500-2.2 Requirements.

500-2.2.1 Installer Qualifications. The installer, whether the Contractor or a subcontractor, shall be a certified installer of the lining system. The installer's personnel shall be adequately trained in maintenance and operation of the required installation equipment, as certified by the lining manufacturer. A letter from the manufacturer of the lining system, verifying the certification of the installer required to be on-site during installation, shall be submitted per 2-5.3.

500-2.2.2 Cleaning, Inspection, and Surface Preparation. Prior to the installation of the lining system, the host structure shall be prepared to produce a concrete or masonry surface suitable for application and adhesion of the specified lining system. Cleaning and surface preparation shall include the inspection of the host structure for any damage or leaks, and the removal of any protrusions on the surface of the host structure that could interfere with the installation of the lining system. Any damage or leaks shall be reported to the Engineer. Cleaning methods may include high pressure water cleaning at a minimum of 5,000 pounds per square inch (34.5 MPa), abrasive blast, or a method recommended by the manufacturer of the lining system, or another cleaning method submitted to the Engineer for approval per 2-5.3. The Contractor shall protect the host structure from damage by the cleaning equipment, water and air pressure. Flow bypassing, if required by the lining system, shall conform to 7-8.4 and 306-3.3.

Debris from the cleaning operation shall not be allowed to enter the sewer system. The Contractor shall furnish, install and remove any necessary debris containment devices while maintaining sewer flow. The Contractor shall remove and dispose of all debris collected from the cleaning operation. If reinforcing steel is exposed, either before or after removing deteriorated concrete, it shall be thoroughly cleaned to remove all contamination and rust particles. Immediately after the cleaned reinforcing steel is inspected and accepted by the Engineer, the Contractor shall place a protective coating on the exposed reinforcing steel. The protective coating shall be approved by the Engineer in accordance with the manufacturers' specifications.

Manhole steps, pull rings and lifting eyes shall be installed or removed as shown on the Plans or specified in the Special Provisions.

500-2.3 Repair, Resurfacing and Active Infiltration.

500-2.3.1 General. Repair, resurfacing and active infiltration elimination materials shall be compatible with the lining system. Proof of compatibility shall be submitted to the Engineer per 2-5.3.

500-2.3.2 Repair. Prior to installation, patching or localized repairs shall be performed using rapid setting repair mortars compatible with the lining system. Repair mortars shall be used to fill surface irregularities, voids, and deteriorated surfaces and to repair the host structure to a uniform surface. Manufacturer's specifications shall be followed when performing repairs, material handling, mixing, installation and curing. A copy of the manufacturer's specifications confirming the compatibility of the materials used in the repair shall be submitted to the Engineer per 2-5.3.

500-2.3.3 Resurfacing. Air-placed concrete (APC) materials, if required by the Special Provisions, shall conform to 303-2.3.1. Prior to the application of APC, the structure shall be prepared to produce a concrete or masonry surface that is suitable for application and adhesion of the specified APC. The APC shall be applied in continuous lifts of 1/2 inch (12.5 mm) minimum thickness or as shown on the Plans and/or as specified in the Special Provisions. Containment devices, approved by the Engineer, shall be used to prevent rebound (non-adhering excess APC) from entering the sewer system. Immediately following the APC placement operation, the containment device shall be removed and the structure's cover reinstalled to provide a moist curing environment. Where moist conditions within the structure do not exist, the Contractor shall water cure the APC for a minimum of 24 hours prior to installation of the lining system. All defects in the APC shall be repaired per 303-2 prior to the installation of the liner system.

500-2.3.4 Active Infiltration. Active leaks within the host structure shall be eliminated prior to installation of the liner system. Leaks shall be eliminated by pressure grouting with chemical grout as specified in the Special Provisions and/or the application of hydraulic cement conforming to 201-1.2. Chemical grouts and hydraulic cements shall be compatible with the lining system used. A copy of the manufacturer's specifications confirming the compatibility of the materials used in the repair shall be submitted to the Engineer per 2-5.3. The host structures shall be visibly dry with no active infiltration prior to lining.

500-2.4 Inspection, Testing and Repair of Installed Liner Systems.

500-2.4.1 General. The party performing the following tests shall be as specified in the Special Provisions. If the testing party is to be selected by the Contractor, the name of the testing party and information on the testing instruments to be used for adhesion testing and its calibration shall be submitted to the Engineer per 2-5.3.

500-2.4.2 Spark Test. The cured lining system shall be spark tested for holidays with the high voltage holiday detector instrument specified by the coating manufacturer or as specified in the Special Provisions. The voltage shall be set at a minimum of 15,000 volts. For thicknesses greater than 150 mils (4 mm), the voltage shall be set at 100 volts per 1 mil (25 μm) of thickness of the applied lining material. Identified holidays shall be marked without contaminating the lining surface and repaired in accordance with 500-2.4.5.

500-2.4.3 Mil Gauge Test. During installation, a mil gauge shall be used to verify that the minimum thickness of the lining meets and/or exceeds the minimum thickness specified herein or specified in the Special Provisions.

500-2.4.4 Adhesion Testing. Adhesion testing shall be performed on a minimum of 1 structure or 15 percent of all rehabilitated structures, whichever is greater, or as shown on the Plans and/or specified in the Special Provisions. Adhesion testing shall be conducted after the liner system has cured in accordance with the manufacturer's specifications. Adhesion testing shall be in accordance with ASTM D4541 as modified herein.

A minimum of one 3/4 inch (19 mm) dolly shall be affixed to the lined surface of the host structure at the upper section or cone area, the midsection, and at the bottom, unless otherwise specified in the Special Provisions. Each testing location shall be identified by the Engineer. The adhesive used to attach the dollies to the liner shall be rapid setting with tensile strength in excess of the liner material and permitted to cure in accordance with the manufacturer's specifications. The lining material and dollies shall be prepared to receive the adhesive in accordance with the manufacturer's specifications. Prior to the pull test, the tester shall utilize a scoring device to cut through the coating until the substrate is reached. Failure due to improper dolly adhesive or scoring will require retesting. The pull tests in each area shall meet or exceed 200 pounds per square inch (1,400 kPa) and shall include substrate adhered to the back of the dolly or no visual signs of coating material in the test hole. Pull tests with results between a minimum 150 pounds per square inch (1,000 kPa) and 200 pounds per square inch (1,400 kPa) may be acceptable if more than 50 percent of the substrate adhered to the back of the dolly. A test result may be disregarded, as determined by the Engineer, if there is a valid nonstatistical reason as specified in Sections 8.4 and 8.5 of ASTM D4541. If any test fails, a minimum of 3 additional locations in the section of the failure shall be tested, as directed by the Engineer. If any of the retests fail, all loosely adhered or unadhered liner in the failed area, as determined by the Engineer, shall be removed and replaced at the Contractor's expense. If a host structure fails the adhesion test, one additional host structure or 10 percent of the initial number of host structures selected for testing shall be tested as directed by the Engineer or as specified in the Special Provisions.

500-2.4.5 Liner Repairs. Holidays, uncured lining material, blisters, surface imperfections and damage to the liner resulting from the adhesion test shall be repaired to a point 1 inch (25 mm) minimum beyond the limits of the damaged area. The repair shall be 125 mils (3 mm) thick or the minimum thickness specified in the Special Provisions. Holidays shall be primed and recoated with the same lining system to a minimum additional thickness of 30 mils (750 μm) unless otherwise specified by the liner manufacturer or approved by the Engineer. Blisters, uncured lining and surface imperfections shall be completely removed and the areas recoated with appropriate lining material to 1 inch (25 mm) minimum beyond the repair areas at a minimum thickness of 100 mils (2540 μm). Additional spark testing shall be performed after repairs are completed.

500-2.5 Integral Locking PVC Manhole and Structure Lining System.

500-2.5.1 General. This subsection specifies an integral locking PVC lining system. This system consists of temporarily erecting a form inside an existing structure, installing PVC lining material with integral locking devices and filling the annular space between the erected form and PVC lining material and the walls of the host structure with Portland cement concrete resulting in a new PVC-lined, monolithic structure within the host structure.

500-2.5.2 Materials.

500-2.5.2.1 Portland Cement Concrete. Portland cement concrete shall be Class 560-C-3250 (330-C-23) conforming to 201-1.1.2, unless otherwise specified in Special Provisions.

500-2.5.2.2 Integral Locking PVC Liner. The liner shall conform to the specifications in 210-2 and be as specified in the Special Provisions. A Certificate of Compliance conforming to 4-1.5 shall be submitted per 2-5.3.

500-2.5.3 Installation and Field Inspection. If existing, steps shall be removed flush with the inside wall of the host structure. Formwork for the lining system shall be installed in a manner that fits the existing walls and creates an equal and approximate 3-inch (75 mm) annular space. Portland cement concrete shall be used to fill the annular space. The installation of the liner shall conform to 311-1. Replacement of steps, if required, shall conform to the requirements shown on the Plans and/or specified in the Special Provisions.

Prior to placement of the Portland cement concrete, the installer shall connect the existing mainline pipe to the host structure as shown on the Plans and/or as specified in the Special Provisions. Exposed Portland cement concrete surfaces within the host structure shall be protected as specified in the Special Provisions.

Field testing shall conform to 210-2.3.4 and 311-1.10 unless otherwise specified in the Special Provisions.

500-2.6 Segmented PVC Lining System.

500-2.6.1 General. This subsection specifies a lining system consisting of PVC liner strips placed so that an annular space is created between the liner and the walls of the host structure. This annular space is then filled with cementitious grout. A Certificate of Compliance conforming to 4-1.5 shall be submitted to the Engineer per 2-5.3 for each material. Surface preparation of the host structure and flow bypass shall conform to 500-2.1.3 unless otherwise specified in the Special Provisions.

500-2.6.2 Materials.

500-2.6.2.1 PVC Liner. PVC liner shall conform to 500-1.5.2 through 500-1.5.5 and Table 207-17.5.

500-2.6.2.2 Cementitious Grout. Cementitious grout shall conform to ASTM F1741, Section 6.4 and be submitted to the Engineer for approval per 2-5.3 unless otherwise specified in the Special Provisions.

500-2.6.2.3 Sealant/Adhesive. The sealant/adhesive shall be compatible with the PVC lining material and cementitious grout. A copy of the manufacturer's specifications confirming the compatibility of the sealant/adhesive materials shall be submitted to the Engineer per 2-5.3.

500-2.6.3 Installation and Inspection. Installation shall be performed by either manually spirally winding PVC strips or placing PVC panels and engaging the complementary locks (male/female) at the edges of the strips/panels in a manner that creates an annular space, of 1 inch (25 mm) minimum thickness, unless otherwise specified in the Special Provisions.

A bead of approved sealant/adhesive shall be applied to the female locking edge of the strip/panel prior to engaging the locking edges. Grouting of the annular space shall be performed in such a manner as to prevent damage or collapse of the liner and completely fill the annular space. Installation shall conform to 500-1.5.6 through 500-1.5.9. Testing shall be performed in accordance with 500-2.4, except 500-2.4.4. Holes in the liner shall be covered with a patch of sealant materials as approved by the Engineer.

500-2.7 Polyurethane and Epoxy Protective Lining System.

500-2.7.1 General. This subsection specifies a polyurethane and epoxy primer protective lining system.

500-2.7.2 Lining Material. Lining material shall consist of 100 percent solid polyurethane material and moisture tolerant epoxy. Polyurethane lining material shall be capable of spray application to 125 mils (3 mm) minimum thickness in one continuous coat. Epoxy shall be capable of spray application to 5 mils (125 µm) thickness in one continuous coat.

500-2.7.3 Installation and Curing. Lining material shall be applied to all prepared surfaces from 1 inch (25 mm) below the low-flow water level to the base of the ring and cover unless otherwise specified in Special Provisions. All termination points of the lining material to the existing subsurface shall be keyed into the subsurface by mechanically scoring a minimum 1/4 inch x 1/4 inch (6 mm x 6 mm) keyway. Prior to application of the polyurethane, the subsurface shall be primed with the epoxy primer to a thickness of 3 mils (75 µm) minimum to 5 mils (125 µm) maximum. Polyurethane shall be applied to a thickness of 125 mils (3 mm) immediately prior to the epoxy primer becoming tack-free. Lining material shall be uniform in color, fully cured, free of holidays, surface imperfections, blisters and sags and adequately adhered to the subsurface.

500-2.7.4 Inspection and Testing. The set or cured lining materials shall be tested in accordance with 500-2.4 unless otherwise specified in the Special Provisions.

500-2.7.5 Performance Requirements. The lining system shall meet or exceed the requirements specified in Table 500-2.7.5.

TABLE 500-2.7.5

	Polyurethane	Epoxy Primer
Tensile Strength ASTM D638, Type IV, psi (MPa) (min)	2,000 (14)	6,000 (41)
Elongation at Break, % ASTM D638, Type IV	40	5
Wear Resistance, mg. wt. Loss Taber abrasion, ASTM D4060	60[1]	100[1]
Hardness, Shore D, Durometer ASTM D2240	55	75
Tear Resistance, ppi (kg/mm) ASTM D624	150 (2.7)	N/A
Peel Strength, Concrete, pli (g/mm) ASTM D903	7[2] (125)	7[2] (125)
Weight Change[3]	± 1.5%	± 1.5%

1. Abrasive wheel No. CS-17, maximum value.
2. Tested as a system. Test results shall be verified on a per job basis or as specified in the Special Provisions.
3. Tested in conformance with 211-2.

500-2.8 Epoxy Lining System.

500-2.8.1 General. This subsection specifies an epoxy lining system.

500-2.8.2 Lining Material. Lining material shall consist of solvent free, high-build epoxy resin capable of spray application to 125 mils (3 mm) minimum thickness in one continuous coat.

500-2.8.3 Installation and Curing. Lining material shall be applied to all prepared surfaces from 1 inch (25 mm) below the low-flow water level to the base of the ring and cover unless otherwise specified in the Special Provisions. Termination points of the lining to the existing subsurface shall be keyed into the subsurface by mechanically scoring a minimum 1/4 inch x 1/4 inch (6 mm x 6 mm) keyway. Epoxy shall be applied to a thickness of 125 mils (3 mm). Lining material shall be uniform in color, fully cured, free of holidays, surface imperfections, blisters and sags and adequately adhered to the subsurface.

500-2.8.4 Inspection and Testing. The set or cured lining materials shall be tested in accordance with 500-2.4 unless otherwise specified in the Special Provisions.

500-2.8.5 Performance Requirements. The lining system shall meet or exceed the specifications in Table 500-2.8.5.

TABLE 500-2.8.5

	Epoxy Liner
Tensile Strength ASTM D638, Type IV, psi (MPa) (min)	3,000 (21)
Elongation at Break, % ASTM D638, Type IV	0.9
Wear Resistance, mg. wt. Loss Taber abrasion, ASTM D4060	115[1]
Hardness, Shore D, Durometer ASTM D2240	80
Weight Change[2]	± 1.5%

1. Abrasive wheel No. CS-17, maximum value.
2. Tested in conformance with 211-2.

500-2.9 Epoxy Mastic and Flexible PVC Liner System.

500-2.9.1 General. This subsection describes the installation of the mastic primer and epoxy mastic that bonds to the cleaned, repaired and prepared interior concrete substrate, then follows with the mechanical locking of the flexible PVC liner into the epoxy mastic. The integral locking extensions in the flexible PVC liner are embedded to their full depth into the epoxy mastic.

500-2.9.2 Materials.

500-2.9.2.1 Plastic Liner. The liner shall be manufactured from a PVC compound in accordance with 210-2. The plastic liner shall be a flexible PVC liner with a minimum thickness of 1/16 inch (1.5 mm) and conform to 210-2.4.

500-2.9.2.2 Mastic Primer. The epoxy mastic primer shall be a 2-part coating that is applied to the prepared concrete substrate.

500-2.9.2.3 Epoxy Mastic. The epoxy mastic shall be a 2-part 100 percent epoxy coating for bonding and filling voids in properly prepared concrete substrate.

500-2.9.3 Locking Extensions. All liner to be embedded in the epoxy mastic shall have integral locking extensions and meet the requirements of 210-2.2.4 except for the dimensions requirement. The locking extensions shall have a shape, height, web thickness, and spacing that will allow the liner to be held permanently in place and be able to meet the pull-out requirements of 500-2.4.4.

500-2.9.4 Chemical Resistance and Physical Property Testing. The plastic liner sheet and accessories shall conform to 211-2 and 210-2.4.

500-2.9.5 Preparation and Repair of Substrate. Prior to applying the mastic primer, the structure shall be cleaned and prepared in accordance with 311-1.6 and repaired in accordance with 311-1.9.

500-2.9.6 Installer Qualifications. Applicators and welders of the plastic liner shall be qualified in accordance with 311-1.2.

500-2.9.7 Installation.

500-2.9.7.1 Priming. The mastic primer shall be applied to 3 mils (75 µm) minimum to 5 mils (125 µm) maximum thickness. The primer shall be allowed to dry before applying the epoxy mastic.

500-2.9.7.2 Epoxy Mastic Application. A finishing trowel or other suitable tool shall be used to apply the epoxy mastic to a uniform minimum thickness of 1/4 inch (6 mm).

500-2.9.7.3 Plastic Liner Application. The plastic liner shall be placed while the wetting ability of the epoxy mastic is at its optimum, be pressed into the mastic, and rolled to remove any trapped air. The lining system shall be allowed to cure for the amount of time recommended by the lining manufacturer. The average dry film thickness of the cured lining system, including the liner sheets and the applied epoxy mastic, when completed shall not be less than 315 mils (8 mm).

500-2.9.8 Field Jointing of Liner.

500-2.9.8.1 General. The Contractor shall utilize the maximum size plastic liner sheet that is practical and will provide the minimum number of seams. Vertical and horizontal seams shall overlap a minimum of 1/2 inch (12.5 mm) and shall be welded with 1 inch (25 mm) weld strips. Corner strips may be used at inside and outside corners, or liner may be wrapped around corners. The Contractor shall be allowed to heat the liner to facilitate turning corners. Excessive heating of the liner material to facilitate turning corners shall be avoided.

500-2.9.8.2 Field Joints in Manhole and Structure Rehabilitation. Field joints in the liner shall be Type AL-2 unless AL-1 or AL-3 is approved by the Engineer.

a) Type AL-1 joint shall consist of a 4-inch (100 mm) wide joint strip centered over a 1 inch (25 mm) maximum gap between sheets and securely welded along each edge of adjacent liner with a 1 inch (25 mm) welding strip.

b) Type AL-2 joints shall be made with integral joint flaps with locking extensions removed 1 inch (25 mm) from one side per 210-2.2.6. The flap shall be overlapped a minimum of 1/2 inch (12.5 mm) and the overlap secured to the adjacent liner by means of a 1 inch (25 mm) welding strip.

c) Type AL-3 joints shall consist of a 1 inch (25 mm) wide weld strip centered over a 1/4 inch (6 mm) maximum gap between sheets and securely welded along each edge of adjacent liner.

500-2.9.8.3 Installation of Welding Strips. Installation of welding strips shall conform to 311-1.5.4.

500-2.9.9 Pull Test for Locking Extensions. Liner locking extensions embedded in epoxy mastic shall withstand a test pull of at least 20 pounds per linear inch (3.5 N per linear mm), applied perpendicularly to the concrete surface for a period of 1 minute without rupture of the locking extensions or withdrawal from the epoxy mastic or delaminating of the mastic from the concrete substrate. This test shall be made at a temperature between 70°F to 80°F (21°C to 27°C).

500-2.9.10 Inspection. After installation of the protective lining system, the surface of the liner shall be cleaned and prepared by the Contractor and then inspected by the Engineer. Field testing shall be in accordance with 311-1.10.

500-2.9.11 Repair of Defects and Holidays. The Contractor shall repair all defects and damage in the plastic liner in accordance with 311-1.9.

500-2.10 Measurement and Payment.

500-2.10.1 Measurement. Manhole and structure rehabilitation will be measured by each.

500-2.10.2 Payment. Payment for manhole and structure rehabilitation will be made at the Contract Unit Price or lump sum price in the Bid for each structure. The Bid price shall include the installation of the lining system, surface preparation and repairs, and performance of testing unless otherwise specified in Special Provisions.

500-3 ANNULAR SPACE GROUTING.

500-3.1 Requirements.

500-3.1.1 General. This subsection covers various requirements of continuous annular space grouting of sliplining systems. The annular space (void between the host and liner pipes) shall be completely grouted to support the liner and provide long-term stability. The Contractor shall engage the services of an Agency approved testing laboratory to certify that the proposed materials and methods comply with these requirements.

500-3.1.2 Preparation. Upon completion of sliplining but prior to grouting, bulkheading of the ends and appropriate venting will be required. This is to seal the annular space from sewer flow to permit the grout to set and withstand the loads imposed by the grout and groundwater. The Contractor shall test the integrity of the installed liner pipe and constructed bulkheads for any leaks by performing the following:

a) Dewater and inject dye water into the annular space (this alternative will not be permitted if the crown or any portion of the host pipe is severely deteriorated to the point where water may escape through the host pipe).

b) Pressurize the annular space to the maximum permissible grouting pressure per the manufacturer's recommendation with approval by the Engineer.

c) The Contractor shall submit a detailed plan to the Engineer that will hold the liner pipe on the invert for a period of time long enough to allow the grout to set where buoyant uplift is a factor.

500-3.1.3 Planned Vents. The Contractor shall submit Working Drawings, including the proposed number and location of vents relative to pipe diameter and stiffness and the depth of sewer flow in the pipeline for the grouting operation.

500-3.1.4 Materials. The grout materials shall consist of cement, Portland cement and fly ash, and/or additives, provided materials are not biodegradable.

a) Compressive Strength. The grout shall have a minimum penetration resistance of 100 pounds per square inch (690 kPa) in 24 hours when tested in accordance with ASTM C403 and a minimum compressive strength of 300 pounds per square inch (2070 kPa) in 28 Days when tested in accordance with ASTM C495 or C109.

b) Performance Requirements. The Contractor shall submit the proposed grout mixes, methods, plans, and criteria of the grouting operations. The grouting system shall have sufficient gauges, monitoring devices, and tests to determine the effectiveness of the grouting operation and to ensure compliance with the liner pipe specifications and design parameters.

c) **Mix Design.** One or more mixes shall be developed to completely fill the annular space based on the following requirements:

1) Size of the annular void
2) Void (size) of the surrounding soil
3) Absence or presence of groundwater
4) Sufficient strength and durability to prevent movement of the pipe
5) Provide adequate retardation, and
6) Provide less than 1 percent shrinkage by volume

d) **Density and Viscosity.** The Contractor shall design a grout mix with a density to meet the requirements of 500-3.1.6 and to prevent floating of the liner pipe. The apparent viscosity shall not exceed 20 seconds in accordance with ASTM C939 unless otherwise approved by the Engineer.

500-3.1.5 Qualifications. The Contractor shall demonstrate to the Engineer its worker's capabilities of filling the annular space and performing their work in conformance with the Plans and the Specifications.

500-3.1.6 Grouting Equipment. The materials shall be mixed in equipment of sufficient size and capacity to provide the desired amount of grout material for each stage in a single operation. The equipment shall be capable of mixing the grout at densities required for the approved procedure and shall also be capable of changing density as dictated by field conditions any time during the grouting operation.

500-3.1.7 Injection Procedure and Pressure. The gauged pumping pressure shall not exceed the liner pipe manufacturer's approved recommendations as stated in 500-1.3.7, 500-1.8.7, and 500-1.11.8. Pumping equipment shall be of a size sufficient to inject grout at a volume, velocity and pressure compatible with the size of the annular space and degree of host pipe corrosion. Once grouting operations begin, grouting shall proceed uninterrupted from bulkhead to bulkhead. Grout placement shall not be terminated until the following conditions are met, unless otherwise approved by the Engineer:

a) the estimated annular volume of grout has been injected;
b) the exhausted grout at each vent is not less than 85 percent of the density of freshly injected grout;
c) the exhausted grout at each vent is not less than 85 percent of the original viscosity of the freshly injected grout; and
d) when recommended by the grout installer.

A grout pressure gauge and recorder shall be installed immediately adjacent to each injection port. During operations, the recorder shall continuously record the actual grouting pressure versus the time on paper with ink. The gauge shall conform to an accuracy of ± 0.5 pounds per square inch (± 3.5 kPa). The range of the gauge shall not be more than 100 percent greater than the design and attached to a saddle-type diaphragm seal (gauge saver) to prevent clogging with grout. All gauges shall be certified and calibrated in accordance with ANSI B40, Grade 2A. The grout pressure recordings shall be identified, as a minimum, with the date, batch, and time of day grouting was performed and shall be submitted to the Engineer at the end of the work day that grouting was performed.

500-3.1.8 Onsite Test. For each batch, the Contractor shall provide all equipment and personnel necessary to perform the following tests in the presence of the Engineer:

a) Density per ASTM C138 or by other methods as approved by the Engineer.
b) Viscosity per ASTM C939.

Grout that exceeds ± 3 pounds per cubic foot (48 kg/m^3) of the design density will be rejected.

500-3.1.9 Test Section. The Contractor shall perform a test on each type of grout and grout system proposed to be used. The test section to be grouted and the size of the annular space considered for each type of grout system shall be determined by the Contractor and approved by the Engineer.

500-3.1.10 Submittals and Required Calculations. The Contractor shall submit the following to the Engineer in accordance with 2-5.3:

a) The proposed grouting mix.
b) The proposed grout densities and viscosity.
c) Initial set time of the grout.
d) The 24-hour and 28-Day minimum grout compressive strengths.
e) The grout working time before a 15 percent change in density or viscosity occurs.
f) The proposed grouting method and procedures.
g) The maximum injection pressures.
h) Proposed grout stage volumes (e.g., Stage 1, to springline; Stage 2, fully grouted).
i) Bulkhead designs and locations.
j) Buoyant force calculations during grouting.
k) Flow control.
l) Provisions for re-establishment of service connections.
m) Pressure gauge, recorder, and field equipment certifications (e.g., calibration by an approved certified lab).
n) Vent location plans.
o) Written confirmation that the Contractor has coordinated grouting procedures with the grout installer and the liner pipe manufacturer.

Data for a) through e) shall be derived from trial grout batches by an approved, independent testing laboratory.

For each different type of grout or variation in procedure or installation, a complete package shall be submitted. The submittal shall include each of the above items and the sewer locations or conditions to which it applies. The Contractor shall obtain approval from the Engineer for any changes to be made in grout mix, grouting procedure, or installation prior to commencement of grouting operations.

500-4 SERVICE LATERAL CONNECTION SEALING.

500-4.1 General. This subsection specifies various SLC sealing systems, and methods of installation. The type of sealing systems and methods to be used shall be as shown on the Plans or specified in the Special Provisions. Unless otherwise specified in the Special Provisions, proof of compliance with the Chemical Resistance Test specified in 211-2 using the weight change specified in Table 500-4.1 shall be submitted to the Engineer in accordance with 2-5.3.

SLC sealing systems shall consist of either a cured-in-place resin saturated felt or fiberglass lining material and tube installed in an existing mainline and HC. Dry or unsaturated areas are not acceptable. The lining material and tube shall be sized such that when installed they are properly aligned, tight fitting and without wrinkles. SLC sealing systems shall be manufactured so as to provide smooth tapered edges after curing. The curing method and schedule shall be submitted to the Engineer in accordance with 2-5.3. The cured SLC sealing system shall meet or exceed the specifications in Table 500-4.1.

TABLE 500-4.1

Property	ASTM Test Method	Initial. PSI (MPa)
Flexural Strength	D790	3,000 (20.7)
Flexural Modulus	D790	250,000 (1,724)
Tensile Strength	D638	3,000 (20.7)
Tensile Modulus	D638	250,000 (1,724)
Weight Change[1]	-	± 1.5%

1. Tested in Conformance with 211-2

Bonding materials used with SLC sealing systems shall be compatible with the existing mainline and HC or with the lining system used in the mainline and HC, and shall be submitted in accordance with 2-5.3.

500-4.2 Requirements.

500-4.2.1 Installer Qualifications. The installer shall be certified by the manufacturer of the SLC sealing system. Personnel installing the SLC sealing system shall be adequately trained in maintenance and operation of the required installation equipment. A letter from the manufacturer of the SLC sealing system, verifying the certification of the installer, shall be submitted in accordance with 2-5.3. The installer shall be on site at all times during installation.

Prior to installation, the Contractor shall submit a detailed installation plan to the Engineer in accordance with 2-5.3. This installation plan shall provide verification of compliance with the physical properties specified in Table 500-4.1, the manufacturer's specified curing time, chemical composition and a detailed description of the SLC sealing system.

500-4.2.2 Cleaning, Inspection, and Surface Preparation. Prior to the installation of the SLC sealing system, the HC, SLC and mainline shall be prepared, as specified by the manufacturer, to produce a surface that is suitable for application of the specified sealing system. Cleaning methods shall be as specified by the manufacturer of the SLC sealing system and submitted to the Engineer in accordance with 2-5.3. Cleaning and surface preparation shall include CCTV inspection of the mainline and HC for locating any damage or leaks. CCTV inspection shall conform to 500-1.1.5. The HC's shall be inspected 16 inches (400 mm) beyond the end of the proposed lining unless otherwise specified in the Special Provisions. Any protrusions on the surface of the mainline and HC that could interfere with the installation of the SLC sealing system shall be removed. All roots larger than 1/8 inch (3 mm) shall be removed during the cleaning operation, and any damage or leaks shall be reported to the Engineer. Flow bypassing, if required, shall conform to 7-8.5.2, 7-8.5.3, and 306-3.3.

Debris from the cleaning operation shall not be allowed to enter the sewer system. The Contractor shall furnish, install, and remove any necessary debris containment devices while maintaining sewer flow. The Contractor shall remove and dispose of all debris collected from the cleaning operation in accordance with 500-1.1.4.

500-4.3 Repair and Active Infiltration.

500-4.3.1 General. Material used to repair active infiltration shall be compatible with the SLC sealing system and mainline lining material. Proof of compatibility shall be submitted to the Engineer in accordance with 2-5.3.

500-4.3.2 Active Infiltration. Active infiltration shall be eliminated by pressure grouting with chemical grout as specified by the SLC system manufacturer or specified in the Special Provisions. Upon the completion of pressure grouting, if required, the area to be sealed shall be visibly clean with no excess grout prior to lining.

500-4.4 Field Inspection Testing and Repair of Installed SLC Sealing Systems.

500-4.4.1 General. The Contractor shall submit information on the equipment to be used in testing installed SLC sealing systems to the Engineer in accordance with 2-5.3.

500-4.4.2 CCTV Inspection. After the installation is complete, the Contractor shall perform CCTV inspection in accordance with 500-1.1.5.

500-4.4.3 Adhesion Testing. Adhesion testing shall be performed on each SLC seal installed. The Contractor shall notify the Engineer 24 hours prior to performing adhesion testing, if the Engineer cannot be on site during testing, the Contractor shall videotape the test at each seal and shall submit the videotape to the Engineer in accordance with 2-5.3.

Adhesion testing shall be conducted after the SLC seal has cured in accordance with manufacturer's specifications and before the final video inspection is performed. Adhesion testing shall consist of inserting a high velocity, hydraulic cleaning type, 360 degree spinning nozzle and CCTV camera in the mainline pipe and positioning the nozzle at the SLC seal. The water from the nozzle shall be directed downstream for a minimum of 1 minute, at each edge of the SLC seal in the mainline at the minimum pressure of 1500 pounds per square inch (10 MPa) and minimum flow rate of 65 gallons per minute (246 L/m).

500-4.4.4 Air Pressure Test. Unless otherwise specified in the Special Provisions, cured SLC sealing systems shall be air pressure tested. A test plug shall be placed adjacent to the upstream and downstream end of the SLC sealing system in the mainline and adjacent to the upstream end in the HC Sewer. The test pressure shall be 4 pounds per square inch (30 kPa) for a 3 minute test time during which the pressure shall not drop below 3.5 pounds per square inch (24 kPa). If the SLC sealing system fails this test, the test plug in the HC Sewer may be moved onto the SLC seal and the test conducted again. If the second test passes, the SLC sealing system will be deemed to have passed the test.

500-4.4.5 Repairs of Sealing Systems. If the SLC sealing system fails either the adhesion or the second air pressure test, the Contractor shall remove and replace or repair the SLC sealing system as recommended by the manufacturer and approved by the Engineer.

