

International Municipal Signal Association presents

IMSA Traffic Signal Inspector



Advancing the Future of Public Safety

Revision #3

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Intent of Refresher Session

- 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 Traffic Signal Inspector 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 expect to 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***, for example:
 - Mast Arm signals Vs. Span Wire signals – you will see both
 - Vehicle detection – you will see inductive loops, magnetic, magnetometer, radar, video, Lidar detection...
 - Construction related questions as well as maintenance related questions, it's all here
 - Field signal devices and inside the controller cabinet devices
 - Specifications and Regulations to partially include NEMA TS1 and TS2, Caltrans, ATCC, MUTCD, FHWA, NEC, NESC, OSHA, NFPA, CEC, ITE...
- 5) These programs cover everything related to traffic signals

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Introduction

Governing Agencies and Standards

Agency Acronym

- FHWA
- MUTCD
- NEC
- NESC
- OSHA
- NEMA
- Caltrans
- ATC/C
- ITE
- IMSA

Governing Agency Name

- Federal Highway Administration
- Manual on Uniform Traffic Control Devices
- National Electrical Code
- National Electrical Safety Code
- Occupational Safety and Health Administration
- National Electrical Manufacturers Association
- California Department of Transportation
- Advanced Transportation Controller/Cabinet
- Institute of Transportation Engineers
- **International Municipal Signal Association**

Governing Agencies and Manuals – References for Canada

- **OHS** (Occupational Health and Safety)
 - In Canada, 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/enforced by the Provincial Safety Act.

Traffic Signal Inspector Program Introduction

- The purpose of a Traffic Signal Inspector is to ensure that traffic signals, also known as traffic lights or traffic control signals, are functioning properly and in compliance with applicable regulations and standards.
- Traffic Signal Inspectors play a crucial role in maintaining road safety by inspecting, evaluating, and acceptance of traffic signal systems.

TRAFFIC SIGNAL INSPECTION CONTRACTOR PRE-INITIAL CHECKLIST
North Dakota Department of Transportation, Planning
SP-100607 (Rev. 02-07-15)

Pre-Inspection Date	Contractor	Inspector Performing Pre-Inspection
Type of Controller	Type of Vehicle	

Contractor Initials	Traffic Signal Cabinet	Comments
	1. Conflict Monitor Test completed and sent to NDDOT Traffic Operations Section	
	2. One copy of cabinet schematic to NDDOT Traffic Operations Section and one copy in cabinet	
	3. One copy of approved shop drawings to NDDOT Traffic Operations Section	
	4. Signal timings in controller are according to plan	
	5. Coordination offsets are correct according to plan and coordination is working properly	
	6. Advanced flashing beacons are working properly and timing is correct according to plan	
	7. Signal colors during start up and during flash operation are correct	
	8. Video detection is detecting, inputting to the correct phase, covering the correct lanes	
	9. Video detection fiber optic is working to the agency's office	
	10. One copy of detector loop test to NDDOT Traffic Operations Section	
	11. Detector rack is labeled correctly	
	12. Wires in controller cabinet are properly identified according to plan and NDDOT specifications	
	13. Controller cabinet base is caulked	
	14. Conduit openings with conductors duct sealed, spare conduit openings capped	
	15. Fiber optic patch panel box wires labeled	
	16. Fiber optic patch panel box is secured to cabinet	
	17. Interconnect is hooked up and working properly	
	18. Cabinet callouts work and are inputting to the correct phase	
	19. Contractor has supplied spare equipment to the owner	
	20. Emergency Pre-emption has been tested and is working properly	
	21. Battery backup has been tested and is working	
	22. Phase designation diagram mounted on cabinet door	
	23. Cabinet door operating properly	
	24. Access panel the correct height above grade	

Traffic Signal Inspector Program Introduction

Here's a checklist of common items a traffic signal inspector reviews during an inspection:

1. General Site Conditions

- Proper location of signal poles, cabinets, and pedestrian equipment
- ADA compliance (ramps, push button height and reach)
- Visibility of signal heads from all necessary approaches
- Absence of obstructions (trees, signs, etc.)

2. Safety and Compliance

- Grounding of all components
- NEC and MUTCD compliance
- NEMA TS-1/TS-2 compliance
- Caltrans 170, 179, 2070, and ATC compliance
- Proper labeling and as-built documentation



Traffic Signal Inspector Program Introduction

Here's a checklist of common items a traffic signal inspector reviews during an inspection:

3. Signal Heads

- Proper mounting height and alignment
- Correct lens orientation (e.g., red on top for vertical signals)
- Secure attachment and weatherproofing
- LED vs incandescent check (if applicable)

4. Wiring and Conduit

- Correct wire gauge and color coding
- Secure connections and proper insulation
- Grounding and bonding checks
- Water-tightness of conduit and handholes



Traffic Signal Inspector Program Introduction

Here's a checklist of common items a traffic signal inspector reviews during an inspection:

5. Controller Cabinet

- Model and type (TS-1 or TS-2)
- Programming/configuration matches signal plans
- Clean and secure wiring
- Power supply and battery backup functionality (if present)
- Communication equipment check (e.g., fiber, modem, or wireless)

6. Timing and Phasing

- Signal timing matches plans and engineering timing sheets
- Proper sequence and coordination with nearby signals
- Detection functioning properly (loops, video, radar, or microwave)



Traffic Signal Inspector Program Introduction

Here's a checklist of common items a traffic signal inspector reviews during an inspection:

7. Detection Systems

- Proper loop placement and seal
- Camera/radar sensor alignment and operation
- Verification of vehicle and pedestrian calls

8. Pedestrian Signals

- Countdown timers operational
- Audible push buttons (if required)
- Push button response and call registration
- Crosswalk signal timing and coordination



Inspection: Compliance with Regulations

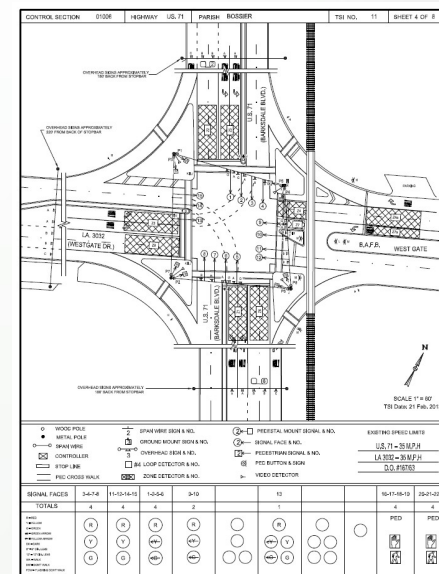
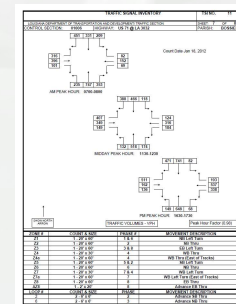
Ensure that the traffic signal installation complies with relevant regulations and standards, including local traffic ordinances, MUTCD (Manual on Uniform Traffic Control Devices) or MUTCDC guidelines, and ADA (Americans with Disabilities Act) requirements.

Documentation and Maintenance: Review documentation related to the installation, such as design plans, specifications, and maintenance records. Confirm that regular maintenance has been conducted and check for any outstanding issues that need attention.

Remember, traffic signal installations are typically inspected by qualified professionals, such as traffic engineers or transportation department personnel, who have expertise in traffic control devices and safety standards.

Review documentation related to the installation, such as design plans, specifications, and maintenance records. Confirm that regular maintenance has been conducted and check for any outstanding issues that need attention.

Contractor Initials	Traffic Signal Cabinet	Comments
1	Conform Monitor Test completed and users to MCOOT Traffic Operations Section	
2	One copy of cabinet schematic to MCOOT Traffic Operations Section and one copy to project	
3	One copy of approved shop drawings to MCOOT Traffic Operations Section	
4	Signal wiring in cabinet as according to plan	
5	Coordination efforts are correct according to plan and coordination is working properly	
6	Advanced Traffic Signals/Systems are working properly and testing is correct according to plan	
7	Signal colors during start up and during the operation are correct	
8	Video detector is detecting, inputting to the correct phase, covering the correct lanes	
9	Video detector: their signs is working to the agency's office	
10	One copy of detector shop test to MCOOT Traffic Operations Section	
11	Detector rack is labeled correctly	
12	Where a resistor cabinet are properly identified according to plan and MCOOT specifications	
13	Controller cabinet base is called	
14	Control openings with conductors that installed, some control openings opened	
15	Flare optic cable panel box wires labeled	
16	Flare optic cable panel box is secured to cabinet	
17	Interconnect is hooked up and working properly	
18	Cabinet callouts work and are inputting to the correct phase	
19	Contractor has supplied spare equipment to the owner	
20	Emergency Pre-Exercise has been tested and is working properly	
21	Battery backup has been tested and is working	
22	Photo-detection diagram mounted on cabinet door	
23	Cabinet door opening properly	
24	Access and the correct height above grade	

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Session 1: PPE, Safety, and Key Personnel

Personal Protective Equipment (PPE)

As a Traffic Signal Inspector, it's important to prioritize your safety by wearing appropriate personal protective equipment (PPE) while performing your duties.

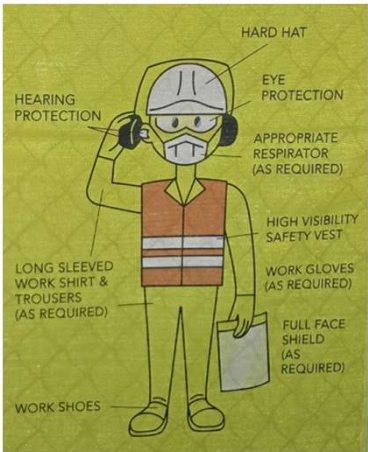
Here are some recommended PPE for a Traffic Signal Inspector :

High-Visibility Vest: Wear a high-visibility vest or jacket that conforms to safety regulations to ensure you are visible to motorists and other workers in the vicinity.

Hard Hat: Protect your head from falling objects or potential head injuries by wearing a non-conductive (plastic) hard hat. It should meet the necessary safety standards. Can also utilize reflective materials or strips for enhanced visibility.

Safety Glasses: Use safety glasses with side shields to shield your eyes from dust, debris, or other potential hazards that may arise while inspecting traffic signals.

Harnesses and Lanyards: Fall protection must be worn to prevent falls and/or reduce the risk of injury when working from bucket trucks, aerial lifts or any elevated surface. (Only use equipment you are trained in using.)



Personal Protective Equipment (PPE)



Gloves: Wear protective gloves to safeguard your hands from sharp edges, electrical components*, or other materials that you may encounter during inspections. Consider using gloves with reflective materials or strips for enhanced visibility, especially when working in low-light conditions.

Steel-Toe Boots: Invest in sturdy, closed-toe shoes or boots with reinforced steel toes to protect your feet from potential hazards, such as heavy objects or accidental impacts. Die-electric soles: can help protect against electrical shocks.

Ear Protection: If you work in noisy environments, it's advisable to wear earplugs or earmuffs to protect your hearing from excessive noise levels.

Face Mask/Respiratory Protection: Depending on the circumstances and local regulations, wearing a face mask may be necessary, especially when working closely with other individuals or in spaces with hazardous materials.

Remember, the specific PPE requirements may vary based on your location, local regulations, and the specific tasks you perform as a Traffic Signal Inspector. Always follow the guidelines provided by your employer and adhere to any safety regulations in your area.

Personal Protective Equipment (PPE)



An ANSI-approved safety vest refers to a high-visibility garment designed to enhance the visibility of workers in hazardous environments or low-light conditions. The American National Standards Institute (ANSI) has established standards for safety vests to ensure consistent levels of visibility and protection. ANSI-approved safety vests are commonly used by construction workers, road crews, surveyors, and others who work near moving vehicles or in areas with poor visibility.

The ANSI standards classify safety vests into three types:
Class 1, Class 2, and Class 3.

PPE — High-Visibility Vest

Class 1 Vest:

- Also known as "off-road" or "breakaway" vests.
- Provides the least amount of reflective coverage among the three types.
- Designed for workers who need high visibility but are not exposed to traffic.
- Primarily used in non-roadway environments or areas with minimal vehicle traffic.
- Typically have the most basic design, with reflective stripe(s) around the torso.
- NOT ACCEPTABLE for working near traffic.



PPE — High-Visibility Vest

Class 2 Vest:

- Offers more coverage and visibility than Class 1 vests.
- Features additional reflective material on the front and back.
- Usually has a solid fluorescent background color for better visibility.
- Widely used by roadway construction workers, utility workers, and emergency responders.
- Can provide more visibility in complex work environments.

The industry rule of thumb is to require Class 2 vests on worksites near traffic flow that is 25 - 50 mph. These safety vests are more noticeable during the day or night at greater distances when compared to Class 1 safety vests.



PPE — High-Visibility Vest

Class 2 safety vests are designed to provide enhanced visibility in environments with moderate to high traffic speeds and where background visibility is reduced. They typically have a minimum of 775 square inches of background material and 201 square inches of reflective tape. Class 2 safety vests should be worn in the following situations:

- **Road Construction:** Workers on road construction sites, including flaggers and surveyors, should wear Class 2 safety vests to enhance their visibility to passing motorists.
- **Airport and Port Workers:** Employees working on airport runways, taxiways, and aprons, as well as port workers, should wear Class 2 vests to ensure their visibility around moving vehicles and equipment.
- **Utility Workers:** Utility workers, such as those employed by electric or telecommunications companies, should wear Class 2 vests when working near roadways or in areas with vehicular traffic.
- **Parking Lot Attendants:** Individuals directing traffic or managing parking lots should wear Class 2 safety vests to increase their visibility and ensure their safety.

PPE — High-Visibility Vest

Class 3 Vest / Apparel:

- Provides the highest level of visibility and coverage.
- Covers a larger portion of the upper body, including the front, back, and sides.
- Incorporates a significant amount of reflective material.
- Designed for workers in high-risk environments with heavy or high-speed traffic and/or complex environment backgrounds.
- Often used by road construction workers, traffic control personnel, and tow truck operators.



PPE — High-Visibility Vest

A Class 3 safety vest is a high-visibility garment designed for workers who require maximum visibility in high-risk environments, particularly on roadways. These vests have a minimum of 1240 square inches of background material and 310 sq. in. of reflective tape.

Here are the situations when you should wear a Class 3 safety vest:

Working in High-Speed Traffic Zones: If you work on or near roadways where traffic speeds exceed 50 miles per hour, it is recommended to wear a Class 3 safety vest. These areas pose a higher risk due to the fast-moving vehicles, and the enhanced visibility provided by the vest helps ensure that you are easily seen by drivers.

Poor Lighting Conditions: Class 3 safety vests are especially crucial in low-light or nighttime conditions when visibility is significantly reduced. The vest's fluorescent color and reflective striping reflect light from headlights, making you more visible to drivers and increasing your safety.

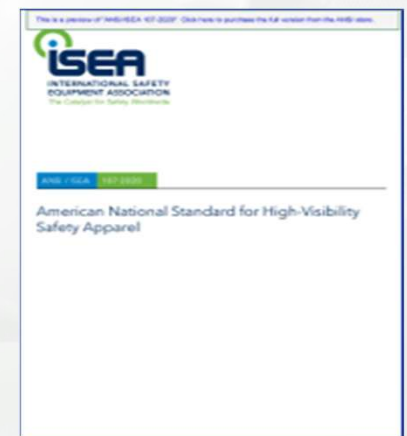
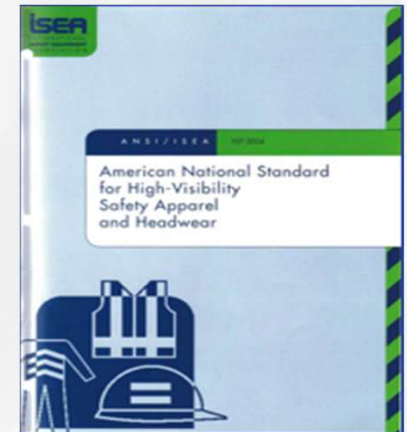
Inclement Weather: During adverse weather conditions such as rain, fog, or snow, visibility can be severely impaired. Wearing a Class 3 safety vest in these situations ensures that you stand out, even in challenging weather, and helps drivers spot you from a distance.

If the reflective safety vest being worn gets wet, the best way to preserve the vest is to hang the wet vest in a protected, and a well-ventilated area to air dry first. Once dry, return it to a proper approved storage area.

PPE — High-Visibility Vest

All ANSI-approved safety vests must meet specific criteria regarding color, retroreflective material, and the placement of reflective stripes. They are typically available in fluorescent colors like orange, yellow, or lime green to enhance visibility during the day, and the reflective stripes ensure visibility in low-light or nighttime conditions.

It's important to note that the specific requirements for safety vests may vary depending on the industry and local regulations. Therefore, it's crucial to consult relevant safety guidelines and regulations applicable to your specific work environment to ensure compliance and adequate protection.



PPE — Fall Protection Equipment

For work at heights, fall protection equipment like safety harnesses, lanyards, and lifelines are used to prevent falls and mitigate the risk of serious injuries.

Safety Harnesses should always be used while working from a Bucket Truck or any other type of Aerial Lift. It should also be used if working on an elevated surface structure where there is a potential of falling from a height of 8 feet or more.



PPE — Fall Protection Equipment



Manual on Uniform Traffic Control Devices

The **MUTCD** stands for the Manual on Uniform Traffic Control Devices. It is a document published by the Federal Highway Administration (FHWA) in the United States that provides guidance on the design and usage of traffic control devices, including signs, signals, and pavement markings. The MUTCD is widely used by transportation agencies at the federal, state, and local levels to ensure uniformity and consistency in traffic control across the country.

The manual covers various aspects of traffic control, including the design and placement of signs, signal timing and operation, pavement markings, traffic signals, work zone safety, and pedestrian and bicycle facilities. It establishes standards, guidelines, and options for traffic control devices to enhance safety and efficiency on roadways.

The IMSA Traffic Signal Inspector should use the MUTCD to find information of the most current versions of applicable standards. For example, the MUTCD should be referenced to make sure a pedestrian push button is ADA compliant.

This inspector should also have a copy or know where to find the Design Standards for details of materials installation.

Manual on Uniform Traffic Control Devices

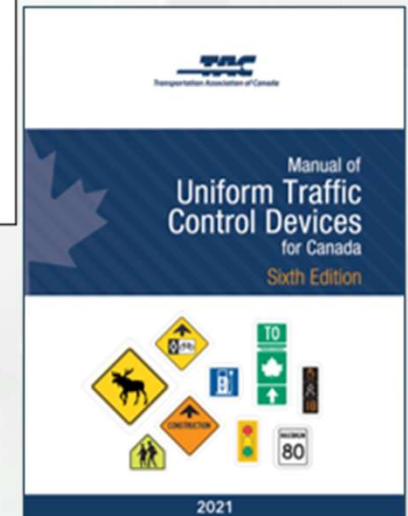
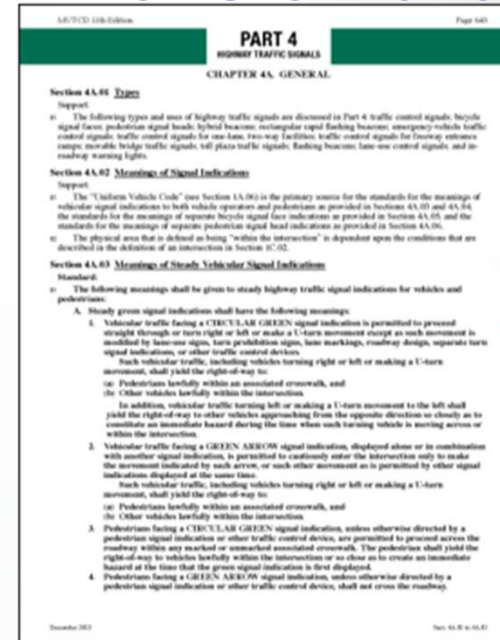
Part 4 of the **MUTCD** is dedicated to all things **Highway Traffic Signals**. This is the reference guide to the United States federal rules regarding warranting, construction, maintaining and inspecting traffic signals. Standards for traffic control signals are important because traffic control signals need to attract the attention of a variety of road users, including those who are older, those with impaired vision, as well as those who are fatigued or distracted, or who are not expecting to encounter a signal at a particular location.

https://mutcd.fhwa.dot.gov/kno_11th_Edition.htm

https://mutcd.fhwa.dot.gov/pdfs/11th_Edition/part4.pdf

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

<https://www.tac-atc.ca/en/knowledge-centre/technical-resources-search/publications/ptm-mutcdc21-e/>



Traffic Signals General – Canada

It is important to note that there are some differences in Traffic Signals defined in the MUTCDC for Canada comparatively to the US MUTCD.

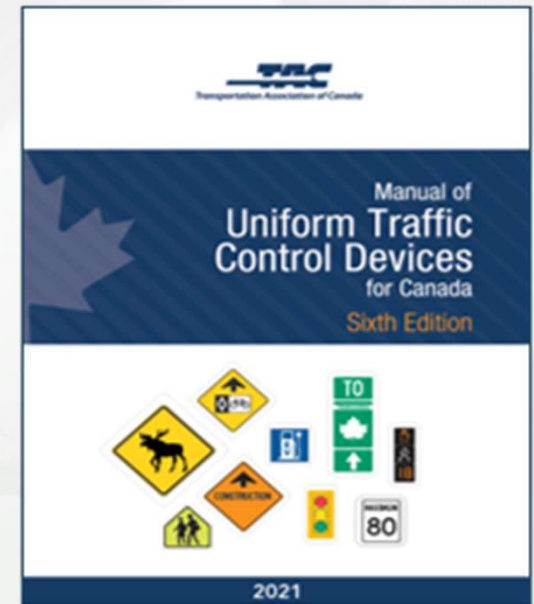
Further, the MUTCDC is published and copyright protected by the Transportation Association of Canada (**TAC**), a national non-profit technical association, not the government of Canada.

The MUTCDC is published as a guide, not legislated provincially or federally.

Some key differences and updates in the Canadian Guide are, the Manual:

- **Does not define** a RED arrow.
- **Does not define** a flashing AMBER arrow as a permissive left turn.
- **Does define** a flashing green arrow “Canada Fast Flash” to be used for exclusive protected left turn movements. (section B3.2.4.3)

The MUTCDC 6th edition has updated information on Count Down Pedestrian Signals and RRFB signals.



National Electrical Code Handbook

The National Electrical Code (**NEC**) Handbook is a comprehensive guidebook that provides detailed interpretations, explanations, and additional information to accompany the National Electrical Code. The NEC Handbook is published by the National Fire Protection Association (**NFPA**), which is responsible for developing and updating the NEC.

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.

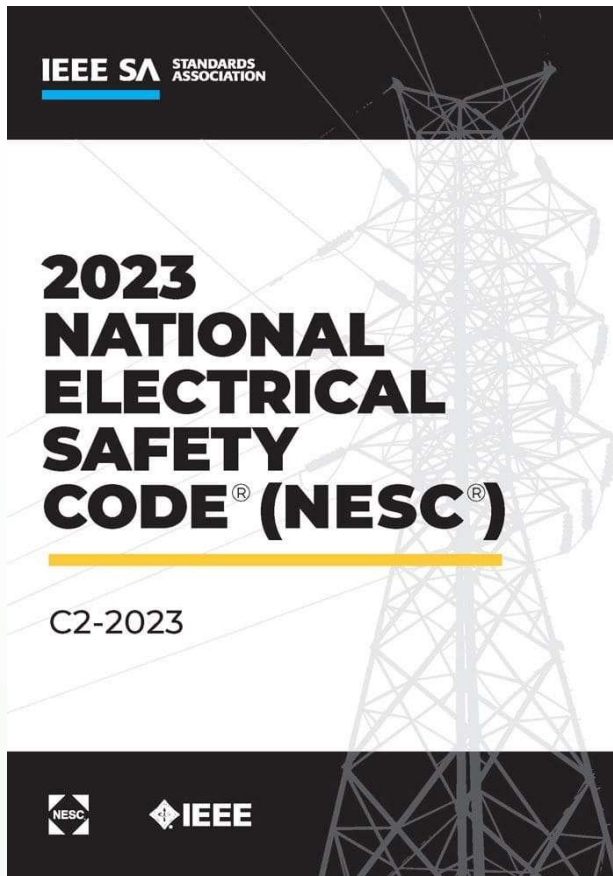
The NEC Handbook offers the following features:

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

<https://www.nfpa.org/product/nfpa-70-handbook/p0070hb>



National Electrical Safety Code



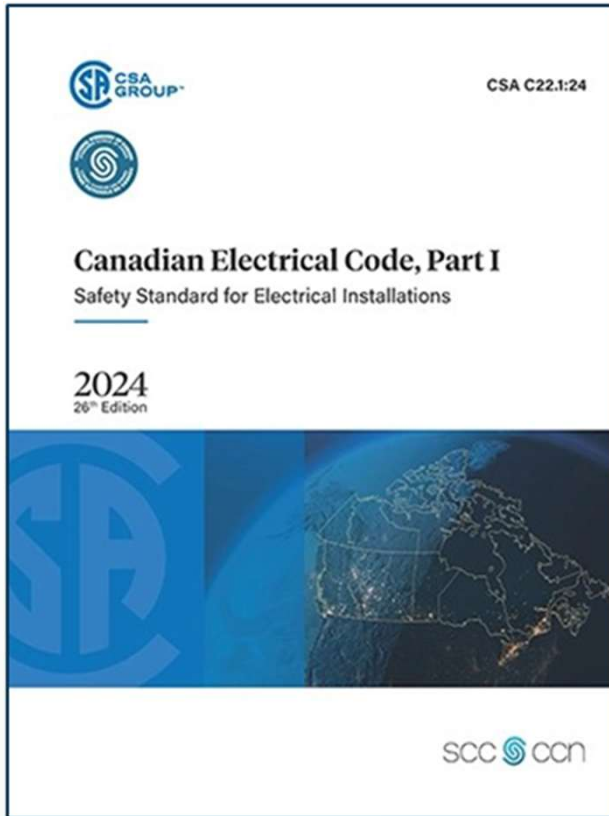
The 2023 NESC® covers general requirements and practical safeguarding of persons during the installation, operation, and/or maintenance of:

- 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.

<https://standards.ieee.org/products-programs/nesc/>

Canadian Electrical Code (CEC)



The Canadian Electrical Code (CEC), officially CSA C22.1, is the safety standard for electrical installations in Canada.

Here's a breakdown of key information:

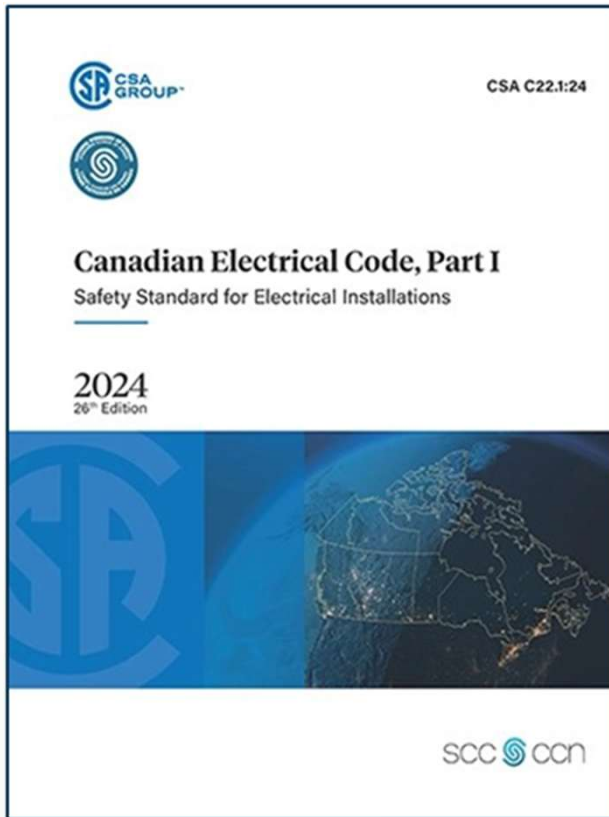
Purpose:

- It sets the rules for safe electrical installations and equipment operation.
- It aims to minimize electrical hazards like fire and shock.

Authority:

- Published by the CSA Group (Canadian Standards Association).
- While a national standard, it's adopted and enforced by provincial and territorial authorities, which may include local amendments. Therefore, there can be slight regional differences.

Canadian Electrical Code (CEC)



Key Aspects:

- It's a prescriptive code, detailing acceptable wiring methods.
- It covers a wide range of electrical installations in buildings and structures.
- It is updated on a regular cycle, to keep up with changing technology.
- The most recent addition is the 2024 edition.

Important Considerations:

- Provincial and territorial authorities have the final say on which edition of the CEC is in force in their jurisdiction.
- Therefore, it's crucial to check local regulations.
- For example, in Ontario, the Ontario Electrical Safety Code, uses the Canadian Electrical Code but also has Ontario specific amendments.

Where to find it:

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

Provincial Utility Codes in Canada

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.

Provincial Utility Codes in Canada

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.

Electrical Equipment and Standards

NEC 110.12 Mechanical Execution of Work. Electrical equipment shall be installed in a neat and workmanlike manner.

NEC 110.12 (A) Unused openings, other than those intended for the operation of equipment, those intended for mounting purposes, or those permitted as part of design for listed equipment, shall be closed to afford protection.

NEC 110.12 (B) Integrity of Electrical Equipment and Connections. There shall be no damaged parts that may adversely affect safe operation or mechanical strength of the equipment such as parts that are broken, bent, cut, or deteriorated by corrosion, chemical action, or overheating.

NEC 110.14(A) Terminals. Connection of conductors to terminal parts shall ensure a thoroughly good connection without damaging the conductors and shall be made by means of pressure connectors (including set-screw type), solder lugs, or splices to flexible leads. Connection by means of wire-binding screws or studs and nuts that have upturned lugs or the equivalent shall be permitted for 10 AWG or smaller conductors. Terminals for more than one conductor and terminals used to connect aluminum shall be so identified.

NEC 110.14(D) Installation. Where a tightening torque is indicated as a numeric value on equipment or in installation instructions provided by the manufacturer, a calibrated torque tool shall be used to achieve the indicated torque value, unless the equipment manufacturer has provided installation instructions for an alternative method of achieving the required torque.

NEC 110.16 Arc-Flash Hazard Warning. (A) General. Electrical equipment, such as switchboards, switchgear, panelboards, industrial control panels, meter socket enclosures, and motor control centers, that are in other than dwelling units, and are likely to require examination, adjustment, servicing, or maintenance while energized, shall be field or factory marked to warn qualified persons of potential electric arc flash hazards.

Electrical Equipment and Standards

NEC 110.16 Arc-Flash Hazard Warning. (A) General. Electrical equipment, such as switchboards, switchgear, panelboards, industrial control panels, meter socket enclosures, and motor control centers, that are in other than dwelling units, and are likely to require examination, adjustment, servicing, or maintenance while energized, shall be field or factory marked to warn qualified persons of potential electric arc flash hazards.

NEC 110-26 (1) Working Space. at least a 3-ft clearance in front of all electrical equipment; 2) a 30 in.-wide working space in front of equipment operating at 600V or less; and 3) minimum headroom clearance of 6 ft or the height of the equipment, whichever is greater.

NEC 200.6(A)(1) Means of Identifying Grounded Conductors. Sizes 6 AWG or smaller: An insulated grounded conductor of 6 AWG or smaller shall be identified by one of the following means: (1) A continuous white outer finish

NEC 230.75 Disconnection of Grounded Conductor. Where the service disconnecting means does not disconnect the grounded conductor from the premises wiring, other means shall be provided for this purpose in the service equipment. A terminal or bus to which all grounded conductors can be attached by means of pressure connectors shall be permitted for this purpose. In a multi-section switchboard or switchgear, disconnects for the grounded conductor shall be permitted to be in any section of the switchboard or switchgear, if the switchboard or switchgear section is marked to indicate a grounded conductor disconnect is located within. (Fusing the neutral)

Occupational Safety and Health Administration

OSHA stands for the Occupational Safety and Health Administration. It is a federal agency within the United States Department of Labor. OSHA's primary mission is to ensure safe and healthy working conditions for employees across various industries in the United States.

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

The role of OSHA is to enforce safety and health regulations, provide guidance and assistance, and promote a culture of workplace safety. By setting and enforcing standards, OSHA plays a vital role in safeguarding the well-being of workers and ensuring they have the necessary protections in their workplaces. <https://www.osha.gov/>



Safety Data Sheet (SDS)

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

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

SDSs (formerly MSDSs or Material Safety Data Sheets) **offer safety information for chemicals you may use in your work environment.**

Safety Data Sheets follow a 16-section format:

- Section 1 – product identification
- Section 2 – hazard identification
- Section 3 – composition of ingredients
- Section 4 – first aid
- Section 5 – firefighting measures
- Section 6 – accidental release measures
- Section 7 – handling and storage
- Section 8 – exposure controls / PPE
- Section 9 – physical and chemical properties
- Section 10 – stability and reactivity
- Section 11 – toxicological information
- Section 12 – Ecological information
- Section 13 – disposal considerations
- Section 14 – transportation information
- Section 15 – regulatory information
- Section 16 – other information not covered above

  	
Safety Data Sheet California CARB Compliant	
1 - Identification	
Product Name: WD-40 Multi-Use Product Aerosol	Manufacturer: WD-40 Company
Product Use: Lubricant, Penetrant, Drives Out Moisture, Removes and Protects Surfaces From Corrosion	Address: 9715 Businesspark Avenue San Diego, California, USA 92131
Restrictions on Use: None identified	Telephone: 1-888-324-7596
SDS Date Of Preparation: August 2, 2021	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.	

Material Safety Data Sheets (MSDS) in Canada

- 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.

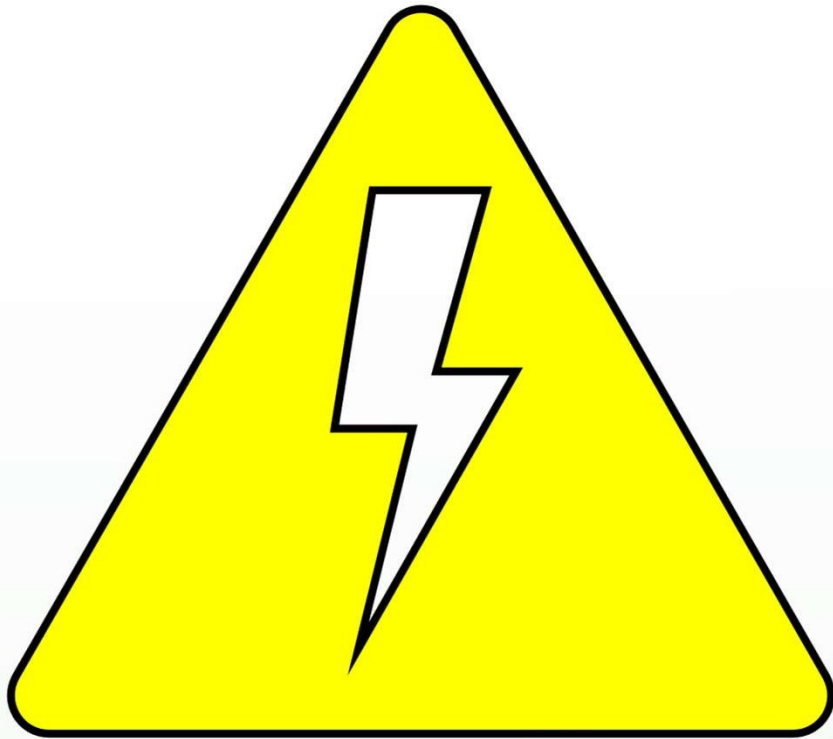
Material Safety Data Sheets (MSDS) in Canada

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

Basic Electrical Theory - Electrical Safety



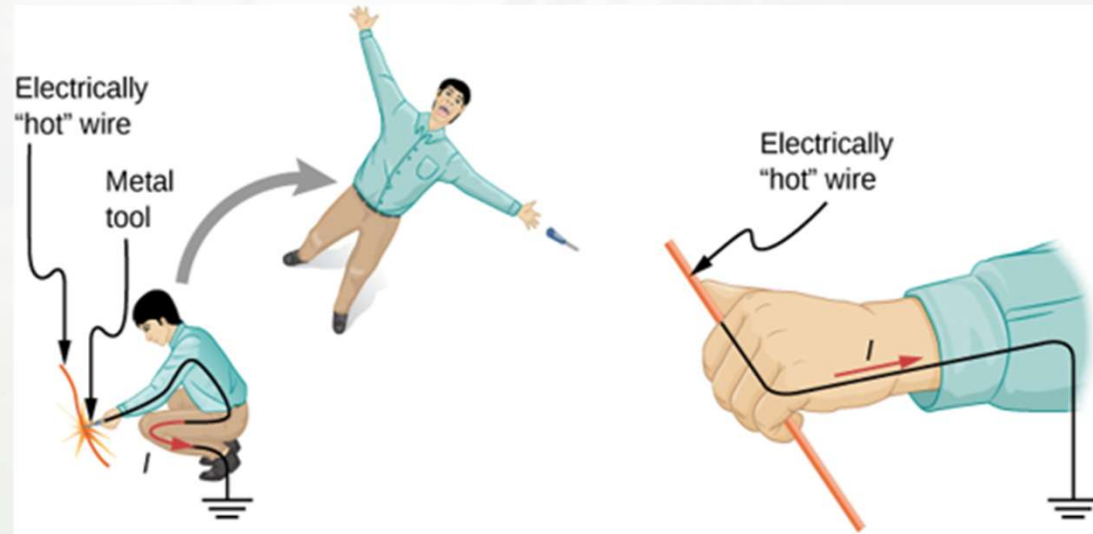
Electricity is Dangerous!

