IMSA Traffic Signal Technician I

STUDENT GUIDE

Revision Date: March 2025

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 Technician gained through job experience and previous training.
- Review the latest concepts of industry standards in an overview format designed to promote group discussion and sharing of ideas.
- Questions should be asked as the presentation is underway and the topic is under discussion – others will benefit from any questions asked!

Course Table of Contents

IMSA Traffic Signal Technician I

Brief History

Advancing the Future of Public Safety

History of IMSA

The International Municipal Signal Association (IMSA) is the oldest known association of its kind in the world. The organization originated in 1896 and counts Thomas A. Edison and the Edison Electric Company among its esteemed members. Today, IMSA certifies tens of thousands of technicians and stands as the most regarded name in public safety.

Advancing the Future of Public Safety

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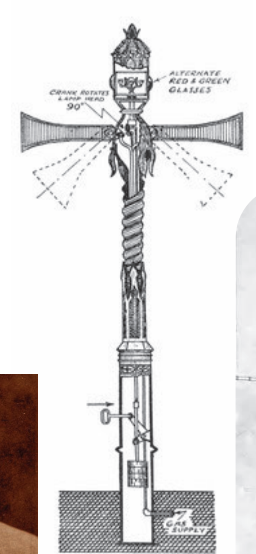
Brief History of Traffic Signals

- The first recorded attempt at regulating traffic flow with a mechanical signal occurred in 1868 in London, England. A gas-lit semaphore tower, designed by railway signaling engineer John Peake Knight, stood at the intersection of Bridge Street and Great George Street. It featured rotating arms with symbols indicating "stop" and "go," providing a rudimentary system of traffic control.

- One of the pivotal milestones came in 1912 when Lester Wire, a Salt Lake City policeman, developed the first electric traffic signal. This novel device, which resembled a large wooden birdhouse, employed red and green lights and a buzzer to guide the flow of vehicles, bringing a semblance of order to the bustling streets.



https://www.kittelson.com/ideas/a-105-year-history-of-the-electric-traffic-signal/

https://en.wikipedia.org/wiki/Lester_Wire

https://www.clevelandpolicemuseum.org/historical/early-electric-traffic-signals/

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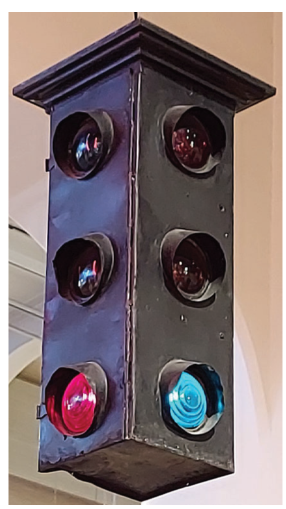
Brief History of Traffic Signals

In 1920, a significant breakthrough occurred with the invention of the three-color signal system by William Potts, a retired Detroit police inspector, who was later coined “Mr. Trafficlight.”

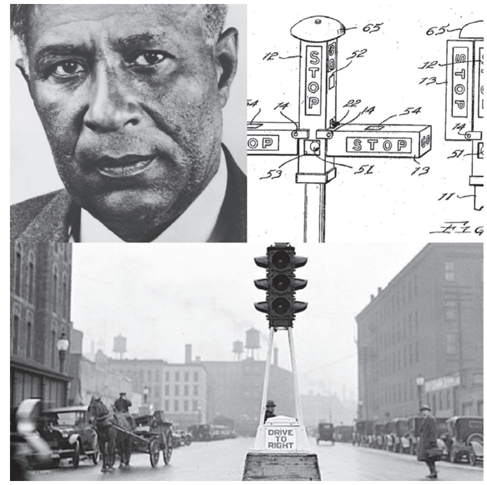
Potts is credited with the first four-way traffic signal. As well as introducing the concept of the amber (or yellow) light, creating a distinct phase that signaled caution, prompting drivers to prepare to stop. The addition of the yellow light added a crucial buffer, preventing sudden and potentially dangerous transitions between the red and green phases.



http://large.stanford.edu/courses/2011/ph240/miller1/docs/moyer/

Brief History of Traffic Signals
- Garrett Augustus Morgan

Garrett Morgan was an African American inventor, businessman, and community leader who made significant contributions to various fields.
One of his most notable inventions was a three-position traffic signal, which greatly improved roadway safety in the early 20th century.
Before Morgan's invention, traffic signals had just two positions: Stop and Go. These simple signals often led to confusion as they didn't provide any buffer between the stopping and going commands, resulting in frequent collisions between vehicles.
Morgan's traffic signal, patented in 1923, added a "warning" position between the Stop and Go signals. This "all directions stop" stage allowed time for vehicles to clear the intersection before others began moving, reducing the risk of crashes. This concept is still used in modern traffic light systems, with the "warning" position now being the yellow or amber light we see today.
In addition to the traffic signal, Morgan is also well known for inventing the Safety Hood (a precursor to the gas mask) that was used to protect firefighters and save countless lives. Despite the widespread use of his inventions, Morgan faced significant racial discrimination during his lifetime, a time when Black inventors rarely received credit or financial reward for their contributions. Despite these challenges, he continued to innovate and serve his community until his death in 1963.



https://www.cnn.com/2023/11/24/us/garrett-morgan-traffic-signal-100-years-reaj/index.html

Brief History of Traffic Signals

Traffic signals have come a long way. Today, traffic signals have become highly sophisticated, incorporating sensors, cameras, and advanced control systems. These intelligent signals can detect vehicle presence, adjust timings based on real-time traffic conditions, and even prioritize certain modes of transportation like buses or pedestrians

IMSA Traffic Signal Technician I

Agencies and Manuals

Advancing the Future of Public Safety

Governing Agencies and Manuals

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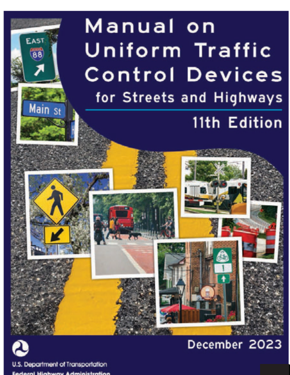
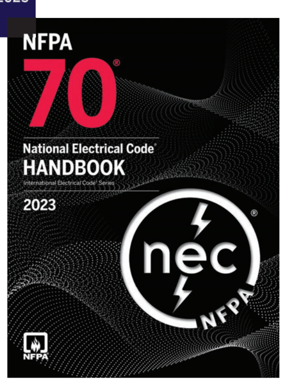
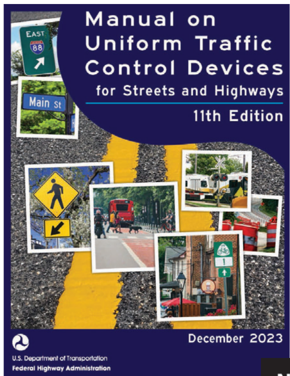
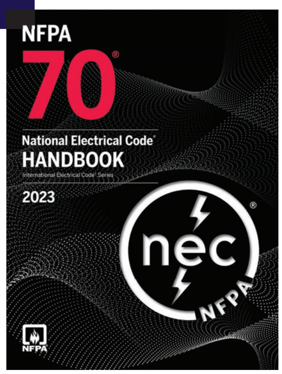




- FHWA (Federal Highway Administration) publishes:
  - SHS (Standard Highway Signs) and the
  - **MUTCD** (Manual on Uniform Traffic Control Devices)
    - Uniformity and Consistency, safety, legal compliance, and efficiency and traffic flow.
- OSHA (Occupational Safety and Health Administration)
  - Worker Safety, Standard Setting, Compliance and Enforcement, whistleblower protection.
  - SDS sheets – safety data sheets for chemicals
- **NEC** (National Electrical Code) published by the
- **NFPA** (National Fire Protection Association)
  - Electrical Safety, National Standards, Electrical System Design, and Installation and Maintenance.

Governing Agencies and Manuals

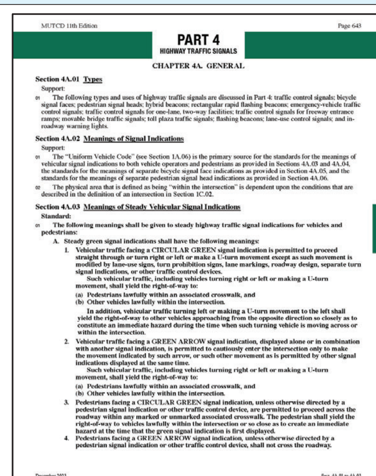




- **IMSA** (International Municipal Signal Association)
- NEMA (National Electrical Manufacturers Association)
  - ➢ Standardization, Safety and Reliability, and Technical Expertise.
- NESC (National Electrical Safety Code)
- CALTRANS/170 (California Department of Transportation)
- ITE (Institute of Transportation Engineers)
- ATCC – Advanced Transportation Controller Cabinet
- ATC - Advanced Transportation Controller

Manual on Uniform Traffic Control Devices - MUTCD

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



MUTCD 11th Edition Page 643

PART 4
HIGHWAY TRAFFIC SIGNALS

CHAPTER 4A. GENERAL

Section 4A.01 Types

Support:

01 The following types and uses of highway traffic signals are discussed in Part 4: traffic control signals; bicycle signal faces; pedestrian signal heads; hybrid beacons; rectangular rapid flashing beacons; emergency-vehicle traffic control signals; traffic control signals for one-lane, two-way facilities; traffic control signals for freeway entrance ramps; movable bridge traffic signals; toll plaza traffic signals; flashing beacons; lane-use control signals; and in-roadway warning lights.

Section 4A.02 Meanings of Signal Indications

Support:

01 The "Uniform Vehicle Code" (see Section 1A.06) is the primary source for the standards for the meanings of vehicular signal indications to both vehicle operators and pedestrians as provided in Sections 4A.03 and 4A.04, the standards for the meanings of separate bicycle signal face indications as provided in Section 4A.05, and the standards for the meanings of separate pedestrian signal head indications as provided in Section 4A.06.

02 The physical area that is defined as being "within the intersection" is dependent upon the conditions that are described in the definition of an intersection in Section 1C.02.

Section 4A.03 Meanings of Steady Vehicular Signal Indications

Standard:

01 **The following meanings shall be given to steady highway traffic signal indications for vehicles and pedestrians:**

A. Steady green signal indications shall have the following meanings:

1. Vehicular traffic facing a CIRCULAR GREEN signal indication is permitted to proceed straight through or turn right or left or make a U-turn movement except as such movement is modified by lane-use signs, turn prohibition signs, lane markings, roadway design, separate turn signal indications, or other traffic control devices.

Such vehicular traffic, including vehicles turning right or left or making a U-turn movement, shall yield the right-of-way to:

(a) Pedestrians lawfully within an associated crosswalk, and
(b) Other vehicles lawfully within the intersection.

In addition, vehicular traffic turning left or making a U-turn movement to the left shall yield the right-of-way to other vehicles approaching from the opposite direction so closely as to constitute an immediate hazard during the time when such turning vehicle is moving across or within the intersection.

2. Vehicular traffic facing a GREEN ARROW signal indication, displayed alone or in combination with another signal indication, is permitted to cautiously enter the intersection only to make the movement indicated by such arrow, or such other movement as is permitted by other signal indications displayed at the same time.

Such vehicular traffic, including vehicles turning right or left or making a U-turn movement, shall yield the right-of-way to:

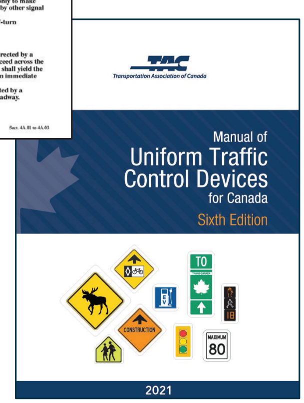
(a) Pedestrians lawfully within an associated crosswalk, and
(b) Other vehicles lawfully within the intersection.

3. Pedestrians facing a CIRCULAR GREEN signal indication, unless otherwise directed by a pedestrian signal indication or other traffic control device, are permitted to proceed across the roadway within any marked or unmarked associated crosswalk. The pedestrian shall yield the right-of-way to vehicles lawfully within the intersection or so close as to create an immediate hazard at the time that the green signal indication is first displayed.

4. Pedestrians facing a GREEN ARROW signal indication, unless otherwise directed by a pedestrian signal indication or other traffic control device, shall not cross the roadway.

December 2023 Sect. 4A.01 to 4A.03

The Manual of Uniform Traffic Control Devices for Canada (MUTCDC) also provides standards and guidelines and promotes similar uniformity across the Canadian provinces.
https://www.tac-atc.ca/en/



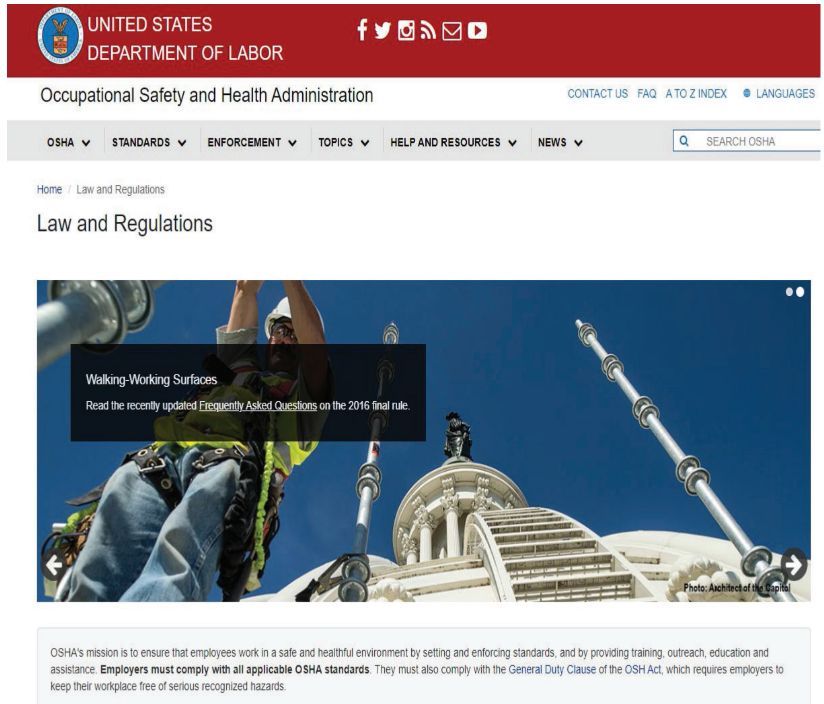
Occupational Safety and Health Administration

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. Record keeping and Reporting
5. Whistleblower Protection
6. Partnerships and Collaboration

https://www.osha.gov/



Safety Data Sheets (SDS)

In 2003, the UN adopted the Globally Harmonized System of Classification & Labeling of chemicals.

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

SDS sheets offer safety information for chemicals you may use in your work environment.

SDS sheets follow a 16-section format:

WD-40 COMPANY

Safety Data Sheet

California CARB Compliant

1 - Identification

Product Name: WD-40 Multi-Use Product Aerosol Product Use: Lubricant, Penetrant, Drives Out Moisture, Removes and Protects Surfaces From Corrosion Restrictions on Use: None identified SDS Date Of Preparation: August 2, 2021	Manufacturer: WD-40 Company Address: 9715 Businesspark Avenue San Diego, California, USA 92131 Telephone: Emergency: 1-888-324-7596 Information: 1-888-324-7596 Chemical Spills: 1-800-424-9300 (Chemtrec) 1-703-527-3887 (International Calls)

2 – Hazards Identification

Hazcom 2012/GHS Classification:
Flammable Aerosol Category 1
Gas Under Pressure: Compressed Gas
Aspiration Toxicity Category 1
Specific Target Organ Toxicity Single Exposure Category 3 (nervous system effects)

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

Label Elements:

- 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 & storage
- Section 8 – exposure controls / PPE
- Section 9 – physical & chemical properties
- Section 10 – stability & 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

National Electrical Code Handbook

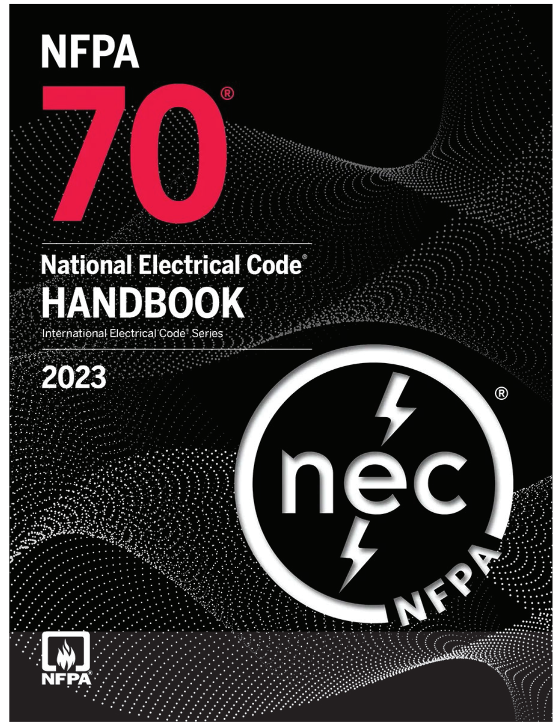
The National Electrical Code (NEC) Handbook is a comprehensive guidebook that provides detailed interpretations, explanations, and additional information to accompany the National Electrical Code.

The NEC Handbook is published by the National Fire Protection Association (NFPA), which is responsible for developing and updating the NEC.

The NEC Handbook 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/codes-and-standards/nfpa-70-standard-development/70

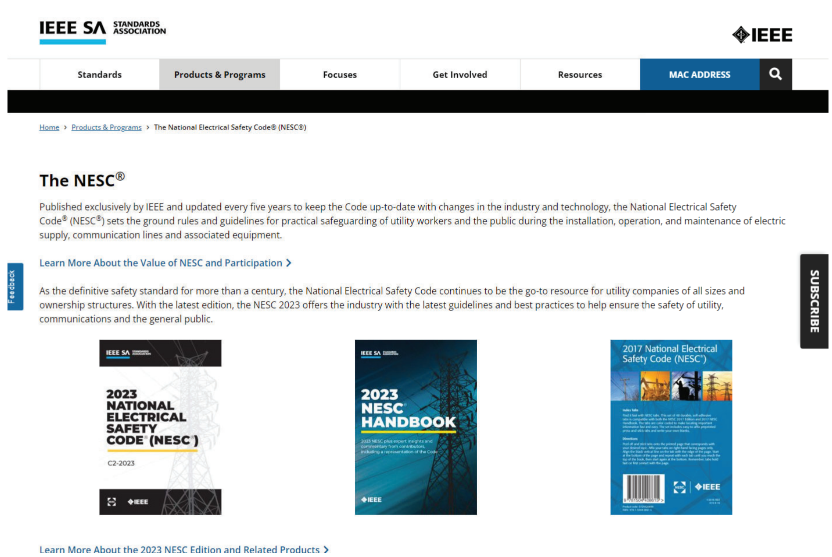


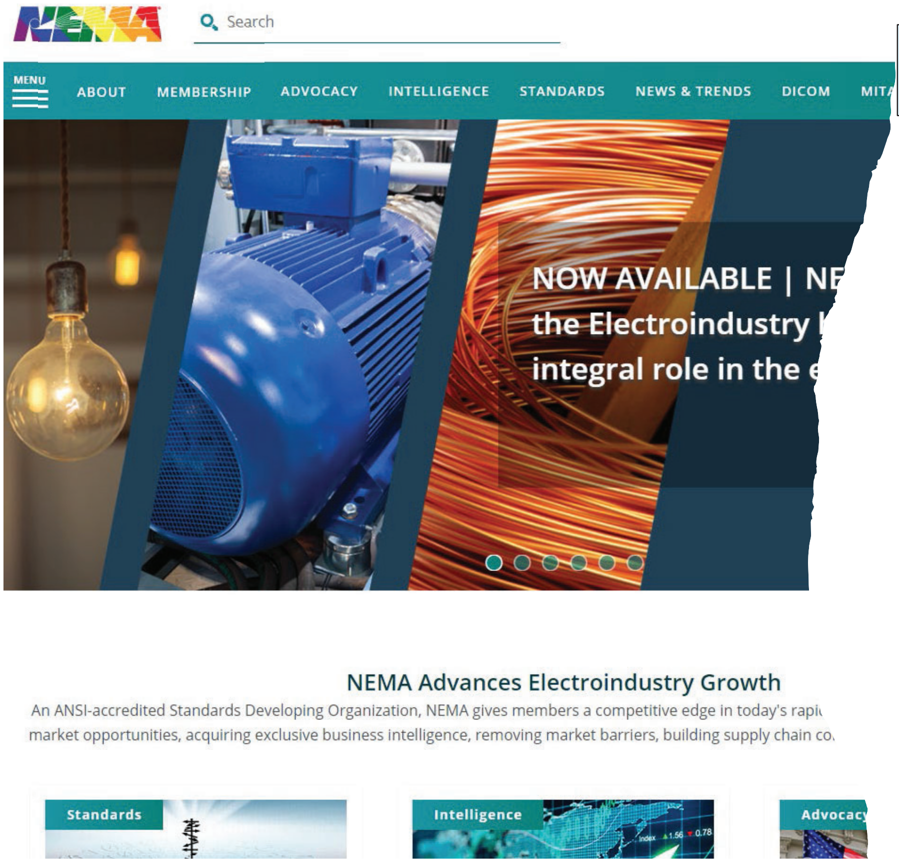
National Electrical Safety Code - NESC

The NESC covers a wide range of topics, including:

1. General Requirements
2. Safety Rules for the Installation and Maintenance of Electric Supply Stations and Equipment
3. Safety Rules for the Installation and Maintenance of Overhead Electric Supply and Communication Lines
4. Safety Rules for the Installation and Maintenance of Underground Electric Supply and Communication Line
5. Work Rules for the Operation of Electric Supply and Communication Lines and Equipment

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





National Electrical Manufacturers Association

The National Electrical Manufacturers Association was founded in 1926.

NEMA is an ANSI-accredited Standards Developing Organization made up of business leaders, electrical experts, engineers, scientists, and technicians.

NEMA convenes a neutral forum for Members to discuss industry-wide concerns and objectives under a legal umbrella by trained NEMA Staff.

https://www.nema.org/

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Knowledge Check: Multiple Choice

Which document determines the hierarchy of utilities on a utility pole?

a) MUTCD

b) NEC

c) NESC

d) OSHA

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Knowledge Check: Multiple Choice

Part four of the ___________ determines all the guidance for traffic signals.

a) MUTCD

b) NEC

c) NESC

d) OSHA

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Knowledge Check: Multiple Choice

What does OSHA stand for?

a) Occupational Health & Safety Administration

b) Operations, Streets, and Highway Administration

c) Occupational Safety & Health Administration

d) None of the above

Knowledge Check: Multiple Choice

Who published and updates the NEC?

a) International Municipal Signal Association

b) National Electrical Manufactures Association

c) Occupational Safety & Health Administration

d) National Fire Protection Association

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Lesson 1: Liability / Legal Responsibility

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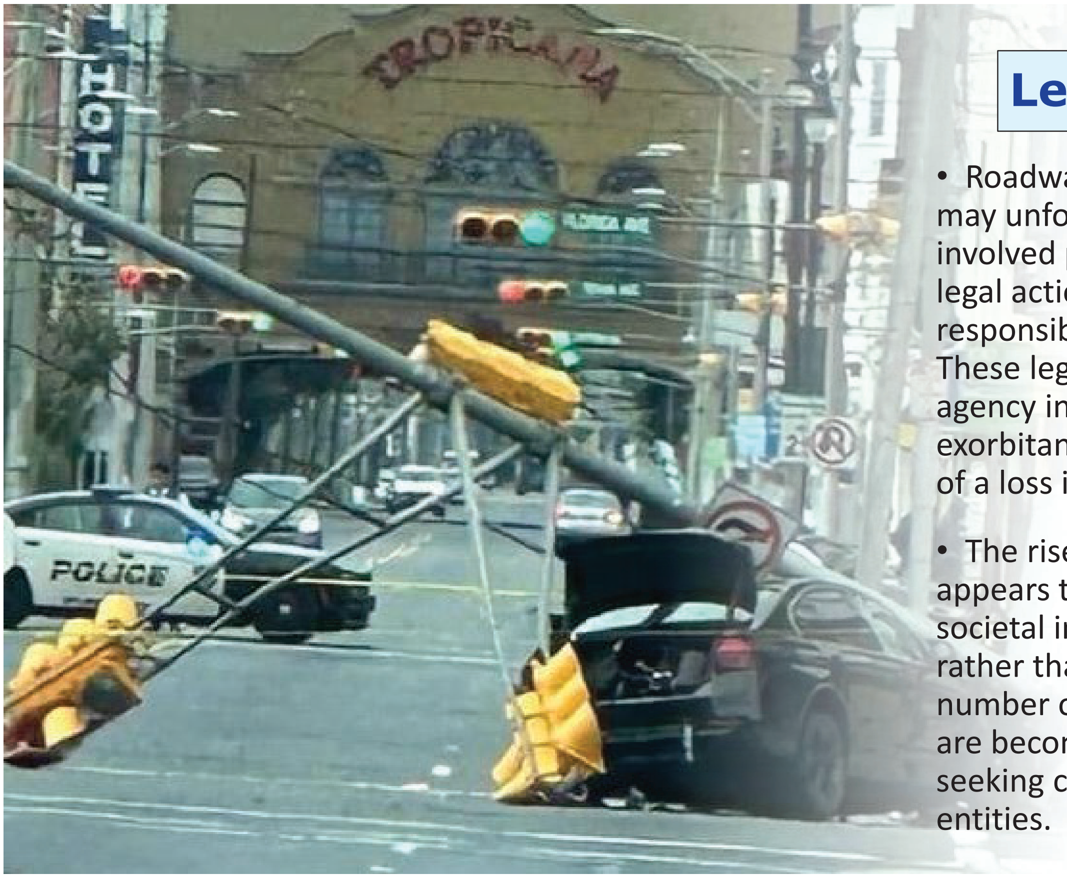

Legal Liability

- Roadway defects leading to accidents may unfortunately result in the involved parties or their families taking legal action against the governing body responsible for the road's upkeep. These legal battles can be costly for the agency involved, potentially leading to exorbitant legal fees and, in the event of a loss in court, substantial damages.

- The rise in legal claims of this nature appears to be more a reflection of a societal inclination towards suing, rather than an actual increase in the number of roadway defects. Attorneys are becoming increasingly proactive in seeking compensation from public entities.

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Legal Liability

Traffic signal technicians who manage the maintenance, testing, or repair of traffic signals bear specific legal liabilities and public safety responsibilities. Their work exposes them to various liabilities, including personal and tort risks. By adhering to established safety protocols and procedures, these technicians can mitigate potential legal risks.

Accidents at signalized intersections have a range of causes. Commonly, they can be traced back to one or more of the following factors:

1. Driver mistakes or distractions, which can be exacerbated by tiredness or impairment.
2. Failures or malfunctions in vehicle equipment.
3. Adverse weather conditions.

Legal Liability

Negligence:

The failure to exercise a reasonable standard of care expected under the circumstances, leading to an increased risk of accidents and harms.

An example of negligence is the agency having jurisdiction does not properly address the malfunctioning intersection.

Gross Negligence:

Refers to a severe degree of carelessness. It occurs when someone's actions or lack of action presents a substantial risk of harm to others because they have not exercised even the most minimal level of care or caution that could reasonably be expected.

An example of gross negligence could be when installing a mast arm the contractor only used two bolts to get the job completed quicker. The arm fell and crushed a car injuring people. Because the proper steps were not taken to complete the work safely, this is an example of gross negligence.

Tort Liability

Tort:

This would be a non-criminal act or failure to act by one party that leads to harm or damages to another party.

An example of this could include situations like not properly maintaining traffic signals, neglecting repairs, or incorrectly installing equipment, which would result in accidents, injuries, or property damage.

Tort Liability

Tort Liability:

Tort liability refers to the legal responsibility of individuals or entities involved in maintaining, installing, or controlling traffic signals for any harm or damages caused by their negligence or wrongful actions. This liability arises when a party fails to fulfill their duty of care in ensuring the proper functioning and maintenance of traffic signals, leading to accidents, injuries, or property damage.

For instance, if a municipality responsible for maintaining traffic signals fails to repair a malfunctioning signal promptly, resulting in a car accident, they may be held liable for any resulting injuries or damages. Similarly, if a contractor improperly installs a traffic signal, leading to confusion or accidents, they could be liable for any harm caused.

Tort liability on traffic signals ensures that those responsible for their maintenance and operation take reasonable precautions to prevent accidents and injuries, and they can be held accountable if they fail to do so.

Knowledge Check: Multiple Choice

Which statement about negligence is correct?

a) Failure to use exact care in one’s actions

b) Failure to use reasonable care in one's actions

c) Failure to act in one’s best interest

d) Failure to act on behalf of the public

Knowledge Check: Multiple Choice

A technician was sent out to an intersection to replace a broken traffic signal head. When he arrived on the scene, he realizes he does not have the proper hardware to reinstall the fixture. He only secures the fixture with two screws and leaves for the evening and forgets to come back to complete the repair.
The fixture falls on a car and causes a serious accident with injuries. This is considered what?

