Electrical Wiring
- OR -
WHY DO WE NEED ALL THIS COPPER?!

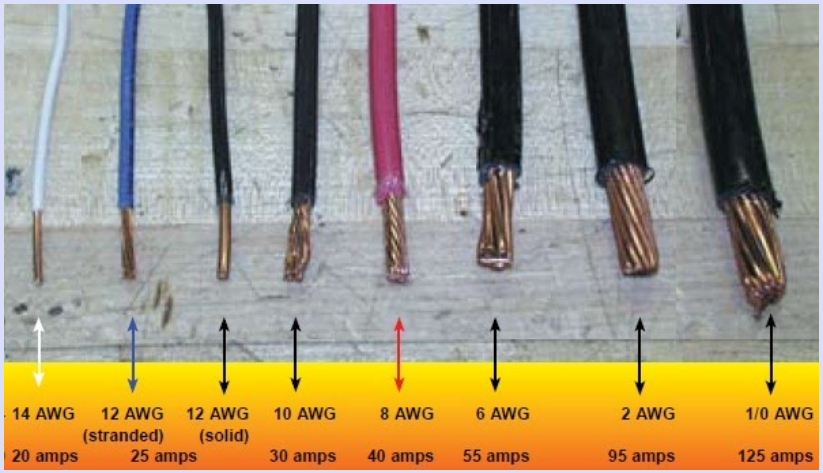
Objectives

- Identify Types of Wires
  - Size
  - Insulation
- Installation Methods
  - Pulling
  - Blowing
- Grounding and Bonding
  - How, where and why
  - Testing
- Splicing conductors
  - Where are splices permitted?
  - Splice “kits”
  - Testing
- Terminations
  - Proper cable/wire termination methods
- Electrical Services
  - Installation and Service Connection
- Documentation
  - Asbuilts
  - LABEL!!

Wire Size

Wire size is measured in AWG (American Wire Gauge)

- The AWG number identifies the size of the conductors the smaller the number the larger the diameter (AWG 0000 – 0.46 in , AWG 18 – 0.04 in)
- NEC defines process for calculating wire size based on Current, Voltage and length of wire.
- Changes in routing may require a change in the wire used to cabinets or field elements.
- Most household wiring is usually 12 or 14 AWG
- DOT Signal, Lighting and ITS wires range from 18 AWG for communications interconnect to 00+ for power service.
- AWG # wire can be either solid or stranded .



Determining Conductor Size

- Typically ampacity and sizing is determined by the designer and provided on the plans
- De-rating of conductors may need to be determined if the cable routing is revised by field personnel or final job layout
  - Derating process is documented in the NEC. Generally requires a review of installation conditions and cable rating.

Conductor Insulation and jacket Types

Insulation and Jacketing identified in Standard Specifications

- XLP or XLPE (Crosslinked Polyethylene) – moisture resistant , flexible, use in wet environments (pull boxes and conduits)

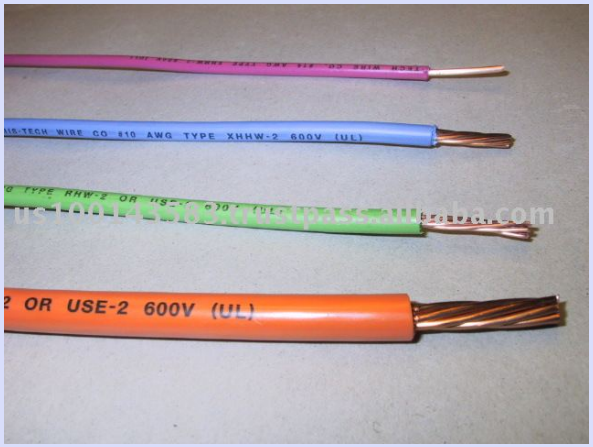
- THHN or THHW (Thermoplastic High Heat resistant Nylon, Heat and Water resistant Nylon) – Suitable for dry or wet locations, high thermal stability, high strength.

- PVC (Poly-Vinyl Chloride) – Low heat resistance, not resistant to sunlight, Not appropriate for wet locations, low flexibility.

