

TRAFFIC SIGNAL SPECIFICATION TSS-500 B

**Public Works Department
Street And Traffic Division
City of Kansas City, Missouri**

Adopted

SECTION I

DESCRIPTION

TRAFFIC SIGNAL INSTALLATION: This work shall consist of furnishing and installing traffic signal equipment and material as specified in the contract and as shown on the drawings. All work shall meet NEC, NESC, NEMA and other relevant standards.

SECTION 2

GENERAL

Existing traffic signal equipment shall remain in operation, except for short shutdown periods to allow for alterations or removals as described in the contract, and as specified in the plans. The Contractor shall notify the Kansas City, Missouri Public Works Department well in advance of temporary shut-down of all, or part of, an existing traffic signal installation. Extended shutdown of existing signal equipment during construction of the new installation will not be permitted unless specifically noted in the plans.

All traffic signal equipment, materials and construction methods relating thereto, shall conform to this specification. References to certain sections of Missouri Standard Specifications for Highway Construction, 2004 or current edition as amended are made herein. Said publication may be purchased from the Missouri Highway Commission, Jefferson City, Missouri. References to other standards and specifications are also made. Abbreviations for the various references are defined as follows:

AASHTO	-	American Association of State Highway and Transportation Officials
ANSI	-	American National Standards Institute
ASTM	-	American Society for Testing and Materials
ITE	-	Institute of Transportation Engineers
MS	-	Military Standard
MCIB	-	Midwest Concrete Industry
NEMA	-	National Electrical Manufacturer's Assn.
UL		Underwriters Laboratories
IMSA	-	International Municipal Signal Association
NEC	-	National Electric Code
NESC	-	National Electric Safety Code

2.1 Temporary Traffic Signals

Transition from existing signal control to the new permanent traffic signal installation may require interim temporary traffic signals. When so specified, temporary traffic signals shall be installed and maintained according to the plans and as specified in the contract. Temporary traffic signal equipment furnished by the Contractor shall become the property of the city of Kansas City after removing, unless otherwise noted in the special provisions section of the Contract.

SECTION 3

MATERIALS AND EQUIPMENT

3.1 General

- 3.1.1 All equipment shall meet the requirements established in Equipment and Materials Standards of the Institute of Transportation Engineers and as specified herein.

Unless otherwise noted in the plans, all equipment, materials and parts used in this work shall be new and of similar manufacture. All incidental parts which are not shown on the plans or described in these Specifications and which are necessary for the completion and successful operation of the system shall be furnished and installed as though such parts were shown on the plans or described in these Specifications. The cost shall be included in the traffic signal installation bid price.

3.2 Material Approval

Before commencing the installation of the traffic signals, a complete schedule of materials and equipment proposed for installation shall be submitted to the Engineer for approval. This schedule shall include catalog cuts, diagrams, drawings, and other such descriptive data that may be required by the Engineer.

All submittals shall include the manufacturer brand name and part number where applicable. Where more than one item is present on a submittal sheet, the appropriate item or items shall be circled, **not highlighted**. All submittals shall be organized as much as practical in order with the summary of quantities sheet in the plans. Six (6) copies of each submittal shall be supplied, with one copy of each submittal included in a submittal package (6 packages total). In the event that any materials or equipment contained in the schedule fail to comply with specification requirements, are not circled, or submittals are not packaged, such items may be rejected. New submittals on rejected items shall be supplied to the Engineer for approval.

When it is required by these specifications that a test be made of the material to be used on the project, the Contractor shall furnish the Engineer a certified copy of

such test prior to the installation of such material. When any reference is made in these specifications to any specification such as ASTM, IPCEA, AIEE, etc., or a related specification referred to by reference therein, or revision thereof which states that a certain test, or tests are to be made only at the request of the purchaser, it shall be considered that the Engineer does request such test or tests to be made at the Contractor's expense and six (6) certified copies of same be furnished as above mentioned.

The submittals should include but not limited to the following:

List of Subcontractors	Submit to Engineer
Construction Schedule	Submit to Engineer if called for
Concrete Mix Design	Follow specifications and submit trip tickets to engineer
Asphalt Mix Design	As above
Mill Certificate on Rebar	Submit delivery ticket to engineer
Shop Drawings if called for	Submit to Engineer
Complete Schedule of Materials and Equipment For Street Lighting	Submit to Engineer
Complete Schedule of Materials and Equipment for all Signal Installation	Submit to Engineer
Certification of Pavement Markings and Materials: Thermo-plastic or Cold-Plastic	Submit to Engineer
Certification of Pavement Markings and Materials: Glass Beads	Submit to Engineer

Certain material, such as ring and covers for manholes and storm sewer structures, street lighting, signal poles and equipment, sealants, concrete mixes, asphalt mixes, rolled erosion control products, etc. are pre-approved for use on public improvements. The list of pre-approved materials is available at the office of the Design Engineer. To add additional material to the list, submit specifications and/or catalog cuts of the proposed addition to the Engineer. Submittal sheets should clearly mark the exact item or material proposed to be used in the project and also give full product specifications and manufacturing details.

3.3 STANDARDS AND TESTING

- 3.3.1** All additional field sampling and testing deemed necessary by the Engineer shall be performed by the City or by a Testing Laboratory selected by the City. The costs of all such tests, showing compliance with the Specifications, shall be paid by the City. However, in the event that any test indicates non-compliance with the Specifications, additional testing will be paid for by the Contractor to determine acceptability of the material or methods.
- 3.3.2** All electrical equipment shall conform to the standards of the National Electrical Manufacturers Association (NEMA). In addition to the requirement of these specifications, all material shall conform to the requirements of the National Electrical Code (NEC), the Standards of the American Society of Testing Materials (ASTM), the American Standards Association (ASA) and local ordinances.
- 3.3.3** All material shall conform to Division 1000, Material Details, Missouri Standard Specifications or ASTM Specifications as follows:

Item	Section/Specification
Concrete	501
Galvanized Coating of Traffic Signal Posts and Appurtenances	712
High-Strength Bolts, Nuts and Washers	712
Low-Carbon Steel Bolts, Nuts and Washers	712
Structural Low Alloy Steel	712
Signs	903
Reinforcing Steel for Concrete	1036
Wood Poles for Power Supplies and Temporary Installations	1050
Rigid / Electrical Conduit	1060
Electrical Conductors	1061
Pull and Junction Boxes	1062
Fiber Optic Cable	1092
Signal Equipment	1092
Nuts for Anchor Bolts	ASTM A 563, Grade C, D or DH or ASTM A 194, Grade 2 or 2H
Stainless Steel Bolts, Screws and Washers	ASTM A 193, Grades B5, B6, B7 or B16
Stainless Steel Nuts	ASTM A 194

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3.4 CONCRETE

Material, proportioning, mixing, slump and transporting of concrete shall be in accordance with Sec 501 for the specific class specified. Concrete shall be placed, finished and cured in accordance with applicable provisions of Sec 703. The entire exposed surface, including sides and top, shall be surface sealed in accordance with the applicable requirements of Sec 703.

Concrete for traffic signal structures shall be: Midwest Concrete Industry, air-entrained, MCIB Mix Number A-629-1/2-2, or as specified in the drawings.

Concrete for curbs, sidewalks and wheelchair ramps shall be the mix as follows, unless otherwise specified:

For areas other than the Central Business District MCIB mix WA610-1-4.

For the Central Business District WA 585-3/4-2 or WA634-3/4-4

both using special aggregates i.e. Trap Rock, Sioux Quartzite Etc.

(The Central Business District or CBD is the area bounded by I-70 on the North and East, I-670 on the South and I-35 on the West.)

3.5 REINFORCING STEEL

All reinforcing steel for concrete shall meet the latest revision of Missouri Standard 1036.

3.6 POSTS, POLES, AND MAST ARMS

Traffic Signal Poles shall conform to these specifications, the plans, and 1994, or latest edition, of AASHTO's Standard Specifications For Structural Supports For Signs, Luminaries and Traffic Signals For 80 MPH Wind Zones.

All poles, posts, arms, brackets, etc shall be provided with manufacturer supplied end caps.

3.6.1 STEEL MAST ARMS AND POLES

- A) The pole and mast arm shall be a round tapered mono-tube made only of one length of the best grade, structural steel sheet of not less than 7 Manufacturing Standard Gauge. Only one longitudinal weld and no transverse welds shall be permitted in the fabrication of the shaft or arm.
- B) A steel anchor base of adequate strength, shape and size shall be secured to the lower end of the shaft by welding in such manner as to develop the full strength of the adjacent shaft section to resist bending action.
- C) The steel poles shall be galvanized to ASTM A-123 standards. All accessories shall be galvanized to ASTM A-153 standards.
- D) The pole shaft shall also include a hand-hole and cover, cast pole top, a J-hook wire support, and a suitable bolt-on type device for attaching the mast arm to the

shaft as shown on the Traffic Signal Standard Drawings. The tapered steel arm shall include a removable end cap.

- E) Where a combination lighting/signal pole is specified on the plans, the above applies with the luminary arm to be mounted in the same vertical plane as the signal arm (except where otherwise noted on the plans). The vertical shaft of the combination lighting/signal pole shall be a one-piece design.
- F) When fully loaded with all equipment as shown on the plans, all mast arms shall be between horizontal (level) to one and one-half degrees (1-1/2°) above horizontal. No perceptible bending of the arm shall be observed when fully loaded, as determined by a visual inspection by the Engineer.
- G) All traffic signal poles shall be detailed on shop drawings by the manufacturer indicating pole and arm dimensions and attachment method along with signal weight, projected areas, and type of mounting that it is designed to accommodate.
- H) The tapered steel shaft shall include high strength anchor bolts and nuts that meet the following requirements:

Tensile Strength, min. psi (min. kPa)	75,000 (517,125)
Yield Strength at 0.2% offset, min. psi (min. kPa)	55,000 (379,225)
Minimum Elongation in 2" (50 mm)	14%
Minimum Elongation in 8"	12%

Nuts for anchor bolts shall conform to ASTM A-563-75, Grades C, D, or DH; or ASTM A-194-75, Grades 2 or 2H. The Contractor shall furnish a certified mill test report showing chemical composition and physical test results on the anchor bolts and nuts or high strength bolts and nuts. Bolts and nuts specified to meet ASTM A-307-74 shall be accompanied by a manufacturer's statement that the material was manufactured per ASTM A-307-74.

The anchor bolts shall be hot dipped galvanized on the threaded end for a minimum of 12 inches from the top after threading. The galvanizing shall include all threads and not less than six inches (150 mm) of the adjacent unthreaded portion of the bolts. The top of the anchor bolts shall be threaded to a length of 4.5 inches or as shown on the plans or the Standard Details. Threads shall be Coarse Thread Series as specified in ANSI B1.1 and may be formed by cutting or rolling. Nuts for anchor bolts shall be Heavy Hex leveling nuts. Nuts shall comply with the proof load or Brinell hardness requirements of ASTM A307. After galvanizing, the thread fit of the bolt-nut combination shall be snug and shall be such that the nuts can be turned on the bolts without the application of excessive torque. The Engineer may conduct proof load tests on the bolt-nut combination to check the thread fit. The bottom four inches of each rod shall be bent 90 degrees to the rest of the rod for proper anchorage.

- I) Traffic signal heads shall be mounted vertically and rigidly to the mast arms utilizing support devices and hardware as specified on the plan sheet. Head support brackets type A and B shall be aluminum or zinc plated steel.
- J) Wire entrances shall be provided on mast arms, one per signal head, as described on the plan sheet. All wire entrances shall be 1 1/2 inch pipe couplings and be provided with end plugs.
- K) A grounding lug or connector shall be located inside the base of the mast arm post at the hand hole for attachment of Number 6 ground wire.
- L) The mounting heights of mast arm traffic signal heads shall be as follows:

The bottom of the housing of a signal face shall not be less than 16 feet nor more than 19 feet above the grade at the center of the roadway. Multiple signal heads mounted on a common mast arm shall be horizontally spaced as shown on the plan sheet and the tops of the signal face housings shall be mounted in a horizontal plane.

3.6.2 Pedestal Poles

- A) **Aluminum Pedestal Posts** - Shall be straight tubing of 6063-T6 aluminum alloy conforming to the requirements of ASTM B 210- 75 with a 4 1/2 inch outside diameter and a nominal wall thickness of 0.125 inch. Pole height shall be as specified in the drawings. The pedestal base casting shall be either permanent mold casting of alloy 356-0-F conforming to the requirements of ASTM B 108-75, or sand castings of alloy 356-0-F, conforming to the requirements of ASTM B 26-75. The base shall be free from imperfections and provided with a suitable access door 8”X8 1/4” for wiring. The access door cover shall be secured to the base with a 1/4” – 20NC x 1” hex head screw. The base and post shall be joined either by threaded or leaded connection. Welded connections will be considered for acceptance. A grounding lug shall be provided inside the base. All hardware shall be non-ferrous metal or stainless steel.

- B) **Streetscape Aluminum Pedestal Post:**

As in A above but the external finish shall conform to relevant Section 8 of this specification.

3.6.3 SPAN WIRE ASSEMBLIES

Span wire assemblies shall include 3/8-inch (10 mm) steel messenger wire, 1/4-inch (6 mm) tether wire, guy wire, all bolts, nuts, washers, clamps, cable straps, and other appurtenances shown on the plans or necessary for proper installation.

Messenger wire shall be Class A galvanized, high-strength grade, seven-wire strand in accordance with ASTM A 475. Tether wire shall be seven-wire high-strength steel cable. Splicing of messenger and tether wires will not be permitted. Clamps shall be fabricated from low alloy steel. Steel posts for span wire assemblies shall have wire inlets and cable

guides with 1-1/2 inch (38 mm) rain tight insulator bushings and other features specified in the contract, and shall be in accordance with the specifications.

Wood poles and steel posts for span wire assemblies shall be as specified in the contract and as shown on the plans. Conduit, junction boxes, service entrance caps, attachment hardware or other appurtenances on the wood poles or steel posts will be as shown on the plans.

