

86 ELECTRICAL SYSTEMS

86-1 GENERAL

86-1.01 SUMMARY

Section 86 includes specifications for installing, modifying, and removing electrical systems.

Comply with part 4 of the *California MUTCD*. Nothing in section 86 is to be construed as to reduce the minimum standards in this manual. The locations of electrical system elements shown are approximate; the Engineer determines the final location.

86-1.015 DEFINITIONS

electrolier: Complete assembly of lighting standard and luminaire.

lighting standard: Pole and mast arm supporting the luminaire.

luminaire: Assembly that houses the light source and controls the light emitted from the light source.

86-1.02 REGULATIONS AND CODE

Electrical equipment must comply with 1 or more of the following:

1. ANSI
2. ASTM
3. 8 CA Code of Regs § 2299 et seq.
4. EIA
5. NEMA
6. NETA
7. UL

Materials and workmanship must comply with:

1. FCC
2. ITE
3. NEC
4. NRTL
5. Public Utilities Commission, General Order No. 95, "Rules for Overhead Electrical Line Construction"
6. Public Utilities Commission, General Order No. 128, "Rules for Construction of Underground Electric Supply and Communication Systems"

86-1.03 SCHEDULE OF VALUES

Determine quantities required to complete work. Submit the quantities as part of the schedule of values.

Provide a schedule of values for each lump sum bid item.

Do not include costs for traffic control system in the schedule of values.

The schedule of values must include type, size, and installation method for:

3. Conduit
4. Pull boxes
5. Conductors and cables
6. Service equipment enclosures

86-1.04 EQUIPMENT LIST AND DRAWINGS

Within 15 days of Contract approval, submit for review a list of equipment and materials that you propose to install. The list must include:

1. Name of manufacturer

2. Dimensions
3. Item identification number
4. List of components

The list must be supplemented by 2 copies of data, including:

1. Schematic wiring diagrams
2. Scale drawings of cabinets showing location and spacing of shelves, terminal blocks, and equipment, including dimensions
3. Operation manual

Electrical equipment constructed as shown will not require detailed drawings and diagrams.

Furnish 3 sets of computer-generated cabinet schematic wiring diagrams.

The cabinet schematic wiring diagram must be placed in a heavy duty plastic envelope and attached to the inside of the door of each cabinet.

Prepare diagrams, plans, and drawings using graphic symbols in IEEE 315, "Graphic Symbols for Electrical and Electronic Diagrams."

86-1.05 CERTIFICATE OF COMPLIANCE

Submit a certificate of compliance for all electrical material and equipment. Certificates shall be written on the manufacturer's letterhead and shall certify that products comply with these technical specifications. Certificates shall be signed by an officer of the manufacturing company.

86-1.06 MAINTAINING EXISTING AND TEMPORARY ELECTRICAL SYSTEMS

86-1.06A General

Keep existing electrical system or authorized temporary replacement in working order during the progress of the work. Shutdown is allowed for alteration or removal of the system. Traffic signal shutdown must be limited to normal working hours. Lighting system shutdown must not interfere with the regular lighting schedule. Notify the Engineer before performing work on the existing system.

Notify the local traffic enforcement agency before traffic signal shutdown.

If lane closures are specified, traffic signal system shutdowns must be limited to the hours allowed for lane closures.

Where an existing or temporary system is being modified and the work is not described but the Engineer considers it necessary to keep the system in working order, the work is change order work.

The Department or local agency will:

1. Continue the operation and maintenance of existing electrical facilities
2. Continue to provide electrical energy to operate existing electrical facilities
3. Repair or replace existing facilities damaged by traffic
4. Pay for electrical energy to operate existing or new facilities undergoing the functional tests specified in section 86-2.14C.

Verify location and depth of existing detectors, conduits, pull boxes, and other electrical facilities before using tools or equipment that may damage those facilities or interfere with an electrical system.

Notify the Engineer immediately if existing facility is damaged by your activities. Repair or replace damaged facility promptly. If you fail to complete the repair or replacement, promptly, the City will repair or replace and deduct the costs from payments due to you.

Replace damaged detectors within 24 hours at your expense. If you fail to complete the repair within 24 hours, the City will repair and deduct the repair costs from payments due to you.

If the roadway remains open to traffic while an existing lighting system is modified:

1. Keep the existing system in working order
2. Make the final connection so the modified circuit is in operation by nightfall

Keep temporary electrical installations in working order until no longer required. Removal of temporary lighting equipment will be performed by others. The Engineer will coordinate removal of temporary lighting equipment. Contractor shall notify the Engineer at least 72 hours in advance of turning on the modified lighting circuit.**86-1.07 SCHEDULING OF WORK**

The first order of work must be to place the order for the electrical equipment. Furnish the Engineer a statement from the vendor that the order for the electrical equipment has been received and accepted by the vendor. Submit the statement as an informational submittal.

Except service installation and service equipment enclosure, do not work above ground until all materials are on hand to complete the electrical work at each location. Schedule work to allow each system to be completed and ready for operation before opening the corresponding section of the roadway to traffic.

If street lighting exists or is installed in conjunction with traffic signals, do not turn on the signals until the street lighting is energized.

Lighting and traffic signals, including flashing operation, will not be placed in operation before starting the functional test period specified in section 86-2.14.

Do not pull conductors into conduit until:

1. Pull boxes are set to grade
2. Metallic conduit is bonded and grounded

Start functional tests on any working day except Friday or the day before a holiday. Notify the Engineer 48 hours before the start of a functional test.

86-2 MATERIALS AND INSTALLATION

86-2.01 EXCAVATING AND BACKFILLING

Dispose of surplus excavated material.

Backfill under section 19-3. Backfill placed in conduit trenches outside the hinge point of slopes and not under pavement must be compacted to a minimum relative compaction of 90 percent. Compact backfill within hinge points and in areas where pavement is to be constructed to a minimum relative compaction of 95 percent.

Backfill trenches and restore sidewalk, pavement, and landscaping at 1 intersection before starting excavation at another intersection.

Unless otherwise specified in section 12, restrict closure for excavation on a street or highway to 1 lane at a time.

86-2.02 REMOVING AND REPLACING IMPROVEMENTS

Replace or reconstruct underlying material damaged by your activities. Replacement material must be of equal or better quality than the material replaced.

If a part of a square or slab of concrete sidewalk, curb, gutter, or driveway is broken or damaged, the entire square or slab must be removed and reconstructed.

Cut the outline of concrete sidewalk or driveway to be removed:

1. Using a power-driven saw
2. On a neat line
3. To a 0.17-foot minimum depth

86-2.05 CONDUIT

Use conduits to run the conductors except for overhead and where conductors are run inside poles.

You may use a larger size conduit than specified as long as you use it for the entire length between outlets. Do not use reducing coupling.

New conduit must not pass through existing foundations for standards.

