

SECTION 26 05 00

COMMON WORK RESULTS FOR ELECTRICAL

(February 04, 2020)

PART 1 - GENERAL

1.1 DESCRIPTION

- A. The work of this section consists of electrical materials and methods; and includes but is not limited to conduit wiring and cable, boxes, wiring devices, grounding and bonding, supporting devices, electrical identification, enclosed switches, fuses, utility service entrance and connections to equipment specified elsewhere in these Specifications. Electrical materials that are a part of equipment specified under other Sections shall meet the requirements of this Section.
- B. Related work specified in other Sections:
 - 1. Section 26 04 00: General Requirements for Electrical
 - 2. Section 34 41 13: Traffic Signals

1.2 QUALITY ASSURANCE

- A. As specified in Section 26 04 00: General Requirements for Electrical

1.3 SUBMITTALS

- A. As specified in Section 26 04 00: General Requirements for Electrical
- B. Product Data:
 - 1. Conduit, fittings, and conduit bodies.
 - 2. Boxes and wiring devices with dimensions, knockout sizes and locations, materials, fabrication detail, finishes and accessories.
 - 3. Each type of cable used.
 - 4. Manufacturer's catalog information showing dimensions, colors, and configurations.
 - 5. Manufacturer's Installation Instructions, including instructions for storage, handling, protection, examination, preparation, installation, and starting of Product.
- C. Wire and Cable:
 - 1. Submit one 18 inches length of cable assembly from each reel. Select each length to include complete set of manufacturer markings. Attach tag indicating cable size and application information.

1.4 REFERENCE STANDARDS

- A. American National Standards Institute
ANSI C80.1 Rigid Steel Conduit, Zinc Coated.

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| | ANSI/NEMA FB 1 | Fittings, Cast Metal Boxes, and Conduit Bodies for Conduit and Cable Assemblies. |
| | ANSI/NFPA 70 | National Electrical Code. |
| B. | National Electrical Contractors Association | |
| | NECA | "Standard of Installation." |
| C. | National Electrical Manufacturers Association | |
| | NEMA TC 2 | Electrical Plastic Tubing (EPT) and Conduit (EPC-40 and EPC-80). |
| | NEMA TC 3 | PVC Fittings for Use with Rigid PVC Conduit and Tubing. |
| | NEMA TC 6 | PVA/ABS Plastic Utilities Duct for Underground Installation. |
| | NEMA TC 9 | Fitting for ABS and PVC Plastic Utilities Duct for Underground Installation. |
| | NEMA WD 6 | Wiring Device Configurations. |
| | NEMA FB 1 | Fittings and Supports for Conduit and Cable Assemblies. |
| | NEMA OS 1 | Sheet-steel Outlet Boxes, Device Boxes, Covers, and Box Supports. |
| | NEMA OS 2 | Nonmetallic Outlet Boxes, Device Boxes, Covers and Box Supports. |
| | NEMA 250 | Enclosures for Electrical Equipment (1000 Volts Maximum). |
| | NEMA WD 1 | General Requirements for Wiring Devices. |
| | NEMA FU1 | Low Voltage Cartridge Fuses. |
| | NEMA KS1 | Enclosed and Miscellaneous Distribution Equipment Switches (600 Volts Maximum). |
| D. | International Electrical Testing Association | |
| | IETA ATS | Acceptance Testing Specifications for Electrical Power Distribution Equipment and Systems (published by the International Electrical Testing Association). |
| E. | The City and County of San Francisco Electrical Code. | |
| F. | California Public Utility Commission: | |
| | G.O 128 | Construction of Underground Electric Supply and Communication System. |
| | G.O 95 | Overhead Electric Line Construction. |
| G. | Caltrans Standard Plans and Specifications. | |
| H. | California Occupational Safety and Health Administration (CAL/OSHA). | |
| I. | Electrical Safety Orders, California Code of Regulations (California Administrative Code) Title 8. | |
| J. | Under Writer's Laboratories, Inc. (UL) | |

UL 6	Rigid Metal Electric Conduits.
UL 514B	Fitting for Conduit and Outlet Boxes.

1.5 PROJECT CONDITIONS

- A. Verify that field measurements are as shown on drawings. Verify routing and termination locations of conduit prior to rough-in.
- B. Conduit, wire and cable routing as shown on the Drawings is approximate unless dimensioned. Route as required to complete wiring system. Where routing is not shown, and destination only is indicated, determine exact routing and lengths required for a complete installation.
- C. Conductor sizes are based on copper.
- D. Conduit with wires, provide duct seal to prevent foreign objects or materials entering the conduit.
- E. Empty conduit provide PVC end plug with pull tab and pull rope.

1.6 COORDINATION

- A. Determine routing to avoid interference with other work and to achieve required separation from other work.
- B. Determine connection locations and requirements.
- C. Sequence rough-in of electrical connections to coordinate with installation and start-up schedule for equipment.

PART 2 - PRODUCTS

2.1 RIGID STEEL CONDUIT, GALVANIZED

- A. The conduit shall be in accordance with Section 601 and the depth shall be in accordance with Section 601.03 of the SSDPWSF and shall meet the NEC requirements and of ANSI C80.1, NEMA FB1, UL 6, with each length bearing manufacturer's stamp and UL label unless otherwise noted.
 - 1. Provide conduit, couplings, elbows, bends, sealing fittings, and nipples conforming to ANSI C80.1 and UL 6, with each length bearing manufacturer's stamp and UL label.
 - 2. Fittings and Accessories
 - a. Provide separable watertight hub fittings with a gasket, separate plastic-insulated throat, and a case-hardened locknut.
 - b. Provide bushings of plastic-insulated metallic and grounding type, with copper grounding lug.
 - c. Provide conduit straps, clamps backs made of galvanized malleable iron.
 - d. Rigid steel conduit shall be a minimum of ¾-inch diameter at exposed and embedded portions.
 - e. Only threaded couplings shall be used.

- f. No threadless fittings shall be used. All conduit shall be threaded.
- g. Tape for conduit stub-out shall be 40 mil PVC corrosion protection tape, for underground rigid steel conduit wrap tape may be 10 mil.
- h. Unilet bodies (condulets) shall be FM7 with clip covers manufactured by Appleton. (In order to obtain a necessary item that is only available from one source.)

