

DIVISION 17**SIGNALS AND INTELLIGENT TRANSPORTATION SYSTEMS****SECTION 1700****GENERAL REQUIREMENTS****1700-1 DESCRIPTION**

Furnish, install, modify, and remove signals, flashing beacons, intelligent transportation systems, electrical systems, and provisions for future systems.

1700-2 MATERIAL

Refer to Article 1098-1 General Requirements.

1700-3 CONSTRUCTION METHODS**(A) General**

Before beginning signal work, verify all existing signal equipment is in satisfactory working order. Report all defective signal equipment to the Engineer so as not to be held responsible for defects.

Locate existing conduit, cable runs, inductive detection loops, lead-in, junction boxes, and detection equipment before installing or using equipment that can damage or interfere with such facilities. The locations of existing inductive detection loops shown are approximate.

Locate all underground utilities before beginning drilling, digging, or trenching operations.

Immediately cease work and notify the Engineer and affected owners if damage to existing utilities, cables, or equipment occurs. Make all required repairs and replacements at no additional cost to the Department.

(B) Regulations and Codes

Furnish material and workmanship conforming to the NEC, NESC, UL, and all local safety codes in effect on the date of advertisement. Comply with Article 4, Chapter 87 of the *North Carolina General Statutes* (Licensing of Electrical Contractors). Comply with all regulations and codes imposed by the owner of affected utility poles. In the event of a conflict between the NEC, NESC, UL, local safety codes and these Specifications, the cited documents will govern.

Where required, conform to ITE, AASHTO, and ASTM in effect on the date of advertisement.

Notify the Engineer, local traffic enforcement agency, local utility company, and affected railroad companies seven business days before operational shutdowns to coordinate connection or disconnection to an existing utility or system.

Install standoffs, meter bases, and service disconnects as required by the NESC, NEC, local utility companies, and local ordinances.

(C) Utility Services

Coordinate all work to ensure electrical power of proper voltage, phase, frequency, and ampacity is available to complete the work. Use electrical services cables with THW insulation.

When electrical, telephone, and telecommunication service is not furnished by the Department and is required, contact the utility company and make application to ensure all work can be completed. Obtain authorization for service in the Department's name and make application for service in the Department's name.

The Department will be responsible for direct payment of monthly utility company usage charges. The Contractor will be responsible for all expenses associated with utility installation costs, hookups, etc.

(D) Maintenance and Repair of Material

Furnish the Engineer with the name, office telephone number, cellular (mobile) telephone number, and pager number of the supervisory employee who will be responsible for maintenance and repair of equipment during all hours.

Maintain and repair all signal and communications related equipment within the project construction limits until completion of the observation period and receipt of written notification of final acceptance of the project.

For all failures, malfunctions, or damages to equipment, begin necessary repairs within four hours of notification. Complete repairs within eight hours of notification. Comply with Section 150 for maintenance of traffic flow. The inability to contact the supervisory employee or prearranged alternate will not extend repair time requirements.

Remove and replace all signal and communications related equipment that fails. The Department will furnish the Contractor replacement equipment for Department-furnished equipment that fails.

Except for damages and malfunctions caused by the Contractor's work activities, the Contractor will not be held responsible for pre-existing conditions reported to the Engineer before starting traffic signal work at the specific intersection. The Contractor will assume responsibility for all maintenance and emergency services necessary once traffic signal work has begun at the specific intersection and for all damages and malfunctions caused either directly or indirectly by the Contractor's work activities.

In the event the Contractor fails to perform in accordance with the plans and Specifications within the time frame specified, the Department reserves the right to perform maintenance and emergency service necessary to ensure continuous traffic signal operation. Further, all expenses incurred by the Department in implementing this option will be deducted from payment due the Contractor, plus \$2,500 liquidated damage per occasion, per day, or any portion thereof, until corrected.

(E) Inspections

The Department may access the Contractor's equipment to perform railroad, signal, and preventative maintenance inspections, or conflict monitor certification as necessary. The Contractor shall be present for these inspections.

(F) Removal of Existing Equipment and Material

Remove all Department-owned signals and communications related equipment and material that will not be used. Assume ownership of removed poles, messenger cable, interconnect cable, communications cable, and supporting hardware. Return all other equipment and material between 8:00 a.m. and 12:00 p.m., Monday through Thursday, to the Traffic Services Office within the Division responsible for administration of the project.

The Department will deduct the cost of Department-owned equipment damaged by the Contractor from money due to the Contractor.

(G) Railroad Preemption

Where railroad preemption is required, coordinate all work with the railroad company. Do not place signals into operation until signal equipment has been interconnected with required railroad-highway crossing devices and railroad preemption is working properly. Ensure preemption sequences begin immediately after activation of train detection.

Contact and coordinate with the railroad company to schedule interconnection of the signal to the railroad controller cabinet. Install lead-in cable from the signal controller cabinet to a railroad company furnished and installed lockable junction box. Interconnection will be made by the railroad company.

Provide fail-safe operation such that removal of voltage from the railroad side of the isolation relay will initiate the railroad preemption sequence.

(H) Vehicle Preemption Systems

Where required, implement and install vehicle preemption systems. Coordinate vehicle preemption work with the proper operating authority. Contact the proper operating authority and schedule installation of preemption equipment.

(I) Timing of Signals

Implement timing values for signal controllers. Modify proposed phasing and timing of existing controllers

Reinstall all existing time-based coordination. As directed, make modifications to existing coordination to account for changes in signal phasing.

The Department reserves the right to make, or have the Contractor make, field timing changes necessary for pattern optimization and to eliminate identifiable, potential hazards to the motoring public. The Engineer will notify the Contractor of timing changes made.

(J) Wire and Cable

For installation in a conduit system, lubricate cable and wires before installing in conduit. Use lubricant that will not physically or chemically harm cable jacket, wire insulation, and conduit.

Splice all electrical wire and cable at recessed-screw, barrier type terminal blocks, in junction boxes, or in condulets. Unless specifically allowed, connect no more than two conductors to the same terminal screw.

Maintain color coding of wires through splices.

Protect ends of wire and cable from water and moisture.

Install all wire and cable with necessary hardware including, but not limited to shoulder eyebolts, washers, nuts, thimbleyelets, three-bolt clamps, J-hooks, split bolt connectors, grounding clamps, and lashing material.

(K) Grounding

Provide a grounding system at all new and revised electrical service points unless otherwise specified.

In addition to NEC requirements, test grounding electrode resistance at connection point to electrical service ground bus for a maximum of 20 ohms. Furnish and install additional ground rods to grounding electrode system as necessary to meet test requirements. Submit a completed Inductive Detection Loop & Grounding Test Results form. The form is located on the Department's website.

Provide a length of marker tape 150 mm to 300 mm below finished grade directly over grounding electrodes and conductors.

(L) Electrical Bonding

Using an approved termination means, connect a number 14 AWG minimum 19-strand copper conductor (Type THW) with green insulation to serve as an equipment grounding conductor to metal poles, vehicular and pedestrian signal pedestals, and other metallic components which are not otherwise bonded through means approved by the Engineer.

(M) Traffic Signal Activation

Do not place signal in steady (stop-and-go) mode until inspected and authorized by the Engineer.

(N) Temporary Traffic Signal Installations

When a traffic signal is installed for control of traffic during construction of the project and scheduled for removal during or upon completion of the project, install

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and remove the temporary traffic signal as required. Upon removal of the temporary traffic signal, restore surface to like-new condition. Rake smooth unpaved areas, repave paved areas, and seed grassed areas that were damaged by Contractor activities.

Prepare intersection for sign control before removing the temporary traffic signal. Install required regulatory signs in accordance with Sections 900, 901, and 903. Cover signs with burlap bags until traffic signal is placed into flashing operation.

Place traffic signal into flashing operation and uncover signs simultaneously. Allow flashing operation for a minimum of seven consecutive days before removal.

Signal cabinets, controllers, detector units, signal heads and accessories, and microwave detectors are property of the Department. Return Department owned equipment between 8:00 a.m. and 12:00 p.m., Monday through Thursday, to the Traffic Services Office within the Division responsible for administration of the project. Assume ownership of removed poles, messenger cable; interconnect cable, communications cable, supporting hardware, and loop emulator detection equipment, unless otherwise specified.