86-2.05A Material

Conduit and conduit fitting must be UL or NRTL listed and comply with the requirements shown in the following table:

Conduit and Conduit Fitting Requirements	
Type 1	Hot-dip galvanized rigid steel conduit and conduit couplings must comply with UL 6 and ANSI C80.1. Zinc coating testing must comply with copper sulfate test requirements in UL 6. Conduit couplings for rigid steel conduit must be electrogalvanized.
Type 2	Hot-dip galvanized rigid steel conduit must comply with requirements for Type 1 conduit and be coated with PVC or polyethylene. Exterior thermoplastic coating must have a minimum thickness of 35 mils. Internal coating must have a minimum thickness of 2 mils. Coated conduit must comply with UL 6; NEMA RN 1; or NRTL PVC-001.
Type 3	Rigid nonmetallic PVC conduit must comply with UL 651. Type A extruded rigid PVC conduit and extruded rigid HDPE conduit must comply with UL 651A. Coilable, smooth-wall, continuous length HDPE conduits must comply with UL 651B. Install at underground locations only.
Type 4	Waterproof flexible metal conduit must consist of conduit with a waterproof nonmetallic sunlight-resistant jacket over an inner flexible metal core. Type 4 conduit must be UL listed for use as the grounding conductor.
Type 5	Intermediate steel conduit and conduit couplings must comply with UL 1242 and ANSI C80.6. Zinc coating testing must comply with copper sulfate test requirements in UL 1242. Conduit couplings for intermediate rigid steel conduit must be electrogalvanized. Type 5 conduit must only be used if specified.

Bonding bushings to be installed on metal conduit must be insulated and either galvanized or zinc alloy type.

Fittings for steel conduit and for watertight flexible metal conduit must be UL listed at UL 514B.

86-2.05B Use

Install Type 1 conduit on all exposed surfaces and at the following locations:

1. In concrete structures
2. Between a structure and nearest pull box

Exposed conduit installed on painted structure must be painted the same color as the structure.

Change or extend existing conduit runs using the same material. Install pull box if an underground conduit changes from the metallic type to Type 3.

Minimum trade size of conduit must be:

1. 1-1/2 inches from electrolier to adjacent pull box
2. 1 inch from pedestrian push button post to adjacent pull box
3. 2 inches from signal standard to adjacent pull box
4. 3 inches from controller cabinet to adjacent pull box
5. 2 inches from overhead sign to adjacent pull box
6. 2 inches from service equipment enclosure to adjacent pull box
7. 1-1/2 inches if unspecified

Two conduits must be installed between a controller cabinet and the adjacent pull box.

86-2.05C Installation

Whether shop or field cut, ream ends of conduit to remove burrs and rough edges. Make cuts square and true. Slip joints and running threads are not allowed for coupling conduit. If a standard coupling cannot be used for coupling metal type conduit, use a threaded union coupling that is UL or NRTL listed. Tighten couplings for metal conduit to maintain a good electrical connection through conduit run.

Cut Type 3 conduit with tools that will not deform the conduit. Use solvent weld for connections.

Cut Type 2 conduit with pipe cutters; do not use hacksaws. Coated conduit must be threaded with standard conduit-threading dies. Tighten conduit into couplings or fittings using strap wrenches or approved groove joint pliers.

Protect shop-cut threads from corrosion under the standards shown in the following table:

Shop-Cut Thread Protection	
Steel conduit and conduit couplings	ANSI C80.1
Electrical intermediate metal conduit and conduit couplings	ANSI C80.6

Paint conduits. Apply 2 coats of authorized unthinned zinc-rich primer of organic vehicle type. Do not use aerosol cans. Paint the following parts of conduits:

1. All exposed threads
2. Field-cut threads before installing conduit couplings to steel conduit
3. Damaged surfaces on metal conduit

Do not remove shop-installed conduit couplings.

Damaged Type 2 conduit or conduit coupling must be wrapped with at least 1 layer of 2-inch-wide, 20-mil-minimum-thickness PVC tape as specified in ASTM D 1000, with a minimum tape overlap of 1/2 inch. Before applying the tape, conduit or fitting must be cleaned and painted with 1 coat of rubber-resin based adhesive as recommended by the tape manufacturer. You may repair damaged spots in the thermoplastic coating by painting over with a brushing type compound supplied by the conduit manufacturer instead of the tape wrap.

The ends of Types 1, 2, or 5 conduit must be threaded and capped with standard pipe caps until wiring is started. The ends of Types 3 and 4 conduit must be capped until wiring is started. If caps are removed, replace with conduit bushings. Fit insulated bonding bushings on the end of metal conduit ending in pull box or foundation. Bell or end bushings for Type 3 conduit must be nonmetallic type.

Conduit bends, except factory bends, must have a radius of not less than 6 times the inside diameter of the conduit. If factory bends are not used, bend the conduit without crimping or flattening using the longest radius practicable. Bend conduits as shown in the following table:

Conduit-Bending Requirements

Type 1	By equipment and methods recommended by the conduit manufacturer.
Type 2	Use standard bending tool designed for use on thermoplastic coated conduit. Conduit must be free of burrs and pits.
Type 3	By equipment and methods recommended by the conduit manufacturer. Do not expose conduit to direct flame.
Type 5	By equipment and methods recommended by the conduit manufacturer.

Install pull tape in conduit that is to receive future conductors. The pull tape must be a flat woven lubricated soft fiber polyester tape with a minimum tensile strength of 1,800 lb and have printed sequential measurement markings every 3 feet. At least 2 feet of pull tape must be doubled back into the conduit at each end.

Existing underground conduit to be incorporated into a new system must be cleaned with a mandrel or cylindrical wire brush and blown out with compressed air.

Install conduit to a depth of not less than 30 inches below finished grade, except in sidewalk and curbed paved median areas, where it must be at least 18 inches below grade. You may lay conduit on existing pavement within new curbed median.

Conduit coupling must be a minimum of 6 inches from the face of the foundation.

Place a minimum of 2 inches of sand bedding in the trench before installing Type 2 or Type 3 conduit. Place a minimum of 4 inches of same material over conduit before placing additional backfill material.

Conduit runs located behind curbs may be installed in the street, within 3 feet of, and parallel with the face of the curb by the trenching in pavement method as specified in section 86-2.05C. Pull boxes must be located behind the curb or at the locations shown.

Obtain authorization before disturbing pavement. If an obstruction is encountered, obtain authorization to cut small holes in the pavement to locate or remove the obstruction. If jacking or drilling method is used, keep jacking or drilling pit 2 feet away from edge of pavement. Pavement must not be weakened or subgrade softened from excess water use.

Conduit used for drilling or jacking must be removed; install new conduit for completed work. If a hole larger than the conduit is pre-drilled and you install conduit by hand or by equipment and method recommended by the conduit manufacturer, you may install Type 2 or Type 3 conduit under the pavement.