- 30,000 non-fatal shock accidents per year
- Nearly 7 kids/day are treated in the ER for electrical shocks or burns (wall outlets)
- Estimated 60 electrocutions/ yr. because of consumer products
- 145 out of 5,486 worker deaths were caused by electrocution (2022)

Basic Electrical Theory - Electrical Safety

Electricity is Dangerous!

- Traffic signal 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 cabinet, pole or any other grounded device.



Don't Complete the Circuit!

Electrical Safety – Arc Flash

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

- Everything turns into molten metal upwards of 35,000 °F (19,400 °C) and can create shrapnel.
- Deafening noise, concussive force, and igniting flammable material to include clothing are also major concerns.



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 and Partnership for Electrical Safety.

Conductors and Insulators

Conductors are materials that conduct electricity.

Most metals are conductors.

Copper is, by far, the most commonly used material for electrical wiring.

- Aluminum is also used for electrical wiring.

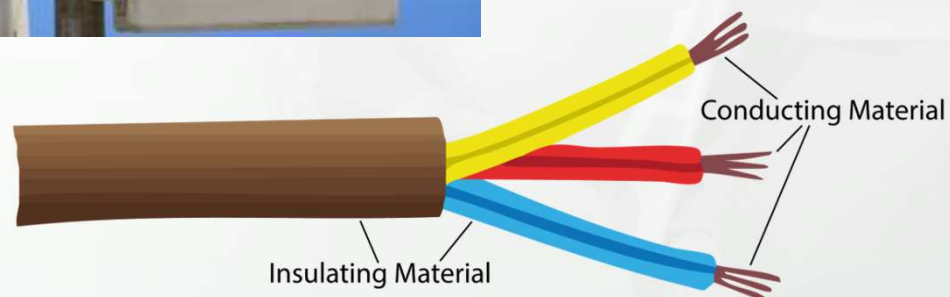
Gold and silver are better conductors than copper but are much more expensive to use for wire; however, these materials are used in electronics.



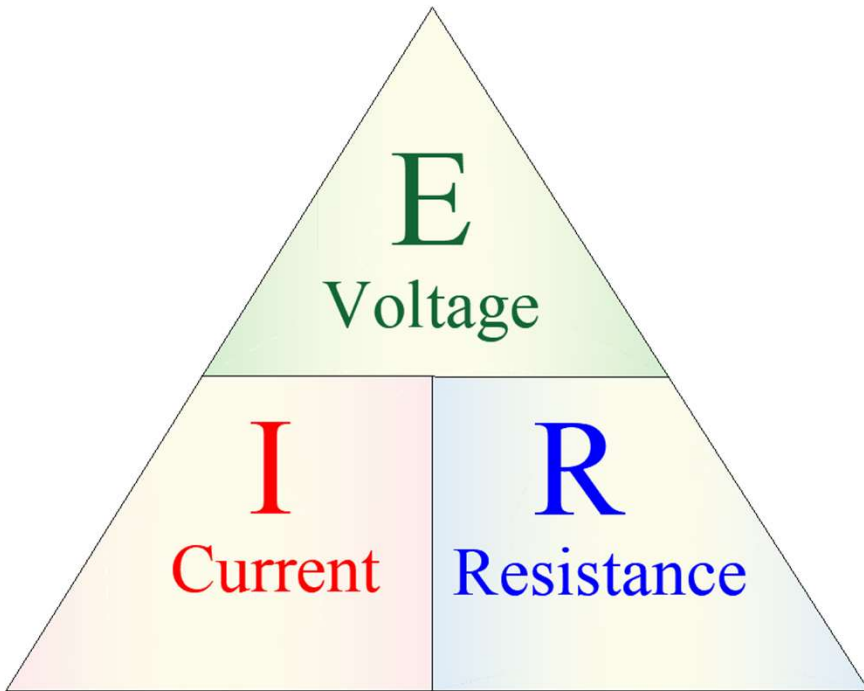
Conductors and Insulators

Insulators are materials that do not conduct electricity.

Some materials commonly used as insulators are various types of plastics, rubber, glass, porcelain, and ceramic.



Ohm's Law



Voltage, Current and Resistance

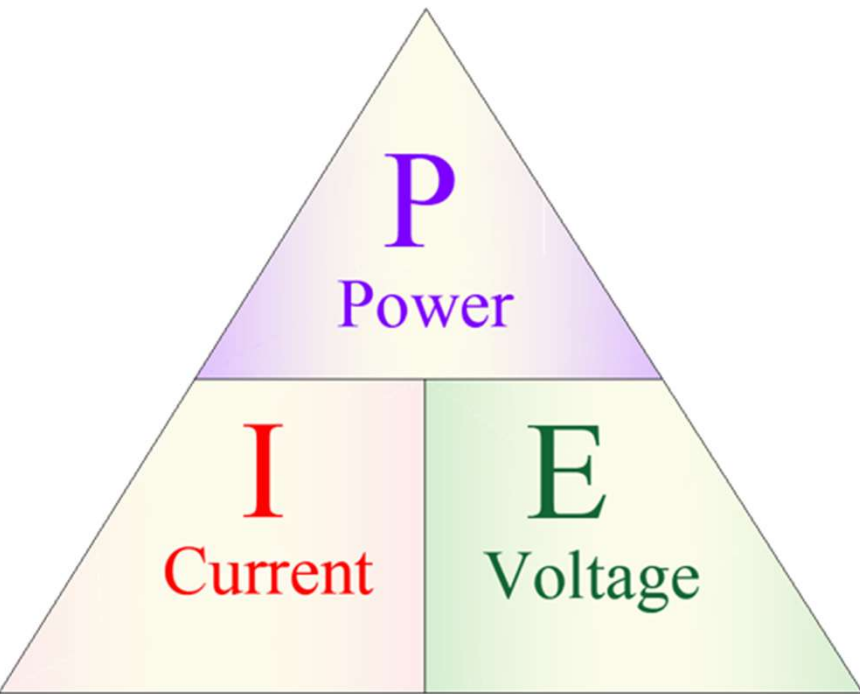
The basis for Ohms Law

A ratio comparison that we use as a formula

$$E = I \times R$$

- **E = Voltage** (Electromotive Force) (Volts)
- **I = Current** (Intensity) (Amps)
- **R = Resistance** (Ohms)

Power Formulas



Power Formulas

$$P = I \times E$$

$$I = P / E$$

$$E = P / I$$

P = Power (Watts)

E = Voltage (Electromotive Force) (Volts)

I = Current (Intensity) (Amps)

This chart works the same way...

There are multiple voltages typically used in traffic signal circuits; **120 VAC, 24 VDC, 12VDC, 12VAC, 48 VDC, and 3-5 VDC**

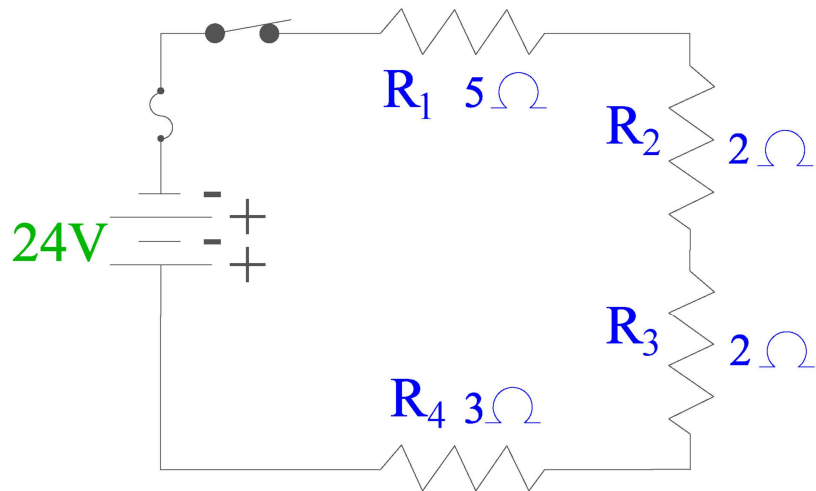
AC / DC

Electric Current

Electric current flows in two ways, as in *Direct Current (DC)* or *Alternating Current (AC)*. The main difference between DC and AC lies in the direction in which the electrons flow.

In DC, the electrons flow steadily in a single direction; while electrons keep switching directions, going forward and then backwards in AC.

Series Circuit

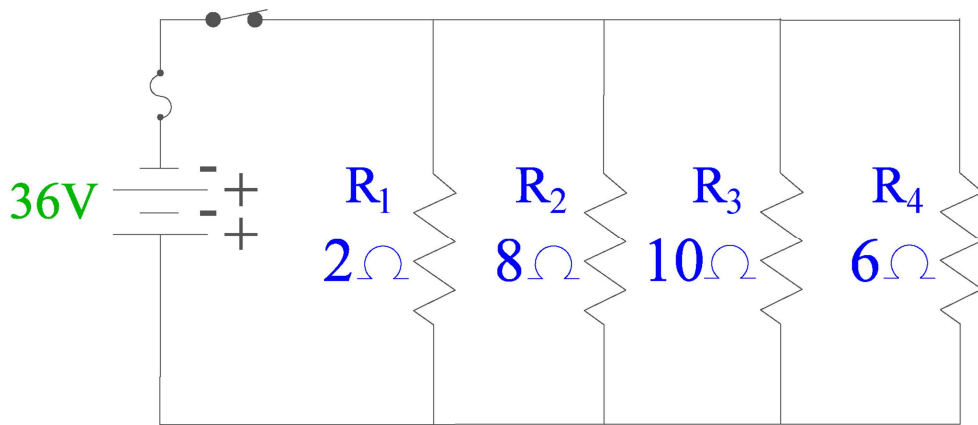


In a series circuit the current remains constant at all points within the circuit.

Current only has one path to flow in the circuit.

An example of a series circuit is a string of lights. If one bulb burns out the entire string of bulbs will be out.

Parallel Circuit

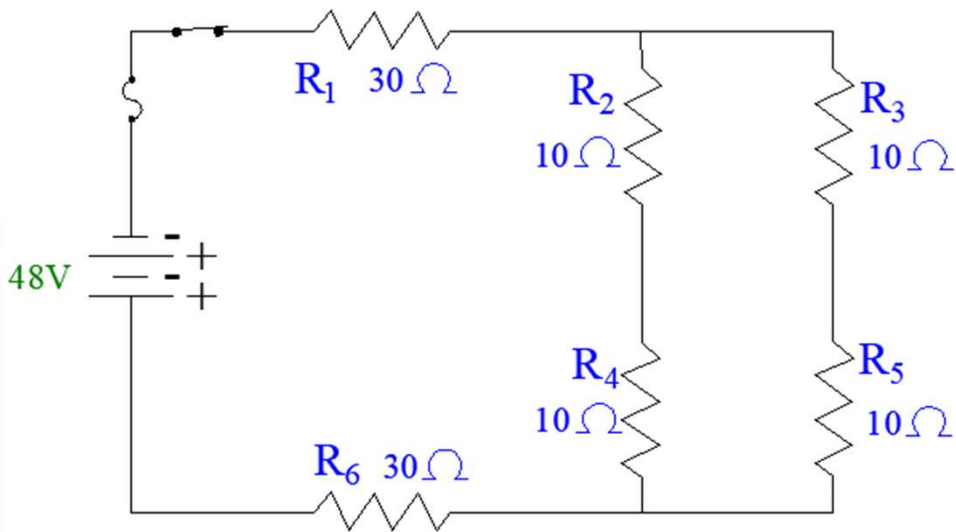


In a parallel circuit voltage remains constant at all points within the circuit.

An example of a parallel circuit is a string of lights. If one bulb burns out the entire string of bulbs will continue to operate minus the bad bulb.

Traffic signal indications are wired in parallel.

Series/Parallel or Combination Circuit

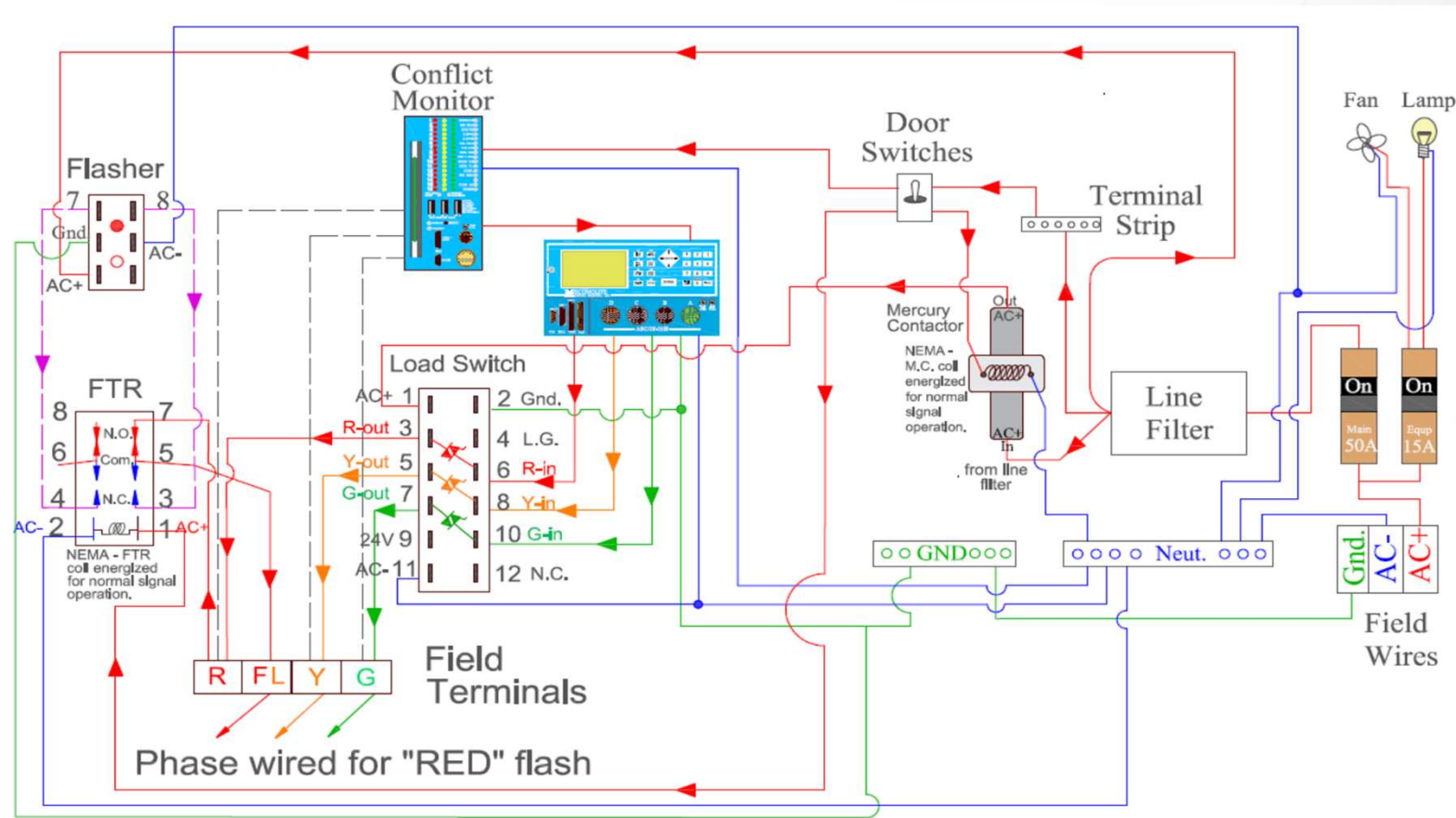


A combination circuit has both series loads and parallel loads.

Traffic signal loop detection may be wired in series, parallel, or in combination.

Circuits on printed circuit boards may also be connected in combination.

Generic NEMA TS-1 Wiring Diagram



This is a generic wiring diagram for a NEMA TS-1 cabinet.

- It illustrates how power enters the cabinet (far right)
- Flows through out the cabinet
- And feeds the signal heads in the field (lower left) in combination.

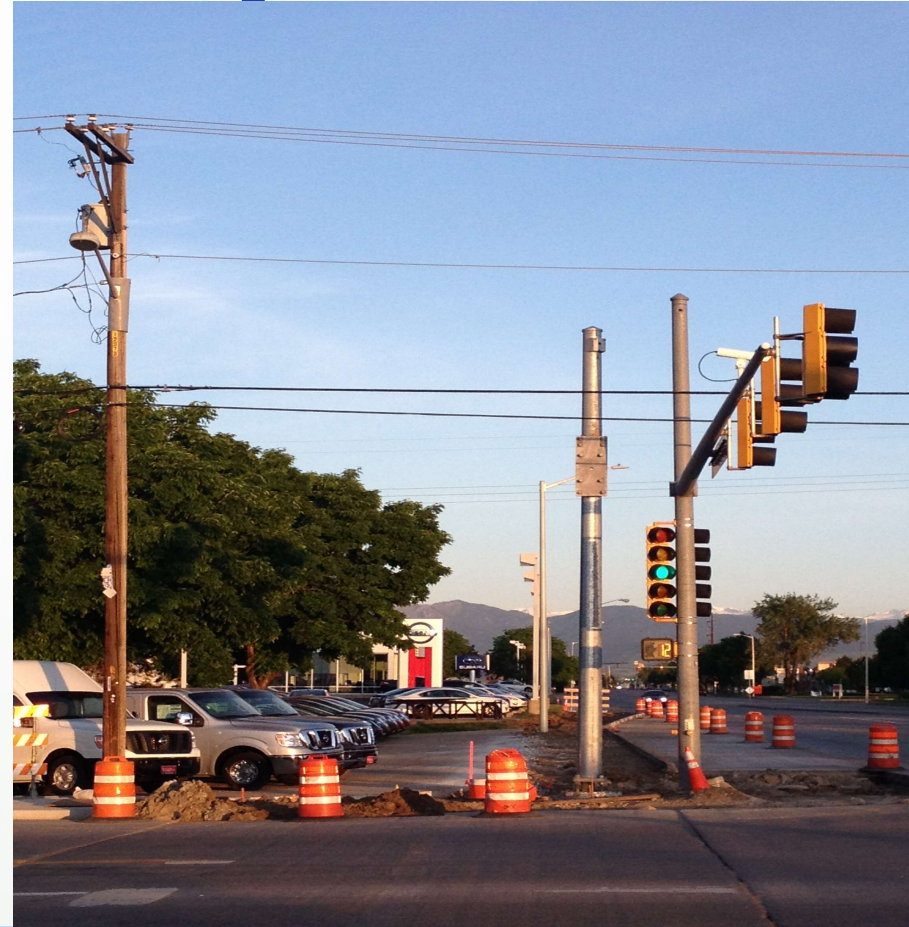
Overhead Safety

“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



Overhead Safety – Power Lines in Canada

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.

Underground Safety



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

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

When digging or excavating is required there is the hazard of harm to yourself as well as exposing or damaging underground utilities.

•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



Underground Safety in Canada

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.

Underground Safety in Canada

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.

Locating Underground Utilities



Cable locators, also known as underground cable locators or cable detectors, are devices used to locate and trace underground cables and pipes. They are commonly used in construction, utility work, and maintenance activities to identify the path and depth of buried cables before digging or excavation work.

Cable locators work based on the principle of electromagnetic field detection. They detect the magnetic fields generated by electric currents flowing through buried cables or pipes. By using a cable locator, you can trace the route of underground cables, identify their depth, and avoid accidentally damaging them during construction or excavation work.

Locating equipment may offer:

- Multiple frequencies for directly connecting to a utility
- Multiple frequencies for inducing a signal onto a utility
- Signal Sensitivity and Gain control
- Directional locating features
- as well as Mapping modes

Utility Notifications

Utility Locate / Mark out Request

Some possible information you may need to provide when calling:

Property Owner/Company Information

- Company name ◦Company's mailing address ◦Company's phone number.

Your Information

- First and last name ◦Your area code and primary telephone number ◦Alternate Mobile telephone number ◦Email address.
Company you are working for ◦Name of another point of contact at company ◦Company mailing address and contact information.

Dig/Locate Site Information

- Town/municipality where work is being done ◦If you're working in a complex ◦County where work is being done
Latitude and longitude (optional) ◦Dig address ◦Nearest intersecting street (to dig site).
- Is proposed area marked in white? (the number of markings? labeled?) ◦Where on property proposed site can be found. ◦Type of work.
- How deep you plan to dig.

Utility Notifications

Damaged Utility Notification

- Secure the area and make it safe for workers and the public.
- Call **911** in the event of a hazard, e.g., gas line fire, electrical line...
- Identify the damaged Utility.
- **Call the utility in question and call 811** to report and create a damaged utility ticket.
- Provide original locate ticket number.
- Expose the damaged facility **IF** it is safe to do so.

What's Down There??



Work Zones / Temporary Traffic Control

The Inspector is often times also responsible for reviewing TTC Zones that have been installed for deficiencies and suggesting adjustments. Be sure to review the TTC plans in relation to the work being done, as well as MUTCD Section 6 for adequate channeling through the Work Zone. https://mutcd.fhwa.dot.gov/pdfs/11th_Edition/part6.pdf

- Traffic Cones and Drums (Barrels)
- Signs
- Barricades
- Arrow Boards or Variable Message Signs
- Temporary Traffic Signals
- Flaggers
- High-Visibility Clothing
- Lighting Devices
- Tapering Devices
- Temporary Pavement Markings



Grounding and Bonding

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.



Grounding and Bonding

Bonding

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.

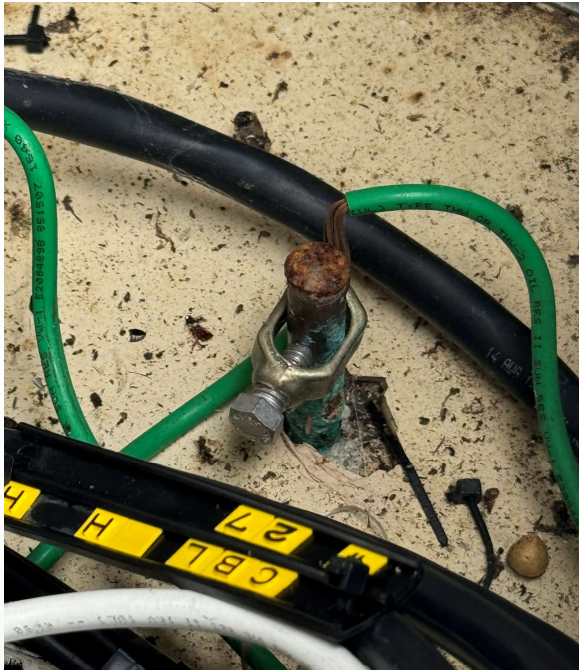
This speaks to why we scrape the paint from contact surfaces of metallic enclosures to make our electrical system bonding connections. Removing the paint, as required in NEC Section 250.12, provides for a better connection and conductivity path.

Grounding and Bonding

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 and Bonding

Grounding and Bonding

In Section 250.4 of the NEC, it explains how to hook up your electrical systems to keep it safe. If your system uses the ground, you need to connect the power system and all the other items to the ground. You also need to make sure anything that can carry electricity is safely connected, so if something goes wrong, the electricity won't go where it shouldn't.

For systems that don't connect to the ground, you do everything the same except for the part about connecting the power system to the ground. By following these rules, you're making a safe path for any stray electricity to go straight to the ground without causing any problems.



Grounding and Bonding in Canada

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.

Knowledge Check

Where would the traffic signal inspector find information of the most current versions of applicable standards?

- a) Authority Having Jurisdiction (AHJ)
- b) MUTCD
- c) NHTSB Website
- d) Signal Contractor

Knowledge Check

Orange paint markings in close proximity to white excavation markings would indicate the possible conflict with what type of utility?

- a) Communication
- b) Gas
- c) Power
- d) Water

Knowledge Check

What type of reflective vest should be worn during the day in a traffic signal construction site on a 45 mph (72KMH) roadway?

- a) Class 1
- b) Class 2
- c) Class 3
- d) Class 4

Knowledge Check

What type of reflective vest should be worn at night in a traffic signal construction site on a 55 mph (88KMH) roadway?

- a) Class 1
- b) Class 2
- c) Class 3
- d) Class 4

Knowledge Check

What locate mark color is for underground electrical lines?

- a) Blue
- b) Orange
- c) Red
- d) White

Knowledge Check

What locate mark color is for underground gas lines?

- a) Blue
- b) Yellow
- c) Red
- d) White

Knowledge Check

The most useful testing tool is a

- a) Multi meter
- b) Omni meter
- c) Ossi meter
- d) Deca meter

Knowledge Check

A ground rod tester should indicate a reading of how many Ohms to ground per the NEC

- a) 35 or less
- b) 30 or more
- c) 25 or less
- d) 25 or more

Knowledge Check

All testing equipment should be tested and certified

- a) Semi Annually
- b) Annually
- c) Every two years
- d) When it fails

Knowledge Check

When a CMU or MMU is bench tested

- a) Ensure that the correct test is applied to the specific model tested
- b) All tests are the same as MMU CMU are basically the same
- c) The test results can be kept by the testing agency and are not needed
- d) As long as the devices passes it can be placed in the back of the signal truck for later installation

Knowledge Check

From whom would the traffic signal inspector obtain the latest approved version of the traffic signal plans associated with a traffic signal project?

- a) Traffic Engineer/Engineer of Record
- b) Traffic Signal Consultant
- c) Traffic Signal Contractor
- d) Traffic Signal Inspector

Knowledge Check

What resource is referenced to make sure a pedestrian push button is ADA compliant?

- a) ADA Manual
- b) DAD Manual
- c) MUTCD
- d) NEC Handbook

Session 2: Pre-Construction

Traffic Signal Inspector Program Introduction



Here are some specific responsibilities and tasks of a traffic signal inspector:

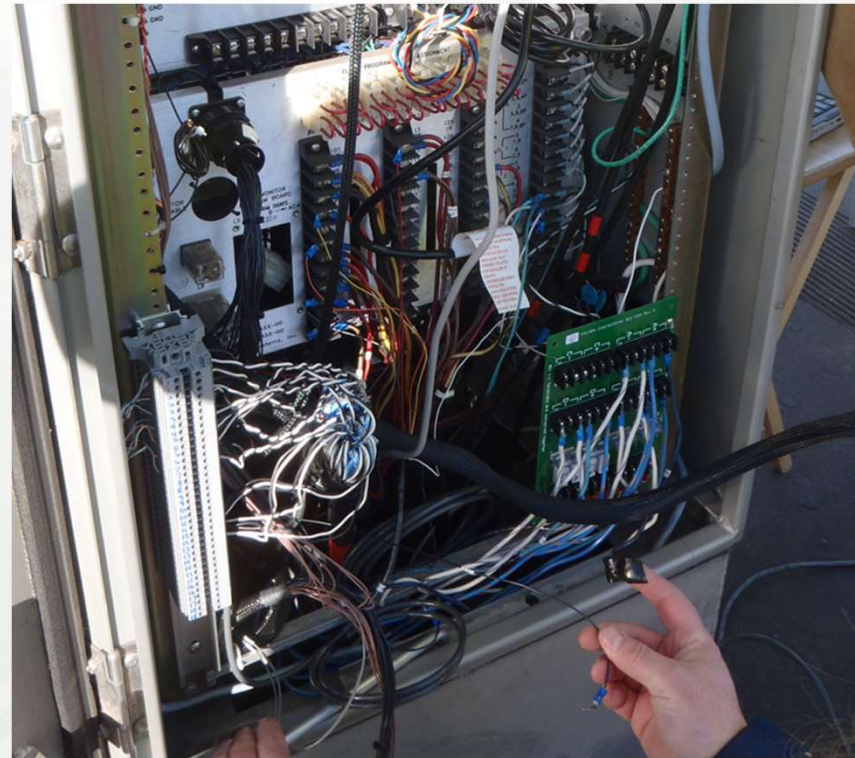
- Inspecting new signal installations to verify proper construction and wiring.
- Ensuring compliance with engineering plans, specifications (e.g., NEMA TS-1/TS-2), MUTCD guidelines (signal timings, etc.), and local standards.
- Testing signal functionality to confirm correct timing, phasing, and operation.
- Identifying defects or safety issues that could impact driver, pedestrian, or worker safety.
- Documenting inspections and reporting deficiencies for corrective action.
- Coordinating with contractors, engineers, and utility companies to resolve problems or delays.

Traffic Signal Inspector Program Introduction

Documenting and Issue Resolution: Investigate and document reported issues with traffic signals, such as signal malfunctions, incorrect timing, or faulty detection. Inspectors identify the cause of the problem and take appropriate action to document it, overseeing resolution to make sure it complies. They do not perform repairs.

Documentation and Reporting: Maintain accurate records of inspections, maintenance activities, and repairs performed on traffic signal systems. Prepare reports on the condition of signal equipment, any identified issues, and actions taken to resolve them.

Overall, the primary goal of a traffic signal inspector is to ensure the safe and efficient operation of traffic signals, contributing to improved traffic flow, reduced congestion, and enhanced road safety for motorists, pedestrians, and cyclists.



Key Personnel

Key personnel involved in traffic signal installation can vary depending on the specific project and the organization responsible for the installation.

However, here are some common roles that are typically involved in traffic signal installation projects:

Traffic Engineer/Transportation Engineer (EOR): Traffic engineers are responsible for planning, designing, and implementing traffic management systems, including traffic signals.

They analyze traffic flow, conduct traffic studies, and determine the optimal signal timings and configurations for efficient traffic management. They are responsible for maintaining the approved product list. They organize the standards and codes applicable to each contractor. EOR should attend all meetings during the Design Phase and Pre-Construction.

Project Manager: A project manager oversees the entire traffic signal installation project. They are responsible for coordinating various tasks, managing resources, setting timelines, leading the traffic signal pre-construction meeting, and ensuring that the project is completed on schedule and within budget. They should stay in constant contact with the inspector as to any delays or environmental concerns that may hinder the timeline of the project.

Electrical Engineer: Electrical engineers play a crucial role in traffic signal installation.

They design and implement the electrical infrastructure required for traffic signal systems. They ensure that the electrical connections, wiring, power supply, and control systems are properly installed and functioning.

Key Personnel

Traffic Signal Technician/Installer: Traffic signal technicians are responsible for physically installing and maintaining traffic signal equipment. They work with electrical components, traffic signal controllers, and other hardware. They ensure that the equipment is correctly installed, connected, and functioning as per the design specifications.

Construction Crew/Contractors: Construction crews or contractors are involved in the physical installation of traffic signal infrastructure, including poles, signal heads, pedestrian crossings, and related infrastructure. They handle excavation, concrete work, pole erection, and other construction tasks as per the design plans utilizing their own expertise. They also produce projected timeline updates and communicate any environmental concerns.

Traffic Control Supervisor: During the installation process, a traffic control supervisor is responsible for ensuring that traffic is safely managed around the construction site. They plan and implement temporary traffic control measures to minimize disruptions and maintain safety for both the workers and road users.

Note: These roles can overlap or vary depending on the scale and complexity of the project, as well as the specific organizational structure and processes involved in the traffic signal installation process.

Inspection: Responsibilities

When inspecting a traffic signal installation, there are several responsibilities the Traffic Signal Inspector needs to accomplish daily:

- ✓ Verify site conditions at the start of each day.
- ✓ Identifies any/all safety concerns and potential hazards.
- ✓ If any personnel are working in an unsafe manner, halt work.
- ✓ Keep logbook of everything that happens on the work site, to include a list of all workers and equipment and how they conduct themselves.
- ✓ Checks Project site layout per Traffic Control plan daily. (Be able to interpret plans and documents)
- ✓ Address any concerns or questions, including from the public

Inspection: Responsibilities

When inspecting a traffic signal installation, there are several responsibilities the Traffic Signal Inspector needs to accomplish daily:

- ✓ Has the responsibility and authority to reject materials that do not match shop drawings and needs to relay this information to the Traffic Signal Contractor Project Manager.
- ✓ Prior to the start of any work, it is most important the construction plans are approved
- ✓ Has Safety responsibility to notify the Contractors of PPE deficiencies.
- ✓ Participates in the onsite project meeting whenever on site.
- ✓ Responsible for ensuring milestones are met during the construction phase.
- ✓ Always wear proper PPE on the work site!

Pre-Construction

- A pre-construction meeting should include the responsible Agency and project team, which includes the construction company's personnel, consultants, and contractors, get together to establish authority and communication (chain of command), clarify responsibilities, identify potential issues, and plan for a successful project before hitting the jobsite.
- Sharing phone numbers, addresses and other contact information for everyone from the general contractor, project foreman, engineer and project manager to the project inspectors, agency and their representatives.
- The start and completion dates need to be communicated during the pre-construction meeting. The [scheduling plans](#) for the project will also be shared with the project team and any potential issues, such as road restrictions, weather or site conditions and time constraints, will be discussed. The general contractor will speak to the estimated duration of the project, whether work will continue weekends and holidays and the status of a notice to proceed documents, if required.

Pre-Construction

- Review the [construction documents](#) and drawings that are most critical to be understood by the project team. There will be too many to go over them all, so you must be selective. But those that are chosen must be thoroughly reviewed with major items discussed by all involved.
- Identify the safety hazards associated with the [construction site](#) to provide a safe working environment for the project team. Introduce the safety professional, if the site requires one.
- When it comes to project materials, factor in a long lead time to ensure that they're on hand when needed during the project. This means you must know that materials and equipment you need and how you'll get them on time.
- Inspector should reach out to the authority having jurisdiction for most current version of applicable standards.

Documentation

Types of Documentation for Inspectors

Daily Journals

§Record contractor activities, labor, equipment, work performed, and weather.

Emails

§Maintain organized correspondence related to project decisions and clarifications.

Weekly Meeting Minutes

§Track action items, changes, and commitments made during coordination meetings.

Photos

§Capture pre-installation, in-progress, and final installation conditions.

§Document deficiencies, corrections, and hidden work (e.g., trench depth).

Documentation

Types of Documentation for Inspectors

Submittals

- §Verify materials and equipment installed match approved submittals.
- §Document on packing slips upon arrival

Engineer of Record (EOR) Correspondence

- §Track design clarifications, approvals, plan changes, and directives.

Fiber Loss Reports

- §Document OTDR and power loss test results; verify they meet project specs.

Electrical Inspections

- §Retain inspection approvals from local jurisdictions and verify compliance.

Documentation

Types of Documentation for Inspectors

Other Jurisdiction Reports

- Collect utility, traffic, electrical, or third-party inspection results.

Grounding Reports

- Confirm acceptable grounding resistance tests for cabinets and poles.

Requests for Information (RFIs)

- Track questions submitted to designers and their resolutions.

Loop Testing Records

- Document continuity, resistance, and insulation tests prior to backfill.

As-builts

- Final inspection punch list.