500-4.5 Full Wrap "T-Style" SLC Sealing System.

500-4.5.1 General. This subsection specifies a full wrap "T-style" SLC sealing system.

500-4.5.2 Sealing Material. The sealing material shall consist of a cured-in-place resin saturated felt tube that provides a full-wrap tube in the mainline centered at the HC, with a tube section extended into the HC. The length of the tube section in the mainline and in the HC shall be as specified in the Special Provisions.

500-4.5.3 Installation and Curing. Installation shall conform to Section 7.0 of ASTM F2561. The installation method shall provide an air-tight seal of the SLC sealing system to the mainline pipe and HC Sewer as specified by the manufacturer and shall be submitted to the Engineer in accordance with 2-5.3. Prior to installation, the felt tube shall be saturated with resin at the Work site and stored at the temperature specified by the resin manufacturer. After installation, the felt tube shall be cured as specified by the resin manufacturer. The method of curing shall be submitted to the Engineer in accordance with 2-5.3.

500-4.6 "Brim Style" SLC Sealing System.

500.4.6.1 General. This subsection specifies a "brim style" SLC sealing system.

500.4.6.2 Sealing Material. The sealing material shall consist of a cured-in-place resin saturated fiberglass or felt material that provides a brim section in the mainline with the brim centered around the HC with a tube section extended in the HC. The length of the tube section in the HC and the size of the brim section in the mainline shall be as specified in the Special Provisions.

500.4.6.3 Installation and Curing. The fiberglass or felt material and tube shall be saturated with resin at the Work site or at the factory and stored at the temperature specified by the resin manufacturer. The resin saturated SLC sealing system shall be loaded on an applicator apparatus, attached to a robotic device and positioned in the mainline at the HC to be sealed. The robotic device shall be equipped with a CCTV camera which shall be used to align and center the SLC sealing system within the HC opening. The applicator apparatus shall include a bladder or an approved mechanical device of sufficient length in the mainline and HC such that the inflated bladder or approved mechanical device extends beyond the end of the SLC seal. The insertion pressure shall be adjusted to fully deploy the SLC sealing system in the HC and to hold the ends of the SLC seal against the pipe walls. The SLC sealing system shall produce a smooth transition between the SLC seal and the pipe walls without a ridge or gap between the SLC seal and the inner diameter of the mainline and HC. The insertion pressure shall be maintained for the duration of the curing process. Curing shall be as specified by the resin manufacturer. The method of curing shall be submitted to the Engineer in accordance with 2-5.3.

500-4.7 Measurement and Payment.

500-4.7.1 Measurement. SLC sealing systems will be measured by "each."

500-4.7.2 Payment. Payment for SLC sealing systems will be made at the Contract Unit Price or lump sum price in the Bid for each SLC. The Contract Unit Price or lump sum price in the Bid shall include furnishing and installing the SLC sealing system, surface preparation and repairs, preparation and tape submittal of all pre- and post-construction CCTV inspection, bypassing if required, and testing, unless otherwise specified in the Special Provisions.

PART 6
TEMPORARY TRAFFIC CONTROL

SECTION 600-ACCESS

600-1 GENERAL. The Contractor's operations shall cause no unnecessary inconvenience to the public or businesses in the vicinity of the Work. The Contractor shall have no greater length or quantity of Work under construction than can be prosecuted with a minimum of inconvenience to the public and other contractors engaged in adjacent or related work.

The Contractor shall provide continuous and unobstructed access to the adjacent properties unless otherwise specified in the Special Provisions or approved by Engineer.

600-2 VEHICULAR ACCESS. Vehicular access to residential driveways shall be maintained to the property line except when necessary construction precludes such access. If backfill has been completed to the extent that safe access may be provided and the street is opened to local traffic, the Contractor shall immediately clear the street and driveways and provide and maintain access.

600-3 PEDESTRIAN ACCESS. Pedestrian access shall be maintained unless otherwise approved by the Engineer.

SECTION 601-WORK AREA TRAFFIC CONTROL

601-1 GENERAL. Work area traffic control shall be as specified in the Special Provisions. The total length of the traffic control zone shall include buffer spaces, advance signing, striping transitions, and the Work site.

Work requiring traffic lane closures shall only be performed between the hours specified in the Special Provisions or shown on the traffic control plan. Traffic shall be permitted to pass through the Work site, unless otherwise specified in the Special Provisions or shown on the traffic control plan.

601-2 TRAFFIC CONTROL PLAN (TCP). If so specified in the Special Provisions, the Contractor shall submit a TCP in accordance with 2-5.3.

The sheets of the TCP shall display the title, phase identification, name of the firm preparing the TCP, name and stamp of the Registered Traffic or Civil Engineer, approval block for each jurisdictional agency, north arrow, sheet number, and number of sheets comprising the TCP. General notes and symbol definitions shall be included when required. Adequate dimensioning shall be provided to allow for proper field installation.

The TCP shall be drawn to a 1 inch = 40 feet (1:500) scale on common size sheets, either 8-1/2 inches x 11 inches, 8-1/2 inches x 14 inches, 11 inches x 17 inches, or 2-foot x 3-foot plan sheets as dictated by the length of the Work.

The requirements in the Special Provisions shall govern the design of the proposed TCP.

601-3 PAYMENT. Payment for work area traffic control and preparation of the TCP, if so required, will be made as specified in the Special Provisions.

PART 7
STREET LIGHTING AND TRAFFIC SIGNAL SYSTEMS

SECTION 700 - MATERIALS

700-1 GENERAL. The following specify the requirements for materials to be installed in street lighting and traffic signal systems.

The Contractor shall submit, prior to acceptance of the Contract, the manufacturer's warranties, guaranties, instruction sheets and parts lists supplied for materials used in the Work.

700-2 Not Used.

700-3 COMMON COMPONENTS

700-3.1 General. Subsection 700-3 specifies the requirements for components common to both street lighting and traffic signal systems. All materials furnished and installed shall be new, except materials shown on the Plans or specified in the Special Provisions to be re-used.

700-3.2 Anchor Bolts, Nuts, and Washers. Anchor bolts shall conform to ASTM A307. Each anchor bolt shall be round, have a minimum of 8 inches (200 mm) of thread, and be provided with 2 nuts and 2 flat 1/4 inch (6 mm) thick washers.

Nuts shall be symmetrically formed with the hole centered and at right angles to the face. Nuts shall be tapped to fit a corresponding thread on the anchor bolt such that the nut can be run the entire length of the thread by the fingers without undue forcing, and without play or rocking.

Anchor bolts, nuts, and washers shall be galvanized by the hot-dip process in accordance with 210-3, or be cadmium plated with Type NS coating conforming to ASTM A165.

700-3.3 Standards.

700-3.3.1 General. Standards shall have an aluminum identification plate attached with stainless steel rivets or screws as shown on the Plans. Each Standard shall have a hand hole in the base and a hand hole cover. The hand hole shall conform to the details shown on the Standard Plans. The hand hole cover shall be securely attached to the Standard with tamper-resistant hardware unless otherwise specified.

700-3.3.2 Straightness. For street lighting and pedestrian Standards the maximum deviation shall not exceed the tolerance shown in Table 700-3.3.2 when measured with the Standard in the vertical position. For traffic signal Standards the maximum deviation shall not exceed the tolerance shown in Table 700-3.3.2 when measured with the Standard in the horizontal position.

TABLE 700-3.3.2

Length of Standard – Excluding Base		Maximum Allowable Deviation From String Line[1]
Over	Equal to or Less	
---	21 feet (6.4 m)	1/2 inch (12.5 mm)
21 feet (6.4 m)	25 feet (7.9 m)	3/4 inch (19 mm)
25 feet (7.9 m)	35 feet (10.7 m)	1 inch (25 mm)
35 feet (10.7 m)	40 feet (12.2 m)	1-1/4 inches (32 mm)
40 feet (12.2 m)	---	As specified in the Special Provisions.

1. The maximum deviation shall be measured from a string line on the face of the Standard, in a plane passing through the longitudinal axis.

Short deviations shall not exceed 1/4 inch (6 mm) from the centerline of the Standard for each 5 feet (1.5 m) of length.

Offsets or jogs due to mold extensions or joints shall not exceed 1/16 inch (1.5 mm) in thickness along the surface of the Standard.

700-3.3.3 Metal Standards.

700-3.3.3.1 General. The top of each Standard shall be equipped with an ornamental cap securely held in place by a 3/4 inch (19 mm) diameter hex head machine bolt. Provisions shall be made for substituting a 3/4 inch (19 mm) diameter steel insulator pin. The cap and cap support surface shall have sufficient strength to transfer to the Standard, from a point 5 inches (125 mm) above the top of the cap, a horizontal load of 950 pounds (4,250 N).

Metal Standards shall a) withstand, without permanent deformation, a maximum horizontal load of 950 pounds (4,250 N) applied to the center of the cap, and b) withstand, without exceeding a deflection of 2-5/16 inches (58 mm), a normal horizontal load of 370 pounds (1,650 N) applied to the cap.

Exposed edges of plates that comprise the base assembly shall be finished smooth. Exposed corners shall be rounded unless otherwise shown on the Plans. Slots or drilled holes shall have a tolerance of 0 to + 1/8 inch (3 mm).

Metal Standards shall be equipped with anchor bolt covers made of metal of the same type as that used for the shafts unless otherwise specified. Anchor bolt covers shall be equipped with all necessary fittings and hardware for securing to the Standard.

700-3.3.3.2 Steel Standards. Unless otherwise specified, steel Standards shall be fabricated from sheet steel of weldable grade having a minimum yield strength, after fabrication, of 40,200 pounds per square inch (276 MPa). When a single-ply 5/16 inch (8 mm) thick steel Standard is specified, a 2-ply steel Standard with an equivalent section modulus may be substituted unless otherwise specified. Test reports that verify conformance to the required minimum yield strength shall be submitted to the Engineer.

Steel Standards may be fabricated from full-length sheets or shorter sections. Each section shall be fabricated from not more than 2 pieces of sheet steel. Where 2 pieces are used, the longitudinal welded seams shall be directly opposite each other. When the sections are butt welded together, the longitudinal welded seams on adjacent sections shall be placed to form continuous straight seams from the base to the top. In addition, butt welded sections shall be strengthened by inserting a welded sleeve at each joint. The sleeve shall be fabricated from steel 1/8 inch (3 mm) nominal thickness or thicker of the same composition as the steel used in the Standard. The sleeve shall have a minimum length of 1 inch (25 mm). The sleeve shall be centered at the joint and have the same taper as the Standard such that the outside of the sleeve is in full contact throughout its length and circumference. The weld metal at the

transverse joint shall extend to the sleeve. No transverse joint shall occur within 3 inches (75 mm) of mast arm fittings.

Welds shall be continuous and conform to AWS D1.1. Welds joining the shaft to the base plate shall be as shown on the Standard Plans. However, alternative weld joint details may be approved by the Engineer. Approval of alternative weld joint details will be contingent upon the proposed weld joint passing both weld procedure and nondestructive testing as deemed necessary by the Engineer.

Longitudinal welds in steel tubular sections may be tested by the Agency in accordance with California Test 664. The sampling frequency will be determined by the Engineer. Welds may be made by the electric resistance welding process. Exposed welds shall be ground flush with the base metal.

Steel Standards shall be galvanized by the hot-dip process in accordance with 210-3, or be cadmium plated with Type NS coating conforming to ASTM A165. If so specified, steel Standards shall be painted. Paint shall conform to 210-1. Painting shall conform to 310.

700-3.3.3.3 Aluminum Standards. Aluminum Standards shall be fabricated from seamless tubing conforming to "6063-T6 wrought aluminum alloy of the Specifications of the Aluminum Association" or the requirements shown in Table 700-3.3.3.3.

TABLE 700-3.3.3.3

ITEM	ASTM
Castings	B26/B26M
Luminaire Arm	B490-90a
Spun Shaft	B241/B241M
Square Extruded Shaft	B429

The wall thickness of the shaft shall be a minimum of 1/4 inch (6 mm). Aluminum Standards shall be supplied with a mill finish and conform to ASTM B209/B209M.

700-3.3.4 Fiberglass Standards. Fiberglass Standards shall consist of fiberglass-reinforced thermosetting plastic poles. Fiberglass Standards shall be hollow, tapered or with tapered sections, non-conductive and chemically inert. Fiberglass Standards shall conform to the AASHTO "Standard Specification for Structural Support for Highway Signs, Luminaires and Traffic Signals" and ANSI requirements. The Contractor shall submit a Certificate of Compliance with each shipment. The certificate shall include a copy of all applicable test reports. The certificate shall certify that the Standards were manufactured in accordance with an Agency-approved testing and quality control program.

Fiberglass Standards shall be constructed of continuous fiberglass filaments combined with thermosetting polyester and ultraviolet-resistant resin. The fiberglass and resin ratio shall contain at least 65 percent glass and 35 percent resin by weight. The resin shall be pigmented as specified and be of uniform color throughout the entire body. The glass filament shall be helically wound under tension at angles to provide axial strength. Hand hole, conduit entrance opening, and mast arm connection areas shall be reinforced. The finish shall be smooth.

Fiberglass Standards shall be flame resistant when tested in accordance with ASTM D635.

Fiberglass Standards shall be either direct burial or have an anchor base as shown on the Standard Plans. The base shall be bonded to the pole with an adhesive recommended by the manufacturer, and coated with an aliphatic-type acrylic-modified polyurethane finish. Each fiberglass Standard shall be equipped with a removable aluminum or galvanized steel pole top cap.

An aliphatic-type acrylic-modified polyurethane coating shall be applied to the exterior. The coating shall be semi-gloss, weather resistant and match the color of the resin specified. The coating shall have a minimum of 3 mils (75 µm) dry film thickness. A 1 quart (1 L) can of the coating that matches the specified color shall be furnished to the Engineer. The coating shall be tested by the manufacturer for adhesion in accordance with ASTM D3359, Method A and have a scale rating of 5A. The adhesion testing shall be conducted before and after the manufacturer's accelerated weathering evaluation. The Contractor shall submit a copy of the test results in accordance with 2-5.3.

Finished surfaces shall be capable of withstanding a minimum of 2,500 hours of accelerated weathering when tested, in accordance with ASTM G154. Testing lamps shall be UV-B (313 nm wavelength). The testing cycle shall consist of 4 hours of ultraviolet (UV) exposure at 140°F (60°C), followed by 4 hours of condensate exposure at 100°F (40°C). After testing, the finished surface shall exhibit the following:

a) Fiber Exposure – None

b) Crazing – None

c) Checking – None

d) Chalking – Very slight

e) Change in color - May dull slightly.

Each Standard shall be spiral-wrapped in its entirety with a weather-proof wrap for protection during shipping and storage.

700-3.4 Mast Arms. Mast arms shall be fabricated from the same material specified for the adjoining Standard, except for fiberglass Standards. Mast arms for fiberglass Standards shall be fabricated from aluminum. Mast arm fabrication shall conform to 700-3.3.3.2 or 700-3.3.3.3. Mast arms shall be smoothly curved to the approximate configuration shown on the Standard Plans. Mast arms shall have an aluminum identification plate attached with stainless steel rivets or screws, as shown on the Standard Plans.

Exposed welds, except fillet and fatigue resistant welds on top of the mast arms shall be ground flush with the base metal.

Mast arms shall be furnished complete with all necessary fittings and hardware for attachment to the adjoining Standard.

700-3.5 Conduit.

700-3.5.1 General. Conduit size and material shall be as shown on the Plans.

700-3.5.2 Rigid Metallic Conduit. Rigid metallic conduit and conduit fittings shall be galvanized by the hot-dip, electrodepositing, or metallizing process in accordance with 210-3. Conduit shall conform to the UL Standard for Rigid Metallic Conduit, Publication UL 6, and shall bear the UL label on each length. The zinc coating shall be tested in accordance with ASTM A239.

700-3.5.3 Galvanized Pipe. Galvanized pipe used as conduit shall conform to the following:

a) ASTM A53 Grade A.

b) Only standard lengths shall be supplied to the Work site.

c) Need not be UL-listed.

700-3.5.4 Rigid Non-Metallic Conduit. Rigid non-metallic conduit shall conform to the UL Standard for Rigid Non-Metallic Conduit, Publication UL 651 (PVC Schedule 80) and UL 651B (HDPE). Rigid non-metallic conduit connections shall be of the solvent-weld-type.

700-3.6 Pull Tape or Rope. Pull tape or rope shall be as specified and used to install wires or cables. Pull tape shall consist of a flat, woven, lubricated, soft-fiber polyester tape with a minimum tensile strength of 1,800 pounds (8,000 N) and shall have a painted sequential measurement marking at least every 3 feet (1 m).

Pull rope shall be 1/4 inch (6 mm) diameter polyethylene rope with a minimum tensile strength of 1,800 pounds (8,000 N).

700-3.7 Pull Boxes. Pull boxes, covers, and extensions shall be as shown on the Standard Plans unless otherwise specified.

Pull box covers for street lighting systems shall be inscribed "STREET LIGHTING HIGH VOLTAGE."

Pull box covers for traffic signal systems, or combined traffic signal and multiple-circuit street lighting systems shall be inscribed "TRAFFIC SIGNAL."

Pull box covers for underground service points, where both traffic signals and street lighting jointly occupy the same box, shall be inscribed "TS-SL."

When a ballast, transformer or other device is to be placed in a non-metallic pull box, the pull box shall be provided with recesses for a hanger.

700-3.8 Splice Insulation.

700-3.8.1 General. Splice insulation shall be tape or heat-shrink tubing unless otherwise specified.

700-3.8.2 Splice Insulation Tape and Pads. Splice insulation tape shall consist of layers of vinyl chloride electrical insulating tape conforming to ASTM D2301, Type I.

Low-voltage tape shall be UL or ETL-listed and shall be the following types:

a) Self-fusing, oil and flame-resistant, synthetic rubber.

b) Pressure-sensitive, adhesive, polyvinyl chloride, 150 μm minimum thickness.

Tape for insulating splices in high-voltage (over 600V) circuits shall be designed for use on 5kV circuits and shall be resistant to ozone, corrosion and water. Insulating pads shall be composed of a laminated 1/16 inch (1.5 mm) thickness of electrical grade polyvinyl chloride and a 1/8 inch (3 mm) thickness of butyl splicing compound with removable liner.

700-3.8.3 Heat-Shrink Tubing. Heat-shrink tubing shall be medium or heavy wall thickness, irradiated polyolefin tubing containing an adhesive mastic inner wall. The minimum wall thickness prior to contraction shall be 1/32 inch (800 μm). When heated, the inner wall shall melt and fill all crevices and interstices of the object being covered while the outer wall shrinks to form a waterproof insulation. Each end of the tube or open end of the end cap of heat-shrink tubing shall, after contraction, overlap the conductor insulation at least 1-1/2 inches (38 mm). Heat-shrink tubing shall conform to the requirements of UL 468D and ANSI C119.1 for extruded insulated tubing at 600V. Heat-shrink tubing shall also conform to the following requirements:

a) Shrinkage Ratio: 33 percent, maximum, of supplied diameter when heated to 257°F (125°C) and allowed to cool to 77°F (25°C).

b) Dielectric Strength: 140kV per 3/8 inch (9.5 mm), minimum.

c) Resistivity: 10^{13} Ω-mm, minimum.

d) Tensile Strength: 2000 pounds per square inch (14 MPa), minimum.

e) Operating Temperature: -40°F to 194°F (-40°C to 90°C) [275°F (135°C) Emergency].

f) Water Absorption: 0.5 percent, maximum.

700-3.9 Bonding and Grounding. Bonding jumpers shall be copper wire or copper braid of the same cross sectional area as No. 6 AWG conductor for multiple circuit lighting systems and No. 8 AWG conductor or larger for series and all other street lighting and traffic signal systems. The cross sectional area of the jumper shall match the cross sectional area of the conductors in the circuit. Equipment grounding conductors shall be color coded to code requirements or shall be bare.

Bonding bushings to be installed on metal conduit shall be of the galvanized or zinc alloy type.

Ground electrodes shall be one-piece, 100-inch (2.5 m) long galvanized steel rod or pipe no less than 1 inch (25 mm) in diameter, or copper-coated (minimum thickness of rod coating 10 mils (250 μm)) steel rod not less than 1/2 inch in diameter by 8 feet long (12.5 mm in diameter by 2.4 m long).

700-3.10 Services. Service conduit shall conform to the requirements of the serving utility and shall not be less than 2 inches (50 mm) in diameter.

Where a kilowatt-hour meter is required, a meter socket with sealing ring, as approved by the serving utility, shall be furnished and installed. Where a meter socket is installed, the meter enclosure shall be provided with factory installed test bypass facilities as required by the serving utility.

Service equipment enclosures shall be galvanized or, if so specified, provided with a factory applied rust resistant prime coat and finish coat.

700-3.11 Circuit Breakers. Circuit breakers shall be of the quick-break type, capable of either automatic or manual operation, and listed by UL or ETL. The operating mechanism shall be enclosed and trip-free from the operating handle on overload. Circuit breakers shall be trip-indicating, have the frame size plainly marked, and the trip rating clearly indicated on the operating handle. Overload tripping breakers shall not be influenced by an ambient temperature range from 0°F (–18°C) to 122°F (50°C). Multiple-pole breakers shall be the internal-trip-type.

700-4 STREET LIGHTING SYSTEM MATERIALS.

700-4.1 Reinforced Concrete Standards.

700-4.1.1 General. Shop Drawings and a concrete mix design shall be submitted in accordance with 2-5.3.

Reinforced concrete Standards shall have a uniform color and surface appearance.

Reinforced concrete Standards shall be constructed of pre-stressed, centrifugally spun, black and white marble aggregate or natural exposed aggregate, Portland cement concrete, and be either the direct burial or anchor base type. The cross section shall not deviate more than 3/16 inch (5 mm) from the shape and dimensions shown on the Standard Plans or approved Shop Drawings. The length shall not deviate more than 1 percent of the total length or a maximum of 3 inches (75 mm) from the dimensions shown on the Standard Plans or approved Shop Drawings. The maximum deviation from a string line at any point shall not exceed 1/32 inch per foot (2.6 mm/m) of length. The maximum deviation from a string line on the face in a plane passing through the longitudinal axis shall not exceed the tolerance shown in Table 700-3.3.2.

A central opening or duct shall be formed throughout the entire length. The opening or duct shall be 1-1/4 inches (32 mm) in diameter unless otherwise shown on the Standard Plans or approved Shop Drawings. The opening or duct shall be free from sharp projections or edges which might damage wire or cable. The base shall be cored to the dimensions shown on the Standard Plans or approved Shop Drawings.

Reinforced concrete Standards used with post-top luminaires shall be terminated with a post-top adapter with a tenon.

700-4.1.2 Reinforcement. Reinforced concrete Standards shall be reinforced with at least 4 pre-stressed steel strands. Each pre-stressed steel strand shall consist of an uncoated 7-wire stress relieved strand conforming to 303-3.3. Each strand shall be mechanically anchored to the base plate or base-reinforcing cage depending on the type of base specified. Strands shall be pre-tensioned to develop the specified design strength. However, in no case shall the stress in the strands immediately after transfer exceed 70 percent of the minimum specified ultimate strength of the strands. Deformed bars may be used in addition to the pre-stressed strands depending on the size and loading.

Longitudinal reinforcing shall be spirally wrapped with No. 11 AWG (3 mm) or larger steel wire on a variable pitch, dependent upon the loading. The maximum pitch shall not exceed 6 inches (150 mm). Transformer bases cast integral with the shaft shall be reinforced with deformed steel bars securely attached to the base anchor lugs or plate and pre-stressing cables.

Four galvanized deformed bar studs at least 1 foot (300 mm) long shall be extended 1 inch (25 mm) above the top for attachment of a bracket arm or tenon when required. Metal components shall conform to the requirements shown in Table 700-4.1.2.

TABLE 700-4.1.2

MATERIAL	ASTM
Pre-stressed Steel	A416
Deformed Bar	A615 Grade 40 or Grade 60/A706
Base Plate	A36
Base Anchor Lugs	A36

700-4.1.3 Casting. Casting shall be in rigid steel molds such that the relief in the design is sharp and distinct. Longitudinal steel reinforcement shall be securely anchored to the top and bottom of the mold plates and provide 3/4 inch (19 mm) minimum of concrete cover except within 2 feet (600 mm) of the top where the minimum cover shall be 5/8 inch (16 mm).

Standards shall be cured in their molds until the concrete has attained a set sufficiently hard to prevent deformation or slipping of cable strands.

After the mold cure is complete, the remaining cure shall conform to 207-2.7.

After sufficient curing, the entire outside surface shall be blasted to remove cement laitance and develop the surface texture.

700-4.1.4 Finish. The finish shall be free of cracks or crazing, rock pockets or any discoloration or ridges and shall have a uniform surface (without objectionable mold marks) and texture throughout the entire length.

Surface defects extending less than 5/8 inch (16 mm) in the shell may be repaired without the prior approval of the Engineer. The repair shall be made by a method that will produce a permanent bond and a surface that blends into the color and surface appearance of the remainder. Surface defects extending greater than 5/8 inch (16 mm) into the shell shall not be repaired prior to inspection by the Engineer. Standards containing voids or insufficient cover over pre-stressing cables, reinforcing steel or a blocked central opening or duct will not be accepted.

700-4.1.5 Acceptance. Reinforced concrete Standards shall be labeled or marked in a permanent fashion to indicate the manufacturer, and month and year of fabrication. Markings shall be located within 2 feet (600 mm) of the bottom but not on the hand-hole cover. Markings shall be visible through the hand hole opening.

A lot shall be defined as 100 Standards or less of the same design, produced in sequence on consecutive production Days, and which bear the specified markings. The Standards composing each lot shall be uniform in color and surface appearance. A new lot number shall be assigned if there is any change in the size, type, or spacing of reinforcing or pre-stressing steel, concrete mix, or curing method. The frequency of sampling and testing, and basis of acceptance, shall be as specified in the Special Provisions. The Contractor shall notify the Engineer, in writing, at least 5 Days prior to any contemplated change in supplier or source of raw materials, and shall obtain approval of any changes before the Standards are delivered.

700-4.2 Wire/Conductors.

700-4.2.1 General. Wire shall be a single strand of drawn metal that may or may not be insulated. Conductors shall be single (solid) or multiple (stranded) strands of metal that are insulated. Cable shall be multiple wires or conductors that are insulated and enclosed in an insulating cable jacket. Copper wire shall conform to ASTM B3 and B8. Wire sizes shall be based on the American Wire Gage (AWG). The wire diameter shall not be less than 98 percent of the specified AWG diameter.

Conductors shall have clear, distinctive and permanent markings on the outer surface throughout the entire length showing the manufacturer's name or trademark, insulation type letter designation, wire size, and voltage rating.

Conductor insulation shall be a solid color or basic colors with a permanent colored stripe. Solid or basic colors shall be homogenous throughout the full depth of insulation except for the clear nylon layer, if present.

700-4.2.2 Conductors for Series Circuits. Conductors for series street lighting systems shall be No. 8 AWG solid copper wire. Wire shall be insulated, covered with 110 mils (2800 µm) of black polyethylene insulation conforming to Standard S-61-402 of the Insulated Power Cable Engineers Association, and designated for operation at 5,000V. The Contractor shall submit a Certificate of Compliance, for 5,000V (6.6A) series lighting conductors.

Where isolating transformers or external (remote) ballasts are used, the secondary wires in the Standard from the transformer or external (remote) ballast to the luminaire shall be insulated No. 10 AWG solid copper wire. The insulation for these wires shall be black and rated and UL approved for 600V operation. The insulation shall be standard THW or THWN/THHN grade polyvinyl chloride, conforming to the applicable provisions of ASTM D2219 and D2220.

700-4.2.3 Conductors for Multiple Circuits. Conductors for multiple circuits shall be of the type, size and insulation colors shown in Table 700-4.2.3 or on the Plans. The insulation shall be THW or THHN/THWN grade polyvinyl chloride, conforming to the applicable provisions of ASTM D2219 and D2220. At any point the minimum thickness of any THW or THHN/THWN insulation shall be 55 mils (1400 µm) for conductor sizes No. 14 AWG to No. 10 AWG inclusive and 59 mils (1500 µm) for No. 8 AWG to No. 2 AWG inclusive.

TABLE 700-4.2.3

Multiple Circuits	Function	Identification			Size
		Insulation Colors		Band Symbols[c]	
		Base	Stripe[a]		
Multiple Service (Stranded)	Ungrounded Line 1	Black	None	NBR	8
	Ungrounded Line 2	Red	None	NBR	8
	Grounded/Neutral	White	None	NBR	8
Street Lighting Pull Box to Pull Box[b] (Stranded)	Ungrounded Line 1 (odd)	Black	None	NBR	8
	Ungrounded Line 2 (even)	Red	None	NBR	8
	Grounded/Neutral	White	None	NBR	8
Street Lighting Pull Box to Luminaire[b] (Solid)	Ungrounded Line 1 (odd)	Black	None	NBR	10
	Ungrounded Line 2 (even)	Red	None	NBR	10
	Grounded/Neutral	White	None	NBR	10
Lighting Control From Luminaires with PEU's to Luminaires without PEU's (Solid)	Ungrounded to PEU	Black	None	C1	10
	Switching leg of PEU to terminal strip.	Red	None	C2	10
	Switching leg of PEU to unswitched Luminaire[d].	Purple	None	NBR	8/10[d]

NBR = No Band Required PEU = Photoelectric Unit

a. Band conductors in each pull box and near ends of termination point.

b. Both wires between external high intensity discharge (HD) ballast lamp shall be black No. 10 AWG Solid wire.

c. "S" if circuit is switched on line side of service equipment by utility.

d. No. 8 AWG Stranded conductor from pull box to pull box and No. 8 AWG solid wire in the Standards.

700-4.3 Splicing Units and Terminal Blocks.

700-4.3.1 Disconnecting Splice Connector (High Voltage).

700-4.3.1.1 Connector Case. The connector case or shell shall be formed of neoprene or plastic having a volume resistivity not less the 3.94×10^{12} ohms per inch (10^{13} ohms per cm). The diameter shall not exceed 2-1/2 inches (63 mm) and the length shall not exceed 10 inches (250 mm). The case shall withstand a load of 200 pounds (900 N) applied normal to the axis of the case without rupture, cracking, or permanent deformation.

Each half of the case shall lock together with screw threads capable of forming a watertight joint and be separated by a neoprene "O" ring under compression when the connector is assembled. The wires that are to be spliced shall attach to the connector by a self threading lug made from a No. 8 AWG solid copper wire. The connecting lug shall be slotted at 90 degrees to provide a pressure fit between the male and female parts. Metal parts shall be cadmium plated.

Each half of the case shall be completely filled with a sealing compound and be held in place with a wire/cable entrance plug designed to accommodate any cable having an overall diameter of between 11/32 inch (9 mm) and 5/8 inch (16 mm).

700-4.3.1.2 Connector Case Sealing Compound. The sealing compound shall be a viscous paste composed of oil and inert mineral filler waterproof and resistant to oxidation, weathering and biological attack. The volume resistivity shall not be less than 3.94×10^{11} ohms per inch (10^{12} ohms per cm).

When exposed to air for 18 hours in a film 1/8 inch (3 mm) thick at a temperature of 70°F ± 2°F (21°C ± 1.1°C) absorption of water shall not exceed 0.02 fluid ounces per square inch (0.6 mL/cm^2) of surface area in contact with the water.

When allowed to dry in contact with air, the lineal shrinkage of the exposed surface shall not exceed 0.2 percent.

700-4.3.1.3 Electrical Characteristics. When 2 wire/cable ends are connected and sealed in the connector case with sealing compound, the unit shall sustain an electrical stress of 11,000V at 70°F ± 2° F (21°C ± 1.1°C), without breakdown, after immersion in water for 18 hours.

700-4.3.2 Fused Splice Connectors. Fused splice connectors shall have no exposed metal parts except for the head of a stainless steel assembly screw. The head of the stainless steel assembly screw shall be recessed a minimum of 1/32 inch (800 µm) below the top of a plastic boss which surrounds the head.

Fused splice connectors shall completely enclose the fuse and protect the fuse against damage from water and weather. The contact between the fuse and the fuse holder shall be the spring-pressure type.

Fuses shall be standard midget, ferrule type, with "slow blow" feature.

