8-20 ILLUMINATION, TRAFFIC SIGNAL SYSTEMS, AND ELECTRICAL

8-20.1 Description

This Work consists of furnishing, installing and field testing all materials and equipment necessary to complete in place, fully functional system(s) of any or all of the following, types including modifications to an existing system all in accordance with approved methods, the Plans, the Special Provisions and these Specifications:

1. Traffic Signal System
2. Illumination System
3. Traffic Data Accumulation and Ramp Metering System

Unless otherwise noted, the location of signals, controllers, standards, and appurtenances shown in the Plans are approximate; and the exact location will be established by the Engineer in the field.

8-20.1(1) Regulations and Code

All electrical equipment shall conform to the standards of the National Electrical Manufacturers Association (NEMA), Electric Utility Service Equipment Requirements Committee (EUSERC), and California Department of Transportation document entitled Transportation Electrical Equipment Specifications (TEES). Traffic signal control equipment shall conform to the Contract and these Standard Specifications: EIA Electronic Industries Alliance, IEEE Institute of Electrical and Electronics Engineers, the American Society for Testing and Materials (ASTM), the American Association of State Highway and Transportation Officials (AASHTO), the American National Standards Institute (ANSI), whichever is applicable, and to other codes listed herein. In addition to the requirements of these Specifications, the Plans, and the Special Provisions, all material and Work shall conform to the requirements of the National Electrical Code, hereinafter referred to as the Code, and any WACs and local ordinances, which may apply.

Wherever reference is made in these Specifications or in the Special Provisions to the Code, the rules, or the standards mentioned above, the reference shall be construed to mean the code, rule, or standard that is in effect at the date of advertising of the project.

In accordance with RCW 39.06.010, the Contractor need not be registered or licensed if the Contractor has been prequalified as required by RCW 47.28.070.

Safe wiring labels normally required by the Department of Labor and Industries will not be required on electrical Work within the Rights-of-Way of Contracting Agency Highways as allowed in RCW 19.28.141.

Persons performing electrical Work shall be certified in accordance with RCW 19.28.161. Proof of certification shall be supplied to the Engineer prior to the performance of the Work.

8-20.1(2) Industry Codes and Standards

The following electrical industry codes and standard procedures are listed for reference purposes:

Air Movement and Control Association (AMCA), 30 West University Dr. Arlington Heights, Illinois 60004.

American Association of State Highway and Transportation Officials (AASHTO), 444 North Capitol Street N.W., Suite 225, Washington, D.C. 20001.

American National Standards Institute (ANSI), 70 East 45th Street, New York, New York.

American Society for Testing and Materials (ASTM), 1916 Race Street, Philadelphia, Pennsylvania.

American Wood Preservers' Association (AWPA), 836 Seventeenth Street, Washington, D.C.

Bell Company Research and Evaluation (Bellcore) 31220 La Baya DR Westlake Village CA 91362.

Edison Electric Institute (EEI), 420 Lexington Avenue, New York, New York.

Electronics Industries Alliance (EIA) 101 Pennsylvania Ave. Washington D. C.

Electric Utility Service Equipment Requirements Committee (EUSERC)

Federal Communications Commission (FCC) 445 12th SW Washington D C 20554.

International Municipal Signal Association (IMSA), P.O. Box 539, 1115 North Main Street, Newark, New York. 14513.

Institute of Electrical and Electronics Engineers (IEEE), 17th Floor, New York, NY 10016

International Telephony Communications Union (ITU) Place des Nations CH 1211 Geneva 20 Switzerland.

Institute of Transportation Engineers (ITE), 2029 K Street, Washington, D.C.20005.

Insulated Power Cable Engineers' Association (IPCEA), 283 Valley Road, Montclair, New Jersey.

National Electrical Manufacturers' Association (NEMA), 155 East 44th Street, New York, New York.

National Fire Protection Association - National Electrical Code (NEC), 470 Atlantic Avenue, Boston, Massachusetts.

National Television Standards Committee (NTSC) 445 12th SW Washington D.C. 20554.

National Transportation Communications for ITS Protocol (NTCIP).

Rural Utilities Service (RUS) 1400 Independence Ave. Washington D C.

Underwriters' Laboratories (UL), 207 East Ohio Street, Chicago, Illinois.

8-20.2 Materials

Materials shall meet the requirements of Section 9-29. Unless otherwise indicated in the Plans or specified in the Special Provisions, all materials shall be new.

Where existing systems are to be modified, the existing material shall be incorporated in the revised system, salvaged, or abandoned as specified in the Contract documents, or as ordered by the Engineer.

8-20.2(1) Equipment List and Drawings

Within twenty-days following execution of the Contract, the Contractor shall submit to the Engineer a completed "Request for Approval of Material" that describes the material proposed for use to fulfill the Plans and Specifications.

If required to do so, the Contractor shall submit supplemental data, sample articles, or both, of the material proposed for use. Supplemental data (6 copies required) would include such items as catalog cuts, product Specifications, shop drawings, wiring diagrams, etc. Any material purchased or labor performed prior to such approval shall be at the Contractor's risk. The Contractor must receive all approvals by the Engineer before materials will be allowed on the job site.

If the luminaries are not listed in the Qualified Products List, the Contractor shall submit 6 copies of the following information for each different type of luminaire required on the Contract:

1. Isocandela diagrams showing vertical light distribution, vertical control limits, and lateral light distribution classification.
2. Details showing the lamp socket positions with respect to lamp and refractor for each light distribution type. This requires that the State know what the light pattern available are and the light distribution.

The Contractor shall submit for approval 6 sets of shop drawings for each of the following types of standards called for on this project:

1. Light standards without pre-approved plans.
2. Signal standards with or without pre-approved plans.

The Contractor will not be required to submit shop drawings for approval for light standards conforming to the pre-approved plans listed in the Special Provisions.

The Engineer's approval of any submitted documentation shall in no way relieve the Contractor from compliance with the safety and performance requirements as specified herein.

Submittals required shall include but not be limited to the following:

1. A material staging plan, should the Contractor propose Contracting Agency-owned property for staging areas.
2. A cable vault installation plan showing the exact proposed installation location by Roadway station, offset and the scheduled sequence for each cable vault installation.
3. A pit plan, for each boring pit, which bears the seal and signature of a licensed professional engineer licensed under title 18 RCW, state of Washington, qualified in civil engineering. The pit plan shall depict the protection of traffic and pedestrians, pit dimensions, shoring, bracing, struts, walers, sheet piles, conduit skids and means of attachment, casing type and casing size.
4. The proposed boring plan which bears the seal and signature of a licensed professional engineer, licensed under title 18 RCW, state of Washington, qualified in civil engineering. The proposed boring plan shall depict the boring system and entire support system.

8-20.3 Construction Requirements

8-20.3(1) General

All workmanship shall be complete and in accordance with the latest accepted standards of the industry.

Existing electrical systems, traffic signal or illumination, or approved temporary replacements, shall be kept in effective operation during the progress of the Work, except when shutdown is permitted to allow for alterations or final removal of the system.

Illumination system shutdowns shall not interfere with the regular lighting schedule, unless permitted by the Engineer. The Contractor shall notify the Engineer prior to performing any Work on existing systems.

Work shall be so scheduled that each electrical system is operational prior to opening the corresponding section of Roadway to traffic.