A: Legal Liability

B: Tort Liability

C: Gross Negligence

D: Both B & C

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Lesson 2: PPE and Work Zone Safety

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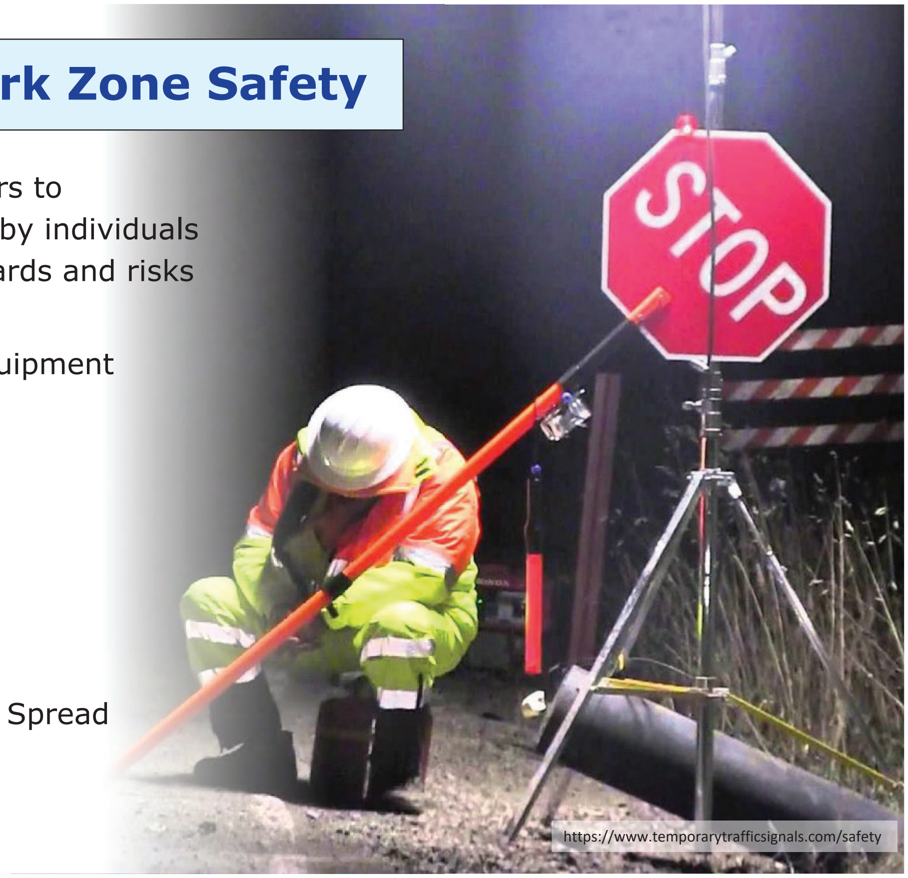
PPE and Work Zone Safety



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

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

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

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Personal Protective Equipment

Personal Protective Equipment you will find as a Signal Tech would be:

- Hard Hat
- Safety Glasses
- Insulated gloves
- Work Boots / safety toe
- High Visibility Retroreflective Safety Vest
- Fall Protection (Harness)
  - With an SRL or shock absorbing lanyard





Personal Protective Equipment

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

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

Here are the classifications:

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

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

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

Work Zone Safety

Work zone safety refers to the measures and practices implemented to ensure the safety of workers, motorists, pedestrians, and equipment in construction or maintenance work zones on roadways.

Key aspects of work zone safety include:

- **Traffic Control**: Proper traffic control measures, including signs, cones, barricades, and flaggers, are essential for directing traffic safely through work zones. Clear and visible signage informs drivers of upcoming changes, lane closures, speed limits, and potential hazards. Sections of the work zone include the advanced warning area, the transition area, the activity area, and the termination area.
- **Flaggers** must always remain in their flagging positions, *but **not like this.*** →
  DO NOT LEAVE YOUR FLAGGING POSITION.
- **Communication**: Effective communication between workers and motorists is critical to ensure awareness of potential dangers and changes in traffic flow. Communication methods such as radio communication, electronic message boards, and temporary signage help convey important information to drivers and workers.

Work Zone Safety

Key aspects of work zone safety include:

- **Work Zone Layout**: The design and layout of work zones should be carefully planned to optimize safety. This includes providing adequate space for equipment and workers, maintaining proper sight distances, and minimizing conflicts between different modes of transportation. Work zones outside the traveled roadway seldom require formal traffic control.
- **Personal Protective Equipment (PPE)**: Workers in work zones must wear appropriate personal protective equipment, such as high-visibility clothing, hard hats, safety glasses, gloves, and safety footwear. PPE helps protect workers from potential hazards and increases their visibility to motorists.
- **Speed Management**: Reduced speed limits are often implemented in work zones to ensure the safety of workers and drivers. Speed reduction measures such as speed bumps, speed enforcement, and speed display devices help promote compliance with posted speed limits.

Work Zone Safety

Setting up an appropriate work zone for traffic signal repair or maintenance requires a variety of parts and devices to ensure the safety of both workers and motorists.

The main goal is to divert traffic effectively and safely around the work zone.

Here's a list of necessary parts and devices:

- 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

Pedestrian Conditions

Ensure safe pedestrian conditions for all nearby crosswalks.

Potential unsafe pedestrian conditions:

1. Obstructed walking paths
2. Potential hazards that should be removed
3. Unsecured work area

Photo credit to Columbiana County, Ohio Newspapers

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

PPE and Work Zone Safety

Bucket Truck Safety Procedures: Here are some basic aspects of bucket truck safety. Please read and follow your individual unit's safety and setup instructions if they differ from this recommendation.

Training: All individuals should be properly trained in the safe operations, use, and setup of the equipment they will be utilizing.

Inspection & Maintenance: Individuals must know how to do inspections on their vehicles to make sure there are no problems with hydraulics, hoses, the bucket, etc.

Fall Protection: Workers using bucket trucks must wear appropriate fall protection equipment, such as harnesses and lanyards, to prevent falls from the bucket or platform. Fall protection systems must be properly anchored and used according to manufacturer guidelines.

PPE and Work Zone Safety

Stability: Bucket trucks should be set up on stable ground and leveled before extending the boom or raising the platform. Outriggers must be deployed to operate the bucket and boom controls. Stabilizers may provide additional stability, especially on uneven terrain or when working at height.

Electrical Safety: When working near power lines or electrical equipment, bucket truck operators should be trained in electrical safety procedures to prevent electrocution hazards. Insulated buckets and tools may be required when working near energized electrical equipment.

Traffic Safety: When working on or near roadways, bucket truck operators should follow traffic control measures and use warning signs, cones, or barricades to alert motorists to the presence of workers and equipment. **When setting up your truck, you should never operate your bucket over the open roadway. You should always utilize a ground person whenever possible. This ensures safety protocols for all.**

Communication: Clear communication between the operator of the bucket truck and any ground workers is essential to coordinate movements and ensure safety during operations.

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Underground Safety

"***Call before you dig***" is another saying for a reason.

- Underground utilities present even more hazards.
- 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

811®

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

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

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Utility Locating Equipment

https://www.acoi.us/3m-product

Very often, signal technicians will need to locate underground traffic signal utilities.

Locating equipment may offer:

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

Damaged Utility Notification

- Secure the area and make it safe for workers and the public.
- Call **911** in the event of a hazard, I.E., gas line fire, electric line explosion…
- Identify the damaged Utility.
- Call 811 to report and create a damaged utility ticket.
  - Know the original locate ticket number.
- Expose the damaged facility ***IF*** it is safe to do so.

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Knowledge Check: Multiple Choice

Which electrical gloves would you use to work near voltages of 1,000 VAC?

a) Class 00

b) Class 0

c) Class 1

d) Class 2

Knowledge Check: Multiple Choice

OSHA mandates that you MUST maintain a minimum of _____ feet clearance from overhead power lines?

a) 3

b) 5

c) 10

d) 15

Knowledge Check: Multiple Choice

Individuals, using arial lift trucks should__________?

a) Be properly trained

b) Inspect their vehicles before every use

c) Wear the appropriate fall protection equipment

d) All of the above

Knowledge Check: Multiple Choice

Which item is NOT part of a Signal Tech's personal protective equipment?

a) Hardhat

b) Gloves

c) Sneakers

d) Harness

Knowledge Check: Multiple Choice

Match each color with the corresponding utility.

Electrical Power Lines	**White**
Communications Lines, Phone, Cable TV, Fiber Optic	**Orange**
Sanitary Sewer & Storm Drains	**Red**
Proposed Excavation	**Yellow**
Natural Gas, Steam, Petroleum, & Oil Lines	**Green**

IMSA Traffic Signal Technician I

Lesson 3: Signal Technician Tools

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Common Tools

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The most commonly used hand tools:

- ❑ Screwdrivers (flathead, phillips)
- ❑ Pliers (lineman's, needle-nose, side-cutters)
- ❑ Wrenches (adjustable, open-end, socket)
- ❑ Utility Knife
- ❑ Cable cutters
- ❑ Wire strippers and crimpers
- ❑ Allen Key (Hex Key)
- ❑ Nut drivers
- ❑ Tape measure
- ❑ Multimeter
- ❑ Hammer
- ❑ Level

The most commonly used power tools:

- ❑ Cordless drill/driver
- ❑ Impact driver
- ❑ Power drill
- ❑ Reciprocating saw
- ❑ Angle grinder
- ❑ Vacuum

This does not list all possible items, but just a simple list of basic items used. Please remember to always have your PPE on when working. (vest, gloves, hard hat, protective glasses, boots, etc.)

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Insulated Tool Set

Dielectric (insulated) Hand Tools:

These include screwdrivers, pliers, wire strippers, and other tools with insulated handles. They are designed to protect the user from electric shock when working with live circuits or components.

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

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Multimeters

An analog meter or a digital multimeter (DMM) is a versatile tool used for electrical troubleshooting and maintenance. It <u>can measure voltage, current, resistance</u>, and a host of other things allowing technicians to test and diagnose electrical issues in traffic signals and roadway lighting systems.

Related Traffic Signal Test Equipment

- **Load Tester –** used to verify the integrity of batteries
- **Fiber Power meter –** used to measure the light loss in a fiber
- **LCR Meter –** measures inductance, capacitance, & resistance
- **TDR/OTDR –** measures anomalies in a wire or optical fiber
- **Megohmmeter –** measures conductor insulation resistance
- **Loop Tester –** measures inductance and frequency
- **Ground Rod Tester –** measures resistance to ground
- **Voltage tester (loaded) –** looks for voltage on a conductor
- **Tone Generator –** place an audible signal on a conductor to locate
- **MMU / CMU Tester -** (certification tester)
- **BIU Tester –** certification tester for the BIU's
- **Load Switch Tester –** verifies the integrity of a load switch

Knowledge Check: Multiple Choice

Which meter would you use to check resistance?

a) An LCR meter

b) A megohmmeter

c) A load tester

d) A multimeter

Knowledge Check: Multiple Choice

Which piece of test equipment would you use to measure the insulation resistance of your conductor?

a) An LCR meter

b) A megohmmeter

c) A load tester

d) A multimeter

Knowledge Check: Multiple Choice

Which piece of equipment would you use to certify your conflict monitor?

a) A Load Tester

b) A Voltage Tester

c) A BIU Tester

d) A MMU/CMU Tester

Knowledge Check: Multiple Choice

Which piece of test equipment is commonly used to measure voltage, resistance and current?

a) A voltage tester

b) A multimeter

c) An amp meter

d) A megohmmeter

Knowledge Check: Multiple Choice

What is **NOT** a commonly used hand tool of a Traffic Signal Technician I?

a) Power Drill

b) Screwdrivers (flathead, Phillip’s)

c) Wire Strippers

d) Pliers (lineman's, needle-nose, side-cutters)

IMSA Traffic Signal Technician I

Lesson 4: Electrical Theory

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Basic Electrical Theory

- **Electrical Safety**
- **Conductors and Insulators**
- **Ohms Law**
- **AC / DC**
- **Series / Parallel**
- **Grounding and Bonding**

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)

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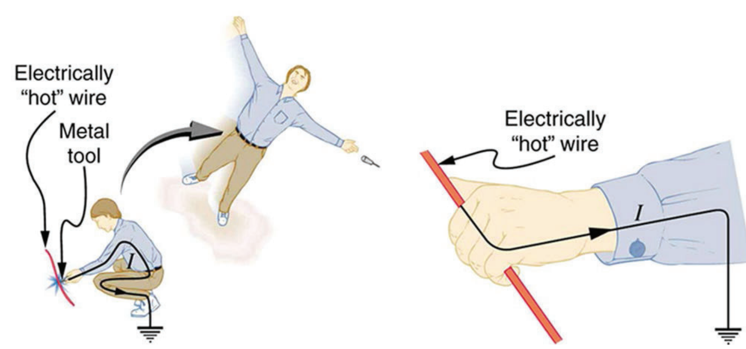
Basic Electrical Theory - Electrical Safety

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 degrees
- The video is in "VERY" slow motion…

Slow Motion 480 Volt Arc Flash

https://www.youtube.com/watch?v=PO6see7_ODY

Basic Electrical Theory - Conductors and Insulators

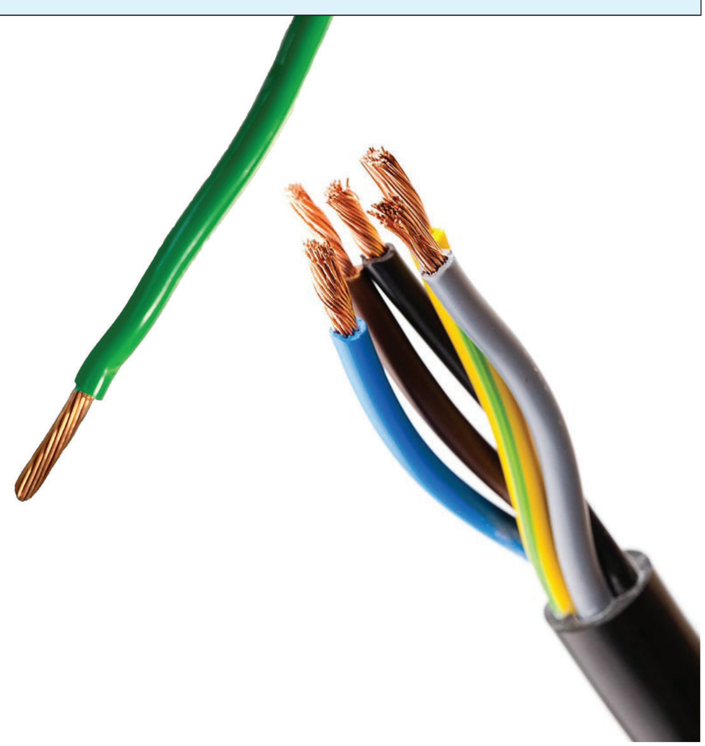
Conductors are materials that conduct electricity.

Most metals are conductors.

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

- Aluminum is also used for electrical wiring.

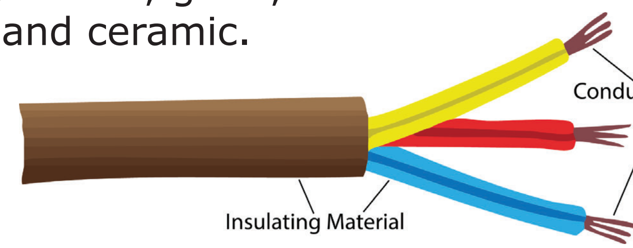
Gold and silver are better conductors than copper but are much more expensive to use for wire; however, these materials are used in electronics.



Basic Electrical Theory - 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.



Basic Electrical Theory - Ohms Law

Understanding electricity

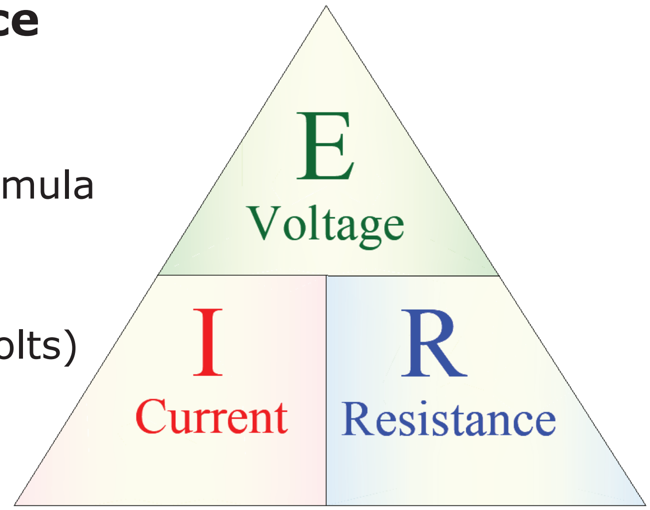
Electricity flowing through wires (conductors) is similar to water flowing through pipes.

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

Basic Electrical Theory -
Ohms Law

Voltage, Current & Resistance

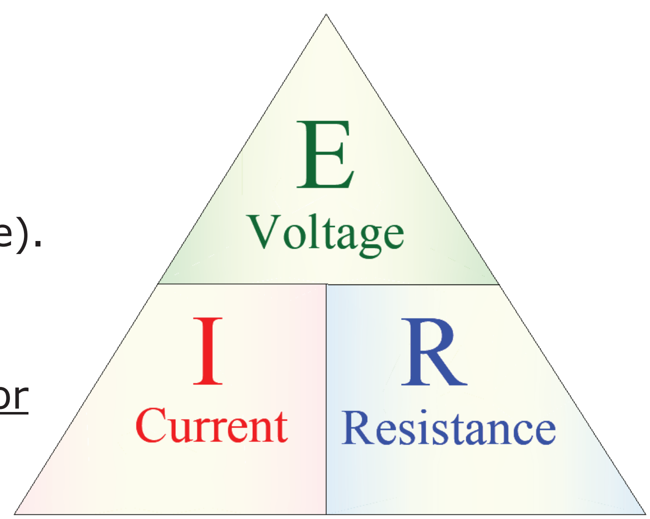
- The basis for Ohms Law
- A ratio comparison that we use as a formula
- **E** = **I** x **R**
  - **E** = **Voltage** (Electromotive Force) (Volts)
  - **I** = **Current** (Intensity) (Amps)
  - **R** = **Resistance** (Ohms)



Basic Electrical Theory -
Ohms Law

When trying to calculate Ohm's Law this is the simplest to understand it:

- Put your thumb over the unit you are trying to solve. Use the other two components to solve your answer.
- Ex: if you put your thumb on E (Voltage). You will multiply I (current) x R (resistance) to get your answer.
- Another example is if you are looking for the resistance you will put your thumb on R. You will then do the following calculation (E/I) E divided by I to get your answer.



Basic Electrical Theory - Power Formulas

Power Formulas

P = I x E

I = P / E

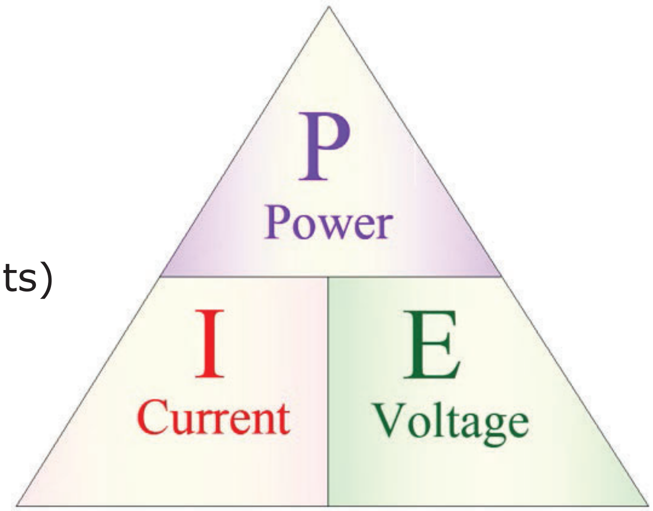
E = P / I

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, & 3-5 VDC**

Basic Electrical Theory - 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.

Basic Electrical Theory - AC / DC

DC – Direct Current

Direct Current (DC) is produced by batteries or power supplies.
Electronic circuits and devices run on DC.
Typical voltages used in electronics are 5 Volts, 12 Volts, and 24 Volts.

Basic Electrical Theory - AC / DC

AC – Alternating Current

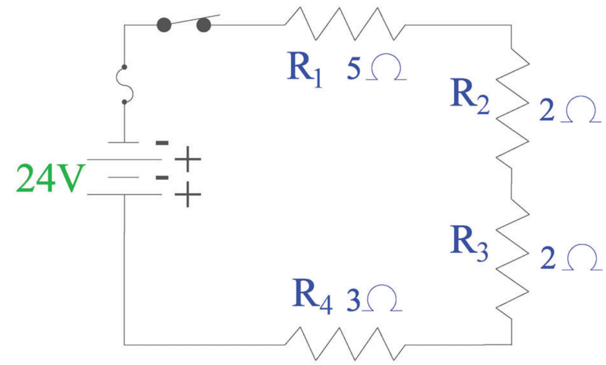
Alternating current (AC) is the type of electricity that powers our homes, businesses and factories, and our traffic signals.
It is generated by various types of generators and distributed through the power grid.
It is typically 120 volts and alternates at 60 cycles per second (60 Hertz).

Basic Electrical Theory - Series

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.



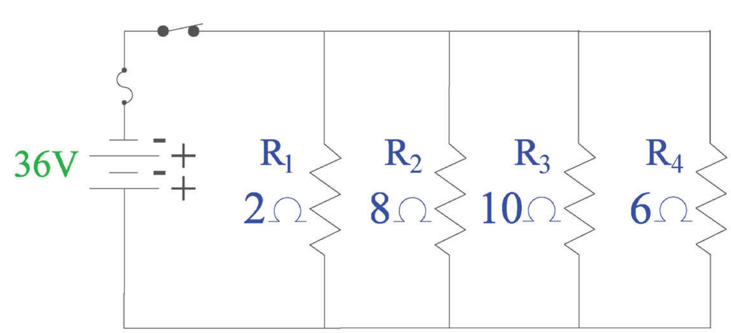
Series Connection

Basic Electrical Theory - Parallel

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.



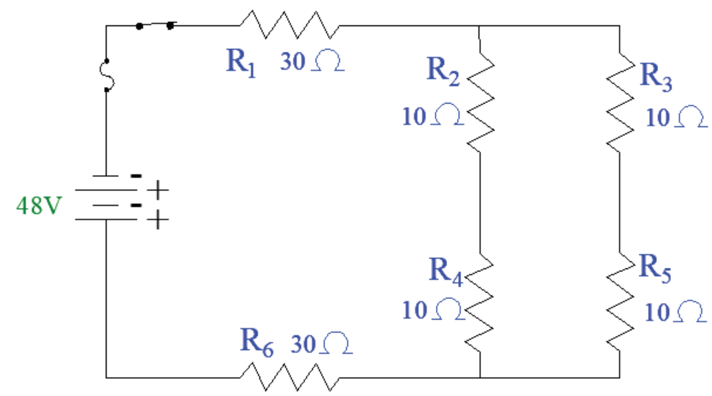
Parallel Connection

Basic Electrical Theory -
Series/Parallel or Combination

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.



Series/Parallel Connection

Basic Electrical Theory -
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.

- Notice how the individual cable tray sections are bonded with jumper wires (4 total)

Basic Electrical Theory - 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.

Basic Electrical Theory - 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.

Basic Electrical Theory -
Grounding and Bonding

Grounding and Bonding

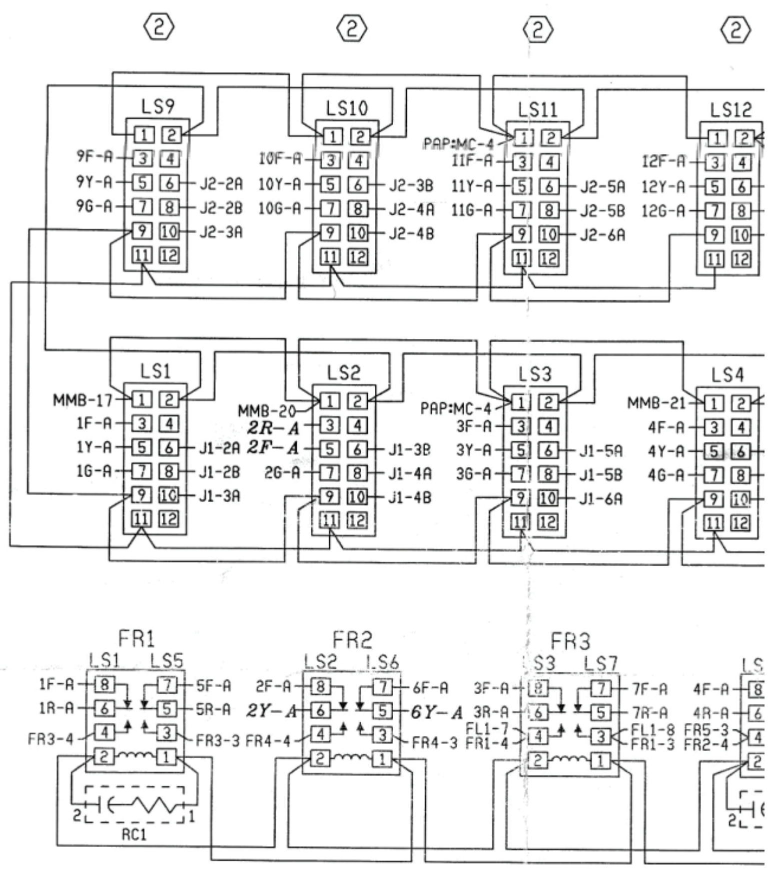
In Section 250.4 of the NEC, it explains how to hook up your electrical systems to keep it safe. If your system uses the ground, you need to connect the power system and all the other items to the ground. You also need to make sure anything that can carry electricity is safely connected, so if something 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.

Wiring Diagrams

A wiring diagram or circuit diagram is also a map that shows every component as a graphical representation and the electrical connections within the circuit for wiring purposes.

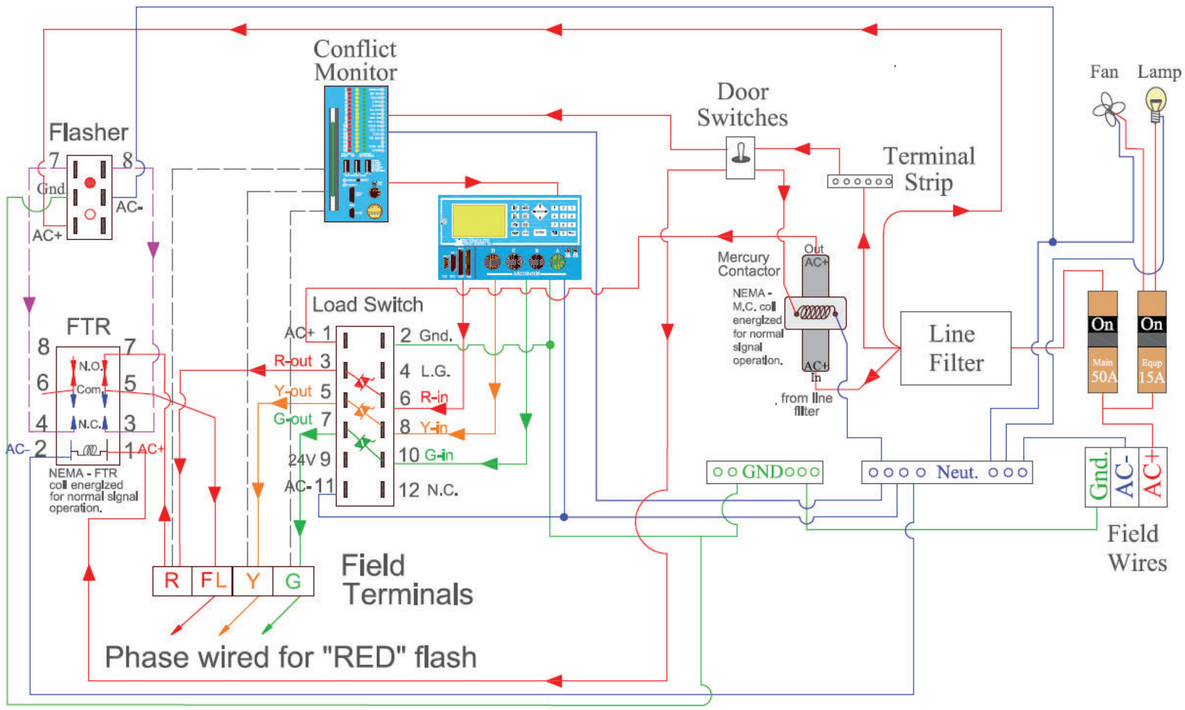
- In a traffic signal cabinet, a wiring diagram would show the load switch, FTR’s, & flasher sockets, the field terminals, the BIU sockets, and all the components on the power distribution panel and all the wiring connections between them.