700-4.3.3 Terminal Blocks. Terminal blocks shall have a minimum of 12 positions with terminals rated at No. 8 AWG or larger to accept the field wires shown on the Plans.

700-4.4 High Pressure Sodium Luminaires. High-pressure sodium luminaires shall be the enclosed cutoff-type with a horizontal burning lamp unless otherwise specified. Each luminaire shall consist of a housing, a reflector, a refractor or lens, a lamp socket, an internal (integral) ballast, a starter, a terminal strip and a lamp.

Each mast arm-mounted luminaire shall be furnished without a photoelectric unit receptacle unless otherwise specified. If a photoelectric unit receptacle is included, a rain-tight shorting cap shall be installed. If a luminaire housing is provided with a hole for the receptacle, the hole shall be closed, covered and sealed with weatherproof material.

The housing shall be fabricated from aluminum. Housings that are painted shall withstand a 1,000-hour salt spray test in accordance with ASTM B117. Other metal parts of the housing shall be fabricated from metal that equals or exceeds the corrosion resistance and finish of the metal used for the housing. The housing shall be equipped with a slip-fitter capable of mounting on a 2-inch (50 mm) pipe tenon and of being adjusted 5 degrees from the axis of the tenon. The clamping brackets of the slip-fitter shall not bottom out on the housing bosses when adjusted within the ± 5 degree range.

No part of the slip-fitter mounting brackets shall develop a permanent set in excess of 1/64 inch (400 µm) when the 4, 3/8 inch (9.5 mm) diameter cap screws used for mounting are tightened to 9.62 foot-pounds (13 J).

Luminaires to be mounted on horizontal mast arms shall be tested in accordance with California Test 611, and be capable of withstanding cyclic loading in (G = Acceleration of Gravity):

a) a vertical plane at a minimum peak acceleration level of 3.0 G peak-to-peak sinusoidal loading (same as 1.5 G peak) with the internal ballast removed, for a minimum of 2,000,000 cycles without failure of any luminaire parts,

b) a horizontal plane perpendicular to the direction of the mast arm at a minimum peak acceleration of 1.5 G peak-to-peak sinusoidal loading (same as 0.75 G peak) with the internal ballast installed, for a minimum of 2,000,000 cycles without failure of any luminaire parts, and

c) a vertical plane at a minimum peak acceleration level of 1.0 G peak-to-peak sinusoidal loading (same as 0.5 G peak) with the internal ballast installed, for a minimum of 2,000,000 cycles without failure of any luminaire parts.

The surface of each reflector shall be specular and protected by either an anodized finish or a silicate film.

Each refractor or lens shall be mounted in a frame that is hinged to the housing and secured with a spring-loaded latch. Each refractor shall be made of glass or polycarbonate plastic. Each lens shall be made of heat and impact resistant glass.

The optical system, consisting of the reflector, refractor or lens, lamp socket and lamp, shall be contained in a sealed chamber. The seal shall consist of a gasket between the reflector and refractor or lens and a gasket between the reflector and lamp socket. The chamber shall have provisions for a filtered flow of air in and out due to lamp heat. Filtering shall be accomplished by either a separate filter or a filtering gasket.

Each lamp socket shall be a porcelain enclosed mogul-multiple type. The shell shall contain integral lamp grips to assure electrical contact under conditions of normal vibration. The socket shall be mounted in the luminaire in a manner to permit pre-setting a variety of specified light distribution patterns. The socket shall be rated for 1500W, 600V, and for a 4kV pulse.

When the ballast, starter and terminal strip are mounted on a down-opening door, the door shall be hinged and secured to the luminaire separately from the refractor or flat lens frame. The door shall be removable and replaceable. The door shall be secured to the housing in a manner to prevent its accidental opening when the refractor or flat lens frame is opened.

Field conductors connected to the luminaire shall terminate on a barrier type terminal block secured to the housing. Terminal screws shall be captive and equipped with wire grips for conductors up to No. 6 AWG. Each terminal position shall be clearly identified.

The minimum light distribution for each luminaire shall be as shown on the isolux diagrams on the Plans. The maximum brightness of each cutoff luminaire, with the lamp indicated, shall be as shown in Table 700-4.4 (A).

TABLE 700-4.4 (A)

Lamp ANSI Code No.	Lamp Wattage	Maximum Brightness (cd/m^2)
S55	150	140
S66	200	140
S50	250	175
S67	310	210
S51	400	260

Brightness readings specified are based on the use of a brightness meter with an acceptance angle of 1.5 degrees. When measured on the 90-degree and 270-degree lateral angle line, the maximum brightness shall not exceed the required brightness when the meter is located at a horizontal distance of 120 feet (37 m) and a vertical distance of 7.5 feet (2.3 m) between the luminaire and the meter, or at an angle of 3 degrees-35 minutes from the horizontal to the line between the luminaire and the meter. Measurements shall be made from both the 90-degree line and the 270-degree line and averaged. The lamp for each test shall be operated at the wattage necessary to produce the light output shown in Table 700-4.4 (B).

TABLE 700-4.4 (B)

Lamp Wattage	Lumens
150	16,000
200	22,000
250	27,000
310	37,000
400	50,000

700-4.5 Lamp Ballasts.

700-4.5.1 General. The input voltage for ballasts and ballast types shall be as specified. The ballast shall be plainly marked as to its operating voltage and wattage characteristics. Noise generated by the ballast or in combination with the starting aid shall be minimized. The ballast, including starting aid, shall incorporate protection against normal lamp failure modes. Ballasts for luminaires to be mounted on mast arms, brackets or lowering assemblies shall be located within the luminaire housing.

Ballasts shall be designed for the type, characteristics and wattage of the lamp it is to operate and shall provide the lamp starting and waveforms, voltage and current specified in the Special Provisions. Ballasts shall also be designed to operate under outdoor conditions, either mounted internally (integral) within the luminaire or lighting fixture or mounted externally (remote) to the luminaire. Ballasts shall have a design life of not less than 100,000 hours. Ballasts shall provide reliable starting and operation at ambient temperatures down to -22°F (–30°C) for the rated life of the lamp.

Ballasts shall be designed for continuous operation at ambient air temperatures from -4°F (-20°C) to 149°F (65°C) without reducing the rated life. Ballasts shall be designed to operate for a minimum of 180 cycles of 12 hours on and 12 hours off, with the lamp circuit in an open or short-circuited condition and without a measurable reduction in the operating requirements specified in 700-4.4.

Heat-generating components shall be mounted so as to use the portion of the luminaire they are mounted on as a heat sink. Capacitors shall be located as far as practicable from heat-generating components or shall be thermally shielded to limit the case temperature to 167°F (75°C).

Transformers and inductors shall be resin-impregnated for protection against moisture. Capacitors, except those in starting aids, shall be encased in metal and hermetically sealed.

Ballasts shall be tested in accordance with ANSI C82.6-1980.

700-4.5.2 Internal Ballasts. Each internal ballast shall consist of separate components, each of which shall be capable of being easily replaced. A starting aid which is encapsulated will be considered as a single component. Each component shall be provided with screw terminals, NEMA tab connectors or a single multi-circuit connector. Conductor terminals shall be identified as to the component terminal to which they are connected.

Internal ballasts shall be tested within the luminaire and shall be rated at a minimum temperature of 221°F (105°C).

700-4.5.3 Remote Ballasts. Ballasts to be located remote (external) from the luminaire shall be the submersible-type and shall conform to 700-4.8.3. All components, including starting aids, shall be enclosed in a single housing. Ballast leads shall extend a minimum of 12 inches (300 mm) from the housing. Steel housings shall be galvanized or painted. Ballast housings shall be clearly labeled to indicate lamp type, lamp wattage and input voltage.

700-4.5.4 Starting Aids. Starting aids, if required, shall be interchangeable between ballasts of the same wattage and manufacturer without adjustment.

700-4.5.5 High Pressure Sodium Lamp - Constant Wattage (CW) or Constant Wattage Auto-Regulator (CWA) – Ballasts. CW and CWA ballasts shall have a ballast characteristic curve which intersects both of the lamp-voltage limit lines between the wattage limit lines and remains between the wattage limit lines throughout the full-range of lamp voltage. This requirement shall be met not only at the rated input voltage of the ballast, but also at the lowest and highest input voltage that the ballast is rated. Throughout the rated lifetime of the lamp, the ballast curve shall fall within the limits of the specified lamp voltage and wattage.

700-4.5.6 Regulator Type Ballasts.

700-4.5.6.1 General. Regulator type ballasts shall be the lag-type or lead-type and conform to the following requirements:

a) For nominal input voltage and lamp voltage, the ballast design center shall not vary more than 7.5 percent from the rated lamp wattage.

b) Ballasts shall be designed such that a capacitance variance of ± 6 percent will not cause more than a ± 8 percent variation in lamp wattage regulation throughout the rated lamp life for nominal input voltage.

c) The lamp current crest factor shall not exceed 1.8 for input voltage variation of ± 10 percent at any lamp voltage from initial through life.

700-4.5.6.2 Lag-Type. Lag-type regulator ballasts shall have the primary and secondary windings electrically isolated and, when operated with the appropriate lamp, conform to the following requirements:

a) The power factor shall be not less than 90 percent throughout the life of the lamp at nominal line voltage with a nominally rated reference lamp.

b) Lamp wattage regulation spread at any lamp voltage from nominal through life shall not vary by more than 18 percent for a ± 10 percent input voltage variation.

700-4.5.6.3 Lead-Type. Lead-type regulator CWA ballasts shall, when operated with the appropriate lamp, conform to the following requirements:

a) The power factor shall be not less than 90 percent when the ballast is operated at nominal line voltage with a nominally rated reference lamp.

b) The lamp wattage regulation spread at any lamp voltage from nominal through life shall not vary by more than 30 percent for ± 10 percent input voltage variation.

700-4.5.7 Autotransformer or Reactor-Type Ballasts. Non-regulating reactor, autotransformer, or high-reactance ballasts shall, when operated with the appropriate lamp, conform to the following requirements:

a) The power factor shall be not less than 90 percent when the ballast is operated at nominal line voltage with a nominally rated reference lamp.

b) The lamp wattage regulation spread at any lamp voltage from nominal through life shall not vary by more than 25 percent for ± 5 percent input voltage variation.

c) For nominal input voltage and lamp voltage, the ballast design center shall not vary more than 7.5 percent from rated lamp watts.

d) The lamp current crest factor shall not exceed 1.8 for an input voltage variation of ± 5 percent at any lamp voltage from initial through life.

700-4.5.8 Physical Requirements. External leads for multiple to multiple and series to multiple secondary connections shall be Type USE No. 10, rated 600V AC. Primary conductors for series to multiple ballasts shall be rated for use on 5000V AC circuits.

Ballast leads shall extend a minimum of 12 inches (300 mm) from the case. The ballast insulation shall be NEMA 365°F (185°C).

Series to multiple ballasts shall withstand the application of 12,000V AC from core to primary coil and from coil to coil for a 1 minute period. Series to multiple ballasts secondaries and multiple-to-multiple ballasts shall withstand the application of 2,200V AC from core to coils and, for multiple units

only, from coil to coil for a 1 minute period. These tests shall be made immediately after operation of the ballast at full-load for 24 hours.

Non-submersible ballasts shall be equipped with metal half-shell coil protection, moisture resistant, synthetic varnish impregnated windings and shall be suitable for outdoor operation in a rain-tight enclosure.

Each ballast to be installed in a pull box shall be the submersible-type and be equipped with a handle and a hanger.

700-4.6 High Pressure Sodium Lamps.

700-4.6.1 General. High pressure sodium lamps shall conform to ANSI Standard C78 "Lamp Specifications, Physical and Electrical Characteristics of High-Intensity Discharge Lamps," when tested in accordance with ANSI Standard C78.388, "Methods of Measurement of High Pressure Sodium Lamp Characteristics." High-pressure sodium lamps shall have a minimum average rated life of 24,000 hours.

700-4.6.2 Lamp Size Identification Targets. Lamp size identification targets shall:

a) be constructed of noncorrosive material that will provide a durable and legible surface that is designed to endure for the life of the luminaire,

b) have a stable color background and black block numerals,

c) be 3 inches (75 mm) square, and

d) have the identification numbers and background color shown in Table 700-4.6.2 (A) and Table 700-4.6.2 (B), respectively. The identifying numerals shall be 2 inches (50 mm) high, minimum, and have a stroke width of 1/4 inch (6 mm).

TABLE 700-4.6.2 (A)

Identifying Numeral	Lamp Wattage
1	18
3	35
5	50 or 55
7	70
9	90
10	100
13	135
15	150 – 55V
15H	150 – 100V
17	175
17B	175 Position Oriented
18	180
20	200
21	215
25	250
25B	250 Position Oriented
30	300
31	310
36	360
40	400
40B	400 Position Oriented
70	700
XI	1000

TABLE 700-4.6.2 (B)

Background Color	Lamp Type
GOLD	High Pressure Sodium
GREEN	High Pressure Sodium/Mercury Ballast
LIGHT BLUE	Mercury
RED	Metal Halide
PURPLE	Incandescent
AQUA	Fluorescent

700-4.7 Photoelectric Controls.

700-4.7.1 General. Photoelectric controls shall consist of a photoelectric unit which plugs into an EEI-NEMA twist-lock receptacle integral with the luminaire. Photoelectric controls, if specified, shall be capable of switching multiple lighting systems directly.

700-4.7.2 Photoelectric Control Units. Photoelectric control units shall provide an output in response to changing light levels. The response level shall remain stable throughout the life of the unit. Components shall not require periodic replacement.

Photoelectric control units shall have a "turn-on" between 10 and 50 lux and a "turn off" at between 1.5 and 5 times "turn-on." Measurements shall be by the procedures specified in "EEI-NEMA Standards for Physical and Electrical Interchangeability of Light–Sensitive Control Devices Used in the Control of Roadway Lighting."

Photoelectric control units shall also conform to the following requirements:

a) The supply voltage rating shall be 60Hz, 105-130V, 210-240V, or 1-5-240V, as specified.

b) The load rating shall be 1000W minimum, incandescent, mercury or fluorescent.

c) The operating temperature range shall be from -20°F (-29°C) to 149°F (65°C).

d) The power consumption shall be less than 10W.

e) Housed in a weatherproof enclosure.

f) The base of the unit shall be provided with a 3-prong, EEI-NEMA standard, twist-lock plug mounting.

g) Equipped with a "fail-on" feature.

700-4.7.3 Contactors. Contactors shall have contacts rated to switch the specified lighting load and shall be normally open, unless otherwise specified. Contactors shall be either the mechanical armature type or the mercury displacement type. The contacts of the mechanical armature type shall be either fine silver, silver alloy, or superior alternative material. Contactors shall have a minimum rating of 30A per contact inductive load.

700-4.7.4 Terminal Blocks. Terminal blocks shall be rated at a minimum of 30A, 600V unless otherwise specified. Terminal blocks shall be molded from phenolic or nylon material and shall be the barrier-type with plated brass screw terminals and integral-type marking strips.

700-4.8 Transformers.

700-4.8.1 General. Multiple to multiple and series to multiple transformers shall be of the single-phase, dry type designed for operation on a 60Hz supply.

700-4.8.2 Electrical Requirements. Transformer ratings shall be 120/480V, 240/480V, 480/120V, or 480/240V for multiple to multiple units unless otherwise shown on the Plans. Transformer ratings for series to multiple units shall be 6.0A/120V or 6.6A/4.8kV unless otherwise shown on the Plans. Secondary 480V windings shall be center tapped. Volt-ampere ratings shall be as shown on the Plans. Transformer efficiency shall exceed 95 percent for multiple to multiple units and 80 percent for series to multiple units.

Secondary voltage regulation and tolerance shall be ± 3 percent from half-load to full-load for multiple to multiple units and +10 percent (maximum) at no load to ± 3 percent at full-load for series to multiple units.

Transformers shall have a decal showing a connection diagram. The diagram shall show either color coding or tagging of wires with primary (H1, H2) or secondary (X1, X2) markers, and shall also show the primary and secondary voltage and volt-ampere rating.

700-4.8.3 Submersible-Type Transformers. Submersible-type transformers shall be securely encased in a corrosion-resistant, watertight case and withstand a 5-Day test of being submerged in 24 inches (600 mm) of salt water (2 percent salt by mass) with 12-hour on and off periods. The operating periods shall be at full-load. Leads shall be brought out through one or more sealed hubs and secured in a manner that will withstand a force of 101 pounds (450 N) static pull without loosening or leaking.

700-5 TRAFFIC SIGNAL MATERIALS.

700-5.1 Steel Pedestrian Standards and Pedestals for Controller Cabinets. Steel pedestrian Standards and pedestals for controller cabinets shall be constructed of 1/8 inch (3 mm) or thicker galvanized steel, 4-inch (100 mm) schedule 40 galvanized steel pipe, or size 103 conduit. Steel pedestrian Standards and pedestals shall conform to 700-3.3, except the top shall be designed for slip-fitting. Push-button posts shall be manufactured of 2-1/2-inch (63 mm) schedule 40 galvanized steel pipe. Galvanized steel pipe shall conform to ASTM A53.

700-5.2 Pedestals. Pedestals shall have an aluminum identification plate attached with stainless steel rivets or screws.

Welds shall be continuous and conform to 700-3.3.3.2. Exposed welds shall be ground flush with the base metal.

Pedestals shall be galvanized by the hot-dip process in accordance with 210-3, or be cadmium plated with Type NS coating conforming to ASTM A165. If so specified, pedestals shall also be painted in accordance with 210-1 and 310.

Pedestals shall be furnished complete with all necessary fittings and hardware for attachment of the controller cabinet to the adjoining pedestal.

700-5.3 Conductors and Cable.

700-5.3.1 General. Copper wire shall conform to ASTM B3 (solid) and 700-4.2. Wire sizes, other than for wires used in loop detector lead-in cable, shall be based on the American Wire Gage (AWG). The wire diameter shall not be less than 98 percent of the specified AWG diameter. Conductors used in loop detector lead-in cable shall conform to ASTM B286. A Certificate of Compliance shall be submitted for each type of cable used in the Work.

Unless otherwise specified, Table 700-5.3.1 shall be used to identify the conductors.

TABLE 700-5.3.1

Circuit	Signal Phase Or Function	Identification			Size [f]
		Insulation Colors		Band Symbols[d]	
		Base	Stripe [a]		
Vehicle Signals [c]	2, 6	Red, Yellow, Brown	Black	2.6	14
	4, 8	Red, Yellow, Brown	Orange	4.8	14
	1, 5	Red, Yellow, Brown	None	1.5	14
	3, 7	Red, Yellow, Brown	Purple	3.7	14
Pedestrian Signals [c]	2p, 6p	Red, Brown	Black	2p, 6p	14
	4p, 8p	Red, Brown	Orange	4p, 8p	14
	1p, 5p	Red, Brown	None	1p, 5p	14
	3p, 7p	Red, Brown	Purple	3p, 7p	14
Pedestrian Push Buttons [c]	2p, 6p	Blue	Black	P-2, P-6	14
	4p, 8p	Blue	Orange	P-4, P-8	14
	1p, 5p	Blue	None	P-1, P-5	14
	3p.7p	Blue	Purple	P-3, P-7	14
Traffic Signal Controller Cabinet [b]	Underground between Service Switch & Cabinet	Black	None	CON-1	6
		Red	None	CON-2	6
Sign Lighting [e]	Ungrounded Line 1	Black	None	SL-1	10
	Ungrounded Line 2	Red	None	SL-2	10
Grounded and Common	Pedestrian Push Buttons	White	Black	NBR	14
	Signals	White	None	NBR	10
	Sign Lighting	White	None	NBR	12
Railroad Pre-Emption		Black	Black	R	14
Spares		Black	None	NBR	14

NBR = No Band Required

a. On overlaps, insulation is striped for first phase in designation, e.g. Phase (2 & 3) insulation is striped as for phase 2.
b. Band for overlap and special phases as required.
c. These requirements do not apply to signal cable.
d. Band conductors in each pull box and near each termination point. On signal light circuits, a single band may be placed around 2 or 3 ungrounded conductors comprising a phase.
e. Conductors between ballasts and sign lighting lamps shall be No. 16 AWG and color shall correspond to the ballast leads.
f. The No. 14 AWG conductor shall be solid copper in a 16 mils (410 µm) minimum polyvinyl chloride insulation encased in a 5 mils (130 µm) minimum clear nylon jacket. The No. 10 conductor shall be solid copper in a 22 mils (560 µm) minimum polyvinyl chloride insulation encased in a 8 mils (200 µm) minimum clear nylon jacket.

Single conductors, multi-conductor cables, and lead-in cables shall have clear, distinctive and permanent markings on the outer surface throughout their entire length showing the manufacturer's name or trademark, insulation type letter designation, conductor size, voltage rating and number of conductors. Multi-conductor cable jackets shall be black polyethylene binder sheath, rated for 600V and 167°F (75°C), or black polyvinyl chloride conforming to IMSA 9-1. Filler material, if used to make the multi-conductor round, shall be polyethylene.

Conductor insulation shall be of a solid color or of basic colors with a permanent colored spiral stripe under the nylon jacket as shown in Table 700-4.2.3 unless otherwise specified. Solid or basic colors shall be homogeneous throughout the full-depth of insulation. Identification stripes shall be a continuous spiral over the entire length of the conductor. For conductor sizes No. 2 and larger, the insulation may be black and the ends taped with electrical insulating tape of the required color for a minimum of 20 inches (500 mm).

700-5.3.2 Materials.

700-5.3.2.1 General. Individual wires shall be solid copper with Type THWN or polyvinyl chloride insulation, and shall conform to 700-4.2.1 and ASTM B286. The minimum thickness of Type THWN insulation, at any point, shall be 12 mils (300 μm) for No. 14 conductor and 16 mils (400 μm) for No. 10 conductor. The minimum thickness of the polyvinyl chloride insulation, at any point shall be 16 mils (400 μm) for No. 14 AWG conductor and 22 mils (560 μm) for No. 10 AWG conductor. No. 14 AWG conductors shall have a clear nylon jacket a minimum of 5 mils (127 μm) thick. No. 10 AWG conductors shall have a clear nylon jacket a minimum of 8 mils (203 μm) thick.

700-5.3.2.2 Three-Conductor Cable. Three-conductor cable shall be used for pedestrian push buttons and a spare.

Three-conductor cable shall consist of 3 No. 14 AWG wires. The cable jacket shall have a minimum average thickness of 43 mils (1100 μm) and a minimum thickness at any point of 35 mils (900 μm). The nominal outside diameter of the cable shall not exceed 3/8 inch (9.5 mm). The color code of the wires shall be blue/black stripe, blue/orange stripe and white/black stripe.

700-5.3.2.3 Five-Conductor Cable. Five-conductor cable shall consist of 5 No. 14 AWG wires. The cable jacket shall have a minimum average thickness of 43 mils (1100 μm) and a minimum thickness at any point of 35 mils (900 μm). The nominal outside diameter of the cable shall not exceed 1/2 inch (12.5 mm). The color code of the wires shall be red, yellow, brown, black, and white.

700-5.3.2.4 Nine-Conductor Cable. Nine-conductor cable shall consist of 8 No. 14 AWG wires and 1 No. 12 AWG wire. The cable jacket shall have a minimum average thickness of 59 mils (1500 μm) and a minimum thickness at any point of 47 mils (1200 μm). The nominal outside diameter of the cable shall not exceed 11/16 inch (17 mm). The color for the No. 12 AWG wire shall be white. The color code for the No. 14 AWG wires shall be as shown in Table 700-5.3.2.4 .

TABLE 700-5.3.2.4

Primary Color	Color Code
Red	Yellow/Black strip
Yellow	Brown/Black strip
Brown	Black
Red/Black strip	White/Black strip

700-5.3.2.5 Twelve-Conductor Cable. Twelve-conductor cable shall be used for vehicle signals, pedestrian signals, spares, and the signal common. Twelve-conductor cable shall consist of 11 No. 14 AWG wires and 1 No. 12 AWG wire. The cable jacket shall have a minimum average thickness of 59 mils (1500 μm) and a minimum thickness at any point of 47 mils (1200 μm). The nominal outside diameter of the cable shall not exceed 3/4 inch (19 mm). The color code of the No. 12 AWG wire shall be white. The color code and functional connections for the No. 14 AWG wires shall be as shown in Table 700-5.3.2.5 unless otherwise specified.

TABLE 700-5.3.2.5

Color Code	Termination	Phase
Red	Vehicle Signal Red	2, 4, 6, or 8
Yellow	Vehicle Signal Yellow	2, 4, 6, or 8
Brown	Vehicle Signal Green	2, 4, 6, or 8
Red/Black stripe	Vehicle Signal Red	1, 3, 5, or 7
Yellow/Black stripe	Vehicle Signal Yellow	1, 3, 5, or 7
Brown/Black stripe	Vehicle Signal Green	1, 3, 5, or 7
Black/Red stripe	Spare, or Ped. Signal use as required for Vehicle Signal red or "Don't Walk"	----
Black/White stripe	Spare, or use as required for Yellow	----
Black	Spare, or Ped. Signal use as required for Vehicle Green or "Walk"	----
Red/White stripe	Ped. Signal "Don't Walk"	----
Brown/White stripe	Ped. Signal "Walk"	----

700-5.3.2.6 Twenty-Eight-Conductor Cable. Twenty-eight-conductor signal cable shall consist of 27 No. 14 AWG wires and 1 No. 10 AWG wire cabled with polyethylene fillers, if necessary to make the cable round. Clear binder tape shall be used to wrap the cable core. The black polyvinyl chloride cable jacket shall have a minimum average thickness of 80 mils (2000 μm) and a minimum thickness at any point of 60 mils (1600 μm). The manufacturer's name, the type of insulation for each wire, the number of wires of each size, the size of the wires in the cable and the voltage rating shall be imprinted on the outside of the cable jacket. Sequential distance markings shall be imprinted at 2-foot (600 mm) intervals. The nominal outside diameter of the cable shall not exceed 7/8 inch (23 mm). The voltage rating shall be 600V and the temperature rating shall be 167°F (75°C). Signal commons in each cable shall be kept separate except at the signal controller. Each cable shall be labeled in each pull box, "C1" or "C2". The cable identified as "C1" shall be used for signal Phases 1, 2, 3 and 4. The cable identified "C2" shall be used for signal Phases 5, 6, 7 and 8. The "C1" and "C2" cable may also be used as specified. The reel size shall allow for a maximum of 2,000 feet (610 m) of cable with a 2-3/4-inch (70 mm) arbor hole.

The color code for the No. 10 AWG wire shall be white. The color code and functional connections for the No. 14 AWG wires shall be as shown in Table 700-5.3.2.6, unless otherwise specified.

TABLE 700-5.3.2.6

Color Code	Termination	Phase
Red/Black stripe	Vehicle Signal Red	2 or 6
Yellow/Black stripe	Vehicle Signal Yellow	2 or 6
Brown/Black stripe	Vehicle Signal Green	2 or 6
Red/Orange stripe	Vehicle Signal Red	4 or 8
Yellow/Orange stripe	Vehicle Signal Yellow	4 or 8
Brown/Orange stripe	Vehicle Signal Green	4 or 8
Red/Silver stripe	Vehicle Signal Red	1 or 5
Yellow/Silver stripe	Vehicle Signal Yellow	1 or 5
Brown/Silver stripe	Vehicle Signal Green	1 or 5
Red/Purple stripe	Vehicle Signal Red	3 or 7
Yellow/Purple stripe	Vehicle Signal Yellow	3 or 7
Brown/Purple stripe	Vehicle Signal Green	3 or 7
Red/2 Black stripes	Ped. Signal DON'T WALK	2 or 6
Brown/2 Black stripes	Ped. Signal WALK	2 or 6
Red/2 Orange stripes	Ped. Signal DON'T WALK	4 or 8
Brown/ 2 Orange stripes	Ped. Signal WALK	4 or 8
Red/2 Silver stripes	Overlap A, C, Red	OLA, OLC
Brown/2 Silver stripes	Overlap A, C Green	OLA, OLC
Red/2 Purple stripes	Overlap B, D Red	OLB, OLD
Brown/2 Purple stripes	Overlap B, C Green	OLB, OLD
Blue/Black stripe	Ped. Push Button	2 or 6
Blue/Orange stripe	Ped. Push Button	4 or 8
Blue/Silver stripe	Overlap A, C Yellow	OLA(y), OLC(y)
Blue/Purple stripe	Overlap B, D Yellow	OLB(y), OLD(y)
White/Black stripe	Ped. Push Button Common	---
Black/Red stripe	Railroad Preemption	---
Black	Spare	---

700-5.3.3 Interconnect Cable.

700-5.3.3.1 Direct Wire. Interconnect cable shall consist of 7 No. 14 AWG tinned copper wires unless otherwise specified. Each wire shall be insulated with color coded, polypropylene material a minimum of 13 mils (330 μm) nominal thickness.

The interconnect cable jacket shall be black, high density polyethylene, rated for a minimum of 300V at 140°F (60°C), and have a nominal wall thickness of 40 mils (1000 μm) minimum. The cable jacket or the moisture-resistant tape directly under the outer jacket shall be marked with the manufacturer's name, insulation type designation, number of wires and wire size, and voltage and temperature ratings.

700-5.3.3.2 Filled Telephone Cable. Filled telephone cable shall consist of paired No. 22 AWG solid annealed copper wires. The cable shall be polyethylene insulated and aluminum shielded, and conform to REA Specification PE-39 for filled telephone cable. The cable sizes shall be 12 and 25-pair.

700-5.3.3.3 Telephone Lines. Telephone lines shall be No. 14 AWG stranded, twisted, pair copper wire having 600V insulation and overall shield and jacket.

700-5.3.4 Fiber Optic Cable.

700-5.3.4.1 General. Fiber optic cable shall be a 6-optical glass fiber cable rated by the manufacturer for the aerial, direct burial, or duct installation specified or shown on the plans. The optical fibers shall be multi-mode graded index optical glass with a nominal fiber core diameter of 50 microns and a nominal fiber cladding diameter of 125 microns. The fiber shall have a numerical aperture of 0.2.

700-5.3.4.2 Performance. The minimum optical performance of each fiber measured at wave lengths of both 850 nanometers and 1,300 nanometers shall have a maximum attenuation of 3.5 decibels per kilometer at 858 nanometers and 1.0 decibel per kilometer at 1,300 nanometers, and shall have a minimum bandwidth of 800 megahertz-kilometers unless otherwise specified.

700-5.3.4.3 Construction. The cable shall be constructed using 6 filled, loose-tube, color-coded dual-layer buffer tubes stranded (reverse oscillation) around a steel central member. The 6 color coded fibers shall be contained in a buffer tube and the remaining buffer tubes shall be natural or white. The tubes shall be held in position around the strength member by a layer of aramid yarn. The buffer tube diameter shall be a nominal 250 microns. The color code for the fibers and the buffer tubes shall be as shown on the Plans.

700-5.3.4.4 Jacket. Fiber optic cable shall be covered with a medium density polyethylene jacket. The color of the jacket shall be black unless otherwise specified. The jacket shall be abrasion and crack resistant, non-nutrient to fungus, electronically non-conductive, compatible with all cable components that it may come in contact with, and free from holes, splits, blisters or other imperfections.

700-5.3.4.5 Identification. Each length of cable shall be imprinted with the manufacturer's name and type of cable at intervals not greater than 6 feet (2 m) along the outside of the jacket. Each length of cable shall be imprinted with length markings at intervals not greater than 3 feet (1 m).

700-5.3.4.6 Reels. Fiber optic cable shall be wound on reels in a manner which provides access to both ends of the cable for testing while the cable is still on the reel.

700-5.4 Controllers.

700-5.4.1 General. Controllers, controller cabinets and auxiliary equipment shall be as specified in the Special Provisions, or shown on the Plans or Standard Plans.

700-5.4.2 Wiring. Conductors shall be No. 22 AWG or larger, with a minimum of 19 strands. Conductors shall conform to Military Specification MIL-W-16878D, Type B or better. The insulation shall have a minimum thickness of 10 mils (250 μm) and be nylon-jacketed polyvinyl chloride, irradiated cross-linked polyvinyl chloride, polyhalocarbon, or polychloro-alkene, except for conductors No. 14 AWG and larger which may be UL Type THHN.

Flat cable may be used in lieu of individual conductors. Cable shall be constructed of No. 28 AWG or larger wires. Conductor insulation shall be rated at 300V and for use at 221°F (105°C). Cables shall be provided with strain relief.