3. Manufacturer: Appleton, PWC, Inc. Allied Tube and Conduit Corp. or equal.

2.2 PVC SCHEDULE 80 CONDUIT

- A. Traffic signal field PVC conduits contain various traffic signal conductors, service conductors, detector cables and 12-conductor cables, unless otherwise noted.
- B. PVC conduit shall be used for all field conduits unless otherwise noted. The minimum size raceway shall be 2 inch unless indicated otherwise on the Drawings. Base and intermediate spacers shall be interlocking plastic type made for the specific sizes of conduits used and installed at maximum 5' on center.
- C. PVC Schedule 80 UL listed for direct burial, conforming to NEMA standard TC6 and UL651 and rated at 90° C.
- D. All PVC conduits shall have a #6 AWG bare stranded copper ground wire unless otherwise noted.
- E. Fittings for use with nonmetallic duct shall be PVC and have solvent-weld-type conduit connections.

2.3 HIGH DENSITY POLYETHYLENE (HDPE)

- A. Liquid-tight flexible HDPE SDR-11 shall be used for all interconnect conduits, except runs between pull boxes and traffic signal controllers foundation can be PVC schedule 80. All HDPE conduit depth shall be in accordance with Section 601.03 SSDPWSF. HDPE Conduit runs shall typically consist of four parallel 2-inch diameter sections with conduit spacer. Note that some conduit runs may only require two 2-inch conduits and will be so indicated on the plans.
- B. HDPE conduit shall be manufactured from high density, extra high molecular weight polyethylene and shall meet the following requirements:
 - 1. The material shall conform to ASTM D2447 for Schedule 80 and ASTM D3035 for SDR-11, UL Listed for direct burial.
 - 2. The minimum bend radius shall be 12 times the conduit inside diameter.
 - 3. The conduit shall be able to withstand 95% soil compaction without collapsing.

2.4 PULL BOXES

- A. Traffic Signal

Composite box material and slip-resistant cover shall consist of polyester resin, fiberglass and calcium carbonate that is high strength and lightweight to meets or exceed SCTE Tier 8 performance rating,

 - 1. Type I Traffic Signal pull box containing any traffic signal conductors shall be

reinforced concrete box with non-skid composite material cover, unless otherwise noted.

2. Type III Traffic Signal pull box shall be composite box and cover.
3. Type IV Traffic Signal pull box shall be reinforced concrete box with two piece non-skid resistant galvanized steel checker plate cover.
4. Type 36X Traffic Signal pull box shall be Composite box 18" high with 6" Composite extension and composite material cover.
5. Type 48X Traffic Signal pull box shall be polymer concrete box 24" high and two piece polymer concrete cover with non-skid resistant coating.
6. Pull boxes containing any traffic signal conductors shall be denoted by "Traffic" (1st line) "Signals" (2nd line) on the pull box cover. Pull boxes containing traffic signal interconnect shall be denoted by "Traffic Signal" (1st line) Interconnect (2nd line) on the pull box cover.

B. Streetlight

1. Pull boxes containing street lighting conductors only shall be reinforced concrete box with non-skid, bolt down reinforced concrete cover with stainless steel tamper resistant screw (stainless steel, penta cap screw with washer and bolt) unless otherwise noted.
2. Pull boxes containing street lighting conductors only shall be denoted by "Street Lighting" (1st line) 120/240 Volt (2nd line).

C. The conduit shall enter the pull box from the side wall and shall protrude a minimum of 1 inch to a maximum of 2 inches into the pull-box. The top of the conduit shall be a minimum 6 inches to a maximum 9 inches below the base of the pull box cover.

D. All details and dimensions shall be per PW Standard Plan 87,201 unless otherwise noted.

E. Traffic rated pull boxes placed in roadways or in areas subject to vehicle and heavy machinery traffic shall be furnished with galvanized steel checker plate traffic covers. In addition, a 6 inch wide by 12 inch High concrete retaining wall shall be constructed all around each pull box installed in such areas. Pull boxes and lid shall be suitable for H-20 loading.

F. Unpaved or Asphalt concrete paved areas, a 12 inch wide by 3 ½ inch deep (minimum) concrete slab shall be constructed all around each pull box (including boxes provided with the 6-inch thick retaining wall set forth for traffic rated box.

G. Provide bonding jumper (3 feet long minimum) for steel covers to be bonded to conduit.

H. Crushed rock pad and grout in the bottom of pull boxes shall not be allowed in Traffic Signal boxes. Interconnect pull boxes shall be crushed rock, grouted smooth on the bottom and a drain shall be installed per interconnect detail.
Streetlight boxes are allow to have crushed rock per SFDPW standard plan.

2.5 BONDING AND GROUNDING

A. Bonding conductor shall be a continuous length of No. 6 bare stranded copper wire.

- B. Ground wire clamps shall have a mechanical bonding attachment to the ground rod.
- C. Grounding rods shall be copper-clad steel, 5/8-inch in diameter, and a minimum of 10 feet long.

2.6 GALVANIZING

- A. Anchor bolts and other ferrous materials shall be hot-dip galvanized after fabrication.
- B. The threads on the conduit shall be coated with rust proof paint.

2.7 EQUIPMENT FOUNDATIONS

- A. No pre-cast foundations will be allowed.
- B. Concrete for equipment foundations shall conform to CTSS for concrete foundation and special provision, unless noted otherwise in the Contract Drawings and related concrete foundation specification.

2.8 DUCT PLUGS, DUCT SEALANT, LOCATING WIRES, PULL TAPE, AND PULL ROPE

A. Duct Plugs

1. All empty PVC conduits 2" and above shall have PVC end plugs with pull tabs. All empty PVC conduits less than 2" shall have PVC end plugs without pull tabs.
2. All interconnect conduits shall be sealed at each pull box with removable and reusable mechanical plugs to prevent the passage of gas, dust, sand, rodents and water. Sealing plugs shall be installed at each pull box conduit end.
 - a. All empty interconnect (HDPE) conduits shall be sealed by means of a polypropylene duct plug equipped with a neoprene or polyurethane gasket. Plugs shall be equipped with an attachment to secure the pull tape in the inner duct of the vacant conduit. Sealing capacity shall withstand 30 psi.
 - b. At places where interconnect (HDPE) cables enter and exit the conduit, the conduit shall be sealed by means of a split internal expansion plug. Sealing capacity shall withstand 22 psi. Any nuts, bolts, fasteners and washers shall be fabricated out of stainless steel. Conduit plugs shall be of the simplex or triplex type depending on the amount of pull tape or wires in the conduit.
 - c. Duct Sealant

Any conduits, pipes clamps and brackets with wiring holes shall be completely sealed with duct seal to prevent foreign objects or materials from entering the conduit. i.e: signal devices, streetlights, wireless equipments.

B. Backfeeding and Locating Wires

Where HDPE interconnect conduits are left empty or filled only with non-metallic (optical fiber cable) conductors., the following shall be provided.

- For locating wires, two (2) #8 AWG UF stranded copper wires shall be furnished and

installed in one of the conduits. One wire shall have red insulation and the other shall have white insulation. The wires shall be continuous between pull boxes and left unbounded in the pull boxes.

