SECTION 655 ELECTRICAL WIRING

655.1 Description

(1) This section describes furnishing and installing electrical wire and cable for all traffic signal, highway/roadway lighting, and other underground installations.

655.2 Materials

655.2.1 Cable In Duct

(1) Furnish conductors conforming to electrical wire, lighting specified in 655.2.6.

(2) Furnish conductors enclosed in a red, or black with a red stripe, coilable polyethylene duct, suitable for direct earth burial, and manufactured from high density polyethylene conforming to the applicable requirements of ASTM D3350.

(3) Use UL or NRTL listed Cable in Duct (CID) conforming to the WSEC specifications for nonmetallic underground conduit with conductors, type NUCC.

655.2.2 Traffic Signal Cable

(1) Furnish solid copper conductor traffic signal cables conforming to IMSA Specification Number 20-1. Provide wire size and number of conductors as the plans show.

(2) For wiring that extends from the terminal strip in each signal head to the mounting base, use an IMSA, 20-1 cable, 14 AWG 4, 5, or 7 conductor as required.

655.2.3 Type UF Cable

(1) Furnish type UF cable with ground including the number and size of conductors as the plans show. Use cable conforming to ANSI/UL 493.

655.2.4 Communication Cable

(1) Furnish communication cable conforming to IMSA Specification 20-6. Use 6 pairs of 18 AWG in each cable. Twist conductors 12 turns per foot by the individual pair.

655.2.5 Grounded Conductor and Equipment Grounding Conductor for Traffic Signals

(1) Use green insulation or green insulation with a yellow tracer applied by thermoset method.

(2) Furnish 10 AWG or 8 AWG, or both, XLP, USE rated, 600 volt AC, single conductor, stranded copper for conductors.

655.2.6 Electrical Wire for Lighting

(1) For underground networks, unless the contract specifies a multi-conductor cable, furnish single conductor, stranded copper, XLP insulated, USE rated wire sized as the plans show.

(2) For underground network to luminaire connections, furnish single conductor, stranded copper, XLP insulated, USE rated wire. Use 12 AWG unless plans show otherwise.

(3) Identify insulated conductors by covering the insulation surface with a tough, strongly adhered color coating conforming to Method I, or by surface printing conforming to Method III of IPCEA (Insulated Power Cable Engineers Association)-NEMA Standard S-19-81. Do not use white coatings on ungrounded conductors.

(4) On 4 AWG conductor or larger, when color coding is necessary, the contractor shall do so per WSEC. On 6 AWG conductor or smaller, use the insulation color as the plans show and furnish conforming to industry standards and the WSEC.

(5) Color code both tails of all ungrounded circuit conductors at splices and fuse holders as the plans show. Use colored tape to identify circuits, half-lap the tape for 2-inches or more using engineer-approved colored tape.

(6) When there is more than one circuit, bundle the circuit conductors with nylon cable ties or approved electrical tape at all access points. At each hand-hole, identify the line side of each circuit with a tape colored as the plans specify.

655.2.7 Loop Detector Lead In Cable

(1) Furnish shielded, 14 AWG, 2 conductor, polyethylene insulated, with 16 AWG drain wire, conforming to IMSA Specification Number 50-2 for loop detector lead-in cable.

655.2.8 Loop Detector Wire

(1) Furnish black 12 AWG, XLP insulated, USE rated, single conductor, 7-strand copper for loop detector wire.

655.2.9 Emergency Vehicle Preemption Detector Cable for Traffic Signals

(1) Furnish 3-conductor shielded, 600 volt, type B control cable conforming to IPCEA-5-61-402/NEMA WC5 with a foil shield, 20 AWG stranded conductors and ground wire, and rated for 75 degrees C. Ensure that the conductors are color coded with 1 blue, 1 orange, and 1 yellow conductor.

655.3 Construction

655.3.1 General

(1) Do not splice underground in pull boxes or conduit, except that the contractor may splice underground loop detector lead-in cable to loop wire. Do not leave wire or cable ends uncovered or submerged in water. If the engineer observes this condition, the engineer may reject the entire length of cable or wire. Make all electrical connections and splices with a UL or NRTL approved mechanical type connector.