3.6.4 SIGNAL POST AND MAST ARM PRE-APPROVAL

Fabricators shall submit six copies of shop drawings and supporting calculations to the City. Submittals shall be approved by the project engineer or his authorized representative in writing prior to fabrication of the signal posts and mast arms. Shop drawings shall indicate complete design details required for post and mast arm fabrication, including material grades and thickness, welding and orientation of any longitudinal seams. The projected areas and weights (masses) of signs and signals used in the design of the post and mast arms shall be shown on the shop drawings. Design details for all possible post and mast arm combinations as shown on the plans may be submitted. Shop drawings shall provide post and mast arm installation and hardware details. All welding procedures shall be prepared by the manufacturer as a written procedure specification and shall be submitted with the shop drawings for approval. Approval of the weld procedures will be required before approval of the shop drawings. Shop drawings shall indicate the specific approved welding procedure to be used for each joint. Shop drawings and supporting stress calculations shall be signed and sealed by a registered professional engineer in the State of Missouri. Manufacturers shall submit any additional documentation, required by the engineer. Upon written approval, pre-approved drawings may be used on any project where the design conditions of the shop drawings are not exceeded.

3.7 SIGNAL HEADS

All Signal heads shall be 12 inch size unless the drawings call for any other size. Unless otherwise specified all signal indications shall be LED's per ITE specifications. Each signal head of one or more signal faces shall be of the conventional type, or when designated on the plans, of the optically limiting type. All signal heads shall be weatherproof and meet the following requirements:

- A) Color of all signal heads shall be in accordance with 3.7.4 below and Section 6 of this specification.
- B) Lamps for all traffic signal heads shall be furnished and installed by the Contractor
- C) Each signal face shall be furnished with a terminal block with circuit capacity as required, but not less than five (5) terminals. If single sections are specified, each section shall be furnished with required terminal block. All terminal blocks shall be rigidly secured to the section housing.

- D) Visors shall be supplied for each signal head; conventional vehicle heads with cut-a-way visors, optically limiting heads with cut-a-way visors, conventional pedestrian signal heads with cut-a-way visors and LED Hand and Walker heads with manufacturer recommended grill visors; unless otherwise specified.
- E) The position of each signal head shall be as specified on the plans.

3.7.1 NON LED INDICATIONS

The signal section shall be self-contained assembly consisting of the optical unit, section housing, housing door, terminal block and the necessary gaskets to insure a weatherproof unit. It shall be capable of separate mounting or inclusion in a signal face containing two or more signal sections. All material used in construction of this type signal head (pedestrian and vehicle types) shall be of ultraviolet stabilized color-impregnated polycarbonate resin. The design of the housing shall be such that with the aid of simple tools and the addition of standard parts, it shall be possible to make any assembly consisting of one or more signal sections and, with the addition of standard bracket assemblies, assemble signal faces into multi-way traffic signal head configurations. Conventional, polycarbonate signal head sections shall meet the following requirements:

- A) The housing of each section shall be one piece with sides, back, top and bottom integrally molded. It shall have a minimum 0.09 inch thickness and shall be ribbed to produce added strength. Internal bosses or inserts shall be provided in each housing for mounting a terminal block and attachment of back-plates. The top and bottom exterior of the housing shall be flat to insure perfect alignment of assembled sections. The top and bottom of the housing shall have a nominal 2-inch diameter opening with 72 molded serrations around each opening to insure positive lock of the sections and pipe bracket and capable of being directed at any angle in horizontal plane in 5-degree increments.
 - 1. Housings shall be rigidly fastened together by a three bolt assembly or by other connectors approved by the engineer. Positive located positioning shall be provided when this type signal is used with serrated brackets, post top, mast arm, or span wire fittings. Nominal 0.10 inch aluminum plates shall be furnished and installed inside and outside the section housing for all top mounted attachments.
 - 2. The housing door of each signal section shall be one piece and hinged to the housing. When closed, the door shall be secured to the housing with two stainless steel screws. Each door shall have provisions for attachment of a cut-a-way or tunnel visor.
- B) The optical unit shall consist of a lens, reflector, lamp receptacle, wiring, and necessary gaskets to insure a weather tight unit and shall be designed in conjunction with the visor to eliminate the return of outside rays entering the unit from above the horizontal.

1. Lenses shall be made of a polycarbonate material and meet the requirements of ANSI D10.1-1966 and of current ITE specifications and standards. Arrow indications and lenses may be formed as an integral part. Reflective paint masks or aluminum metal masks shall not be used to form the arrow on the lens. The lens and the reflector; in conjunction with a molded gasket and lamp receptacle, shall form a sealed unit.
2. Reflectors shall be made of high purity spun aluminum to shape and treated by the Alzak process or of a one-piece polycarbonate design having an aluminum reflective surface. Reflectors shall conform to requirements of ANSI D10.1-1966 and with applicable ITE standards and specifications.
3. The lamp receptacle shall be designed so that it will be impossible for the lamp to loosen due to vibration. The receptacle shall be of heat resisting material designed to hold normal base 67-69, 116, 150-165 watt traffic signal lamps, as specified and specified focal lengths of respective reflectors. The lamp receptacle shall be of the fixed focus type and shall rotate about its axis in order to position the opening of the lamp filament without the use of tools. A lamp receptacle retainer shall be provided which can be installed or removed without the use of tools. Wiring for each lamp receptacle shall be provided by color-coded Number 18 AWG insulated stranded copper wire with sufficient length to extend, without splicing, to the terminal block with reflector and holder in the fully open position.
4. Lamps for conventional signal heads shall be furnished and installed by the Contractor. Heavy duty standard base, clear bulbs having a rating of 8,000 hours at 130 volts shall be provided. Lamps for 1211 round signal sections shall have a light center length of three inches and be 150 to 165 watts with initial lumen output of 1745 to 1950. Lamps for 1211 pedestrian signal heads shall have a light center length of 2 7/16 inches and be 116 watts with initial lumen output of 1275. Lamps for 911 pedestrian signal heads shall have a light center length of 2 7/16 inches and be 67 to 69 watts with initial lumen output of 610 to 675. Lamps are to be mounted in respective receptacles, horizontally with the open segment of the filament up.

3.7.2 LED INDICATIONS

LED Modules shall be in accordance with the relevant ITE specifications and meet the following requirements:

- A) The lens of each red indication shall be tinted with a wavelength-matched color to reduce sun phantom effect and enhance on/off contrast. The tinting shall be uniform across the lens face. If a polymeric lens is supplied, a surface coating shall be applied to provide abrasion resistance.
- B) LED modules shall not contain Aluminum Gallium Arsenide (AlGaAs) LEDs.

- C) LED modules shall provide constant light output under power. Modules with dimming capabilities shall have the option disabled or set on a non-dimming operation
- D) In the event of a power outage, light output from the LED modules shall cease instantaneously.

3.7.3 OPTICALLY LIMITING SIGNAL HEADS

Signal section shall be 12 inch Aluminum heads with high visibility in programmed range, capable of precision lane control adjustments with tilting capabilities of up to 10 degrees above and below the horizontal, in 2 to 5 degree increments, while still maintaining a common vertical axis. Ease and efficiency of masking and proper lane communication shall be an important consideration. The signal shall preferably be circuited to automatically adjust the light output according to environment lighting.

The signal section shall be a self-contained assembly consisting of an optical unit, section housing, housing door, terminal block, and necessary gaskets to insure a weatherproof unit. It shall be capable of separate mounting or inclusion in a signal face containing two or more signal sections. If existing housings are to be combined with new housings, the new housings shall be adaptable to the existing. All new signal sections shall meet the following requirements:

Housing:

Each signal housing shall be die cast aluminum having a chromate preparatory treatment. The signal housing and lens holder shall be sealed with weather resistant gaskets. Hinge and latch pins shall be corrosion resistant metal. The lens holder and interior of the housing shall be optical black. The housing shall mount to standard 1 1/2 inch fittings as a single section, as a multiple section face, or in combination with conventional signals. The signal housing shall be provided with an adjustable connection that permits incremental tilting from zero to 10 degrees above or below the horizontal while maintaining a common vertical axis through the mounting assembly. Housing connection shall permit external adjustment about the mounting axis in 2 to 5 degree increments. Attachments such as visors, back- plates or adapters, shall readily fasten to mounting surfaces without affecting weatherproof characteristics and light integrity of the signal.

Door:

Shall be heavy duty die-cast aluminum with a minimum of two integrated cast hinge lugs mounted to the housing with stainless steel hinge pins. Positive latching is to be achieved without the use of any special tools by stainless steel eyebolts and wingnut assemblies. Shall provide a moisture proof and dust tight seal with necessary gasket fitted to the door.

Light Source:

The light source shall be LED type and shall meet ITE specifications for signal indications. The LED's shall be furnished and installed by the contractor.

LENS:

Acrylic lenses shall be colored to meet the latest ITE specifications. These lenses shall be bonded to Fresnel optical lens for programmability. Each lens shall be sealed to the door. The lens shall be held in place by suitable means, preferably stainless lens clips and stainless steel screws to create moisture and dust proof seal.

OPTICAL:

Programming shall be accomplished through the use of Fresnel lens and a smaller clear lens by masking off the area of the clear lens that you do not want the oncoming traffic to see. All programming shall be done to manufacturer's specifications.

TERMINAL BLOCK:

Each signal section shall have a 5 position, barrier block with 15 quick disconnect terminals for easy socket lead assembly and 5 screw clamp terminals for field wiring.

VISORS:

Visors shall be cut away type and painted dull black from inside. See Section 3.7.5 for details.

3.7.4 PAINTING AND FINISHING

All aluminum signal head parts, including the housing, housing doors, visors, louvers and back plates, except the mounting brackets and other hardware, shall be primed and painted flat black in their entirety. All polycarbonate signal head parts, including the housing, housing door, visors and back-plates shall be constructed from ultraviolet stabilized black-impregnated poly-carbon resin. The mounting brackets and hardware, except the aluminum pipe brackets and polycarbonate side mounted brackets, shall be galvanized steel or unfinished aluminum. Aluminum pipe brackets shall have a spun finish. Painting of the mounting brackets and hardware **will not** be permitted. If the surface finish of any equipment is damaged, such surface shall be repaired as per the manufacturer's instructions and specifications and presented to the project manager with necessary warranties from the manufacturer for acceptance. If the end product is not approved than the contractor should replace the item at his own cost. See also Section 8 of these specifications.

All threaded mounting parts shall be either Steel or Iron. No threaded Aluminum mounting parts will be accepted. All threads shall be greased to prevent rust and corrosion and grease used shall be of approved outdoor type.

3.7.5 SIGNAL VISORS

- A) Standard cut-a-way visors shall be made from polycarbonate material not less than 0.090 inch thick. Visors shall fit tightly against the door and not permit any perceptible filtration of light between them and the housing door. Lengths of cut-a-way visors provided on pedestrian signal heads and on optically limiting heads shall be equal to the nominal lens size for each respective signal section. Visors shall angle downward from horizontal not less than three or more than seven and

one-half degrees and shall be held in place on the housing door by four fastening screws or bolts, by four wedge-pressure connector lugs or by other methods approved by the engineer.

- B) Standard tunnel visors shall be of the same material and thickness, be within the downward tilt range of standard cut-a-way visors, and conform to other requirements in (A) above. Nominal lengths of tunnel visors shall be 8 inches for eight-inch diameter signal units and 12 inches for twelve-inch diameter signal units.
- C) Type of visors to be used shall be as per the plans. Color of visors shall be as specified in Section 8.

3.7.6 LOUVERS

Unless otherwise specified by the manufacturer, Louvers, if called for in the plans, shall be installed in a tunnel visor with the fins or baffles in a vertical position. Louvers shall be marked as to degree of cut-off. The degree of cut-off shall be stamped on the louver or printed on a decal on the front of the louver and be visible after installation.

- A) Fixed louvers shall be formed of 0.025-inch (0.6 mm) sheet aluminum. The top and bottom bends of each fin shall be securely fastened to the inside of the supporting ring. The angles of cut-off from either side of the center axis of the light beam shall be provided by six types of louvers: Type A-3 degrees, Type B-7 degrees, Type C-10 1/2 degrees, Type D-14 degrees, Type E-18 1/2 degrees and Type F-26 1/2 degrees.
- B) Adjustable louver units shall be composed of an ABS plastic housing and polycarbonate baffles. The unit shall be designed to prevent light leakage between the housing and the visor. The unit shall have an adjustable view range of 7 to 42 degrees. All plastic materials shall be ultraviolet stabilized. All hardware shall be brass or stainless steel.

(C) (GPL) GEOMETRICALLY PROGRAMMED LOUVERS

GENERAL:

It is the intent of this specification to set forth minimum acceptable standards for a 12" louver assembly designed to direct the light beam from the traffic signal section to a predetermined viewing range.

The louver shall meet or exceed the following requirements:

1. Fit all manufacturers' 12" signals.
2. Retrofit into existing 12" signals.
3. Provide a full round ball display, with minimum slat effect, throughout the selected view range.
4. Provide an absolute exact visual cut-off.
5. Allow the view angle within each signal section to be adjusted to a designated area.
6. Have minimum glow outside the view range.

7. Allow for controlling either the horizontal or vertical view range within the signal visor.
8. Be of lightweight construction (Not to exceed 3 lbs plus or minus 0.10).
9. Capable of easy installation with minimum labor.
10. Maintenance free.

HOUSING:

1. The housing shall consist of a two-piece assembly; injection molded from black UV inhibited ABS plastic, capable of being fastened together, preferably with brass inserts and stainless steel screws.
2. The housing O.D. shall be 11½” and have spherical contour which allows the light beam from the signal section to be directed up to 10 degrees in all directions from the centerline of the visor/lens system.
3. The inside surface shall have a multiplicity of grooves for positioning light directing baffles. The remaining inside surface shall be grooved to prevent surface reflections of light.
4. At least two (2) O-rings shall be positioned in grooves on the outside surface to prevent light leakage between the housing and the visor.
5. The housing design shall allow the baffle positions to be changed in order to adjust the view angle.