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)



Knowledge Check: Matching Activity

The left column shows electrical component. The right column shows the explanation of those components using the water flowing through pipes analogy.
Match each component with the comparable explanation.

a) Voltage	1) Size of the pipe
b) Current	2) Water pressure
c) Resistance	3) Water consumed
d) Power	4) Water flow

Knowledge Check: Matching Activity

The left column shows electrical components. The right column shows units of measure for those components.
Match each component with the correct unit of measurement.

a) Electrical pressure	1) Amps
b) Current	2) Watts
c) Resistance	3) Volts
d) Power	4) Ohms

Knowledge Check: Multiple Choice

Ohms law is based on the following formula:

a) E = I x P

b) E = I x R

c) E = R x P

d) I = E x P

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Knowledge Check: Matching Activity

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

1) Series Circuit

2) Parallel Circuit

3) Combination Circuit

a) Voltage remains the same

b) Current remains the same

c) Resistance adds up

d) Power

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Knowledge Check: Multiple Choice

Bonding & grounding means to:

a) Bond everything to ground

b) Bond everything to a difference of electrical potential and then ground it

c) Bond everything to the same electrical potential and then ground it

d) Bond everything to each other

Knowledge Check: Multiple Choice

What is the most common material used in electrical wiring?

a) Aluminum

b) Gold

c) Silver

d) Copper

Knowledge Check: Multiple Choice

Traffic signals typically operate on what type of power?

a) 120 VDC

b) 120 VAC

c) 240 VAC

d) 12 VDC

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Lesson 5: Traffic Signal Operational Concepts

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Engineering Study / Engineering Judgement

Engineering Study:
Study of traffic conditions, pedestrian characteristics, and physical characteristics of the location shall be performed to determine whether installation of a traffic control signal is justified at a location.

Engineering Judgement:
It involves using technical knowledge, principles, and practical judgment to address complex issues and balance various factors in the context of traffic planning, design, operation, and safety. Some examples are:

1. Traffic Signal Timing
2. Roadway Design
3. Traffic Impact Assessments
4. Safety Analysis
5. Intelligent Transportation Systems (ITS)
6. Traffic Control Measures

Engineering Studies - Traffic Signal Warrants

As per the MUTCD 4B.04:

"A careful analysis of traffic operations, pedestrian and bicyclist needs, and other factors at a large number of signalized and unsignalized locations, coupled with engineering judgment, has provided a series of signal warrants, described in Chapter **4C**, that define the minimum conditions under which installing traffic control signals might be justified."

Warrant 1, Eight-Hour Vehicular Volume
Warrant 2, Four-Hour Vehicular Volume
Warrant 3, Peak Hour
Warrant 4, Pedestrian Volume
Warrant 5, School Crossing
Warrant 6, Coordinated Signal System
Warrant 7, Crash Experience
Warrant 8, Roadway Network
Warrant 9, Intersection Near a Grade Crossing

Traffic Signal Operation Theory Flow of traffic at a signalized intersection

Controlling the flow of traffic at a signalized intersection requires a *two-step* process:

- Step #1 – Each movement of approaching traffic to be controlled by the traffic signal is assigned a "phase" number
- Step #2 – all the phases must somehow work in unison with each other

Step #1 – The Vehicle Phase

Phase -

A group of controller timing intervals and settings used to control one movement of traffic at a signalized intersection.

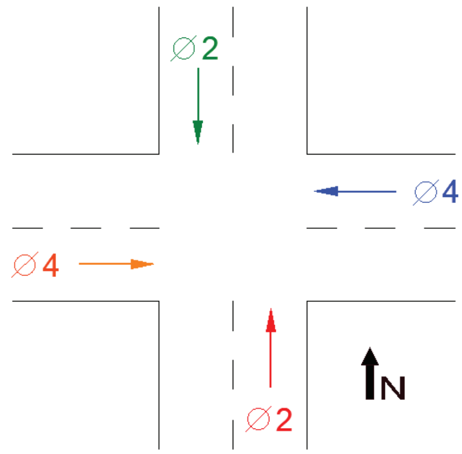
Typical vehicle movements that are controlled by the signal are:

- Straight thru movements
- Left turn movements
- Right turn movements

Vehicle phases are symbolized with "∅"

Vehicle phases are also assigned numbers, typically 1 thru 8

This intersection has four vehicle approaches controlled with two vehicle phases



Step #2 - Rings and Barriers

Ring -

NEMA defines:

"A ring consists of two or more sequentially timed and individually selected conflicting phases so arranged as to occur in an established order".

- Each ring is sequentially timed which means phases in the same ring will *NEVER* be compatible, i.e., always "conflicting"

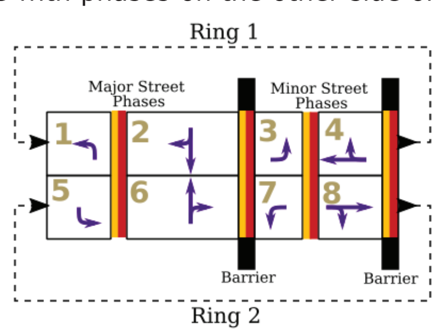
THE RING CONTROLS EVERYTHING

Barrier –

Otherwise known as a "compatibility line", NEMA defines as:

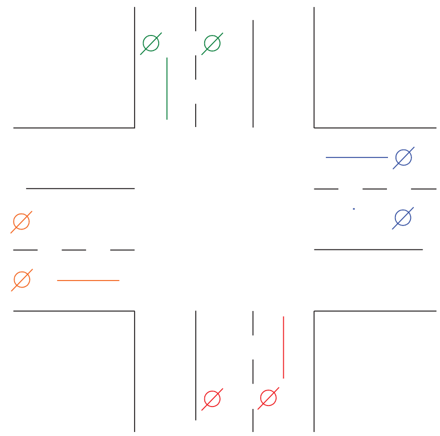
"A reference point in the preferred sequence of a multi-ring controller in which all rings are interlocked."

- Which means the rings must work together by crossing the barrier at the same time.
- Phases on one side of the barrier will never operate with phases on the other side of the barrier



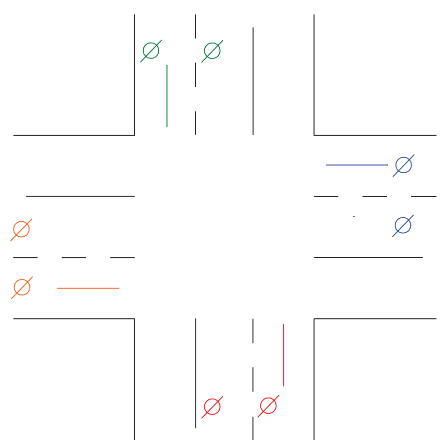
Traffic Signal Operation Theory
Assignment of Phases to Movements of Traffic

- **Standard NEMA phasing:**
  - Odd phase numbers are assigned to the left turn movements; 1,3,5,& 7
  - Even phase numbers are assigned to the thru movements; 2,4,6,& 8
  - Phases 1,2,5,6 are assigned to the Main street movements
  - Phases 3,4,7,8 are assigned to the side street movements
  - Phases rotate around the intersection in a clockwise direction
    - Phase rotation counts the left turn movements separately from the thru movements
  - Compatible and conflicting phase numbers are assigned to compatible and conflicting vehicle movements



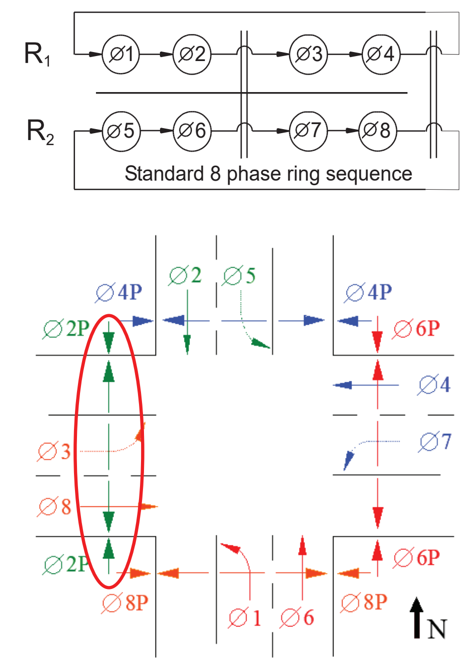
Traffic Signal Operation Theory
Assignment of Phases to Movements of Traffic

- The 4 phases assigned to the main street is called a concurrent group. 1-2-5-6
- 3-4-7-8 make up the side street concurrent group
- Barriers divide the concurrent groups
- A <u>concurrent</u> phase can be on with another phase in its concurrent group.
- 1 or 2 can be on with 5 or 6.
- 3 or 4 can be on with 7 or 8.



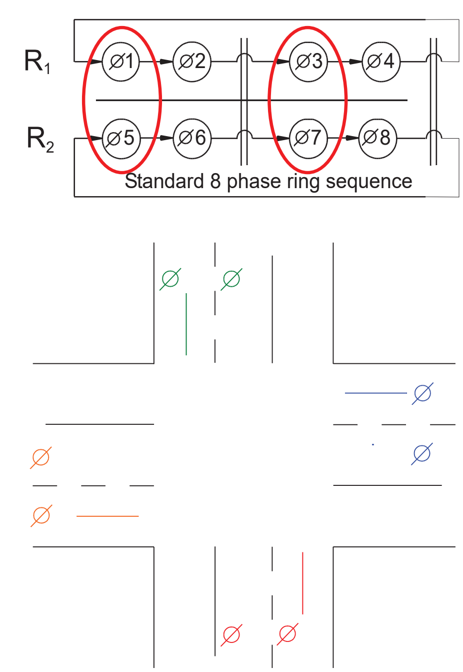
Traffic Signal Operation Theory
Pedestrians

- Pedestrians ***MUST*** be protected from any conflicting vehicle movements that may cross their path.
- For example, a pedestrian crossing the west side of the intersection (north to south):
  - Pedestrians must cross with compatible vehicle phases
  - Therefore, the only active vehicle phase that is compatible with this pedestrian movement is ∅2.
    - Any other active vehicle phase will conflict with this pedestrian movement



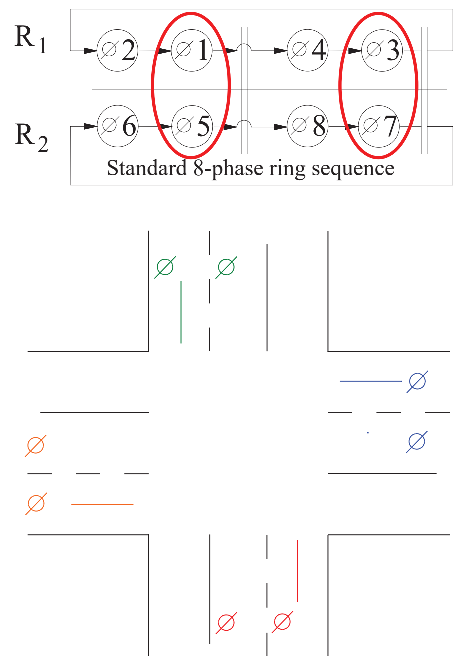
Traffic Signal Operation Theory
Lead / Lag Phases

- Leading phases are defined as the first phase(s) serviced once you cross a barrier
- Leading / Lagging are specifically referred to the left turn movements
  - In the example at the right, the first phases serviced once a barrier is crossed are the <u>left turn movements</u>
    - <u>Leading</u> left turn movements



Traffic Signal Operation Theory
Lead / Lag Phases

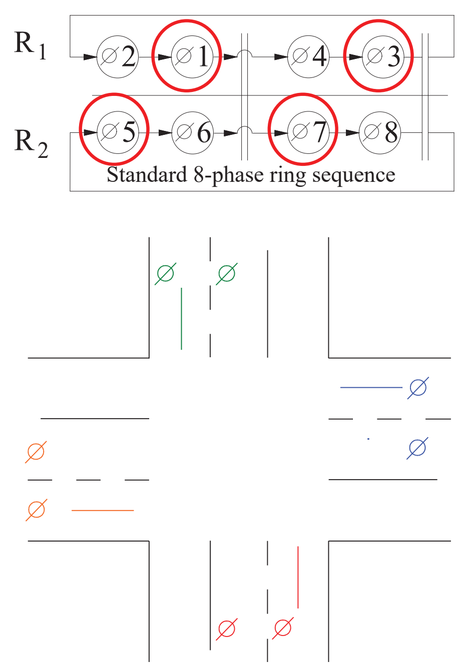
- Leading phases are defined as the first phase(s) serviced once you cross a barrier
- Leading / Lagging are specifically referred to the left turn movements
  - In the example at the right, the first phases serviced once a barrier is crossed are the <u>thru movements</u>
    - <u>Lagging</u> left turn movements



Traffic Signal Operation Theory
Lead / Lag Phases

Lead-Lag Left-Turns

During this operation, leading left-turn phasing and lagging left-turn phasing are provided on opposing approaches of the same street. This operation produces independence between the through phases, being desirable under coordinated operations, and to accommodate platoons of traffic arriving from each direction at different times.



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Traffic Signal Operation Theory
Split Phasing

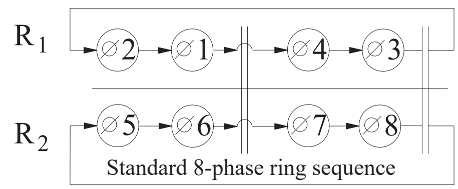
Split Phase Left-Turns

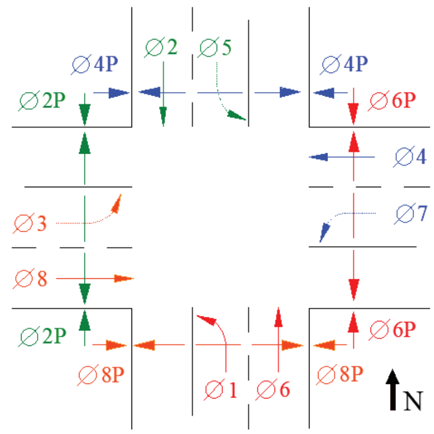
During this operation, assuming there is a demand for service on all phases, the north / south phases would be serviced with a concurrent lead-lag operation.

The split phases (side street movements), however, would service all the movements in one direction only; the thru, left turn, & right turn.

Referring to the ring diagram at the right, the sequence of phases would look like this:

- South and South left turn (Ø2 & Ø5)
- South and North (Ø2 & Ø6)
- North and North left turn (Ø1 & Ø6)
- West and West left turn (Ø4 & Ø7)
- East and East left turn (Ø3 & Ø8)





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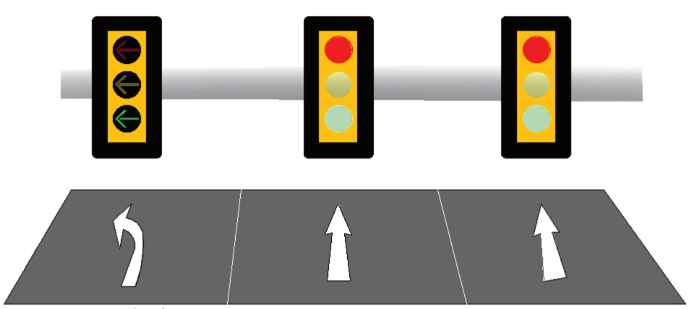
Protected and Permissive Phases

Protected Phase:

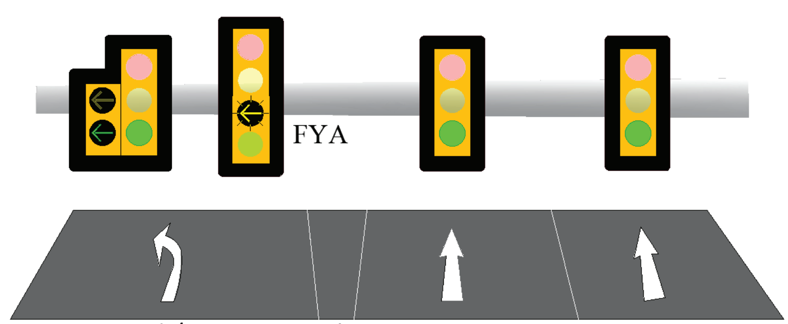
Protected phases provide exclusive right-of-way to a specific movement, allowing vehicles or pedestrians to proceed with no conflicting traffic.

Permissive Phases:

Permissive phases allow a movement to proceed with caution when there is a gap in conflicting traffic. These phases typically involve yielding or giving right-of-way to opposing or crossing traffic.



Protected Phase

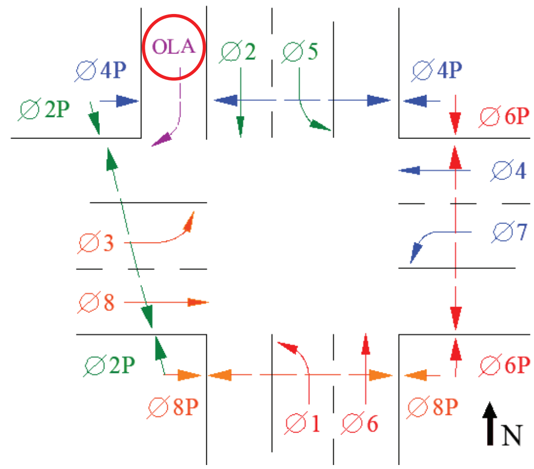


Protected / Permissive Phase

Overlaps

Overlaps:

- *A GREEN indication that allows a movement of traffic to flow during the GREEN and clearance intervals of one or more phases.*
- The overlap indications must be controlled by a vehicle phase, a ped phase, or another controller command.
- Think of an overlap as a "*clean-out*". This is an area of the intersection that you do not want traffic backing up, thus prohibiting the movement of other vehicle phases.
- An overlap helps you gain more efficiency in the flow of traffic thru a signalized intersection.



OLA Depicts FYA or delayed green

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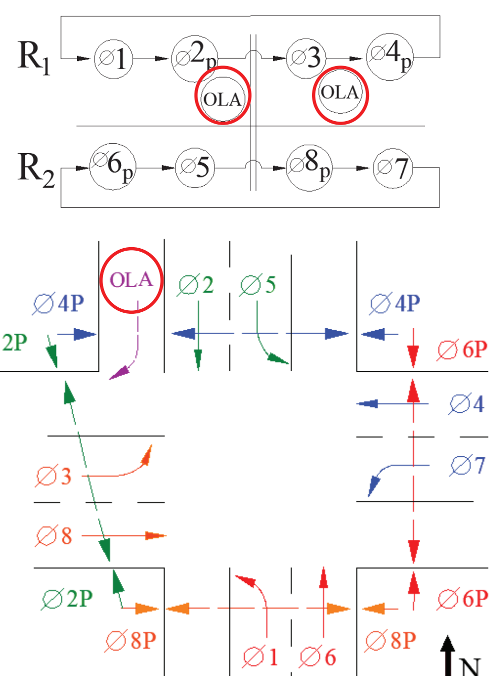
Overlaps

Overlaps:

- NEMA defined four overlaps; "A", "B", "C", & "D"
- There are two types of overlaps:
  - "*Parent / Child*"
  - "*Independent*", "*Timed Overlaps*" or "*Double Clearance*"
- The overlap must work within the ring diagram to avoid conflicts
- Overlaps may be displayed in the ring diagram for channel compatibility
- When can the SB GREEN right turn arrow be displayed without conflicting with other movements of traffic?



OLA Depicts FYA or delayed green

Traffic Signal Operation Types

Fully-Actuated Operation: In fully-actuated operation, detection is provided to all the phases at an intersection.

- ideally suited to isolated intersections / less predictable traffic demands

Semi-Actuated Operation: In semi-actuated operation, detection is provided to the phases controlling the minor movements and the left turn movements at an intersection.

- best suited for sporadic or low volumes on the side streets
- will require programming of controller to recall non-actuated phases

Pre-timed / Coordinated Operation: Pre-timed operation provides a predetermined cycle length, regardless of flow of traffic or pedestrians. Coordinated operation synchronizes multiple intersections.

- may be vehicle or pedestrian detection

Recalls

Recalls are operational options that sends internal inputs into the controller to place a constant demand for service on any given phase(s).

- The controller will service recalls in every cycle regardless of vehicle or pedestrian demand.
- There are multiple types of recall. The three most common are:

Minimum (Min) recall: Minimum recall puts a demand for vehicle service on any given phase(s). Once the controller services the phase, it begins timing minimum GREEN interval.

Maximum (Max) recall: Max recall puts a demand for vehicle service and forces the controller to time the MAX I, II or III interval. The phase(s) will remain in a GREEN condition for the maximum amount of time regardless of traffic flow.

Pedestrian (Ped) recall: Ped recall puts a demand for pedestrian service on a phase(s) and forces the controller to time the 'Walk' and the Flashing 'Don't Walk' intervals each time the controller services the phase(s).

Signal Intervals and color phases

Signal Intervals:

- The Interval is the time allocated to each color (Red, Yellow, Green, Walk, Don't Walk) to remain illuminated before transition to the next phase.
- The duration is crucial in regulating the movement of vehicles and pedestrians at an intersection, ensuring smooth traffic flow and minimizing conflicts.
- The length of each interval can vary depending on local traffic engineering standards and the specific needs of the intersection.

Signal Intervals and color phases

Calculating signal intervals:

1) **Turning movement counts** – collecting data on traffic volumes at intersection. This includes Pedestrians and cyclist. This will help determining peak times in which is the highest volume of traffic at a given time of day.
2) **Signal Phasing** – Determine the number and direction of movements that need to be accommodated.
3) **Minimum Green Time** – Minimum green is the guaranteed amount of time for a particular phase. Its purpose is to get the queue of vehicles moving into the intersection once the phase turns green.
4) **Pedestrian Clearance Time** – Pedestrian Intervals calculated to allow safe crossing by pedestrians and cyclists. This varies based on width of road and crosswalk and Pedestrian Volume

Signal Intervals and color phases

Calculating signal intervals:

5) **Yellow Clearance Interval** – The yellow intervals are warnings to drivers that the associated green indication has ended, and the right-of-way is about to change.
   - The length of the Yellow interval is typically based on driver PRT (Perception-reaction time) and the distance to safely stop the vehicle, however **it will never be anything less than 3.0 seconds as per the FHWA, 5.3.2**.

5) **Red Clearance Interval** - is added to allow vehicles to clear the intersection before moving conflicting cross-traffic.

6) **Coordination** – In cases where multiple traffic signals are along a corridor, signals can be coordinated to allow for vehicles to travel smoothly through multiple intersections.

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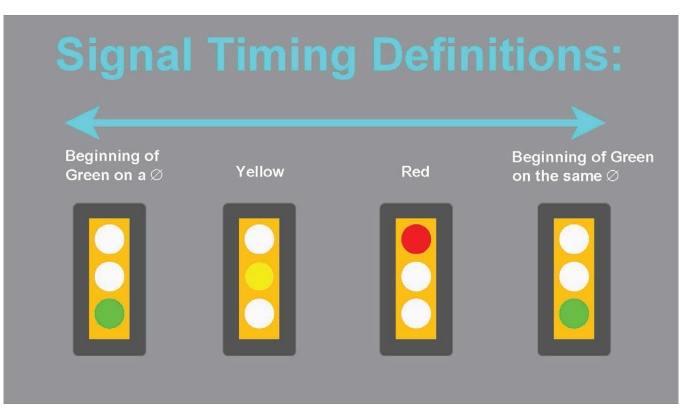
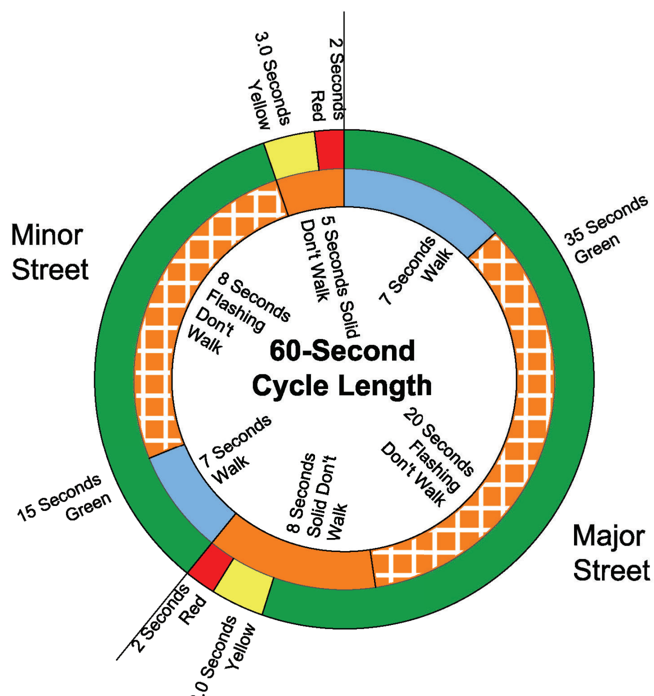
Cycle Length

A **cycle length** refers to the total time taken for a complete sequence of signal indications. It represents the duration required for the signal to go through all of its programmed phases, including the green, yellow, red, walk and flashing don't walk intervals for all movements per the ring diagram at an intersection.





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Splits and Offsets

Cycle Splits:

A "*split*", as defined by NEMA refers to the segment of the cycle length allocated to each phase that MAY occur. It represents the duration or percentage of the total cycle length that is dedicated to a particular signal phase, allowing vehicles or pedestrians in that movement to proceed.

The split can be expressed as a percentage or a number of seconds of the total cycle length. For example, if a cycle length is 120 seconds and the split for a specific movement is 20 seconds, the split would be 20/120 or 16.67% of the cycle length. This means that the signal phase associated with that movement could be active for 20 seconds within each cycle.

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Splits and Offsets

Offset:

Offset is the time relationship, expressed in seconds or percent of cycle, determined by the difference between a defined point in the coordinated green and a system reference point.

For that reason, it is imperative that the clock and calendar always be kept with the proper date & time. Most agencies traffic systems automatically synchronize the date and time every 24 hours.

- *The last thing you always do before leaving a traffic signal cabinet, is to verify the date and time in the controller and monitor if so equipped.*

Effective offset coordination can help reduce stops, improve travel times, enhance fuel efficiency, and enhance the overall capacity and performance of the road network. However, it is important to note that offsets change throughout the day with coordination pattern changes.

Knowledge Check: Multiple Choice

Which statement is correct about standard NEMA phasing?

a) Phases count in a counter-clockwise direction

b) Even phase numbers are assigned to the left turn movements

c) Phases 1, 2, 5, & 6 are assigned to the side street

d) None of the above

Knowledge Check: Multiple Choice

A ring is defined as:

a) Two or more sequentially timed &

b) Individually selected conflicting phases so

c) Arranged to occur in an established order

d) All the above

Knowledge Check: Multiple Choice

What best describes a barrier?

a) An obstacle preventing vehicles from entering a closed lane

b) An interlock in a multi-ring controller

c) It forces conflicting phases into concurrent timing

d) None of the above

Knowledge Check: Fill the Blanks

Fill in the blanks with the correct words from the box below:

Lead	Protected	Semi-actuated	Parent/child overlap
Lag	Permissive	Fully Actuated	Timed overlap

a) Left turn on a green arrow only is a _______________ phase which may be the ____________ phase once the barrier is crossed.

b) A _________________ will terminate after its controlling phase has terminated which may operate as either a ______________ or ______________ phase.

Knowledge Check: Fill the Blanks

Fill in the blanks with the correct words from the box below:

	Semi-actuated	Parent/child overlap
Permissive	Fully Actuated	

a) A flashing yellow arrow operates as a ____________ phase in an intersection that is _____________ because there is no vehicle detection on the main street movements.

b) An intersection that operates with vehicle detection on all approaches is _____________.

c) A movement of traffic that is controlled by two or more phases is known as _________________.