(2) Cover tape with a liberal coating of an engineer-approved electrical varnish or sealant providing flexible protection from oil, moisture, and corrosion. Make electrical connections in the traffic signal base with spring wound wire nuts, insulated with a soft flexible covering or as detailed on the plans. Extend wire for termination 18 inches beyond the pole or traffic signal standard access point. Provide 60 inches of cable wire to be pulled into cabinets and left for terminations.

(3) For all cables entering each pull box, except loop detector lead in cables, provide an extra loop, approximately 6 feet in length, to remain in each pull box. This loop of cable is in addition to the amount needed to reach from the entrance conduit raceway end to the opening in the exiting conduit raceway.

(4) Install conductors in continuous lengths without splices from termination to termination. The contractor may splice only at hand-holes in the bases of the traffic signal standards or poles. At locations where no transformer bases exist, splice at the hand-holes in poles.

655.3.2 Cable In Duct

(1) Under the Cable In Duct bid items, furnish and install underground cable in duct of the specified quantity and wire size of conductors.

(2) Locate the cable as the plans show. Locate underground cable to preclude damage resulting from other construction operations.

(3) Install cable in duct at least 30 inches below the finished grade or within the protection of conduit as the plans show. Should physical conditions at the cable location preclude placing to this depth, the contractor may modify the depth requirement as the WSEC allows. Place the cable in rigid steel conduit conforming to 652.2.2 for metallic conduit.

(4) Set the underground cable in duct assembly 3 feet above the top of each light base or finished grade. Cap or seal the duct until completion of the electrical connections.

(5) Continue the polyethylene duct to within 6 inches of a terminal connection.

(6) If the size of the cable in duct prevents insertion through the conduit in a concrete base, the contractor may cut the duct off the assembly to allow for wire installation. In this case, after placing the wire, ensure at least one foot of intact duct remains in the conduit to protect the wires at the conduit entrance.

(7) It is the intent of this specification that the cable duct will form a usable raceway as well as protection for the cable. Unreel the cable in duct, do not take off the side of the reel. Install the duct so it is free of kinks, sharp radii, and unnecessary wiggles. At the engineer's request, demonstrate free movement of the conductors within the duct after installation, and demonstrate the easy removal and replacement of the conductors within the duct.

(8) If installing cable in duct by plowing, use round duct free of kinks or constrictions while fed into the plowing mechanism. At the engineer's request, excavate the cable in duct to check for depth violations. Correct all depth variations as specified in 105.3.2. Do not splice the cable in duct; replace it to the previous termination point.

(9) Before installing cable in duct by trenching, remove rocks, stones, and concrete chunks from the trench, and place a layer of granular fill, free of damaging materials around the duct, 6 inches below and 12 inches above. Use select backfill material, with 100 percent passing a one-inch sieve.

(10) Install ungrounded conductors or grounded circuit conductors in continuous lengths without splices from terminal to terminal. Splice only in hand-holes of poles, transformer bases, sign bridge columns, or junction boxes as the plans show. Do not splice in pull boxes.

655.3.3 Traffic Signal Cable

(1) Under the Traffic Signal Cable bid item, furnish and install multi-conductor cable for traffic signals and make all connections.

(2) Numbers of conductors, in excess of those required are for future use.

(3) Wrap back the conductors from spare multi-conductor cables along the multi-conductor cable and tape to the cable.

(4) Effectively ground all spare or unused conductors in the signal control cabinet to the equipment grounding terminal strip.

(5) Group and identify sets of conductors in signal cables, per signal phase, whether insulated with red, yellow, green, or other colors at each pertinent termination. Unless the plans show otherwise, use conductors colored to match lens colors.

(6) Tag all traffic signal cables terminating in the signal control cabinet with waterproof tape and mark with indelible ink. Tape a plastic coated copy of the cable routing diagrams to the inside cabinet wall. Ensure markings indicate the geographical location. Indicate NW quadrant, S median, etc. The engineer will approve the method of identification.

(7) Ensure that the grounded conductor in feeder cables is 12 inches longer than the ungrounded conductors. Also ensure that the pole cable from the signal heads to the signal base extends 24 inches beyond the access door.

(8) If mounting more than one signal head on a standard or pole, wire each head with a separate cable from the mounting base to the appropriate terminal strips.