The Department will deduct the cost of Department-owned equipment damaged by the Contractor from money due to the Contractor.

1700-4 MEASUREMENT AND PAYMENT

There will be no direct payment for work covered in this section. Payment at the contract unit prices for the various items in the contract will be full compensation for all work covered by this section.

SECTION 1705 SIGNAL HEADS

1705-1 DESCRIPTION

Furnish and install vehicle and pedestrian LED signal heads, visors, interconnecting brackets, wire entrance fittings, mounting assemblies, signal cable, lashing wire, pedestrian push buttons, pedestrian signal signs, grounding systems and all necessary hardware.

1705-2 MATERIAL

Material, equipment, and hardware furnished under this section shall be pre-approved on the Department's QPL. Refer to the project special provisions.

1705-3 CONSTRUCTION METHODS

(A) General

Bag new pedestrian and vehicle signal heads with burlap bags or bags made of non-ripping material specifically designed for covering signal heads until signal heads are placed in operation. Do not use trash bags of any type.

When new signal heads are placed into operation, immediately bag and remove signals heads that are not to be reused.

Adjust each signal head vertically and horizontally so that light output will be of maximum effectiveness for traffic and pedestrians. Do not tilt signal heads forward.

Reposition signal heads as required for various construction phases.

(B) Vehicle Signal Heads

Install vehicle signal heads at the heights required in the *North Carolina Supplement to the MUTCD* in effect on the date of advertisement.

Where vehicle signal heads are installed on messenger cable, install mounting hardware consisting of messenger cable hanger, balance adjuster, bottom cap, wire entrance fitting bracket, and insulating bushings.

Where vehicle signal heads are installed on mast arms, install mounting hardware consisting of rigid vehicle signal head mounting brackets.

Install signal cable in continuous lengths between signal controller cabinets and signal heads. Route signal cable to minimize the length of cable installed, and the number of cables and conductors in each run. Pull 0.9 m of additional signal cable into controller cabinets.

Wrap signal cable to messenger cable with at least four turns of wrapping tape spaced at intervals less than 380 mm or lash signal cable to messenger cable with one 360 degree spiral of lashing wire per 305 mm.

Make electrical connections inside each signal head, signal controller cabinet, and termination compartment in metal poles. Do not splice cable at any other point between signal heads and controller cabinet.

Coil sufficient signal cable beside each vehicle signal head to accommodate head shifts during various construction phases. For final signal head locations, coil 0.9 m on each side of signal head if signal cable comes from both directions. If signal cable terminates at the signal head, coil 0.9 m of signal cable on the same side as the cable run.

(C) Pedestrian Signal Heads

Install signs with mounting hardware immediately above pedestrian push buttons.

Connect pushbutton to controller cabinet using lead-in cable. Bond pushbutton housing and all metal components to cabinet ground using cable ground.

1705-4 MEASUREMENT AND PAYMENT

Vehicle Signal Head (_____) and *Pedestrian Signal Head* (___) will be measured and paid for as the actual number of signal heads of each type, size, and number of sections furnished, installed, and accepted.

No measurement will be made of visors, wire entrance fittings, interconnecting brackets, mounting assemblies, pedestrian push buttons, and pedestrian signal signs as these will be considered incidental to furnishing and installing signal heads.

Signal Cable will be measured and paid for as actual linear meter of signal cable furnished, installed, and accepted. Measurement will be point to point with no allowance for sag. 7.6 meters will be allowed for vertical segments up or down poles.

No measurement will be made for drip loops, coiled sections, or lashing wire as these will be considered incidental to furnishing and installing signal cable.

Payment will be made under:

Pay Item	Pay Unit
Vehicle Signal Head (_____)	Each
Pedestrian Signal Head (_____)	Each
Signal Cable	Linear Meter

**SECTION 1706
BACKPLATES**

1706-1 DESCRIPTION

Furnish and install backplates for vehicle signal heads with all necessary hardware.

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1706-2 MATERIAL

Material, equipment, and hardware furnished under this section shall be pre-approved on the Department's QPL.

Refer to Article 1098-2 Backplates.

1706-3 CONSTRUCTION METHODS

Install backplates for vehicle signal heads so as not to interfere with the function of all door hinges, signal section latches, and mounting hardware. Do not bend or deform backplates during installation. Gooseneck fittings may be installed in reverse to accommodate backplates. Use stainless steel fasteners for attaching backplates to signal sections.

1706-4 MEASUREMENT AND PAYMENT

Backplates will be measured and paid for in units of each, furnished, installed, and accepted. No measurement will be made for different sizes of backplates.

Payment will be made under:

Pay Item	Pay Unit
Backplate	Each

**SECTION 1710
MESSENGER CABLE**

1710-1 DESCRIPTION

Furnish and install messenger cable (spanwire) with cable clamps, machine bolts, eyebolts, 3-bolt clamps, eye nuts, split-bolt connectors, and all necessary hardware.

1710-2 MATERIAL

Material, equipment, and hardware furnished under this section shall be pre-approved on the Department's QPL.

Refer to Article 1098-3 Messenger Cable.

1710-3 CONSTRUCTION METHODS

Install guy assemblies before installing messenger cable.

Use 10 mm messenger cable for spans supporting vehicle signal heads, and/or signs.

Use 6 mm messenger cable for spans supporting only cables unless otherwise specified.

For messenger cable crossing over railroad tracks, provide a minimum of 8.2 m of vertical clearance, unless otherwise specified.

For permanent installations, install messenger cable in continuous lengths with no splices except where an insulator is required. With prior approval, existing messenger for temporary installations may be extended instead of installing new messenger cable.

Tension messenger cable to eliminate appreciable sag and to match sag of surrounding utilities. Otherwise, allow 3 to 4 percent sag of the span length between poles.

Provide three-bolt clamp assemblies consisting of 16 mm diameter machine bolts, J-hooks, washers, and square nuts to attach messenger cable to wood poles. Provide machine bolts that are 75 mm longer than the pole diameter.

Attach messenger cable to poles using three bolt cable clamps with J-hooks in mid-runs and deadend strandvises at termination poles.

Maintain electrical continuity at all splices.

Messenger Cable for Signal Heads or Loop Lead-In Cable: For messenger cable attached to joint use poles, install a new grounding system that complies with

Article 1720-3 for bonding messenger cable. If a pole ground exists on the joint use pole, bond new pole grounding system to existing pole ground using number 6 AWG minimum solid bare copper grounding wire terminated with split bolt connectors or Burndy clamps (UCG25RS) at each end.

Messenger Cable for Communications Cable: For messenger cable attached to joint use poles, bond messenger cable to existing pole ground using Burndy clamps (UCG25RS) at ends and at 396 m intervals. If existing poles do not have a grounding system, install new grounding system that complies with Article 1720-3 for bonding messenger cable.

On multiple messenger cable arrangements, connect all messenger cable ends with number 6 AWG minimum solid bare copper wire and bond with split bolt connectors or Burndy clamps (UCG25RS) or equivalent and terminate to pole ground.

1710-4 MEASUREMENT AND PAYMENT

Messenger Cable (_____) will be measured and paid for as actual horizontal linear meter of messenger cable furnished, installed, and accepted. Measurement will be point to point with no allowance for sag.

No measurement will be made of cable clamps, machine bolts, eyebolts, three-bolt assemblies, eye nuts, split bolt connectors, and pole grounding systems as these will be considered incidental to furnishing and installing messenger cable.

Payment will be made under:

Pay Item	Pay Unit
Messenger Cable (_____)	Linear Meter

**SECTION 1715
UNDERGROUND CONDUIT**

1715-1 DESCRIPTION

Furnish and install conduit for underground installation with tracer wire, miscellaneous fittings, all necessary hardware, marker tape, backfill, graded stone, paving materials, and seeding and mulching.

1715-2 MATERIAL

Material, equipment, and hardware furnished under this section shall be pre-approved on the Department’s QPL.