Traffic signals shall not be placed in operation for use by the public until all required channelization, pavement markings, illumination, signs, and sign lights are substantially complete and operational unless otherwise allowed by the Project Engineer.

All costs incurred by the Contractor for providing effective operation of existing electrical systems shall be included in the associated electrical Bid items.

8-20.3(2) Excavating and Backfilling

The excavations required for the installation of conduit, foundations, poles and other-accessories shall be performed in a manner that prevents damage to the streets, sidewalks, and other improvements. The trenches shall not be excavated wider than necessary for the proper installation of the electrical accessories and foundations. Excavating shall not be performed until immediately before installation of conduit and other accessories. The material from the excavation shall be placed where the least interference to vehicular and pedestrian traffic, and to surface drainage, will occur.

All surplus excavated material shall be removed and disposed of by the Contractor in accordance with Section 2-03, or as ordered by the Engineer in accordance with Section 1-04.4.

The excavations shall be backfilled in conformance with the requirements of Section 2-09.3(1)E, Structure Excavation.

At the end of each day's Work and at all other times when construction operations are suspended, all equipment and other obstructions shall be removed from that portion of the Roadway open for use by public traffic.

Excavations in the street or Highway shall be performed in such a manner that not more than 1 traffic lane is restricted in either direction at any time unless otherwise approved by the Engineer.

8-20.3(3) Removing and Replacing Improvements

Improvements such as sidewalks, curbs, gutters, Portland cement concrete and hot mix asphalt pavement, bituminous surfacing, base material, and any other improvements removed, broken, or damaged by the Contractor, shall be replaced or reconstructed with the same kind of materials as found on the Work or with other materials satisfactory to the Engineer.

Whenever a part of a square, slab, or section of existing concrete sidewalk, curb, gutter or driveway is broken or damaged, the entire square, slab or section, curb, gutter, driveway shall be removed and the concrete reconstructed as specified above.

The outline of all areas to be removed in Portland cement concrete sidewalks and pavements and hot mix asphalt pavements shall be cut to a minimum depth of 3-inches with a saw prior to removing the sidewalk, driveway, slabs and pavement material. The cut for the remainder of the required depth may be made by a method satisfactory to the Engineer. Cuts shall be neat and true with no shatter outside the removal area.

8-20.3(4) Foundations

Foundation concrete shall conform to the requirements for the specified class, be cast-in-place concrete and be constructed in accordance with Section 6-02.2, and 6-02.3. Concrete for posts, standards, pedestals, and cabinets shall be constructed of concrete Class 3000. Concrete that will fall 5-feet or more shall be placed using an approved tremie, except that a tremie will not be required for placing concrete for a standard 3-foot diameter by 4.5-foot deep luminaire foundation. Steel reinforcing bars for foundations shall conform to Section 9-07.

The bottom of concrete foundations shall rest on firm ground. If the portion of the foundation beneath the existing ground line is formed or cased instead of being cast against the existing soil forming the sides of the excavation, then all gaps between the existing soil and the completed foundation shall be backfilled and compacted in accordance with Section 2-09.3(1)E.

Foundations shall be cast in 1 operation where practicable. The exposed portions shall be formed to present a neat appearance.

The top edges of the luminaire foundation, traffic signal standard foundations, electrical service foundations, traffic signal controller cabinets, Transformer cabinets, ITS Standards, and ITS cabinets shall have a ¾-inch chamfer on the top edge of the foundation. Where 1 or more of the above foundations directly abut each other, no chamfer shall be permitted.

The foundations shown in the Plans shall be extended if conditions require additional depth, and galvanized culvert pipe, of the correct size shall be installed for forming purposes where soil conditions are poor. Such additional Work, if ordered by the Engineer, will be paid for as extra Work as provided in Section 1-04.4.

When slip bases are installed the conduit, anchor bolts, and other obstructions shall terminate at a height below the elevation of the top of the bottom slip plate. The galvanized surfaces of the slip plates, the keeper plate and the luminaire base plate shall be smooth, without irregularities, to reduce friction and to prevent slacking of bolt tension due to flattening of the irregularities. Slip base luminaire foundations shall have a maximum conduit size of 1-inch.

Forms shall be true to line and grade. Tops of foundations for posts and standards, except special foundations, shall be finished to ground line or sidewalk grade, unless otherwise noted in the Plans.

Forms shall be rigid and securely braced in place. Conduit ends and anchor bolts shall be plumbed and rigidly placed in proper position and to proper height prior to placing concrete and shall be held in place by means of a template until the forms are removed.

Anchor bolts shall be installed so that 2 full threads extend above the top of the top heavy-hex nut, except that slip base anchor bolt extensions shall conform to the specified slip base clearance requirements. Anchor bolts shall be installed plumb, plus or minus 1-degree.

See Standard Specifications Section 8-20.3(9) for additional grounding requirements.

Plumbing of standards shall be accomplished by adjusting leveling nuts. Shims or other similar devices for plumbing or raking will not be permitted except on power installed hot dipped galvanized steel luminaire foundations.

The top heavy-hex nuts of light standards and signal standards shall be tightened in accordance with Section 6-03.3(33), and as follows:

1. The top heavy-hex nuts for all clamping bolts of slip base light standards and Type RM and FB signal standards, shall be tightened using a torque wrench to the torque specified in Sections 8-20.3(13)A and 8-20.3(14)E, respectively.
2. The top heavy-hex nuts for all anchor bolts shall be tightened by the Turn-Of-Nut Tightening Method to minimum rotation of ¼-turn and a maximum rotation of ⅓-turn past snug tight. Permanent marks shall be set on the base plate and nuts to indicate nut rotation past snug tight.

Both forms and ground which will be in contact with the concrete shall be thoroughly moistened before placing concrete; however, excess water in the foundation excavation will not be permitted. Foundations shall have set at least 72-hours prior to the removal of the forms. All forms shall be removed, except when the Plans or Special Provisions specifically allow or require the forms or casing to remain.

Class 2 surface finish shall be applied to exposed surfaces of concrete in accordance with the requirements of Section 6-02.3(14)B.

Where obstructions prevent construction of planned foundations, the Contractor shall construct an effective foundation satisfactory to the Engineer.

The combined height of the light standard concrete foundation plus the anchor bolt stub height shall not exceed 4-inches above the ground line.

8-20.3(5) Conduit

Installation of conduit shall conform to appropriate articles of the Code and these Specifications.

The size of conduit used shall be as shown in the Plans. Conduits smaller than 1-inch electrical trade size shall not be used unless otherwise specified, except that grounding conductors at service points may be enclosed in ½-inch diameter conduit.

It shall be the option of the Contractor, at no expense to the Contracting Agency, to use larger size conduit if desired, and where larger size conduit is used, it shall be for the entire length of the run from outlet to outlet. Reducing couplings will not be permitted.

The ends of all conduits, metallic and non-metallic shall be reamed to remove burrs and rough edges. Field cuts shall be made square and true. Slip joints or running threads will not be permitted for coupling metallic conduit; however, running threads will be permitted in traffic signal head spiders and RGS outerduct. When installing rigid galvanized steel conduit and standard coupling cannot be used, an approved 3-piece coupling shall be used. The threads on all conduit shall be rust-free, clean. All couplings shall be tightened so that a good electrical connection will be made throughout the entire length of the conduit run. If the conduit has been moved after assembly, it shall be given a final tightening from the ends prior to backfilling. Non-metallic conduit shall be assembled using the solvent cement specified in Section 9-29.1. Where the coating on galvanized conduit has been damaged in handling or installing, such damaged areas shall be thoroughly painted with galvanizing repair paint, Formula A-9-73. Conduit ends shall

be capped (do not glue non metallic caps). Metallic conduit ends shall be threaded and capped with standard threaded conduit caps until wiring is started. When conduit caps are removed, the threaded ends shall be provided with approved conduit bushings or end bells (do not glue in place) for nonmetallic conduit

Conduit stubs from controller cabinet foundations shall extend to the nearest junction box in that system.