BAFFLES:

1. Shall be injection molded from flat black, 10% glass filled UV inhibited virgin polycarbonate.
2. Each baffle shall be thin opaque disc with a multiple of parallel evenly spaced apertures (openings). Each structural member forming the aperture shall have a cross section which allows for good stiffness and structural integrity, but shall have a thin edge to prevent reflection (glow) outside the desired viewing range.
3. All baffles shall be identical in design and interchangeable within the housing.
4. The plane of each baffle shall be 90 degrees to the centerline axis of the housing.

ATTACHING HARDWARE:

Each louver assembly shall be supplied with six (6) black, self-threading screws (or other approved attaching method) for attaching the louver to the signal section visor.

INSTALLATION KIT:

An installation kit shall be available as an aid in installing the louver assembly. The following items shall be made available:

1. Complete set of installation instructions.
2. Visor marking template and marker.
3. Adjustment tool for rotating the louver assembly within the signal visor, complete with a locator rod for positioning the louver assembly in relation to the signal lens.
4. Shock cords to aid in positioning and aiming the louver assembly.
5. Other necessary specialty tools.

3.7.7 BACK-PLATES

Back-plates shall be provided as shown on the plans. The back-plates shall be black in color and constructed of flat pre-cut or preformed thermoplastic. Flat pre-cut thermoplastic back-plates shall have a minimum thickness of 0.250 inches (6 mm). Preformed thermoplastic back-plates shall have rolled out edges and a minimum final thickness of 0.1 inches (2.5 mm). Stainless steel bolts, nuts and flat washers shall be used to fasten the back-plate to the head. Bolt lengths shall be selected to not interfere with maintenance operations. Any connection to the top of any signal section shall be watertight.

3.7.8 SIGNAL HARDWARE

- A) All side-mount brackets for single vehicle heads, or a vehicle/pedestrian head combination, on streetscape installations shall be of polycarbonate material.
- B) All other pipes, nipples, elbows and tees may be of aluminum, iron or steel, 1 1/2 inch pipe size. Elbows, tees and crosses shall be threaded and shall provide rigid unit mounting at each connection. Fittings which attach to the signal head section shall incorporate matching serrations, or by use of an adapter ring, be compatible with the serrations on the housing. Fittings shall be secured to the signal housing, on the interior side, by a threaded nipple and hex nut. Hardware for the post mounting of more than one signal head shall include an external terminal compartment as shown on the plans.
- C) Color of hardware shall be as specified in Section 8 and 3.7.4.

3.7.9 PEDESTRIAN SIGNAL HEADS

Unless otherwise specified all pedestrian signal indications shall meet the following minimum specifications and conform to the latest ITE, MUTCD specifications and standards for pedestrian traffic control.

3.7.9.1 LED Indications

The pedestrian signal heads shall be 16 inch LED modules with filled “Walker” and “Upraised Hand” symbols per ITE specifications. The enclosures must be sealed and moisture resistant. Compatible for easy installation into existing signal enclosures when required and designed to reduce glare.

Operating Voltage Range shall be 80VAC to 135VAC (120VAC nominal)

Shall have built in line and load protection devices

Operating Temperature Range: -40°C to +75°C plus or minus 3°C

Written manufacturer’s warranty (One year for controlling circuits and five years for LEDs).

Shall meet FCC Title 47, Subpart B, Section 15 Regulations for electrical noise.

- A) Pedestrian signal head housings shall be constructed as shown on the plans of a one-piece, 0.250-inch (6 mm) thick, polycarbonate material. The housing shall include an integral mounting bracket designed for side-of-pole mounting on all makes of signal poles with a terminal compartment and minimum 5-position, double-row terminal block.
- B) The door, lens and any openings in the housing shall have gaskets or seals to exclude dust and moisture from the inside of the compartment.
- C) Lenses shall be constructed of polycarbonate material.
- D) Pedestrian signal head units shall be provided with a manufactured, preformed rectangular visor or screen-type louver.
- E) All plastic materials shall be ultraviolet stabilized.
- F) Indications shall be ITE Class 3 symbol messages. The "UPRAISED HAND" symbol shall be illuminated with a filled, Portland orange LED module. The "WALKING PERSON" symbol shall be illuminated with a filled, lunar white LED module.
- G) Pedestrian traffic control signal faces shall be constructed such that both messages are displayed from the same message bearing surface. The "WALKING PERSON" symbol shall be located to the right of the "UPRAISED HAND" symbol.

3.7.9.2 COUNTDOWN PEDESTRIAN SIGNALS

The Countdown pedestrian signal heads shall be 16 inch LED modules with filled Walker and Hand symbols per ITE specifications. In addition to the relevant specifications from 3.7.9.1 above, it shall meet the following minimum requirements:

If specified, countdown pedestrian signals shall consist of Portland orange numbers that are a minimum of six inches (150mm) in height on a black opaque background. The numbers shall be located immediately adjacent to the “Upraised Hand”.

3.7.9.3 Non LED indications

When specified these signals shall be furnished in 12 inch rectangular design as specified on the plans. The "DON'T WALK" and "WALK" signal sections shall

be contained in separate housings unless otherwise specified. The "DON'T WALK" indication shall be mounted directly above the "WALK" indication. The illuminated words shall be uniform upper case letters: "WALK" - lunar white in color and "DON'T WALK" - Portland orange in color. Minimum letter heights shall be 5 inches for 12 inch sections. Minimum legibility distances, when illuminated, shall be 130 feet for 12 inch sections

3.8 CONDUITS

The size of the conduit used shall be as shown on the plans. It shall be the privilege of the Contractor, at his own expense, to use larger size conduit if desired. Where larger size conduit is used, it shall be for the entire length of the run from outlet to outlet. No reducing couplings will be permitted

3.8.1 CONDUITS FOR TRAFFIC SIGNALS

All conduit for traffic signal installations shall be either Schedule 40 polyvinyl chloride (PVC) conduit or Schedule 40 high density polyethylene (HDPE) conduit. HDPE conduit shall be smooth-walled inside and out. The conduit shall be manufactured to ASTM D2447 and NEMA TC7 specifications and shall meet the following applicable requirements:

Minimum Wall Thickness: For 3" (75 mm) Schedule 40 Conduits -0.216" (5.5 mm)

Tensile Strength	3300psi (22.75 Mpa)	ASTMD-638
Elongation	800%	ASTMD-638
Density	0.955 g/cm ³	ASTMD-1505
Melt Index	0.320 gms/10 min	ASTMD-1238E)
Brittle Temp	<-103° F (<-75° C)	ASTMD-746
ESCR (Bell Test)	>1500 F50 hrs	ASTMD-1693C)
Rockwell Hardness L	49	ASTMD-785
Shore Hardness D	61	ASTMD-2240

3.8.2 CONDUITS FOR STREET LIGHTS

All conduit for street lighting installations shall be either Schedule 40 polyvinyl chloride (PVC) conduit or Schedule 40 high density polyethylene (HDPE) conduit. PVC conduit shall bear an Underwriters' Laboratories (UL) label. HDPE conduit shall be smooth-walled inside and out. The conduit shall be manufactured to ASTM D2447 and NEMA TC7 specifications and shall meet the following applicable requirements:

Minimum Wall Thickness: For 2" (50 mm) Schedule 40 -0.216" (5.5 mm)

Tensile Strength	3300psi (22.75Mpa)	ASTM D-638
Elongation	800%	ASTM D-638
Density	0.955 g/cm ³	ASTM D-1505
Melt Index	0.320 gms/10 min	ASTM D-1238E)

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Brittle Temp	< -103° F (<-75° C)	ASTM D-746
ESCR (Bell Test)	>1500 F50 hrs	ASTM D-1693C)
Rockwell Hardness L	49	ASTM D-785
Shore Hardness D	61	ASTM D-2240

3.9 CONDUCTOR CABLE AND WIRE

Wire and cable shall conform to IMSA specifications, as referenced, and shall be plainly marked on the outside of the sheath with the manufacturer's name and identification of cable type. Each type and gauge of conductor cable shall be accompanied by manufacturer's certificate in triplicate that the conductor cable meets the following requirements:

- A) Multi-conductor switching cable shall be soft or annealed, stranded, copper wire, tinned or un-tinned, meeting the requirements of IMSA Specification Number 20-1, 1991 or the latest.
- B) Power cable shall be single conductor, stranded wire meeting the requirements of IMSA Specification 20-1, 1991 or the latest and be Type USE.
- C) Detector loop lead-in cable shall be Number 14 AWG, soft drawn, stranded copper wire meeting the requirements of IMSA Specification Number 50-2, 1999 or the latest, cable shall be installed as shown on the plans.
- D) Paired communication cable shall be three pair Number 20 AWG polypropylene-insulated, shielded pairs, jacketed with electrical shielding, IMSA 19-2; Beldon 9883 or equivalent.
- E) Loop detector wire shall be Number 14 AWG, 19 strand copper wire meeting the requirements of IMSA Specification Number 51-5 and shall be installed as shown on sheet TCD-0-4 of the Standard Details.
- F) Cables for Video Cameras:
See Video Camera Specification: Section 3.15.1 Clause F1 and F2.
- G) Cables for Fiber Optics
See Fiber Optics Specifications Section 4.

3.10 PULL BOXES AND JUNCTION BOXES

The contractor shall furnish a manufacturer's certification in triplicate showing typical test results representative of the materials used in manufacture of pull boxes and covers, and certifying that the material supplied conforms to all specified requirements. Pull box covers and rings to be installed in the street shall have machined bearing / Skid resistant surfaces. The boxes shall be installed as shown on specification sheet TCD-0-3. All Traffic Rated or Heavy Duty Pull Boxes shall have a ring of concrete, ten inches wide and twelve inches deep, starting flush to the finished pavement, as shown in the drawings. The concrete ring shall have a minimum of one ring of #4 rebar at the center.

Pull boxes shall be Type I, II or III as shown in the drawings.

3.10.1 PULL BOX TYPE I & II

Pull Box Type I and II shall be corrugated steel pipes with cast iron rings and lids, as per standard detail drawings. Pull Boxes shall be light duty (Non-Traffic) or Heavy Duty (Traffic Rated) as specified in the drawings.

3.10.2 TYPE III PULL BOXES

A) SCOPE:

1. These specifications describe the minimum acceptable requirements for underground enclosure assemblies. Enclosures shall consist of a box and a cover and shall have the dimensions shown.
2. Enclosures shall be suitable for use in areas subject to light vehicle and pedestrian traffic and shall be able to withstand the loads specified herein. Enclosure covers shall support a test load of at least 20,000 lbs.

B) PRODUCT REQUIREMENTS:

1. Enclosures shall be made from a combination of polymer concrete (PC) and structural fiberglass reinforced polymers (FRP).
2. Enclosure design shall include a concrete interlock all around the perimeter of the upper box area. Interlock design shall ensure keying into sidewalk or boulevard paving.
3. Covers fit shall retard the entrance of sheet flow run-off water.
4. Standard covers shall have KCMO TRAFFIC SIGNALS FIBER OPTIC logo cast into the top surface as shown in the drawings.
5. Covers shall have polymer concrete on the top surface and on all edges.
6. Box shall be equipped with a bottom foundation flange or footing design to support and stabilize the box in normal soil conditions.
7. All exposed surfaces shall be concrete gray in color.
8. Covers shall be equipped with stainless steel hex head bolts to secure the cover to the box. Bolt sizes shall be as specified on approved drawings. Bolt shall be captive in the cover and shall be designed to stay in the up position during cover removal and replacement to prevent thread damage.
9. Boxes shall be equipped with a self-centering non-ferrous nut that is easily removable for replacement in the field. The bolt hole shall pass through below the nut to permit debris removal.
10. The cover shall have a minimum coefficient of friction of 0.6 on the top surface when tested according to the method given in ASTM C1028. Coatings may not be used to achieve skid resistance.
11. All boxes shall have a light gray interior to improve lighting during maintenance operations. All inside surfaces shall be smooth and free from fiberglass or any other sharp protrusions that might injure workmen or cable.
12. The following accessories shall be available for all enclosures:

13. Extensions that can be installed under the box before installation to increase the depth.
14. Terminators or knockouts to accept trade conduit sizes shall be available in either the sides or ends of the box wall. Wall construction shall be suitable for field cutting using standard carbide tipped hole saws or power saws.
15. Magnetic or other location markers.

C) MATERIAL REQUIREMENTS:

1. All materials used in the manufacture of the enclosures shall be new, of the highest quality. Polymer concrete shall be manufactured from one of the general types and grades defined in *Polymers in Concrete Structural Applications State of the Art Report*, ACI 548.6R-96 for structural uses. Thermoplastics will not be acceptable.
2. Enclosure assemblies shall be designed for ASTM C857, Minimum Structural Design Loading for Underground Pre-cast Concrete Utility Structures, load designation A8 with a minimum safety factor of 1.7 for vertical loads and 3.0 for soil pressures.
3. Binding polymers used in the manufacture of the PC and the FRP shall be of the same formulation or from formulations with demonstrated chemical compatibility to assure complete chemical bonding of all components. FRP wall sections must be cast integrally into and chemically bonded within the upper polymer concrete casting.
4. Enclosure walls shall be made from pattern cut structural fiberglass cloths to assure uniform, pre-measurable fiberglass content on all areas. All manufacture shall be from pre-approved construction meeting the specified structural requirements.
5. The materials used for making the enclosures shall be non-biodegradable when buried underground, exposed to water, and when exposed to ambient temperatures of -20 deg. F to 120 deg. F. Manufacturers shall submit test reports indicating that materials meet or exceed the requirements of Western Underground Committee Guide 3.6 Non-Concrete Enclosures for durability and chemical resistance.
6. The life expectancy of the finished product shall be at least 25 years. Satisfactory performance of similar products of the vendor for a period of at least 10 years shall be accepted as reasonable proof of achieving the 25-year requirement. A written statement is required. Accelerated service tests in accordance with ASTM D 756-56, procedure E, shall be accepted as a satisfactory alternative.

D) TESTING AND ACCEPTANCE:

1. The purchaser retains the option of conducting product and material tests to verify compliance with the specifications. Purchaser reserves the rights

to randomly select product from delivered stock and return it to the producer for witnessed compliance testing.