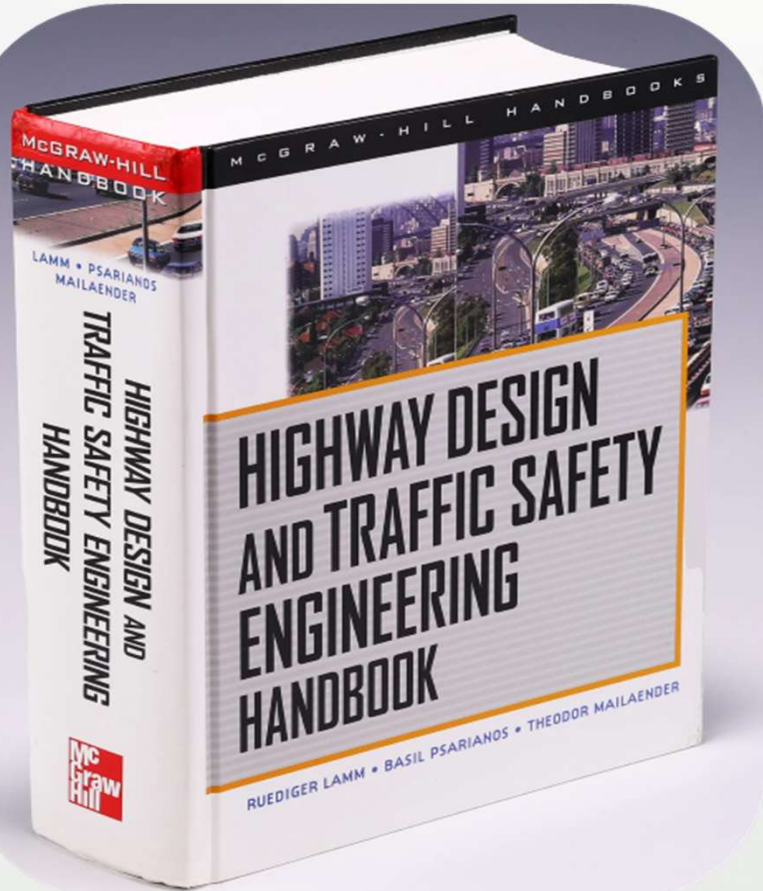
Session 3: Traffic Signal Construction

Engineering Survey



Before constructing a traffic signal, an engineering survey is conducted to determine the appropriate location. Factors such as traffic volume, pedestrian flow, visibility, and nearby intersections are considered.

Engineering Survey



Once the location is determined, Engineers create a detailed design for the traffic signal system, including signal heads, signal poles, detection equipment, and timing plans. This design may need to comply with local transportation department guidelines and obtain necessary permits.

The EOR must approve everything before it goes to the client.

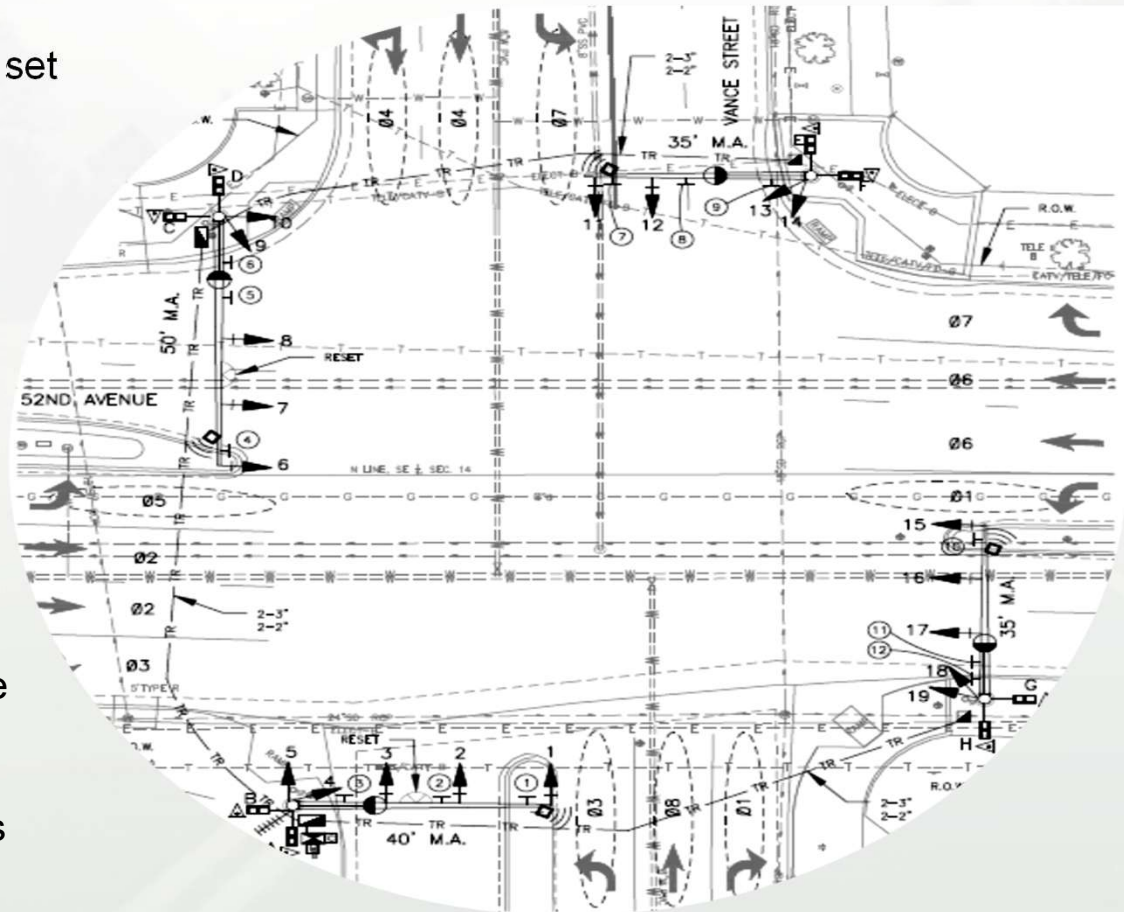
Traffic Signal Construction Plans

Every traffic signal project begins with an approved set of plans and special provisions to include:

- # and size of underground conduits and routing
- Foundation locations and pole placement
- Cabinet location
- Vehicle phasing
- Mast Arm length
- Traffic signal head placement
- Detection
- Power feed
- Crosswalks and striping

Once construction is complete, these plans become the basis for “as built” or “red line” drawings.

- This becomes the permanent record of what was installed and where it was placed.



Traffic Signal Construction Plans

A typical traffic signal construction plan set includes several sections that outline different aspects of the project. The specific sections may vary depending on the jurisdiction and the complexity of the project, but here are some common sections you might find in a traffic signal construction plan set:

Cover Sheet: This section provides basic information about the project, such as the project name, location, and contact details for the parties involved.

General Notes: This section includes general information and instructions applicable to the entire plan set, such as construction standards, materials specifications, and any special requirements.

Existing Conditions: This section provides detailed information about the existing conditions at the project site, including existing roadways, utilities, structures, and any other relevant features.

Pictures will almost always win arguments.

Traffic Control Plan: This section outlines the temporary traffic control measures that will be implemented during construction to ensure the safety of motorists, pedestrians, and workers. It includes details on lane closures, detours, signage, and any necessary flagging operations.

Traffic Signal Construction Plans

Traffic Signal Plans: This section contains detailed drawings and specifications for the traffic signal equipment, including the signal heads, poles, mast arms, controllers, and wiring diagrams. It also includes information on the timing and phasing of the signal operation. Any required or requested changes to the Traffic Signal plans will be made with a red pencil/pen and communicated immediately to the project manager

Electrical Plans: This section provides detailed drawings and specifications for the electrical components of the traffic signal system, such as the power supply, conduits, pull boxes, and grounding details.

Construction Details: This section includes detailed drawings and specifications for various construction elements, such as foundations for signal poles, signal cabinet installations, pavement markings, and signal interconnect systems.

Landscaping and Right-of-Way: If landscaping or modifications to the right-of-way are required as part of the project, this section will provide the necessary details, including planting plans, tree protection measures, and any necessary permits or approvals.

Traffic Signal Construction Plans

Specifications: This section contains detailed technical specifications for the materials, equipment, and construction methods to be used in the project. It may include requirements for signal equipment, pavement markings, wiring, and other relevant items.

Bid Documents: If the project is being put out to bid, this section will include instructions to bidders, contract forms, and any other documents necessary for contractors to submit their bids.

It is important to note that the content and organization of a traffic signal construction plan set can vary upon approval by the engineer, and additional sections may be included based on the specific requirements of the project or jurisdiction.

Traffic Signal Construction Plans

A Traffic Signal Contractor is responsible for installing and maintaining traffic signals and related infrastructure.

Their main tasks typically include:

Installation: The contractor installs traffic signal systems, including traffic lights, signal poles, controllers, and wiring. This involves coordinating with local authorities, engineers, and transportation departments to ensure proper placement and functionality of the signals. And to ensure that the ROW is not worked in.

Electrical Work: Traffic signal contractors are skilled in electrical work and are responsible for connecting and wiring the traffic signal components. This includes ensuring the proper electrical connections, grounding, and power supply for the signals to operate effectively. The Signal Project plans show all splices.

Testing and Commissioning: Once the installation is complete, the contractor tests the entire traffic signal system to ensure proper functioning. This includes checking the electrical connections, signal visibility, timing accuracy, and coordination with other nearby signals. It should be noted that all installs are subject to verification of proper operation.

Knowledge Check

Which of the following is a section of the traffic signal construction plan set?

- a) Plumbing
- b) Traffic control plan
- c) HVAC
- d) Itemized billing receipts

Knowledge Check

Which of the following is a section of the traffic signal construction plan set?

- a) A list of all contractors required for the project.
- b) any changes or modifications from the current revision
- c) any safety concerns and deficiencies that occurred throughout the project
- d) any traffic control used throughout

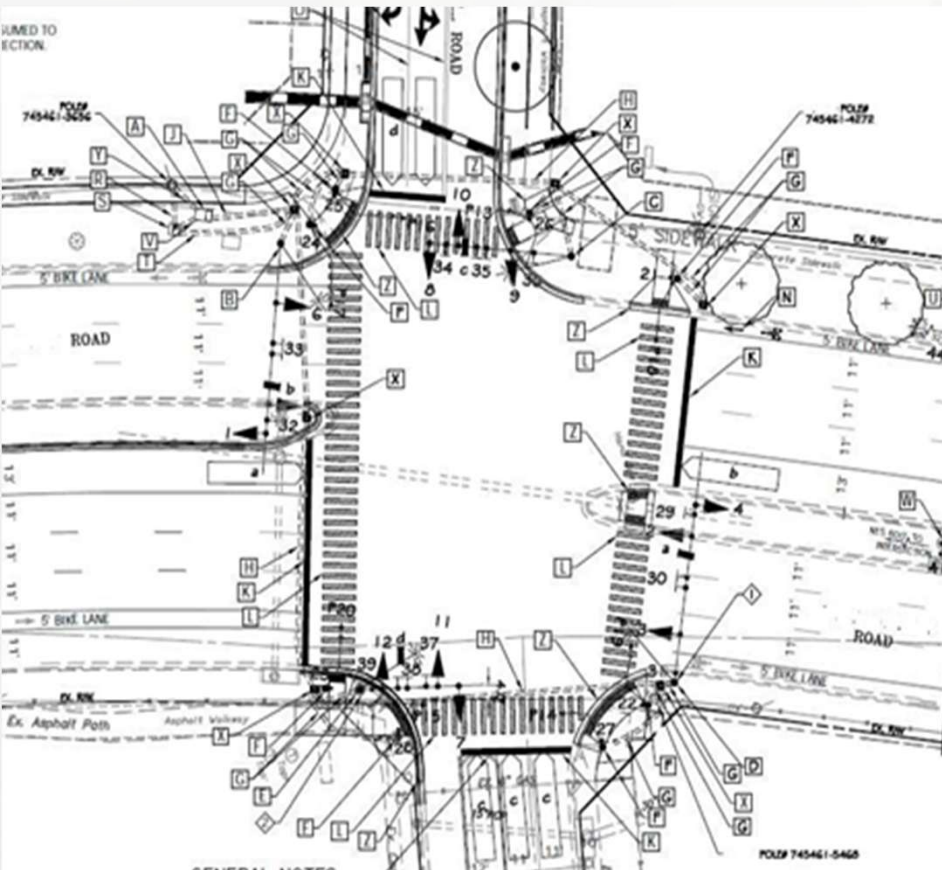
Knowledge Check

What color pencil should revisions to traffic signal plans be made in?

- a) Blue
- b) Orange
- c) Pink
- d) Red

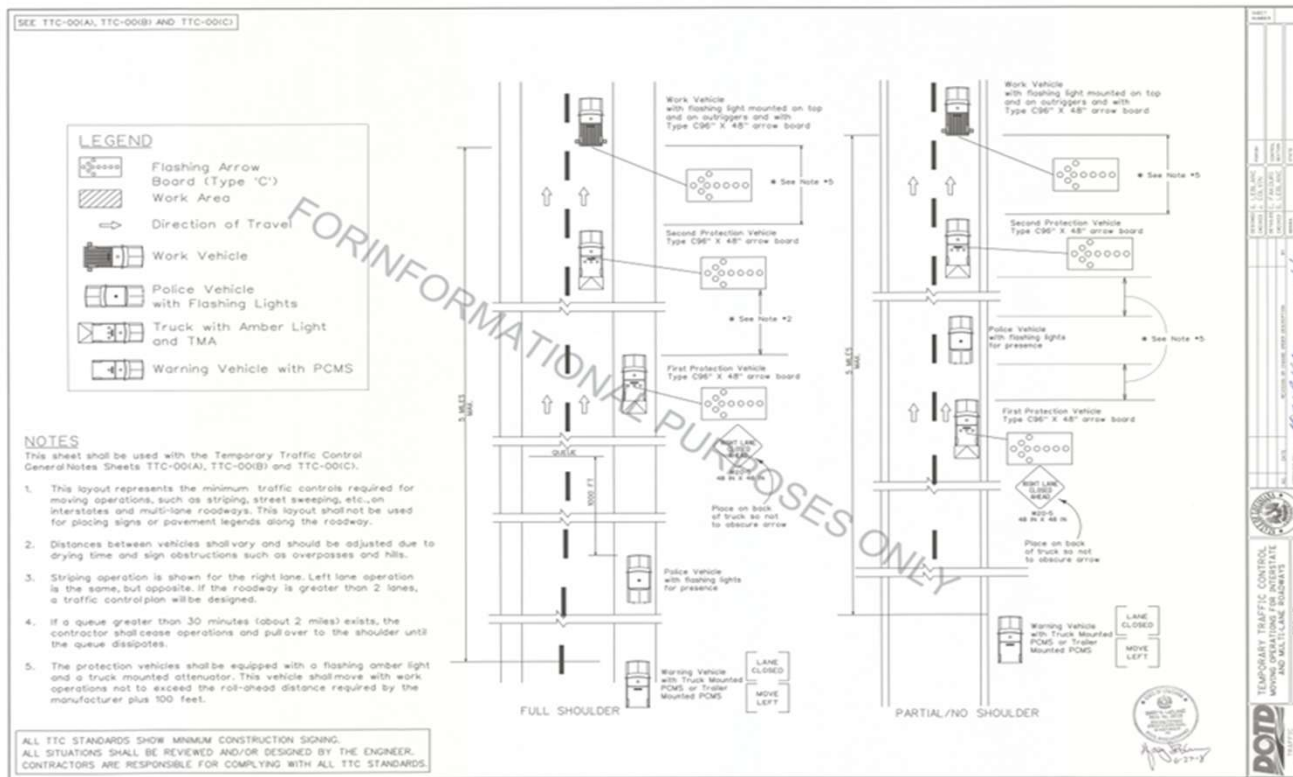
Session 4: Traffic Control Plans

Traffic Control Plans



Traffic Control Plan: A traffic control plan is developed to ensure the safety of motorists, pedestrians, and construction workers during the installation process. This plan includes temporary traffic signs, barricades, and detour routes, if required, and any Road closures that will be needed. Nighttime work will require inspection of condition of reflective materials and possible light plans. Road closures and detour requests are approved by the governing municipal body. (Traffic Engineer)

Traffic Control Plans

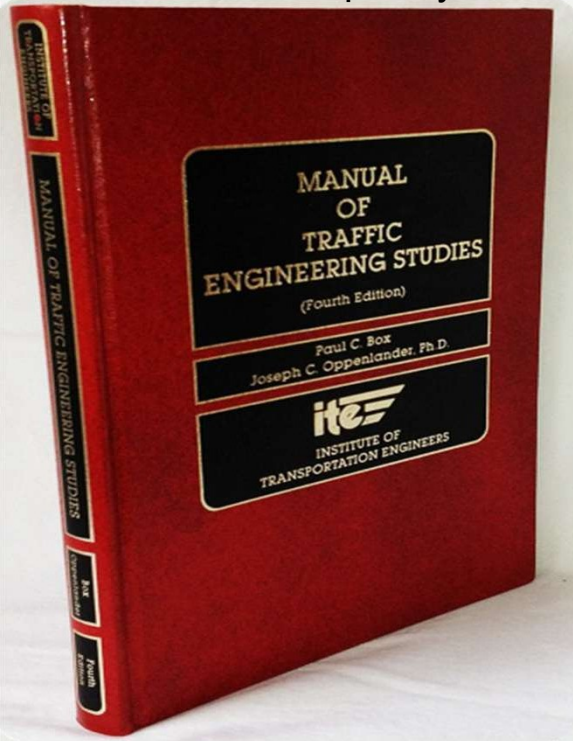


Traffic control plans are detailed strategies designed to manage the flow of vehicular and pedestrian traffic during construction or maintenance activities, special events, or emergencies. These plans help ensure the safety of workers, drivers, and pedestrians while minimizing disruptions to traffic flow.

The following slides show some key components typically included in a traffic control plan:

Traffic Control Plans

Traffic Flow Analysis: This involves assessing the existing traffic patterns, volume, and congestion levels in the area under consideration. It includes collecting data on peak hours, traffic counts, and travel speeds. This analysis helps determine how temporary traffic control measures may affect the overall traffic flow and identify potential bottlenecks.



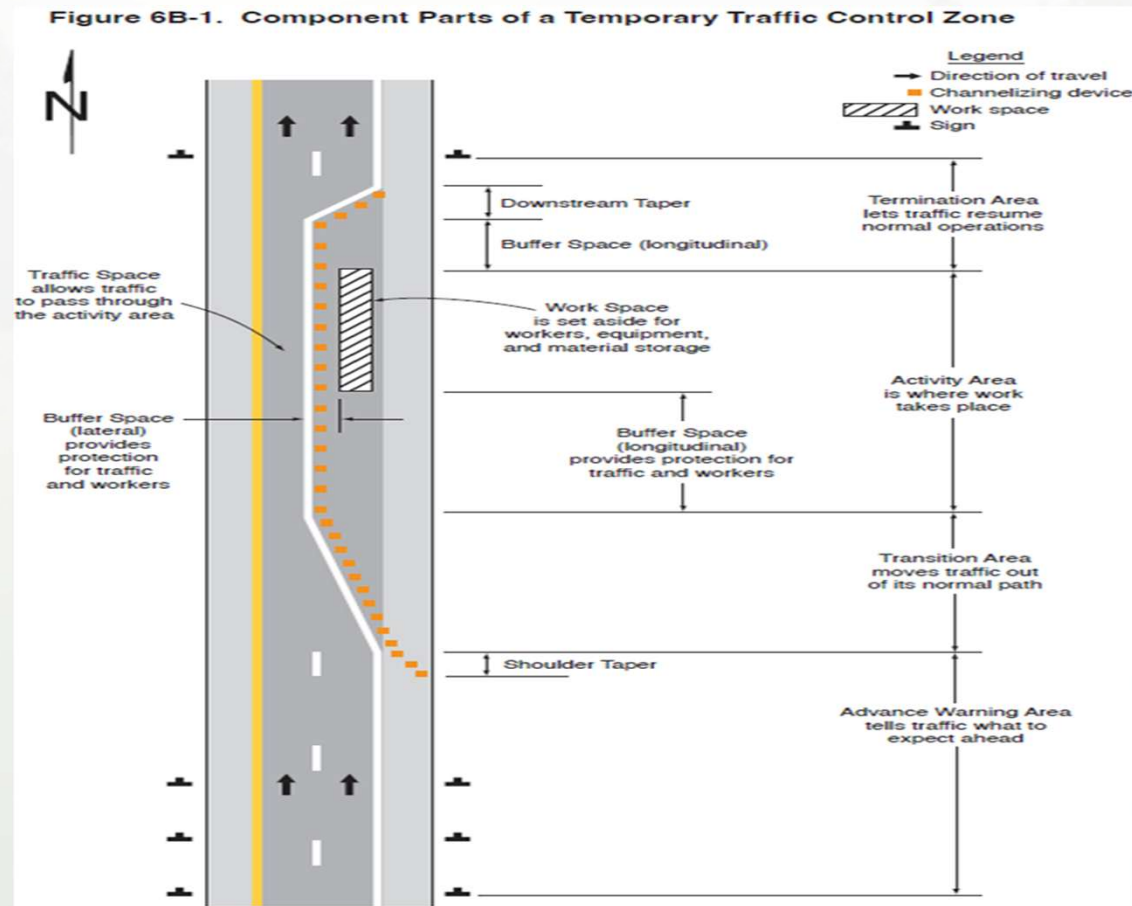
There are several methods and tools used for traffic flow analysis, including:

- Traffic Counts
- Speed Measurement
- Travel Time Studies
- Traffic Simulation Models
- Traffic Signal Optimization
- Capacity and Level of Service Analysis
- Data Analytics and Machine Learning

Traffic Control Plans

Work Zone Setup: The plan outlines the layout and setup of the work zone, including the placement of traffic control devices such as cones, barricades, signs, and flaggers. The goal is to create a safe and clearly delineated area for workers while maintaining an organized flow of traffic.

A great way to document proper work zone setup is visual inspection and pictures.



Traffic Control Plans



Temporary Traffic Control Devices: The plan specifies the appropriate placement of temporary traffic control devices, such as signs, barricades, cones, and delineators, to guide motorists and pedestrians safely through or around the work zone. These devices help maintain traffic flow, provide clear instructions, and warn drivers of any hazards or changes in road conditions.



Detour Routes: In cases where the planned activity requires a complete or partial closure of a roadway, alternative detour routes must be identified and communicated to drivers. The plan should clearly outline the detour routes, signage, and any temporary traffic signals required to guide drivers safely around the work zone.

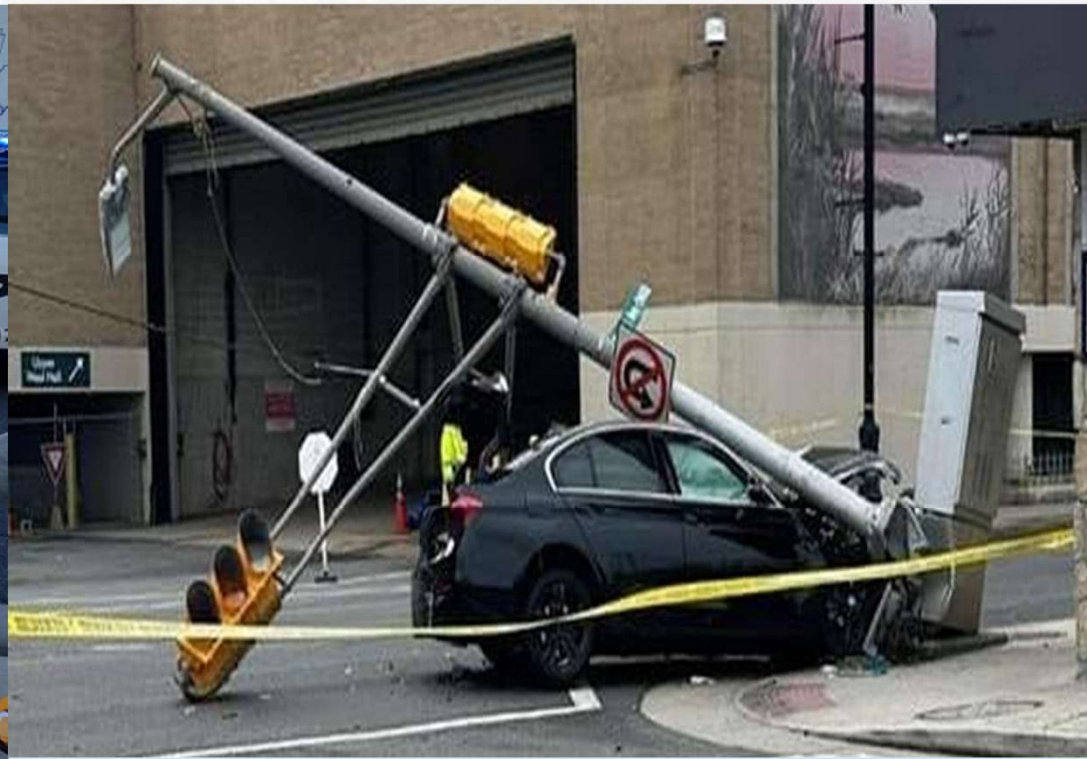
Traffic Control Plans



Flagging Operations: If flaggers are needed to direct traffic, the plan should include guidelines for their deployment. This includes the number of flaggers required, their positioning, and communication procedures to ensure smooth traffic flow and the safety of both workers and drivers.

Traffic Control Plans

Emergency Response: The plan should also account for emergency situations and outline procedures to be followed in case of accidents, vehicle breakdowns, medical emergencies, or any other unforeseen circumstances that may affect traffic flow or endanger workers or the public.



Traffic Control Plans

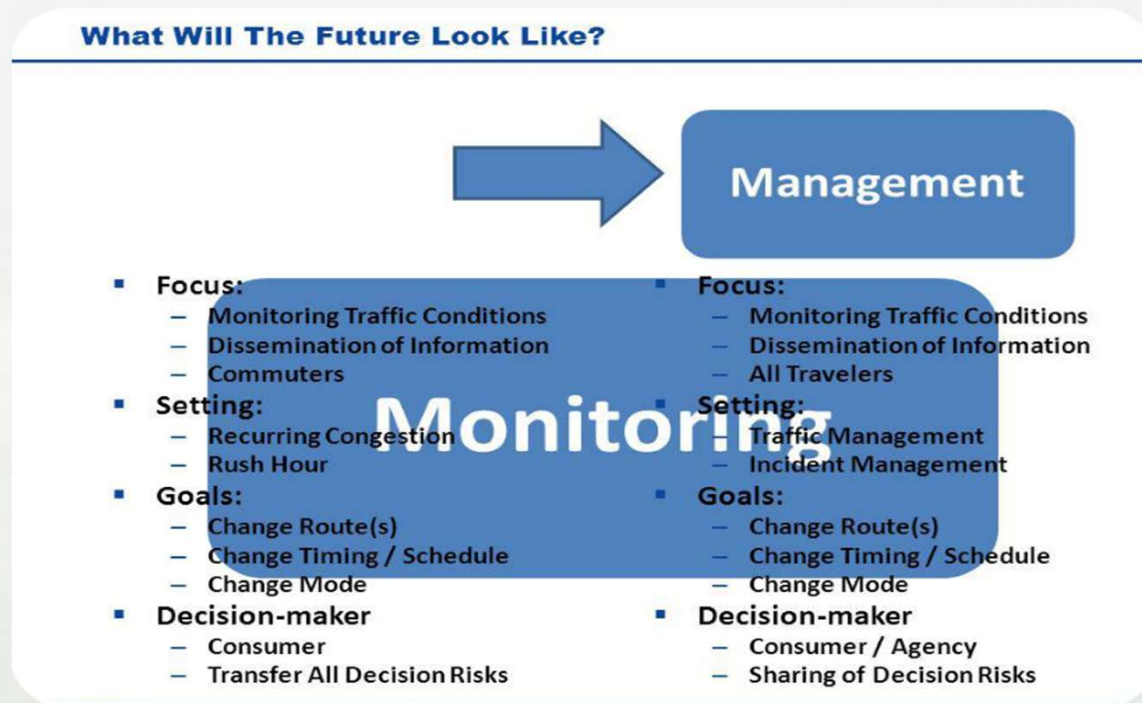
Determining public relations needs for temporary traffic control involves understanding the specific goals, challenges, and stakeholders involved in the project. Here are some steps to help you determine the public relations needs for temporary traffic control:

- **Identify project goals**
- **Define target audience**
- **Conduct stakeholder analysis**
- **Assess communication channels**
- **Develop key messages**
- **Establish a communication plan**
- **Engage with stakeholders**
- **Monitor and evaluate**

Remember, effective public relations for temporary traffic control requires proactive communication, transparency, and a focus on addressing the needs and concerns of the affected stakeholders. In today's digital age, Social Media would seem to be the best means of communicating to the public however News and press releases are still more effective for most discernment of information.

Traffic Control Plans

Monitoring and Evaluation: Regular monitoring and evaluation of the traffic control plan are essential to identify any issues or areas for improvement. This includes conducting traffic counts, assessing the effectiveness of traffic control measures, and making adjustments as needed.



Traffic Control Plans

It is important to note that traffic control plans may vary depending on local regulations, specific project requirements, and the scale of the planned activity. Local transportation authorities, construction companies, event organizers, traffic engineer/engineer of record, or emergency management agencies are typically responsible for creating and implementing traffic control plans.

Knowledge Check

What is the process a traffic signal inspector uses for implementing proposed changes to a traffic control plan?

- a) Document and submit proposed changes to the traffic control plan as needed to the project manager for review and approval.
- b) Document and submit proposed changes to the traffic control plan to the project manager. The project manager forwards these requests to the traffic engineer/engineer of record for approvals.
- c) Implement any necessary changes to the traffic control plan as needed directly. Document changes and notify the project manager.
- d) Traffic signal contractors can directly make any needed changes to the traffic control plan at any time throughout the duration project.

Knowledge Check

What document is used to properly implement a detour as part of a traffic project?

- a) Signal control plan
- b) Traffic control plan
- c) Traffic signal plan/special provisions
- d) Traffic volume/movement study

Knowledge Check

What is the BEST method for communicating to the public about signal construction detour or lane closure?

- a) City council meeting
- b) Press release
- c) Public bulletins
- d) Social media

Session 5: Inspection of Traffic Structures, Controls, and Associated Equipment

Inspection: Equipment

- ✓ Check the physical condition, proper installation, and functionality of the signal equipment, including traffic signal heads, pedestrian signals, countdown timers, and any additional devices such as emergency vehicle preemption systems. Document any damage found prior to starting work for liability purposes.
- ✓ Familiarize yourself with the installation plans, including electrical diagrams, signal equipment specifications, and any relevant documentation provided by the manufacturer or regulatory bodies.
- ✓ Start by visually inspecting the signal equipment and its components. Look for any physical damage, loose connections, or signs of improper installation. Ensure that all components are properly mounted and secured.
- ✓ Inspect all grounding ground rods, proper size wires, cad welded connector to rod, and check ground readings with the proper equipment.

Inspection of Structures



Underground Construction

- Conduit
- Foundations
- Tie-ins
- Wiring

Overhead Construction

- Poles and Mast Arms
- Signal Heads
- Pedestrian Heads and Push Buttons
- Detection

Wiring and Electrical Connection Inspection

- ✓ Inspect the wiring and electrical connections for signs of damage, wear, or corrosion. Ensure that all connections are secure and properly insulated. Test electrical components and circuits to verify they are functioning correctly.
- ✓ Use appropriate testing equipment to check the electrical connections, voltage levels, continuity, and grounding of the wiring. Verify that the wiring is correctly installed, properly insulated, and free from any short circuits or exposed conductors.
- ✓ Test each signal component to verify its functionality. This may include signal heads, lamps, LED displays, audible devices, sensors, and communication interfaces. Activate and observe the signals to ensure they respond correctly according to the intended design and traffic control plans, if required make sure ALL WIRES are labeled.
- ✓ All grounding must be checked as well, using the appropriate meter as well.

Continuity Test

A continuity test is a method used to verify the electrical continuity of a cable. It is commonly performed using 2 people to ensure that all the conductors within a cable are properly terminated, there are no breaks or open circuits, and are on the correct phase.

To conduct a cable continuity test, you will need a few tools:

Multimeter: A multimeter is a versatile device used to measure voltage, current, and resistance. It typically has a continuity testing function that can be used for this purpose.

Test leads: These are the cables with probes that connect the multimeter to the cable being tested.

It's important to note that a continuity test only checks for a complete path of conductors in the cable. It does not verify the quality of the signal or the cable's ability to transmit data accurately, which may require specialized tests.

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

Continuity Test

Here is a step-by-step guide on how to perform a cable continuity test:

- Ensure that the cable is not connected to any power source or equipment. This is crucial for safety reasons.
- Set your multimeter to the continuity or resistance mode. The exact setting may vary depending on the model of your multimeter.
- Connect one probe of the multimeter to one end of the cable you want to test.
- Connect the other probe of the multimeter to the opposite end of the cable.
- Observe the multimeter reading. If the cable 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 cable.
- Move the probes along the cable, testing different segments, to identify any discontinuities or breaks in the cable. If the multimeter does not emit a beep sound or shows a high resistance reading (infinite or significantly high ohms), it suggests an open circuit or a break in the cable.
- Repeat the test for each conductor within the cable.

Inspection: Signal Poles and Mounting Hardware

Signal poles and mounting hardware inspection involves assessing the condition and functionality of poles and the associated hardware used for mounting various signals, such as traffic lights, streetlights, or signage. The inspection ensures that these structures are in proper working order, meet safety standards, and are maintained appropriately.

Here are the key aspects to consider during a signal poles and mounting hardware inspection:

Visual Inspection: Start by visually inspecting the signal poles and mounting hardware for any signs of damage, corrosion, wear and tear, or other visible defects. Look for cracks, rust, loose bolts, bent components, or missing parts.

Structural Integrity: Check the structural integrity of the poles by examining their stability and alignment. Ensure that the poles are straight, firmly anchored to the ground, and not leaning or showing signs of instability.

Mounting Hardware: Assess the condition of the mounting hardware, such as brackets, clamps, or straps. Ensure that they are securely fastened, without any signs of rust or damage. Verify that the hardware is appropriate for the specific signal and capable of holding it in place.

Inspection: Signal Poles and Mounting Hardware

Inspector will need to be sure installation is according to plan specifications.

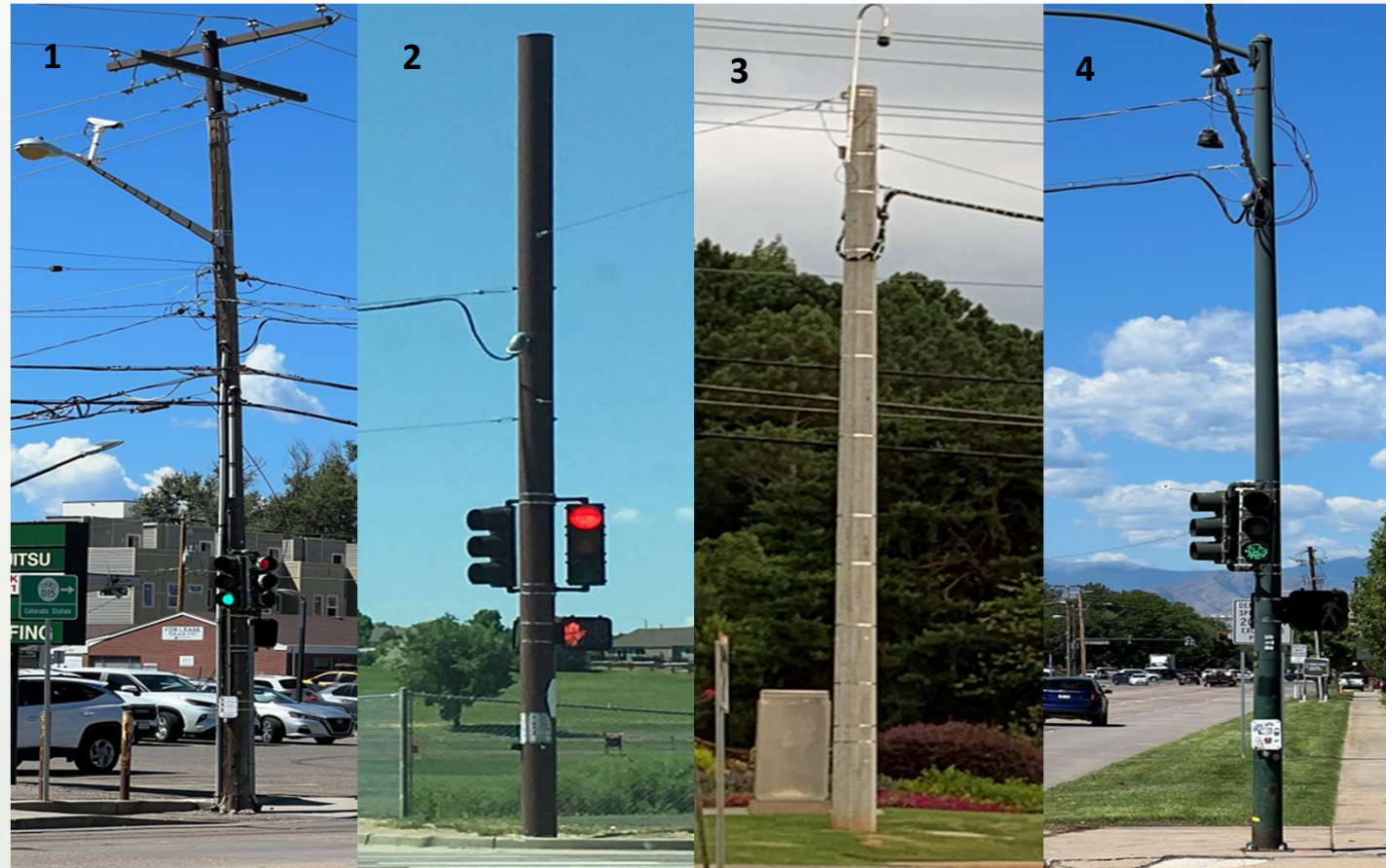
- Pole assembly includes upper and lower parts of 2-part poles
- Transformer bases if applicable
- Luminaire arms
- Wiring
- Pole hardware such as pole caps and handhole covers
- Mast arm and span wire poles may need to be “**raked**” (leaned back) upon installation to counter act the force applied to them; i.e., the weight of the mast arm or the force of the span wire.
- Bolt-down style poles are set on “leveling nuts” for adjustment



Span Wire - Poles

The span wire system consists of:

- A messenger cable stretched between wood poles [1], embedded steel [2], concrete poles [3], or tapered steel strain poles [4] (much like a mast arm pole).
- Multiple traffic signal heads and other devices attached to the wire at various points.