Metallic conduit bends, shall have a radius consistent with the requirements of Article 344.24 and other articles of the Code. Where factory bends are not used, conduit shall be bent, using an approved conduit bending tool employing correctly sized dies, without crimping or flattening, using the longest radius practicable.

Nonmetallic conduit bends, where allowed, shall conform to Article 352.24 of the Code.

Conduit shall be laid so that the top of the conduit is a minimum depth of:

1. 24-inches below the Subgrade including asphalt or concrete Shoulder areas and asphalt or concrete sidewalk areas.
2. 48-inches below the bottom of ties under railroad tracks unless otherwise specified by the railroad company.
3. 18-inches below the finish grade in all other areas.

Galvanized steel conduit shall be installed at the following locations:

1. All open cut Roadway crossings.
2. All railroad crossings.
3. All runs installed at traffic signal installations unless nonmetallic is specified in the Contract.
4. All pole risers, except when as otherwise required by owning utilities.
5. All runs externally attached to Structures.
6. All runs installed in barrier that is constructed by slip forming.

Nonmetallic conduit may be employed as an alternate to metallic conduit at other locations unless specified otherwise in the Contract. Where nonmetallic conduit is installed, care shall be used in excavating, installing, and backfilling, so that no rocks, wood, or other foreign material will be left in a position to cause possible damage.

Metallic and nonmetallic conduit installation shall include equipment grounding conductor and shall conform to requirements noted in the Standard Plans.

Liquid tight flexible metal conduit is allowed only at locations called for in the Plans.

Aluminum conduit will be an alternate to galvanized steel conduit subject to the following:

1. The use of aluminum conduit shall be restricted to above ground locations.
2. Aluminum conduit shall not be placed in concrete.

Conduit shall be placed under existing pavement by approved directional boring, jacking or drilling methods, at locations approved by the Engineer. The pavement shall not be disturbed unless allowed in the Plans, or with the approval of the Engineer in the event obstructions or impenetrable soils are encountered.

Where boring with casing is called for the casing shall be placed using an auger inside of the casing to remove the soil as the casing is jacked forward. The auger head shall proceed no more than 4-inches ahead of the pipe being jacked. Boring operations

shall be conducted to prevent caving ahead of the pipe. Installed casing pipe shall be free from grease, dirt, rust, moisture and any other deleterious contaminants.

The space between the conduit and casing shall be plugged with sand bags and a grout seal 12-inches thick at each end of the casing. Casing abandoned due to an encountered obstruction shall be grout sealed in the same manner. Grout shall obtain a minimum of 4000-PSI compressive strength at 7-days.

In lieu of sand bags and grout, unopened of prepackaged concrete may be used to seal the casing.

Material shall not be removed from the boring pit by washing or sluicing.

All joints shall be welded by a Washington State certified welder. Welding shall conform to AWS D 1.1-80 Structural Welding Code, Section 3, Workmanship.

Directional boring for electrical installations shall be supervised by a licensed electrical contractor in accordance with Section 8-20.1(1). Where directional boring is called for, conduit shall be installed using a surface launched, steerable drilling tool. Drilling shall be accomplished using a high-pressure fluid jet toolhead. The drilling fluid shall be used to maintain the stability of the tunnel, reduce drag on the conduit and provide backfill between the conduit and tunnel. A guidance system that measures the depth, lateral position and roll shall be used to guide the toolhead when creating the pilot hole. Once the pilot hole is established a reamer and swivel shall be used to install the conduit. Reaming diameter shall not exceed 1.5 times the diameter of the conduit being installed. Conduit that is being pulled into the tunnel shall be installed in such a manner so the conduit is not damaged during installation. The pullback force on the conduit shall be controlled to prevent damage to the conduit. A vacuum spoils extraction system shall be used to remove any excess spoils generated during the installation. Excess drilling fluid and spoils shall be disposed of. The method and location used for disposal of excess drilling fluid and spoils shall be subject to the Engineers approval. Drilling fluid returns (caused by fracturing of formations) at locations other than the entry and exit points shall be minimized. Any drilling fluid that surfaces through fracturing shall be cleaned up immediately. Mobile spoils removal equipment capable of quickly removing spoils from entry or exit pits and areas with returns caused by fracturing shall be used as necessary during drilling operations.

Conduit installed using the directional boring method shall be UL listed High Density Polyethylene (HDPE) schedule 80 or rigid galvanized steel. The connection between HDPE conduit and conduit routed to associated junction boxes shall be made with an approved mechanical coupler.

Bore pits shall be backfilled and compacted in accordance with Section 2-09.3(1)E. Directional boring, and jacking or drilling pits shall be kept 2-feet from the edge of any type of pavement wherever possible. Excessive use of water that might undermine the pavement or soften the Subgrade will not be permitted.

When approved by the Engineer, small test holes may be cut in the pavement to locate obstructions. When the Contractor encounters obstructions or is unable to install conduit because of soil conditions, as determined by the Engineer, additional Work to place the conduit will be paid in accordance with Section 1-04.4.

When open trenching is allowed, trench construction shall conform to the following:

1. The pavement shall be sawcut a minimum of 3-inches deep. The cuts shall be parallel to each other and extend 2-feet beyond the edge of the trench.
2. Pavement shall be removed in an approved manner.

3. Trench depth shall provide 2-feet minimum cover over conduits.
4. Trench width shall be 4-inches or the conduit diameter plus 2-inches, whichever is larger.
5. Trenches located within paved Roadway areas shall be backfilled with Controlled density fill (CDF) meeting the requirements of Section 2-09.3(1)E. The controlled density fill shall be placed level to, and at the bottom of the existing pavement. The pavement shall be replaced with paving material that matches the existing pavement.

On new construction, conduit shall be placed prior to placement of base course pavement.

Conduit terminating in foundations shall extend a maximum of 2-inches above the foundation vertically including grounded end bushing or end bell.

Conduit entering through the bottom of a junction box shall be located near the end walls to leave the major portion of the box clear. At all outlets, conduit shall enter from the direction of the run, terminating 6 to 8-inches below the junction box lid and within 3-inches of the box wall nearest its entry location.

Galvanized rigid steel conduit entering cable vaults shall extend 2-inches for the installation of grounded end bushing and bonding. PVC conduit entering cable vaults and pull boxes shall terminate flush with the inside walls of the Structure. All conduit ends shall be terminated with termination kits.

When conduit or casing is to be placed under pavement it shall be placed prior to the placement of a surfacing, and pavement.

Innerduct conduit ends shall be terminated with termination kits. Galvanized rigid steel conduit ends shall be terminated with grounded end bushings. PVC conduit ends shall be terminated with bell ends.

Fittings shall be installed in accordance with the current electrical codes.

All covered underground conduit shall be cleaned with an approved sized mandrel and blown out with compressed air prior to pulling wire.