2. Proof of design compliance will be based on the following tests and test loads:

2.1 A vertical test load of 20,000 lb. applied to a 10x10-inch area at any position on the cover surface shall cause no signs of distress during or after testing. Cover deflection at 10,400 lb. working load shall not exceed 0.25-inch per foot of cover width.

2.2 Horizontal design loads calculated according to ASTM C857. Test loads shall be uniformly applied to the largest wall of the box. Minimum failure load shall be at least the load given in the table. The cover shall be fastened in place during the test. Deflection shall not exceed 0.25-in per foot of wall length at the design load. Design and test loads for the sizes given are:

Nominal Size	Design (lbs)	Test (lbs)
11x18x18	700	550
17x30x18	925	910
24x36x30	900	2,200
30x48x36	1200	3,740
30x60x30	940	4,200

2.3 Impact Load. Any point on the cover surface shall withstand a 72 ft-lb. impact administered with a C-type according to ASTM D-2444 without penetration or cracking. Minor damage at the point of impact is acceptable.

3. Fatigue Testing: Vendor shall provide test results showing ability of box covers and cover bearing areas to withstand a minimum of 20,000 cycles of loading that varies between 8,000 lb. (100%) and 800 lb.(10%) or less. Sufficient data shall be on file to verify load cycles in the prescribed range and that at least 50% of the cover stiffness has been retained.

4 Submittals: Vendors shall submit drawings that describe all of the particulars and the key dimensions, including applicable tolerances, of all products to be supplied for approval. Information included shall be adequate to assure conformance to structural requirements. Vendors shall also submit test data certified by a licensed professional engineer showing compliance with all requirements of this specification when requesting product approval. Vendors must be approved by the purchaser prior to supplying any products covered by this specification.

5 Vendor shall not make any changes in design or manufacture of the product as shown on the approved shop drawings. After award of the contract, all material sent may be checked against the drawings and

specifications. Material not meeting these specifications shall be rejected. Vendor shall, at his own expense, replace rejected material with material that complies with the specifications and the said expense to include costs for: replacement parts, transportation, handling and testing.

Type III shall be fiberglass reinforced polymer boxes with reinforced polymer concrete covers, of the size and shape as shown on the Standard Detail sheet in the accompanying plans. Pull box material shall be an aggregate consisting of sand and gravel bound together with a polymer and reinforced with continuous woven glass strands. Material shall be non-conductive and unaffected by UV light, moisture, freezing, high temperatures and sub-soil chemicals. Hardware shall be stainless steel to prevent corrosion. It must have the following minimum mechanical properties:

Compressive Strength	11,000psi (75845kPa)
Tensile Strength	1,700psi (11,722kPa)
Flexural Strength	7,500psi (51,713kPa)

Lids shall be bolt down type and designed to prevent them from slipping into the round box. Pull boxes with adjustable top ring may be permitted if approved by the Engineer. Pull Box Covers shall have the city logo as shown in the drawings. Pull Boxes shall be light duty (Non-Traffic) or Heavy Duty (Traffic Rated) as specified in the drawings.

3.10.3 JUNCTION BOXES

Junction boxes, designed for flush mounting, shall be as shown on the plans and shall be fiberglass reinforced polymer concrete of a size and shape as indicated on the Standard Detail sheet in the accompanying plans. Junction box material to be an aggregate consisting of sand and gravel bound together with a polymer and reinforced with continuous woven glass strands. The material must have the following mechanical properties:

Compressive Strength	11,000psi (75845kPa)
Tensile Strength	1,700psi (11,722kPa)
Flexural Strength	7,500psi (51,713kPa)

They shall be drilled and tapped for all conduit connections. The cover shall be made watertight with suitable gasket, secured with stainless steel or cadmium plated screws or bolts.

3.11 LOOP SEALANT

Loop sealant shall have the following minimum characteristics:

- A) The loop sealant used to fill the saw cuts and other gaps shall be of a type intended for and designed to be used as traffic loop embedding. The sealant shall

be designed for installation when the surface temperature of the roadway is between 40 F and 120 F (4 C and 49 C) and exhibit minimal shrinkage and stringing during and after installation. The curing time of the sealant shall be a maximum of 72 hours. Cured sealant shall retain permanent flexibility to 0 F (-18 C), be temperature stable and ensure the integrity of the loop detector installation from -40 F to 200 F (-40 C to 93 C). The loop sealant shall adhere to the roadway pavement and resist the effects of weather (including freeze-thaw cycles), de-icing chemicals, salts, gasoline and motor oils, so that the operation of the detector is not affected.

- B) The three types of allowable loop sealant shall be two-part polyester resin, one-part moisture curing polyurethane and hot-melt bituminous.
- C) The loop sealant shall provide a minimum shelf-life of nine months. Before the installation of any detector loop sealant, the material safety data sheet (or an OSHA Form 20 along with the manufacturer's technical data sheet) shall be submitted to the engineer. Any sealant used on loop detectors shall meet the approval of the engineer.
- D) Loop sealant shall be proportioned, mixed and installed per the manufacturer's specifications and instructions. After the loop slots are cut into the pavement, the surface shall be cleaned with a power washer and all loose debris removed. After application of the sealant, the roadway shall be tack-free and capable of being open to the motoring public within four hours without tracking. Loop sealant shall fully encapsulate the loop wires as shown on the plans. One-inch (25 mm) long backer rods shall be placed every 3 feet (1 m) to ensure one-inch (25 mm) depth coverage of loops. Excessive overfill will not be permitted.

Sealant for detector loops shall be of the following types or approved equivalent, mixed and applied according to manufacturer's instructions.

3M Sealant	Above 40 F
Crafco 34221 – E 3405	Below 40 F and in base asphalt lift.

3.12 SIGNS

Unless otherwise stipulated, the Contractor shall furnish and install all signs as specified in the drawings.

All permanent traffic signing and traffic control signing shall conform to the requirements of the Manual on Uniform Traffic Control Devices (MUTCD). All signs shall be fabricated from standard aluminum blanks utilizing high intensity reflective sheeting as called for in the accompanying plans.

3.12.1 OVERHEAD STREET NAME SIGNS

These signs shall be constructed of 0.125-inch (3.2mm) aluminum sheeting of the size as indicated on the plans. Minimum size requirements for any sign shall be 18" x 60" (450 mm x 1500 mm). All sign faces shall be High intensity Green background with high intensity Silver / White letters and border, 8 inch series C

upper and lower case letters. Refer project drawings for details. All signs shall have a white/silver 0.75-inch (19 mm) wide border. All signs shall have the legends centered on the face with the letters or numbers spaced to produce a readable, professional quality sign. Actual size drawings of the proposed signs shall be submitted to the Engineer for approval. Bolt hole locations shall be field located and drilled or punched for proper installation. Signs shall be mounted to the mast arms using Astro-Brackets or using methods approved by the engineer.

3.12.2 SIGNS FOR PUSH BUTTONS

These should be 9x12 inches in size and mounted immediately above or incorporated in the pedestrian push button unit. Signs shall be Black lettering on White background meeting the MUTCD standards.

3.12.3 OTHER SIGNS

As specified in the drawings.

3.13 CABINETS AND CONTROLLERS

Traffic controllers are defined as the complete assembly of all required equipment and components for control of traffic signal indications. Each controller and its associated equipment shall be designed to operate on 120 volts, 60 Hz, single phase, alternating current. Variations in the voltage of the power supply of plus or minus 10 percent, or sustained temperatures inside the cabinet between 20 F and 165 F shall not change the total time cycle of pre-timed controllers, or the length of any interval, portion, period, or unit extension of actuated controllers by more than 5 percent, or cause electrical or mechanical damage. Heater elements shall not be used to attain compliance with these requirements. Vibration shall not affect normal operations.

3.13.1 CABINETS

- A) The type of cabinet shall be as specified in the drawings. Controller Cabinets shall be 0.125 inch reinforced shell aluminum alloy, and be of clean-cut design and appearance. The cabinets to be furnished shall be in accordance with the "Traffic Signal Control Specifications"; Published by the State of California, Business, Transportation & Housing Agency: Department of Transportation (CALTRANS), dated January, 1989, and all current Addenda and Revisions. Further, the equipment shall meet the following Specifications. In case of conflict, the Department Specifications shall govern.
- B) Bids shall provide a certification that the equipment proposed is included on the most current (QPL) of CALTRANS and MoDOT Approved Products List. Exception: Department specific equipment that is not defined in the CALTRANS specification is exempt from this QPL requirement.
- C) The additional requirements for the model 332 and the model 336S stretched cabinet assemblies to be supplied by the bidder are as follows. Supplier must be approved for model 332 cabinet. All cabinets shall exhibit a "bare" aluminum finish. The handles for each door shall swing outward. All main cabinet doors

shall accept a No. 2 Corbin Key. Two sets of keys shall be supplied with each cabinet. All cabinet assemblies shall be supplied with a Power Distribution Assembly Number 2, (PDA#2). The 336S stretched cabinet shall be provided with the standard "M" base adapter and anchor bolts. If any auxiliary output file is specified, the C5 connections shall be included.

- D) Each cabinet shall include two (2) fluorescent lighting fixtures mounted inside the front and back portion of the cabinet. These fixtures shall include a cool white lamp with protective cover and shall operate by a normal power UL listed ballast. A door actuated switch shall be installed to turn on the cabinet light when the door is open. Each switch should work each individual light.
- E) The police panel door shall contain two DPST toggle switches. One shall be labeled FLASH/AUTOMATIC and may be used to switch output control from the switch packs to the flash unit and vice versa. In addition to the above there shall be one ON / OFF switch.
- F) All output field conductors shall be terminated in the cabinet on a 600 volt heavy duty mechanical screw connector offset tang assembly. Each mechanical screw connector shall accommodate up to four No. 12 AWG conductors. Each clamp shall be captive to the contact screw and the screw captive to the contact. Field wiring shall not be spade lugged. The A.C. neutral buss and chassis ground buss shall be a 17 position solid copper terminal that allows the wires to be attached without tang assemblies.
- G) The output file shall be hand wired, no printed circuit boards shall be allowed except for red fail monitoring.
- H) A 420 auxiliary output file shall be required when called for on the plans. This file shall meet the latest CALTRANS Specifications.

3.13.2 PULL OUT DRAWER

A pull-out, hinged-top drawer, having sliding tracks, with lockout and quick-disconnect feature, such as a Vent-Rak Retractable Writing Shelf, #D-4090-13 or equivalent. The pull-out drawer shall extend a minimum of 14 inches in order to facilitate removal of the processor by providing the processor with an aluminum platform covered by a Formica type chemical proof plastic sheet while the rear connector is being removed. It shall be possible to lift this hinged platform in order to gain access to the interior of the drawer. Minimum interior dimensions of the drawer shall be 1 inch high, 13 inches deep and 16 inches wide. The drawer shall be capable of supporting a 40 pound controller when fully extended. Drawer shall be mounted immediately below the controller assembly.

3.13.3 SURGE PROTECTION:

- A) Each cabinet shall be provided with devices to protect the control equipment from surges and over voltages. This shall include power lines, the Input File, the Output File, and communication lines.
- B) All inputs for the input file should be protected with a 30V MOV with (30 Joule rating). P/n ERZ-C20 DK 470 or equal. The output of all load switch outputs

shall be protected with a 150V MOV (80 Joule Rating). P/n ERZ-C20 DK 241U or equal. The MOV's shall be connected from the AC positive field terminal to the chassis ground.

- C) For the 332A cabinet, appropriate input surge protection shall be mounted on the Lower Input Termination Panel (LIP). The power distribution assembly (PDA#2) of each controller cabinet shall include a surge protection unit on the AC Service Input. The protector shall be installed between the applied line voltage and earth ground. The surge protector shall be capable of reducing the effect of lightning transient voltages applied to the AC line. The protection device shall be a two stage series parallel device, and shall be an SHA 1210. (Refer to MoDOT approved product list.) It shall include the following features and functions:

1. Maximum AC line voltage: 140 VAC
2. Twenty pulses of peak current, each of which will rise in 8 microseconds and fall in 20 microseconds to 2 the peak: 20000 Amperes.

The protector shall be provided with the following terminals:

1. Main line (AC line first stage terminal).
2. Main Neutral (AC Neutral input terminal).
3. Equipment Line Out (AC Line second stage output terminal, 10 Amps.).
4. Equipment Neutral Out (Neutral terminal to protected equipment).
5. GND (Earth connection).

- D) The Main AC line in and the Equipment Line out terminals shall be separated by a 200 Micro-Henry (minimum) inductor rated to handle 10 Amp AC Service. The first stage clamp shall be between Main Line and Ground terminals.

- E) The second stage clamp shall be between Equipment Line out and Equipment Neutral.

- F) The protector for the first and second stage clamp must have a MOV or similar solid state device rated at 20KA and be of a completely solid stage design (i.e. no gas discharge tubes allowed).

- G) The Main Neutral and Equipment Neutral Out shall be connected together internally and shall have an MOV similar solid state device or gas discharge tubes rated at 20 KA between Main Neutral and Ground terminals.

- H) Peak clamp voltage: 350 Volts at 20 KA (Voltage measured between Equipment Line Out and Equipment Neutral Out terminals. Current applied between Main Line and Ground Terminals with Ground and Main Neutral terminals externally tied together). Voltage shall never exceed 350 volts.

- I) The protector shall be epoxy encapsulated in a flame retardant material.

- J) Continuous service current, 10 Amps at 120 VAC RMS.

- K) The Equipment Line Out shall provide power to the Type 170 and to the 24V power supply.
- L) Communications line protector for incoming and outgoing communication lines shall be EDCO part # PC642C-008 or equivalent with mounting connector # PCBIB or equivalent.

