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**PART 00900 - PERMANENT TRAFFIC CONTROL AND ILLUMINATION SYSTEMS****Section 00905 - Removal and Reinstallation of Existing Signs****Description**

**00905.00 Scope** - This work consists of one or both of the following:

- Removing existing signs, specific service signs and tourist-oriented directional signs (TODS) as shown or directed.
- Removing and moving existing signs, specific service signs and tourist-oriented directional signs (TODS) from their existing locations and reinstalling them at new locations as shown or directed.

**Construction**

**00905.40 General** - Do not remove signs from existing supports until new supports are in place, ready to receive the signs. Install the signs on the new supports immediately after removing from existing supports. Provide temporary supports as required. Provide permanent supports according to Sections 00910, 00920, and 00930 as required.

Protect specific service signs (business logos) and TODS from damage, whether the signs are to remain in place or are placed on temporary supports, until reinstalled on permanent supports. Repair or replace damaged signs at no cost to the Agency. Liquidated damages will be assessed against the Contractor in the amount of \$200 per day for each sign out of service for more than five calendar days.

Install rigid, temporary vertical ties to the back of all extruded aluminum panel signs to prevent buckling of the sign panels and/or their legends during removal, moving and reinstallation of the signs. Repair any damage inflicted to the signs or their legends.

Remove to 0.3 m (1 foot) below the ground line those installations with concrete or steel footings set in the ground unless indicated otherwise. Fill the resultant hole and finish the surface to correspond with the surrounding area. Do not remove the existing appurtenances until ordered. Dispose of all existing appurtenances removed and not used in reinstallation, according to 00310.43.

**Measurement**

**00905.80 Lump Sum Basis** - No measurement of quantities will be made for this work.

**Payment**

**00905.90 General** - Removing existing signs will be paid for at the Contract lump sum amount for the item "Remove Existing Signs". Removing, moving and reinstalling existing signs will be paid for at the Contract lump sum amount for the item "Remove and Reinstall Existing Signs". Payment will be payment in full for all Materials, Equipment, labor and Incidentals necessary to complete the work as specified.

**Section 00910 - Wood Sign Posts**

**Description**

**00910.00 Scope** - This work consists of furnishing and installing preservative treated or naturally decay-resistant wood sign posts at the locations shown or as directed.

**Materials**

**00910.10 General** - Fabricate the wood posts from either Douglas fir, Hem fir, Western cedar or Port Orford cedar to conform to the following requirements:

Posts.....	02110.40
Preservative treatment of posts .....	02190

**Construction**

**00910.40 Post Holes** - Excavate post holes to the lines and grades established and to the depth shown or to a depth necessary to achieve the required mounting height, whichever is greater. If necessary, obtain the required depth by blasting. Do not set the post until the location, lines and grades of the holes have been approved. Align the post to a vertical position in the hole and backfill the hole. Backfill with selected general backfill meeting the requirements of 00330.13. Place in layers not greater than 150 mm (6 inches). Solidly ram and tamp the layers into the excavated area around the post. Dampen during placement if too dry to compact properly. On completion of the work, replace and finish the surface around the post to match the surrounding surface.

**Measurement**

**00910.80 General** - The quantities of wood posts will be measured by volume (foot board measure, FBM), using actual sizes and lengths, of each wood post installed. Post volume will be determined by multiplying the nominal post size by the commercially available length shown on the standard drawings. For calculation purposes, post length will be determined by rounding the installed length to the nearest higher commercial length.

The post lengths indicated in the plans are estimated for bid purposes only. Final lengths of wood posts will be determined or verified by the Engineer prior to fabrication.

**Payment**

**00910.90 General** - The accepted quantities of wood sign posts will be paid for at the contract unit price per m<sup>3</sup> (foot board measure, FBM) for the item "Wood Sign Posts".

Payment will be payment in full for furnishing all materials, equipment, labor and incidentals necessary to complete the work as specified.

No separate payment will be made for route marker frames or special sign brackets.

## Section 00920 - Sign Support Footings

### Description

**00920.00 Scope** - This work consists of constructing sign support footings of the dimensions and design shown and at the locations shown or directed. Sign support footings include footings and pedestals for overhead sign structures, footings used to support breakaway sign posts, pipe sign posts and footings for sign supports.

### Materials

**00920.10 General** - Materials for constructing sign support footings shall meet the following requirements:

Commercial grade concrete .....	00440 or 00540, as shown or specified
Reinforcement.....	00530
Conduit .....	02920.10 - .12
Backfill (unless otherwise directed).....	00510.10 or .11
Anchor bolts .....	02560.30

### Construction

**00920.40 Excavation and Backfill** - Excavate and backfill footings according to Section 00510.

Finish the surface of backfill to match the existing surface., Where required, reinstall curbs and asphaltic markers.

**00920.41 Concrete** - Construct concrete sign foundations according to Section 00440 or Section 00540 as shown.

Pour concrete spread footings and concrete shaft footings against undisturbed material or backfill with selected granular backfill material according to 00510.11. Compact to 95% maximum density according to 00330.43 or as shown.

During concrete placement, accurately and securely hold in place all anchor bolts or post stubs until the concrete has set.

**00920.42 Reinforcement** - Fabricate and place steel reinforcement according to Section 00530.

**00920.43 Conduit** - Fabricate and install conduit according to Sections 00970 and 00990.

### Measurement

**00920.80 Lump Sum Basis** - No measurement of quantities will be made for work under this Section unless plan changes are ordered.

The estimated quantity of concrete required to complete the footings and pedestals will be listed in the Special Provisions for the purpose of providing a basis for adjustment if changes in the work are ordered. No adjustment in the Contract lump sum amount will be made except as provided above. Any adjustment in the Contract lump sum amount will be made according to 00190.10(e).

00920.90

### **Payment**

**00920.90 General** - Payment for constructing sign support footings will be made at the Contract lump sum amount for the item "Sign Support Footings" unless this price is adjusted according to 00920.80.

Payment, plus or minus adjustments if any, will be payment in full for excavation, backfill, shoring, reinforcement, anchor bolts, conduit, and all materials, equipment, labor and Incidentals necessary to complete the work as specified.

## Section 00930 - Metal Sign Supports

### Description

**00930.00 Scope** - This work consists of furnishing, fabricating, galvanizing and erecting metal sign supports, including sign bridges and sign structures.

**00930.01 Definitions and Terms:**

**(a) Multi-Post Breakaway Sign Supports** - The complete structure is composed of post stubs, base plates, posts, hinges, sign support members, and fastenings, but does not include the sign support footings.

**(b) Pipe Sign Posts, Special Pipe Sign Supports, Square Tube Sign Supports, Single Post Breakaway Sign Supports, Triangular Base Breakaway Sign Supports and Offset Single Sign Supports** - The complete structure is composed of post stub, base plates, metal post, sign support members, and fasteners, but does not include the sign support footings.

**(c) Sign Bridge, Ell Sign Bridge, Butterfly Sign Structure and Cantilever Sign Structure** - The complete structure is composed of base plates, support columns, cantilever arms, trusses, sign support arms, supporting brackets, and fasteners, but does not include the sign illumination equipment, maintenance walkways and sign support footings.

**(d) Double Sign Support and Triple Sign Support** - The complete structure is composed of post stub, base plate, pipe support column, sign frames, and supporting brackets, but does not include the sign support footing.

**(e) Structure Mount** - The I-beam or special detailed attachments used for mounting signs to bridge structures, and includes all necessary support brackets and arms, and fasteners, but does not include sign illumination equipment and maintenance walkways.

**(f) Exit Number Sign Supports** - The I-beams, spacers, special mounting brackets, and fasteners, necessary to install the exit number signs.

**(g) Sign and Luminaire Supports and Signal Pole Mounts** - The complete support including horizontal and vertical arms, supporting brackets, and fasteners.

**(h) Route Marker Frames** - The channel frame used to mount two or more route shield assemblies to a single support.

**(i) Special Sign Bracket** - The bracket used to mount two or more signs on a single support when all signs are not parallel or at right angle to the others.

**(j) Maintenance Walkways** - The complete structure is composed of safety rails and posts, horizontal and vertical walkway support arms (except sign support arms), grating, post brackets, supporting brackets, and fasteners, but does not include sign illumination equipment.

**00930.02 Working Drawings** - Submit six copies of stamped working drawings, plans, details, and calculations according to 00150.35(b-1) for all structural metal work. Any material ordered or work done before the review of working drawings shall be at the Contractor's risk. All engineered details and drawings that are not prepared by the Agency but are required in the Contract Documents and Specifications for the Project shall be submitted for review prior to fabrication.

In addition to the working drawings, submit six copies of all available data including manufacturer's pamphlets and brochures, technical bulletins, working drawings and other technical information relative

to products used on the Project. After installation, submit corrected working drawings that represent the material as installed and in operation. Include sufficient information to enable the Agency's maintenance forces to replace all or part of the commercially manufactured sign structures, under routine or emergency maintenance, by direct reference to the information furnished by the Contractor.

Working drawings are not required for the following types of steel supports:

- Single Post Breakaway Sign Supports
- Triangular Base Breakaway Sign Supports
- Multi-Post Breakaway Sign Supports

Working drawings for these supports will be provided by ODOT's Sign Design Unit. Use the Field Verification of Post Lengths form, available from the Engineer, to provide necessary site data to the Sign Design Unit for use in producing working drawings. Any work done, or materials ordered, prior to receiving working drawings from the Sign Design Unit will be at the Contractor's expense.

**00930.03 Commercially Manufactured Products** - Instead of fabricating "Sign Structures" as shown, the Contractor may offer for consideration and approval, as a substitution, a standard manufactured product of aluminum or steel. Submit stamped engineered details and drawings for manufactured products according to 00150.35(b-1).

If commercially manufactured sign structures are furnished, they shall be designed for the ultimate sign size and wind pressure given on the plans and meet the requirements of the current AASHTO "Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals".

Furnish complete, proposed material specifications and fabrication criteria with the working drawings.

**00930.09 Identifying Tags** - Overhead sign support structures, except structure mounts, shall have stainless steel or brass identifying tags attached to all posts, arms, and truss sections. The tags shall be at least 1.5 mm (1/16 inch) thick. Tag lettering shall be at least 6.4 mm (1/4 inch) in height, and shall be stamped into the tag. Tags shall be attached with stainless steel pop rivets of at least 4.76 mm (3/16 inch) nominal body diameter. Do not locate pop rivet holes within 150 mm (6 inches) of welds. Post tag shall be located approximately 1.5 m (5 feet) above the baseplate. Holes for pop rivets shall be drilled prior to hot-dip galvanizing. Remove excess hot-dip galvanizing from holes and repair according to ASTM A780.

Tags shall include the following information:

- Structure number
- Manufacturer
- Month and year of manufacture

### **Materials**

**00930.10 General** - Provide structural steel materials conforming to the applicable portions of Section 02530, with masses (weights) and sizes as shown or specified.

Provide galvanized bolts, nuts, hardened washers and direct tension indicators conforming to 02560.20.

All components of steel sign structures shall be galvanized after fabrication and before assembly. Galvanizing shall conform to the requirements of Section 02530.

## Labor

**00930.30 Fabricators** - Fabricators of metal sign supports shall have either a current AISC Simple Steel Bridge Structures (Sbr) certification or a current AISC Major Steel Bridges (Cbr) certification.

## Construction

**00930.40 Fabrication and Erection** - Fabricate and erect according to the applicable portions of Section 00560, except where in conflict with the following:

**(a) General** - Erect breakaway sign posts, pipe sign posts and pipe support columns at a true vertical.

Where two or more posts are required to support a sign, orient and position both posts so that no twist or warp will be imparted to the sign panels.

**(b) Assembly of Metal** - Accurately assemble the parts as shown on the plans and follow any match marks. Handle the material carefully so that no parts will be bent, broken or otherwise damaged. Clean bearing surfaces and surfaces to be in permanent contact before the members are assembled. Roughen faying surfaces of slip-critical structural connections utilizing high strength bolts by means of hand wire brushing after galvanizing. Power wire brushing is not permitted.

**(c) Welding** - Weld steel sign structures according to AWS D1.1. The fabricator shall inspect welds in accordance with details and requirements called out on the Contract Documents. This requirement will override all appropriate weld inspection requirements called out in Section 1.4.2 WELDING OF STEEL STRUCTURES in AASHTO "Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals". Submit all testing procedures for Engineer's review prior to starting inspection. Submit certified copies of inspection reports to the Engineer for review.

If requested by the Engineer, additional weld inspection may be required upon arrival of the material at the job site. If defects are found by this additional inspection, the Contractor shall be responsible for the additional testing and repair costs. If no defects are found, the Engineer will be responsible for the additional inspection costs.

**(d) Bolt Installation** - Do not reuse galvanized high strength bolts. Other high strength bolts may be reused, if approved, but not more than once. Retightening previously tightened bolts that may have been loosened by the tightening of adjacent bolts will not be considered a reuse.

Provide all high strength bolts with hardened washers under the element turned (nut or bolt head) in tightening. If bolts are installed in an oversize, short slotted or long slotted hole in an outer ply, use a plate hardened washer or a continuous bar made of structural grade steel and at least 8 mm (5/16 inch) thick with standard holes. Make the washer or bar sufficiently large to completely cover the slot after installation.

Unless shown, specified or allowed otherwise, provide new, unused direct tension indicators mechanically galvanized according to Section 02560. Do not permit the surfaces contacting the protrusions of a direct tension indicator to turn during the tightening operation.

Protect fasteners from dirt and moisture at the jobsite. Do not remove the lubricant that is present in as-delivered condition. Clean and relubricate fasteners that accumulate dirt resulting from jobsite conditions before installation.

Furnish, at no additional compensation, a calibrated torque wrench of a capacity appropriate to the size of the high-strength bolts installed and tightened for all methods of tightening except direct tension indicator method. Confirm the accuracy of the calibrated torque wrench through calibration by an approved independent testing agency at least once a year.

**(1) Bolt Installation for Slip Bases (Breakaway)** - Remove any dirt and moisture from the lubricated fasteners, and recoat the lubricated fasteners with a fresh, second coat of lubricant immediately before tightening. Tighten the bolts, in the presence of the Engineer, to the minimum torque or tension shown to seat the bolts in the base plate slots. After all the bolts in the slip base are tightened, loosen each bolt and retighten to the prescribed torque or tension shown in the same order as the initial tightening.

**(2) Bolt Installation for Nonslip Connections** - Tighten threaded bolts by direct tension indicator method unless noted otherwise. The calibrated torque wrench method of final tightening is not acceptable. Use of direct tension indicators is not permitted with Type 3 high-strength bolts in AASHTO M 270/M 270, Grade 345W (50W) (ASTM A 709/A 709M, Grade 50W (345W); ASTM A 588/A 588M), unpainted weathering steel connections.

**a. Direct Tension Indicator Tightening** - Install bolts using direct tension indicators conforming to 02560.20(d) and 02560.40(b), with indicators in all holes of the connection according to the manufacturer's installation procedure, and bring to a snug-tight condition. Snug-tight is indicated by partial compression of the direct tension indicator protrusions. Then tighten all fasteners in the connection, progressing systematically from the most rigid part of the connection to the free edges in a manner that will minimize relaxation of previously tightened fasteners. In some cases, proper tensioning of the bolts may require more than a single cycle of systematic partial tightening before final tightening to deform the protrusion to nil gap or as specified.

"Nil gap" is achieved when the 0.125 mm (0.005 inch) feeler gage is refused in 2, 3, 3, 4, or 4 spaces of a direct tension indicator having 4, 5, 6, 7, or 8 spaces respectively between protrusions, and a visible gap exists in at least one space.

**b. Turn-of-Nut Tightening** - If turn-of-nut tightening is allowed, install bolts in all holes of the connection and bring to a snug-tight condition. Snug-tight is defined as the tightness that exists when the plies of the joint are in firm contact and the initial torque in the bolt as measured by the calibrated torque wrench is not less than 20% of the torque calculated using the equation in 02560.60(a-1), where P shall be the minimum tension in the bolt according to table 00560-1 in Section 00560. Systematically snug-tighten all bolts from the most rigid part of the connection to the free edges, and then retighten the bolts in a similar systematic manner as necessary until all bolts are simultaneously snug-tight and the connection is fully compacted. Following this initial operation, tighten all bolts in the connection further by the applicable amount of rotation specified in Table 00560-3 in Section 00560. During the tightening operation do not permit rotation of the part not turned by the wrench.

**(e) Bolt Inspection:**

**(1) General** - The Engineer will observe the installation and tightening of bolts to determine that the selected tightening procedure is properly used and that all bolts are tightened, and in the case of direct tension indicators that the correct indication of tension has been achieved. Bolts may reach tensions substantially above the value given in Table 00560-1 in Section 00560, but this will not be cause for rejection.

**(2) Direct Tension Indicator Method** - Install and tighten bolts using direct tension indicators as recommended by the direct tension indicator manufacturer. The gap in the direct tension indicators shall be nil unless shown otherwise.

Provide the Engineer full opportunity to witness installation of bolted connections. The Engineer will periodically observe the installation and tightening operations to insure that proper procedures are being adhered to.

Upon completion of a bolted joint, the Engineer will determine that all bolts have been tightened. A minimum of 10%, but not less than two bolts in each joint, will be inspected. If all gaps checked are nil or as shown, the joint will be accepted as properly tightened. If gaps checked are in excess of the above, reinspect all bolts and retighten bolts in the joint, as required, then resubmit the joint for inspection.

Apply the feeler gauge to all of the openings between protrusions around the indicator circumference. To satisfy the nil gap requirement, the feeler gauge shall be refused by at least one-half of the applied places.