Rated for Wet location in accordance with NEC 310.104(A)

Requirements for WIRE

- Type **USE-2** or RHH or RHW-2 copper conductors are suitable for use in raceways installed underground in wet locations



- Type **UF-B** (Underground Feeder Cable) has a broad range of usage as defined in Article 340 of the National Electrical Code (NEC). Type UF-B may be installed as interior wiring in wet, dry, or corrosive locations at temperatures not to exceed 90°C

- Stranded or Solid – Requirements vary by application

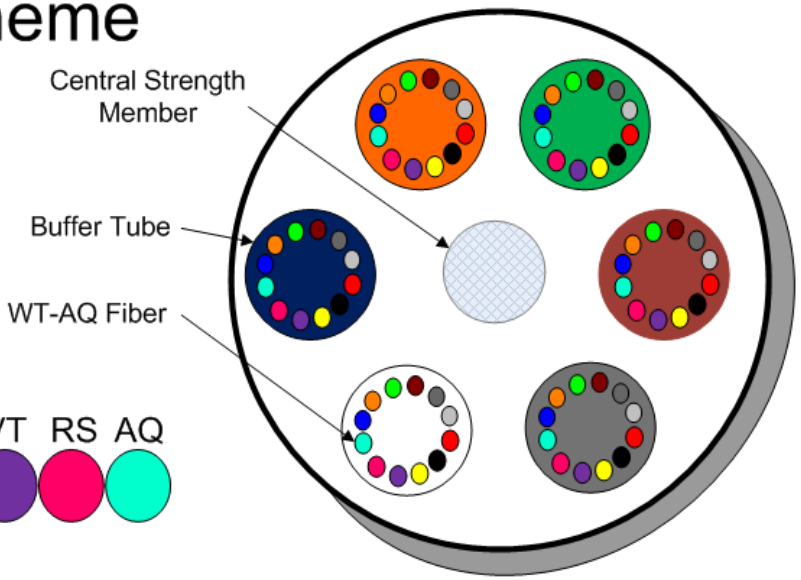
Fiber Optic Cable

- Single Mode optical fiber
  - Long distances,
  - High splicing costs
  - High cost end equipment (optics)
- Multi Mode optical fiber
  - Much shorter distance
  - Relatively easy to splice

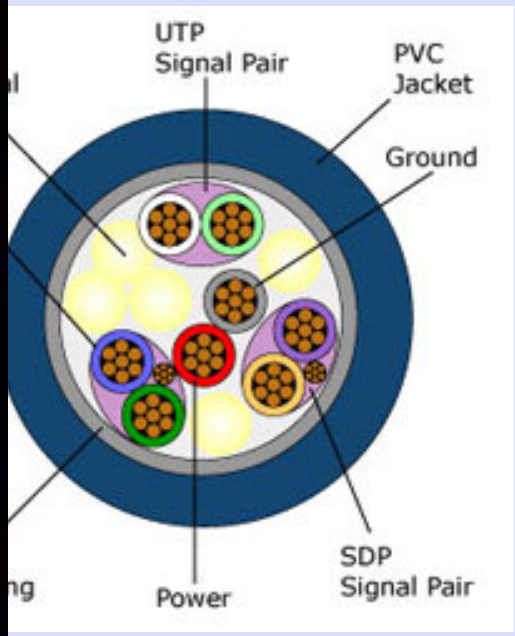
Most fiber being installed by the DOT today is single mode fiber between 6 and 72 strands

Standard Color Scheme

"Loose Tube Buffer" cables are built with a central strength member for pulling surrounded by hollow buffer tubes which each contain multiple fibers