Conductors shall conform to the following color-code requirements.

a) The grounded conductor of a circuit shall be identified by a continuous white or natural gray color.

b) The equipment grounding conductor shall be identified by a continuous green color or by a continuous green color with one or more yellow stripes.

c) Ungrounded conductors shall be identified by any color not specified above.

Conductors shall terminate with properly sized captive or spring-spade-type terminals, or be soldered to a through-panel solder lug on the rear side of the terminal block. Crimp-style connectors shall be applied with a tool that is designed to prevent opening of the handles until the crimp is complete.

An equipment grounding conductor bus shall be provided in each controller cabinet. The bus shall be grounded to the cabinet and connected to the metal conduit system or other approved ground with a No. 8 or larger, grounding conductor.

With all of the cabinet equipment in place and connected, the resistance between the grounded conductor terminal bus and the equipment grounding conductor bus shall be 50,000,000 ohms minimum, when measured with an applied voltage of 150V DC.

If a DC circuit is to be grounded, the circuit shall be connected to the equipment ground only.

Two or more terminal blocks shall be provided for field connections. Terminals blocks for field connections shall be installed within 22 inches (550 mm) of the face on the cabinet and shall be oriented for screwdriver operation from the door opening. All terminals shall be a minimum of 5 inches (125 mm) above the foundation.

No more than 3 conductors shall be brought to any one terminal. Two flat metal jumpers, straight or U shaped, may also be placed under a terminal screw. At least 2 full threads of all terminal screws shall be fully engaged when the screw is tightened. No live parts shall extend beyond the barrier.

Wiring diagrams shall conform to 700-4.3.

700-5.4.3 Cabinets.

700-5.4.3.1 General. Controller cabinets shall be rainproof and conform to the dimensions shown on the Standard Plans.

Cabinets and doors shall be fabricated from 1/16 inch (1.5 mm) minimum thickness cold rolled steel, 1/16 inch (1.8 mm) minimum thickness stainless steel, or 1/8 inch (3 mm) minimum thickness aluminum. Exterior seams shall be continuously welded.

Exterior welds shall be ground smooth. Edges shall be filed to a minimum radius of 1/32 inch (800 µm).

Metal shelves or brackets shall be provided to support the controller unit and auxiliary equipment.

Machine screws and bolts shall not protrude beyond the outside wall.

Conduit shall enter the bottom and towards the front of the cabinet unless otherwise shown on the Plans.

A pliable seal, composed of caulking compound or mastic, shall be placed between the controller cabinet and the concrete foundation.

700-5.4.3.2 Steel Cabinets. Steel cabinets shall be finished with a polymer or enamel coating system conforming to Color No. 14672 of Federal Standard 595B. Coatings shall be commercially smooth, substantially free of flow lines, paint washout, streaks, blisters and other defects that would impair serviceability or distract from the general appearance. Coatings shall conform to the following requirements:

a) Hardness. The finish shall have a pencil lead hardness of HB minimum.

b) Salt Spray Resistance. Undercutting of the film of the coating system shall not exceed 1/8 inch (3 mm) average, from lines scored diagonally and deep enough to expose the base metal, after 336 hours exposure in a salt spray cabinet in accordance with ASTM B117.

c) Loss. No coating loss shall be incurred when subjected to the following:

   1) Two test specimens 4 inches x 8 inches (100 mm x 200 mm) of the same material and coating as the cabinet supplied shall be furnished by the Contractor for testing.

   2) Two 9-inch (225 mm) diagonal scratches exposing bare metal will be made on one specimen. The specimen will be soaked in de-mineralized water for 192 hours. A 1 inch (25 mm) wide strip of masking tape will be tightly affixed to the scratched surface and removed with one quick motion. Evidence of blistering, softening, or peeling of the paint or coating from the base metal will be cause for rejection. Testing will be performed in accordance with California Test 645, except the 180-degree bend test will not be required.

Metal preparation shall conform to the 3-step iron phosphate conversion coating bonderizing technique. The inside walls, doors, and ceiling of the housing shall be finished the same as the outside.

700-5.4.3.3 Stainless Steel Cabinets. Cabinets fabricated from stainless steel shall conform to the following requirements:

a) Annealed or quarter-hard stainless steel sheet shall be used and shall conform to ASTM A666 for Type 304 Grades A or B.

b) Welding shall be by the gas tungsten arc welding process using bare stainless steel welding electrodes. Electrodes shall conform to AWS A5.9 for ER308 chromium-nickel bare arc welding electrodes.

c) Procedures, welders and welding operators for welding on stainless steel shall conform to AWS C5.5.

d) Exposed, exterior surfaces shall be ground or brushed to a 0.6 µm to 1.3 µm finish using iron-free abrasives or stainless steel brushes.

e) Overlapping exterior seams shall conform to NEMA Type 4 enclosures.

f) After grinding or brushing, no rust discoloration shall show when subjected to the following:

1) Forty-eight hours of exposure in a salt spray cabinet in conformance with ASTM B117; and

2) Twenty-four hours of exposure in a tap water spray cabinet with the water temperature between 100°F (38°C) and 113°F (45°C). Any cabinet which shows rust discoloration anywhere on its surface after the test will be rejected.

g) Cabinets that have been rejected because of surface discoloration may be cleaned, passivated, and resubmitted for testing.

700-5.4.3.4 Aluminum Cabinets. Aluminum cabinets shall conform to ASTM B209 or B209M for 5052-H32 aluminum sheet and the following requirements:

a) Welding shall be done by the gas metal arc welding process using bare aluminum welding electrodes. Electrodes shall conform to AWS A5.10 for ER5356 aluminum alloy bare welding electrodes.

b) Procedures, welders and welding operators for welding on aluminum shall be qualified in accordance with AWS B3.0 and C5.6.

c) Surfaces shall be finished in accordance with Military Specification MIL-A-8625C "Anodic Coatings for Aluminum and Aluminum Alloys" for a Type II, Class 1 coating, except that anodic coating shall have a minimum thickness of 20 µm and a minimum coating weight of 40 $\mu g/mm^2$. Anodic coating shall be sealed in a 5 percent aqueous solution of nickel acetate (pH 5.0 to 6.5) for 15 minutes at 207°F (97°C). Prior to applying anodic coating the cabinets shall be cleaned and etched as follows:

1) Immerse in inhibited alkaline cleaner, 6 to 8 ounces per gallon (45 to 60 g/L), 160°F (71°C) for 5 minutes.

2) Rinse in cold water.

3) Etch in a solution of 0.39 ounces (11 g) of sodium fluoride, plus 4 to 6 ounces of sodium hydroxide per gallon (30 to 45 g/l) of distilled water at 140°F to 149°F (60°C to 65°C) for 5 minutes.

4) Rinse in cold water.

5) Desmut in a 50 percent, by volume, nitric acid solution at room temperature for 2 minutes.

6) Rinse in cold water.

700-5.4.3.5 Doors. Cabinets shall have a single front door equipped with a lock. The door width shall be as shown on the Standard Plans. When the door is closed and latched, the door shall be locked. The handle shall have provisions for locking in the closed position. The handle shall have a minimum length and steel shank as shown on the Standard Plans. The handle shall be fabricated of cast aluminum or of zinc-plated or cadmium-plated steel. The cabinet frame shall be designed so that the latching mechanism will hold tension on and form a firm seal between the door gasket and frame. Locks shall be the solid brass, 6-pin tumbler rim type, with rectangular, spring-loaded bolts. Locks shall be left hand, and rigidly mounted with stainless steel machine screws approximately 2 inches (50 mm) apart. Keys shall be removable in the locked and unlocked positions, and 2 keys shall be furnished with each cabinet. The front position of the lock shall extend 1/8 to 1/4 inch (3 to 6 mm) beyond the outside surface of the door.

The latching mechanism shall be a 3-point cabinet latch with nylon rollers. The center catch and pushrods shall be zinc-plated or cadmium-plated steel. Pushrods shall be turned edgewise at the outer supports and shall be 1/4 inch (6 mm) x 3/4 inch (19 mm) minimum. Nylon rollers shall have a minimum diameter of 3/4 inch (19 mm) and shall be equipped with ball bearings.

Cadmium plating shall conform to Military Specification MIL-QQ-416b. Zinc plating shall conform to 210-3.

Doors shall be equipped with 3-bolt butt hinges. Each hinge shall have a fixed pin. Doors larger than 22 inches (550 mm) or 6 square feet (0.56 m^2) in area shall be equipped with catches to hold the door open at both 90 degrees and 180 degrees, plus or minus 10 degrees. Catches shall be plated steel rods a minimum of 3/8 inch (9 mm) in diameter. Catches shall be capable of holding the door open at 90 degrees in a 56 miles per hour (90 km/h) wind at an angle perpendicular to the plane of the door.

A police panel shall be mounted on the front door as shown on the Standard Plans and shall be equipped with a lock keyed to a master police key. Two keys shall be furnished with each cabinet. Each police key shall have a shaft at least 1-3/4 inches (45 mm) in length. Police panels shall not be furnished for controllers that do not control traffic signals.

Door hinges, pins and bolts shall be made of stainless steel. Hinges on aluminum cabinets may be aluminum with a stainless steel hinge pin. Hinges shall be bolted to the cabinet. Hinge pins and bolts shall not be accessible when the door is closed.

Gasketing shall be provided on all door openings and shall be dust-tight. Gaskets shall be permanently bonded to the metal. The mating surface shall be covered with a silicone lubricant.

Shop Drawings of alternative designs shall be submitted in accordance with 2-5.3.

700-5.4.3.6 Cabinet Ventilation. Each controller cabinet shall be equipped with one of the following as specified in the Special Provisions:

a) Eight screened, rain-tight vent holes 1/2 inch (12.5 mm) in diameter or larger, in the lower side or bottom of the cabinet.

b) Louvered vents with a permanent metal mesh.

c) A 4-ply woven polypropylene air filter held firmly in place capable of passing 100 cubic feet per minute (2.83 m^3/min.) of air.

Each controller cabinet shall be equipped with an electric fan with ball or roller bearings and a capacity of at least 100 cubic feet per minute (2.83 m^3/min.). The vents shall be able to pass this volume of air.

The fan shall be thermostatically controlled and shall be manually adjusted to turn on between 90°F (32°C) and 150°F (65°C) with a differential of not more than 10°F (6°C) between automatic turn-on and turn-off. The cabinet fan circuit shall be fused at 125 percent of the ampacity of the fan motor installed.

The fan and cabinet vent holes shall be located with respect to each other so as to direct the bulk of the air flow over the controller or through the ventilating holes of the controller where those holes exist.

700-5.4.3.7 Cabinet Accessories. The following accessories shall be furnished with each cabinet assembly unless otherwise specified:

a) Labels. A permanent printed, engraved or silk screened label shall be provided for the following equipment and for all other removable items of equipment:

1) Receptacles for relays and switching devices.

2) Switches, fuses and circuit breakers.

3) Labels shall conform to the designations on the cabinet wiring diagram. Labels for all shelf-mounted equipment shall be on the face of the shelf below the item. Labels for wall-mounted equipment shall be below the item.

b) Convenience Receptacle. A convenience receptacle shall be mounted in a readily accessible location inside the cabinet. The convenience receptacle shall be a duplex, 3-prong, NEMA, Type 5-15R grounding outlet and shall conform to UL Standard 943.

c) Lighting Fixture. The lighting fixture shall be a fluorescent lighting fixture, mounted on the inside top of the cabinet near the front edge. The fixture shall be provided with an F15T8, cool white lamp operated from a normal power factor UL or ETL listed ballast. The "On-Off" switch for the lighting fixture shall be either of the following:

1) A toggle switch mounted on the inside door panel.

2) A door-actuated switch that turns the light on when the door is open, and off when the door is closed.

d) Surge Arrestor. The surge arrestor shall reduce the effects of power line voltage transients and shall have ratings as follows:

Recurrent peak voltage 184V
Energy rating maximum ..... 20 J
Power dissipation average 0.85W
Peak current for pulses less than 7 picoseconds 1250A

Standby current shall be 1 milliampere or less for 60 Hz sinusoidal input.

e) **Terminal Blocks.** Terminal blocks shall be rated 600V AC minimum, and shall be provided with nickel, silver or cadmium plated brass binder head screw terminals.

Heavy duty terminal blocks shall be rated at 20A and shall be provided with 12 poles with No. 10 x 5/16 inch (8 mm) nickel plated brass binder head screws and nickel plated brass inserts. Each pole position shall be provided with 2 terminal positions. The terminal blocks shall be the barrier type, with shorting bars in each of the 12 positions, and shall be provided with integral-type marking strips.

Light duty terminal blocks shall be rated at 5A and shall be provided with 12 poles with No. 6 x 1/8 inch (3 mm) binder head screws. Each pole position shall be provided with one terminal position.

700-5.4.4 Components.

700-5.4.4.1 Toggle Switches. Toggle switches shall have poles as required and shall be rated at 200 percent of circuit current for circuits of 10A or less and 125 percent of circuit current for circuits over 10A.

700-5.4.4.2 Cartridge Fuses. Cartridge fuses shall be installed in panel mounted fuse holders. Fuse type and rating shall be as recommended by the fuse manufacturer for the type of load being protected.

700-5.4.4.3 Circuit Breakers. Circuit breakers shall conform to 700-3.11 except that the circuit breakers shall have a minimum interrupting capacity of 5000A, RMS.

700-5.4.4.4 Connectors. Connectors used for interconnecting various portions of circuits together shall be designed and constructed for the application involved. Connectors shall be designed to provide positive connection of all circuits, and easy insertion and removal of mating contacts. Connectors shall be permanently keyed to prevent improper connection of circuits.

Connectors, or devices plugging into connectors, shall be provided with positive means to prevent any individual circuit from being broken due to vibration, pull on connecting cable or similar disruptive force.

700-5.4.5 Dual 5-Way Active Data Bridges.

700-5.4.5.1 General. Dual 5-way active data bridges shall be provided in controller assemblies if specified. Bridges shall provide a 4-wire transmission interconnection between a dedicated common port and four multiple ports. Bridges shall incorporate a splitter channel and a combiner channel. Multiple inputs shall be connected to a common output in the combiner channel. In the splitter channel, a common input shall be connected to multiple outputs. Splitter and combiner shall be separate and independent allowing operation in full-duplex data transmission applications.

Bridges shall be equipped with a front-panel-accessible potentiometer with continuous adjustment of cross-bridge gain or loss within 2 switch-selectable loss/gain ranges suitable for most data applications; –30dB to –10dB and –10dB to +10dB. Either range shall be independently selectable for each channel. The level to which each channel is adjusted shall be common to all cross-bridge port combinations in that channel (that is, if the splitter-channel potentiometer is set for +3dB gain, all common-to-multiple-port paths in the splitter shall receive a +3dB level increase).

Ports, both common and multiple, shall be characterized by a balanced 600 ohm terminating impedance. The module's active circuit shall allow unused multiple ports to be left un-terminated without affecting the transmission response of the ports in use.

Input, output and line monitor jacks on the front panel shall allow isolated-module, isolated-facility, and cross-bridge measurement of transmission parameters in both the splitter and combiner channels.

Bridges shall be powered from input voltage of –22 to –56V DC at a maximum current of 60 mA.

Each unit shall be individually packaged in a housing. Circuitry shall be solid state, and constructed on removable industry standard circuit boards with plug-in edge connectors.

Test jacks, edge connectors and external plug connectors shall be of a type and material suitable for use in the environment specified without deterioration for the useful life of the equipment. The physical size of the case shall not exceed 105 cubic feet (3700 cm^3) (approximately 7 inches x 8 inches x 4 inches (175 mm x 200 mm x 100 mm) and shall be suitable for mounting to the frame of a field cabinet.

Mounting holes shall be provided for attaching the unit to one side of the frame of a relay rack. Input and output ports shall be provided for 5 full-duplex telephone circuits with input and output ports labeled as to function. Level control or switches and level adjustment potentiometers along with the input and output level test jacks shall provide external adjustments without removal of the housing.

700-5.4.5.2 Application. A bridge shall be used to interconnect several 4-wire data modems to a common data channel or data link. The common data link shall be terminated at the distant end into a central processor unit (CPU) or computer. A bridge shall be used to provide the central transmission arrangement or "hubbing" network, that extends data transmission to outlying terminals.

Tandem bridge arrangements to expand the number of multiple ports of a 4-wire data hubbing network shall be effected by direct connection of one multiple port in each channel of the first bridge to the common port of the same channel of a second bridge to provide a 4-wire data bridge with one common and 7 multiple ports.

700-5.4.5.3 Circuit Description. The combiner channel of the bridge shall consist of a variable-gain integrated-circuit-operational amplifier with an input summing circuit. The summing circuit shall add the transmission energy from all multiple input ports at a low-impedance summing point to provide input port isolation. The output of the amplifier shall be connected to a transformer for balanced connection to the facility.

The splitter channel shall consist of a transformer-input-variable-gain, integrated-circuit-operational amplifier, and a power amplifier. The output of the power transformer shall be low impedance and drive 8, 300-ohm resistors to drive impedance at the multiple output circuits and provide isolation between output circuits.

The multiple ports in the splitter and combiner channels of the bridge shall be isolated and balanced via an output transformer and matched precision resistors in each channel.

700-5.4.5.4 Electrical Requirements. Bridges shall conform to the electrical requirements shown in Table 700-5.4.5.4.

TABLE 700-5.4.5.4

Splitter channel loss/gain	-30 to +10 dB usable range
Combiner channel loss/gain	-30 to +10 dB usable range
Maximum output level (overload point)	Splitter: +5 dbmW Combiner: +12 dBm
Level change with loading	1 dB maximum, one port to all ports loaded.
Noise	20 dBm maximum
Input port impedance	Splitter (multiple ports): 600 Ω balanced. Combiner (common port): 600 Ω balanced.
Output port impedance	Splitter (multiple ports): 600 Ω balanced. Combiner (common port): 600 Ω balanced.
Harmonic distortion	Splitter: less than one percent at + 3 dBmW Combiner: less than one percent at + 8 dBmW
Frequency response	± 1 dBmW re: 1000 Hz level, 300 to 5000 Hz
Delay distortion	Less than 75 µs, 400 to 3000 Hz
Cross-port coupling loss (crosstalk)	Greater than 55 dB
Mounting	One position
Operating environment	-19°F to 129°F (-7°C to 54°C), humidity to 95% (no condensation)

700-5.4.5.5 Testing and Troubleshooting. Complete testing and troubleshooting instructions, circuit diagrams and pictorial component location and identification guides shall be provided with each bridge.

700-5.5 Traffic Signal Faces and Fittings.

700-5.5.1 Vehicle Signal Faces. Each vehicle signal face shall be of the adjustable type conforming to ITE Publication ST-008B. The testing specified shall be performed by the manufacturer.

Metal signal sections shall be tested in accordance with California Test 666. Any fracture within the housing assembly or a deflection of more than 1/2 the lens diameter of the signal section during the wind load test will be considered a structural failure.

Plastic signal sections shall be tested in accordance with California Test 605. Any fracture within the housing assembly, or deflection of more than 10 degrees in either the vertical or horizontal plane after the wind load has been removed from the front of the signal face, or a deflection of more than 6 degrees in either the vertical or horizontal plane after the wind load has been removed from the back of the signal face will be considered a structural failure.

Vehicle signal faces, except arrow and "X" faces, shall be tested in accordance with California Test 604.

Adjustment shall permit rotation of 360 degrees about a vertical axis. The number and type of sections shall be as shown on the Plans. Each vehicle signal face shall be installed at the location and mounted in the manner shown on the Plans.

All new vehicle signal faces, except the programmed visibility type, installed at any one intersection shall be of the same manufacturer and of the same material.

Top openings of signal faces shall be sealed with neoprene gaskets.

700-5.5.2 Optical Units. Each optical unit shall consist of a lens, a reflector or reflector assembly, a lamp receptacle, and a clear traffic signal lamp conforming to the following requirements:

a) Lenses, reflectors, reflector assemblies, lamp receptacles, lamps, wiring and light distribution shall conform to ITE Publication ST-008B.

b) Each lens shall be glass, true to color, and free of imperfections.

c) Reflectors shall conform to ITE Publication ST-008B except that the reflectors shall be made of silvered glass or of specular aluminum with an anodic coating. Reflector ring holders shall be made of cast aluminum.

A single piece formed metal reflector ring holder may be used.

700-5.5.3 Vehicle Signal Sections. Each vehicle signal section housing shall be either die-cast or permanent mold-cast aluminum conforming to ITE Publication ST-008B or, when so specified, structural plastic.

Signal sections shall conform to the following requirements:

a) Maximum height shall be 10 inches (250 mm) for 8-inch (200 mm) sections and 14 inches (375 mm) for 12-inch (300 mm) sections.

b) Housings shall be provided with a one-piece, hinged, square-shaped door designed to permit access for re-lamping without the use of tools. The door shall be secured by a method that will hold the door closed during the loading tests specified in 700-5.5.1. The lens shall be mounted in the door in a watertight manner.

c) Exposed hardware, such as hinge pins and door latching devices, shall be manufactured of Type 304 or 305 stainless steel. Interior screws and fittings shall be manufactured of stainless steel or steel with a corrosion resistant plating or coating.

d) An opening shall be provided in the top and bottom of each section to receive a 1-9/16-inch (40 mm) pipe. Eight-inch (200 mm) and 12-inch (300 mm) sections produced by an individual manufacturer shall be capable of joining to form a signal face in any combination. This interchangeability is not required between metal and plastic signal sections.

e) Gaskets, including those for the door, lens, reflector and lampholder, shall be made of a material that is not affected when installed in a signal section with a metal or plastic housing that is operated continuously for 336 hours.

700-5.5.4 Metal Signal Sections. Each metal signal section shall be provided with a metal visor and/or backplate as specified. Visors shall conform to 700-5.5.8. Backplates shall conform to 700-5.5.10.

700-5.5.5 Plastic Signal Sections. Plastic signal sections shall be constructed of plastic which has ultraviolet ray stability, is unaffected by the heat of the lamp, and is self-extinguishing. The housing shall be either molded in one piece or fabricated from 2 or more pieces joined into a single piece. The housing and doors shall be colored throughout. The color shall be black matching Color No. 17038, 27038 or 37038 of Federal Standard 595B.

Each plastic signal face shall be equipped with a plastic or metal visor as specified. Visors shall conform to 700-5.5.8. Plastic signal sections shall also be equipped with plastic backplates if so specified. Plastic backplates shall conform to 700-5.5.10.2.

A serrated nylon washer shall be inserted between each plastic signal section and the metal mounting assembly. Each washer shall be not less than 5/32 inch (4 mm) nor more than 1/4 inch (6 mm) thick. Serrations shall match those on the signal section and the mounting assembly.

700-5.5.6 Fittings. Each section in a face shall be joined to the adjacent section by one of the following methods:

a) A minimum of 3 machine screws for 8-inch (200 mm) sections and 4 machine screws for 12-inch (300 mm) sections installed through holes near the front and rear of the housings. Machine screws shall be No. 10 and provided with a nut, flat washer and lock washer.

b) Two machine screws (each with a nut, flat washer and lock washer) through the 1- 9/16-inch (40 mm) pipe opening. The fastening system shall consist of 2 large flat washers to distribute the load around the pipe opening and 3 carriage bolts, each with a nut and lock washer. The minimum size of the machine screws shall be No. 10. The minimum size of the carriage bolts shall be 1/4 inch (6 mm).

The supporting section of each signal face supported solely at the top or bottom shall be provided with reinforcement.

Reinforcing plates shall be either sheet aluminum, galvanized steel or cast aluminum. Each plate shall be not less than 7/64 inch (2700 μm) thick and have a hole concentric with the 1- 9/16-inch (40 mm) pipe mounting hole in the housing. Sheet aluminum reinforcing plates shall be placed both inside and outside the housing. Galvanized steel reinforcing plates shall only be placed inside, and aluminum reinforcing plates shall only be placed on the outside. Reinforcing plates placed on the outside shall be finished to match the color of the signal face and mounting hardware. A minimum of 3 No. 10 machine screws shall be installed through holes in the plates and matching holes in the housing. Each screw shall have a round or binder head and shall be provided with a nut and lock washer.

Where a signal face is to be supported by a side attachment slip-fitter inserted between 2 sections, a spacer or spacers shall be placed between the 2 sections. The vertical dimensions of the spacers shall permit proper seating of the serrations between the slip-fitter and the 2 sections. Holes in spacers shall align with the front holes in the section housings. In addition to the fastening through the large opening in the housings, the 2 sections shall be joined with at least 2 machine screws through holes near the front of the housings and the spacers, and through matching holes in a reinforcing plate installed in each housing. Machine screws shall be No. 10 size. Spacers shall be made of the same material as the signal housings. Reinforcing plates and machine screws shall be as specified herein.

Reinforcing plates will not be required where the housing is provided with reinforcing webs connecting the rear of the housing with the top, bottom and sides.

Holes for machine screws shall be either cast or drilled during fabrication of the signal section. Each hole shall be surrounded by a 1/8 inch (3 mm) minimum width boss to permit contact between signal sections about the axis of the hole.

700-5.5.7 Electrical Components. Lamp receptacles and wiring shall conform to ITE Publication ST–008B. The metal portion of the medium base lamp socket shall be brass, copper or phosphor bronze.

Each lamp receptacle shall be wired with a conductor, connected to the shell of the receptacle, with white insulation, and a conductor, to the bottom or end terminal of the receptacle, with a black insulation or insulation color-coded.

Conductors shall, in turn, be connected to a terminal block mounted inside at the back of the housing. The terminal block shall have sufficient screw-type terminals or NEMA-type tab connectors to terminate all field conductors and lamp conductors independently. The terminals to which field conductors are attached shall be permanently identified or conductors shall be color-coded to facilitate field wiring.

Lamp receptacle conductors shall be No. 18, or larger, 600V, appliance wiring material (AWM), with 1/32 inch (800 μm) thickness insulation rated for 221°F (105°C) or with insulation conforming to Military Specification MIL-W 16878 D, Type B, with vinyl nylon jacket rated for 239°F (115°C). The manufacturer's name or trademark, conductor size, insulation type letter designation and temperature rating shall be marked on the insulation or a Certificate of Compliance shall be submitted with each shipment.

700-5.5.8 Visors. Each signal section shall be provided with a removable visor conforming to ITE Publication ST-008B. Visors shall be classified on the basis of lens enclosure as full-circle, tunnel (bottom open), or cap (bottom and lower sides open). Unless otherwise specified, visors shall be the tunnel-type.

Visors shall be a minimum of 9-7/16 inches (240 mm) in length for nominal 12-inch (300 mm) round lenses and 7-1/16 inches (180 mm) in length for nominal 8-inch (200 mm) round lenses, with a downward tilt between 3 degrees and 7 degrees.

Metal visors shall be made from 3/64 inch (1.2 mm) minimum thickness, aluminum alloy sheets.

Plastic visors shall conform to the following requirements:

a) Visors shall be either formed from sheet plastic or assembled from one or more injection, rotational or blow molded plastic sections.

b) Sections shall be joined using thermal, chemical or ultrasonic bonding, or with aluminum rivets and washers permanently colored to match the visor.

c) Visors shall be of black, homogeneous colored material with lusterless finish.

Each visor shall be secured to its door in a manner that will prevent its removal or permanent deformation when the wind load specified in California Test 605 for plastic visors or California Test 666 for metal visors is applied for 24 hours.

700-5.5.9 Directional Louvers. Directional louvers shall be furnished and installed in the signal visors as shown on the Plans. Directional louvers shall be so constructed as to have a tight fit in the signal visors. Dimensions of louvers and arrangements of vanes shall be as shown on the Plans.

The outside cylinder may be constructed of 1/32 inch (800 μm) nominal thickness or thicker sheet steel. Vanes may be constructed of 1/64 inch (400 μm) nominal thickness, or thicker, sheet steel. Alternatively, the cylinder and vanes may be constructed of 5052-H32 aluminum alloy of equivalent thickness.

700-5.5.10 Backplates.

700-5.5.10.1 General. Backplates shall be furnished and installed on signal faces if shown on the Plans. No background light shall show between the backplate and the signal face or between sections.

700-5.5.10.2 Plastic Backplates. Plastic backplates shall be either formed from sheet plastic or assembled from extruded molded or cast sections. Backplates shall be made of black, homogeneous colored material with a lusterless finish. Each plastic backplate shall be secured to the plastic signal face in a manner that will prevent its removal or permanent deformation when the wind load test specified in 700-5.5.8 is applied to either the front or the rear of the signal face. The permanent deformation of any portion of a backplate shall not exceed 5 degrees forward or backward after the wind loading has been applied for 24 hours.

Sections shall be factory-joined using:

a) solvent cement recommended by the manufacturer,

b) aluminum rivets and washers painted or permanently colored to match the backplate, or

c) No. 10 machine screws provided with a washer, lock washer and nut painted to match the backplate.

When a plastic backplate requires field assembly, it shall be joined with a minimum of 4 No. 10 machine screws at each field assembled joint. Each machine screw shall be provided with an integral or captive flat washer, a hexagonal head slotted for a standard screwdriver, and either:

d) a locking nut with an integral or captive flat washer, or

e) a nut, flat washer, and lock washer.

Machine screws, nuts, and washers shall be stainless steel or steel with a zinc or black oxide finish.

In lieu of screws, plastic backplates may be fastened to the plastic signal face using self-threading No. 10 steel screws. The screws shall have an integral or captive flat washer and a hexagon head slotted for a standard screwdriver, and shall be stainless steel or steel with a zinc or black oxide finish.

700-5.5.10.3 Metal Backplates. Where a metal backplate consists of 2 or more sections, the sections shall be fastened with rivets or with aluminum bolts peened after assembly to prevent loosening.

700-5.5.11 Circular Light Emitting Diode (LED) Signal Modules.

700-5.5.11.1 General. LED signal modules shall consist of an assembly that utilizes LED's as the light source. Modules shall be from the same manufacturer and each size shall be the same model. Modules shall be single, self-contained devices not requiring on-site assembly for installation into existing traffic signal section housings. Modules shall fit into traffic signal section housings built in conformance with the ITE publication ST-008B without modification to the housing. Special tools shall not be required for installation. Installation shall only require removal of the optical unit components (lens, gaskets, lamp, lamp socket and reflector).

Modules shall be installed in, and sealed to, the door frame with a one-piece ethylene propylene rubber gasket and shall be weather-tight.

LED signal modules shall be sealed units with 2 conductors for connecting to power, a printed circuit board, a power supply, a lens and gasket and weatherproof after installation and connection. The circuit board and power supply shall be contained inside the module. Circuit boards shall conform to Chapter 1, Section 6, of the "Transportation Electrical Equipment Specifications" published by the State of California Department of Transportation unless otherwise specified.

Conductors for LED signal modules shall be 3 feet (1 m) in length, with terminals attached, and shall conform to 700-5.3.

Connections shall be to the terminal block in the signal face or utilize an adapter that screws into the medium base lamp socket. Contacts shall be brass. Splices will not be allowed.

The lens shall be integral to the module, convex with a smooth outer surface, and made of ultraviolet stabilized plastic or glass. The lens shall be capable of withstanding exposure to ultraviolet light for a minimum period of 48 months without exhibiting evidence of deterioration.

LED's shall utilize aluminum indium gallium phosphate technology and shall be the ultra bright type or equivalent rated for 100,000 hours of continuous operation from -42°F (–40°C) to 165°F (+74°C).

Each individual LED shall be wired such that physical damage or failure will result in the loss of not more than 5 percent of the LED signal module light output.

Maximum power consumption requirements shall be as shown in Table 700-5.5.11.1.

TABLE 700-5.5.11.1

LED Signal Module	Power Consumption at	
	77°F (25°C)	165°F (74°C)
12-inch (300 mm) Circular	25.0 W	30.0 W
8-inch (200 mm) Circular	15.0 W	18.0 W
12-inch (300 mm) Arrow	15.0 W	18.0 W

LED signal modules shall be rated for a minimum useful life of 48 months.

