supplied to the LED chips. The driver converts the incoming AC voltage into the appropriate DC voltage and current required by the LED circuits. It also provides dimming and control capabilities for energy management and adaptive lighting systems.

Mounting Bracket: The mounting bracket attaches the lighting fixture to the roadway pole or arm. It ensures stability and proper positioning of the fixture for optimal lighting distribution.



Photocell or Motion Sensor (Optional): Some LED roadway lighting fixtures may include additional components like photocells or motion sensors. Photocells detect ambient light levels and can automatically adjust the lighting output based on the natural light conditions. Motion sensors detect movement and can trigger the lights to turn on or off, providing energy savings when the area is not in use.

These components work together to provide efficient and reliable lighting for roadways while minimizing energy consumption and maintenance needs. LED roadway lighting fixtures offer advantages over traditional lighting technologies in terms of energy efficiency, longevity, and environmental friendliness.



Lamp Basics:

- The wattage / lumens correlation comparison doesn't hold true with LED lamps either.
- For example: This 250-watt LED equivalent only consumes 70-100 watts of power while outputting anywhere between 9,300 to 22,000 lumens.



A 250W, 22,000 Lumen, HID metal halide lamp – 4,000K

- 50% of all traffic accidents happen in the overnight hours. These accidents tend to have a higher fatality rate since there is less traffic and people may travel much faster. This increases the time needed to stop. That is why lighting not only along the roadway but at intersections is very important.
- Increased visibility at intersections at nighttime is important since various modes of travel cross paths at these locations.



NEMA Decal Information

17 **40** **25**

Color Coding	Light Source	Numeric Code/Wattage	
		3 = 35	20 = 200
Yellow	High Pressure Sodium	5 = 50	25 = 250
Red	Probe Start Metal Halide	7 = 70	32 = 320
Red and White*	Pulse Start Metal Halide	10 = 100	35 = 350
Light Blue	Mercury	15 = 150	40 = 400
White	LED**	17 = 175	75 = 750
			X1 = 1000

*Position Oriented Pulse Start is divided horizontal for horizontal lamp and vertically for a vertical lamp.

** LED is actual wattage in Black on a white label.

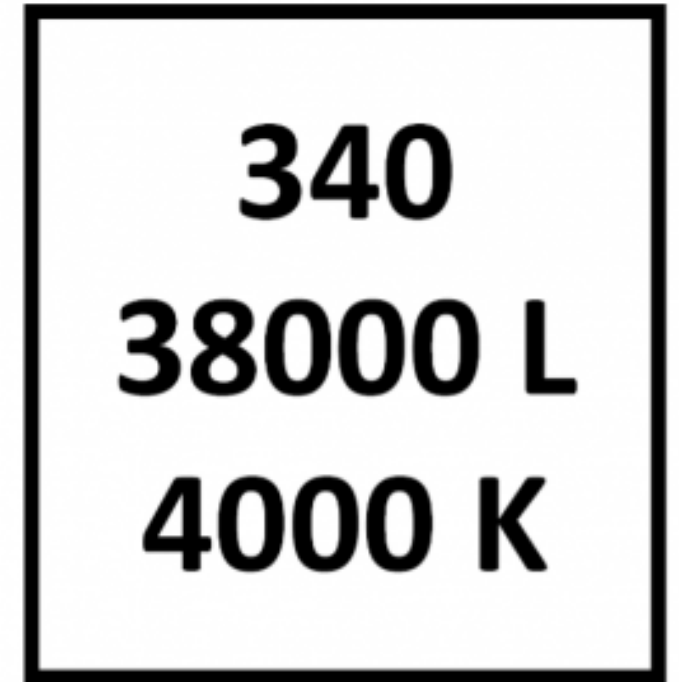
Gas Discharged Fixtures -
Unless you are new to the industry, you've grown accustomed to the yellow, red, and blue labels that tell us the HID Source and wattage on fixtures. We could tell from the ground what lamp wattage and source was needed without having to go up the pole.

LED labels started as a white label with black text providing the actual wattage of the LED fixture. Later the label was rounded to the nearest 10 (i.e., a 73-watt LED has a label for 70 watts, and a 95-watt LED has a label for 100 watts).

The labels are changing again, and you may start seeing these in your shipments. ANSI (American National Standards Institute) and NEMA (National Electric Manufacturers Association) allow manufacturers to phase these in as they use up label stock.

What does the new label look like?

Per the ANSI C136.15 Luminaire Field Identification, **it will add the color temperature and the lumen output**. This helps us to recognize the changes in color temperature and lumen output that have been prevalent with LED upgrades. The wattage will continue to be rounded to the nearest 10 and lumens to the nearest 1000.



LED Labels: Initially, labels were white with black text showing actual wattage.

New ANSI C136.15 Standards: Current shipments are phasing in new labels that include **color temperature** and **lumen output**.

Label Requirements:

- Wattage
- Lumens

Standardization is overseen by ANSI (American National Standards Institute) and NEMA (National Electric Manufacturers Association).

Sample show:

Brand NXT-M

60 LEDS

Medium sized luminaire body

525 mA drive currents

4000K CCT (Standard)

3000K & 5000K CCT (Optional)



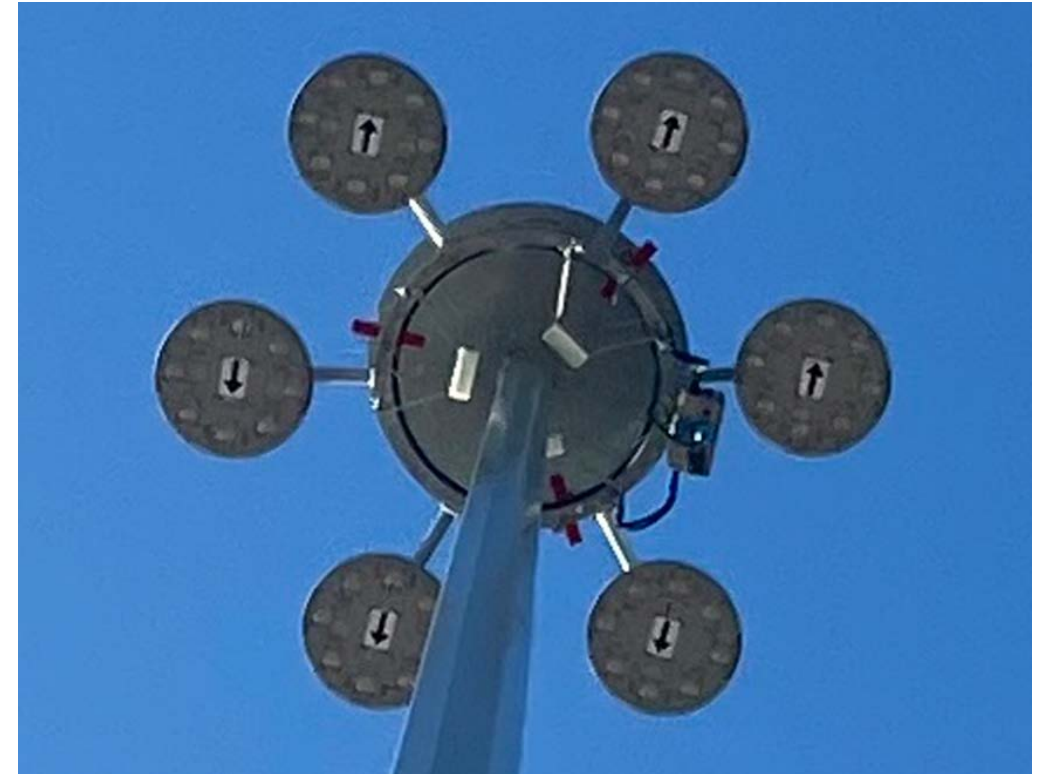


- NXT-M**
- 48, 60, 72 LEDs
 - Medium sized luminaire body
 - 350-700 mA drive currents
 - 4000K CCT (Standard)
 - 3000K & 5000K CCT (Optional)

ELECTRICAL	NXT-48M (48 LEDs)					NXT-60M (60 LEDs)					NXT-72M (72 LEDs)				
Drive Currents (mA)	350mA	450mA	525mA	600mA	700mA	350mA	450mA	525mA	600mA	700mA	350mA	450mA	525mA	600mA	700mA
Power Consumption* (W)	53 W	68 W	80 W	92 W	108 W	65 W	84 W	99 W	113 W	133 W	78 W	100 W	117 W	135 W	158 W
Input Voltage* (V)	120 - 240V (Standard), 277V (Optional), 347 - 480V (Optional)														
Surge Protection	Meets the requirements of ANSI C-High (10kV/10kA)														
Power Factor	> 0.90														
OPTICS & PERFORMANCE	NXT-48M (48 LEDs)					NXT-60M (60 LEDs)					NXT-72M (72 LEDs)				
Photometry (Distribution Types)	Type II, III, IV, V														
Color Temperature* (CCT)	5000K (Standard) 3000K & 4000K (Optional)														
Color Rendering Index* (CRI)	~70														
Drive Currents (mA)	350mA	450mA	525mA	600mA	700mA	350mA	450mA	525mA	600mA	700mA	350mA	450mA	525mA	600mA	700mA
Fixture Efficacy* (Lm/W)	123	120	118	115	109	123	120	117	113	109	123	119	116	112	107
Fixture Output* (Lm)	6,540	8,190	9,420	10,570	11,760	8,020	10,070	11,510	12,820	14,550	9,590	11,930	13,600	15,140	17,010
LED L70 (Hours)	> 100,000 hours (@ 350mA)														

High Mast Lighting Application

- **Lighting Fixture Labels:** Standard labeling practices
- **Specific High Mast Requirement:** For High Mast systems, **EACH** individual fixture on the carriage assembly must be labeled separately the direction of the rotation.



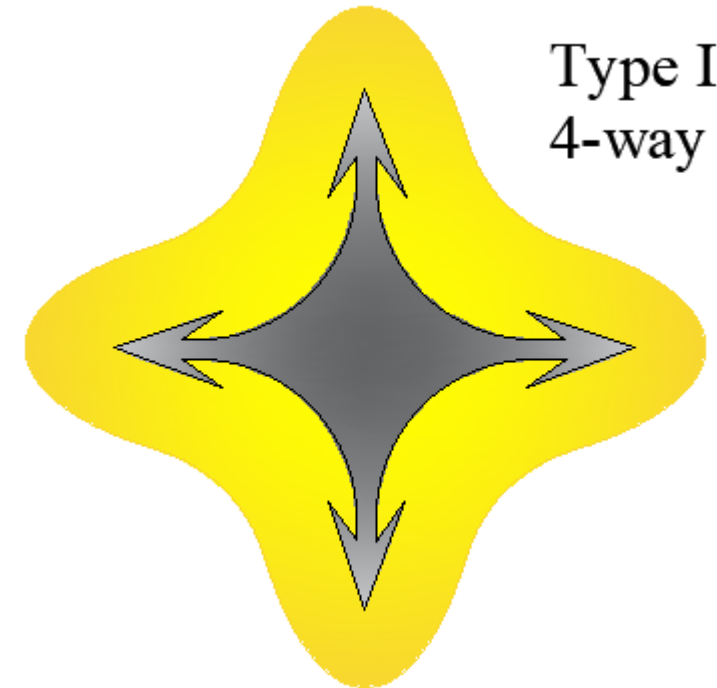
Roadway lighting fixtures are classified by “**Type**.” The type of the light fixture determines the light pattern that will be cast.

- **Type I** – This light spreads a symmetrical light pattern whereby the width of the pattern is nearly equal to the height of the light. You’ll find this type of light used in the center of a walkway or sidewalk.
- **Type I, Four-way** – This light spreads a symmetrical light pattern in two directions, which may be used where two sidewalks cross.

Type I

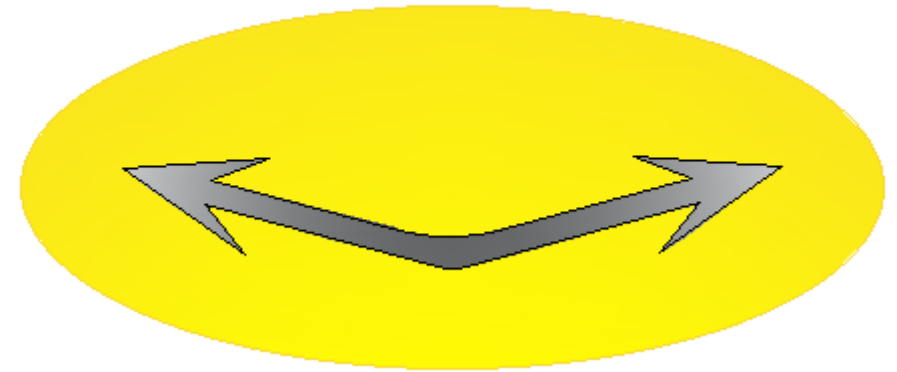


Type I
4-way

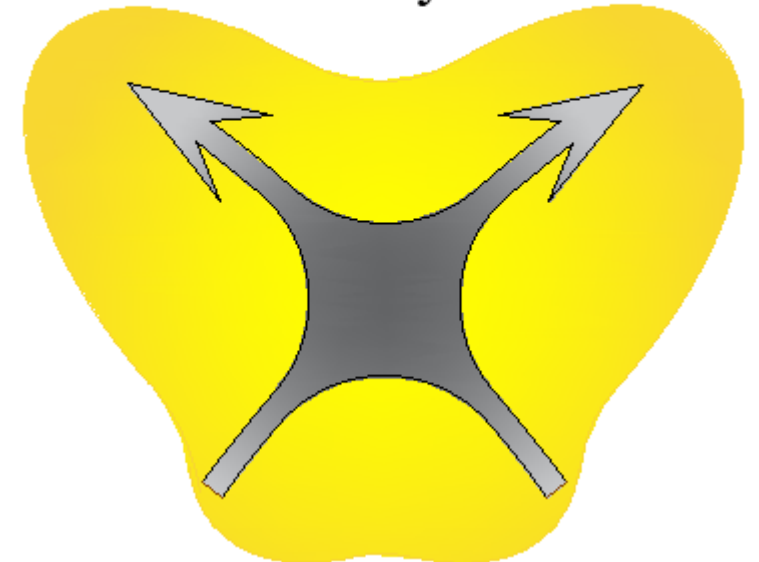


- **Type II** – This light spreads a slightly wider light pattern that is 1.5 times wider than the mounting height. You may find these along wider walkways, alleys, and along the edge of side streets.
- **Type II, Four-way** – Again, this light spreads the pattern in two symmetrical directions where a wider light coverage is needed.

