

PART 5

MECHANICAL WORK

SECTION 500

GENERAL REQUIREMENTS

500.01 RULES AND REGULATIONS. - Mechanical work, equipment and materials, including the installations thereof, shall be in full accordance with the requirements of the National Board of Fire Underwriters; the Pacific Fire Rating Bureau; the State Fire Marshal; the Safety Orders issued by the Division of Industrial Safety, Department of Industrial Relations of the State of California; the San Francisco Building, Fire and Plumbing and Gas Appliance Codes; and any other prevailing codes and regulations pertinent to adequate protective measures and prevention of hazardous conditions.

500.02 PERMITS. - The Contractor shall obtain, at his own expense, prior to start of any mechanical work in buildings and in other locations outside of street areas, all necessary permits from the Department of Public Works for the work covered by the specifications, except as such permits may have been previously obtained by the City.

500.03 ADJUSTMENT OR RELOCATION OF EXISTING FACILITIES. - If required to permit the prosecution of the work, adjustment or relocation, as approved by the Engineer, of existing electrical conduit and contained wires, existing pipes or existing ducts, where such conduit and pipes are 1-1/4 inches or less in nominal diameter and the ducts are one square foot or less in cross-sectional area, shall be considered Incidental Work. The adjustment or relocation of larger sized existing facilities, however, unless specifically indicated for such adjustment or relocation on the plans or in the Special Provisions, if necessary as determined by the Engineer, shall be done as directed, as Extra Work in accordance with the requirements of Section 112.

500.04 FLOOR, WALL AND CEILING OPENINGS. - The Contractor shall secure the Engineer's approval of the locations for holes and openings in floors, walls and ceilings, necessary for the installation of mechanical equipment, ducts, piping and appurtenances, and shall keep to a practicable minimum the size of such holes and openings. He shall conduct his operations in such manner as to prevent cracking or otherwise damaged floors, walls and ceilings. He shall close all holes and openings, and repair, in an approved manner, all damage resulting from his operations, leaving no impairment of structural, functional, or architectural quality and shall match the configuration, texture and color of the adjacent existing surfaces. He shall, except as otherwise specified, paint all patched surfaces, with one coat of primer and two coats of finish paint to match the surrounding area. Painting and preparation therefor shall be in accordance with the applicable requirements of Section 809.

Holes and openings in or through existing concrete or masonry floors, walls and ceilings shall be made by drilling with proper size

carboly-tipped twist drills, diamond drill bits, or diamond core drills. The use of impact drills of any type will be permitted only with the approval of the Engineer.

**500.05 UNINSPECTED WORK NOT TO BE CLOSED IN.** - The Contractor shall not cover up nor enclose any of his work until it has been tested by him in the presence of the Engineer and until it has been inspected and approved by the Engineer. Should any of the work be enclosed or covered up before such inspection and test, the Contractor shall, at his own expense, uncover the work, and after it has been inspected, tested and approved, restore such covering and enclosure.

Backfilling shall not commence until after structures, mechanical equipment, piping and appurtenances have been properly constructed, or furnished and installed, as applicable, and inspected, and, if required tested.

**500.06 DAMAGE BY LEAKS OR BREAKS.** - Damage to any part of the premises or its improvements caused by leaks or breaks in the equipment, piping or appurtenances installed by the Contractor, or caused by leaks or breaks in existing equipment, piping or appurtenances resulting from his operations, shall be considered defects in the work or damage to existing improvements, as the case may be, as set forth in Section 105.10, and as such shall be the responsibility of the Contractor for a period of one year following the date of acceptance of the work in the case of surface improvements.

**500.07 WATER METER INSTALLATIONS.** - When water meters are required in conjunction with the contract work, the Engineer will make all necessary arrangements with the San Francisco Water Department for the installation of such meters and, if required, the removal of any existing meters, all at the locations shown on the plans. The installation of each meter, including the service piping thereto, and the connection of such piping to City water mains, will be accomplished by San Francisco Water Department personnel, but all fees and costs therefor shall be solely the responsibility of the Department of Public Works.

The Contractor shall notify the Engineer not less than fifteen days prior to the date on which the Contractor intends to make use of the City-furnished water for contract work, in order to allow San Francisco Water Department personnel sufficient time to complete their respective work.

The Contractor shall make a complete downstream piping connection to each installed water meter.

**500.08 GAS METER INSTALLATIONS.** - When gas meters are required in conjunction with the contract work, the Contractor shall make all necessary arrangements with the Pacific Gas and Electric Company for the installation of such meters at the locations shown on the plans. The installation of each meter, including the service piping thereto, and the connection of such piping to Pacific Gas and Electric Company gas mains and pressure reducing valve, where required, between the meter and the gas mains, will be accomplished by Pacific Gas and Electric Company personnel, but all fees and costs therefor shall be solely the responsibility of the Contractor.

The application for new service shall be made not less than thirty (30) days prior to the completion date of the contract in order that the Pacific Gas and Electric Company may perform the work within the specified contract period.

## SECTION 501

### STEEL WORK

501.01 STEEL AND HARDWARE. - Steel, and the fabrication and installation thereof, shall be in accordance with the applicable requirements of Section 802.

All bolts and nuts shall conform to ASTM "Standard Specification for Low-Carbon Steel Externally and Internally Threaded Standard Fasteners, Designation A 307, Grade "B" and shall be standard machine bolts with cold pressed hexagonal nuts, except as otherwise specified. All bolts and nuts specified to be galvanized shall have a free running fit. Anchor and assembly bolts shall be of ample size and strength for the purpose intended. No existing bolts, nuts, washers, etc., shall be reused in contract work, unless specifically indicated for such reuse on the plans or in the Special Provisions.

### 501.02 WELDING.

General. - All welding shall be performed in accordance with the applicable requirements of the latest "Standard Code for Arc and Gas Welding in Building Construction." Serial Designation D 1.0, of the American Welding Society, or the latest Specifications for Fusion Welding of the American Institute of Steel Construction, and Section 806 of these Standard Specifications.

Only those welders who are experienced and have passed qualification tests under the AWSS "Standard Qualification Procedures" shall be employed and the Contractor may be required to show Certified employment and test records for each welder.

All welding shall be done in the shop before galvanizing, if the latter is required, except as specifically otherwise permitted by the Engineer.

All welding work to be subsequently galvanized shall be thoroughly cleaned and prepared so as not to impair the quality of galvanizing.

Surfaces to be welded shall be cleaned by wire brushing, chipping or hammering away any loose mill scale, rust, paint or other foreign matter present on the metal. The cleaning shall extend at least two inches on each side of the weld, except as otherwise specified. Welds shall be cleaned each time the electrode is changed.

In assembly and during welding, the component parts shall be held by sufficient clamps or other adequate means to keep the parts in the proper positions and in close contact.

Welds shall show uniform sections, smoothness of metal, feather edges without undercuts or overlays and freedom from cracks, porosity or clinkers. Visual inspection of edges and ends of fillets and butt joint welds shall indicate good fusion with and penetration into the base

metal. All burrs and lumps of metal shall be removed, leaving a neat and workmanlike appearance.

All weld slag and spatter shall be completely removed before galvanizing or painting.

Any welds or portions of welds found defective, in opinion of the Engineer, shall be removed and replaced.

Welding of Steel Pipe and Fittings. - All welded joints for steel pipe, attachments and fittings, unless otherwise shown on the plans or specified in the Special Provisions, shall be fusion-welded in accordance with the AWS Code for Industrial Piping, using suitable welding rods as recommended by the American Welding Society. All joints shall be open, single "V" type with all pipe and fitting ends scarfed on an approved angle to within 1/16-inch of the inside wall of the pipe or fitting. The abutting ends shall be separated and properly spaced and aligned before tacking. All finished welds shall be of sound metal and shall present a neat and workmanlike finish. All welded pipes and fittings shall be subjected to a hydrostatic test pressure not less than that specified in the Special Provisions, followed by a soap-and-water test for leaks. All defects in the welding shall be corrected. All welds that leak or sweat are defective, and shall be cut away. The pipe and/or fittings shall then be resurfaced and new welds made and retested.

501.03 GALVANIZING. - Galvanizing shall be done where shown on the plans or when specified.

Equipment and materials to be galvanized shall be hot-dip galvanized in accordance with the requirements of Section 807.

## SECTION 502

### PIPING, TUBING, FITTINGS, VALVES AND OTHER APPURTENANCES - MATERIALS AND INSTALLATION

502.01 GENERAL. - All piping, tubing, fittings, valves and other piping system appurtenances shall be free of defects, and of the make, brand and quality specified, or approved equal. All such piping, tubing and appurtenances shall be installed by the Contractor where and as shown on the plans, or where directed by the Engineer.

The kind and size of pipe, tubing and appurtenances to be used for the particular application shall be as shown on the plans and/or as specified in the Special Provisions.

Workmanship shall be of the highest quality, and installation shall be in accordance with the practices recognized as best by the plumbing trade.

When sizes and strengths of pipes are omitted from the plans and not set forth in the Special Provisions, the sizes and strengths shall be adequate for the functions to be performed, as determined by the applicable codes and regulations and as approved by the Engineer, unless heavier materials or more stringent requirements are indicated, in which case the indicated sizes will govern.

All piping shall be erected to accurate lines and grades, and where possible, pipes shall be laid horizontally or vertically, and parallel or

perpendicular to each other and to building walls, to make a workmanlike installation.

All lines, fittings, valves and appurtenances in buildings or elsewhere shall be located so that they can be easily removed or repaired without disturbing other parts of the lines; shall be adequately stayed, braced and anchored, and shall be installed in a neat and workmanlike manner. Appearance as well as utility shall be given consideration.

All vertical lines in buildings shall be supported by brackets or standard clamps and shall not depend upon resting or hanging from other pipelines or equipment.

Maximum clearance beneath overhead piping in buildings shall be maintained.

Union shall be provided at all points where necessary to facilitate the assembly of screwed piping.

Fittings required but not shown on the plans shall be furnished and installed by the Contractor at his sole expense to the extent required by Section 103.03.

No hot water line shall parallel a cold water supply line at less than 10-inch center-to-center distance except where necessary in the immediate vicinity of a plumbing fixture being served.

Except as otherwise specified, piping installed in lawn and other planted areas, or under center or traffic island pavement, shall have a minimum of 10 inches of cover; under sidewalk areas, a minimum of 24 inches of cover; and under roadway pavement, a minimum of 30 inches of cover; all measured from the finished ground or pavement grade, as applicable.

#### 502.02 STEEL PIPING AND FITTINGS.

General. - Where weight or strength of pipe is referred to in the Special Provisions or on the plans by "Schedule Number," such "Schedule Number" refers to Standard B-36.10 as adopted by American National Standards. Standard Weight pipe is referred to as "Schedule 40" and extra strong pipe is referred to as "Schedule 80".

Steel pipe and fittings used for domestic hot and cold water piping, waste and vent piping, and gasoline piping, shall be galvanized.

Fittings and Flanges. - Screwed fittings for steel pipe, unless otherwise specified, shall be threaded, square band, malleable or cast iron and cut with full threads. Fittings for steel pipe used for waste lines, unless otherwise specified, shall be of the long sweep pattern, cast iron drainage fittings.

Flanged fittings for steel pipe, unless otherwise specified, shall be 125-pound cast iron, and shall be in accordance with the requirements of ANS Specification B 16.1 American Standard dimensions, facing and drilling.

Steel butt-welding fittings shall be in accordance with the requirements of ANS Specification B 16.9.

Flanges for steel pipe, unless otherwise specified, shall be forged steel "slip-on" welding flanges, 150-pound standard, welded inside and outside, or forged steel welding neck flanges, 150-pound standard. Where steel flanges are bolted to 125-pound cast iron flanges, the raised faces on the steel flanges shall be removed.

Fittings and flanges shall be as specified on the plans or in the Special Provisions. Only one make of fittings and flanges will be permitted in the "roughing-in" of the piping system.

Making Up Screwed Joints. - Piping shall be cut square and true, and ends of pipe shall be carefully reamed open to full diameter removing all burrs and sharp edges. Pipes shall be free from tool marks.