**(3) Turn-of-Nut Method** - Use the following inspection procedure if the turn-of-nut method is allowed for bolt tightening:

- In the presence of the Engineer, use an inspection wrench, which may be a calibrated torque wrench.
- Place three bolts of the same grade, diameter and condition as those under inspection individually in a calibration device capable of indicating bolt tension. Use a hardened washer under the part turned in tightening each bolt.
- Tighten each bolt specified in the paragraph above in the calibration device by any convenient means to an initial condition equal to 20% of the required tension, and then to a tension not less than 5% greater than specified for its size in Table 00560-1 in Section 00560. Tightening beyond the initial condition must not produce greater nut rotation than 1.5 times that permitted in Table 00560-3 in Section 00560. Then apply the inspecting wrench to the tightened bolt and determine the torque necessary to turn the nut or head 5 degrees, approximately 26 mm at 300 mm (1 inch at 12 inches) radius, in the tightening direction. Take the average torque measured in the tests of three bolts as the job inspecting torque to be used in the manner specified in the next paragraph.
- Test bolts that have been tightened in the structure and are represented by the sample prescribed above with the inspecting wrench. Apply the job inspecting torque to 10% of the bolts, but not less than two bolts selected at random. If no nut or bolt head is turned by this application of the job inspecting torque, the connection will be accepted as properly tightened. If any nut or bolt head is turned by the application of the job inspecting torque, test all bolts in the connections. Retighten all bolts whose nut or head is turned by the job inspecting torque, and re-inspect. Retighten all of the bolts in the connection and then resubmit the connection for the specified inspection.

**00930.41 Adjustable Sign Mounts** - Furnish and install a bracket that is adjustable horizontally and vertically to facilitate signal pole mast arm and pole mounting of flat sign sheets. The mount shall allow vertical adjustment for positioning the sign and shall rotate to plumb the sign. Construct the bracket from cast aluminum and galvanized steel elements that attach to the signal pole mast arm or other support with stainless steel straps. Use galvanized or stainless steel nuts, bolts and washers for fasteners.

### Measurement

**00930.80 Lump Sum Basis** - No measurement of quantities will be made for metal sign supports unless plan changes are ordered or the field-verified post length increases or decreases by more than 25% of the length specified.

The estimated quantities of structural steel for an item will be listed in the Special Provisions for the purpose of providing a basis for adjustment. No adjustment in the lump sum Contract amount will be

00930.80

made, except as provided above. Any adjustment in the lump sum Contract amount will be made according to 00190.10(e).

**00930.81 Unit Basis** - Measurement of adjustable sign mounts will be on a unit basis, per each, by actual count of adjustable sign mounts installed and accepted.

### Payment

**00930.90 General** - Payment will be made at the Contract lump sum amount for the following items, unless this price is adjusted according to 00930.80:

Pay Item	Unit of Measurement
<b>Bridges</b>	
(a) Sign Bridge .....	Lump Sum
(b) Ell Sign Bridge .....	Lump Sum
<b>Structures</b>	
(c) Butterfly Sign Structures .....	Lump Sum
(d) Cantilever Sign Structures .....	Lump Sum
<b>Mounts</b>	
(e) Structure Mounts.....	Lump Sum
(f) Signal Pole Mounts.....	Lump Sum
<b>Posts</b>	
(g) Pipe Sign Posts.....	Lump Sum
<b>Supports</b>	
(h) Multi-Post Breakaway Sign Supports.....	Lump Sum
(i) Special Pipe Sign Supports.....	Lump Sum
(j) Single Post Breakaway Sign Supports.....	Lump Sum
(k) Triangular Base Breakaway Sign Supports.....	Lump Sum
(l) Offset Single Sign Supports.....	Lump Sum
(m) Double Sign Supports.....	Lump Sum
(n) Triple Sign Supports.....	Lump Sum
(o) Exit Number Sign Supports.....	Lump Sum
(p) Sign and Luminaire Supports.....	Lump Sum
(q) Mast Arm Sign Supports.....	Lump Sum
(r) Square Tube Sign Supports.....	Lump Sum
(s) Square Tube Sign Supports W/TBB.....	Lump Sum
<b>Walkways</b>	
(t) Maintenance Walkways .....	Lump Sum

Item (t) includes support arms as specified except where sign support arms perform the dual purpose of supporting walkways and signs. Payment for the dual purpose sign support arms will be included in payment for the sign structure.

No separate payment will be made for route marker frames or special sign brackets. Payment will be included in payment made for one or more of the listed pay items.

Payment, plus or minus adjustments if any, will be payment in full for furnishing and placing all materials and furnishing all equipment, labor and Incidentals necessary to complete the work as specified.

**00930.91 Unit Basis** - Payment for accepted quantities of adjustable sign mounts will be at the Contract unit price per each for the pay item "Adjustable Sign Mounts". Payment will be payment in full for furnishing, attaching and adjusting the mounts and includes equipment, labor and Incidentals necessary to complete the work.

## Section 00940 - Signs

### Description

**00940.00 Scope** - This work consists of furnishing, fabricating and erecting traffic signs of the types shown.

**00940.01 Sign Backgrounds** - Use either reflectorized or nonreflectorized sign backgrounds as shown and according to 00940.02.

**(a) Color** - Use sign background colors conforming to the current edition of the Federal Highway Administration's "Standard Color Tolerance Charts". Reflective sheeting shall conform to 02910.20 for Type I (enclosed lens), or 2910.30 for Type III (encapsulated lens) sheeting.

In addition, specified color coordinates shall be subject to visual matching by the Engineer to determine that all panels in any one sign match.

**00940.02 Types of Signs** - Traffic signs are classified by sign type as follows:

- "B" Blue encapsulated lens reflective sheeting background with silver-white encapsulated lens permanent or removable legend, or silver-white encapsulated lens reflective sheeting overlaid with blue transparent paste background with reflectorized silver-white screened legend on extruded aluminum panels, sheet aluminum, or plywood.
- "B1" Blue enclosed lens reflective sheeting background with silver-white encapsulated lens permanent or removable legend, or silver-white encapsulated lens reflective sheeting overlaid with blue transparent paste background with reflectorized silver-white screened legend on extruded aluminum panels, sheet aluminum, or plywood.
- "B2" Blue nonreflective sheeting on extruded aluminum panels with silver-white encapsulated lens reflectorized removable legend.
- "B3" Blue encapsulated lens reflective sheeting on extruded aluminum panels with white prismatic lens removable legend.
- "C" Brown encapsulated lens reflective sheeting background with silver-white encapsulated lens permanent or removable legend, or silver-white encapsulated lens reflective sheeting overlaid with brown transparent paste background with reflectorized silver-white screened legend on extruded aluminum panels, sheet aluminum, or plywood.
- "C1" Brown encapsulated lens reflective sheeting on extruded aluminum panels with white prismatic lens removable legend.
- "F" Silver-white encapsulated lens reflective sheeting overlaid with red and blue transparent paste background with silver-white screened legend or encapsulated lens permanent legend on sheet aluminum or plywood.
- "FA" White prismatic lens reflective sheeting overlaid with red and blue transparent paste background on sheet aluminum with white prismatic lens reflectorized permanent legend.
- "G" Green encapsulated lens reflective sheeting background with silver-white encapsulated lens permanent or removable legend, or silver-white encapsulated lens reflective sheeting overlaid with green transparent paste background with reflectorized silver-white screened legend on extruded aluminum panels, sheet aluminum, or plywood.

- "G1"** Green encapsulated lens reflective sheeting on extruded aluminum panels with white prismatic lens removable legend.
- "G2"** Green encapsulated lens reflective sheeting on sheet aluminum with white Type A prismatic lens legend.
- "G3"** Green encapsulated lens reflective sheeting on sheet aluminum with white Type B prismatic lens legend.
- "O"** Orange enclosed lens reflectorized sheeting background on extruded aluminum panels, sheet aluminum, or plywood with nonreflectorized black legend.
- "OO"** Orange encapsulated lens reflectorized sheeting background on extruded aluminum panels, sheet aluminum, or plywood with nonreflectorized black legend.
- "O3"** Orange encapsulated lens reflective sheeting background on sheet aluminum or plywood with nonreflectorized black screened or cut out permanent legend and reflectorized red symbol (Stop or Yield Ahead Symbol Sign).
- "O4"** Orange fluorescent prismatic lens reflective sheeting background on sheet aluminum or plywood with non-reflectorized black screened or cut out permanent legend.
- "R"** Silver-white encapsulated lens reflective sheeting overlaid with red transparent paste background on sheet aluminum or plywood with encapsulated lens silver-white legend.
- "R1"** White prismatic lens retroreflective sheeting overlaid with red transparent paste background on sheet aluminum or plywood with prismatic lens white legend.
- "RR"** Silver-white encapsulated lens reflective sheeting background on sheet aluminum or plywood overlaid with screened red transparent paste triangle and legend.
- "W1"** Silver-white encapsulated lens reflective sheeting background with nonreflectorized black screened, cut-out permanent or removable legend on extruded aluminum panels, sheet aluminum, or plywood.
- "W2"** Silver-white encapsulated lens reflective sheeting background on sheet aluminum or plywood with a screened nonreflectorized black legend and a reflectorized circle and continuous diagonal bar overlaid with red transparent paste.
- "W3"** Silver-white encapsulated lens reflective sheeting background on sheet aluminum or plywood with transparent brown screened legend or brown encapsulated lens reflective sheeting cut-out permanent legend.
- "W4"** Silver-white encapsulated lens reflective sheeting background on sheet aluminum or plywood with transparent red screened legend or red encapsulated lens reflective sheeting cut-out permanent legend.
- "W5"** Silver-white encapsulated lens reflective sheeting background on sheet aluminum or plywood with transparent green screened legend or green encapsulated lens reflective sheeting cut-out permanent legend.
- "W6"** Silver-white encapsulated lens reflective sheeting on extruded aluminum panels with nonreflective black removable legend.

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- "W7" White prismatic lens reflective sheeting background on sheet aluminum with nonreflectorized black screened legend or nonreflectorized black cut-out legend.
- "W8" Silver-white encapsulated lens reflective sheeting background on plywood with transparent blue screened legend or blue encapsulated lens reflective sheeting cut-out permanent legend.
- "WA" Silver-white encapsulated lens reflective sheeting background on sheet aluminum with nonreflectorized black screened legend or nonreflectorized black cut-out legend.
- "Y1" Yellow encapsulated lens reflective sheeting background with nonreflectorized black screened, cut-out permanent or removable legend on extruded aluminum panels, sheet aluminum, or plywood.
- "Y2" Signal ahead symbol sign. Yellow encapsulated lens reflective sheeting background on sheet aluminum or plywood with a screened nonreflectorized black legend and reflectorized circles overlaid with red and green transparent paste. The center circle shall be part of the background.
- "Y3" Yellow prismatic lens reflective sheeting background with nonreflectorized black screened, cut-out permanent or removable legend on extruded aluminum panels or sheet aluminum.
- "Y4" Stop or Yield Ahead Symbol Sign. Yellow encapsulated lens reflective sheeting background on sheet aluminum or plywood with nonreflectorized black screened or cut-out permanent legend and reflectorized red symbol.
- "Y5" Fluorescent yellow wide-angle prismatic lens reflective sheeting background on sheet aluminum with nonreflectorized black screened or cut-out permanent legend.
- "YG" Yellow-green fluorescent wide-angle prismatic lens reflective sheeting background on sheet aluminum with black non-reflective legend.

**00940.03 Drawings** - Copies of working drawings for non-standard signs will be made available to the Contractor by the Engineer. Standard signs called for in the Contract Documents shall be constructed using Agency-supplied working drawings.

### **Materials**

**00940.10 General** - Materials for signs shall conform to Section 02910.

**00940.11 Alternate Materials** - The use of alternate materials will be allowed as specified. Alternate materials may be used interchangeably throughout the Project. However, only one alternate, plywood or aluminum, will be permitted on an individual support.

In cases where the Contractor utilizes a standard manufactured item in the construction of signs, do not permit the mixing of items from more than one manufacturer unless otherwise shown or specified.

### **Construction**

**00940.40 General** - Finished signs shall conform to the designs shown or specified.

Choose the substrate material from the following table:

Sign Size	Acceptable Substrate Materials
Up to 1.2 m x 1.5 m (4' x 5')	Sheet aluminum Plywood Extruded aluminum panels
From 1.2 m x 1.5 m (4' x 5') to 1.2 m x 2.4 m (4' x 8')	Plywood Extruded aluminum panels
Over 1.2 m x 2.4 m (4' x 8')	Extruded aluminum panels
Over 2.4 m (8') in any dimension	Extruded aluminum panels

See Table 02910-1 in Section 2910 for sheet aluminum thicknesses for various sizes of signs.

Construct standard signs as shown in the FHWA "Standard Highway Signs" manual or in the metric or English version (as appropriate) of ODOT's "Sign Policy and Guidelines for the State Highway System". The latter are available for purchase from the ODOT Traffic Management Section, Transportation Building, Salem.

#### **00940.41 Aluminum Panel Sign Fabrication:**

**(a) General** - Fabricate aluminum panel signs as shown or specified. Do not round corners of panels outside the border. Reinforced sheet aluminum signs will not be allowed.

**(b) Extruded Aluminum** - Each panel of extruded aluminum panel signs shall be a continuous section. Apply the nonreflective sheeting of Type "B2" and the reflective sheeting of all other types to the extrusion a sufficient distance around the edge to insure that no aluminum surface is visible on the face of the sign.

**(c) Sheeting** - The sign sheeting applied to the extrusions shall be the background color of the sign.

**(d) Legend** - Signs consisting of only one extrusion and sign faces consisting of several extrusions shall use permanent legend only if none of the legend overlaps or crosses the joint between extrusions. If any of the legend crosses the joint between extrusions all of the legend on the sign shall be removable.

**(e) Transparent Paste** - Do not use transparent paste background on extruded aluminum signs.

#### **00940.42 Sheet Aluminum Sign Fabrication:**

**(a) General** - Cut the sheet aluminum sign to size and shape as shown or specified. The sign shall be free of buckles, warps, dents, cockles, burrs and defects resulting from fabrication.

Before application of reflective or nonreflective sheeting, treat the entire surface of the sign with a conversion film according to the sheeting manufacturer's recommendations .

#### **(b) Mounting Holes:**

**(1) On Posts** - Signs having a vertical dimension of less than 1.2 m (48 inches) and mounted on wood or metal posts shall have at least two mounting holes. Signs having a vertical dimension of 1.2 m (48 inches) or greater shall have three mounting holes. Place the third mounting hole near

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the center of the sign. Locate mounting holes so the mounting hardware will not cover any portion of the legend unless otherwise shown.

**(2) On Extruded Aluminum Signs** - Provide a minimum of eight mounting holes for sheet aluminum signs mounted on extruded aluminum signs as shown.

**00940.43 Plywood Sign Fabrication** - Perform all fabrication with saw blades that do not tear plywood grain. Cut all holes clean and uniform. Splicing will not be permitted unless specified. Locate mounting holes so that the mounting hardware will not cover any portion of the legend. Provide mounting holes for signs according to 00940.42(b).

After fabrication and before the application of reflective or nonreflective sheeting, seal all edges with plywood sealer tinted to match the color of the panel overlay material. Where reflective or nonreflective sheeting is to be applied, prepare the surface of the sign according to the sheeting manufacturer's recommendations.

**00940.44 Reflective or Nonreflective Sheeting Application** - Apply the sheeting according to the sheeting manufacturer's recommendations on extruded aluminum panel signs. Up to 25% of the extruded aluminum panel signs required in the plans will be permitted one manufacturer's splice per sign. One patch will be permitted per 5 m<sup>2</sup> (50 square feet) of sign to a maximum of three patches per sign. Patches shall be between 20 mm (3/4 inch) and 85 mm (3 3/8 inches) in diameter. No Contractor splices will be allowed.

On all other signs, manufacturer's splices will not be permitted except as noted on approved shop drawings, or when sign dimensions exceed the sheeting manufacturer's capabilities. Make these splices horizontal with the upper section of sheeting overlapping the lower by a minimum of 10 mm (3/8 inch) on encapsulated lens sheeting, and butt splice prismatic lens sheeting with no appreciable substrate visible. The use of overlaid transparent paste will not be allowed on overlapped splices. No Contractor splices will be allowed.

**00940.45 Legend Installation:**

**(a) General** - The word "legend" means the entire message and border for a sign. A group of words, numbers and/or symbols constitute the "message" for a sign. Install the type of legend for each traffic sign as shown and according to 00940.02.

Spacing between letters and/or numbers shall conform to the FHWA "Standard Alphabets for Highway Signs" manual.

Spacing between words for Series "E" (modified) legend shall be 1.5 times the upper case letter height. Spacing between words for other fonts shall be as tabulated below unless otherwise shown:

<b>Legend Series</b>	<b>Word Spacing</b>
B	(0.531) H
C	(0.625) H
D	(0.836) H
E	(1.000) H

Where H = height of upper case letter

Spacing between symbols shall conform to FHWA "Standard Highway Signs" unless otherwise shown.

Space all lines equally between side borders unless otherwise shown. Space the legend vertically as shown. For diamond shaped signs, space between lines in the legend a minimum of one half the

average letter height and space between the message and the borders equally so the message is centered on the sign.

**(b) Attachment** - Attach removable legend to aluminum panels using aluminum, domed head, 3 mm (1/8 inch) diameter, self-plugging blind rivets. Remove aluminum shavings from the sign face before attaching the legend. The entire sign will be rejected if any shavings are left beneath the legend. Drill 3.25 mm (0.128 inch) diameter holes in the removable legend and sign panel as indicated on the "Mounting Details for Removable Legend" Standard Drawings.

Apply screened legend according to the sheeting manufacturer's recommendations. Apply cut-out legend according to 00940.44.

Attach 25 mm (1 inch) reflectorized removable border sections by placing two rivets 13 mm (1/2 inch) from the end of each border section with additional rivets spaced at a maximum of 152 mm (6 inches) apart, centered in the section. Corner border sections shall be attached with a minimum of five rivets, two rivets 13 mm (1/2 inch) from each end, and the remaining rivet centered in the middle of the section.

Attach 51 mm (2 inch) reflectorized removable border sections by placing two rivets 13 mm (1/2 inch) from the end of each border section with additional rivets spaced at a maximum of 152 mm (6 inch) apart, along the top and bottom edge of the section. Corner border sections shall be attached with a minimum of five rivets, two rivets 13 mm (1/2 inch) from each end, and the remaining rivet centered in the section.