Type II



Type II
4-way



- **Type III** – The light pattern is 2.75 times wider than the mounting height. You'll find these fixtures along the side of larger roadways, the edge of parking lots, or in sports and shopping complexes.
- **Type IV** – These are known as asymmetrical light fixtures. The light pattern is cast outward from the fixture at 2.75 times the mounting height and offers a more rounded light pattern. You'll find these fixtures on the side of a building, in a pedestrian tunnel, under a bridge, or around a perimeter area.

Type III

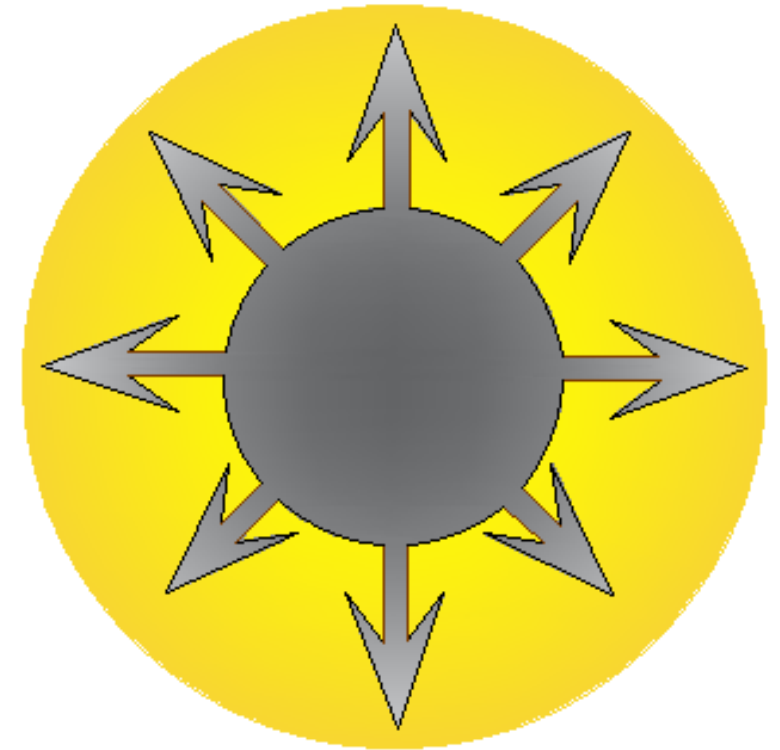


Type IV



- **Type V** – This light fixture is used to evenly cover large areas in a round or square light pattern. You may find these in parking lots, large commercial or industrial areas, interchanges, or at the corners of major intersections.

Type V



- The dark sky initiative is a global effort to limit light pollution thereby protecting the nighttime sky.
- Illuminating Engineering Society (IES) defines "Obtrusive Light" , *any light that is distributed beyond the target area*, into three categories:
 - **Light Trespass** - when light is directed into unintended areas
 - **Glare** - light that is directed into an observer's eye
 - **Sky Glow** - light from poorly directed light fixtures and excessive lighting that results in uplighting

Methods for combating obtrusive light:

- Understand the purpose of light
- Direct the light where needed
- Limit the light output
- Shielding
- The light should only be "on" when necessary
- Use light with warmer color temperatures

Flagstaff, Arizona was named the first dark sky city in 2001



There are currently over 230 dark sky places across 22 countries

Roadway lighting conductors, also known as street lighting conductors or streetlighting cables, are electrical conductors used to supply power to the roadway lighting circuit.

Streetlight circuits may use individual conductors or an assembly of conductors to form a cable.

Conductors used in underground roadway lighting circuits are insulated to protect against electrical hazards and environmental conditions such as moisture, temperature variations, and physical damage.

Conductors used in overhead roadway lighting circuits may be insulated or non-insulated (bare conductors). Caution must be used when working around overhead electrical circuits.

Conductors used in street lighting circuits are either made of copper or aluminum.

- Copper is known for its excellent conductivity and resistance to corrosion
- Aluminum is lighter weight, especially for overhead circuits and less expensive

The size and capacity of the roadway lighting conductors depend on various factors, such as:

- the power requirements of the lighting fixtures
 - the number of lighting fixtures
 - the distance of the lighting circuit
 - the voltage drop limitations.
- It's worth noting that specific regulations and standards may vary depending on the country or region.
 - Local electrical codes and industry standards provide guidelines for the installation and maintenance of roadway lighting conductors to ensure safety and compliance with electrical standards.




Single Phase, 120 VAC

- **Black** – Phase, Hot, or Line "L"
- **White** – Neutral "N"
- **Green, Green W/yellow**, Bare – Ground

Single Phase, 240VAC

- **Black** – Phase, Hot, or Line "L"
- **Red** – Phase 2, Hot2, Line 2, "L2"
- **White** – Neutral "N"
- **Green, Green W/yellow**, Bare – Ground

NEC Wiring Color Code for AC Voltage

Phase Supply	Wire & Cable	NEC - 120V, 208V, & 240V	NEC - 277V / 480V
Single Phase	Line "L"		
Earth Ground "PG" Protective Ground			 
Common	Neutral "N"		
Three Phase	Line #1 "L1"		
	Line #2 "L2"		
	Line #3 "L3"		


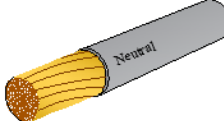




Three Phase, 208 VAC

- **Black** – Phase 1, Hot 1, or Line 1 "L1"
- **Red** – Phase 2, Hot 2, Line 2 "L2"
- **Blue** – Phase 3, Hot 3, Line 3 "L3"
- **White** – Neutral "N"
- **Green, Green W/yellow**, Bare – Ground

Three Phase, 277/480 VAC

- **Brown** – Phase 1, Hot 1, or Line "L1"
- **Orange** – Phase 2, Hot 2, Line 2, "L2"
- **Yellow** – Phase 3, Hot 3, Line 3, "L3"
- **White** – Neutral "N"
- **Green, Green W/yellow**, Bare – Ground







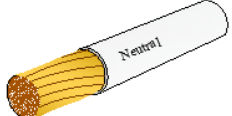
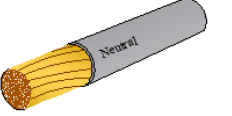
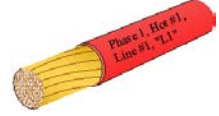
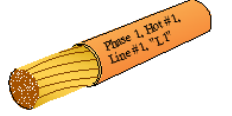




NEC Wiring Color Code for AC Voltage

Phase Supply	Wire & Cable	NEC - 120V, 208V, & 240V	NEC - 277V / 480V	
Single Phase	Line "L"			
Earth Ground "PG" Protective Ground				
Common	Neutral "N"			
Three Phase	Line #1 "L1"			
	Line #2 "L2"			
	Line #3 "L3"			

CEC Wiring Colors

Single Phase, 120 & 240VAC

- **Black** – Phase 1, Hot 1, or Line "L1" **OR...**
- **Red** – Phase 2, Hot2, Line 2, "L2"
- **White** – Neutral "N"
- **Green, Green W/yellow**, Bare – Ground

Canada Wiring Color Code for AC Voltage			
Phase Supply	Wire & Cable	CEC - 120V, 208V, & 240V	CEC - 277V / 480V
Single Phase	Line "L"		
			
Earth Ground "PG" Protective Ground			
Common	Neutral "N"		
Three Phase	Line #1 "L1"		
	Line #2 "L2"		
	Line #3 "L3"		






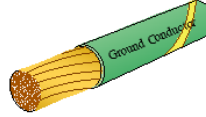
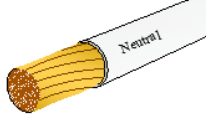
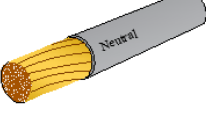




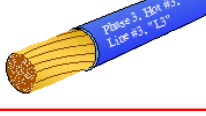
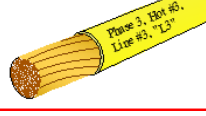
CEC Wiring Colors

Three Phase, 208 VAC

- **Red** – Phase 1, Hot 1, Line 1 "L1"
- **Black** – Phase 2, Hot 2, or Line 2 "L2"
- **Blue** – Phase 3, Hot 3, Line 3 "L3"
- **White** or **Gray** – Neutral "N"
- **Green, Green W/yellow**, Bare – Ground

Three Phase, 277/480 VAC

- **Orange** – Phase 1, Hot 1, Line 1, "L1"
- **Brown** – Phase 2, Hot 2, or Line "L2"
- **Yellow** – Phase 3, Hot 3, Line 3, "L3"
- **White** or **Gray** – Neutral "N"
- **Green, Green W/yellow**, Bare – Ground

Canada Wiring Color Code for AC Voltage			
Phase Supply	Wire & Cable	CEC - 120V, 208V, & 240V	CEC - 277V / 480V
Single Phase	Line "L"		
			
Earth Ground "PG" (Protective Ground)			
Common	Neutral "N"		
Three Phase	Line #1 "L1"		
	Line #2 "L2"		
	Line #3 "L3"		

Breakaway fuse holders are designed to ensure safe and reliable operation. They typically have features such as:

Pull-apart design: The fuse carrier can be easily separated from the base by pulling it out, disconnecting the circuit from the power source.

It is very important to install these correctly so that you do not have a live electrical, exposed fuse end when you disconnect the light feed from the circuit.

Fuse protection: The fuse holder base provides protection for the fuse against external elements, such as dust or moisture, while still allowing easy access for fuse replacement.



Reliability in Infrastructure

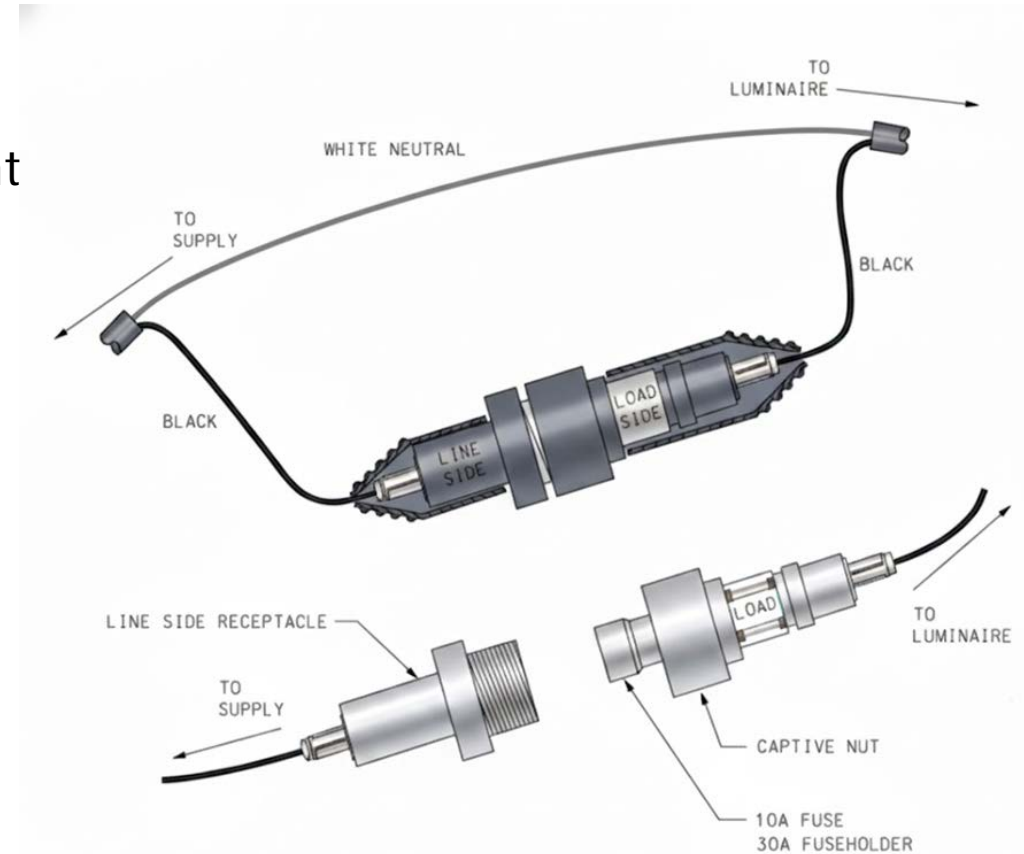
- Critical Role: Ensuring safe, consistent operation in public electrical systems.
- Primary Application: Essential for street lighting and roadway infrastructure.
- Safety Standard: Engineered to protect both the equipment and the public.

Pull-Apart Design

- Instant Disconnection: Allows the fuse carrier to separate easily from the base.
- Safe Isolation: Quickly disconnects the circuit from the power source for maintenance or in the event of a collision.