700-5.5.11.2 Physical and Mechanical Requirements. LED signal modules shall conform to the following requirements:

a) Have a maximum weight of 4.4 pounds (2.0 kg).

b) Be rated for use in the operating temperature range of -42°F (-40°C) to +165°F (+74°C).

c) Be protected against dust and moisture intrusion in accordance with NEMA Standard 250-1991 for Type 4 enclosures.

d) Be manufactured to withstand mechanical shock and vibration from winds and other sources as specified.

e) Have the manufacturer's name, trademark, model number, serial number, lot number and the month and year of manufacture permanently marked on the back of each module.

f) Have prominent and permanent vertical markings for correct indexing and orientation within a signal housing. The markings shall consist of an "UP" arrow, or the word "UP" or "TOP."

700-5.5.11.3 Operating Characteristics. The following operating characteristics shall be identified and submitted to the Engineer:

a) Rated voltage.

b) Power consumption.

c) Volt-ampere (VA).

Enclosures, excluding the lens, containing either the power supply or electronic components shall be made of UL 94VO flame retardant materials.

Lens' may be tinted or use transparent film or material with similar characteristics to enhance "on/off" contrasts. The use of tinting or other materials to enhance "on/off" contrasts shall not affect chromaticity and shall be uniform across the face of the lens. If a polymeric lens is used, a surface coating or chemical surface treatment shall be used to provide front surface abrasion resistance.

700-5.5.11.4 Photometric Requirements. The minimum initial luminous intensity values shall conform to Section 11.94 of ITE Publication ST-008B at 77°F (25°C). Luminous intensity values shall meet or exceed 85 percent of the standard light output values specified in the ITE VTCSH, after 48 months of continuous use over the temperature range of -42°F (-40°C) to 165°F (+74°C) in a traffic signal operation.

Measured chromaticity coordinates shall conform to Section 8.04 and Figure 1 of the ITE VTCSH over the temperature range of -42°F (-40°C) to 165°F (+74°C).

700-5.5.11.5 Electrical Requirements.

a) Modules shall operate over a voltage range from 95V AC to 135V AC at a frequency of 60 Hz ± 3 Hz.

b) Fluctuations of line voltage shall have no visible effect on the luminous intensity of the indications. Rated voltage for the measurements shall be 120V.

c) Modules and associated on-board circuitry shall conform to FCC Title 47, Sub-Part B, Section 15 regulations concerning the emission of electronic noise.

d) Circuitry shall include voltage surge protection to withstand high-repetition noise transients as specified in Section 2.1.6 of NEMA Standard TS2-1992.

e) Circuitry shall prevent perceptible flicker over the specified voltage range.

f) Modules shall provide a power factor of 0.90 or greater while operating throughout the temperature range of -42°F (-40°C) to 165°F (+74°C).

g) Total harmonic distortion (current and voltage) induced into an AC power line shall not exceed 20 percent while operating throughout this temperature range.

h) Wiring and terminal blocks shall conform to Section 13.02 of the ITE VTCSH. Two secured color coded 600V, No. 20 AWG minimum, jacketed wires shall be provided for electrical connection for each module. The wires shall conform to the NEC, and be rated for service at 221°F (105°C) or greater.

Modules shall be operationally compatible with the controller assemblies (solid state load switches, flashers and conflict monitors) specified.

700-5.5.11.6 Arrow LED Signal Modules. Arrow LED signal modules shall conform to Section 9.01 of the ITE VTCSH for arrow lenses. LED's shall be spread evenly across the illuminated portion of the arrow area. Each arrow LED signal section indication shall provide an average luminous intensity of 511 candelas per square foot (5500 cd/m^2). Measurements shall be performed at the rated operating voltage of 120V AC.

700-5.5.11.7 Testing Requirements. LED signal modules tested or submitted for testing shall be representative of typical average production units. Circular LED signal modules shall be tested in accordance with California Test 604. Optical testing shall be performed with the module mounted in a standard traffic signal section but without a visor or hood attached. The number of units tested (sample size) shall be determined by the quantity of each model in the shipment. The sample size shall conform to the American National Standards Institute/Acceptance Sampling in Quality Control (ANSI/ASQC) Z1.4.

The sampling parameters to be used for the random sample testing, if any, shall be as specified in the Special Provisions. The specified parameters may be tested on the sample.

Acceptance or rejection of the shipment will be based upon ANSI/ASQC Z1.4 for shipments which are sampled randomly. Upon rejection of a shipment, the Contractor shall arrange for pick-up of the rejected shipment.

700-5.5.11.8 Certificate of Compliance. The Contractor shall submit a Certificate of Compliance with each shipment.

700-5.5.12 Programmed Visibility Vehicle Signal Sections.

700-5.5.12.1 General. Programmed visibility vehicle signal sections shall provide a nominal 11-3/4-inch (300 mm) diameter circular or arrow indication. Color and arrow configuration shall conform to ITE Publication ST-008B. Each signal section shall be provided with the following:

a) A cap visor.

b) An adjustable connection that permits incremental tilting from 0 to 10 degrees above or below the horizontal while maintaining a common vertical axis through couplers and mounting. Terminal connections shall permit external adjustments about the mounting axis in 5 degree increments.

Signal sections shall be mountable with ordinary tools and capable of being serviced without tools.

Adjustments shall be preset at 4 degrees below the horizontal unless otherwise specified.

700-5.5.12.2 Programmed Visibility. The Contractor shall program the signal section as specified. The visibility of each indication shall be capable of adjustment or programming within the section. When programmed, the indication shall be visible only in those areas or lanes to be controlled, except during dusk and darkness when a faint glow on each side will be permissible.

Prior to programming, each signal section with a yellow indication shall provide:

a) A minimum luminous intensity of 2500 candelas on the optical axis.

b) A maximum intensity of 100 candelas at 15 degrees from 0.5 to 2 degrees horizontal from the axis.

c) A maximum of 10 candelas from 2 to 15 degrees horizontal from the axis.

Under the same conditions, the intensity of the red indication and the green indication shall be a minimum of 19 and 38 percent, respectively, of the yellow indication.

Each signal face or signal section shall include integral means for regulating its luminous intensity between limits in proportion to the individual background luminance. Lamp intensity shall not be less than 97 percent of uncontrolled intensity at 10,000 lux and shall reduce to 15 ± 2 percent of maximum intensity at less than 10 lux. The dimming device shall operate over an applied voltage range of 95 to 135V, 60 Hz, and a temperature range of –42°F (–40°C) to 165°F (74°C).

700-5.6 Pedestrian Signal Sections.

700-5.6.1 General. Pedestrian signal sections shall be as specified. Message symbols shall be a white "WALKING PERSON" and a Portland orange "UPRAISED HAND" conforming to the ITE "Pedestrian Traffic Control Signal Indications" and the California MUTCD. The height of each symbol shall be not less than 9-3/4 inches (250 mm) and the width of each symbol shall be not less than 6-1/2 inches (163 mm). Each housing, including the front screen, shall have maximum overall dimensions of 18-1/2 inches (463 mm) wide, 19 inches (475 mm) high and 11-1/2 inches (288 mm) deep. All new pedestrian signal sections installed at any one intersection shall be of the same manufacturer and type.

The luminance of the "UPRAISED HAND" symbol shall be 349 candelas per square foot (3750 cd/m^2) minimum, and the luminance of the "WALKING PERSON" symbol shall be 493 candelas per square foot (5300 cd/m^2), minimum, when tested in accordance with California Test 606. The uniformity ratio of an illuminated symbol shall not exceed 4 to 1 between the highest and the lowest luminance area. The luminance difference between a non-illuminated symbol and the background around the symbol shall be less than 30 percent when viewed with the visor and front screen in place and at a low sun angle.

Brightness measurements for sections designed for an incandescent lamp shall be made when the signal is equipped with an A-21 traffic signal lamp operated at a voltage to produce 665 lumens.

700-5.6.2 Components.

700-5.6.2.1 General. Each pedestrian signal section shall consist of a housing, 2-color message plate, a reflector assembly, one incandescent lamp or one LED module conforming to 700-5.5.11 with sockets and a front screen.

700-5.6.2.2 Message Plates. Message plates shall be one-piece and shall be made of 1/8 inch (3 mm) minimum thickness, ultraviolet stabilized polycarbonate plastic or 3/16 inch (5 mm) tempered glass. The symbols shall be applied to the inside smooth surface.

700-5.6.2.3 Reflector Assemblies. Reflector assemblies shall consist of a double reflector or 2 single reflectors. Reflectors shall conform to ITE Publication ST-008B. Reflectors shall be made of either aluminum or plastic. Each completed reflector shall, when operated with the appropriate lamp and lens, provide the message brightness specified.

Plastic reflectors shall consist of molded or vacuum-formed plastic with a vacuum-deposited aluminum reflecting surface. The plastic used shall not distort when the reflector is used with the lamp of the wattage recommended by the section manufacturer. The UL non-mechanical loading temperature of the material shall not be exceeded by more than 50°F (10°C) in accordance with UL 746B.

700-5.6.2.4 Front Screens. Front screens shall be provided on each signal face as shown on the Plans. Front screens, when laying in a horizontal position and supported on their edges, shall not fracture, separate at the welds, or compress more than 1/8 inch (3 mm) when a 3-inch (75 mm) diameter, 4-pound (1.8 kg) ball is dropped onto it from a height of 4 feet (1.2 m). When the pedestrian housing is used to support the front screen during the test, the message plate will be removed from the pedestrian signal housing so there will be no back support for the screen.

The screen and frame shall be fabricated from aluminum anodized flat black, finished with lusterless black exterior grade latex paint formulated for application to properly prepared metal surfaces, or fabricated from flat black plastic.

One of the following types of screens shall be provided as specified:

a) Honeycomb Screens. Honeycomb screens shall consist of:
   1) Aluminum 3/16 inch (5 mm) hexagon cells, 3/8 inch (9.5 mm) thick or,
   2) Plastic 3/8 inch (9.5 mm) squares, 1/2 inch (12.5 mm) thick with a wall thickness of 1/16 inch (1.5 mm).
   3) A clear front cover of 1/8 inch (3 mm) minimum thickness acrylic plastic sheet or 1/16 inch (1500 μm) minimum thickness polycarbonate plastic.

   Honeycomb screens shall be installed tilting downward, at an angle of 15 ± 2 degrees, out from the top. Screens shall completely cover the message plate. The screen and cover shall be held firmly in place by stainless steel or aluminum clips, or stainless steel metal screws.

b) Eggcrate or Z-crate Screens. Eggcrate or Z-crate screens shall consist of a 1-1/2-inch (38 mm)-deep eggcrate or Z-crate screen of 1/32 inch (800 μm) nominal thickness polycarbonate. Screens shall be mounted in a frame constructed of 1/32 inch (800 μm) minimum thickness aluminum alloy or polycarbonate.

Eggcrate or Z-crate screens shall be installed parallel to the face of the message plate and shall be held in place by stainless steel screws. The visor specified in 700-5.6.2.6 is not required with this type screen.

700-5.6.2.5 Housings. Housings shall conform to 700-5.5.3.

700-5.6.2.6 Visors. Visors shall be constructed of a material similar to the housing. The top of the visor shall extend a minimum length of 6 inches (150 mm) at the top and 5 inches (125 mm) at the bottom when measured from the front surface of the housing. The front shall be normal to the top.

700-5.6.3 Finish. The exterior of each housing and visor and the interior of the visors shall be painted in conformance with 210 unless otherwise specified.

700-5.6.4 Controls. Pedestrian signals sections shall be capable of being controlled by solid-state switching devices specified for traffic signal controller assemblies.

700-5.6.5 Terminal Blocks. Each pedestrian signal section shall be provided with a terminal block conforming to 700-4.3.3 unless otherwise specified. All field wiring shall connect to this terminal block.

700-5.6.6 LED Pedestrian Signal Section "Upraised Hand" Modules.

700-5.6.6.1 General. Installation shall not require modification of a standard lamp socket or reflector. Modules shall be designed as retrofit replacements for existing optical units and shall not require special tools for installation.

Maximum power consumption requirements shall be 15W at 77°F (25°C) and 18W at 165°F (74°C).

The luminance of the "Upraised Hand" symbol shall be a minimum of 348 candelas per square foot (3,750 cd/m^2). The color of the "Upraised Hand" shall be Portland orange conforming to the requirements of ITE "Pedestrian Traffic Control Signal Indications" and the California MUTCD. The height of each symbol shall be not less than 10 inches (250 mm) and the width of each symbol shall not be less than 6-1/2 inches (163 mm).

The uniformity ratio of an illuminated symbol shall not exceed 4 to 1 between the highest luminance area and the lowest luminance area.

LED modules shall be rated for a minimum useful life of 48 months.

700-5.6.6.2 Physical and Mechanical Requirements. Physical and mechanical requirements shall conform to 700-5.5.11.2 and the following:

a) Modules shall not require a specific mounting orientation or have a variance in light output, pattern or visibility for any mounting orientation. Installation shall only require removal of the lamp.

b) Modules shall be rated for use in the operating temperature range of –42°F to 165°F (–40°C to +74°C).

700-5.6.6.3 Photometric Requirements. The minimum initial luminous intensity values shall be 347 candelas per square foot (3750 cd/m^2). Luminous intensity values shall meet or exceed 85 percent of 347 candelas per square foot (3750 cd/m^2) after 48 months of continuous use over the temperature range of –42°F to 165°F (–40°C to +74°C) in a traffic signal operation.

The measured chromaticity coordinates shall conform to 5.3.2.1 and Figure C of the ITE VTCSH while operating throughout the temperature range of –42°F to 165°F (–40°C to +74°C).

700-5.6.6.4 Electrical Requirements. Electrical requirements shall conform to 700-5.5.11.5 unless otherwise specified.

700-5.6.6.5 Testing. Modules tested or submitted for testing shall be representative of the typical average production units. Modules shall be tested in accordance with California Test 606. Optical testing shall be performed with the module mounted in the specified housing but without a visor or hood attached.

700-5.6.6.6 Quality Assurance Testing. Quality assurance testing may be performed by the Agency on each new LED pedestrian signal module. The number of units tested (sample size) will be determined by the quantity of each model in the shipment. The sample size will conform to the requirements in ANSI/ASQ Z1.4.

The Engineer will determine the sampling parameters to be used for the random sample testing. The parameters specified in the Special Provisions may be tested on each sample.

The basis of acceptance or rejection of the shipment will be the criteria specified in ANSI/ASQ Z1.4 for shipments that are sampled randomly. Upon rejection of a shipment the Contractor shall arrange for pick-up and return it to the manufacturer.

700-5.6.6.7 Certificate of Compliance. A Certificate of Compliance shall be submitted with each shipment.

700-5.7 Signal Mounting Assemblies. Signal mounting assemblies shall consist of Size 41 standard steel pipe or galvanized conduit, necessary fittings, slip-fitters and terminal compartments. Pipe fittings shall be ductile iron, galvanized steel, aluminum alloy Type AC-84B No. 380, or bronze. Mast arm slip-fitters, post top slip-fitters and terminal compartments shall be cast bronze or hot-dip galvanized ductile iron. After installation, any exposed threads of galvanized conduit brackets and areas of the brackets damaged shall be cleaned with a wire brush and painted with 2 applications of an approved un-thinned zinc-rich primer (organic vehicle type) conforming to 210. Aerosol cans shall not be used.

Each terminal compartment shall be fitted with a terminal block containing a minimum of 12 poles, each with 2 screw-type terminals. Each screw-type terminal shall be designed to accommodate at least 5 No. 14 conductors. A cover shall be provided on the compartment to give ready access to the terminal block. Where used to bracket mount signals, the terminal compartment shall be designed to bolt securely to a pole or Standard.

The horizontal dimension of the mounting assembly members between the vertical centerline of the terminal compartment or slip-fitter and the vertical centerline of each signal face shall not exceed 11 inches (275 mm), except where required to provide proper signal face alignment or permit programming of programmed visibility signal faces unless otherwise directed by the Engineer. Mounting assemblies shall be watertight and free of sharp edges or protrusions which might damage conductor insulation. Mounting assembly members shall be either plumb or level, symmetrically arranged and securely assembled. Each mounting assembly shall be provided with positive locking, serrated fittings that, when mated with similar fittings on the signal faces shall prevent the faces from rotating. Fittings shall permit fastening at increments of not more than 7 degrees. Construction shall be such as to permit all conductors to be concealed.

For post-top mounting of signals, a slip-fitter shall be used. The slip-fitter shall fit over a 4-1/2-inch (113 mm) outside diameter pipe or tapered Standard end. Each slip-fitter shall be provided with cadmium-plated steel set screws, arranged as shown on the Standard Plans. Each slip-fitter used to post-top mount signals with brackets shall be provided with an integral terminal compartment.

Each mounting assembly shall be oriented to provide maximum horizontal clearance to the adjacent roadway.

700-5.8 Detectors.

700-5.8.1 General. Vehicle and bicycle detectors shall be the type or types shown on the Plans. Sensor units, control units and amplifiers shall conform to the requirements in the Special Provisions. The units shall not be affected by transient voltages when tested in accordance with California Test 667. After a power interruption the units shall return to normal operation within one minute.

Each unit shall be provided with a light or meter, for each output circuit, to indicate when the detector is detecting a vehicle. Each detector shall operate over the range of voltages from 100V to 135V at 60Hz.

Circuitry shall be solid-state, except relays with normally closed contacts may be used for the output circuit. Units shall use printed circuit boards designed to facilitate identification of components by either part identification markings or by providing a pictorial diagram showing the physical location and identification of each component. Each printed circuit board shall conform to the following minimum quality requirements:

a) NEMA FR-4 glass cloth base epoxy resin board, 1/4 inch (6 mm) minimum thickness.

b) Organic masking.

c) Gold plated contacts.

Units shall be designed to provide vehicle detection without readjustment from 0°F to 160°F (–18°C to 71°C).

700-5.8.2 Inductive Loop Detectors.

700-5.8.2.1 General. The term "inductive loop detector" shall be defined as a complete installation consisting of a loop or group of loops installed in the roadway as shown on the Plans, lead-in cable, and a sensor unit with a power supply installed in a controller cabinet.

700-5.8.2.2 Sensor Units. "Card" type sensor units shall conform to the requirements in the "Traffic Signal Control Equipment Specifications" published by the State of California Department of Transportation. Shelf mounted sensor units shall conform to the requirements in Section 11 of NEMA TS-1.

Capacitors or inductors necessary for loop tuning shall not be mounted external to the sensor unit.

700-5.8.2.3 Conductors. Conductors for inductive loop detectors shall be continuous and un-spliced and conform to the following requirements unless otherwise specified:

a) Type 1 loop wire shall be Type RHW-USE neoprene-jacketed or Type USE cross-linked polyethylene insulated No. 12 stranded copper wire. The minimum insulation thickness at any point shall be 1/32 inch (800 µm).

b) Type 2 loop wire shall consist of a conductor inside of plastic tubing. The conductor shall be Type THWN or Type XHHW, No. 14 stranded copper wire. The tubing shall be polyethylene or vinyl, rated for use at 221°F (105°C), and resistant to oil and gasoline. The tubing shall have a maximum outside diameter of 1/4 inch (6 mm) and a minimum wall thickness of 1/32 inch (800 µm). The conductors shall not be spliced inside the tubing.

Conductors for loop detector lead-in cable shall be 2 No. 16 AWG (19 x 29) stranded tinned copper. Loop detector lead-in cable shall conform to the calculated cross sectional area of ASTM B286, Table 1. Lead-in cable shall conform to the following requirements unless otherwise specified:

a) Type B lead-in cable shall be insulated with 1/64 inch (400 µm) of high-density polyethylene. The conductors shall be twisted together with at least 6 turns per 3 feet (1 m) and the twisted pair shall be protected with a copper or aluminum polyester shield. A No. 20 AWG, minimum, copper drain ground wire shall be provided and connected to the equipment ground within the cabinet. The cable shall be provided with a high-density polyethylene or high-density polypropylene outer jacket with a nominal thickness of 1/32 inch (800 µm). An amorphous interior moisture penetration barrier of non-hydroscopic polyethylene or polypropylene fillers shall be provided.

b) Type C lead-in cable shall conform to the IMSA Specifications No. 50-2. A No. 20 AWG minimum copper drain ground wire shall be provided and connected to the equipment ground within the cabinet.

All detector lead-in cable connections and/or terminations shall be soldered.

700-5.8.2.4 Sealants. Sealants shall be packaged in containers clearly labeled "detector loop sealant" and the label shall include the batch and lot number of the manufacturer. The sealant for filling slots shall conform to one of the following:

a) Elastomeric Sealant. Elastomeric sealant shall be a polyurethane material of a composition that will, within its stated shelf life, cure only in the presence of moisture. Sealant shall be suitable for use in both asphalt concrete and Portland cement concrete. The cured sealant shall have the performance characteristics shown in Table 700-5.8.2.4 (A).

TABLE 700-5.8.2.4 (A)

Specifications	ASTM	Requirement
Hardness (indentation) at 77°F (25°C) and 50% relative humidity (Type A Model 1700 only)	D2240 Rex.	65-85
Tensile Strength, pulled at 20 inches (500 mm) per minute	D412 Die C	500 psi (3.45 MPa) min.
Elongation: pulled at 20 inches (500 mm) per minute	D412 Die C	400%, min.
Flex at -40°F (–40°C): 0.6 mm Free Bend (180°) over a 1/2 inch (12 mm) Mandrel.	---	No cracks
Weather Resistance: Weatherometer 350 h cured 7 Days at 77°F (25°C) @ 50% relative humidity.	D822	Slight chalking
Salt Spray Resistance: 28 days at 100°F (38°C) with 5% NaCl, Die and pulled at 20 inches (500 mm) per minute.	B117	500 psi (3.45 MPa) min. tensile, 400% min. elongation
Dielectric Constant over a temperature range of -22°F (–30°C)	D150	Less than 25% change

b) Asphaltic Emulsion Sealant. Asphaltic emulsion sealant shall conform to State Specification 8040-41A-15 and shall only be used for filling slots in asphalt concrete pavement. This material shall not be used in slots which exceed 5/8 inch (16 mm) in width or where the slope causes the material to run from the slot. The material shall not be thinned in excess of the manufacturer's recommendations and shall not be placed when the air temperature is less than 45°F (7°C).

c) Hot-Melt Rubberized Asphalt Sealant. Hot-melt rubberized asphalt sealant shall be in solid form at room temperature and fluid at an application temperature of 375°F (190°C) to 400°F (205°C). Fumes from the material shall be non-toxic. Sealant shall be suitable for use in both asphalt concrete and Portland cement concrete. Performance characteristics of the cured hot-melt rubberized asphalt sealant shall conform to the requirements shown in Table 700-5.8.2.4 (B).

TABLE 700-5.8.2.4 (B)

Specification	ASTM	Requirement
Cone Penetration, 77°F (25°C) 5.3 oz (150 g), for 5 sec.	D3407, Sec. 5	1/8 inch (3 mm) max.
Flow, 40°F (60°C)	D3407, Sec. 6	3/16 inch (5 mm) max.
Resilience, 77°F (25°C)	D3407, Sec. 8	25% min.
Softening Point	D36	180°F (82°C) min.
Ductility, 77°F (25°C) 2 inches (50 mm) /min.	D113	11-13/16 inches (300 mm) /min.
Flash Point, Cleveland Open Cup, °F (°C)	D92	550°F (288°C)
Viscosity, Brookfield Thermosel, No. 27 Spindle, 20 rpm, 374°F (190°C)	D4402	2.5-3.5 Pa·s

700-5.9 Pedestrian Push Button Assemblies. Pedestrian push button assembly housings shall be either die-cast or permanent mold cast aluminum or, when specified, shall be ultraviolet light stabilized, self-extinguishing, structural plastic. Plastic housings shall be black matching Color No. 17038, 27038 or 37038 of Federal Standard No. 595B unless otherwise specified and shall be colored throughout. Assemblies shall be rainproof and shockproof in any weather conditions.

Switches shall be the phenolic enclosed precision snap-acting type, single-pole, double-throw, switching unit, with screw type terminals, rated 15A at 125V AC, and shall conform to the following:

a) Have a stainless steel plunger actuator and be provided with a U-frame to permit recessed mounting in the push button housing.

b) Have an operating force of 9 ounces (2.5 N) to 13 ounces (3.6 N) and a minimum release force of 4 ounces (1 N).

c) Pre-travel shall be 1/64 inch (400 µm) maximum.

d) Overtravel shall be 1/32 inch (800 µm) minimum.

e) Differential travel shall be 0.01 mm to 0.05 mm.

f) The actuator shall have a minimum diameter of 2 inches (50 mm).

Pedestrian push button signs shall be porcelain enameled metal or structural plastic.

SECTION 701 - CONSTRUCTION

701-1 GENERAL. The following specifies the requirements for the installation and construction of street lighting and traffic signal systems. Street lighting and traffic signal materials to be furnished and installed shall conform to 700 unless otherwise specified.

Incidental parts that are not shown on the Plans or specified in the Specifications and are necessary to complete the Work, shall be furnished and installed as though such parts were shown on the Plans or specified in the Specifications.

Unless otherwise directed or specified, the Contractor shall submit a list of equipment and materials to be installed. The list shall include the name of the manufacturer, size, and identifying number of each item. In addition, the Contractor shall submit detailed drawings and wiring diagrams for the electrical equipment to be used.

If requested by the Engineer, the Contractor shall submit for review samples of the material proposed for use.

Upon completion of the Work, the Contractor shall submit one complete set of "as-built" Plans showing in detail all construction changes.

701-2 MAINTENANCE OF EXISTING AND TEMPORARY SYSTEMS. The Contractor, during the progress of the Work, shall maintain existing or temporary street lighting and traffic signal systems.

701-3 COORDINATION WITH THE SERVING ELECTRICAL UTILITY. Safety clearances between new or existing Standards (including luminaires, arms or signal heads) and overhead power and communication lines shall conform to the State of California Industrial Safety Orders, General Order 95. Construction in proximity to high-voltage overhead lines shall be performed in accordance with the California Code of Regulations, Title 8 and the latest revision of Article 86, State of California High Voltage Electric Safety Orders. The Contractor shall inspect the location of each Standard for safety clearance requirements and notify the Engineer and the serving electric utility, in writing, of the locations where safety clearances are required. The Contractor shall be responsible for the necessary coordination with the serving electric utility.

Requests for safety clearances shall be made at least 21 Days in advance of the date the Contractor will be working at each location requiring a safety clearance by the serving electric utility. If required, the Contractor shall make the necessary arrangements with the serving electric utility to raise their overhead facilities in order to provide for required clearances.

Coordination with the serving electrical utility, and the provision of safety clearances, shall be shown as individual activities on the construction schedule specified in 6-1.1.

701-4 DAMAGE TO EXISTING SYSTEMS. Should any damage to an existing system occur, which is not part of the work shown on the Plans, the Contractor shall immediately notify the Engineer and arrange for the immediate repair and restoration of service. The Contractor shall commence repairs or replacements within 72 hours of damaging the system or receiving approval of the equipment and materials by the Engineer, whichever takes longer. Electrical safety clearance shall be obtained from the serving utility before performing any work on existing energized circuits. Equipment and materials used for repairs or replacements shall conform to 700 and be approved by the Engineer.

701-5 TEMPORARY SYSTEMS.

701-5.1 General. The Contractor shall provide temporary street lighting and/or traffic signal systems whenever the existing systems are removed or relocated. Temporary systems shall be in operation prior to the removal or relocation of the existing systems. Temporary street lighting systems shall provide an average illumination and uniformity ratio (average/minimum) that matches or exceeds the existing lighting levels utilizing standard roadway lighting optics. The Contractor shall submit Working Drawings in accordance with 2-5.3. Construction of the temporary systems shall be shown as an individual activity on the construction schedule specified in 6-1.1.

Should a temporary system incur any damage, the Contractor shall immediately notify the Engineer and arrange for repair and restoration of service in accordance with 700-4.

701-5.2 Temporary Wiring. Temporary wiring specified herein shall not apply to circuits exceeding 150V to ground. Temporary wiring for circuits exceeding 150V to ground shall be as specified in the Special Provisions.

Temporary wiring may utilize either overhead or underground conductors. Temporary overhead traffic circuit runs shall be 28-conductor cable (except service wire).

Temporary overhead conductors shall be slack-spanned with 20-foot (6 m) minimum overhead clearance above thoroughfares and 12-foot (4 m) minimum clearance above sidewalk areas. Temporary conductors may not run on top of the ground or across any sidewalk area unless adequately protected in an electrical conduit. Temporary conductors less than 10 feet (3 m) above ground level must be protected in an electrical conduit. Temporary overhead conductors shall be multi-conductor cable or single conductors, securely tied or taped at intervals not to exceed 5 feet (2 m). No spare conductors are required.

Splices within 10 feet (3 m) above ground level shall be enclosed in metal junction boxes. Splices made at ground level shall be enclosed in pull boxes. Splices shall conform to 701-13.3. All circuits shall be grounded and conform to 701-13.4.

701-5.3 Temporary Standards, Signals, Luminaires and Lamps. Temporary Standards shall be installed adjacent to existing Standards. Combination poles that allow mounting of both street lighting luminaires and traffic signal heads shall not be utilized.

For street lighting systems, the mounting height shall be a minimum of 30 feet (9 m). The minimum lamp size shall be 200 watts. Luminaires shall be cutoff with a type 3 distribution pattern.

Temporary traffic signal heads shall provide a minimum of 2 clearly visible signal faces for each phase for traffic from each direction. One signal face shall be adjacent to the left side of the traveled way and the other signal face shall be adjacent to the right side of the traveled way. Temporary mast arms shall be installed as necessary.

Temporary traffic signals shall be securely mounted approximately 10 feet (3 m) high, on poles, platform Standards, or semi-permanent structures. Mast arms, where required, shall provide a minimum clearance of 17 feet (5 m) from the traveled way to the bottom of the traffic signal head. Primary and mast arm traffic signals shall have backplates. Mast arm traffic signals and arrow indications shall be 12-inch (300 mm) in size and other signals shall be of the same size as the permanent heads being replaced.

Traffic signal shutdown periods shall be as specified in the Special Provisions. Preliminary work associated with the shutdown shall be performed prior to the actual shutdown.

Shutdowns, flashing operations, and turn-ons shall be requested at least 48 hours in advance and will be overseen or performed by the Engineer.

701-5.4 Payment. Payment for preparing Working Drawings, and furnishing and installing temporary systems complete and in-place shall be considered as included in the Contract Unit Price or lump sum price in the Bid for the work that required a temporary system.

701-6 ORDERING MATERIALS. The Contractor shall submit a letter to the Engineer stating that the Contractor-furnished street lighting and/or traffic signal system materials have been ordered. The letter shall contain the names and addresses of the suppliers and the estimated delivery dates. The letter shall be submitted to the Engineer within 5 Working Days after acceptance of the submittal for the materials specified in 2-5.3.

701-7 EXCAVATION AND BACKFILL.

701-7.1 General. Excavation required for the installation of conduit, foundations, and other equipment shall be performed in such a manner as to cause the least possible damage to the streets, sidewalks, and other existing improvements. Excavation shall not be performed until just prior to installation of equipment. Material generated from excavations shall be placed in a location that will cause the least obstruction to surface drainage and vehicular and pedestrian traffic.

Excavations that are required in concrete sidewalk, cuts and joints shall conform to 300-1.3.

At the end of each Working Day and at other times when construction operations are suspended, equipment, material, and debris shall be removed from that portion of the right of way open for vehicular and pedestrian traffic. Barricades shall be erected at excavations not backfilled or finished to final grade.

Excavations that are required shall be kept backfilled and maintained in a smooth and free draining condition until permanent repairs are completed. Excavations, including those resulting from removal of existing equipment, shall be backfilled, compacted, and the surface restored to match existing improvements. Restoration shall conform to 7-9, 306-12.2, and 306-13.

701-7.2 Trenches. Trenches shall not be excavated wider than necessary for the installation of the conduit. Trenching is not permitted through concrete improvements. When encountered, galvanized rigid steel conduit shall be jacked, or rigid non-metallic conduit shall be bored beneath the improvements.

701-7.3 Payment. Payment for excavation and backfill of trenches shall be considered as included in the Contract Unit Price or lump sum price in the Bid for the work that required excavation and backfill of trenches.

701-8 FOUNDATIONS, FOUNDATION CAPS AND SLABS.

701-8.1 General. Work shall conform to the lines, elevations and grades shown on the Plans or established by the Engineer. Construction of concrete foundations, caps and slabs construction shall conform to 303-1, 303-5, and 305-1.3.

701-8.2 Foundations. Foundations shall be constructed in a single placement of concrete of the class shown in Table 201-1.1.2. The bottom of the foundations shall rest securely on firm, unyielding soil.