**(c) Border Sizes** - Unless otherwise shown, the width of the sign borders shall be according to the following:

<b>METRIC</b>	
<b>Maximum Letter Size</b>	<b>Border Width</b>
127 mm Capital or Upper Case	13 mm
203 mm or 271 mm Upper Case	25 mm
254 mm or 305 mm Capital	25 mm
339 mm or 406 mm Upper Case	51 mm
381 mm or 406 mm Capital	51 mm
<b>ENGLISH</b>	
<b>Maximum Letter Size</b>	<b>Border Width</b>
5" Capital or Upper Case	1/2"
8" or 10 2/3" Upper Case	1"
10" or 12" Capital	1"
13 1/3" or 16" Upper Case	2"
15" or 16" Capital	2"

The corner radii shall be approximately one-eighth of the least dimension of the sign, but not exceeding 305 mm (12 inches). Except for the corners, mount the border flush with the edge of the sign. Do not round the corners of the aluminum panels.

**00940.46 Inspection** - The Engineer will inspect signs at the fabrication shop or at the jobsite. Inspection will be for conformance to plans and Specifications. Testing for nighttime visibility will be according to ODOT TM 804. The Contractor's expense for sign inspection will be according to 00165.91.

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**00940.47 Sign Erection** - Erect all signs at the locations staked and as shown or directed. Do not erect individual signs until the sign is complete with legend. Signs not mounted as shown or directed will not be accepted.

Erect the signs so the sign face is vertical, unless otherwise directed.

When signs are installed on supports 3 m (10 feet) or less from the edge of guardrail, curb, or shoulder, set them to reflect 3 degrees away from traffic. When signs are installed on supports more than 3 m (10 feet) from the edge of guardrail, curb or shoulder, set them to reflect 3 degrees toward traffic.

The closest edge of any column or overhead sign structures shall be as shown.

Where signs are mounted to supports by bolting through the sign, a sheeting manufacturer-approved lubricant may be used on the nylon and metal washers to prevent sign sheeting deformation. Replace damaged signs, or signs with sheet deformation, with new signs at the Contractor's expense.

If a sign installation is a replacement for an existing sign, install the new sign immediately after removal of the existing sign unless otherwise directed.

### **Measurement**

**00940.80 General** - The quantities for signs will be measured by multiplying height by width, using the dimensions shown. No deductions will be made for irregular shapes cut from the rectangle.

Route markers and other signs fastened to the face of larger signs will be measured as separate signs.

### **Payment**

**00940.90 General** - The accepted quantities of signs will be paid for at the Contract unit price per m<sup>2</sup> (square foot), in place, for the item "Type \_\_\_\_\_ Signs In Place".

The type of sign will be inserted in the blank with a separate pay item provided for each type.

Payment will be payment in full for furnishing all materials, equipment, labor and Incidentals necessary to complete the work.

**Section 00941 - Sign Covers****Description**

**00941.00 Scope** - This work consists of covering sign faces as shown, specified or directed.

**Materials**

**00941.10 General** - For permanent signs, use sign covers from the QPL or porous cloth covers pre-approved by the sign sheeting manufacturer.

Do not use plywood for permanent sign covers.

Covers for temporary signs shall conform to Section 00225.

**Construction**

**00941.40 Fabrication** - Fabricate sign covers in one piece, unless otherwise directed. Make them large enough to completely cover the sign, and capable of easy attachment to the sign without damaging the sign face.

**00941.41 Installation** - Lap covers over all sign edges and secure to the sign or support as recommended by the sign sheeting manufacturer.

**00941.42 Alternate** - The Contractor may elect one or more of the following as alternate methods subject to approval:

- Install signs in conjunction with the movement of the traffic flow.
- Remove demountable legend from signs and re-install legend as directed.
- Remove entire sign and store in a vertical position for future reinstallation.

**Measurement**

**00941.80 General** - Sign covers are considered incidental to the work. No measurement will be made.

**Payment**

**00941.90 General** - No separate or additional payment will be made for sign covers or for the alternate methods listed in 00941.42. The cost for this work is included in one or more of the listed pay items.

## Section 00950 - Removal and Reinstallation of Highway Illumination and Traffic Signals

### Description

**00950.00 Scope** - This work consists of removing, abandoning, salvaging and reinstalling existing illumination and traffic signal material as shown or directed.

### Materials

**00950.10 General** - The materials covered under this Section are those materials shown, specified and required to properly repair and refurbish salvaged materials that are to be reinstalled.

### Construction

**00950.40 General** - Remove existing illumination or traffic signal devices in the order directed. Do not damage reusable equipment when removing and salvaging existing material. Replace material damaged by the removal and salvage operations at the Contractor's expense. If directed, replace all other material salvaged for reinstallation that is not repairable, or that is not electrically or mechanically sound, with new material according to Section 00196.

Keep existing installations to be removed in operation until the new installations are ready to be turned on or as directed. If downtime is authorized, keep downtime to change from the existing operation to the new operation to a minimum. Perform the changeover with a minimum disruption to traffic.

Remove or salvage existing materials, as specified or approved, which interfere with or which are incompatible with new construction, before completion of the new construction. Notify the Engineer at least four calendar days in advance of such action.

**00950.41 Removal and Abandonment** - Unless otherwise specified, remove from the right of way underground conduit, conductors and foundations not reused and dispose of according to 00310.43. Items not interfering with construction may be abandoned in place with written approval. Plug abandoned conduit.

If a foundation is abandoned, remove the top of the foundation, anchor bolts, and conduits to a depth not less than 0.6 m (2 feet) below the adjacent finished ground line. Backfill the resulting hole with material equivalent to the surrounding material. Finish and blend the surface area to the adjacent surface area.

Give the location of all abandoned items to the Engineer.

Correct or repair any holes or damage to existing surfacing caused by removal of existing installations as directed at the Contractor's expense.

**00950.42 Stockpiling Existing Materials** - Remove, deliver and stockpile all materials specified to be stockpiled at the locations specified or directed.

**00950.43 Reinstalling** - If shown or specified, utilize existing material in the construction of new installations. Thoroughly clean, repair and refurbish salvaged material to be reinstalled to a like new condition before reinstallation. Replace damaged parts as directed.

Furnish and install all miscellaneous materials including anchor bolts, nuts, washers and concrete required to complete the reinstallation according to Sections 00960, 00970, and 00990.

Relamp all roadway luminaires, traffic signals and interior illuminated signs to be reinstalled with new lamps of the size and type required for new installations, according to Sections 00970 and 00990, except where such lamp appurtenances as sockets, et cetera, do not permit the installation of the specified lamps. In such instances, furnish and install a new lamp of the same manufacture as is currently installed in the unit.

If it is determined that there are conditions existing within the proposed project scope that do not meet the current applicable electrical codes or variances, obtain approval to furnish and install all necessary materials to meet the applicable electrical codes.

### **Measurement**

**00950.80 Lump Sum Basis** - There will be no measurement for work done under this Section.

### **Payment**

**00950.90 Lump Sum Basis** - Payment for work performed under this Section will be made at the Contract lump sum amount for the following items:

<b>Pay Item</b>	<b>Unit of Measurement</b>
(a) Removal of Existing Illumination .....	Lump Sum
(b) Removal of Existing Traffic Signals.....	Lump Sum
(c) Reinstallation of Existing Illumination.....	Lump Sum
(d) Reinstallation of Existing Traffic Signals .....	Lump Sum

Payment will be payment in full for removing, abandoning, salvaging and reinstalling existing illumination and traffic signals including all materials, equipment, labor and Incidentals necessary to complete the work as specified.

Items shown or specified as work to be done to bring existing installations into conformance with current electrical codes, will be considered incidental to the work and no separate or additional payment will be made.

Items not shown or specified, but necessary to bring existing installations into conformance with current electrical codes, will be paid for according to Section 00196.

**Section 00960 - Common Provisions for Highway Illumination and Traffic Signals****Description**

**00960.00 Scope** - This work consists of furnishing and installing materials for highway illumination and traffic signal projects and for modifying existing installations. The location of illumination/signal material shown is approximate, with exact locations established in the field.

**00960.01 Regulations, Standards, and Code** - All electrical materials and workmanship shall conform to the following standards where applicable:

- American National Standards Institute (ANSI)
- International Municipal Signal Association (IMSA)
- Underwriter's Laboratories, Inc. (UL)
- National Electrical Manufacturers Association (NEMA)
- National Electrical Safety Code (NESC)
- National Electrical Code, Oregon Amended (NEC)
- Standards of the American Society for Testing and Materials (ASTM)
- Local laws

Wherever reference is made to any of the standards mentioned above, the reference means the code, order, or standard in effect on the date the Project is advertised.

**00960.02 Equipment List and Drawings** - Within 30 calendar days after execution of the Contract, submit at least six copies of:

- A list of materials the Contractor proposes to install, unless otherwise permitted in writing. List all material shown or specified by manufacturer's name, size, and identity number of each item, if it is necessary or customary in the trade to identify such materials. Supplement the list with other data, including but not limited to, detailed scale drawings according to 00150.35.
- Wiring diagrams for all circuits and any nonstandard or special equipment.
- Brochures, technical bulletins, parts lists, service instructions, working drawings and other technical information relative to products proposed for use on the Project.
- Use materials from the current list of acceptable signal materials. The updated list is available from the Engineer. Mark the list according to the instructions on it. The list eliminates the need for most catalogue cutsheets.
- Designs of all poles and nonstandard pole foundations.

All engineered details and drawings which are not prepared by the Agency, but are required in the Contract Documents, shall be submitted for review prior to fabrication. Designs, details, plans and calculations shall be stamped and submitted according to 00150.35(b-1).

Upon completion of the installation, submit six copies of any data required to show in detail all changes made from the original plans. The information furnished shall include all modifications made and shall represent the material installed and in operation. It shall be sufficiently detailed to enable maintenance forces to replace or repair any part of the Project under routine or emergency maintenance by direct reference.

## Materials

**00960.10 General** - Materials shall meet the following requirements:

Aluminum Poles .....	02920.31
Anchor Bolts.....	02920.34
Ballasts .....	02920.52
Cabinets.....	02920.40
Cable and Wire .....	02920.20 -28
Circuit Breakers .....	02920.41
Conduit .....	02920.10 -12
Detection Devices .....	02920.45
Electrical Splice Materials .....	02920.25
Frangible Bases .....	02920.33
Illumination Control Devices.....	02920.42
Interior Illumination Signs.....	02920.61
Junction Boxes.....	02920.13
Lamps .....	02920.50 -51
Luminaires .....	02920.53
Signal Indication Devices.....	02920.60
Steel Poles.....	02920.31
Steel Towers .....	02920.32
Traffic Signal Control Devices.....	02920.42
Wood Poles.....	02920.30

## Labor

**00960.30 Licensed Electricians** - In accordance with Oregon Administrative Rule 918-282-0120(1), every person engaged in the installation of electrical equipment and wiring systems shall possess a valid Oregon Electrical Supervising or Journeyman's License, or be registered as an Electrical Apprentice. Every person who installs electrical systems on the Project shall submit a copy of his/her electrical license or apprentice registration to the Engineer prior to performing any work. Contractor employees who are not licensed electricians or registered apprentices will not be allowed to perform electrical work. This includes, but is not limited to:

- Assembling conduit systems
- Installing field mounted enclosures, junction boxes, and terminal cabinets
- Installing or splicing wiring for vehicle detector systems
- Participating in the installation of electrical conductors in conduits or poles (i.e. pulling wire)

## Construction

**00960.40 General** - Complete all construction according to the Contract Documents or as directed.

Correct faulty workmanship and materials at no cost to the Agency, even if not notified by the Engineer.

The Agency will continue operation and maintenance, including the furnishing of electrical energy, of existing illumination facilities.

Maintain new illumination equipment installed on an existing illumination system until the second notification by the Engineer. The Agency will continue to furnish electrical energy.

**00960.41 Excavation:**

**(a) General** - Protect all existing pipes that become a part of a foundation as directed by the Engineer or local utility company.

Do all excavation, backfilling and resurfacing work necessary to complete the work. This includes removal and replacement of curbs, sidewalks, paved surfaces and other materials. On completion of the work, replace and finish all surfaces to correspond with the existing surfaces.

Excavate trenches to lines, grades and cross sections established or approved. Furnish, place, and remove any shoring required to prevent caving of walls.

When excavating in paved areas, cut with an approved pavement cutting saw to a depth of at least 50 mm (2 inches) along the neat boundaries of the area to be removed. Cut sharp and well-defined pavement edges with no evidence of cracking, delaminating, or stressing.

Do not install conduit by means of plowing without approval. Submit the request in writing and include details on how the plowing will be performed.

Restore all disturbed landscaping and underground systems to original condition at Contractor's expense upon completion of the work. Use hand excavation if directed.

**(b) Excavation for Pole, Pedestal and Tower Foundations** - Make all excavations for pole, pedestal and tower foundations to the neat lines of the foundations. Hand excavation may be required. Place the concrete directly against the sides of the excavation in undisturbed or well-compacted material.

**(c) Excavation for Conduit** - Excavate and backfill conduits as follows, unless otherwise directed:

**METRIC**

**Minimum Cover (mm) from Finished Surface <sup>1</sup>**

Type of Conduit	Roadway and Shoulders	Sidewalks and Paved, Curbed Medians	Other Areas
Metal <sup>2</sup>	600	300	450
Rigid Nonmetallic	750	450	450

**ENGLISH**

**Minimum Cover (inches) from Finished Surface <sup>1</sup>**

Type of Conduit	Roadway and Shoulders	Sidewalks and Paved, Curbed Medians	Other Areas
Metal <sup>2</sup>	24	12	18
Rigid Nonmetallic	30	18	18

<sup>1</sup> Use local jurisdiction depths if greater than these.

<sup>2</sup> If shown or specified, wrap with corrosion protection tape at least 0.250 mm (10 mils) thick, with quality equal to 3M Scotchwrap®.

Place the conduit under curbs without disturbing curbs.

If the trench is not backfilled the same day the rigid nonmetallic conduit is placed:

- Cap or plug all conduit ends,

- Leave one end of conduit run free until backfill is started, or
- Install a rigid, nonmetallic conduit expansion joint in the run

**(d) Conduit under Paved Surfaces** - Install conduit under all paved surfaces by jacking, drilling, or the open trench method.

**(1) Jacking or Drilling** - Jacking or drilling shall not "hump" or deform the pavement and shall be guided. Pneumatic hammers are not allowed. Keep jacking or drilling pits at least 600 mm (2 feet) from the edge of pavement unless otherwise authorized in writing. Do not use water to the extent that the pavement might be undermined or subgrade softened. Sand bedding and marking tape are not required with this method. When the work must be left overnight, cover the jacking pit with adequate planking.

**(2) Open Trench** - If the open trench method is used, do the following:

- a. **Width** - Hold trench width to a practical minimum.
- b. **Pavement Cuts** - Cut the existing pavement as required in 00960.41(a).
- c. **Safety** - Backfill and pave or plate all trenches across paved surfaces during non-working hours.

**(e) Conduit under Railroad Tracks** - Install conduit inside a galvanized, rigid metal conduit at the depth required by the governing railroad company. Construct so that conduit ends are at least 3.7 m (12 feet) beyond the centerline of every track or other distance as required by the railroad. When the work must be left overnight, cover the jacking pit with adequate planking.

**(f) Disposition of Waste Materials** - On completion of the work, or as directed, dispose of all waste materials according to 00330.41(a-6) or as directed.

**(g) Backfill** - Use an approved sand blanket, selected general backfill meeting the requirements of 00330.13, selected granular backfill meeting the requirements of 00330.14, or concrete meeting the requirements of Section 00440 as follows:

**(1) Rigid Nonmetallic Conduit:**

- a. **Bedding** - Place 50 mm (2 inches) of approved sand blanket in trench bottom before placing conduit.
- b. **Cover** - Cover conduit with 50 mm (2 inches) of additional sand drainage blanket.
- c. **Backfill** - Backfill according to the following:

**1. New Roadway and Shoulder, or Existing Non-roadway, Non-shoulder Pavement** - Place and compact selected granular backfill in accordance with 00405.41 to the top of subgrade or bottom of the existing pavement.

**2. Existing Roadway and Shoulder** - Backfill all traffic signal conduit trenches in roadway areas (including paved shoulders) in the following manner:

Construct CLSM backfill according to 00442, placed to an elevation 150 mm (6 inches) below the surface of the existing pavement or to the bottom of the existing pavement, whichever is lower. When this method is used the sand blanket may be omitted.

**3. Unpaved Areas** - Place and compact selected general backfill in accordance with 00405.41 to the top of trench, surrounding ground level or upper limit of excavation as directed. The sand drainage blanket requirement of 1 and 2 above may be deleted as approved when excavated material does not contain large, angular stones that could fracture or dent conduit.

**d. Pavement** - Place and compact AC according to 00749.13 or PCC according to Section 00755 as follows, unless otherwise directed.

**1. Existing Non-roadway, Non-shoulder Pavement** - Match surfacing thickness.

**2. Existing Roadway and Shoulder** - In paved areas, pave to a minimum thickness of 150 mm (6 inches).

**e. Finish** - In paved areas, finish to a smooth riding surface.

**(2) Rigid Metal or Intermediate Metal Conduit** - Omit the sand drainage blanket of a. and b. above, and backfill according to c.

**(3) Signal Conduits in Paved Areas** - Backfill all trenches in new or existing roadway areas, including paved shoulders, with CLSM conforming to 00442. Trenches in existing pavement but not in roadway areas may be backfilled with selected granular backfill or concrete backfill at the Contractor's option.

#### **00960.42 Conduit:**

**(a) General** - Conduit runs shown on the plans are for bidding purposes only. Locations may be changed to avoid obstructions, if approved. Larger size conduit than specified may be used at the option and expense of the Contractor. Use it for the entire length of the run from outlet to outlet. Reducer couplings will not be permitted. Install all underground conduit runs and conduit risers on poles as needed, even if not shown.