Conduits installed for future use shall be prepared as follows: After final assembly in place, the conduit shall be blown clean with compressed air. Then, in the presence of the Engineer, a cleaning mandrel correctly sized for each size of conduit shall be pulled through to ensure that the conduit has not been deformed. As soon as the mandrel has been pulled through, both ends of the conduit shall be sealed with conduit caps. All conduits scheduled for future use shall originate in a foundation or junction box as detailed in the Plans and terminate in a junction box. All equipment grounding conductors, and the bonding conductor for metallic conduits shall be bonded in all junction boxes in accordance with Standard Specification 8-20.3(9).

Where surface mounting of conduit is required, supports shall consist of stainless steel channel with stainless steel or galvanized 2-hole clamps sized for the conduit. Support spacing shall comply with the Code or shall be as noted in the Contract. Approved expansion fittings shall be installed at all expansion joints. Approved deflection fittings shall be installed at the joint between the bridge end and the retaining wall end and the transition point from the bridge attachment to the underground section. PVC conduit shall not be installed on concrete surfaces or on bridge under-decks.

Spacing of stainless steel channel supports for conduit shall not exceed 5-feet. Conduit clamps shall attach to the supports on both sides of the conduit with bolts and

associated hardware. The minimum distance between adjacent clamps and between the clamp and the end of the supports shall be 1-inch. Channel supports shall be installed with stops, to prevent clamps from sliding out of the ends. Channel installations shall provide for future conduit installation. Channel shall be at least 1-foot longer than required.

Existing conduit in place scheduled to receive new conductors shall have any existing conductors removed and a cleaning mandrel sized for the conduit shall be pulled through.

Conduit runs shown in the Plans are for Bidding purposes only and may be changed, with approval of the Engineer, to avoid obstructions.

Conduit with innerduct shall be installed as shown in the Plans encased in controlled density fill. A maximum of 1000-feet of continuous open trench will be allowed, unless otherwise approved by the Engineer. All conduit with innerduct exposed above grade level, or on any elevated Structures, or as noted in the Plans shall be galvanized rigid steel conduit.

Innerduct warning tape shall be placed above all innerduct installed in trenches. The warning tape shall be polyethylene with a metallic backing. The polyethylene shall have a minimum 4 mils thicknesses and be 3-inches wide. The polyethylene shall be orange in color and printed in black with the words conveying message of Fiber Optic Cable Buried Below.

Location 14 AWG stranded orange USE insulated wire shall be placed directly above all innerduct installed in trenches. Splices shall be crimped using a non- insulated butt splice, soldered and covered with moisture blocking heat shrink.

After final assembly in place, all innerducts shall be blown clean with compressed air. Then, in the presence of the Engineer, a cleaning mandrel, correctly sized for the innerduct, shall be pulled through to ensure that the conduit has not been deformed. As soon as the mandrel has been pulled through, a 200-lb. minimum tensile strength pull string shall be installed in each innerduct and attached to duct plugs at both ends of the innerduct.

At all innerduct conduit terminus points, including those in cable vaults and pull boxes, removable and reusable mechanical plugs shall be employed as follows:

Outerduct conduits shall be plugged using a quadplex expansion plug inside the conduit around the innerduct. Duct plugs shall be installed in all unused innerducts (those that are specified as empty) at the time of conduit installation. Duct plugs shall be installed in all used innerducts (as specified in the Plans) at the time of conduit installation, unless cable pulling for those innerducts will commence within 48-hours.

Innerduct containing 1 cable shall be plugged using an expandable split plug. Innerducts with multiple cables shall be sealed with self-expanding waterproof foam. The waterproof foam shall not be placed more than 2-inches into the innerduct.

8-20.3(6) Junction Boxes ,Cable Vaults, and Pull boxes

Standard junction boxes, pull boxes and cable vaults shall be installed at the locations shown in the Plans. The Contractor may install, at no expense to the Contracting Agency, such additional boxes as may be desired to facilitate the Work. Junction box installation shall conform to details in the Standard Plans.

Cable vaults and pull boxes shall be installed accordance with the following:

1. Excavation shall be performed in accordance with Section 2-09.

2. Cable vaults and pull boxes shall be installed on 6-inches of crushed surfacing top course, per Section 9-03.9(3), placed on a compacted or undisturbed level foundation.
3. All openings around conduits shall be sealed and filled with grout in accordance with Section 6-02.3(20), to prevent water and debris from entering the vaults or pull boxes.
4. Backfilling around the Work shall not be allowed until the concrete or mortar has set.
5. Pull boxes shall be installed in accordance with Plans and details.
6. Pull boxes shall be configured such that the tensile and bending limitations of the fiber optic and other cables are not compromised. Pull boxes shall be configured to mechanically protect the fiber optic and other cables against installation force as well as inert forces after cable pulling operations.
7. Upon acceptance of Work, cable vaults, and pull boxes shall be free of debris and ready for cable installation. All grounding requirements shall be met prior to cable installation.
8. Where installed near steel casings, the pull boxes and cable vaults shall be offset 3-feet, minimum from the centerline of the casing. Factory bends shall be used to route the conduits to the cable vault or pull box.

Adjustments involving raising or lowering the junction boxes shall require conduit modification if the resultant clearance between the top of the conduit and the junction box lid becomes less than 6-inches or more than 8-inches in accordance with the Plans.

Cable vaults and pull boxes shall be adjusted to final grade using risers or rings manufactured by the cable vault and pull box manufacturer. Cable vaults and pull boxes with traffic bearing lids shall be raised to final grade using ring risers to raise the cover only. All voids resulting from the adjustment shall be backfilled with materials matching adjacent surfacing material and compacted in accordance with Section 2-09.3(1)E.

Damage to the junction boxes, pull boxes, cable vaults and the associated conduit system, or wiring resulting from the Contractor's operations, shall be repaired to the Engineer's satisfaction at no additional cost to the Contracting Agency.

Both existing and new junction boxes, pull boxes, and cable vaults shall be adjusted to be flush with the finished grade as well as with the grade during the various construction stages proposed in the Contract.

Where conduit and junction boxes are placed in barrier, the Prime Contractor shall coordinate the Work of the Contractor constructing the barrier and the electrical Contractor so that each junction box placed in the barrier is placed in correct alignment with respect to the barrier, with the face of the box flush or uniformly chamfered within ½-inch of the barrier surface. If any point on the surface of the junction box placed in barrier is recessed more than ½-inch from the surface of the barrier, the Contractor shall install a box extension meeting the Engineer's approval and grout around the extension or remove and replace the entire section of barrier.

8-20.3(7) Messenger Cable, Fittings

Messenger cable shall be secured to steel strain poles by means of pole bands, and to timber poles by means of single strand guy eye bolts. Pole bands and eyebolts shall be installed as detailed in the Plans.

Messenger cable shall be secured to eye bolts or strain clamps at poles by the use of approved self-locking cable clamp type dead-ending devices. Messenger cable shall be secured to bull rings and anchors by 2 approved U-bolt connectors and guy thimbles.

Traffic signal control cable shall be secured to the messenger cable by cable ties. The ties shall be black nylon with ultraviolet protection and rated at 120-pound minimum unlocking strength.

Down guy assemblies shall be installed as detailed in the Standard Plans.