Threads on pipes shall be carefully cut with clean dies so that the axes of screwed fittings will coincide with the axes of the pipe to which they are attached.

Threads on stainless steel pipe shall be carefully cut with dies manufactured specifically for cutting threads on stainless steel pipe, and shall be cut in accordance with the pipe manufacturer's recommendations.

Screwed joints, except for gasoline and diesel fuel oil piping and high pressure hydraulic (oil) system piping, shall be made up with graphite red lead and linseed oil, or approved joint compound.

Pipe make-up dope for gasoline and diesel fuel oil piping shall be a product approved for use in petroleum piping, nonsoluble in gasoline or oil.

Screwed joints for high pressure hydraulic (oil) system piping shall be made up with approved teflon tape thread sealant, suitable for high pressure oil systems.

Screwed fittings shall be run up a minimum of eight full threads. Joint compound shall be applied to the male thread only when assembly is made and all excess compound shall be wiped off all joints. Care shall be taken to keep pipe free from dirt and debris, and compound shall be applied in such a manner that it will not enter pipe lines. Cord, string, caulking, etc., will not be permitted on threaded piping to make joints tight.

Making Up Flanged Joints. - Flanged joints shall be made in accordance with the best standard practice.

When making up joints for flanged pipe and fittings, the Contractor shall furnish and install gaskets where necessary, or required.

Gaskets, unless otherwise specified, shall be ring type gasket at least 1/16-inch thick, and made of the material specified in the Special Provisions. Gaskets for 125-pound cast iron flanged joints, or for steel flanges with faces removed which are bolted to 125-pound cast iron flanges, shall be full face.

Flanges shall be carefully cleaned before being gasketed and bolted. Flanged joints shall be made up square with even pressure on gaskets and shall be watertight.

Flanged joint bolts shall be standard machine bolts with cold pressed hexagonal nuts, and both shall be galvanized steel.

Flanged joint bolts for pipe submerged in water or sewage shall be of high strength cast iron having a minimum tensile strength of 50,000 pounds per square inch.

#### 502.03 BELL AND SPIGOT CAST IRON PIPING AND FITTINGS FOR PLUMBING WORK.

General. - All cast iron pipe and fittings for sewers, soil lines, wastes, leaders and vents shall conform to the requirements of ASTM

"Standard Specification for Cast Iron Soil Pipe and Fittings," Designation A 74, or Commercial Standard CS-188-59, "Cast Iron Soil Pipe and Fittings," and shall be marked as specified therein.

All underground sewer, soil, waste and vent lines shall be of extra heavy (XH) weight cast iron soil pipe and fittings.

All cast iron piping for above ground soil lines, wastes, leaders and vents shall be of service (SV) weight cast iron soil pipe and fittings.

All cast iron pipe and fittings shall be concentric, sound, free from all defects, and completely coated inside and outside with coal tar pitch, applied hot.

Fittings for cast iron pipe used in plumbing work shall be of the same make, material, and inside diameter as the pipe with which they are used, and shall be of equal quality and weight, coated both inside and outside with coal tar pitch, applied hot.

Lead for joints shall be in accordance with the requirements for Common Delivered Lead. ASTM "Standard Specifications for Pig Lead." Designation B 29.

Making Up Joints and Installation. - The Contractor shall make all joints in accordance with the following requirements:

The spigot end of each piece of pipe shall be inserted into the corresponding bell and full depth of the bell and the spigot adjusted in the bell so as to give a uniform space for the joint, which shall be made of first quality oakum and pig lead. The oakum shall be thoroughly and evenly packed into the bell so as to fill it tightly for a depth of one inch (allowance shall be made in each joint for not less than one pound of lead for each inch of nominal pipe diameter). The remaining space shall then be filled with pure lead, which has been brought to the proper temperature and cleaned of scum, a bead being left on the outside of the face of the bell sufficient to allow for caulking so that when the joint is properly caulked the lead will be flush with the face of the bell. The use of cold plugs will not be allowed.

In pouring lead, the melting pot shall be kept near the joint to be poured and only one pour shall be made for each joint. The joint shall be perfectly clean and dry when the lead is applied. Dross shall not be allowed to accumulate in the melting pot.

Care shall be taken in making joints to provide suitable escape for the air in the joint when it is being poured.

The joints shall be thoroughly caulked by competent workmen using proper and satisfactory tools, in such a manner as to secure a tight joint without overstressing the iron in the bells. In all cases, the caulking shall be done towards the gate and other points where the lead is likely to be porous, so as to compact it there.

In disconnecting existing pipe and fittings, the joints shall be melted out. The faces of all bells, and six inches of the spigots of all pipe and fittings, shall be thoroughly cleaned of all dirt, scale and other foreign matter before new lead joints are made.

Where pipe is buried underground, trenches shall be excavated so that the barrel of the pipe will have an even bearing along its entire length, and with sufficient clearance provided for any necessary operations in connection with the laying of the pipe. Pipe shall be supported for the entire length, not by the bell ends only, on the required sand bed. Bell holes shall be excavated for each pipe bell or joint and shall be of sufficient size to ensure proper making of joints.

Backfilling for the pipe shall be as specified in Section 703.

Where pipes are laid on grades, the pipes shall be installed with the bells up grade.

#### 502.04 CAST IRON PRESSURE PIPING AND FITTINGS.

General. - Pressure type cast iron pipe shall be in accordance with ANSI Specification for "Cast Iron Pipe Centrifugally Cast in Metal Molds for Water or Other Liquids," Designation A 21.6. Barrel thickness of pipe shall be as specified in the Special Provisions.

Mechanical joints and Tyton joints for cast iron pipe shall conform with ANSI Specification A 21.11.

Flanged joint pipe, unless otherwise specified, shall be made up by threading plain end pipe, screwing the flanges on, and machine-tightening until the pipe protrudes past the face of the flange. The pipe end and the flange shall then be faced giving a flush surface across the end of the pipe and the face of the flange.

Flanges shall be faced and drilled in accordance with ANSI Specification B16.1 for Class 125 and ANSI Specification B 16.2 for Class 250.

Flanged joints shall be made in accordance with the best standard practice and as specified hereinbefore in Section 502.02.

Fittings - Fittings for mechanical and Tyton joint pipe shall be short body, cast iron fittings in accordance with ANSI Specification A 21.10 and joints therefor shall be mechanical joints conforming to ANSI Specification A 21.11.

Fittings for cast iron flanged pipe shall be cast iron flanged fittings in accordance with ANSI Specification B16.1 for Class 125 and B 16.2 for Class 250.

Cement Lining. - All cast iron pipe and fittings, unless otherwise specified, shall be cement lined. Cement lining shall be in accordance with ANSI Specification for "Cement Mortar Lining for Cast Iron Pipe and Fittings," Designation A 21.4, except for the thickness requirement, which shall be 1/16-inch minimum.

#### 502.05 COPPER TUBING AND FITTINGS.

General. - Copper tubing unless otherwise specified, shall be Type "K" for underground and Type "L" for above ground, hard temper tubing, and shall conform to ASTM "Standard Specification for Seamless Copper Water Tube," Designation B 88. Soft temper tubing shall be used, when specified on the plans or in the Special Provisions, or where directed by the Engineer, for cases where flexibility or a minimum of joints are desired or in the case of limited access. No bends shall be made in copper tubing except by use of preformed fittings or with tools insuring smooth bands without kinks.

Fittings. - Fittings for copper tubing shall be of the sweated-type, wrought copper, solder-joint type, fabricated in accordance with ANS Specification B 16.22 and meeting ASTM "Standard Specification for Seamless Copper Tube," Designation B 75.

Union shall be the ground joint type and of copper or bronze. Long screw or other similar packed joints will not be permitted.



Elbows, tees and other fittings installed in the vicinity of plumbing fixtures shall be of the drop-ear or flanged type and shall be securely anchored to a suitable backing or to the building framework, as directed by the Engineer, so as to permit no pipe movement at the fixtures.

Dielectric type unions, connectors or couplings, or 6-inch long bronze nipples shall be used at all connections of copper tubing to ferrous metal piping and equipment, unless otherwise specified in the Special Provisions.

All fittings shall be sweated except at connection to equipment and valves where screwed, flared, or flanged fittings shall be used or as otherwise specified. All valves shall be bronze and shall have Iron Pipe Size (IPS) screwed connections or solder type connections.

Making Up Joints. - Copper tubing shall be cut with a tubing cutter or hacksaw, full length with square ends, and shall be fully reamed with a tubing reamer and sandpapered clean before soldering. Cutters designed for steel pipe shall not be used. After cutting, the tubing shall be sized with a sizing tool, if required.

Joints shall be made either with 95-5 tin-antimony or 95-5 lead-tin solder, ASTM "Tentative Specifications for Solder Metal," Designation B 32, Grade 5A, unless otherwise specified. Joints shall be made with torches designed for the purpose; the use of blow torches will not be permitted.

Copper-to-copper joins for condensate return tubing and other tubing to be used for carrying high temperature fluids shall be made by brazing with phosphor-bearing 15-percent silver solder. If copper-to-ferrous metal soldered joints are specifically called for in tubing for carrying high temperature fluids, such joints shall be made with 35 to 50-percent silver, phosphor-free solder and an appropriate flux. Extreme care and enough welding tips shall be used to prevent overheating of silver brazed joints. Any joints showing evidence of overheating shall be removed and replaced at the Contractor's expense. Finished silver brazed joints shall show a fillet of bright silver alloy completely around the edge of the joint.

Fastening of Tubing. - Copper tubing shall be fastened to buildings or structures at six-foot intervals to prevent excess noise and vibration, shall be braced to prevent excess swaying, and shall be separated from steel at hangers, straps, etc., with three thicknesses of dielectric tape, except in cases where hangers are of a special copper-plated type.

#### 502.06 HYDRAULIC FLUID LINE TUBING AND FITTINGS.

General. - Hydraulic (oil) line tubing shall be American Materials Standard (AMS) 5050E of cold-drawn seamless low carbon steel, annealed for bending and flaring.

Tubing shall be specially processed to insure a clean interior necessary in hydraulic (oil) systems. When delivered to the job site, both ends of each section of tubing shall be capped to protect the interior of the tubing from foreign matter. Tubing shall be of the sizes and wall thickness as shown on the plans.

Tubing fittings shall be as specified in the Special Provisions or as indicated on the plans.

Tubing and fittings shall conform to the specifications and recommended practice of the Joint Industry Conference (JIC) "Hydraulic Standards for Industrial Equipment."

Minimum Bend Radii - When installing tubing, the minimum bend radius of tubing bends shall be as shown in the following schedule:

<u>Tubing Sizes</u> <u>Outside Diameter (Inches)</u>	<u>Minimum Radius to</u> <u>Tubing Center Line (Inches)</u>
1/4	9/16
3/8	15/16
1/2	1-1/2
5/8	2-1/4
3/4	3
7/8	3-1/2
1	4

Tubing shall be free of kinks and flat spots causing an area reduction of more than 20 percent.

Making Up Joints. - When making joints, the burrs shall be removed from the inside of the tubing end and, for flare type fittings, the flare carefully made so that there are no cracks or flaws in the surface coming in contact with the fitting.

When tubing is used for high pressure hydraulic (oil) systems, screwed joints to equipment, cylinders, valves, etc., shall be made up with approved teflon tape thread sealant, suitable for high pressure oil systems.

Fastening or Tubing. - Tubing shall be supported securely with Super Strut, or equal, channels and O.D. tubing pipe clamps, hot-dip galvanized after fabrication. Supports shall be spaced in accordance with the following schedule.

<u>Tubing Sizes</u> <u>Outside Diameter (Inches)</u>	<u>Distance</u> <u>Between Support (Feet)</u>
1/4, 5/16, 3/8, 1/2.	4
5/8, 3/4, 7/8, 1.	5

Cleaning of Lines - After final assembly, but before making final connections to equipment, and before final tests, all tubing line shall be cleaned by washing with alkaline solution or benzine.