Foundations shall cure for 24 hours before erecting Standards and 72 hours before erecting mast arms. Pile foundations shall cure for 48 hours before erecting Standards and 7 Days before erecting mast arms.

Foundations constructed within the sidewalk or parkway shall pose no hazard to pedestrian traffic. The above-ground portion of a foundation, if any, and/or anchor bolts, conduits etc. shall be protected with protection devices approved by the Engineer. The Contractor shall connect the protection devices to the foundation. Protection devices shall protect pedestrians from the above ground portion of the foundation, and/or exposed anchor bolts, conduit, etc. Protection devices shall remain and be maintained in place until the related equipment is installed on the foundation.

701-8.3 Foundation Caps. Foundation caps shall be the same color, finish, and material as the adjacent sidewalk, and be a minimum of 3 inches (75 mm) thick unless otherwise specified. Foundation caps shall be placed after the Standard is set in its final position. The longitudinal grade shall be the same as the grade for the top of the existing curb. If there is no curb, the longitudinal grade will be established by the Engineer.

The transverse grade shall be established as follows:

a) Existing curb and no sidewalk - by sloping upward from the top of the back face of curb at the rate of 1/4 inch/foot (20 mm/m).

b) Existing curb and sidewalk – by straight grade from the top of the back face of curb to the top of the near edge of sidewalk, and shall join all around in full-width sidewalk or sidewalk constructed adjacent to the curb.

c) Service road parkways – by a straight line between the top of the back face of one curb to the top of the back face of the other curb.

d) If the lateral grade of the existing parkway exceeds a slope of ± 1 inch/foot (80 mm/m), the Contractor shall construct retaining curbs and sidewalk as directed by Engineer.

701-8.4 Concrete Slabs. Wherever the edge of a concrete foundation extends within 18 inches (450 mm) of any existing concrete improvement, a concrete slab with a minimum thickness of 3 inches (75 mm) unless otherwise specified shall be extended to meet the existing improvement.

701-8.5 Measurement. Foundations will be measured by the lump sum or by the cubic yard (m^3) for each type and size.

701-8.6 Payment. Payment for foundations, including protection devices, bolt circles, reinforcement and foundation cap, will be made at the Contract Unit Price or lump sum price in the Bid for each size and type. Payment for concrete slabs will be made in accordance with 303-5.9.

701-9 ANCHOR BOLTS, NUTS, AND WASHERS.

701-9.1 General. Anchor bolts, nuts, and washers, including those required for the relocation of existing Standards, shall be furnished by the Contractor. Anchor bolts, nuts and washers shall be of the type and size shown on the Plans or Standard Plans.

701-9.2 Payment. No separate payment will be made for anchor bolts. Payment for furnishing and installing anchor bolts, nuts, and washers shall be considered as included in the Contract Unit Price or lump sum price in the Bid for the work that required the anchor bolts, nuts, and washers.

701-10 STANDARDS, PEDESTALS AND MAST ARMS.

701-10.1 General. Street lighting and traffic signal Standards, pedestals for cabinets, mast arms and other similar equipment furnished shall be as shown on the Plans or Standard Plans.

Vertical alignment shall be performed by adjusting the nuts on the anchor bolts before the foundation cap is placed. Shims or other similar devices shall not be used.

If base covers or foundation caps are not used, anchor bolts shall be cut 1/4 inch (6 mm) above the nuts. If anchor bolts are cut, the cut surfaces shall be repaired in accordance with 210-3.5.

Holes left in the shafts of existing Standards, due to removal of equipment, shall be repaired as follows:

a) Steel shafts – by welding a suitable disc, grinding smooth, and painting as specified in 210-3.

b) Concrete shafts – by grouting to match the existing texture and color.

701-10.2 Mast Arms. Mast arms for Standards shall conform to the dimensions shown on the Plans or Standard Plans. The joint between a Standard and a mast arm shall be rain-tight.

701-10.3 Measurement. Standards, mast arms, and pedestals will be measured by each type and size.

701-10.4 Payment. Payment for Standards, mast arms, and pedestals will be made at the Contract Unit Price or lump sum price in the Bid for each size and type.

701-11 PULL BOXES.

701-11.1 General. Pull boxes, covers, and extensions shall be of the type, size, and details shown on the Plans or Standard Plans.

Where the surrounding sidewalk surface is composed of a special material (terrazzo, pavers etc.), pull box covers shall be made of matching material unless otherwise specified.

Pull boxes shall be installed at the locations shown on the Plans. If not shown, the maximum distance between pull boxes shall be:

a) 300 feet (90 m) for traffic signal interconnect,

b) 200 feet (60 m) for street lighting systems, and

c) 600 feet (180 m) apart for fiber optic cable systems.

Pull boxes shall be placed:

a) Adjacent to Standards with a 3-foot (900 mm) clearance from the side of the foundation unless otherwise approved by the Engineer.

b) A minimum of 5 feet (1500 mm) from the top of the "X" dimension of driveways and access ramps. Pull boxes shall not be installed in any part of a driveway, curb ramp, or other traveled way unless otherwise specified.

c) At least 6 inches (150 mm) from any substructure or back of curb unless otherwise approved by the Engineer.

Pull boxes shall be installed with the long side parallel to the curb unless otherwise approved by the Engineer.

The bottom shall rest firmly on a 12-inch (300 mm)-thick bed of 1 inch (25 mm) crushed rock conforming to 200-1.2, extending 6 inches (150 mm) beyond the outside edges. The grade for the top shall be established as specified in 701-8.3.

Where ballasts or transformers are installed in a pull box, a pull box extension shall be used.

The Contractor may, at its own expense and subject to the approval of the Engineer, install additional pull boxes to facilitate the Work.

701-11.2 Measurement. Pull boxes will be measured by the number of each type.

701-11.3 Payment. Payment will be made at the Contract Unit Price or lump sum price in the Bid for the number of each type.

701-12 CONDUIT.

701-12.1 General. Conduit shall be of the type and size shown on the Plans. If so specified, galvanized pipe or rigid non-metallic conduit may be substituted for galvanized electrical conduit. Conduit shall be installed by trenching, jacking or directional boring methods as specified.

Conduit shall be placed, bored, or jacked to a depth of not less than 30 inches (750 mm) nor more than 60 inches (1500 mm) below the flowline grade, unless otherwise specified. Conduit placed behind a curb shall not be less than 14 inches (350 mm) nor more than 36 inches (900 mm) below the top of curb. Conduit placed under railroad tracks shall not be less than 36 inches (900 mm) nor more than 60 inches (1500 mm) below the bottom of the ties, unless otherwise required by the jurisdictional railroad. Conduit may be placed directly behind the curb if so approved by the Engineer. If there are obstructions, the conduit may be placed further behind the curb. In no case shall the conduit be placed more than 36 inches (900 mm) behind the curb unless otherwise approved by the Engineer.

Jacking or directional boring pits shall be kept 2 feet (600 mm) clear of the edge of any type of pavement unless otherwise approved by the Engineer.

Jacking pits adjacent to railroad tracks shall be constructed not less than 25 feet (7.6 m) from the centerline of track.

Conduit laid in an open trench shall not be covered nor shall any trench or inspection hole be backfilled until the Engineer has approved the installation. Jacking or directional boring pits and trenches left open overnight shall be covered with steel plates.

Detector, telephone interconnect, or street lighting conduit shall be 1 inch (25 mm) nominal size unless otherwise specified. Direct interconnect, utility service, inductive loop detector, or traffic signal conduit shall be 2-inch (50 mm) nominal size unless otherwise specified. The Contractor may use conduit of a larger size than that specified, provided the larger size is used for the entire length of the run. Reducing couplings shall not be used.

Conduit entering a pull box shall enter not less than:

a) 5 inches (125 mm) below the top of the box,

b) 2 inches (50 mm) above the bottom of the box.

Conduit shall terminate within 2 to 4 inches (50 to 100 mm) inside the box wall. The prolongation of the conduit shall pass through the top of the pull box. Conduits shall enter from the direction of the run.

Spare conduit stubs from foundations shall extend a minimum of 6 inches (150 mm) from the face and a minimum of 14 inches (360 mm) below the top of foundation and shall be capped on each end.

The ends of the conduit, whether shop or field cut, shall be reamed to remove burrs and rough edges. Cuts shall be made so that the ends will come together for the full circumference thereof. Slip joints or running threads shall not be used for coupling conduit. Threads shall be treated with the joint compound specified or approved by the Engineer before fittings are placed thereon.

Conduit installed on the surface of poles or structures or other exposed locations or in concrete structures and foundations shall be unpainted, except that exposed conduit installed on a painted structure shall be painted the same color as the structure. Conduit runs on the surface of structures shall be secured with galvanized malleable iron clamps spaced not more than 5 feet (1.5 m) apart.

A No. 12 AWG pull wire, or a tape or rope shall be installed in all complete conduit runs that are to receive future new conductors. A minimum of 2 feet (600 mm) of pull wire, tape or rope shall be secured and extended beyond each end of the conduit run.

Conduit ends shall be capped until the pulling of conductors is started. The conduit shall be blown clean with compressed air prior to installing conductors. In the presence of the Engineer, the Contractor may be required to pass a mandrel through the conduit. Existing conduit being incorporated into a new or modified system shall be cleaned with a mandrel or cylindrical wire brush and blown clean with compressed air.

A minimum of 1 foot (300 mm) length of continuous oakum or other approved or specified sealant shall be securely packed into all uncapped conduit ends. Oakum, if used, shall be string oakum that is tar or oil saturated to be water resistant. The oakum or sealant shall be packed into the uncapped conduit immediately after the installation of conductors in the conduit. The oakum or sealant shall be packed around the conductors in such a manner that no visible gaps remain between the conductors and conduit, and with sufficient care to avoid damage to conductors, bushings or conduit.

Conduit terminating in traffic signal pull boxes shall not be transposed.

Conduit abandoned in place shall be terminated a minimum of 1 foot (300 mm) below finished grade.

701-12.2 Rigid Metallic Conduit. Expansion fittings, shall be installed where the conduit crosses an expansion joint in a structure. Each expansion fitting shall be provided with a No. 8 AWG copper bonding jumper.

Rigid metallic conduit shall be bent without crimping or flattening and shall have a radius of not less than 6 times the inside diameter of the conduit.

Rigid metallic conduit fittings shall be galvanized steel unless otherwise specified. Couplings shall be securely tightened to provide an electrical and mechanical connection throughout the entire length of the conduit run. When a standard coupling cannot be used, a UL or ETL listed threaded union coupling approved by the Engineer shall be used.

When rigid metallic conduit is capped and the caps are removed, the ends of the conduit shall be provided with conduit bushings. Caps and bushings may be manufactured of metal or plastic, threaded or push-on.

701-12.3 Galvanized Pipe. Should "necking" occur when any length of pipe is installed, the length of pipe where the "necking" occurred shall be removed.

Couplings shall have a uniform thread which ensures that the ends of the pipe to be joined are in full surface contact when the couplings are in place. Couplings with tapered threads shall not be used.

701-12.4 Rigid Non-Metallic Conduit. Rigid non-metallic conduit shall only be installed in underground locations. A separate No. 8 AWG, solid bare ground wire and a pull rope or tape shall be inside at the time of installation. A pull box shall be installed whenever an underground conduit changes from a metallic type to a non-metallic type. The Contractor shall pull a mandrel approved by the Engineer through all rigid non-metallic conduit.

701-12.5 Abandonment of Conduit. Conduit that is to be abandoned in place shall have all wires or cable removed. The conduit shall then be removed to a minimum depth of 1 foot (300 mm) below the surface and have both ends crimped or capped.

701-12.6 Measurement. Conduit will be measured by the linear foot (m) or lump sum for each size and type.

701-12.7 Payment. Payment for conduit will be made at the Contract Unit Price or lump sum price in the Bid for each size and type. No additional payment will be made if the Contractor chooses to use a larger size conduit than what is specified.

Payment for abandoning conduit in place shall be considered as included in the Contract Unit Price or lump sum price in the Bid for the work that required the conduit to be abandoned.

701-13 WIRES, CONDUCTORS AND CABLES.

701-13.1 General. Conductors shall be run in conduit except when inside Standards, pedestals or for overhead and temporary installations unless otherwise specified.

Low-voltage conductors run in Standards containing high-voltage conductors, either the low-voltage or the high-voltage conductors shall be encased in flexible or rigid metallic conduit to a point where the different types of conductors are no longer in the same raceway.

Conductors/cables shall be pulled by hand. Winches or other power-actuated pulling equipment shall not be used. Only lubricants specified or approved by the Engineer shall be used in pulling conductors/cables in conduit.

A total of 2 feet (600 mm) of slack shall be left at each Standard, and within each pull box sufficient slack shall be left to extend 18 inches (450 mm) above the top of the pull box.

Small, permanent identification bands shall be marked as specified in 700-4.2, 700-5.3, or as follows. Permanent identification bands shall be securely attached to conductors in pull boxes and near the termination of each conductor. Where circuit and phase are clearly indicated by conductor insulation, bands need not be used. Permanent identification bands shall be embossed, 6-mil (150 µm), oil-resistant polyvinyl chloride tape with pressure-sensitive backing. Tape shall be of a type such that symbols contrast with the background color.

701-13.2 Splices. Splices shall conform to the details shown on the Plans unless otherwise specified. Splices shall only be made in pull boxes and Standard bases. Splices shall be capable of operation under continuous submersion in water. Multi-conductor cables shall be spliced and insulated to provide a watertight joint and to prevent absorption of moisture by the cable. Where more than 1 conductor enters the sleeve of a ballast installed in a pull box, the insulation and taping shall be applied between the conductors in such a manner as to provide a watertight joint.

Splice insulation shall be applied to a thickness equal to the thickness of, and lapped over, the original insulation.

Wire/conductor insulation shall be well-penciled, trimmed to a conical shape, and roughened before applying the splice insulation. Tape shall be applied to a thickness equal to the thickness of, and lapped over, the original insulation.

When 3 or more conductors are to be enclosed within a single splice using heat-shrink tubing, mastic shall be placed around each conductor prior to being placed inside the heat-shrink tubing. The mastic shall be of the type recommended by the manufacturer of the heat-shrink tubing.

Heat shrink tubing shall only be heated with a device specifically designed for such. Heating with an open flame will not be permitted. After contraction, the ends and seams of heat-shrink tubing shall be painted with an electrical insulating coating recommended by the manufacturer.

The Contractor may, at its option, use either of the following splice insulation methods:

a) A minimum of 2 thicknesses of electrical insulating pads. Pads shall be applied to the splice in accordance with the manufacturer's recommendations.

b) Heat-shrink tubing conforming to 700-3.8.3.

Conductors shall be joined together by connectors conforming to 700-4.3 unless otherwise specified or approved by the Engineer. Connectors and terminals used with aluminum utility power service conductors shall be aluminum and greased with the inhibitor specified or approved by the Engineer.

701-13.3 Bonding and Grounding. Metallic cable sheaths, metal pull box covers, metallic conduit, equipment grounding conductors, ballast and transformer cases, service equipment, sign switches, anchor bolts, and metal Standards that form a continuous system shall be grounded.

At service points, grounding of metallic conduit, service equipment, and neutral conductors shall conform to the applicable code and the requirements of the serving utility, except that grounding electrode conductors shall be No. 6 AWG solid copper wire or larger.

Each multiple service disconnect location shall be grounded. Ground electrodes shall be installed in accordance with the provisions of the NEC. The service equipment shall be bonded to the ground electrode by use of a ground clamp or exothermic weld and No. 6 AWG or larger solid copper wire enclosed in a size 16 or larger diameter conduit.

For equipment grounding purposes in rigid non-metallic conduit, a No. 6 AWG solid copper wire shall be run continuously in circuits used for series street lighting, and a No. 8 AWG minimum solid copper wire shall be run continuously in all other street lighting and traffic signal circuits. The bonding wire size shall be increased to match the circuit breaker size, unless otherwise specified. Whenever rigid non-metallic conduit is to be installed for future conductors, the solid copper wire may be omitted. Equipment bonding and grounding conductors are not required in conduit which contain only loop lead-in cable or signal interconnect cable or both.

Bonding of Standards shall be accomplished by means of a No. 8 AWG bonding wire attached from a grounding bushing to a foundation bolt or a 3/16 inch (5 mm), or larger, brass or bronze bolt installed in the lower portion of the Standard. The bonding jumper in Standards with hand holes and traffic signal pull box lid covers shall be attached by a 3/16 inch (5 mm) or larger brass bolt and shall be run to the conduit or bonding wire in the adjacent pull box. Standards without hand holes shall be bonded by a jumper attached to each anchor bolt, and shall be run to the conduit or bonding wire in the adjacent pull box. The grounding jumper shall be visible after the cap has been placed on the foundation.

Bonding of metallic conduit in metal pull boxes shall be by means of locknuts, 1 inside and 1 outside of the pull box.

Bonding of metallic conduit in nonmetallic pull boxes shall be by means of copper strap or galvanized grounding bushing and bonding jumpers.

For series circuits, the metallic conduit or bonding conductor system shall be grounded at intervals not to exceed 500 feet (150 m) by one of the following:

a) galvanized pipe driven to a depth of 8 feet (2 m) having its upper end not more than 3 inches (75 mm) above the conduit; or,

b) copper-coated steel rod, driven to a depth of 8 feet (2 m); or,

c) metal water service pipe on the street side of the meter, with the approval of the owner. The water pipe shall be thoroughly scraped and cleaned prior to connection.

For multiple circuits, the metallic conduit or bonding conductor system shall be grounded at the service points.

On wood poles, all equipment mounted less than 8 feet (2 m) above the ground surface shall be grounded.

701-13.4 Payment. No separate payment will be made for wire, conductor and cables, nor for bonding and grounding. Payment shall be considered as included in the Contract Unit Price or lump sum price in the Bid for each type and size of conduit.

701-14 SERVICES.

701-14.1 General. Before any work is begun, the Contractor shall obtain daily circuit clearance from the serving electric utility.

The Contractor shall furnish and install all material and equipment necessary to complete the electrical connection between the terminating point of the serving electric utility and the electrical system shown on the Plans. Electrical service installation and materials shall conform to the requirements of the serving electric utility. Installation of service equipment shall be scheduled so as to enable the serving electric utility to complete its work in advance of the completion of the Work.

Upon the Contractor's written request, the Engineer will arrange with the serving electric utility to complete service connections for permanent installations.

701-14.2 Services on Utility-Owned Poles. When service equipment is to be installed on a utility-owned pole, the Contractor shall furnish and install conduit, conductors and other necessary material to complete the installation of the service. The position of the riser and equipment will be determined by the serving utility unless otherwise shown on the Plans.

Each service shall be provided with an in-line fuse holder on each non-grounded service conductor, except the neutral conductor.

701-14.3 Services in Vaults. The Contractor shall contact the serving utility to determine the location of stub outs for vault service points.

Thirty feet (9 m) of slack in each conductor entering a vault shall be provided for the serving utility to "rack" the conductor on the walls of the vault.

In the service pull box, the Contractor shall furnish and install 2 disconnect splices for each circuit. Disconnect splices shall be installed so that the 2 service wires may be connected together.

701-14.4 Measurement. Services will be measured by "each."

701-14.5 Payment. Payment for the electrical connection between the "service point" and the nearest pull box will be paid at the Contract Unit Price or lump sum price in the Bid for each service connection.

Where the "service point" is indeterminate or shown on the Plans as an "approximate location" or "service point not yet established", payment for the connection between the "service point", when established, and the nearest pull box shown on the Plans will be paid for as Extra Work.

Payment for utility services other than electrical shall be as specified in the Special Provisions.

The Agency will pay all costs and fees required by the serving utility for the service connections for permanent installations unless otherwise specified.

701-15 CIRCUIT BREAKERS.

701-15.1 General. Circuit breakers shall be constructed at the locations shown on the Plans. Circuit breakers used as service disconnect equipment shall be enclosed in a NEMA rain-tight enclosure with a dead-front panel and hasp with a 7/16 inch (11 mm) hole for a padlock. The padlock will be furnished by the Agency.

701-15.2 Payment. No separate payment will be made for circuit breakers. Payment will be considered as included in the Contract Unit Price or lump sum price in the Bid for the equipment requiring circuit breakers.

701-16 STREET LIGHTING CONSTRUCTION.

701-16.1 General. Street lighting materials shall conform to 700-3 and 700-4.

701-16.2 Conduit. Conduit terminating in street lighting Standards shall not be transposed. Conduit shall terminate as near the door of the Standard as possible with the end of the conduit below, but within 1 inch (25 mm) of the lower edge of the door. The prolongation of the conduit shall pass through the door opening.

701-16.3 Wiring/Conductors. Single conductors shall be used for all circuits.

For series-circuit conductor splices, sufficient synthetic oil-resistant rubber tape conforming to the requirements of ASTM D119 shall be applied over the conductor to fill all voids before placing vinyl chloride tape. The splice shall then be covered with a coating of the insulating material specified or approved by the Engineer.

For multiple circuits, a fused disconnect splice connector shall be installed in each ungrounded conductor between the line and the ballast. The connector shall be installed in the base of the Standard or in an adjacent pull box and be readily accessible.

701-16.4 Fused Splice Connectors. In the pull box adjacent to each Standard, a fused disconnect splice connector shall be installed on each ungrounded conductor between the line and the ballast. The connector shall be readily accessible in the pull box regardless of whether the ballast is remote or integral with the luminaire.

Terminals shall be rigidly crimped, using a tool of the type recommended by the manufacturer of the fused splice connector, onto the line conductors and the conductors to the ballasts. Terminals shall be insulated, waterproof, and conform to the splice connector manufacturer's recommendations.

Fused splice connectors shall not be used in series circuits.

701-16.5 Terminal Blocks. Barrier type terminal blocks rated for 40A minimum shall be provided in each service equipment enclosure. Field conductors shall be terminated using crimped, insulated loop connectors.

701-16.6 Services. For series street lighting systems served from overhead circuits, a switch of 5,000V rating shall be connected to control each circuit. The switch shall be enclosed in a NEMA Type 3R, 18-inch x 24-inch x 6-inch (450 mm x 600 mm x 150 mm) terminal box. The terminal box shall be fitted with a cover permanently inscribed "DANGER – HIGH VOLTAGE." The cover shall be attached to the box to form a rain-tight plate and shall require tools for removal. The terminal box shall be installed not less than 10 feet (3 m) above the ground.

701-16.7 Luminaires.

701-16.7.1 Lamp Size and Identification. Each lamp shall be identified with a tape target affixed to the underside of horizontal luminaires or on the body facing oncoming traffic for upright luminaires.

Existing targets shall be removed and disposed of or covered.

701-16.7.2 Photoelectric Units. Photoelectric electric units shall be installed as shown on the Plans or specified in the Special Provisions.

701-16.7.3 Measurement. Luminaires shall be measured by each type and size.

701-16.7.4 Payment. Payment for luminaires, including ballasts and photoelectric units, will be made at the Contract Unit Price or lump sum price in the Bid for each size and type.

701-17 TRAFFIC SIGNAL CONSTRUCTION.

701-17.1 General. Traffic signal materials shall conform to 700-3 and 700-5.

701-17.2 Controllers.

701-17.2.1 General. The Contractor shall supply the controller, cabinet and all auxiliary equipment required to provide a complete functioning controller unless otherwise specified.

701-17.2.2 Controller Cabinet Wiring Diagrams. A wiring diagram for field modifications to existing controller cabinets including, but not limited to, the installation of sensor units, switch packs, etc. shall be submitted to the Engineer at least 10 Working Days prior to performing work in the affected controller cabinet.

Controller cabinet documentation, labeling, and placards shall be corrected/updated to reflect any changes made within the controller cabinet that are the result of all current modifications.

Prior to acceptance of the Contract, the Contractor shall furnish 5 sets of traffic signal controller cabinet schematic wiring diagrams conforming to the phase designations shown on the Plans for the intersection. The diagrams shall show the location of the installation and list all equipment installed in each cabinet. In addition, for each signal installation, the Contractor shall furnish an intersection sketch showing Standards, detectors, and phasing. One copy of the controller cabinet diagram and the intersection and phase diagram, as reviewed by the Engineer, shall be placed in a plastic envelope and attached to the inside of the door.

701-17.2.3 Controller Slabs. In unpaved areas, a 4-inch (100 mm)-thick concrete slab shall be constructed in front of each controller cabinet. Construction shall conform to 303-5. The slab shall extend the full-width of the cabinet foundation and extend out 3 feet (1 m) from the face of the foundation.

701-17.2.4 Controller Cabinet Wiring. Wiring for field modifications and equipment installation shall conform to 700-5.4.2 unless otherwise specified.

701-17.2.5 Service Checks. Service checks shall be performed by the Contractor. The Contractor shall measure the service voltage at the live AC terminal before the main circuit breaker in the controller assembly. If the voltage is less than 110 volts, the Contractor shall notify the Engineer. A resistance measurement shall also be made between the service neutral terminal and the chassis ground terminal. If the resistance is more than 4 ohms, the Contractor shall notify the Engineer. The Engineer will notify the serving electric utility to rectify the problem.

701-17.2.6 Measurement. Controllers will be measured by each type. Controller slabs will be measured by the square foot (m^2) or by the cubic yard (m^3).

701-17.2.7 Payment. Payment for controllers will be made at the Contract Unit Price or lump sum price in the Bid for each type. Payment for controller slabs will be made at the Contract Unit Price per square foot (m^2) or per cubic yard (m^3).

701-17.3 Conduit. Conduit terminating in traffic signal Standards shall not be transposed. Conduit terminating in traffic signal Standards shall extend vertically a minimum of 1 inch (25 mm) above the foundation cap and be centered within the bolt circle.

Rigid non-metallic conduit shall be installed in open trenches, except in the vicinity of pull boxes where it may be bored in, pre-drilled, augered or through air blown holes.

701-17.4 Wiring, Conductors and Cable.

701-17.4.1 General. Multi-conductor cable shall be used for all circuits in lieu of individual conductors. Multi-conductor cable shall be as shown on the Plans. Wires shall be solid copper of the gauge shown in Table 700-5.3.1 unless otherwise specified.

The neutral for pedestrian push-button circuits shall be separate from the signal light circuit neutral.

Splices shall be made only in pull boxes.

Where telephone circuits are installed adjacent to other electrical circuits, the telephone conductors shall be encased in UL approved metallic conduit conforming to 700-3.5.2.

Multi-conductor cable entering controller cabinets shall be neatly arranged, secured, and tagged. Each cable shall be identified by a plastic tag 1/2 inch x 2 inches (12.5 mm x 50 mm) in size, stamped with the cable run identification characters in 1/4 inch (6 mm) letters and secured to the conductor with 2 nylon tie-wrap devices.

Each multi-conductor cable shall be identified in communication cabinets by an aluminum tag, 1 inch x 4 inches (25 mm x 100 mm) in size, stamped with the cable run identification characters in 1/2 inch (12.5 mm) letters and secured to the cable with 2 nylon tie-wrap devices.

Whenever new conductors are to be installed in a conduit with existing individual conductors (except service wire), all individual conductors shall be removed and replaced with multi-conductor cable. A 28-conductor cable shall be installed in new cross street runs unless otherwise shown on the Plans.

Stranded conductors shall be terminated with approved terminal lugs.

701-17.4.2 Conductor Splicing and Termination. Field-spliced solid wires shall be twisted together and secured using vinyl, water-tight, spring-tensioned, silicone-filled, direct-burial wire connectors. The Contractor shall provide a minimum of 3 feet (1 m) of slack. The slack shall be neatly coiled in a clockwise direction within each pull box. Splice insulation shall conform to 700-3.8.

Stranded conductors shall be terminated with a terminal connector. Stranded conductors shall be properly compressed for minimum resistance at the attachment.

Where optimum operation of circuits requires minimum resistance, the connections and/or terminals shall be soldered.

701-17.4.3 Ground Rods. Copper ground rods shall be installed in controller foundations and service pull boxes unless otherwise directed by the Engineer.

701-17.4.4 Interconnect.

701-17.4.4.1 Direct Wire/Conductor. Conductors shall be continuous from controller to controller, unless splices are specifically approved by the Engineer. Splices, where approved, shall be soldered and shall be secured using vinyl, water-tight, spring-tensioned, silicone-filled, direct-burial wire

connectors, unless otherwise specified. A minimum of 3 feet (1 m) of slack shall be provided at each splice and 7 feet (2 m) at each controller cabinet. Spliced conductors shall be insulated with heat-shrink tubing of the appropriate size and overlap the conductor insulation at least 19/32 inch (15 mm). The overall cable splice shall be covered with hear-shrink tubing with at least 1-9/16 inches (40 mm) of overlap of the cable jacket.

701-17.4.4.2 Filled Telephone Cable. Cable splices shall be made at communication or controller cabinets or other splice points specified in the Special Provisions. Splices shall conform to 700-3.8.

701-17.4.4.3 Identification. Each cable in communication cabinets shall be identified by an aluminum or plastic tag 1 inch x 4 inches (25 mm x 100 mm) in size, stamped with the cable run identification characters in 1/2 inch (12.5 mm) letters and secured to the cable with 2 nylon tie-wrap devices.

Each cable shall be identified in controller cabinets or other specified splice points by a plastic tag 1/2 inch x 2 inches (12.5 mm x 50 mm) in size, stamped with the cable run identification characters in 1/4 inch (6 mm) letters and secured to the cable with 2 nylon tie-wrap devices.

701-17.4.5 Fiber Optic Cable.

701-17.4.5.1 General. Fiber optic cable installation and handling procedures shall conform to the manufacturer's recommendations.

In pull boxes with outside dimensions of 22 inches x 34 inches (550 mm x 850 mm), there shall be 10 feet (3 m) minimum of additional looped cable. In splice cabinets and vaults, there shall be 100 feet (30 m) minimum of additional looped cable for each cable entering or leaving.

701-17.4.5.2 Splicing. Fiber optic cable shall only be spliced at the locations shown on the Plans or specified in the Special Provisions.

Splicing shall be performed by the fusion technique. Cables shall be prepared and spliced in accordance with the cable manufacturer's recommendations. Completed splices shall be protected by either heat-shrink tubing, or metal protective sleeves unless otherwise specified.

Completed splices shall be enclosed in re-enterable splice enclosures that seal to form a moisture resistant enclosure. Splice enclosures shall be as shown on the Plans or Standard Plans. The splice case or enclosure shall contain a removable splice organizer or crib that shall secure the individual fibers and protect the splices. The splice organizer or crib shall be attached to the steel strength members in the fiber optic cable and shall be bonded to a ground stud on the exterior of the splice case or enclosure. There shall be adequate space inside the enclosure to hold at least 5 feet (1.5 m) of cable.

701-17.5 Signal Heads.

701-17.5.1 General. New vehicle signal heads installed at any individual intersection shall be of the same style and from the same manufacturer, except for programmed visibility heads.

Mast arm and arrow indications shall be a minimum of 12 inches (300 mm). Other signal indications shall be 8 inches (200 mm).

Backplates shall be installed unless otherwise specified. Pedestrian heads shall be equipped with a glare reduction device unless otherwise specified.

Signal heads shall not be installed at any intersection until all other signal equipment, including the controller, is in place and ready for operation, except that signal heads may be mounted if the faces are turned away from traffic or are covered.

Signal heads shall be located and aimed as shown on the Plans. Mounting and location on Standards shall be as shown on the Plans.

701-17.5.2 Signal Head Mountings. Pipe assemblies shall be installed plumb or level, as applicable, and be symmetrically arranged, and securely tightened. Top horizontal members shall be approximately 12 inches (300 mm) in length. Construction shall be such that all conductors are concealed within a Standard or pipe assembly.

Unless otherwise specified, heads shall be installed with terminal compartment mountings. For top mounting of a one-way head and mast arm mountings, a slip-fitter without a terminal compartment shall be used. Clamp-type mountings may be used for installation of heads on existing concrete Standards if inserts for terminal compartment mountings have not been provided. The terminal compartment shall be mounted on the Standard on the side away from traffic and parallel with the prolongation of the nearest curb face.

701-17.5.3 Visors. Vehicle signal indications at signalized intersections shall be provided with removable beveled or long visors if shown on the Plans.

701-17.5.4 Directional Louvers. Where shown on the Plans, louvers shall be furnished and installed in the visors of the signal head sections.

701-17.5.5 Measurement. Signal heads will be measured by the number of each type and size. Visors and directional louvers will not be measured separately.