- For backfeeding wires, two (2) #8 AWG UF stranded copper wires and one (1) #10 AWG UF shall be furnished and installed in one of the conduits. One #8 UF wire shall have red insulation, one #8 UF wire shall have white insulation, and one #10 UF wire shall have green insulation (for ground). The wires shall be continuous between pull boxes and left unbounded in the controller cabinets.

C. Pull Tape

Pull tape shall be used in all empty interconnect conduits. Pull tape shall be a woven multi-fiber polyester ribbon with a minimum width of 3/8-inch. The tape shall be permanently printed with the rated tensile strength (1250 pounds minimum) and sequential footage markings. For empty non-HDPE conduits, pull tape can be used in place of pull rope.

D. Pull Rope

Either pull rope or pull tape shall be used in empty non-PVC conduits. If the Contractor chooses to use pull rope, the rope shall be 1/4" polypropylene. If the Contractor chooses to use pull tape, the tape shall be as specified in the previous section. Pull rope shall not be used in HDPE conduits.

2.9 CONDUCTORS AND FIELD WIRING

A. Traffic Signal and Street Light Conductor

1. Conductors for all traffic signals running between the traffic signal controller and the termination point shall be Type UF. The termination point is either a terminal block inside the terminal compartment of a traffic signal assembly or the signal head itself if no terminal compartment is used. Conductors within traffic signal framework shall be UF or THW and may be either solid or stranded provided that such framework contains a terminal compartment (otherwise Type UF wire shall terminate at the signal head). Conductors for street or site lighting shall be Type THW. Traffic signal service wire shall be UF. Wire #8 and larger shall be stranded; #10 through #14 shall be solid.
2. Each conduit that contains traffic signal conductors shall include one bare #6 AWG copper stranded conductor that is bonded at each end.
3. The installation of any conductors in conduits shall not take place until the Contractor has demonstrated to the Engineer's satisfaction and approval that the contractor has employed all means necessary, or required, to clean and prepare the conduits for the installation of conductors therein.
4. If the existing grouping, taping, or lacing of conductors is disturbed in the course of work, the Contractor shall regroup, tape, or lace as applicable.
5. All conductors terminating in a metallic enclosure shall terminate on a terminal board equipped with screw-type or box-type terminals fabricated from the copper or copper-alloy material.
6. Conductors terminating in screw type termination shall be equipped with self-insulated self-locking spade-type terminals.

7. Conductors terminating on box-type terminals shall be connected directly without using spade-type pressure terminals attached to the conductor ends.
8. Ends of all unused conductors shall be individually taped prior to intersection turn-on or switchover.
9. Contractor shall provide weather/water-proof labeling with cable tie at the incoming service/ line side of the fuse if there are more than one service location inside the pull box to identify the streetlight service connection.
10. Traffic Signal and Service Conductor Color Codes, Labels, and Grouping
 - a. Conductor labeling material shall be Self Laminating Labels. Labeling and grouping requirements apply to all new and all existing conductors to remain at a given intersection. Old nylon tags shall be removed from all existing conductors to remain.
 - b. Wires shall be sized, color-coded and labeled in accordance with the following schedule:

CIRCUIT	AWG	PHASE	BASE COLOR	STRIPE	LABEL
Vehicle Signals	#14	2, 6 (A) 4, 8 (B) 1, 5 (C) 3, 7 (D)	Red, Yellow, Brown Red, Yellow, Brown Red, Yellow, Brown Red, Yellow, Brown	None White Black Orange	Head # Head # Head # Head #
Bicycle Signal	#14	All	Red, Yellow, Brown	Green	Head #
Pedestrian Signals	#14	2p, 6p 2p, 6p 4p, 8p 4p, 8p 1p, 5p 1p, 5p 3p, 7p 3p, 7p	"DON'T WALK" Red "WALK" Brown "DON'T WALK" Red "WALK" Brown "DON'T WALK" Red "WALK" Brown "DON'T WALK" Red "WALK" Brown	None None White White Black Black Orange Orange	Head # Head # Head # Head # Head # Head # Head # Head #
Pedestrian Push Buttons	#14	2p, 6p 4p, 8p 1p, 5p 3p, 7p	Blue Blue Blue Blue	None White Black Orange	Ped. Head # on same corner and same phase as button
Pedestrian Push Button's Return Wire	#14	All	White	Black	
Spare Signal Wire	#14	N/A	Black	None	None
Signal (Vehicle and Ped) Neutral	#10 or #14	N/A	White Use # 10 only when crossing Roadways.	None	None

CIRCUIT	AWG	PHASE	BASE COLOR	STRIPE	LABEL
Trolley & preempt Switches Both Wires	#14	PE 1 PE 2 PE 3	Orange Orange Orange	None White Black	TS # or PE #
12-Conductor Cable	#14	N/A	Black (jacket)	None	Per plans
Detector Cable	#12	All	Black (jacket)	None	Per plans
Detector Loop Wire	#14	N/A	Black	None	Per Plans
Service (AC+)	#8	Phase A	Black	None	Phase A
	#8	Phase B	Red	None	Phase B (Spare)
Service (AC neutral)	#8	N/A	White	None	None

* Install labels on 12-Conductor cable near each conduit end. For example, a single cable in a pull box requires two labels – one label near each conduit end. 12-Conductor Cable labels shall identify where cable is headed, i.e. north, south, east, west, controller, etc.

- c. In all pull boxes and the controller cabinets, all traffic signal conductors shall be grouped by signal head with electrical tape and labeled by signal head number as designated on plan sheets.
- d. In all pull boxes, all conductors running between the same two conduits shall be further grouped and wrapped in at least one location with electrical tape near the center of the slack.
- e. In the controller cabinet, all conductors shall be further grouped and labeled by phase in an orderly manner.