502.07 PIPING, TUBING, AND FITTINGS OF OTHER MATERIALS, CLASSES AND TYPES. - The piping, tubing, and fittings specified hereinbefore in Section 502.02 through 502.06, inclusive, are of those materials, classes and types used most frequently in Bureau of Engineering mechanical construction, replacement and reconstruction, and maintenance and repair jobs. Not precluded is the use of piping, tubing, and fittings as otherwise may be specified in the Special Provisions, including, but not limited to, the following:

Alloy steel pipe and fittings;  
Seamless stainless steel tubing and flared-tube fittings;  
High silicon iron alloy pipe and fittings, bell and spigot type,  
extra heavy weight, of "Duriron," "Corrosiron," or equal;  
Red brass pipe and fittings;  
Asbestos-cement pressure pipe and fittings;  
Polyvinyl chloride (PVC) and other plastic pipe and fittings;  
Vitrified clay pipe and fittings.

**502.08 VALVES.** - Valves shall be installed with the stems vertically up, but may, if necessary and approved by the Engineer, be installed with stems in a horizontal position.

Gate valves shall be used where the service requires valves to be either wide open or shut tight.

Globe and angle valves shall be installed so that the pressure is under the disc and shall be placed where and as shown on the plans or where throttling is required.

All valves shall be of the same size as the piping to which they are connected, unless otherwise specified on the plans or in the Special Provisions, or equal. Only valves of one manufacturer shall be furnished and installed, if possible.

No valves, existing in piping to be replaced under any contract, shall be reused or relocated unless specifically designated on the plans or in the Special Provisiosn for such reuse or relocation.

**502.09 INSULATION OF PIPING AND APPURTENANCES.** - Unless otherwise specified herein or in the Special Provisions, piping and tubing, required to be insulated, shall be covered with 85-percent magnesia asbestos sectional or segmental covering with eight-ounce canvas jacket tightly stretched, neatly pasted on, and securely held in place by two (2) metal bands for each three-foot section. Thickness of insulation shall be as specified on the plans or in the Special Provisions. After the insulation has dried thoroughly, it shall be sized, in place, with an approved lagging adhesive, with anti-mold for ratproofing.

Fittings, valve bodies, stub ends and similar parts, except unions and flanges, unless otherwise specified, shall be covered with 85-percent magnesia asbestos plastic cement built up to the same thickness as the adjacent pipe covering and then covered with eight-ounce canvas jacket securely held in place and lapped to the canvas of the adjacent pipe insulation. The insulation shall be sized, in place, as set forth hereinbefore.

Unless otherwise specified in the Special Provisions, hot water piping and tubing, however, required to be insulated, shall be covered with an approved fiber glass sectional covering, with standard factory attached canvas pasted smoothly over the insulation, and each three-foot section additionally secured with at least two metal bands. Thickness of insulation shall be as specified on the plans or in the Special Provisions. All fittings and other appurtenances, except unions, unless otherwise specified, shall be covered as set forth hereinbefore or with an approved insulating cement equal to the thickness of the adjoining pipe covering and finished with canvas. All canvas shall be additionally finished with one heavy brush coat of an approved lagging adhesive.

Pipe insulation at hanger and support locations shall be fitted with steel protection saddles.

Any existing insulation damaged during the course of the work shall be replaced.

Piping appurtenances shall not be insulated until after installation, inspection, testing and approval. Pipe shall be clean and dry prior to application of insulation.

Piping normally requiring insulation includes, but is not limited to, steam supply lines, exposed condensate return lines within six feet of floors, and hot water lines.

#### 502.10 PIPING IDENTIFICATION AND COLOR CODE.

General. - Piping furnished and installed in new buildings and pipe tunnels shall be identified and the direction of flow indicated by means of approved colored, pressure sensitive, self-adhesive markers, as specified herein. Piping furnished and installed in existing buildings and pipe tunnels shall be labeled similarly only when specifically called for on the plans or in the Special Provisions. The markers shall be applied after all cleaning and painting of the piping and insulation is completed.

The identification shall be applied to all piping, except for that piping which is located in furred spaces without access to permit entrance of personnel, and except for that piping which is buried in the ground or in concrete.

Printed legends and flow arrows shall be applied at all valve locations, at all points where piping enters or leaves a wall, partition, bulkhead, cluster of piping, or similar obstruction, and adjacent to under-floor lighting, and at approximately 20-foot intervals on pipe runs elsewhere. Where different equipment is supplied from a common main, the main shall be identified and each respective branch takeoff properly identified.

Practicable variations or changes in location and spacing of piping identification may be made with the specific approval of the Engineer to meet specific conditions.

Wherever two or more pipes run parallel, the printed legend and other markings shall be applied properly grouped and neatly arranged.

The markings shall be located so as to be conspicuous from any reasonable point of vantage.

Legend and flow arrow backgrounds shall be in the colors indicated in the "Pipe Marking Schedule." Letters and flow arrows proper shall be black except that yellow letters and arrows may be used where brown background is called for, to permit better visibility. All markers shall be placed with the legend parallel to the pipe run.

The sizes of printed lettering and flow arrows shall be used as follows:

<u>Outside Diameter of Pipe or Covering</u>	<u>Height of Printed Letter</u>	<u>Minimum Length of Flow Arrow</u>
5/8 to 1-1/2 inches	5/16 to 1/2 inch	1-1/2 inches
2 to 2-1/2 inches	5/8 to 1 inch	1-1/2 inches
3 inches and larger	2 inches	3 inches

The Pipe Marking Schedule shall be as follows:

<u>Legend</u>	<u>Background Color</u>
Air	Green
Blow Off Water	Yellow
Boiled Feed Water	Yellow
City Water	Green
Cold Water	Green
Compressed Air	Green
Condensate	Yellow
Condensate Return-Gravity	Yellow
Drinking Water	Yellow
Fire-Automatic Sprinklers	Red
Fire-Dry Stand Pipe	Red
Fire Protection Water	Red
Fresh Water	Green
Heating Return	Yellow
Heating Steam	Yellow
Heating Supply	Yellow
Hi Press Air	Yellow
Hi Press Condensate	Yellow
Hot Water	Yellow
Lo Press Air	Green
Lo Press Steam	Yellow
Plumbing Vent	Brown
Sprinkler Fire	Red
Sprinkler Water	Red
Steam	Yellow
Treated Water	Green

High pressure steam is above 15 psig.

Low pressure steam is 15 psig and lower.

Services not listed shall be provided with suitable legends on colored backgrounds in accordance with American National Standards Bulletin A-12.

All piping shall be dry and clean of any dirt, grease or loose surface material before application of markets.

Backing cards shall be removed and installation completed in accordance with the manufacturer's application instructions.

In lieu of applying the pressure sensitive, self-adhesive markers, the Contractor may elect to paint the colored backgrounds on piping and stencil letters and flow arrows thereover in accordance with the color requirements specified hereinbefore.

Sewage Pumping Stations. - Piping and valves furnished and installed in sewage pumping stations, and which are exposed, unless otherwise specified, shall be painted in colors to conform to the following schedule. Services not designated shall be painted as specified in the Special Provisions, or as directed by the Engineer.

<u>Service</u>	<u>Piping</u>	<u>Valve Ring</u>	<u>Valve Spokes</u>
Sewage Influent	Brown	Brown	Brown
Sewage Influent Drain	Brown	Brown	Brown
Sewage Effluent	Black	Black	Black
Sewage Effluent Drain	Yellow-Brown	Yellow	Black
Water Supply from Meter to Air Gap	Aluminum	Aluminum	Aluminum
Domestic Water	Blue	Blue	Blue
Domestic Water Drain	Yellow-Blue	Yellow	Blue
Seal Water	Orange	Orange	Orange
Seal Water Drain	Yellow-Orange	Yellow	Orange
Washdown	Green	Green	Green
Washdown Drain	Yellow-Green	Yellow	Green
High Pressure Oil	Purple	Purple	Purple
Fuel Oil	Pink	Pink	Pink

#### 502.11 PIPE HANGERS AND SUPPORTS.

General. - All piping furnished and installed in buildings shall be properly and adequately supported and anchored by hangers, brackets, standard clamps, etc., as applicable, as shown on the plans, or, if not shown, as approved by the Engineer. Any lines which sway, crawl or vibrate shall be supported additionally and braced as necessary, or required. Pipe shall not rest on, nor hang from, other pipelines or equipment.

Plumber's tape or similar strap will not be considered an approved method of support.

Horizontal piping shall be supported in harmony with the exposed structure and, unless otherwise specified, at maximum intervals of ten feet with a separate hanger for each branch over six feet long. Vertical piping, unless otherwise specified, shall be supported by riser clamps at each floor level and at not over ten-foot intervals.

Hangers shall not be attached to the tension side of beams.

Expansion Shields. - All fastenings to concrete, other than inserts, shall be made by using Diamond Expansion Bolt Company expansion shields, Star Expansion double-interlocking expansion shields, or Western Expansion Bolt Company Forway machine bolt expansion shields, or equal; except as otherwise noted on the plans or specified in the Special Provisions.

Loads designated by the Engineer as minor may be supported with Philips Drill Company, or equal, flush shells.

Unless otherwise allowed, inserts shall be used for new construction.

#### 502.12 ESCUTCHEONS, SLEEVES AND FLASHING.

Escutcheons. - Chromium plated pressed steel floor and ceiling plates, unless otherwise specified, shall be furnished and set in place on all pipes that pass through finished floors, walls and ceilings in buildings. These plates shall be held securely in place with set screws and set with provision for the movement of the pipes.

Sleeves. - All pipes passing through rough holes made in existing concrete floors, walls and ceilings of buildings, unless otherwise

specified or shown on the plans, shall be operated by means of pipe sleeves made of galvanized sheet metal of gauge adequate for rigidity, approximately one inch larger in diameter than, and concrete with, the enclosed pipe and extending the full thickness of the concrete. Where piping is to be insulated, the sleeves shall allow for the full thickness of the insulation, plus one-half inch clearance all around. Pipe sleeves passing through such existing concrete shall have the spaces around the sleeves filled and neatly pointed with an approved cement mortar. Spaces between pipes, or pipes and insulation, and sleeves shall be first packed with oakum and then filled mastic at both ends.

All pipe passing through smooth machine-cored holes made in existing concrete floors, walls, and ceilings of buildings, unless otherwise specified or shown on the plans, shall have the same clearances, packing and mastic as specified hereinbefore.

Pipes shall pass through new building construction, existing concrete walls below grade and concrete floor slabs on ground as detailed on the plans or specified in the Special Provisions.

Flashing. - Flashing for all piping through roofs, unless otherwise specified, shall be made with sheet lead weighing not less than eight pounds per square foot and extending not less than ten inches in all directions from the pipe. A lead pipe collar of the same thickness, and not less than eight inches in height, shall be attached by a wiped joint. This flashing shall then be counter-flashed with a piece of lead pipe of the same thickness as the collar, turned down inside of the pipe and down over the lead flashing four inches.

502.13 CONTRACTOR TO CLEAN LINES. - After final assembly, but before making final connections to equipment, pumps, valves, meters, etc., and before final tests are made, the Contractor shall, unless otherwise specified, flush clean the inside of all lines by blowing with air, washing with water, or by other methods approved by the Engineer.

502.14 TESTING. - Except as otherwise specified or covered by San Francisco Plumbing and Gas Appliance Code, the Contractor shall subject all completed piping and appurtenances furnished and installed under the contract to a hydrostatic test pressure not less than that specified in the Special Provisions. Gravity drainage systems shall be tested by filling the system with water to the highest point of overflow or by subjecting the system to an equivalent pressure. Gauge pressure readings shall stay constant for one hour unless otherwise specified. If leaks exist, the Contractor shall make proper repairs and replacements and repeat the testing until the piping satisfactorily withstands the test pressure. Caulking of leaking threaded joints will not be permitted.

Upon completion of the hydrostatic tests, the Contractor shall put each portion of the work completed under the contract through an operational test, and shall adjust, correct, or properly repair, as the case may be, all leaks and malfunctions revealed by the test until the piping facilities are leakfree and operate properly, all as determined by, and the the satisfaction of, the Engineer.

The Contractor shall furnish all equipment, apparatus and materials necessary, or required, to properly conduct the tests.