Refer to the following articles:

Item	Section
Conduit	1098-4
Backfill	1018-2
Graded Stone	545-2 and 545-3

1715-3 CONSTRUCTION METHODS

(A) General

Ensure conduit is free of moisture and debris before pulling cables.

Following installation of conduit where cable is not immediately installed, or conduit is for future use (spare), seal the ends of the conduit with a duct plug. Secure a pull line to the duct plug in such a manner that it will not interfere with installation of the duct plug and provides a watertight seal.

Extend ends of conduit 50 to 100 mm above concrete surfaces and 100 mm above crushed stone bases. For metallic conduit, install metallic bushings and bond conduits.

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(1) Conduit Entering Junction Boxes

Terminate conduits installed for communications cables in oversized junction boxes. Do not install other conduits in the oversized junction box unless otherwise specified.

Terminate conduits installed for signal wiring, including loop lead-in cable, in standard size junction boxes unless otherwise specified.

For all conduits entering junction boxes, seal spare conduits with approved duct plugs. Seal conduits containing fiber-optic communications cable with mechanical sealing devices. Seal conduits containing signal cable and loop lead-in wire with moldable duct seal.

(2) Tracer Wire

Install tracer wire in all conduits containing fiber-optic cable. Pull tracer wire simultaneously in a continuous length with the fiber-optic cable. Where multiple pulls of fiber-optic cable are required and conduit is placed in the same trench, only one tracer wire is required. Where multiple pulls of fiber-optic cable are required and conduits may separate into individual trenches, install a tracer wire in each conduit run. Provide waterproof butt splices where tracer wire is spliced. Splicing is allowed only in cabinets and junction boxes. Label all tracer wires entering the equipment cabinet.

(3) Plan of Record Drawings

Upon completion of the conduit system for communications, furnish the Engineer with a plan of record drawing detailing the locations of the conduit system.

(B) Trenching

In certain cases the Contractor may use an alternate material and method of installation between trenching and plowing based on existing field conduits and preferences. Obtain approval before proceeding.

(1) General

Install PVC, HDPE, or rigid metallic conduit for all underground runs. Install metallic conduit at all locations where conduits cross beneath railroad tracks. Clean existing underground conduit to be incorporated into a new system. Bond all metallic conduit.

If more than one conduit is required between the same points, install conduit in one common trench. Install non-detectable marker tape.

Install longitudinal runs of conduit a minimum of 0.3 m from back of curb or 1.8 m from edge of pavement in the absence of curb.

Upon completion, restore surface to like-original condition within seven calendar days of occurrence of damage. Remove all rock and debris from backfill material. Remove excess material from site and compact area according to Article 300-7. Backfill with excavated material and compact to 95% of original density.

Backfill trench at locations along the trench path where non-movable objects, such as rocks and boulders, cannot be avoided. The purpose of the backfill is to provide a gradual change in elevation of the trench, so that excessive bending and stress will not be transferred to conduits once underground conduit system is installed.

After installation of conduits and upon completion of tamping and backfilling, perform a mandrel test on each conduit to ensure no conduit has been damaged. Furnish a non-metallic mandrel having a diameter of approximately 50% of the inside diameter of the conduit in which it is to be pulled through. If damage has occurred, replace the entire length of conduit. Ensure pull line is re-installed.

(2) Unpaved Trenching

Install conduit in all unpaved areas. Rake smooth the top 40 mm seed with same type of grass as surrounding area. Finish unpaved areas flush with surrounding natural ground.

(3) Paved Trenching

On concrete surfaces, replace the entire joint of concrete unless otherwise specified. On all other surfaces, neatly cut and replace the width of trench with like material.

Finish paved areas with materials matching damaged areas. For conduit installed under roadways, cut neatly and replace the width of paved area damaged by trenching. For conduit installed under sidewalks and walkways, remove entire section of slab from joint to joint and replace. Place graded stone material to temporarily maintain traffic where repairs cannot be performed immediately. Comply with Article 545-4.

(C) Plowing (HDPE Conduit Only)

Direct plow HDPE ducts simultaneously using chute plow method. Direct plow ducts at a minimum depth so the top of the highest duct is 760 mm deep unless otherwise approved.

Provide sufficient personnel to feed chute, operate prime mover and equipment carrying reels (if separate equipment is used), observe chute feeding, observe plowing, and observe reel payout. Use chute with adequate dimensions to allow for passage of duct without damage. During plow operation, continuously check chute opening and path to be sure there are no obstructions and monitor payout reels to be sure reels are turning at a steady rate.

With prior approval, install a junction box at locations where splicing or coupling of the underground polyethylene conduits is necessary. Otherwise, splicing or joining of underground polyethylene conduit is prohibited.

(D) Directional Drilling

(1) Pre-Approvals and Minimum Depth Requirements

Obtain approval before beginning drilling operations.

At all points where HDPE conduit will traverse under roadways, driveways, sidewalks, or Controlled Access Areas including entrance/exit ramps, maintain a minimum depth of 1.2 m or 8 times the back reamer's diameter, whichever is deeper. For an installation that runs parallel to a controlled access area or entrance/exit ramps maintain a minimum depth of 760 mm below finished grade. Maintain a minimum clearance of 760 mm below finished grade when crossing ditch lines. For the following structures, the minimum clearance requirements are:

Man-made Structure	Minimum Clearance Requirement
Bridge foundation	1.5 m horizontal & 1.2 m vertical (clearances greater than minimum horizontal should continue to use the 4V:5H ratio, i.e., 3.0 m horizontal should be no deeper than 2.4 m)
Drainage pipes less than 60"	0.3 m above or below [while maintaining a minimum depth of 760 mm below grade]
Drainage pipes greater than 60"	0.3 m above or 1.2 m below [while maintaining a minimum depth of 760 mm below grade]
Box Culverts	0.3 m above or 1.2 m below [while maintaining a minimum depth of 0.760 mm below grade]
Slope protection	0.6 m below
Slope protection foundation footing	1.5 m below

Guarantee the drill rig operator and digital walkover locating system operator are factory-trained to operate the make and model of equipment

provided and have a minimum of one year experience operating the make and model of drill rig. Submit documentation of the operators' training and experience for review at least two weeks before start of directional drilling operations.

Provide a means of collecting and containing drilling fluid/slurry that returns to the surface such as a slurry pit. Provide measures to prevent drilling fluids from entering drainage ditches and storm sewer systems. Prevent drilling fluid/slurry from accumulating on or flowing onto pedestrian walkways, driveways, and streets. Immediately remove all drilling fluids/slurry that are accidentally spilled.

(2) Directional Drill Operations

Provide grounding for the drill rig in accordance with the manufacturer's recommendations.

Place excavated material near the top of the working pit and dispose of properly. Backfill pits and trenches to facilitate drilling operations immediately after drilling is completed.

Use drill head suitable for type of material being drilled and sized no more than 50 mm larger than the outer diameter of the conduit. Direct drill to obtain proper depth and desired destination. Pressure grout with an approved bentonite/polymer slurry mixture to fill all voids. Do not jet alone or wet bore with water.

During drilling operation, locate drill head every 3 m along drill path and before traversing underground utilities or structures. Use digital walkover locating system to track drill head during directional drilling operation. Ensure locating system is capable of determining pitch, roll, heading, depth, and horizontal position of the drill head at any point.

Once drill head has reached final location, remove head, and install back reamer of appropriate size (no more than 50 mm larger than outer diameter of conduits) to simultaneously facilitate back reaming of drill hole and installation of conduit. Back reamer is sized larger than actual conduits to ensure conduits are not adversely subjected to deviations caused by the original drill operation and are as straight as practical in their final position.

The intent of these Specifications is to limit the diameter of the actual drill shaft/hole so that it is no more than 50 mm larger than the conduit outer diameter. The 50 mm larger diameter may be accomplished during the original bore or during the back reaming/conduit installation process.

Once installation of conduit has started, continue installation without interruption so as to prevent conduit from becoming firmly set. Apply bentonite/polymer slurry mixture during conduit installation.