Use non-metallic, intermediate metal, or rigid metal conduit where permitted by NEC or shown.

Use rigid metal or intermediate metal conduit elbow when converting from an underground, rigid, nonmetallic conduit to an above-ground run or extension.

In areas to be paved or landscaped, place all conduit before paving or landscaping, unless otherwise allowed in writing.

If corrosive soil conditions exist and if shown or specified, coat metallic conduit with a non-metallic coating or wrap with corrosion protection tape according to 00960.41(c).

**(b) Conduit on Wood Poles** - Mount conduit on Agency-owned wood poles with two-hole, galvanized, steel conduit straps spaced no more than 1 m (3 feet) apart. Mount conduit on utility-owned wood poles according to local utility regulations. Use stand-off brackets if required.

**(c) Conduit on Metal Poles** - Mount conduit on metal poles with 20 mm (3/4 inch), stainless steel straps or a single-hole, galvanized metal strap, drilled and tapped with galvanized bolts. Place straps no more than 1 m (3 feet) apart. After tightly drawing steel bands, cut and fold under the ends to eliminate protruding edges. Mount only service conduit on the outside of poles unless otherwise shown or approved.

**(d) Conduit in Foundations** - Use rigid metal or intermediate metal conduit and extend it 50 mm to 75 mm (2 inches to 3 inches) above the top of the cabinet foundations or pole anchor bolts, and

250 mm to 300 mm (10 inches to 12 inches) beyond the bottom or side of controller or pole foundations.

Install the ground and/or bond conductor conduit on the side of the foundation adjacent to the driven ground rod. Terminate it at least 150 mm (6 inches) below the finished grade at the ground rod location. This conduit may be a bend as described under 00960.42(f).

Group conduits in foundations so that, with the pole in place, it is possible to place an insulated bushing on each conduit end. On breakaway poles, do not extend the conduit above the slip plane of the base.

Place all conduit in the foundation. Surface-mounted conduit will not be accepted.

When a new conduit is required in an existing signal foundation, install the conduit by cutting a slot in the foundation, without cutting reinforcing steel, or by core drilling, as directed. Install the conduit and patch the opening with grout. Extend the new conduit far enough into the base of the pole to allow attachment of a ground clamp. Ground the new conduit to the ground lug inside the pole with a No. 6 copper ground wire. Do not damage the surrounding foundation or reinforcement during these operations. Do not use pavement-breaking equipment.

Install the conduit into an existing controller using an "LB" fitting through the controller riser frame as shown.

**(e) Underground Conduit Installation** - Make conduit runs continuous between any two poles or junction boxes and cabinets. Give the location of conduit and junction boxes to the Engineer. Permanently mark all underground conduit runs by installing an underground marking tape directly over the conduit.

The underground marking tape shall be:

- A red polyethylene film, 150 mm (6 inches) wide, and at least 0.1 mm (4 mils) thick
- Imprinted with the following or similar legend:

**CAUTION CAUTION CAUTION BURIED ELECTRIC LINE**

- Placed 150 mm  $\pm$  25 mm (6 inches  $\pm$  1 inch) below the surface
- Continuous between pole bases, junction boxes and cabinet locations

Do not cover conduit runs until inspected, unless prior approval to proceed is given.

Installation of HDPE conduit may be by jacking, drilling or open trench methods, or by plowing if approved,. Minimum cover shall be 1 m (3 feet).

**(f) Conduit Bends** - Use a standard factory bend where a conduit bend is required, unless factory conduit bend sizes are not commercially available, or a special bend is required. Bends performed on the job or in the shop shall:

- Have a radius of at least six times the inside diameter of the conduit
- Be bent without crimping or flattening
- Be rigid metal or intermediate metal conduit conforming to 02920.10(a), or (b) if the bend is 45° or more, unless otherwise specifically permitted. At junction boxes containing 120 volt circuits, all conduit sweeps and risers shall be galvanized steel and bonded. Conduits entering junction

boxes that contain only detector loop, interconnect, push-button, or communication wiring shall use galvanized steel sweeps and PVC risers with no bonding. Rigid nonmetallic conduit bends may be used for loop detector conduit between the precast concrete junction box and the street pull-box, except where connection is made to the metal street pull-box.

**(g) Conduit Ends and Couplings** - Ream the ends of all conduits, whether cut in the shop or field, to remove burrs and rough edges. Make cuts square and true so the ends will fit together for their full circumference. Slip joints or running threads will not be permitted for coupling conduit. Use an approved threaded union coupling when a standard coupling cannot be used.

Paint the following with rust-preventative coating:

- Threads on all metal conduit before couplings are made up
- Areas where the coating has been damaged so underlying metal is exposed
- Exposed, ungalvanized threads resulting from field cuts

Tighten all couplings until the conduit ends are brought together throughout the entire length of the run.

Cut nonmetallic conduit with a hacksaw or other approved tool, and connect with solvent welds.

Plug or cap all conduit ends with approved material until wiring is started.

Thread nonmetallic conduit fittings for connecting nonmetallic conduit to metal conduit on the metal conduit side.

Use insulated metallic bushings on all conduit ends, whether metal or PVC. Ground bushings where the conduit contains AC circuits; bushings on conduits containing only DC circuits need not be grounded. Bond conduit end bushings to the equipment ground wire, and connect the grounding bushings in the metal pole to the pole grounding lug with a jumper. Install insulated bushings on all conduits. For ground rod conduits, use push-on nylon/PVC bushings.

For signal installations, furnish and install a nonhardening compound or plug/cap that will prevent moisture from entering signal system conduits, whether AC, DC, or combinations. Seal all conduit ends beneath the finished ground line, including those in junction boxes, with this compound or plug/cap, using care to encase individual conductors or cables to achieve a secure seal. Do not use aluminum bushings.

**(h) Conduit in Junction Boxes:**

**(1) General** - Install conduit in junction boxes according to the following:

- Enter through the bottom of boxes where possible.
- Enter the box from the direction of the run.
- Terminate conduit 25 mm (1 inch) inside the box wall when entering through the side walls.
- Use factory 90° ells of metal conduit.

**(2) Cast Iron Junction Boxes** - Conduit entrances into new or existing cast iron junction boxes shall:

- Use a watertight malleable iron hub for metal conduit entrances.
- Use a watertight malleable iron hub when NEMA 3R or NEMA 4 junction boxes are specified.
- Be cut with a hole saw.

Repair damage to galvanizing of existing cast iron junction boxes as directed.

**(3) Concrete Junction Boxes** - Install conduit entrances into concrete junction boxes according to the following:

- Locate conduits near the end walls to leave the major portion of the box clear.
- Orient conduit ends towards the top of the box so that conductors may be pulled out of the conduit from the top of the box without touching the side of the box or other conduits.

**(i) Conduit Installed for Future Use** - If conduit is noted on the plans for future use, with no conductors installed, insert a polyethylene line with at least 1 kN (210 pounds) break strength.

In poles, controller boxes, and junction boxes leave 1 m (3 feet) of slack in the polyethylene line and seal the conduit ends with duct tape. Tuck 1 m (3 feet) of slack into underground conduit ends, and cap the conduit with a standard conduit cap.

**(j) Existing Conduit** - Use existing conduit only where shown. Clean existing conduit, without conductors, with a mandrel or cylindrical wire brush, and blow out with compressed air before incorporating into a new system. Where new junction boxes are placed in existing conduit runs, fit the conduit as specified in (h) above. Install bushings as required by 00960.42(g).

**(k) Conduit in or on Structures** - Install conduit in or on structures according to the plans and Section 00583. Use approved expansion devices at all expansion joints in or on a structure. Install Type "AX" conduit expansion joints with bonding jumper where conduits cross bridge and other expansion joints. The expansion joints shall permit a 200 mm (8 inch) conduit movement on steel structures and a 100 mm (4 inch) conduit movement on concrete structures.

Expansion-deflection fittings shall consist of two silicon bronze couplings and a molded neoprene sleeve with a bonding jumper passing through a separate waterproof compartment. Fittings shall permit at least 20 mm (3/4 inch) expansion and contraction and a 20 mm (3/4 inch) deflection without deformation.

**(l) Installation by Plowing, Jacking or Drilling** - Where specifically approved for the Project, high-density polyethylene conduit conforming to 02920.11(c) may be used for interconnect conduit runs between controllers. Installation may be by plowing, jacking, drilling or open trench. Use 1 m (3 feet) minimum cover.

#### **00960.43 Foundations:**

**(a) General** - Construct foundations for signal and luminaire poles, pedestals, posts, towers, cabinets and tower service pads of concrete ( $f'c = 20$  MPa (3,000 psi)) according to the applicable portions of Section 00440 or 00540 as shown or specified. Place concrete:

- With a continuous pour

#### 00960.43(a)

- To the elevation shown or directed
- With conduit ends and anchor bolts held securely in proper vertical position, to proper height, with a manufacturer's recommended template until the concrete sets

Make no adjustment of anchor bolts after concrete has set. Any adjustment made may be cause for rejection of the foundation.

Maintain rebar clearances during concrete pour.

Set forms square and true to line and grade. Construct forms of rigid materials that remain in position until the concrete has set. In foundations for signal, luminaire and high-mast luminaire poles, use a steel template to accurately locate the anchor bolts and hold them plumb and in proper alignment. Out-of-position anchor bolts and anchor bolts installed more than 1:40 (H:V) out of plumb are cause for rejection of the foundation. Field bending of anchor bolts and field modification of the base plate are not allowed.

Finish tops of foundations to roadway, sidewalk or curb grade, or as directed.

Finish exposed concrete foundations to present a smooth, neat appearance. Fill all holes.

Where breakaway bases are specified, the post stub projection shall not exceed the limits shown.

Where obstructions prevent the construction of planned foundations, construct the foundations in the location directed. Any extra cost due to the site change will be paid according to Section 00196.

If it is determined that foundations must extend deeper than shown, the extra foundation depth will be paid according to Section 00196.

**(b) Treatment for Aluminum-Concrete Contact** - If aluminum poles are used, furnish anchor bolts, nuts, and washers as specified for steel poles.

Separate the aluminum from the concrete with one layer of 13 kg (30 pound) nonperforated, asphalt-saturated felt meeting the requirements of 02920.31(b). Neatly trim the felt pad to the size and shape of the base contact surface.

#### **00960.44 Junction Boxes:**

**(a) General** - Install junction boxes at the approximate locations shown on the plans, or no more than 60 m (190 feet) apart. The Contractor may, at no additional cost to the Agency, install additional junction boxes to facilitate the work.

Size all junction boxes as required by the NEC for the number and size of conductors to be placed in the box. Sizes of junction boxes shown on the plans or in the Special Provisions are inside dimensions.

The tops of junction boxes installed in the ground or in sidewalk areas shall be flush with the surrounding grade or top of curb. Where practical, place pull boxes shown behind curbs against the back of the curb. If installed in the roadway or shoulder, leave the top of junction box about 15 mm (1/2 inch) below the pavement surface.

In boxes having an open bottom, construct a sump of reasonably well graded 9.5 mm - 0 (3/8" - 0) rounded gravel, 300 mm (12 inches) deep covering the approximate area of the box. Do not install conductors until the sump has been constructed. All conduits shall have 250 mm (10 inch) clearance to the lid after the junction box is installed.

Ground metal junction boxes and covers and make them electrically secure to form a continuous system with metallic conduit, grounding wire, metal standards and controller cabinets. Leave enough slack in the ground wire to the cover to allow complete removal of the cover. Junction boxes and covers containing only loop feeders, emergency vehicle preemption cables and DC interconnect do not need to be grounded.

**(b) Junction Box Locations** - Mark the location of all flush-mounted junction boxes installed in unsurfaced areas with a delineator, placed about 1 m (3 feet) behind the box, or as directed.

Use delineators that conform to the dimensions for Type 1, as shown on Drawing RD800 and the applicable portions of 02850.10, and 02850.20. Use white targets with black, 75 mm (3 inch), series "B" letters reading "JCT. BOX". Reflectors are not required.

#### **00960.45 Cable and Wire:**

**(a) General** - Arrange wiring neatly within cabinets and junction boxes. Use approved lubricants when inserting conductors in conduit. Before pulling wires through underground conduit runs, blow the conduit out with 3.4 m<sup>3</sup>/s (120 cubic feet per second) compressed air. Prevent damage to the insulation when installing wire.

Before cable installation, clean all existing and new conduit with an approved cylindrical mandrel of the proper size for that conduit and blow out with compressed air. Mechanical pulling methods may be used for conduit cleaning.

Do not use tapes, straps, ties or other binding materials to bundle single conductors or cables together inside conduits or poles. Bundling of conductors or cables will be permitted at the terminating end points for pulling only.

Install pre-wired factory equipment according to the manufacturer's instructions.

Pull all wire on a straight line with the conduit opening to prevent damage to insulation. If pulls are made with poles or controller cabinet in place, use a pulley device to achieve a straight pull. Other methods may be used if approved.

Use spade-type pressure connectors to connect all traffic signal conductors to terminal screws in cabinets.

#### **00960.46 Metal Poles:**

**(a) General** - Metal poles include towers, mast arm poles, strain poles, pedestals, posts, upsweep arms, mast arms, luminaire arms and necessary mounting appurtenances. The fabrication of metal poles from steel and other metals shall comply with all applicable portions of 02920.31 and AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals. before the pole is placed. Do not erect poles until the Engineer has made a visual inspection of pole welding.

Furnish steel or aluminum poles as shown or specified. Luminaire poles may be of different material and design than traffic signal poles, but poles for similar use must be of same material and design.

Fabricate entrance openings in metal poles and arms, including handholes, before galvanizing, except as shown for mounting traffic signal material.

**(b) Design** - All metal poles with self-supporting upsweep arms shall be designed similar to details shown on the plans.

**(c) Pole Height** - Before poles are ordered, the Engineer will check the pole heights in the field and verify that the specified luminaire mounting heights above pavement are provided. The length of upsweep bracket arms shall be as shown in the Metal Light Pole Table or on the plans. Height of traffic signal poles shall be as shown or specified. Height of poles requiring slip plate bases is the length of shaft above the slip plate.

**(d) Mast Arm** - Install mast arms for traffic signals and signs according to details provided by the manufacturer. Mounting appurtenances shall be the proper type and size to correctly fit the pole furnished, or as shown. Mast arms shall be self-supporting without tie rods, or braces. Mast arms may be tapered, and may be either round, octagonal, or elliptical, if similar in design to those shown.

All mast arms shall allow wiring entrances directly into the pole from inside the mast arm.

**(e) Luminaire Arm** - The luminaire end of the arm shall be level when loaded to design mass (weight). Use a bolted, flange type connection to join the upsweep arm to the pole. The connection shall be raintight and shall develop the strength of the arm. The mast arm rise shall be according to the Metal Light Pole Table, or as shown or specified.

Arms shall be self-supporting without tie rods, or braces. Measure upsweep rise from the point of attachment to the pole to the end tangent portion of the arm. Arms shall be tapered and either round, octagonal, or elliptical, if similar in design to those shown on the plans.

All arms shall allow for wiring entrances directly into the pole from inside the arm.

All pole bracket attachments for mounting upsweep arms shall have reamed, smooth ends.

The nominal mounting height (MH) shown in the Metal Light Pole Table or on the plans is the distance between the roadway at the edge of the pavement and the luminaire. This height may vary plus or minus 0.3 m (1 foot).

**(f) Deflection** - The horizontal dead load deflection at the top of the poles shall not exceed 1% of the pole length (2% for strain poles).

**(g) Deviation from Straightness** - After the poles are delivered to the jobsite, and before they are erected on the foundations, the Contractor may be required to check any or all poles for deviation from straightness according to the following:

**(1) Deviation in One Plane and One Direction Only** - A straight line joining the surface of the pole at the base and the same surface of the pole at the top shall not be more than 15 mm (1/2 inch) from the surface of the pole for each 3 m (10 feet) of length from the closest of these points. The opposite surface shall meet the same requirement.

**(2) Deviation in Any Plane** - A straight line connecting the midpoint of the pole at the base, with the midpoint at the top, shall not pass through the surface of the pole at any intermediate point.

Any pole not meeting these requirements will be rejected. If more than 25% of the poles fail to meet these requirements, sufficient cause exists to reject the entire shipment of poles for the Project.

**(h) Erecting Metal Poles:**

**(1) General** - Erect metal poles and towers on concrete foundations and according to the recommendations of the pole manufacturer and as shown. Exercise reasonable care to prevent marking the finish and damaging poles and towers.

Install all joint traffic signal and illumination poles so the distance from the pavement to the light center is as shown or specified. Use the same tapered design for traffic signal and street light arms.

Bolt protrusion on slip base poles shall not interfere with the breakaway action of pole. File sharp edges smooth, and paint the top of any steel bolt that has been cut off.

**(2) Repair Damaged Finish** - Repair damaged galvanizing or other finish as approved. Apply cold galvanizing to 100 mm (4 inch) diameter poles after cutting threads.

**(3) High-Mast Luminaire Support (Tower) Slip Joint Assembly** - Tightly pull together all telescopic fit joints. Field welding will not be permitted. Pull sections together by chain hoists used in conjunction with choker type hitches of nylon slings. For towers assembled on the ground, use blocking to provide proper alignment.

Other methods or materials may be used only with prior approval.

**(4) Assembly of Supports and Bolt Tightening** - Nuts shall have full thread engagement.

Furnish, at no additional compensation, a calibrated torque wrench of a capacity appropriate to the size and type of the bolts being tightened. Confirm the accuracy of the calibrated torque wrench through calibration by an approved independent testing agency at least one a year.

**a. Anchor Bolts for Signal Supports, Fixed Base Luminaire Supports, and High Mast Luminaire (Tower) Supports** - After foundation concrete strength and curing requirements are satisfied and after inspection of the foundation, pole installation may begin.

Lubricate anchor rods and nuts according to 02560.70. Estimate the required rake, if any, and set the lubricated leveling nuts accordingly, so that when pole installation is complete and all appurtenances are installed on the pole, the top of the pole is plumb with the base of the pole.