Signal Head Installation – Span Wire

Different components

- Span
- Messenger cable
- Catenary
- Tether
- Span wire poles
- Hardware



Mast Arms

Mast Arm Installations:

- Mast arms are cantilever structures that are supported from one end and extend out above the roadway.
- They can be positioned to control the flow of traffic from multiple directions.
- Traffic signal heads and signs are attached to the mast arm with ridged mounting hardware, thereby limiting any movement in the wind.
- All signal cabling is protected inside the mast arm and pole.
- Regulatory signs are placed as near to the feature they are controlling.
- Make sure Mast Arm is installed according to plan specifications.



Pole and Mast Arm Inspection

In order to maintain the integrity of the pole and the arm, you must inspect them both and document and report, any of the following issues:

- Rust and corrosion
- Blistering paint
- Cracked welds
- Loose bolts
- Missing covers
- Missing rodent screens
- Exposed wires
- Improper grounding and bonding

If any of the above conditions are found, make sure you report it to your supervisors for further action.

Truss Structures



- A triangulated system of straight interconnected structural elements.
- They can cover long spans, are light weight, and provide full lane coverage with the signals.
- These structures are also used in areas where weather events like wind, ice and snow are an issue.
- Signal heads are ridged mounted and installed anywhere along the truss.
- Signal cabling is protected inside the truss structure.

Monotube Structures

- These structures cover wide roads and provide full lane coverage.
- They are assembled with multiple arm sections (2 in the picture).
- Signal heads are ridged mounted and installed anywhere along the monotube.
- Signal cabling is protected inside the monotube structure.



Signal Head Mounting

Traffic signal heads may be mounted on mast arms or other overhead structures in several ways:

- Ridged mounting:
- Pipe and nipple
- Plumbizer (slip fitter) style
- Adjustable Bracket style
- Flexible mounting
- Balance hanger



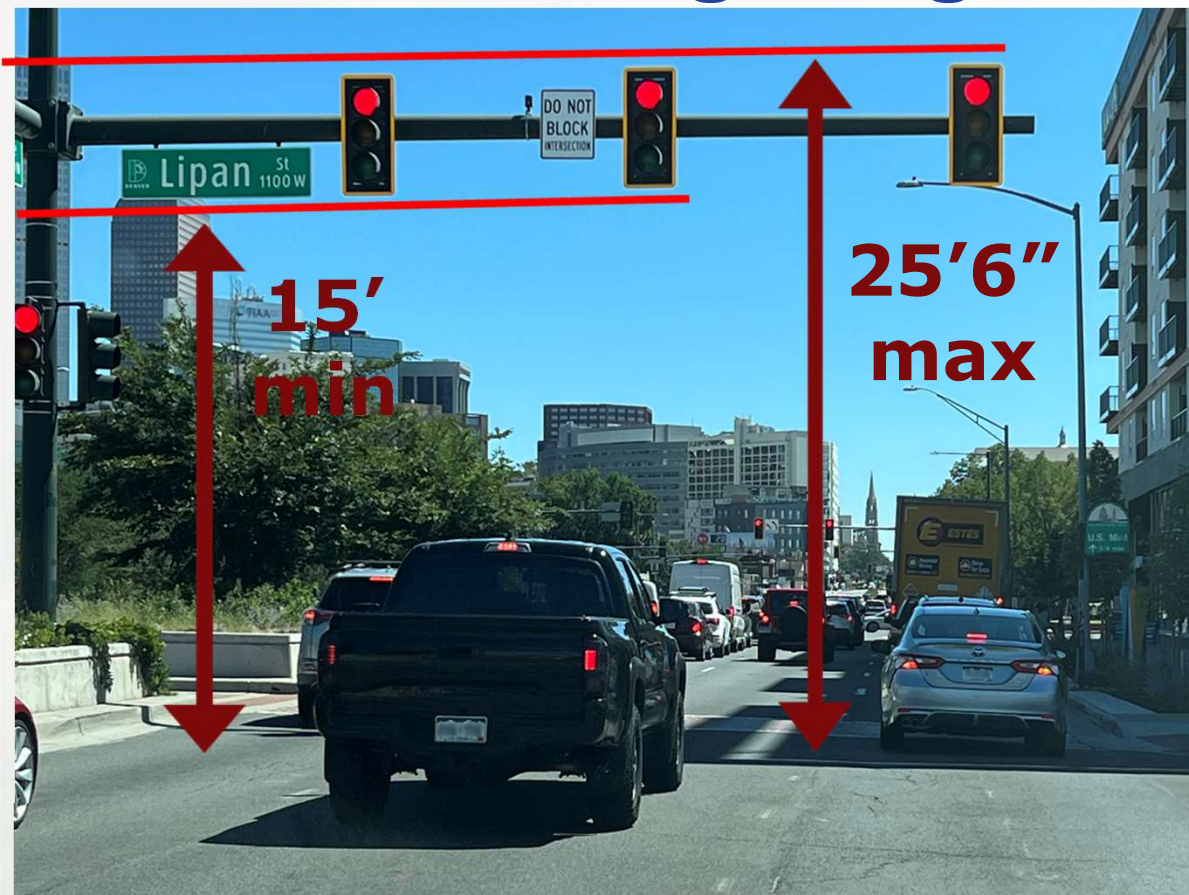
Side - Mounted

Side-Mounted Installations:

- Signal heads are mounted directly onto poles or structures positioned at the side of the roadway (**not** located **over** a roadway).
- Commonly used in situations where overhead or mast arm installations are not feasible, such as narrow roadways or areas with height restrictions.
- Side-mounted signal heads are positioned to face the approaching traffic and provide clear indications.
- **Bottom of the signal housing** shall be a minimum of **8** feet and a maximum of **19** feet above the sidewalk or, if there is no sidewalk, above the pavement grade at the center of the roadway.
- **Pedestrian heads** shall be mounted between **7** and **10** feet to the bottom of the head above sidewalk level.
- Validate that any cables are correctly wired and gromets are installed correctly.



Mounting Height of Signal Faces



MUTCD 4D.09:

- The bottom of the signal housing and any related attachments to a vehicular signal face located over any portion of a highway that can be used by motor vehicles **shall be at least 15** feet above the pavement.
- The top of the signal housing should not be more than 25½ feet above the pavement.

Traffic Signal Mounting Heights & Misc - Canada

Some key differences in the Canadian MUTCDC Guide are:

(refer to section B3 of the MUTCDC for complete and detailed information)

- Overhead **minimum height** (primary signal) is **4.5m** (15 Feet) - **maximum height is 6.0m** (20 feet).
- Minimum height (secondary signal) clear of roadway is **2.5m** (8.2 feet) above the sidewalk.
- Minimum height for pedestrian signal heads, clear of roadway is **2.5m** (8.2 feet) above the sidewalk.



Traffic Signal Heads

Traffic Signal Heads:

- The traffic signal heads, or signal heads, are the visible indicators that display the signal aspects to road users.
- They are typically mounted on poles, span wires, gantries or larger truss structures at intersections.
- Signal heads consist of multiple lamps or LED modules, each representing a different signal Interval.
- Such as red, yellow, and green for vehicles, and white or Portland orange lights for pedestrian heads.
- Note head lane placement, visibility from stop bar.



Parts of a Traffic Signal Head



It is important to know the individual parts of a signal head.

- **Signal Section** or housing
- **Door** – the front of the section
- **Signal face** – an assembly of one or more signal sections
- **Lens** – the colored part
- **Reflector and Lamp**
- **LED module**
- **Visor**
- **Backplate**
- **Louvers**



Parts of a Traffic Signal Head



Inspection: Signage and Markings



Verify the presence and accuracy of traffic signs and pavement markings associated with the traffic signal installation. Ensure that signs are properly placed and adequately reflect nighttime visibility standards.

Blank Out Signs

Blank out signs have become another traffic control item that is gaining in popularity.

- Blank out signs only illuminate during special conditions at the intersection, otherwise they remain dark.

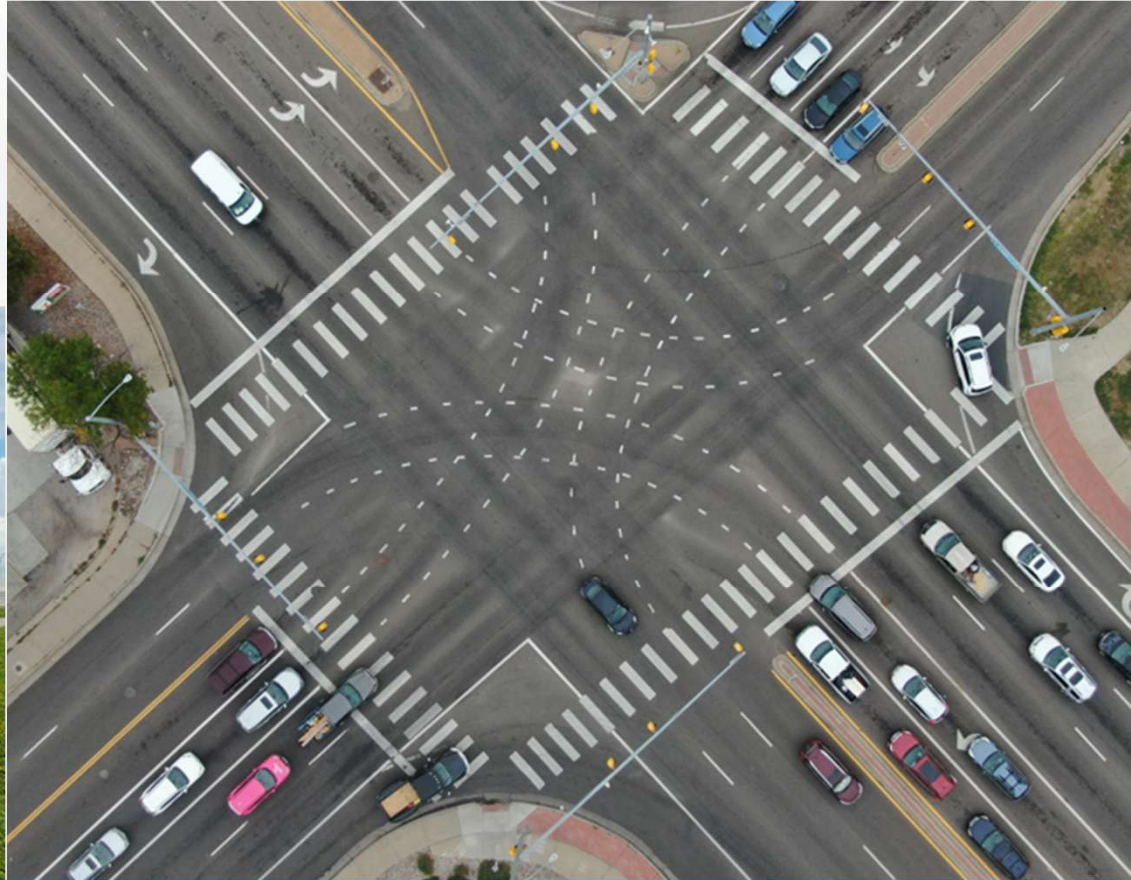
Special conditions may include:

- Railroad preemption
- Emergency vehicle preemption
- Priority control for public transportation vehicles
- Time of day events
- Pedestrian crossings with the need of further protection from turning vehicles
- Special lane use control at sporting or concert events



Blank Out Signs

Pay attention to pedestrian crosswalks and associated safety features. Inspect push buttons, audible signals, and signage to ensure they are in good working order. Verify that pedestrian signal timings provide sufficient crossing time. These should meet ADA / MUTCD guidelines according to the plans.



Inspection: Footings



When conducting a footing inspection for a traffic signal installation, there are several key aspects to consider. Here is a general overview of the process:

Familiarize yourself with the approved design plans for the traffic signal installation. Pay close attention to the specifications and dimensions of the footings. Ensure that the footing excavations are in the correct positions according to the design plans. Check for any discrepancies or deviations from the approved layout. Inspect the footing excavations for proper depth and width as specified in the design plans. The dimensions should comply with the engineering requirements to provide stability and support for the traffic signal pole.

Examine the soil within the excavation to evaluate its properties and suitability for the footing. The soil should have sufficient bearing capacity to support the load imposed by the traffic signal pole. Inspect the reinforcement bars (rebar) placed within the footing excavation. Verify that the rebar is correctly positioned and adequately tied to provide the required structural integrity. Check the formwork to ensure it is properly constructed, providing the desired shape and dimensions for the footing.

Inspection: Footings

Verify that the footing excavation maintains the required clearances from any underground utilities, such as electrical cables or water pipes. The footings should not encroach on these utilities or compromise their integrity. Ensure that the soil within the footing excavation is appropriately compacted to achieve the necessary stability. Improper compaction can lead to settlement and structural issues over time. Examine the bottom of the footing excavation to ensure it is clean and free from any debris or loose material. This will allow for proper contact and load transfer between the footing and the underlying soil. If you find your foundation hole fills halfway with water, use a pump to remove the water to be able to complete the concrete pour in a timely manner.

Document your findings, including photographs and detailed notes, to maintain a record of the footing inspection. Note any observations, issues, or corrective measures taken during the inspection. Based on your inspection findings, determine whether the footings meet the required standards and specifications. If everything is satisfactory, approve the footings for further construction and installation of the traffic signal pole. If not satisfactory, notify contractor, then project manager, then project engineer.

When pouring concrete in colder conditions, ensure the concrete footing is covered with a blanket to trap the heat to allow the concrete to cure naturally and retain strength when temperatures fall below freezing.

Installation of Strain Poles

Identify the types of strain poles commonly used in traffic signal installations:

- Steel strain poles
- Concrete strain poles
- Wood poles (in limited/rural cases/emergency repairs)
- Understand MUTCD/MUTCDC standards for pole placement, alignment, and foundation depth.
- Verify that poles are properly oriented to withstand expected signal head and span wire loads.
- Inspect anchorage and base plate installation (bolt alignment, leveling nuts, and grout placement).
- Ensure poles meet clearance requirements (lateral offset from traveled way, height above ground).
- Check grounding and bonding per NEC or CEC.

Drill Shaft Preparation

Drill Shaft Preparation

Location

- Confirm placement matches approved construction plans.
- Ensure setback distances meet MUTCD or MUTCDC clearance standards.

Utilities (Overhead and Underground)

- Review utility locates and markings before excavation.
- Confirm overhead power line clearance for drill rigs and future pole placement.

Soil Type and Conditions

- Identify whether soil is stable, sandy, rocky, or clay-heavy.
- Recognize conditions requiring casing or slurry to stabilize excavation.

Materials

- Check reinforcement cage dimensions, cover, and tying per plan.
- Ensure materials (steel, concrete) meet specifications and are on-site before drilling.
- Verify grounding rods and conduits are prepped for embedment.

Digging Drill Shaft

Excavating

- Ensure drilling equipment matches required shaft diameter and depth.
- Confirm shaft depth and diameter per approved plans.

Shoring the Walls

- Inspect use of temporary casing or slurry for unstable soils.
- Ensure excavated shafts are not left open longer than allowed.
- Verify no groundwater infiltration or wall collapse risks exist.

Safety Considerations

- Confirm compliance with OSHA excavation safety standards.
- Ensure proper traffic control devices (per MUTCD Part 6) are in place around work zone.
- Check that personnel are protected from falling into open shafts.

Pre-Pour Inspection

- Verify shaft is free of loose material, water, or debris before concrete placement.
- Inspect reinforcement cage installation and spacing.
- Confirm proper placement of anchor bolts and templates for pole base.



Prep for Structures

Inspector should be familiar with prep required for strain poles and structures

- Review approved plans and specifications to confirm pole/structure type, size, and placement.
- Verify that **foundation design and locations** have been properly staked and marked.
- Ensure utility locates have been completed before excavation begins.
- Confirm adequate work zone traffic control per **MUTCD Part 6** before prep work.
- Check that anchor bolt templates, reinforcement cages, and grounding provisions are ready for installation.
- Confirm compatibility of strain poles/structures with intended span wire loads, mast arms, and mounted equipment (signals, signs, cameras, etc.).

Poles and Structures

Poles and structures should be checked when delivered

Inspect immediately upon delivery to prevent delays or hidden defects:

Proper Structure

- Verify type and size matches project plans (strain pole, mast arm, pedestal, etc.).
- Confirm structure is designed for the correct wind loading zone per MUTCD / MUTCDC references.

Color / Finish

- Ensure paint, galvanizing, or powder coating meets specifications.
- Check for chips, scratches, or corrosion on the finish.

Mounting Bolt Diameter and Pattern

- Verify anchor bolts match the required diameter, length, grade, and threading.
- Confirm bolt circle template aligns with pole base plate dimensions.

Arm Length

- Measure mast arm or strain arm length to confirm compliance with plan requirements.
- Ensure mounting holes and attachments are properly located and free of damage.

General Condition

- Check for dents, bends, weld cracks, or shipping damage.

Storing Structures

Structures should be stored in accordance with manufacturer's specifications

- Place poles and arms on **padded supports** to prevent coating or structural damage.
- Store on level ground away from standing water to avoid corrosion.
- Cover or cap open ends of poles to prevent moisture or debris intrusion.
- Separate painted/galvanized structures with padding to avoid surface damage.
- Follow stacking limits provided by the manufacturer to prevent deformation.
- Protect sensitive hardware (anchor bolts, nuts, washers) in sealed containers until installation.
- Maintain proper inventory control and inspection logs for stored materials.

Poles and Structures Prep

Poles and structures should be prepped with whatever hardware, signal heads, and wiring they will need before being assembled:

Pre-Assembly Preparation

- Confirm all hardware (signal heads, mounting brackets, backplates, visors, signs, CCTV, detection devices) is on site and matches plan specifications.
- Verify wiring harnesses are cut to correct lengths and pre-pulled through poles or arms where required.
- Ensure grounding hardware and bonding jumpers are properly installed.

Signal Head Prep

- Check that signal heads are assembled in correct orientation (e.g., red on top, per MUTCD).
- Confirm visors, backplates, and louvers are installed as shown on plans.
- Verify LED modules meet approved specifications.

Wiring and Conduit Prep

- Inspect that wiring is color-coded and labeled per standard (per NEMA/MUTCD conventions).
- Ensure adequate slack is left for terminations and splicing.
- Confirm conduit fittings and bushings are in place to prevent abrasion.

Safety Checks

- Ensure all prep work follows electrical codes (NEC, local jurisdiction).
- Confirm lifting points and brackets are properly installed for safe handling.

Plan Sheets

Plan sheets will give location/measurements on where hardware/devices should be mounted

Review Construction Plans

- Confirm that mounting heights and offsets are consistent with MUTCD/MUTCDC minimums for signal head placement.
- Verify lateral clearances from travel lanes and sidewalks.
- Ensure mast arms, strain poles, and pedestals are installed at the exact stationing noted on plans.

Device Location

- Confirm placement of ancillary devices (cameras, pedestrian push buttons, signs) is per plan and accessible to roadway users.
- Verify pedestrian signal indications are positioned for clear visibility at crosswalk locations.

Measurements

- Double-check vertical and horizontal clearances using survey equipment or measuring tools.
- Inspect that bolt hole locations on arms match the plan sheet layouts.

Mounting Locations

Inspector should be verifying mounting locations prior to arm or pole installations

Pre-Installation Verification

- Inspect that foundation anchor bolts are positioned and aligned per approved templates.
- Verify that pole orientation (e.g., mast arm direction, signal face orientation) matches plan layout.

Mounting Locations

- Check bolt circle alignment against mast arm base plates before hoisting structures.
- Confirm signal head mounting holes/locations on arms are correct before lifting.

Preventing Rework

- Ensure all pre-drilled mounting locations correspond to actual plan measurements before structure is erected.
- Require contractors to correct misalignments before poles or arms are set in place.

Documentation

- Record verification checks in inspection log before final structure placement.
- Photograph and note compliance with MUTCD clearances and alignment requirements

Knowledge Check

Daily responsibilities of the inspector includes all except which of the following

- a) Maintaining a logbook of daily activities
- b) Notify the contractor of safety deficiencies
- c) Only focus on PPE when the EOR is on site
- d) Ensuring that milestones are being met

Knowledge Check

According to the MUTCD the mounting height of Signal Faces shall be

- a) 15 ft above the roadway
- b) 16 ft above the roadway
- c) 17 ft above the roadway
- d) 18 ft above the roadway

Knowledge Check

Traffic Signal UPS (Uninterruptible Power System) are

- a) a cure all device and can run a traffic signal indefinitely
- b) Devices that run a traffic signal for a few hours
- c) Devices that can run a traffic signal for 12 or more hours
- d) Devices that provide clean power to the traffic signal

Knowledge Check

When installing poles and structure, one of the most important items is to

- a) Confirm the bolt circle template aligns with the pole base plate dimensions
- b) Confirm that the hurricane evac route is clear
- c) Have the EOR is on site during installation to ensure compliance

Session 6: Underground – Conduit, Pull Boxes, Cable / Wiring

Standards and Specifications

Standards and Specifications

MUTCD/MUTCDC: Ensure cabling supports proper signal head operation, visibility, and fail-safe functionality.

NEC/CEC (National Electrical Code and Canadian Electrical Code): Confirm compliance with grounding, bonding, conduit fill, and insulation standards.

State DOT / Agency Specifications: Review project-specific requirements for wire size, type, insulation, and jacket material.

NEMA and IMSA Standards: Be familiar with standard cable types (IMSA 20-1, 20-2 for signal control, IMSA 50-2 for loop detector lead-in, etc.).

Manufacturer's Recommendations: Check that cable handling, bending radius, and pulling tension are consistent with manufacturer specs.

Standards and Specifications

Cable Types and Usage

Identify the different types of signal cabling:

- **Power cables** (120V/240V circuits to controllers, cabinets, and signal heads).
- **Control/signal cables** for interconnect between controller and heads.
- **Detector cables** (inductive loop, video, radar, or microwave detection wiring).
- **Communications cables** (fiber optic, twisted pair, Ethernet for ITS/coordination).

Ensure correct type is being used in the correct application per plans.

Standards and Specifications

Installation Methods

Verify cables are properly routed through conduit, poles, junction boxes, and cabinets.

Check for correct **conduit fill ratios** ($\leq 40\%$ per NEC/CEC).

Ensure proper **separation of power and communication cabling** to reduce interference.

Confirm proper splicing methods (gel-filled connectors, waterproof splices, junction boxes).

Inspect strain relief and drip loops to prevent water intrusion.

Standards and Specifications

Quality and Safety

Confirm that contractor follows safety procedures when pulling cable (lubricants, pull boxes, winches).

Inspect for cable damage (nicks, cuts, abrasions) during installation.

Ensure that all terminations are neat, labeled, and match the wiring diagrams in the plan set.

Verify testing is performed (continuity, insulation resistance, OTDR for fiber optic) before acceptance.

Standards and Specifications

Documentation and Records

Confirm “as-built” wiring diagrams match actual installation or if different, has been documented.

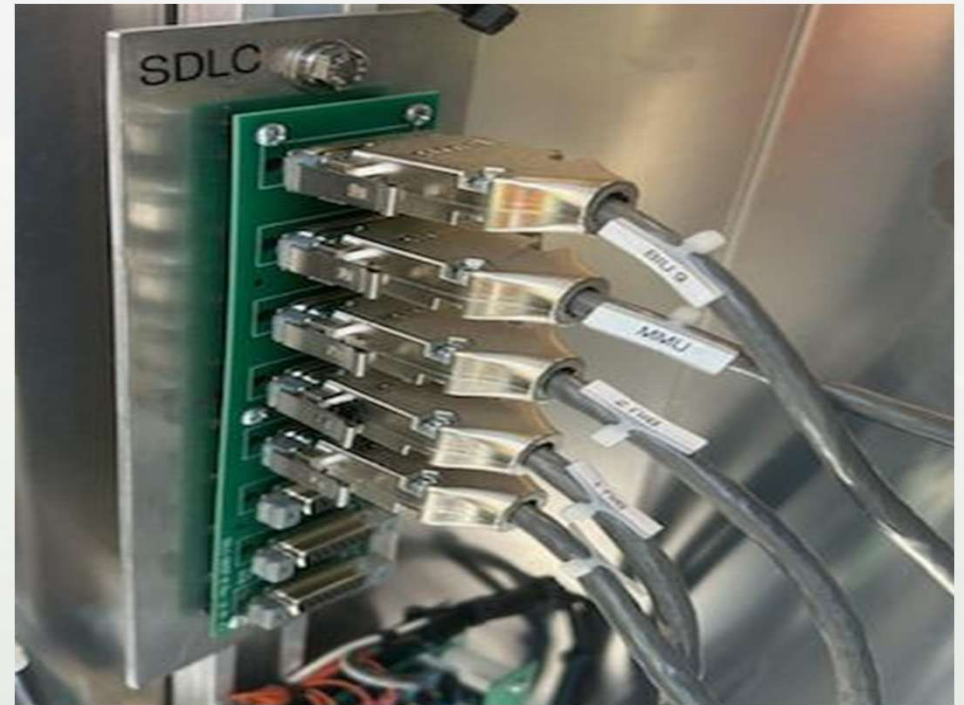
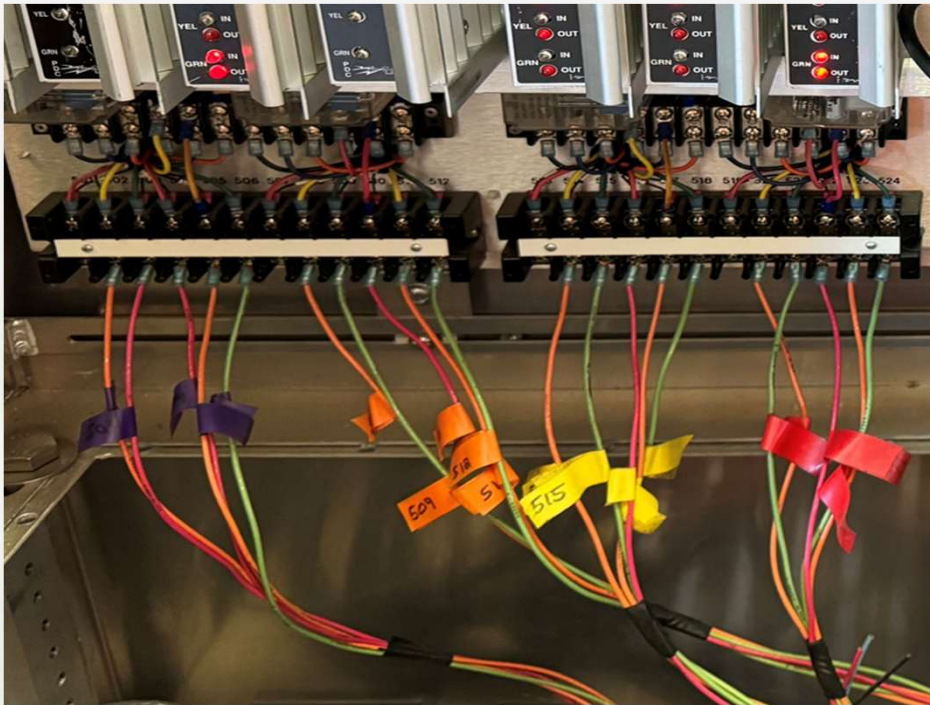
Require contractor to submit test results and cable certification records.

Maintain inspection logs of cabling checks performed during construction.

For Fiber Optics, test on the reel to meet all standards.

Wire Labeling

- Ensure that all wires/ cables are labeled according to the phasing diagram in the signal plans or timing sheet.
- These must be clearly marked. Labels must match prints, actual plans, and field.



IMSA Conductors and Cables

IMSA cables are typically used to wire traffic signals:

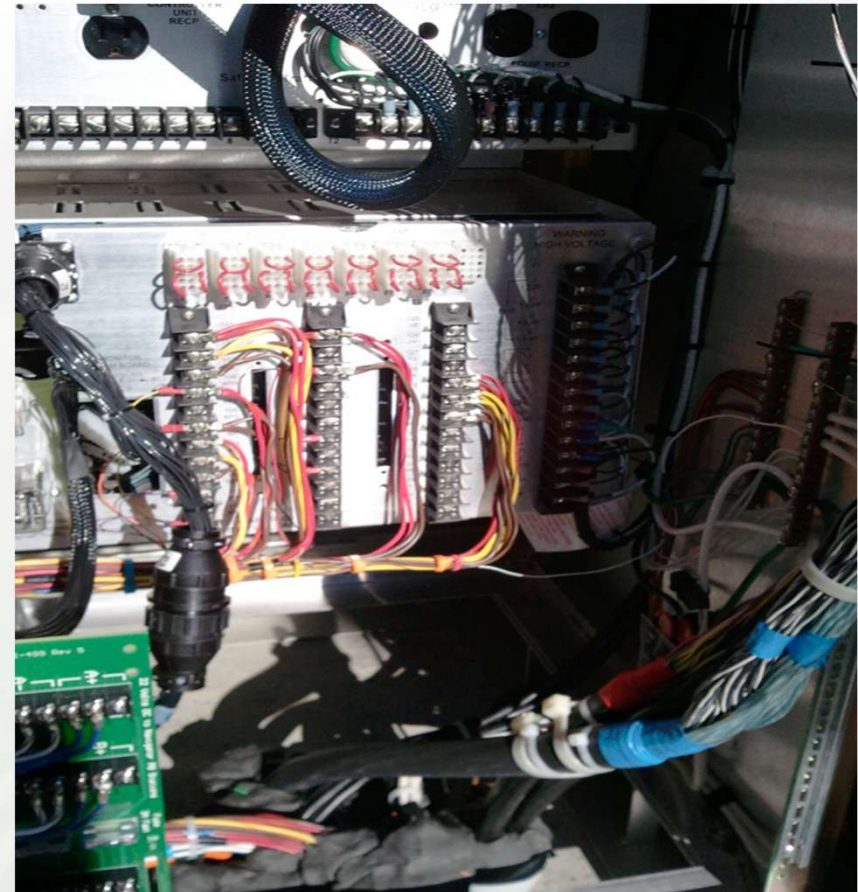
- Cabling from the controller cabinet to the signal poles
- Signal heads on mast arms / spans
- Signal heads on the side of the poles
- Pedestrian poles

Once the field wiring has been completed, always verify each conductor with AC voltage at the cabinet to make sure it's identified properly and serves the correct signal indications.

IMSA specifies two types of cable jacketing:

- IMSA 19-1 spec - PVC jacket
- IMSA 20-1 spec - Polyethylene (PE) jacket

If the plans call for these cables, be sure they are used.



IMSA Cable

Conductors are available in solid or stranded copper.

IMSA conductors are available in #10 awg. to #16 awg. wire sizes.

- #12 and #14ga. wire is typically used in traffic signals.

IMSA signal cable conductors follow a specific hierarchy for the conductor colors. (see table to the right)

- numbers in red text are typical cable counts available from most suppliers.

IMSA Hierarchy	BASE COLOR	TRACER COLOR
1	Black	n/a
2	White	n/a
3	Red	n/a
4	Green	n/a
5	Orange	n/a
6	Blue	n/a
7	White	Black
8	Red	Black
9	Green	Black
10	Orange	Black
11	Blue	Black
12	Black	White
13	Red	White
14	Green	White
15	Blue	White
16	Black	Red
17	White	Red
18	Orange	Red
19	Blue	Red
20	Red	Green
21	Orange	Green
22	Black	White & Red
23	White	Black & Red
24	Red	Black & White
25	Green	Black & White

Right Wire / Cable for the Job

Possible use of IMSA cable examples:

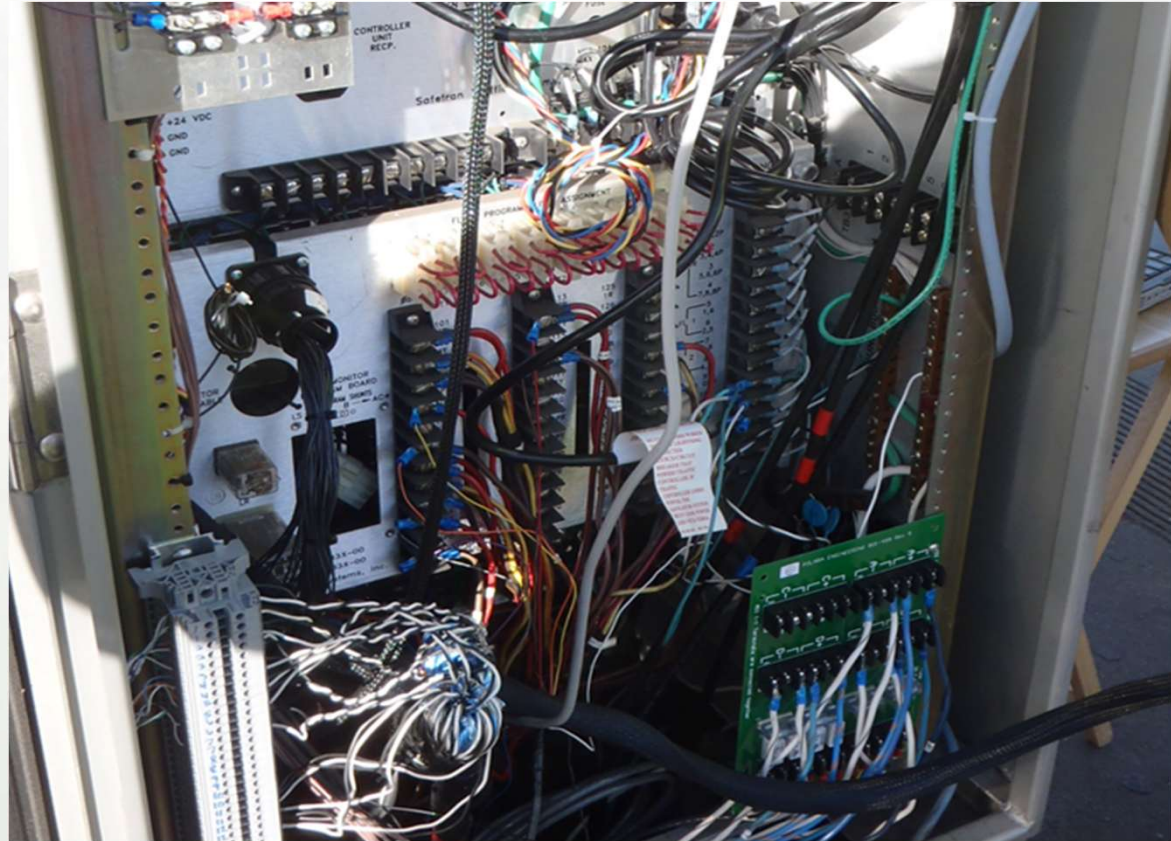
- A 19, 21, or 25-conductor is run to each corner of the intersection from the controller cabinet.
- 7-conductor to the outer head on the mast arm or span wire.
- 5-conductor to the 4-section signal heads or multiple ped heads.
- 4-conductor to individual 3-section signal heads.
- 3-conductor to individual ped heads.
- 2-conductor to individual ped buttons.