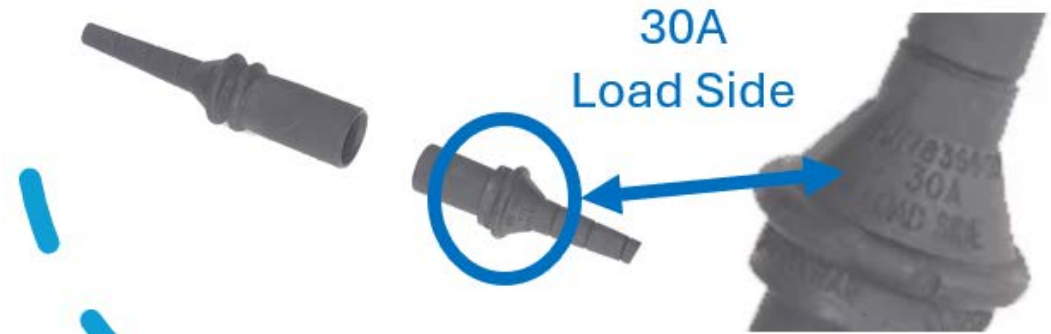
Integrated Fuse Protection

- Environmental Shielding: Protects the fuse from dust, moisture, and debris.
- Serviceability: Designed for rapid, tool-free fuse replacement to minimize downtime.



Mandatory Installation Protocol

- **Orientation Matters:** Holders must be installed in the correct direction to prevent electrical hazards.
- **Zero Exposure:** Proper installation ensures that **no live electrical ends** are exposed when the light feed is disconnected.
- **Risk Mitigation:** Incorrect wiring creates a lethal shock hazard for technicians and emergency responders.



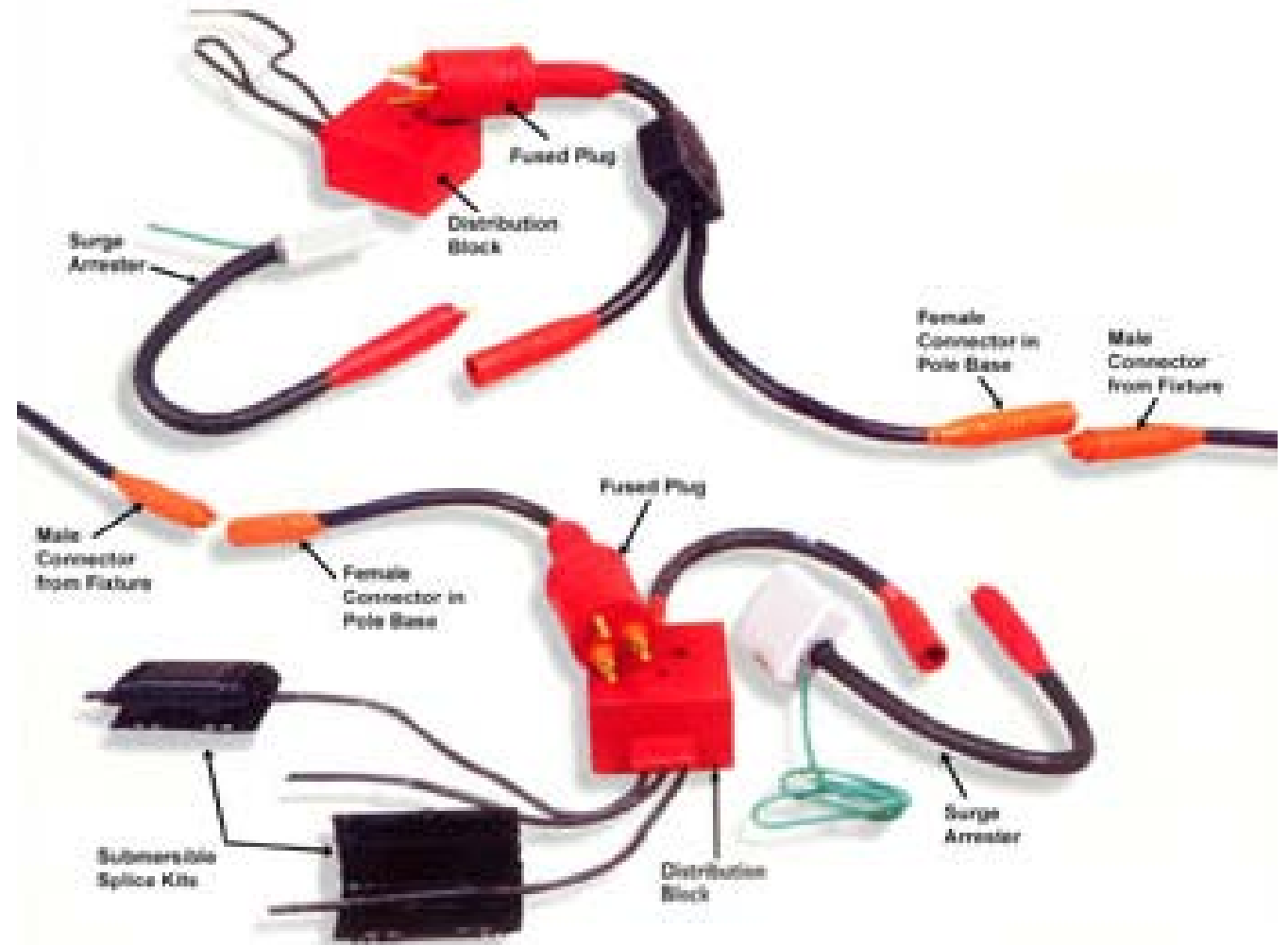
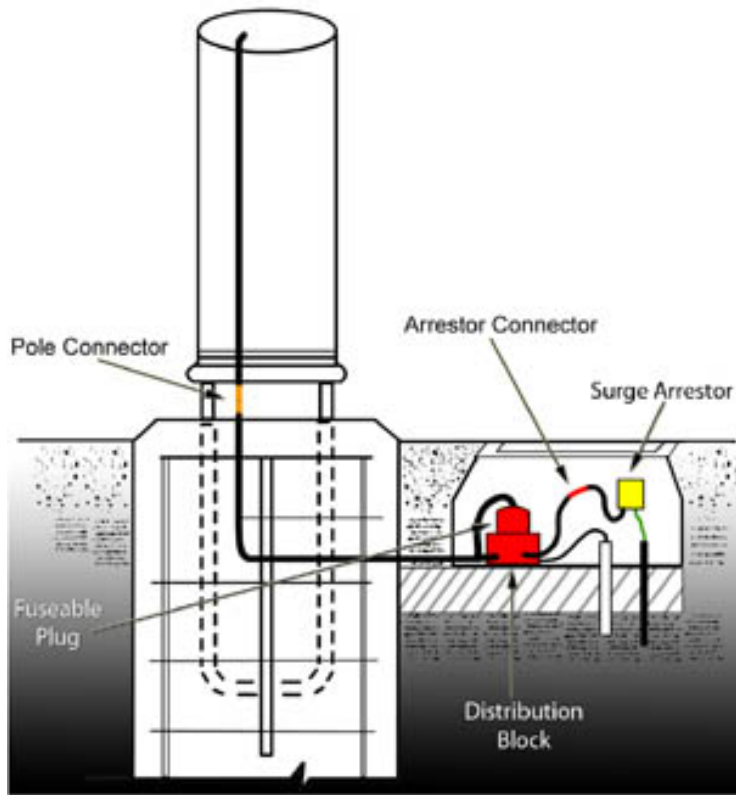
Components of the DOTPLUG Breakaway Wiring System

The DOTPLUG breakaway system is composed of a modular color-coded cable system consisting of rubber cords with integrally molded watertight submersible connectors, inline fuses, submersible surge arrester and breakaway connectors. The system provides power from the junction box to the luminaire. The cables extend from a junction box near the base of the pole to the luminaire(s) at the top of the pole. Pursuant to AASHTO Guidelines and other Passive Safety Standards, upon knockdown, the pole cable system electrically disconnects at the foundation, leaving no more than four inches (0.10 m) of wires, cables, or connectors protruding from the electrical conduit. All fusing for electrical fixtures is located and protected below grade.

A pole cable system must be considered on all breakaway lighting systems and even may provide additional safety, maintenance, and economical benefits to non-breakaway lighting systems.



DOT•PLUG Breakaway Wiring System for Roadway Lighting Systems



A roadway lighting control cabinet is a piece of infrastructure used to control and manage the lighting system along a road or highway. It is typically installed at specific intervals along the road and houses various electrical components that control the operation of the roadway lights.

Electrical components found in the roadway lighting control cabinet could include:

- Electric Utility Meter
- Circuit Breakers
- Fuse
- GFCI Outlet
- Photocell Sensor
- Time Clock



Here are some key features and components you might find in/on a roadway lighting control cabinet:

Control System: The control system is the brain of the cabinet, responsible for managing the lighting operations. It may include programmable logic controllers (PLCs), relays, or other electronic devices to control the switching and dimming of lights.

Photocells or Light Sensors: These sensors detect the ambient light levels and enable the lighting system to automatically adjust its intensity based on the surrounding conditions. They ensure that the roadway lights are properly dimmed or brightened depending on the time of day or specific lighting requirements.

Time Clocks: Time clocks or timers allow for the scheduling of lighting operations. They can be programmed to turn the lights on or off at specific times, helping to conserve energy during daylight hours or activate lighting during specific periods, such as evening rush hour and automatic time setting.

Fuses & Circuit Breakers: Fuses and breakers are overcurrent devices that are used for the protection of a circuit in the event of an electrical short circuit or an electrical overload of excessive or failed equipment, both of which create an excessive amount of heat that would cause damage to the circuit. For breakers, refer to manufacturer for torque specifications.

Communication Equipment: Some advanced lighting control cabinets may be equipped with communication devices such as Ethernet, Wi-Fi, or cellular modules. This allows for remote monitoring and control of the lighting system, enabling real-time adjustments, monitoring of energy consumption, and the ability to receive alerts or notifications about system issues.

Surge Protection and Electrical Distribution: The cabinet may include surge protection devices to safeguard the electrical components from power surges or voltage spikes. It also houses the electrical distribution components to provide power to the lighting fixtures.

Status Indicators: LED indicators or display screens are often present on the cabinet to provide visual feedback on the operational status of the lighting system. They can indicate whether the lights are on or off, if there are any faults or malfunctions, or display system information.

Roadway lighting control cabinets play a crucial role in managing the energy consumption, maintenance, and overall performance of the lighting system along roads and highways. They help improve safety, optimize energy usage, and provide a more efficient and reliable lighting infrastructure for drivers and pedestrians.

Also called smart street lighting, goes beyond simply turning lights on and off, offering advanced features that improve safety, efficiency, and sustainability.

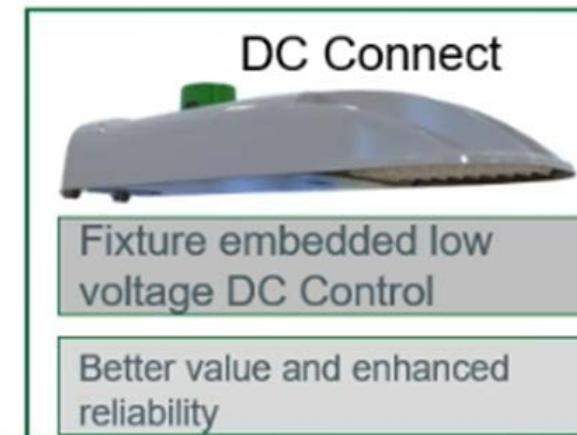
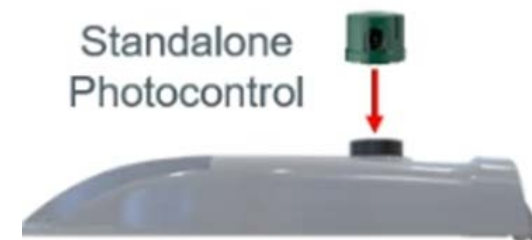
- **Remote Monitoring & Control:** Operators can adjust brightness levels, turn lights on/off, or run diagnostics from a central system.
- **Adaptive (Dynamic) Dimming:** Lights automatically adjust brightness based on factors like traffic volume, pedestrian activity, or time of night.
- **Sensor Integration:** Motion, environmental, or acoustic sensors can trigger lights to brighten when people or vehicles are nearby, improving energy efficiency while the emphasis of safety is maintained.
- **Predictive Maintenance:** Built-in diagnostics and reporting alert maintenance teams when bulbs are failing or components need replacement, reducing downtime and repair costs.
- **Communication Networks:** Systems connect via wired or wireless networks. This allows streetlights to “talk” to each other and to a central control hub.
- **Emergency / Security communication:** Lighting can be automatically brightened in specific zones to guide first responders. Lights can be set to increase brightness in areas with detected activity, deterring crime.

Intelligent Street Lighting



- Manufacturer Name
- Luminaire Catalog Number
- Manufactured Date
- Nominal Input Power
- Nominal Input Voltage
- Nominal Light Output
- CCT (Color Temperature)
- Distribution Type (Type II, II, etc.)
- Luminaire Color

Feature	Technical Functionality	Operational Value
Remote Control	Centralized ON/OFF/DIM & diagnostics.	Eliminates manual site visits for scheduling.
Adaptive Dimming	Logic-based output via traffic/pedestrian sensors.	Maximizes energy savings and lamp lifespan.
Integrated Sensors	Installation of motion, acoustic, and env. sensors.	Real-time "on-demand" lighting and data collection.
Smart Diagnostics	Automated fault reporting and component health.	Shifts from reactive to predictive maintenance.
Mesh Networking	Wired/Wireless node-to-node communication.	Creates a resilient, "talking" infrastructure grid.
Emergency Sync	Zonal brightening for security and responders.	Enhances public safety and deters criminal activity.



At what depth would you install a 38-foot wood pole?

- A) 4'
- B) 4.6'
- C) 5'
- D) 5.8'

What purpose does a transformer base serve?

- A) They look nice
- B) They have ample room for the fuses
- C) They reduce the force of an impact
- D) They elevate the pole

Which of the following has the widest color temperature range?

- A) LED
- B) HPS
- C) Incandescent
- D) Fluorescent

What best describes a lumen?