8-20.3(8) Wiring

All underground wiring shall be installed in conduit unless specifically noted otherwise in the Contract. All wiring in conduit shall be installed with a lubricant recommended by cable/conductor manufacturer.

With the exception of induction loop circuits, magnetometer circuits and illumination circuits, all wiring shall run continuously, without splices, from a terminal located in a cabinet, compartment, pedestrian push button assembly, or signal head to a similarly located terminal. Illumination circuit terminals and traffic circuit signal terminals located below grade will not be allowed. Video detection systems cable installation shall follow manufacturer's Specification, except no below grade terminals will be allowed.

All splices in underground illumination circuits, induction loops circuits, and magnetometer circuits shall be installed in junction boxes. The only splice allowed in induction loop circuits and magnetometer circuits shall be the splice connecting the induction loop lead in conductors or magnetometer lead in conductors to the shielded lead in cable. Splices for induction loop circuits and magnetometer circuits shall be: heat shrink type with moisture blocking, material sized for conductors, epoxy filled clear rigid mold splice kits or rigid re-enterable type splice kits. Conductors for rigid mold kits shall be centered in the splice mold prior to installation of the encapsulation material. Magnetometer and induction loop splices shall be soldered. All connections with #10 and smaller wire shall use copper crimped connectors installed with a positive action (ratchet) tool, except where setscrew connections are allowed for quick disconnects as described in Section 9-29.7. The non-insulated die shall be an indent type and insulated die shall be of a smooth shape capable of crimping pre-insulated terminals and connectors. The tool shall be compound lever type with a ratchet mechanism to ensure positive closure for full crimping cycle. The tool shall be field adjustable to proper calibration with common tools and materials. All connectors installed in splices shall be wrapped with 2 layers of electrical tape. All epoxy splice kits shall be physically separated from other splices and wiring within the junction box to avoid damage from heat during the casting process.

Aerial illumination splices shall employ vice or crimp type pressure connectors. Splice insulation may be epoxy, heat shrink, or tape. Tape splice insulation, where allowed, shall consist of thermoplastic electrical insulating tape equivalent to the original wire insulation rating. It shall be well lapped over the original insulation, and there shall be a coating of moisture resistant varnish applied and allowed to dry. Two layers of friction tape will then be applied, and the splice shall be finished with a second complete coating of moisture resistant varnish.

Quick disconnect connectors, fused or unfused as required, shall be installed at all poles supporting a luminaire. Installation shall conform to details in the Standard Plans.

Pole and bracket cable shall be installed between the disconnects and the luminaire.

Sufficient slack wire shall be installed at each junction box to allow any conductor, cable, or splice within the junction box to be raised a minimum of 18-inches outside of the box.

Insulated neutral conductors shall be identified in accordance with the NEC requirements. Every conductor at every wire termination, connector, or device shall have an approved, (9-29.13(7)B & C) wire marking sleeve bearing as its legend, the circuit number indicated in the Contract. All terminal strips shall also bear the circuit number consistent with the Contract.

At all illumination circuit splices, each wire entering the splice shall have an approved wire marking sleeve bearing as its legend the circuit number indicated in the Contract.

All wiring, exclusive of the previously mentioned illumination circuits, at junction boxes and at the controller cabinet shall have an approved tag with legends as follows:

1. Individual conductors — the circuit number indicated in the Contract.
2. Multiconductor cable — the numbers of the signal heads and/or pedestrian push buttons served.
3. Loop lead-in cable — the numbers of the loops served.
4. Magnetometer cable — the numbers of the magnetometers served.
5. Camera lead-in cable — The numbers of the phases the camera served.

Drip loops shall be provided on all aerial conductors where they enter poles, signal heads, or weather heads.

When conductors, either cable or single, are being installed, care shall be exercised to not exceed tension limitations recommended by the manufacturer. Conductors may be pulled directly by hand. However, if conductors are pulled by any mechanical means, a dynamometer with drop-needle hand shall be used on every mechanical pull.

On mechanical pulls, insulation shall be stripped off the individual conductor and the conductor formed into a pulling eye and firmly taped, or a cable grip shall be used. The maximum pulling force applied directly to the conductor; i.e., when pulling eyes are used or when the conductor is formed into a loop, shall be limited to that shown in the following table for copper conductor. When a cable grip is applied over nonmetallic sheathed cables, the maximum pulling force shall be limited to 1,000-pounds provided this is not in excess of the force as calculated above.

Conductor	Pounds
8	132
6	210
4	334
3	421
2	531
1	669
1/0	845
2/0	1,065
3/0	1,342
4/0	1,693

To limit the sidewall pressure at bends in duct and conduit runs, the pulling force in pounds shall not exceed 100 times the radius of the bend in feet. Adequate lubrication of the proper type to reduce friction in conduit and duct pulls shall be utilized as necessary. The grease and oil-type lubricants used on lead sheathed cables shall not be used on nonmetallic sheathed cables.

When wiring is noted for future connection, the ends of each wire or cable shall be sealed with an approved heat shrink end cap.

If loop lead splices are not installed immediately after the installation of the loop leads into the adjacent junction box, the ends of the 2 conductor "home run" cable shall be sealed with heat shrink end caps to prevent entry of moisture into the 2 conductor cable. All coaxial cables shall have heat shrink end caps installed prior to aerial or underground installation of the cables to prevent moisture entry into the cable.

Multiconductor cable for signal displays shall be installed entirely through the mounting fitting to a point a minimum of 1-inch inside the signal display housing before the outer insulation is stripped back for the connection of individual conductors to the terminal block.

8-20.3(9) Bonding, Grounding

All metallic appurtenances containing electrical conductors (luminaires, light standards, cabinets, metallic conduit, etc.) shall be made mechanically and electrically secure to form continuous systems that shall be effectively grounded.

Where conduit is installed, the installation shall include an equipment ground conductor, in addition to the conductors noted in the Contract. Bonding jumpers and equipment grounding conductors shall be installed in accordance with Section 9-29.3 and NEC. Where existing conduits are used for the installation of new circuits, an equipment grounding conductor shall be installed unless an existing equipment ground conductor, which is appropriate for the largest circuit, is already present in the existing raceway. The equipment ground conductor between the isolation switch and the sign lighter fixtures shall be a minimum of a 14 AWG stranded copper conductor. Where parallel circuits are enclosed in a common conduit, the equipment-grounding conductor shall be sized by the largest overcurrent device serving any circuit contained within the conduit.

Junction boxes with metallic lids shall have one 4-foot long tinned braided copper equipment bonding strap with full circle connector lugs installed from each metallic junction box lid(s) to the junction box frame. A non-insulated 8 AWG minimum stranded copper conductor, with a full circle crimp on connector (crimped with a manufacturer recommended crimper) shall be connected to the junction box frame or frame bonding stud, the other end shall be crimped to the equipment bonding conductor, using a "C" type crimp connector. The equipment ground conductor shall not be cut or spliced except at junction boxes.

Supplemental grounding shall be provided at light standards, signal standards, cantilever and sign bridge Structures. Steel sign posts which support signs with sign lighting or flashing beacons shall also have supplemental grounding. The supplemental ground conductor shall be connected to the foundation rebar (all rebar crossings shall be wire tied) by means of a grounding connector listed for use in concrete, and lead up directly adjacent to a conduit installed within the foundation. The free end of the conductor shall be terminated to the ground terminal, with an approved clamp, within the pole. If no ground terminal is provided, bond to standard or post. Three-feet of slack shall be provided inside the standard. Where a concrete and rebar foundation is

not used the supplemental ground shall be a grounding electrode placed in the hole next to the post prior to back fill. For light standards, signal standards, cantilever and sign bridge Structures the supplemental grounding conductor shall be a non-insulated 4 AWG stranded copper conductor. For steel sign posts which support signs with sign lighting or flashing beacons the supplemental grounding conductor shall be a non-insulated 6 AWG stranded copper conductor.