This may vary depending on municipality – Know the specs and plans prior to inspection.

Other Signal Cabling

There are many types of wire and cables at an intersection:

- Power wires / cable – #4 - #6 THHN Cu stranded.
- Be aware of voltage drop due to load.
- Communication cables– fiber, twisted and shielded pair, Ethernet, radio cables...
- Be aware of voltage drop and signal loss due to distance. For example: Standard ethernet cables has a limitation on how far it can run.
- Video, radar, and loop detection cables– hybrid, coax, Ethernet, twisted pair Cu and Al cables with drain wires.
- Loop crosstalk issues may be solved by tying the drain wire to the ground buss in the cabinet.
- Pre-emption cables – 4-conductor cable
- **Absolutely NO splices**



Traffic Signals and the NEC

The NEC is very clear about grounding:

NEC 250.4 (A)(1): Electrical systems that are grounded shall be connected to earth in a manner that will limit the voltage imposed by lightning, line surges, or unintentional contact with higher-voltage lines and that will stabilize the voltage to earth during normal operation.

- Equipment grounding conductors shall be bare, covered or insulated.
- The outer finish shall be green or green with one or more yellow stripes.

The above part addresses service conductors and equipment.

So, what does a signal technician do with the green conductors in signal cables?

NEC 250.119, exception #3: Conductors with green insulation shall be permitted to be used as ungrounded signal conductors where installed between the output terminations of traffic signal control and traffic signal indicating heads...and provided that these conductors are clearly marked at their terminals.



Traffic Signal Wire and the CEC / CSA

The Canadian Electrical Code (**CEC**), more specifically CSA C22.1, Part I, Section 10, provides the rules for grounding and bonding, including the use of green wire for ground.

Rule 10-204 specifically addresses grounding connections for alternating-current systems.

The CEC mandates that bare copper wires or green insulated wires be used as ground conductors.

While CEC does not specifically allow Green wire for Traffic Signal Green, some agencies still specify it and use it today.

In Canada there are many installs with Green wire used as Traffic Signal Green.

It is important to note that the traffic technician should follow specifications and designs set out by the Engineer and in turn accepted by the local authority.

Key reference:

Section 10:

'This section of the CEC outlines the general requirements for grounding and bonding, which applies to all electrical installations unless specified otherwise in other sections.'

Traffic Signal Construction

Underground Construction: Conduit

Conduit runs are otherwise known as “raceways”

Types of Rigid *Metallic* conduit:

- GRC – Galvanized Rigid Conduit

Types of Rigid *Non-Metallic* conduit:

- PVC – Polyvinyl Chloride
- HDPE – High-Density Polyethylene (Poly pipe)

The NEC mandates that multi-conductor cables **cannot fill more than 40%** of a conduit.



Traffic Signal Construction

Underground Construction: Conduit

Rigid metallic conduit

GRC – Galvanized Rigid Conduit

- Thickest walled conduit
- Conduit and fittings are threaded

Metallic conduit must be coated for corrosion protection if it is to be buried.



Traffic Signal Construction

Underground Construction: Conduit

Inspector should make sure size matches plans:

- Rigid non-metallic conduit
- PVC – Polyvinyl Chloride

Wall thickness is based on “schedules”

- Sch. 20, Sch 40, Sch. 80
- The higher the schedule number, the thicker the wall

HDPE – High-density Polyethylene (Poly pipe)

Originally designed for pressure applications such as gas, water, and steam...

Wall thickness based on SDR (standard dimension ratio)

- The higher the SDR number, the thinner the wall
- SDR 11, 15.5, 21...



Traffic Signal Construction

Underground Construction: Conduit

- Installation of conduit
- May be installed in an open trench
 - Conduit laid on the bottom of the trench, backfilled, and Compacted.
 - May be installed on “chairs” with “spacers” for a duct bank installation as in the picture to the right.
- May be hydraulically pushed through the earth with a “T-Machine”
- May be installed in a void made with a pneumatic piercing tool (missile)
- May be directionally bored – Poly pipe only

All open conduits ends should be finished with a “bushing”.



Pull Boxes



- A **pull box** is also known as a “**junction box**” or a “**handhole**”
- Pull boxes are used to access the underground conduit system, break up long runs of conduit, or where conduit runs change direction.
- Most pull boxes used today are “traffic rated”.
- Meaning they can withstand “occasional” traffic driving over them.
- They are made from a polymer-concrete composite material, actual concrete, fiberglass reinforced polymer, or HDPE polyethylene.
- Pull boxes follow a “Tier” rating, which means:
- The box underwent a three-position testing; **lateral side-wall, vertical sidewall, and the center of the lid**
- The box was tested at 1.5 times its tier rating.
- The tier rating is represented by a number times 1000. For example, a tier 8 box is rated for 8,000 pounds.

Pull Boxes

Inspector needs to understand the different types and sizes of pull boxes being used on the project

Types of Boxes

- **Standard traffic signal pull boxes** (polymer concrete, fiberglass, precast concrete, cast iron).
- **Load-rated boxes** for installation in roadways or heavy vehicle load zones.
- **Specialty boxes** for fiber optic communications or detector loop terminations.

Pull Boxes

Sizes

- Be familiar with common dimensions (e.g., 12"x18", 17"x30", 24"x36").
- Understand how size requirements are determined (number of conduits, conductor bends, splice volume, NEC conduit fill rules).

Covers

- Must be traffic-rated (H-20) where installed in the roadway.
- Covers should be marked appropriately (e.g., "Traffic Signal," "Fiber Optic," "Communications") per agency standards.

Material Compliance

- Ensure the box material meets state DOT and AASHTO specifications for durability, grounding, and corrosion resistance.



Pull Boxes

Inspector will be responsible for assuring proper location in regards to plan placement, ROW

Plan Review

- Verify box locations match construction plans and agency-approved standards.
- Check clearances from utilities, poles, driveways, and intersections.

Right-of-Way (ROW) Considerations

- Ensure boxes are installed within ROW or easements, not on private property.
- Confirm accessibility for future maintenance crews.

Field Adjustments

- If conflicts arise (utilities, drainage, obstructions), verify that adjustments are approved and documented before installation.
- Ensure relocated boxes still allow efficient conduit runs and access.

Pull Boxes

Documenting proper installation (depth, gravel base, concrete peds if needed)

Excavation and Depth

- Verify box is installed to the specified depth below grade, ensuring cover is flush with ground or pavement surface.
- Confirm excavation meets agency compaction requirements to prevent settling.

Base Material

- Ensure **gravel or crushed stone base** (typically 6–12 inches) is placed for drainage and stability.
- Verify materials meet DOT gradation and compaction standards.

Pedestals and Foundations

- Confirm when concrete pads/pedestals are required for stability or ADA access.
- Check proper alignment and finishing of pads.



Pull Boxes

Documenting proper installation (depth, gravel base, concrete peds if needed)

Conduit Entries

- Ensure conduits enter the box at correct elevations and positions per plans.
- Verify use of proper duct terminators or bushings to protect wiring.

Drainage

- Confirm drainage holes are open, or gravel sump is provided to prevent water accumulation.

Final Placement

- Check that box lids are flush with final grade (not tripping hazards, not submerged).
- Ensure lids fit securely and lock properly if required.

Documentation

- Take photographs of box installation before backfill.
- Record GPS coordinates if required by the agency.
- Log box size, type, depth, and any deviations from the plans.



Knowledge Check

According to the NEC/CEC maximum conduit fill is

- a) 30%
- b) 40%
- c) 50%
- d) 60%

Knowledge Check

Once field wiring has been installed, the inspector shall

- a) Trust that the contractor has completed the installation correctly
- b) Use a multimeter to check the impedance on each circuit
- c) Use the AC Voltage to ensure that the correct signal indication is wired
- d) While in the cabinet have another inspector check the Signal Heads

Knowledge Check

Types of underground conduit include all but one

- a) GRC
- b) GRU
- c) PVC
- d) HDPE

Knowledge Check

When it comes to pull boxes or hand holes, the inspector should be aware of these factors except

- a) Verify that locations meet construction plans and that they are approved
- b) Pull boxes follow a tier rating for lateral, vertical, and center strength
- c) Any change in location from the plan should be noted in the as built
- d) That the pull boxes are interchangeable as long as they are approved in the plan set

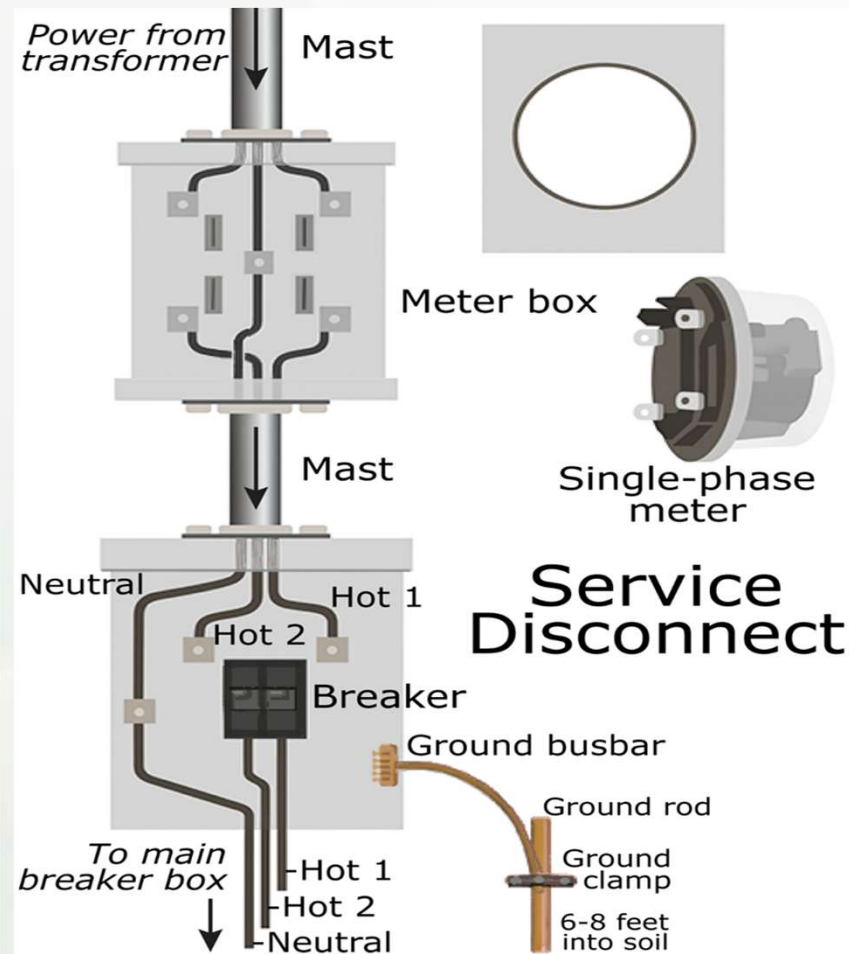
Knowledge Check

Underground conduit may be installed by the following methods, except

- a) Hydraulically with a T machine
- b) Laid in the bottom of trench
- c) With a pneumatic tool or missile
- d) Transitional with rigid PVC

Session 7: Signal Field Devices

Electrical Services



Power Service Fundamentals

Electrical service is brought from the utility provider to the traffic signal cabinet.

Identify standard service voltages (typically 120V AC, sometimes 240V for lighting systems).

Recognize the difference between utility-owned vs. agency-owned service equipment.

Purpose of meter bases, service disconnects, and distribution panels.

Electrical Services

Overcurrent and Surge Protection

- Recognize service disconnects, fuses, and breakers as critical protection devices.
- Understand surge protection requirements for sensitive electronics in controllers and detection systems.
- Verify correct installation of surge arrestors and transient voltage suppression.

Electrical Services

Safety and Compliance

Understand lockout/tagout requirements when inspecting electrical service.

Recognize potential hazards such as exposed wiring, improper grounding, or overfilled conduits.

Verify compliance with MUTCD/MUTCDC, NEC/CEC, and state DOT electrical standards.

Electrical Services

Inspection Documentation

Record service location, utility provider, and meter number.

Verify that service diagrams and as-built drawings match actual field installation.

Document grounding resistance test results and protective device ratings.

Note any deviations from plans or specifications for correction.

DC Cabinets

Purpose and Function

Understand that DC cabinets house low-voltage power supplies and control equipment for devices such as pedestrian push buttons, detection systems, or solar-powered equipment.

Power Conversion and Distribution

Recognize how AC utility service is converted to DC power within the cabinet.

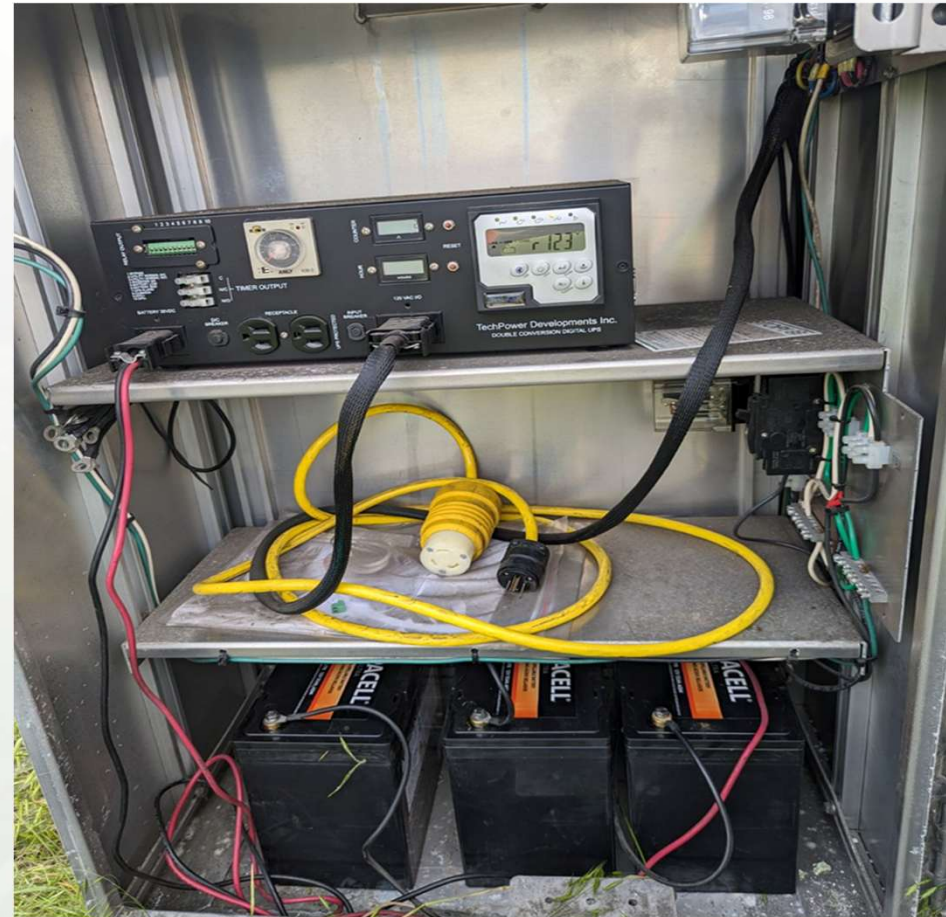
Know typical voltage ranges used (e.g., 12V, 24V, 48V DC) depending on device type.

Safety and Protection

Understand overcurrent protection (fuses, breakers) within DC circuits.

Recognize proper grounding and bonding practices for DC systems.

Be aware of risks with battery-backed or solar DC supplies (stored energy).



DC Cabinets

Equipment Housing and Layout

- Know general cabinet construction, weatherproofing, and security requirements.
- Be able to verify cable entry points are sealed and strain-relieved.

Inspection Checks

- Verify wiring is neat, labeled, and matches plans/as-builts.
- Confirm terminals, connectors, and protective devices are correctly installed.
- Look for signs of overheating, corrosion, or water intrusion.

Integration

- Understand that DC cabinets often work in conjunction with signal controllers, detection equipment, and communication devices.
- Recognize their role in supporting ITS field devices as part of the broader traffic signal system.

Solar Systems

Purpose and Application

- Understand that solar systems provide power for isolated traffic signal devices (e.g., flashers, school zone beacons, temporary signals) where grid power is unavailable or impractical.

System Components

- Recognize the main elements: solar panels, charge controller, batteries, wiring, and DC cabinet.
- Know how each component contributes to energy capture, storage, and delivery.



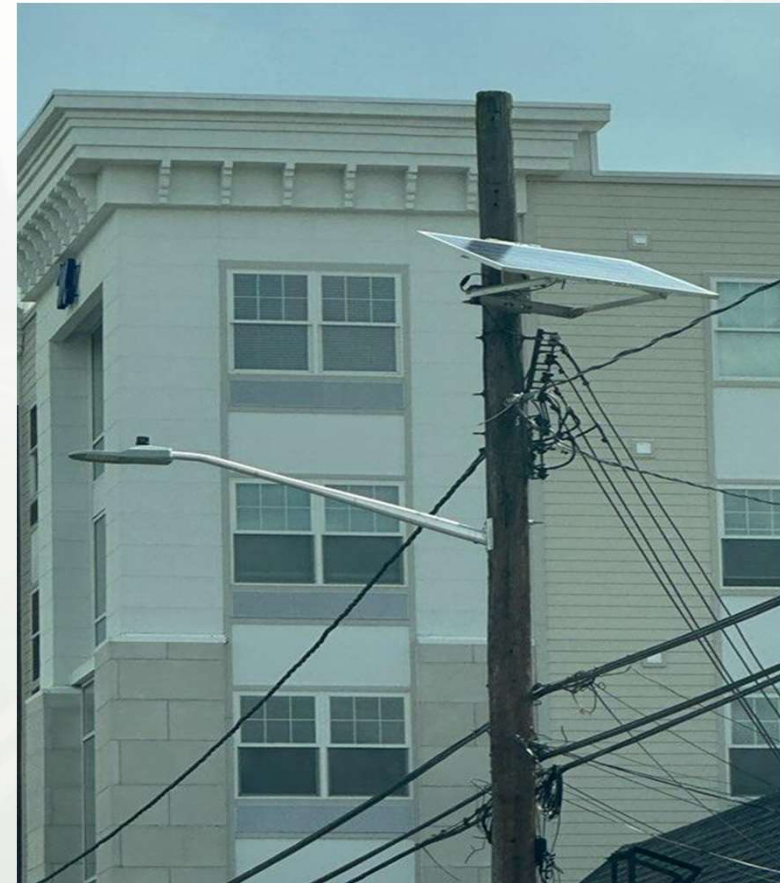
Solar Systems

Power Output and Capacity

- Be familiar with typical voltage and wattage ratings for traffic applications.
- Understand the relationship between solar panel capacity, battery storage, and device load requirements.

Installation and Orientation

- Recognize that solar panels must be oriented correctly (tilt, direction) for maximum sunlight exposure.
- Understand the need for shading analysis during placement.



Solar Systems

Inspection and Maintenance

- Verify panels are secure, clean, and free of shading or damage.
- Check that wiring and connectors are weatherproof and strain-relieved.
- Confirm battery condition, enclosure ventilation, and charge levels.

Safety and Protection

- Understand the role of charge controllers in preventing battery overcharge or deep discharge.
- Recognize protective devices (fuses, breakers, surge protectors) in solar-powered systems.
- Make sure batteries are housed according to specifications.

Integration

- Know how solar systems interface with field devices, cabinets, and communication systems.
- Understand limitations (reduced performance in extended cloudy conditions, winter months).

Roadway Lighting



The inspector must have a working knowledge of the various types of roadway lighting used in the industry.

They should be able to read and interpret project drawings to verify that the specified lighting fixtures and components are correctly installed on-site.

Roadway Lighting



The inspector is responsible for confirming that all electrical connections are properly made and compliant with code.

This includes checking whether the unit is wired correctly—such as the integration of photocells, timers, or other control devices—and verifying the presence and proper installation of key components like meter cabinets and fuses.

Pre-emption

Basic Understanding of EVP

Know that EVP provides priority signal control to authorized emergency vehicles (fire, EMS, police).

Understand difference between *preemption* (disrupts normal timing for emergency response) and *priority* (adjusts timing without full interruption).

Types of Pre-emption

- **Optical systems** – detect emergency vehicle emitters via infrared or strobe.
- **Acoustic systems** – detect sirens through microphones.
- **GPS / Radio-based systems** – use wireless communications for priority requests.
- **Railroad pre-emption** – provides clear crossings for trains.

System Components

- Vehicle-mounted emitters or transmitters.
- Field detectors (optical sensors, antennas, microphones).
- Interface equipment in the signal cabinet (pre-emption cards/modules).

Pre-emption

Inspector Responsibilities

- Verify EVP detectors are installed at correct height, orientation, and setback according to specifications.
- Verify wiring or communication integration into cabinet inputs or network ports with a technician.
- Ensure preemption channels and programming match the plans and agency standards.

Functional Testing

- Conduct field verification using test vehicles or authorized simulators.
- Observe controller entering preempt sequence correctly (Phase termination, preempt phase, return sequence).
- Confirm logs or timestamps are recorded in controller/central system.

Pre-emption

Safety and MUTCD Alignment

- Ensure EVP operation aligns with MUTCD Part 4 (Traffic Control for Intersections).
- Verify that EVP does not compromise pedestrian safety or railroad preemption when both exist.
- Document all testing results and any operational issues.

Documentation

- Ensure pre-emption equipment and timing settings are recorded in plans.
- Note any functional tests performed (e.g., activating a test emitter).

Verify with technician all priorities are met

- (1 and 2) Railroad and Bridge
- (3,4,5 and 6) Emergency Vehicle
- (7+) Busses, transit, snowplows, streetsweepers, etc.

Session 8: Traffic Signal Cabinet and Cabinet Equipment

Cabinets

Essentially Six basic types of cabinets and controllers

- Electrical Mechanical
- Pre-NEMA
- NEMA TS1 – Military style “A”, “B”, “C” and sometimes “D” connectors
- NEMA TS2 – 15 Pin Serial Connector port 1
- CALTRANS/170/179/2070 (controllers)
- ATC
- All cabinets and controllers operate on a series of electrical inputs and outputs.
- Inputs/outputs as well as all the circuits and devices within the cabinet can be traced on the cabinet prints.

Cabinet Components



Controllers



Power Supplies



Circuit Boards / Back Panels



Traffic Signal Heads



Flashing Beacons



Detectors and Sensors



Communication Devices



Signal Conflict Monitors / MMUs



Battery Backup Systems



Surge Protection Devices

Cabinet Components - Controller



Controller -

The controller is the brain of the traffic signal system. It receives inputs from sensors and detectors in the field, processes the information, and generates output commands to control the operation of the traffic signals. The controller is responsible for timing the signal phases, coordinating signal sequences, and optimizing traffic flow.

Controllers

Traffic signal controllers are devices used to regulate the flow of traffic at intersections or road junctions. They control the operation of traffic signals, ensuring that vehicles and pedestrians move safely and efficiently through the intersection.

Traffic should be monitored, not only at the intersection that is being worked on but also monitor intersections next to the work for any issues that may have been unforeseen by the work we are doing.

The Traffic Signal Inspector needs to verify that the Software is up to date and approved as well as timings in the controller. The Inspector needs to run the controller in manual/technician flash and ensure all phases are being serviced prior to the controller being brought out of flash.

The Traffic Signal Inspector needs to verify the vehicle and pedestrian detectors are working and that the controller is receiving, servicing, and dropping the calls.

Controllers

Make sure the timing sheet and controller match the engineer's plan.

TRAFFIC SIGNAL INVENTORY																		District 04		TSI NO. 11						
LOUISIANA DEPARTMENT OF TRANSPORTATION AND DEVELOPMENT TRAFFIC SECTION																		SHEET: 1 of 8								
INTERSECTION: US 71 (BARKSDALE BLVD.) @ LA 3032 (WESTGATE DR.)																										
CITY: BOSSIER CITY PARISH: BOSSIER																		INSTALLATION DATE:								
TYPE SIGNAL: ACTUATED - INTERCONNECTED																		LAST REVISION DATE: 02/21/13								
SIGNAL PHASES ↓	02 + 06				02 + 05				03 + 08				04 + 08				04 + 07				01 + 06					
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	FL			
								R											R	+G	+Y		R			
	1							R											R	+G	+Y		R			
	2							R											R	+G	+Y		R			
	3	G	G	Y				R											R	G	G	G	Y	R		
	4	G	G	Y				R											R	G	G	G	Y	R		
	5							R											R					R		
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	7	G	G	G	G	G	Y	R											R					R		
	8	G	G	G	G	G	Y	R											R					R		
	9							R											R					R		
	10							R	+G	+Y									R					R		
	11							R	G	G		G	G	Y	Y				R					R		
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	16							R											R					R		
	17	WA	WA	WA	WA	WA	FW	DW	DW										DW					OK		
	18	WA	WA	WA	WA	WA	FW	DW	DW										DW					OK		
	19							DW	WA	WA	WA	WA	FW	DW	DW				DW					OK		
	20							DW	WA	WA	WA	WA	FW	DW	DW				DW					OK		
	21							DW	WA	WA	WA	WA	FW	DW	DW				DW					OK		
22	WA	FW	DW				DW					WA	FW	DW	DW			DW					OK			
23	WA	FW	DW				DW					WA	FW	DW	DW			DW					OK			
24							DW					WA	FW	DW	DW			DW					OK			
TIME	21.0 4.9 1.0				21.0 4.9 1.0				4.6 1.0				21.0 4.7 1.0				21.0 4.7 1.0				4.8 1.0				Offset = NA	
PLAN	PLAN = 1/ FREE CYCLE LENGTH = FREE TIMES OF OPERATION = SUN 0000-0800, M-F 0000-0600, SAT 0000-0600																									
TIME	21.0 4.9 1.0				21.0 4.9 1.0				4.6 1.0				21.0 4.7 1.0				21.0 4.7 1.0				4.8 1.0				Offset = 112	
PLAN	PLAN = 3 CYCLE LENGTH = 120 TIMES OF OPERATION = SUN 0800-2400, M-F 0900-1500 & 1900-2400, SAT 0600-2400																									
TIME	21.0 4.9 1.0				21.0 4.9 1.0				4.6 1.0				21.0 4.7 1.0				21.0 4.7 1.0				4.8 1.0				Offset = 111	
PLAN	PLAN = 4 CYCLE LENGTH = 130 TIMES OF OPERATION = M-F 1500-1900																									
TIME	21.0 4.9 1.0				21.0 4.9 1.0				4.6 1.0				21.0 4.7 1.0				21.0 4.7 1.0				4.8 1.0				Offset = 50	
PLAN	PLAN = 4 CYCLE LENGTH = 130 TIMES OF OPERATION = M-F 1500-1900																									
TIME	21.0 4.9 1.0				21.0 4.9 1.0				4.6 1.0				21.0 4.7 1.0				21.0 4.7 1.0				4.8 1.0				Offset = 50	
PLAN	PLAN = 4 CYCLE LENGTH = 130 TIMES OF OPERATION = M-F 1500-1900																									
TIME	21.0 4.9 1.0				21.0 4.9 1.0				4.6 1.0				21.0 4.7 1.0				21.0 4.7 1.0				4.8 1.0				Offset = 50	
PLAN	PLAN = 4 CYCLE LENGTH = 130 TIMES OF OPERATION = M-F 1500-1900																									
TIME	21.0 4.9 1.0				21.0 4.9 1.0				4.6 1.0				21.0 4.7 1.0				21.0 4.7 1.0				4.8 1.0				Offset = 50	
PLAN	PLAN = 4 CYCLE LENGTH = 130 TIMES OF OPERATION = M-F 1500-1900																									
TIME	21.0 4.9 1.0				21.0 4.9 1.0				4.6 1.0				21.0 4.7 1.0				21.0 4.7 1.0				4.8 1.0				Offset = 50	
PLAN	PLAN = 4 CYCLE LENGTH = 130 TIMES OF OPERATION = M-F 1500-1900																									
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Conflict Monitor

The primary objective of a Traffic Signal Conflict Monitor is to prevent conflicts and accidents by detecting and managing potential crashes between different road users. It accomplishes this by monitoring the movements of vehicles and pedestrians within an intersection and analyzing their patterns for potential conflicts.

Every outgoing command sent from the controller is checked by the conflict monitor. The device is hard-wired to prevent conflicting movements from being sent to the signal's lights in the event of a controller malfunction. If there is a problem with a controller, the monitor itself, or if signal light wiring is removed or damaged, the conflict monitor automatically puts the signal into flash mode until the issue is resolved.

Conflict Monitor Test

Conflict Monitor test will verify opposing green and yellows indications will not run together unless allowed. Use jumpers (tap) to energize only the green terminals on opposing phases while they are not on to perform Conflict Monitor test on just green indications. Use caution when performing this test.

Conflict Monitor / MMU

Signal Conflict Monitor / MMU:

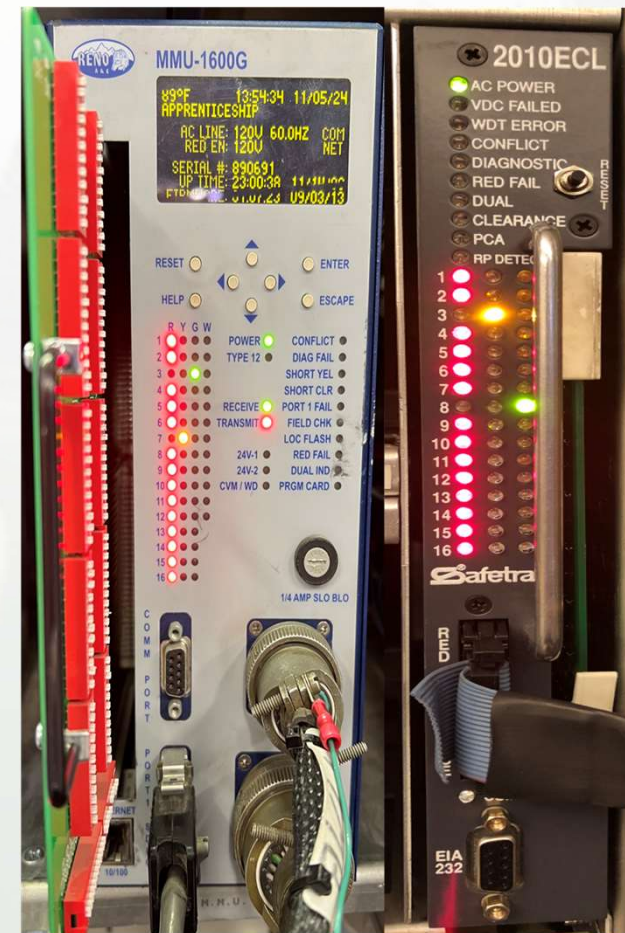
- Conflict Monitor Units (CMU) – exist in TS-1 & Type 170 cabinets
- MMU's – exist in TS-2 cabinets and 2070
- CMU's (cabinet monitor units) exist in the ATC cabinets

The CMU/MMU serves two purposes:

- **Signal monitor** – which monitors the conditions of the signals, such as conflicting signals, lack of signals, or multiple signals on a single phase.
- **Voltage monitor** – which monitors operating voltages within the cabinet, such as the AC line voltage, controller operating voltages, and the DC voltages.

If any of the above conditions occur, the monitor takes immediate action and places the signals in a flashing state until repairs can be made, or voltages return.

A flashing signal is far safer for motorists to navigate rather than dangerous signal indications that cause confusion.

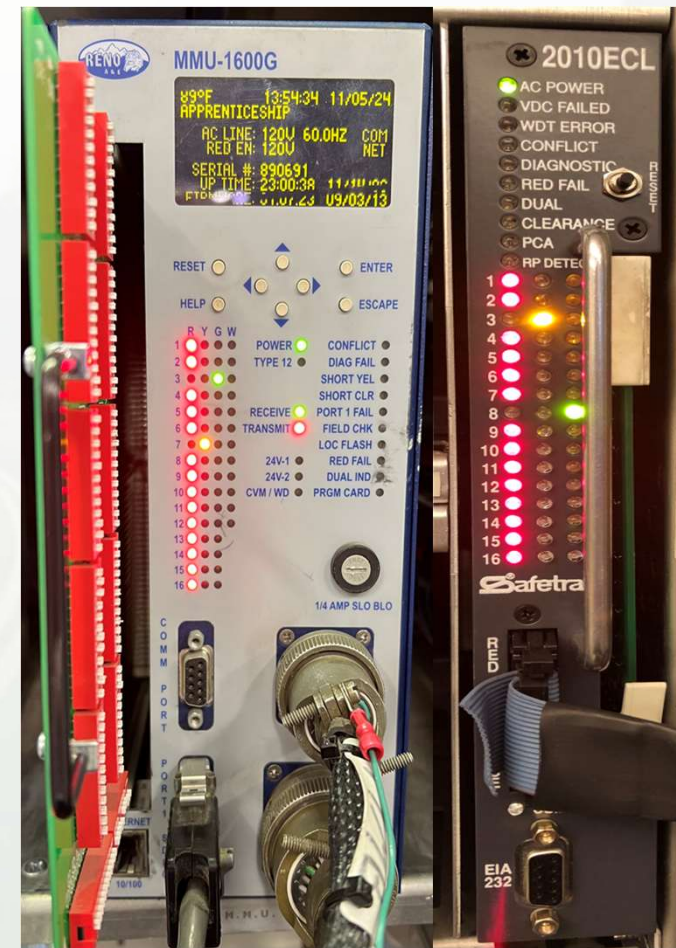


Conflict Monitor / MMA

Signal Conflict Monitor / MMU:

- The monitor is the one safety device in the cabinet that signal techs and motorists rely on.
- Monitor will only perform correctly if the intersection is wired properly.
- **Field wiring, programming, and settings must be correct!!!**
- CMU/MMU manufacturers recommend that **all monitors should be tested and recertified annually** with CMU/MMU test equipment
- The tester should also be recertified annually
- A strongly recommended practice is that, when you change out a monitor for testing, you record the model number and serial number of the old unit to be tested and the new monitor to be installed.

GOOD RECORD KEEPING IS ESSENTIAL!!!



Detection Devices



Traffic signal cabinets use detectors to input calls for vehicles, pedestrians, and emergency vehicle and railroad preemption.

Test vehicle detection in “free”, not “coordination”
These detectors can be found in the detection rack.

They include:

- Loop amplifiers
- Magnetometers
- Video detection processors
- Radar detectors
- AC and DC isolators
- EVP or RR preemption detection

Input Components

Loop Detection (Inductive Loop Detectors)

Function: Detect vehicles through inductive changes in embedded pavement loops.

Typical Location:

- Loops cut into pavement at approaches; lead-in cables terminate in the cabinet detector racks or detection panel.

Interface with Cabinet:

- Loop wires connect to detector amplifiers or cards that convert signals to logic inputs for the controller.
- Inputs trigger phase calls or extend green times.

Troubleshooting:

- Check for open or short circuits using a megohmmeter.
- Verify detector sensitivity and frequency settings.
- Inspect for damaged loop wire, poor splices, or moisture intrusion.



Input Components

Pedestrian Isolation Panel (PIP)

Function: Provides interface between pedestrian pushbuttons and the signal controller, isolating AC power from field wiring.