- A) The amount of power a lamp consumes
- B) The amount of voltage a lamp needs
- C) The negative coefficient of a lamp
- D) The amount of light output from a source

What part of an HID lamp actually lights up?

- A) The filament
- B) The pilot
- C) The gas tube
- D) The contacts

Which lamp operates with a negative temperature coefficient?

- A) An incandescent lamp
- B) An HID lamp
- C) An LED lamp
- D) A quartz lamp

What part of a metal halide light fixture prevents damage to the lamp ?

- A) The starter
- B) The capacitor
- C) The ballast
- D) The photocell

What is meant by a multi-tap ballast?

- A) The ballast can operate different types of lamps
- B) The ballast can operate with different line voltages
- C) The ballast can operate with different load voltages
- D) The ballast can operate with different photocells

What type of light pattern would a “wall-pack” fixture output?

- A) A type I
- B) A type II
- C) A type IV
- D) A type V

Roadway lighting fixtures use a NEMA labeling system. These labels allow to see what wattage and type fixture is used. NEMA and ANSI are adding what information to the label for LED fixtures?

- A) HID Source
- B) Color Temperature and Lumen output
- C) Type of Fixture
- D) Position Oriented Pulse start

What is the main reason breakaway wiring systems are used?

- A. To allow water to be trapped in connectors and trip if it gets too wet
- B. To ensure cable will not be damaged
- C. In the event a pole is hit - the fuse will disconnect, not allowing the pole to be energized
- D. All metal poles must use breakaway fuse design

The main purpose of a breakaway BASE is?

- A) To reduce excessive damage due to the impact, and the risk of electrical shock, and injuries
- B) Keep anchor bolts from damage
- C) Keep damage to pole at a minimum
- D) To ensure vehicle that hit base stays at accident scene

IMSA Roadway Lighting Technician

Session 5: Installation of Roadway Lighting

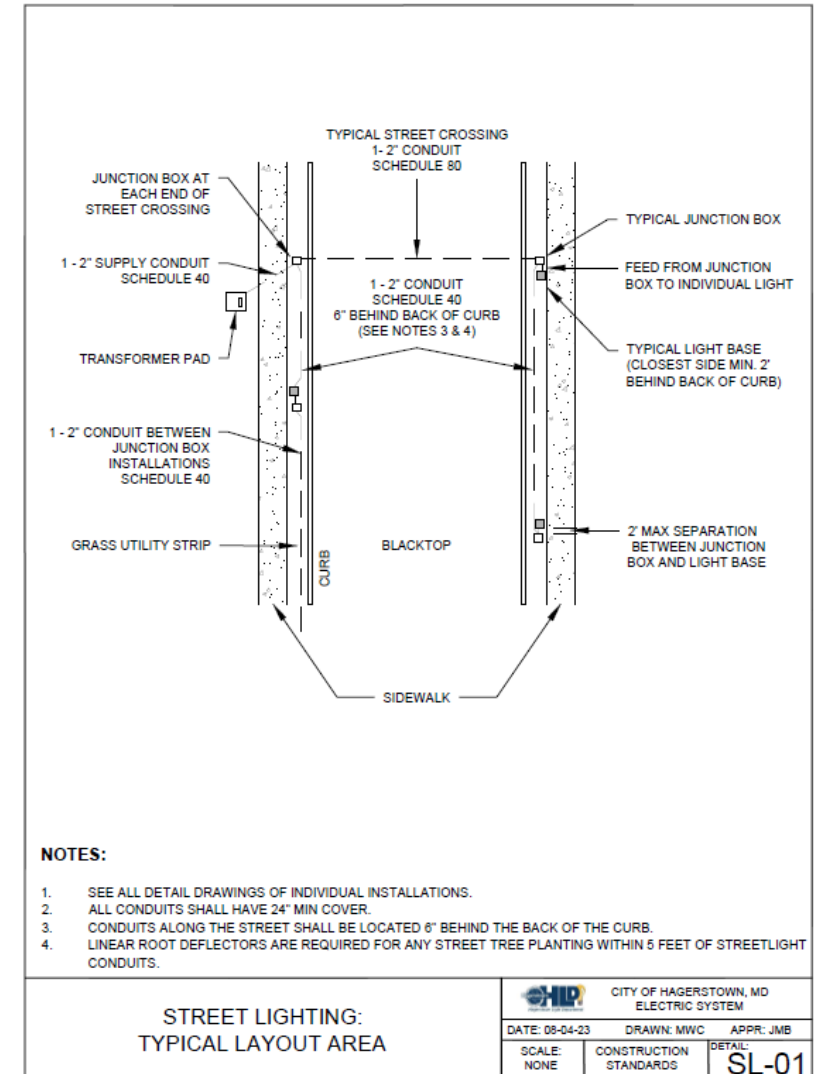


Advancing the Future of Public Safety

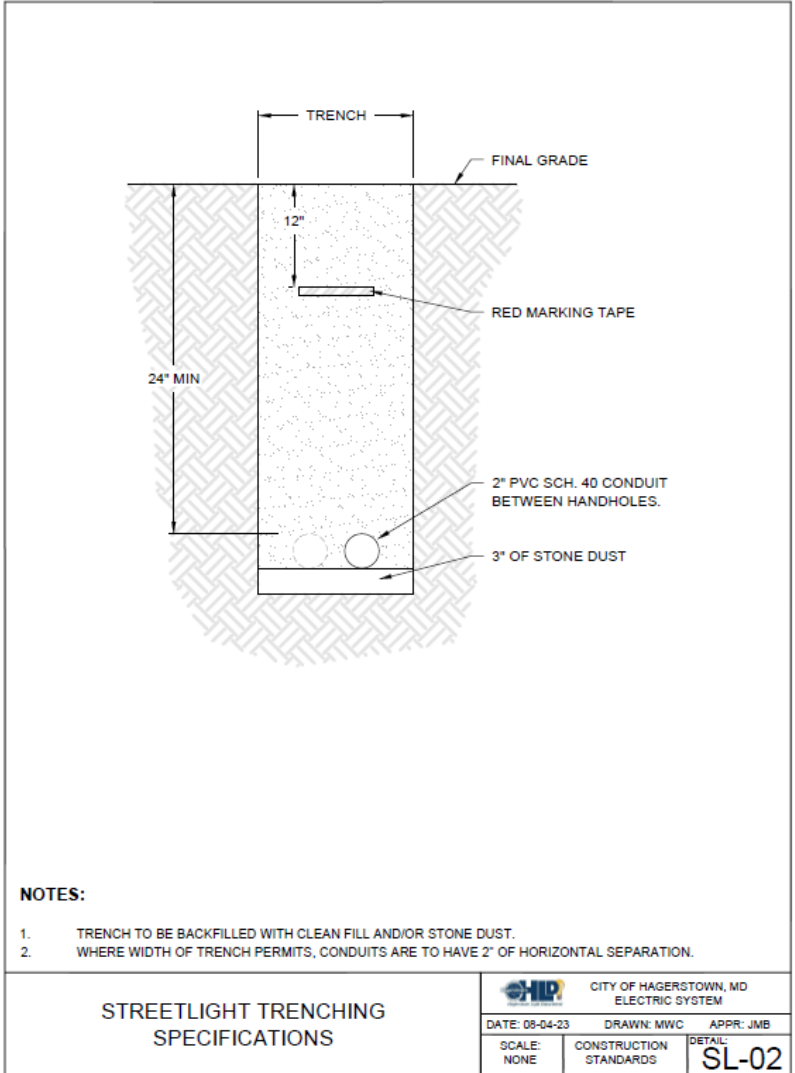
Review the load list and determine which materials to obtain.

Materials:

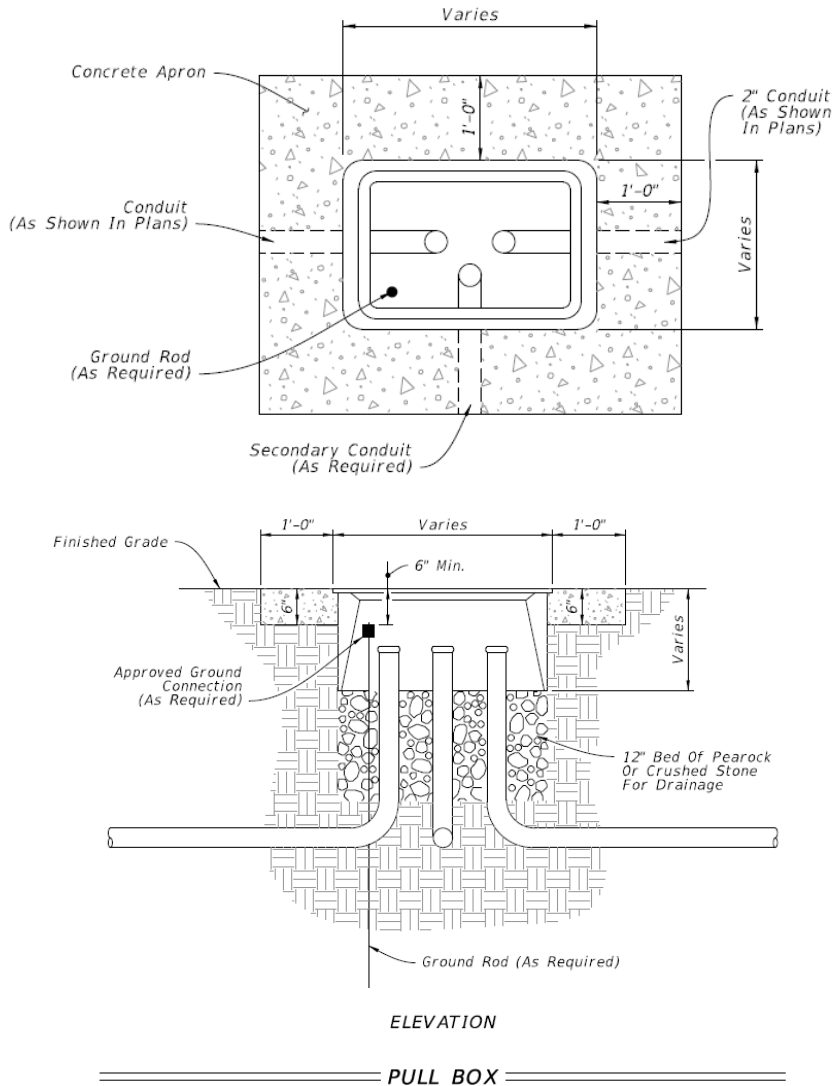
- Installation plans
- Measuring wheel
- Trencher, auger, shovel
- Conduit (proper size and length)
- Fittings (90-degree and elbow)
- Glue
- Pull boxes
- Pea gravel for drainage
- Prefabricated foundation OR
 - Concrete
 - Anchor bolts
 - Rebar cage
 - PVC pipe
- Pole
- Luminaires
- Lamps
- Wire and cable
- Fuses and fuse holders
- Ground rods and clamps
- Service and contactor
- Photocell/Time clock



Underground Conduit Installation



1. Identify the appropriate area to install conduit.
2. Contact utility company or call 811 before excavating.
3. Excavate the conduit area. Be sure to follow OSHA/CCOHS excavation safety rules.
4. Cut, debur, thread, bend conduit as necessary.
5. Install underground conduit and 90-degree bends.
6. Temporarily tape open ends.
7. Duct seal for permanent sealing.
8. Bury and tamp dirt surrounding conduit.



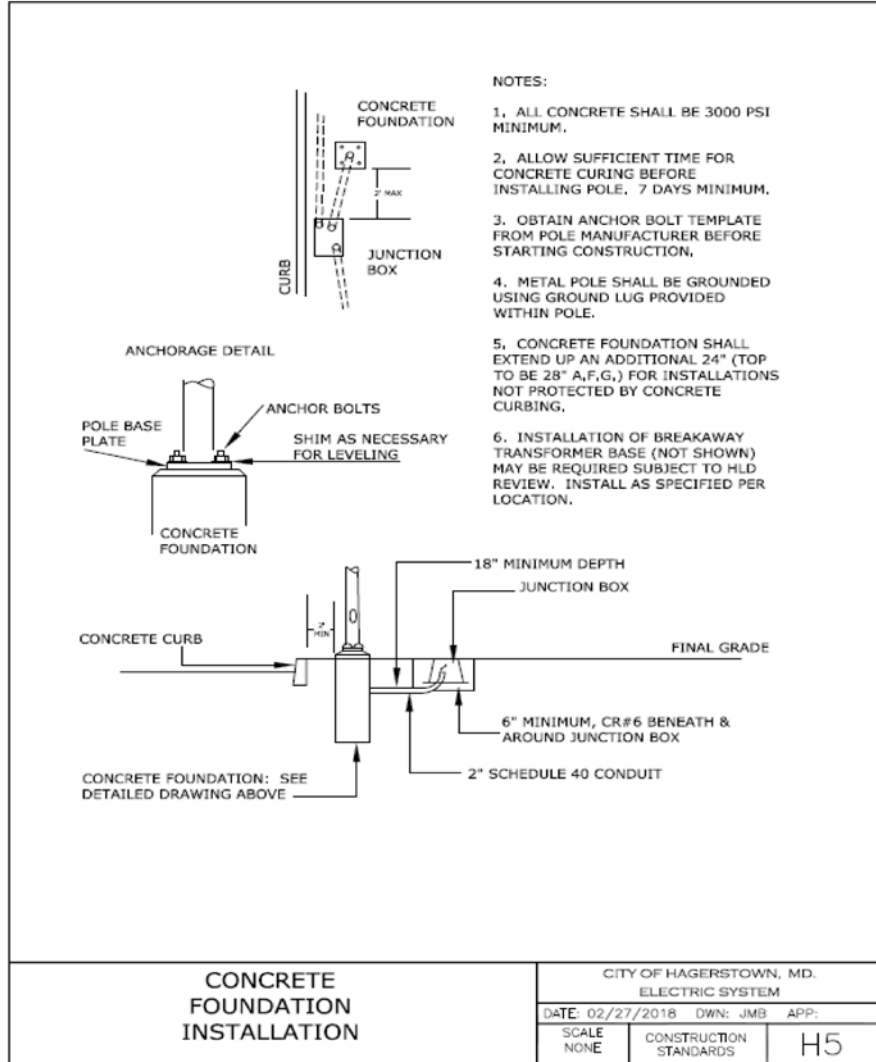
1. Tape or sealed the ends of the conduit.
2. Pour pea gravel.
3. Level pull box.
4. Install ground rods
5. Metal pull box lids must be bonded & grounded
6. Bury and compact dirt surrounding box or install concrete apron.
7. Tamper proof bolts may be installed for increased security.
8. Pull boxes are considered wet locations by the NEC