All connectors between bonding jumpers and equipment grounding conductors shall be installed in accordance with the NEC. Identification of the equipment grounding conductor shall conform to all code requirements.

Bonding of the equipment grounding system and neutral at the service point shall be accomplished as required under the NEC. Grounding of the neutral shall be accomplished only at the service or at a separately derived system.

Two service grounds shall be installed at each electrical service installation and at each separately derived power source. Each service ground shall conform to the detail in the Standard Plans for "Service Ground." If soil conditions make vertical ground rod installation impossible see NEC as an alternate installation procedure. The service ground installations shall be located a minimum of 6-feet apart. The first service ground rod shall be connected to a continuous grounding electrode conductor running to the service neutral bus. The second service ground rod shall be connected to the same continuous grounding electrode conductor connected to the first ground rod. Ground electrodes shall be bonded copper, ferrous core materials and shall be solid rods not less than 10-feet in length if they are ½-inch in diameter or not less than 8-feet in length if they are ⅝-inch or larger in diameter.

The connection of the grounding electrode conductor to the grounding electrode shall be made with 2 approved ground clamps.

Messenger cable shall be bonded to steel strain poles by means of a bond strap connected between an approved U-bolt connector and a bonding lug on the pole.

At points where shields or shielded conductors are grounded, the shields shall be neatly wired and terminated on grounding terminal strip.

8-20.3(10) Services transformer, Intelligent Transportation System Cabinet

Power sources shown in the Plans are approximate only; exact location will be determined in the field.

Aerial fed transformer cabinets and type A, type B, or type C service cabinets shall include a timber pole, as specified in Section 9-29.6(3), a meter base, installed in accordance with serving utility requirements, a 2 or 3 wire service breaker of size noted in the Plans, the necessary conduit risers and ground assembly as noted in the Standard Plan. The timber pole shall be set at a depth of 10-percent of the total pole length plus 2-feet. Modified type B, type D and type E services shall be installed per Contract Plan, and service description in Standard Plans. Pad mounted transformer cabinets shall be installed per Contract Plans.

The service breaker shall be a standard thermal circuit breaker encased in a raintight housing that can be padlocked.

Upon request of the Contractor, the Engineer will make the necessary arrangements with the serving utility to complete the service connections. Electrical energy used prior to Completion of the Contract will be charged to the Contractor, except that the cost of

energy used for public benefit, when the Engineer orders such operation, will be borne by the Contracting Agency.

The service, transformer and ITS cabinets shall be marked with the service agreement letters and numbers as noted in the Plans. The markings shall be installed on the outside cabinet door near the top of the cabinet. The markings shall be series C using stencils and black enamel alkyd gloss paint conforming to Federal Specification TT-E-489F.

8-20.3(11) Testing

The Contractor shall conduct the following tests on all electrical circuits with nominal operating voltage between 115-volts and 600-volts, in the presence of the Engineer:

1. Test the continuity of each circuit.
2. Test for grounds in each circuit, which shall consist of the physical examination of the installation to ensure that all required ground jumpers, devices, and appurtenances do exist and are mechanically firm.
3. Using a megohm meter, a 500-volt test on each new circuit between the conductor and ground with all switch boards, panel boards, fuse holders, switches, receptacles, and overcurrent devices in place. All readings shall be recorded. The Contractor shall furnish the Engineer with 3 copies of the test results identifying observed readings with their respective circuits.

   The insulation resistance shall not be less than 50-megohms between the conductor and ground on new circuits with a total single conductor length of 2,500-feet and over, nor less than 50 megohms on new circuits with single conductor length of less than 2,500-feet.

   Any change in the above stated minimum readings must be approved in writing by the Engineer. Only those factors based on dialectric properties of conductor insulations, splicing insulations, terminal strip castings, etc., will be cause for consideration of a variance.
4. A functional test in which it is demonstrated that each and every part of the system functions as specified.

For those new circuits below 115-volts nominal, except induction loop circuits and test direct burial circuits, the circuits shall be tested with a 500-volt megger for continuity, ground, and a test to demonstrate the circuit functions as specified. The megger test shall show an insulation resistance of not less than 8-megohms to ground.

Any fault in any material or in any part of the installation revealed by these tests shall be replaced or repaired by the Contractor in a manner approved by the Engineer, and the same test shall be repeated until no fault appears.

When the project includes a traffic signal system, the Contractor shall conduct tests noted in Section 8-20.3(14)D. The Contractor shall provide the Engineer a minimum of 5-days advance written notice of the proposed traffic signal turn-on date and time. The traffic signal turn-on procedure shall not begin until all required channelization, pavement markings, illumination, signs, and sign lights are substantially complete and operational unless otherwise allowed by the Engineer. The Contractor shall provide traffic control to stop all traffic from entering the intersection. The Contracting Agency electronics technician will program the controller and enter the timing data, then turn the traffic signal system to its flash mode to verify proper flash indications. The Contracting

Agency electronics technician will then conduct functional tests to demonstrate that each part of the traffic signal system, illumination system, or other electrical system, functions as specified. These demonstrations shall be conducted in the presence of a Contracting Agency electronic technician, the Contracting Agency electrical Inspector, and Regional Traffic Engineer or his/her designee. The Contracting Agency electronics technician will then turn the traffic signal to stop and go operation for no less than 1 full cycle. Based on the results of the turn-on, the Engineer will direct the Contracting Agency electronics technician to either turn the traffic signal on to normal stop and go operation, to turn the signal to flash mode for a period not to exceed 5-calendar days, or to turn the signal off and require the Contractor to cover all signal displays and correct all deficiencies.

If the Contractor is directed to turn off the traffic signal, the Contractor shall schedule a new turn-on date with the Engineer in accordance with the previously mentioned procedures.

Unless approved by the Engineer no change to signal stop and go operation will be allowed between 6 AM to 10 AM and 2 PM to 7 PM on Monday through Thursday, nor will signal operation changes be allowed on Friday, weekends, holidays, or the day preceding a holiday.

8-20.3(12) Painting

All painting required shall be done in conformance with applicable portions of Section 6-07.

8-20.3(13) Illumination Systems

8-20.3(13)A Light Standards

Light standards shall be handled when loading, unloading, and erecting in such a manner that they will not be damaged. Any parts that are damaged due to the Contractor's operations shall be repaired or replaced at the Contractor's expense.

Light standards shall not be erected on concrete foundations until foundations have set at least 72-hours or attained a compressive strength of 2,400-PSI, and shall be raked sufficiently to be plumb after all load has been placed.