701-17.5.6 Payment. Payment for signal heads will be made at the Contract Unit Price or lump sum price in the Bid for each type and size. The Contract Unit Price shall include visors and directional louvers where shown on the Plans for signal heads to be so equipped.

701-17.6 Detectors.

701-17.6.1 General. Vehicle and bicycle detectors shall be of the type or types shown on the Plans. The location of each detector shall be as shown on the Plans.

701-17.6.2 Sensor Units. A minimum of 1 sensor unit shall be provided for each approach for each separately controlled phase of operation unless otherwise specified. Sensor units shall be housed in the controller cabinet unless otherwise specified.

701-17.6.3 Inductive Loop Detectors.

701-17.6.3.1 General. Inductive loop detectors shall be installed at the locations shown on the Plans. Unless otherwise specified, each vehicle loop shall consist of 3 clockwise turns of conductor, and each bicycle loop shall consist of 4 clockwise turns of conductor.

The Contractor shall install and activate inductive loop detectors within 14 Days of the activation of the controller.

701-17.6.3.2 Installation. Each loop shall be installed entirely within one continuous type of paving material. Slots 1/4 inch (6 mm) minimum to 1/2 inch (12.5 mm) maximum in width shall be cut in the pavement, washed or blown clean, and thoroughly dried before installation. The depth shall be as shown on the Plans. Triangular corner cutoffs, 18 inches (450 mm) long on 2 adjacent sides shall be provided on all loops. Residue resulting from slot cutting operations shall not be permitted to flow across lanes occupied by traffic. Residue shall be removed from the pavement surface by vacuuming or other methods approved by the Engineer.

Installation shall conform to the following:

a) Two leads for each loop shall be installed as a pair, twisted at a rate of 360 degrees per foot (300 mm) in a common saw slot. Inductive loop detector leads may share a common saw slot with leads from other loops. However, inductive loop detector leads shall not cross any loops and shall not be installed within 20 inches (500 mm) of any other loop.

b) Lead-in cable shall consist of No. 12 AWG-THW [45 mil (1 mm)] twisted pair and be continuous from the pull box where connections are made to the loops to the cabinet containing the sensor units.

c) Continuity and insulation resistance tests shall be performed after installation on both inductive detector loops and lead-in cables. Measurements shall be made using the conduit system as ground and with the shield (if any) of the lead-in grounded.

The input (or start) wire shall be tagged with an odd number, the output (or finish) wire with the next higher number. A plastic tag 1/2 inch (12.5 mm) by 2 inches (50 mm) shall be wrapped around each loop pair to identify each pair by timing phase and number of individual conductors.

Where circuits are to be spliced, each splice shall be crimped and soldered with rosin core solder. Splices shall be taped and sealed with an electrical waterproofing compound unless otherwise specified. Acid core solder or acid paste shall not be used.

Loop conductors shall be installed without splices and shall terminate in the pull box shown on the Plans. In addition to the requirements for splices in detector circuits, the open end of the cable jackets or tubing shall be sealed in a manner similar to the splicing requirements. Loops shall be joined in the pull box in series so that optimum sensitivity is obtained at the sensor unit. Final splices between loops and lead-in cable shall not be made until the operation of the loops under actual traffic conditions is approved by the Engineer. Loop conductors for each direction of travel, for the same phase of a traffic signal system, and in the same pull box, shall be spliced to a detector lead-in cable.

Loop conductors for inductive loop detector traffic signal and traffic monitoring installations shall be identified and banded, in pairs, by lane, in the pull box adjacent to the loops. The pull box shall be near the termination of the conductor in the controller or traffic monitoring station cabinet.

Loop conductors for traffic monitoring shall terminate in a pull box or terminal strip in the traffic monitor station cabinet when a cabinet of that type is installed.

Inductive loop detector lead-in cable shall extend from the pull box adjacent to the loop detector to a sensor unit mounted in the controller cabinet. Inductive loop detector lead-in cable from the pull box to the controller cabinet shall have 4 conductors (consisting of 2 twisted pairs). Detector lead-in cable connections and/or terminations shall be soldered.

After the loop conductors have been installed in the slots cut in the pavement, the slots shall be filled with sealant to within 1/8 inch (3 mm) of the pavement surface. The sealant shall be a minimum of 1 inch (25 mm) above the top conductor in the saw cut. Before setting, excess sealant shall be removed from the adjacent road surface without the use of solvents.

If specified, the loops shall be installed prior to placing the asphalt concrete surface course. The loops shall be installed, as shown on the Plans, in the compacted layer of asphalt concrete pavement immediately below the asphalt concrete surface course. Installation details shall be as shown on the Plans, except the sealant shall fill the slot flush to the surface.

701-17.6.3.3 Sealants. Hot-melt rubberized asphalt sealant shall be melted in a jacketed, double boiler type melting unit. Temperature of the heat transfer medium shall not exceed the flash point of the sealant or 475° F (240° C), whichever is less.

Sealants shall be applied with a pressure-feed applicator or pour pot. Sealants shall be applied when the pavement surface temperature is greater than 40° F (4° C).

701-17.6.4 Not Used.

701-17.6.5 Measurement. Inductive loop detectors will be measured as specified in the Special Provisions.

701-17.6.6 Payment. Payment for inductive loop detectors will be made at the Contract Unit Price or lump sum price in the Bid.

701-17.7 Pedestrian Signals.

701-17.7.1 General. The Contractor shall provide one visible operating pedestrian head at all times for each direction of each signalized crosswalk while modifying the pedestrian head. Non-functioning pedestrian heads at a signalized crosswalk shall be covered as specified. Pedestrian signal heads shall be installed as shown on the Plans. Accessible pedestrian signals shall conform to the requirements specified in the Special Provisions.

701-17.7.2 Pedestrian Push Buttons. Pedestrian push buttons shall be furnished and installed at the locations shown on the Plans. Pedestrian push button assemblies shall be equipped as specified. Assemblies and signs shall be installed on the crosswalk side of the Standard or pedestal parallel to the crosswalk to which it is intended unless otherwise shown on the Plans. Arrows on push button signs shall point in the same direction as the corresponding crosswalk.

Where a pedestrian push button is attached to a pedestal, the housing shall be shaped to fit the curvature of the pedestal and secured to provide a rigid installation. Saddles shall be provided to make a neat fit when required. Where mounted on the top of a pedestal, the housing shall be provided with a slip-fitter fitting and the screws required to secure it rigidly to the pedestal.

701-17.7.3 Not Used.

701-17.7.4 Measurement. Pedestrian signal heads and push buttons will be measured by "each".

701-17.7.5 Payment. Payment for pedestrian signal heads and push buttons will be made at the Contract Unit Price or lump sum price in the Bid.

701-18 TESTING.

701-18.1 General. Prior to completion of the Work, the Contractor shall perform the following tests on all electrical circuits, in the presence of the Engineer:

a) Continuity. Each circuit shall be tested for continuity.

b) Ground. Each circuit shall be tested for unintentional ground.

c) Megger. A megger test at 500V DC shall be performed on each circuit between the circuit and a ground. The insulation resistance shall be not less than 10 megaohms on all circuits, except for inductive loop detector circuits which shall have an insulation resistance value of not less than 100 megaohms.

d) Functional. A functional test shall be performed which shows that the system functions as specified. The test shall not commence until approval is received from the Engineer.

The functional test for each new or modified electrical system shall consist of not less than 5 Days of continuous, satisfactory operation. If unsatisfactory performance of the system develops, the condition shall be corrected and the test shall be repeated until the 5 Days of continuous satisfactory operation are obtained. Functional tests shall not start nor turn-ons be made on a Friday, or on the day preceding a legal holiday. Shutdown caused by factors beyond the Contractor's control shall not constitute discontinuity of the functional test.

Any material revealed by these tests to be faulty in any part of the installation shall be replaced or corrected by the Contractor at its expense in a manner approved by the Engineer, and the same test shall be repeated.

701-18.2 Payment. No separate payment will be made for testing.

701-19 PAINTING AND GALVANIZING.

701-19.1 General. New equipment to be painted or galvanized shall be as shown on the Plans or specified in the Special Provisions. Painted or galvanized equipment that has been relocated shall be repainted or galvanized as shown on the Plans or specified in the Special Provisions. Paint or galvanizing material shall conform to 210. Painting shall conform to 310.

701-19.2 Payment. No separate payment will be made for painting or galvanizing. Payment shall be considered as included in the Contract Unit Price or lump sum price in the Bid for each item that requires painting or galvanizing.

701-20 SALVAGE. Unless otherwise specified, wires/conductors/cables, Standards, mast arms, pedestals, electrical equipment, and foundations that are not specified in the Special Provisions or shown on the Plans to be salvaged shall become the property of the Contractor and shall be removed from the Work site.

PART 8
LANDSCAPING AND IRRIGATION
SECTION 800 - MATERIALS

800-1 LANDSCAPING MATERIALS.

800-1.1 Topsoil.

800-1.1.1 General. Topsoil shall be designated as Class A (imported), Class B (selected) or Class C (unclassified). The Engineer will determine the suitability of topsoil prior to use. The Engineer may make such inspections and perform such tests as deemed necessary to determine that the material meets the requirements. Topsoil shall be transported from the source to its final position unless stockpiling is specified in the Special Provisions.

800-1.1.2 Class "A" Topsoil. Class "A" topsoil shall be from a source outside the limits of the Work selected by the Contractor.

At least 15 Days before scheduled use, the proposed source of topsoil shall be submitted to the Engineer for approval. The Contractor shall submit a written request for approval which shall be accompanied by a written report from a testing agency certified by the State for agricultural soil evaluation which states that the topsoil proposed conforms to the requirements for "Class A topsoil." Class "A" topsoil shall have the same relative composition and structure, a friable sandy loam character, and be free of roots, clods and stones larger than 1 inch (25 mm) in greatest dimension, pockets of coarse sand, noxious weeds, sticks, brush, and other litter. It shall not be infested with nematodes or other undesirable insects and plant disease organisms.

Class "A" topsoil shall meet the following additional requirements:

a) **Gradation Limits**. Sand, 50 to 80 percent; clay, 20 percent maximum; and silt, 30 percent maximum. The sand, clay, and silt gradation limits shall conform to ASTM D422.

b) **Permeability Rate**. Not less than 1/2 inch (12.5 mm) per hour nor more than 2 inches (50 mm) per hour when tested in accordance with ASTM D2434, California Test 220, or other approved methods.

c) **Agricultural Suitability**. The topsoil shall be suitable to sustain the growth of the plants specified.

800-1.1.3 Class "B" Topsoil. Class "B" is defined as material which is obtained from sources and in the quantities designated on the Plans or in the Special Provisions and which requires transport to the designated landscape areas. Such designated sources of the Class "B" topsoil may be within or outside the Work limits.

Except as provided above, Class "B" topsoil shall be considered selected material in accordance with 300-2.7, 300-2.8, and 300-2.9.

800-1.1.4 Class "C" Topsoil. Class "C" topsoil is defined as soil found in place in the designated landscape area, including soil compacted in place as part of the Work.

800-1.2 Soil Fertilizing and Conditioning Materials.

800-1.2.1 General. Fertilizing materials shall comply with the applicable requirements of the State Food and Agricultural Code. Fertilizing materials shall be packaged first grade, commercial quality products identified as to source, type of material, weight and manufacturer's "guaranteed analysis."

Fertilizing materials shall not contain toxic ingredients or fillers in quantities harmful to human life, animals or plants.

When required by the Engineer, the Contractor shall furnish a Certificate of Compliance.

800-1.2.2 Manure. Manure shall be the product of yard-fed cattle; free of weed seed, straw, or other inert material; and aged at least 3 months. The manure shall have been processed by grinding and screening and shall be of a consistency that will readily spread with a mechanical spreader.

Manure may be supplied in bulk if the source is approved in advance by the Engineer.

800-1.2.3 Commercial Fertilizer. Commercial fertilizer shall be a pelletized or granular product having the chemical analysis shown on the Plans or specified in the Special Provisions. Commercial fertilizer shall be free-flowing material delivered in unopened sacks. Material which becomes caked or otherwise damaged shall not be used.

800-1.2.4 Organic Soil Amendment. Organic soil amendment shall be selected from Type 1, 2, or 3 products as described herein.

Type 1 organic soil amendment shall be a ground or processed wood product derived from redwood, fir, or cedar sawdust, or from the bark of fir or pine, treated with a non-toxic agent to absorb water quickly, and shall comply with the requirements shown in Table 800-1.2.4.

TABLE 800-1.2.4

Gradation: Sieve Size	Percent Passing (minimum)
1/4 inch (6.3 mm)	95
No. 8 (2.36 mm)	80
No. 35 (500 µm)	30
Nitrogen Content (%, dry weight)	
Redwood	0.4 – 0.6%
Fir	0.56 – 0.84%
Cedar	0.56 – 0.84%
Fir bark	0.8– 1.2%
Pine bark	0.8 – 1.2%

Salinity: Maximum saturation extract conductivity: 2.50 millisiemens per centimeter (6.35 millimhos/inch) at 77°F (25°C).

Wettability: When one teaspoon of tap water is applied to 4 cubic inches (1 cm^3 of top water is applied to 15 cm^3) (volumetric ratio of 1:15) of the air-dry product, the material shall become completely damp in a period not exceeding 2 minutes. Any wetting agent added shall be guaranteed non-phyto-toxic at the rate used.

Type 2 organic soil amendment shall be a relatively dry friable organic composite derived from sewage sludge processed for agricultural use. It shall contain at least 1 percent nitrogen by dry weight and comply substantially with the gradation for Type 1 organic soil amendment.

Type 3 organic soil amendment shall be hay and stable bedding which has been processed and used as the growing medium for the commercial production of mushrooms. It shall contain at least 1 percent nitrogen by dry weight and comply substantially with the gradation for Type 1 organic soil amendment.

800-1.2.5 Mulch. Mulch shall be designated by Type in accordance with the requirements herein. Mulch shall be packaged in bales or bags unless the Engineer approves a bulk source in advance of delivery to the Work site.

a) Type 1 mulch (ground wood product), shall conform to Type 1 organic soil amendment.
b) Type 2 mulch (sewage sludge product), shall conform to Type 2 organic soil amendment.
c) Type 3 mulch (mushroom compost) shall conform to Type 3 organic soil amendment.

d) Type 4 mulch (peat), shall be brown compressed sphagnum or hypnum.
e) Type 5 mulch (fir bark chips), shall be fir bark chips conforming to the gradation specified.
f) Type 6 mulch (straw), shall be either threshed new straw or stable bedding material derived from rice, oats or barley. Straw in an advanced state of decomposition will not be acceptable.

800-1.3 Seed. Seed shall be fresh, clean, new crop seed, mechanically premixed to specified proportions.

Seed shall be delivered to the Work site in original unopened containers bearing the dealer's "guaranteed analysis" and germination percentage, and a certificate or stamp or release by a County Agricultural Commissioner. Any seed tagged "warning, hold for inspection" shall be inspected and released by the Agricultural Commissioner of the County within which the seeds are to be planted.

800-1.4 Plants.

800-1.4.1 General. Plants shall be inspected and approved at the nursery by the Engineer prior to shipment to the planting site.

Plants shall have a growth habit normal to the species and shall be sound, healthy, vigorous and free from insect pests, plant diseases, sun scalds, fresh bark abrasions, excessive abrasions, or other objectionable disfigurements. Tree trunks shall be sturdy and well "hardened off." Plants shall have normal well-developed branch systems, and vigorous and fibrous roots systems which are neither root- nor pot-bound and are free of kinked or girdling roots.

Other than the normal side pruning during the growth period, no pruning shall be done prior to inspection at the nursery.

800-1.4.2 Trees. Trees shall be of the specified height and crown to the last division of the terminal leader and diameter. The height shall be measured from the root crown. The diameter shall be measured 6 inches (150 mm) above the root crown. The height of palm trees shall be measured from the groundline to the base of the growing bud. The tree shall stand reasonably erect without support.

800-1.4.3 Shrubs. Shrubs shall be of the specified type and size, selected from high quality, well-shaped nursery stock.

800-1.4.4 Flatted Plants. Groundcover plants and other flatted plants shall be grown and remain in the flats until transplanted at the Work site. The soil and spacing of the plants in the flat shall ensure the minimum disturbance of the root system at time of transplanting.

800-1.4.5 Sod and Stolons (turf grass). Stolons shall be fresh, clean, living sections of runners of hybrid Bermuda grass or hybrid bent grass as specified in the Contract Documents. They shall be free of turf disease, insects, or weeds, and capable of healthy vigorous growth.

For mechanical or hand spreading, Bermuda grass stolons shall be 1 to 4 inches (25 mm to 100 mm) long and bent grass 4 to 8 inches (100 mm to 200 mm) long. Stolons to be planted in a slurry mixture shall be supplied in shorter sections as required.

800-1.4.6 Cuttings. Cuttings shall be fresh stock cut with a sharp hand tool from the stems of healthy vigorous plants of the species specified.

800-1.5 Headers, Stakes, and Ties.

800-1.5.1 General. Lumber for landscape work shall be construction heart rough redwood in the sizes specified. Nails, lag screws, and miscellaneous hardware shall be galvanized commercial quality material. Miscellaneous fabricated metal items shall be made from steel conforming to ASTM A36.

800-1.5.2 Headers and Stakes. Headers shall be 2 inches x 4 inches (50 mm x 100 mm) except that 2, 1 inch x 4-inch (25 mm x 100 mm) boards shall be supplied for laminations on turns and curves. Header stock shall be supplied in lengths of at least 10 feet (3 m). Stakes for headers shall be pointed 2 inches x 4 inches (50 mm x 100 mm), at least 18 inches (450 mm) long. Joint splicing lumber shall be 1 inch x 4 inches (25 mm x 100 mm), 2 feet (0.6 m) long.

800-1.5.3 Tree Stakes. The type of tree stake shall be as specified in the Special Provisions. The tree support stakes shall be 10 feet (3 m) long.

Guy wire shall be No. 12 BWG (2.64 mm) zinc-coated iron. Plastic ribbon tie material shall be 1 inch (25 mm) wide with a minimum tensile strength of 500 pounds (2 kN).

Deadman stakes shall be either 2 inches x 4 inches (50 mm x 100 mm) redwood or 3/4 inch (19 mm) diameter steel pipe 3 feet (1 m) long. Covers for wire shall be garden hose, 1/2 inch (12.5 mm) minimum diameter.

800-2 IRRIGATION SYSTEM MATERIALS.

800-2.1 Pipe and Fittings.

800-2.1.1 General. The type of pipe materials and fittings shall be as shown on the Plans or specified in the Special Provisions and shall comply with the following.

800-2.1.2 Steel Pipe. Steel pipe shall be galvanized standard weight (Schedule 40) conforming to ASTM A120. Steel pipe shall be jointed with galvanized, threaded, standard weight malleable iron fittings and couplings.

800-2.1.3 Plastic Pipe for Use with Solvent Weld Socket or Threaded Fittings. Plastic pipe shall be rigid unplasticized polyvinyl chloride PVC 1220 (Type 1, Grade 2), conforming to ASTM D1785. Plastic pipe marked with product standard PS-21-70 conforms to the ASTM requirements. The minimum gaskets shall be rigid un-plasticized polyvinyl chloride pressure rating shall not be less than the working pressures indicated therein for the schedule and sizes listed.

Schedule 40 pipe shall be used for installation on the discharge side of control valves and Schedule 80 pipe shall be used for continuously pressurized pipe on the supply side of control valves. Schedule 80 only shall be supplied when threaded joints are specified or otherwise permitted by the Engineer.

Fittings and couplings for plastic pipe shall be threaded or slip-fitted tapered socket solvent weld type. Threaded adapters shall be provided with socket pipe for connections to threaded pipe. Plastic pipe fittings and couplings shall be PVC I or PVC I/II material supplied in the same schedule size specified for the pipe. The type of plastic material and schedule size shall be indicated on each fitting or coupling. Fittings and couplings shall conform to the requirements shown in Table 800-2.1.3.

TABLE 800-2.1.3

Socket Fittings	
Schedule 40	ASTM D2466
Schedule 80	ASTM D2467
Threaded Fittings	
Schedule 80	ASTM D2464

800-2.1.4 Plastic Pipe for Use with Rubber Ring Gaskets. Plastic pipe for use with rubber ring PVC 1120 (Type 1, Grade 1) shall conform to ASTM D2241. Plastic pipe marked with product standard PS 22-70 conforms to ASTM requirements. Pipe shall be supplied with plain ends or with an integral

thickened expanded bell with rubber ring groove. Couplings for plain end pipe shall be of the single-rubber-ring-type with solvent weld socket on one end or shall be of the double ring type.

Rubber ring gaskets shall be of a synthetic rubber conforming to ASTM D1869.

Pipe shall be furnished in the following standard dimension ratios (SDR) and pressure ratings:

160 psi (1100 kPa), SDR 26

200 psi (1380 kPa), SDR 21

800-2.1.5 Copper Pipe. Copper pipe shall be Type K conforming to ASTM B88/B88M. Copper pipe shall be jointed with the appropriate solder type wrought copper fittings for 2-1/2-inch (63 mm) and smaller sizes. Cast brass fittings shall be used for sizes over 2-1/2-inch (63 mm).

800-2.2 Valves and Valve Boxes.

800-2.2.1 General. Valves shall be of the size, type, and capacity shown on the Plans or specified in the Special Provisions.

Valves except garden valves shall be capable of satisfactory performance at a working pressure of 200 pounds per square inch (1380 kPa). Valves shall be designed to permit disassembly to replace sealing components without removal of the valve body from the pipeline.

800-2.2.2 Gate Valves. Gate valves in sizes 2 inches (50 mm) and smaller shall be all bronze double disc-wedge-type with integral taper seats and non-rising stem.

Sizes 2-1/2 inches (63 mm) and larger shall be iron body, brass trimmed with other features the same as for 2-inch (50 mm) and smaller.

800-2.2.3 Manual Control Valves. Manual control valves shall be brass or bronze, and shall be straight or angle pattern globe valves, full-opening, key-operated with a replaceable compression disc and ground joint union on the discharge end.

800-2.2.4 Remote Control Valves. Remote control valves shall be:

a) electrically or hydraulically operated,

b) brass or bronze with accurately machined valve seat surfaces,

c) equipped with flow control adjustment and capability for manual operation, and

d) made so that they may be readily disassembled for servicing.

800-2.2.5 Garden Valves. Garden valves shall be brass or bronze except for the handle. They shall have a replaceable compression disc, and shall be 3/4 inch (19 mm) straight-nosed, key operated and pressure rated for operation at 150 pounds per square inch (1035 kPa).

800-2.2.6 Quick-Coupling Valves and Assemblies. Quick-coupling valves shall be brass or bronze with built-in flow control and self-closing valve and supplied in 3/4 inch (19 mm) size unless otherwise required. When a quick-coupler assembly is specified, it shall consist of the valve, quick-coupler connection and hose swivel.

800-2.2.7 Valve Boxes. Valve boxes and covers shall be constructed of precast concrete.

800-2.3 Backflow Preventer Assemblies. Backflow preventer assemblies shall consist of a backflow preventer unit and related components conforming to the governing code requirements.

800-2.4 Sprinkler Equipment. Sprinkler heads, bubbler heads and spray nozzles shall be of the types and sizes shown on the Plans. Such equipment shall be brass, bronze and stainless steel except for minor components. Equipment of one type and flow characteristic shall be from the same manufacturer and all equipment shall bear the manufacturer's name and identification code in a position where they can be identified in the installed position.

Fixed head sprinklers shall have a one-piece housing with provision for interior parts replacement. Pop-up sprinklers shall rise at least 1 inch (25 mm) during operation.

Shrubbery and bubbler heads shall be adjustable from full-flow to shutoff.

800-3 ELECTRICAL MATERIALS.

800-3.1 General. The Contractor shall furnish and install all electrical equipment and materials required for a complete electrical system.

All equipment and materials shall comply with the requirements of the governing code and the serving utility and shall be approved and identified by Underwriters Laboratories, Inc. (UL).

800-3.2 Conduit and Conductors.

800-3.2.1 Conduit. Conduit shall be galvanized steel conforming to 700-3.5.

800-3.2.2 Conductors. Line voltage conductors shall be supplied in the sizes and types shown on the Plans and shall be THW or THWN, 600-volt insulation rating, conforming to ASTM D2219 and D2220.

Low voltage control conductors shall be Type UF and supplied in the sizes shown on the Plans or in accordance with the control equipment manufacturer's recommendation, and shall be UL approved for direct burial installation.

800-3.3 Controller Unit. The type of controller unit shall be as shown on the Plans. It shall be fully automatic, with provisions for manual operation, sized to accommodate the number of stations or control valves included in the system. Outdoor models shall be housed in a vandal-proof and weatherproof enclosure with locking cover.

SECTION 801 - INSTALLATION

801-1 GENERAL. This section includes specifications for the preparation, planting, and irrigation system construction for landscape areas shown on the Plans.

Unless otherwise specified, walls, curbs, planter boxes, walks, irrigation systems, and similar improvements shall be constructed following rough grading and before landscaping.

All work on the irrigation system, including hydrostatic and coverage tests, preliminary operational tests of the automatic control system, and the backfill and densification of trenches, and other excavations shall be performed after topsoil work and before planting.

801-2 EARTHWORK AND TOPSOIL PLACEMENT.

801-2.1 General. Earthwork and topsoil placement shall include the preparation for and the spreading, densification, cultivation, and raking of topsoil, including fertilization and conditioning.

Preliminary rough grading and related work to prepare areas for landscaping work to within 0.1 foot (30 mm) of finish grade, or to subgrade for Class A or Class B topsoil, shall conform to 300-2, 300-4, and 301-1.

801-2.2 Topsoil Preparation and Conditioning.

801-2.2.1 General. The type and thickness of topsoil shall be as shown on the Plans, or if not shown, shall be Class "A", 6 inches (150 mm) thick. Planting areas shall be free of weeds and other extraneous materials to a depth of 12 inches (300 mm) below finish grade before topsoil work.

Soil shall not be worked when it is so wet or so dry as to cause excessive compaction or the forming of hard clods or dust.

The existing soil below subgrade for Class "A" topsoil shall be scarified to a depth of 6 inches (150 mm) prior to spreading topsoil.

Class "C" topsoil shall be scarified and cultivated to a finely divided condition to a depth of 8 inches (200 mm) minimum below finish grade. During this operation, all stones over 1 inch (25 mm) in greatest dimension shall be removed.

801-2.2.2 Fertilizing and Conditioning Procedures. The planting area shall be brought to finish grade before spreading the fertilizers or conditioning materials specified.

Fertilizing and conditioning materials shall be mechanically spread at a uniform rate. The quantities of materials necessary for the planting area shall be at the Work site and verified by delivery tickets furnished to the Engineer before spreading.

After spreading, the fertilizing and conditioning materials shall be uniformly cultivated into the upper 6 inches (150 mm) of soil by suitable equipment operated in at least 2 directions approximately at right angles. The resulting soil shall be in a friable condition.

801-2.3 Finish Grading. The finish grade shall be smooth, uniform, and free of abrupt grade changes and depressions to ensure surface drainage.

The finish grade below adjacent paving, curbs or headers shall be 1 inch (25 mm) in lawn areas and 2 inches (50 mm) in shrub or groundcover areas.

After fertilizing and conditioning, the soil shall be watered and allowed to settle to provide a stable surface, not overly compacted to the extent that it will prevent aeration and water infiltration. After the soil has dried out to a workable condition, the planting areas shall be regraded, raked, and smoothed to the required grades and contours. Finish surfaces shall be clean and suitable for planting.

801-3 HEADER INSTALLATION. Headers shall be installed at the locations and grades shown on the Plans prior to planting.

Stakes shall be located at splices, corners, and at intervals not to exceed 5 feet (1.5 m) and driven slightly below the top of the header. Splice plates shall be used at butt joints. Headers shall be nailed to stakes with 2 nails, clinched 1/2 inch (12.5 mm). Splice plates shall be centered on the joint and nailed to each header with 4, 10d box nails.

801-4 PLANTING.

801-4.1 General. The types, sizes, and quantities of plant materials shall be as specified in the Special Provisions or shown on the Plans.

All plants will be inspected prior to planting, including plants previously approved at the nursery. The Contractor shall be responsible for the condition of all plants, planted or otherwise, until completion of the Work.

Planting shall be performed with materials, equipment, and procedures favorable to the optimum growth of the plants and in compliance with these procedures.

Except as noted for specimen planting, all planting shall follow the completion of the irrigation system.

801-4.2 Protection and Storage. The Contractor shall keep all plant material delivered to the Work site in a healthy condition for planting. Plants shall not be allowed to dry out. Bare root stock shall be separated and "heeled in" moist earth or other suitable material. Balled and burlapped plants shall have the root ball covered with moist sawdust, wood chips, or other approved material.

801-4.3 Layout and Plant Location. Planting areas will be staked by the Engineer. Detailed layout within the planting areas shall be performed by the Contractor and approved by the Engineer prior to planting. Parkway trees will be located in the field by the Engineer before planting.

The first row of plants in areas designated for center-to-center spacing of plants shall be located at one-half of designated spacing from the edge of the area.

801-4.4 Specimen Planting. Plants in boxes 24 inches (600 mm) and larger shall be planted before installation of lateral irrigation lines.

Irrigation lines conflicting with specimen plant locations shall be rerouted to clear the root ball.

801-4.5 Tree and Shrub Planting. Planting holes shall be approximately square with vertical sides twice the depth and width of the plant container or ball, and shall be larger if necessary to permit handling and planting without injury or breakage of the root ball or root system. Any plant with a broken or cracked root ball before or during planting shall not be planted.

Containers shall be opened and removed in such a manner that the root is not injured. Balled plant wrappings shall be loosened or cut back after the plant is positioned in the planting hole.

The native soil at the bottom of planting holes shall be scarified to a depth of 6 inches (150 mm).

Planting holes shall be backfilled with a prepared soil mix. Soil shall consist of 50 percent of the specified topsoil and 50 percent Type 1, 2, or 3 organic soil amendment.

Planting shall conform to the following requirements.

a) A layer of prepared soil mix shall be deposited in the planting hole.
b) The plant shall be set approximately at the center of the hole.
c) Prepared soil mix shall be deposited in the remainder of the hole to finish grade.
d) The backfill shall be thoroughly water-settled and additional prepared soil mix added to fill any remaining void below finish grade.
e) A circular watering basin slightly larger than the planting hole, 4 inches (100 mm) high for trees and 2 inches (50 mm) high for shrubs, shall be left around the plant. The bottom of the basin shall be at approximate finish grade or slightly lower. Type 1, 2, 3, or 4 mulch shall be spread at least 2 inches (50 mm) thick in the basin.
f) The plant shall be guyed and staked as specified in 801-4.6.
g) The area around the plant shall be re-graded to finish grade. The excess soil shall be disposed of by the Contractor.

After planting, the plant shall be plumb, with the root crown at its natural growing depth with respect to finish grade.

801-4.6 Plant Staking and Guying.

801-4.6.1 Method "A" Tree Staking. The tree shall be staked with a 1-1/2-inch (38 mm) nominal diameter x 10-foot (3 m) long galvanized steel pipe conforming to 800-2.1.2, installed vertically, positioned at least 6 inches (150 mm) from the trunk at ground level, and 30 inches (750 mm) into the soil in a manner to avoid injury to the roots or breaking the root ball. The trunk shall be secured to the pipe with one tie just below the head of the tree. The tie shall be No. 12 BWG galvanized iron wire covered with garden hose, or other approved tie. The loop shall be 1 inch (25 mm) greater in diameter than the trunk. The tie shall be attached to the pipe through a hole drilled at the tie location described above. The wire ties shall be secured by twisting the ends.

801-4.6.2 Method "B" Tree Staking. The tree shall be staked with 2, No. 6 (No. 19M) steel reinforcing bars 6 feet (1.8 m) long driven 24 inches (600 mm) into the ground. The stakes shall be 18 inches (450 mm) from each side of the tree trunk, and stakes and tree shall be in a plane parallel to the street centerline. Ties shall be made of 1 inch (25 mm) or wider flexible plastic ribbon material having a minimum tensile strength of 500 pounds (2.2 kN). Four ties shall be used; 2 at 2 inches (50 mm) from the top of each stake and 2 at 2 feet (0.6 m) above the ground. Ties shall be loops secured to the stake on one end and shall be long enough to provide for 3 inches (75 mm) of slack to permit the tree trunk limited movement in any direction.

