

	(*50 mm to 150 mm diameter)	
809.015 to 809.100	* ___ millimeter Electrical Conduit - Flexible Metallic	Meter
	(*15 mm to 100 mm diameter)	
810.	Conduit Encased in Concrete - SD4.041	Meter
811.10 to 811.14	Electric Manhole - SD2.0* (* SD2.010 to SD2.014)	Each
811.20 to 811.24	Electric Handhole - SD2.0* (* SD2.020 to SD2.024)	Each
811.30	Pull Box 200 millimeters by 585 millimeters - SD 2.030	Each
811.31	Pull Box 300 millimeters by 300 millimeters - SD 2.031	Each
811.35	Pull Box Adjusted	Each
811.36	Electric Manhole Adjusted	Each
811.37	Electric Handhole Adjusted	Each
811.40 to 811.52	Junction Box ___ x ___ x ___ millimeters	Each
812.10 to 812.15	Light Standard Foundation SD3.01* (* SD3.010 to SD3.015)	Each
812.20	Lighting Load Center Foundation	Each
812.30	Standard Signal Post Foundation	Each
812.31	Pedestal Signal Post Foundation (SD3.031)	Each
812.40	Signal Mast Arm Foundation	Each
812.50	Signal Control Cabinet Foundation	Each
815.98	Footing Cost Adjustment	Meter
144.	Class B Rock Excavation	Cubic Meter
191.	Drive Sample Boring	Meter
191.11	Core Boring	Meter
193.	Mobilization and Dismantling of Boring Equipment	Lump Sum

SECTION 813

WIRING, GROUNDING AND SERVICE CONNECTIONS

DESCRIPTION

813.20 General.

This work shall consist of furnishing and installing wire and cable of the type and size indicated for traffic signals, highway lighting and related electrical systems, equipment grounding systems, new ground electrodes or connections to existing ground electrodes and all materials and equipment necessary to deliver power to traffic signal, highway lighting and related electrical systems.

Service points shown on the plans are approximate only. The Contractor shall determine exact locations and riser elevations from the serving utility, arrange to complete the service connections and be responsible for all charges incidental thereto.

All electrical connections, splicing, grounding, resistance tests, service connections and circuit identification shall be done by a licensed electrician holding "Certificate B" issued by the State Board of Examiners of Electricians.

813.21 Cable Types and Uses.

A. General.

The types of wire and cable shall be used in the following manner:

- Type 1 – All traffic control signal circuits above ground supported by a messenger wire, in duct or other electrical wire and cable raceway and shall be installed only when the air temperature is above 2 °C.
- Type 2 – Same as Type 1 except may be installed at any air temperature above -6 °C.
- Type 3 – All traffic control circuits installed above ground supported by integral messenger.
- Type 4 – Same as Type 3 and when an electrical continuous metallic shield is required.
- Type 5 – All traffic signal circuits for direct earth burial or severe service conditions.
- Type 6 – Traffic control signal heads.

- Type 7 – All power and lighting distribution systems in duct or other electrical wire and cable raceways.
- Type 8 – Same as Type 7 and includes direct earth burial, services and roadway wire loops (USE XLP only).
- Type 9 – Special purpose when specified.
- Type 10 – Grounding and bonding traffic control and highway lighting systems.
- Type 11 – Shielded detector lead-in cable for wire loop detectors.
- Type 12 – Multi-conductor heavy duty portable power cord for traffic control signal mast arm and high mast tower lighting.
- Type 13 – Loop detector wire with tube.

MATERIALS

813.40 General.

A. Wire and Cable.

Unless otherwise specified, all traffic signal cable connectors shall be not less than #14 AWG, solid or stranded, and all conductors for mast arm and/or span wire shall not be less than #16 AWG stranded. Materials shall meet the requirements specified in Section M8.

B. Equipment Grounding.

Unless otherwise specified, equipment grounding conductors shall be not less than #8 AWG insulated or bare, solid or stranded copper wire meeting the requirements specified in Section M8.16.10.

C. Ground Electrodes.

Ground electrodes shall consist of a water pipe, driven rods or other devices approved for the purpose. Water pipes and driven rods used as grounding electrodes shall conform to the following requirements:

1. A metallic underground water piping system shall be used as grounding electrodes where such a system is available.
2. Where a water system is not available, the grounding connection shall be made to an electrode meeting the requirements specified in Section M8.

D. Service Connections.

All equipment furnished shall be new unless specifically mentioned otherwise and shall meet the current requirements of NEMA, UL and the code wherever such standards apply.