CABLE – v- WIRE

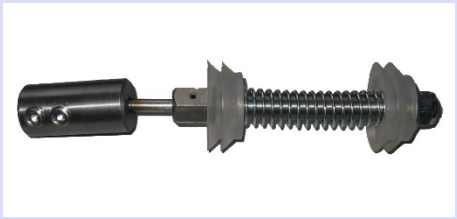


Underground Wire and Cable

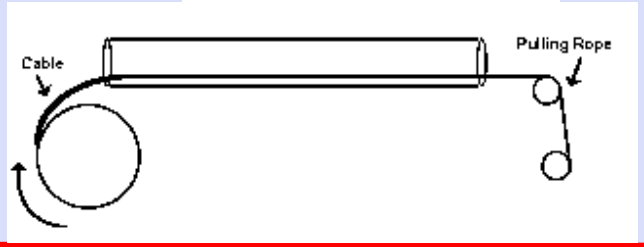
- Pre-installed cable in duct (CID)
- Traffic Signal Cable (IMSA 20-1 standard, 14AWG 4,5 or 7 conductor from signal head to base)
- Underground Feeder Type UF (Size as shown in plan, ANSI/UL 493)
- Communications Cables(Fiber optic & copper)
- Single Conductors (Power & Lighting) (Size as shown in plan, IMSA 20-1)
- Grounded and Equipment Grounding Conductors (green insulated, 10 or 8 AWG, USE, XLP, 600V, stranded)
- Loop Detector Wire (XLP insulated, USE rated single wire, 7 strand, 12 AWG)
- Loop detector Lead In Cable (Polyethylene insulated, shielded, 14 AWG 2 conductor, 16 AWG drain wire, NFPA 50-2)
- Emergency Vehicle Pre-emption Detector Cable for Traffic Signals (20 AWG stranded, 3 conductor, shielded, 600V, conductors colored blue, orange and yellow)

Cable and Wire Installation

Cable can be pulled or blown through conduit



- Pulling Tension
- Avoiding damage
- Avoiding entry of moisture into cables until final termination



- Mechanical advantage equipment
- Best practices to avoid twists and kinks
- Marking incoming line side leg of cable loops
- LUBRICATE

Pulling Tension

Fiber Optic Cable

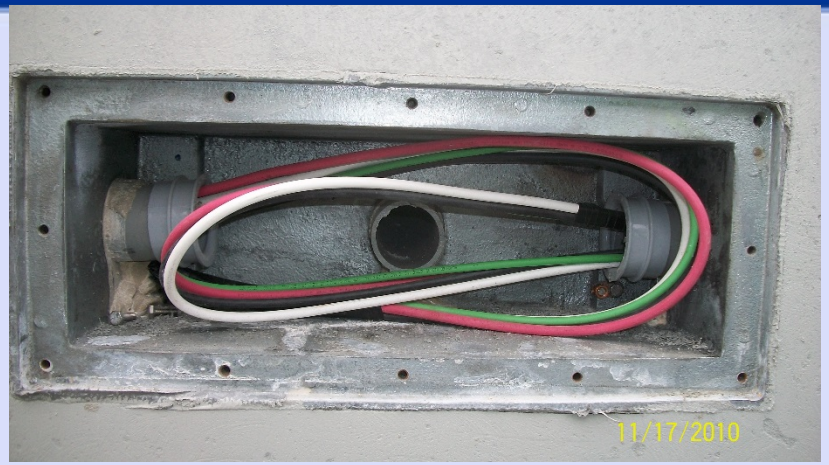
- Installation Techniques(supervised by FOA certified technician)
  - Dynamic load
  - Installation Tension
  - Minimum bend radius
- Splicing and Terminating(Performed by FOA certified technician)
  - Fusion Splicing
  - ST Connectors

Provide minimum cable slack

Pull Boxes	10-FT
Embedded Junction Boxes	3-FT
Distribution Center/ Load Center	10-FT
Poles	5-FT IN and 5-FT OUT

Minimum slack for Fiber Optics

Fiber Vaults	50-FT
Fiber Splice Vaults	100-FT
Cabinets	50-FT
Pull Boxes	30 – FT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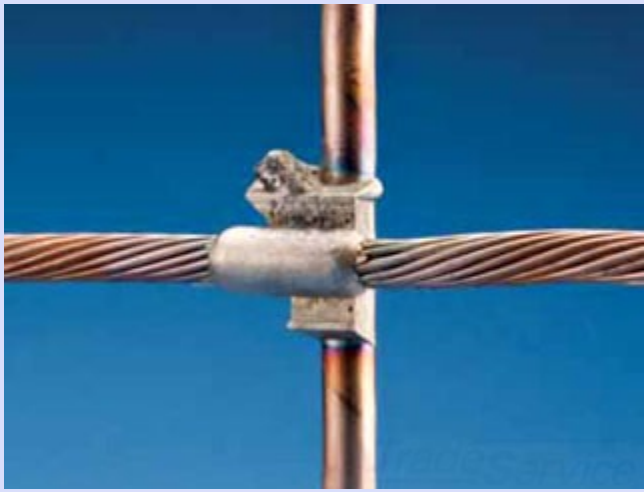
Grounding and Bonding