Slip base installation shall conform to the following:

1. The slip plane shall be free of obstructions such as protruding conduit or anchor bolts. The anchor bolts, and other obstructions shall terminate at a height below the elevation of the top of the slip plate. Conduit shall extend a maximum of 2-inches above the top of the foundation, including grounding end bushing.
2. Washers in the slip plane shall be placed between the slip plate and the keeper plate.
3. Anchor bolts shall extend through the top heavy-hex nut 2 full threads to the extent possible while conforming to the specified slip base clearance requirements. Anchor bolts shall be tightened by the Turn-Of-Nut Tightening Method in accordance with Sections 6-03.3(33) and 8-20.3(4).
4. Clamping bolts shall be tightened in accordance with Sections 6-03.3(33) and 8-20.3(4). The clamping bolts shall be tightened to the specified torque, plus or minus 2-percent, in 2 stages using an accurately calibrated torque wrench before erecting the light standard. Except as otherwise specified, the Contractor

shall install 1-inch diameter clamping bolts in all slip bases to a torque of 95-foot-pounds.

5. The galvanized surfaces of the slip plates, the keeper plate and the luminaire base plate shall be smooth, without irregularities, to reduce friction and to prevent slackening of bolt tension due to flattening of the irregularities.
6. Anchor bolts damaged after the foundation concrete is placed shall not be repaired by bending or welding. The Contractor's repair procedure is to be submitted to the Engineer for approval prior to making any repairs. The procedure is to include removing the damaged portion of the anchor bolt, cutting threads on the undamaged portion to remain, the installation of an approved threaded sleeve nut and stud, and repairing the foundation with epoxy concrete. Epoxy concrete shall meet the requirements of Section 9-26.3(1)B.
7. The grout pad shall not extend above the elevation of the bottom of the anchor plate.
8. Wiring for slip base installation shall conform to details in the Standard Plans.

Breakaway coupling installation shall conform to the following:

1. At existing foundations, the anchor nuts, pole, grout pad, and leveling nuts shall be removed. Conduits shall be cut to a maximum height of 2-inches above the foundation including grounding end bushing or bell end. Galvanizing repair paint, conforming to Formula A-9-73 in Section 9-08.2, shall be applied to the cut conduit that has been threaded. Anchor bolts that are damaged shall be repaired with approved sleeve nuts as noted under slip base installation procedures.
2. All existing anchor bolts shall be cut off 2½ to 3-inches above the foundation. At new foundations, the anchor bolts shall be installed with top of bolt 2½ to 3-inches above the foundation.
3. Couplings shall be installed to within ⅛ to ⅜-inch of the foundation. Couplings shall then be leveled.
4. The pole shall be set and plumbed; and washers, nuts, and skirt installed per manufacturer's recommendations.
5. The conduit installed in a luminaire foundation shall not exceed 1-inch, trade size.

Slip base insert installations shall conform to details in the Standard Plans, and shall conform to items 1 through 8 above for slip base installation, except that the specified torque for the ⅞-inch diameter clamping bolts shall be 50-foot-pounds.

Prior to installation all relocated metal light standards shall have existing painted identification markings removed. Manufactures Identification tag shall not be removed. Damaged surfaces and coatings shall be repaired with material matching the existing coating.

All new light standards shall have an approved metal tag riveted to the pole above the handhole. The information provided on the tag shall be as noted on the pre-approved drawings.

All new and relocated metal light standards shall be numbered for identification using painted series C numbers installed 3-feet above the base facing the Traveled Way. Paint shall be black enamel alkyd gloss conforming to Federal Specification TT-E-489. The following information shall be provided as shown in the Plans:

1. Luminaire number.
2. Luminaire wattage.
3. Luminaire voltage.
4. Service number

In setting timber poles, the Contractor shall provide a minimum burial of 10-percent of the total pole length plus 2-feet and shall rake the poles as shown in the Plans.

8-20.3(13)B Vacant

8-20.3(13)C Luminaires

The Contractor shall mark the installation date on the inside of the luminaire ballast housing using a permanent marking pen.

All luminaires shall be mounted level, both transverse and longitudinally, as measured across points specified by the manufacturer. Leveling and orientation shall be accomplished after pole plumbing.

8-20.3(13)D Sign Lighting

Where indicated in the Plans, the Contractor shall furnish and install external sign illumination equipment. Sign illumination equipment shall include fixtures, brackets, conduit, electrical wire, and other material required to make the sign lighting system operable. Sign illumination fixtures shall be fused and circuit breakers installed per the table in Section 9-29.7. The Contractor shall intercept electrical conductors and make approved conductor splices at the nearest junction box or other source of power as noted in the Plans.

8-20.3(13)E Sign Lighting Luminaires

Sign lighting luminaires shall meet the requirements of Section 9-29.10.

The sign lighting luminaire shall be supported by a lighting bracket assembly as detailed in the Plans. If the sign Structure includes a maintenance walkway, the luminaire fixture mounting plate shall be bolted to the walkway grating.

An isolation switch shall be provided in the line side conductors, mounted over the Shoulder to de-energize all luminaires for maintenance purposes. The switch shall be single pole, single throw, or double-pole, single throw as necessary to open all conductors to the luminaires other than neutral and ground conductors. The switch shall contain 600-volt terminal strips on the load side with solderless box lugs as required plus 4 spare lugs per strip. The switch enclosure shall be rated NEMA 3R.

8-20.3(14) Signal Systems

8-20.3(14)A Signal Controllers

All control cabinets and control equipment shall be factory wired ready for operation. Field work will be limited to placing cabinets and equipment and connecting the field wiring to field terminal strips. All controller cabinets shall be installed on a silicone seal pad.

Controllers for portable traffic signal systems shall conform to the requirements of Section 9-29.13(7).

8-20.3(14)B Signal Heads

Unless ordered otherwise by the Engineer, signal heads shall not be installed at any intersection until all other signal equipment is installed and the controller is in place, inspected, and ready for operation at that intersection, except that the signal heads may be mounted if the faces are covered to clearly indicate the signal is not in operation.

Three section displays mounted on type M mounts shall have the plumbizer between the top and second display. Four and 5 section vertical displays mounted on type M mounts shall have the plumbizer between the second and third display.

8-20.3(14)C Induction Loop Vehicle Detectors

Induction loops shall be constructed as detailed in the Contract and the following:

1. Loop wire shall conform to Section 9-29.3.
2. When Type 2 or 6' round (R) loops are grouped at the stop line, the front edge of the first loop shall be 1-foot behind the stop line. Each additional loop installed in the lane shall be on 15-foot centers.
3. Lead-in cable shall conform to Section 9-29.3.
4. All loops shall be installed after grinding or prior to paving the final lift of asphalt designated in the Contract. Loop conductors shall be held at the bottom of the saw cut by high temperature backer rod (sized to fit snugly in the saw cut). Two-inch long pieces of the backer rod shall be installed on 24-inch centers along the entire loop and home run(s) and at the entrance and exit of all turns greater than 45-degrees. If new loops are installed over existing the old loops shall be removed by grinding and the grinding shall be deep enough to destroy any existing operational loop conductors. If not listed as incidental to another item or paid for under another Bid item the additional Work to remove the existing loops shall be paid in accordance with Section 1-04.4.
5. Each loop shall be the size and number of turns indicated in the Plans.
6. No loop installation will be done in rainy weather or when the pavement is wet.
7. All sawcuts shall be cleaned with a high-pressure washer and dried with 100-PSI minimum air pressure, to the satisfaction of the Engineer. If traffic is allowed over the sawcut prior to wire installation, the sawcuts shall be cleaned again.
8. Wiring shall be installed with a blunt-nosed wooden wedge.
9. Prior to the installation of the high temperature backer rod all slack shall be removed from the wiring. Kinks in wiring or folding back of excess wiring will not be allowed.
10. High temperature backer rod, sized for snug fit shall be installed in the saw cut on 2-foot' centers and at all sharp turns.
11. Install sealant as per Contract or as approved by the Engineer.
12. Sealant shall be applied such that air bubbles or foam will not be trapped in the sawcut.