CONSTRUCTION METHODS

813.60 Wire and Cable.

A. Steel Messenger Cable Fittings.

Messenger cable (integral with Types 3 & 4 Traffic Signal Cable) shall be secured to strain poles by means of pole bands. Pole bands shall be installed as detailed on the Standard Drawings. Strain insulators shall be installed as shown on the plans. Attachments to utility owned poles shall be according to the local utility company requirements and under the supervision of the local utility company Engineer. The Contractor shall furnish and install back guys, head guys, anchors, etc. that may be requested by the local utility Engineer, where guys are necessary due to the placement of traffic signal equipment on utility poles.

Traffic signal cable shall be attached to messenger cables by spinning the cable to the messenger with an approved lashing material (stainless steel or Kevlar-Aramid fiber core with nylon jacket) or when approved in writing, steel cable rings approved for the purpose may be used.

B. Installation of Copper Wire and Cable.

Installation of wire and cable shall not begin until the conduit system has been tested in accordance with the requirements of Section 801.60 Conduit, Paragraph H, Testing Installations.

All conductors and grounding wire shall be drawn, by hand, into ducts or conduits without damage to covering, sheath, insulation or wires. This wiring shall not be done until all work which may damage the wires has been completed. In pulling, all wires shall be drawn freely into conduits without kinks or bends, twisting or lapping. In general, all conductors in each conduit run shall be pulled at the same time, fed from free running reels. Powdered soapstone, talcum or other approved lubricant may be used to assist in placing wire and cable in conduits.

A sufficient length of slack shall be allowed for each cable in all manholes, handholes, pull and junction boxes and

equipment enclosures, to provide for neat racking and movement due to thermal expansion and contraction.

C. Splicing.

Splices shall be made in accordance with the Electrical Code by Journeymen Electricians holding “Certificate B” issued by the Board of State Examiners of Electricians.

Splices shall be made only in manholes, handholes, control cabinets, junction boxes or signal and lighting bases.

Pull boxes shall not be used for splicing, except in pull boxes where vehicle detectors are used, soldered splices will be permitted in the pull box nearest the detector (see Subsection 813.60, B). Detector leads shall not run in the same cable sheath or jacket in cable carrying signal currents.

The conductors shall be joined by the use of connectors and terminal lugs, listed by Underwriters Laboratory, and meet all requirements of the Massachusetts Electrical Code.

Splices shall be insulated. Unless otherwise specified, the Contractor may use any of the following:

1. A filler compound or moisture-resistant self-fusing tape, applied to a thickness equal to, and well lapped over, the original conductor insulation, followed by two layers of electrical insulating tape.

The dielectric strength of splices shall be at least equal to that of the cable insulation.

2. An UL approved electrical spring connector (“wire-nut”) with an approved sealing compound for protection from dampness and water.

3. An approved re-enterable rigid body splice kit with a non-hardening sealing compound compatible with the wire insulation.

4. An approved heat-shrinking cable sleeve or tape, designed to provide electrical insulation and protect overhead and underground splices from moisture penetration, corrosion and electrical breakdown.

After wiring and splicing is completed, all conduit runs shall be plugged at all manholes, handholes, pull boxes, junction boxes, cabinets and foundations to form a complete closed conduit or duct system to prevent air circulation.

Approved sealing compound (including foam) shall be used in liberal amounts, carefully forced into the ends of the conduits and tightly packed around all wire and cables completely sealing the opening.

D. Highway Lighting Circuit Identification.

The Contractor shall furnish and install colored tapes and identification tags on all lighting conductors at the points where they connect to equipment and on cables in all pull and junction boxes and pole shafts. The colored tapes shall cover 150 millimeter portion of the conductor at these points, line 1 - black, neutral - white, line 2 - red, line 3 - blue. In pole shafts, line - black, neutral - white, photocell bypass - red. The tags shall be nylon or other suitable non-metallic material, not less than 20 millimeters in diameter, and not less than

1 millimeter thick. Identification markings shall be stamped on the tags by means of small tool dies. Each tag shall be securely tied to the proper conductor by nylon or other suitable non-metallic cord (plastic or nylon).