655.3.4 Type UF Cable

(1) Under the Cable Type UF bid items, furnish and install the underground cable network for highway lighting at traffic signal installations.

(2) If installing lighting in conjunction with traffic signals, use type UF, 2 conductor with ground, solid or stranded copper conductor cable, sized as the plans show, from the traffic signal control cabinet to the pertinent light pole base or bases.

(3) Strip the minimum length of jacket necessary to make terminations in a neat and technically proficient manner.

655.3.5 Communication Cable

(1) Under the Communication Cable Plowed bid item, furnish communication cable for interconnecting traffic signals, and install the cable by plowing.

(2) If installing communication cable by plowing, install at least 32 inches below finished grade.

(3) Under the Communication Cable Trenched bid item, furnish communication cable for interconnecting traffic signals, construct a trench, and install the cable in the trench.

(4) Install trenched communication cable as specified in 652.3.1.2 for underground installation except do not install less than 32 inches below finished grade.

(5) During installation, prevent damage to the communication cable.

(6) Under the Communication Cable Installed in Conduit bid item, furnish communication cable for interconnecting traffic signals, and install the cable in new or in existing, in place traffic signal conduit.

(7) If installing communication cable in conduit, do not damage or disturb existing cable within the conduit. Use wire lube on the full length of installed communication cable, if wire or cables exist in conduit.

(8) Install all communication cable without splices between traffic signal control cabinets. Extend cable into each signal control cabinet for 6 feet. Provide an extra loop, approximately 4 feet in length, to remain in each pull box.

(9) Test the communication cable following installation. Use a megger to perform ground resistance testing of all conductors including the shield, and conductor-to-conductor, including all individual conductors to the shield. Ensure that all conductor tests, including the shield, read infinity to ground, and from conductor to

conductor and all individual conductors to the shield, read infinity. Replace cable not meeting the infinity test result at no expense to the department, whether one or many readings per cable are defective.

655.3.6 Grounded Conductor and Equipment Grounding Conductor for Traffic Signals

(1) Connect the white 14 AWG wires in the signal head mounting base to the white grounded conductor in the feeder cable.

(2) Terminate all grounded conductors on a bus mounted in the cabinet and isolated from the cabinet and equipment grounding conductor. Terminate the grounded conductor bus at the grounding lug in the electrical service meter pedestal or meter socket.

(3) Terminate all equipment grounding conductors on the equipment grounding bus that is isolated from the grounded conductor bus. Terminate the equipment grounding bus at the grounding lug in the electrical service meter breaker pedestal service disconnect, or meter socket, or terminate at the grounding lug of the breaker enclosure if the service is unmetered.

(4) Make the equipment grounding connection in the signal pedestal base, or in a pole transformer base, with a pigtail and wire nut or split bolt to an equipment grounding conductor. Extend the equipment grounding conductor from the equipment grounding bus in the traffic signal cabinet, from base to base around the intersection in a complete closed circuit. Ensure that the pull box is bonded to the frame and the cover is bonded to the frame with a jumper from the nearest signal base.

(5) Under the Electrical Wire Traffic Signals bid items, furnish and install electrical wire for traffic signals and make all connections.

(6) Make electrical connections in the traffic signal base with spring wound wire nuts, insulated with a soft flexible covering.

(7) For the pigtail, use 10 AWG, bare copper wire or green XLP insulated, a minimum 16 inches in length. Attach one end of the pigtail to an approved mechanical connector, lug, and place the connector inside the base under the head of a 1/4” -20 x 3/4” hex-head stainless steel cap screw tapped into the base.

655.3.7 Electrical Wiring for Lighting

(1) Under the Electrical Wire Lighting bid items, furnish and install electrical wire of the specified conductor size for lighting, and make all connections.

(2) Provide an 18 inch length of wire in each hand-hole for termination. For all wires entering each pull box, provide an extra loop, approximately 6 feet in length, to remain in each pull box. This loop of wire is in addition to the amount needed to reach from the entrance conduit raceway end to the opening in the exiting conduit raceway.

(3) Install conductors in continuous lengths without splices from the cabinet terminal to pole hand-hole or transformer base. Do not splice in pull boxes.