Lift the pole into position on the leveling nuts and washers. Make sure all leveling nuts and washers are in full contact with the base plate.

Install washers and lubricated top nuts, and bring to a snug tight condition. Snug tight is defined as the condition when all plies of the connection are in firm contact, and can be obtained by the full effort of a worker on the end of a 305 mm (12 inch) long wrench. Several passes may be required to obtain uniform snug tightness.

When all anchor bolts are snug tight, proceed with installation of arms and other appurtenances, if not previously installed. When installation of arms and appurtenances is complete, and the pole is plumb as defined above, final anchor bolt tightening may begin. If the pole is not plumb, adjust as required and repeat snug tightening as described above. As a safety measure, provide crane support of the pole until anchor bolt tightening is completed.

Mark the position of each turned element (nut or bolt head) with a felt tip pen or similar marker. Rotate each top nut past snug tight by the amount shown in .d below. Several passes may be required to obtain uniform final tightness. "Cheater" bars or slugging wrenches are allowed if required for large diameter anchor bolts.

**b. Anchor Bolts for Slip Base (Break-away) Luminaire Supports** - After foundation concrete strength and curing requirements are satisfied and after inspection of the foundation, pole installation may begin.

Lubricate anchor rods and nuts according to 02560.70. Estimate the required rake, if any, and set the lubricated leveling nuts accordingly, so that when pole installation is complete and all appurtenances are installed on the pole, the top of the pole is plumb with the base of the pole.

Install the anchor plate on the leveling nuts and washers. Make sure all leveling nuts and washers are in full contact with base plate.

Install washers and lubricated top nuts, and bring to a snug tight condition. Snug tight is defined as the condition when all plies of the connection are in firm contact, and can be obtained by the full effort of a worker on the end of a 305 mm (12 inch) long wrench. Several passes may be required to obtain uniform snug tightness.

When all anchor bolts are snug tight, proceed with the "Slip Base Bolting Procedure" as shown on the plans. When the "Slip Base Bolting Procedure" is complete, final anchor bolt tightening may begin. As a safety measure, provide crane support of the pole until anchor bolt tightening is complete.

Mark the position of each turned element (nut or bolt head) with a felt tip pen or similar marker. Rotate the top nut of each anchor bolt past snug tight by the amount shown in .d below. Several passes may be required to obtain uniform final tightness. "Cheater" bars or slugging wrenches are allowed if required for large diameter anchor bolts.

**c. High-Strength Bolts in Mast Arm-to-Pole Connections and Luminaire Arm-to-Pole Connections** - Lubricate high-strength bolts according to 02560.70. Provide all high-strength bolts with hardened flat washers under the element turned during tightening.

If arms or appurtenances are attached after pole erection, support them until bolts are snug tight.

Install high-strength bolts to a snug tight condition. Snug tight is defined as the condition when all plies of the connection are in firm contact, and can be obtained by the full effort of a worker on the end of a 305 mm (12 inch) long wrench. Several passes may be required to obtain uniform snug tightness.

Mark the position of each turned element (nut or bolt head) with a felt tip pen or similar marker. Rotate each top nut past snug tight by the amount shown in .d below. Several passes may be required to obtain uniform final tightness.

**d. Final Tightening** - Required final tightening of anchor bolts and high-strength bolts is shown in the following Table:

Connection Type	Rotation Past Snug Tight
ASTM A 307 Anchor Bolts	30° (1/12 turn)
ASTM A 449 Anchor Bolts	60° (1/6 turn)
ASTM A 325 Arm Connection Bolts	60° (1/6 turn)

**(5) Bolt Inspection** - The Engineer will observe the installation and tightening operations to insure that proper procedures are followed. All inspections will be visual and no testing will be conducted.

**00960.47 Wood Poles** - Rake wood poles away from the direction of the service drop and/or opposite the applied load, unless otherwise specified. Compact backfill thoroughly around wood poles. See Table 00960-1 for depth of pole settings.

**TABLE 00960-1  
SETTING DEPTHS FOR WOOD POLES**

<b>METRIC</b>		
Length of Pole (m)	Depth in Soil (m)	Depth in Rock (m)
7.6	1.5	1.1
9.1	1.7	1.1
10.7	1.7	1.2
12.2	1.8	1.2
13.7	2.0	1.4
15.2	2.1	1.5
16.8	2.3	1.5
18.3	2.4	1.7
19.8	2.6	1.8
21.3	2.7	2.0
22.9	2.9	2.0
<b>ENGLISH</b>		
Length of Pole (feet)	Depth in Soil (feet)	Depth in Rock (feet)
25	5.0	3.5
30	5.5	3.5
35	5.5	4.0
40	6.0	4.0
45	6.5	4.5
50	7.0	5.0
55	7.5	5.0
60	8.0	5.5
65	8.5	6.0
70	9.0	6.5
75	9.5	6.5

Where soil is underlain with rock, the depth of the hole in the rock is to be 70% of the depth required in soil.

Example: Given a 15.2 m (50 foot) pole in 0.6 m (2 feet) soil over rock,

Required depth of hole for all soil setting (from Table)	=	2.1 m (7.0 feet)
Actual soil depth	=	<u>0.6 m (2.0 feet)</u>
Difference	=	<u>1.5 m (5.0 feet)</u>
Depth of hole required in rock portion		
$1.5 \text{ m} \times 0.7 \text{ (5 feet} \times 0.7)$	=	1.1 m (3.5 feet)
Depth of hole through soil	=	<u>0.6 m (2.0 feet)</u>
Total Depth of Hole	=	1.7 m (5.5 feet)

Where poles are located on other than level areas, measure the setting depths from the low side of the hole.

**00960.48 Coating** - Coatings shall conform to all applicable portions of Section 00594. Do not paint equipment fabricated of aluminum, stainless steel, or hot-dipped galvanized material, except as shown or specified.

**00960.49 Electrical Service:**

**(a) General** - Service points shown on the plans are approximate only. The exact location will be determined in the field. If service equipment is to be installed on utility-owned poles, position and attach the service equipment as required by the serving utility. When the size of wire from the utility company's secondary to the disconnect circuit breaker is not shown on the plans, use the size specified by the NEC, but not less in current-carrying capacity than the disconnect circuit breaker rating. Do not use less than No. 6 AWG for the service conductor. Wiring connections to the terminal screws on the circuit breakers and contactors shall make full contact under the screw head. Install conduit and weather heads on the service pole as required by the local utility or as shown. Size and depth of power service conduit shall be as specified by the supplying power company.

Where eyebolts are to be used on signal or illumination poles to receive overhead power service, determine from the local serving utility the direction the eyebolt should face.

Equip each service cabinet with a solid copper neutral bus and the number and size of switches or circuit breakers shown or specified. Install all overcurrent protection and relays as shown and according to the applicable portions of the NEC. Notify the local serving utility before making any contacts to utility poles.

As a part of each service installation, furnish and install a meter base approved by the serving utility (with cover, if required by the utility), when shown.

**(b) Circuit Breakers** - Provide circuit breakers of the rating shown or specified and meeting the requirements of 02920.41.

Install overcurrent protection and relay material for signal installations, as shown or specified, according to the best common practice, with materials and installation meeting all applicable requirements of the NEC for roadway lighting installations. Jack-mount and key relays for proper alignment.

**00960.50 Grounding and Bonding:**

**(a) General** - Make all conduit, metal poles, grounding wire, metallic junction boxes, metallic junction box covers and cabinets mechanically and electrically secure to form a continuous, effectively grounded system. Bond together all rigid steel conduit ends that terminate at the same location. Bond the copper equipment ground wire between the metal poles to the grounding rod at each foundation. Use stranded conductors for all ground and bond wires.

The ground rod for signal equipment may be placed in the nearest junction box within 4.6 m (15 feet) of a cabinet or pole, or in a separate junction box at least 150 mm (6 inches) from the cabinet or pole foundation. Install a separate PVC conduit and ground wire to the junction box.

**(b) Ground Rods** - Construct accessible grounding conditions with electrodes of at least 15 mm x 2.4 m (5/8 inch x 8 foot) nonrusting, copper covered, steel ground rods with bronze grounding wire clamps. Drive ground rods into the ground with the top about 150 mm (6 inches) below the finished grade at the ground rod locations. Install a separate ground rod for each electrical system that originates from a separate power source.

If approved, grounding rods may be driven diagonally. Where rock prevents full length driving, if approved, a buried iron or copper plate may be installed at the bottom of the concrete foundation hole. The plate shall be at least 0.6 m (2 foot) square and 6 mm (1/4 inch) thick.

If resistance to ground is greater than 25  $\Omega$ , furnish and install a second ground rod, at no additional expense to the Agency. Place electrodes at least 1.8 m (6 feet) apart.

If resistance to ground is greater than 25  $\Omega$  after a second rod is driven, additional grounding methods, as approved, will be paid as Extra Work according to 00196.

Use No. 6 AWG copper wire to connect the ground rod to the electrical system.

**(c) Services and Cabinets** - Ground the neutral conductor, the control cabinets, and the metal base to a ground rod. Locate ground rods at ground mounted cabinets outside bases with the ground wires entering the cabinet through a 25 mm (1 inch) metal conduit sweep (non-metallic conduit sweep for signal installation foundations, except remote service cabinets). Connect the conduit sweep, other conduit inside the cabinet, and the ground wire to the ground lug inside the cabinet.

Instead of placing the ground rod outside the traffic signal controller cabinet foundation, the ground rod may be placed within the cabinet base opening.

**(d) Structure Mounted Poles and Cabinets** - Ground all poles and cabinets mounted on structures or walls to a common ground rod at the end of the structure. Ground the system at the first convenient acceptable location off the structure.

**(e) Metal Poles** - Install a ground rod at each pole, pedestal, or tower foundation, except those containing low voltage DC current. At each pole or tower location, supply and install a separate 27 mm (1 inch) metal conduit bend (non-metallic conduit bend for signal installations, except remote service cabinets), with a grounding wire from a lug inside the pole or tower to the ground rod lug at the ground rod. Bond all conduit within the pole or tower together and to the ground rod. Use No. 6 AWG copper grounding or bond wire.

For metal illumination poles (fixed and slip base), install the ground rod for each pole in the concrete junction box at the pole. Install a separate 27 mm (1 inch) non-metallic conduit with No. 6 AWG copper ground wire from the pole base to the junction box and ground rod.

In sidewalk or other areas where the ground rod cannot be made accessible, the ground rod may be driven diagonally through the foundations of fixed anchor base poles. If this method is used, drive the ground rod at least 1.2 m (4 feet) into earth and leave at least 75 mm (3 inches) exposed through the top of the foundation. Bend the rod so that the exposed end is vertical and near the center of the pole. Connect the steel reinforcing cage to the ground rod using a No. 6 AWG copper wire. Securely clamp the wire to the reinforcing steel, through the ground rod clamp, and to the pole grounding lug. Do not use this method on slip base poles.

On the inside of tower shafts, weld a 12.7 mm (1/2 inch), Type 308, 309, or 310 threaded stainless steel stud for a grounding lug. Locate the grounding lug 90° from, and level with, the bottom of the handhole.

For slip base poles, the grounding wire shall not intrude into the slip plane. Instead, run a bond wire from the grounding electrode to a 12.7 mm (1/2 inch), Type 308, 309 or 310 threaded stainless steel stud welded to the bottom base slip plate.

For standard four-bolt anchor base poles, provide a grounding nut for a 12.7 mm (1/2 inch), Type 308, 309 or 310 threaded stainless steel bolt or stud on the inside of the shaft. Locate the grounding nut directly opposite and level with the handhole in the pole.

**(f) Wood Poles** - On wood poles, ground all metallic conduit, messenger cable, terminal cabinet, and other equipment.

00960.50(g)

**(g) Nonmetallic Conduit** - In all nonmetallic type conduit, run a bond/ground wire continuously between all poles, pedestals, posts, and cabinets. Bond/ground wire shall be No. 10 AWG copper wire, or as required by NEC, or as shown. Bond wires are not required:

- At traffic signal installations when the conduit contains only loop feeders, emergency vehicle preemption cables, or DC interconnect cable
- Where nonmetallic conduit is to be installed for future conductors
- Where only low voltage DC currents are present

**00960.70 Electrical Energy** - Obtain the required permits and have the power service inspected by the utility providing power. The Engineer will then arrange for the utility to make the electrical hookup. When agreeable to the Agency and the local power company, power consumption for traffic signals may be flat-rated.

Electrical energy costs to operate traffic signals and/or illumination will be billed to the Agency or those named in the construction agreement. Do not use for construction purposes electrical energy billed to the Agency or other agencies.

The Agency will assume energy and maintenance costs according to 00170.80 for the following:

- New roadway illumination systems, installed and complete
- Independent roadway illumination subsystems (installed complete at a meter service) that have passed the field test prior to Project completion and acceptance

## Section 00970 - Highway Illumination

### Description

**00970.00 Scope** - In addition to requirements of Section 00960, "Common Provisions for Highway Illumination and Traffic Signals", the following Specifications apply to highway illumination installations.

**00970.02 Equipment List and Drawings** - Submit six copies of isocandela diagrams indicating the vertical light distribution, vertical control limits and the lateral light distribution classifications for each type of luminaire submitted for approval. Include a letter from the luminaire manufacturer detailing lamp socket position with respect to lamps and refractors furnished for each I.E.S. light distribution type specified.

Upon request, submit one copy of luminous intensity distribution data in I.E.S. format in an ASCII file on an 88 mm, IBM compatible, computer disk for each type of luminaire submitted with the following:

- **Vertical angles** - Provide data in increments of 5 degrees or less for the vertical angles of 0 to 90 degrees, inclusive.
- **Horizontal angles** - Use a maximum of 10 degree increments for all horizontal angles.

Complete description data is required.

**00970.03 Luminaire Submittal** - Provide a sample luminaire for inspection and photometric testing if required. Sample luminaires may be considered as part of the shipment furnished for installation.

### Construction

**00970.41 Metal Light Pole or Tower Table** - The metal light pole or tower table for the Project can be found on the highway illumination plans.

**00970.42 Cable and Wire** - Use type XHHW stranded copper wire in all current-carrying conductors in raceways.

Support the conductors at the top of the pole using a flexible metal cable support grip to prevent insulation damage at the upsweep arm opening. When splicing into a new or existing circuit at a pole base (minimum wire length: 500 mm (18 inches) outside handhole), install a watertight, in-line fuseholder in the pole base for each ungrounded wire going up the pole. This fuseholder shall conform to the requirements of 02920.26 and be constructed so the wire to the ballast can be disconnected without cutting or disconnecting wiring at the ballast.

Use No. 12 AWG Type XHHW or THWN wire from the control cabinet to the photoelectric relay.

Use No. 10 AWG Type XHHW or THWN wire from the pole base handhole to the high-intensity discharge (HID) ballast.

Wire from the ballast to the lamp holders shall conform to the manufacturer's recommendations.

**00970.43 Photocontrol Electronic Relay** - Equip the photocontrol electronic relay for either luminaire, wood pole or metal pole mounting as shown or specified.

Use a pole-top mounted, photocontrol electronic relay with twistlock plug where shown or specified. Furnish and install a pole-top, slip-fit adaptor with terminal board. Securely fasten the pole-top adaptor to the pole top with setscrew studs, and follow EEI-NEMA specifications for mounting tubeless control

units. Mount the relay above adjacent light units, so the light sensitive element's surface is oriented to the northern sky. Mark the date of installation on the bottom of the photocontrol electronic relay.

**00970.44 Luminaires** - Level luminaires on the upsweep arms in both the transverse and the longitudinal direction, as recommended by the manufacturer.

On roadway grades greater than 4%, orient luminaires on the upsweep arm so that the light beams strike the pavement equidistant from the luminaire.

**(a) Mounting Height** - Mount luminaires at heights shown. Measure the nominal mounting height from the top of the nearest edge of pavement to be lighted to the center of the luminaire.

**(b) Lamp Marking** - Mark the month and year the lamp is installed on the lamp base dating system with a sharp instrument.

**(c) Lamp Size and Identification Decals:**

**(1) Identification Decals for High-Intensity Discharge Lamps** - Indicate the lamp size and type with a NEMA-approved decal on each luminaire as specified below. Apply decals on clean and prepared surfaces. Use decals that provide a durable, legible surface for the life of the luminaire, and:

- Are at least 75 mm (3 inches) square
- Are made of noncorrosive, pressure sensitive material
- Have a colored background with black numbers as shown in Table 00970-1

For pole-mounted luminaires, install the decals on the bottom side of the luminaire or on the arm adjacent to the luminaire, whichever is more visible, as directed.

For wall-mounted luminaires, install the decals vertically on the luminaire housing or adjacent to the luminaire on the wall, as directed.

For pendant-mounted luminaires, install the decals horizontally on the ballast housing or externally at the top portion of the reflector if a remote ballast installation.

(2) **Lamp Size and Identification Decal Code** - Use the lamp size and color codes that conform to the following:

**Tables 00970-1 A and B - Lamp Decal Code  
High Intensity Discharge Lamps**

TABLE 00970-1 A		TABLE 00970-1 B	
Lamp Wattage	Identifying Number	Lamp Type	Background Color
35	3	Clear Mercury	Blue (Light)
50	5	Phosphor-Coated Mercury	White
70	7		
90	9		
100	10		
135	13	High Pressure Sodium	Gold - Yellow
150	15		
175	17		
180	18	Clear Metal Halide <sup>1</sup>	Red
200	20		
250	25	Phosphor-Coated Metal Halide <sup>1</sup>	Green
310	31		
400	40	Low-Pressure Sodium	
700	70		
1000	x1		

<sup>1</sup> In addition, metal halide lamp targets shall include a 12 mm (1/2 inch) wide by 75 mm (3 inch) long strip of pressure sensitive, flat top, wide angle reflective tape to show lamp burning position requirements. Apply tape 15 mm (1/2 inch) from the lamp size target as follows:

Lamp Burning Position	Target Color
Any position	None
Base up to horizontal	None
Base down to horizontal	Gold
Position-oriented-mogul socket (POM)	Red

**00970.45 Pole Identification** - Identify luminaire poles with a numbered label corresponding to the pole numbers on the highway illumination plans. Labels shall:

- Be made of noncorrosive, pressure-sensitive material suitable for outdoor use and resistant to fading and abrasion
- Have blue or black numbers with a high-contrast colored background
- Have 6 mm (1/4 inch) block numbers at least 50 mm (2 inches) high

Install labels on poles so they are visible from a passing vehicle.