11. Splicing

- a. In general, splicing shall not be permitted except for mast arm heads as detailed below, unless otherwise noted on the contract plans, or as directed by the Engineer. The Contractor shall install the specified wiring throughout the conduits without unnecessarily splicing the wires in an adjacent pull box or hand hole. The wiring, once connected to the relative signal head, shall form a continuous run from the relative signal head to the controller. The Contractor shall pull new wiring, at the Contractor's expense, when it is determined that unnecessary splicing has occurred. Traffic signal multi-conductor cable shall be jacketed with twelve (12) 600-volt insulated, No. 14 AWG, solid, copper conductors. Cable shall meet the requirements of International Municipal Signal Association, Inc., Specification No. 19-1 latest specification.
- b. In cases where splicing is required, it shall be completed in pull boxes, hand holes or manholes or as directed by the Engineer. Splices shall conform to the details shown on the SSDPWSF plan 87,204.
- c. All splicing devices shall be UL approved. All splicing devices shall be of the correct size range for the wires being spliced. All splices shall be wrapped with one wrap of rubber splicing tape, taped with a minimum of four wraps of all weather 7-millimeter thick UL listed and ASTM approved

plastic electrical tape and coated with a waterproofing electrical rubberized exterior liquid splice coating. See Section 34 41 13 for additional 12-conductor and fiber optic cable splice requirements. Where 12-Conductor splices are specified, provide 12-conductor splice kits that are UL listed. The splice tape noted above shall be supplied without a liner, be based on ethylene propylene rubber and be capable of emergency operating cable temperature of 130 degree C. The tape must be capable of being applied in either stretched or un-stretched conditions without resulting in loss of either physical or electrical properties. The tape shall not split, crack, slip or flag when exposed to various environments (indoor or outdoor). The tape shall be compatible with all synthetic cable insulations and have a shelf life of five years.

- d. Butt splices: Only non-insulated butt splices shall be used. Butt splices shall be tinned coppers. Crimping shall be performed using the correct tool and shall result in a deeply dimpled cross section or hex shaped cross section (no flat shaped crimp cross sections shall be accepted). Butt splice must be mechanically and electrically secure -soldering is required if splice is below grade.
- e. Split bolt type splice: Split bolt type splicing devices shall be copper. Splice must be mechanically and electrically secure, insulated, and coated with a waterproofing electrical rubberized exterior liquid splice compound.
- f. Twist Splices: Splices shall be twisted as tightly as possible without kinking the splicing area. Twist splices shall be 50/50 solder. "Wire nuts" or similar splicing methods shall NOT be used.
- g. Slack loop for each conductor in hand holes on standards shall not be less than 2 feet long on each side of a splice. Slack loop for each conductor in pull boxes shall not be less than 6-feet long in total.

B. INTERCONNECT CABLE/COMMUNICATIONS NETWORK MEDIA

1. 12-CONDUCTOR CABLE

- a. Traffic signal multi-conductor cable shall be jacketed with twelve (12) 600-volt insulated, No. 14 AWG, solid, copper conductors. Cable shall meet the requirements of International Municipal Signal Association, Inc., Specification No. 19-1 latest specification. The function of each conductor and corresponding insulation color code shall be as follows:

Color & Terminal Strip Order	FUNCTION
Green	Offset 1
Blue w/ black stripe	Offset 2
Green w/ black stripe	Offset 3
Black	Dial 2
Blue	Dial 3
Orange w/ black stripe	Flash
Red	Split 2
Orange	Split 3
White w/ black stripe	Spare
Red w/ black stripe	Spare
Black w/ white stripe	Spare
White	Interconnect Common

- b. The Contractor shall identify the direction of all existing interconnect cable at the intersection. The Contractor shall label all existing and new interconnect cable at the intersection in every pull box and the controller cabinet prior to intersection turn-on or switchover.
- c. Install labels on 12-Conductor cable near each conduit end. For example, a single cable in a pull box requires two labels – one label near each conduit end. 12-Conductor Cable labels shall identify where the cable is headed, i.e. north, south, east, west, controller, etc.
- d. All splicing devices shall be UL approved. All splices shall be wrapped with one wrap of rubber splicing tape, taped with a minimum of four wraps of plastic electrical tape and then coated with a waterproofing coating with 12-Conductor splice kits that are UL listed.

C. TWISTED PAIR COPPER

1. Twisted Pair Cable shall be International Municipal Signal Association (IMSA) Specification number 60-2 including the following characteristics:
 - a. Contains 12 twisted pairs, each 19 AWG solid copper conductors
 - b. Rated for 300V
 - c. Black polyethylene (PE) jacket
 - d. Shielded with copper tape
 - e. Filled with translucent petroleum-polyethylene gel compound
 - f. IMSA twisted pair color code with tip/ring combination:
white/blue, white/orange, white/green, white/brown, white/slate, red/blue, red/orange, red/green, red/brown, red/slate, black/blue, and black/orange. Specific pair jacket color coding is found in the table below:

Pair	Wire 1	Wire 2	Description
1	Blue	Red	Intersections 1, 2, 3 & 4
2	Blue	White	Intersections 1, 2, 3 & 4
3	Brown	Red	Intersections 5, 6, 7 & 8
4	Brown	White	Intersections 5, 6, 7 & 8
5	Green	Red	Intersections 9, 10, 11 & 12
6	Green	White	Intersections 9, 10, 11 & 12
7	Grey	Red	Intersections 13, 14, 15 & 16
8	Grey	White	Intersections 13, 14, 15 & 16
9	Orange	Red	Intersections 17, 18, 19 & 20
10	Orange	White	Intersections 17, 18, 19 & 20
11	Black	Blue	Spare
12	Black	Orange	Spare

2. Filled cable
 - a. Filled cable refers to a petroleum-polyethylene translucent gel compound applied in liquid state to twisted pair cable core assemblies and to both sides of the overall metal shielding tape(s). Thus, the entire cable assembly under the outer cable jacket is 100% flooded (filled); thereby

eliminating possible moisture migration or humidity changes due to ingress and/or outer jacket damage.

D. VEHICLE TAGGING SYSTEM AND OVERHEAD LINE SIGNAL CONTROL SYSTEM

1. Wire sizes indicated conform to American Wire Gage (AWG) standard sizes. THW-2, XHHW-2 wire size shall be #12 AWG minimum and stranded copper except as noted. Wire shall be rated 600 volts except as noted.
2. Grounding and bonding jumper wiring shall be bare stranded copper wires, No. 6 AWG minimum unless otherwise required to be larger by Codes.
3. VTS controller cable shall be rated 600 volts, stranded, PVC jacketed and shielded 2 conductor No. 14 AWG cable.
4. VTS loop wire shall be No. 12 AWG copper, stranded with XHHW cross linked polyolefin insulation.
5. Overhead line signal control cable shall be rated 2000 volts, stranded, with # 10 AWG minimum, RHH-RHW, type DLO, extra flexible tinned copper cable.