3.13.4 CABINET ACCESSORIES

- A) **Model 222 Loop Detector Amplifiers.** The loop detector amplifier units shall be as specified in the CALTRANS Specifications. The quantity of units shall be as described on the plans.
- B) **Model 242 D.C. Isolator.** The D.C. isolators shall be the Model 242 as specified in the CALTRANS Specifications. A minimum of (1) shall be supplied. Additional quantities of units shall be needed for actuated pedestrian, preemption or as described in plans.
- C) **Model 200 Load Switch.** The load switch shall be the Model 200 as specified in the CALTRANS Specifications. The quantity of units shall be as described on the plans.
- D) **Model 204 Flasher.** The flashers shall be the Model 204 as specified in the CALTRANS Specifications. Each cabinet shall be supplied with two (2) model 204 flashers.
- E) **Model 252 A.C. Isolator.** The A.C. isolators shall be the Model 252 as specified in the CALTRANS Specifications. The quantity of units shall be as described on the plans.
- F) **Model 430 Flash Transfer Relay.** The flash transfer unit shall be the Model 430 as specified in the CALTRANS Specifications. Each cabinet shall be supplied with four (4) model 430 flash transfer relays (2 additional model 430 flash transfer relays when a 420 auxiliary is shown on plans).
- G) **Emergency Pre-emption.** The Contractor shall furnish and install an Optical Pre-emption and Priority Control System for emergency pre-emption as shown in the plans and as specified in the Traffic Signal Quantities. The cable shall be run continuous from the detector to the controller cabinet with no splices. The detector shall be installed as shown in the plans or by a method approved by the Engineer. The Contractor shall be responsible for the proper alignment of the detector to ensure maximum detection time for the emergency preemption equipment. It shall be the responsibility of the contractor to deliver, install and test a system in which all individual components and the system as a whole is working to its optimum to meet the design requirements and deliver the intended results.

Optical Preemption and Priority Control System

Optical Signal Processor Card Specifications

Modular Card Standard:

The processor card shall meet the 170 standards for input modules.

Signal Coding:

The processor shall be capable of receiving, decoding, and prioritizing the Emergency and Transit signals transmitted by optical emitters. The processor shall be software configurable to accept or reject older non-identifying optical signals.

Signal Acquisition Time:

Typical signal acquisition time shall be approximately 2.5 seconds.

Simultaneous Signals:

Each signal processor module shall be capable of receiving and decoding up to 10 coded signals simultaneously. Additional simultaneous signals will be ignored.

Range:

2500 feet maximum adjustable down to 300 feet in gradual steps for each signal band.

Range Adjustment:

The Range shall be adjustable via front panel switches/software and emitter.

Minimum Number of Codes:

The processor shall respond to 30,000 or more unique identification software configurable codes.

Priority Determination:

Signals in the Emergency signal band shall be given priority over signals in the Transit signal band. Signals in the same band shall be serviced on a first-come, first-served basis. The user shall have the option to define up to 16 additional priority classes within each signal band.

Event Logging:

The system shall log all valid signal receipts along with the time, date, and duration of receipt. The logging capacity of the card shall be a minimum of 1300 events standard, expandable to 15,000 events or more. The oldest events shall be discarded when newer events are received. The stored logs shall be downloadable via RS-232 port. The processor's operating system shall allow connection to a controller, a local computer, or a modem. Any device hooked to its serial port shall be able to query it for logged data.

Output Signals:

The processor shall provide four optically isolated output channels for placing calls on the traffic controllers preempt inputs. All output signals shall comply with 170 signal level definitions.

Max Call Timer:

Each channel shall be equipped with a MAX CALL TIMER which will disable a

channel's response to an emitter code should that code remain within range for more than 5 minutes. Once the emitter is shut off for 5 seconds or more the channel shall again respond to that emitter.

Electrical Requirements:
120VAC 50/60 Hz.

Transient Protection: Input power shall be MOV and fuse protected from line transients.

- H) **Model 400 Modem.** The quantity of units shall be as described on the plans.
- I) **Model SM 2400 Modem.** The quantity of units shall be as described on the plans.
- J) **Computer Cable.** The cable will consist of both male and female amp connectors as described in addendum 8 section 2-5-6 C2, C30 and C40 Detail Dated November 19, 1993, of Caltrans Traffic Signal Control Specifications dated January 1989. The female connector of the cable will extend past the front edge of the rack a minimum of .5 inches and a maximum of 1 inch. The male connector will be on the cable end and will be in the back of the cabinet. This cable will extend 14 inches along the side of the rack with a minimum of 12 inches free that can be used to plug into any of the 170E's four ports. The cable will consist of one wire connecting the like pin in the other connector starting with A and ending with R. The wire should be 20 gauge (one cable shall be supplied for each cabinet).
- K) **Conflict Monitor.** Each cabinet shall be supplied with a Model 210 Conflict Monitor as specified in the CALTRANS specification and addenda as follows:
 - 1. The conflict monitor shall be capable of monitoring for the absence of voltage on all of the inputs of a channel (defined here as red, yellow, and green). If an input is not present on at least one input of a channel at all times, the unit shall begin timing the duration of this condition. If this condition exists for less than 700 milliseconds, the unit shall not trigger, if this condition exist for more than 1000 milliseconds, the unit shall trigger as if a conflict had occurred, causing the intersection to transfer immediately into a flashing mode, and stop-time to be applied to the controller, a red signal shall require the presence of a minimum of 60 (+/- 10) volts ac to satisfy the requirements of a red indication.
 - 2. A connector and terminal assembly designated as P20 (Magnum P/N 722120 or equivalent) for monitoring the absence of red shall be an integral part of the output file. The connector shall terminate and be compatible with the cable and connector of a Type 170 conflict monitor unit (CMU), capable of monitoring the absence of red. The pin assignments of the P20 connector and terminal assembly shall be provided with the cabinet plans. The OP20 connector shall be physically alike to the cable and connector of a Type 170 CMU to prevent the absence of red cable connector from being inserted into the P20 connector 180 degrees

out of alignment. Programming of the unused red channels shall be accomplished via jumpers. These jumpers shall cause 115 VAC to be applied to any and all unused red monitoring channels. These jumpers and their respective attachment points shall be part of the output file.

3.13.5 TYPE 170E MICROCOMPUTER SIGNAL CONTROLLER

Except as herein modified, the Microcomputer 170E controller shall conform to the CALTRANS TRAFFIC SIGNALS CONTROL EQUIPMENT SPECIFICATIONS as published January, 1989, with the exception that Chapter 2, and details related to the Model 170 controller unit, are superseded by addendum 8, dated November 1993, which are herein incorporated by reference and form a part of this Specification as follows:

- A) This controller shall be fully compatible with the software specified on the plans.
- B) The C2, C20, C30 and C40 connectors shall be amp standard.
- C) If fiber optics are specified, a fiber optic modem shall be supplied.
- D) Diagnostic Test Program.

For each 10 or less Model 170E controllers purchased, the bidder shall provide a Diagnostic Test Program Prom Chip that shall test the operation of the Model 170E controller units, including but not limited to, internal memory, the Program Module, the real-time clock, input-output circuitry, the modem, and the display and keyboard. The program shall be capable of operating with an external CRT (provided by others), and with controller keypad entries and displays. Full documentation on the program shall be included. The software shall be configured to work on a 412C prom module.

3.13.6 PROM MODULE

Each Model 170E controller unit shall be furnished with one (1) Program Module, Model 412C as specified in the CALTRANS Specification, dated January, 1989 and all addendum's up to and including addendum 8, including back up lithium battery, and real time clock adjuster circuit, 1 Dallas 1225 chip, two 6264 ram chips.

3.13.7 SOFTWARE

The most recent revisions of Wapiti W4IKS or W7OSM shall be mounted on the prom module and configured accordingly.

The processor chip is HCII and the software provided shall meet the most recent revision of Wapiti W4IKS or W7OSM which supports this processor.

The City shall be responsible for programming the controllers with all operating parameters and timings.

3.13.8 EQUIPMENT TESTING

- A) Controllers and cabinets purchased under this contract shall be tested for conformance to CALTRANS, "Traffic Signal Control Equipment Specifications" dated January 1989 and the latest addenda. Testing may be done by an independent laboratory if the manufacturer does not have sufficient facilities to carry out the testing. A copy of the test results for all equipment purchased shall be supplied by the manufacturer.
- B) Each Model 170E controller unit shall be tested over a temperature range of minus 34 to plus 74 degrees Celsius. Proper operation of the unit shall be verified at both temperature extremes and at ambient. This testing is not a substitute for any quality control testing or final inspection testing normally performed, it is a process to be carried out prior to final inspection.
- C) Environmental chamber(s) shall have provision for remotely controlling the Model 170E controller being testing. Proper operation of the equipment shall be verified at minus 34, plus 74 degrees Celsius and ambient. Cold and hot soak times shall be sufficient to allow all components in the device to reach the temperatures desired. A minimum soak time of three hours shall be used for all testing.
- D) A representative of the agency may travel to the testing site to verify that the environmental testing is being carried out properly and to observe manufacturing practices at the factory.
- E) The manufacturer shall submit a proposed testing procedure and schedule 30 days in advance for evaluation by the Agency. Test procedures, environmental chambers, automatic test equipment, display boards, power supplies, and controls shall be described in detail. A "dry run" should be carried out in order to work out any problems with the test procedure. Any problems should be resolved before the arrival of the representative of the Agency.
- F) Minimum test requirements are given below. The manufacturer is free to suggest additional tests or variations on the test given below. Any changes should be described in the testing proposal.
 - 1. Cabinet:
Cabinets shall be tested at ambient conditions only. An automatic or semi-automatic method of checking cabinet wiring between equipment harnesses and field connections is required.
 - 2. Controller:
Shall pass the following test at least 5 times at each temperature extreme and ambient.

- a) Recovery from a short power interrupt of approximately 500 milliseconds.
- b) Recovery from a long power interrupt of approximately 5 seconds.

Front panel displays should be visible from a window in the environmental chamber. Signal outputs shall be brought out of the chamber to display board if controllers cannot be directly observed.

The vendor shall provide a method of testing controller inputs and outputs. Diagnostic software and wraparound connector for controller harnesses may be used. If diagnostic software is not used, outputs shall be brought out to a display board. Inputs may be paralleled to each controller.

3.14 2070 LIGHT CONTROLLERS

KANSAS CITY MODEL 2070 CONTROLLER HARDWARE SPECIFICATION

3.14.1.0 OVERVIEW

The Advanced Transportation Controller (ATC) is a general purpose field computer that is intended for continuous unattended operation in harsh environments.

These specifications define specific, interchangeable modules that are combined to form a Type 2070L or 2070LC ATC that is capable of running control software that might be obtained from a variety of suppliers. The California Department of Transportation (CALTRANS) Transportation Electrical Equipment Specifications (TEES) dated August 16, 2002, as amended and these specifications define module options arranged in a configuration to meet the needs of the Kansas City Advanced Transportation Management System (ATMS).

These Technical Special Provisions are a document to be used for the procurement of the Model 2070 Advanced Traffic Controllers for use in Kansas City, Missouri.

The specifications are derived from existing documents, the CALTRANS TEES dated August 16, 2002, as amended and the ATC Standard Specification for the Type 2070 Controller written by the following entities:

American Association of State Highway and Transportation Officials (AASHTO)
444 North Capitol St., NW Suite 249
Washington, DC 20001

Institute of Transportation Engineers (ITE)
525 School St., SW, Suite 410
Washington, DC 20024-2797

National Electrical Manufacturers Association (NEMA)
1300 N. 17th Street, Suite 1847
Rosslyn, Virginia 22209-3801

The ATC Standard Specification for the Type 2070 Controller is derived from the CALTRANS TEES document dated August 16, 2002, as amended, but is written to be non-agency or vendor specific.

Table 1 below depicts the hardware modules needed to compile the Kansas City Model 2070L ATC.

Table 1. Kansas City Model 2070L – Advanced Transportation Controller Configuration

Item	Description	2070L
Unit Chassis	19” Rack Mountable Unit Chassis	x
Model 2070-1A	CPU Module (Multiple Board)	
Model 2070-1B	CPU Module (Single Board – Serial Hub)	x
Model 2070-2A	Field I/O Module (170 Style Cabinets)	x
Model 2070-2B	Field I/O Module (ITS (C) & NEMA Style Cabinets)	x*
Model 2070-3A	Front Panel Module (4x40)	
Model 2070-3B	Front Panel Module (8x40)	x
Model 2070-3C	Front Panel Module (Blank)	
Model 2070-4A	Power Supply (10 AMP)	
Model 2070-4B	Power Supply (3.5 AMP)	x
Model 2070-5A	VME Cage Assembly	
Model 2070-5B	MCB 1A Mounting Assembly	
Model 2070-6A	Async/Modem Serial Com Module (300-1200 bps)	
Model 2070-6B	Async/Modem Serial Com Module (0-9600 bps)	
Model 2070-6C	Not yet defined	
Model 2070-6D	Async/Modem Serial Com Module (0-9600 bps)	
Model 2070-7A	Async/Fiber Modem Module	x
Model 2070-7B	Async Serial Com Module (EIA-232, 9-pin)	x**
Model 2070-8	Async Serial Com Module (EIA-485, 15-pin)	
Model 2070-9	NEMA Interface Module	
	Model 2070N Back Cover	

*Used in place of 2070 2A for ATC cabinet use

**Used for terminal & facilities communication in ATC cabinet

3.14.2.0 YEAR 2000 COMPLIANCE

The 2070L unit shall comply with the following Year 2000 Compliance Mandate:

"Year 2000 compliance for Systems in the State of Missouri is achieved when applications or system products (including software, microcode and microprocessors),

programs, files, databases, and functionality have or create no logical or mathematical inconsistencies when dealing with dates prior to and beyond 1999. The years 2000 and 2034 are recognized and processed as leap years. The product must also operate accurately in the manner in which it was intended for date operation without requiring manual intervention."

3.14.3.0 TIMING

Accuracy of Intervals:

The values shall be fixed discrete increments.

Repeatability:

The digital timing shall relate to the input line frequency such that no cumulative or drift errors will occur in timing intervals. No interval shall deviate by more than plus or minus 100 ms from its set value, at a VAC power source frequency of 60 Hz.