801-4.6.3 Guying. Trees and other plants, except specimen plants, to be guyed will be shown on the Plans or specified in the Special Provisions.

Guying shall be done immediately after planting. Three guys per plant shall be installed in accordance with the following:

a) Each guy shall be secured to the appropriate main branch by a twisted loop of No. 12 BWG galvanized iron wire housed in garden hose.
b) Each guy shall be anchored to a driven stake located at a horizontal distance from the tree equal to the vertical distance from the ground to the connection of the guy wire on the tree branch.
c) Each guy shall be covered with highly visible garden hose or plastic tubing to a height of 6 feet (1.8 m) above grade.
d) Slack in each guy shall be removed by hand so as not to bend or twist the plant.

801-4.7 Ground Cover and Vine Planting. Soil preparation and fine grading shall be completed prior to ground cover planting.

Ground cover and vines shall be planted in moist soil and spaced as indicated on the Plans.

Each plant shall be planted with its proportionate amount of flat soil to minimize root disturbance. Soil moisture shall be such that the soil does not crumble when removing plants.

Following planting, ground cover and vine areas shall be regraded to restore smooth finish grade and to ensure proper surface drainage. A 1 inch (25 mm) layer of Type 1, 2, 3, or 4 mulch shall be spread over the planted areas. Watering shall begin immediately following mulching.

When necessary to prevent plant damage from pedestrian traffic during the initial growing stage, the Contractor shall erect temporary protective fencing to be removed at the end of the plant establishment period.

Vines shall be tied to walls, fences, etc., in the manner prescribed on the Plans. Temporary staking shall be removed at the end of the plant establishment period.

801-4.8 Lawn Planting.

801-4.8.1 General. Before beginning lawn planting soil preparation and fine grading shall be completed.

801-4.8.2 Seed. Seed lawn planting may be accomplished by Method A (dry method) or Method B (hydraulic method). Seeding shall not be performed when the wind velocity exceeds 5 miles per hour (8 km/h), or is detrimental to the uniform distribution of the seed.

a) Method A. The area to be seeded shall be lightly raked to provide a seed bed.

The required seed mixture shall be sown uniformly at the specified rate. Seeding shall be done in 2 operations with the spreader set to sow 1/2 the specified amount in each operation. The second sowing shall be at right angles to the first.

After sowing, the area shall be evenly covered to a depth of 1/4 to 1/2 inch (6 mm to 12.5 mm) with an approved mulch.

The lawn area shall be watered in a manner so as not to cause surface erosion.

Newly seeded surfaces shall be kept moist continuously throughout the germination period.

b) Method B. The seed, fertilizer, fiber, and other materials in the slurry mixture shall be as specified in the Special Provisions or shown on the Plans. All materials shall be of such character that they will disperse into a uniform slurry when mixed with water. The mixture shall be such that an absorbent, porous mat will be formed.

All materials must be available for inspection prior to application. Weights and contents of containers shall be clearly identified. A green coloring additive shall be used in the slurry for visual inspection purposes.

The slurry shall be applied under pressure at the specified rates.

Areas to be planted by this method shall be moistened to a depth of 6 inches (150 mm) but shall not be surface wet at the time of application.

The slurry planted areas shall be kept moist during the germination period, but ponding shall be avoided.

801-4.8.3 Sod. The type and thickness of sod and the areas to be sodded shall be as shown on the Plans or specified in the Special Provisions.

Subgrade for sod shall be the specified thickness of the sod below finish grade. Soil conditioning and fine grading shall be completed before sodding. No heavy equipment shall operate over the subgrade after grading is completed.

The subgrade shall be moist but not wet when sod is laid. Sod shall be laid with closely fitted joints, and the ends of the strips shall be staggered. Openings shall be plugged with sod or topsoil.

Within 2 hours after installing sod and before rolling, the sod shall be lightly irrigated. All seams and joints shall then be rolled until the sod is bonded to the subgrade.

The area shall then be watered thoroughly to penetrate the subgrade at least 8 inches (200 mm). Watering shall be repeated as necessary to keep the sod moist until rooted into the subgrade. Sodded areas shall be protected against foot traffic until the sod is well established.

801-4.8.4 Stolon Planting. Topsoil preparation and conditioning and finish grading shall be completed before stolon planting.

The area to be planted shall be thoroughly irrigated to a depth of at least 8 inches (200 mm). As soon as the soil can be worked, the specified commercial fertilizer shall be worked into the top 1 inch (25 mm) of soil.

At the time of planting, the top 2 inches (50 mm) of soil shall be friable and contain enough moisture to prevent stolons from drying out during the planting operation. The stolons shall be worked into the soil to a depth of 1/2 to 1-1/2 inches (12.5 mm to 38 mm) by a mechanical or hand planter, or broadcast by hand and covered with 1/4 inch (6 mm) of mulch.

When the area to be planted exceeds 10,000 square feet (1000 m^2), a mechanical spreader shall be used; when less than 10,000 square feet (1000 m^2) and more than 2,000 square feet (200 m^2), the use of a hand planter or mechanical planter is optional; and when less than 2,000 square feet (200 m^2), handplanting or broadcasting with mulch is optional.

The planted stolons shall not be allowed to dry out. Watering shall begin immediately after planting and the stolons kept moist at all times until the plants are well established.

When overseeding is required, the seed shall be spread in accordance with 801-4.8.2, Method A, immediately after planting.

801-4.9 Erosion Control Planting.

801-4.9.1 General. Erosion control planting shall be for slope protection. Topsoil preparation and conditioning shall conform to 801-2.3.

801-4.9.2 Straw Stabilization. When straw stabilization is specified, Type 6 mulch shall be incorporated into the slope topsoil either by discing or with a steel plate studded roller. The steel plate studs shall be at least 6 inches (150 mm) long, not more than 6 inches (150 mm) wide, and

approximately 1 inch (25 mm) thick, with rounded edges. The roller shall be capable of forcing the straw into the soil a sufficient depth to tie down the surface soils.

801-4.9.3 Seeding and Mulching. Seed, fertilizer, mulch, and other specified materials may be applied on slopes by Method A or Method B specified in 801-4.8.2.

801-4.9.4 Sprigging. Sprigging shall consist of planting turf grasses, cut stems of plants, and plants with attached root system, but without adhering soil.

Sprigs shall be harvested and planted within a 24-hour period. Ice plant sprigs shall be harvested between 48 and 96 hours before planting so that a thin callus is formed over the cut surface of each sprig. Sprigs shall be shaded during callusing, but shall not be moistened.

Turf grasses shall be planted in accordance with 801-4.8.4.

Ice plant sprigs shall be planted in moist soil in holes or furrows 4 inches (100 mm) deep and the hole or furrow refilled with soil and made firm around the plant in such a manner that the plant is not damaged.

Sprigs shall be planted individually at the specified spacing. When row sprigging is specified, planting shall be in furrows cut along the contour of the slope.

If mulching of sprigged areas is required, it shall immediately follow planting.

801-4.9.5 Watering. All seeded and planted areas shall be kept moist during the plant establishment period.

Areas containing ice plants shall be maintained in a barely moist condition to a depth of 1 inch (25 mm) below the planted root depth.

When a permanent irrigation system is not available, the Contractor shall provide whatever temporary system is necessary to provide adequate watering during the plant establishment period without erosion detrimental to the planting.

801-5 IRRIGATION SYSTEM INSTALLATION.

801-5.1 General. Unless otherwise specified, the irrigation system layout shown on the Plans shall be considered schematic. With the Engineer's approval, the Contractor may make adjustments where necessary to conform to actual field conditions. The irrigation system shall be operational, with uniform and adequate coverage of the areas to be irrigated, prior to planting.

Service connections shall be as shown on the Plans, or designated by the serving utility and will be installed by others at no cost to the Contractor. The Contractor shall notify the Engineer at least 3 weeks prior to the time electrical and water services are required. The Contractor shall be responsible for furnishing the labor and materials to connect to the service connection.

After completing the irrigation system, the Contractor shall submit as-built drawings showing the location of pipe, valves, tubing, wiring, controllers, and electrical services as constructed.

801-5.2 Trench Excavation and Backfill. Trenches and other excavations shall be sized to accommodate the irrigation system components, conduit, and other required facilities. Additional space shall be provided to assure proper installation and access for inspection.

Unless otherwise specified, the minimum depth of cover over pipelines and conduit shall be as follows:

a) Electrical conduit – 24 inches (600 mm) (36 inches (900 mm) under roadways).

b) Waterlines continuously pressurized – 24 inches (600 mm) (36 inches (900 mm) under roadways).

c) Lateral sprinkler lines – 12 inches (300 mm).

The bottom of trenches shall be true to grade and free of protruding stones, roots, or other matter which would prevent proper bedding of pipe or other facilities.

Trenches and excavations shall be backfilled so that the specified thickness of topsoil is restored to the upper part of the trench. Backfill shall be jetted in accordance with 306-12.4.

Trenches through paved areas shall be resurfaced in accordance with 306-13.

801-5.3 Irrigation Pipeline Installation.

801-5.3.1 General.

Pipe fittings shall be installed in accordance with the manufacturer's recommendations and these Specifications. When requested by the Engineer, the Contractor shall furnish the manufacturer's printed installation instructions before pipe installation.

Pipe shall be bedded in at least 2 inches (50 mm) of finely divided material to provide a firm, uniform bearing. After laying, the pipe shall be surrounded with additional finely divided material to at least 2 inches (50 mm) over the top of the pipe. Trench backfill, sufficient to anchor the pipe, may be deposited before the pipeline pressure testing, except that joints shall remain exposed until satisfactory completion of testing.

When 2 or more pipelines are installed in the same trench, they shall be separated by a minimum horizontal clear distance of 6 inches (150 mm) and they shall be installed so that each pipeline, valve, or other pipeline component may be serviced or replaced without disturbing the other.

All assemblies shall be assembled as specified and in accordance with the manufacturer's directions.

During installation of pipe, fittings, valves, and other pipeline components, foreign matter shall be prevented from entering the system. All open ends shall be temporarily capped or plugged during cessation of installation operations.

Changes in pipeline size shall be accomplished with reducer fittings.

801-5.3.2 Steel Pipeline. Ends of pipe shall be cut square and reamed to full size with a long taper reamer.

Threads shall be cut with clean, sharp dies and shall conform to American Standards Association Specification B2.

Joints shall be made with a nontoxic, non-hardening joint compound applied to the male threads only.

When wrapped pipe is specified, joints and any remaining unwrapped portion of the pipeline shall be similarly wrapped after pressure testing.

801-5.3.3 Plastic Pipeline. Plastic pipe shall be jointed by socket-type solvent-welded fittings, threaded fittings, rubber-ring fittings, or by other means specified. When plastic pipe is joined to steel pipe, the steel pipe shall be installed first.

Plastic pipe shall be cut square, externally chamfered approximately 10 to 15 degrees, and all burrs and fins removed.

Solvent welded joints shall be made in accordance with ASTM D2855. The solvent recommended by the manufacturer shall be used.

Plastic pipe installation shall be in accordance ASTM D2774 and the requirements herein.

Care shall be exercised in assembling a pipeline with solvent welded joints so that stress on previously made joints is avoided. Handling of the pipe following jointing, such as lowering the assembled pipeline into the trench, shall not occur prior to the set times specified in ASTM D2855.

Solvent shall be applied to pipe ends in such a manner that no material is deposited on the interior surface of the pipe or extruded into the interior of the pipe during jointing. Excess cement on the exterior of the joint shall be wiped clean immediately after assembly.

Threads shall be cut with clean, sharp dies and shall conform to American Standards Association Specification B2. A plug shall be installed in the bore of the pipe to prevent distortion prior to threading.

Threaded pipe joints shall be made using teflon tape or other approved jointing material. Solvent shall not be used with threaded joints.

Pipe shall be protected from tool damage during assembly. Vises shall have pleated jaws and strap wrenches shall be used for installation of fittings and nipples.

Plastic pipe which has been nicked, scarred, or otherwise damaged shall be removed and replaced. Plastic pipe shall be snaked from side to side in the trench to allow 1 foot (0.3 m) of expansion and contraction per 100 feet (30 m) of straight run.

The pipeline shall not be exposed to water for 24 hours after the last solvent welded joint is made.

801-5.3.4 Copper Pipeline. Copper pipeline shall be made with sweated solder joints.

Before jointing, the end of the pipe for the depth of the fitting, and the interior of the fitting shall be buffed to a bright finish and coated with solder flux. A continuous solder bead shall show around the joint circumference after soldering.

Copper pipe shall be joined to steel or cast iron pipe with a dielectric union.

801-5.4 Installation of Valves, Valve Boxes, and Special Equipment. Valves, backflow preventers, pressure regulators, and related accessories shall be furnished and installed as specified.

Valves and other equipment shall be installed in a normal upright position unless otherwise recommended by the manufacturer, and shall be readily accessible for operation, maintenance, and replacement. Sectional control valves shall not be located within range of sprinklers they control.

Valves shall be same size as the pipeline in which they are installed.

Gate valves and sectional control valves shall be installed below ground. Gate valves shall be housed in a covered concrete box that will permit access for servicing. Sectional control valves shall be equipped with a sleeve and cap centered on the valve stem.

Quick-coupler valves and garden valves projecting above grade shall be installed 3 feet (0.9 m) from curbs, pavement, and walks. In lawn areas, such equipment shall be installed in a covered concrete box set to finish grade. In ground cover and shrubbery areas, quick-coupler valves shall be set 6 inches (150 mm) above finish grade, and garden valves shall be set between 12 and 15 inches (300 mm and 375 mm) above finish grade. Quick-coupler valves and garden valves shall be installed on a double-swing-joint riser assembly and secured to a driven No. 4 (No. 13M) reinforcing steel rod in accordance with 801-5.5.3.

All valve boxes, pipe sleeves, and caps shall be set to finish grade, and valves shall be set at sufficient depth to provide clearance between the cover and the cap, valve handle, or key when the valve is in the fully open position.

Backflow preventers shall be provided with pipe supports and the accessories necessary to properly secure the assembly. All backflow preventers shall be assembled with pipe and fittings of galvanized steel.

801-5.5 Sprinkler Head Installation and Adjustment.

801-5.5.1 General. Mains and laterals, including risers, shall be flushed and pressure tested in accordance with 801-5.7 before installing sprinkler heads, after which a water coverage test shall be performed.

801-5.5.2 Location, Elevation, and Spacing. Sprinkler head spacing shall not exceed the maximum shown on the Plans or recommended by the manufacturer.

In new lawn areas, sprinkler heads shall be installed 3 inches (75 mm) above grade and then reset flush with the finish surface just prior to the first mowing. Lawn sprinklers shall be installed 2 inches (50 mm) clear of adjacent walks, curbs, paving, headers, and similar improvements.

Sprinkler heads shall be installed 4 inches (100 mm) from adjacent vertical elements projecting above grade such as walks, planter boxes, curbs, and fences.

Shrub heads, bubbler heads, and oscillating sprinklers shall be installed 6 inches (150 mm) above finish grade.

Nozzle lines shall be installed at least 12 inches (300 mm) above finish grade. Sprinkler heads projecting above finish grade shall be at least 12 inches (300 mm) from adjacent curbs, walks, paving, and similar improvements.

801-5.5.3 Riser and Nozzle Line Installation. Risers shall be oriented perpendicular to finish grade.

Risers for oscillating sprinklers and nozzle lines shall be galvanized steel pipe. All other risers may be galvanized steel or Schedule 80 PVC. Pipe between the connection to the lateral or main and the sprinkler head shall be threaded.

Sprinkler head riser assemblies shall be top outlet, single-swing joint, or double-swing joint.

Sprinkler head risers and nozzle risers installed above grade within 24 inches (600 mm) of roadway paving, curbs, walks, and similar improvements shall be of the double-swing joint type.

A top outlet riser assembly shall consist of a pipe riser threaded into a top outlet ell or tee installed in the lateral supply line.

Double-swing joint and single-swing joint riser assemblies shall utilize a horizontal 6-inch (150 mm) pipe nipple threaded into a side outlet ell or tee installed in the lateral supply line. For a double-swing joint, three ells shall be used in the remaining assembly ahead of the vertical riser pipe. For a single-swing joint, one ell shall be used.

Risers for nozzle lines, oscillating sprinklers, and other sprinkler heads installed above grade within 24 inches (600 mm) of curbs, walks, roadways, and similar improvements shall be supported by a No. 4 (No. 13M) reinforcing steel rod. The upper end of the rod shall be at finish grade and be of such length that it extends 24 inches (600 mm) below the lateral supply line.

Where nozzle lines cannot be supported on adjacent fences, guard rails and the like, they shall be supported on driven 1/2 inch (12.5 mm) pipe stakes, 4 feet (1.2 m) long at 8-foot (2.4 m) centers. The nozzle line shall be secured to the top of the stake with 3/8 inch (9.5 mm) anchor rings, 12 inches (300 mm) long.

801-5.5.4 Sprinkler Head Adjustment. When all sprinkler heads are installed and the irrigation system is operating, each section or unit shall be adjusted and balanced, with all section control valves fully open to obtain uniform and adequate coverage.

Sprinkler heads having adjustable pin nozzles or orifices shall have the pins adjusted to provide adequate distribution of water over the coverage pattern. The Contractor shall substitute larger or smaller nozzle cores in nonadjustable sprinkler heads as necessary.

If additional work other than the prescribed above is necessary to correct a deficiency in the system installed as specified, such work will be considered as Extra Work.

801-5.6 Automatic Control System Installation. The Contractor shall install a complete automatic irrigation control system including the automatic controller, remote control valves and wiring, and all necessary accessories and utility service connection.

The automatic controller shall be installed outside of the coverage pattern of the irrigation system at the location shown on the Plans. The foundation for the controller shall be walk concrete, as specified in 201-1, of the size shown on the Plans or recommended by the manufacturer. The control components in the controller shall be fused and the chassis shall be grounded.

Remote control valves shall be compatible with the automatic controller. When the valve is to be housed in a concrete box, it shall be installed with at least a 6-inch (150 mm) clearance below the concrete cover. The box shall be set to finish grade on a 12-inch (300 mm) layer of 1 inch (25 mm) crushed rock.

All service wiring shall be installed in galvanized steel conduit from the service point to the controller. A separate disconnect switch or combination meter socket, as required, shall be installed between the source of power and the controller. The minimum service wire shall be No. 12 AWG copper, 600V, Type TW, THW, THWN, or larger as specified in the Special Provisions or by the controller manufacturer. Wire splices shall be located only in pull boxes and shall be made with a packaged kit approved for underground use, or as specified in 701-13.2. Pull boxes shall be concrete, set to grade on a 12-inch (300 mm) layer of 1 inch (25 mm) crushed rock.

Control wiring or hydraulic control tubing shall be housed in conduit between the controller and a concrete pull box installed at least 12 inches (300 mm) outside the limits of the controller foundation, or the structure foundation where the controller is housed. All other wiring and hydraulic control tubing issuing from the pull box shall be direct burial installed in main or lateral waterline trenches wherever practicable. The wiring or tubing shall be bundled and secured to the lower quadrant of the irrigation pipeline at 10-foot (3 m) intervals with plastic electrical tape. Sufficient slack shall be left in the wiring or tubing to provide for expansion and contraction. When the control wiring or tubing cannot be installed in a pipe trench, it shall be installed a minimum of 18 inches (450 mm) below finish grade and a bright colored plastic ribbon with suitable markings shall be installed in the trench 6 inches (150 mm) below grade directly over the wire or tubing.

Control wiring shall be suitably color coded as necessary for identification. All common wire shall be the same color. Unless otherwise specified, all control wiring shall be direct burial, Type UF, No. 14 AWG copper. Splices in control wire shall be made in accordance with the requirements for service wire. At least 2 feet (0.6 m) of slack shall be left at each splice and point of connection in pull boxes and valve boxes.

All wiring shall be tested for continuity, open circuits, and unintentional grounds prior to connecting to equipment. When tested for a period of 4 hours, the hydraulic control system shall maintain a constant test pattern of 125 pounds per square inch (860 kPa). Upon completion of the Work, the control system shall be in operating condition with an operational chart mounted within the controller cabinet.

Upon completion of the Work, the control system shall be in operating condition with an operational chart mounted within the controller cabinet.

801-5.7 Flushing and Testing.

801-5.7.1 General. After completion and prior to the installation of any terminal fittings, the entire pipeline system shall be thoroughly flushed to remove dirt, scale, or other material. After flushing, the

following tests shall be conducted by the Contractor in the sequence listed below. All equipment, materials, and labor necessary to perform the tests shall be furnished by the Contractor and all tests shall be conducted in the presence of the Engineer.

801-5.7.2 Pipeline Pressure Test.

801-5.7.2.1 General. Pressure testing for leakage shall be performed on supply lines, pressure mains, and laterals installed by the Contractor, except for non-rigid pipelines and pipelines with spray nozzles installed into the pipe. Pipelines to be tested shall be installed, and each open end of the pipeline shall be plugged or capped prior to testing.

Pipelines installed by trenching and backfilling and pipelines which are completely visible after installation shall be tested by either Method A or Method B. The method used shall be at the Contractor's option. All other pipelines, including those installed in the ground by methods other than trenching and backfilling, shall be tested by Method A. Waterline crossovers shall be tested by Method A except the test period and allowable drop in pressure shall be modified from one hour to 1/2 hour and from 5 pounds per square inch (35 kPa) to no drop in pressure, respectively.

801-5.7.2.2 Method A. Method A pressure testing for leakage shall conform to the following procedure.

The Contractor shall notify the Engineer at least 24 hours prior to performing a pressure test. The Engineer will observe each pressure test.

Pipelines to be tested shall be filled with water and a pressure gage shall be connected to the pipeline. The pipeline shall then be placed under a pressure of 125 pounds per square inch (860 kPa) except as otherwise specified below, by air or water pressure, after which the source of pressure shall be cut off leaving the line under the required pressure.

The pipeline shall be tested under the required pressure for a test period of one hour. The pressure gage shall remain in place until each test period has been completed. Leaks that develop in the tested portion of the system shall be located and repaired after each test period when a drop of more than 5 pounds per square inch (35 kPa) is indicated by the pressure gage. After the leaks have been repaired, the one hour pressure test shall be repeated and additional repairs made until the drop in pressure is 5 pounds per square inch (35 kPa) or less.

When a system consists of new pipelines installed as part of the Work and existing pipelines, the new pipelines shall be isolated from the existing pipelines and the new pipelines shall be tested at 125 pounds per square inch (860 kPa).

801-5.7.2.3 Method B. Method B pressure testing for leakage shall conform to the following procedure.

The Contractor shall notify the Engineer at least 24 hours prior to performing a pressure test. Pressure tests shall be performed such that the test periods are within the working hours specified in the Special Provisions. The Engineer will observe each pressure test.

Before any portion of the pipeline on the supply side of a control valve is backfilled, water shall be turned into that portion of the line and maintained at full pressure from the water source for a period of not less than 8 consecutive hours after air has been expelled from the line. Before any portion of the pipeline on the discharge side of a control valve is backfilled, a similar test shall be performed, except the test shall be for a period of one hour. Leaks that develop in a tested portion of the system shall be repaired. After the leaks have been repaired, the pressure test shall be repeated and additional repairs made until no leaks occur.

801-5.7.3 Sprinkler Coverage Test. The coverage test shall be performed after sprinkler heads have been installed and shall demonstrate that each section or unit in the irrigation system is balanced to provide uniform and adequate coverage of the areas serviced. The Contractor shall correct any deficiencies in the system in accordance with 801-5.5.4.

801-5.7.4 Operational Test. The performance of all components of the automatic control system shall be evaluated for manual and automatic operation.

During the maintenance period and at least 15 Days prior to final inspection, the Contractor shall set the controller on automatic operation and the system shall operate satisfactorily during such period. All necessary repairs, replacements, and adjustments shall be made until all equipment, electrical work, controls, and instrumentation are functioning in accordance with the Contract Documents.

801-6 MAINTENANCE AND PLANT ESTABLISHMENT. The Contractor shall maintain all planted areas on a continuous basis as they are completed during the progress of the Work and during the plant establishment period.

All planted areas shall be kept free of debris and shall be weeded and cultivated at intervals not to exceed 10 Days. The first mowing of lawn areas shall be performed when the grass is 2-1/2 inches (63 mm) high and shall be repeated as often as necessary to maintain the lawn at a height of 2 inches (50 mm). In no case shall the lawn be cut lower than 1-1/2 inches (38 mm) in height.

Any required pruning of plants will be designated by the Engineer at the start of the plant establishment period and the Contractor shall perform the pruning as part of the plant establishment work.

The Contractor shall request a final inspection to begin the plant establishment period after all planting and related work have been completed in accordance with the Contract Documents.

After planting is completed, a field notification will be issued to the Contractor to establish the effective beginning date of the plant establishment period. The plant establishment period shall be for a period of 30 Days unless otherwise specified in the Special Provisions and will be extended by the Engineer if the planted areas are improperly maintained, appreciable plant replacement is required, or other corrective work becomes necessary.

Upon completion of the plant establishment period, a final inspection will be performed by the Engineer. If the plant establishment period is satisfactorily completed ahead of other work included in the Contract, the maintenance of planted areas shall be continued by the Contractor until all other work has been completed.

801-7 MEASUREMENT. Landscaping and irrigation will be measured as specified in the Special Provisions and as shown in the Bid.

801-8 PAYMENT. Payment for landscaping and irrigation will be made at the lump sum prices or Contract Unit Prices shown in the Bid.

APPENDIX A

SAMPLE ENABLING ORDINANCE

(For use by municipalities in adopting Standard Specifications For Public Works Construction by reference)

Ordinance No _____

An ordinance regulating materials of construction and their use in the erection, installation, alteration, repair, removal, conversion, demolition, and construction of public works improvements in the City (County) of .....; providing for the administration of contracts as well as permits issued in connection with such improvements; and repealing all ordinances and parts of ordinances in conflict therewith.

The People of the City (County) of.....do ordain as follows:

Except as may otherwise be provided herein, the provisions of the 2015 edition of the "Standard Specifications for Public Works Construction," prepared and promulgated by Public Works Standards, Inc., a California Nonprofit Mutual Benefit Corporation, whose members are the American Public works Association, the Associated General Contractors of California, the Engineering Contractors' Association, the Southern California Contractors Association and BNI Publications, Inc., are adopted and applicable to all public works construction undertaken after the effective date of this ordinance.

REFERENCE DOCUMENTS

Following is a list of documents referred to in this book, arranged alphabetically.

AMERICAN FOREST AND PAPER ASSOCIATION. 1111 19th St., N.W. Suite 800, Washington, D.C. 20036.

AMERICAN NATIONAL STANDARDS INSTITUTE. (Formally the United States of American Standards Institute, also the American Standards Association). Published by the American National Standards Institute, 25 West 43rd St., 4th Floor, New York, New York 10036.

AMERICAN PETROLEUM INSTITUTE STANDARDS. Published by the American Petroleum Institute, 1220 L St., N.W. Washington, D.C. 20005.

AMERICAN SOCIETY FOR TESTING AND MATERIALS. Standards and Metric Practice Guide E380. Published by the American Society for Testing and Materials, 100 Barr Harbor Dr., Conshohocken, PA 19428-2959.

AMERICAN WATER WORKS ASSOCIATION STANDARDS (AWWA). Published by the American Water Works Association, 6666 W. Quincy Avenue, Denver, CO 80235.

AMERICAN WELDING SOCIETY (AWS) STANDARDS AND SPECIFICATIONS. Published by the American Welding Society, 550 N.W. LeJeune Road, Miami, FL 33126.

AMERICAN WOOD PRESERVERS ASSOCIATION (AWPA) BOOK OF STANDARDS. Published by the American Wood Preservers Association, 2345 Grand Blvd Ste 500, Kansas City, MO 64108-2625.

ASPHALT PROTECTIVE COATING FOR PIPELINES. Published by the Asphalt Institute, Research Park Dr., P.O. Box 14052, Lexington, KY 40512-4052.

FEDERAL SPECIFICATIONS. Available through the Federal Supply Service Bureau, Specification Section, 470 East L'Enfant Plaza S.W., Suite 8100, Washington, D.C. 20407.

MANUAL OF STANDARD PRACTICE. Published by the Concrete Reinforcing Steel Institute, 933 N. Plum Grove Rd., Schaumburg, IL 60173-4758.

MANUAL OF STEEL CONSTRUCTION (AISC). Published by the American Institute of Steel Construction, Incorporated, One East Wacker Drive, Suite 3100, Chicago, IL 60601-2001.

MANUAL OF WARNING SIGNS LIGHTS, AND DEVICES.

MATERIALS MANUAL, VOLUMES I, II, & III TESTING AND CONTROL PROCEDURES.

MILITARY SPECIFICATIONS. Available through the Superintendent of Documents, US Government Printing Office, Washington, DC 20402.

NATIONAL ELECTRIC CODE. Published by the National Fire Protection Association, One Batterymarch Park, Quincy, MA 02269.

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION STANDARDS. Published by the National Electrical Manufacturers Association, 1300 N 17th St. Ste 1847, Rosslyn, VA 22209.

PLACING REINFORCING BARS. (Formerly Recommended Practice for Placing Reinforcing Bars). Published by the Concrete Reinforcing Steel Institute, 933 N. Plum Grove Road, Schaumburg, IL 60173-4758.

RULES FOR OVERHEAD ELECTRIC LINE CONSTRUCTION- GENERAL ORDER NO. 95. Published by the State of California, Public Utilities Commission, 505 Van Ness Ave, San Francisco, CA 94102.

SAFETY ORDERS-BASIC ELECTRICAL REGULATIONS, TITLE 24, CONSTRUCTION, GENERAL INDUSTRY, TUNNEL. Published by the Office of Procurement, Publications Section[1], P.O. Box 1015, North Highlands, California 95660.

SOFTWOOD PLYWOOD, CONSTRUCTION & INDUSTRIAL. (Formerly Douglas Fir Plywood, Construction & Industry). Published by the U.S. Department of Commerce, Business and Defense Services Administration, Office of Technical Services, Commodity Standards Division; Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

SPECIFICATIONS FOR THE DESIGN, FABRICATION AND ERECTION OF STRUCTURAL STEEL FOR BUILDINGS. Published by the American Institute of Steel Construction, One East Wacker Dr., Suite 3100, Chicago, IL 60601-2001.

SPECIFICATION FOR WELDED HIGHWAY AND RAILWAY BRIDGES. Published by the American Welding Society, 550 N.W. LeJeune Rd., Miami, FL 33126.

STANDARD GRADING RULES FOR WEST COAST LUMBER. (Formerly Standard Grading and Dressing Rules for West Coast Lumber). Published by the West Coast Lumber Inspection Bureau, P.O. Box 23145, Portland, OR 97281-3145.

STANDARD SPECIFICATIONS.

STANDARD SPECIFICATIONS FOR GRADES OF CALIFORNIA REDWOOD LUMBER. Published by the California Redwood Association, 405 Enfrente Dr., Suite 200, Novato, CA 94949.

STANDARD SPECIFICATIONS FOR HIGHWAYS MATERIALS AND METHODS OF SAMPLING AND TESTING. Published by the American Association of State Highway and Transportation Officials, PO Box 96716, Washington DC, 20090-6716.

STANDARDS FOR INSULATED POWER CABLE. Published by the Insulated Cable Engineers Association, P.O. Box 1568, Carrollton, GA 30112.

STANDARDS OF OPERATIONS OF TRUCK MIXERS AND AGITATORS. (National Ready Mixed Concrete Association). Published by the National Ready Mixed Concrete Association, 900 Spring Street, Silver Spring, MD 20910.

TRUCK MIXER & AGITATORS STANDARDS. (Truck Mixer Manufacturers Bureau). Published by the Truck Mixer Manufacturers Bureau, 900 Spring Street, Silver Spring, MD 20910.

UNDERWRITERS LABORATORY, INC. LISTINGS AND STANDARDS. Published by the Underwriters Laboratory, Inc., 333 Pfingsten Rd., Northbrook, IL 60062-2096.

U.S. CORPS OF ENGINEERS TEST METHODS. Available through the Corps of Engineers, U.S. Army, Waterways Experimental Stations, 3909 Halls Ferry Rd., Vicksburg, MS 39180-6199.

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