2.10 WARNING TAPE

- A. General. Warning tape shall be non-detectable underground utility marking tape conforming to ASTM D2103. It shall consist of a minimum 4.0 mil overall thickness, inert 100% virgin low density polyethylene plastic film formulated for extended use underground. The materials shall be acid and alkali resistant. Width of warning tape shall be 6 inches. Warning tape shall be ShieldTec as manufactured by THOR Enterprises, Inc., the equivalent product manufactured by Line Guard Inc., or approve equal.
- B. Color Coding: The tape shall conform to the American Public Works Association color code as follows:
 1. Secondary Power Conduit: Warning tape color shall be safety red.
 2. Control Conduit: None required.
- C. Message Inscription: The warning tape shall include an inscription in black letters to identify the type of utility conduit on or over which it is installed. The inscription shall be impregnated with color-fast, lead-free, organic pigments suitable for direct burial and prolonged exposure to the elements normally encountered in moderately corrosive type soils. The height of the message letters shall be 1.5 inches minimum, and the message inscription shall be repeated at approximately 2 foot intervals. The message inscription for the different types of pipelines shall be as follows:
 1. Secondary Power Conduit: The message on the tape shall be "CAUTION – SECONDARY ELECTRICAL CONDUIT BELOW"

2.11 CONDUIT SEALANTS

- A. Moisture Barrier Types: Sealant shall be a non-toxic, non-shrink, non-hardening, putty type hand applied material providing an effective barrier under submerged conditions.
- B. Fire Retardant Types: Fire stop material shall be a reusable, non-toxic, asbestos-free, expanding, putty type material with minimum an hour rating in accordance with UL Classification 35L4.

- C. Hazardous Locations gas conduit seal by Appleton or Crouse-Hinds

PART 3 - EXECUTION

3.1 GENERAL

- A. Install electrical materials, equipment, and accessories in locations as indicated, rigid and secure, plumb and level, and in alignment with related and adjoining work to provide a complete and operable system. Do not weld electrical materials for attachment or support.
- B. Conduit alignments shown on plans are schematic. Where obstructions are encountered and with prior approval of the Engineer, location of conduit may be changed or alignment be curved according to the conduit-bending restrictions specified in the detail plans.
- C. The Contractor shall be responsible for field locating existing facilities that may be in conflict with new conduits, including existing detector loops. The Contractor shall maintain existing facilities in the vicinity of new conduit, and shall repair all damage resulting from the Contractor's operations within a 48 hour period at the Contractor's expense. Where new conduits conflict with an existing utility or other underground installation, the depth of the new conduit shall be increased to avoid the conflict. The Contractor is responsible for avoiding damaging or removing curb ramps and traffic detector loops and will be responsible for repairing them at his own expense. Minimum clearances from existing utilities shall conform to utility owner requirements.

3.2 CONDUIT

- A. The conduit shall be installed in accordance with Section 601.03 of SSDPWSF except as specifically modified herein.
- B. The trade size, type, and general routing and location of conduits, raceways, and boxes shall be as indicated or specified.
- C. Install individual conductors and multiple-conductor sheathed cables in conduits, unless otherwise indicated.
- D. Use of explosive fasteners is prohibited.
- E. After conductors have been installed, the end of conduits terminating in pull boxes and controller cabinets shall be sealed with an approved type of sealing compound for conduit with wires.
- F. Conduit bend radius at foundations or other underground structures shall be 12 times internal diameter of the conduit, minimum. Conduit coming out of foundation shall be straight and have 3" (+/-) above foundation.
- G. The maximum number of bends in any one conduit run shall be as follows for rigid steel conduits: A run of conduit between the bases of standards and controller pedestals shall not contain more than the equivalent of two 90 degree and one 45 degree bends; a run of conduit between pull or junction boxes shall not contain more than the equivalent of four 45 degree bends; a run of conduit between the base of a standard or controller pedestal and pull or junction box shall not contain more than the equivalent of one 90 degree and one 45 degree bend. Only large radius elbows shall be allowed per SSDPWSF 601.03. NOTE: The above required bends include both the cumulating of horizontal and vertical

bends. THIS MAXIMUM ALLOWABLE CUMULATION OF BENDS WILL BE STRICTLY ENFORCED. ANY DEVIATIONS FROM THIS SPECIFICATION WITHOUT THE PRIOR APPROVAL OF THE ENGINEER SHALL BE CONSIDERED INCORRECTLY INSTALLED AND ANY DEVIATIONS WILL RESULT IN THE CONTRACTOR REINSTALLING THE CONDUIT AT THEIR OWN COST.

- H. Conduit shall not be installed at a depth greater than 48 inches below pavement surface; and minimum depth of conduit shall be 24 inches in roadway areas and 18 inches in sidewalk and unpaved areas. See SSDPWSF Section 601.03 for further details.
- I. Where parallel runs of conduit are installed in a common trench, such conduits shall have a minimum separation of 2-inches or with conduit spacer.
- J. Clearances with Other Underground Utilities: Conduit shall be installed with the following minimum clearances with other underground utilities:
 - 1. Water pipelines. Minimum horizontal clearance shall be 3 feet. Minimum vertical clearance shall be 6 inches.
 - 2. Sanitary sewers and storm drains. Minimum horizontal clearance shall be 3 feet. Minimum vertical clearance shall be 6 inches.
 - 3. Other Utilities. Minimum horizontal clearance shall be 3 feet. Minimum vertical clearance shall be 6 inches.
- K. SSDPWSF Section 601.03 for Underground Conduit on page 6-13 number five (5) shall be modified to read as follows:

"If an existing pipe, duct or duct bank is in the path of new conduit, the laying of underground conduit at normal depth, and if such obstacle extends to a depth greater than 4 feet, the conduit shall cross over the obstacle as directed by the Engineer. If such obstacle extends only to a depth of 4 feet or less, the conduit shall cross one foot below the obstacle".
- L. Installing conduit by jacking conduit or pulling and pushing conduit in the ground will not be allowed, except when specifically noted on plans.
- M. Protect shop-cut threads from corrosion under the standards shown in CTSS Conduit Installation. Apply 2 coats of unthinned organic zinc-rich primer to metal conduit before painting. Use a primer on the Authorized Material List for organic zinc-rich primers. Do not use aerosol cans. Do not remove shop-installed conduit couplings.
- N. Conduit, when required, shall be cut, threaded, fitted with extension and grounding bushings for GRS conduit, PVC conduit shall be fitted with End Bells.
- O. Coupling of existing conduit to new conduit to match existing types and size where required.
- P. All conduit inside the basement and entering from the exterior pullbox to the basement shall be Galvanized Rigid Steel.
- Q. Prior to backfilling trenches and covering buried conduit, the Contractor shall have the Engineer verify that conduit bends and depths are in compliance with these Specifications.
- R. All empty conduits shall have pull tape. Pull tape must be a flat, woven, lubricated, soft-fiber, polyester tape with a minimum tensile strength of 1,800 lb. The tape must have

sequential measurement markings every 3 feet, GRS or PVC conduit can have a 1/4" polypropylene pull rope provided inside. Provide PVC end plug with pull tabs for tying the pull rope for two inches conduit and above. For conduit below two inches, the pull rope shall be tied outside the conduit with knots to prevent slippage. Plug shall be provided on both end of the conduits.