### Maintenance

**00970.60 Maintaining Existing and Temporary Illumination Systems** - Keep existing illumination systems (street and highway lighting and sign illumination), their approved temporary replacements, or temporary construction lighting in effective operation for the benefit of the traveling public during

progress of the work, except when shutdown is permitted to allow alteration or final removal of the systems. Lighting system shutdowns shall not interfere with the regular lighting schedule unless otherwise permitted. Notify the Engineer before performing any work on existing systems.

Determine the exact location of existing conduit runs and pull boxes before using equipment that may damage such facilities or interfere with any system.

If damage is caused by the Contractor's operations, repair or replace damaged facilities promptly at no additional compensation according to 00150.70. If the Contractor fails to perform the required repairs or replacements, the Agency retains the right to perform this work according to 00150.75.

Where roadways are to remain open to traffic and existing lighting systems are to be modified, keep the existing systems in operation until the final connection to the modified circuit is made. The modified circuit is to be complete and operating by nightfall of the same day the existing system is disconnected.

Keep temporary construction lighting installations in effective operation until they are no longer required for the protection of the traveling public.

### **Finishing and Testing**

**00970.70 Field Test** - Operate the completed lighting system or subsystem continuously for seven consecutive days and an additional seven days normal burn afterwards. When the lighting performance is satisfactory, the Contractor may be relieved of maintenance responsibility according to 00170.80(b).

Before completing the work, conduct the following tests on all lighting circuits in the presence of the Engineer .

- A Megger test on each circuit between the conductor and ground with all switchboards, panelboards, fuse holders, switches, receptacles and overcurrent devices in place. Record all readings. Furnish the Engineer with one copy of the test results identifying observed readings with their respective circuits.
- Test the insulation resistance between conductor and ground. Resistance shall be as follows on circuits with total single conduction length of:
  - 750 m (2,500 feet) and over - at least 6 M $\Omega$
  - Less than 750 m (2,500 feet) - at least 8 M $\Omega$

Any change in the above minimum readings must be requested in writing, and written approval obtained from the Engineer. Only those factors based on dielectric properties of conductor insulation, splicing insulation, terminal strip castings, etc., will be cause for consideration of a variance.

### **Measurement**

**00970.80 General** - No measurement of quantities will be made for this work. If plan changes are ordered, or the field-verified pole or arm lengths increase or decrease for lighting poles and arms, adjustment will be made according to 00970.91.

The estimated quantities of lighting poles and arms will be listed in the Special Provisions for the purpose of providing a basis for adjustment. No adjustment in the Contract lump sum amount will be made, except as provided above. Any adjustment in the Contract lump sum amount will be made according to 00190.10(e).

## Payment

**00970.90 Lump Sum Basis** - Payment will be made at the Contract lump sum amount for the following items:

Pay Item	Unit of Measurement
(a) Pole Foundations .....	Lump Sum
(b) Lighting Poles, Fixed Base .....	Lump Sum
(c) Lighting Poles, Slip Base .....	Lump Sum
(d) Lighting Pole Arms .....	Lump Sum
(e) Luminaires, Lamps and Ballasts .....	Lump Sum
(f) Switching, Conduit, and Wiring .....	Lump Sum
(g) Refurbishing and Reinstalling Existing Illumination Systems .....	Lump Sum

Item (a) includes all concrete foundations for lighting poles.

Item (f) includes all switches, conduit, cabinets, wiring, delineators and other items required to construct the lighting system as specified.

Item (g) includes all refurbishing, reinstalling, and other work as specified and not included in the removal of existing illumination.

Labeling lights or poles will be considered incidental to the appropriate light or pole pay item.

Payment will be payment in full for furnishing and placing all materials, and furnishing all equipment, tools, labor and incidentals necessary to complete the work as specified.

**00970.91 Adjustments** - In items (b), (c) and (d) no adjustment in payment will be made for increases or decreases of individual pole or arm lengths up to and including 1 m (3 feet).

Adjustment in payment for increases or decreases of individual pole or arm lengths more than 1 m (3 feet) will be made only on the increased or decreased length more than 1 m (3 feet).

**00970.92 Electrical Energy Costs** - All electrical energy costs for the lighting systems or subsystems will be paid for by the Agency.

**00970.93 Incidental Items** - If shown or specified as part of the work under the pay items for concrete bridges or retaining walls, all conduit, junction boxes, cabinets and other items permanently encased within the concrete of bridges and retaining walls, as well as pole foundations incorporated in a bridge or wall, will be considered incidental to the work for those items. Include the cost of this work in those items.

**Section 00980 - Sign Illumination**

**Description**

**00980.00 Scope** - This work consists of furnishing and installing all necessary conduit, junction boxes, cabinets, wiring and other equipment as shown and specified for sign illumination.

**00980.01 Regulations and Code** - All electrical equipment and work shall conform to 00960.01.

**00980.02 Equipment Lists and Drawings** - Submit required equipment lists, working drawings and as-constructed drawings according to 00960.02.

Submit six copies of isocandela diagrams for each different size sign to be illuminated. Provide data in tabular form showing the luminance levels, in lx (footcandles), at 0.3 m (1 foot) intervals in both the horizontal and vertical directions over the entire sign surface. Submit from the luminaire manufacturer details of lamp socket position with respect to lamps and refractors furnished, for each type of luminaire specified.

Complete description data is required including noted exclusions for any of the luminaires specified.

**00980.03 Luminaire Submittals** - If directed, provide a sample luminaire for inspection and photometric testing. Sample luminaires may be considered as part of the shipment furnished for installation.

**Materials**

**00980.10 General** - Materials shall meet the following requirements:

Ballasts .....	02920.52
Cabinets.....	02920.40
Cable and wire .....	02920.20 -28
Conduit .....	02920.10 -12
Control devices .....	02920.42
Electrical splice materials.....	02920.25
Junction boxes.....	02920.13
Lamps .....	02920.50
Wood poles.....	02920.30

All conduit, junction boxes, and cabinets for sign illumination circuits, that are also used for roadway illumination are discussed in Section 00960 and Section 00970.

**00980.11 Sign Luminaire Ballasts** - Provide high-intensity discharge ballasts of the type and wattage shown or specified.

**00980.12 Sign Luminaires:**

**(a) General** - Bottom-mount all sign luminaires as shown.

Electrical components of the sign luminaires shall bear the label of approval by the Underwriters' Laboratories, Inc.

**(b) High Intensity Discharge Sign Luminaires** - Fabricate high-intensity discharge sign luminaire housings of either cast aluminum, 2 mm (0.80 inch) minimum die-formed aluminum, or 1.6 mm (0.064 inch) minimum extruded aluminum. The reflector shall be die-formed, anodized specular aluminum. Fabricate lens frames of cast or extruded aluminum. Mount the refractor in the lens frame

assembly and hinge to the luminaire housing. The refractor and lens frame assembly, when closed, shall exert even pressure against a gasket seat. Furnish gaskets of material capable of withstanding temperatures encountered. Securely seat the gasket in place. Glassware shall be thermal, shock-resistant borosilicate glass.

Provide stainless steel or corrosion-resistant fasteners. Protect all aluminum surfaces with either an anodized finish or an approved aluminum paint finish.

Mount ballasts integrally with the luminaire. Mount luminaires on the luminaire support arms as shown and with a low profile, not to exceed 280 mm (11 inches) in height when mounted. Shield luminaires so no light will be visible from behind the luminaire.

Determine, provide and install the number of luminaires needed to illuminate each sign.

The total nominal lamp power (not including ballast) for each sign length shall not exceed the following:

<b>METRIC</b>	
<b>Sign Length, L</b>	<b>Maximum Lamp Power (watts)</b>
Less than 2.7 m	250
2.7 m to less than 5.2 m	500
5.2 m to less than 7.9 m	750
7.9 m to 10.7 m	1000

<b>ENGLISH</b>	
<b>Sign Length, L</b>	<b>Maximum Lamp Power (watts)</b>
Less than 9' 0"	250
9' 0" to less than 17' 0"	500
17' 0" to less than 26' 0"	750
26' 0" to 35' 0"	1000

Use only 100, 175 or 250 W phosphor coated mercury vapor lamps. When necessary, adjust spacing of the luminaires and/or safety rail posts to prevent interference.

The photometric performance of mercury vapor luminaires equipped with a 4000, 8000, or 11 500 lm lamp, with the light center 300 mm (12 inches) below and 1.2 m (48 inches) in front of the sign (1.4 m (54 inches) when sign height is equal to, or greater than, 2.1 m (7' 0")), shall meet the following criteria on each sign:

<b>METRIC</b>	
Average Horizontal lx, minimum	350
lx, minimum	85
Maximum/minimum uniformity	6.0:1 or less
Maximum gradient	1.7:1 or less
Uniformity of illumination, minimum	60%

**ENGLISH**

Average Horizontal Footcandles, minimum	35.0
Footcandles, minimum	8.5
Maximum/minimum uniformity	6.0:1 or less
Maximum gradient	1.7:1 or less
Uniformity of illumination, minimum	60%

Maximum gradient is the ratio of the illumination value on any 0.1 m<sup>2</sup> (1 square foot) area of the sign to the value on any adjacent 0.1 m<sup>2</sup> area (1 square foot).

$$\text{Uniformity of Illumination} = \left( 1 - \frac{\text{mean deviation}}{\text{average FC}} \right) \times 100\%$$

$$\text{Where mean deviation} = \frac{\sum \text{ABS}(\text{FC}_{\text{point}} - \text{FC}_{\text{ave}})}{\text{number of points}}$$

**00980.13 Sign Luminaire Identification Decals for High-Intensity Discharge Lamps** - Provide identification decals meeting the requirements of 00970.44(c-1) and (c-2). Install decals on the bottom side of luminaires to provide good visibility from the ground.

**Construction**

**00980.40 General** - Furnish and place miscellaneous materials not shown or specified, but required to complete the illumination installation, as shown or specified. Such materials will be approved as suitable for the use intended.

Construct and test according to this Section and Sections 00960 and 00970.

**00980.41 Installation of Wiring and Conduit** - Install all sign illumination wiring, both above and below ground, according to the NEC with type and wire size as shown or specified. Install all conduit according to Section 00970. All conduit, junction boxes and cabinets for sign illumination circuits, which are used for roadway illumination are covered under Section 00960 and Section 00970.

Use No. 10 AWG type XHHW wire from the sign disconnect breakers to the sign luminaires.

Install rigid metal or intermediate metal steel conduit on the sign structure with flexible conduit connections to the junction box on the pipe support and at the end connection to the sign luminaires. The minimum size of any type of conduit to be installed shall be 19 mm (3/4 inch).

Install the power feed conductors from the service pole to the sign structures as shown.

**00980.42 Grounding and Bonding** - Ground and bond according to 00960.50, except provide a handhole in the sign support column to provide access to the grounding conductor and grounding lug. Ground metal sign support structures using the same method as for metal light poles.

**00980.43 Sign Control Equipment** - Install electrical sign disconnect circuit breakers of the size shown in disconnect cabinets on sign support structures or where shown, or provide one circuit breaker for each overhead sign and all ballasts for that sign.

**00980.44 Cabinets** - Mount the sign control cabinet on the support column on the side away from traffic.

**00980.45 Galvanizing** - Galvanize all components of steel sign illumination equipment after fabrication and before assembly. Galvanize according to AASHTO M 111M/M 111 (ASTM A 123/A 123M).

#### **Measurement**

**00980.80 Lump Sum Basis** - There will be no separate measurement for work done under this Section.

#### **Payment**

**00980.90 General** - Payment will be made at the Contract lump sum amount for the item "Sign Illumination Equipment". Payment will be payment in full for all equipment labor and incidentals necessary to complete the work.

**00980.91 Incidental Items** - If shown or specified as part of the work under the pay items for concrete bridges or retaining walls, all conduit junction boxes, cabinets and other items permanently encased within the concrete of bridges and retaining walls, as well as pole foundations incorporated in a bridge or wall, will be considered Incidental to the work for those items.

## Section 00990 - Traffic Signals

### Description

**00990.00 Scope** - In addition to requirements of Section 00960, install traffic signals according to the Manual on Uniform Traffic Control Devices with Oregon Supplements, Institute of Traffic Engineers standards, and the following Specifications.

### Materials

**00990.10 General** - Materials required for completion of the installation will be shown or specified. Materials shall meet the requirements of the following:

Aluminum poles .....	02920.31
Anchor bolts .....	02920.34
Audible pedestrian signal .....	02920.66
Ballasts .....	02920.52
Cabinets .....	02920.40
Cable and wire .....	02920.20 -28
Circuit breakers .....	02920.41
Conduit .....	02920.10 -12
Detection devices .....	02920.45
Electrical splice materials .....	02920.25
Flasher mechanism (remote from controller cabinet) .....	02920.42
Frangible bases .....	02920.33
Illumination control devices .....	02920.42
Inductive loop feeder cable .....	02920.22(d)
Inductive loop wire .....	02920.23(b)
Interior illumination signs .....	02920.61
Junction boxes .....	02920.13
Lamps .....	02920.50 -51
Luminaires .....	02920.53
Pedestrian signal heads and push buttons .....	02920.65
Signal heads .....	02920.64
Signal indication devices .....	02920.60
Steel poles .....	02920.31
Steel towers .....	02920.32
Traffic signal control devices .....	02920.42
Wood poles .....	02920.30
Wood sign posts .....	00910

Use pre-formed loops, fire preemption systems, backer rod material, and hot-melt loop sealant from the QPL.

### Construction

#### **00990.40 Cable and Wire:**

**(a) General** - Install wire and cable according to 00960.45 and the following:

Install wire between pole or pedestal bases and terminating points without splicing. Install control cable from signal spans to terminal cabinets without splicing. Do not use junction boxes for splicing, except for loop wire splicing to loop wires or loop feeder cables.

Termination of the conductors of interconnect cable in interconnect cabinets and controller cabinets will be by others.

Leave slack in each wire and cable at each pull box, pole, and controller cabinet as follows:

- 0.6 m (2 feet) in pull boxes and poles
- 2.0 m (6 feet) in controller cabinets

Use stranded wire as shown for single conductors and cables inside poles and conduit. In mast arm poles and arms, use control cable from the pole terminal cabinet to vehicle signal heads and signs. Run a separate No. 14 AWG cable as required, including common or as shown, for each signal head. Signs powered from the same output may use a common 2-conductor (No. 12 AWG for interior illumination and No. 10 AWG for Part Time Restriction) control cable.

Provide and install spare wires from the controller to the terminal cabinet as shown.

Where new conductors are to be added to an existing system, remove the existing conductors and pull the new and existing conductors together unless another procedure is approved.

Carry the push button common throughout the system as a separate wire.

**(b) Control Cable Attachment** - Use self-locking plastic straps to attach control cables to the messenger cable. Do not allow gaps between the control cable and the messenger cable. After tightening, trim all excess material neatly.

Where supervisory control cable is run aurally between intersections, attach the control cable to the messenger cable by either self-locking plastic straps, or by lashing the control cable to the messenger.

Provide sufficient conductors to perform the functional operation shown. Tape the ends of extra conductors with insulating tape. Where the plans omit necessary wiring to provide the operation shown, furnish and install wire as needed to meet the operational requirements shown or specified. The number of conductors in a cable may be greater than that shown.

**(c) Messenger Cable** - Attach messenger cable at least 150 mm (6 inches) below the top of the pole, unless otherwise shown or specified.

Use an eyebolt and StrandVise<sup>®</sup> to attach messenger cable to Agency-owned wood poles.

Make attachments to utility-owned poles according to the local utility company's regulations and under its supervision.

Do not weld eyebolts to poles. Install the eyebolts through the entire pole. Pull the shoulder of the eye tight against the front face of the pole.

**(d) Tether and Stabilizer Cable** - Install tether and stabilizer cables on traffic signal spans where shown. Tighten cables to limit signal and sign movement. Install Agency-furnished S-hooks between the eyebolt and turnbuckle.

**(e) Interconnect Cable:**

- (1)** Splices or breaks in the interconnect cable and shield will not be permitted except as shown.

Use weatherheads for the pole entrance of interconnect cable. Weld all around the pole entrance fitting. Use a Bonney Forge Co. Thredolet<sup>®</sup>, a Phoenix Forge Co. Trans-O-Con<sup>®</sup>, or equivalent.

Clean all welds, wire brush, and paint with at least two coats of zinc paint. Weatherheads used for interconnect cable shall be sized as shown.

## **(2) Interconnect Cable Installation:**

All cable installation shall meet the requirements of the Standard Specifications, the National Electric Code, and the National Electrical Safety Code, and will be approved by the Engineer and the utility engineer, where applicable. Use approved cable guides, feeders, shoes and bushings to prevent damage to the cable during installation. Do not pull cable over edges or corners, over or around obstructions or through unnecessary curves or bends. Cable shall enter the box or cabinet directly from the reel or storage stack. Pull directly out of the next downstream box or cabinet.

Match the sag as closely as possible with wires already on poles to minimize movement in windstorms and conflict with adjacent wires.

Use a grip or "come-along" to grip the jacketed messenger when pulling and tensioning. Pull and tension cable without damaging the jacket. When separating the messenger on figure-8 cable from the jacketed conductor assembly for dead-ending or splicing, split the web using approved tools designed for this task.

At corners and run ends, dead-end the messenger strand with approved automatic StrandVises<sup>®</sup> or similar devices. Cut the strand and remove the jacket, exposing enough strand so that the ends of the strands coming through the chucks of both vises can be overlapped and bonded together to form a continuous ground. Use a one-bolt guy clamp to bond the strand ends together. Where figure-8 cable is used, remove existing unused messenger cable.