Knowledge Check: Multiple Choice

A complete sequence of signal indications is better known as a:

a) Split

b) Offset

c) Cycle length

d) An interval

IMSA Traffic Signal Technician I

Lesson 6: Controller Assembly - Cabinet Components

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Lesson Introduction - Cabinets and Components


Controller


Power Supply


Circuit Boards / Back Panel


Traffic Signal Heads


Flashing Beacons


Detectors and Sensors


Communication Devices


Signal Conflict Monitor / MMU

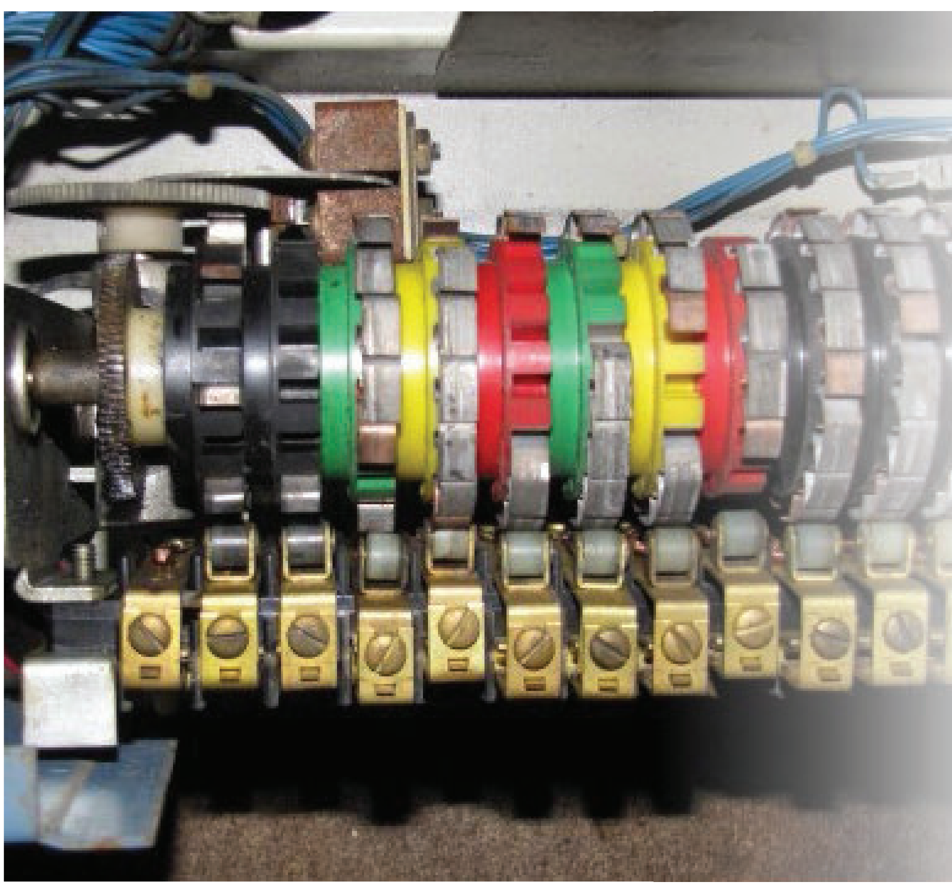

Battery Backup Systems


Surge Protection Devices

Essentially Six basic types of cabinets & 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 & 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.

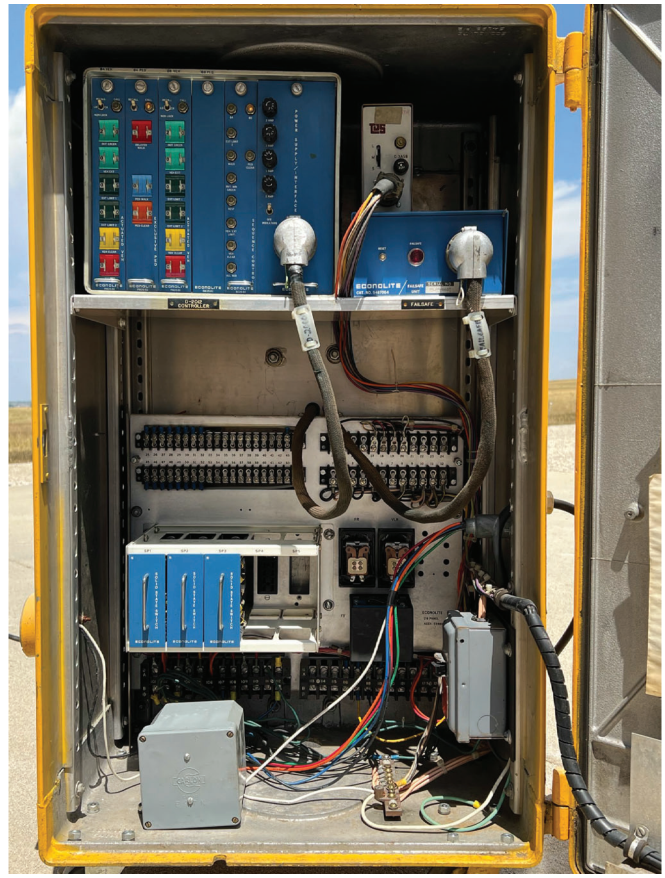


Electromechanical Controller

The dials are equipped with keys that activate a switch. As each key passes a microswitch, a cam motor is activated. The motor turns a cam shaft loaded with breakout cams. These cams open and close contacts, which turns on the signal indications in the field.

During installation, gears are installed to control the speed of rotation of each dial.

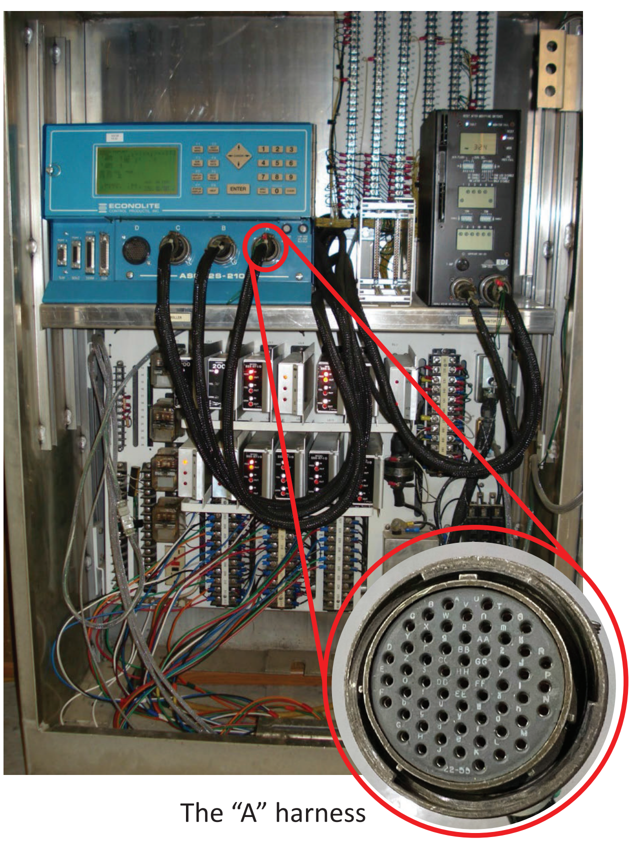
Pre-NEMA



Pre-NEMA

This was the age when the first solid state electronic devices came into the public realm. Many manufacturers that were already doing electronic assembly for all types of electronic equipment began making traffic signal controllers and cabinets.

- The problem that soon became evident to the end users was that there was no compatibility in equipment between manufacturers products.



The "A" harness

NEMA TS-1

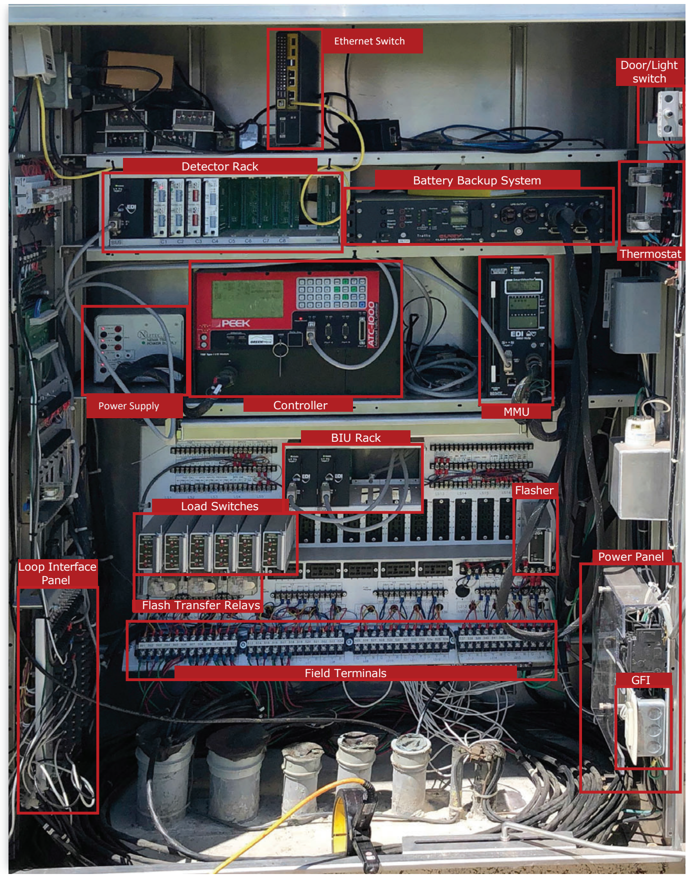
National Electrical Manufacturers Association created the first traffic signal standards in 1976. The NEMA TS1 standard outlines the design, functionality, and performance requirements for traffic signal cabinets & controllers.

- NEMA defined:
  - The cabinet style and 7 sizes by numbers (W x D x H):
    - #1 - 16" x 12" x 24" (pedestal or pole mount)
    - #2 - 20" x 14" x 32" (pedestal or pole mount)
    - #3 - 24" x 15" x 40"or #4-24" x 16" x 46" (G) (ped, pole, or base mount)
    - #5 - 30" x 16" x 48" (M) (pole or base mount)
    - #6 - 44" x 24" x 52" (P) (base mount)
    - #7 - 44" x 24" x 72" (R) (base mount)
  - Controller functions in the "A", "B", "C" harnesses
  - Conflict monitor functions and harnesses
  - Load switches, flasher, and flash transfer relays
  - Inductive loop detectors

NEMA TS-2

National Electrical Manufacturers Association (Traffic Signal Controller Type 2) is an advanced standard for traffic signal controllers used in transportation and traffic management systems. It builds upon the features and capabilities of the NEMA TS1 standard, offering more advanced functionalities and communication options.

- This is what a typical TS-2 cabinet may look like



Caltrans Type 170, New York 179 & 2070

170/179/2070

The robust and intelligent design of the 170/179/2070 cabinet series is perfect for any traffic control need. Meeting requirements set forth by Caltrans, New York, and the FHWA, these rugged cabinets offer easy access to interior assemblies.

- Original cabinet sizes:
  - 332 (67” H x 24” W x 30” D)
  - 336 (46” H x 24” W x 20” D)

Cabinet Type –
ATCC & ATC

The Advanced Transportation Controller and the Advanced Transportation Cabinet are the latest controller/cabinet standards designed to provide an open architecture platform to support a wide variety of ITS applications, while utilizing high-density / low voltage equipment.

- Traffic Management systems
  - Traffic Signals, Ramp Metering, CCTV's...
- Emergency management
- Freeway management
  - Tolling, lane control, accident management...
- Public Transportation
  - Light rail, busses...
- And the list goes on....

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Cabinet Components - Controller

https://www.cubic.com/transportation/intelligent-systems

https://www.econolite.com/solutions/controllers/cobalt-series/

https://www.businesswire.com/news/home/20180605005654/en/Trafficware-Delivers-Game-Changing-Smart-Signal-Controller

https://tcstraffic.com/traffic-controllers/

Controller -

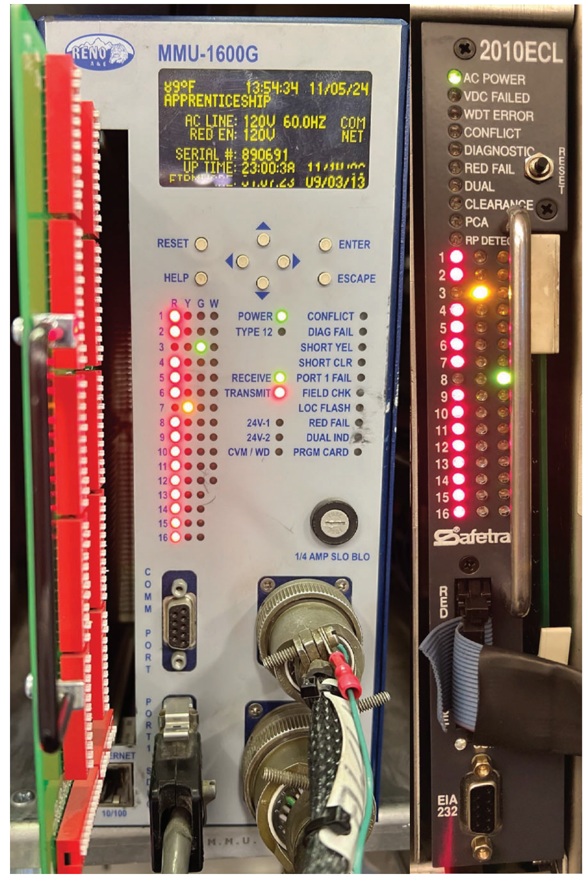
The controller is the brain of the traffic signal system. It receives inputs from sensors and detectors in the field, processes the information, and generates output commands to control the operation of the traffic signals. The controller is responsible for timing the signal phases, coordinating signal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

Cabinet Components – 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
- CMU's (cabinet monitor units) exist in the ATC cabinets

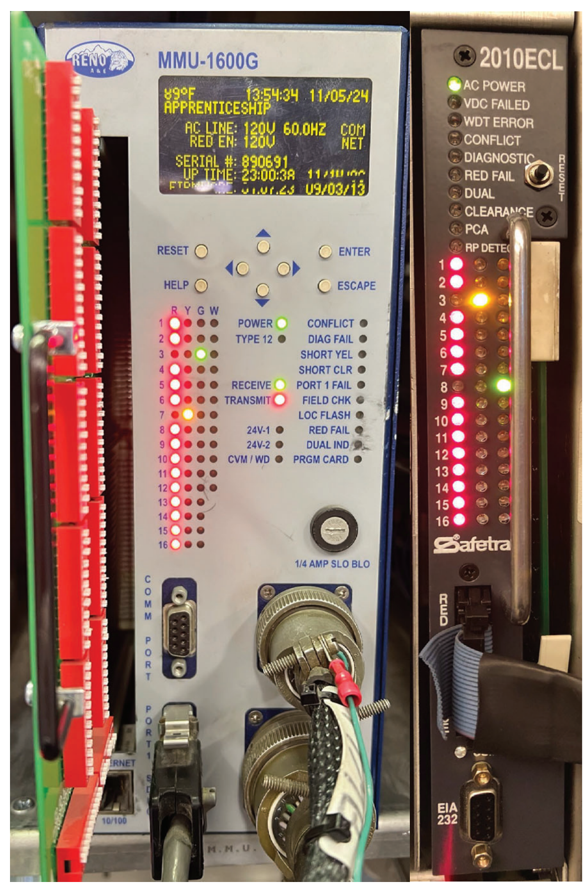
- The CMU/MMU serves two purposes:
  - **Signal monitor** – which monitors the conditions of the signals, such as conflicting signals, lack of signals, or multiple signals on a single phase.
  - **Voltage monitor** – which monitors operating voltages within the cabinet, such as the AC line voltage, controller 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.*



Cabinet Components – Conflict Monitor / MMU

Signal Conflict Monitor / MMU:

- The monitor is the one safety device in the cabinet that signal techs and motorists rely on.
- *So great care must be taken when working with one.*
- **Programming & settings *must* be correct!!!**
  - CMU/MMU manufacturers recommend that all monitors should be tested and recertified annually with CMU/MMU test equipment
  - 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!!!



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Detection Devices

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

These detectors can be found in the detection rack. They include:

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

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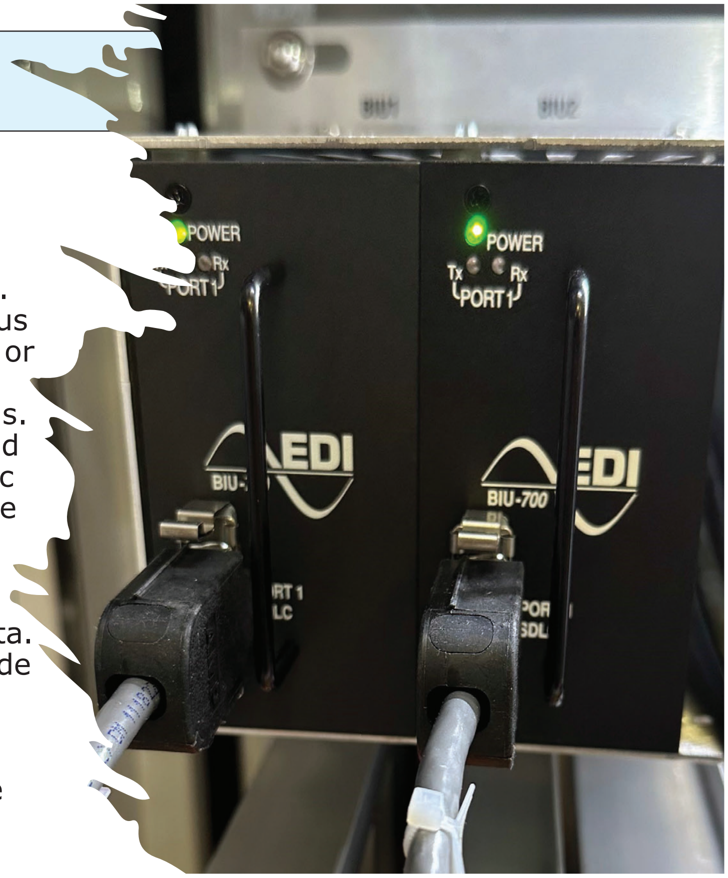
Cabinet Components – Power Supply

Power Supply:

The power supply provides electrical power to the traffic signal cabinet and its components. It typically includes transformers, circuit breakers, 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:

1. **Traffic Signal Controller**: The BIU connects the controller to the rest of the devices in the cabinet.
2. **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.
3. **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.
4. **MMU**: The BIU communicates with the MMU so that the controller and the MMU may compare data.
5. **Preemption Equipment**: The BIU can also include preemption modules that allow other external devices, such as remote monitoring systems or emergency vehicle preemption systems.
6. **Power Supply**: The BIU receives power from the cabinet's power supply.

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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).

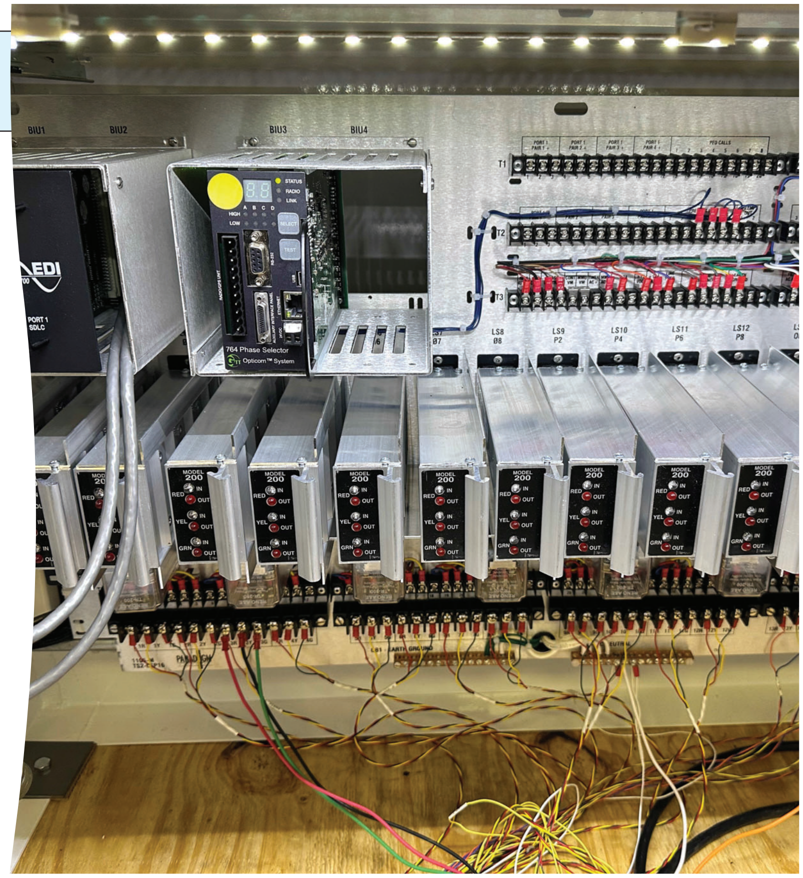
- **Inputs and Outputs**: The SIU receives the detection inputs from the detectors in the cabinet and relays them to the controller. It also drives the output signals from the controller to the high-density switch packs. It communicates this through serial bus #1 (SB1) and serial bus #2 (SB2).

https://www.tacel.ca/products-services/traffic-signal-monitors/its-cabinet/siu-218

Load Switches

Load Switches / Load 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

High-density switch packs:

- These high-density switch packs are only used in the ATCC 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.

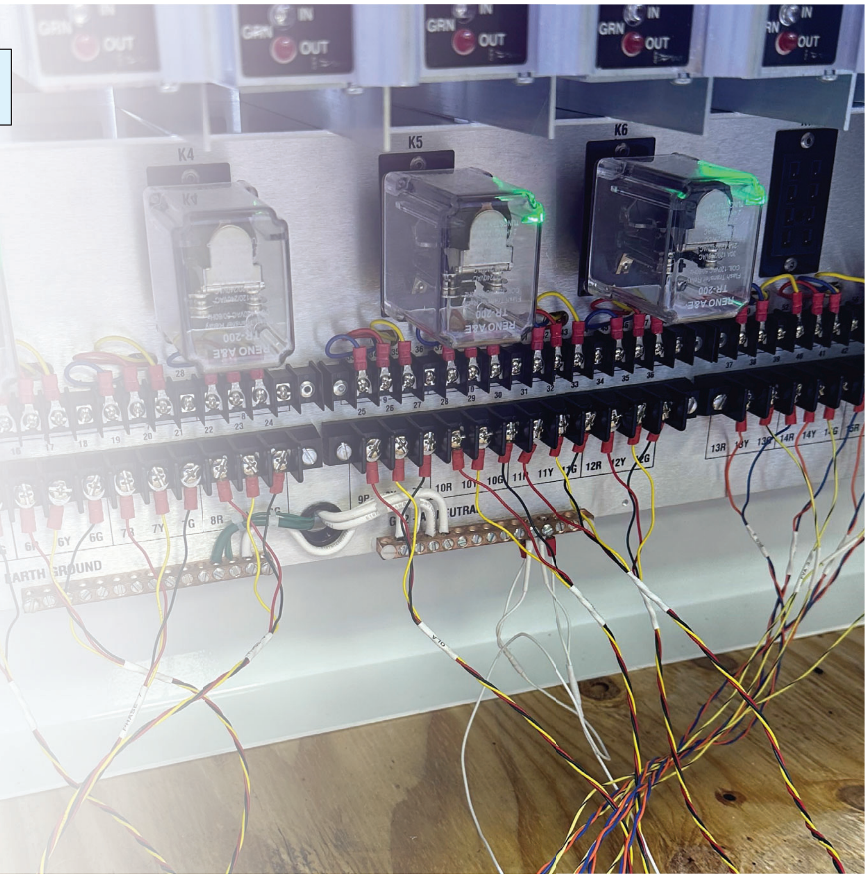
Flash Transfer Relays

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.

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
    - Dirt
    - Reduces sparking between the contacts
- Has an LED light to show the coil is energized

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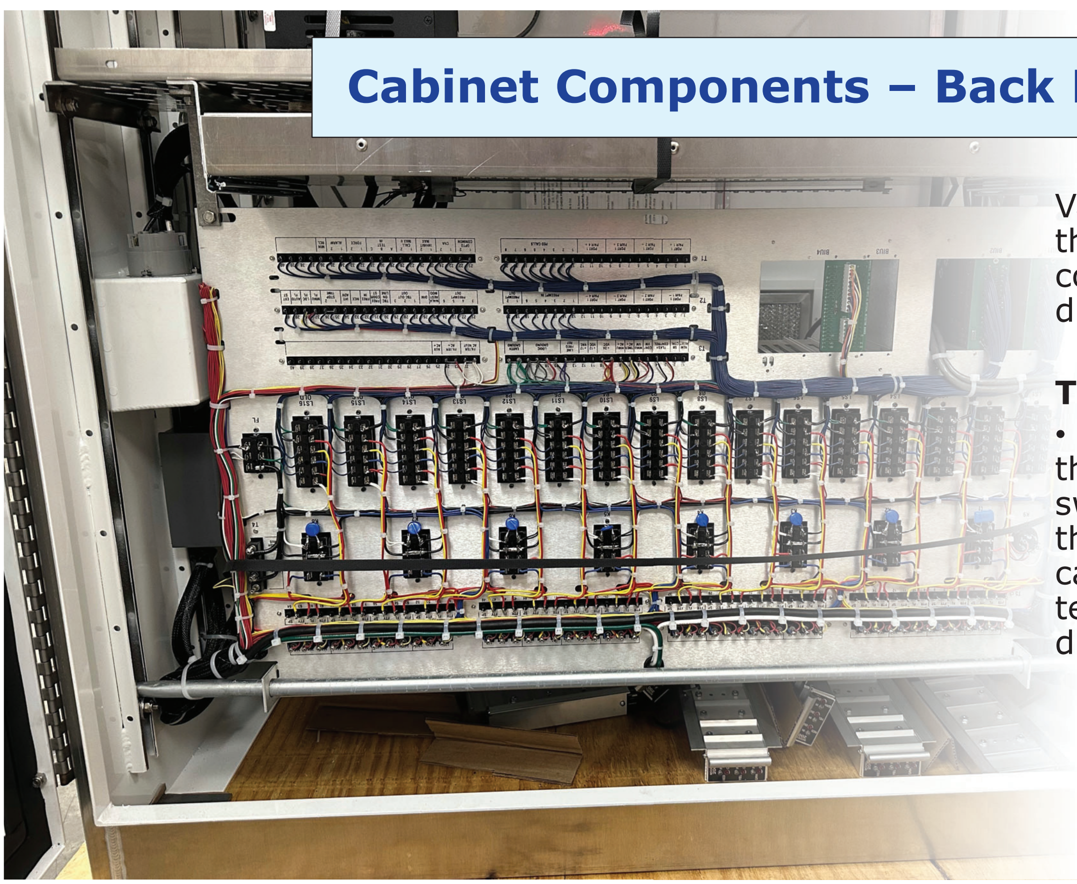
Flashers

- 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.



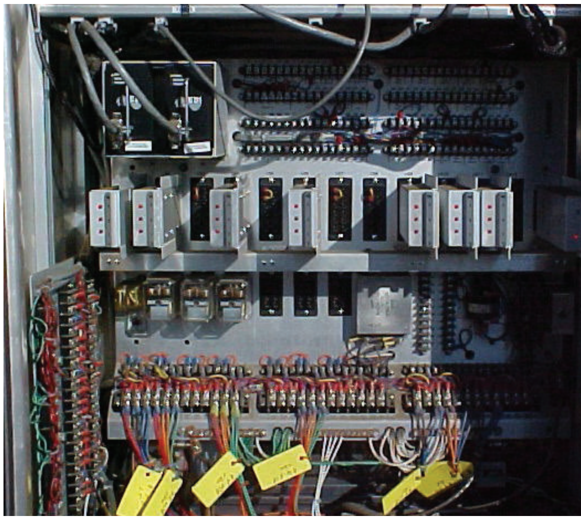
Cabinet Components – Back Panel

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.

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.

Telemetry panels - Facilitates communications between the controller and a T.O.C. or other system.

Preemption Panel - Facilitates the EV & RR preemption inputs from the field and the controller.

Electrical Protection

Main & 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.

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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 or pull box to improve the reliability and performance of the signal electronics by ensuring a clean and stable power source.