All testing shall be done in the presence of the Engineer, and where applicable, in the presence of the Chief Plumbing Inspector or his authorized representative.

In order to expedite the work, piping facilities may be tested in sections, approved by the Engineer.

Testing of all underground piping shall be done prior to backfilling the pipe trenches.

The Contractor shall, when applicable, furnish at his own expense, a certificate of inspection from the Bureau of Building Inspection, Department of Public Works, City and County of San Francisco, certifying that all plumbing system and gas piping regulations have been carried out fully.

## SECTION 503

### DUCTWORK, APPURTENANCES AND ACCESSORIES

#### MATERIALS AND INSTALLATION

**503.01 GENERAL.** - All ductwork and appurtenance and accessories, including, where applicable, ducts, turning vanes, dampers, access doors, registers, grilles, diffusers, isolation joints, flexible connections, hangers, supports, etc., shall be as specified herein, or approved equal. All such ductwork and appurtenances and accessories shall be installed by the Contractor where and as shown on the plans, or where directed by the Engineer. All direct drive blower units and exhauster units shall comply with the applicable sections of the San Francisco Electrical Code.

**503.02 SHEET METAL DUCTS.** - The duct information shown on the plans is correct for design purpose. The Contractor may vary the location and proportions of the ducts as required by field conditions; however, the equivalent cross-sectional area must remain undiminished.

All ducts shall be diagonally creased for stiffness and all ducts located outside buildings shall be made weatherproof.

Changes in direction or elevation shall be made, wherever possible, only by curved sections, except as otherwise shown on the plans. Changes in sizes of ducts shall be made by uniformly tapering sections.

Every effort shall be made to keep the centerline radius ratio of elbows at 1.5 or more.

Metal ventilation ducts, except as otherwise specified, shall be constructed in accordance with the recommendations on construction for regular sheet-metal ducts or on construction for round and flat-oval ducts, as applicable, of the latest revision of the ASHRAE Guide and Data Book, or "Duct Manual and Sheet Metal Construction for Ventilation and Air Conditioning Systems" of SMACNA.

Bolted joints shall be made air-tight with approved chromate gasketing, 3/4-inch wide.

All field joints shall be taped for vapor and air-tightness with an approved tape.

Elbows and transition sections shall be formed with Pittsburgh corner seams.

Double compounded elbows and other complicated fittings shall be constructed with double-seam corners.



503.03 TURNING VANES. - All elbows having centerline radii of less than 1.5 times the width of the duct in the direction of the turn, including all square-turn elbows, shall be fitted with turning vanes so designed that each elbow loss will not exceed, by 10 percent, the normal loss in an elbow having a centerline radius 1.5 times the duct width. Turning vanes shall be riveted securely to the sides of ducts at the correct angle.

503.04 SPLITTER DAMPERS. - Adjustable splitter type deflector dampers, each of length equal to one-half the width of the duct, shall be furnished and installed where shown on the plans for branch ducts or wherever necessary to provide complete control for balancing air flows as called for on the plans. Dampers shall be constructed to conform to Figure "B," Plate No. 28, of SMACNA "Duct Manual and Sheet Metal Construction for Ventilating and Air Conditioning Systems" (with all supplements issued) and as shown on the plans. Each damper shall be located so that it will be readily accessible for inspection and adjustment. All metal parts shall be galvanized or treated with rust inhibitor after assembly.

503.05 ACCESS DOORS. - Access doors shall be provided on ducts at all fire damper locations and wherever access for cleaning and servicing of equipment will be required. Duct access doors shall be constructed to conform to Plates Nos. 30 and 31 of SMACNS "Duct Manual and Sheet Metal Construction for Ventilating and Air Conditioning Systems" (with all supplements issued) and as shown on the plans.

503.06 REGISTERS, GRILLES AND DIFFUSERS. - Registers, grilles and diffusers shall be as indicated on the plans or in the Special Provisions and shall be fitted with sponge or foam rubber gaskets under the rims to prevent smudging of adjacent surfaces.

503.07 ISOLATION JOINTS. - Dielectric isolation strips of an approved chromate gasket material shall be furnished and installed at all points of connection of aluminum and steel or of aluminum and brass.

503.08 FLEXIBLE CONNECTIONS. - Flexible connections, in general, shall be made with neoprene impregnated canvas, or other approved similar type connection material, designated to prevent the transmission of vibrations, and shall be attached securely to fans or blowers and ducts with metal bands and clamps, but not stretched too tightly.

Flexible connections between fans or blowers and ducts for sewage pumping and treatment plant ventilation systems shall be made with approved 32-ounce weight, heavy grade, fiber glass fabric coated with neoprene, which shall be resistant to alkalis, acids, corrosive gases, oils, solvents and grease, and shall withstand high pressures and vacuums. The fabric shall be fastened to fans or blowers and ducts with an approved nonpourable cement, applied in a band 1/8-inch thick by 4 inches wide and bonded securely in place with bolted 2-inch wide straps. The straps shall be tightened to allow a layer of nonpourable cement, 1/8-inch thick, to remain between the duct and the fabric to form a flexible vapor and pressure-tight joint.

503.09 HANGERS AND SUPPORTS. - Hangers and supports for ducts shall be furnished and installed to conform with the applicable Plates in the SMACNA "Duct Manual and Sheet Metal Construction for Ventilating and Air Conditioning Systems" (with all supplements issued) and as shown on the plans.

All sharp exposed angles and surfaces on hangers over, or adjacent to, walkways shall be rounded.

503.10 LOCATION OF DUCTS. - All ducts shall be run parallel and perpendicular to floors, walls and ceilings, and shall follow the general lines of rooms to make a neat and, where applicable, symmetrical, installation. All ductwork shall be located near the ceiling or shall hug walls in order to give a maximum of headroom and free space.

503.11 PROTECTION OF FANS IN SEWAGE PUMPING AND TREATMENT PLANTS. - The interior surfaces of ventilating fans, furnished and installed in sewage pumping and treatment plants, shall be painted with "Amercoat," or equal, material, which shall resist corrosion by hydrogen sulfide, ammonia and other common sewage gases and vapors under dry and wet conditions. Coatings and preparation shall be as follows:

Surfaces to be painted shall have all weld splatter removed, rough welds and sharp edges ground smooth, and shall be dry sandblasted to provide a surface free of all millscale, rust, paint or foreign matter. Immediately thereafter one prime coat of "Amercoat" No. 23 Prime Coat, or equal, shall be applied. After priming, two coats of "Amercoat" No. 23 Body Coat, or equal, and three Coats of "Amercoat" No. 33 Seal Coat, or equal, shall be applied. Total film thickness shall be not less than .010 inches (10 mils).

503.12 BALANCING OF VENTILATION SYSTEMS. - The Contractor shall balance the ventilation systems to provide the air quantities indicated on the plans for each outlet.

Immediately before balancing, all dampers shall be placed in a neutral position, the rotating equipment shall be lubricated and checked for proper rotation, and air filters shall be cleaned thoroughly.

The Contractor shall begin by taking readings across the supply or return fans with a calibrated anemometer, velometer or Pitot tube. Care shall be taken to obtain an average velocity over each face area. All registers, grills and diffusers shall then be read and adjusted to obtain the proper quantity and diffusion of air in each area. After all dampers have been adjusted and the systems are balanced, the Contractor shall submit to the Engineer six copies of a list of all outlets indicating the outlet location, air quantity in cubic feet per minute, and air velocity in feet per minute. In addition, the Contractor shall list the fan speed and motor speed, current and voltage.

The Contractor shall furnish all testing equipment and materials necessary, or required, for balancing of the air systems, all subject to the approval of the Engineer.

END PART 5

PART 6  
ELECTRICAL WORK  
SECTION 600  
GENERAL REQUIREMENTS

600.01 STANDARDS AND CODES. - The following are the standards and code applicable to electrical work. The latest revision at the time of receipt of Bids shall be used.

American National Standards Institute (ANSI)

American Society for Testing and Materials (ASTM)

American Wire Gage (AWG)

California Administrative Code, Title 8, Subchapter 5

California Administrative Code, Title 24

Electrical Safety Orders

General Order 95 of the Public Utilities Commission

Institute of Electrical and Electronic Engineers (IEEE)

Institute of Traffic Engineers (ITE)

Insulated Power Cable Engineers' Association (IPCEA)

National Electrical Code (NEC)

National Electrical Manufacturers Association (NEMA)

National Electrical Safety Code (NESC)

National Fire Protection Association (NFPA)

Occupational Safety and Health Act (OSHA)

Rules for Overhead Electrical Line Construction

San Francisco Electrical Code (SFEC-84)

Underwriters' Laboratory (UL)

600.02 PERMITS. - The Contractor shall obtain, at his own expense, prior to start of any electrical work in buildings and in other locations outside of street areas, all necessary permits from the Department of Public Works for the work covered by the specifications,

and shall deliver the certificate of final inspection to the Engineer upon completion of the work. City work is exempt from electrical permit fees.

**600.03 ADJUSTMENT OR RELOCATION OF EXISTING FACILITIES.** - If required to permit the prosecution of the work, the adjustment or relocation, as approved by the Engineer, of existing electrical conduit and contained wires, existing pipes or existing ducts, where such conduit and pipes are 1-1/4 inches or less in nominal diameter and the ducts are one square foot or less in cross-sectional area, shall be considered Incidental Work. The adjustment or relocation of larger sized existing facilities, however, unless specifically indicated for such adjustment or relocation on the plans or in the Special Provisions, if necessary, as determined by the Engineer, shall be done as directed, as Extra Work in accordance with the requirements of Section 112.

**600.04 FLOOR, WALL AND CEILING OPENINGS.** - The Contractor shall secure the Engineer's approval of the locations for holes and openings in floor, walls and ceilings, necessary for the installation of electrical equipment, conduit, and appurtenances, and shall keep to a practicable minimum the size of such holes and openings. All requirements of Section 500.04 shall apply to the work under this Section, except that the use of any type of impact drill will not be permitted in basement walls or in sidewalks directly above basements.

**600.05 UNINSPECTED WORK NOT TO BE CLOSED IN.** - The Contractor shall not cover up nor enclose any of his work until it has been tested by him in the presence of the Engineer if testing is required, and until it has been inspected and approved by the Engineer. Should any of the work be enclosed or covered up before such testing and inspection, the Contractor shall, at his own expense, uncover the work and, after it has been tested, inspected and approved, restore such covering and enclosure.

**600.06 ELECTRIC SERVICE.** - The City will order the required electric services and pay all costs directly to the Pacific Gas and Electric Company. Any service equipment, materials and connections that are the responsibility of the Contractor shall comply with the current rules of the Pacific Gas and Electric Company.

For service other than for street lighting or traffic signals, the Contractor shall communicate with the Pacific Gas and Electric Company to determine the extent of the work that Company will perform, and the labor and materials the Contractor must furnish.

The Contractor shall make all arrangements with the Pacific Gas and Electric Company for the connection of electric services and, if required, for the installation of meters.

The Pacific Gas and Electric Company will make electric connections in their service handholes and manholes, and will install pole riser conduit and wiring from their service poles to the City pull box adjacent to each such pole.

Conduit and conductors from the work to handholes and manholes for service connections shall be furnished and installed by the Contractor, and will be paid for under the appropriate Bid item when conduits are bid at unit prices.

The Contractor shall be responsible for all materials and services required of him and for all charges by the Pacific Gas and Electric Company for energy used during testing and adjusting of the work, or for energy supplied for construction purposes. He shall do such work, furnish such materials and pay such charges as Incidental Work, payment for which shall be included in the price or prices bid.

600.07 BONDING AND GROUNDING. - All steel conduits terminating in manholes, pull boxes, and bases of standards and traffic signal controller shall be effectively bonded, both together and to exposed metallic surfaces of traffic signal controllers, metal standards and other equipment, by means of grounding bushings, bonding jumpers, grounding "studs" and screw-type pressure solderless lugs, as applicable.

Materials and devices used for bonding and grounding shall be in accordance with the requirements of Section 607 and wherever employed in this regard, the machine screws, lock washers and nuts shall be stainless steel.

Conduit bushings with grounding wedges and lock nuts may be substituted for grounding bushings.