Upon completion of conduit installation, perform a mandrel test on conduit system to ensure conduit has not been damaged. Furnish non-metallic mandrel with a diameter of approximately 50% of the inside diameter of the conduit in which it is to be pulled through. If damage has occurred, replace the entire length of conduit and ensure that pull line is re-installed.

(3) Drilling Fluids

Use lubrication for subsequent removal of material and immediate installation of the conduit. The use of water and other fluids in connection with directional drilling operations will be permitted only to the extent necessary to lubricate cuttings. Do not jet alone or wet bore with water. Use drilling fluid/slurry consisting of at least 10 percent high-grade bentonite/polymer slurry to consolidate excavated material and seal drill hole walls.

Transport waste drilling fluid/slurry from site and dispose of in a method that complies with local, state and federal laws and regulations.

(4) Conduit Splicing

With prior approval, install a junction box at locations where splicing or coupling of conduit is necessary. Otherwise, splicing or joining of HDPE conduit is prohibited.

(E) Bore and Jack

For bore and jack areas, comply with Subarticles 1540-3 A & B except as follows:

For bore and jack areas, install metallic conduit at a minimum depth of 760 mm below finished grade or 150 mm below roadway sub-grade, whichever is greater. Provide 0.9 m clearance to conduit from back of curb or from edge of pavement. Terminate ends of conduit into junction boxes.

Comply with the *NCDOT Policies and Procedures for Accommodating Utilities on Highway Rights-of-Way* in effect on the date of advertisement.

1715-4 MEASUREMENT AND PAYMENT

Tracer Wire will be measured along the horizontal linear meter of tracer wire furnished, installed, and accepted. Measurement will be along the approximate centerline of the conduit system. Payment will be made in linear meter. No payment will be made for excess tracer wire in junction boxes and/or cabinets.

Unpaved Trenching (qty)(size) & (qty)(size) will be measured horizontal linear meter of trenching for underground conduit installation of each type furnished, installed, and accepted. Measurement will be along the approximate centerline of the conduit system. Payment will be in linear meter.

Paved Trenching (qty)(size) & (qty)(size) will be measured horizontal linear meter of trenching for underground conduit installation of each type furnished, installed, and accepted. Measurement will be along the approximate centerline of the conduit system. Payment will be in linear meter.

Plowing (qty)(size) & (qty)(size) will be measured horizontal linear meter of plowing for underground conduit installation furnished, installed, and accepted. Measurement will be along the approximate centerline of the conduit system. Payment will be in linear meter.

Directional Drill (qty)(size) & (qty)(size) will be measured horizontal linear meter of directional drill for underground conduit installation furnished, installed, and accepted. Measurement will be along the approximate centerline of the conduit system. Payment will be in linear meter.

Bore and Jack (qty)(size) & (qty)(size) will be measured in horizontal linear meter of bore and jack for underground conduit installation furnished, installed, and accepted. Measurement will be along the approximate centerline of the bore from junction box to junction box. Payment will be in linear meter.

No measurement will be made of vertical segments, non-metallic conduit, metallic conduit, sealing devices, backfill, graded stone, paved materials, miscellaneous fittings, pull lines, and seeding and mulching as these will be considered incidental to conduit installation.

Conduit will be paid for per linear meter based on quantity and size of conduits. As examples, an installation of a single 30 mm HDPE conduit would be paid as:

Directional Drill (1)(30 mm) Linear Meter

An installation of two 30 mm and four 50 mm HDPE conduits would be paid as:

Directional Drill (2)(30 mm)&(4)(50 mm) Linear Meter

Payment will be made under:

Pay Item	Pay Unit
Tracer Wire	Linear Meter
Unpaved Trenching (qty)(size) & (qty)(size)	Linear Meter

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Paved Trenching (qty)(size) & (qty)(size)	Linear Meter
Plowing (qty)(size) & (qty)(size)	Linear Meter
Directional Drill (qty)(size)	Linear Meter
Directional Drill (qty)(size) & (qty)(size)	Linear Meter
Bore and Jack (qty)(size) & (qty)(size)	Linear Meter

**SECTION 1716
JUNCTION BOXES**

1716-1 DESCRIPTION

Furnish and install junction boxes (pull boxes) with covers, graded stone, grounding systems, and all necessary hardware.

1716-2 MATERIAL

Material, equipment, and hardware furnished under this section shall be pre-approved on the Department's QPL.

Refer to Article 1098-5 Junction Boxes and Section 545 Graded Stone.

1716-3 CONSTRUCTION METHODS

Comply with Article 1411-3 Electrical Junction Boxes, except as follows:

Install junction boxes flush with finished grade. Do not install sealant compound between junction boxes and covers.

Install junction boxes where underground splicing of cable is necessary and where transitioning from below ground to above ground installation or vice-versa.

1716-4 MEASUREMENT AND PAYMENT

Junction Box (_____) will be measured and paid in actual number of junction boxes of each size and type furnished, installed, and accepted.

No measurement will be made of covers, graded stone, and grounding systems as these will be considered incidental to furnishing and installing junction boxes.

Payment will be made under:

Pay Item	Pay Unit
Junction Box (_____)	Each

**SECTION 1720
WOOD POLES**

1720-1 DESCRIPTION

Furnish and install wood poles with grounding systems and all necessary hardware.

1720-2 MATERIAL

Material, equipment, and hardware furnished under this section shall be pre-approved on the Department's QPL.

Refer to Subarticles 1082-3(F) Treated Timber and Lumber – Poles and 1082-4(G) Preservative Treatment – Poles.

1720-3 CONSTRUCTION METHODS

Mark final pole locations and receive approval before installing poles. Unless otherwise specified, locate poles a minimum of 1.8 m behind face of curb or 3.0 m from edge of travelway.

Drill or auger a hole for placement of pole and to allow for compacting. Set pole at manufacturer's recommended depth, but at a minimum depth of 1.5 m. Ensure the pole is within two degrees of vertical when fully loaded.

Backfill hole with pole installed and tamp backfill in 150 mm lifts with a mechanical tamp until compacted density is at least 95% of original density.

On new Department owned poles, install a grounding system consisting of number 4 or 6 AWG solid bare copper wire that is exothermically welded to a ground rod. Install ground wire so as to minimize damage from vandalism and environmental exposures. Install ground wire up pole to a point adjacent to the uppermost span. Use hot-dipped galvanized wire staples to secure ground wire to pole. Install ground rod at base of pole.

1720-4 MEASUREMENT AND PAYMENT

Wood Pole will be measured and paid as the actual number of wood poles furnished, installed, and accepted.

No measurement will be made for installing grounding systems as these will be considered incidental to furnishing and installing wood poles.

Payment will be made under:

Pay Item	Pay Unit
Wood Pole	Each

**SECTION 1721
GUY ASSEMBLIES**

1721-1 DESCRIPTION

Furnish and install guy assemblies with all necessary hardware.

1721-2 MATERIAL

Material, equipment, and hardware furnished under this section shall be pre-approved on the Department’s QPL.

Refer to Article 1098-6 Guy Assemblies.

1721-3 CONSTRUCTION METHODS

(A) Guy Assemblies for Signal Heads or Loop Lead-in Cable

Install guy assemblies with guy cable, guy guards, anchors, three-bolt clamps and associated fittings. Use two-bolt attachment method where there is adequate room on the pole to comply with the NESC. Attach guy assembly and guy cable to two separate bolts with one bolt for span and one bolt for guy cable.

Where adequate spacing is not available and a violation of the NESC would occur with the two-bolt attachment method, use approved one-bolt attachment method for attaching messenger cable and guy assembly.

Bond guy assembly to new pole grounding system as described in Section 1710-3.

Do not attach to existing guy assemblies unless specifically approved by owner.

(B) Guy Assemblies for Communications Cable

When installing messenger cable for supporting only communications cable, use approved one-bolt attachment method for attaching messenger cable and guy assembly.

Bond guy assembly to existing pole ground using Burndy Clamp (UCG25RS) or equivalent. If existing poles do not have a grounding system, install new grounding system for bonding guy assembly that complies with Article 1720-3.

Do not attach to existing guy assemblies unless specifically approved by owner.