3.14.4.0 CLOCK CIRCUIT FOR TIME BASE COORDINATION (TBC)

The clock circuit of the TBC units may use either the 60 Hz VAC power source or a crystal oscillator as the timing reference. If a crystal oscillator is used as the timing reference, the frequency tolerance of the clock circuit shall be 1 minute per 30 days.

3.14.5.0 BACKUP POWER SOURCE

The TBC units shall be provided with a capacitor supply to power the clock circuit and memory for a minimum of 7 days when the 120 VAC power source is disconnected.

3.14.6.0 UNIT CHASIS

The Chassis shall consist of the metal housing, Serial Motherboard, Back-plane Mounting Surface, Power Supply Module Supports, Slot Card Guides, Wiring Harnesses, and Cover Plate(s).

3.14.7.0 TYPE 2070-1B CONFIGURATION

3.14.7.1 2070 Ethernet option

The 68360 SCC1 shall be reassigned to ETHERNET (ENET) Network meeting ETHERNET 10 MBPS IEEE 802-3 (TP) 10 BASE T Standard Requirements, both hardware and software. The four network lines shall be used to route ETHERNET across the Motherboard to the “A” Connectors. DC Grounding plane around the network connectors and lines shall be provided. Network Lines shall be assigned as: Network 1 = ENET TX+, Network 2 = ENET TX-, Network 3= ENET RX+, and Network 4 = ENET RX-. In addition, the conditioned ETHERNET shall be brought out on RJ 45 C14S Connector mounted on the CPU-1B Front Panel. Four LEDs labeled “TX, RX, TX Collision and TX Status” shall be mounted on the front panel signifying ETHERNET operational conditions.

3.14.7.2 Current requirements

The 2070-1B CPU shall not draw more than 1.00 Amperes of +5VDC and 500 mA of ISO+12 VDC.

3.14.7.3 Validation Suite

A validation suite of software and associated documentation shall be provided. It shall include all diagnostic programs necessary to test all 2070 functions. The diagnostic programs shall demonstrate that all software and hardware functions operate in conformance to specified functionality. It shall provide a working example of how to program all functions

3.14.7.4 Deliverables

A software package resident on the FLASH Memory shall be provided, including the Embedded OS-9 kernels, platform drivers, and a validation suite.

3.14.7.4.1

All software shall be delivered in the following forms:

1. Fully commented source code of contractor developed software (OS-9 not required)
2. Microware Ultra-C Version 2.4 compatible linkable object code
3. Memory map listing

3.14.7.5

The Model 2070-1B module shall become a standard module in the Model 2070L ATC for Kansas City.

3.14.8.0 TYPE 2070-2B MODULE

The module shall consist of the Serial Communication Circuitry, DC Power Supply and Module Connector C12S mounted on the module front plate.

3.14.8.1 FIELD CONTROLLER UNIT (FCU)

The FCU shall include a programmable microprocessor/controller unit together with all required clocking and support circuitry. Operational software necessary to meet housekeeping and functional requirements shall be provided resident in socketed firmware.

3.14.8.1.1 Parallel I/O Ports

The I/O Ports shall provide 64 bits of input using ground-true logic. Each input shall be read logic "1" when the input voltage at its field connector input is less than 3.5 VDC, and shall be read logic "0" when either the input current is less than 100 μ A or the input voltage exceeds 8.5 VDC. Each input shall have an internal pull-up to the isolated +12 VDC and shall not deliver greater than 20 mA to a short circuit to ground.

The I/O Ports shall provide 64 bits of output. Each output written as a logic "1" shall have a voltage at its field connector output of less than 4.0 VDC. Each output written as a logic "0" shall provide an open circuit (1 mega ohm or more) at its field connector output. Each output shall consist of an open-collector capable of driving 40 VDC minimum and sinking 100 mA minimum.

Each output circuit shall be capable of switching from logic "1" to logic "0" within 100 μ s when connected to a load of 100 K-Ohms minimum. Each output circuit shall be protected from transients of 10 \pm 2 μ s duration, \pm 300 VDC from a 1 K-Ohm source, with a maximum rate of 1 pulse per second.

Each output shall latch the data written and remain stable until either new data is written or the active-low reset signal. Upon an active-low reset signal, each output shall latch a logic "0" and retain that state until a new writing. The state of all output circuits at the time of Power Up or in Power Down state shall be open. It shall be possible to simultaneously assert all outputs within 100 μ s of each other.

An output circuit state not changed during a new writing shall not glitch when other output circuits are updated.

3.14.9.0 MODEL 2070-3B FRONT PANEL ASSEMBLY

The Type 2070-3B Front Panel Assembly (FPA) shall be delivered with option B. The option shall consist of a panel with latch assembly and two hinge attaching devices, assembly PCB, external serial port connector(s), CPU active LED indicator, and FP Harness Interface.

3.14.9.1 OPTION B

This option includes an FPA controller, two keyboards, AUX switch, alarm bell and Display B.

3.14.9.1.1 Display B

The Display shall consist of a Liquid Crystal Display (LCD), a backlight and a contrast potentiometer control. Display B shall have 8 lines of 40 characters, each with minimum dimensions of 2.65 mm wide by 4.24 mm high and either LED or EL backlight.

Each character shall be composed of a 5 x 7 dot matrix with a underline row or a 5 x 8 dot matrix. The viewing angle of the LCD shall be optimized for direct (90°) viewing, $\pm 35^\circ$ vertical, $\pm 45^\circ$ horizontal. The LCD shall have variable contrast with a minimum ratio of 4:1. The LCD shall be capable of displaying, at any position on the Display, any of the standard ASCII characters as well as user-defined characters.

The backlight shall be turned on and off by the controller circuitry. The backlight and associated circuitry shall consume no power when in the OFF state. A potentiometer shall control the LCD contrast with clockwise rotation increasing contrast. The contrast shall depend on the angular position of the potentiometer, which shall provide the entire contrast range of the LCD.

Cursor display shall be turned ON and OFF by command. When ON, the cursor shall be displayed at the current cursor position. When OFF, no cursor shall be displayed. All other cursor functions (positioning, etc.) shall remain in effect.

3.14.10.0 TYPE 2070-4 POWER SUPPLY MODULE

The Type 2070-4A Power Supply Module shall be an independent, self contained module, vented and cooled by convection only. The Module shall slide into the unit's power supply compartment from the back of the Chassis and be attached to the Backplane Mounting Surface by its four TSD #3 Devices. The Type 2070-4B Module

shall meet the same requirements as the 2070-4A except for 3.5 Amperes of +5 VDC and the +5 VDC STANDBY Power.

3.14.10.1 MODULE FRONT

An "On/Off" POWER Switch, four LED DC Power Indicators, PS Receptacle POWER Connectors, and the Incoming AC Fuse protection shall be provided on the Module Front. The LED DC POWER Indicators shall indicate all required DC voltages meet the following conditions: the +5 VDC is within 5% and the 12 VDC is within 8% of their nominal levels.

3.14.10.2 INPUT PROTECTION

Two 0.5-ohm, 10-watt wire-wound power resistors with a 0.2 μH inductance shall be provided (one on the AC+ Line and one on the AC- Line). Three 20 Joule surge arrestors shall be provided between AC+ to AC-, AC+ to EG, and AC- to EG. A 0.68 μF capacitor shall be placed between AC+ & AC- (between the resistor & arrestors).

3.14.10.3 POWER SUPPLY REQUIREMENTS

Voltage	Tolerances	I Min	I Max
+5 VDC	+ 4.875 to + 5.125 VDC	1.0 AMP	10.0AMP - MODULE 2070-4A 3.5 AMP - MODULE 2070-4B
+12 VDC Serial	+11.4 to +12.6 VDC	0.1 AMP	0.5 AMP
-12 VDC Serial	-11.4 to -12.6 VDC	0.1 AMP	0.5 AMP
+12 VDC	+11.4 to +12.6 VDC	0.1 AMP	1.0 AMP

3.14.10.3.1 Line/Load Regulation - shall meet the table tolerances values for voltage range of 90 to 135 VAC, minimum and maximum loads called out in the table & including ripple noise.

3.14.10.3.2 Efficiency - 70 % minimum

3.14.10.3.3 Ripple & noise - Less than 0.2% rms, 1% peak to peak or 50 mV, whichever is greater

3.14.10.3.4 Voltage Overshoot - No greater than 5 %, all outputs

3.14.10.3.5 Over voltage Protection- 130% Vout for all outputs

3.14.10.3.6 Circuit Protection Automatic recovery upon removal of fault

3.14.10.3.7 Inrush Current - Cold Start Inrush shall be less than 25A at 115VAC

3.14.10.3.8 Transient Response - Output voltage back to within 1% in less than 500 μs on a 50% Load change. Peak transient not

to exceed 5%

3.14.10.3.9 Holdup Time

- The power supply shall supply 30 watts minimum for 550 ms after ACFAIL going LOW. The supply shall be capable of holding up the Unit for two 500 ms Power Loss periods occurring in a 1.5-second period

3.14.10.3.10 Remote Sense

+5 VDC compensates 250 mV total line drop. Open sense load protection required.

3.14.11

RESERVED

3.14.12.0 INTEGRATED CIRCUIT CHIPS

All RS 485 line drivers/receivers may be socket mounted.

3.14.13.GLOSSARY OF TERMS AND ACRONYMS

- 1.0 A – Ampere. The unit of measurement for electrical current.
- 2.0 AC – Alternating Current. Electrical current that flows one way and then reverses during each relative half of a cycle.
- 3.0 AGENCY – Purchasing Agent.
- 4.0 ASCII – American Standard Code for Information Interchange. A 7-bit binary code representation of letters, numbers and special characters. It is universally supported in computer data transfer.
- 5.0 ASSEMBLY – A complete machine, structure or unit of a machine that was manufactured by fitting together parts and/or modules.
- 6.0 ASYNCHRONOUS – Data transmission in which the actual data is preceded by a start bit and followed by a stop bit, since the time between transmitted characters varies.

- 7.0 BIT – Binary digit. A single basic computer signal consisting of a value of 0 or 1, off or on.
- 8.0 bps – bit per second. Transmission rate (speed) of data.
- 9.0 Bus – A set of parallel conductors in a computer system which makes a main transmission path.
- 10.0 BYTE – A binary word consisting of eight bits.
- 11.0 CLEARANCE – The change interval(s) where a traffic controller reassigns the right-of-way from one movement to another.
- 12.0 CPU – Central Processing Unit. The decision-making unit within a computer. Also known as the microprocessor.
- 13.0 CTS – Clear to Send. A circuit in a serial device which, when on, indicates to another connected serial device that the first unit is ready to receive data.
- 14.0 DCD – Data Carrier Detect. A circuit in a serial device which, when on, indicates to another connected serial device that a carrier wave is detected.
- 15.0 DRAM – Dynamic Random Access Memory.
- 16.0 DTE – Data Terminal Equipment. The device that is the originator or destination of the data sent by a modem.
- 17.0 DTR – Data Terminal Ready. A signal generated by most modems indicating a connection between the DTE (computer) and the modem. When DTR is high (on), the computer is connected.
- 18.0 EG – Earth Ground.
- 19.0 EIA – Electronic Industries Association.
- 20.0 FLASH – A +5 VDC powered Integrated Circuit memory device with nonvolatile, electrically erasable, programmable, 100K read/write minimum cycles and fast access time features.
- 21.0 HEX – Hexadecimal. A base16 number system used by computers.
- 22.0 Hz – Hertz. The common unit for frequency or cycle.
- 23.0 IC – Integrated Circuit.
- 24.0 INTERVAL – The period in time where a traffic signal does not change indications.

- 25.0 IRQ – Interrupt Request. A channel assigned to a device to effect attention from the CPU.
- 26.0 KB – Kilobyte. One thousand bytes.
- 27.0 LED – Light Emitting Diode.
- 28.0 LOGIC – Negative Logic Convention (Ground True) State.
- 29.0 LSB – Least Significant Byte.
- 30.0 lsb – Least Significant Bit.
- 31.0 MB – Megabyte. One million bytes.
- 32.0 MCB – Main Controller Board.
- 33.0 mm – Millimeter. One meter divided by one thousand.
- 34.0 ms – Millisecond. One second divided by one thousand.
- 35.0 MSB – Most Significant Byte.
- 36.0 msb – Most Significant Bit.
- 37.0 μ s – Microsecond. One second divided by one million.
- 38.0 μ F – Microfarad. One farad divided by one million. A farad is the unit of measurement for capacitance.
- 39.0 MIL – Military Specifications.
- 40.0 MODEM – Modulation/Demodulation Unit.
- 41.0 MODULE – A functional unit that plugs into an assembly.
- 42.0 MOTHERBOARD – A printed circuit connector interface board with no active or passive components.
- 43.0 MOS – Metal-Oxide Semiconductor.
- 44.0 MOV – Metal-Oxide Varistor.
- 45.0 MS – Military Standards.
- 46.0 NEMA – National Electrical Manufacturer’s Association.
- 47.0 n – Nano. One billionth of a unit.
- 48.0 NLSB – Next Least Significant Byte.
- 49.0 nlsb - Next Least Significant Bit.
- 50.0 NMSB – Next Most Significant Byte.
- 51.0 nmsb – Next Most Significant Bit.
- 52.0 OHM – The unit of measurement for resistance to electrical current.

- 53.0 PASSAGE – The interval of a traffic phase which times an extension of the green time based upon an input from a detector.
- 54.0 PCB – Printed Circuit Board.
- 55.0 PDA – Power Distribution Assembly.
- 56.0 PHASE - A traffic phase is defined as those green, change and clearance intervals in a cycle assigned to any independent movement of traffic.
- 57.0 PLA/PAL – Programmable Array Logic Device.
- 58.0 ppm – Parts-per-million.
- 59.0 PWM – Pulse Width Modulation.
- 60.0 RAM – Random Access Memory.
- 61.0 RF – Radio Frequency.
- 62.0 RMS – Root Mean Square.
- 63.0 ROM – Read Only Memory Device.
- 64.0 RTS – Request to Send. A signal from a serial device which, when on or in the high state, has queued data and is requesting to send the data to another serial device.
- 65.0 R/W – Controller Unit Read/Write Control Line.
- 66.0 Rx – Receive data circuit.
- 67.0 S – Logic State.
- 68.0 s - Second.
- 69.0 SCI – Serial Communications Interface.
- 70.0 Second Sourced – Produced by more than one manufacturer.
- 71.0 SRAM – Static Random Access Memory.
- 72.0 SW – Switch.
- 73.0 TB – Terminal Block.
- 74.0 TOD – Time of Day Clock.
- 75.0 Triac – Silicon-Controlled Rectifier that controls power bilaterally in an AC switching circuit.
- 76.0 TSD – Thumb Screw Device. A retractable screw fastener with projecting stainless steel screw, spring and natural aluminum knob finish.
- 77.0 TTL – Transistor-Transistor Logic.