If trenching in pavement method is specified, conduit installation under pavement that is not a freeway lane or freeway to freeway connector ramp, must comply with the following:

1. Use Type 3 conduit. Place conduit under pavement in a trench approximately 2 inches wider than the outside diameter of conduit, but not exceeding 6 inches in width. Trench depth must not exceed the greater of 12 inches or conduit trade size plus 10 inches, except that at pull boxes the trench may be hand dug to required depth. The top of the installed conduit must be a minimum of 9 inches below finished grade.
2. Trenching installation must be completed before placing final pavement layer.
3. Cut pavement to be removed with a rock cutting excavator. Minimize shatter outside the removal area.
4. Place conduit in the bottom of the trench and backfill with minor concrete. Minor concrete must contain a minimum of 590 lb of cementitious material per cubic yard. If the trench is in asphalt concrete pavement and pavement overlay is not placed, backfill the top 0.10 foot of the trench with minor HMA.
5. Backfill trenches, except for the top 0.10 foot, by the end of each day. The top 0.10 foot must be filled within 3 days after trenching.

Conduit installed beneath railroad tracks must be:

1. Type 1 or 2
2. 1-1/2-inch minimum diameter
3. Placed a minimum depth of 42 inches below the bottom of the rail.

If jacking or drilling method is used, construct jacking pit to a minimum of 13 feet from the centerline of track at the near side of jacking pit. Cover jacking pit with substantial planking if left overnight.

Conduit ending in a standard or pedestal must not extend more than 3 inches vertically above the foundation and must be sloped toward the handhole opening. Conduit entering through the side of a nonmetallic pull box must end inside the box within 2 inches of the wall and 2 inches above the bottom and be sloped toward the top of the box to facilitate pulling of conductors. Conduit entering through the bottom of a pull box must end 2 inches above the bottom and be located near the end walls to leave the major portion of the box clear. At the outlet, the conduit must enter from the direction of the run.

Underground conduit runs, including under sidewalks, that are adjacent to gasoline service stations or other underground gasoline or diesel storage, piping, or pumps and that lead to a controller cabinet, circuit breaker panel, service, or enclosure where an arc may occur during normal operations must be sealed if the conduit is within the limits specified in the NEC for Class 1, division 1. Use Type 1 or Type 2 conduit for these runs.

Conduit for future use in structures must be threaded and capped. Conduit leading to soffit, wall, or other lights or fixtures below pull box grade must be sealed and made watertight, except where conduit ends in a No. 9 or No. 9A pull box.

Support for conduit in or on a wall or bridge superstructure must comply with the following:

1. Steel hangers, steel brackets, and other fittings must comply with section 75-1.03.
2. Construct precast concrete conduit cradles using minor concrete and commercial quality welded wire fabric. Minor concrete must contain a minimum of 590 lb of cementitious material per cubic yard. The cradles must be moist cured for a minimum of 3 days. Bond precast concrete cradles to the structure with one of the following epoxy adhesives:
 - 2.1. Epoxy adhesive for bonding freshly-mixed concrete to hardened concrete.
 - 2.2. Rapid set epoxy adhesive for pavement markers.
 - 2.3. Standard set epoxy adhesive for pavement markers.
3. Use pipe sleeve or form an opening for conduit through the bridge superstructure concrete. Sleeve or opening through either prestressed member or conventionally reinforced precast member must be:
 - 3.1. Transverse to the member.
 - 3.2. Through the web.
 - 3.3. Not more than 3 inches maximum gross opening in concrete.
4. Where conduits pass through the abutment concrete, wrap conduit with 2 layers of asphalt-felt building paper securely taped or wired in place. Fill the space around the conduit that runs through the bridge abutment wall with mortar under section 51-1 except the proportion of cementitious material to sand must be 1 to 3. Fill the space around the conduits that run through the abutments after prestressing is completed.
5. Run surface-mounted conduit straight and true, horizontal or vertical on the wall, and parallel to walls on ceilings or other similar surfaces. Support conduit at a maximum of 5-foot intervals or closer where necessary to prevent vibration or unsightly deflection. The supports must include galvanized malleable iron conduit clamps and clamp backs secured with expansion anchorage devices as specified for concrete anchorage devices in section 75-1.03. Threaded studs must be galvanized and be of the largest diameter that will pass through the mounting hole in conduit clamp.
6. Where pull boxes are placed in conduit runs, the conduit must be fitted with threaded bushings and bonded.
7. Mark the location of conduit end in structure, curb, or wall with a "Y" that is a minimum of 3 inches tall, directly above conduit.

86-2.06 PULL BOXES

You may use a larger standard size pull box than that described.

86-2.06A Materials

Pull box, cover, and extension for installation in ground or sidewalk area must be precast reinforced concrete or nonconcrete material. Nonconcrete material must:

1. Be fire resistant with a burn rate no greater than 0.3 inch per minute per 0.1 inch of thickness when tested under ASTM D 635
2. Show no significant change in physical properties with exposure to weather
3. Be dense, free of voids or porosity, and gray or brown in color

Nonconcrete pull box must comply with the following:

1. Top dimensions must not exceed the bottom dimensions by more than 1 inch.
2. Extension must be of the same material as the pull box and attached to the pull box to maintain the minimum combined depths as shown.
3. Cover must not fail and must not deflect more than 1/4 inch when a vertical force of 1,500 lb is applied through a 1/2-by-3-by-6-inch steel plate to a nonconcrete cover on the pull box. Center the steel plate on the cover with its longitudinal axis coinciding with the longitudinal axis of the cover.

Nonconcrete pull boxes must be of sufficient rigidity that when a designated concentrated force is applied perpendicularly to the midpoint of one of the long sides at the top while the opposite long side is supported by a rigid surface, it must be possible to remove the cover without the use of tools. The designated concentrated force must be 150 lb for a No. 3-1/2 pull box and must be 100 lb for a No. 5 or No. 6 pull box.

If a transformer or other device must be placed in a nonmetallic pull box, include recesses for a hanger.

Secure cover, except ceiling pull box cover, with 3/8-inch hold down bolts, cap screws, or studs, washers, and brass stainless steel or other noncorroding metal nut. Stainless steel hardware must have an 18 percent chromium content and an 8 percent nickel content.

Galvanize ferrous metal parts under section 75-1.05.

Traffic pull box must be provided with steel cover and special concrete footing. Steel cover must have an embossed nonskid pattern.

Traffic pull box and cover must have a vertical proof-load strength of 25,000 lb. Comply with Federal Specification RR-F-621 and distribute the 25,000 lb load through a 9-by-9-by-2-inch steel plate. You must be able to place the load anywhere on the box and cover for 1 minute without causing cracks or permanent deformations.

No. 3-1/2(T) and No. 5(T) traffic pull box must be reinforced with a galvanized Z bar welded frame and cover similar to that shown for No. 6(T) pull box. Frame must be anchored to the box with 1/4 by 2-1/4 inch concrete anchors. Four concrete anchors must be included for No. 3-1/2(T) pull box; one placed in each corner. Six concrete anchors must be included for No. 5(T) and No. 6(T) pull boxes; one placed in each corner and one near the middle of each of the longer sides.

Hold down screws must be 3/8-inch hex flange cap screws of Type 316 stainless steel. Nut must be zinc-plated carbon steel, vibration resistant, and have a wedge ramp at the root of the thread. Nut must be spot welded to the underside or fabricated with galvanized Z-bar pull box frame.