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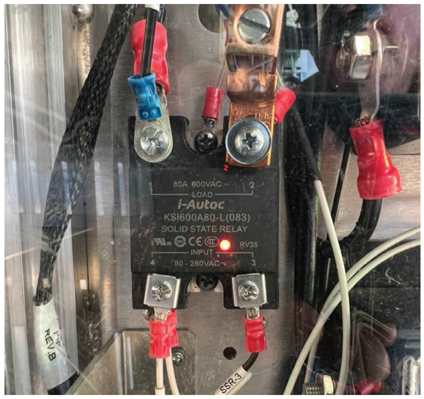
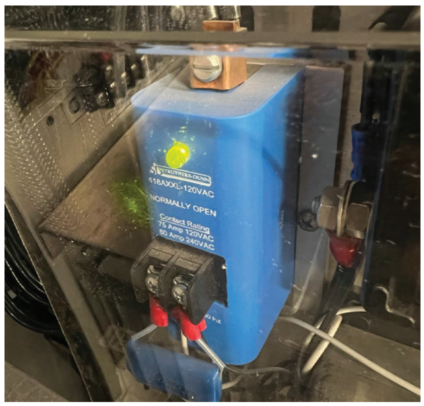
Ground Fault Circuit Interrupter (GFCI)

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 this relay serves 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's)(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 85^0–170^0
- 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

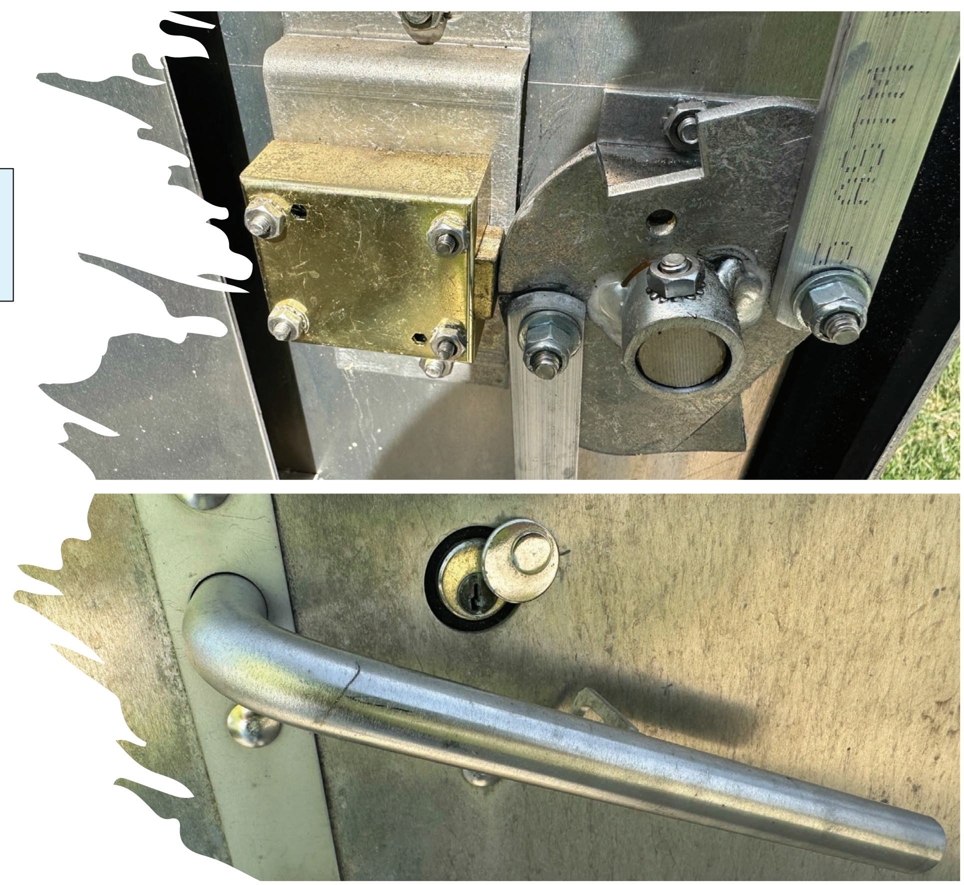
Cabinet Lighting

Lighting:

• Inside a typical traffic signal cabinet, which houses the electronic components and control systems for traffic signals, various types of lighting are used for different purposes. Here are the common lighting options found inside a traffic signal cabinet:

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

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

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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
- Dedicated Communication Cables

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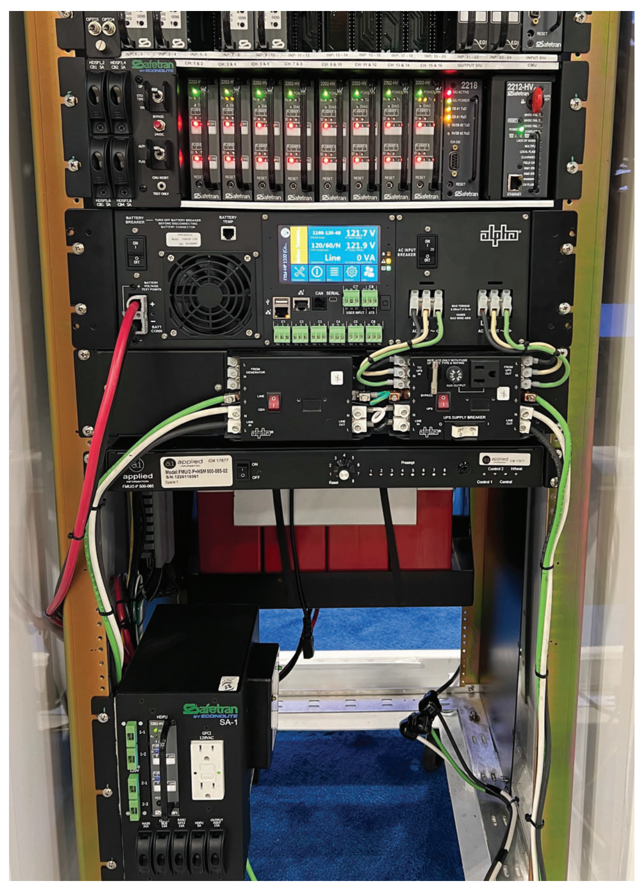
UPS / Battery Backup



UPS / Battery Backup System:

• A UPS (Uninterruptable Power Supply) otherwise known as a battery backup system provides temporary power to the traffic signal cabinet in case of a power outage. It ensures that the traffic signals continue to operate, albeit in a limited capacity, during power interruptions.

Maintenance Switch Panel

Signal Tech Maintenance Switch Panel:

- It is a specialized control panel inside the cabinet door that provides technicians or maintenance personnel with a convenient and safe way to perform maintenance, testing, and troubleshooting tasks on the traffic signal system.
- Toggle switches in this panel are SPST or DPDT type switches

- **Typical controls available:**
  - Lights on/off
  - Manual Detection Input
  - Manual intersection control
  - Flash on/off
  - Stop time on/off/auto
  - Equipment power on/off

Police Switch Panel

Police Switches:

- These Compartments are located on the outside of the signal cabinet which gives access to authorities to manually control the signals with the use of a normally open (N.O.) push button switch.

- **Typical controls available:**
  - Signal Lights on/off
  - Manual intersection control
  - Flash on/off

Knowledge Check: Multiple Choice

Which statement is correct?

a) We should replace the fan if a multimeter shows there is no power going to the fan.

b) The cabinet fan automatically turns on when a technician opens the cabinet.

c) The thermostat should be within a safe temperature range of 85-165 degrees.

d) Wires need to be color coded according to the wiring schematics.

Knowledge Check: Multiple Choice

What cabinet device acts as an interface device between the controller and the field terminals?

a) Conflict monitor

b) Power supply

c) Flasher

d) Load switch

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Knowledge Check: Multiple Choice

What cabinet device switches the traffic signals between a flash state and normal operation?

a) Load switch

b) Flash Transfer Relay

c) Flasher

d) Bus Interface Unit

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Knowledge Check: Multiple Choice

What cabinet device facilitates communications between the field terminals, the detection devices and the MMU?

a) Flash Transfer Relay

b) Bus Interface Unit

c) Flasher

d) Load switch

Knowledge Check: Multiple Choice

The MUTCD states that the flashing output on a flasher must be between ________ per minute?

a) 40-50

b) 50-60

c) 60-80

d) 40-60

Knowledge Check: Multiple Choice

What unit is described as the brain of the traffic signal system?

a) Traffic Cabinet

b) CMU/MMU

c) Controller

d) Pre-Emption System

Knowledge Check: Multiple Choice

It is recommended that a CMU/MMU get tested & recertified ________?

a) Every year

b) Every other year

c) After every accident

d) When replacing it with a new one

IMSA Traffic Signal Technician I

Lesson 7: Traffic Signal Construction

Advancing the Future of Public Safety

Lesson Introduction - Traffic Signal Construction

- **Underground Construction –**
  - Conduit
  - Foundations
  - Tie-ins
  - Wiring
- **Overhead Construction -**
  - Poles & Mast Arms
  - Signal Heads
  - Pedestrian Heads & Push Buttons
  - Detection

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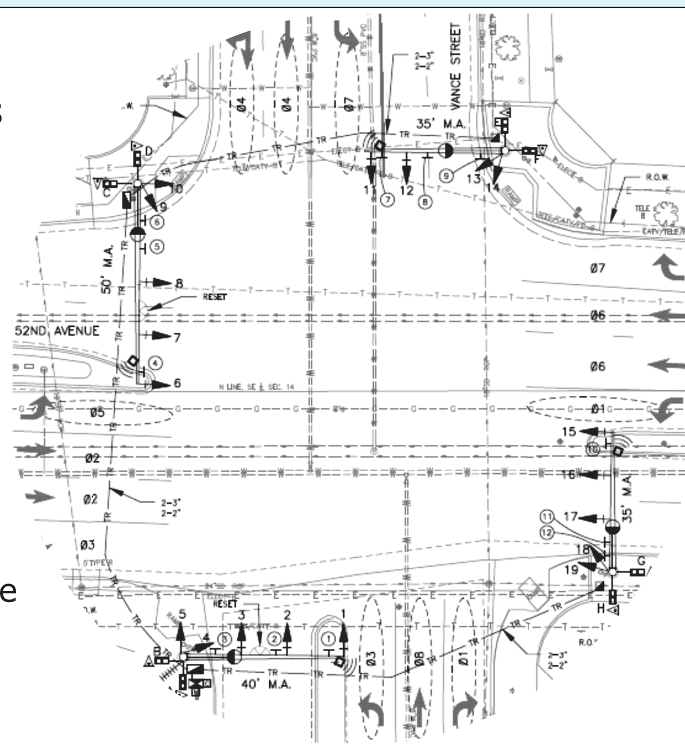
Traffic Signal Construction

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

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



Equipment used in Traffic Signal Work

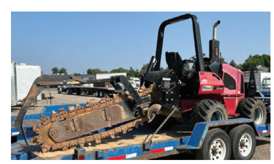
Traffic signal work would never be completed without the use of equipment.

- Some of the underground equipment you will be using may include:
  - Trenchers
  - Mini excavators
  - Back hoes
  - Skid steers

- The overhead equipment may include:
  - Digger derrick trucks
  - Truck mounted cranes
  - Bucket trucks
  - Platform trucks

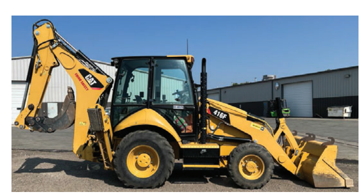
Equipment used in Traffic Signal Work

When working with ***underground*** *equipment, you must remember:*



- Equipment is powerful and can cause a lot of damage
- You are not insulated from underground electrical hazards
  - In fact, ALL underground utilities pose hazards
  - **Make sure you always wear your PPE!!!**
- You must work within the limits of the equipment
  - Thinking "*Just this once*" is what leads to accidents

- Be aware of your surroundings, I.E., people, equipment, traffic…
- Always use underground excavation safety precautions:
  - Trenching & shoring, sloping, benching, soils classifications, confined space awareness, hazardous soils, utility safety, weather conditions…



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Equipment used in Traffic Signal Work

*When working with **overhead** equipment,*
you must remember:

- You must be certified to operate cranes and digger derricks
- How much a boom or jib can lift is determined by the "load chart"
- You are not insulated from overhead electrical hazards
  - In fact, ALL overhead utilities pose hazards
  - **You must maintain a minimum of 10' clearance from overhead powerlines**

- Wheels on overhead equipment must be "chocked" prior to use
- Always extend the outriggers (if equipped) prior to use
- **Always wear your PPE**
  - You must wear fall protection when exposed to a fall of more than 6'. Yes, you must be tied off while working in a bucket truck
- All bucket trucks have a weight limit...do NOT exceed it

Traffic Signal Construction

Underground Construction: Conduit

- Conduit runs are otherwise known as "raceways"
- Types of Rigid *Metallic* conduit:
  - GRC – Galvanized Rigid Conduit
  - IMC – Intermediate Metallic Conduit
  - EMT – Electrical Metal Tubing
- 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 that 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
  - IMC – Intermediate Metallic Conduit
    - Thinner walled conduit but can still be threaded for fittings
  - EMT – Electrical Metal Tubing
    - Thinned walled conduit
    - Cannot be threaded
    - Must use set screw type or compression type connections

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

Traffic Signal Construction

Underground Construction: Conduit

- 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, & 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".

Traffic Signal Construction

Underground Construction: Foundations

- Pole foundations can also be known as "caissons" when there is groundwater involved with the drilling of the hole.
- Pole foundations begin by drilling a shaft (right) in the earth. There are two types of classified structural soil:
  - **Cohesive soils** – soils that have a high clay content. Wet soils tend to stick together and maintain the shape of the drilled shaft. Cohesive soils compact very well.
  - **Cohesionless soils** – soils that tend to be granular in nature; I.E., sand & gravel. These soils have a hard time holding the shape of the drilled shaft and tend to sluff off. Cohesionless soils are harder to maintain compaction.

Traffic Signal Construction

Underground Construction: Foundations

- Reinforcing steel (rebar) cages are set into the hole to add tensile strength to the concrete
  - Vertical bars hold the design load
  - Horizontal rings hold the shape of the cage
- Anchor bolts are placed in a template that matches the pole base plate and is set *at the proper grade*
  - The template assembly is placed in the hole

Traffic Signal Construction

Underground Construction: Foundations

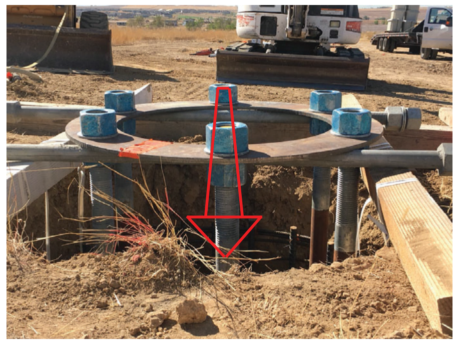
- Conduits are placed in the center of the anchor bolt pattern
- Column Tube may be used to maintain the shape of the caisson above grade
  - May also be used below grade if the walls of the shaft sluff off
- Concrete is then poured in the shaft and possibly finished if the final surface is to be exposed

Traffic Signal Construction

Underground Construction: Foundations

- Anchor bolts must be properly aligned for the correct mast arm orientation

View looking 90-degrees to the east while facing south



View looking to the south. Use the anchor bolts as a rifle site for alignment. This mast arm should be 90^0 to the flow of traffic.

View looking 90-degrees to the west while facing south

Installing the Cabinet

- Place the cabinet base in the public right-of-way with easy access and a clear view of the traffic signals.
- The cabinet should be positioned such that a signal technician can see as much of the traffic signal as possible when standing in front of the cabinet.
- Install the cabinet square to the base
- Bolt the cabinet onto the base
- Seal the bottom of the cabinet to the base with a weatherproof sealant

Traffic Signal Construction

Corner conduit Tie-ins

- **You must tie-in all the conduits on the corner**
- Conduit runs from across the street
- Conduit runs from the pole base
- Conduit runs from the controller base

Remember, a single conduit run is only allowed 360^0 degrees of total bend.

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 were 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.
  - Pull boxes follow a "Tier" rating, which means:
    - The box underwent a three-position testing; **lateral side-wall, vertical sidewall, & 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 should be installed on a bed of rock (aggregate), which provides drainage.
  - Pull boxes should be installed level to the surrounding grade.
  - Do NOT install pull boxes in a handicap curb ramp.

Traffic Signal Poles

Traffic signal poles may need to be assembled prior to installation.

- 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
- Proper rigging and boom truck skills to lift and install the pole on the foundation
- Mast arm & 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

Traffic Signal Mast Arms

Traffic signal mast arms may need to be assembled prior to installation.

- Mast arm assembly includes multi-part mast arms
- Signal head installation
- Wiring
- Hardware such as end caps and sign hardware
- Proper rigging and boom truck skills to raise and install the arm onto the pole

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

Two types of cameras are used:

- Straight 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.

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"

Knowledge Check: Multiple Choice

Schedule 80 conduit is an example of:

a) GRC conduit

b) HDPE pipe

c) EMT conduit

d) PVC conduit

Knowledge Check: Multiple Choice

In relation to cameras, what does PTZ stand for?

a) Primary Traffic Zero

b) Pacific Time Zone

c) Pan, Tilt, Zoom

d) Private, Tilt, Zoom

Knowledge Check: Multiple Choice

When installing a traffic control cabinet, which of the following should you **NOT** do?

a) Place the cabinet in the public right-of-way

b) Install cabinet square to the base

c) Secure cabinet so technician can see as much of signals as possible when standing in front of cabinet

d) Secure cabinet facing the intersection, so technician's back is to the intersection

Knowledge Check: Multiple Choice

When installing Polyvinyl Chloride conduit (PVC) what is the strongest option available?

a) Schedule 20

b) Schedule 40

c) Schedule 60

d) Schedule 80

Knowledge Check: Multiple Choice

What is the maximum allowable total degree of bend for a single conduit run?

a) 360 Degree

b) 45 Degree

c) 120 Degree

d) 90 Degree

Knowledge Check: Multiple Choice

What is **NOT** a part of underground traffic signal construction?

a) Conduit

b) Wiring

c) Detection

d) Foundation

IMSA Traffic Signal Technician I

Lesson 8: Cabling

IMSA

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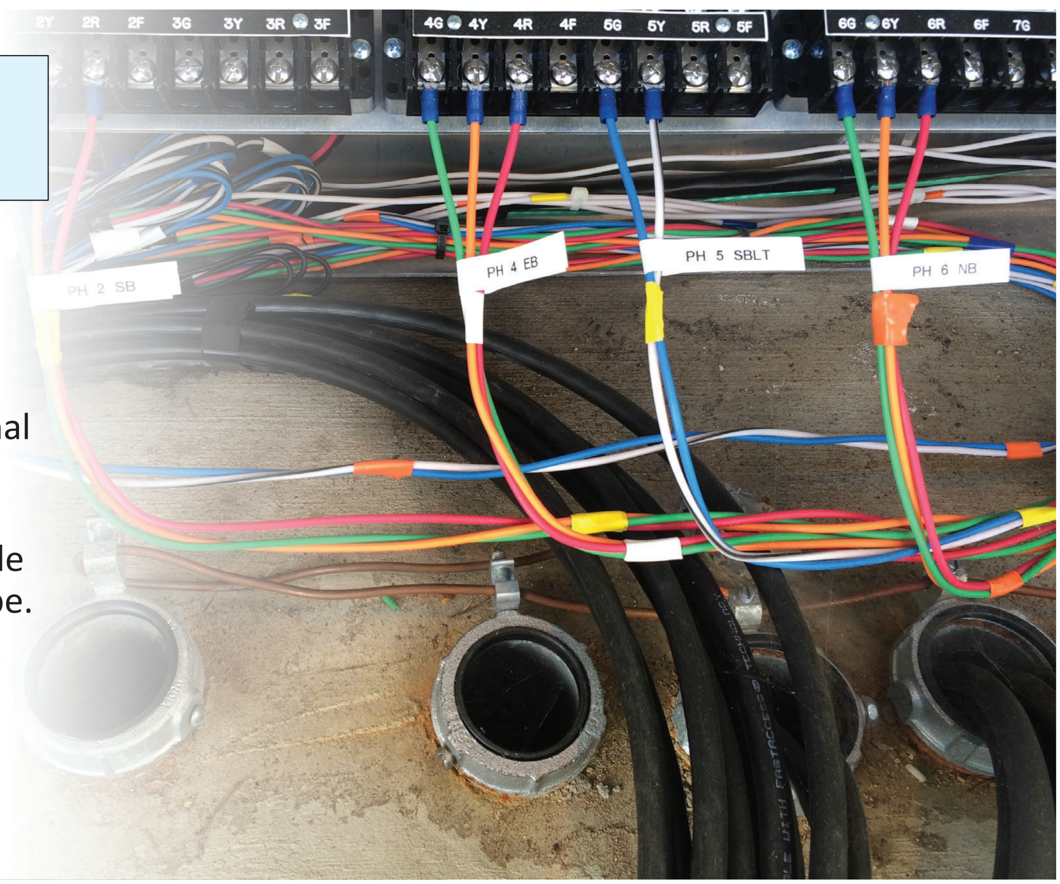
Wire Labeling

- Ensure that all wires are labeled according to the phasing diagram in the signal plans or timing sheet.
- You will thank yourself in the long run with good cable labeling or color-coding tape.



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

IMSA Cable

Conductors are available in solid or stranded copper

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

- #12 & #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

Use of IMSA cable examples:

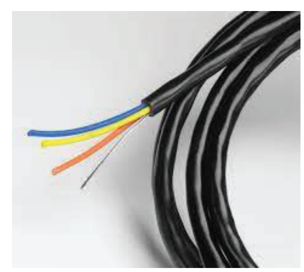
- A 19, 21, or 25-conductor is run to each corner of the intersection from the controller cabinet.
- 7-conductor to the outer head on the mast arm or span wire.
- 5-conductor to the 4-section signal heads or multiple ped heads.
- 4-conductor to individual 3-section signal heads.
- 3-conductor to individual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

Other Signal Cabling

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

- Power wires / cable – #4 - #6 THHN Cu stranded
  - Be aware of voltage drop due to load
- Communication cables– fiber, twisted & shielded pair, Ethernet, radio cables…
  - Be aware of voltage drop and signal loss due to distance. For example: Ethernet cables can maintain signal strength for 328’ (100M)
- Video, radar, & loop detection cables– hybrid, coax, Ethernet, twisted pair Cu & 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**

https://www.amazon.com/



http://www.signalcontrol.com/products/gtt/Opticom_138_Detector_Cable.pdf

https://www.fiberopticcableshop.com/mmdup625.html

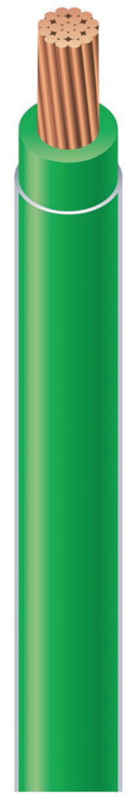
https://www.bhphotovideo.com/

https://oc2me.com/hybrid-cable-coaxial-power/

https://www.google.com/

https://www.walmart.com/

Traffic Signals & the NEC



https://whiteheadindustrial.com/

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 lighting, 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…

Knowledge Check: Matching Activity

Match an IMSA 7-conductor cable to the proper conductor colors inside the cable.

a) IMSA 7-conductor

1) black, white, red, green, blue, white W/black, red W/black

2) black, white, red, green, orange, blue, red W/black

3) black, white, green, orange, blue, white W/black, red W/black

4) black, white, red, green, orange, blue, white W/black

Knowledge Check: Multiple Choice

What is the maximum distance an Ethernet cable can transmit a signal while maintaining strength?

a) 250' (76.2M)

b) 300' (91.4M)

c) 328' (100M)

d) 425' (129.5M)

IMSA Traffic Signal Technician I

Lesson 9: Signal Head / Installation Methods

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MUTCD & Traffic Signal Heads

What does the MUTCD say?

Sections 4A.02 - Section 4A.04

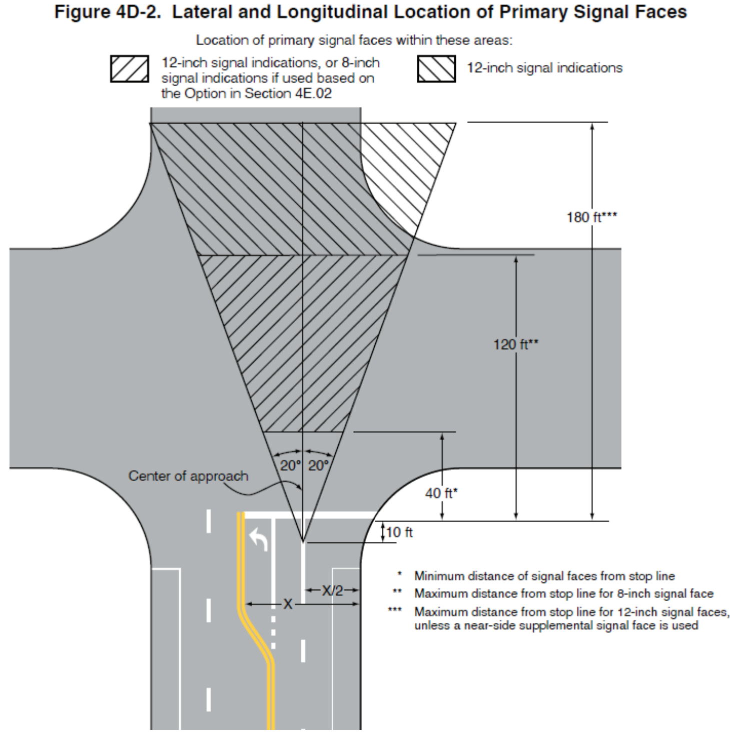
- **RED:** shall mean “Stop” before entering the intersection.
- **YELLOW:** means the associated Green is being terminated.
- **GREEN:** means traffic may proceed in any direction that is lawful & practical while yielding the right-of-way to other vehicles or pedestrians lawfully within the intersection.
- **RED ARROW:** motorists shall not enter the intersection.
- **YELLOW ARROW:** means the associated green arrow is being terminated.
- **FLASHING YELLOW ARROW:** motorists are allowed to make the movement indicated by the arrow while yielding the right-of-way to other vehicles or pedestrians lawfully within the intersection.
- **GREEN ARROW:** allowed to make the movement indicated by the arrow while yielding the right-of-way to other vehicles or pedestrians lawfully within the intersection.

MUTCD & Traffic Signal Heads

What does the MUTCD say?

- 4D.05: A minimum of **two** primary signal faces shall be provided for the through movements.
- 4D.07: Lateral positioning at a point 10’ behind the stop line, signal faces shall be located within 20^0 left and right of the center of approach.
- 4E.01: Letters and numbers shall not be displayed within vehicular signal indications.
- 4E.02: Traffic signal heads for vehicles shall be 8” or 12” in diameter.
- 4F.01: When a traffic control signal is being operated in a steady stop-and-go mode, at least one indication in each signal face shall be displayed during all intervals of the cycle.

Figure 4D-2. Lateral and Longitudinal Location of Primary Signal Faces



Signal Head Installation

<u>Signal head installations</u> refer to the different methods and configurations for mounting and installing traffic signal heads at intersections. Several common types of signal head installations include:

1. Overhead Span Wire
2. Mast Arm
3. Side-Mounted
4. Pedestrian-Mounted
5. Combination Installations

Traffic Signal Heads

Traffic Signal Heads:

- The traffic signal heads, or signal heads, are the <u>visible indicators that display the signal</u> aspects to road users.
- They are typically mounted on poles or gantries 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.

Signal Head Mounting

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

- Ridged mounting:
  - Pipe & nipple
  - Plumbizer (slip fitter) style
  - Astrobrac® style
- Flexible mounting
  - Balance hanger

Traffic Signal Heads – Properly Working

Ensuring that traffic signal heads are working properly is critical for several reasons:

- **Safety**: Traffic signals control the flow of traffic at intersections, and malfunctioning signals can lead to confusion and accidents.

- **Efficiency**: Properly functioning traffic signals help maintain efficient traffic flow, reducing congestion and travel times.

- **Legal Compliance**: There are legal or regulatory requirements to maintain traffic signals in good working order. (MUTCD 4D.01,03)

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

Traffic Signal Heads – Common Issues

Traffic signal heads may need to be cleaned, repaired, or replaced due to several common issues:

•**Dirty Signal Lenses/reflectors:** Due to poor visibility, signal lenses and reflectors may need to be cleaned with a mild glass cleaner or soap & water.

•**Burned Out Lights or LED modules**: One of the most common issues is simply that the lamps or the LED modules burn out and need to be replaced.

•**Damage**: Traffic signal heads can be damaged by weather, accidents, vandalism, or even birds building nests inside them.

•**Electrical Issues**: Wiring problems, shorts, power surges, or other electrical issues can cause problems with traffic signal heads.

•**Age/Obsolescence**: Older signal heads may not meet current standards for visibility, energy efficiency, or other factors. In such cases, they may need to be replaced even if they're still functioning.

Traffic Signal Heads

Traffic signal indications can go dark for a variety of reasons:

- **Power Outage**: The most common reason is a power outage, which could be due to a local blackout, a malfunction in the power supply to the signal, or a problem with the signal's internal wiring.
- **Burned-out Bulbs**: If the signal uses incandescent or halogen bulbs, they can burn out and need to be replaced.
  LEDs, which are commonly used in newer signals, have a much longer lifespan but can still fail occasionally.
- **Damage or Vandalism**: Physical damage to the signal, whether from weather, accidents, or vandalism, could also cause the lights to go out.

As for fixing these issues, the approach depends on the cause:

- **Power Outage**: If the outage is local or city-wide, the lights should come back on once power is restored. If the problem is specific to the signal, a technician will need to check the power supply and internal wiring.
- **Burned-out Bulbs**: These will need to be replaced. This should be done as soon as possible to maintain the proper function of the signal.
- **Damage or Vandalism**: Any physical damage will need to be repaired. This could involve replacing the whole signal head, or just certain components.

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Parts of a Traffic Signal Head

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

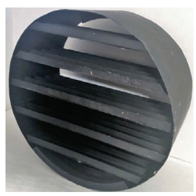
- **Signal Section** or housing
- **Door** – the front of the section
- **Signal face** – an assembly of one or more signal sections
- **Lens** – the colored part
- **Reflector & Lamp**
- **LED module**
- **Visor**
- **Backplate**
- **Louvers**

https://lightingequipmentsales.com/12-inch-300-mm-led-traffic-signal-module.html

https://lightingequipmentsales.com/ge-gtx-8-inch-200-mm-led-traffic-signal-module.html

https://www.nbc12.com/2021/11/15/crews-begin-project-improving-traffic-signal-visibility-richmond/

https://www.econolite.ca/solutions/cabinets/vehicle-signals/



https://www.ebay.com/

https://www.mccain-inc.com/products/signals/signal-accessories/signal-visors

https://lightingequipmentsales.com/sintra-12-inch-300-mm-led-traffic-signal-module.html

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Back Plates

Back Plates: The backplate of a traffic signal head serves several purposes.