1721-4 MEASUREMENT AND PAYMENT

Guy Assembly will be measured and paid as the actual number of guy assemblies furnished, installed, and accepted.

Section 1721

No measurement will be made of guy cable, guy guards, anchors, clamps, or fittings as these will be considered incidental to furnishing and installing guy assemblies.

Payment will be made under:

Pay Item	Pay Unit
Guy Assembly	Each

SECTION 1722 RISER ASSEMBLIES

1722-1 DESCRIPTION

Furnish and install riser assemblies with clamp-on, aluminum weatherheads or heat shrink tubing, galvanized pole attachment fittings, and all necessary hardware.

1722-2 MATERIAL

Material, equipment, and hardware furnished under this section shall be pre-approved on the Department's QPL.

Provide rigid metallic conduit for risers. Refer to Subarticle 1098-4(B)(1) Rigid Metallic Conduit.

Provide Tyco™(Raychem™) part number 066193-000 or equivalent heat shrink tubing for the installation of fiber-optic or coaxial cable in new risers.

Provide Tyco™(Raychem™) part number FOSC-ACC-CABLE-SEAL-2-NW or equivalent heat shrink tubing retrofit kits for the installation of new fiber-optic or coaxial cable in existing riser with existing fiber-optic or coaxial cables.

1722-3 CONSTRUCTION METHODS

Install risers with required weatherheads or heat shrink tubing on poles using pole attachment fittings.

Install heat shrink tubing retrofit kits in existing risers as specified.

Use separate 13 mm riser with weatherhead for pedestrian pushbutton.

Use separate 25 mm riser with weatherhead for electrical service.

Use separate 50 mm riser with weatherhead for signal cables (bundled). Use separate 50 mm riser with weatherhead for the combination of all lead-in and twisted-pair communications cable. Install conduit on all risers for lead-in cable.

Use separate 50 mm riser with heat shrink tubing for fiber-optic communications cables and coaxial cable. Install risers with heat shrink tubing so that cable can be installed without violating its minimum bending radius. Install cable so it does not share a riser with any other cable.

Install heat shrink tubing in accordance with manufacturer's recommendations. Provide tubing a minimum of 130 mm in length with a minimum of 60 mm extended over cables and 60 mm extended over risers after heat has been applied. Use nylon filler rods with UV protection or equivalent, and sealing spacer clips to separate cables where multiple cables enter a riser. Ensure sealing spacer clips have a heat activated sealing compound with the sealing compound fully encapsulating the space between cables. Ensure heat shrink tubing provides a watertight fit around individual cables and outer walls of risers. Do not use cut sections of cable or any other devices in lieu of filler rods. Use aluminum tape around cables to prevent damage from sealing chemicals. Use a heat source that will provide even heat distribution around tubing. Ensure no damage occurs to any cables.

1722-4 MEASUREMENT AND PAYMENT

 mm Riser with will be measured and paid as the actual number of risers of each type and size furnished, installed, and accepted. No measurement will be

made of weatherheads, heat shrink tubing, or pole attachment fittings as these will be considered incidental to furnishing and installing risers.

Heat shrink tubing retrofit kit will be measured and paid for as the actual number of heat shrink tubing retrofit kits furnished, installed, and accepted.

Payment will be made under:

Pay Item	Pay Unit
__mm Riser with _____	Each
Heat Shrink Tubing Retrofit Kit	Each

**SECTION 1725
INDUCTIVE DETECTION LOOPS**

1725-1 DESCRIPTION

Furnish and install inductive detection loops with loop slot sealant, loop wire, conduit with fittings, and all necessary hardware.

1725-2 MATERIAL

Material, equipment, and hardware furnished under this section shall be pre-approved on the Department’s QPL.

Refer to Article 1098-8 Inductive Detection Loops.

1725-3 CONSTRUCTION METHODS

All work performed in this section shall be done in the presence of the Engineer.

Notify Engineer one week before installing inductive detection loops.

Coordinate sawcutting and loop placement with pavement markings. For new construction or for resurfacing, install inductive detection loops before placing final layer of surface course. On unmarked pavement, pre-mark locations of stop lines and lane lines before locating inductive detection loops.

Before sawcutting, pre-mark inductive detection loop locations and receive approval. Sawcut pavement at approved pre-marked locations. Do not allow vehicles to travel over unsealed loop slots.

Install conduit with bushings from edge of pavement to junction box. Do not sawcut through curb.

Remove all loose material and wash saw slots with a high-pressure method using an air and water mixture. Dry saw slots with compressed air. Clear saw slots of jagged edges and protrusions. Seat loop conductor at bottom of saw slot without damaging loop wire.

Before sealing loop conductors, test that impedance from the loop wire to ground is at least 100 megohms. For each location with inductive loops, submit a completed Inductive Detection Loop & Grounding Test Results form and place copy in controller cabinet. Ensure all loops are included on form. The form is located on the Department’s website.

Embed loop conductors in saw slot with loop sealant. Seal saw slot and dispose of excess sealant in an environmentally safe manner. Provide Engineer with Material Safety Data Sheet and manufacturer’s test data.

Between corners of loops and junction boxes, twist loop conductor pairs a minimum of 16 turns per meter. Permanently label each twisted pair in the junction box with nylon cable tie using indelible ink. Indicate loop number and loop polarity on the tie.

1725-4 MEASUREMENT AND PAYMENT

Inductive Loop Sawcut will be measured and paid as the actual linear meter of inductive loop sawcut furnished, installed, and accepted.

Section 1725

No measurement will be made of loop slot sealant, loop wire, conduit, and conduit fittings as these will be considered incidental to furnishing and installing inductive detection loops.

Payment will be made under:

Pay Item	Pay Unit
Inductive Loop Sawcut	Linear Meter

**SECTION 1726
LOOP LEAD-IN CABLE**

1726-1 DESCRIPTION

Furnish and install loop lead-in cable with all necessary hardware.

1726-2 MATERIAL

Material, equipment, and hardware furnished under this section shall be pre-approved on the Department’s QPL.

Refer to Article 1098-9 Loop Lead-In Cable.

1726-3 CONSTRUCTION METHODS

For underground runs, install lead-in cable in 50 mm non-metallic conduit. For aerial installation, wrap lead-in cable to messenger cable with at least four turns of wrapping tape spaced at intervals less than 380 mm or lash lead-in cable to messenger cable with one 360 degree spiral of lashing wire per 300 mm.

Where railroad preemption is required, install lead-in cable from signal controller cabinet to railroad company furnished and installed lockable junction box.

Splicing of lead-in cable will be allowed only for runs in excess of 229 m. Splice lead-in cable in junction boxes or condulets on poles.

Test each complete loop system from the controller cabinet by using a megger to verify that impedance from the loop system to the ground is at least 50 megohms. After successful completion of megger test, test loop system resistance using an electronic ohmmeter to verify loop system resistance is less than 0.029 ohms per meter.

1726-4 MEASUREMENT AND PAYMENT

Lead-in Cable (_____) will be measured and paid as the actual linear meter of lead-in cable of either 18-2 pair or 18-4 pair furnished, installed, and accepted. Measurement will be made by calculating the difference in length markings located on outer jacket from start of run to end of run for each run. Terminate all cables before determining length of cable run. Measurement will be determined on 2-pair/4-pair combination resulting in the least number of linear meter.

If markings are not visible, measurement will be point to point with no allowance for sag. 7.6 m will be allowed for vertical segments up or down poles.

Payment will be made under:

Pay Item	Pay Unit
Lead-in Cable (_____)	Linear Meter

**SECTION 1730
FIBER-OPTIC CABLE**

1730-1 DESCRIPTION

Furnish and install single mode fiber-optic (SMFO) communications cable and drop cable assemblies with grounding systems, fiber-optic cable storage racks (snow shoes), communications cable identification markers, lashing wire, and all necessary hardware.

1730-2 MATERIAL

Refer to Article 1098-9 Fiber-Optic Cable.

1730-3 CONSTRUCTION METHODS**(A) General**

Provide cable manufacturer's attenuation and Optical Time Domain Reflectometer (OTDR) testing data for each reel of cable upon request.

Install SMFO communications cable, snow shoes, communications cable identification markers, lashing wire, and all necessary hardware.