Steel cover must be countersunk approximately 1/4 inch to accommodate the bolt head. When tightened, the bolt head must not exceed more than 1/8 inch above the top of the cover. A 1/4-inch tapped hole and brass bonding screw must be included.

Concrete placed around and under traffic pull boxes must be minor concrete.

86-2.06B Cover Marking

Marking must be clearly defined, uniform in depth, and parallel to either the long or short sides of the cover.

Marking letters must be between 1 to 3 inches high. Cover markings shall say "Street Lighting".

Before galvanizing steel or cast iron cover, apply marking by one of the following methods:

1. Use cast iron strip at least 1/4 inch thick with letters raised a minimum of 1/16 inch. Fasten strip to cover with 1/4-inch flathead stainless steel machine bolts and nuts. Peen bolts after tightening.
2. Use sheet steel strip at least 0.027 inch thick with letters raised a minimum of 1/16 inch. Fasten strip to cover by spot welding, tack welding, or brazing, with 1/4-inch stainless steel rivets or 1/4-inch roundhead stainless steel machine bolts and nuts. Peen bolts after tightening.
3. Bead weld the letters on cover such that the letters are raised a minimum of 3/32 inch.

86-2.06C Installation and Use

Space pull boxes no more than 200 feet apart. You may install additional pull boxes to facilitate the work.

Pull box in ground or sidewalk area must be installed as follows:

1. Embed bottom of the pull box in crushed rock.
2. Place a layer of roofing paper on the crushed rock.
3. Place grout over the layer of roofing paper. Grout must be 0.50 to 1 inch thick and be sloped toward the drain hole.
4. Make a 1-inch drain hole in the center of the pull box through the grout and roofing paper.
5. Place grout between the pull box and the pull box extension, and around conduits.

Reconstruct the sump of an existing pull box if disturbed by your activities. Remove old grout and replace with new if the sump was grouted.

After installation of traffic pull box, install the steel cover and keep it bolted down when your activities are not in progress at the pull box. When the steel cover is placed for the final time, the cover and Z bar frame must be cleaned of debris and tightened securely.

86-2.08 CONDUCTORS AND CABLES

86-2.08A General

Conductor must be copper wire that complies with ASTM B 3 and B 8.

Wire size must comply with the requirements shown in the following table:

Wire Size Requirements	
Conductor usage	Requirement
In loop detector lead-in cable	ASTM B 286
Everywhere except in loop detector lead-in cable	AWG ^a

^aExcept conductor diameter must not be less than 98 percent of specified AWG diameter.

Single conductor and cable, except detector lead-in cable, must have clear, distinctive, and permanent markings on the outer surface throughout its length. The markings must include the manufacturer's name or trademark, insulation type letter designation, conductor size, voltage, and temperature rating, and for cables, it must also include number of conductors.

86-2.08B Conductor Identification

Conductor insulation must be a solid color with a permanent stripe as specified below. The solid color must be homogeneous through the full depth of insulation. Identification stripe must be continuous throughout the length of conductor. For conductor sizes No. 2 and larger, the insulation may be black and

the ends of the conductors must be taped for a minimum length of 20 inches with electrical insulating tape of the required color. Conductor identification must comply with the requirements in the following table:

Conductor Identification

Circuit	Signal phase or function	Identification			Size
		Insulation color ⁱ		Band symbols ^f	
		Base	Stripe ^a		
Vehicle signals ^{a, b, d}	2, 6	Red, Yel, Brn	Blk	2, 6	14
	4, 8	Red, Yel, Brn	Ora	4, 8	14
	1, 5	Red, Yel, Brn	None	1, 5	14
	3, 7	Red, Yel, Brn	Pur	3, 7	14
	Ramp meter 1	Red, Yel, Brn	None	NBR	14
	Ramp meter 2	Red, Yel, Brn	Blk	NBR	14
Pedestrian signals ^d	2p, 6p	Red, Brn	Blk	2p, 6p	14
	4p, 8p	Red, Brn	Ora	4p, 8p	14
	1p, 5p	Red, Brn	None	1p, 5p	14
	3p, 7p	Red, Brn	Pur	3p, 7p	14
Pedestrian push buttons ^d	2p, 6p	Blu	Blk	P-2, P-6	14
	4p, 8p	Blu	Ora	P-4, P-8	14
	1p, 5p	Blu	None	P-1, P-5	14
	3p, 7p	Blu	Pur	P-3, P-7	14
Traffic signal controller cabinet	Ungrounded circuit conductor	Blk	None	CON-1	6
	Grounded circuit conductor	Wht	None	CON-2	6
Highway lighting pull box to luminaire	Ungrounded-line 1	Blk	None	NBR	14
	Ungrounded-line 2	Red	None	NBR	14
	Grounded	Wht	None	NBR	14
Multiple highway lighting	Ungrounded-line 1	Blk	None	ML1	10
	Ungrounded-line 2	Red	None	ML2	10
Lighting control	Ungrounded to PEU	Blk	None	C1	14
	Switching leg from PEU unit or SM transformer	Red	None	C2	14
Service	Ungrounded-line 1 (signals)	Blk	None	NBR ^e	6
	Ungrounded-line 2 (lighting)	Red ^h	None	NBR ^e	8
Sign lighting	Ungrounded-line 1	Blk	None	SL-1	10
	Ungrounded-line 2	Red	None	SL-2	10
Flashing beacons ^g	Ungrounded between flasher and beacons	Red or Yel	None	F-Loc. ^c	14
Grounded and common	Pedestrian push buttons	Wht	Blk	NBR	14
	Signals and multiple lighting	Wht	None	NBR	10
	Flashing beacons and sign lighting	Wht	None	NBR	12
	Lighting control	Wht	None	C-3	14
	Service	Wht	None	NBR	14
Railroad preemption		Blk	None	R	14
Spares		Blk	None	NBR	14

NBR = No band required PEU=Photoelectric unit

^aOn overlaps, insulation is striped for 1st phase in designation. e.g., phase (2+3) conductor is striped as for phase 2.

^bBand for overlap and special phases as required.

^cFlashing beacons having separate service do not require banding.

^dThese requirements do not apply to signal cable.

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

^fBand conductors in each pull box and near ends of termination points. On signal light circuits, a single band may be placed around 2 or 3 ungrounded conductors comprising a phase.

^gUngrounded conductors between service switch and flasher mechanism must be black and banded.

^hBlack acceptable for size No. 2 and larger. Tape ends for 20 inches with indicated color.

ⁱColor Code: Yel-Yellow, Brn-Brown, Blu-Blue, Blk-Black, Wht-White, Ora-Orange, Pur-Purple.

86-2.08C Circuit Conductors

Circuit conductors must be UL or NRTL listed and rated for 600 V(ac) operation. Insulation for No. 14 to No. 4 conductors must be one of the following:

1. Type TW PVC as specified in ASTM D 2219
2. Type THW PVC
3. Type USE, RHH, or RHW cross-linked polyethylene

Minimum insulation thickness for the insulation types shown must comply with the following table:

Insulation Thickness		
Insulation type	Conductor size	Insulation thickness (mils)
USE, RHH, or RHW	No. 14 to No. 10	39
	No. 8 to No. 2	51
THW or TW	No. 14 to No. 10	27
	No. 8	40
	No. 6 to No. 2	54

Insulation for No. 2 and larger conductor must be one of the types listed above or Type THWN.86-2.09 WIRING

Solder conductors by hot iron, pouring, or dipping method, connectors and terminal lugs for conductor sizes No. 8 and smaller. Do not perform open-flame soldering.