- It enhances the visibility of the signal by providing a contrast between the signal indications and the background; I.E., the sky, trees, buildings…
- It can block the sun or other light sources from washing out the signal lights

Here are some common issues that might require the backplate to be repaired or replaced:

- **Physical Damage** - A damaged or misaligned backplate could potentially obscure the signal, leading to safety risks.
- **Wear and Tear** – backplate parts could fall on the vehicles below
- **Misalignment** – may cause confusion for the motorists
- **Retroreflective Band Deterioration** – reduced visibility

Yellow Reflective Optional

https://www.mccain-inc.com/products/signals/signal-accessories/backplates-with-retroreflective-borders

Replacing Signal Head Back Plates

- Disconnect and secure signal head **power leads** if removing the signal head.
- Remove the **backplate** and mounting brackets.
- Install new backplate, mounting brackets, and signal head.
- Reconnect the wires and test with a **multimeter.**

Image: mototrex.com

Visors

- A traffic signal indication visor is a protective cover or shield that is typically installed on the signal face door to improve visibility and reduce the impact of external factors on the signal's visibility.
- It is designed to shield the signal's lights from direct sunlight, rain, snow, and other environmental elements that can hinder the clarity of the signal.

Snow Scoop

Cutaway

Angled

Tunnel

Tunnel open bottom

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Signal Head Installation – Span Wire

Different components

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

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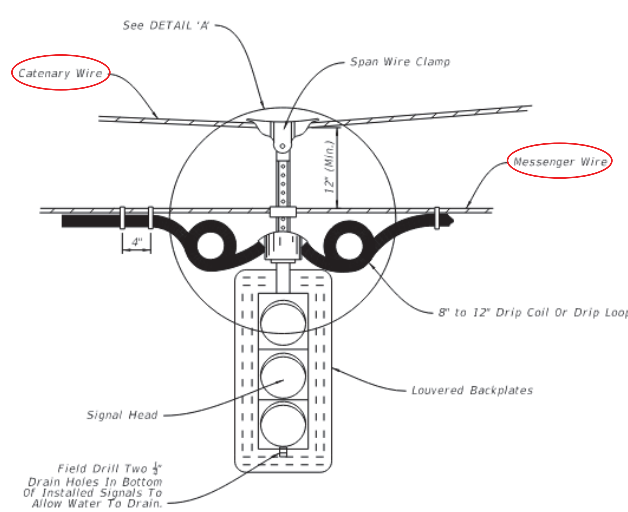
Span Wire – Catenary vs. Messenger

Some contradiction in terms exists in traffic signal span wire installations when it comes to the term "*catenary*."

By definition, catenary means:
"the curved shape a chain or rope assumes once it is hung and supported from both ends."

- Some public agencies, however, use catenary as an identifier for a particular span wire; Florida for example at the right
- Most other public agencies simply refer to the span wires as "*messengers*"



SIGNAL ATTACHMENT

Span Wire – Catenary vs. Messenger

- **Messenger** wire/cable – the span wire cable used to support the signal heads, signal wiring, detection equipment, signs, and other fixtures
- **Catenary** wire/cable – a reference used in a two or three wire span to divide and support the weight of the signal heads on one span and the signal cables on the other span.
- Span wire signals provide better lane coverage and signal head adjustment; however, all the signal cabling is exposed to the weather.
- Everything mounted on the span wire moves in the wind and is subject to exposure to harsh weather conditions.

Span Wire – Messenger Cable

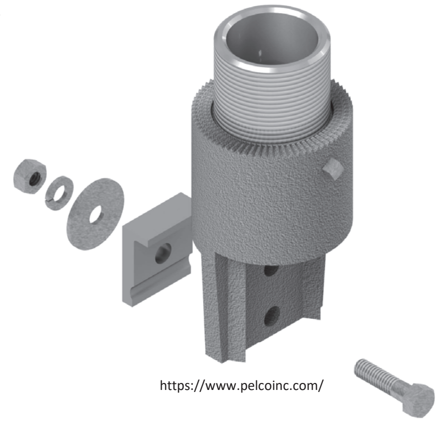
The messenger cable:

- made of a 7-strand, steel cable.
- messenger cables measure anywhere from 5/16” to 9/16” in diameter.
- strong enough to bear the weight of the traffic signal heads, cabling, signs, & other fixtures.
- can withstand environmental factors such as wind, snow, ice, and other weather events.

Span Wire – Tether Cables

A "*tether*" refers to a cable or wire that is used to support the bottom of the traffic signal heads.

- The bottom of the traffic signal heads are connected to the tether wire with a break-away clamp.
- It provides stability and prevents excessive movement of the signal head due to wind.
  - Signal heads that swing in the wind tend to give the motorists a sense that the signal heads may be dark.



https://www.pelcoinc.com/

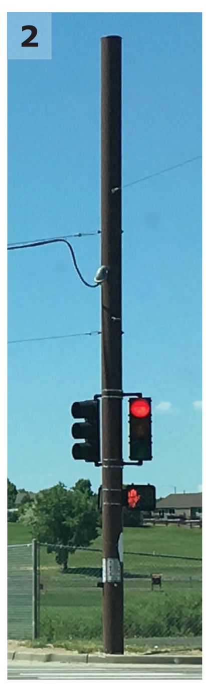
Tether cables are constructed in the same way as messenger cables;

- 7 steel strands wound together to form a single cable.
- Tether cables are usually 1/4" to 7/16" in diameter.

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.



Span Wire - Hardware

- Thimble-eye bolt or nut
- Eye bolt or nut
- Pole band clamp
- Strand vise
- Strand links

https://www.macleanpower.com/product/pole-line-hardware-a-e/bolts/oval-eye

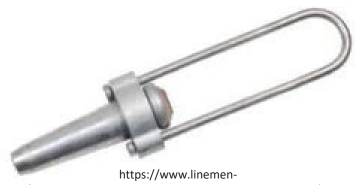
https://www.albanycountyfasteners.com/316-stainless-steel-style-a-eye-nuts/1520-006.htm

https://www.linemen-tools.com/1_4_Steel_Guy_Wire_Strandlink_All_Grade_0_240_0_p/h-5000.htm

https://www.macleanpower.com/product/pole-line-hardware-a-e/bolts/thimble-eye-bolts

https://www.linemen-tools.com/Thimble_Eyenut_1_J16512_ALL5095_p/h-j16512-all5095.htm

https://www.powertelcom.com/pole-line-hardware/pole-band/



https://www.linemen-tools.com/5_16_Steel_Guy_Wire_Strandvise_Universal_Grade_p/h-5251.htm

Span Wire - Hardware

- Porcelain insulators
- Span wire hanger assembly w/ a tri-stud assembly (L) and a close nipple (R)
- Disconnect Hanger
- Cable rings
- Tether Assembly
- Weather Head

https://www.indiamart.com/

https://www.multicominc.com/

https://www.generaltrafficequip.com/signal-mounting-assemblies

https://www.generaltrafficequip.com/

https://www.pelcoinc.com/

https://www.supplyhouse.com/ Southwire

https://www.trafficlights.com/

Span Wire Installations

Single span wire

- The signal heads, signal cables, detection equipment, signs, and all other fixtures are all supported by a single messenger cable

Span Wire Installations

Single span wire with a tether wire

- The signal heads, cables, and signs are supported by a single messenger cable
- *The bottom of the signal heads are supported with a tether wire*
  - Reduces the effect of them swinging in the wind

Span Wire Installations

Double span wire with a tether wire

- The signal heads are supported by one messenger cable
- The signal *cables* are supported by another messenger cable
  - This distributes the total weight between two messenger cables
- *The bottom of the signal heads are supported with a tether wire*

Span Wire – Types of Damage

- **Weather Conditions**: Extreme weather conditions such as high winds, ice, or heavy snow can exert extra pressure on the span wires, leading to damage. Lightning can also cause damage.
- **Vehicle Impacts**: High-profile vehicles, such as trucks or buses, might accidentally hit the traffic signals or the wires, causing them to break or get damaged.
- **Wear and Tear**: Over time, environmental exposure can lead to wear and tear, including rust or other forms of corrosion as well as ultraviolet light from the sun.
- **Vandalism**: Though less common, intentional acts of vandalism can also damage span wires.

https://www.researchgate.net/figure/Typical-span-wire-traffic-signal-system_fig2_343182853

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Span Wire – Repairing Damage

To repair damaged span wire cables:

- **Minor Damage**: If the cable is slightly frayed but still intact, a qualified technician might be able to repair it by cutting out the frayed section, adding additional wire and using suitable span wire hardware.
- **Major Damage**: If the wire is severely damaged or completely broken, it will need to be replaced. This involves removing the old wire and installing a new one, which should be done by trained professionals due to the potential risks involved.

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 & pole.
- Regulatory signs are placed as near to the feature they are controlling.

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.

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

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Mounting Height of Signal Faces

MUTCD 4D.09:

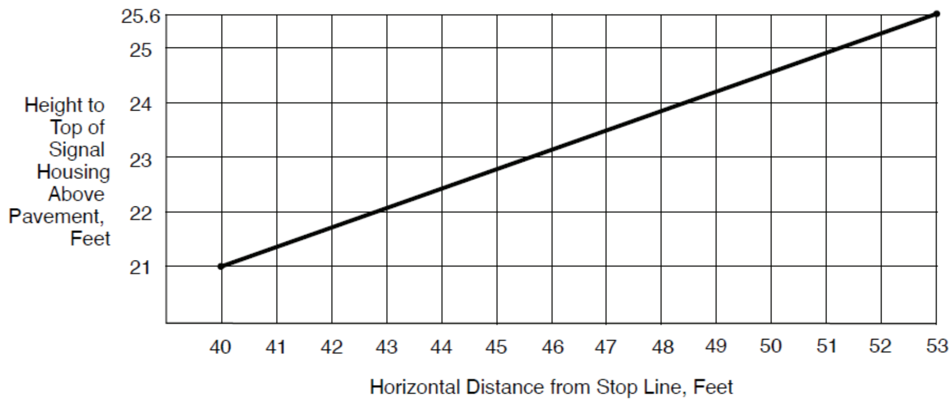
- The <u>bottom of the signal housing</u> and any related attachments to a vehicular signal face <u>located over any portion of a highway</u> that can be used by motor vehicles shall be <u>at least **15** feet above the pavement</u>.
- *The <u>top of the signal</u> housing should <u>not be more than **25.6** feet above the pavement.</u>*

Mounting Height of Signal Faces

MUTCD 4D.09, *Guidance 04:*

- *For viewing distances between 40 and 53 feet from the stop line, the maximum mounting height to the top of the signal housing of a vehicular signal face located over any portion of a highway that can be used by motor vehicles should be as shown in Figure 4D-3.*

Figure 4D-3. Maximum Mounting Height of Signal Faces that Are Located between 40 Feet and 53 Feet from the Stop Line



Lateral Positioning and Offset of Signal Faces

- MUTCD 4D.07: The required signal faces for through traffic on an approach shall be located <u>not less than **8** feet apart</u> measured horizontally perpendicular to the approach between the centers of the signal faces.
- MUTCD 4D.10: Signal faces mounted at the side of a roadway <u>at less than **15** feet</u> from the bottom of the housing and any related attachments <u>should have a horizontal offset of not less than **2** feet</u> from the face of a vertical curb or the edge of a shoulder.

Side-Mounted

Side-Mounted Installations:

- Signal heads are mounted directly onto poles or structures positioned at the side of the 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.
- **Signal heads** 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.

Longitudinal Positioning of Signal Faces

MUTCD 4D.08: A signal face installed to satisfy the requirements for primary left-turn signal faces (see Sections 4F.02 through 4F.08) and primary right-turn signal faces (see Sections 4F.09 through 4F.15), and at least one and preferably both of the minimum of two primary signal faces required for the through movement (or the major turning movement if there is no through movement) on the approach shall be located:

1. No less than **40** feet beyond the stop line, and
2. No more than **180** feet beyond the stop line unless a supplemental near-side signal face is provided.
3. As near as practical to the line of the driver's normal view, if mounted over the roadway.

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Pole & Mast Arm Inspection

In order to maintain the integrity of the pole and the arm, you must inspect them both and **repair, if possible,** any of the following issues:

- Rust & 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.

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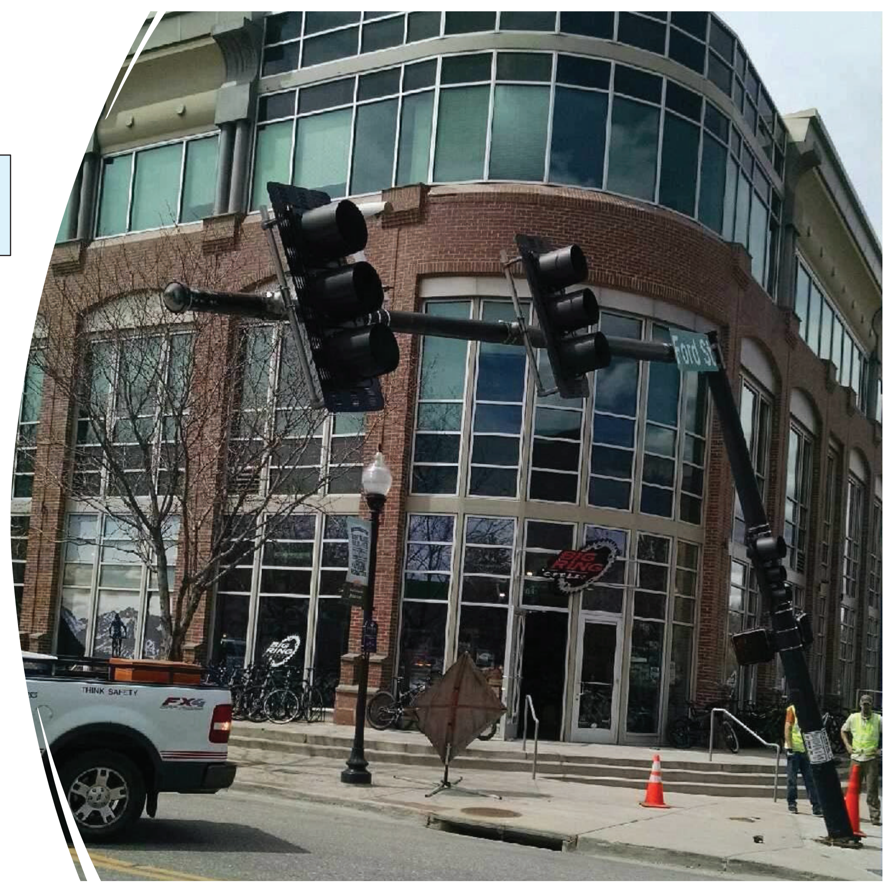
Pole & Mast Arm Inspection

You may need to **replace** the pole and/or the mast arm if you find:

- Cracks
- Corrosion – that causes flaking metal or holes in the pole
- Dents
- Leaning, bent, or twisted poles



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Knowledge Check: Multiple Choice

What should you **NOT** do when cleaning lenses?

a) Verify the type of cleaners to use.

b) Spray and wipe the lenses.

c) Remove snow if present from the lenses.

d) Sand the lenses.

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Knowledge Check: Multiple Choice

What supports the signal heads, signal cabling, signs, detection devices and other fixtures on a span wire signal?

a) Tether wire

b) Catenary wire

c) Messenger wire

d) Support wire

Knowledge Check: Multiple Choice

A cantilever structure would be found in a:

a) A span wire signal

b) A pedestrian pole

c) A butterfly pole

d) A mast arm signal

Knowledge Check: Multiple Choice

As per the MUTCD, what is the mounting height of traffic signals over the roadway?

a) 15′ to the bottom of the signal head, 19′ to the top of the signal head

b) 17′ to the bottom of the signal head, 21′ to the top of the signal head

c) 16′ to the bottom of the signal head, 23′-6″ to the top of the signal head

d) At least 15′ to the bottom of the signal head, not more than 25′-6″ to the top of the signal head

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Knowledge Check: Multiple Choice

As per the MUTCD, what horizontal distance must be maintained from the face of curb for side-of-pole signal heads mounted less than 15’ vertically?

a) 1’

b) 1’-6”

c) 2’

d) 2’-6”

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Knowledge Check: Multiple Choice

As per the MUTCD, what is the minimum horizontal mounting distance between overhead signal heads?

a) 6’

b) 7’-6”

c) 8’

d) 8’-6”

Knowledge Check: Multiple Choice

What would you find during a pole inspection that would lead you to replace the pole?

a) Chipped paint

b) Cracked welds

c) A missing hand hole cover

d) Missing bolts

IMSA Traffic Signal Technician I

Lesson 10: Luminaries and Lighting

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Luminaires - Lighting

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

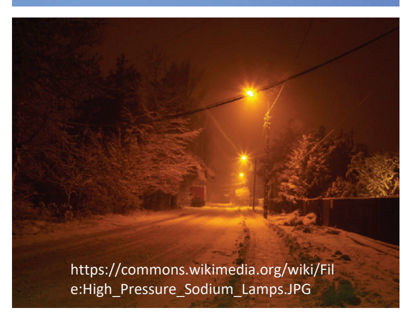
- Increased visibility at intersections at nighttime is important since various modes of travel cross paths at these locations.

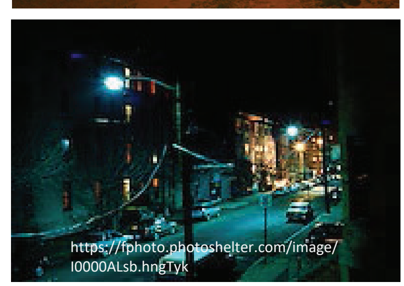
Luminaires - Lighting

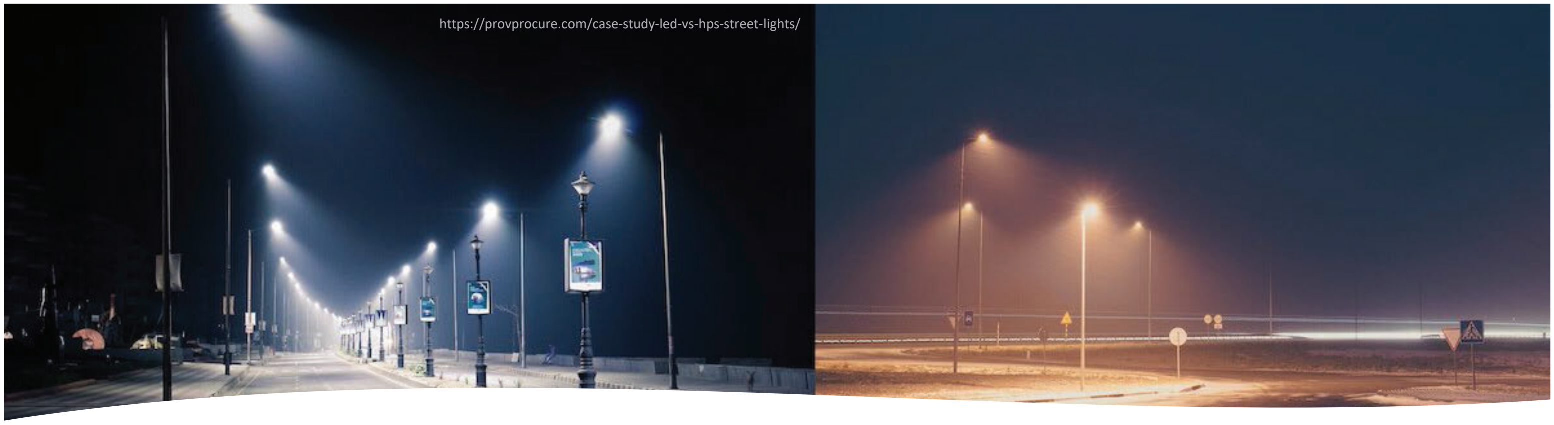
There are several types of luminaires commonly used for traffic signals. Here are some of the main types:

1. **Incandescent Luminaires**: These were the first type of electric street light fixtures that used incandescent bulbs. They produce light by passing an electric current through a filament, which becomes hot and emits light. Incandescent luminaires have been phased out in many places due to their low energy efficiency and shorter lifespan compared to other options.

2. **High-Intensity, Gas-Discharge (HID) Luminaires**: HID luminaires use a high-pressure arc discharge to produce light. HID lights include fluorescent tubes, mercury vapor, low and high-pressure sodium, and metal halide. Metal halide lamps provide a white light output, while high-pressure sodium lamps produce a yellowish light and mercury vapor produces a blueish light.







https://provprocure.com/case-study-led-vs-hps-street-lights/

Luminaires - Lighting

3. **LED Luminaires**: Light Emitting Diode (LED) luminaires have become the most common choice for traffic signals. LED lights are highly energy-efficient, have a long lifespan, and offer better visibility. They also provide the ability to adjust the light intensity and color. LEDs are now widely used due to their cost-effectiveness and environmental benefits.

- **Optical Lenses**: In addition to the type of luminaire used, the design and configuration of the optical lens system also play a crucial role in traffic signal lighting. Lenses are used to control the light distribution, ensuring maximum visibility to drivers and pedestrians from different angles. Lenses can be designed to provide specific beam patterns, such as full-circle, arrow-shaped, or pedestrian symbol-shaped signals.

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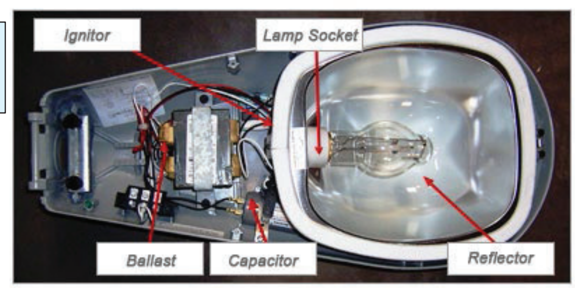
Luminaires - Lighting



https://www.glendaleaz.com/live/city_services/transportation_services/streetlights

Key parts of a streetlight:

- **Lamp** – may be gas discharged or LED
  - Gas discharged lamps may cycle "on"/"off" if the lamp is failing
- **Ballast** – a current limiting device that regulates the current & voltage feeding the lamp
  - If the ballast fails, the lamp may cycle "on"/"off" or may not come on at all
  - The ballast must be matched to the type of lamp in the fixture and the line voltage
- **Photocell** – The automatic control device for turning the lamp "on" and "off"
  - If photocells fail, the lamp may cycle "on"/"off", may not come on at all, or may stay on all the time.

https://www.mecampbell.com/catalogsearch/result/?q=hps+lamp&product_list_order=stock.qty-desc

https://www.unlimitedlights.com/products/m250ml5ac3m500k-core-and-coil-mh-ballast-120v-to-277v-and-480v-for-250w-mh?_pos=109&_sid=6752cd80e&_ss=r

https://www.amazon.com/

Knowledge Check: Multiple Choice

What type of street light lamps would be better known as HID lamps? Choose all that apply.

a) High pressure sodium

b) Incandescent

c) LED

d) Metal halide

Knowledge Check: Multiple Choice

What percentage of traffic accidents occur during overnight hours?

a) 40%

b) 50%

c) 60%

d) 75%

Knowledge Check: Multiple Choice

What type of light produces a bluish hue?

a) Mercury Vapor

b) Metal Halide

c) High Pressure Sodium

d) Fluorescent Tubes

IMSA Traffic Signal Technician I

Lesson 11: Vehicle Detection

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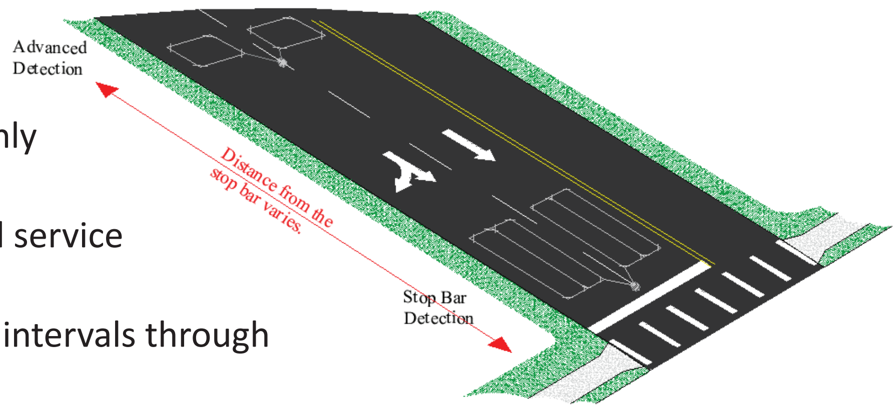
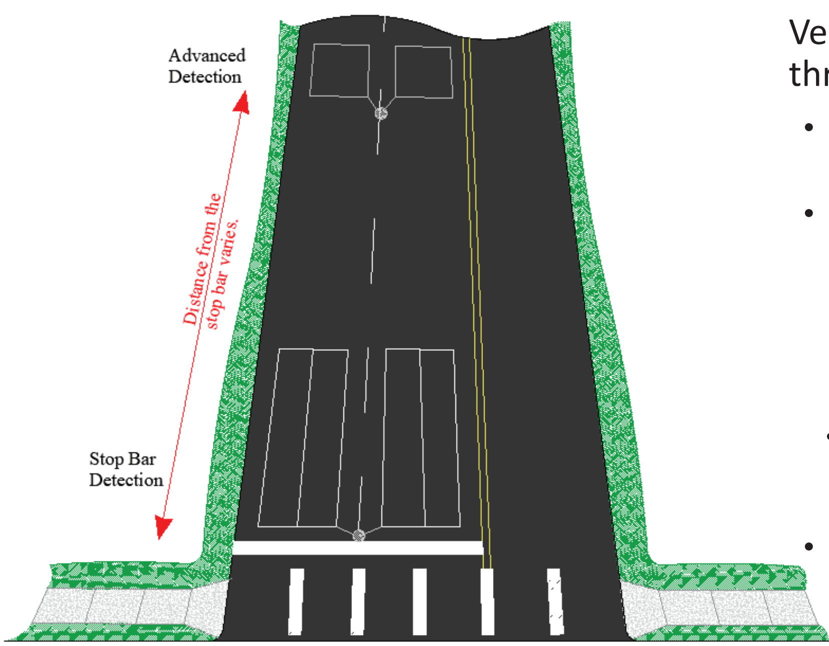
Detection Purpose



The efficiency of traffic signals is highly dependent on vehicle detection.

- Vehicles can place calls to demand service on specific phase(s).
- Vehicles can extend certain phase intervals through vehicle detection.
- Traffic data, such as volume, occupancy, and speed are acquired through detection.
- Detection may be used for a signal system to help traffic move through a coordinated arterial

Detection Placement



Vehicle detection takes place primarily in three areas:

- ***Stop bar detection*** – the area just behind the stop bar where vehicles queue during a red light
- ***Advanced detection*** – an area on the approach to a signal in advance of the stop bar. The distance from the stop bar is determined by the approach speed, the amount of storage between the stop bar and the advance detector, and the dilemma zone.
  - The dilemma zone is the area where a motorist must decide whether to stop or run the light upon seeing the yellow indication.
- ***System Detection*** - may be used on the departure side of the intersection to collect traffic data to be used on the approach at the next intersection.

Detection Types

***ALL* vehicle and pedestrian detection systems accomplish one thing… *they send an input into the traffic signal controller*.**

- **Detectors and Sensors -** Detectors and sensors are used to detect and measure traffic conditions at the intersection. Inductive loop detectors, video cameras, microwave sensors, or radar sensors may be employed to detect vehicles and pedestrians, estimate traffic volume, and trigger signal changes based on demand or pre-timed plans. Detectors are either ***"intrusive"*** (must disturb the roadway surface for installation) or ***"non-intrusive"*** (does not disturb the roadway surface for installation)

1. Inductive Loops

- Loop detection, also known as inductive loop detection, is a technology used in traffic signals to detect the presence of vehicles at intersections or along roadways. It involves the installation of loops, which are wire coils embedded in the pavement, and measures decreased changes in inductance to determine the presence and movement of vehicles.

2. Video

- Video detection in traffic signals refers to the use of cameras to monitor and detect vehicles at intersections or along roadways. It involves capturing video footage and utilizing image processing techniques to analyze the visual information and make decisions regarding traffic signal control.

Detection Types

Detectors and Sensors (Continued):

3. Magnetometer

- A magnetometer sensor is a device used for traffic signal detection that detects the magnetic shadow underneath vehicles due to the concentration of magnetic flux lines through the ferrous metals in the vehicle. It is commonly employed in traffic management systems to monitor traffic flow and control signal timings efficiently.
  - A traffic **Puck** sensor is a popular detection choice today that is a self-contained magnetometer with a power source. The unit is typically embedded in the pavement of roadways and intersections and is designed to detect the presence and movement of vehicles.