Comply with manufacturer's recommendations. Install communications cable on signal poles, utility poles, messenger cable, and in conduits as required to bring the fiber-optic cable into and, if necessary, out of each splice enclosure.

Take all precautions necessary to ensure cable is not damaged during storage, handling, and installation. Do not violate minimum bending radius of 20 times the radius of cable diameter or manufacturer's recommendation, whichever is greater. Do not step on cable nor run over cable with vehicles or equipment. Do not pull cable over or around obstructions, or along the ground.

Determine lengths of cable necessary to reach from termination-point to termination-point. Install cable in continuous lengths between approved splicing facilities. Additionally, provide a sufficient amount of slack cable to allow for an additional 6.1 m of cable to be present after removal of outer sheath for termination. Measure slack cable by extending cable straight out of cabinet door.

Keep cable ends sealed at all times during installation to effectively prevent the ingress of moisture. Use approved heat shrink cable end cap. Do not use tape to seal cable ends.

Before installing cable, provide three copies of cable manufacturer's recommended and maximum pulling tension. Do not exceed manufacturer's recommended pulling tension. Use pulling grips containing a rotating swivel. Coil cable in a figure-8 configuration whenever cable is unreeled for subsequent pulling.

Install fiber-optic cable in separate 50 mm risers with heat shrink tubing or conduits. Do not share risers or conduits containing fiber-optic cable with other type cable.

(B) Aerial Installation

Double lash fiber-optic cable to messenger cable with one 360 degree spiral per meter.

Use pole attachment hardware and roller guides with safety clips to install aerial run cable.

Maintain tension during the pulling process for aerial run cable by using an approved mechanical clutch (dynamometer) device. Do not allow cable to contact the ground or other obstructions between poles during installation. Do not use a motorized vehicle to generate cable pulling forces.

Use a cable suspension clamp when attaching cable tangent to a pole. Select and place cable blocks and corner blocks so as not to exceed the cable's minimum bending radius. Do not pull cable across J-hooks.

Store 30 m of each fiber-optic cable on all cable runs that are continuous without splices where specified. Obtain approval for spare cable storage locations. Store spare fiber-optic cable on fiber-optic cable storage racks (snow shoes). Locate spare cable storage in the middle of spans between termination points. Do not store spare fiber-optic cable over the roadway or driveways.

Section 1730

Install one communications cable identification marker within 914 mm of pole attachment points and at locations where more than one cable originates or terminates.

(C) **Underground Installation**

Install fiber-optic cable underground in conduit using cable pulling lubricants recommended by the fiber-optic cable manufacturer.

Obtain approval of cable pulling lubricant and method of pulling before installing underground fiber-optic cable.

Use a dynamometer (clutch device) so as not to exceed maximum allowable pulling tension if cable is pulled by mechanical means. Do not use a motorized vehicle to generate cable pulling forces.

Keep tension on cable reel and pulling line at start of each pull. Do not release tension if pulling operation is halted. Restart pulling operation by gradually increasing tension until cable is in motion.

For pulling cable through manholes, junction boxes, and vaults, feed cable by manually rotating the reel. Do not pull cable through intermediate junction boxes, handholds, or openings in conduit unless otherwise approved.

Install communications cable identification markers on each communications cable entering a junction box.

(D) **Installation of Drop Cable Assembly**

Determine length of drop cable needed, including slack, to reach from termination point to termination point.

At aerial splice enclosures, store 30 m of slack cable on cable storage racks. At below ground splice enclosures, coil 30 m of slack cable in manhole or junction box where enclosure is located.

At equipment cabinet end of drop cable assembly, terminate all fibers with ST-PC connectors to the connector panel. Label all connectors, pigtails, and the connector panel. At the aerial splice enclosure location, cap off all unused fibers and label to correspond with the connector panel.

1730-4 **MEASUREMENT AND PAYMENT**

Communications Cable (____-fiber) will be measured and paid as the actual linear meter of fiber-optic cable of each fiber count furnished, installed, and accepted. Measurement will be made by calculating the difference in length markings located on outer jacket from start of run to end of run for each run. Terminate all fibers before determining length of cable run.

Drop Cable will be measured and paid as linear meter of fiber-optic drop cable assemblies furnished, installed, and accepted. Sag and vertical segments will not be paid for as these distances are considered incidental to the installation of drop cable assemblies.

No measurement will be made for terminating, splicing, and testing fiber-optic cable, communications cable identification markers, or fiber-optic cable storage racks, as these will be considered incidental to the installation of fiber-optic cable.

Payment will be made under:

Pay Item	Pay Unit
Communications Cable (____-Fiber)	Linear Meter
Drop Cable	Linear Meter

**SECTION 1731
FIBER-OPTIC SPLICE CENTERS**

1731-1 DESCRIPTION

Furnish and install fiber-optic interconnect centers, fiber-optic splice enclosures, and all necessary hardware.

1731-2 MATERIALS

Material, equipment, and hardware furnished under this section shall be pre-approved on the Department's QPL.

Refer to Article 1098-10 Fiber-Optic Splice Centers.

1731-3 CONSTRUCTION METHODS

(A) General

Install interconnect centers with connector panels, splice trays, storage for slack cable or fibers, mounting and strain relief hardware, and all necessary hardware.

Install splice enclosures with splice trays, basket containment assemblies, racking for slack cable or fibers, mounting and strain relief hardware, and all other necessary hardware.

Fusion splice and secure SMFO cable in splice trays inside the splice enclosure. Ensure all buffer tubes are contained within splice trays so no bare fibers are outside tray.

Do not exceed 0.05 dB of attenuation per splice.

Furnish strain relief so that no tensile force is on SMFO cable when it is held within the interconnect center or splice enclosure.

Do not damage fiber or violate the minimum bending radius of the fiber.

(B) Termination and Splicing within Interconnect Center

Terminate and splice all fibers including unused fibers.

Label all fiber-optic connectors, whether on jumpers, connector panels, or other equipment, to prevent improper connection. Obtain approval of fiber-optic connector labeling method.

For all fibers designated for termination to connector panel within interconnect center, fusion splice fibers to pigtails.

For all cut fibers designated to pass through interconnect center, fusion splice fibers.

For all buffer tubes designated to pass through interconnect center, neatly coil excess tubing inside interconnect center.

(C) Termination and Splicing within Splice Enclosure

Fusion splice all fibers including fibers designated to be coupled with fibers from a drop cable assembly and cut fibers designated to pass through splice enclosure.

For all buffer tubes designated to pass through splice enclosure, neatly coil excess tubing inside basket provided with enclosure.

Label all fiber-optic splices. Obtain approval of fiber-optic connector labeling method.

Install heat shrink cable shields using methods recommended by the manufacturer of the enclosure. Perform a pressurization flash test on enclosure in accordance with manufacturer's recommended procedures at the conclusion of splicing procedure and before final placement of enclosure.

For aerial installations, secure enclosures to messenger cable using manufacturer supplied hardware. Secure SMFO cable and drop cable assemblies to snowshoes.

Section 1731

Install enclosures with enough slack cable to allow enclosure to be lowered to ground level and extended into a splicing vehicle.

For underground, manhole, and junction box facility installations, place the enclosure along with required spare cables in the facility in a neat and workmanship like manner.

(D) Testing

Provide written notification a minimum of ten days before beginning OTDR tests.

After splicing is completed, perform bi-directional OTDR tests on each fiber, including unused fibers. Install a 305 m pre-tested launch cable between the OTDR and fiber optic cable to be tested.

Ensure fusion splice losses do not exceed 0.05 dB and connectors have a loss of 0.5 dB or less. If any fiber exceeds maximum allowable attenuation or if fiber properties of the cable have been impaired, take appropriate actions up to and including replacement of the fiber cable. Corrective action will be at no additional cost to the Department

Clearly label each OTDR trace identifying a starting and ending point for all fibers being tested. Record the attenuation level of each fiber and clearly indicate OTDR trace results in report format. Furnish one hard copy of each of the OTDR trace results and electronic copies of all trace results on a compact disk. Furnish the manufacturer’s make, model number, and software version of the OTDR used for testing.