The Contractor shall furnish and apply an anti-oxidant coating on all exposed junctions of bonding and grounding materials.

600.08 SERVICE INTERRUPTIONS. - Where work under the contract requires connection to existing services and it is necessary to keep the existing facilities in operation, as determined by the City, all service interruptions shall be held to a minimum and shall be scheduled in advance by the Contractor and approved by the Engineer.

Extra shifts of work resulting from the requirement that service cut-over operations be made at other than regular working hours, shall be done at no additional cost to the City.

600.09 SAFEGUARDING FIRE ALARM SYSTEMS. The Contractor shall not cut into any existing City fire alarm conduit, shall not disturb, splice or cut any existing City fire alarm wiring, and shall take every precaution necessary, or required, to protect such conduit and wiring.

He shall be responsible for the repair or replacement, as required, to the satisfaction of the General Manager of the Department of Electricity and the Engineer, of any damage to existing fire alarm facilities resulting from his operations.

600.10 WORK AT UTILITY FACILITIES. - The Contractor shall conduct his work in manholes, vaults, handholes, and pull boxes of the Pacific Bell Company, the Pacific Gas and Electric Company, the Public Utilities Commission of the City and County of San Francisco, the Department of Electricity, and in all other such facilities not owned by the Department of Public Works, in strict accordance with the requirements of the owners thereof. He shall notify the owners of manholes, vaults, handholes, and pull boxes at least 48 hours before commencing work therein.

The Contractor shall not commence the installation of conduit into any manhole, vault, handhole, or pull box until an authorized representative of the owner thereof has designated the point of entry of the conduit. The Contractor shall install the conduit where designated.

Conduit installed to utility company manholes or handholes shall terminate within the wall thereof at a point 3/4-inch from the inside face of wall. The manhole or handhole wall shall be refinished and rounded off with Class B mortar to conform to the interior surface.

The Contractor shall not connect or disconnect any wire or cable, except that exclusively for traffic signal control, in any such manhole or vault.

All persons entering or leaving manholes or vaults shall do so only by ladders, so as to avoid damage to cables and other facilities.

Suitable barricades shall be placed around each open manhole, handhole, or pull box, and a flagman shall be stationed at the manhole during the entire time the manhole cover is off, in accordance with the applicable requirements of Section 110.12.

#### 600.11 NAMEPLATES, SIGNS, AND MARKINGS.

General. - Unless otherwise specified on the plans or in the Special Provisions, the Contractor shall furnish and install nameplates and signs in accordance with the following provisions:

Nameplates. - The following shall be equipped with nameplates:

1. All motors, motor starters, motor control centers, control stations, control panels, and time switches;
2. Disconnect switches, fused or unfused; switchboards and panelboards; circuit breakers, contactors, relays, or other control devices in separate enclosures;
3. Power receptacles where the nominal voltage between any pair of contacts is greater than 150 volts;
4. Wall switches controlling outlets for lighting fixtures or equipment, where the outlets are located not within sight of the controlling switch;
5. Telephone, intercom, radio, television and other special electrical systems shall be properly identified at junction and pull boxes, terminal cabinets, and equipment racks;
6. Signal outlets, such as antenna, radio, television, microphone, audio-visual, and controls, such as volume controls and channel selectors; and
7. High voltage boxes and cabinets. (above 600 volts)

In addition, terminal blocks shall be furnished with legend strips, properly inscribed with circuit function or to correspond with notations on pertinent wiring diagrams. Legend strips shall be enclosed in clear plastic sheathings.

Nameplate inscriptions shall adequately describe the function or use of the particular equipment involved, and shall be subject to approval of the Engineer. Where nameplates are detailed on the plans, inscription and size of letters shall be as shown.

Nameplates for panelboards and switchboards shall include the panel designation, voltage and phase of the supply; for example: "Panel A. 277/480V, 3ph. 4W".

The name of the machine on the motor nameplates for a particular machine shall be exactly the same as that used on all motor starter, disconnect and control station nameplates for that machine.

Nameplates shall be laminated phenolic plastic, black front and back with white core, with lettering etched through the outer covering. Lettering shall be 3/16-inch high at control stations, thermal overload switches, receptacles, wall switches and similar devices, where the nameplate is attached to the device plate. At all other locations, lettering shall be 1/4-inch high, unless otherwise detailed on the plans. Nameplates shall be securely fastened to equipment with No. 4 Phillips, round-head, cadmium-plated steel selftapping screws or nickel-plated brass bolts.

Motor nameplates may be of non-ferrous metal not less than 1/16-inch thick, die stamped.

In lieu of separate plastic nameplates, engraving directly on device plates is acceptable, if approved by the Engineer. Engraved lettering shall be filled with either black or white enamel, as determined by the Engineer.

Warning Signs. - Warning signs shall be furnished and installed in accordance with the following provisions:

1. On enclosures containing high voltage equipment, the signs shall read, "DANGER - HIGH VOLTAGE - DO NOT ENTER." Signs shall be 7 inches x 14 inches, with all lettering 1 inch high, except the word "DANGER" which shall have 1-1/2-inch high letters. The aforementioned dimensions are minimum requirements.
2. On non-load disconnects and cutouts, the signs shall read "DO NOT OPEN UNDER LOAD." Letters shall be 1 inch high, minimum.

Warning signs shall be of standard manufacture, fabricated of No. 18-gauge steel, or heavier, with a procelain enamel finish. Letters shall be red on white background.

High Voltage Marking. - All high voltage boxes, cabinets, and conduits in exposed or accessible locations shall be marked with the letters "HIGH VOLTAGE." Markings shall be either by means of stenciling or with approved, pressure sensitive, self-adhesive markers.

The markings shall be located so as to be readily conspicuous at all times from any reasonable vantage point. All surfaces to be identified shall be dry and clean of any dirt, grease or loose surface material before application of markers. Backing cards shall be removed and installation completed in accordance with the manufacturer's instructions.

Letters shall be black on orange background, not less than 1-7/8 inches high. If the dimensions of the surfaces to be marked deem the use of 1-7/8-inch high letters impracticable, then a smaller size lettering shall be used, all as determined by the Engineer. On conduit runs, markings shall be applied at intervals not exceeding 10 feet in any

individual area. All markings shall be made after painting of all other work under the contract has been completed. Freehand lettering will not be acceptable.

600.12 WIRING DIAGRAMS. - Accurate, complete as-built wiring diagrams consisting of one or more good quality transparencies (sepias are not acceptable) and two sets of prints shall be furnished for each panel, cabinet or enclosure which houses electrical and electronic equipment, communicating equipment, controls and protective devices or which are used as wiring termination panels or cabinets. One set of the prints shall have each print laminated in clear plastic and attached to the inside of the door for single diagrams or enclosed in a clear heavy-duty plastic envelope and placed in a document holder or pocket mounted on the inside of the door for multiple diagrams. New single print wiring diagrams shall be furnished with brass eyelets, stainless steel screws, nuts, shakeproof washers and brass springs for attachment means.

In addition, the Contractor shall furnish and install a new wiring diagram in existing cabinets to which he has made modifications or circuit changes, or when modifications or circuit changes made by him affect the existing equipment within the cabinets. Existing wiring diagrams shall remain the property of the City, and the Contractor shall deliver them to the Engineer. Each replacement wiring diagram shall be properly dated, and shall make reference to the origin and number of the diagram it supersedes.

600.13 PRESERVATION AND CLEANING. - After all other work in the area, including sanding and painting has been completed, electrical equipment such as lighting fixtures, panelboards and switchboards shall be cleaned to remove all dust, dirt, grease or other marks, and the work left in a condition satisfactory to the Engineer.

600.14 MAINTAIN EXISTING ELECTRICAL EQUIPMENT IN SERVICE.

General. - Existing electrical equipment or approved temporary replacements shall be kept in operation throughout the life of the contract.

The duration of each shutdown period shall be kept to a minimum by proper planning and preparation, and the provisions of Section 110.08 shall be observed.

Before commencing the work, the Contractor shall submit in writing to the Engineer a description and detailed schedule of his intended operations relative to keeping the electrical equipment in operation as hereinbefore specified. Such schedule shall be part of the Progress Schedule required by Section 107.04.

The Contractor shall furnish and install whatever temporary or permanent conduit, wiring, and equipment is necessary, shall make all connections and shall do all other work necessary to maintain normal operation. At the conclusion of the need therefore the Contractor shall remove all temporary facilities from the site.

The Contractor shall temporarily relocate existing City-owned equipment required to be maintained in service until replaced, where the present location thereof conflicts with an installation under the contract.



The Contractor shall be completely responsible for the maintenance and continuity of operation of any temporary electrical facility installed by him.

Before final acceptance of the work the costs of any emergency work necessary to be performed by City or other forces to repair any facility installed or damaged by the Contractor, including all investigative work relative thereto, shall be borne by the Contractor.

The cost of electrical energy required for any temporary facility will be borne by the City but the Contractor shall bear all costs of any temporary service connections.

Traffic Signals and Street Lights. - Shut down of traffic signal systems will be allowed during the period from 9:00 A.M. to 4:00 P.M. subject to prior approval by the Engineer. Lighting system shutdowns shall not interfere with the regular lighting schedule unless otherwise permitted by the Engineer.

The Contractor shall notify the Engineer and the Department of Electricity, 901 Rankin Street, Telephone No. (415) 821-5591, at least 24 hours in advance of removing, disconnecting or doing any work on any existing traffic signal equipment, wiring or conduit, or placing in service any traffic signal equipment installed under the contract. Further, in the case of placing in service newly installed signal equipment, he shall similarly notify the Bureau of Traffic Engineering and Operations, Telephone No. (415) 558-3371.

Traffic signal controllers shall be first placed in operation only on Tuesday, Wednesday or Thursday between 9 a.m. and 4 p.m., provided such days do not precede a holiday.

In the event it is foreseen that the Contractor cannot complete the work to restore any existing traffic signal to normal service before 4:00 p.m., he shall install or reinstall temporary wiring at his own expense, to put such equipment in service by that time.

Lamps in traffic signal heads or luminaires installed or relocated by the Contractor that burn out during the life of the contract shall be replaced by him with new, approved equal lamps.

The Contractor shall notify the Engineer and the Bureau of Light, Heat and Power, Tel: 550-6507, 24 hours in advance of the time he will place new street light equipment and circuit in service or request clearances to work on or interrupt existing high voltage street lighting circuits.

Disconnection of any existing or temporary street lights will not be permitted until the new equipment has been tested and properly adjusted.

#### 600.15 UNDERGROUND WORK.

Removing and Replacing Improvements. - Improvements such as sidewalks, curbs, gutters, portland cement concrete and asphalt concrete pavement, underlying material, lawns and plants, and any other improvements removed, broken or damaged by the Contractor's operations shall be replaced or reconstructed with the same kind of material as found on the work or with materials of equal quality. The new work shall be left in a serviceable condition.

Whenever a part of a square or slab of existing concrete sidewalk, curb, gutter, or driveway is broken or damaged, the entire square,

section or slab shall be removed and the concrete reconstructed as above specified.

The outline of all areas to be removed in concrete sidewalks and driveways and in pavement shall be cut to a minimum depth of 0.17-foot with an abrasive type saw prior to removing the sidewalk, driveways and pavement material. Cuts shall be neat and true along score lines, with no shatter outside the removal area.

The excavations required for the installation of conduit, foundations, and other appurtenances shall be performed in such a manner as to avoid any unnecessary damage to streets, sidewalks, landscaping, and other improvements. The trenches shall not be excavated wider than necessary for the proper installation of the electrical appurtenances and foundations. Excavation shall not be performed until immediately before installation of conduit and other appurtenances. The material from the excavation shall be placed in a position that will not cause damage or obstruction to vehicular and pedestrian traffic nor interfere with surface drainage.

Foundations from which electrical equipment has been removed and which are not to be reused in the work, as well as excavated materials not suitable for backfilling of constructing embankment, and all surplus excavated materials, shall be removed from the site by the Contractor as his property within 48 hours and disposed of in a legal manner.