4. Magnetic detection

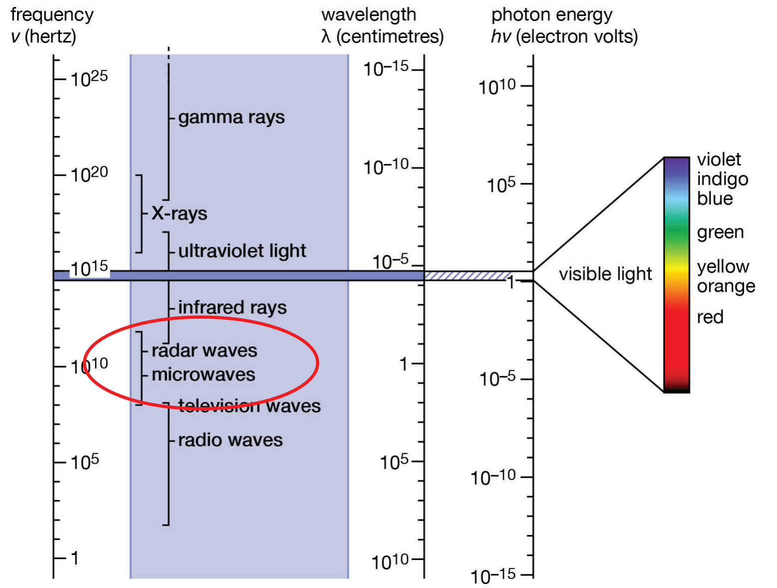
- Magnetic detectors detect the movement in the earth's magnetic field caused by the motion of a vehicle. The magnetic flux lines are pushed in front of a vehicle much the same way as the air is pushed. Magnetic detectors can only detect motion and therefore are not used as much anymore for traffic signal detection.

Detection Types

Detectors and Sensors (Continued):

Radar

- Radar detection, as it is referred to in traffic signal applications is again a term that is somewhat misused. Radar technology was developed and refined during World War II. Radar works by emitting an electromagnetic signal at an object and waiting for a return signal. Each of the signals has a specific wavelength. The measured difference between the wavelengths determines the presence of an object as well as the speed, size, and distance of that object from the radar unit.



https://www.britannica.com/science/electromagnetic-spectrum

Detection Types

Detectors and Sensors (Continued):

5. Microwave

- Microwave detection, also known as microwave radar detection, is a technology used in traffic signals to detect the presence and movement of vehicles on the road. It utilizes microwave radar technology to measure the reflection of microwave signals from vehicles, allowing for accurate detection and monitoring. Microwave detection operates in the 300MHz to 300GHz range of the electromagnetic spectrum.

6. Ultrasonic detection

- Ultrasonic detectors transmits ultrasonic sound energy and measures the returned signal. The shift in signals again determines the presence of an object in the detection zone. Ultrasonic detection operates beyond the range of what the human ear can hear, usually above 20kHz.

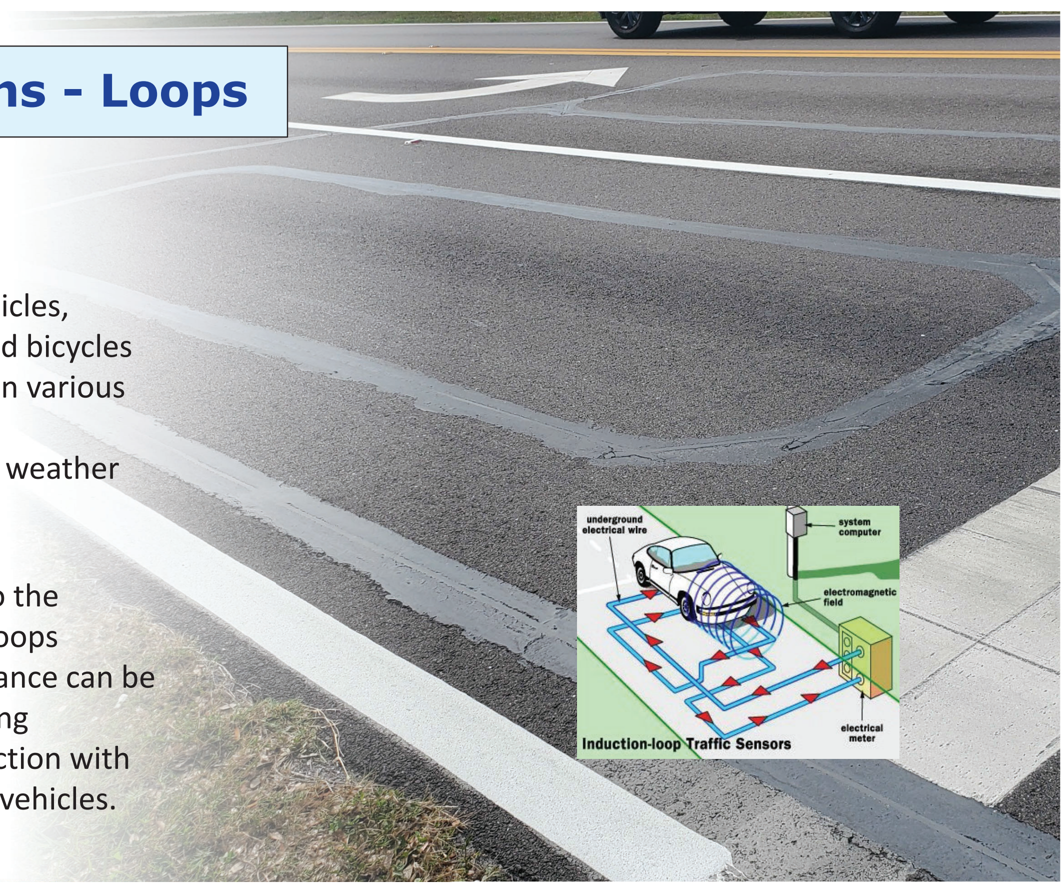
Detection Types

Detectors and Sensors (Continued):

7. Infrared detection

- Infrared detection operates on thermal radiation, otherwise known as heat. There are two types of infrared detector used for traffic signal detection; Active infrared and Passive infrared.
  - **Active** infrared detectors illuminate the detection zone with a pulsed, low powered infrared energy signal. The infrared energy is reflected off an object back to the detection unit, which is then processed to produce an output to the traffic signal controller.
  - **Passive** infrared detection simply look for a change in the heat signature of the detection zone and anything that enters the zone with a different heat signature. The difference in heat signatures is again processed to produce an output to the controller.
- Infrared detection is also a popular choice for emergency vehicle detection. An infrared emitter on the emergency vehicle sends a signal that is read by a sensor at the traffic signal. The signal is processed for the proper wavelength and frequency before a detection output is sent to the controller.

Detection Systems - Loops



Induction-loops:

- **Advantages:**
  - Reliable detection of vehicles, including motorcycles and bicycles
  - Can differentiate between various vehicle sizes and lengths
  - Can detect vehicles in all weather conditions
- **Disadvantages:**
  - Requires saw cutting into the pavement to install the loops
  - Installation and maintenance can be costly and time-consuming
  - Limited accuracy in detection with stopped or slow-moving vehicles.

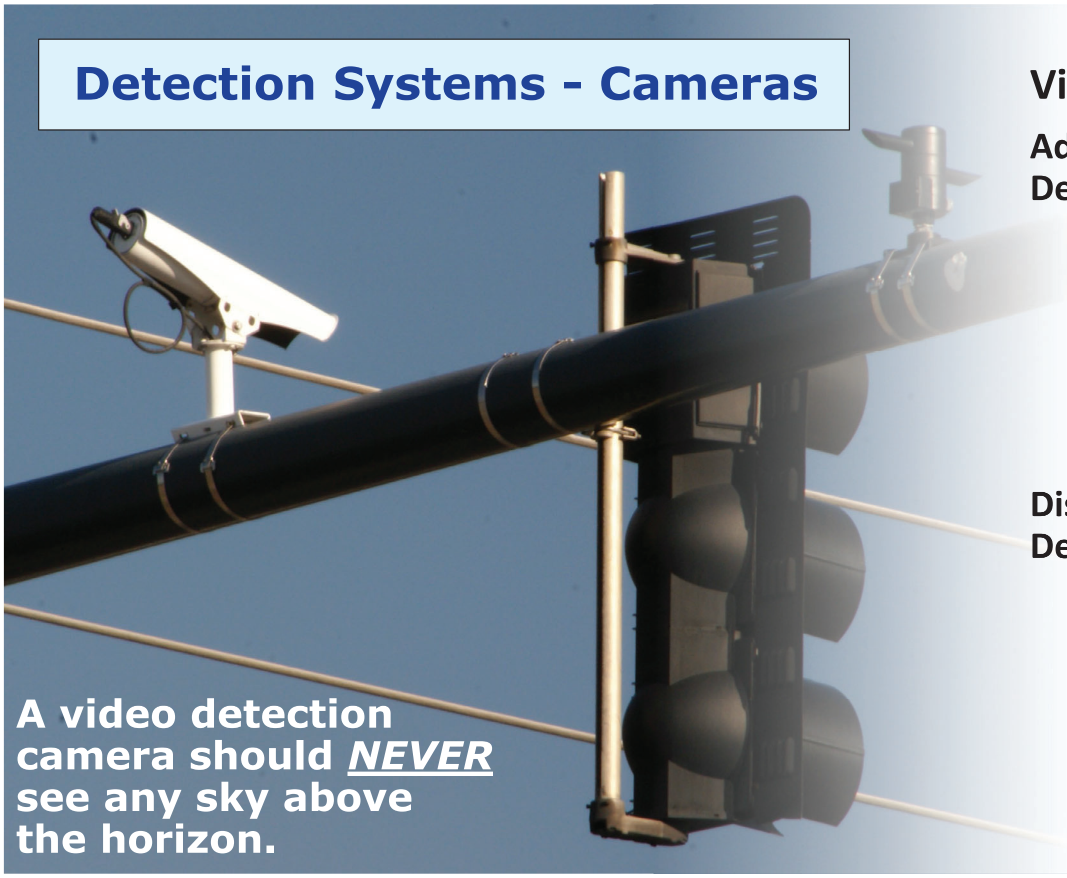
Detection Systems - Loops

- **Operational Concerns:**
  - **Crosstalk** – electrical interference causing false calls, multiple calls, or no call situations.
    - Adjacent loops should be set at different frequencies to avoid crosstalk
    - Crosstalk may be solved by grounding the drain wire in the homerun cable
  - **Splashover** - a loop in one lane detecting a vehicle in an adjacent lane.
    - Loop sensitivity should be turned down if it is detecting vehicles in adjacent lanes
    - The width of the loop may need to be cut smaller, so the outside edge of the loop isn't too close to the adjacent lane.

Detection Systems - Loops

- **Operational Concerns:**
  - **Splicing** – Loop splices to the homerun cable are to be soldered and waterproofed.
    - Loops may be connected to form a series, parallel, or combination circuit.
  - **Pavement** – compromised pavement (right), such as movement, cracked, broken roadway surfaces and poor loop sealants account for the greatest number of loop failures.
    - Poor loop connections to the homerun cable would account for the second most loop failures.

Detection Systems - Cameras



A video detection camera should ***NEVER*** see any sky above the horizon.

Video Detection:

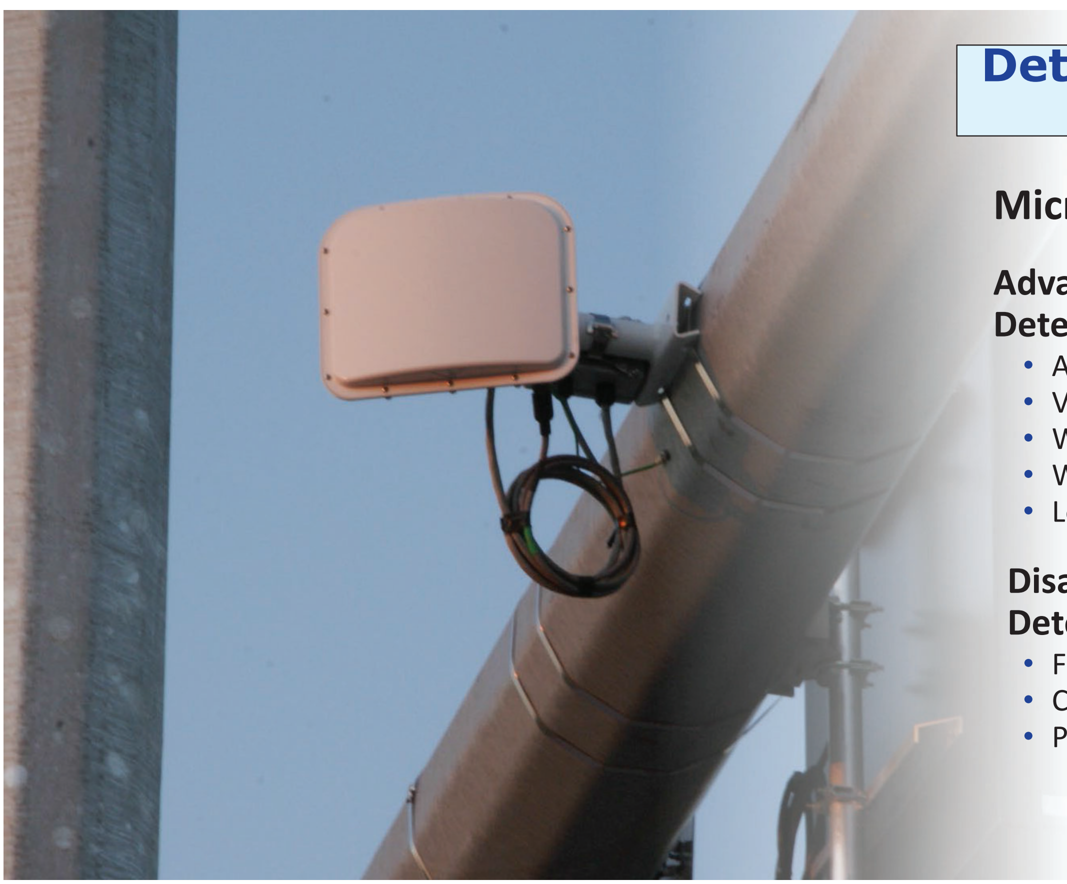
Advantages of Video Detection in Traffic Signals:

- Comprehensive Data
- Versatility
- Integration Potential
- Flexibility
- Multi-Purpose Usage

Disadvantages of Video Detection in Traffic Signals:

- Cost
- Weather & Glare Sensitivity
- Line-of-Sight Limitations
- Privacy Concerns
- Proprietary software

Detection Systems - Microwave



Microwave Detection:

Advantages of Microwave Detection in Traffic Signals:

- Accuracy
- Versatility
- Weather Independence
- Wide Coverage
- Low Maintenance

Disadvantages of Microwave Detection in Traffic Signals

- False Alarms
- Complexity
- Potential Interference

Magnetometer

Magnetometer (Pucks)

Advantages of Magnetometer Sensors for Traffic Signal Detection:

- Accuracy
- Real-time Monitoring
- Low Maintenance
- Reliability
- Cost-effectiveness
- Durability

Disadvantages of Magnetometer Sensors for Traffic Signal Detection:

- Intrusive Detection
- Sensitivity to External Magnetic Interference
- Limited Detection Range
- Weather Conditions
- Installation Complexity
- Maintenance Challenges

Detection Issues You May Encounter

Traffic signal detection systems are critical for ensuring that traffic flows efficiently through an intersection. They can, however, encounter issues that can hinder their functionality. Here are some of the common issues:

- **Power Outages or Fluctuations**: Like all electronic devices, traffic signal detection systems can be affected by power issues.
- **Sensor Malfunctions**: Sensors can malfunction due to wear and tear, environmental factors, or mechanical damage. For example, an inductive loop detector might get damaged due to roadway wear or construction activities.
- **Weather Conditions**: Extreme weather conditions such as heavy rain, snow, or fog can interfere with certain types of sensors, like video or radar detectors.
- **Faulty Wiring or Connections**: Over time, wiring can degrade, or connections can become loose, leading to intermittent or complete failure of the detection system.
- **Software Issues**: Faults can also arise from software bugs, incorrect settings, or other software-related issues.

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Detection Issues You May Encounter

How to fix these issues:

- **Regular Maintenance and Inspection**: Regularly check the system for any visible damages or changes.
- **Sensor Calibration**: Over time, sensors might need recalibration to continue functioning properly.
- **Repair or Replace Faulty Components**: If a component like a sensor or wiring is damaged, it might need to be repaired or replaced.
- **System & Software Updates**: If the issue is related to the software, system updates or patches might need to be applied.

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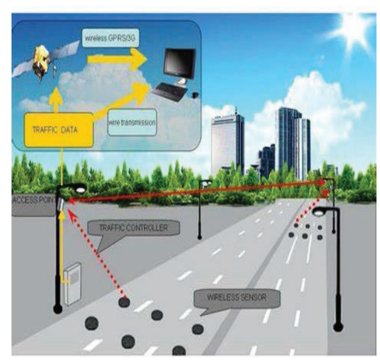
Emergency Vehicle Preemption & Priority

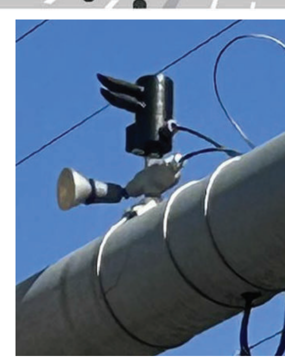
Emergency vehicle (E.V.) preemption is a specialized system used in traffic management to detect the approach of railroads and emergency vehicles, such as ambulances, fire trucks, or police cars, to an intersection.



"***Preemption***" operates in a hierarchy and services E.V. & RR:

- Railroad and draw bridges are the first two priorities; #1 & #2
- Emergency vehicles are the next four priorities; #3, #4, #5, & #6
- A higher priority number normally supersedes a lower priority number

"***Priority***" operates in a lower hierarchy and services public transportation; light rail and busses on priorities #7 thru #10



There are four 4 common types of Emergency Vehicle Detectors:

1. Infrared Detection
2. Acoustic Detection
3. Radio Frequency (RF) Detection
4. GPS-based Detection

Types of Emergency Vehicle Preemption

- **Infrared Detection**: This was the first type of EV preemption that came on the market. The detection system has three parts:
  - The infrared optical emitter on the vehicle
  - The infrared detector(s) on the traffic signal structures
  - The phase selector(s) in the cabinet
- This system is based on "line-of-sight". Hills, curves, and roadway obstructions may cause detection issues with these systems

- **Acoustic Detection**: This system is based on detecting the sound and frequency of the emergency vehicle siren. An array of microphones are installed on the traffic signal structures to listen for the siren(s). A processor card is placed in the cabinet to process the input from the microphones and place a call to the controller.
  - Anything damping the acoustic signal or creating echoes, such as bridges or tunnels may be problematic for these systems

Types of Emergency Vehicle Preemption

- **Radio Frequency Detection**: This system places a radio transmitting a specific frequency in the emergency vehicle. When the detector in the cabinet receives the radio call, it inputs a preemption call into the controller.
  - Any radio type of interference can cause problems with this system

- **GPS Detection**: This system simply works off the GPS position of the emergency vehicle along a predefined route in relation to the signalized intersection. As the emergency vehicle approaches the intersection(s), the receiver in the cabinet inputs a preemption call to the controller.
  - Any thing that interferes with visibility to the sky; tall buildings, mountains, or canyons may interfere with this preemption system.

Knowledge Check: Multiple Choice

What is the one thing that ALL detection devices have in common?

a) They operate on 48 VDC

b) They receive an output from the controller

c) They send an input to the controller

d) They can be programmed by time of day

Knowledge Check: Matching Activity

The left column shows detection components that need an inspection.
The right column shows items that a technician must check.
Match each detection component with the item to be checked.

a) Detection zone location	1) Misalignment
b) Camera orientation	2) Obstruction by sunlight glare
c) Camera and radar	3) Damaged wiring
d) Cables and connectors	4) Inaccurate program or fault

Knowledge Check: Matching Activity

Match the detection technology on the left with the principle by which it works on the right.

a) Loops	1) Magnetic shadows
b) Infrared	2) Inductance
c) Microwave	3) Radar
d) Magnetometer	4) Heat

Knowledge Check: Multiple Choice

Splashover is an operational concern with:

a) Video detection

b) Loop detection

c) Radar detection

d) Magnetic detection

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Knowledge Check: Multiple Choice

What detection technologies are **NOT** affected by weather?

a) Radar detection

b) Video detection

c) Ultrasonic detection

d) Metal detection

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Lesson 12: Pedestrian Detection and Service

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Pedestrian Signal Poles and Buttons

Signal Pedestrian Poles are specialized poles designed to support and display pedestrian signals at crosswalks and pedestrian crossings.

Key features of Pedestrian poles:

1. **Pole Height:** Ped poles may measure anywhere between **8** and **16** feet.
2. **Mounting and Construction**: Ped Poles may be mounted on a pedestal base or directly buried. Base mounted ped poles can be ***"shimmed"*** to ensure the pole is plumb.
3. **Signal Head Placement**: Pedestrian signal heads are to be placed between **7** and **10** feet above the sidewalk grade to the bottom of the head.
4. **Pole hardware:** may include a hand hole cover, a pole cap, or a post top fitter piece to install signal heads on top of the pole, which may require reinforcement to stabilize the signal head.
5. **Accessibility**: involves features such as tactile indicators, audible signals, or accessible push buttons that allow individuals with visual or mobility impairments to navigate and interact with the pedestrian signal.

Where do you place the ped button?

There are several federal agencies/guidelines to follow:

- MUTCD: Manual on Uniform Traffic Control Devices
- ADA: Americans with Disabilities Act
- ABA: Architectural Barriers Act
- PROWAG: Public Right-of-Way Accessibility Guidelines (*not yet Federally adopted*)

All of these references have something to say about pedestrian accessibility within the public right-of-way.

- *That includes the pedestrian push buttons*

MUTCD – Push Button Location

Figure 4I-2. Preferred Push Button Location Area

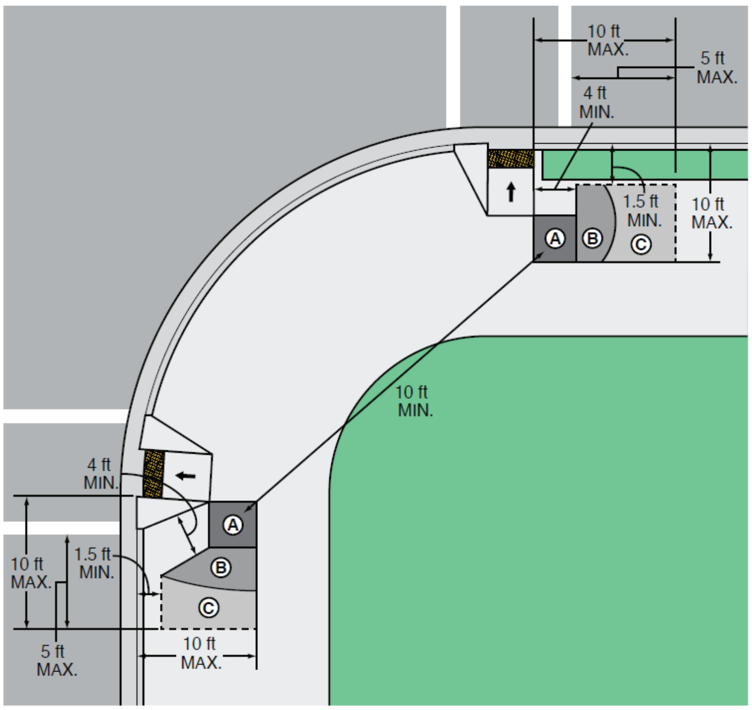
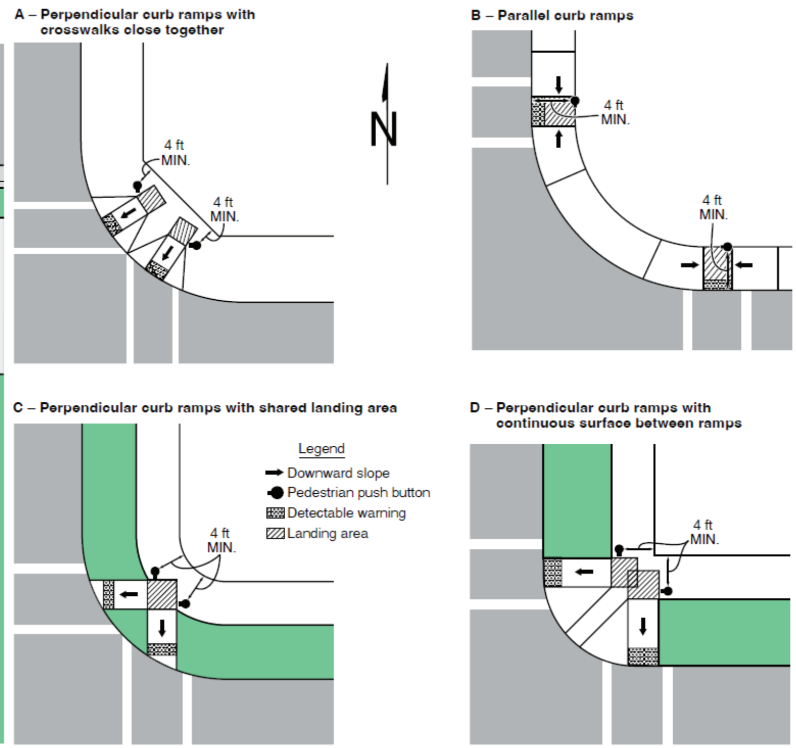


Figure 4I-3. Typical Push Button Locations



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MUTCD Requirements for pedestrian buttons

All guidelines are provided in the best interest of pedestrian movements and accessibility, which leads to increased safety.

The **MUTCD** says:

- **Ped Button Height**: The recommended height is between **42** and **48** inches (91-122 cm) above the ground.
- **ADA** says **15”** to **48”** for vertical reach limits and **10”** for horizontal reach limits.
- **Proximity**: Pedestrian push buttons shall be located no greater than **5 feet** from the side of a curb ramp

PROWAG (R307) Requirements

- **Tactile and visual cues such as**:
  - a raised arrow or tactile symbol indicating the direction of the crossing
  - an auditory and visual signals to indicate when it is safe to cross.
- **Contrast and visibility**: The button should contrast with its background to ensure easy identification.
- **Clear space**: Avoid obstructions such as poles, signs, or vegetation that may impede access.
  - If access is obstructed, the affected phase(s) should be placed on ped recall until access is cleared.

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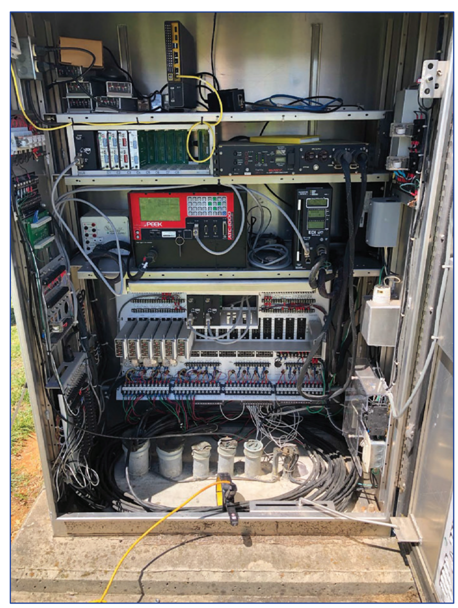
Isolation Panel

The isolation panel serves as an interface between the audible ped button in the field and the controller in the cabinet.

- This panel could be a point of failure if the ped button actuation doesn't end up as a ped call in the controller.

Picture of wires inside isolation panel



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MUTCD & Pedestrian Signals

What does the MUTCD say?

Sections 4A.06

- **WALK (WALKING PERSON):** means pedestrians shall be permitted to start to cross the roadway.
- **FLASHING (UPRAISED HAND) DON'T WALK:** means that pedestrian shall not start to cross the roadway; however, if they have already started to cross on the WALK indication, they shall continue to proceed.
- **STEADY (UPRAISED HAND) DON'T WALK:** pedestrians shall not enter the roadway.

Pedestrian Heads

- Pedestrian heads started out with the old 8x8" or 12x12" vertical stack.
- These heads displayed the words "WALK" and "DON'T WALK".
- <u>International pedestrian symbols soon replaced the words.</u>
- Newer pedestrian heads are a single, 16x16" unit with both symbols on one face.
- Countdown features countdown the time remaining in the *ped clearance interval.*
- The "DON'T WALK" color is Portland Orange.