86-2.09A Circuitry

86-2.09B Installation

Use a UL- or NRTL-listed inert lubricant for placing conductors in conduit.

Pull conductors into conduit by hand, using pull tape specified in section 86-2.05C. Do not use winches or other power-actuated pulling equipment.

If adding new conductors or removing existing conductors, remove all conductors, clean the conduit under section 86-2.05C, and pull all conductors in the conduit as 1 unit.

Leave slack for each conductor as shown in the following table:

Conductor Slack Requirements

Location	Slack (feet)
Signal standard	1
Lighting standard	1
Signal and lighting standard	1
Pull box	3
Splice	3
Standards with slip base	0

After conductors are installed, seal ends of conduits with an authorized sealing compound.

To form a watertight seal, tape the ends of spare conductors and conductors ending in pull boxes.

Conductors and cables inside a fixture or cabinet must be neatly arranged and tied together by function with self-clinching nylon cable ties or enclosed in a plastic tubing or raceway.

Permanently identify conductors by function.

Label, tag, or band conductors by mechanical methods. Identification must not move along the conductors.

86-2.09C Connectors and Terminals

Connectors and terminals must be UL- or NRTL-listed crimp type. Use a manufacturer-recommended tool for connectors and terminals to join conductors. Comply with MIL-T-7928.

Terminate stranded conductors smaller than No. 14 in crimp style terminal lugs.

86-2.09D Splicing and Terminations

Splices are allowed for:

1. Grounded conductors in a pull box.
2. Pedestrian push button conductors in a pull box.
3. Conductors in a pull box adjacent to each electrolier or luminaire.
4. Ungrounded traffic signal conductors in a pull box, if traffic signals are modified.
5. Ungrounded traffic signal conductors to a terminal compartment or a signal head on a standard with conductors of the same phase in the pull box adjacent to the standard.
6. Ungrounded lighting circuit conductors in a pull box, if lighting circuits are modified.

86-2.09E Splice Insulation

You may use "Heat-shrink tubing" or "Method B" to insulate splices.

Splice must function under continuous submersion in water.

Multi-conductor cable must be spliced and insulated to form a watertight joint and to prevent moisture absorption by the cable.

Low-voltage tape must be:

1. UL or NRTL listed
2. Self fusing, oil and flame-resistant, synthetic rubber
3. PVC, pressure-sensitive adhesive of 6 mils minimum thickness

Insulating pad must be a combination of an 80-mils thick electrical grade PVC laminate and a 120-mils thick butyl splicing compound with removable liner.

Heat-shrink tubing must comply with the following:

1. Be medium or heavy wall thickness, irradiated polyolefin tubing with an adhesive mastic inner wall.
2. Before contraction, minimum wall thickness must be 40 mils.
3. Comply with requirements for extruded insulated tubing at 600 V(ac) in UL Standard 468D and ANSI C119.1, and the requirements shown in the following table:

Heat-Shrink Tubing Requirements

Shrinkage ratio	33 percent, maximum, of supplied diameter when heated to 125 °C and allowed to cool to 25 °C
Dielectric strength	350 kV per inch, minimum
Resistivity	25 ¹³ Ω per inch, minimum
Tensile strength	2,000 psi, minimum
Operating temperature	-40 °C to 90 °C (135 °C in emergency)
Water absorption	0.5 percent, maximum

Insulate splices using "Heat-shrink tubing" by performing the following:

1. Completely cover the splice area with electrical insulating coating and allow to dry.
2. Heat as recommended by the manufacturer. Do not perform open-flame heating.
3. When heated, the inner wall must melt and fill crevices and interstices of the covered object and the outer wall must shrink to form a waterproof insulation.
4. After contraction, each end of the heat-shrink tubing or the open end of end cap of heat-shrink tubing must overlap the conductor insulation at least 1-1/2 inches.
5. If 3 or more conductors are to be enclosed in 1 splice, place mastic around each conductor before placing inside tubing. Use mastic type recommended by heat-shrink tubing manufacturer.
6. Cover entire splice with electrical insulating coating and allow to dry.

Insulate splices using "Method B" by performing the following:

1. Completely cover the splice area with electrical insulating coating and allow to dry.
2. Apply 2 layers of electrical insulating pad with a minimum thickness of 1/8 inch each layer or 2 layers of half lapped low voltage tape.
3. Apply 3 layers of half lapped polyvinyl chloride tape.
4. Cover entire splice with electrical insulating coating and allow to dry.

Use at least 2 thicknesses of electrical insulating pad. Apply pad to splice as recommended by the manufacturer.

86-2.09F Fused Splice Connectors

Install a fused disconnect splice connector in each ungrounded conductor, between the line and the ballast, in the pull box adjacent to each luminaire. Connector must be accessible in the pull box. Connector may be placed in the hand hole of the lighting standard if there is no adjacent pull box.

For 240 and 480 V(ac) circuits, each connector must simultaneously disconnect both ungrounded conductors. Connector must not have exposed metal parts except for the head of the stainless steel assembly screw. Recess the head of the stainless steel assembly screw a minimum of 1/32 inch below the top of the plastic boss that surrounds the head.

Splice connector must protect the fuse from water or weather damage. Contact between the fuse and fuseholder must be spring loaded. Splice connector terminals must be:

1. Rigidly crimped, using a tool recommended by the manufacturer of the fused splice connector, onto ungrounded conductors
2. Insulated
3. Watertight

Fuses must be standard midget ferrule type, with "Non-Time-Delay" feature, and 13/32 by 1-1/2 inches.

86-2.10 BONDING AND GROUNDING

Secure all metallic components, mechanically and electrically, to form a continuous system that is effectively grounded.

Bonding jumper must be copper wire or copper braid of the same cross sectional area as a No. 8 or larger to match the load. Equipment grounding conductors must be color coded as specified in NEC or be bare.

Attach bonding jumper to the standard as shown in the following table:

Bonding Jumper Attachment	
Standard type	Requirements
Standard with handhole and traffic pull box lid cover	Use UL-listed lug and 3/16-inch diameter or larger brass or bronze bolt. Run a jumper to the conduit or bonding wire in adjacent pull box. Grounding jumper must be visible after the standard is installed and mortar pad is placed on foundation.
Standard without handhole	Use UL-listed ground clamp on each anchor bolt.
Slip base standard	Use UL-listed ground clamp on each anchor bolt or attach UL-listed lug to bottom slip base plate with 3/16-inch diameter or larger brass or bronze bolt.

Ground 1 side of the secondary circuit of step-down transformer.

Ground metal conduit, service equipment, and grounded conductor at the service point as specified by NEC and service utility, except grounding electrode conductor must be No. 6 or larger.