In transition areas from overhead to underground, continue the aerial cable underground to the nearest termination panel. If figure-8 type cable is used for overhead locations, strip the messenger wire from the cable, using approved tools, where the cable is within a conduit, pole or cabinet.

Cable in trunk runs may be installed by hand or by mechanical methods, as approved. Trunk runs are those lengths of conduit that will have 25 or more pairs of interconnect cable installed. Install all other cable by hand methods only.

Before installing cable, provide the Engineer with one copy of the cable manufacturer's recommended and maximum pulling tensions for each cable type. Specify these pulling tensions for both pulling from the cable's conductors and for pulling from the cable's outer jacket.

When installing cable using a pulling eye, do not exceed the cable manufacturer's maximum recommended pulling tension for pulling from the pulling eye. When installing cable using a pulling sock over the outer jacket, do not exceed the cable manufacturer's maximum recommended pulling tension for pulling by the outer jacket, or 80% of the manufacturer's maximum recommended pulling tension for pulling by a pulling eye, whichever is smaller. Use an approved dynamometer to ensure that the maximum allowable pulling tension is not exceeded during installation.

Run all cable continuously without splicing from termination point to termination point. Splicing cable at any location other than shown is not permitted. Splicing cable in conduit, junction boxes, underground vaults, manholes, or handholes is not permitted.

Do not pull cable through any intermediate junction box, handhole, or any other opening in the conduit, unless shown or approved. Pull the necessary length of cable to be installed from one junction box, handhole, controller cabinet, or terminal cabinet to the immediate next downstream box, handhole, or cabinet. Carefully store the remaining length of cable to be installed in the next conduit in a manner that is not hazardous to pedestrian or vehicular traffic, and protects the cable

from damage. Store the cable so that it can be safely pulled into the next conduit. Obtain the Engineer's approval of the storage methods to be used.

At all termination points, seal cable ends with an approved end cap to prevent moisture or dirt from entering the cable end. Do not use tape to seal the cable end.

Label all interconnect cable with approved bronze or plastic labels, permanently and ruggedly attached. The labels shall be embossed with the cable identification number. Additionally, labels used on utility facilities shall bear the legend "TRAFFIC SIGNAL". Label all ends of cables. Label all overhead cable in each direction away from the point of attachment, 0.6 m (2 feet) from utility poles. Do not install labels until the Engineer approves the labels and attachment mechanism. Label all cables in the interconnect terminal cabinets and at terminal panel locations. In all junction boxes, interconnect terminal cabinets, auxiliary cabinets, controller cabinets, and terminal cabinets, permanently attach 250 mm (10 inch) lengths of 25 mm (1 inch) wide light blue or royal blue plastic surveyor's marker tape, or equivalent, to all interconnect cable. No adhesive marker tape or other such malarkey will be permitted.

Where the Contractor is to remove or install interconnect cable in conduit containing service wiring and/or field wiring, whether or not the plans indicate service and/or field wiring in that conduit, use the following procedure, unless another procedure is approved:

- a. The Agency will disconnect all necessary service and/or field wiring.
- b. Furnish, install and maintain all traffic control devices and procedures.
- c. Remove all cable and wiring from the conduit, being careful not to damage any wiring. Replace to the Engineer's satisfaction all wiring to be reinstalled that is damaged by the Contractor, at no expense to the Agency. Any wiring, except solid-conductor ground wiring, not suitable for reinstallation that has been removed by the Contractor with all reasonable care, as determined by the Engineer, shall be replaced to the Engineer's satisfaction and paid for as Extra Work.
- d. Replace all solid-conductor ground wiring removed from conduit with No. 6 bare or green THWN stranded copper wire.
- e. Clean the conduit as described in 00960.45(a).
- f. The Agency will reconnect all wiring.

Protect existing cables or equipment from damage as required by 00150.50(c) and 00150.70. Should existing cables or equipment be damaged by the Contractor's operations, immediately notify the Engineer and the affected owner. The cost to repair damages caused by the Contractor's actions may be withheld according to 0170.91.

**(3) Interconnect Cable Testing** - Test interconnect cable according to 00990.70(i).

#### **00990.41 Cabinet:**

##### **(a) Signal Circuit Overhead Terminal Cabinets:**

**(1) General** - Mount a signal circuit terminal cabinet on traffic signal poles as shown. All terminal cabinets shall be 150 mm x 200 mm x 460 mm (6" x 8" x 18"), with a 60 mm (2 1/2 inch) wire entrance and three terminal block mounting brackets.

If a mast arm pole has no span wire attachment, locate the terminal cabinet above the pedestrian signal mounting brackets as shown.

In each cabinet, install the number of double terminals needed for the circuits, plus two spare terminals. These spares are not to be used by the Contractor. Divide the number of terminals required as evenly as possible over the three mounting brackets in the cabinet.

Where a signal system common enters a terminal cabinet, the cabinet shall contain a 50A double terminal for the system common. If necessary, add other terminals of the same capacity to accommodate all of the commons. If other terminals are required, use a wire jumper of the same size as the system common between the terminals.

All other terminals shall have sectional or stackable 600 V terminal blocks and be of sufficient size to accommodate all required wires. Use Square D<sup>®</sup>, Type K channel mounting terminal blocks or approved equal.

Enter on the marking strip the wire number and/or letter as coded at the terminal strips in the controller cabinets. Use only mechanically printed labels.

Use weatherproof compression fittings in the bottom of the cabinets for cable entrances.

For the pole entrance into terminal cabinets, use a 60 mm (2 1/2 inch) Thredolet<sup>®</sup> as manufactured by Bonney Forge Co., a Trans-O-Con<sup>®</sup> as manufactured by Phoenix Forging Co., or equivalent. Weld the fitting all around. Clean, wire brush, and paint welds with at least two coats of zinc paint. Instead of this, the fitting may be placed by the manufacturer and hot-dip galvanized with the pole.

**(2) Existing Terminal Cabinet** - If it is determined that existing terminal cabinets need to be replaced, and this work is not covered by the Contract Documents, furnish and install the cabinet with the required number of sectional double terminals on an Extra Work basis according to Section 00196.

**(b) Remote Detector Amplifier Cabinet** - The minimum size for cabinets shall be:

Number of Detector Amplifiers	Height	Width	Depth	Number of Shelves
4 or less	400 mm (16")	300 mm (12")	250 mm (10")	1
5 to 8	500 mm (20")	400 mm (16")	250 mm (10")	2

All amplifier cabinets shall contain:

- A 20A circuit breaker for power disconnect
- A 12 mm (1/2 inch), screened drain hole in the bottom. Use a fine mesh screen made of either brass or stainless steel, soldered or spot-welded in place.
- An adequate number of double-barrier screw terminals, as determined by the Contractor, based on the number of field connections required and cable harness connections

Crimp and solder all spade connectors on wires connecting the input panel to the input files.

Submit the cabinets with amplifiers for visual inspection and testing.

**(c) Flasher Cabinet** - Flasher cabinets shall be 200 mm x 200 mm x 460 mm (8" x 8" x 18"). Cabinets shall contain the devices shown.

**(d) Power Service Cabinet** - Install traffic signal service cabinets so that the meter placement is acceptable to the local power company.

**(e) Cabinet Protection** - Keep interiors of all cabinets clean and free of dust, dirt, moisture, and other foreign matter. In inclement weather, use tents to cover cabinets when doors are open. Vacuum and dry out all cabinets immediately before installing equipment unless otherwise directed. Correct any damage caused by dust, dirt, moisture or foreign matter at no cost to the Agency.

#### **00990.42 Indication Equipment:**

**(a) Standard Vehicle Signal Heads** - Standard traffic signal heads shall be one-way, three-section heads, adjustable through 360 degrees about a vertical axis, and designed for the method of mounting shown or specified. Furnish heads complete, including lamps, lenses, red LEDs, visors, reflectors, sockets, backboards and mounting appurtenances. Install all lamps with the open end of the horseshoe-shaped filament in the up position.

Vehicular signal heads shall be:

- Designed so they can be suspended from mast arms or span wires, or mounted on brackets or pedestals as required
- Equipped with positive lock rings and fittings designed to prevent the heads from turning due to external forces
- Equipped with all necessary appurtenances for the type of mounting required

Tighten all backboards and visors securely against the signal head.

For requirements relating to special vehicle signal heads (signal heads required to produce an indication other than those resulting from the use of standard red, yellow and green lenses) see the Special Provisions.

**(b) LED Traffic Signal Head Retrofit Kits** - Retrofit kits in new or existing heads shall fit into all types of 305 mm (12 inch) traffic signal heads without the need to modify the head, except for removal of lens, reflector, bulb and socket assembly. Mount the kit using the existing lens mounts. Kits are not required to fit 3M<sup>®</sup> optically programmed signal heads.

**(c) Optically Programmed Vehicle Signals** - Furnish and install complete, optically programmed vehicle signals that conform to all applicable portions of 00990.42(a). A complete vehicle signal includes the required number of signal sections with optical components, individual intensity control, cutaway visor, backboard and mounting hardware.

**(1) Optical System** - Optically programmed vehicle signals shall:

- Have lenses with a nominal diameter of 305 mm (12 inch)
- Use lamps of the type and wattage recommended by the signal manufacturer
- Permit selective programming of the visibility zone of the projected indication anywhere within 15 degrees of the optical axis of each signal section
- Include an easily accessible visibility-limiting device that can be programmed to restrict the viewing area of the projected indication without the use of hoods or louvers

- Include an integral means for regulating the intensity of the projected indication as a function of the ambient light conditions. The reduction in lamp intensity shall be proportional to the reduction in ambient light within the following limitations:
  - If ambient light is 10 000 lx (1,000 footcandles) or more, the lamp intensity shall be at least 97% of maximum.
  - If ambient light is 10 lx (1 footcandle) or less, reduce the lamp intensity to approximately 15% of maximum.

**(2) Installation** - Provide a manufacturer-certified technical representative who shall:

- Program the visibility-limiting device as outlined by the signal manufacturer. The technical representative shall furnish all needed special materials
- Program the signals satisfactorily before placing the signal installation in operation

On programmed vehicle signals mounted on span wires, install washers on the pin that connects the signal hanger to the cable clamp. Install enough washers to limit the lateral movement of the hanger to a minimum.

**(d) Pedestrian Signal Heads** - All relevant portions of 00990.42(a) and 02920.65 apply to pedestrian signal heads.

**(e) Flashing Beacon Signal Heads** - Flashing beacons shall:

- Conform to all applicable portions of this subsection
- Be of single-section construction
- Be equipped for the type of mounting shown

Use the size of lamps specified in 02920.51. Do not wire green arrows into the flashing circuit where used with flashing beacon indications.

Where a flashing yellow lens of 305 mm (12 inch) nominal or greater diameter is to be used as a beacon, provide and install an effective voltage reducer to the lamp circuit that will reduce the voltage level at least 33%, but not more than 50%, of rated voltage when ambient light conditions reach about 1 lx (0.1 footcandle).

Mount single-section heads on span wires as shown for three-section heads. Hang heads as nearly plumb as feasible.

**(f) Suspension of Signal Heads** - Suspend vehicle and pedestrian signal heads as shown.

**(g) Vehicular Signal Head Covers** - Cover mounted vehicle signal heads at all times until the signal installation is ready for continuous operation. Cover the entire face of the signal head to the rim of the backboard with burlap, canvas, black plastic or other approved cover material, except that 10% of each lens may be left visible to facilitate testing.

**(h) Audible Pedestrian Signal (APS)** - When shown or specified, the APS shall provide a unique sound coincidental with the WALK indication. The APS shall include a solid state electronic board(s), power supply, enclosure, loudspeaker and mounting hardware necessary for fulfilling the intended use stated herein and in applicable portions of Chapter 1 of the September 1998 Standard Specification for Microcomputer Signal Controller.

**(1) General** - The exterior dimensions of the APS unit shall not exceed 150 mm (6 inches) in height, 100 mm (4 inches) in width, and 150 mm (6 inches) in depth.

The mass (weight) of the APS unit shall not exceed 0.5 kg (1 pound).

The delay time shall be adjustable in one-second increments throughout the range of 0 to 15 seconds.

The APS unit shall have a sound inhibit circuit capable of control by an external device.

**(2) Electrical Requirements** - The APS unit shall operate on 95 to 130 VAC, 60Hz,  $\leq 3$  W.

Provide a power protection circuit consisting of both fuse and transient protection.

Provide an optically isolated circuit allowing delayed actuation of the audible signal.

**(3) Environmental Requirements** - The APS unit shall function properly throughout an ambient air temperature range of  $-37^{\circ}\text{C}$  to  $+74^{\circ}\text{C}$  ( $-35^{\circ}\text{F}$  to  $165^{\circ}\text{F}$ ).

**(4) Outputs** - Provide voice message including automatic repeat capability for messages up to 20 seconds in length.

The audible signal shall be self-adjusting based on ambient noise during the WALK period.

The volume level at a distance of 1 m (3 feet) from the APS enclosure shall be 66dB typical, with a maximum of 90dB.

The minimum volume level shall be adjustable proportionally from 66dB to 90dB without dismantling the APS unit housing.

Provide two switch-selectable electronic sounds as specified in the following:

Parameter	Sound #1	Sound #2
Sound type	"Peep-peep"	"Cuckoo"
Method	Electronic var. frequency tone	Electronic var. frequency tone
Period	1.0 sec. $\pm 20\%$	1.5 sec. $\pm 20\%$
Duration	0.2 sec. $\pm 20\%$	0.6 sec. $\pm 20\%$
Frequency Base	2800 Hz $\pm 20\%$	1100 Hz $\pm 20\%$
Frequency Deviation	- 800 Hz $\pm 20\%$	+120 Hz $\pm 20\%$

#### 00990.43 Traffic Signal Detection Devices:

**(a) Pedestrian Push Buttons** - Mount pedestrian push buttons on a pole, pedestal or post whose foundation directly abuts an asphalt concrete or portland cement concrete landing or walkway. Equip push buttons with an instruction sign having an arrow pointing to the crosswalk for which it is intended.

#### **(b) Inductive Loop Detectors:**

**(1) Saw Cut** - Make cuts compatible with construction and in the most practical, direct line between loops and junction boxes, except where parallel to, or nearly parallel to, a lane line; then locate cuts under the lane lines.

Make saw cuts at least 13 mm (1/2 inch) wide for loop wire and loop feeder cable. 13 mm (1/2 inch) saw cuts may be made with single blades. For wider cuts, use multiple-blade saws.

Saw cuts shall have smooth bottoms, with no edges due to differences in cut depth.

Saw cuts shall not require greater than a 130-degree bend in loop wire. Cuts shall not create islands of pavement less than 0.25 m<sup>2</sup> (2 1/2 square feet) in area.

Flush cuts thoroughly with a high-pressure water stream immediately after sawing, and before the cuttings dry. Blow free of water, debris, rock, and grit with high-volume or high-pressure air. Slots may also be cleaned by means of a high-pressure water injection/vacuum extraction system.

Dry before placing wire. Remove rocks or other material that may be wedged in the cut.

Any number of loop wires may be installed in a single saw cut, as long as the minimum cover shown is provided (see standard drawings) and adequate pavement depth is available. The Engineer may limit the allowable saw cut depth and width to avoid damage to the pavement.

Do not make saw cuts in a new open-graded AC wearing course. Instead, install loops in the base lift, or in the existing surfacing if it is to be overlaid, and after milling has been completed.

In an existing open-graded AC surface, the saw cut and installation shall be similar to the detail, "Installation Below Existing Pavement or If Existing Wearing Surface is Open Graded Mix" on the Standard Drawings. This applies to full-depth AC standard loop installations as well as the preformed loop shown.

When there is insufficient pavement depth and when shown, construct detector loop pads. Detector loop pads not shown, but required by the Engineer, will be paid for as Extra Work according to Section 00196.

When preformed loops are called for, refer to Standard Drawings for requirements. Preformed loops may be used in lieu of sawn-in loops, if minimum loop cover can be obtained. Use materials from the QPL.

Preformed loops installed during the paving operation shall have a minimum cover of 50 mm (2 inches). Slotting of the underlying surface may be required to obtain this clearance. Replace loops damaged during installation at no additional cost to the Agency. Fill preformed detector loops and runs to junction boxes with an approved sealant if subjected to high temperatures and compaction of backfill.

Round loops, 1.8 m (6 feet) or 1.5 m (5 feet) in diameter, may be used in 3.6 m (12 foot) or wider lanes as an alternate to standard 1.2 m (4 foot) diamond vehicle detector loops. Round loops, 1.5 m (5 feet) in diameter, may be used in lanes less than 3.6 m (12 feet) in width as an alternate to standard 1.2 m (4 foot) diamond vehicle detector loops. Install according to standard loop installation Specifications, but make the saw cut exiting the loop perpendicular to the loop.

**(2) Wire** - Use XHHW loop wire conforming to 02920.23(b). Encase loop wire in a polyethylene tube conforming to IMSA Specification No. 51-7.

Place a permanent plastic label on each loop feeder cable with the loop numbers, in indelible ink, as shown on the Loop Detector Wiring Diagram. Place labels at all accessible points on the system. Place labels within 100 mm (4 inches) of the end of the jacket at each end of the feeder loop cables.

Do not remove the outside jacket and shield of loop feeder cables more than 150 mm (6 inches) from the end, inside the controller cabinet.

**(3) Installation** - The Engineer will mark or approve the center point location of all loops to be installed. Do not place wire in saw cuts until the cuts have been inspected by the Engineer.

After the saw cut is cleaned of debris, place the loop wire by pushing it into the slot with a blunt, nonmetallic object. Use care to avoid damaging the insulation.

Use one continuous, unbroken length of loop wire to form a loop of the number of turns required and to reach the loop feeder cable splice point shown or specified. Use one continuous, unbroken length of loop feeder cable from the loop wire splice point to the cabinet.