S. Methods

1. The Contractor may elect, at his or her option, to install conduit by either trenching or by directional boring. However, this option in no way constitutes City's approval of directional boring for this contract. Prior to exercising either option, the contractor shall obtain the written approval from the Bureau of Street Use and Mapping (BSM) and secure all required permits to perform said work. The bid item for furnishing and installing polyethylene conduits shall be for trenching and/or directional boring. Payment for this bid item shall be at the same price regardless of the method used for installation (trenching or directional boring). If directional boring is chosen, no additional cost will be granted for unforeseen conditions resulting from said operations. When site conditions prevent conduit installation utilizing the directional boring method or BSM denies approval of directional boring, trenching shall be used. All potholing required as a condition of permit approval to utilize directional boring shall be performed as incidental work.
2. Trenching
 - a. The pavement cutting, street excavation and trench backfill shall be in accordance with this Project Manual and Section 11 - Pavement Base Restoration Requirements of DPW's Regulations for Excavating and Restoring Streets of San Francisco (Order No. 176, 707).
 - b. Conduits shall be fastened together with spacers at five-foot intervals, and maintain a minimum separation of three-quarters of one inch (3/4") between each.
 - c. Conduit shall have a minimum 6-inch thick bedding of sand, measured from the center of conduit system, at top, bottom and sides of the conduit bundle. Four (4) inch red colored warning tape shall be placed between six (6) inches and twelve (12) inches above the top of the conduit bundle longitudinally for the entire length of the trench. The red warning tape shall be extrusion laminated, rated for direct burial, chemically inert with most typical substances in soil, and with tape color form 100% pigmented plastic.
3. Directional Boring
 - a. All interconnect conduits in the same block shall be installed with directional boring, unless otherwise accepted by the Engineer.
 - b. The contractor shall obtain excavation permit(s) and a temporary occupancy permit(s) issued by BSM before commencing work. The contractor shall be responsible to ascertain if BSM will allow the use of directional boring for the project streets. If the permits are issued, it is the contractor's sole responsibility to comply with all requirements of the permit.
 - c. The contractor shall use the technique of creating and directing a borehole along a predetermined path to a specified target location. The directional drilling technique shall involve the use of mechanical and hydraulic equipment to change the boring course and shall use

- instrumentation to monitor the location and orientation of the boring head assembly along the predetermined course.
- d. Directional boring shall be accomplished with fluid-assisted mechanical cutting. Unless otherwise accepted, boring fluids shall be a mixture of bentonite and water or polymers and additives. Bentonite sealants and water shall be used to lubricate the drilling head. It is mandatory that minimum pressures and flow rates be used during boring operation so as not to fracture the subgrade material around and/or above the bore. Uncontrolled jetting (where the primary purpose is to use fluid force to erode soil for creation of the final bore hold diameter) is prohibited.
 - e. The directional boring system shall utilize small-diameter fluid jets to fracture, and mechanical cutters to cut and excavate the soil as the head advances forward. After installation of conduits in the bored hole, voids in the hole shall be sealed with bentonite slurry.
 - f. No additional payment will be made to the contractor for encountering underground obstructions and/or problems resulting from said operation of directional boring.
 - g. Conduit used for fiber optics shall be installed as straight as possible to protect fiber optic quality.
- T. When underground conduit passes through concrete walls, concrete envelopes shall be extended through and finished flush with inside surfaces. Grout around conduit tie-ins entering pull/splice boxes, vaults, or building floors and walls. Where conduit enters building, seal openings with approved duct seal to prevent circulation of air or moisture. Obtain approval from the Engineer before backfilling.
- U. Where coring or cutting of existing structure in basement walls or tunnels is required for installation of new conduit, the refinishing of the wall shall be made watertight and all work shall conform to Division 3, Concrete.
- V. Location: Conduit shall be installed true to line and grade as shown on the Contract Drawings. Buried conduit shall be installed at a continuously sloping grade between points of given elevation without low or high points. Location of the pipeline may be modified by the Engineer to clear obstructions. Depth of cover over the conduit to finish grade shall be as shown on the Contract Drawings, but in no case less than minimum ANSI/NFPA 70 requirements.
- W. Handling: Conduit shall be handled carefully to prevent damage. Conduit shall be kept clean and shall be plugged at the end of each day's work or when conduit is not being laid to prevent the entry of water or foreign material.
- X. Trench Conditions: Each conduit section shall have a full, even bearing for its entire length on the floor of the trench. All conduit shall be laid in the dry; the Contractor shall dewater the trench as required. Conduit ends shall be clean when joints are made.
- Y. Rock Conditions: If rock is encountered during excavation, the trench shall be excavated 6 inches below conduit grade and 6 inches of sandy material shall be placed in the trench bottom. The sandy material shall be free of sharp-edged materials of any kind. Occasional rounded rocks less than 1/4 inch diameter is acceptable.
- Z. You may use a larger size conduit than specified for the entire length between termination points. Do not use a reducing coupling.

AA. Galvanized Rigid Steel (GRS) Conduit

1. Metallic conduits shall be electrically and mechanically continuous and connected to ground by bonding to the grounding system for all underground conduit and where required. Insulated bonding bushings are required with copper grounding lug.
2. Apply zinc primer conductive compound to the threads of threaded rigid conduit joints. Do not use compounds containing lead. Do not use spray cans. Terminate the conduit in appropriate boxes, and junction points.
3. When field cutting of conduit is required, thread and ream the conduit to remove rough edges. Where a conduit enters a box or other fitting, provide a bushing to protect the wire from abrasion. Provide insulation type bushings and double locknuts on ends of rigid conduits terminating at steel boxes, panelboards, cabinets, and similar enclosures.
4. Support individual horizontal conduits not larger than 1-1/2 inches in diameter by means of one-hole conduit strap with back spacers or individual conduit hangers.
5. Support individual horizontal conduits larger than 1-1/2 inches in diameter by individual hangers and forged steel conduit strap for vertical runs.
6. Space conduits installed against concrete surfaces ¼ inch away from the surface by clamp backs or other approved means.
7. Exposed conduit shall be supported at intervals as required by the N.E.C. or at a closer spacing as directed by the Engineer to eliminate sagging.
8. Conduit terminating in enclosures other than NEMA 1 shall be terminated with Meyers type gasketed conduit hubs.
9. Terminate conduit installed for future extension with flush threaded couplings set to finished floor level or wall, unless otherwise indicated. Provide pull cord/tape and plug for open end.
10. The installation of nonferrous, non-threaded conduit fittings, running threads and single-bolt split type conduit couplings is prohibited.
11. Tape-wrap all rigid steel conduit installed underground continuous over entire buried length and 6" above penetration.
12. All streetlight conduit shall be GRS unless otherwise noted.
13. All conduit inside the sub-sidewalk basement shall be GRS.
14. All conduit entering the sub-sidewalk basement shall be GRS.