Rock Cutter. - Conduits may be installed under roadway pavement by use of rock cutter in accordance with the following requirements:

Prior to starting trenching operations, the Contractor shall:

1. Notify all utility companies and have them mark the locations of their underground facilities on the pavement.
2. Use a pipe locator or other means to determine the depth of any pipe or conduit within the proposed trench line and to the depth of the proposed conduit installation.

The Contractor agrees that if any existing underground facilities are damaged due to his trenching operations that he will pay the cost to repair such damaged facilities.

Conduit shall be placed under existing pavement in a trench approximately 2 inches wider than the outside diameter of the conduit to be installed. Trench width shall not exceed 6 inches. The top of the installed conduit shall be a minimum of 9 inches below finish grade.

The outline of all areas of pavement to be removed shall be cut to a minimum depth of 3 inches with an abrasive type saw or with a rock cutting excavator specifically designed for this purpose. Cuts shall be neat and true with no shatter outside the removal area. Dust control shall be provided by using water with the cutting wheel.

The conduit shall be placed in the bottom of the trench and the trench shall be backfilled with commercial quality concrete, containing not less than 564 pounds of cement per cubic yard, to not less than 2-inches below the pavement surface for asphalt-surfaced roadways and 6-inches below the pavement surface for portland-cement concrete-surfaces roadways. This concrete backfill shall be colored red to serve as a warning for future excavations of the location of the installed conduit. The top 2-inches of asphalt surfaced roadways shall

be backfilled with asphalt concrete produced from commercial quality paving asphalt and aggregates, and the top 6-inches of portland cement concrete surfaced roadways shall be backfilled with commercial quality concrete containing not less than 705 pounds of cement per cubic yard and accelerating admixtures or other provisions of high-early strength. Calcium chloride shall not be used in concrete which will be in contact with metal conduit.

Spreading and compacting of asphalt concrete shall be performed by any method which will produce an asphalt concrete surfacing of uniform smoothness, texture, and density.

Spreading and finishing of portland cement concrete surfacing shall be performed by any method which will produce a portland cement concrete surfacing of uniform smoothness, and texture equal to the adjacent surface.

Except in intersection areas the alignment of the trench shall be adjacent to the concrete parking strip or gutter or where directed by the Engineer.

All trenches shall be backfilled with concrete the same day they are cut. The 2-inch asphalt concrete wearing surface shall be restored on these trenches no later than 3 working days after trenching.

All City noise requirements shall be observed in all operations.

**600.16 PAINTING.** - All electrical equipment furnished and installed by the Contractor shall be painted unless it is factory painted. Existing equipment worked on by the Contractor shall be touch up painted. All painting done by the Contractor shall be according to Section 809.

Equipment cabinets, switchboards, and enclosures for which factory paint is available shall be factory painted. Factory paint shall be by electrodiposition process or equal. It shall consist of one prime coat and two coats of finish at the minimum. The finish shall have a dry film thickness of at least 3 mils. The finish outside color shall be ANSI 61 light gray and the finish inside color shall be ANSI 70 off-white.

All exposed conduits shall be painted to blend in with the background.

For street lighting and traffic signal work, all metal surfaces except luminaires and stainless steel screws shall be painted as follows:

**Prime Painting.**

**First Coat:** One (1) application of a zinc dust-zinc oxide paint conforming to the requirements of Federal Specification TT-P641, Type II, applied immediately following the completion of all pre-painted preparations.

**Second Coat:** One (1) application of a pre-treatment vinyl wash primer conforming to the requirements of Caltrans Standard Specifications Section 91-2.07. The vinyl wash primer shall be applied by spraying or brushing to produce a uniform wet surface.

City furnished traffic signal standards shall be primed with one (1) coat of the zinc dust-zinc oxide paint specified above.

Finish Painting.

Two (2) separate and complete applications of finish paint shall be applied. Paint for the first application shall be tinted with a compatible coloring agent to slightly contrast with the color of the final application.

The paint used for the finish coats shall be one of the following:

1. Stainless Steel Beige Enamel - Federal Specification TT-E-1593;
2. Alkyd Gloss Medium Gray Enamel - Federal Specification TT-E-489f;
3. Traffic Signal Dark Olive Green Enamel - Caltrans Standard Specifications, Section 91-4.02;
4. White Enamel - MIL-E-1115A
5. Aluminum Paint - Caltrans Standard Specifications, Section 91-2-2.08; and
6. Stenciling Paint - Federal Specification TT-P-98B.

The total thickness of applied paint at all points shall be not less than 5 mils.

600.17 TESTING.

General.- Whenever a unit is shipped in more than one piece, it shall be assembled to assure that it fits together and shall be tested as specified with all componentes assembled by the Contractor.

Factory Testing. - Electrical equipment units in bulk quantities (cables, panels, lighting transformers, etc.) of the same or similar type, rating, class, and characteristics shall receive a full factory performance test on the first unit, or when specified, the first unit of each batch.

Major electrical equipment units (motor control centers, switchgear, power transformers, engine/generator sets, ets.) each shall be fully factory tested per applicable standards.

All factory test results shall be documented, and copies identifying the applicable equipment unit shall be submitted to the Engineer.

Functional Testing. - Prior to start of functional testing, the Contractor shall perform the following tests in the presence of the Engineer.

Continuity - Each circuit shall be checked and tested for continuity.

Ground - Each circuit and equipment with grounding provision shall be checked and tested for grounds.

Circuits to be energized with a line-to-line voltage of 250 volts or more shall receive insulation resistance tests. These tests shall be made after all equipment has been connected. The insulation shall be tested with a 500 volt d.c. insulation resistance tester with a scale reading 100 megohms. The insulation resistance shall be 30 megohms or more.

A functional test shall be made by the Contractor, in the presence of the Engineer, in which it is demonstrated that each and every part of the system functions as specified. Each test shall be performed three times.

## SECTION 601

### RIGID STEEL CONDUIT, GALVANIZED

601.01 GENERAL. - The Contractor shall furnish and install galvanized rigid steel conduit complete with fittings and appurtenances, where and as shown on the plans or where required, including all excavating, backfilling, restoring pavement, and other Incidental Work necessary or required for a complete, legal and satisfactory installation.

601.02 MATERIAL. - Rigid steel conduit, including couplings, elbows, and nipples, shall be new, first quality, standard weight, wrought steel, galvanized on the exterior and interior surfaces and furnished with plastic thread protectors. Galvanizing shall be by hot-dipping, electroplating, sherardizing, or metallizing process, and shall meet the latest requirements of the National Electric Code. Each length shall bear the label of the Underwriters' Laboratories, Inc., and the name of the manufacturer.

All surfaces of conduit and fittings shall be free of obstructions, projections, roughness, blisters, scale, sharp edges and rust.

All conduit fittings, such as couplings, elbows, outlet boxes, junction boxes, caps and locknuts, shall be threaded fittings, and, together with covers therefor, shall be galvanized ferrous material.

Covers shall be furnished with neoprene gaskets cemented thereto and stainless steel screws. Gasket cement shall be of the type approved for automotive engine application. Non-cemented surfaces of gaskets shall be coated with a lubricant containing silicon and of the type approved for application on rubber-like materials.

Hot dipped galvanized rigid steel conduit shall be used for all installation underground, outdoors above ground, and cast in concrete.

Rigid steel conduit for above ground use in buildings, except conduit buried in concrete, may have sherardized or equivalent coating.

### 601.03 INSTALLATION.

General. - Rigid steel conduit shall not be cut with pipe cutters but shall in all cases be cut with a hack saw. Both ends of every length and piece of conduit shall be carefully reamed open to the full diameter, and all burrs and sharp edges shall be removed. Threads shall be cut clean and true with sharp dies. No connections shall be made with defective threads. No pipe fittings, except caps, shall be used. Three piece union couplings shall be used at each point of conduit union. All conduit and screwed fittings shall be securely tightened and installation made in a workmanlike manner.

Except for indoor work in dry locations, the external threads only of all steel conduit and fittings, except at grounding bushings, shall be well painted with conductive pipe joint compound before assembly, so that the compound will not be forced into the conduit in tightening the

joints. The heating of any metallic conduits for the purpose of bending is prohibited.

All conduit, including existing conduit intended for reuse, damaged on the job, before and during installation, shall not be used in the work, and shall be removed from the job site immediately.

Conduit shall be brought into pull boxes and junction boxes in such a manner that sufficient space is allowed for proper bonding of the conduits. All conduit shall be installed so that the cable or wire will not be damaged in pulling.

After installation, the Contractor shall clean out all new and reused conduits by pulling a mandrel or steel brush, approved by the Engineer, through each run. At all stages of the work, everything possible shall be done to prevent foreign material from entering conduits.

All ends of conduit not immediately connected or used shall be capped. After conductors have been installed, the ends of conduits terminating in pull boxes and control enclosures shall be sealed with an approved type of sealing compound.

Conduit fittings shall be installed with the cover facing the installer, and so that the cover screws are accessible and not obstructed. The Contractor shall furnish and install all necessary fittings for attaching the conduit at its entrance to equipment.

Where metallic conduits enter panel boxes, pull boxes, or outlet boxes, except where entering concrete pull boxes, the conduits shall be secured in place by galvanized locknuts and bushings, one locknut inside and one locknut outside the box, and a bushing on the conduit end, all drawn tight to insure perfect electrical and mechanical contact. The locknuts shall be tightened against the box without deforming the box. Insulating bushings shall be installed as required by code. Insulating bushings shall have the insulating material permanently fastened to the fittings.

The installation of conduit, to facilities of utility companies or to facilities not owned by the Department of Public Works, shall be in accordance with the requirements of Section 600.10.

Where existing conduits are shown on the plans to be reused and any portions thereof are damaged or the ends and terminal elbows thereof are rusted or lack threads, the Contractor shall furnish and install conduit, elbows and nipples to replace the existing conduit. Such conduit replacement will be paid for as Extra Work. Such Extra Work will be approved only if, in the opinion of the Engineer, the Contractor has made every reasonable effort, including the use of compressed air and approved lubricants and solvents, to use the existing conduit; further, the Extra Work will be subject to the limitation that work to the extent specified to be alterations shall be done as Incidental Work.

On Structures. - Where conduit runs are exposed, whether singly or in multiple runs, whenever possible they shall be installed straight and true, parallel with respect to each other and the adjacent construction, or perpendicular thereto.

Neither perforated strapping nor steel wire will be acceptable as conduit supports. Conduit clamps for surface mounted conduits on steel poles shall be attached using stainless steel round head screws.

A minimum separation of 6 inches shall be maintained between conduits and steam or hot water lines.

Except for offsets required to connect conduits to enclosures, all changes in directions of conduit runs installed on walls and structures shall be made with condulets of the approved type.

Holes drilled for conduit through walls and other structural members shall be completely sealed around the conduit with caulking and waterproofing compounds in accordance with recommendations of the manufacturer.

Surface mounted conduit on poles and standards shall be installed on the side opposite the roadway or intersection.

The use of an impact rotary type drill for drilling holes through concrete walls is prohibited.

Conduit and conduit clamps installed on structures, and basement and other concrete walls and ceilings, shall be primed with one coat of Subox Incorporated, Subalox No. 111FD, or Dupont No. 67-Y-744, or equal primer, and finish painted with one coat of approved aluminum paint, all in accordance with the requirements of Section 809.

Each conduit run in basements shall be identified with one-inch high letters stenciled in black at intervals not greater than 18 feet.

Underground. - The Contractor shall lay underground conduit in open trench, except that he may install rigid steel conduit in the ground by opening sections of trench and pushing the conduit from one opening to the next without breaking the surface between openings. However, conduit may be jacked only by a machine which does not rotate the conduit and which applies a constant pushing or pulling force, not impact, provided that the conduit is not damaged nor the galvanized coating removed, and provided that existing underground facilities will not be damaged.

In addition, jacking of conduit will be permitted only when the conduit is preceded by a fitting having a diameter twice that of the conduit being installed. Such a fitting may be a section of conduit or pipe with a reducing coupling and square head pipe plug on the lead end, and a reducing coupling of the proper size on the other end.

If jacking of conduit is employed, inspection holes shall be opened, as required, for the Engineer to determine compliance with the requirements for depth and line.