Equipment Grounding and Bonding

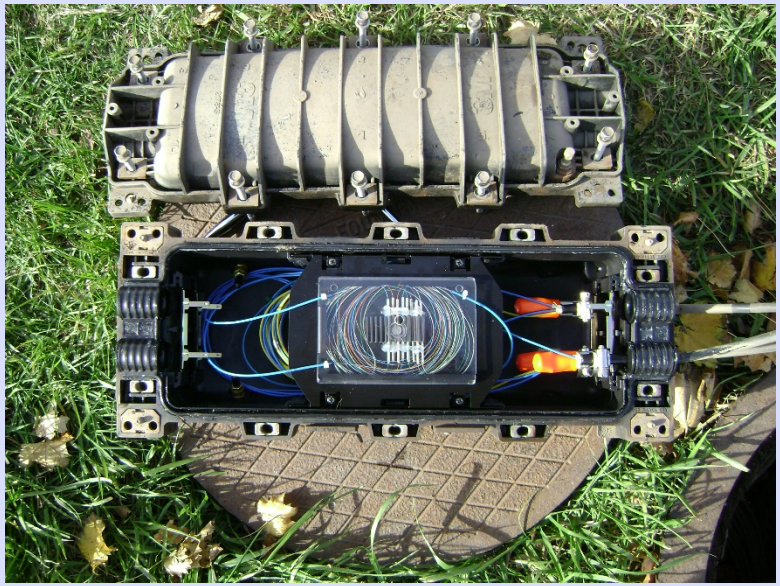
- The purpose is to ensure operation of overcurrent devices and prevent metallic equipment from becoming energized.
- Specifications require bare or green-insulated copper equipment grounding conductor in all underground conduit systems.
- Equipment grounding conductor attached to poles, control cabinets, pull boxes, manhole rings and covers.
- Size of equipment grounding conductor as indicated on plan.
- If length of circuit is modified equipment grounding conductor size might need to be increase.
- Unused conductors from a signal cable should be terminated on the grounding bus

- Grounding electrodes are 5/8” dia by 8 ft long (min).
- All connections to ground rods shall be exothermically welded.
- Wisconsin code requires a minimum of 2 electrodes spaced at least 6 ft apart.
- Grounding electrode conductor used to connect the ground rods to the service enclosure must be in unbroken length.



Splicing and Terminating cables

- A **splice** is a method to connect two or more wires together with a minimum amount of voltage or signal loss.
- A **termination** is a connector or other treatment at the end of a wire. This can be at a piece or equipment a terminal block or a patch panel.
- Loop detector lead-in cable splices to loop detector wire are the only wire splices in pull boxes. No splices are aloud underground or in conduit
- Fiber Optic cable splices are located in designated splice vaults using a water tight splice enclosure.
- Cover tape with electrical varnish or sealant.
- Spring wound wire nets are used in signal bases
- Signal and lighting wire splices are permitted at hand-holes in poles or signal transformer bases.



Loop detector splices

- Lead in cables and conductors need to be identify with waterproof tags.
- Lead in cables and conductors need to be protected from moisture during installation.
- If unsealed conductors ends have been submerged in water they will need to be replaced.
- Conductors and cables should be meggered prior to splicing.
- Splices are made using scotchcast splicing kits.
- Splices in conductors are to be soldered.