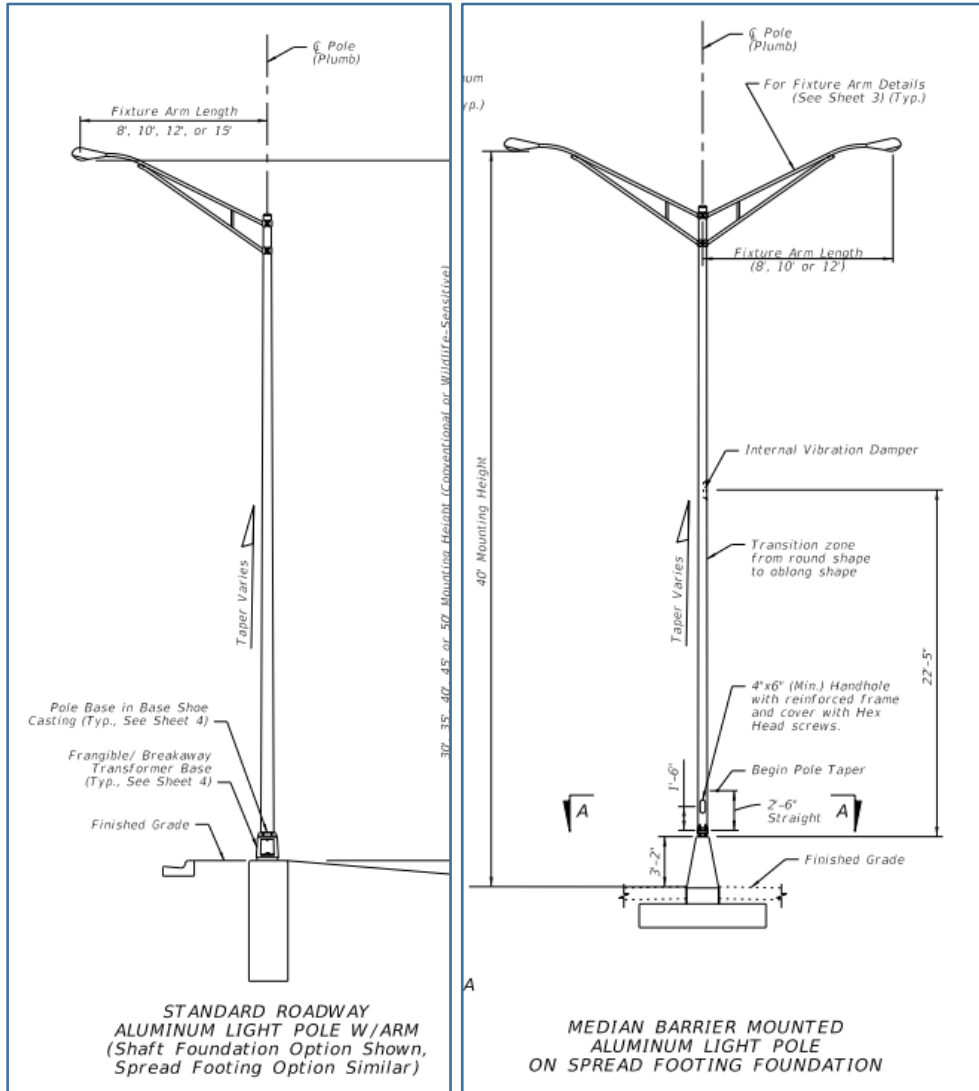
Check for good storage as well as any damage prior to start.

1. Site Selection
2. Excavation
3. Placement
4. Backfill / Complete

Concrete Foundation Installation



1. Drill or vacuum the hole
2. Install rebar cage and anchor bolts with proper orientation.
3. Install the appropriate conduit.
4. Pour & finish the concrete foundation
 1. *Concrete typically reaches its design strength in seven days*
5. *OR*, Install a pre-fabricated light foundation

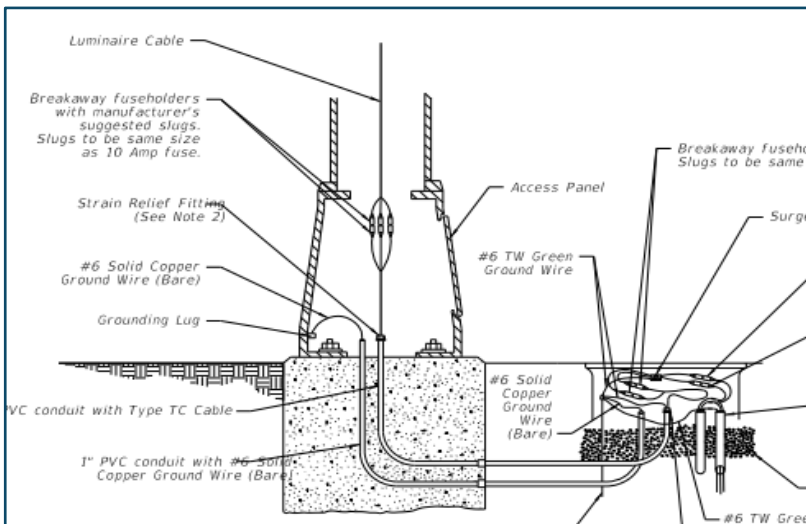
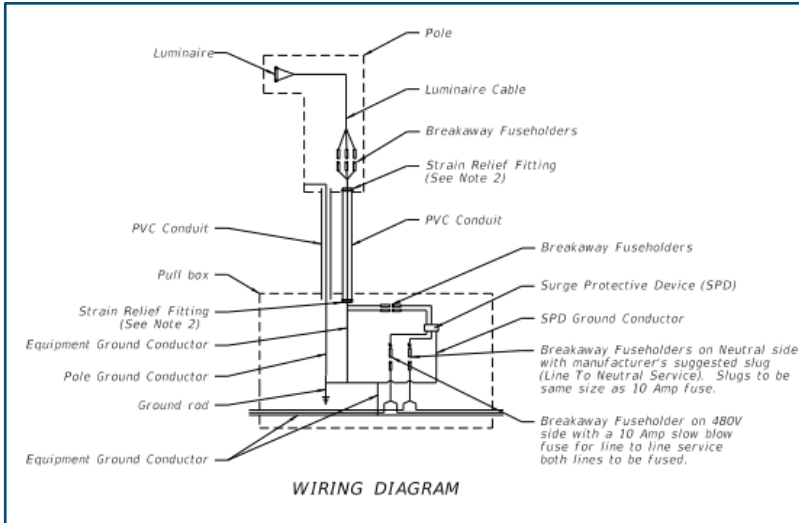


1. Assemble pole, luminaire arm, wire, and mount luminaire fixture.
2. Install pole assembly on foundation.
3. Align pole to maximize lighting efficacy.
4. Ensure bolts are properly tightened using a combination wrench and/or torque wrench per agency specifications.
5. Tamper proof hardware and hand hole covers may be installed for increased security.
6. Level the fixture

Pole Installation Video



https://www.youtube.com/watch?v=1pFxugh_0Po - 'Street Light Installation' by Pacific Utility Installation



[FDOT Standard Plans Conventional Wiring Diagram](#)

1. Determine type of wiring to use.
2. Install grounding rods.
3. Pull cables through conduit, pull boxes, PVC, and pole base.
4. Install service contactor and photocell or time clock.
5. Install meter.
6. Make appropriate connections; I.E. waterproof in pull box, hand hole, luminaire, and control.
7. Connect fuses and run them up to the luminaire.
8. Test components.

When installing:

1. Separate wiring - as to not blow the circuit in signal cabinet, if installing on a signal pole
2. Wind load
3. Clearance to power lines





Remove trash and debris from performed work



Inspect site for necessary landscape cleanup



Conduct final sweep of site with photo verification

Ensure that all tasks including inspections, repairs, replacements, and materials used are documented. All assets for every work site should be current and accurate.

Include the following items in your worksite documentation:

- Category of work completed
- Equipment, labor, and materials
 - Manufacturer materials
- Supplemental materials (receipts, etc.)
 - Other relevant information



A MINIMUM of ___ days is considered sufficient time for concrete to cure before installing pole.

- A) 2
- B) 5
- C) 7
- D) 11

What is the first step to installing the concrete foundation?

- A) Pour concrete foundation
- B) Install PVC/Conduit
- C) Install rebar cage
- D) Install anchor bolts

What material should be poured around the conduit for drainage?

- A) Sand
- B) Pea gravel/Crushed stone
- C) Dirt/Clay
- D) Mulch/Topsoil

Which is NOT included in a prefabricated foundation?

- A) Anchor bolts
- B) Rebar cage
- C) Electrical wiring
- D) PVC pipe

What is the first step in the installation process for conduit?

- A) Pouring of a concrete base
- B) Identify the appropriate area to install conduit
- C) Installing the pole in nearby location
- D) Assemble luminaires

True or False:

Failure to tamp down or compact dirt around conduit and pull boxes can result in erosion in the dirt over time, causing a tripping hazard.

IMSA Roadway Lighting Technician

Session 6: Roadway Lighting Maintenance



Advancing the Future of Public Safety

Maintaining roadway lighting is essential to ensure safe, reliable, and energy-efficient illumination for motorists and pedestrians. A well-planned preventive maintenance program includes the following key elements:

1. Regular Inspections:

- Conduct routine visual inspections (during both day and night) to identify malfunctioning lights, damaged fixtures, or signs of wear.
- Use advanced monitoring systems where applicable to detect issues in real-time.
- Schedule inspections based on jurisdiction, standard intervals, complaints, or performance data.

2. Cleaning and Vegetation Management:

- Clean light fixtures, lenses, and reflectors to remove dirt, dust, and other contaminants.
- Manage nearby vegetation with the proper authority (e.g., tree branches) that may obstruct light distribution or access to equipment.



3. Lamp Replacement:

- Promptly replace burned-out or failing lamps to maintain consistent lighting.
- Replace the lamp with the same type of lamp. The lamp **MUST** match the ballast and voltage used in the fixture.
- Dispose of lamp as appropriate for hazardous materials
- Maintain an inventory of spare lamps to reduce downtime.
- Use LED or other energy-efficient technologies for improved longevity and reduced operational costs.



4. Electrical System and Connections:

- Inspect and maintain wiring, transformers, control panels, and electrical connections.
 - Look for corrosion, oxidation, or other contaminants that may compromise any electrical connections
- Tighten loose connections to prevent flickering or system failure.
- Monitor voltage levels and ensure a stable power supply.



5. Timers, Sensors, and Control Systems:

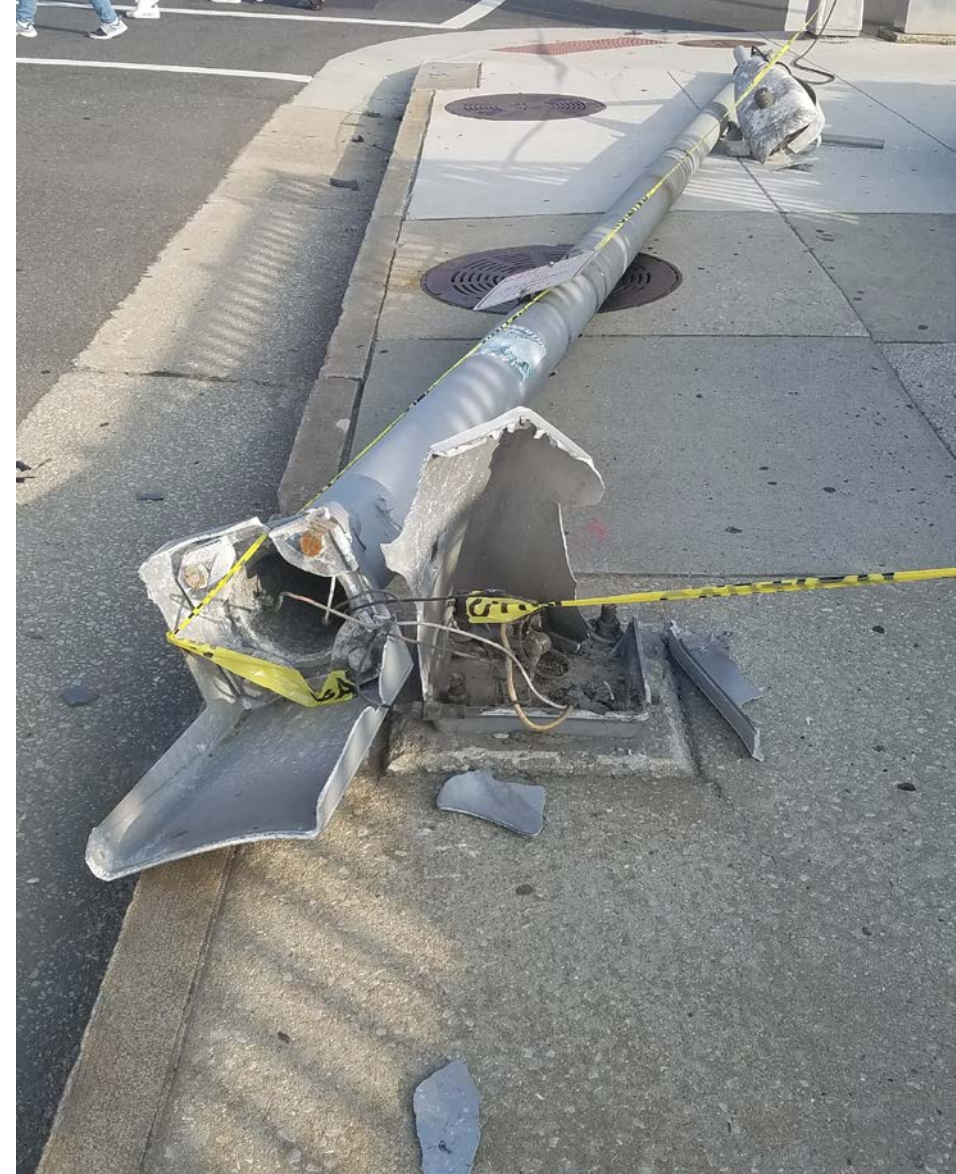
- Test and calibrate timers, photocells, and automated controls regularly.
- Adjust settings to align with seasonal daylight changes and optimize energy use.