3.3 PULL BOX

- A. Pull box notches shall be saw cut. Cracked pull boxes will not be acceptable
- B. Crushed rock pad and smooth grout in the bottom of pull boxes shall not be allowed in traffic signal boxes except for interconnect boxes. Streetlight boxes shall have crushed rock per SFDPW standard plan

- C. Abandoned conduits inside pull boxes that are modified or replaced shall be cut or removed six inches beyond the exterior wall.
- D. All debris, soil, sand and mud shall be removed to expose all cables in all new, adjustable and relocated boxes.
- E. **INTERCONNECT PULL BOXES**
 - 1. **General**
 - a. Interconnect pull box notches shall be saw cut. Cracked interconnect pull boxes will not be accepted.
 - 2. **Bending Restrictions**

Interconnect (HDPE) conduit must meet the following bending restrictions:

 - a. For outdoor installations:
 - i. Entering a pull box or vault, individual conduit bends shall not exceed 30 degrees.
 - ii. Conduit bends for rise of elbows into pull boxes shall not exceed 30 degrees maximum, as measured from the extended horizontal plane.
 - iii. The total cumulative bending angle shall not exceed 120 degrees between pull boxes. That is, the conduit run between pull boxes shall contain no more than 2 horizontal and 2 vertical bends (of 30 degrees each).
 - b. For indoor installations:
 - i. The minimum conduit sweep radius shall be five times the outside diameter of the conduit.
 - ii. No sweeps will be allowed into indoor junction boxes.
 - 3. **Conduit Entrance into Pull Boxes**
 - a. To gain maximum bending radius inside of a pull box, conduits shall enter on the opposite sides of the box extension near the bottom of the extension box aligning on the same long side of the box, or enter on the diagonally opposite corners of the box extension per interconnect pull box detail drawing.

3.4 WIRING

- A. The installation of any wiring in conduits shall not take place until the Contractor has demonstrated to the Engineer's satisfaction and approval that he, the Contractor has employed all means necessary, or required to clean and prepare the conduits for the installation of wiring therein.
- B. If the existing strapping or lacing of wiring is disturbed in the course of work, the Contractor shall replace or re-strap as applicable.
- C. All wires terminating in a metallic enclosure shall terminate on a terminal board equipped with screw-type or box-type terminals fabricated from the copper or copper-alloy material. Wires terminating on screw type terminations shall be equipped with self-insulated self-locking spade-type terminals. Wires terminating on box-type terminals shall be

connected directly without using spade-type pressure terminals attached to the wire ends.

- D. Wiring shall be installed so that no cuts or abrasions in the insulation or protective covering or kinks in the conductor occur.
- E. Lubricant shall be applied as an aid in pulling, only UL approved material as recommended by wire manufacturer and no injurious to the wire sheath or insulation shall be used.
- F. Any wire damaged during installation shall be removed and replaced with the equivalent wire at the Contractor's expense.
- G. No splicing of conductors shall be allowed except where specifically indicated.
- H. VTS wires shall not be spliced. VTS wire runs shall be continuous from loop connector unit to VTS cabinet.
- I. All new wirings shall be identified at their terminations with approved wire markers indicating the originating panel and circuit letter or number.
- J. Wiring of different systems installed in a common enclosure shall be separately assembled within such enclosures and laced or tied in cable form.
- K. Install wire and cable in conduit as indicated. Do not pull wiring into conduit until conduits have been thoroughly cleaned and swabbed. Do not use block and tackle or other mechanical means for pulling conductors smaller than No. AWG in raceways.
- L. Provide suitable installation equipment to prevent cutting and abrasion of conduits and wire during the pulling of cables.
- M. All wires terminating in a metallic enclosure shall be terminated on terminal board(s) with screw-type or box-type terminals fabricated from copper or copper alloy material.
- N. All splice in 600 volts insulated power wiring shall be permitted only in pull boxes.
- O. Where splices are required, the procedures shall be mechanically secure the wires, tape, waterproof and in accordance with manufacturer's recommendation.
- P. Clear plastic tubing may be applied over each energized conductor, as a temporary insulation, which shall be removed when the Engineer is prepared to test each splice.

3.5 INTERCONNECT CABLE/COMMUNICATIONS NETWORK MEDIA

- A. 12 CONDUCTOR CABLE
 - 1. 12-conductor cable splices shall be performed as directed on the plans. Where 12-conductor splices shall be heat-shrinkable, butt type connectors and 12-conductor splice kits shall be UL listed.
- B. TWISTED PAIR COPPER
 - 1. Twisted pair 12 pair cable Installation Procedures Needed.

3.6 DUCT PLUGS, DUCT SEALANT, LOCATING WIRES, PULL TAPE, AND PULL ROPE

A. Sealing Ducts, Locating Wires, and Pull Tape

1. All exposed conduit ends shall be temporarily and securely capped at all times during construction, including on-site storage, and until conductor installation by an accepted method. The contractor shall be responsible for the removal of any foreign material inside conduits at no additional cost to the City.
2. All interconnect conduits shall be sealed at each pull box with removable and reusable mechanical plugs to prevent the passage of gas, dust, sand, rodents and water. Sealing plugs shall be installed at each pull box conduit end. Empty conduits shall be sealed by means of a polypropylene duct plug equipped with a neoprene or polyurethane gasket. At places where interconnect cables enter and exit the conduit, the conduit shall be sealed by means of a split internal expansion plug.
3. Where HDPE interconnect conduits are left empty or filled only with non-metallic (optical fiber cable) conductors, two (2) #8 AWG THW or UF stranded copper locating wires (one with black and one with white insulation) shall be installed in one of the conduits.
4. Continuous pull tape shall be furnished and installed in each individual empty HDPE conduit. A minimum of 5 feet of slack shall be provided in the pull box at each end of the pull tape. Although pull rope can be used as an alternative in non-HDPE conduits, pull rope shall not be used in HDPE conduits. Pull tape shall be installed in continuous lengths without any cuts or ties.
5. After conductors have been installed, the end of conduits terminating in pull boxes and controller cabinets shall be sealed with an approved type of sealing compound.
6. Where conduit is exposed to different temperatures, seal the conduit to prevent condensation and passage of air from one area to the other.
7. All penetrations through concrete walls shall be core-drilled, non-shrink epoxy grouted and sealed openings with approved duct seal to prevent circulation of air or moisture and leakage into the building, constructed as Incidental Work. Provide UL listed fire-rated seals for all conduit and raceway penetrations through fire-rated walls and floors. Seal and maintain fire separation rating.
8. Any opening or gap opening due to wires entries or equipment mounting shall be completely air/water-tight sealed with duct seal to prevent foreign objects from entering.