E. Traffic Control Signal Circuit Identification.

The Contractor shall wire and splice traffic control signal circuits to conform to the following color identification code:

5/C Cable	Vehicle Phases	Overlaps	Pedestrian Phases
1. Black	Spare	Spare	Push Button Switch
2. White	Phase 1 through 8 - C	Overlap - C	Walk/Don't Walk - C
3. Red	Phase 1 through 8 - R	Overlap - R	Don't Walk - R
4. Green	Phase 1 through 8 - G	Overlap - G	Walk - G
5. Orange	Phase 1 through 8 - Y	Overlap - Y	Push Button Switch
6. Blue	Spare		
7. White/Black	Phase 2 - C		
8. Red/Black	Phase 2 - R		
9. Green/Black	Phase 2 - G		
10. Orange/Black	Phase 2 - Y		
11. Blue/Black	Spare		
12. Black/White	Phase 3 - C		
13. Red/White	Phase 3 - R		
14. Green/White	Phase 3 - G		
15. Blue/White	Phase 3 - Y		
16. Black/Red	Phase 4 - R		

17. White/Red	Phase 4 - C
18. Orange/Red	Phase 4 - Y
19. Blue/Red	Phase 4 - G
20. Red/Green	Spare

The number of conductors required for each traffic control signal system shall be as follows:

All systems shall have a minimum of one (1) five (5) conductor cable for each of the following controller outputs to field wiring required by the timing and sequence plan for the system:

Vehicle Phases	Overlap Phases	Pedestrian Phases
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Approval may be given, when requested in writing, for alternate use of one (1) 20/C cable in lieu of four (4) of the above 5/C cable.

The Contractor shall furnish and install colored tapes and identification tags on all cables at the points they connect to equipment, in all signal bases, in all pole shafts, and in all pull and junction boxes.

The tapes shall cover a 150 millimeter portion of the cables at the above locations with the following colors:

Black for Ring 1

Red for Ring 2

Brown for Detectors

Orange for Overlaps

Yellow for Pedestrian Phases

The tags shall be nylon or other suitable non-metallic material, not less than 20 millimeters in diameter and not less than 1 millimeter thick. Identification markings shall be as follows:

Vehicle Phase Numbers Ring 1

Vehicle Phase Numbers Ring 2

Detector Phase Numbers

Overlap Phase Numbers and Letters

Pedestrian Phase Numbers

The identification markings shall be stamped on the tags by means of small tool dies. Each tag shall be securely tied to the proper cable by nylon or other suitable non-metallic ties.

813.61 Equipment Grounding.

With each cable run an equipment grounding conductor shall be installed to which all equipment shall be bonded in accordance with standard practice and the Code.

Metallic cable sheaths, metal conduit, non-metallic conduit grounding conductors, ballast and transformer cases, metal poles and pedestals, metal junction and pull boxes, and metal cabinets shall be made mechanically and electrically secure to form a continuous system and shall be effectively grounded to the ground electrode installed at the service point.

Bonding of traffic signal standards, pedestals, strain poles and mast arms shall be accomplished by installing a 5 millimeter or larger brass bolt in the lower portion of the shaft.

For bonding purposes in all non-metallic type conduit, the grounding conductor shall be run continuously. Where non-metallic conduit is to be installed for future use, the above mentioned conductor may be omitted.

In lieu of the continuous equipment grounding conductor, when approved by the Engineer, a ground electrode may be installed at each pole or standard.

Bonding of metallic conduit systems in concrete foundations and pull boxes shall be by means of approved grounding bushings (compatible with the conduit) and bonding jumpers.

All expansion sleeves in metallic conduit runs shall be provided with a bonding jumper, as specified.

813.62 Ground Electrodes.

A. General.

When an underground water system is used as the grounding electrode, the grounding conductor shall be securely attached to the piping system by welding or brazing or other approved means.

If a water-piping system is not available, a driven rod, as specified in Subsection 813.40C, shall be used as the

grounding electrode. Driven rods should, as far as practical, be embedded below permanent moisture level. Except where rock is encountered, rods shall be driven to a depth of at least 2.5 meters. Where rock is encountered, other devices approved for the purpose shall be used (see Article 250 - Grounding MEC).

B. Resistance Tests.

Grounding electrodes shall, where practicable, have a resistance to ground not to exceed 25 ohms. Where the resistance is not as low as 25 ohms, additional rods shall be driven, placed at least 2.5 meters apart and connected in parallel with a #6 AWG bare copper solid or stranded conductor, as directed by the Engineer.

The measurement shall be made with either a Ground Ohmer or Megger Ground Tester with all wire disconnected (except parallel connections and test wires) from the rod and in the presence of the Engineer. The Contractor shall furnish the Engineer with a report of all resistivity tests, indicating the values obtained for each and combinations (parallel connected) of rods tested. This report shall become a part of the "as built" records.

813.63 Service Connections.

Each service shall include a meter socket; a three wire single phase or four wire three phase solid neutral disconnect of size noted; the necessary conduit; conduit risers; cable and ground assembly; all installed in accordance with the Code, serving utility and Department requirements.

Service equipment shall include all equipment from the distribution lines of the serving utility to and including the metering equipment. Meter will be furnished and installed by serving utility.

Service disconnect, unless otherwise specified, shall be a standard type circuit breaker, encased in a NEMA Type 3R raintight enclosure that can be padlocked.