Except as hereinafter specified, conduit shall not be installed at a depth greater than 36 inches below pavement surface, nor 30 inches below ground surface in unpaved areas; and minimum depth of conduit shall be 24 inches in roadway areas and 18 inches in sidewalk and unpaved areas.

If an existing pipe or duct is in the path of, or obstructs, the laying of underground conduit at normal depth, and if such pipe or duct extends to a depth greater than 3 feet, the conduit shall cross over the pipe or duct. If such pipe or duct extends only to a depth of 3 feet or less, the conduit shall cross one foot below the pipe or duct.

Conduit installed beneath railway track beds shall be installed one foot below the bottom of the ballast bed.

Where parallel runs of conduits are installed in a common trench, such conduits shall have a minimum separation of two inches.

Conduit holes through any underground walls shall be filled as specified for bridge abutment walls.

Where basements exist under sidewalks in the path of conduit runs, the Contractor shall notify the owners of the affected buildings and

arrange for installing the conduit in each such basement. Conduit placed in basements under sidewalk shall be attached to the street retaining wall of the basement or shall be supported from the sidewalk structure immediately adjacent to the retaining wall as determined by the Engineer.

Where underground conduit changes direction, long radius sweeps shall be used instead of short bends, and in no case, except at foundations or where otherwise specified, shall a bend radius of less than 30 inches be used. Bends at foundations or other underground structures shall be of maximum possible radius, in no case less than 12 times the internal diameter of the conduit. Conduit shall not be flattened in bending, and shall be free of kinks and indentations. In addition, unless otherwise directed, the maximum number of bends in any conduit run shall be as follows: a run of conduit between the bases of standards and controller pedestals shall not contain more than the equivalent of two 90° and one 45° bends; a run of conduit between pull or junction boxes shall not contain more than the equivalent of three 45° 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° and one 45° bend.

601.04 PAYMENT. - Rigid steel conduit, galvanized, of each size, if the Proposal does not contain a Bid Item therefor, shall be furnished and installed as Incidental Work and payment therefor shall be included in the price or prices bid.

If the Proposal contains a Bid Item or Bid Items for rigid steel conduit, galvanized, each size thereof for which there is a Bid Item, satisfactorily furnished and installed, complete in place, as specified, will be paid for at the price bid per linear foot.

The quantity to be paid for will be the aggregate length of conduit measured along the actual longitudinal centerline, thereof in place, including all fittings, bends, elbows and bushings in the conduit runs. The length of any fitting connecting sections of conduit of different sizes will be included in the length of the larger size conduit.

If the Proposal includes a Bid Item or Bid Items, other than for conduit, specifically for or specifically including appurtenances such as pull boxes and junction boxes, no deduction will be made from the aggregate length of conduit because of such appurtenances in the conduit run.



## SECTION 602

### ELECTRICAL METALLIC TUBING

**602.01 GENERAL.** - The Contractor shall furnish and install electrical metallic tubing complete with fittings and appurtenances, where and as shown on the plans or where required, including all Incidental Work necessary or required for a complete, legal, and satisfactory installation.

All applicable requirements for rigid steel conduit and fittings and the installation thereof shall apply equally to electrical metallic tubing and fittings.

**602.02 MATERIAL.** - Electrical metallic tubing shall be cold rolled steel tubing with a zinc coating on the outside and a protective enamel coating on the inside.

Fittings shall meet the same requirements for finish and materials as electrical metal tubing.

**602.03 INSTALLATION.** - Electrical metallic tubing may be used at the following locations only:

1. In furred spaces.
2. In partitions other than concrete or solid masonry
3. For exposed work above switch height indoors, except on boiler structures or in refrigerated rooms.
4. In hollow concrete block walls, in the vertical cells or horizontal courses not containing steel.

**602.04 PAYMENT.** - Electrical metallic tubing shall be furnished and installed as Incidental Work and payment therefor shall be included in the price or prices bid.

## SECTION 603

### FLEXIBLE CONDUIT

**603.01 GENERAL.** - The Contractor shall furnish and install flexible conduit, complete with fittings and appurtenances, where and as shown on the plans or where required, including all Incidental work necessary or required for a complete, legal, and satisfactory installation.

All applicable requirements for rigid steel conduit and fittings and the installation thereof shall apply equally to flexible conduit and fittings except that flexible conduit shall not be installed buried in the ground or embedded in concrete.

**603.02 MATERIAL.** - Flexible conduit shall be spirally wound continuous length steel strip with a continuous zinc coating. Fittings shall be of an approved type which clamp the flexible conduit securely to the fitting.

Liquid-tight flexible conduit shall be hot-dip galvanized, spirally wound continuous length steel strip, with continuous extruded polyvinyl covering and watertight connectors.

603.03 INSTALLATION. - The installation of flexible conduit shall be in accordance with the following requirements:

1. All flexible conduit installed in outdoor or damp locations and inside refrigerated rooms shall be liquid-tight type.
2. Flexible conduit shall be used for connection of all motor terminal boxes to conduit stubs, outlets or junction boxes. Flexible conduit connecting to splash-proof or totally-enclosed motors shall be liquid-tight type, regardless of location. Where motors are mounted on sliding bases, the flexible connection shall be of sufficient length to allow full travel of motor on base.
3. Continuity of equipment ground shall be obtained by installing inside the conduit a bonding wire, each end of which shall be attached to an outlet or junction box by separate lugs for each wire.

603.03 PAYMENT. - Flexible conduit shall be furnished and installed as Incidental Work and payment therefor shall be included in the price or prices bid.

## SECTION 604

### RIGID PLASTIC CONDUIT

604.01 GENERAL. - The Contractor shall furnish and install rigid plastic conduit, complete with fittings and appurtenances, where and as shown on the plans or where required, including all Incidental Work necessary or required for a complete, legal, and satisfactory installation.

All applicable requirements for rigid steel conduit and fittings and the installation thereof shall apply equally to rigid plastic conduit and fittings.

Rigid plastic conduit and fittings shall be impervious to soil or environmental chemicals, and that for use underground shall be designed for direct burial and shall have a minimum wall thickness of 1/8 inch. Only virgin materials shall be used in the manufacture of rigid plastic conduit. Such conduit containing reclaimed materials will be rejected.

Rigid plastic conduit and fittings shall be designed for solvent-weld joining.

604.02 INSTALLATION. - Cover for rigid plastic conduit shall be as specified in Section 601.03 except that, if not encased in concrete, the minimum cover shall be 30 inches measured from the finished ground or pavement grade, as the case may be.

Connections shall be made in accordance with the manufacturer's recommendations, a copy of which the Contractor shall give to the

Engineer in the field. All joints shall be made watertight and vapor-proof. All conduit shall be kept clean during construction.

After the conduit has been aligned, proper fill material shall be placed and carefully and firmly tamped under, around and over the conduit with hand tampers, in accordance with the requirements of Section 703.

604.03 PAYMENT. - Rigid plastic conduit, of each size, if the Proposal does not contain a Bid Item therefor, shall be furnished and installed as Incidental Work and payment therefor shall be included in the price or prices bid.

If the proposal contains a Bid Item or Bid Items for rigid plastic conduit, each size thereof, for which there is a Bid Item, satisfactorily furnished and installed, complete in place, as specified, will be paid for at the price bid per linear foot.

The quantity to be paid for will be as specified in Section 601.04.

## SECTION 605

### PLASTIC COATED RIGID STEEL CONDUIT

605.01 GENERAL. - The Contractor shall furnish and install plastic coated rigid steel conduit, complete with fittings and appurtenances, where and as shown on the plans or where required, including all Incidental Work necessary or required for a complete, legal and satisfactory installation.

All applicable requirements for rigid steel conduit and fittings and the installation thereof shall apply equally to plastic coated rigid steel conduit and fittings except as otherwise specified herein.

605.02 MATERIAL. - Conduit shall be as specified for rigid steel conduit, galvanized. Conduit shall be coated with polyvinyl chloride or polyethylene. The exterior thermoplastic coating shall have a minimum thickness of 35 mils.

605.03 INSTALLATION. - Plastic coated conduit shall be cut only with pipe cutters. Hack saws shall not be used to cut plastic coated conduit. Coated conduit shall be threaded with standard conduit threading dies. Coating shall not be removed prior to the threading, but shall be removed by threading die only. Conduit shall be tightened into couplings or fittings using strap wrenches or approved groove joint pliers.

Plastic coated conduit couplings and conduit damaged by wrenches, groove joint pliers, threading machine chucks or otherwise shall be wrapped with at least one layer of 2-inch wide, 20-mil, minimum thickness, polyvinyl chloride tape, conforming to ASTM "Standard Methods of Testing Pressure-Sensitive Adhesive Coated Tapes Used for Electrical Insulation," Designation D 1000, with a minimum tape overlap of 1/2 inch. Before applying the tape, conduit and fittings shall be cleaned and painted with one coat of rubber resin based adhesive as recommended by the tape manufacturer. Damaged spots in the plastic

coating may be repaired by painting over with a brushing type compound as supplied by the conduit manufacturer, in lieu of the tape wrap.

Plastic coated conduit shall be bent with a standard bending tool designed for use on plastic coated conduit, and shall be free of burrs and pits.

**605.04 PAYMENT.** - Plastic coated rigid steel conduit, of each size, if the proposal does not contain a Bid Item therefor, shall be furnished and installed as Incidental Work and payment therefor shall be included in the price or prices bid.

If the proposal contains a Bid Item or Bid Items for plastic coated rigid steel conduit, each size thereof, for which there is a Bid Item, satisfactorily furnished and installed, complete in place, as specified, will be paid for at the price bid per linear foot. The quantity to be paid for will be as specified in Section 601.04.

## SECTION 606

### ELECTRICAL BOXES

**606.01 GENERAL.** - Boxes shall be installed in concealed locations flush with finished surfaces. Boxes shall be installed in a rigid and satisfactory manner. Wall-mounted boxes shall be supported independently of conduit by bar hangers in frame construction or fastened directly with wood screws on wood, bolts and expansion shields on concrete or brick, toggle bolts on hollow masonry units, and machine screws or welded threaded studs on steelwork. Threaded studs driven by a powder charge and provided with lock washers and nuts are acceptable in lieu of expansion shields. Where boxes are concealed in walls, if not embedded in concrete, the hole shall be no larger than required to receive the box. Free standing boxes shall be secured to concrete floors or slabs with anchors or other approved means. Locations indicated on the plans are approximate.

Boxes shall be furnished with screw-fastened covers. All boxes shall be readily accessible and shall not be installed in finished areas. Pull boxes shall be provided not more than 150 feet apart in long runs, unless otherwise approved by the Engineer.

Where indicated or required, specified boxes shall be installed below grade with cover flush with finished grade in locations outside of paved areas or walkways. If adjacent structure is available, NEMA 3R box may be mounted on structure surface just above finished grade in unobtrusive location.

Exterior boxes in ground and pavement shall be precast concrete complete with concrete or steel cover, drain rock and fittings such as pulling irons, cable racks and ground rods where specifically required.

A concrete slab, 3 feet x 3 feet x 3-1/2 inches, shall be furnished and installed around each pull and junction box installed in unpaved, rock and asphalt concrete sidewalk areas unless otherwise noted.

In addition to cover legends shown on the plans, additional cover legends may be used as applicable. Cover legends shall be confirmed in the shop drawing review process.

Boxes for embedment in structure concrete shall be of code gauge sheet steel of the size as shown on the plans. Boxes shall have gaskets and drains. Each box shall have a grounding lug. Boxes shall have a factory or shop applied final paint finish except where installed in a wet location. At wet locations the boxes shall be hot-dip galvanized. All boxes mounted on concrete walls shall have concrete contact surfaces coated with polyethylene tape or coal tar mastic.

Boxes shall be gasketed cast metal type having threaded hubs in outdoor locations, and shall be flush or surface mounted on exterior surfaces.

Boxes in other areas shall be of the cadmium-plated or zinc-coated sheet metal type. Boxes shall be not less than 1-1/2-inches deep. Ceiling and bracket outlet boxes shall be not less than 4-inches octagonal. Switch and receptacle boxes shall be 2-inches by 4-inches minimum.