Equipment bonding and grounding conductors are required in conduits. Run a No. 8 minimum bare copper wire continuously in a conduit system. The bonding wire must be sized as specified in the NEC.

Ground electrode must be:

1. 1 piece
2. 10-foot minimum length of one of the following:
 - 2.1. Galvanized steel rod or pipe not less than 3/4 inch in diameter
 - 2.2. Copper clad steel rod not less than 5/8 inch in diameter
3. Installed as specified in NEC
4. Bonded to service equipment using one of the following:
 - 4.1. Ground clamp
 - 4.2. Exothermic weld
 - 4.3. No. 6 or larger copper conductor

Bond metallic conduit in nonmetallic pull box using bonding bushing or bonding jumper.

Bond metallic conduit in metal pull box using bonding bushings and bonding jumpers connected to bonding wire running in the conduit system.

86-2.11 SERVICE

86-2.11A General

Electrical service installation and materials must comply with service utility requirements.

Install service equipment early on to allow service utility to schedule its work before project completion.

Circuit breakers must:

1. Be quick-break on either automatic or manual operation
2. Have operating mechanism that is enclosed and tripfree from operating handle on overload
3. Be trip indicating
4. Have frame size plainly marked
5. Have trip rating clearly marked on operating handle
6. Have overload tripping of breakers not influenced by ambient temperature range of -18 to 50 degrees C
7. Be internal trip type
8. Be UL or NRTL listed and comply with UL 489 or equal
9. Have minimum interrupting capacity of 10,000 A, rms, if used as service disconnect

Service equipment enclosure must be a NEMA 3R enclosure with a dead-front panel and a hasp with a 7/16-inch hole for a padlock. Enclosure must be field marked as specified in the NEC to warn qualified persons of potential electric arc flash hazards.

Service equipment enclosure, except Types II and III, must be galvanized or have a factory-applied rust-resistant prime coat and finish coat.

Types II and III service equipment enclosures must be manufactured from one of the following:

1. Galvanized sheet steel
2. Sheet steel plated with zinc or cadmium after manufacturing
3. Aluminum

Manufacture service equipment enclosure as specified in section 86-3.04A. Overlapping exterior seams and doors must comply with requirements for NEMA 3R enclosures in the NEMA Enclosure Standards.

If an alternative design is proposed for Type II or III service equipment enclosure, submit plans and shop drawings to the Engineer for authorization before manufacturing.

Except for falsework lighting and power for your activities, when you submit a written request, the Engineer will arrange:

1. With the service utility to complete service connections for permanent installations and the Department will pay all costs and fees required by the service utility. Submit request at least 15 days before service connections are required.
2. For furnishing electrical energy. Energy used before Contract completion will be charged to you, except cost of energy used for public benefit as ordered will be paid by the Department or local authorities.

86-2.13 LIGHTING AND SIGN ILLUMINATION CONTROL

Enclosure for the circuit breaker for lighting and sign illumination control must:

1. Be NEMA 3R
2. Be galvanized, cadmium plated, or powder coated
3. Include dead front panel and a hasp with a 7/16-inch-diameter hole for padlock

86-2.14 TESTING

86-2.14A Materials Testing

Deliver material and equipment to be tested to either the METS or a testing location as ordered.

Allow 30 days for acceptance testing from the time material or equipment is delivered to test site. You must pay for all shipping, handling, and related transportation costs associated with testing. If equipment is rejected, you must allow 30 days for retesting. Retesting period starts when corrected equipment is delivered to test site. You must pay for all retesting costs.

If equipment submitted for testing does not comply with specifications, remove the equipment within 5 business days after notification that the equipment is rejected. If equipment is not removed within that period, it may be shipped to you at your expense.

When testing is complete, you will be notified. You must pick up the equipment at the test site and deliver it to the job site.

Testing and quality control procedures for all other traffic signal controller assemblies must comply with NEMA TS Standards for Traffic Control Systems.

86-2.14B Field Testing

Before starting functional testing, perform the following tests in the presence of the Engineer:

86-2.14B(1) Continuity

Test each circuit for continuity.

86-2.14B(2) Ground

Test each circuit for grounds.

86-2.14B(3) Insulation Resistance

Perform insulation resistance test at 500 V(dc) on each circuit between the circuit and a ground. Insulation resistance must be 10 MΩ minimum on all circuits, except for inductive loop detector circuits that must have an insulation resistance value at least 100 MΩ.

86-2.14C Functional Testing

Test periods must comply with section 86-1.07.

Acceptance of new or modified traffic signal will be made only after all traffic signal circuits have been thoroughly tested.

Perform functional test to show that each part of the system functions as specified.

Functional test for each new or modified system must include at least 5 business days of continuous, satisfactory operation. If unsatisfactory performance of the system occurs, the condition must be corrected and the system retested until the 5 business days of continuous, satisfactory operation is obtained.

Except for new or modified parts of existing lighting circuit and sign illumination system, the Department or local agency will maintain the system during test period and pay the electrical energy cost. Except for electrical energy, you must pay the cost of necessary maintenance performed by the Department or local agency on new circuits or on the portions of existing circuits modified under the Contract.

Shutdown of electrical system caused by traffic, a power interruption, or unsatisfactory performance of Department-furnished materials does not constitute discontinuity of the functional test.

86-2.15 GALVANIZING

Galvanize under section 75-1.05. Cabinet material may be galvanized before fabrication as specified in ASTM A 653/653M, Coating Designation G 90.

Steel pipe standard and mast arm must be hot-dip galvanized after manufacturing and must comply with section 75-1.05. Remove spikes from galvanized surfaces.

A minimum of 10 inches of upper end of anchor bolts, anchor bars or studs, and nuts and washers must be galvanized as specified in section 75-1.05.

After galvanizing, bolt threads must accept galvanized standard nuts without requiring tools or causing removal of protective coatings.

Galvanizing existing materials in an electrical installation will not be required.

86-2.16 PAINTING

Paint electrical equipment and material and comply with the following:

1. Use paint material specified in section 91.
2. Factory or shop cleaning methods for metals are acceptable if equal to the methods specified.
3. Instead of the temperature and seasonal restrictions for painting as specified in section 59, for electrical installations, paint may be applied to equipment and materials at any time the Engineer allows.
4. Ungalvanized ferrous surface to be painted must be cleaned before applying the prime coat. Blast cleaning is not required.
5. If an authorized prime coat is applied by the manufacturer, and in good condition, the 1st primer application is not required.
6. Existing equipment to be painted in the field, including Department-furnished equipment, must be washed with a stiff bristle brush using a solution of water containing 2 tablespoons of heavy duty detergent powder per gallon. After rinsing, surface must be wire brushed with a coarse, cup-shaped, power-driven brush to remove badly bonded paint, rust, scale, corrosion, grease, or dirt. Dust or residue remaining after wire brushing must be removed before priming.
7. Do not paint galvanized metal guard post, galvanized equipment, Department-furnished controller cabinet, and wood pole for traffic signal or flashing beacon.
8. New galvanized metal surface to be painted in the field must be cleaned as specified for existing equipment before applying the prime coat. Do not wire brush new galvanized surface.
9. After erection, examine exterior surface for damaged primer, clean, and spot coat with primer.
10. Paint Types II and III steel service equipment enclosures with a polymeric or an enamel coating system matching color no. 14672, of FED-STD-595. Coating must be commercially smooth and free of flow lines, paint washout, streaks, blisters, and other defects that would impair serviceability or detract from general appearance. Coating must comply with the requirements shown in the following table:

Property	Requirements
Coating hardness	Finish must have pencil lead hardness of HB, minimum, when tested under ASTM D 3363.
Salt spray resistance	Undercutting coating system's film must not exceed 1/8 inch average, from lines scored diagonally and deep enough to expose the base metal, after 336 hours of exposure in a salt spray cabinet complying with ASTM B 117.
Adherence	Must not have coating loss when tested under California Test 645. Perform testing by applying coating to 4" x 8" x 0.024" test specimens of the same material as the cabinet, using the same application method.