Conductor and Cable Splicing

- Rated for the installation environment
- Correct for the conductor size
- Torque requirements
- Epoxy resin encapsulated
- Break away connections
- Service loop locations


06/01/2010


Littelfuse
600V 30A 200KA IR
75°C WIRE CU ONLY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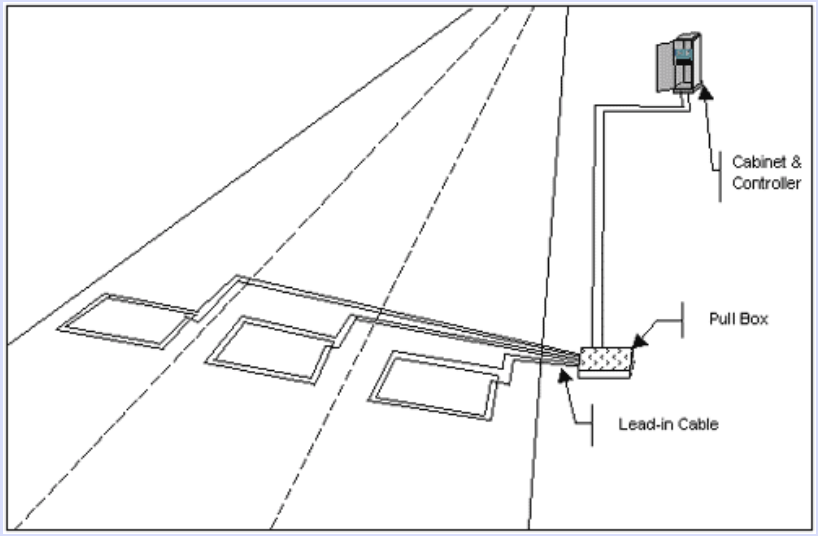
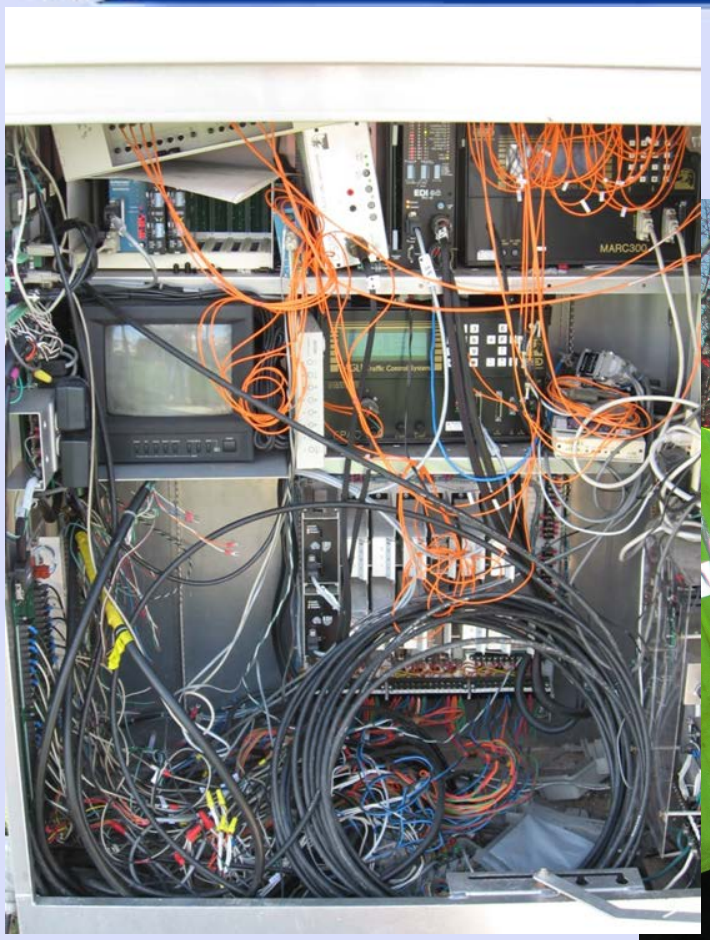
Placement of Conduit and Conductors



- Loop detectors installed in the roadway surface or follow the plan, some are installed in the base course
- Loop detector shall be located in the lane of traffic as indicated in plans.
- Loop detectors consist of four parts:
  - Wire loop
  - Lead in cable
  - Pull box
  - Electronics unit

Inspection Requirements

- See checklist(CMM 6-55)
- Notify of DOT for Inspection before covering underground conduit and prior to wire/cable installation
- Phone number and contact information is on plans
- Conductors are not to be installed until inspection is complete and all non-compliance items corrected

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Fiber optic splicing

- Fusion splicing must be performed by a DOT approved splicing technician.
- No mechanical splices are acceptable
- Fiber terminations must be either fusion spliced “pigtails” including gator patches, or approved field installed terminations using hot melt or UV cured adhesive.
- After fiber splicing and terminations are complete an OTDR (optical time domain reflectometer) is used to test.