8-20.3(14)D Test for Induction Loops and Lead-in Cable

All tests shall be performed by the Contractor in the presence of the Engineer for each loop. The tests shall be performed at the amplifier location after complete installation of the loop. All costs associated with testing shall be included in the unit Contract prices of the respective Bid items.

Test A — The DC resistance between the 2 lead-in cable wires will be measured by a volt ohmmeter. The resistance shall not exceed 10-ohms.

Test B — A megohm meter test at 500-volts DC shall be made between the lead-in cable shield and grounding, prior to connection to grounding. The resistance shall equal or exceed 100-megohms.

Test C — A megger test shall be made between the loop circuit and grounding. The resistance shall equal or exceed 100-megohms.

Test D — An inductance test to determine the inductance level of each inductance loop. The Contractor shall record the inductance level of each inductance loop installed on the project and shall furnish the findings to the Engineer. An inductance level below 150-microhenries is considered a failure for a Type 1 loop, any 1 round loop and an inductance level below 75-microhenries is considered a failure for a Type 2 loop.

If any of the installations fails to pass all tests, the loop installation or lead-in cable shall be repaired and replaced and then retested.

8-20.3(14)E Signal Standards

Traffic signal standards shall be furnished and installed in accordance with the methods and materials noted in the Contract and the following:

1. All dimensions and orientations will be field verified by the Engineer prior to fabrication.
2. The signal standard component identification shall conform to details in the Plans.
3. Disconnect connectors complete with pole and bracket cable shall be installed in any signal standard supporting a luminaire. Illumination wiring installation shall conform to details in the Plans for slip base wiring.
4. No field drilling will be allowed on signal mast arms except for the installation of any required pre-empt indicators , pre-empt detectors, microwave detector, or type “N” signal mountings. The maximum diameter shall be 1-inch.
5. All pole entrances required for pole-mounted signal heads, cabinets, signs, pedestrian push button assemblies, etc., shall be field drilled.
6. Damage to the galvanized pole surface resulting from field drilling shall be repaired with approved zinc rich paint.
7. Field welding will not be allowed, except as shown in the Plans.
8. All tenons shall be factory installed.
9. All welding shall be completed prior to galvanizing.
10. Foundations shall be constructed to provide the pole orientation noted in the Plans. Anchor bolts shall be tightened in accordance with Sections 6-03.3(33) and 8-20.3(4).
11. Slip base installation for Type RM and FB signal standards shall conform to the slip base installation requirements specified in Section 8-20.3(13)A, except that the specified torque for the ¾-inch diameter clamping bolts shall be 50 foot-pounds.
12. The pole shall be plumbed after signal heads are installed.
13. The space between the bottom base plate and the top of foundation shall be filled with grout with a ⅜-inch plastic drain tube.

Signal standards shall not be erected on concrete foundations until the foundations have attained 2400-PSI or 14-days after concrete placement. Signal standards without mast arms may be erected after 72-hours. Type IV and V strain pole standards may be erected but the messenger cable (span wire) shall not be placed until the foundation has attained 2400-PSI or 14-days after concrete placement.

Signal supports used with portable traffic signal systems shall provide a minimum of 2 signal displays, spaced a minimum of 8-feet apart.

When portable traffic signals are used to provide alternating one-way control, a minimum of 1 of the signal displays shall be suspended over the Traveled Way. The minimum vertical clearance to the Traveled Way for this signal display is 16-feet 6-inches.

Timber strain poles shall be set a burial depth of 10-percent of the total length plus 2-feet and shall be raked as noted in the Plans.

8-20.3(15) Grout

Grout shall conform to the requirements of Section 6-02.3(20).

8-20.3(16) Reinstalling Salvaged Material

When the Contract requires salvaged electrical equipment to be reinstalled, the Contractor shall furnish and install all necessary materials and equipment, including anchor bolts, nuts, washers, concrete, etc., required to install the salvaged equipment.

8-20.3(17) "As Built" Plans

Upon Physical Completion of the Work, the Contractor shall submit corrected shop drawings, schematic circuit diagrams, or other drawings necessary for the Engineer to prepare corrected Plans to show the Work as constructed.

These drawings shall be on sheets conforming in size to the provisions of Section 1-05.3.

8-20.4 Measurement

When shown as lump sum in the Plans or in the Proposal as illumination, traffic data accumulation and ramp metering, or traffic signal system no specific unit of measurement will apply, but measurement will be for the sum total of all items for a complete system to be furnished and installed.

Conduit of the kind and diameter specified will be measured by the linear foot for the actual neat line length in place, unless the conduit is included in an illumination system, signal system, Intelligent Transportation (ITS) or other type of electrical system lump sum Bid item.

Casing – will be measured by the linear foot for the actual length of casing placed, unless the casing is included in an illumination, signal or other electrical system lump sum Bid item.

Directional boring will be measured by the linear foot for the length of the boring tunnel.

8-20.5 Payment

Payment will be made in accordance with Section 1-04.1, for each of the following Bid items that are included in the Proposal:

"Illumination System ____", lump sum.

"Traffic Signal System ____", lump sum.

"Traffic Data Accumulation and Ramp Metering System____", lump sum.

The lump sum Contract price for "Illumination System, ____", "Traffic Signal ____", "Traffic Data Accumulation and Ramp Metering System_____", shall be full pay for the construction of the complete electrical system, modifying existing systems, or both, including sign lighting systems, as described above as shown in the Plans and herein specified including excavation, backfilling, concrete foundations, conduit, wiring, restoring facilities destroyed or damaged during construction, salvaging existing materials, and for making all required tests. All additional materials and labor, not shown in the Plans or called for herein and which are required to complete the electrical system, shall be included in the lump sum Contract price.

"Conduit Pipe ____ In. Diam.", per linear foot.

The unit Contract price per linear foot for "Conduit ____ In. Diam." shall be full pay for furnishing all pipe, pipe connections, elbows, bends, caps, reducers, conduits, and unions; for placing the pipe in accordance with the above provisions, including all excavation, jacking or drilling required, backfilling of any voids around casing, conduits, pits or the trenches, restoration of native vegetation disturbed by the operation, chipping of pavement, and bedding of the pipe; and all other Work necessary for the construction of the conduit, except that when conduit is included on any project as an integral part of an illumination, traffic signal, or ITS systems and the conduit is not shown as a pay item, it shall be included in the lump sum price for the system shown.

All costs for installing conduit containing both signal and illumination wiring shall be included in the Contract prices for the signal system.

All costs for installing junction boxes containing both illumination and signal wiring shall be included in the Contract prices for the signal system.

"Casing", per linear foot.

The unit Contract price per linear feet for "casing" shall be full payment for boring, jacking or drilling for installing casing, and backfilling any voids around the casing and pits or back filling of the trenches required to install the casing. This cost will also include any restoration of native vegetation disturbed by the operation.

"Directional Boring", per linear foot

The unit Contract price per linear foot for "Directional Boring", shall be full pay for furnishing all labor, materials, equipment and electrical supervision associated with the directional boring.