In general, all traffic signal services will be 120 volts or 120/240 volts, single phase, 60 hertz, alternating current, and all highway lighting will be 120/240 volts, 240/480 volts, single phase, or 277/480 volts, three phase, 60 hertz, alternating current.

Conduit for services shall not be less than 32 millimeters and be rigid metal above ground, securely fastened every 1 meter.

All wire and cable shall conform to Subsection M8, Type 8. The wires between the serving utility distribution lines and service disconnect shall not be smaller than #6 AWG.

The ground electrode shall conform to the requirements of Subsection 813.62.

Ground clamps shall be approved by UL and acceptable to the local power company.

In the case of underground services the Contractor shall furnish and install all equipment as required by the serving utility.

The Contractor shall make adjustments in the installation to comply with the varied requirements of the Code and serving utility and perform all work to the satisfaction of the Code, serving utility and the Department.

COMPENSATION

813.80 Method of Measurement.

A. Wire and Cable.

All cable will be measured by the meter, the measurement being made along the center line of the conduit in which the conductor is placed. No allowance will be made for the necessary lengths of slacked cable laid around the sides of manholes, handholes, junction boxes, pull boxes, or extending from foundations for making splices, taps in cable, and connecting the internal components of control cabinets.

B. Equipment Grounding.

Equipment grounding will be measured as a unit including all nuts, bolts, washers including lockwashers, connectors, clamps and incidental materials to form a continuous system. Equipment grounding conductor will be measured by the meter conforming to Subsection 813.80 A.

C. Ground Electrodes.

When a metallic underground water system is used as the grounding electrode, measurement will be made on the basis of the grounding conductor installed and connected to the metallic water-pipe system.

Measurement for ground rods will be based on units 2.5 meters, 3.0 meters or longer, as specified. If in the driving of standard units, obstructions are encountered, measurement will be made for the actual length driven. The ground rod shall then be withdrawn and redriven at a new location to meet requirements specified above.

D. Service Connections.

Service Connections of each type will be measured on the basis of the number of services installed and connected to the serving utility distribution lines with all appurtenances in acceptable operating condition.

813.81 Basis of Payment.

A. Wire and Cable.

All cable will be paid for at the respective contract unit price per meter for the type and size specified, which price shall include installation and connection of wire and cable and all splices and circuit identification. All additional materials required to complete the installation shall be considered as incidental thereto and included in the contract price for wire and cable and no additional compensation will be allowed.

B. Equipment Grounding.

The lump sum price for "Equipment Grounding" shall be full compensation for work necessary or incidental to the installation of the equipment ground, modifying existing grounds, or both, as shown on the plans. All additional materials and labor not shown on the plans or standard drawings called for herein and which are required to complete the installation shall be considered as incidental thereto and be included in the contract price for equipment grounding.

Equipment grounding conductor will be paid for at the contract unit price per meter as specified in Subsection 813.81 A.

C. Ground Electrodes.

This work will be paid for at the relevant unit price which price shall include all ground clamps, #6 AWG copper conductors, excavation, backfilling, compaction, welding or brazing, all tests, reports and work incidental thereto.

Allowance will be made for ground rods not driven to minimum depths because of obstructions and will be paid for at the contract unit price per meter for ground rod.

D. Service Connections.

Service connections will be paid for at the contract unit price for each service connection complete in place.

All additional work called for herein which is required to complete the service connection shall be considered as incidental to the construction.

813.82 Payment Items.

813.10	Traffic Signal Steel Messenger Cable - Type 0	Meter
813.21 to 813.25	Traffic Signal Cable - Type # (#1 to #5)	Meter
813.26	Traffic Signal Head Wire Type 6	Meter
813.30 to 813.39	Wire Type 7 No. * General Purpose (*10 to 4/0)	Meter
813.40 to 813.49	Wire Type 8 No. * Direct Burial (*10 to 4/0)	Meter
813.50	Wire Type 9 Special Purpose (TW-THW)	Meter
813.51	Wire Type 9 Special Purpose (UF)	Meter
813.52	Wire Type 10 - #8 Grounding and Bonding	Meter
813.53	Wire Type 11 - Loop Detector Lead-in	Meter
813.54	Wire Type 12 - Heavy Duty Portable Cord	Meter
813.55	Wire Type 13 - Loop Detector Wire and Tube	Meter
813.60	Equipment Grounding	Lump Sum
813.70	Ground Rod	Meter
813.71	Ground Rod 2.5 meters Long	Each
813.72	Ground Rod 3.0 meters Long	Each
813.80	Service Connection (Overhead)	Lump Sum
813.81	Service Connection (Underground)	Lump Sum