1731-4 MEASUREMENT AND PAYMENT

Interconnect Center will be measured and paid as the actual number of fiber-optic interconnect centers furnished, installed, and accepted.

Splice Enclosure Actual number of fiber-optic splice enclosures furnished, installed, and accepted. No measurement will be made between aerial, underground, manhole, or junction box installation of the fiber-optic splice enclosure.

No measurement will be made of splice trays, pigtails, jumpers, connector panels, and testing, as these will be considered incidental to furnishing and installing fiber-optic interconnect centers and splice enclosures.

Payment will be made under:

Pay Item	Pay Unit
Interconnect Center	Each
Splice Enclosure	Each

**SECTION 1732
FIBER-OPTIC TRANSCEIVERS**

1732-1 DESCRIPTION

Furnish and install fiber-optic transceivers with all necessary hardware.

1732-2 MATERIALS

Material, equipment, and hardware furnished under this section shall be pre-approved on the Department’s QPL.

Refer to Article 1098-11 Fiber-Optic Transceivers.

1732-3 CONSTRUCTION METHODS

Install fiber-optic transceivers in each equipment cabinet and comply with manufacturer’s installation instructions.

1732-4 MEASUREMENT AND PAYMENT

Actual number of fiber-optic drop and repeat transceivers furnished, installed, and accepted.

Actual number of fiber-optic self-healing ring transceivers furnished, installed, and accepted.

Payment will be made under:

Pay Item	Pay Unit
Fiber-Optic Transceiver – Drop and Repeat	Each
Fiber-Optic Transceiver – Self-Healing Ring	Each

**SECTION 1733
DELINEATOR MARKERS**

1733-1 DESCRIPTION

Furnish and install delineator markers with all necessary hardware.

1733-2 MATERIAL

Material, equipment, and hardware furnished under this section shall be pre-approved on the Department’s QPL.

Refer to Article 1098-12 Delineator Markers.

1733-3 CONSTRUCTION METHODS

Submit sample of proposed delineator markers for approval before installation.

Install delineator markers using a method that firmly and securely anchors delineator marker in the ground to prohibit twisting and easy removal.

1733-4 MEASUREMENT AND PAYMENT

Actual number of *Delineator Markers* furnished, installed, and accepted.

Payment will be made under:

Pay Item	Pay Unit
Delineator Marker	Each

**SECTION 1734
REMOVE EXISTING COMMUNICATIONS CABLE**

1734-1 DESCRIPTION

Remove existing communications cable.

1734-2 CONSTRUCTION METHODS

Removal of existing aerial communications cable also includes proper disposal of communications cable, messenger cable and mounting hardware, including abandoned risers.

Removal of existing underground communications cable includes proper disposal of communications cable and junction boxes, if required. Where junction boxes have been removed, backfill hole to 95% of surrounding density.

Do not reuse any removed communications cable, messenger cable, junction boxes, pole attachment hardware or abandoned risers on the project, unless otherwise specified. In the event that any of the removed communications cable, junction boxes or pole attachment hardware is to be returned to the Engineer, it will be so noted on the plans.

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1734-3 MEASUREMENT AND PAYMENT

Remove Existing Communications Cable will be measured in horizontal linear meter of existing communications cable removed and accepted. Payment will be in linear meter. Sag, vertical segments, or spare segments of communications cable will not be paid for as these distances will be considered incidental to the removal of existing communications cable.

No additional measurement will be made for multiple cables being removed from the same conduit or same pole. Where multiple adjacent conduits exist (each containing multiple cables), each conduit will be considered separately for purposes of payment. No payment will be made for cable that cannot be removed and is abandoned in place.

No measurement will be made of the removal of messenger cable, pole attachment hardware, and junction boxes, as these will be considered incidental to removing existing communications hardware.

Payment will be made under:

Pay Item	Pay Unit
Remove Existing Communications Cable	Linear Meter

**SECTION 1735
CABLE TRANSFERS**

1735-1 DESCRIPTION

Remove and reinstall existing communications cable for pole relocations.

1735-2 CONSTRUCTION METHODS

During project, transfers of existing communications cable to new poles may be required. Perform transfers as directed by the Engineer. Remove existing cables from pole to be removed and reinstall these cables and any existing attachment hardware on new pole. Remove all communications hardware from existing pole. Furnish and install any new attachment hardware as required.

1735-3 MEASUREMENT AND PAYMENT

Cable Transfer will be measured and paid as the actual number of cable transfers with attachment hardware to new poles furnished, installed, and accepted.

Payment will be made under:

Pay Item	Pay Unit
Cable Transfer	Each

**SECTION 1743
SIGNAL PEDESTALS**

1743-1 DESCRIPTION

Furnish and install signal pedestal assemblies with foundations, grounding systems, and all necessary hardware.

1743-2 MATERIAL

Material, equipment, and hardware furnished under this section shall be pre-approved on the Department's QPL.

Refer to Article 1098-13 Pedestals.

1743-3 CONSTRUCTION METHODS

Locate foundations, determine elevation, and submit findings. Obtain the Engineer's approval of foundation locations and elevations before constructing foundations.

Excavate in accordance with Section 410 Foundation Excavation. If encountered, remove rock or boulders to a depth sufficient to obtain stability necessary to support the structure for design loads. Ensure ground is level before installing foundations.

Construct foundations in accordance with Section 825 Incidental Concrete Construction. Cast concrete for pole foundations against undisturbed soil unless otherwise permitted. Provide forms with chamfer strips that measure 25 mm along diagonal face at all corners above ground level. Do not install foundations over uncompacted fill or muck. Install conduit in foundations.

Securely place, position, and align anchor bolts symmetrically about the center of foundation.

Give exposed vertical concrete surfaces an ordinary surface finish. Give exposed horizontal surfaces a float finish.

Level tops of concrete foundations. Do not allow tops to exceed 150 mm above adjacent ground surface. Pour and finish foundation to a level flush with surrounding sidewalk when possible.

Do not erect pedestals until concrete has attained a minimum compressive strength of 17.2 MPa as determined by cylinder breaks.

1743-4 MEASUREMENT AND PAYMENT

Signal Pedestal with Foundation will be measured and paid as the actual number of signal pedestals with foundations furnished, installed, and accepted.

Payment will be made under:

Pay Item	Pay Unit
Signal Pedestal with Foundation	Each

**SECTION 1745
SIGNS INSTALLED FOR SIGNALS**

1745-1 DESCRIPTION

Furnish and install signs for signals with cable hangers, rigid sign mounting brackets, U-channel posts, and all necessary hardware.

1745-2 MATERIAL

Comply with Article 901-2 Sign Fabrication.

Use Type III retroreflective sheeting, except for black sheeting. Use non-reflective for black sheeting.

Conform to the message layout, size, and color as required in the *MUTCD*.

For messenger cable mounting, furnish either messenger cable hangers with free-swinging, 360 degree adjustable sign brackets or three bolt clamps as directed. Furnish aluminum, galvanized steel, or stainless steel sign supporting hardware.

For ground mounting, furnish steel, 1.4 kg, U-channel posts with hardware for ground mounting. Comply with Article 903-2 Sign Supports.

For mast-arm mounting, furnish rigid aluminum, galvanized steel or stainless steel sign mounting brackets.

1745-3 CONSTRUCTION METHODS

Install signs with applicable mounting hardware. Comply with sign offsets and mounting heights as shown in the *MUTCD* and Standard Drawing numbered 904.50.

For messenger cable mounting, install signs 150 mm minimum from signal heads.

For ground mounting, comply with Article 903-3 Ground Mounted Supports.

Section 1745

For mast arm mounting, install attachment brackets to allow adjustment so signs:
are aimed in required direction,
are plumb as viewed from respective approaches,
may be tilted forward or backward as required, and
may be raised or lowered on mast arm throughout full length of sign.

1745-4 MEASUREMENT AND PAYMENT

Sign for Signals will be measured and paid as the actual number of signs for signals, regardless of mounting method, furnished, installed, and accepted.