Typical Location:

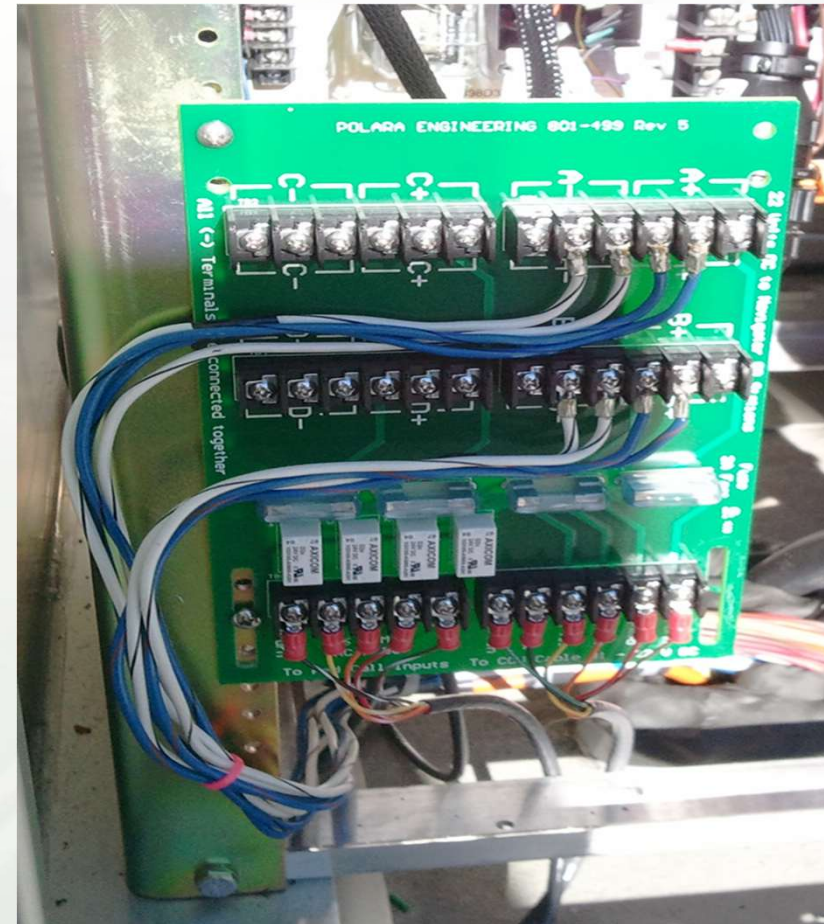
- Inside cabinet, adjacent to terminal blocks or detection panel.

Interface with Cabinet:

- Inputs from pedestrian pushbuttons feed into the PIP; outputs go to the controller inputs for pedestrian phases.

Troubleshooting:

- Verify voltage and continuity of button circuits.
- Inspect for corrosion or loose connections.
- Check grounding and ensure isolation from high-voltage components.
- Test buttons individually that they are in correct phases from the controller.



Input Components

Detection Interface Panel (DIP)

Function: Central connection point for all detection systems (loops, video, radar, magnetometers).

Typical Location:

- Mounted near detector racks or controller input modules in the cabinet.

Interface with Cabinet:

- Routes detection signals to correct phase inputs in the controller.
- Often includes terminal strips, fuses, and isolation relays.

Troubleshooting:

- Verify signal presence from each detection device.
- Inspect terminal blocks for loose or corroded connections.
- Confirm correct labeling and wiring per as-built diagrams.

Input Components

Communication Interface Panels (CIP)

Function: Provides communication pathways between the local controller and remote systems (central software, other intersections, or ITS devices).

Typical Location:

- Upper cabinet area or near controller shelf; may include modems, fiber, or Ethernet interfaces.

Interface with Cabinet:

- Connects via RS-232, fiber optics, or Ethernet cables to controller and communication networks.
- May house surge protectors and network switches.

Troubleshooting:

- Check link lights, IP addresses, and data transfer status.
- Test cables for continuity or signal loss (fiber or copper).
- Verify grounding and surge protection are intact.
- Check for loose connections and corroded wires.

Power Supply

The power supply provides electrical power to the traffic signal cabinet and its components.

It typically includes transformers, fuses, and power distribution equipment to ensure a stable and reliable power source.



Bus Interface Unit

The roll of the BIU and how it interacts with Various Components:

- **Traffic Signal Controller:** The BIU connects the controller to the rest of the devices in the cabinet.
- **Traffic Detectors:** The BIU interfaces with various traffic detectors, such as inductive loop detectors or video cameras, which provide input about the presence and movement of vehicles or pedestrians.
- **Terminal Facilities:** The BIU connects to the load switches, which output voltage to the actual traffic lights. It controls the timing and sequencing of the lights based on the instructions received from the traffic signal controller.



Bus Interface Unit

The roll of the BIU and how it interacts with Various Components:

- **MMU:** The BIU communicates with the MMU so that the controller and the MMU may compare data.
- **Preemption Equipment:** The BIU can also include preemption modules that allow other external devices, such as remote monitoring systems or emergency vehicle preemption systems.
- **Power Supply:** The BIU receives power from the cabinet's power supply.



Serial Interface Unit

A serial interface unit (SIU) is used in the ATC cabinets which is a device used to facilitate communication and data exchange between the controller and the other devices in the cabinet. The main functions of a serial interface unit in traffic signal cabinet include:

- **Communication Protocols:** The SIU supports specific communication protocols, such as NTCIP (National Transportation Communications for ITS Protocol) or other proprietary protocols, to enable seamless communication between the controller and the traffic signal equipment or ITS equipment in the cabinet, such as the input file which houses the detector devices, the Cabinet Monitor Unit (CMU), and the output file, which houses the high-density switch packs (HDSP).
- **Inputs and Outputs:** The SIU receives the detection inputs from the detectors in the cabinet and relays them to the controller. It also drives the output signals from the controller to the high-density switch packs. It communicates this through serial bus #1 (SB1) and serial bus #2 (SB2).



UPSs

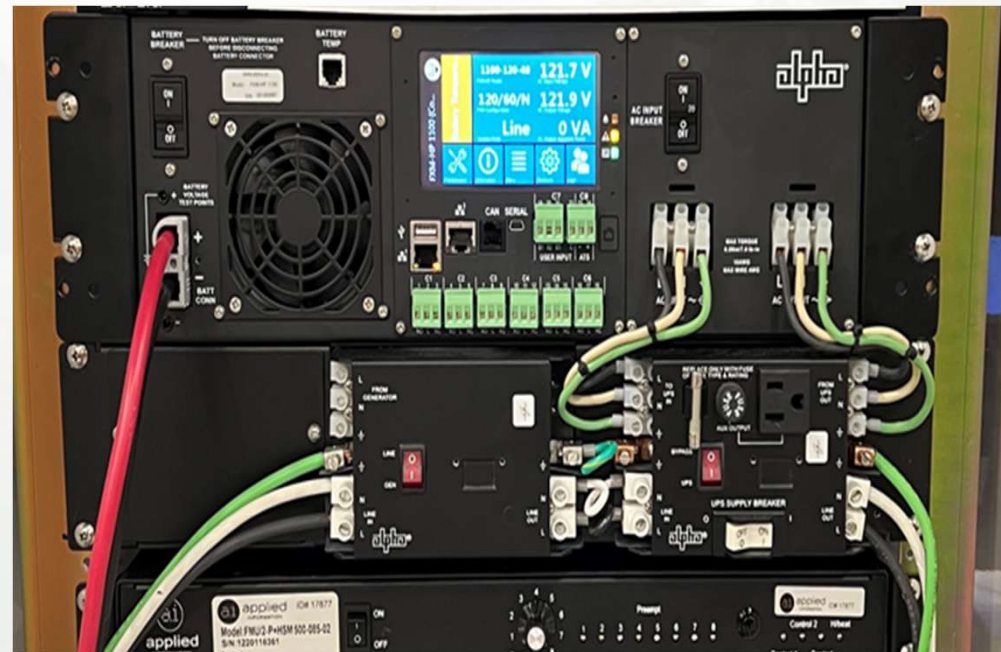
Different Types of UPSs (Uninterruptible Power Supplies)

Standby (Offline) UPS

- Provides power only when utility power fails.
- Common in smaller intersections or low-power systems.
- Switches to battery power within milliseconds of power loss.

Line-Interactive UPS

- Regulates voltage continuously; automatically corrects minor sags and surges.
- Most common UPS type used in modern traffic cabinets.
- Extends component life by providing cleaner, stable power.



UPSs

Double-Conversion (Online) UPS

- Continuously converts AC to DC and back to AC for full isolation from utility power.
- Ideal for high-reliability or ITS-critical intersections.
- Provides seamless transition to battery power with no switchover delay.

Battery Types Used

- Sealed lead-acid (AGM or gel-cell) or lithium-ion depending on system design.
- Must be temperature compensated and enclosed per NEMA TS-2 standards.



UPSs

Functions, Programming, and Troubleshooting

Primary Functions

- Maintain power to controller, conflict monitor, and communications during outages. Protect cabinet electronics from surges, brownouts, and transients. Automatically recharge batteries when utility power returns. Test by turning off main circuit breaker at service to verify UPS switches over when no power applied to cabinet.
- **Caution** – if not wired correctly, intersection could go dark.



UPSs

Programming / Configuration

- Set voltage thresholds, battery test intervals, and switchover priorities via front panel or software.
- Configure alarm outputs to alert maintenance staff of power events.
- Log data for run-time, voltage levels, and power quality analysis.

Troubleshooting

- Check AC input/output voltage and inverter function.
- Inspect fuses, breakers, and battery terminals for corrosion or loose connections.
- Run self-tests to verify battery capacity and inverter response.
- Monitor status indicators and event logs for alarms or error codes.
- Ensure correct communication with controller (if networked).



UPSs

Knowledge of the Different Ways to Wire a UPS into a Signal Cabinet

Series Wiring (In-Line)

- UPS placed directly between utility power source and signal cabinet input.
- Protects all cabinet components and ensures uninterrupted operation during outages.

Parallel Wiring (Selective Load Support)

- UPS powers only critical components (controller, monitor, communication equipment).
- Non-critical loads (e.g., signal heads) may not be connected to preserve battery life.



UPSs

Bypass Circuit

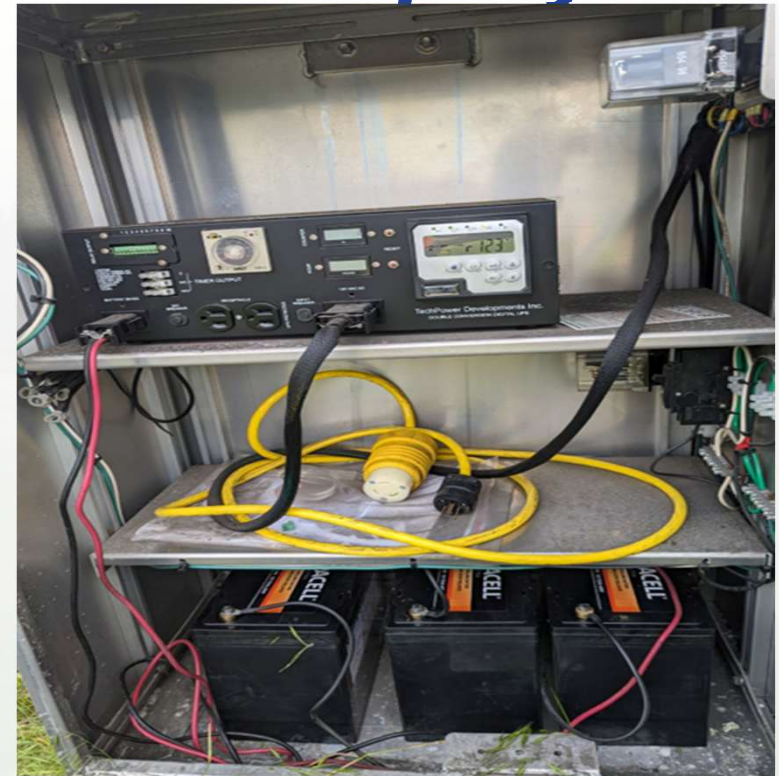
- Allows cabinet to operate on utility power while isolating UPS for maintenance.
- Required by most NEMA TS-2/ITE-compliant installations.

Grounding and Safety

- Must follow NEC Article 480 for battery systems and grounding.
- Ensure proper bonding to prevent stray voltage and electrical hazards.



Inspection: Emergency and Backup System



If applicable, inspect any emergency and backup systems, such as battery backups or generator connections, to ensure they are functioning correctly. Test these systems to verify their effectiveness during power outages or emergencies.

Power Flow Through the Cabinet

Power Flows from the Electrical Service Through the Cabinet

Electrical Service Entry

Utility power (typically **120 VAC single-phase**, sometimes **240 VAC**) enters through the **service disconnect**.

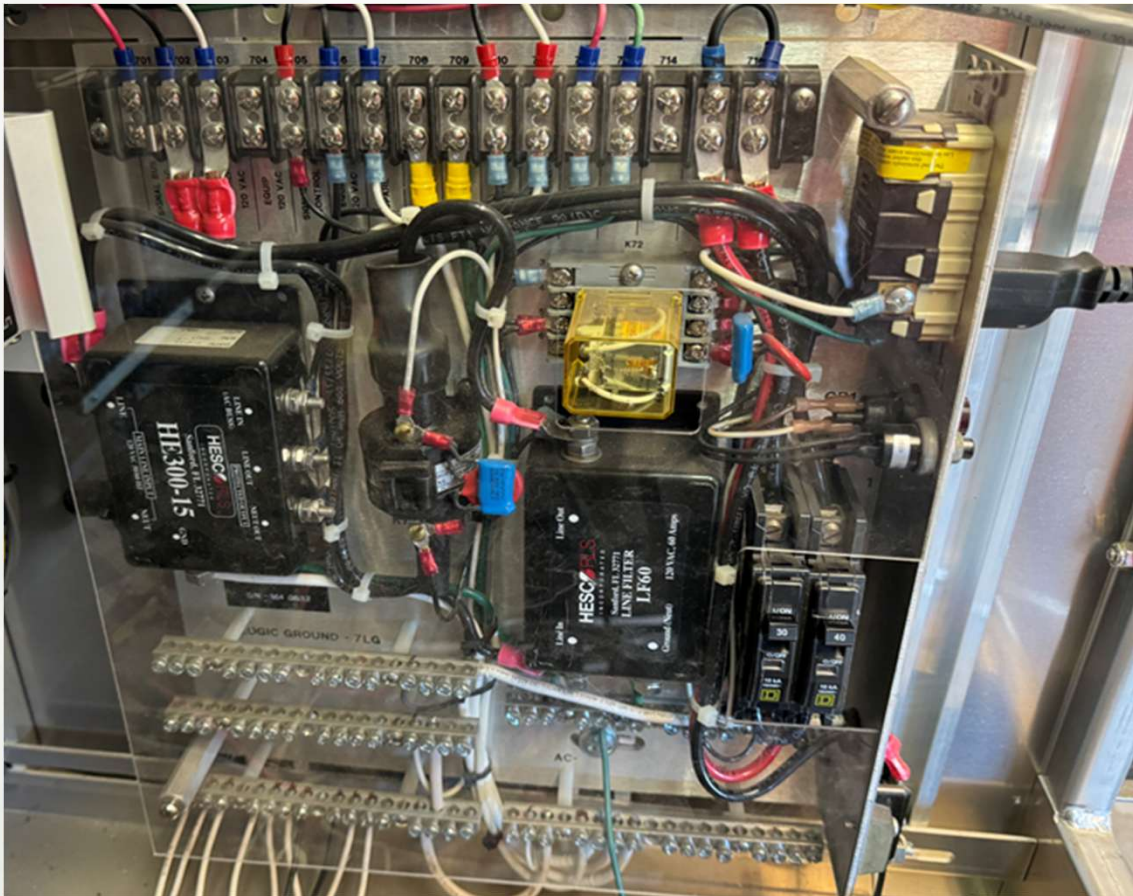
Power then passes through **main breakers or surge protection** devices for system protection.

Power Panel / Distribution

AC power routed through **power distribution blocks or relays** to cabinet components.

Includes **circuit breakers** for controller, load switches, and auxiliary devices.

Grounding and bonding connections ensure safe operation and compliance with NEC Article 250.



Power Flow Through the Cabinet

Power Supply Section

- Converts **AC to DC** for low-voltage systems inside the cabinet.
- Provides regulated **+24 VDC**, **+12 VDC**, or **+5 VDC** outputs for controller logic, detection, and communications.

Controller / Monitor / Load Switches

- **Controller:** Distributes logic signals to load switches.
- **Load Switches:** Convert logic-level inputs into AC outputs for signal heads (red/yellow/green).
- **Conflict Monitor (MMU):** Continuously checks for overlapping or unsafe signal outputs, and absence of signal, and forces flashing mode on fault detection.

Overall Flow Summary:

Utility Power → Service Disconnect → AC/Filter → Breakers/Surge Protection → Power Supply → Controller → Load Switches → Signal Heads

Power Flow Through the Cabinet

Different Voltages Encountered in Various Cabinet Types and How to Test Them

Common Voltages in Signal Cabinets:

120 VAC: Primary service voltage for signal indications, load switches, and power supplies.

240 VAC: Occasionally used for special applications or high-load systems.

24 VDC: Common for detectors, communications, relays, and certain logic circuits.

12 VDC / 5 VDC: Used internally by controllers and detection electronics.

48 VDC: Found in some ATC or ITS cabinets for network and communication equipment.

Power Flow Through the Cabinet

Testing Procedures:

Use a **True RMS multimeter** to measure AC and DC voltages safely.

Test **line voltage** at the service disconnect and **load voltage** at the power distribution block.

Verify **DC output** from power supplies to confirm regulator performance.

Confirm **voltage at signal outputs** matches lamp requirements.

Always check **neutral-to-ground potential** to ensure proper bonding.

Safety Considerations:

Follow **lockout/tagout procedures** when accessing live circuits.

Use insulated probes and PPE compliant with OSHA electrical safety standards.

Verify calibration of test equipment regularly.

Load Switches

Load Switches / Switch Packs:

- Load switches are interface devices between the controller and the field signals.
- The primary function of a load switch is to receive the 0/24 VDC input control signals from the controller and output a 120 VAC signal to the appropriate signal indications in the field.
- These devices are used in both **NEMA cabinets (load switches)** and **Type 170 cabinets (“200” load Packs)**.
- If a load switch is not used in a TS-1 cabinet or a type 170 cabinet, the red input to the conflict monitor must be loaded with 120 VAC.
- If a load switch is not used in a TS-2 or an ATC cabinet, the MMU or CMU input channel must be disabled so that the monitor doesn't see a fault on that channel.



High-Density Switch Packs

HDSPs:

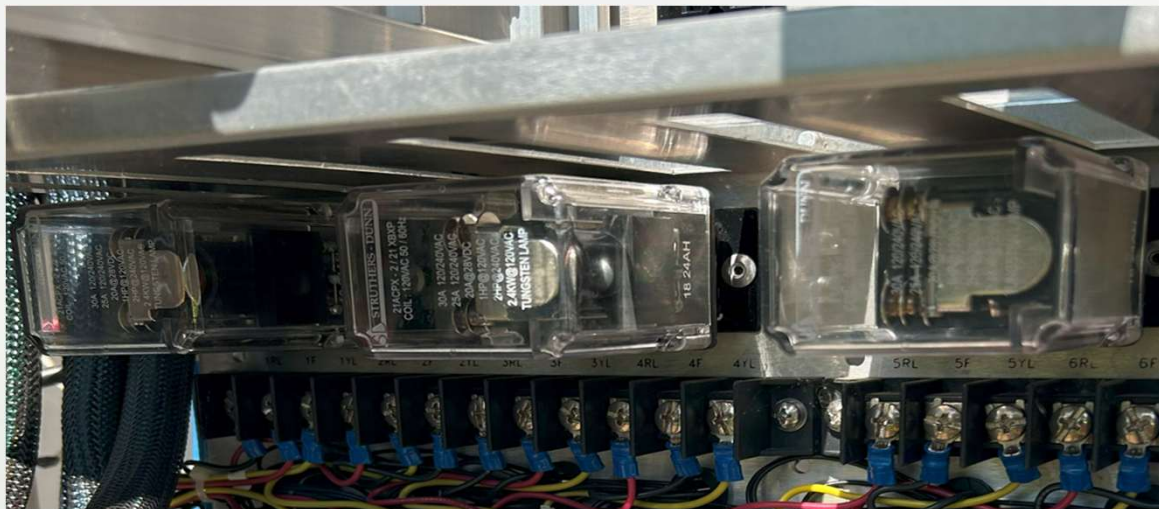
- These high-density switch packs are only used in the ATC cabinets
- They serve the same purpose as the traditional load switches, however...
- Due to the high-density design, there are two load switches on one card for a total of six outputs.
- These devices also ***double up as flasher units***.



Flash Transfer Relays

Flash transfer relays are electrical switching devices used in traffic signal systems to control the flashing mode of the traffic signals. It is an electrical switch that is controlled by energizing or de-energizing the coil, thereby changing the state of the contacts through magnetism.

What you are changing is either the RED or YELLOW load switch output or the flasher output to the signal indications in the field.



These relays are used in both NEMA and Type 170 cabinets. (Energized in NEMA but not in Caltrans)

Newer units may have an LED light to indicate an energized coil.

ATC Flash Transfer Relays

The next generation of flash transfer relays used in ATC cabinets has:

- A much smaller design

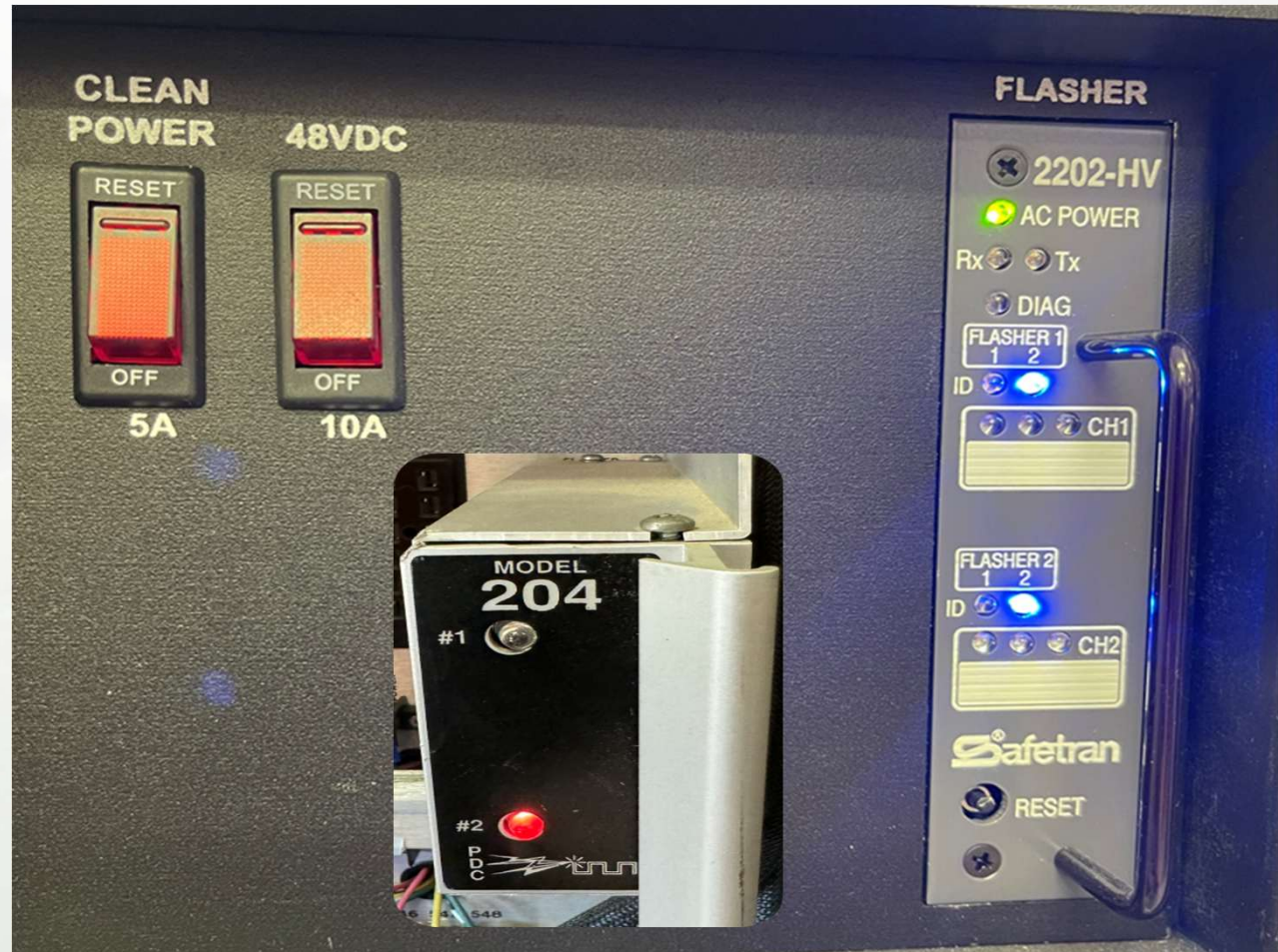
These relays are hermetically sealed and contain dry nitrogen gas to:

- Keep out Moisture, Insects, and Dirt
- Reduce sparking between the contacts
- Has an LED light to show the coil is energized

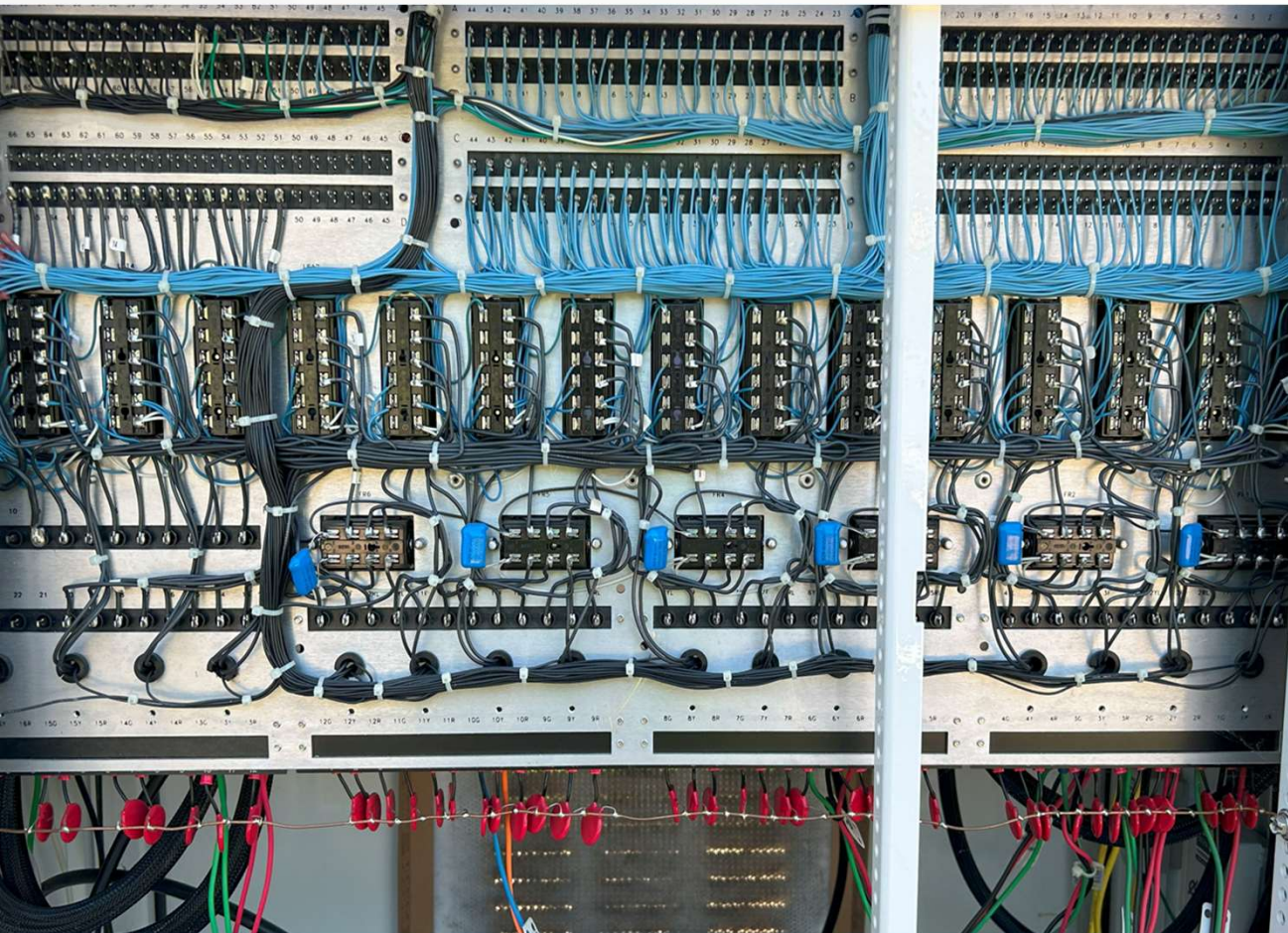


Flashers

- The flasher is the device that alternates two flashing, 120 VAC outputs to the signal indications.
- The rate of the flashing outputs per the MUTCD is 50 – 60 flashes per minute.
- The upper flasher is strictly used in the ATC cabinets.
- The lower “204” flasher is used in both NEMA and Type 170 cabinets.



Cabinet Components – Cabinet Panels



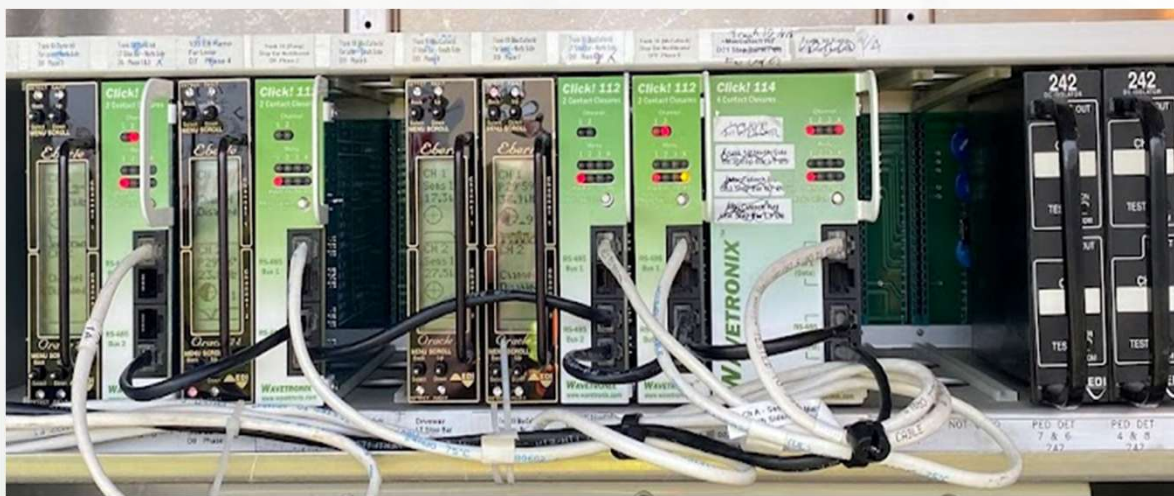
Various panels are used in the traffic signal cabinet to control and interface with different components.

The Back Panel:

- The back panel includes the field terminals, the load switch bay, the flasher(s), the FTR's, and in some cases, the input/output terminals, and the power distribution components.

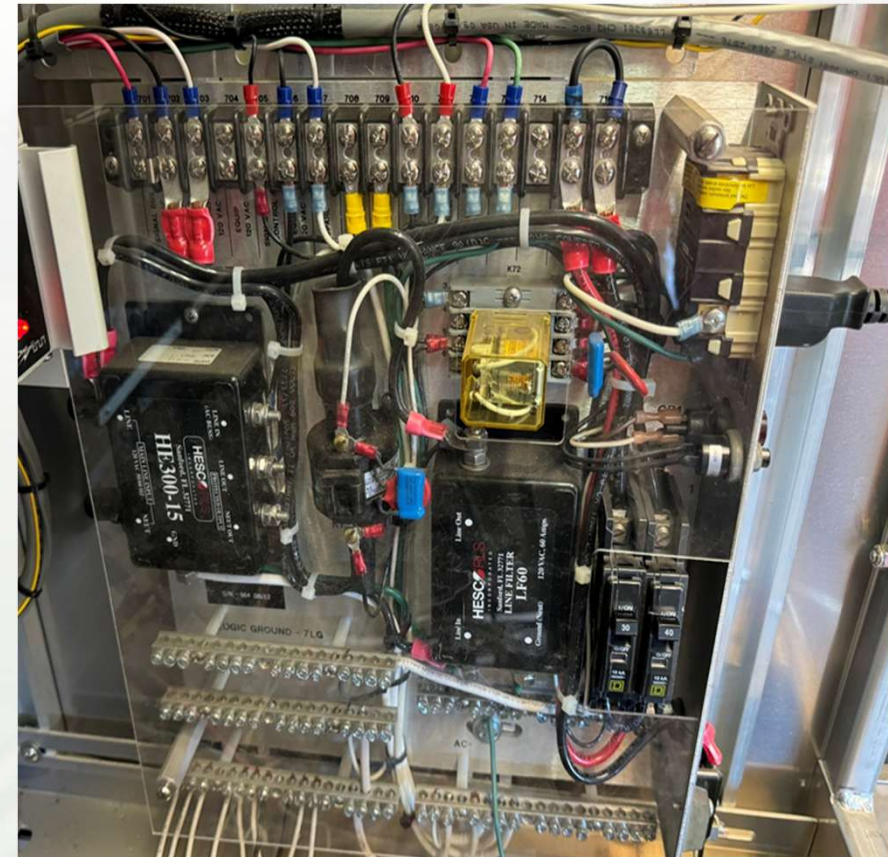
**Image is of the rear of the back panel.

Cabinet Components – Cabinet Panels

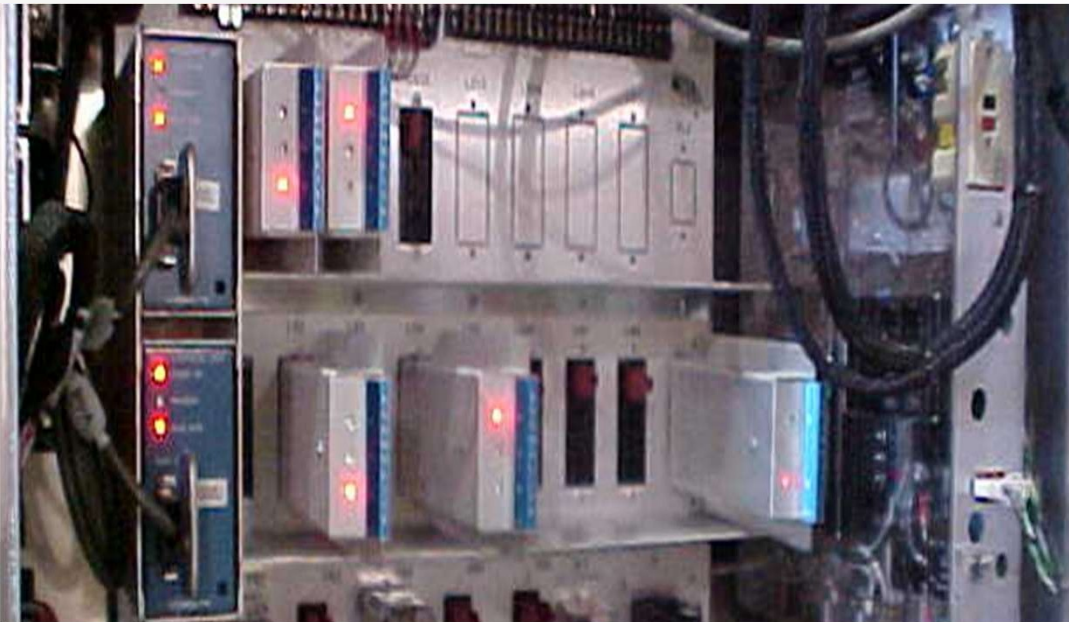


Power Panels: These panels include the power distribution equipment responsible for distributing power throughout the cabinet.

Detection Panels: These panels facilitate the detection inputs from the field and interface them into the controller.