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Pedestrian Control Features

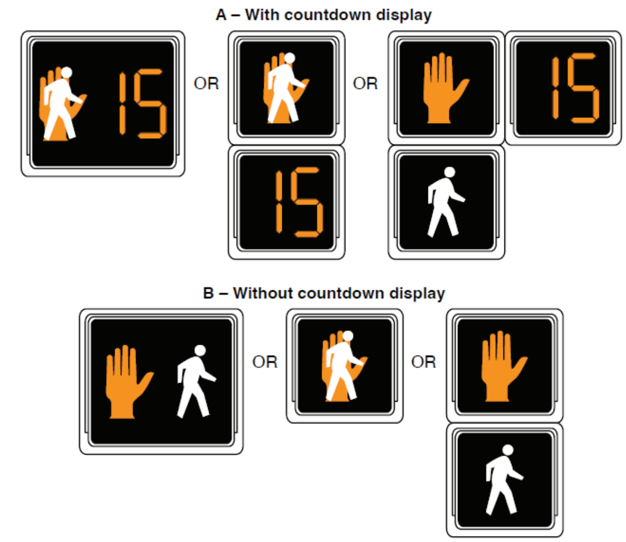
These signal indications consist of the illuminated symbols of a WALKING PERSON (symbolizing WALK) and an UPRAISED HAND (symbolizing DON'T WALK).

Pedestrian signal head indications shall have the following meanings:

1. A steady WALKING PERSON (symbolizing WALK)
2. A flashing UPRAISED HAND (symbolizing DON'T WALK), means that a pedestrian shall not start to cross in the direction of the signal indication, but that any pedestrian who has already started to cross on a steady WALKING PERSON (symbolizing WALK) signal shall proceed.
3. A steady UPRAISED HAND (symbolizing DON'T WALK)

A flashing WALKING PERSON signal indication has no meaning and shall not be used.

Figure 4I-1. Typical Pedestrian Signal Indications



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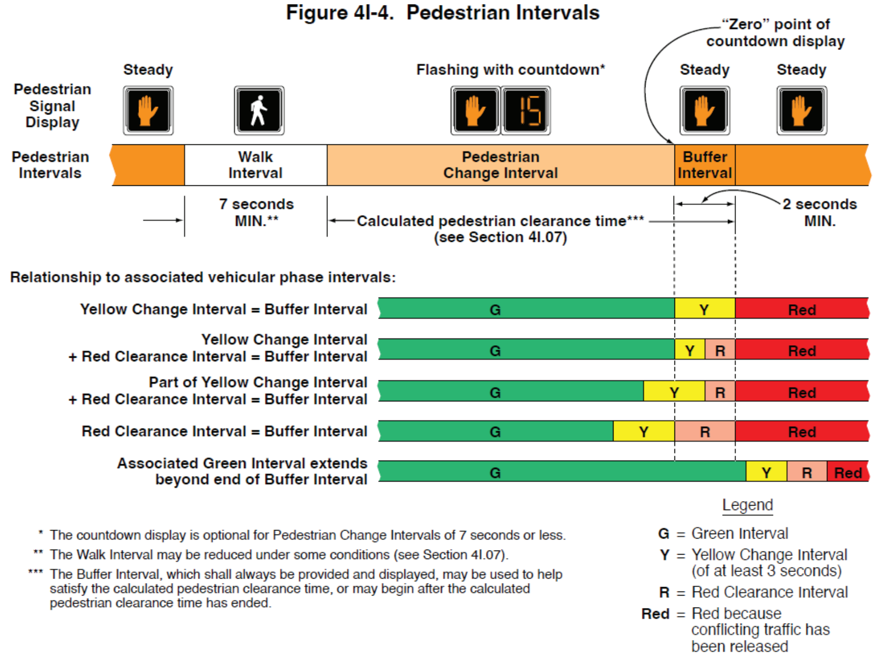
Pedestrian Intervals and Signal Phases

Intervals and Phases-

At intersections equipped with pedestrian signal heads, the pedestrian signal indications shall be displayed except when the vehicular traffic control signal is being operated in the flashing mode. At those times, the pedestrian signal indications shall not be displayed.

- **4I.05 Guidance**: Except as provided in Paragraph 8, the pedestrian clearance time should be sufficient to allow a pedestrian crossing in the crosswalk who left the curb or shoulder at the end of the WALKING PERSON (symbolizing WALK) signal indication to travel at a walking speed of **3.5** feet per second to at least the far side of the traveled way or to a median of sufficient width for pedestrians to wait.

Figure 4I-4. Pedestrian Intervals

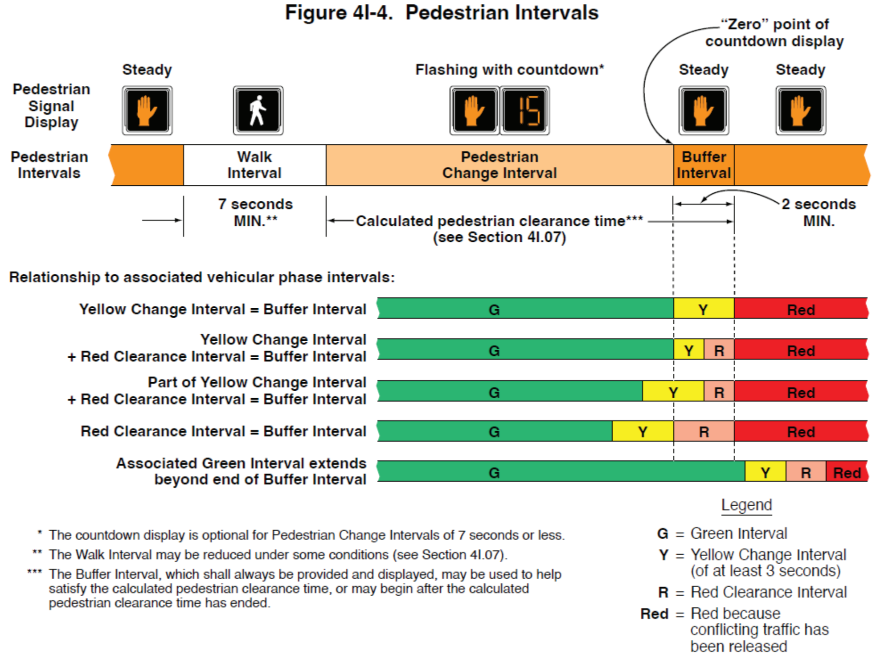


Pedestrian Intervals and Signal Phases

Intervals and Phases-

- **4I.05 Option**: A walking speed of up to 4 feet per second may be used to evaluate the sufficiency of the pedestrian clearance time at locations where an extended pushbutton press function has been installed to provide slower pedestrians an opportunity to request and receive a longer pedestrian clearance time. Passive pedestrian detection may also be used to automatically adjust the pedestrian clearance time based on the pedestrian's actual walking speed or actual clearance of the crosswalk.

Figure 4I-4. Pedestrian Intervals



* The countdown display is optional for Pedestrian Change Intervals of 7 seconds or less.
** The Walk Interval may be reduced under some conditions (see Section 4I.07).
*** The Buffer Interval, which shall always be provided and displayed, may be used to help satisfy the calculated pedestrian clearance time, or may begin after the calculated pedestrian clearance time has ended.

Audible Pedestrian Push Buttons

Every pedestrian push button inputs a call to the controller on the appropriate phase when pushed.

If testing **audible** pedestrian push buttons, inspect the following components:

- **Audible content**: Ensure the audible tone is present and that any message is correct.
- **LEDs**: Ensure LEDs are functioning.
- PROWAG R307.8.2 - Ped button locator tones shall be audible 6 to 12 feet from the button.

When testing any pedestrian button, verify if it is placing a call (an input) to the controller.

PROWAG (R308) Requirements

• An audible push button system for traffic signals is a feature designed to assist pedestrians with visual impairments or other disabilities in safely crossing the street.

• It consists of a push button device located at pedestrian crossings that emits audible signals, typically in the form of chirps, beeps, or speech messages.

PROWAG (R308) Requirements

According to PROWAG guidelines, pedestrian push buttons at traffic signals must incorporate audible signals as a standard feature.

- Audible walk indications shall be louder than ambient sound up to a maximum volume of **5 dBA** louder than ambient sound.
- The push button should also provide a tactile indication, such as a vibration or raised arrow, to assist pedestrians with visual and hearing impairments.

Ped Button and Pole Damage

Pedestrian push buttons for traffic signals can become damaged for several reasons:

- **Regular Wear and Tear**: Pedestrian push buttons are exposed to the elements and receive a lot of use, which can cause them to wear out over time.
- **Vandalism**: Unfortunately, pedestrian buttons can be a target for vandalism, which can lead to them becoming damaged.
- **Accidents**: Whether from cars, bikes, or other accidents, pedestrian buttons can be damaged by physical impacts.
- **Water Damage**: If the seal on the button is not effective, water can seep in, causing damage to the electrical components.

If a damaged ped button is found not to be placing a call in the controller, the affected phase(s) should be placed on ped recall until repairs can be made.

Ped Button and Pole Damage

Here's how you might repair them:

- **Button Replacement**: Often, if the button itself is damaged, the easiest solution is to replace it. This usually involves unscrewing the button from the pole, disconnecting it, and then installing a new button.
  - Always verify the repaired/replaced button activates the proper ped phase
- **Electrical Repairs**: If the issue is with the wiring or other electrical components, a technician will need to diagnose and repair the problem. This might involve replacing wires, fixing connections, or even replacing the entire button assembly.
- **Pole Repairs**: If the pole holding the button has been damaged (for instance, in a vehicle collision), it might need to be repaired or replaced.

Push Button Damage

If the push button itself is failing, **replace** the malfunctioning push button.

If the sign or sticker is compromised, it too may need to be replaced.

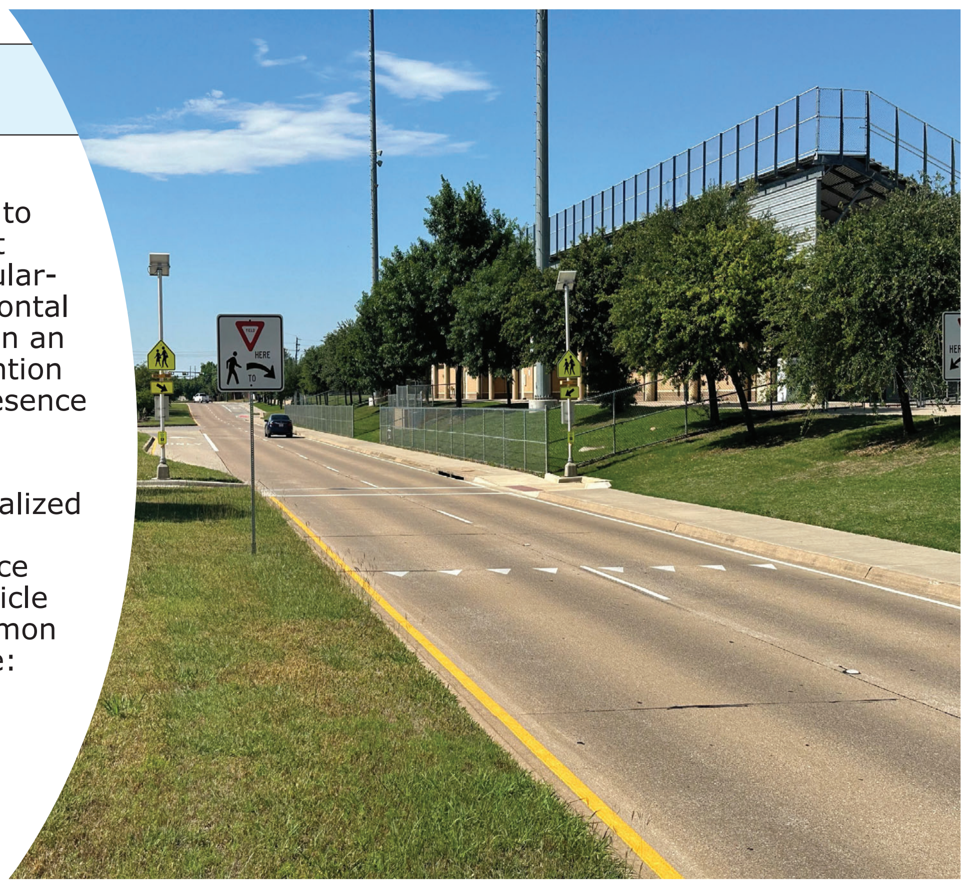
https://www.wieandlaw.com/will-insurance-pay-if-im-hit-car-pedestrian-philadelphia/

RRFB – Rectangular Rapid Flashing Beacon

A Rectangular Rapid Flashing Beacon (RRFB) is a traffic control device used to enhance the visibility of pedestrians at crosswalks. It consists of two rectangular-shaped LED lights mounted on a horizontal bar or sign. These lights flash rapidly in an alternating pattern, grabbing the attention of drivers and alerting them to the presence of pedestrians.

RRFBs are typically installed at unsignalized pedestrian crossings or mid-block crosswalks, where pedestrians may face challenges in crossing due to high vehicle speeds or limited visibility. Some common locations for RRFB installations include:

- **School Zones**
- **Pedestrian-Intensive Areas**
- **Multi-Lane Crossings**
- **Residential Areas**
- **High-Speed Roadways**



RRFB – Rectangular Rapid Flashing Beacon

- **Pedestrian-Intensive Areas**: RRFBs can be placed in areas with a high volume of pedestrians, such as downtown areas, shopping districts, or parks. They help improve pedestrian safety by increasing driver awareness and encouraging them to yield to pedestrians.

- **Multi-Lane Crossings**: At wide roadways or intersections with multiple lanes, RRFBs can be installed to enhance the visibility of pedestrians attempting to cross. They provide an additional visual cue to drivers, increasing the likelihood of yielding.

- **Residential Areas**: RRFBs may be placed in residential neighborhoods where pedestrian traffic is significant, particularly near parks, community centers, or areas frequented by residents.

- **High-Speed Roadways**: In situations where pedestrian crossings intersect with high-speed roadways, RRFBs can be installed to provide a visual warning to drivers to slow down and yield.


https://www.ayresassociates.com/hawk-signals-get-attention-safe-crossing/

Hawk Traffic Beacon

A **HAWK (High-intensity Activated Cross Walk) beacon**, also known as a Pedestrian Hybrid Beacon (PHB), is a type of traffic control device used to assist pedestrians in crossing busy or higher-speed roadways at locations where a full signal (red-yellow-green) isn't justified.

Components of a HAWK Beacon System:

1. **Pedestrian Signal Heads**: These are located on the opposite side of the street for pedestrians. The walk indication is a symbolic walking person (in white) and the don't walk indication is an upraised hand (in orange).

2. **Vehicle Signal Heads:** These are located on the opposite side of the road for drivers. They consist of two red lenses above a single yellow lens. When the HAWK is idle, the lenses are unlit. When a pedestrian presses the button to cross, the yellow lens flashes, then turns solid, warning drivers to prepare to stop. The lenses then change to solid red, requiring drivers to stop. Once the red lenses begin to alternately flash, drivers can proceed if the crosswalk is clear.

3. **Pedestrian Push-Button:** This is a button that pedestrians press to activate the HAWK beacon.

4. **Crosswalk:** The designated area for pedestrians to cross.

Hawk Traffic Beacon – Advantages and Disadvantages

Advantages of a HAWK Traffic Beacon System:

1.Increased Safety: The main advantage of HAWK Traffic Beacon is that they improve pedestrian safety. Research has shown that they significantly reduce pedestrian crashes.

2.More Efficient: HAWK Traffic Beacon only stop traffic when needed, unlike traditional traffic signals which may stop traffic at fixed intervals. This improves traffic flow.

3.Cost-Effective: These systems are less expensive to install and maintain compared to traditional traffic signal systems.

4.Flexibility: They can be installed in a variety of locations, including mid-block and on multi-lane roads where traditional signals might not be practical.

Disadvantages of a HAWK Traffic Beacon System:

1.Driver Confusion: HAWK Traffic Beacon are not as common as standard traffic signals, so some drivers might be confused by them, which can potentially lead to accidents.

2.Limited Awareness: Pedestrians and drivers may not be familiar with HAWK signals, which requires education and awareness campaigns.

3.Not Ideal for Heavy Traffic: In areas of high traffic, a traditional traffic signal may be more effective as it provides more control and can handle larger volumes of both pedestrian and vehicular traffic.

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Knowledge Check: Multiple Choice

As per the MUTCD, what elevation are pedestrian push buttons installed?

a) 2.5′ to 3′

b) 3′ to 3.5′

c) 3.5′ to 4′

d) 4′ to 4.5′

Knowledge Check: Multiple Choice

What does it mean when a pedestrian sees a flashing don’t walk signal?

a) Begin crossing the street

b) Do not step off the curb.

c) Finish crossing the street if already in the crosswalk

d) Both B and C

Knowledge Check: Multiple Choice

As per the MUTCD, what is the “average” walking speed of a pedestrian?

a) 2.5’ per second

b) 3.0’ per second

c) 3.5’ per second

d) 4.0’ per second

Knowledge Check: Multiple Choice

RRFB’s are a popular choice for pedestrian crossings.
What does RRFB stand for?

a) Rectangular Rapid Flashing Beacon

b) Rapid Rectangular Flashing Beacon

c) Rectangle Rapid Flashing Beacon

d) Rapid Rectangle Flashing Beacon

Knowledge Check: Multiple Choice

What type of traffic assembly is allowed to be dark if it is sitting idle?

a) Fire station signals

b) Mid-block pedestrian signals

c) Hawk Traffic Beacon

d) Temporary traffic signals

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Lesson 13: School Zone Flashers

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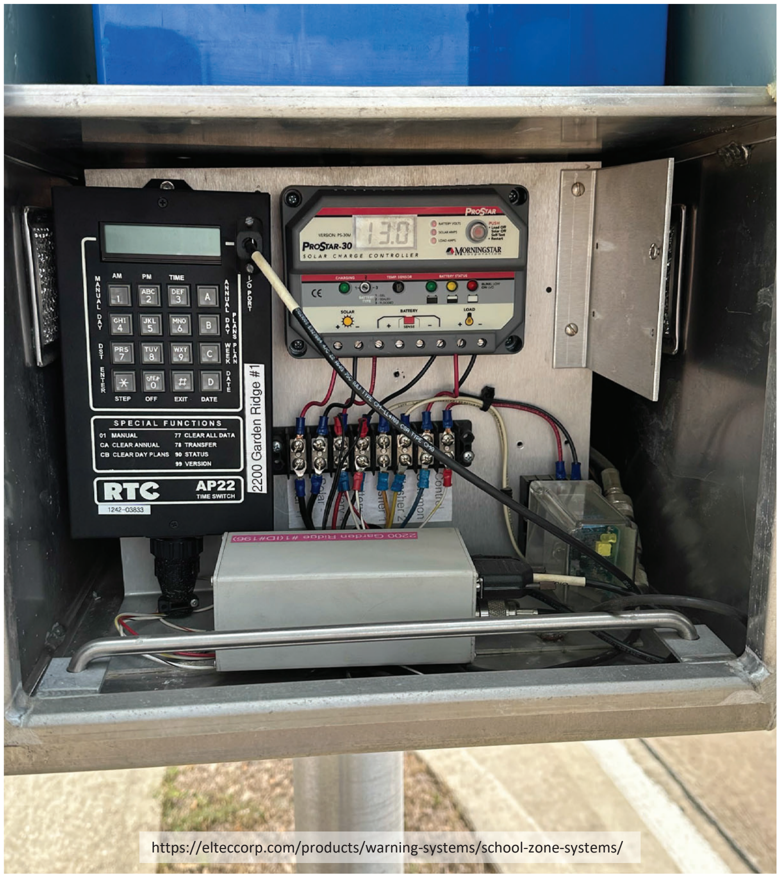
School Zone Flashers

A school zone flasher, also commonly known as a school zone flashing beacon, is a traffic control device used to alert drivers that they are entering an area near a school where a reduced speed limit is enforced during certain hours.

Components of a School Zone Flasher Assembly to be checked:

1. Flashing Beacon – half cycle "on", half cycle "off"
2. Signage
3. Power Source / battery
4. Controller/Timer
5. Pole/Mounting Hardware
6. Protective Housing
7. Solar Panels (Optional)



https://elteccorp.com/products/warning-systems/school-zone-systems/

School Zone Flashers

Importance of School Zone Flashers:

- **Safety**: School zone flashers play a critical role in ensuring the safety of children. They alert drivers to slow down, thus reducing the risk of accidents in areas where children may be present.
- **Enforcement of Speed Limits**: The flashers help to enforce speed limits in school zones. Drivers who see the flasher are reminded of the need to slow down.
- **Visibility**: In conditions of poor visibility, such as in fog, rain, or at dusk or dawn, the flashers increase the visibility of the school zone sign, further enhancing safety.
- **Flexibility**: With the ability to control the hours of operation, school zone flashers can be adjusted to match the schedule of the school, including irregular hours for events or activities.

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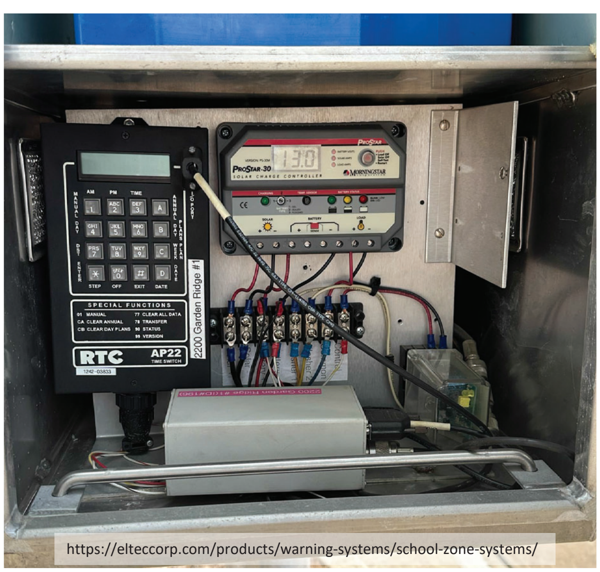
School Zone Flashers

Here are some common guidelines for when and where school zone flashers should be installed:



https://elteccorp.com/products/warning-systems/school-zone-systems/

•**Near schools:** School zone flashers should be installed in the vicinity of schools. They are typically found before the start of the school zone, to give drivers enough time to slow down before they reach the area where children are likely to be crossing the street.
•**On both sides of the road:** For safety, the flashers should be visible to drivers traveling in both directions. This means they should be installed on both sides of the road.
•**Before crosswalks:** If there's a crosswalk in the school zone, it's particularly important to install a school zone flasher before it. This helps alert drivers that they need to watch for children who might be crossing the street.
•**Operation timing:** School zone flashers should operate during school arrival and departure times. This typically includes a period in the morning when students are arriving at school, and a period in the afternoon when they're leaving. The exact times can vary based on the school's schedule.
•**Special Events:** The flashers may also be used during special events, like school sporting events or parent-teacher conferences, when there might be more children and pedestrians around than usual.

Solar Panels

- Inspect **solar panels** for damage, check its orientation, and verify proper function.
- Clean solar panels if there is a **buildup of dirt** or debris.
- Replace solar panels if there are **cracks** or damage.

https://ustrafficsystems.com/product/double-flashing-beacon-school-zone-system/

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Lesson 14: Maintenance

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Routine Preventative Maintenance: Monthly, Quarterly, & Annual

Emergency Response Maintenance

Routine Monthly or Quarterly Preventative Maintenance

Routine Monthly or Quarterly Preventative Maintenance

Regular proactive inspections and maintenance will help keep your traffic light infrastructure running efficiently as well as make life easier for technicians to work at a location.
Here is an example of monthly or quarterly maintenance items to check.

- Check signal heads for visibility and proper lane alignment.
- Check for broken or missing parts.
- Verify all ped push buttons for proper operation
- Check detectors for proper operation & alignment with vehicles in detection zones
- Check preemption for visibility and proper alignment to roadway
- Maintain accessibility to pull boxes and cabinets
- Locate, clean around, and inside all pull boxes
- Check all wiring in pull boxes for damage
- Check all pull boxes for proper grounding
- Remove ALL dirt & debris from under and around signal poles

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Routine Monthly or Quarterly Preventative Maintenance

- Remove any graffiti & stickers from the cabinet, poles, signs, and metered service
- Clean inside of the metered service and check breakers
- Clean inside of, and check switches in, Police Panel
- Clean inside of Generator access area
- Clean and vacuum cabinet, including floor of the base, shelves, and the equipment
- Check lights & fan for proper operation
- Check the flasher for two flashing outputs
- Check all Load Switches and replacement jumpers are secure
- Check the FTR's for proper operation
- Record status of LED on lightning arrestor (Note status in comments)
- Check CCTV cameras are operational
- Check timing sheets in cabinet and match to controller
- Check Time and Date in controller and monitor
- Check SYS/FREE switch is in SYS position
- Verify that MMU "DIP" Switches or CMU settings are correct
- Check signs and markings for faded, missing, damaged, incorrect
- Sign Signal Inspection Maintenance log

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Routine Annual Maintenance

Annual signal inspections are far more in depth than monthly or quarterly inspections. These types of inspections may take a half a day or more to completely check everything. An annual inspection list might look like this:

- Tighten all pole base nuts
- Check that anchor bolts are intact and not broken, corroded, or damaged
- Check signal, pedestrian, and Preemption heads visibility & alignment.
- Drill or fill drain holes as necessary
- Check cabinet sealant to the base
- Perform self-test on preemption cards
- Tighten ALL wire terminals
- Check all wiring for labels & organization
- Check all Flash Transfer Relays "K switches" are secure
- Check resistance to ground with a ground rod tester - 25Ω or less
- Clean inside UPS cabinet & air filter
- Record any UPS Alarms
- Record UPS battery Voltage and availability level from LCD readout via laptop
- Check UPS is in "UPS Mode" NOT "Line/Transfer Mode"
- Check UPS Battery Breaker is "ON"

Routine Annual Maintenance

- Check UPS input circuit breaker is "ON"
- Test UPS system by switching "OFF" the electric service breaker. Let the UPS run in battery backup for 10 minutes.
- Inspect the UPS batteries for cracks or swelling. Replace as necessary.
- Load check each battery individually
- Clean or Change cabinet air filter
- Lubricate cabinet door locks & hinges
- Lubricate generator door lock
- Lubricate cabinet drawer tracks (do not allow to drip on electronics)
- Check UPS LCD to verify "INVERTER" operation
- Check UPS LCD to verify normal operation
- Remove any Load Switch; Check intersection enters flash mode
- Record which load switch was removed
- Run Conflict Monitor/MMU Certification test
- Print 2 copies of Certification (1 for office & 1 for intersection)
- Check Conflict Monitor or MMU Card for correct jumpers only are on board
- Check Time and Date in controller and monitor
- Clear Conflict Monitor/MMU Logs

Routine Annual Maintenance

- Check Welds and Anchor Point (for rust, cracks, corrosion, and other damages)
- Check Preemption matches intersection data sheet
- Check Phasing matches intersection data sheet
- Check Timing Plans match intersection data sheet
- Check Timing Sheets match controller programming and replace if necessary
- Remove any unused equipment from cabinet (extra BIU, etc.)
- Check SYS/FREE switch is in SYS position
- Verify that MMU "DIP" Switches or CMU setting are correct
- Add copy of certification to intersection files in office
- Record Span Wire Height:
  - Measure shortest distance between span/head to roadway (*Report immediately if below agency minimum*)
- Check mast arms for movement or misalignment with roadway
- Sign Annual Signal Inspection Log

Responding to Signal Emergencies, Flashing & Outages

IF the Intersection is Flashing:

- ***Determine the cause of the signal condition - What Happened?***
- Read the monitor and the controller for information
- **DO NOT HIT THE RESET BUTTON!!!**
  - *You need the information these devices provide*
  - *Once you hit the reset button, you've lost everything*
- Look for other clues:
  - Unsafe conditions
  - Weather
  - Accidents
  - Construction
  - Vandalism…

IF the Intersection is found Dark:

- Motorists should treat it as a four-way stop.
- Check voltage into signal cabinet
- Check voltage in service cabinet
- Check breakers
- Check battery backup system
- Try to activate battery backup systems
- Check batteries
  - Battey Backup nonoperational?
  - Connect generator
  - If no generator is available, Setup temporary traffic control devices (Stop Signs)

IMSA Traffic Signal Glossary

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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)

Glossary of Terms

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)

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.

Glossary of Terms

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

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)

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.

Glossary of Terms

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.

Canadian Electrical Code, CE code (CEC), 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)

Glossary of Terms

Changeable Message Sign (CMS) – also known as Variable Message Sign (VMS) or Dynamic Message Sign (DMS). CMS's 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 form or 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.

Glossary of Terms

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

Controller Unit – that part of a 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.

Glossary of Terms

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 Departments 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)

Detection Zone – that area of the roadway within which a vehicle will be detected by a vehicle sensor (NEMA). Also called 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.

Glossary of Terms

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)

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)

Advancing the Future of Public Safety

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 and 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)

Glossary of Terms

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.

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.

Glossary of Terms

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)

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.

Glossary of Terms

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)

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)

Glossary of Terms

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)

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)

Glossary of Terms

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)

Glossary of Terms

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)

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)

Glossary of Terms

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)

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)

Glossary of Terms

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)

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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 or 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)

Glossary of Terms

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)

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)

Glossary of Terms

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)

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)

IMSA Traffic Signal Technician I

This Concludes the Review Session

Advancing the Future of Public Safety