6. Poles, Fixtures, and Mounting Structures:

- Inspect poles, brackets, and mounting structures for corrosion, rust, damage, or instability.
- Document, repair or replace components as needed to maintain structural integrity and safety.
- Check fixture integrity, including lenses and protective covers.

7. Power Supply and Backup Systems:

- Ensure reliable line and load power connections.
- Ensure the integrity of all electrical components.
- Test and maintain any backup systems, such as generators or battery backups, to prepare for outages.



8. Preventive Maintenance Scheduling:

- Establish a systematic schedule based on manufacturer recommendations, industry standards, and local conditions.
- Include recurring tasks such as cleaning, inspections, adjustments, and replacements.

9. Documentation and Record-Keeping:

- Track maintenance activities with detailed logs (dates, tasks performed, issues found, materials used).
- Use records for planning, budgeting, invoicing, and performance evaluations.

10. Reporting and Documenting Outages:

- When documenting outages be sure to follow your agency's/owner's procedures.



11. Community Feedback and Reporting:

- Encourage public reporting of lighting outages or safety concerns.
- Reporting comes from Citizens, Police departments, Automated systems, Visual inspection, and Power companies

12. Coordination with Local Authorities:

- Work collaboratively with transportation and public works departments.
- Ensure alignment with regulatory requirements, safety standards, and infrastructure upgrades.

A proactive, well-documented maintenance strategy extends the life of roadway lighting infrastructure, ensures safety, reduces energy use, and minimizes costly emergency repairs.



Survey Scheduling

Review the survey schedule to determine the appropriate lights for inspection.

Conducting the Survey

Drive around the scheduled area during the day and at night.

Preventative Maintenance Tools

Compare the survey results to your truck's inventory to determine the materials necessary for preventative maintenance.

Examples:

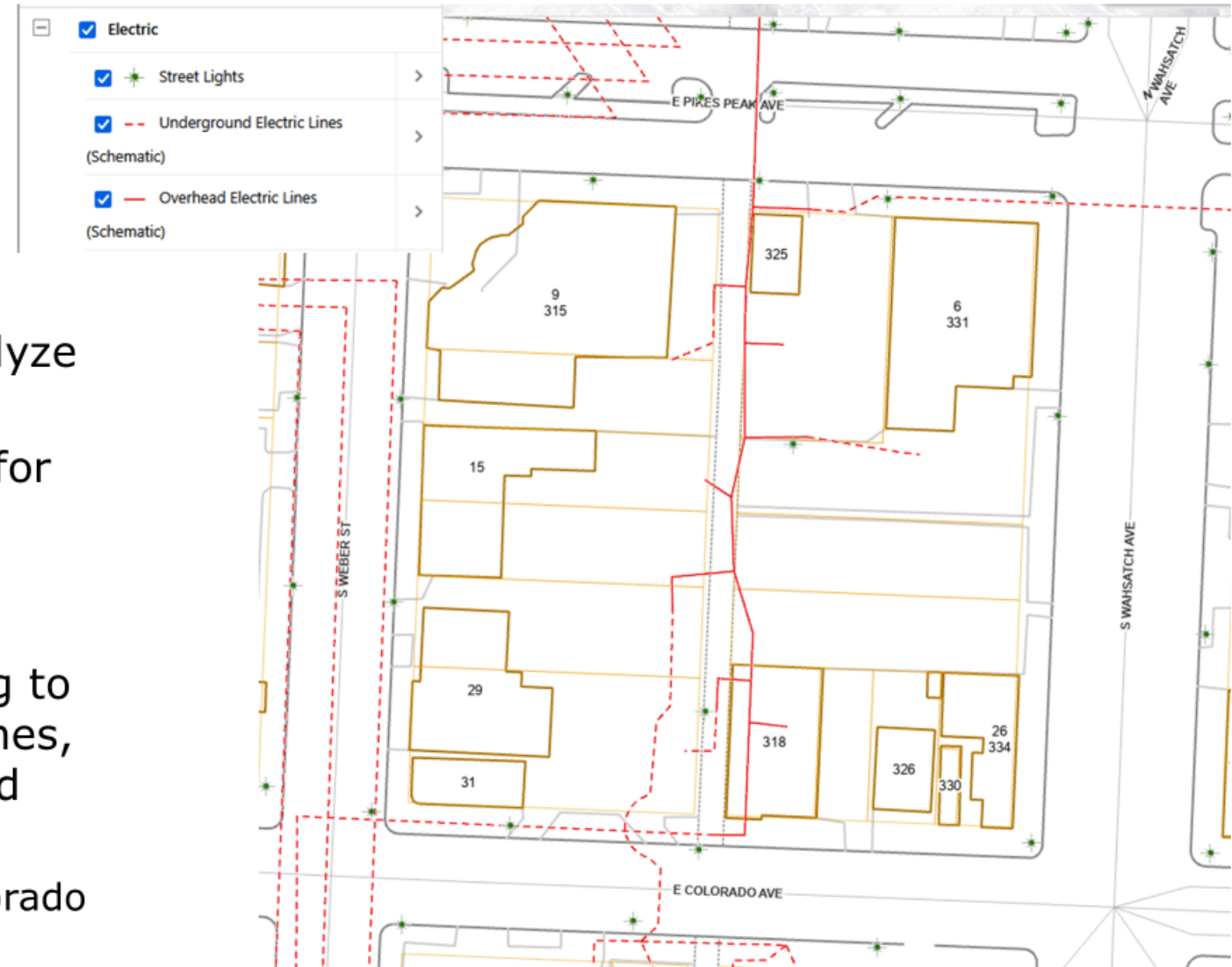
- Safety Data Sheets
- Bug/Wildlife Protection



GIS mapping is a technology that combines data with modern mapping techniques

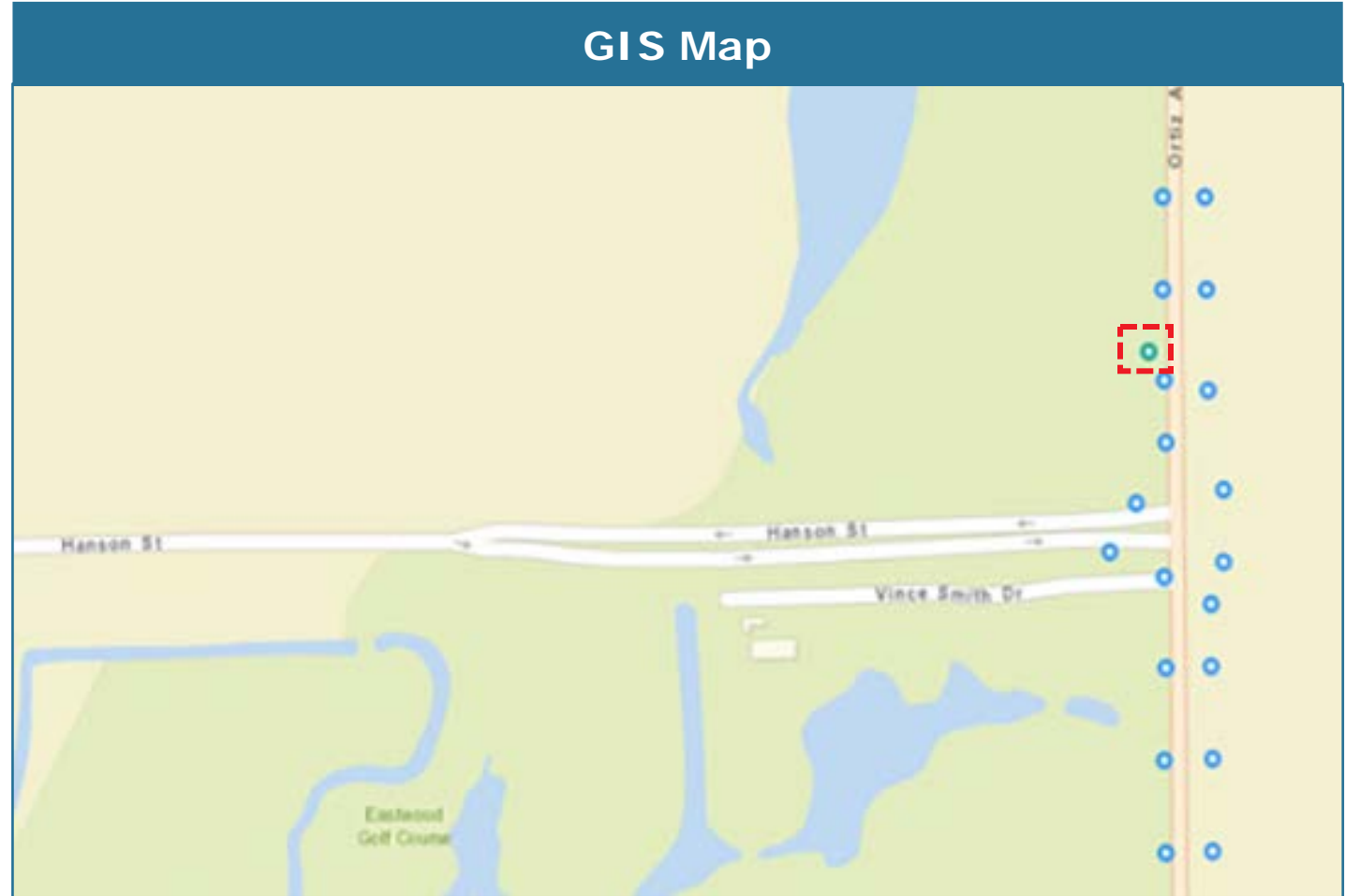
Google maps, Zillow, Cragislist use GIS mapping

- It allows us to create, manage, and analyze data based on geographic locations
- Many public agencies use GIS mapping for elevation data, interactive maps, flood plains, land use, crime, census data, environmental, & transportation needs...
- Many utility companies use GIS mapping to track their inventories, such as power lines, poles, transformers, switch cabinets, and streetlights
- This picture shows one square block in Colorado Springs showing streetlights & powerlines



1. Locate power source for the site
2. Acquire permission, if necessary
3. Check voltage with multimeter

Note: Always use lockout / tagout procedures during power maintenance.



Streetlights (Luminaires)

Electric Service (Power Source)

Visually Inspect and Test the following components:

- Overall, Pole & Lighting Assembly
- Circuits & Voltage
- Grounding
- Photocell
- Timeclock
- Fuses, breakers, surge protection
- Wiring
- Lamps
- Ballasts/Drivers
- Capacitors

Note: Inspect and test items on ground if possible before getting into lift.