Payment will be made under:

Pay Item	Pay Unit
Sign for Signals	Each

SECTION 1750 SIGNAL CABINET FOUNDATIONS

1750-1 DESCRIPTION

Furnish and install signal cabinet foundations and all necessary hardware.

Furnish either poured concrete foundations or preformed cabinet pad foundations and all necessary hardware. Obtain approval of foundation type.

1750-2 MATERIAL

Preformed cabinet pad foundation material, equipment, and hardware furnished under this section shall be pre-approved on the Department's QPL.

Refer to Article 1000-4 Portland Cement Concrete and Article 1098-14 Signal Cabinet Foundations.

1750-3 CONSTRUCTION METHODS

Comply with Section 825 Incidental Concrete Construction-General.

Obtain approval for final cabinet foundation locations before pouring concrete base. Locate new cabinets so as not to obstruct sight distance of vehicles turning on red.

Do not install foundations over uncompacted fill or muck.

Use procedures, equipment, and hardware as follows:

Hand tamp soil before placing concrete.

Maintain 305 mm minimum from service pole to closest point on foundation unless otherwise approved.

Use a minimum of four 13 mm diameter expanding type anchor bolts to secure cabinet to foundation.

Install minimum 100 mm above and 100 mm below finished grade.

Locate external stubbed out conduit at cabinet foundation so conduit is in middle of cabinet. Provide service conduit as the rightmost conduit coming into cabinet. Provide two spare conduits stubbed out; one pointed toward service pole and the other toward direction of lead-in cable. Inscribe identification arrow in foundation indicating direction of spare conduits.

Give cabinet foundation a broom finish.

Seal space between cabinet base and foundation with permanent, flexible, waterproof sealing material.

If using preformed cabinet pad, ensure ground is level before installation.

1750-4 MEASUREMENT AND PAYMENT

Signal Cabinet Foundation will be measured and paid as the actual number furnished, installed, and accepted.

Payment will be made under:

Pay Item	Pay Unit
Signal Cabinet Foundation	Each

SECTION 1751 CONTROLLERS WITH CABINETS

1751-1 DESCRIPTION

Furnish and install controllers with cabinets and all necessary hardware. Furnish all pole or foundation mounting hardware, detector sensor cards, external electrical service disconnects, one Corbin Number 2 cabinet key, one police panel key, conflict monitors or malfunction management units, surge protection, grounding systems, AC/DC isolator cards, and all necessary hardware.

1751-2 MATERIAL

Material, equipment, and hardware furnished under this section shall be pre-approved on the Department's QPL. Refer to the contract.

1751-3 CONSTRUCTION METHODS

(A) General

Remove existing controllers and cabinets where required. Remove maintenance diary from cabinet and place in new cabinet or deliver to the Engineer. Take existing equipment out of service only at the time directed.

Locate new cabinets so as not to obstruct sight distance of vehicles turning on red.

Install controllers, cabinets, detector sensor units, and hardware that provide required phasing, color sequence, flash sequence, interconnection, railroad clearance and preemption, and emergency vehicle clearance and preemption.

Stencil signal inventory number on cabinet side facing roadway. Use 75 mm black characters.

Provide external electrical service disconnect at all new and existing cabinet locations unless otherwise specified.

Do not program controller for late night flashing operation at railroad preemption installations. For all other installations, do not program controller for late night flashing operation unless otherwise directed. Ensure all signal heads for same approach flash concurrently during flashing operation.

Provide serial number and cabinet model number for each new controller and controller cabinet installed.

Install pole mounted cabinets so height to cabinet middle is 1.2 m.

Activate controllers with proposed phasing and timing.

(B) System Interconnection

When interconnection of signals is required, install interface equipment and hardware for signals. Demonstrate proper operation of interconnection using manual commands after interconnection is complete.

Program telemetry command sequences and enable devices necessary for testing of communication between local controllers and field master controllers, and between field master controllers and Department-furnished central computer.

(C) Workshop

Provide enclosed workshop to set up and test new controllers and cabinets before installation. Locate workshop within Division responsible for project administration. Ensure workshop provides protection from weather and sufficient space to house two test observers, all necessary test equipment and material, controllers and cabinets.

Section 1751

Configure and test each controller and cabinet to match the proposed signal design. Ensure all equipment furnished and installed or modified by the Contractor at each location operates in full compliance with the plans and project special provisions. Test each controller and cabinet for proper color sequence, flashing operation, phase timings, preemption, coordination, and conflict monitor programming or malfunction management unit programming. Ensure that simultaneous conflicting phase outputs will cause the cabinet to revert to flashing operation. For intersections with any type of preemption, submit a completed Preemption Test Procedure Checklist. The checklist is located on the Department’s website.

Test the cabinet and controller for eight hours minimum. Following this test, and before installation, the Engineer will inspect the equipment in operation. The Engineer may require other tests to ensure proper operation. These tests shall be at no additional cost to the Department.

1751-4 MEASUREMENT AND PAYMENT

Controllers with Cabinets (____) will be measured and paid as the actual number of each type of controllers with cabinets furnished, installed, and accepted.

Detector Cards will be measured and paid as the actual number furnished, installed, and accepted.

No measurement will be made of conflict monitors, malfunction management units, external electrical service disconnect, grounding systems, modems, meter bases, and workshop as these will be considered incidental to furnishing and installing controllers with cabinets.

Payment will be made under:

Pay Item	Pay Unit
Controller with Cabinet (_____)	Each
Detector Card (_____)	Each

**SECTION 1753
CABINET BASE ADAPTER/EXTENDER**

1753-1 DESCRIPTION

Furnish and install cabinet base adapters and extenders with all necessary hardware for 170 Cabinets.

1753-2 MATERIAL

Refer to Article 1098-15 Cabinet Base Adapter/Extender.

1753-3 CONSTRUCTION METHODS

Install cabinet base adapter at locations requiring new Model 332A cabinet on existing/modified foundation.

Install cabinet base extender at locations requiring new Model 332A cabinet on new foundation or existing Model 332A cabinet that does not have cabinet base extender.

Where Model 336 cabinet is used as base mount cabinet, install adapter or extender, as required.

Use permanent, flexible waterproof sealing material to:

- Seal between cabinet base and cabinet base adapter/extender,
- Seal two-piece cabinet base adapter/extender seams, and
- Seal space between cabinet base adapter/extender and foundation.

1753-4 MEASUREMENT AND PAYMENT

Cabinet Base Adapters will be measured and paid as actual number furnished, installed, and accepted.

Cabinet Base Extenders will be measured and paid as the actual number furnished, installed, and accepted.

Payment will be made under:

Pay Item	Pay Unit
Cabinet Base Adapter	Each
Cabinet Base Extender	Each

SECTION 1755 BEACON CONTROLLER ASSEMBLIES

1755-1 DESCRIPTION

Furnish and install beacon controller assemblies with cabinets. Furnish all pole mounting hardware, solid state flashers, one Corbin Number 2 cabinet key, surge protection, grounding systems, and all necessary hardware.

1755-2 MATERIAL

Refer to Article 1098-16 Beacon Controller Assemblies.

1755-3 CONSTRUCTION METHODS

Remove existing beacon controller assemblies where required. Remove maintenance diary from cabinet and place in new cabinet or deliver to the Engineer. Take existing equipment out of service only at the time directed.

Locate new beacon controller assemblies so as not to obstruct sight distance of turning vehicles.

Install new beacon controller assemblies. Provide external electrical service disconnect at new and existing cabinet locations unless otherwise specified.

Stencil signal inventory number on cabinet side facing roadway. Use 75 mm black characters. Provide serial number and cabinet model number for each new beacon controller assembly.

Install pole mounted cabinets so height to cabinet middle is 1.2 m.

1755-4 MEASUREMENT AND PAYMENT

Beacon Controller Assembly and Cabinet (____) will be measured and paid for as the actual number furnished, installed, and accepted.

No measurement will be made of surge protectors, external electrical service disconnect, grounding systems, and removing existing beacon controller assemblies as these are considered incidental to furnishing and installing beacon controller assemblies.

Payment will be made under:

Pay Item	Pay Unit
Beacon Controller Assembly and Cabinet (____)	Each