Electrical Service

Electrical Service Equipment

- Local Utility Requirements
- 100Amp, 120/240Volt Single Phase
- 22,000-AIC Rated Equipment per spec 656.2.3
- Main Breaker Disconnect Box spec 656.2.6
- Service Grounding
- Installations With Intersection Lighting
- Overhead Meter Socket Service
- Pedestal Meter Socket Service

Local Utility Requirements

- Electrical service equipment must conform to local utility requirements.
- Obtain meter pedestal location letter provided by the utility.
- Utility company needs to be consulted regarding location of the service pedestal. (this should happen at design but occasionally the location is changed during construction)

100Amp, 120/240Volt Single Phase

- Local utility provides a 100 Amp, 120/240 Volt single phase underground service, unless specified otherwise on the plan.
- Highway lighting system services may operate at voltages and currents other than 120/240 Volt single phase

Change picture

Main Breaker Disconnect Box

- Breaker enclosure needs to be NEMA 3 outdoor rated enclosure.
- Breaker enclosure has 6 spaces for breakers or as the plan show.
- Main breaker shall have an Amp rating of 15 Amp unless otherwise specified.
- Circuits for roadway lighting must be at a separate breaker.
- Circuits utilizing 240 V require the use of a 2 pole common trip breaker.

Service Grounding

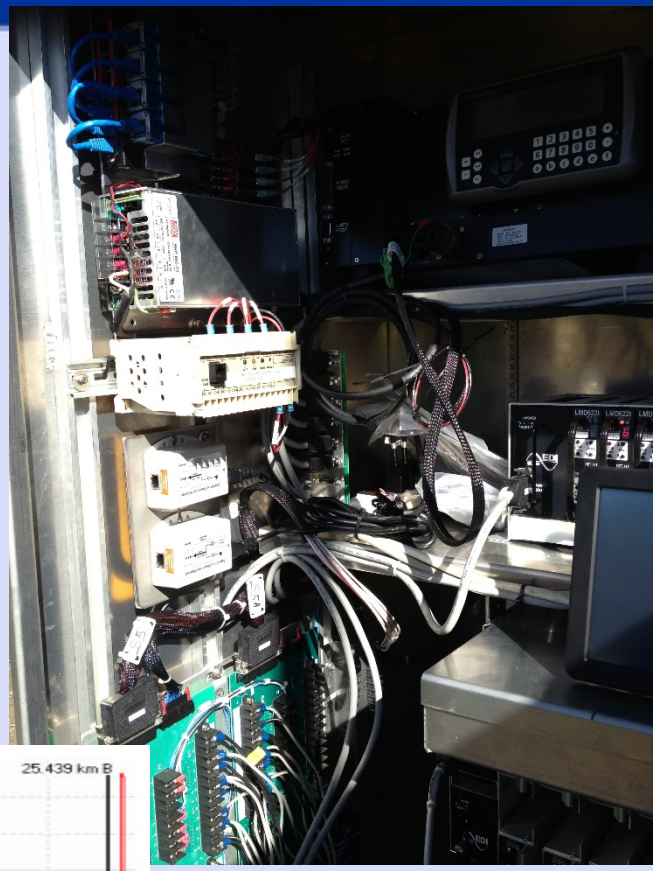
- Grounding electrode system must be connected to the grounded conductor in the meter socket.
- A main bonding jumper must be installed between the equipment ground and the system ground.

Pedestal Meter Socket Service

- After the pedestal is installed the contractor sends an affidavit to the utility confirming the service conforms to all requirements.
- The utility will install and test the meter.
- When a service is energized make sure an approved meter seal is installed at all access points.

Labeling and Documenting

- All cables terminated in a cabinet should be labeled to identify their function, and the location they are terminated or spliced.
- OTDR traces (bi-directional if possible) and strand length and loss shall be provided for all fiber splices.



QUESTIONS?