After loop wire is placed and before the saw slot is sealed, install loop wire hold-downs (backer rods) made of closed-cell polyurethane. Place 25 mm (1 inch) lengths of the hold-down material along the loop perimeter and all other saw slots containing loop wire 150 mm (6 inches) from loop corners and at maximum 300 mm centers (12 inch). Hold-downs shall fit snugly in saw slots.

After placing the wire, test before filling the slots with hot-melt sealant. Install the sealant in slots according to the manufacturer's instructions and recommendations using an approved pressure feed wand system. Pour pot application will not be allowed. Furnish a copy of the manufacturer's specifications including application procedures. The Engineer may order a test run of any application method or material before filling saw cuts. Have a manufacturer's representative present if using a sealant for the first time on an Agency project.

Do not use epoxy in the slots. Sealant shall not protrude above the pavement, nor be more than 3 mm (1/8 inch) below the pavement level after curing. Where cuts are made on a slope and sealant runs or puddles, start at the low end, pour the sealant, and hold it in place with 50 mm (2 inch) duct tape placed on the roadway surface over the cut. If duct tape or other device is used to contain the sealant in the saw cut, remove it on the same day, after the sealant is fully cured.

In order to prevent heat damage to the insulation, do not allow the temperature of the sealant to exceed 210 °C (410 °F) during application. Install hot-melt sealants in layers to prevent damage to wire insulation. Allow each layer to cool before the next layer is installed. Do not use water to accelerate cooling. Do not seal street boxes with sealant that remains soft after setting or cooling. See Standard Drawings.

Sealants that crack or pull away from the saw cuts after curing, at any time within the warranty period, will be rejected. Remove sealant that fails within this period, clean the cuts of debris and reseal with a sealant satisfactory to the Engineer at no additional expense to the Agency.

There are three options for loop wire access points. Refer to the plans for the option to be used at each location. Do not make loop wire splices in the access point.

Splice loop wires to feeder cable in junction boxes. Connect loop wires to loop feeder cable with a soldered-compression splice. Remove 100 mm - 150 mm (4" - 6") of feeder cable outer jacket, drain wire and shield. Do not cut the conductor insulation. Offset splices to insure they do not make contact with each other. Strip feeder and loop conductors back about 15 mm (1/2 inch). Crimp with seamless, non-insulated butt connector (3M<sup>®</sup> part #M14BCX or equivalent) of the proper size. Solder the splice with 60/40 rosin-core solder using a soldering iron, gun or flameless soldering torch. Do not use an open flame torch. Ensure solder fills voids in the splice. Make sure all edges are smooth. Cover the splice with self-sealing shrink tubing (UL 486, 90 °C, 600 V) constructed of homogeneous polyolefin and having an internally applied sealant. Use heat-shrink tubing on individual wire splices and also over the entire cable splice, extending the tubing at least 25 mm (1 inch) beyond the ends of the insulation and/or inner heat-shrink tubing.

#### 00990.43(b)

Solder all loop feeder connector terminations from field wiring in signal controller cabinets after crimp lugs have been installed. Crimp lugs used for loop wire field terminals may be insulated or uninsulated.

**(4) Resistance Testing** - The resistance to ground of the loop and loop feeder combinations, tested with a 500 V Megger tester, shall be 200 MΩ or greater when checked both before placing the sealant and after the sealant has set.

**(5) Loop Sensitivity** - Loops shall be sensitive to bicycles. After installation is complete the Engineer will test each loop with a lightweight bicycle or other approved device. If the bicycle is not detected on the highest amplifier sensitivity setting, replace the detector at no additional expense to the Agency, and repeat the procedure.

#### **00990.44 Traffic Control Signs:**

**(a) General** - The type of sign and method of mounting will be as shown or specified. Provide a hanger with span wire mounted signs that will permit both vertical and horizontal adjustments.

**(b) Advance Warning Signs** - Signs shall conform to applicable portions of Section 00940. Sign message shall be as shown. If called for on the plans, complete the sign with a flashing beacon unit and/or floodlights.

**(c) Overhead Interior Illuminated Signs (Fluorescent Tube, Neon Tube or Fiber Optic)** - Use signs designed for span wire, bracket, bridge or mast arm mounting and make sign legends as shown or specified.

Drill and tap setscrews used in sign mountings through the first wall of the conduit. The conduit shall extend a minimum of 15 mm (1/2 inch) beyond the setscrew.

**(d) Overhead Aluminum Signs** - Signs shall use retroreflective sheeting (wide angle) Prismatic, Type A, and shall conform to the applicable portions of Section 00940.

#### **00990.46 Fire Preemption** - Fire preemption systems shall:

- Include all required discriminator modules, detector feeder cable, wiring harness, interface circuitry and miscellaneous hardware
- Have detector feeder cable of the type and size recommended by the supplier of the preemption equipment
- Have cable that runs continuously without splices from the detector unit to the controller cabinet
- Include Agency-approved rack-mounted discriminators or interface cards with all Model 170 signal controllers
- Not include emitter units

**00990.47 Railroad Interconnect** - Where interconnection to railroad circuits is shown or specified, interconnect the traffic signal cabinet and the railroad cabinet. The railroad company will furnish a set of contacts in the railroad cabinet. The contacts are normally closed, but open upon actuation of the track circuit by a train. The contacts are a "fail-safe" device which will cause an actuation if power to the track circuit is interrupted.

Run the circuit conductors in underground electrical conduit of the size shown. Terminate the conduit in the railroad cabinet at the location and in the manner directed by the railroad company. Extend the ends of the wire at least 1 m (3 feet) beyond the end fitting inside the railroad cabinet. All other work inside the railroad cabinet is the responsibility of the railroad.

Do not under any circumstance do any work in the immediate vicinity of the railroad cabinet without first notifying the Engineer and receiving permission. The Agency will obtain supervisory personnel from the railroad company.

Do not place any materials or equipment in the vicinity of the tracks without observing proper clearance (see 00170.01(e)).

#### **00990.48 Coating:**

**(a) Signal Heads** - Pedestrian signal heads, vehicle signal heads, beacon heads and backboards shall be powder coated inside and outside to meet Federal Standard 595b-37038 (dull black). Powder coating shall consist of 75  $\mu\text{m}$  (3 mils) of primer and 50  $\mu\text{m}$  (2 mils) of moisture-cured polyurethane.

**(b) Signal Control Cabinets** - Construct anodize signal control cabinets of aluminum.

**(c) Brackets and Hangers** - Apply two coats of aluminum paint to signal head mounting brackets, arms and ungalvanized hangers after they have been primed.

**(d) Interior Illuminated Metallic Sign Cabinets (Fluorescent Tube)** - Paint cabinets according to the following:

**(1) Inside of Cabinet** - Wash all exposed aluminum and steel parts with a metal cleaning solvent. When metal is thoroughly dry, spray on one coat of zinc chromate paint. When dry, finish with two coats of high quality white enamel.

**(2) Outside of Cabinet** - Apply two coats of aluminum paint to any exposed metal parts, other than aluminum, on the outside of the cabinet.

**(3) Handling** - Refinish any scratches or abrasions on the finished surface of the cabinet to the Engineer's satisfaction.

**(e) Interior Illuminated Metallic Sign Cabinets (Neon Tube)** - Paint cabinets according to the following:

**(1) Inside of Cabinet** - Follow the procedure of (d-1) above, except after the zinc chromate paint is dry, finish with three coats of a dull, flat, gray or white, weather-resistant paint. Finish the front, exposed face louvers and the tube supports on the inside of the hood with three coats of the same paint.

**(2) Outside of Cabinet** - Prime the outside of the cabinet and apply two coats of the flat black enamel.

**(3) Handling** - Same as (d-3) above.

**(f) Fiber-optic Sign Cabinets** - Paint cabinets according to the following:

**(1) Inside of Cabinet** - Do not paint interior surfaces of the cabinet.

**(2) Outside of Cabinet** - Same as (e-2) above.

**(3) Handling** - Same as (d-3) above.

### Finishing

**00990.70 Testing and Turn-on** - This work consists of testing traffic signal control equipment, testing traffic signal installations, and turning on completed traffic signal installations. Do not conduct turn-ons on Fridays unless approved.

**(a) Delivery of Control Equipment** - Provide manuals, diagrams and other documents as required by the Agency. Deliver all traffic signal control equipment, including wiring diagrams and operation manuals, in one shipment. Partial shipments will not be accepted and will be returned, at Contractor's expense, to the Contractor. Include the following information with equipment shipments:

- Contractor
- Supplier
- Manufacturer
- Location
- Contract number
- Agency for which the equipment is to be tested. For agencies other than ODOT, include a complete set of plans and specifications to which the equipment is to be tested.

Deliver the traffic signal control equipment and information for testing to:

Oregon Department of Transportation  
Traffic Signal Services Unit  
2445 Liberty St. NE  
Salem, Oregon 97303-6738

**(b) Control Equipment Testing** - The following traffic signal control equipment will be tested by the Agency for conformance with the Contract Documents before being installed:

- Controller unit
- Controller cabinet
- Power supplies
- Input devices
- Output devices
- Conflict monitors
- Flasher units
- Relays
- Preemption devices
- Auxiliary equipment in the cabinet
- Other equipment required for the operation of the installation

Control equipment will be tested at no cost to the Contractor.

The control equipment will be tested in three categories: physical, functional and environmental. ODOT will require six weeks for completion and evaluation of the testing.

**(1) Physical Testing** - Physical testing of the traffic signal control equipment will consist of an inspection for quality of work and conformance to Contract Documents. The inspection will include:

- All specified equipment, wiring diagrams, operation manuals and documentation supplied
- The overall quality of the equipment and cabinet wiring

**(2) Functional Testing** - The functional testing of traffic signal control equipment will include checking:

- All specified input and output control functions for proper operation
- For proper operation of all noncontrol devices, such as switches, circuit breakers, outlets, fans and ground fault interrupts (GFIs)

Functional testing will be done at normal temperature and supply voltage, with the control devices set up and connected to a display panel and input simulator.

The controller unit timing and control functions will be programmed, and the inputs adjusted to simulate actual traffic control conditions.

The control devices will be visually observed during the test for proper input, output and control operation.

**(3) Environmental Testing** - Environmental testing of traffic signal control equipment will include checking the ability of devices to operate as specified, under conditions of variable temperature and power supply voltage.

The control equipment will be set up in an environmental chamber. Testing, monitoring and simulation apparatus will be connected and adjusted. Controller unit timing and control functions will be programmed. The control equipment will be turned on and the operation allowed to stabilize at least 30 minutes before testing.

The initial testing is performed at normal temperature and power supply voltage, and includes the spike test and timing test.

The spike test introduces 300 V AC positive and negative spikes onto the power supply. The equipment is observed for any disruption to normal operation.

The timing test monitors and records the accuracy of controller timing functions, such as minimum green, maximum green, walk, and yellow.

The control equipment will be cycled through temperatures from -34 °C to +73 °C (-30 °F to +165 °F). The control equipment will be required to operate for a maximum of 12 hours at both the high and low temperatures. During operation of the high and low temperature limits the accuracy of the controller unit timing functions will again be monitored and recorded.

The power supply voltage will be varied between 95 V AC and 130 V AC during the temperature test. Standard procedure is to use 95 V AC during the low temperature cycle and 130 V AC during the high temperature cycle.

Following completion of the temperature testing, the control equipment is removed from the environmental chamber, set up and connected to a display panel and input simulator. The control equipment will be required to operate for a maximum of 72 hours at normal temperature and power supply voltage under simulated traffic control conditions. Operation will be visually observed on a random basis during the test.

**(c) Control Equipment Failure** - A traffic signal control equipment failure is any occurrence that results in nonspecified operation of the equipment.

The Contractor will be notified of all control equipment failures, and shall make on-site repairs within five days of receiving the notification.

Following repair of the control equipment, the testing will be resumed at the beginning of the test category in which the failure occurred.

**(d) Control Equipment Rejection** - The traffic signal control equipment will be rejected under either of the following conditions:

**(1) Twice Fail** - The control equipment fails twice in the same testing category.

**(2) Failure to Repair** - The Contractor fails to repair the control equipment within five days of receiving notification of the failure.

Pick up rejected traffic signal control equipment within 10 days of receiving the rejection notice, or it will be returned, at Contractor's expense, to the Contractor.

Replace with control equipment having a different serial number.

Rejected control equipment will not be accepted for testing or installation on any subsequent traffic signal project within the State of Oregon.

**(e) Control Equipment Acceptance** - Traffic signal control equipment that successfully passes the testing procedure will be certified by the Agency as acceptable for installation. Acceptability for installation does not guaranty final acceptance of the completed installation.

The successful completion of the testing does not relieve the Contractor of the responsibility to furnish a complete working signal installation at the time the equipment is placed in operation.

The Contractor will be notified when the testing has been completed. Pick up the controller cabinet at the test facility.

**(f) Control Equipment Installation** - Be responsible for pick-up, delivery and installation of the controller cabinet.

The Agency will be responsible for delivery and installation of the other control equipment, such as controller units, input devices, switch packs, monitor units, miscellaneous plug-in devices and auxiliary devices not permanently installed in the controller cabinet.

Other control equipment that the Agency is to install will be stored at the test facility until the signal installation is ready to be turned on.

**(g) Field Testing** - Field testing of traffic signal installations will be performed by Agency electrical crews. Notify the Engineer one week in advance of the anticipated signal completion date. The Engineer will notify the Agency's Traffic Signal Services Unit and the Agency's electrical crew of the anticipated completion date. Field testing will be performed within one week following the date of completion. The Engineer will notify the Contractor of the test results. If an intermediate Contract Time is specified for signal work, the Engineer may suspend that portion of the work so that time may be excluded according to 00180.50(e) after the final corrections have been completed, or the signal is turned on.

Information on Agency testing procedures is available from the Engineer.

**(h) Traffic Signal Turn-on** - The Engineer will establish the date and time the installation is to be turned on. The Agency will turn on the signal within one week after completion of corrections.

Be present at the Project Site to assist as necessary.

After traffic signals are turned on and operating as designed, the agency ultimately responsible for maintenance will assume operation and maintenance of the signal. Turn-on does not constitute final approval. The Contractor is still obligated to finish any incomplete portion of the installation and correct problems with workmanship or replace material that does not meet Specifications. After turn-on, damage to the traffic signal installation caused by conditions beyond the Contractor's control will be the responsibility of the maintaining agency.

**(i) Interconnect Cable Testing:**

Test each interconnect cable circuit installed in the system. Test the complete system only when all terminations for each cable circuit are completed, by the Agency, from the interconnect or controller cabinet at the beginning of the new cable run to the controller or interconnect cabinet at the end of the new cable run. If any test is failed, repair the circuit and repeat the entire test series for that cable circuit.

Perform all tests in the presence of the Engineer. Document the test results. When the tests are completed, whether successful or not, furnish the test results and the test data to the Engineer. Conduct tests, as described below, for all cable conductors, including spares, the cable shield, and all field terminations.

In addition to testing the complete system, perform the following tests for each cable circuit:

**(1) Continuity** - Perform a continuity measurement for each conductor and the cable shield in the system. Conductor resistance shall not be more than 10  $\Omega$  per 305 m (1,000 feet) for each cable pair and shield of the communications cable. Measure the resistance with an ohmmeter having a minimum input impedance of 10 M $\Omega$ /V. Record the resistance of each pair and furnish to the Engineer as described above.

**(2) Isolation** - Perform an isolation measurement for each conductor and cable shield in the system. Measure the insulation resistance with all connections to the conductor or shield under test removed and all other conductors in the cable grounded. Make the measurement with a DC potential of not less than 360 V nor more than 550 V, continuously applied for one minute. Insulation resistance of each cable conductor and the shield shall exceed 621 M $\Omega$ /km (1,000 M $\Omega$  per mile). Use a Megger tester with a meter scale for measurements, marked with a range from 100 K $\Omega$  to 100 G $\Omega$ , and with zero and infinity also marked.

**00990.75 Warranty** - The warranty of 00170.85(b) and other warranty provisions apply to work done under this Section. See the Special provisions for details.

### Measurement

**00990.80 General** - Quantities of work done under this Section, installed and accepted, will be measured on the lump sum basis or the unit basis, as follows:

**(a) Lump Sum Basis** - Measurement on the lump sum basis will be for all work on the Project under the particular pay item.

**(b) Unit Basis** - Measurement on the unit basis will be per each by actual count of intersections at which the specified work is performed.

**Payment**

**00990.90**    **General** - Payment will be made at the Contract price for the following items:

<b>Pay Item</b>	<b>Unit of Measurement</b>
(a) Traffic Signal Installation.....	Each
(b) Fire Preemption System.....	Each
(c) Model 170 Controller.....	Each
(d) Traffic Signal Modifications.....	Each
(e) Loop Detector Installation.....	Each
(f) Ramp Meter Signal Installation.....	Each
(g) Traffic Signal Installation.....	Lump Sum
(h) Loop Detector Installation.....	Lump Sum
(i) Ramp Meter Signal Installation.....	Lump Sum

Items (a) through (i) include payment for replacement of disturbed earthwork, base and surfacing, when applicable.

Items (a) and (g) include furnishing and installing all items of the traffic signal system, except the fire preemption system, the controller equipment and the control program, and include payment for removing, salvaging and stockpiling traffic signal equipment as specified.

Item (d) includes furnishing and replacing or installing items for an existing traffic signal installation as specified.

Items (e) and (h) include furnishing and installing a complete traffic loop detector installation, including incidental controller equipment for existing traffic signal installations.

Items (f) and (i) include furnishing all items of the ramp meter signal system, except the controller equipment and controller program.

Payment for item (e) includes furnishing and installing a complete traffic loop detector installation, including incidental controller equipment for existing traffic loop detector installations.

Payment for replacement of solid conductor ground wire with THWN wire according to 00990.40(e-2-d) will be considered incidental to the work of this Section, and no extra payment will be made.

Payment for providing railroad company personnel to supervise interconnection with railroad cabinets will be considered incidental to the work of this Section, and no extra payment will be made.

Payment will be payment in full for all materials, equipment, labor and Incidentals necessary to complete the work as specified.