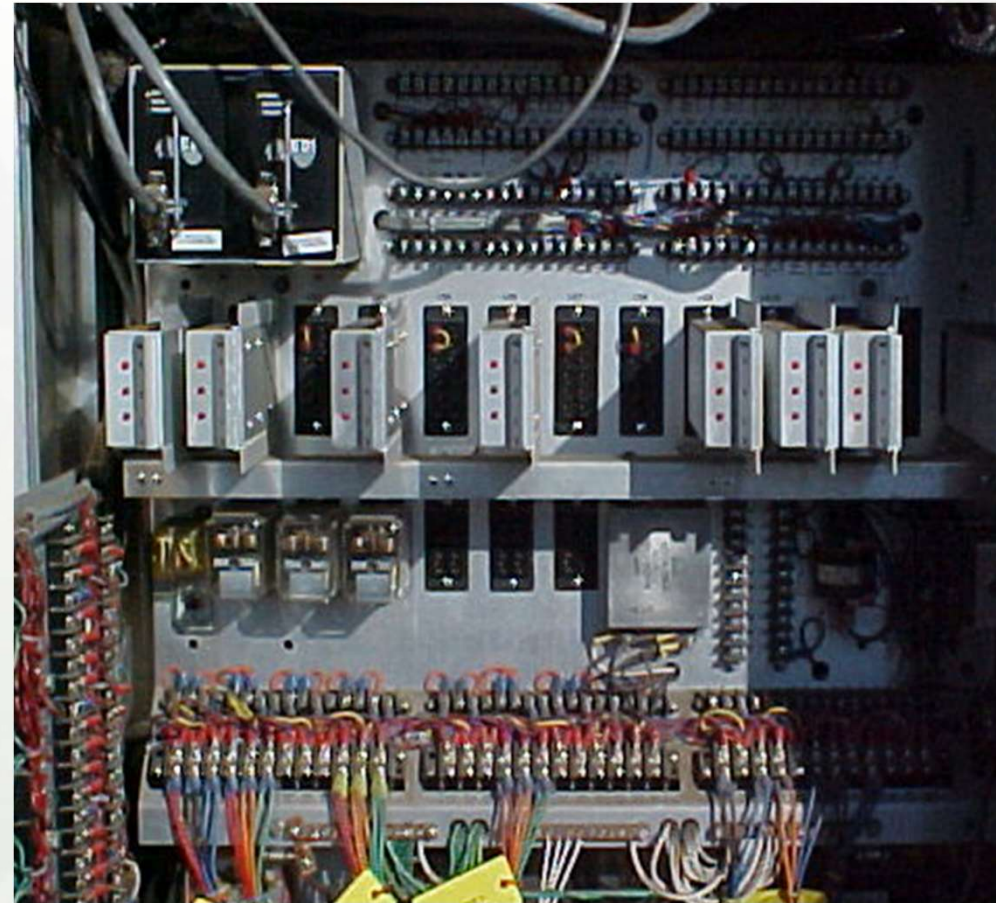


Cabinet Components – Cabinet Panels



Telemetry Panels: Facilitates communications between the controller and a T.O.C. or other system.

Preemption Panels: Facilitates the EV and RR preemption inputs from the field and the controller.



Electrical Protection

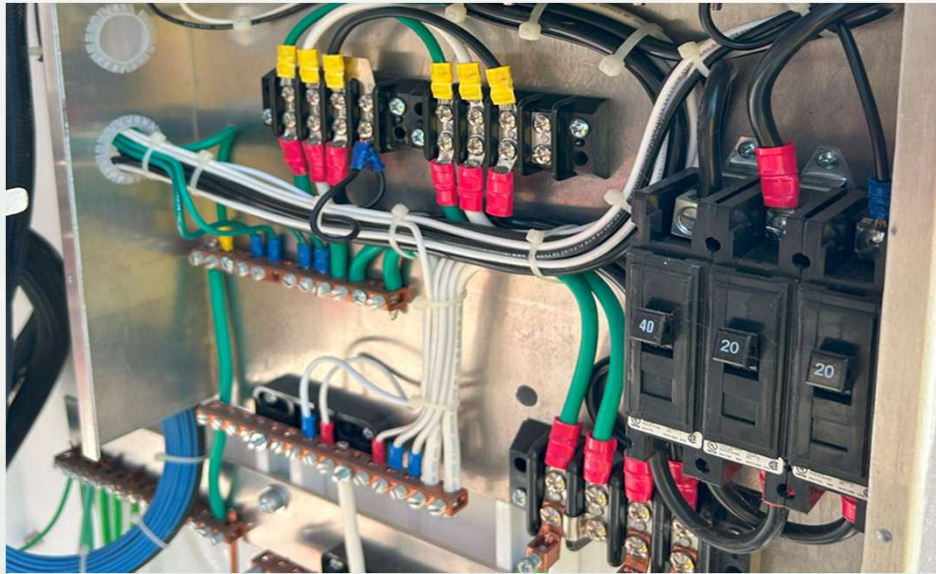


Main and Auxiliary Breakers:

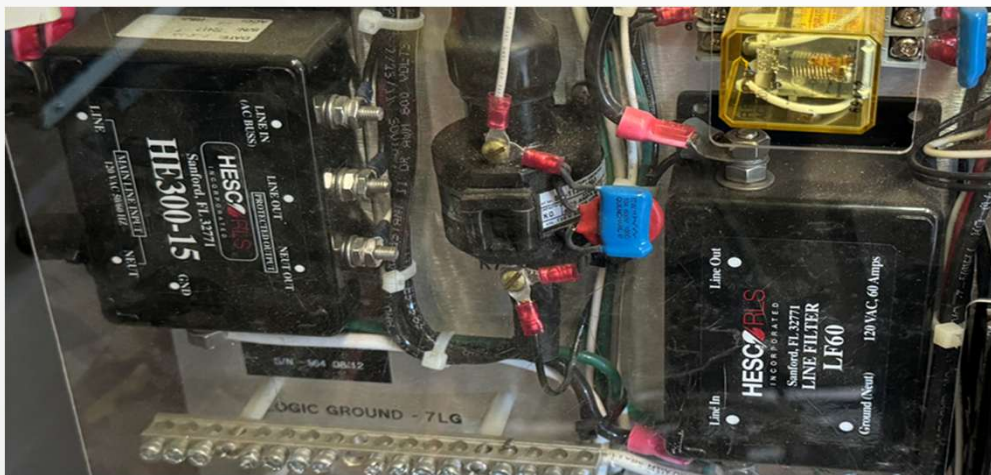
- Circuit breakers are devices that protect electrical circuits and devices from overcurrent situations.
- Traffic signal cabinets have always had a 50 amp “main breaker.” Thanks to the onset of LED signals, main breakers are now rated at 30 amps.
- Cabinets also have auxiliary breakers, rated at 15 amps for cabinet equipment, such as the light, fan, and electrical outlets.

Surge Protection Devices:

- These devices safeguard the components in the traffic signal cabinet from power surges or lightning strikes. They divert excess electrical energy to the ground, protecting sensitive electronic equipment from damage.
- These devices are used in all types of cabinets.



Line Filters



Within the traffic signal cabinets are electronic devices used to reduce or eliminate electrical noise and interference from the power supply line that feeds the traffic signal system.



They are installed in the signal cabinet to improve the reliability and performance of the signal electronics by ensuring a clean and stable power source.

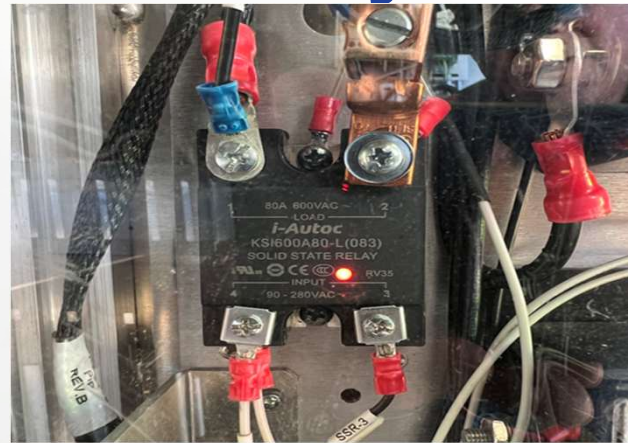
Ground Fault Circuit Interrupter (GFCI)

Ground Fault Interrupter:

- GFCI's protect devices and workers from electrical shock.
- They trip because of an electrical imbalance (overload) and within a 1/40th of a second.
- Use GFCI testing device to verify proper function.
- **Never plug cabinet equipment into the GFCI.**



Mercury Contactor



Another relay found in traffic signal cabinets, but often misunderstood, is the **mercury relay** (*far left*), or sometimes referred to as a mercury contactor.

- This relay is found on the power panel.
- The only purpose is to supply AC power to the load switches during normal signal operation.
- If the signal is put into a flashing condition, this relay cuts AC power to the load switches.
- Due to the hazardous nature of mercury and the restrictions that have ensued, these relays are being replaced with solid state (**SSR**) (*above right*) or hybrid relays (*lower right*).

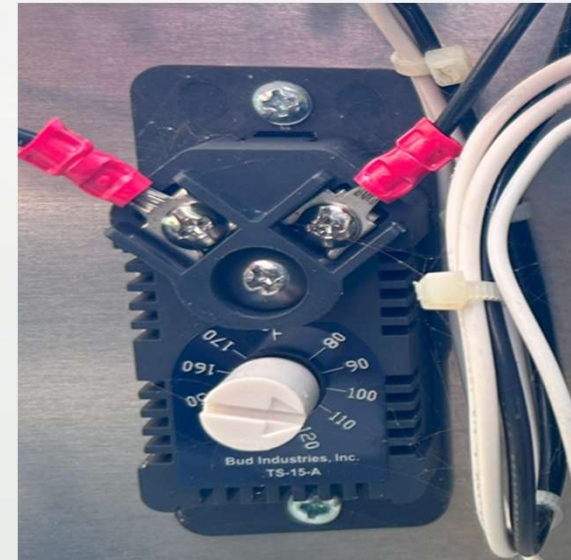
Fan / Thermostat

The primary function of the fan system is to provide proper ventilation and cooling to the electronic components and equipment housed inside the cabinet. Here are some key reasons why the fan system is important:

- Heat Dissipation
- Temperature Regulation; Thermostat ranging from 85⁰–170⁰
- Moisture Control

Maintenance issues related to the fan system in traffic signal cabinets may include:

- Testing the fan by turning down the thermostat lower than the ambient temperature, thus turning on the fan.
- Dust Accumulation
- Fan Failure
- Electrical Problems
- Noise and Vibration
- Environmental Factors



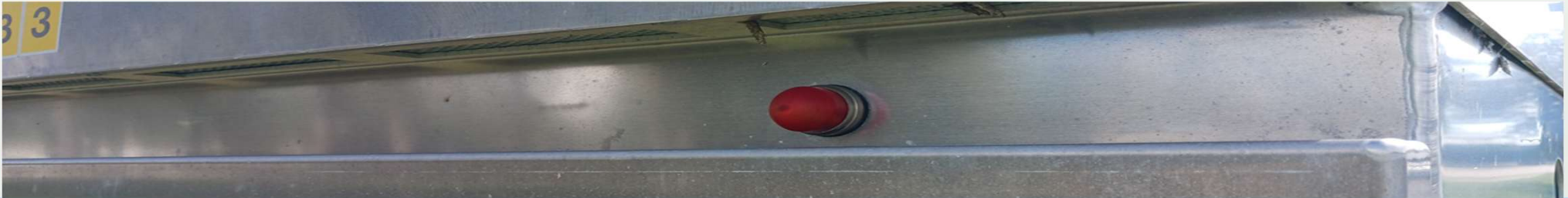
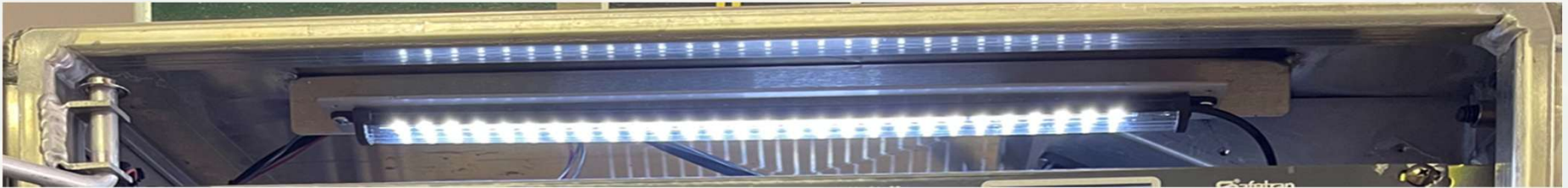
Thermostat ranging from 80°-170°F

Fan / Thermostat

Lighting:

Inside a typical traffic signal cabinet, various types of lighting are used for different purposes. Here are the common lighting options found inside or on a traffic signal cabinet:

- Cabinet Interior Lighting
- Indicator Lights
- Alarm / Emergency Lights



Locks, Hinges, and Door Seals

Locks, Hinges, and Seals

- Secures the cabinet, and keeps dust and debris out
- Standard Corbin #2 key for the locks used to be standard
- Lock types now vary
(See local requirements and manufactures specifications on maintenance)



Power Out of Cabinet

How Power Flows from the Load Switches and Controller Out to the Traffic Signal Heads in the Field

Load Switch Function

Each **load switch** corresponds to a specific signal indication to a specific signal phase color (e.g., Northbound Green, Southbound Yellow).

The load switch receives a **logic input (low-voltage DC)** from the controller and outputs **switched AC voltage (typically, 120 VAC)** to the field wiring.

Controller Role

The **controller** determines signal timing and phase changes, sending low-voltage logic signals to activate load switches.

Interfaces with the **conflict monitor** to ensure safe and non-conflicting outputs.

Power Out of Cabinet

Power Flow Path

Controller logic → Load switch output → Field terminal block → Cable conductors → Signal head indications (R/Y/G)

Each color indication has its own conductor; shared **neutral return** line completes the circuit.

Power flows through **field terminal blocks** inside the cabinet, which distribute current to multiple signal approaches.

Protective Components

Fuses or circuit breakers protect each signal circuit from overloads.

Surge protectors prevent voltage spikes from damaging field wiring or lamps.

Field Wiring Layout

Signal cables typically run through **underground conduit** or **aerial wiring** to poles and mast arms.

Conductors must meet **NEC and IMSA specifications** for insulation and color coding (e.g., white = neutral, red/yellow/green = indications).

Power Out of Cabinet

Splicing Practices

Splices may occur in **pole bases, junction boxes, or handholes** to connect cabinet wiring to field signal conductors.

Use **compression connectors, wire nuts, or heat-shrink splices** rated for wet and underground environments. Must be **waterproof, corrosion-resistant, and mechanically secure** per NEC Article 300.5 and local DOT standards.

Avoid excess slack or tension in spliced conductors to prevent failures. No splices inside a conduit or outside of an approved enclosure.

Termination Points

Signal conductors terminate at **terminal strips or lugs** inside signal housings or pole bases.

Each termination must be **labeled, color-coded, and documented** for maintenance reference.

Inspectors verify **tightness, continuity, and insulation integrity** during acceptance inspections.

Power Out of Cabinet

Testing and Verification

Use a **megohmmeter** to test insulation resistance between conductors and ground.

Perform **continuity tests** to confirm correct phase-to-signal connections.

Inspect all splices for proper sealing and grounding continuity.

Safety Considerations

Always de-energize and lock out circuits before performing field inspections.

Basic Installation Procedures

Layout and Orient the Cabinet Foundation at the Intersection

Site Layout and Orientation

Cabinet location should match **approved plan sheets**—typically placed near the signalized intersection, outside of pedestrian paths, and within right-of-way.

Ensure **clear sight lines** to the intersection and adequate **service access** for maintenance vehicles.

Cabinet should be **oriented, so the door opens away from traffic flow** for technician safety.

Verify that **conduits align** correctly with planned entry points for field wiring and power service.



Basic Installation Procedures

Utility and Clearance Considerations

Confirm location is free from **underground conflicts** (gas, water, telecom).

Maintain **minimum clearances** from curbs, poles, and sidewalks per local or DOT standards (e.g., 3–5 ft from curb).

Ensure compliance with **ADA accessibility** and **electrical service easements**.

Foundation Layout

Use **survey stakes and reference points** to verify orientation matches intersection geometry.

Check **grade elevation** to prevent water intrusion into the cabinet.

Ensure conduit stub-ups are positioned and spaced per design drawings.



Basic Installation Procedures

Foundation Installation

Excavation and Forming

Foundation dimensions must meet **plan specifications** (width, depth, rebar layout).

Use **proper forms, reinforcement steel, and conduit placement** before pouring.

Concrete Pour and Curing

Use **approved concrete mix**; pour evenly to avoid voids or weak spots.

Finish top surface **level and smooth** for accurate cabinet mounting.

Allow adequate **curing time** before mounting cabinet (typically, 48–72 hours).



Basic Installation Procedures

Grounding

Install **ground rod(s)** and bonding wire per NEC Article 250 recommendations.

Verify grounding continuity from cabinet base to foundation rebar (if specified).

Documentation

Inspect and record **depth, alignment, and conduit verification** prior to pour.

Submit photos or inspection forms for project documentation.



Basic Installation Procedures

Mounting Types and the Importance of Squaring the Cabinet on the Foundation

Mounting Types

- **Direct Bolt-Down:** Cabinet base mounts to anchor bolts embedded in the concrete foundation.
- **Base Plate or Pedestal Mount:** Cabinet secured to raised plate or pole for smaller intersection controllers.
- **Pad Mount:** Cabinet sits on pre-cast or poured concrete pad for larger, multi-bay cabinets.

Importance of Squaring the Cabinet

- Cabinet must be **square and level** to ensure proper door alignment and weather sealing.
- Correct squaring ensures **load alignment** on conduit connections and internal wiring integrity.
- Misalignment can stress conduit fittings or cause drainage and access issues.
- Verify squareness by **measuring diagonals** or using a **laser level** prior to tightening anchor bolts.

Final Inspection Checks

- Confirm **door clearance**, **drainage slope**, and **secure anchoring**.
- Verify all conduits and wiring are **protected and sealed** against moisture entry.
- Ensure cabinet orientation matches design plans and maintenance safety guidelines.
- Equipment warranties

Knowledge Check

The Flash Transfer Relay allows for the signals to

- a) Switch between the phases of the controller
- b) Alternate between the Walk and Don't Walk in the cabinet
- c) Allows the Traffic Signal to transfer from Red to Green
- d) Change the load switch output to Red or Yellow in the field

Knowledge Check

Inside the Traffic Signal Cabinet there are several electrical outlets installed with GFCI's, and they can be used with the following devices

- a) BIU
- b) SIU
- c) Cordless Drill
- d) Never plug cabinet equipment into the GFCI outlet

Session 9: Communication Devices

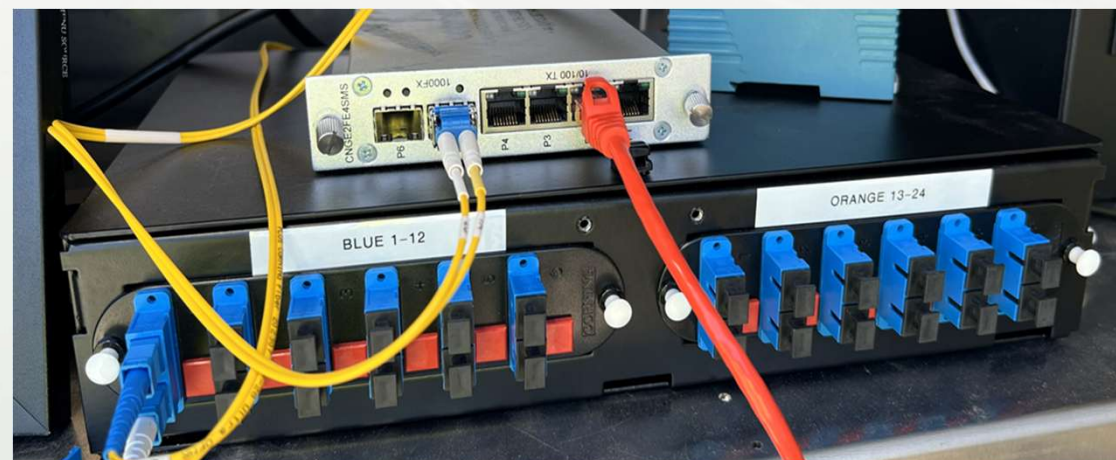
Communication Components



Communication Devices: allow the traffic signal cabinet to connect with a centralized traffic management system or other devices.

These devices can include:

- Modems
- Ethernet Switches
- Fiber-Optic Transceivers
- Wireless Communication Modules



Communication Media

Different Types of Communication Media

Copper (Twisted Pair or Coaxial)

- Common in older systems or short-distance communications between controllers.
- Carries analog or serial (RS-232/RS-485) data signals.
- Requires proper shielding and grounding to prevent interference.

Fiber Optic Cable

- Used for **high-speed, long-distance** communication between intersections or to central systems.
- Two main types: **Single-mode (long distance)** and **Multimode (short distance)**.
- Immune to electrical interference; requires precise splicing and cleanliness during installation.

Communication Media

Different Types of Communication Media

Wireless / Radio (Microwave, Wi-Fi, Cellular, or Mesh Network)

- Used when physical cable is impractical or costly.
- Requires **line-of-sight alignment**, antenna mounting, and frequency coordination.
- Subject to interference, weather effects, and regulatory frequency management.

Ethernet / IP-Based Communication

- Standard for modern **ATC** and **ITS** systems.
- Uses CAT5e/CAT6 cables, network switches, and routers within cabinets.
- Supports remote monitoring, coordination, and data logging.

Hybrid Systems

- Combine multiple media types (e.g., fiber backbone with wireless last-mile connection).
- Require coordination between network types and compatible interface hardware.

Communication Media

Installation and Testing Processes That Must Be Documented

Installation Inspection Responsibilities

- Verify **communication conduit routing and depth** match plan specifications.
- Inspect **pull boxes, handholes, and junction points** for correct location, alignment, and accessibility.
- Ensure **minimum bend radius, proper labeling, and protection from moisture or crushing**.
- Confirm all terminations and connectors are **secure, sealed, and labeled**.
- For fiber, check **splice enclosures** and ensure **fiber slack** and **routing** meet manufacturer standards.

Communication Media

Installation and Testing Processes That Must Be Documented

Testing Processes

- **Copper Cabling:** Perform **continuity, resistance, and insulation tests**; verify polarity and shielding.
- **Fiber Optic:** Conduct **OTDR (Optical Time-Domain Reflectometer)** and **light loss (dB) tests** to confirm integrity and signal strength. Fiber needs to be documented while on the reel. Pay attention to what is in the specifications.
- **Ethernet / IP:** Test for **ping response, bandwidth, and packet loss**; confirm proper network addressing and communication with the controller.
- **Wireless:** Test **signal strength, latency, and interference** using spectrum analysis tools.
- Ensure all **test results are documented** in project records with location data and technician signatures.

Communication Media

Installation and Testing Processes That Must Be Documented

Documentation Requirements

- Maintain detailed **as-built drawings** showing routes, terminations, and communication types.
- Include **test reports, device serial numbers, and installation photos**.
- Verify that **system communication logs** confirm connection between field devices and central systems before project acceptance.
- Submit all documentation per agency or DOT project closeout standards.

Copper Wire / Phone

Copper Interconnect Installation and Testing

Used for communication between controllers or to a central system.

Installed using **twisted-pair, shielded copper** in conduit or aerial routes.

Maintain **proper separation** from power cables and **seal conduit entries**.

Terminate on labeled, corrosion-free **terminal boards or punch-down blocks**.

Test for **continuity, insulation resistance, crosstalk, and polarity**; document results.

Copper Wire / Phone

Hardened Phone Line (Twisted Pair) Communication

Provides **modem-based communication** with remote traffic management systems.

Components include **twisted-pair copper**, **modem**, **termination board**, and **telco hookup**.

Install per **NEC Article 800** and **NEMA TS-2**; ensure proper **grounding and isolation**.

Test for **loop resistance**, **line quality**, **modem connectivity**, and **data transmission integrity**.

Record all tests and verify full communication link function.

Wireless Communication

Wireless Communication Types Used in Traffic Signal Projects

Broad Spectrum / Wi-Fi (2.4 or 5 GHz): Short-range, used for local controller-to-controller links.

Microwave: Point-to-point, long-range high-capacity backhaul; requires **line-of-sight** alignment.

900 MHz Radio: Common for low-data-rate communication between isolated intersections.

Cellular (4G/5G): Used for **remote access** to controllers or central systems via modems.

DSRC (Dedicated Short-Range Communications): Enables **vehicle-to-infrastructure (V2I)** applications like SPaT and safety messaging.

Wireless Communication

Components of Installation That Must Be Documented

Modem / Head Unit:

- Records model, serial number, firmware version, and communication protocol.
- Verify mounting, connections, and power source per manufacturer specs.

Power Supply:

- Confirm correct voltage and fuse protection.
- Document wiring connections and grounding integrity.

Termination Panel in Cabinet:

- Ensure proper labeling of data, power, and antenna cables.
- Check for surge protection and tight, corrosion-free connections.

Wireless Communication

Components of Installation That Must Be Documented

Antenna Wiring:

- Verify **coax or Ethernet cable type**, length limits, and shielding.
- Confirm proper routing to avoid EMI (electromagnetic interference).

Antenna and Mounting Hardware:

- Document **mounting location, orientation, and height**.
- Ensure **line-of-sight** and compliance with manufacturer alignment specs.

Manufacturer-Approved Grounding:

- Record **grounding point**, conductor size, and bonding to cabinet or pole ground.
- Ensure compliance with **NEC Article 810 and NEMA TS-2 grounding standards**.

Fiber Optic Communication

Types of Fiber Optic Communication Being Installed

Purpose: Fiber provides **high-speed, low-latency communication** between traffic signal devices, cabinets, and central systems.

Start with the Device:

- Identify what the fiber connects — **Device-to-Device**, **Outside Plant (OSP)** trunk line, or **Inside Plant (ISP)** to servers/switches.
- Verify each type meets project design and functional intent.

Fiber Optic Communication

Types of Fiber and Configuration Components

Single-Mode Fiber (SMF):

- Long-distance, high-bandwidth; typical for **backbone or trunk lines**.
- Smaller core (≈ 9 microns), uses **laser light source**.

Multi-Mode Fiber (MMF):

- Shorter distances (≤ 2 km), often used **within intersections or buildings**.
- Larger core (50 or 62.5 microns), uses **LED light source**.

Jumpers and Patch Cords:

- Used to connect panels, switches, and media converters.
- Configurations vary (**LC, SC, ST** connectors); must match system design and polarity.

Fiber Optic Communication

Field Installation and Inspection Focus

Verify the fiber installation is done according to the project specifications and documentation

Conduit and Pull Box Verification:

- Confirm conduit type, size, and depth meet **plan and NEC/IMSA specs**.
- Check slack loops and bend radius compliance.
- Ensure fiber is **not kinked, crushed, or overstressed** during pulls.
- Verify **labeling** per design standards.

Fiber Optics

A fiber optic injector, also known as an optical power meter or optical power injector, is a device used in fiber optic networks to measure and inject optical power. It is primarily used for testing and troubleshooting fiber optic cables and components.

Fiber optic injectors/meters are commonly used by network technicians, engineers, and installers to validate fiber optic installations, troubleshoot network issues, and verify signal integrity. They are crucial tools for maintaining and optimizing the performance of fiber optic networks

An OTDR (Optical Time Domain Reflectometer) is a unit that helps determine the signal quality, length, and losses along the fiber optic link.

Fiber Optics

Here's a brief explanation of how a fiber optic injector/meter works:

Optical Power Measurement: The fiber optic injector/meter measures the power level of light signals transmitted through fiber optic cables. It typically uses a calibrated sensor or photodiode to convert the light power into an electrical signal.

Measurement Units: The optical power is usually expressed in units of decibel milliwatts (dBm) or watts (W), depending on the device.

Wavelength Range: Fiber optic injectors/meters can operate over a specific wavelength range or multiple wavelength bands. They are designed to work with different types of fiber optic networks, such as single-mode or multimode, and support various wavelengths like 850 nm, 1300 nm, 1310 nm, 1550 nm, etc.

Power Injection: In addition to measuring optical power, some fiber optic injectors also have the capability to inject optical signals into the fiber optic network. This feature is useful for testing and verifying the functionality of optical links, connectors, and network components.

Networking

Agencies are expanding their transportation systems more than ever.

- The key to managing the system is based on communications through a computer network to all devices.
Each of which must have a unique address.
- Internet Protocol (IP) addresses provide two things:
 - Network interface identification
 - Location addressing
 - An IP address might look like “192.0.128.64”
 - This is how a computer finds a specific device on a network
- In addition, each device has a unique MAC address assigned by the manufacturer
 - A MAC address looks something like this “D2-FF-23-00-C3-A1”

Inspectors should verify proper installation, labeling, grounding, and configuration per design plans.



Networking

Understanding of Different Devices

Modems:

- Convert data between digital and analog formats for **cellular, fiber, or copper** communication.
- Verify **signal strength, antenna connections, and IP configuration**.

Switches (Managed / Unmanaged):

- Connect multiple devices (controllers, detectors, cameras) within the network.
- Check **port labeling, power supply (PoE if used), and fiber/copper connections**.
- Managed switches require configuration for **VLANs, IP routing, and diagnostics**.

Routers / Gateways:

- Provide **network traffic management and external connectivity** to central systems.
- Verify **network addressing, firewall settings, and firmware versions**.

Media Converters:

- Convert **fiber-to-copper** or **different communication standards**.
- Confirm **power input and link light status** for signal integrity.

Networking

Communication Tests That Must Be Performed and Documented

Inspector verifies that the following tests have been completed and documented:

- Continuity / Link Verification
- Ping / IP Connectivity Tests
- Bandwidth / Latency Checks
- Fiber / Cable Testing

Knowledge Check

Communication devices in traffic signal equipment can include the following except

- a) Modems
- b) TTY
- c) Ethernet Switches
- d) Fiber Optic Transceivers

Knowledge Check

At the completion of testing communication devices, and any other device, you should

- a) Ensure that all results are documented per agency or project standards
- b) Ensure that the tech's completing the testing have clocked in per agency standards
- c) Ensure that all testing equipment have been correctly assigned and are agency equipment
- d) Ensure that everyone on the job site is aware that you are the inspector

Session 10: Detection Devices

Detection Devices

Identify Detection Types Shown in the Plans

- Be able to read construction plans and signal design sheets to identify the detection technology specified (loops, video, radar, microwave, magnetometers, infrared, thermal, pushbuttons, etc.).
- Verify that the type, quantity, and placement of detection devices match the approved plans.
- **Verify With a Technician How Detection Works Inside the Signal Cabinet.**

Detection Devices

Theory of Operation (Basic Understanding)

- Understand the basic operating principles of each detection type (e.g., inductive loop magnetic fields, radar microwave reflection, video pixel change, magnetometer disturbance).
- Understand environmental or physical factors that influence detection (weather, occlusion, pavement condition, vibration, shadows, mounting height).
- Understand the intended purpose of detection: vehicle presence, passage, speed, queue detection, pedestrian actuation, or bicycle detection.

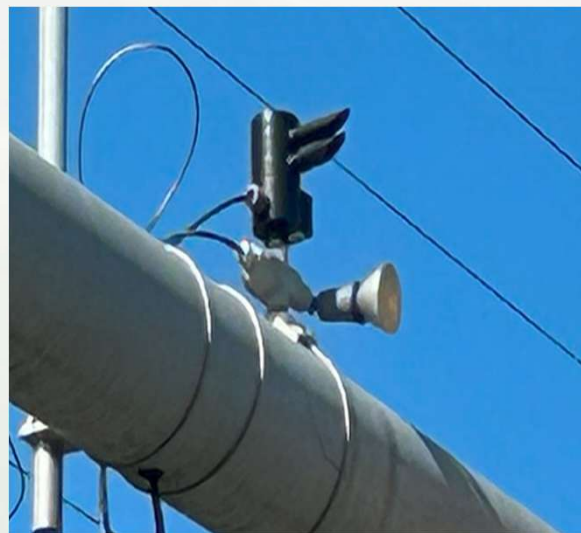
Inspector Verification in the Field

- Verify proper installation: depth, saw-cut spacing, camera/radar aim and height, conduit routing, grounding, and backfilling.
- Confirm visibility and detection zones correspond to plan-defined stop bars, approach lanes, and turning movements.
- Check that detector operation is correctly reported in the cabinet during functional testing (watch for channel activation in controller software).
- Do both daytime and nighttime verification.

Detection Devices

Follow Installation Specifications

- Inductive Loop Detection
- Video Detection
- Thermal / Infrared Detection
- Microwave / Radar Detection
- Manual Push Button Detection (Pedestrian)
- Connected Vehicle Systems (CVS / V2X) Detection



Detection Devices

General Installation Requirements

- Verify device type, location, and orientation match the approved plans.
- Confirm proper mounting height, angle, and setback for above-ground devices.
- Check conduit routing, pull boxes, grounding, and sealants for in-ground devices.
- Ensure all materials meet agency specifications and MUTCD/NEC requirements.

Inductive Loops

- Verify saw-cut dimensions, loop geometry, and depth.
- Check wire turns, splice kits, and proper backfill.
- Test continuity, resistance, and isolation before activation.

Video Detection

- Confirm camera alignment, focus, mounting height, and field-of-view coverage.
- Perform zone setup in the processor per lane and approach geometry.
- Validate detection using walk/drive tests.

Detection Devices

Thermal / Infrared Detection

- Verify sensor is correctly aimed at target lanes or crosswalks.
- Confirm clear line of sight—no vegetation, poles, or signs obstructing view.
- Perform operational test during day and night if possible.

Microwave / Radar Detection

- Check mounting bracket stability, angle, and distance settings.
- Program directional or range settings according to speed approach.
- Perform field test to confirm consistent activation in cabinet.

Pedestrian Push Buttons

- Confirm ADA installation requirements—height, reach, orientation, and signage.
- Test actuation, LED indicator (if present), and conductor continuity.
- Verify proper termination at pedestrian input channels in cabinet.

Detection Devices

Connected Vehicle / V2X Detection

- Verify proper placement and orientation of RSU antenna.
- Confirm power, network connection, and firmware updates.
- Test CV message reception using approved OBU test vehicle or simulator.

Inspector Testing Responsibilities. Validates with technician or IT department

- Validate detector channel activation in the controller during field testing.
- Confirm detection timing parameters (presence, delay, extension) match plans.
- Document installation data, test results, and any deviations.

Knowledge Check

With detection systems the inspector needs to test and validate all except

- a) Detector channel activation in the controller
- b) Confirm detection timing parameters match the plans
- c) Ensure that V2X is connected in the tech panel
- d) Document installation data, test results, and any deviation per agency req's

Session 11: ITS Devices

ITS Devices

General ITS Device Awareness

- Understand the purpose of ITS devices in traffic management and system efficiency.
- Be able to read plans and identify ITS device locations, mounting methods, and communication requirements.
- Verify equipment matches project specifications and approved submittals.

CCTV Cameras

- Confirm proper mounting height, pole orientation, and field-of-view based on plans.
- Check power and communication connections (fiber, wireless, or coax depending on system).
- Verify camera pan/tilt/zoom (PTZ) functions during testing.
- Ensure surge protection, grounding, and weatherproof housings are correctly installed.

Closed Circuit TV Cameras

Many agencies are installing CCTV cameras as part of their transportation infrastructure.

The cameras are used for:

- Vehicle detection
- Pedestrian detection
- Red light photo radar
- Speed enforcement
- Security surveillance
- Incident management

Types of cameras are used:

- Straight/bullet cameras that can focus and zoom in and out.
- Pan, Tilt, Zoom (PTZ) dome style cameras that can see one half of a sphere, hence the name.
- Infrared



ITS Devices

Dynamic Message Signs (DMS)

- Confirm structural supports, cabinet access, and sign orientation match the design.
- Ensure proper electrical service, grounding, and cabinet wiring.
- Validate communication links to the Traffic Management Center (TMC).
- Observe pixel testing, brightness controls, and message display functionality.

Bluetooth / Wi-Fi Detection Units

- Verify placement per plans—height, offset, and directional alignment are critical.
- Confirm power source and network connections (cellular, fiber, or wireless).
- Ensure the unit can detect Bluetooth/Wi-Fi MAC addresses after anonymization protocols.
- Check data transmission to central servers for travel time or analytics.



ITS Devices

Connected Vehicle (C2X / V2X) RSUs

- Confirm RSU mounting height and antenna orientation for roadway coverage.
- Verify device power supply, grounding, and network integration.
- Ensure firmware, configuration settings, and security certificates are installed according to plans.
- Validate reception of Basic Safety Messages (BSMs) or SPaT/MAP message broadcasting.

Inspector Responsibilities Across All ITS Devices

- Confirm installation follows MUTCD, manufacturer specs, and agency standards.
- Verify cable routing, labeling, conduit systems, and weatherproofing.
- Conduct or witness operational testing and communication checks.
- Document as-installed details, test results, and any deviations or nonconformities.
- All documentation and warranties are disseminated to all stakeholders.