- 78.0 Tx – Transmit Data Circuit.
- 79.0 UL – Underwriter’s Laboratories, Inc.
- 80.0 VAC – Voltage Alternating Current.
- 81.0 VDC – Voltage Direct Current.
- 82.0 VME – Versa Module Eurocard, VMEbus Standard IEEE P1014/D1.2.
- 83.0 x - Number Value.
- 84.0 XX – Manufacturer’s Option.
- 85.0 WDT – Watchdog Timer. A monitoring circuit, external to the device watched, which senses an Output Line from the device and reacts.

3.15 Detectors

3.15.1 Video Cameras

Specification for a Modular (Single Camera), Detector Rack Mounted Video Detection System

A) General

This specification sets forth the minimum requirements for a system that detects vehicles on a roadway using only video images of vehicle traffic.

1. System Hardware

The video detection system shall consist of one video camera, a video detection processor (VDP) which mounts in a standard detector rack, and a detector rack mounted extension module (EM).

2. System Software

The system shall include software that detects vehicles in multiple lanes using only the video image. Detection zones shall be defined using only a video menu and a pointing device to place the zones on a video image. Up to 24 detection zones per camera shall be available.

B) Functional Capabilities

The VDP shall process video from one source. The source can be a video Camera or video tape player. The video shall be input to the VDP in RS170 Format and shall be digitized and analyzed in real time.

The VDP shall detect the presence of vehicles in up to 24 detection zones per Camera. A detection zone shall be approximately the width and length of one car.

Detector zones shall be programmed via a menu displayed on a video monitor And a pointing device connected to the VDP. The menu shall facilitate placement Of the detection zones. A separate computer shall not be required for programming detection zones.

The VDP shall store up to three different detector zone patterns. The VDP can Switch to any one of the three different detector patterns within 1 second of User request via menu selection with the pointing device.

The VDP shall detect vehicles in real time as they travel across each detector zone.

The VDP shall have an RS232 port for communications with an external computer.

The VDP shall accept new detector patterns from and external computer through the RS-232 port.

The VDP shall send its detector patterns to an external computer through the RS-232 port when requested.

The extension module (EM) shall be available to avoid the need to rewire the detector rack, by enabling the user to plug an extension module into the appropriate slot in the detector rack. The extension module shall be connected to the VDP by a 10 wire cable with modular connectors, and shall output contact closures in accordance with user selectable channel assignments.

C) Vehicle Detection

A minimum of 24 detection zones shall be supported and each detection zone can be sized to suit the site and the desired vehicle detection region.

A single detection zone shall be capable to replace multiple loops and detection zone may be ANDed or ORed together to indicate vehicle presence on a single phase of traffic movement.

Placement of detection zones shall be done by using only a pointing device and a graphical interface built into the VDP to draw the detection zones on the video image from each video camera.

Up to 3 detection zone patterns shall be saved within the VDP memory and this memory shall prevent loss during power outages.

The selection of the detection zone pattern for current use shall be done through a menu. It shall be possible to activate a detection zone pattern for a camera from VDP memory and have that detection zone pattern displayed within 1 second of activation.

When a vehicle is detected crossing a detection zone, the detection zone will flash a symbol on the screen to confirm the detection of the vehicle.

Detection shall be at least 98% accurate in good weather conditions and at least 96% accurate under adverse weather conditions (rain, snow, or fog). Detection accuracy is dependent upon site geometry; camera placement, camera quality and detection zone location, and these accuracy levels do not include allowances for occlusion or poor video due to camera location or quality.

Detector placement shall not be more distant from the camera than a distance of ten times the mounting height of the camera.

The VDP shall provide up to 8 channels of vehicle presence detection through a standard detector rack edge connector and one or more extension modules.

The VDP shall provide DZR to enable normal detector operation of existing zones except the one being added or modified during the setup process. The VDP shall output a constant call on any detection channel corresponding to a zone being modified.

D) VDP and EM Hardware

1. The VDP and extension module shall be specifically designed to mount in a standard detector rack, using the edge connector to obtain power and provide contact closure outputs. No adapters shall be required to mount the VDP in a standard detector rack. No detector rack rewiring shall be required.
2. The VDP and extension module shall operate satisfactorily in a temperature range from -34°C to $+60^{\circ}\text{C}$ and a humidity range from 0%RH to 95%RH, non-condensing.
3. The VDP and extension module shall be powered by 24 volts DC.

4. VDP power consumption shall not exceed 450 milliamps. The EM power consumption shall not exceed 100 milliamps.
5. The VDP shall include an RS232 port for serial communications with a remote computer. This port shall be a "D" subminiature connector on the front of the VDP.
6. The VDP shall utilize flash memory technology to enable the loading of modified or enhanced software through the RS232 port and without modifying the VDP hardware.
7. The VDP and extension module shall include detector output pin out compatibility with industry standard detector racks.
8. The front of the VDP shall include detection indications for each channel of detection that display detector outputs in real time when the system is operational.
9. The front of the VDP shall include one BNC video input connection suitable for RS170 video inputs. The video input shall include a switch selectable 75 ohm or high impedance termination to allow camera video to be routed to other devices, as well as input to the VDP for vehicle detection.
10. The front of the VDP shall include one BNC video output providing real time video output which can be routed to other devices.

E) Camera

The video cameras used for traffic detection shall be furnished by the VDP supplier and shall be qualified by the supplier to ensure proper system operation.

The camera shall produce a useable video image of the bodies of vehicles under all roadway lighting conditions, regardless of time of day. The minimum range of scene luminance over which the camera shall produce a useable video image shall be the minimum range from night time to daytime, but not less than the range 0.1 lux to 10,000 lux.

The camera shall use a CCD sensing element and shall output monochrome video with resolution of not less than 350 lines vertical and 380 lines horizontal.

The camera shall include an electronic shutter control lens.

The camera shall include a variable focal length lens with variable focus that can be adjusted, without opening up the camera housing, to suit the site geometry. A single camera configuration shall be used for all approaches in order to minimize the setup time and spares required by the user.

The camera electronics shall include AGC to produce a satisfactory image at night.

The camera shall be housed in a weather-tight sealed enclosure. The housing shall be field rotate able to allow proper alignment between the camera and the traveled road surface.

The camera enclosure shall be equipped with a sun shield. The sunshield shall include a provision for water diversion to prevent water from flowing in the cameras field of view. The camera enclosure with sunshield shall be less than 5 inches diameter, less than 14 inches long, and shall weigh less than 5 pounds when the camera and lens are mounted inside the enclosure.

The camera enclosure shall include a thermostatically controlled heater to assure proper operation of the lens shutter at low temperatures and prevent moisture condensation on the optical faceplate of the enclosure.

When mounted outdoors in the enclosure, the camera shall operate satisfactorily in a temperature range from -34C to +60C and a humidity range from 0%RH to 100%RH.

The camera shall be powered by 120 VAC, 60Hz. Power consumption shall be 15 Watts or less under all conditions.

Recommended camera placement height shall be 33 feet (or 10 meters) above the roadway, and over the traveled way on which vehicles are to be detected. Cameras shall be mounted as shown in the drawings. Mounting can either be on an extension arm on a mast arm or a luminary arm or as specified by the Engineer. All open ends of the arms and or extensions shall be properly capped.

The camera shall view approaching vehicles at a distance not to exceed 350 feet for reliable detection (height to distance ratio of 10:100). Camera placement and field of view (FOV) shall be unobstructed and as noted In the installation documentation provided by the supplier.

The camera enclosure shall be equipped with separate, weather-tight connections for power and video cables at the rear of the enclosure.

These connections may also allow diagnostic testing and viewing of video at the camera while the camera is installed on a mast arm or pole using a lens adjust module (LAM) supplied by the VDP supplier. Video and power shall not be connected within the same connector.

The video signal output by the camera shall be RD170 format.

The video signal shall be fully isolated from the camera enclosure and power cabling.

F) Installation

Coaxial cable for transmission of video signals shall be Belden #8281 or equivalent. This cable shall be suitable for installation in conduit or overhead with appropriate span wire. BNC plug connectors should be used at both the camera and cabinet ends. The coaxial cable, BNC connector and crimping tool shall be approved by the supplier of the video detection system and the manufacturer's instructions must be followed to ensure proper connection.

The power cabling shall be 16 AWG three conductor cable. The cabling shall comply with the National Electric Code, as well as local electrical codes.

The video detection system shall be installed as recommended by the supplier and as documented in installation materials provided by the supplier.

G) Warranty

1. The video detection system shall be warranted to be free of defects in material and workmanship for a period of two years from date of shipment from the supplier's facility. During the warranty period, the supplier shall repair with new or refurbished materials, or replace at no charge, any product containing a warranty defect provided the product is returned FOB to the supplier's factory or authorized repair site. Product repaired or replaced under warranty by the supplier will be returned with transportation prepaid. This warranty does not apply to products damaged by accident, misuse, abuse, improper operation, service by unauthorized personnel, or unauthorized modification.
2. In recognition of the substantial influence on video detection performance exerted by the quality of the physical installation, including selection of locations for cameras as well as cabling and connector integrity, no warranty of merchantability or fitness for purpose is made for the video detection system. Under no

circumstances shall supplier be liable for any loss or damage, whether direct, indirect, special, incidental, or consequential, to the contracting agency or any third party arising out of the use or inability to use the products.

3. The foregoing warranties are expressly made in lieu of all warranties expressed or implied and are the sole remedy of customers.
4. During the warranty period, technical support shall be available from the supplier via telephone within 4 hours of the time a call is made by a user, and this support shall be available from factory certified personnel or factory-certified installers.
5. During the warranty period, updates to VDP software shall be available from the supplier without charge.

H) **Maintenance and Support**

1. The supplier shall maintain an adequate inventory of parts to support maintenance and repair of the video detection system. These parts shall be available for delivery within 30 days of placement of an acceptable order at the supplier's then current pricing and terms of sale for said parts.
2. The supplier shall maintain an ongoing program of technical support for the video detection system. This technical support shall be available via telephone, or via personnel sent to the installation site upon placement of an acceptable order at the supplier's then current pricing and terms of sale for on site Technical support services.
3. Installation or training support shall be provided by a factory authorized representative.
4. All product documentation shall be written in the English language.

3.15.2 Induction Loop Detectors

Induction loop vehicle detectors shall detect a vehicle stopped within the field of the loop or passing over it at speeds to 80 miles per hour. All controls, connections and indications shall be provided to select pulse or full presence operation in the pulse mode, a single vehicle entering the loop shall cause an output of one second or less. In the presence mode, the detector shall indicate the presence of a vehicle stopped in the detection area until the detector times out. The detector, after installation and initial adjustment, shall automatically tune

itself to various loop configurations ranging in size from 6 feet by 6 feet minimum to 6 feet by 30 feet maximum, with a maximum lead-in length 750 feet. The detector shall time out and retune itself automatically if it senses a continuous vehicle occupation of the loop field for a nominal time of 10 to 30 minutes. In the event of power loss to the detector, a continuous call shall be made to the controller. The sensing unit shall have a light which shall illuminate when a vehicle is within the loop field.

3.15.3 Micro loop Probe

The device shall transform an increase in magnetic field intensity into a decrease in inductance. The device shall be a small cylindrical unit designed to be buried beneath the road surface. When the device is connected to an inductive loop detector, all vehicles containing significant vertical sections of ferromagnetic material shall be detected. The unit assembly shall be sealed against moisture entry and shall have a temperature range of -35 to +165 F. The unit shall have a humidity range of 0 percent to 100 percent including submersion in solutions of chemical typical of roadway runoff. AC magnetic field intensity must be less than 10 millioerstads peak-to-peak divided by the number of probes connected in series. The unit shall operate normally in ambient magnetic field intensity of 200 to 600 millioerstads. The inductance shall be 25 micro henries nominal per probe plus 21 micro henries nominal per 100 feet of interconnecting and lead-in cable. The resistance shall be 0.5 ohms per probe plus 3.2 ohms per 100 feet of interconnecting and lead-in cable. "IQ" shall be nominally 3 at 40 KHZ 400 millioerstads ambient magnetic field intensity, nominally 5 at 100 KHZ, 400 millioerstads magnetic field intensity. The sensitivity shall be 3.5 to 8.0 nano henries per millioerstad at 40 KHZ, 400-millioerstad ambient magnetic field intensity.

3.15.4 Sonic Detectors

Ultrasonic detectors shall be mounted at the locations shown on the plans and in accordance with manufacturer's recommendations. All wiring shall be continuous and without any splice from the detector unit to the controller. Contractor shall make necessary adjustments for proper operation of the unit.

3.15.5 Pedestrian Push Button

(For signs specifications see the section 3.12 on signs)

Pedestrian push buttons shall be direct push contact type. Each push button shall be a removable contact assembly mounted in a durable metal case. Contacts shall be normally open, entirely insulated from the case and operating button, and have connecting terminals. The case shall have one outlet tapped for 1/2 inch pipe. The

operating button shall be brass or other corrosion resistant metal alloy and shall be sturdy. The operating voltage shall not exceed 18 volts. The entire assembly shall be weather- proof, secure against electrical shock to the user, and of such construction as to withstand hard usage. A mounting height of approximately 3 Feet 6 Inches above the sidewalk should be used.

SECTION 4

FIBER OPTICS

FIBER OPTIC INTERCONNECT SYSTEM

4.1 Description

This work shall include furnishing, installing, and testing a fiber optic interconnect system as shown on the plans. The system shall include all equipment listed or shown in the plans and described in this special provision and shall include any incidental items necessary for the satisfactory operation of the system.