11. Finish interior of metal signal visor, louver, and front face of backplates with 2 applications of lusterless black exterior grade latex paint formulated for application to properly prepared metal surface. Good condition factory finish will be acceptable.
12. Finish metal signal section, signal head mounting, brackets and fittings, outside of visor, pedestrian push button housing, pedestrian signal section and visor, and back face of back plate with 2 applications of lusterless black or dark olive green exterior grade latex paint formulated for application to properly prepared metal surface. Match color to color chip no. 68 filed at METS.
13. Prepare and finish conduit and conduit fitting above ground the same as adjacent standard or post.
14. Relocated, reset, or modified equipment previously finished under this section, except for previously-finished galvanized standard with traffic signal yellow enamel, must be given a spot finishing application on newly primed areas and 1 finishing application over the entire surface. If the signal face

or mounting brackets are required to be painted under this section, all signal faces and mounting brackets on the same mounting must be repainted.

15. Small rusted or repaired areas of relocated or reset galvanized equipment must be cleaned and painted as specified in section 75-1.05 for repairing damaged galvanized surfaces.
16. Stencil equipment number neatly on the standard or adjacent structure. Obtain number from the Engineer.
17. Perform painting neatly. The Engineer reserves the right to require use of brushes if the work performed by a paint spraying machine is unsatisfactory.

86-6 LIGHTING

86-6.11 PHOTOELECTRIC CONTROLS

Photoelectric controls must be capable of directly switching multiple lighting systems. Type V photoelectric control shall be used.

86-6.11A Types

Photoelectric control must be of the types shown in the following table:

Photoelectric Control Types	
Type I	Includes: 1. Remote photoelectric unit 2. Test switch housed in an enclosure
Type II	Includes: 1. Remote photoelectric unit 2. Separator contactor and test switch located in a service equipment enclosure
Type III	Includes: 1. Remote photoelectric unit 2. Separator contactor and a test switch housed in an enclosure
Type IV	Includes a photoelectric unit that plugs into an NEMA twist-lock receptacle integral with the luminaire.
Type V	Includes a photoelectric unit, a separator contactor, and a test switch located in a service equipment enclosure.

A switch to allow manual operation of the lighting circuit must be included for each Type I, II, III, and V photoelectric control. Switches must be single-hole mounting toggle type, single pole, single throw, rated at 12 A with a voltage rating that matches the circuit. Switches must have an indicating nameplate reading "Auto-Test" and be connected in parallel with the load contacts of the photoelectric unit. Test switches must not have an "Off" position.

Photoelectric unit for Types I, II, and III photoelectric controls must be pole-top mounted.

86-6.11B Equipment Details

86-6.11B(1) Photoelectric Unit

Photoelectric unit must:

1. Have an output in response to changing light levels. Response level must remain stable throughout the life of the control unit.
2. Have a "turn-on" between 1 and 5 footcandles and a "turn-off" between 1.5 and 5 times the "turn-on." Measurements must be made by procedures in NEMA standards for physical and electrical interchangeability of light-sensitive control devices used in the control of roadway lighting.
3. Have a NEMA type receptacle. Mounting brackets must be used where pole-top mounting is not possible. Photoelectric controls must be installed at locations shown and oriented.
4. Be screened to prevent artificial light from causing cycling.
5. Have a supply voltage rating of 60 Hz, 105-130 V(ac), 210-240 V(ac), or 105-240 V(ac), as specified.
6. Have a load rating of 800 W minimum, high intensity discharge or fluorescent.

7. Operate at a temperature range of -20 to 55 degrees C.
8. Have a power consumption less than 10 W.
9. Be housed in a weatherproof enclosure.
10. Have a base with a 3-prong, NEMA standard, twist-lock plug mounting.
11. Have a "fail-on" feature.

Unit components must not require periodic replacement.

Photoelectric controls, except Types IV and V, must include a 4-inch-minimum-inside-diameter pole-top mounting adaptor containing a terminal block, and cable supports or clamps to support pole wires.

For switching 480 V(ac), 60 Hz circuits, a 100 VA, minimum, 480/120 V(ac) transformer must be installed in the contactor enclosure to allow 120 V(ac) for the photoelectric control unit. If more than 1 photoelectric unit is to be installed at a location, a single transformer with a volt-ampere rating capable of handling the total controlled load may be used.

86-6.11B(2) Contactor

Contactor must:

1. Have contacts rated to switch the specified lighting load
2. Be normally open
3. Be the mechanical armature type with contacts of fine silver, silver alloy, or superior alternative material

86-6.11B(3) Enclosure

Enclosure for Types I and III photoelectric controls must be NEMA 3R. Enclosure must be supplied with a factory-applied rust-resistant prime coat and finish coat. Two applications of paint to match the color of the standard must be applied as specified in section 86-2.16. Enclosure may be hot-dip galvanized instead of painting. A minimum of 2-1/2 inches must be provided between contactor terminals and the end of the enclosure for wiring connections. Enclosure must be mounted on the same standard as the photoelectric unit at a height of about 6 feet above finished grade.

86-6.11B(4) Terminal Blocks

Terminal blocks must be rated at 25 A, 600 V(ac), molded from phenolic or nylon material, and of the barrier type with plated-brass screw terminals and integral-type marking strips.

86-7 REMOVING, REINSTALLING, OR SALVAGING ELECTRICAL EQUIPMENT

86-7.01 REMOVING ELECTRICAL EQUIPMENT

Existing electrical equipment, pull boxes, and conduits, to be removed and not reused or salvaged, become your property and you must dispose of it. Unused underground conduit may be abandoned in place after all conductors have been removed except that conduit terminations from the conduit to be abandoned must be removed from the pull boxes to remain.

Exercise care in salvaging equipment so it will not be damaged or destroyed. Mast arms must be removed from the standards. Luminaires, signal heads, and signal mounting assemblies must be removed from the standards and mast arms.

Holes resulting from removing pull boxes must be filled with material equivalent to the surrounding material.