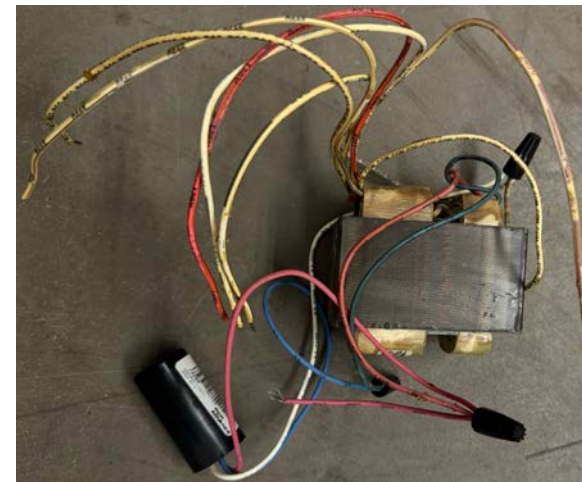
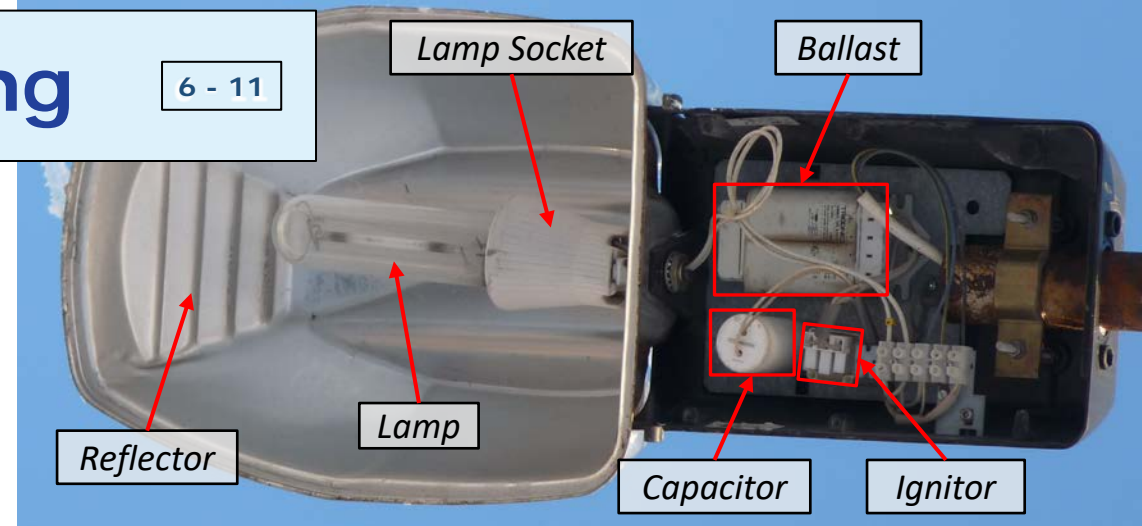


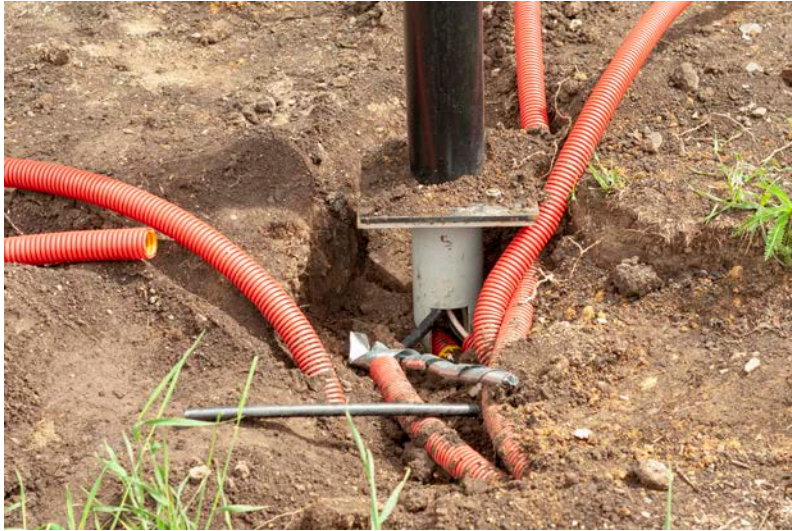
Luminaires - Lighting

6 - 11

Key parts of a streetlight:

- **Lamp** – may be gas discharged or LED
 - Gas discharged lamps may cycle "on"/"off" if the lamp is failing
- **Ballast** – a current limiting device that regulates the current & voltage feeding the lamp
 - If the ballast fails, the lamp may cycle "on"/"off" or may not come on at all
 - The ballast must be matched to the type of lamp in the fixture and the line voltage
 - *No Ballast in LED lighting fixtures*
- **Photocell** – The automatic control device for turning the lamp "on" and "off"
 - If photocells fail, the lamp may cycle "on"/"off", may not come on at all, or may stay on all the time.





Damage

- Ensure no visible damage to wire (nicks, kinks, etc.).
- Check continuity.
- Use fault locator to identify damage if necessary.



Connections

- Ensure connections are tight.
- Tighten connections if necessary.
- Replace connectors if necessary.



Proper Wiring

- Ensure proper wiring is used.
- Replace wiring if it does not align with local/NEC standards.



Damage

- Ensure there are no breaks in conduit.
- Repair breaks with PVC glue if necessary.
- Use duct seal if necessary.



Proper Bends

- Ensure bends do not exceed 360 degrees.
- Add a pull box where the conduit changes direction, to break up long runs, and to access the underground conduit system.



Proper Type/Size

- Ensure proper conduit is used. (Size and type)
- Ensure pull boxes are used when more than one type of conduit is needed.
- Refer to NEC Table C for conduit space requirements relating to number of wires permissible.



Damage

- Ensure box cover and other components are intact.
- Ensure metal lids are bonded and grounded
- Replace components or box if necessary.



Proper Installation

- Ensure dirt surrounding box is compacted.
- Re-install box if necessary.



Proper Box Size/Type

- Ensure proper sized pull box is used.
- Ensure box is traffic bearing.
- Ensure APL is displayed.
- Replace box if necessary.

Blown Fuses/Tripped Breaker

- Be sure to have on PPE prior to any work.
- **Disconnect power and isolate the fuse.**
- Test a fuse with a multimeter
- Clear the short
- Replace failed fuses with ones of the same amperage.
- *OR* - Reset the circuit breaker as necessary

Corrosion/Damage

- If corrosion is present, clean or replace disconnect with the same/larger load rating.
- If gaps, cracks, holes, etc. are present, replace panel.

Proper Fuse Type/Class

- Ensure proper fuse type and class is used.
- Replace if necessary.



Photocell/Motion Sensor Function

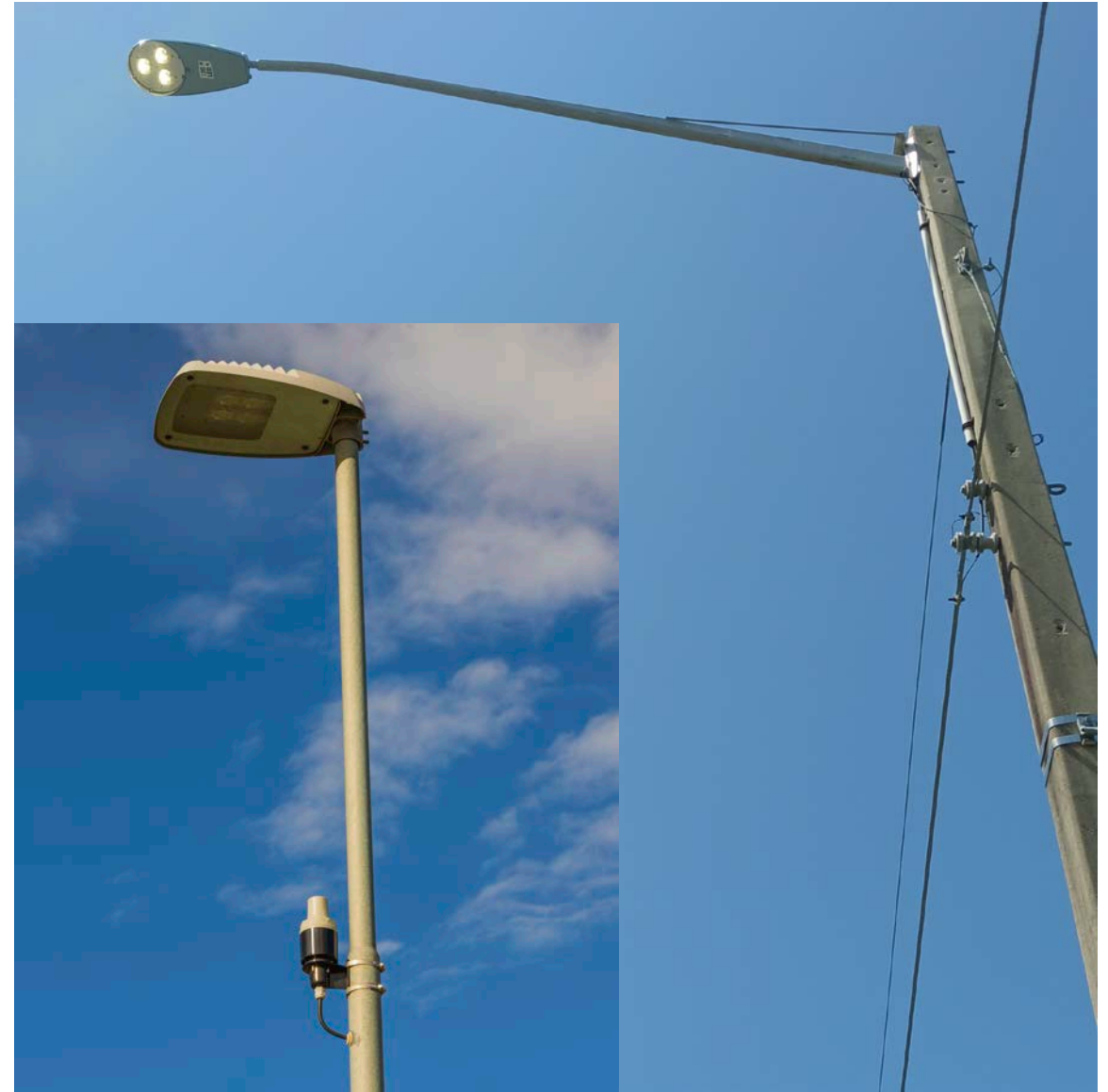
- Cover photo eye to see if light turns on when nighttime is simulated.
- Replace photocell or sensor if light remains powered on or cycles.

Photocell/Motion Sensor Position

- Ensure sensor eye is facing to the north.
- Reposition the socket if necessary.

Proper Components

- Ensure proper photocell/motion sensor control components are used.
- Replace if necessary.

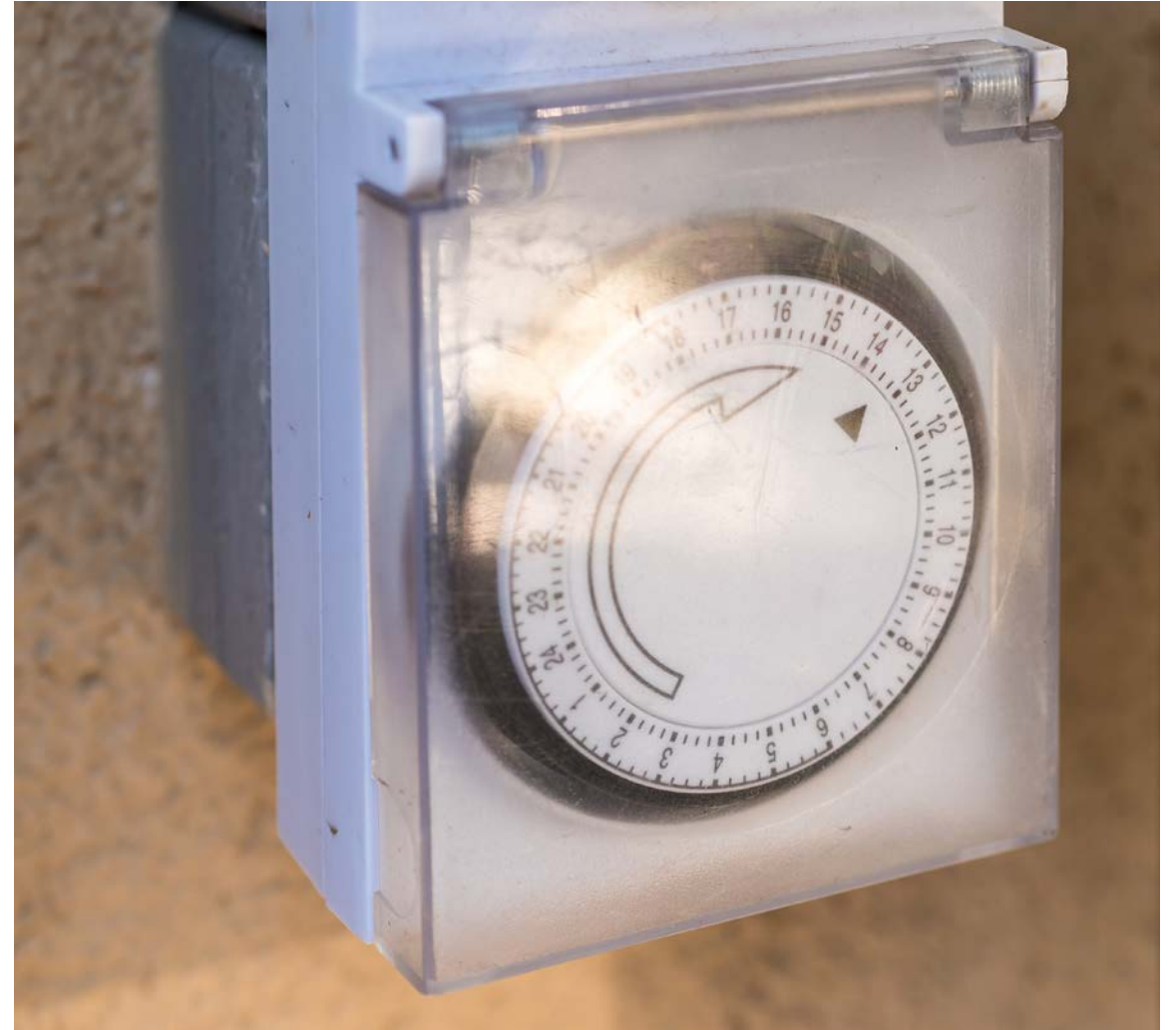


Battery Replacement

- Check battery voltage and replace battery if necessary.
- Reset the time clock and replace if necessary.

Time Adjustments

- Ensure time and date tabs/pins are set correctly.
- Reset tabs if necessary.



Many older street lighting assemblies use High Intensity Discharge (HID) lamps, which provide a large amount of light per unit of energy.

If HID luminaire is not functioning:

1. Inspect pole and lighting assembly and remove potential hazards.
 2. Inspect the door of the assembly.
 3. Follow manufacturer's guidelines to inspect lamps, starters, ballasts, and capacitors.
- Make you fully discharge the capacitor before making any inspections or conducting any maintenance.



LEDs have a long lifespan, are energy efficient, do not have a “cool down” and “restrike” period, and can be dimmed via automatic lighting systems.