Knowledge Check

ITS devices do not include

- a) CCTV cameras
- b) DMS
- c) Bluetooth and WiFi Detection Units
- d) REM

Session 12: Documentation

Maintenance Documentation

Inspector is responsible for documentation of maintenance records and project is completed per the plan. Inspector should be notified of any emergency maintenance.

Types of Maintenance:

- Emergency
- Preventative

Maintaining:

- Traffic Signals and Poles
- Pedestrian Signals
- Traffic Signal Cabinets
- Other Electronic/Flashing Signs
- Other Aerial Repairs/Maintenance



Session 13: Testing Equipment

Testing Equipment

CCTV

1. Physical Installation Inspection

- Verify pole is installed per plans (orientation, plumb, anchor bolt pattern, height).
- Confirm cabinet installation (mounting, labeling, grounding, clearances).
- Check conduit and pull box installation (depth, routing, sealing, size, fittings).
- Inspect cabling: correct type, proper strain relief, labeling, and protection.
- Ensure proper bonding/grounding of pole, cabinet, camera, and support hardware.
- Confirm mounting hardware is correct, secure, corrosion-resistant, and manufacturer-approved.

2. Electrical Turn-On Testing

- Validate power to the CCTV cabinet (voltage checks, breaker labeling, surge protection).
- Confirm internal cabinet wiring is completed and terminated correctly.
- Check operation of power supplies, converters, or PoE injectors if applicable.
- Verify camera receives proper power (AC, DC, PoE) and turns on without faults.

Testing Equipment

3. Local Communication Testing (Cabinet ↔ Camera)

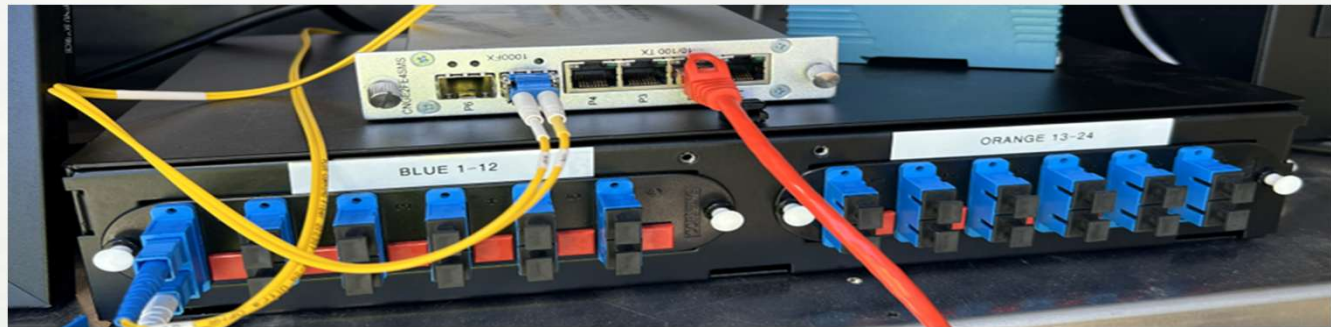
- Confirm proper cabling connection between cabinet and camera (fiber, CAT6, coax, etc.).
- Verify link lights, communication indicators, or device discovery in software.
- Test basic camera operations locally:
 - PTZ control (pan/tilt/zoom)
 - Iris and focus controls
 - Preset creation and recall
 - Camera identification and naming
- Check initial programming/settings per agency standards (resolution, codecs, frame rates).
- Ensure local recording or buffer storage (if used) is functioning.



Testing Equipment

4. Network Communication Testing (Camera ↔ TMC)

- Confirm camera is visible on network maps, switches, or NVR/VMS systems at the TMC.
- Validate IP addressing, VLAN assignment, and device registration.
- Test full remote functionality:
 - PTZ response
 - Iris/focus
 - Presets
 - Video stream quality
- Confirm latency, bandwidth usage, and connection stability.
- Verify that TMC operators can perform the same controls as local cabinet testing.



Testing Equipment

5. Documentation Requirements

- Record test results for local and TMC testing.
- Document serial numbers, IP addresses, MAC addresses, and camera IDs.
- Note as-built cable routes, pull box locations, and fiber strand assignments.
- Log any deficiencies, corrections, or deviations from plans.

Testing Equipment

Wireless Communication Testing

General Responsibilities

- Verify wireless equipment is installed per plans, manufacturer specifications, and agency standards.
- Ensure all components—including radios, antennas, mounts, cabling, and grounding—are properly installed before testing begins.
- Confirm all safety procedures are followed when working near towers, poles, or elevated equipment.

Spectrum Analyzer

- Inspector should verify and document the following
 - Confirm radio frequency (RF) channels are clear and not experiencing interference.
 - Correct frequency, channel width, modulation, and signal strength.
 - Check for unexpected RF noise sources that may affect communication performance.
 - Document baseline RF conditions for project records.

Testing Equipment

Wireless Communication Testing

Power Meter Inspector should verify and document the following

- Used to test transmit and receive power levels from radio devices.
- Ensure radios are transmitting within specified power limits.
- Verify antenna cables are delivering appropriate signal levels without excessive attenuation.
- Confirm power output matches manufacturer and agency requirements.

Continuity Testing Inspector should verify and document the following

- Check continuity of coaxial cables, Ethernet cables, and power conductors feeding wireless devices.
- Ensure no breaks, opens, shorts, or pin-out errors exist.
- Validate proper shielding and cable condition, especially for outdoor-rated installations.
- Confirm connectors are tight, weather-sealed, and professionally terminated.

Testing Equipment

Wireless Communication Testing

Grounding Tests Inspector should verify and document the following:

- Verify all wireless communication equipment—antenna, radio, cabinet, mounts—are bonded to the grounding system.
- Test grounding resistance per project specifications and NEC compliance (typically ≤ 5 ohms or per agency standard).
- Confirm surge protectors and lightning arrestors are properly connected and operational.
- Ensure grounding conductor size and routing meet plans and manufacturer instructions.

System Documentation and Acceptance Inspector should verify and document the following:

- Record all test results and compare them to required specifications.
- Document signal strength, bandwidth, latency, and reliability metrics.
- Confirm successful integration with the traffic signal cabinet and central system (TMC).
- Ensure that all testing forms, photos, and logs are submitted as part of the project's final acceptance documentation.

Testing Equipment

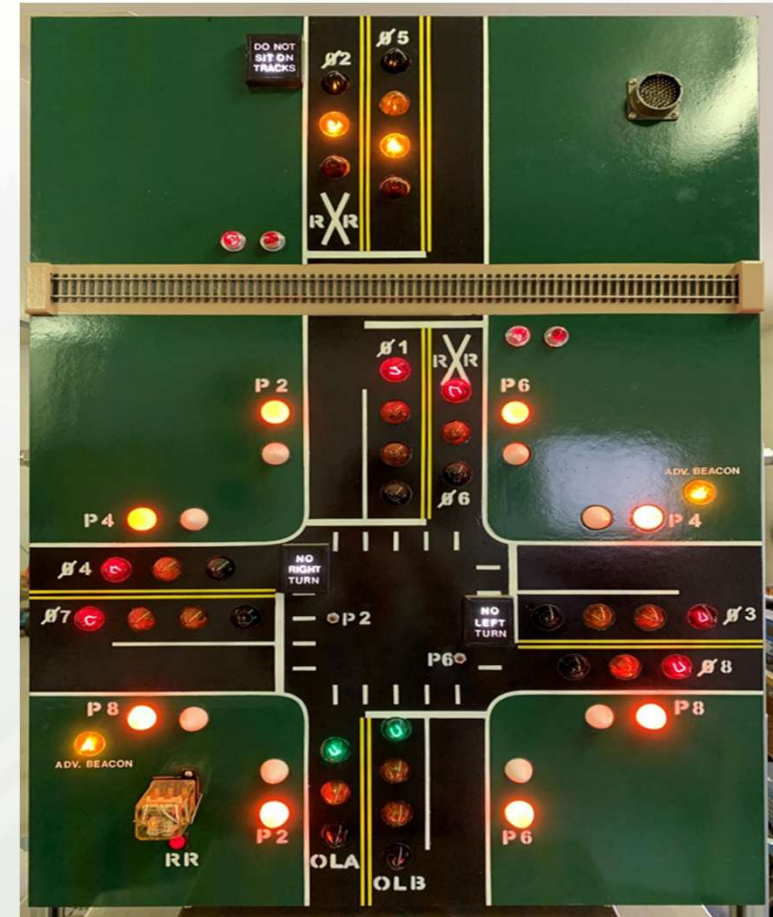
Testing other equipment

Bench Testing Inspector should verify and document the following:

- Verify functionality of signal equipment (controllers, MMUs, load switches) before field installation.
- Use manufacturer test procedures and NEMA/TS standards for acceptable readings.
- Document pass/fail results and compare against asset specifications.
- Confirm firmware versions, configuration settings, and burn-in performance.

Field Testing Inspector should verify and document the following:

- Validate installation workmanship, wiring, grounding, and equipment configuration.
- Confirm detector operations, phase timing (from signal timing chart), pedestrian systems, and communication links.
- Test cabinet safety circuits, conflict monitoring, and proper interconnect.
- Record results in inspection reports required by agency SOPs.



Testing Equipment

Multimeter Inspector should verify and document the following:

- Measure AC/DC voltage, resistance, and continuity for cabinet components.
- Validate power supply outputs, load switch commands, and detector circuit integrity.
- Check grounding and bonding resistance within acceptable range.
- Confirm zero-voltage conditions before handling equipment.

Amprobe / Clamp-On Meter Inspector should verify and document the following:

- Measure current loads on signal heads, pedestrian indications, and cabinet components.
- Verify current draw on load switches and field wiring for abnormal consumption.
- Confirm proper operation of flasher circuits, fans/heaters, and power panels.



Testing Equipment

Ground Rod Tester / Ground Resistance Testing

Inspector should verify and document the following:

- Measure resistance-to-ground per agency or NEC requirements ($<25\Omega$ typical, unless spec differs).
- Confirm signal cabinet grounding system integrity (rod, conductor, bonding).
- Identify high-resistance or corroded ground connections.



Testing Equipment

CMU/MMU Tester (Conflict Monitor Unit / Malfunction Management

Unit / Cabinet Monitor Unit)

Inspector should verify and document the following:

- Test input/output channels for proper voltage levels and flash transfer operation.
- Validate conflict monitoring, dual indication protection, and red fail functionality.
- Confirm programmed settings (voltage thresholds, timing, channel assignments).
- Verify proper logging and reset features.



BIU Tester (Bus Interface Unit)

- Inspector should verify and document the following
- Confirm BIU communications for TS-2 cabinets onSDLC channels.
- Check BIU's channel assignment, addressing, andvoltage levels.
- Validate communication with controller and otherBIUs in the ring.



Testing Equipment

Controller Tester

- Perform timing, phase, and ring/overlap logic verification.
- Validate detector input processing and preemption/priority responses.
- Confirm communication outputs (SDLC, serial, Ethernet) are functioning.
- Verify firmware, configuration, and fail-safe operations.



Load Switch / Switch Pack Tester

- Confirm proper ON/OFF switching, leakage current, and flashing operation.
- Test triac output, channel isolation, and load-handling capability.
- Verify conformance with NEMA TS-1/TS-2 electrical characteristics.

Loop Tester

- Measure inductance and resistance of loops to ensure acceptable range.
- Verify loop continuity, insulation, and proper frequency tuning.
- Identify shorts, opens, and cross-talk between adjacent loops.



Testing Equipment

Surge Suppression Tester

Inspector should verify and document the following:

- Validate performance of surge protection devices (SPD/MOVs).
- Check grounding and bonding to ensure effective surge diversion.
- Identify failed or degraded suppression components.

Megohmmeter (Insulation Resistance Tester)

Inspector should verify and document the following:

- Test the insulation integrity of field wiring (loops, pedestrian wiring, signal cables).
- Identify moisture penetration, deteriorating insulation, or crushed cable.
- Ensure insulation resistance meets agency minimums (often $>50 \text{ M}\Omega$).



Testing Equipment

OTDR (Optical Time Domain Reflectometer)

Inspector should verify and document the following:

- Locate faults, breaks, splices, and connector losses in fiber optic networks.
- Measure distance to reflective events and attenuation levels.
- Provide documentation for as-built fiber performance.

Optical Loss Test Set (OLTS)

Inspector should verify and document the following:

- Measure end-to-end optical power loss through installed fiber links.
- Validate that total system loss meets design requirements.
- Confirm connector quality and cleanliness.



Knowledge Check

The most useful testing tool is a

- a) Multi meter
- b) Omni meter
- c) Ossi meter
- d) Deca meter

Knowledge Check

A ground rod tester should indicate a reading of how many Ohms to ground per the NEC

- a) 35 or less
- b) 30 or more
- c) 25 or less
- d) 25 or more

Knowledge Check

All testing equipment should be tested and certified

- a) Semi Annually
- b) Annually
- c) Every two years
- d) When it fails

Knowledge Check

When a CMU or MMU is bench tested

- a) Ensure that the correct test is applied to the specific model tested
- b) All tests are the same as MMU CMU are basically the same
- c) The test results can be kept by the testing agency and are not needed
- d) As long as the devices passes it can be placed in the back of the signal truck for later installation

Conclusion

IMSA Traffic Signal Glossary

Glossary of Terms

Accessible Pedestrian Signal – a device that communicates information about pedestrian timing in non-visual format such as audible tones, verbal messages, and/or vibrating surfaces. (MUTCD)

Active Grade Crossing Warning System – the flashing-light signals, with or without warning gates, together with the necessary control equipment used to inform road users of the approach or presence of trains at highway-rail grade crossings or highway-light rail transit grade crossings. (MUTCD)

Active Sensor – a sensor that transmits energy, a portion of which is reflected or scattered from a vehicle or other objects and surfaces in its detection zone, back toward the receiving aperture of the sensor.

Actuated Traffic Signal Controller – the computer in the cabinet that receives vehicle detection and/or pedestrian sensors to improvise appropriate signal timing. It is not a pre-timed computer.

Actuated Operation – a type of traffic control signal operation in which some or all signal phases are operated on the basis of actuation. (MUTCD)

Actuation – initiation of a change in or extension of a traffic signal phase through the operation of any type of detector. (MUTCD)

Advanced Transportation Controller (ATC) – a standardized effort intended to provide an architecture hardware and software platform that can support a wide variety of Intelligent Transportation Systems (ITS) applications including traffic management, safety, security and others. The ATC Standards are being developed and maintained under the direction of the ATC Joint Committee (JC) which is made up of representatives from the American Association of State Highway and Transportation Officials (AASHTO), the Institute of Transportation Engineers (ITE), and the National Electrical Manufacturers Association (NEMA). (ITE Standards)

Glossary of Terms

Alternating Current (ac) – a current that reverses its magnitude and direction of flow at regular intervals. The rate of reversal is expressed in hertz (cycles per second).

American Wire Gauge (AWG) – is a standardized wire gauge system used since 1857 for the diameters of round, solid, nonferrous, electrically conducting wire. (American Society for Testing and Materials)

Americans with Disabilities Act of 1990 (ADA) – requirements ensuring equal opportunity for persons with disabilities in employment, State and local government services, public accommodations, commercial facilities, and transportation. (ADA)

Ampere – the unit expressing the rate of flow of electrons through a conductor. One ampere is the current flowing through a 1-ohm resistance with 1-volt pressure.

Analog – an electronic design that uses continuously varying voltages, rather than discrete digital values.

Approach – all lanes of traffic moving towards an intersection or a midblock location from one direction, including any adjacent parking lane(s). (MUTCD)

Approved Product List – Also known as APL or also known as the Qualified Products List (QPL), is a list of traffic control devices, signal hardware, and ITS equipment pre-approved

Arterial – a main street generally considered to be a thoroughfare with preferential right-of-way.

Auxiliary Equipment – separate devices used to add supplementary features to a controller assembly (NEMA).

Average Day – a day representing traffic volumes normally and repeatedly found at a location; typically, a weekday when volumes are influenced by employment or a weekend day when volumes are influenced by entertainment or recreation. (MUTCD)

Glossary of Terms

Back Panel – a board within the controller cabinet upon which are mounted field terminals, fuse receptacles or circuit breakers, and other portions of the controller assembly not included in the controller unit or auxiliary devices.

Background Cycle – cycle length run at the master controller that, once at the start of the cycle, outputs the system reference to the local controllers. May also be run at a controller operating TBC, which supervises the actuated operation of the intersection.

Band (Green Band) – through or green elapsed time between the first and last possible vehicle permitted through an intersection on a progressive coordination system.

Beacon – a highway traffic signal with one or more signal sections that operates in a flashing mode. (MUTCD)

Cable – a group of separately insulated conductors wrapped together and covered with an outer jacket.

California Department of Transportation (Caltrans) – manages more than 45,000 miles of California's highway and freeway lanes, provides inter-city rail services, permits more than 400 public-use airports and special-use hospital heliports, and works with local agencies. Caltrans carries out its mission of improving mobility across California with six primary programs: Aeronautics, Highway Transportation, Mass Transportation, Transportation Planning, Administration and the Equipment Service Center. (California Department of Transportation)

Call – a registration demand for right-of-way by traffic and controlling unit (NEMA). A call comes to the controller from a detector at the intersection upon vehicle approach. The approach is defined by both the distance and direction of travel.

Glossary of Terms

Canadian Electrical Code (CEC), CE code, or CSA C22.1 code – since 1927, the Canadian Standards Association's (CSA's) Canadian Electrical Code has provided the signature standards for addressing shock and fire hazards of electrical products in Canada which is regularly updated to address changing technology and operating conditions. (CSA)

Changeable Message Sign (CMS) – also known as Variable Message Sign (VMS) or Dynamic Message Sign (DMS). CMSs are traffic control devices used for traffic warning, regulation, routing and management, and are designed to affect the behavior of motorists (thus improve the flow of traffic) by providing real-time highway related information. (ITS)

Circuit – a closed path followed by an electric current.

Coil – a coiled conductor, wound on a core, which uses electromagnetic induction to cause changes in a current.

Conductor – a medium for transmitting electrical current. A conductor usually consists of copper or other electrically conductive materials.

Conflict Monitor Unit (CMU) – a device used to detect and respond to improper or conflicting signal indications and improper operating voltages in a traffic controller assembly. Monitors “faults” in controller operation (such as conflicting phases), monitors condition of controller (voltage and programming). (MUTCD)

Conflicting Phases – two or more traffic phases which will cause interfering (i.e., conflicting) traffic movements if operated concurrently.

Controller Assembly – a complete electrical device mounted in a cabinet for controlling the operation of a highway traffic signal. (MUTCD)

Glossary of Terms

Controller Unit – part of the controller assembly that is devoted to the selection and timing of the display of signal indications. (MUTCD)

Also referred to as the **Dispatcher** or **Timer**. Another controller class (i.e., Type 170, 179, and 2070) standardizes hardware modules and uses specialized software to implement traffic management functions.

Cross Talk – the adverse interaction from two channels on the same amplifier on each other from sensors in the road. Crosstalk can occur via mutual coupling of magnetic fields in nearby inductive loops.

Crosswalk – Any portion of a roadway at an intersection or elsewhere distinctly indicated as a pedestrian crossing by lines on the surface, which may be supplemented by a contrasting pavement texture, style, or color. (MUTCD)

Cycle Length – the time required for one complete sequence of signal indications. (MUTCD)

Dark Mode – the lack of all signal indications at a signalized location. The dark mode is most associated with power failures, ramp meters, beacons, and some moveable bridge signals. (MUTCD)

Demand – the request for service, e.g., one or more vehicles desiring to use a given segment of roadway during a specified unit of time.

Demand Operation – a mode of operation whereby the service provided at an intersection reflects the presence of demand for that service without regard to background cycles. (Traffic Detector Handbook, Third Edition, Volume II)

Density – a measure of the concentration of vehicles, stated as the number of vehicles per mile per lane.

Department of Transportation (DOT) – Established in 1966 as a federal Cabinet department of the United States government concerned with transportation. The Department's mission is to serve the United States by ensuring a fast, safe, efficient, accessible and convenient transportation system that meets our vital national interests and enhances the quality of life of the American people, today and into the future. (DOT)

Glossary of Terms

Detection Zone – that area of the roadway within which a vehicle will be detected by a vehicle sensor (NEMA). Also referred to as: zone of detection, sensing zone, area of detection, detection area, effective loop area, field of influence, field of view, or footprint.

Detector – a device used for determining the presence or passage of vehicles or pedestrians. (MUTCD)

Detector Amplifier (or Electronics Unit) – An electronic device that energizes the wire loop(s), monitors the loop(s) inductance by filtering and amplifying the signals it receives, and responds to a predetermined decrease in inductance with an output that indicates the passage or presence of vehicles in the detection zone.

Direct Current – an electric current that is time-independent or, by extension, periodic current the direct component of which is of primary importance.

Dual-Arrow Signal Section – a type of signal section designed to include both a yellow arrow and a green arrow. (MUTCD)

Emergency Vehicle Traffic Control Signal – a special traffic control signal that assigns the right-of-way to an authorized emergency vehicle. (MUTCD)

Equal Employment Opportunity (EEO) – prohibits specific types of job discrimination in certain workplaces. (U.S. Department of Labor)

Flasher – a device used to turn highway traffic signal indications on and off at a repetitive rate of approximately once per second. (MUTCD)

Flashing Mode – a mode of operation in which at least one traffic signal indication in each vehicular signal face of a highway traffic signal is turned on and off repetitively. (MUTCD)

Glossary of Terms

Frequency-Modulated Continuous Wave (FMCW) – is a radar system where a known stable frequency continuous wave energy is modulated by a triangular modulation signal so that it varies gradually and then mixes with the signal reflected from a target object (vehicle) with this transmit signal to produce a detection.

Fully-Actuated Operation – a type of traffic control signal operation in which all signal phases function on the basis of actuation. (MUTCD)

High-Density Polyethylene (HDPE) or Polyethylene High-Density (PEHD) – a type of conduit used in traffic signals installations (typically in drilling installations), made of a dense, economical, hydrocarbon-plastic having good moisture barrier and chemical resistance but low gas barrier properties.

Highway Traffic Signal – a power operated traffic control device by which traffic is warned or directed to take some specific action. These devices do not include signals at toll plazas, power-operated signs, illuminated pavement markers, warning lights, or steady-burn electric lamps. (MUTCD)

Institute of Transportation Engineers (ITE) – an international educational and scientific association of transportation professionals who are responsible for meeting mobility and safety needs. ITE facilitates the application of technology and scientific principles to research, planning, functional design, implementation, operation, policy development and management for any mode of transportation. (ITE)

Intelligent Transportation Systems (ITS) – improves transportation safety and mobility and enhances productivity through the use of advanced information and communications technologies. ITS encompass a broad range of wireless and wire line communications-based information and electronics technologies. (ITS)

Glossary of Terms

International Municipal Signal Association (IMSA) – Organization 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. (IMSA)

Intersection – (a) the area embraced within the prolongation or connection of the lateral curb lines, or if none, the lateral boundary lines of the roadways of two highways that join one another at, or approximately at, right angles, or the area within which vehicles traveling on different highways that join at any other angle might come into conflict; (b) the junction of an alley or driveway with a roadway or highway shall not constitute an intersection. (MUTCD)

Intersection Control Beacon – a beacon used only at an intersection to control two or more directions of travel. (MUTCD)

Interval – the part of a signal cycle during which signal indications do not change. (MUTCD)

Interval Sequence – the order of appearance of signal indications during successive intervals of a signal cycle. (MUTCD)

Lane-Use Control Signal – a signal face displaying signal indications to permit or prohibit the use of specific lanes of a roadway, or to indicate the impending prohibition of such use. (MUTCD)

Light-Emitting Diode (LED) – a solid-state device embodying a PN junction, emitting optical radiation when excited by an electric current. LED is a PN junction semiconductor device that, by spontaneous emission, emits incoherent optical radiation by injecting electrons and/or holes across the PN junction.

Locking Detection Memory – a selectable feature of the circuit design for a controller phase, whereby the call of a vehicle arriving on the red (or yellow) is remembered or held by the controller after the vehicle leaves the detection area until it has been satisfied by the display of a green interval to that phase.

Glossary of Terms

Loop Detector – an active sensor partly composed of wire wrapped in one or more circles and embedded in the pavement of a traffic lane, whose inductance decreases in response to the passage or presence of a (metallic) vehicle in the detection area that it creates.

Magnetic Detector – a passive device that senses changes in the Earth's magnetic field caused by the movement of a ferrous-metal vehicle in or near its detection zone. It is placed under or in the roadway to detect the passage of a vehicle over the sensor. These sensors generally detect only moving vehicles. Also known as induction and search coil magnetometers.

Major Street – the street normally carrying the higher volume of vehicular traffic. (MUTCD)

Malfunction Management Unit (MMU) – a device used to continually check for the presence of conflicting signal indications and other malfunctions and to provide an output response to conflict or malfunction. MMU is an advanced type of conflict monitor that also communicates and monitors controller function.

Manual on Uniform Traffic Control Devices (MUTCD) – defines the standards used by road managers nationwide to install and maintain traffic control devices on all streets and highways.

The MUTCD is published by the Federal Highway Administration (**FHWA**) under 23 Code of Federal Regulations (CFR), Part 655, Subpart F. (MUTCD)

Manual of Uniform Traffic Control Devices for Canada (MUTCDC) – published by the Transportation Association of Canada (**TAC**), defines the standards used by road managers nationwide to install and maintain traffic control devices on all streets and highways in Canada. (MUTCDC)

Glossary of Terms

Master – a control device for supervising TOD (time of day) changes of cycle lengths, offsets and splits, monitoring a system of secondary local controllers, maintaining time and date to all secondary controllers and/or accomplishing other supervisor functions. In the case of traffic responsive operation, the master generally includes computation and recording equipment. The master is also able to upload and download secondary databases.

Module – a packaged circuit or device easily removed without tools and contains a specified function. Frequently is duplicated to handle similar functions in different areas such as phase modules, load switch modules, etc. (Missouri DOT Engineering Policy Guide, Section 902.12, Glossary)

Megohmmeter (Megger) – A device used by power companies to measure very high resistance to earth ground.

Megohm – one million ohms, which is the unit of electrical resistance.

Minor Street – the street normally carrying the lower volume of vehicular traffic. (MUTCD)

National Electrical Code (NEC), or NFPA 70 – is a standard that governs the use of electrical wire, cable, and fixtures, and electrical and optical communications cable installed in buildings. The NEC was developed by the NEC Committee of the American National Standards Institute (**ANSI**), was sponsored by the National Fire Protection Association (**NFPA**) and is identified by the description ANSI/NFPA 70-XXXX, the last four digits representing the year of the NEC revision. (ITS)

National Electrical Manufacturers Association (NEMA) – is a trade association of choice for the electrical manufacturing industry. Founded in 1926 and headquartered near Washington D.C., its approximately 450 member companies manufacture products used in the generation, transmission and distribution, control and end-use of electricity. These products are used in utility, medical imaging, industrial, commercial, institutional, and residential applications. (NEMA)

Glossary of Terms

Non-Locking Memory – a mode of actuated controller unit operation that does not require memory (NEMA). In this mode of operation, the call of a vehicle arriving on the red (or yellow) is forgotten or dropped by the controller as soon as the vehicle leaves the detection area.

Occupancy – the percentage of time a sensor's detection zone is occupied. Occupancy is a pseudo-measure of density on a roadway. (Traffic Detector Handbook, Third Edition, Volume II)

Offset – the time difference or interval in seconds or percentage of a cycle length between the start of the green indication of the coordinated phase and the system reference signal. This can be seen by watching Main Street GREEN at one intersection and the offset time when the next downstream intersection Main Street GREEN is on.

Passage Detection – the ability of a vehicle sensor to detect the passage of a vehicle moving through the detection zone and to ignore the presence of a vehicle stopped within the detection zone (NEMA).

Pedestrian Change Interval – an interval during which the flashing UPRAISED HAND (symbolizing DON'T WALK) signal indication is displayed. When a verbal message is provided at an accessible pedestrian signal, the verbal message is "wait." (MUTCD)

Pedestrian Clearance Time – the time provided for a pedestrian crossing in a crosswalk, after leaving the curb or shoulder, to travel to the far side of the traveled way or to a median. (MUTCD)

Pedestrian Signal Head – a signal head, which contains the symbols WALKING PERSON (symbolizing WALK) and UPRAISED HAND (symbolizing DON'T WALK), that is installed to direct pedestrian traffic at a traffic control signal. (MUTCD)

Glossary of Terms

Permissive Mode – a mode of traffic control signal operation in which, when a CIRCULAR GREEN signal indication is displayed, left or right turns are permitted to be made after yielding to pedestrians and/or oncoming traffic.

(MUTCD)

Phase – a traffic signal phase may have different meanings in traffic signal terminology: also see Signal Phase

- NEMA defines a **Vehicular phase** as a time period that is allocated to one specific vehicular traffic movement (e.g., eastbound through traffic).

Phase Sequence – the predetermined order of which one vehicular movement follows another. Determines which vehicular movement gets the green light and in which order.

Platoon – a group of vehicles or pedestrians traveling together as a group, either voluntarily or involuntarily, because of traffic signal controls, geometrics, or other factors. (MUTCD)

Polyvinyl Chloride (PVC) – a type of conduit used in traffic signal installation; it is a thermoplastic material. Thermoplastic materials are those that can be melted again and again. PVC is commonly used in the construction, industrial, and healthcare sector.

Preemption Control – the transfer of normal operation of a traffic control signal to a special control mode of operation. (MUTCD)

Presence Detection – the ability of a vehicle sensor to detect a moving or stopped vehicle in its detection zone.

Presence Loop Detector – an inductive loop detector that can detect the presence of a standing or moving vehicle in any portion of the effective loop area (ITE).

Glossary of Terms

Pretimed Operation – a type of traffic control signal operation in which none of the signal phases function on the basis of actuation. (MUTCD)

Priority Control – a means by which the assignment of right-of-way is obtained or modified. (MUTCD)

Protected Mode – a mode of traffic control signal operation in which left or right turns are permitted to be made when a left or right GREEN ARROW signal indication is displayed. (MUTCD)

Pushbutton – a button to activate pedestrian timing. (MUTCD)

Pushbutton Locator Tone – a repeating sound that informs approaching pedestrians that they are required to push a button to actuate pedestrian timing and that enables pedestrians who have visual disabilities to locate the pushbutton. (MUTCD)

Queue Length – number of vehicles stopped or slowly moving in a line, where the movement of each vehicle is constrained by that of the lead vehicle.

Ramp Control Signal – a highway traffic signal installed to control the flow of traffic onto a freeway at an entrance ramp or at a freeway-to-freeway ramp connection. (MUTCD)

Ramp Meter – see Ramp Control Signal. (MUTCD)

Recall – an operational mode for an actuated controller whereby a phase, either vehicle or pedestrian, is displayed each cycle whether demand exists for it or not. Recall is placed into operation usually in a temporary or emergency situation.

Red Clearance Interval – an optional interval that follows a yellow change interval and precedes the next conflicting green interval. (MUTCD)

Glossary of Terms

Right-of-Way (Assignment) – the permitting of vehicles and or pedestrians to proceed in a lawful manner in preference to other vehicles or pedestrians by the display of signal indications. (MUTCD)

Ring – two or more sequentially timed and individually selected conflicting phases so arranged as to occur in an established order.

Roadway Network – a geographical arrangement of intersecting roadways. (MUTCD)

Semi-actuated Operation – a type of traffic control signal operation in which at least one, but not all, signal phase's function based on actuation. (MUTCD)

Separate Left-Turn Signal Face – a signal face, for controlling a left turn movement that sometimes displays a different color of circular signal indication than the adjacent through signal faces display. (MUTCD)

Shared Left-Turn Signal Face – a signal face, for controlling both a left turn movement and the adjacent through movement that always displays the same color of circular signal indication that the adjacent through signal face or faces display. (MUTCD)

Signal Backplate – a thin strip of material that extends outward from and parallel to a signal face on all sides of a signal housing to provide a background for improved visibility of the signal indications. (MUTCD)

Signal Coordination – the establishment of timed relationships between adjacent traffic control signals. (MUTCD)

Signal Face – that part of a traffic control signal provided for controlling one or more traffic movements on a single approach. (MUTCD)

Signal Head – an assembly of one or more signal sections. (MUTCD)

Signal Housing – that part of a signal section that protects the light source and other required components. (MUTCD)

Glossary of Terms

Signal Indication – the illumination of a signal lens or equivalent device. (MUTCD)

Signal Lens – that part of the signal section that redirects the light coming directly from the light source and its reflector, if any. (MUTCD)

Signal Louver – a device that can be mounted inside a signal visor to restrict visibility of a signal indication from the side or to limit the visibility of the signal indication to a certain lane or lanes, or to a certain distance from the stop line. (MUTCD)

Signal Phase – the right-of-way, yellow change, and red clearance intervals in a cycle that are assigned to an independent traffic movement or combination of movements. (MUTCD)

Signal Section – the assembly of a signal housing, signal lens, and light source with necessary components to be used for providing one signal indication. (MUTCD)

Signal System – two or more traffic control signals operating in signal coordination. (MUTCD)

Signal Timing – the amount of time allocated for the display of a signal indication. (MUTCD)

Signal Visor – that part of a signal section that directs the signal indication specifically to approaching traffic and reduces the effect of direct external light entering the signal lens. (MUTCD)

Signal Warrant – a threshold condition that, if found to be satisfied as part of an engineering study, shall result in analysis of other traffic conditions or factors to determine whether a traffic control signal or other equipment is justified. (MUTCD)

Speed Limit Sign Beacon – a beacon used to supplement a SPEED LIMIT sign. (MUTCD)

Glossary of Terms

Split – a division of the cycle length allocated to each of the various phases or vehicular movements (normally expressed in percent but can also be in seconds).

Split Phasing – serving an intersection one approach at a time.

Steady (Steady Mode) – the continuous illumination of a signal indication for the duration of an interval, signal phase, or consecutive signal phases. (MUTCD)

Stop Beacon – a beacon used to supplement a STOP sign, a DO NOT ENTER sign, or a WRONG WAY sign. (MUTCD)

Terminal – any fitting used for making a convenient electrical connection.

Time-Based Coordination – control systems in which basic coordination is provided by a highly accurate real time clock within the traffic signal controller. This information is used to determine the local signal timing of offset and cycle/split or actuated timing based on the Time-of-Day/Day-of-Week.

Also called **time-based coordinated control**.

Time-of-Day (TOD) – timing plans which are pre-developed based upon traffic counts taken on the roadways. Signal timing usually has a minimum of three different timing plans, those being the A.M. (morning) peak period, P.M. (evening) peak period, and off-peak period. (ITE)

Traffic Control Signal (Traffic Signal) – any highway traffic signal by which traffic is alternately directed to stop and permitted to proceed. (MUTCD)

Transportation Association of Canada (TAC) – is a national association with a mission to promote the provision of safe, secure, efficient, effective, and environmentally and financially sustainable transportation services in support of Canada's social and economic goals. (TAC)

Glossary of Terms

Transportation Electrical Equipment Specifications (TEES) – This publication contains specifications for transportation electrical equipment, with focus on Intelligent Transportation Systems (ITS). Included are specifications for the following type of equipment: general, enhanced controller unit and associated modules, auxiliary and ITS cabinet units, detector sensor units, elements and isolator models, ITS cabinet assembly, and peripheral and controller.

Twisted Pair – two insulated conductors twisted together with each end marked for identification.

Variable Initial Interval – a controller design feature that adjusts the duration of the initial green time interval accordingly to the number of vehicles in the queue.

Vibrotactile Pedestrian Device – a device that communicates, by touch, information about pedestrian timing using a vibrating surface. (MUTCD)

Visibility-Limited Signal Face or Signal Section – a type of signal face or signal section designed (or shielded, hooded, or louvered) to restrict the visibility of a signal indication from the side, to a certain lane or lanes, or to a certain distance from the stop line. (MUTCD)

Volts of Alternating Current (VAC – for 120 VAC) – a measurement of how many volts of alternating current are being carried. Alternating current is current which constantly changes in amplitude, and which reverses direction at regular intervals. (Integrated publishing)

Walk Interval – an interval during which the WALKING PERSON (symbolizing WALK) signal indication is displayed. When a verbal message is provided at an accessible pedestrian signal, the verbal message is “walk sign”. (MUTCD)

Glossary of Terms

Warning Beacon – a beacon used only to supplement an appropriate warning or regulatory sign or marking. (MUTCD)

Yellow Change Interval – the first interval following the green interval during which the yellow signal indication is displayed. (MUTCD)