(4) Install conductors from the luminaire to the fuse assembly using a continuous length of 12 AWG, XLP wire without splices. Provide sufficient length in the pole shaft to allow easy removal and subsequent servicing of the fuse assembly through the pole hand-hole.

655.3.8 Loop Detector Lead In Cable

(1) Under the Loop Detector Lead In Cable bid item, furnish and install loop detector lead in cable, splice loop and lead in cable together in the pull box, and connect the lead in cable to proper terminals in the control cabinet.

(2) Install the loop detector lead in cable in electrical conduit furnished under other bid items. For lead in cable from the pull box to the control cabinet, install lead in cable in conduit either with or without other cables. Do not provide an extra length of loop lead in cable in pull boxes. For each loop, use a separate lead in cable to the control cabinet. Cut the drain wire flush with the lead in cable jacket.

(3) Splice cables using cast in place splice kits from an approved manufacturer. Make splices as soon as possible after installing loop detector lead in cable.

(4) If unable to splice to the lead in cable the day installing the wire, seal the cable ends with tar or electrical sealant to keep water out of the insulating jacket of the cable. If water does enter the insulating jacket, remove the cable and replace with new cable at no expense to the department.

(5) A splice consists of a non-insulated butt connector, connecting one loop wire to one loop lead-in cable wire. Crimp and solder this connection with electrical multi-flux core. Crimp connect and solder the second 2 wires in the same manner. Half lap tape the solder connections with an approved rubber high

voltage tape. Half lap tape each connection with an approved vinyl electrical tape and insulate connections from each other before placing in the splice kit. Coat each connection with an approved electrical varnish and allow the coating to dry. After drying, install the splice capsule conforming to the manufacturer's instructions.

(6) If the engineer directs, open one randomly selected loop detector splice and inspect it for compliance with installation specifications. If the engineer determines the splice is non-compliant with the specifications, replace all loop detector splices on the project at no expense to the department.

(7) After splicing the loop wire to the loop lead in cable, measure inductance, ground resistance, and wire resistance at the cabinet end of the lead in cable. Furnish a copy of the readings to the engineer for evaluation.

655.3.9 Loop Detector Wire

(1) Under the Loop Detector Wire bid item, furnish and install loop detector wire.

(2) Install the loop detector wire in one-inch loop detector PVC conduit furnished under another bid item. The contractor may install loop wire before placing the conduit.

(3) Do not provide an extra length of loop detector wire in the pull boxes.

(4) Install the loop wire from the pull box at the side of the road, around the loop in the number of turns the plans show, and back to the pull box at the side of the road, in one continuous non-spliced length.

(5) If unable to splice to the lead in cable the day installing the wire, seal the wire ends with tar or electrical sealant to keep water out of the insulating jacket of the wire. If water does get into the insulating jacket, remove the wire and replace with new wire at no expense to the department.

(6) Measure the loop inductance, ground resistance, and loop wire resistance at the pull box end of the loop wire immediately after installation. Furnish a copy of the readings to the engineer for evaluation.

(7) Measure ground resistance using a megger. Replace loop wire not attaining a reading of infinity to ground.

655.3.10 Emergency Vehicle Preemption (EVP) Detector Cable for Traffic Signals

(1) Under the Traffic Signal EVP Detector Cable bid item, furnish and install the EVP cable and mount department-furnished brackets. The department will determine the exact location to ensure that the installation does not create a sight obstruction. The department will mount the heads, terminate the ends, and install the discriminators and card rack in the cabinet.

(2) Ensure that the cable runs continuously without splicing from the pull box closest to the cabinet including the specified extra cable. Do not splice EVP cable from the detector assembly to the controller terminations. Provide 8.5 feet of extra cable at the mounting bracket with 6 feet at the bracket and 2.5 feet extending out of the mounting bracket. Provide 6 feet of extra cable in each pull box plus an additional 20 feet at the nearest pull box to signal base where the EVP detector head is mounted.

(3) Mark each end of the lead as the plans show. Notify the department to gain access to the control cabinet. The department will only provide access while a department electrician is present.

(4) Notify the engineer upon completion of the installation at each intersection.

655.4 Measurement

(1) The department will measure the Cable In Duct bid items by the linear foot acceptably completed. This measurement includes conductors that had the duct cut away.