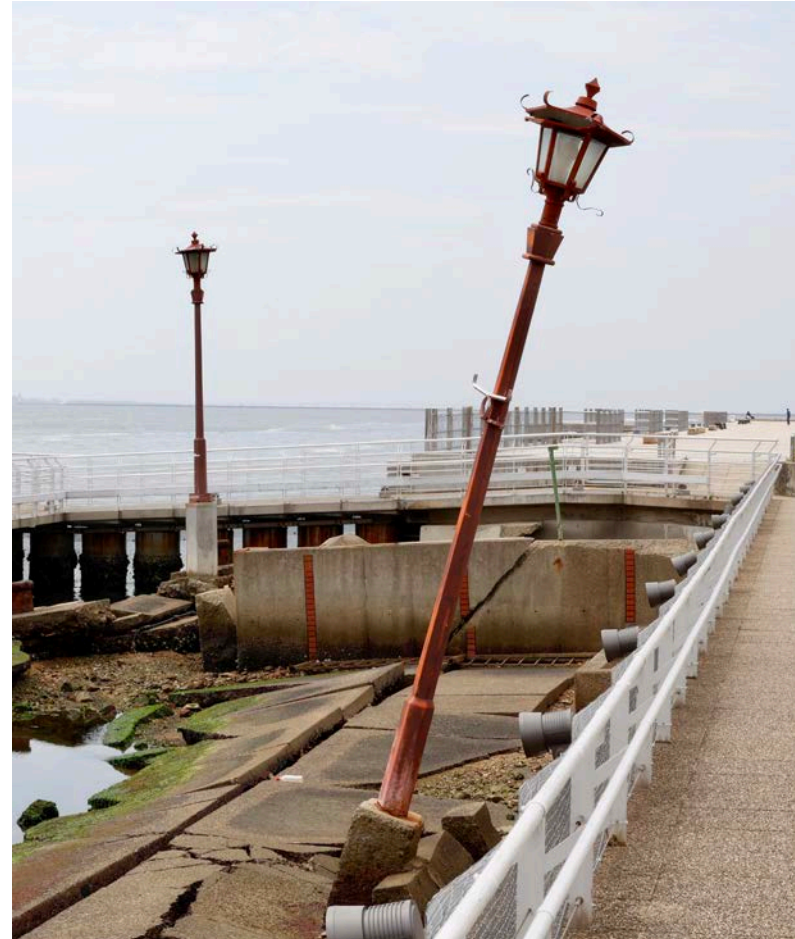
If LED is not functioning:

1. Inspect pole and lighting assembly and remove potential hazards.
2. Inspect voltage and replace the string of LEDs if possible.
3. Inspect LED driver.
4. Inspect driver surge protection module.



Always inspect the following components:

1. Pole alignment for proper light distribution
2. Base of the pole
3. Anchor bolts & nuts
4. Concrete/Foundation





1. If pole or foundation needs to be replaced, follow protocol for utility marking.
2. Remove nuts, pole, and existing lighting fixture.
3. Remove existing foundation.

New Pour-in-place Foundation:

1. Set up rebar
2. Place the anchor bolts in a template with proper orientation for the alignment of the light fixture
3. Install the conduit.
4. Pour concrete.

New pre-cast foundation:

1. Excavate the hole as necessary
2. Set the pre-cast foundation to the proper grade
3. Tie in the conduit
4. Backfill and tamp around the foundation
5. Install pole and light fixture.
6. Ensure pole and fixture is properly aligned.





Cleaning Preventative Maintenance:

- Use water, cleaning supplies, scraping tools, etc. to remove advertisements, stickers, and graffiti.
- If items cannot be removed, you may need to paint over them.



Painting Preventative Maintenance:

- Remove rust and clean up chipped paint.
- Match new paint as best as possible to the original.
- Protect the work area.
- Remove damaged paint and repaint.

Often, roadway lighting will need repair of some kind.

Make sure you are prepared:

- Equipment may include a bucket truck, a digger derrick truck, or underground equipment
- Tools may include wrenches/socket sets, rigging materials, splicing tools, multimeter, and various hand tools
- Replacement parts may include lamps, photocells, ballasts, fuses & fuse kits, fixtures, hand hole covers
- Proper disposal means for materials with hazardous waste





<https://www.youtube.com/watch?v=AI9TdTFHJjk>
"On the Clock" with Street Light Maintenance by City of Arlington, TX

Identify the lights that need replacement or repair based on the maintenance survey.

Maintenance and Repair Tasks:

1. Ensure ownership and jurisdiction.
2. Identify site conditions and gain access.
3. Remove and replace existing lamps/luminaires to match existing.
4. Return to troubleshooting steps for electrical issues and submit work order if necessary.
5. Confirm proper operation as a final step



Across north Texas, there are hundreds of thousands of streetlights.



High mast lighting is commonly used in outdoor areas such as highways, airports, sports stadiums, and large parking lots. These tall structures are equipped with multiple light fixtures mounted on a moveable carriage assembly, providing effective illumination over a wide area.

Here are some key aspects of high mast maintenance:

Lowering the light assembly: Begin by releasing and lowering the carriage assembly to the ground level. Do not stand under the assembly while lowering/raising.

Inspection: Conduct routine inspections to identify any signs of damage that may compromise the integrity of the system such as cracks, loose connections, or corrosion. Inspect the mast structure, carriage assembly cables and alignment, electrical components, and anchor bolts.



Here are some key aspects of high mast maintenance:

Electrical Systems: Inspect the electrical components, including the power supply, cables, connectors, and control panels. Ensure that all connections are secure and free from damage. Test the functionality of switches, timers, and sensors.

Cleaning: Regularly clean the fixtures, lenses, and reflectors to remove dirt, dust, and debris that can diminish the lighting output. This can be done using appropriate cleaning solutions and tools, following the manufacturer's guidelines.

Lamp Replacement: High mast lighting system lamps require periodic replacement. Monitor the performance of the lamps and replace any faulty or burned-out lamps promptly. Follow the manufacturer's specifications for lamp replacement to ensure compatibility and optimal performance.



Here are some key aspects of high mast maintenance:

Alignment and Adjustment: Verify that the lights are correctly aligned and aimed at the desired area. Adjust the fixtures as necessary to maintain uniform lighting coverage and avoid light pollution.

Lubrication: Lubricate moving parts, such as the hinges, pulleys, and mechanical components, to reduce friction and ensure smooth operation. Use appropriate lubricants recommended by the manufacturer.

Structural Integrity: Regularly inspect the mast structure for signs of damage or deterioration. Check for cracks, rust, or any structural weaknesses. Ensure that the anchor bolts are secure and properly tightened.



Here are some key aspects of high mast maintenance:

Safety Measures: During maintenance activities, follow proper safety procedures, such as using appropriate personal protective equipment (PPE), working at heights with proper safety harnesses, and adhering to electrical safety guidelines.

Documentation: Maintain detailed records of maintenance activities, including inspection reports, repair work, lamp replacements, and any other relevant information. This documentation can help track the maintenance history and identify patterns or recurring issues.

It's important to consult the manufacturer's guidelines and recommendations for specific maintenance procedures for your high mast lighting system. Additionally, consider engaging qualified professionals or specialized maintenance services to ensure the proper upkeep of your high mast lighting infrastructure.



Here are some key aspects of high mast maintenance:

Access & Operation

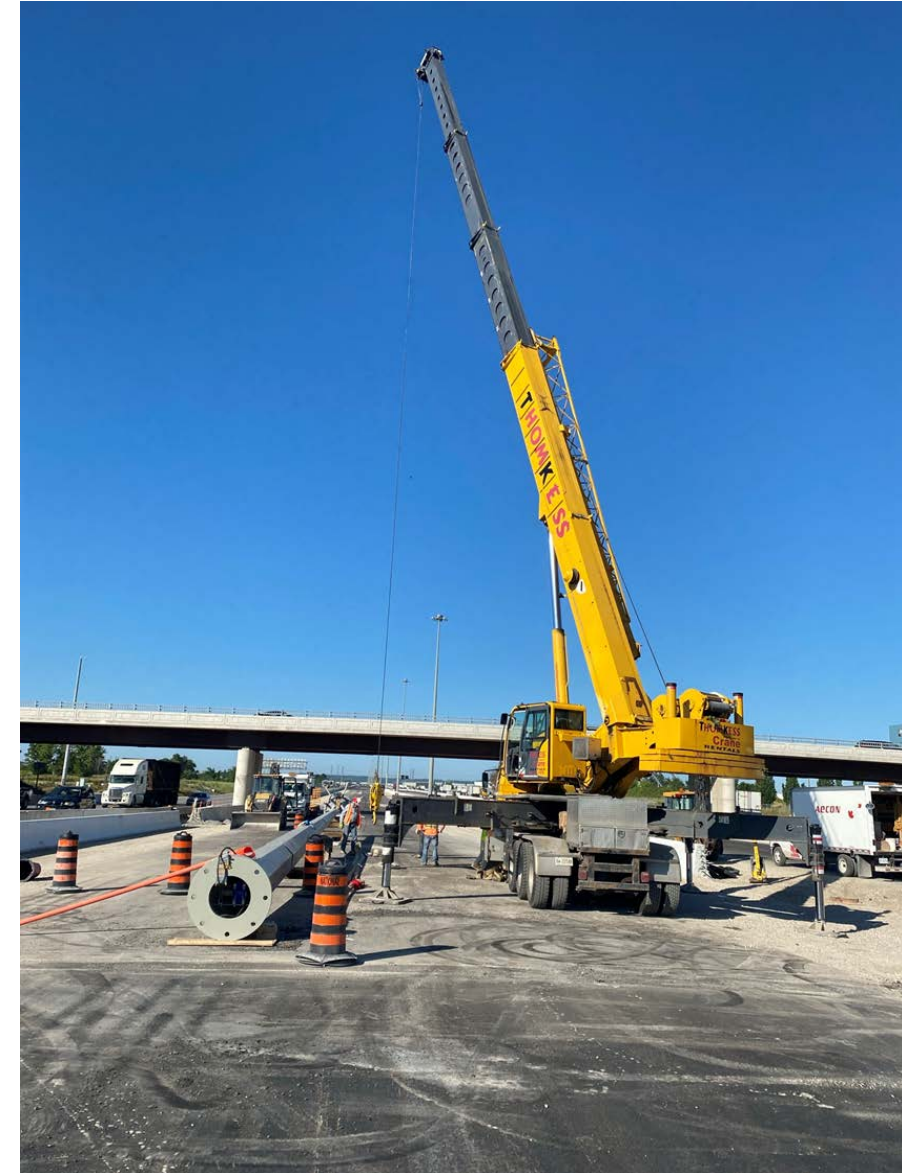
- Mechanical Lowering:** Initiate the maintenance cycle by safely releasing and lowering the moveable carriage assembly to ground level.
- System Positioning:** Ensure the carriage is fully stabilized before commencing technical work.

Comprehensive Inspection Standards

Structural Integrity:

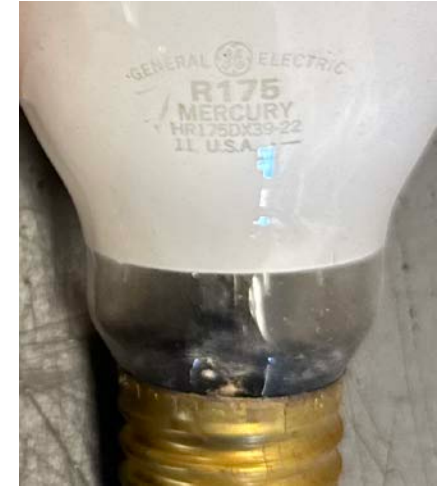
Evaluate the mast structure and anchor bolts for cracks, corrosion, or material fatigue.

- Mechanical Components:** Verify the condition of hoisting cables and ensure the carriage assembly maintains proper alignment.
- Electrical & Hardware:** Inspect all light fixtures and electrical connections for loose wiring or environmental damage.



A final consideration is **PROPER DISPOSAL** or **RECYCLING** of **USED MATERIAL**.

- Be aware of special disposal procedures for mercury and other hazardous materials.*
- Know the proper procedure for disposing of each element of the high mast.
- Each area may differ in removal and what is required for disposal.



*For disposing of roadway lighting lamps, especially those containing mercury like High-Intensity Discharge (HID) lamps, it's crucial to use specialized recycling kits that comply with EPA and Department of Transportation (DOT) regulations. These kits are designed to safely contain and transport hazardous materials, ensuring environmental safety and regulatory compliance.

Which of the following is NOT a recommended step after completing work at a site?

- A) Remove trash and debris from the work area
- B) Conduct a final sweep of the site with photo verification
- C) Leave the site without documenting completed tasks
- D) Ensure all tasks and materials used are accurately documented

During lighting maintenance, what safety measure should be prioritized?

- A) Using minimal lighting
- B) Working without a harness
- C) Adhering to electrical safety guidelines
- D) Skipping documentation of activities

What should be done if vegetation obstructs the light distribution of roadway lighting?

- A) Ignore it
- B) Trim and manage the vegetation around the lighting fixtures
- C) Relocate the lighting fixtures
- D) Increase the wattage of the bulbs

Which of the following tasks is essential for lighting maintenance?

- A) Regularly replacing the poles
- B) Inspecting the electrical systems
- C) Painting the ground beneath the lights
- D) Increasing the height of the mast

Why is it important to maintain cleanliness of lighting fixtures and lenses?

- A) To reduce labor costs
- B) To maintain optimal light output and visibility
- C) To avoid inspection requirements
- D) To make them look new

What is a key aspect of preventive maintenance for roadway lighting systems?

- A) Ignoring lamp replacement
- B) Conducting regular inspections
- C) Using outdated cleaning methods
- D) Skipping documentation

True or False:

If unscheduled maintenance is required, create an additional work order and complete the task (if possible).

True or False:

Fiberglass should be kept clean because dirt and dust can carry electricity.

True or False:

Lighting strikes and power surges are the most common cause of LED damage.

True or False:

It is not necessary to turn the power off before working with fuses and breakers.

True or False:

Site conditions only need to be documented at the end of the job.

True or False:

If a site cannot be accessed in an emergency, leave the work order open until the site is accessible.

IMSA Roadway Lighting Technician

Conclusion



Advancing the Future of Public Safety