3.7 GROUNDING AND BONDING

- A. Steel standards with hand holes, controller cabinets and other enclosures providing access to the conduit ends shall be bonded to the conduit with a grounding conductor terminated in a screw-type copper box-shaped terminal. The terminal shall be secured to the interior surface of the equipment near the foundation with a stainless steel screw equipped with a stainless steel internal tooth-lockwasher or to the neutral bus provided in such enclosures unless otherwise noted or directed. The head of the screw shall be installed on the interior surface of the equipment and the end of the screw shall be terminated with the exterior surface of the equipment.
- B. Pole standards shall be bonded to a conduit in the nearest pull box. Bonding and grounding jumpers shall be a continuous length of No. 6 AWG bare stranded copper wire.

- C. In multiple face signal heads, bonding conductor shall run to one face only. The bonding conductor shall be attached to the bottom section of the signal face, using a screw-type copper box-shaped terminal, secured to the housing of the signal face with a roundhead stainless steel machine screw, a stainless steel internal tooth lockwasher and a stainless steel nut.
- D. The service equipment shall be bonded to the ground rod with a ground clamp and No. 6 AWG bare stranded copper wire. Grounding conductors shall terminate in box-shaped terminal.
- E. Ground wires shall be effectively bonded at controller ground bus bar.
- F. Install the grounding system in accordance with National Electrical Code, as indicated on the Drawings and as specified herein.
- G. The continuity of metallic conduit through concrete pull boxes and metallic enclosures shall be preserved by installing appropriate ground fittings and grounding conductors.
- H. Where grounding conductors are shown in Drawings or required, bond the wires to metallic enclosures at each end and to all intermediate metallic enclosures.
- I. Steel poles with hand holes and other enclosures providing access to conduit ends, shall be bonded to the conduit with grounding conductor terminated in a screw-type copper box-shaped terminal. The terminal shall be secured to the interior surface of the equipment near foundation with a stainless steel screw equipped with a stainless steel internal tooth-lockwasher or to a neutral bus provided in such enclosure unless otherwise noted or directed by Engineer. The head of the screw shall be terminated with the exterior surface of the equipment.
- J. The bonding conductor shall be attached to the bottom section of the signal face, using a screw type copper box-shaped terminal, secured to the housing of the signal face with a roundhead stainless steel machine screw, a stainless steel internal tooth lockwasher and a stainless steel nut.
- K. For Buried and Embedded Ground Connections: Prior to backfilling, cleaning and coat welded connections with bitumastic epoxy coating. Make weld in accordance with the manufacturer's requirements. Compression-type mechanical connectors are not acceptable.
- L. Grounding Conductors: Continuous grounding conductors without splices, or splice by exothermic weld only.
- M. Ground all exposed non-current carrying metallic parts of electrical equipment, controller cabinet, raceway system and the neutral of all wiring systems.
- N. Inspect all ground connections for tightness and assure connections shown on Drawings have been completed.
- O. Test grounded equipment enclosures, raceways, conduits, exposed expansion joints, trolley poles for continuity to ground rod system.
- P. All test shall be performed by City certified, independent testing agency and in accordance with NETA recommended test procedures and standards.

3.9 ELECTRICAL TESTING

- A. Carry out tests specified in this Section and in DPW Standard Specifications, and as specified under individual sections of this Division. If remedial measures or replacement of equipment or materials are required as a result of the tests, they shall be made by the Contractor without additional cost to the City.
- B. Contractor shall test all conductors for continuity, after installation.
- C. Grounds: Test all wiring connections for continuity and grounds before any loads are connected.
- D. Contractor shall test the insulation resistance of each wire, after installation, and prior to connecting to equipment. Wire insulation resistance shall not be less than one (1) mega-ohm to ground.
- E. Operations: After the electrical system installation is completed and at such time as the Engineer may direct, conduct an operating test for approval. Demonstrate that the equipment (such as Voltage Contactors, Signal Control Boxes, Push Button Stations and VTS etc.) operates in accordance with the requirements of these Specifications. Furnish all instruments and personnel required for the tests.
- F. Perform all tests in the presence of the Engineer.
- G. For all applicable sections where electrical testing is required, Contractor shall submit procedures and schedules to the Engineer for approval 10 working days prior to the actual date of the test.
- H. Contractor shall maintain a written record of all tests.
- I. Contractor shall provide all testing and recording devices which may be required for specified tests.
- J. Contractor shall maintain the testing instruments in calibration per the requirements of NETA 5.3.
- K. Step-by-step procedure including set point check, system testing parameters shall be specified.
- L. Safety procedures per NETA 5.1 shall be adhered to.
- M. All tests shall be non-destructive. Any damage caused to devices and equipment during testing shall be corrected at the Contractor's expense.
- N. Upon completion of all work, individual testing, submittal of Operation and Maintenance Manuals, and prior to proceeding with the acceptance test, Contractor shall demonstrate to the Engineer proper and complete operation of all installed systems.

3.9 RISER CONDUIT

- A. Risers to overhead: Provide rigid galvanized steel conduit with 90-degree sweep bend. Size as shown on the Contract Drawings.
- B. Firmly secure conduit to Power Utility pole with galvanized steel stand-off brackets. Connection to Power Utility facilities will be by the Power Utility Owner.

3.10 PULL CORD

- A. Pull cords shall be installed in unused conduit. The pull cord shall be securely attached to conduit plugs or caps.
- B. Pull wires are not permitted.

3.11 WARNING TAPE

- A. Each underground electrical power conduit, or parallel pair of electrical power conduit, shall be installed with a continuous strip of warning tape located directly above the conduit at a distance 12 inches below finish grade or as otherwise shown on the Contract Drawings. In addition, each electrical power conduit, or parallel pair of conduits, shall be installed with a continuous strip of warning tape placed over the top of the conduit(s).

3.12 CLEANING

- A. Conduit shall be thoroughly cleaned to remove all dirt, rocks, debris or other obstructions introduced into the conduit during the construction operations. Cleaning shall be by pulling a satisfactory swab through each conduit run. The Contractor shall remove swabbings from all pull/splice boxes.
- B. The Contractor shall prove, in a manner acceptable to the Utility Owner, that the conduit system is free of obstructions.

3.13 NOTIFICATION OF OTHER PARTIES

The Contractor shall notify Outdoor Systems at (415) 882-4949 a minimum of 72 hours in advance of working at an intersection near a MUNI bus shelter.

END OF SECTION