(2) The department will measure the Cable Traffic Signal bid items, the Cable Type UF bid items, Communication Cable Plowed, Communication Cable Trenched, Communication Cable Installed in Conduit, and Traffic Signal EVP Detector Cable by the linear foot acceptably completed.

(3) The department will measure the Electrical Wire Traffic Signals and Electrical Wire Lighting bid items by the linear foot acceptably completed, measured separately for each conductor.

(4) The department will measure Loop Detector Lead In Cable by the linear foot acceptably completed, measured from the splice with the loop lead in wire along the centerline of the conduit to its connection with terminals in the control cabinet.

(5) The department will measure Loop Detector Wire by the linear foot acceptably completed, measured around the loop, including the number of turns and its lead to and from the splice with the lead in cable.

655.5 Payment

(1) The department will pay for measured quantities at the contract unit price under the following bid items:

ITEM NUMBER	DESCRIPTION	UNIT
655.0100 - 0199	Cable In Duct (# of conductors) (AWG)	LF
655.0200 - 0299	Cable Traffic Signal (# of conductors) (AWG)	LF
655.0300 - 0399	Cable Type UF (# of conductors) (AWG)	LF
655.0400	Communication Cable Plowed	LF
655.0405	Communication Cable Trenched	LF
655.0410	Communication Cable Installed in Conduit	LF
655.0500 - 0599	Electrical Wire Traffic Signals (AWG)	LF
655.0600 - 0699	Electrical Wire Lighting (AWG)	LF
655.0700	Loop Detector Lead In Cable	LF
655.0800	Loop Detector Wire	LF
655.0900	Traffic Signal EVP Detector Cable	LF

(2) Payment for the Cable In Duct bid items is full compensation for providing all materials, including cables and duct; for excavating trenches; for placing cable in duct; for providing rigid steel conduit as needed; for backfilling; for restoring disturbed or damaged areas, including seeding and sodding; for making connections and testing installed cable system; and for disposing of surplus material.

(3) Payment for the Cable Traffic Signal bid items, is full compensation for providing cable; for making all connections; for providing all connectors, including wire nuts; and for testing the circuits. The department will pay for wiring from the signal head terminal strip to the mounting base under the Cable Traffic Signal bid items appropriate for the conductor number and wire size the plans show.

(4) Payment for the Cable Type UF bid items is full compensation for providing the cable; for making all connections; for providing all connectors, including wire nuts, splices, tape, insulating varnish, or sealant; and for testing the circuits.

(5) Payment for Communication Cable Plowed is full compensation for providing all materials including cable; for plowing in the cable; for making all connections; for testing the installed cable; for restoring damaged or disturbed areas, including seeding or sodding; and for disposing of surplus material.

(6) Payment for Communication Cable Trenched is full compensation for providing all materials including cable and backfill material; for constructing the trench, installing the cable in the trench, and backfilling; for making all connections; for testing the installed cable; for restoring disturbed or damaged areas, including seeding or sodding; and for disposal of surplus material.

(7) Payment for Communication Cable Installed in Conduit is full compensation for providing all materials including cable; for installing the cable in existing conduit; for making all connections; and for testing the installed cable.

(8) Payment for the Electrical Wire Traffic Signals bid items is full compensation for providing electrical wire; for making all connections; for providing all connectors, including wire nuts and lugs; and for testing the circuits.

(9) Payment for the Electrical Wire Lighting bid items is full compensation for providing electrical wire; for making all connections; for providing all connectors, including wire nuts, fuses, fuse holders, splices, tape, insulating varnish or sealant; and for testing the circuits. The department will pay for wiring from the underground feeder system to the luminaire under the Electrical Wire Lighting bid item appropriate for the wire size the plans show.

(10) Payment for Loop Detector Lead In Cable is full compensation for providing the lead-in cable; for making necessary cabinet connections; and for furnishing splice kits and splicing to the loop detector wire.

(11) Payment for Loop Detector Wire is full compensation for providing loop detector wire.

(12) Payment for Traffic Signal EVP Detector Cable is full compensation for providing emergency vehicle preemption detector cable for traffic signals.

(13) The department will not pay for replacing loop wire not attaining a reading of infinity to ground as required under 655.3.9.

(14) Pedestrian push button wiring is incidental to the Pedestrian Push Buttons bid item under section 658.