Junction boxes for conduits below grade shall be of the watertight, cast metal type. The minimum size shall be 8 inches by 8 inches by 4-inches.

602.02 PAYMENT. - Electrical Boxes, if the Proposal does not contain a Bid Item therefor, shall be furnished and installed as Incidental Work and payment therefor shall be included in the price or prices bid.

If the Proposal contains a Bid Item or Bid Items for Electrical Boxes, each type of box for which there is a Bid Item, satisfactorily constructed or furnished and installed, as the case may be, complete in place, as specified, will be paid at the unit price bid therefor.

## SECTION 607

### MATERIALS, DEVICES AND APPURTENANCES

607.01 GENERAL. - The Contractor shall furnish, and place or install, as the case may be, all materials, devices, and appurtenances necessary for the satisfactory construction of complete legally operable electrical facilities, where and as shown on the plans or where required, and including all other necessary or required Incidental Work.

607.02 PAYMENT. - Materials, devices, and appurtenances used in the construction of electrical facilities shall be furnished, and placed or installed, as Incidental Work, and payment therefor shall be included in the price or prices bid.

## SECTION 608

### WIRE AND CABLE

**608.01 GENERAL.** - The Contractor shall furnish, install, connect, test and label, where required, all wire, cable and appurtenances, where and as shown on the plans, as required by the specifications and where required for a satisfactory, safe and legally operable installation, including doing all other necessary or required Incidental Work.

#### **608.02 MATERIAL.**

**Conductors 600 Volts and Below.** - Conductors shall be copper with the type of insulation specified. Conductors, including insulation, cabling, jacket, filler, shielding, covering, and testing, shall meet all applicable requirements of IPCEA S-19-81 and S61-402. Conductor sizes shall be not less than those shown.

Conductors No. 8 AWG or larger shall be stranded and have THW insulation. Conductors No. 10 AWG or smaller shall be solid and have THWN insulation. Conductors shall be factory color-coded with a separate color for each phase used consistently throughout system.

Fixture wire shall be furnished and installed in fixtures and at equipment where the specified power and control wire does not have the required temperature rating. Fixture wire shall be 600-volt, silicone rubber insulated, 200°C, type SF-2 fixture wire with stranded copper conductors.

All traffic signal conductors shall be Type UF.

**Conductors Above 600 Volts.** - High-voltage conductors shall be stranded copper with cross-linked polyethylene (XLP) insulation, extruded semi-conducting strand and insulation shields, copper drain wires and a polyvinyl chloride jacket. The conductors shall be single-conductor, shielded, 5 KV, 133 percent insulation level, UL Type RHH/RHW, or shielded, 15 KV, 133 percent insulation level as indicated and shall meet applicable portions of IPCEA S-66-524, NEMA WC7-1971 and AEIC Ionization Level Requirements. Cable shall be UL listed Type MV-90.

All high-voltage conductor splices and terminations shall be made with approved splice and termination kits rated for application to 25 KV system and suitable for the type and size cable furnished. Slip-on type terminators, shall be used suitable for single-conductor, cross-linked polyethylene insulated cable of the size indicated. Terminators rated in accordance with IEEE No. 48, pothead Standards shall be provided.

**Equipment Grounding Conductors.** - Conductors for equipment grounding shall be stranded copper. Conductors shall have green Type THWN insulation.

**Control Cable.** - Control cable shall be stranded multiconductor, color-coded, industrial control cable. Cable shall be insulated in accordance with IPCEA S-66-524.

Single conductors (Type 1) shall be nineteen-strand, No. 14 AWG minimum copper conductors, 600-volt, individually insulated with

color-coded (IPCEA Method 1) cross-linked polyethylene, conductor group covered with polyester-film tape. Conductors shall have overall PVC jacket.

One twisted and shielded pair (Type 2) shall be seven-strand, No. 18 AWG minimum tinned-copper conductors, 300-volt, individually insulated with polyvinyl chloride. Insulated conductors shall be twisted into a pair. Paired assembly shall be covered with aluminum-polyester cable tape, 12.5 percent overlap, and tinned-copper drain wire. Conductors shall have overall PVC jacket.

Multi-twisted and shielded pairs with a common overall shield (Type 3) shall be seven-strand, No. 20 AWG minimum, tinned-copper conductors, 300-volt, individually insulated with numeric printed coded polyvinyl chloride. Insulated conductors shall be twisted into pairs. Paired assembly shall be covered with aluminum-polyester cable tape, 12.5 percent overlap, and tinned-copper drain wire. Conductors shall have overall PVC jacket.

Traffic Signal Multiconductor Cable. - Traffic signal multiconductor 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 1983 (or current later date). The function of each conductor and corresponding insulation color code shall be as follows:

<u>Insulation Color</u>	<u>Function</u>
Black	Dial 2
Black w/white stripe	Spare
White	Common
White w/black stripe	Spare
Red	Spare
Red w/black stripe	Spare
Orange	Spare
Orange w/black stripe	Flash
Green	Offset 1
Green w/black stripe	Offset 3

Traffic Signal Inductive Detection Loop Cable. - The cable shall consist of a continuous, unspliced, No. 14 AWG, stranded, copper conductor with 600-volt, type THHN or THWN insulation loosely encased in a flexible polyvinyl chloride (PVC) tube. Tubing shall be rated 105°C and shall have wall thickness of 1/32-inch, inner diameter of 0.182-inch (Min.) - 0.198 (Max.), dielectric strength approximately 900 v/mc, moisture absorption.

### 608.03 INSTALLATION.

General. - Wire and cable shall not be pulled into conduits until conduits have been cleaned. The installation of any wiring 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 wiring therein.

Pulling wire and cable into conduit or trays shall be completed without damaging or putting undue stress on the cable insulation.

Soapstone, talc or UL listed pulling compounds are acceptable lubricants for pulling wire and cable. Grease is not acceptable. Raceway construction shall be complete and protected from the weather before cable is placed.

All wires or cables shall be pulled into or out of a conduit at the same time. If new wiring is to be added in a conduit containing existing wiring, the existing wiring shall first be withdrawn. Both the new and the withdrawn existing wiring shall be attached to a common pulling device and drawn into the conduit simultaneously.

No wire or cable shall be pulled by an automobile or truck, but mechanical devices with quick-release mechanisms may be used if such devices are specifically approved by the Engineer. Cable shall be pulled by means of approved cable grips of "wire baskets."

Splices shall not be made on conductors except at pullboxes, manholes, boxes, outlets, devices supplied with pigtails, cabinets or panels. Splices shall not be permitted in conduit bodies. Wire connectors of insulating material or solderless pressure connectors properly taped for all splices shall be used. Soldered mechanical joints insulated with tape will not be acceptable. Vinyl plastic tape of suitable quality is acceptable in lieu of rubber and friction tapes. Connectors shall be approved for the type of conductor material used. Solid conductors shall be spliced with electrical spring connectors. Conductor and cable markers shall be provided at splice points.

Connectors shall be tool applied compression type. Connectors shall be tin-plated high-conductivity copper. Connectors for wire sizes No. 10 AWG and smaller shall be nylon self-insulated locking-spade terminals. Connectors for wire sizes No. 8 AWG and larger shall be NEMA one-hole lugs up to size No. 3/0 AWG, and NEMA two-hole or four-hole lugs for size No. 4/0 and larger. Mechanical clamp, dimple, screw-type connectors are not acceptable.

Terminations at devices with 120-Volt pigtail leads shall be made using self-insulating tubular compression connectors.

Compression lugs and connectors shall be installed using manufacturer's recommended tools.

Conductors No. 6 AWG and smaller in panels and electrical equipment, shall be bundled and laced at intervals not greater than 6 inches, spread into trees and connected to their respective terminals. Lacing shall be made up with plastic cable ties. Lacing is not necessary in plastic panel wiring ducts. Conductors crossing hinges shall be bundled into groups not exceeding 12 and shall be so arranged that they will be protected from chafing when the hinged member is moved.

If existing strapping or lacing of wiring is disturbed in the course of the work, the Contractor shall replace or restrap it as applicable.

All wires terminating in a metallic enclosure or any designated termination enclosure shall terminate on a terminal board equipped with screw-type or box-type numbered terminals fabricated from copper or copper-alloy material. Wiring terminating on screw type terminations shall be equipped with self-insulated self-locking, spade-type terminals. Each power and control conductor shall be identified by an approved marking system and means at each terminal to which it is connected. All power and control cables shall have clear, distinctive and permanent marking on the outer surface throughout the entire length showing manufacturer's name or trademark, insulation type letter designation, conductor size, voltage rating, and number of conductors.



All wires and cables shall be of sufficient length to provide for slack loops and routing along the walls in all pull boxes, condulets, switch enclosures, manholes, and handholes. Slack loops shall not be less than 3 feet long in handholes and shall not be less than 6 feet long in sidewalk pull boxes, junction boxes, and manholes.

For traffic signal work all wiring shall be tagged as to origin or destination (such as "SE CORNER") in accordance with the plans and wiring diagrams. Tags shall be made of sheet aluminum or brass and shall be stamped with the appropriate marking, subject to the approval of the Engineer. Tags shall be fastened to the conductors in all pull boxes, manholes, bases of standards, and other enclosures. Additional tagging requirements for traffic signal wiring are set forth hereinbefore.

Control Cable. - No splices shall be made without permission of the Engineer. Splices shall be located where necessary, only in readily accessible cabinets or junction boxes using terminal strips.

Maintaining the integrity of shielding of control cables is essential. Special care shall be taken in cable installation to insure that grounds do not occur because of damage to the jacket over the shield.

After installation and conductor termination the Contractor shall perform tests witnessed by the Engineer to insure that control cable shields are isolated from ground, except at the grounding point. All improper grounds shall be removed at no additional cost to the City.

Conductors Above 600 Volts. - Splices will not be permitted unless specifically indicated or approved by the Engineer. Terminators shall be provided at the high voltage switchgear, unit substation high-voltage switches, and at other locations shown on the plans.

All splices and terminations shall be made in strict accordance with the cable manufacturer's instructions. These instructions shall be submitted to the Engineer for approval before any splices or terminations are made. Splices and terminations shall be made by craftsmen experienced in this work. Once started, any splice or termination shall be completed as a continuous operation.

Two working days' notice shall be given to the Engineer prior to making the splices or terminations to allow the Engineer to witness the actual work if he elects to do so.

The ducts, raceways, manholes, pull boxes, etc., required for the high-voltage cables shall be arranged so that the installed minimum bending radii of these cables is 12 times the overall cable diameter.

Testing. - High voltage cable shall be tested after installation in the presence of the Engineer. Each length of each phase cable in the system shall be tested with splices and terminations in place but disconnected from equipment. Necessary test equipment, experienced testing personnel, and necessary electric power shall be furnished.

High-potential tests shall be performed in strict accordance with IPCEA S-660524, Voltage Tests After Installation. Use dc test voltage of 65 KV for 15 KV (133 percent insulation) cable and 25 KV for 5 KV (133 percent insulation) cable applied for 15 minutes. Current and voltage shall be recorded as a function of time throughout each test. Test results shall be included in operations and maintenance manuals. Cables not passing tests shall be replaced or tests repeated. Repaired cables must pass the same test.

**WARNING:** Following these tests, hazardous voltages may exist on the cable. Immediately following tests, cable tested shall be grounded to permit any charge to drain to earth.

**608.04 PAYMENT.** - Wire and cable, if the Proposal does not contain a Bid Item therefor, shall be furnished and installed and Incidental Work and payment therefor shall be included in the price or prices bid.

If the Proposal contains a Bid Item or Bid Items for wire or cable, each for which there is a Bid Item, satisfactorily furnished and installed, complete in place, as specified, will be paid for at the lump sum price bid therefor, or at the price bid per linear foot, as the case may be.

## SECTION 609

### PAYMENT

Electrical work, satisfactorily constructed or furnished and installed, complete, in place, as specified, will be paid for at the lump sum price bid therefor, except that if electrical work is not shown on the Proposal, it shall be done as Incidental Work, and payment therefor included in the price or prices bid for the improvement of which it is a part.

END PART 6