86-7.02 REINSTALLING REMOVED ELECTRICAL EQUIPMENT

If removed electrical equipment is to be reinstalled, you must supply all necessary materials and equipment, including signal mounting assemblies, anchor bolts, nuts, washers, and concrete as required to complete the new installation.

Luminaires to be reinstalled must be cleaned and relamped.

Existing materials required to be reused and found to be unsatisfactory by the Engineer must be replaced with new material and the replacement cost is change order work

86-9 POLE MOUNTED RECEPTACLES

Pole mounted receptacles for decorative lighting circuits shall be Taymac MX3200, or approved equal, GFCI duplex with metal weatherproof in-use covers. Receptacles shall be installed per manufacturer's instructions to ensure secure weatherproof installation.

3 #12 conductors shall be installed inside the lighting standard and connected to the receptacle. The #12 conductors shall be spliced to the main decorative lighting circuit in the pull box adjacent to the lighting standard or in the lighting standard hand hole if there is no adjacent pull box.

86-10 REDIRECT EXISTING CONDUIT TO NEW PULL BOX

Where new pull boxes are installed next to an existing lighting standard one existing conduit entering the lighting standard foundation shall be intercepted and new rigid metal conduit attached to redirect the conduit into the new pull box.

86-11 INSULATION RESISTANCE TESTING OF EXISTING STREET LIGHT CONDUCTORS

The Contractor shall perform insulation resistance tests on the existing street light conductors to assist with determining whether the conductors inside the street light standards must be replaced.

The Contractor shall cut the existing conductors at the point at which they would be spliced to the new street light circuit conductors, i.e. in the adjacent pull box or in the hand hole. The Contractor shall perform the insulation resistance test on the section of existing conductor that extends between the pull box or hand hole and the luminaire.

The test shall be conducted with both ends of the conductor disconnected from any electrical equipment, including the luminaire. The Contractor shall protect loose ends of the conductor as necessary to prevent extraneous current leaks. The test shall consist of applying 1000V DC to the conductor for 1 minute with the resistance reading taken at the end of the 1 minute period. A resistance reading of less than 1 megohm shall be a failing result and the Contractor shall replace the conductor with a new #12 conductor. The Contractor shall keep a record of all test results and provide a copy to the Engineer.

The performance of this test does not remove the requirement to perform insulation resistance tests on circuits per Section 86-2.14B(3).

86-12 PAYMENT

Bid price for Series Circuit Replacement shall include all labor, material, and equipment costs required for completion of the scope of work not included in other bid items, including but not limited to mobilization, project management, and temporary traffic controls. Payment shall be a lump sum amount.

Bid prices for Furnish and Install 1.5" Conduit (Type III) and Furnish and Install 2.0" Conduit (Type III) shall include all new conduit to be installed between lighting standards, between the service equipment enclosure and lighting standards, and between the PG&E service connection point and the service equipment enclosure, but shall exclude furnishing and installing Type I conduit between lighting standard or service equipment enclosure foundations and the adjacent pull boxes. The Contractor shall have the option of installing new Type III conduit using directional bore or trench in pavement methods. The base material under Caledonia Street and Bridgeway is unknown and may be concrete with utilities directly beneath the concrete. The price for installation of new conduit shall assume concrete beneath the asphalt. The Bid prices shall include all labor, equipment, and materials required to furnish and install the conduit. Payment shall be per linear foot as measured between the end locations of the conduit run. For example, the length of a conduit run between two pull boxes shall be measured as the straight line

distance between the two pull boxes. If the path of the conduit follows curvature in the road the measurement shall similarly follow the curvature of the road. The method of measurement shall be a measuring wheel or other similar measuring device mutually agreed upon by the Contractor and the Engineer.

Bid price for Furnish and Install No. 5 Pull Box shall include all labor, equipment, and materials required to furnish and install No. 5 pull boxes, including cutting and replacing sidewalk. Payment shall be per pull box installed.

Bid price for Redirect Existing Conduit to New Pull Box shall include all labor, equipment, and materials necessary to redirect an existing conduit leading into a lighting standard foundation to a new adjacent pull box, including the new rigid metal conduit, but shall exclude the new pull box. Payment shall be made per conduit redirected.

Bid price for Furnish and Install Service Enclosure and Foundation shall include all labor, equipment, and materials required to install a fully functioning Type III-AF service equipment enclosure, including the foundation, all equipment indicated on the service wiring diagram on the plans, the conduit between the adjacent pull box and the enclosure, and all wiring and splicing in the enclosure and the adjacent pull box. The bid price shall also include coordinating connection of electrical service with the serving utility, and all fees due to the serving utility to complete the service connection. Payment shall be a lump sum amount.

Bid price for Furnish and Install GFCI Receptacle shall include all labor, equipment, and materials required to furnish and install GFCI receptacles with weatherproof in-use covers on the poles, install the required #12 conductors between the splice point in the pull box or hand hole and the receptacle, and make all necessary connections and splices. Payment shall be made per GFCI receptacle installed.

Bid price for Insulation Resistance Testing of Existing Street Light Conductors shall include all labor, equipment, and materials necessary to perform insulation resistance testing as described in Section 86-11, but excludes replacement of conductors that fail the test. Replacing conductors that fail the test shall be paid for at the unit price for the additive item "Furnish and Install #12 Street Light Conductors in Lighting Standard." Payment shall be made per conductor tested.

Bid prices for Furnish and Install #2 Conductors, Furnish and Install #8 Conductors, and Furnish and Install #10 Conductors shall include all labor, equipment, and materials necessary to furnish and install the #2, #8 and #10 conductors required to complete the street lighting and GFCI outlet circuits. Payment shall be made per linear foot of conductor installed. Length of conductor installed shall be measured the same way as the length of the conduit in which the conductor is installed.

Bid price for Install City Furnished LED Luminaires shall include all necessary labor, equipment, and materials required to attach the City furnished LED luminaires to the lighting standard luminaire arm, connect lighting circuit wires to the luminaire, splice the lighting circuit wires in the adjacent pull box or hand hole, and install the in-line fuse connector. Payment shall be made per LED luminaire installed.

Bid price for Pot Hole Utility Conflict shall include all necessary labor, equipment, and materials required to dig pot holes to locate utility conflicts prior to installation of conduit. The base material under the roadway is unknown and previous work has encountered concrete beneath the asphalt. The bid price shall assume pot holes will be dug through concrete. Payment shall be made per pot hole dug.

Bid price for Abandon Existing Conduit (Remove & Dispose of Existing Conductors) shall include all necessary labor, equipment, and materials required to remove and dispose of the existing conductors in the abandoned conduit. Payment shall be made per linear foot of conduit abandoned. Measurement shall be made the same was as described for measurement of newly installed conduit.

Bid price for Furnish and Install #12 Street Light Conductors in Lighting Standard shall include all necessary labor, equipment, and materials required to install #12 conductors in a street lighting standard between the luminaire and the adjacent pull box, or between the luminaire and the hand hole if there is no adjacent pull box. Payment shall be per linear foot of conductor installed. Measurement shall be the

height of the standard plus the length of the luminaire arm plus the distance between the center of the adjacent pull box and the center of the standard base.