Fiber optic cable shall be installed to provide communications to link on-street masters and local controllers to Kansas City's central signal system. Any unused fibers are for future unspecified uses that might include Intelligent Transportation Systems (ITS) applications such as video cameras.

4.2 General.

4.2.1 Compatibility with Adjacent Controller

The contractor shall ensure that the new systems are compatible with all existing components in the system.

4.2.2 Maintenance personnel shall be trained on maintenance and repair of all serviceable equipment including but not limited to the system, fiber optic data link, D-Panel wiring, etc. Training shall include field level troubleshooting and bench repair. This training shall be for a minimum of eight hours in one day.

4.2.3 Warranty.

All warranties provided on equipment supplied shall be transferred to the City upon project acceptance.

4.3 Equipment

Only equipment specified in the standard specifications or the plans will be accepted for use.

4.3.1 Fiber Optic Cable System

The interconnect cable shall be a 12-fiber cable as specified in this specification.

4.3.2 Specifications and Test Results

For all fiber optic cables, the contractor shall deliver to the engineer a copy of the cable manufacturer's specifications and test results attesting to the proof of performance of the fiber product used by the manufacturer. Cables used shall have a manufacture date of not over twelve months, to ensure newness of the product used.

4.3.3 Fiber Cable

All fiber cable shall meet the following specifications and shall be riser rated. The fiber cable shall contain gel filled loose buffer tubes containing the glass fibers. All buffer tubes shall be color coded. Each color-coded buffer tube shall be filled with a gel to prevent moisture penetration. Each individual fiber within each buffer tube shall be individually color-coded. Tape shall not be used to confine the water-blocking compound. A glass reinforced plastic shall be used for the central member. High tensile aramid or fiberglass yarn, helically stranded evenly around the cable core, shall be utilized for additional tensile strength. A medium density polyethylene outer jacket with a nominal thickness of 1/16 inch (1.5 mm) shall be applied overall and shall be labeled in consecutively numbered 3 foot (1 m) increments so that cable lengths between any two points can be readily determined.

Multimode Graded Index Fiber	
Core Diameter	50 ± 3.0 microns
Cladding Diameter	125.0 ± 2.0 microns
Coating Diameter	250 ± 15 microns
Numerical Aperture	0.275 ± 0.015
Operating Wavelengths	850 nm and 1300 nm
Maximum Attenuation	@ 850 nm - 3.75 dB/km
Maximum Attenuation	@ 1300 nm - 1.5 dB/km
Minimum Bandwidth	@ 850 nm - 160 MHz km
Minimum Bandwidth	@ 1300 nm - 500 MHz km
Proof Test	100 kpsi
Single mode Fiber	
Typical Core Diameter	8.3 microns
Cladding Diameter	125.0 ± 1.0 microns
Coating Diameter	245 ± 10 microns
Colored Fiber Diameter	nominal 250 Microns
Maximum Attenuation	@ 1310 nm - 0.4 dB/km
Maximum Attenuation	@ 1550 nm - 0.3 dB/km

Maximum Dispersion @ 1290 to 1330 nm - 2.8 ps/(nmkm)
Maximum Dispersion @ 1550 nm - 18 ps/(nmkm)
Proof Test 100 kpsi
Cable
Color Coding EIA/TIA Standard
Tensile Strength During Installation 2700 N (608 lbf)
Long Term Strength 890 N (200 lbf)
Crush Resistance 220N/cm (non-armored)
Operating Temperature Range -40 C to 70 C (-40 F to 160 F)
Storage Temperature Range -40 C to 70 C (-40 F to 160 F)
Installation Temperature Range -30 C to 70 C (-20 F to 160 F)
Minimum Bend Radius (Installation) 15 x Cable O.D.
Minimum Bend Radius (Long-Term) 10 x Cable O.D.

4.3.4 2-Fiber Cable

The primary interconnect cable shall be a 12-fiber cable assembly consisting of two gel-filled, loose buffer tubes each with six color-coded fibers. The orange colored tube shall contain single mode fibers and the other tube shall contain multimode fibers.

4.3.5 6-Fiber Cable (Multimode)

Unless otherwise specified in the plans, the interconnect cable installed between the splice cabinet and the signal controller cabinet for closed-loop system communication shall be a 6-fiber cable assembly consisting one gel-filled, loose buffer tube with six color-coded, multimode graded index fibers.

4.3.6 6-Fiber Cable (Single mode)

If specified on the plans, this cable shall be a 6-fiber cable assembly consisting of one gel-filled, loose buffer tube with six color-coded, single mode graded index fibers.

4.3.7 Duplex Jumper Cable

Duplex fiber optic jumpers shall be provided to interconnect the fiber terminated at the fiber distribution unit in the controller cabinet with the fiber optic data link (modem) typically inside the signal controller unit. The duplex jumper shall be heavy duty and shall consist of two individually tight tube buffered fibers, with an additional outside jacket, terminated with SC connectors as described in this provision. The fibers shall be multimode or single mode as required by the system. The fibers shall be sized as specified for the other interconnect cables described in this special provision. The duplex jumper cable shall be approximately 6 feet (2 m) long and shall positively identify the two fibers. The cable shall be pliable, allowing a tight bending radius as required in the specified cabinets without compromising system operation. Each jumper assembly shall be supplied with optical performance test data indicating insertion loss for that jumper assembly.

4.4 CONDUITS:

Unless otherwise specified polyethylene conduits of specified diameter shall be used for installing cables. Conduit shall be orange in color, as approved by the Engineer.

4.5 PULL BOXES:

Pull Boxes shall be generally installed at 300 feet centers or as shown in the plans. Any additional pull boxes required by the contractor for ease of work shall be at the contractor's expenses and such additional pull boxes shall be installed if approved by the Engineer. Pull boxes installed in fiber optics interconnects shall be Type III and meet the specifications for fiber optics pull boxes, specified in this section and as shown on the plans. (See Section 3.10.2).

4.6 SC Connectors

All fiber optic cable end connectors shall be industry standard SC style connectors designed for field installation and to operate within a temperature range of -30 F to 165 F (-35 C to 75 C). The connector shall be a low loss type comprised of a ferrule, crimp sleeve and a two-inch (50 mm) strain relief boot. The ferrule shall have a ceramic tip. Each connector shall be provided with a dust cap. The SC connector shall be designed for the type of fiber to which it is attached. All unspecified fiber shall be tested through the SC connectors.

4.7 Splice Cabinet

The splice cabinet shall be required only when noted on the plans. The splice cabinet shall be installed adjacent to controller cabinets and shall be a model 336 cabinet with an EIA 19 inch (480 mm) rack cage and fiber distribution units as required in the project drawings.

4.7.1 The model 336 cabinet and EIA 19 inch (480 mm) rack cage shall conform to the Traffic Signal Control Specifications published by the California Business, Transportation & Housing Agency, Department of Transportation (CALTRANS), dated January 1989, and all current addenda and revisions. The housing shall include, but not be limited to, the enclosure, doors, latches/locks, hinges and door catches, ventilation, gasketing, cage supports and mounting, the rack cage and anchor bolts.

4.7.2 Each splice cabinet shall include a fiber distribution unit, with removable interior, to provide a termination and service access point for the fiber optic cables. The fiber distribution unit shall be mounted on the 19 inch (480 mm) rack cage and shall be a modular design to support both fusion and mechanical splices of multimode and single mode fiber. The single cabinet construction shall have a minimum termination/connection capacity of 24 fibers and 4 splice trays. The connector panel, to be located at the top of the unit shall be designed to accommodate ST and other standard connectors. Six ST couplings with ceramic inserts, designed to accommodate both single mode and multimode fiber, shall be

provided and installed for future use. One single mode splice tray and one multimode splice tray each with a closure for 12 fusion splices, plus one spare tray for 12 strands, as a minimum, shall be provided in each cabinet. Additional trays shall be provided as necessary to splice or terminate fibers in accordance with the system design and this special provision. The design of the unit shall allow stacking of splice trays in a manner that permits access to individual trays without disturbing other trays and splicing to be conducted at a distance from the unit. The lower portion of the unit shall provide for the neat storage of continuous tubes. Excess cable may be stored either in the fiber distribution unit or within the splice cabinet. The unit shall provide both front and rear access with hinged door access and cable strain relief accommodations. The unit and splice tray shall be constructed of durable approved construction, designed for outdoor applications. Plastic doors may be considered for approval.

A two rack space patch cord manager shall be used between fiber enclosures or between enclosure and the electronics.

4.8 Fiber Optic Data Link (Modem)

- A) The data link between the fiber optic cable and the master or local intersection 2070 or 170 controller shall be accomplished using a data link (referred to as a modem in the plans) compatible with daisy chain operation to transceive RS-232 data using fiber optics. This data link shall be compatible with and installed in the 2070 or 170 controller unit in accordance with the manufacturers' recommendations.
- B) The fiber optic data link shall be capable of operating in a full duplex mode of operation, employing asynchronous RS-232 data link protocols. RS-232 signals shall be converted to light and transmitted from data link to data link until the light is reconverted to RS-232 electrical signals sent to a particular controller. The fiber optic data link shall operate in a daisy chain communication mode.
- C) On the data link assembly, there shall be two pairs of clearly labeled optical emitters and optical detectors, designed to attach to standard SC connectors. There shall be two clearly labeled LED's , one for transmit and one for receive. These LED's shall illuminate when the fiber optic data link is either receiving or transmitting at the local controller. There shall be a slide switch labeled "M" for master operation and "L" for local operation.
- D) In the master mode of operation, the electrical data entering the fiber modem from the controller unit shall be transmitted as optical signals in a parallel mode from each of the two emitters. The optical signals received by the two detectors shall be converted to electrical signals and sent in parallel to the controller.
- E) In the local mode of operation, optical signals received by detector 1 shall be converted to electrical signals and sent the to the controller unit. These same

signals shall be regenerated and transmitted by emitter 2 to the next adjacent fiber optic data link downstream in the daisy chain. Optical signals received by detector 2 shall be regenerated and transmitted by emitter 1 to the next adjacent fiber link upstream. Electrical signals received by emitter 1 from the controller shall be transmitted to the next adjacent fiber link upstream. Regeneration shall maintain pulse fidelity within ± 0.1 percent for each data link.

- F) The fiber optic data link shall have an emergency backup power source that allows continued daisy chain operation when the 2070 or 170 controller unit is removed or if the power to the controller has been turned off. The backup power source shall provide uninterrupted operation of the daisy chain interconnect system, both upstream and downstream from the affected data link, for a period of 24 hour based on 50% duty cycles. An RJ11/4 jack shall be available on the assembly to interface an external data link, allowing fiber optic communications in four directions. The Modem shall be delivered with dust caps on all ports. The data link shall operate with all fiber ranging from 50/125 glass to 1 mm plastic fiber and shall meet the following electrical requirements:

Electrical Requirements	
Voltage	12-volt DC
Current	26 mA Continuous (165 mA peak)
Wavelength	850 nm
Data Link Sensitivity	
Maximum	0 dBm
Minimum	-40 dBm
Data Rate	100 to 19.2 k baud
Operating Range	1.9 miles (3 km) from data link to data link

4.8.1 Cabinet Accessories

Fiber Distribution Unit: Each controller cabinet shall be equipped with a fiber distributed unit as required in the drawings, to facilitate a termination, storage and service access point for fiber optic cables. The fibers in the interconnect cable(s) shall be terminated on one side and duplex jumpers shall extend on the other side to the data links (modems). The fiber distribution unit shall be a modular design to support a minimum termination/connection capacity of 12 fibers, one splice tray and strain relief for up to four cables (no splice tray is required). The connector panel shall be designed to accommodate SC connectors for both multimode and single mode fibers, as appropriate. SC couplings with **ceramic** inserts shall be provided to accommodate all fibers brought into the controller cabinet from the splice cabinet. The unit shall provide both front and rear access with hinged door access. The unit shall be constructed of durable construction for outdoor applications. Plastic doors may be considered for approval. The unit shall be sized to fit in the controller cabinet and shall be positioned to allow fiber cables to be routed with bending radii exceeding manufacturer's recommendation.

The unit shall not conflict with other cabinet components or panels. Fiber cables shall not conflict with other cabinet wiring.

Cabinets with one signal cable shall be provided with one, 12-position bulkhead assembly. These will generally be cabinets located at the terminus of cable runs. Cabinets located at midpoints will be provided with two, 12-position bulkhead assemblies; one for the inbound cable and one for the outbound cable. The 12-position bulkhead assemblies shall consist of a series of 12 SC mating adapters. The adapters shall be constructed with a nickel-plated die cast zinc alloy body and a ceramic split alignment sleeve. The 12 adapters shall be mounted on 1-inch (25 mm) centers on a 1/8-inch (3.2 mm) thick, 8-inch (200 mm) long, 1-1/2-inch x 1-1/2-inch (38 mm x 38 mm) aluminum right angle mounting bracket to be attached by an approved method to the EIA rack inside the controller cabinet. Each bulkhead assembly shall be provided with 24 dust caps; one installed on each of the 24 ports. Each bulkhead assembly shall also be provided with a duplex fiber jumper as described in these Specifications.

Standard breakout kit(s) shall be used to terminate all signal interconnect cable(s). Breakout kits(s) shall be colored to match the fiber strands, a minimum of 18 inches (460 mm) in length and be configured for the specified signal interconnect cable.

4.9 Construction Requirements.

4.9.1 Fiber Optic Cable Installation.

- A) The contractor shall provide trained and experienced personnel to supervise the installation of the fiber optic cable. Fiber optic cable shall be installed by trained personnel having a minimum of one year current installation experience in fiber optic systems. The contractor shall provide a certification for each person installing fiber cable. The certification shall show the amount of experience, the company or companies where experience was obtained and fiber training received. Methods of fiber optic installation, connections, splicing or other types of work with fiber optic cable shall be as approved by the engineer before implemented by the contractor. Work with, upon or to fiber optic cable included in this project shall not be allowed without the engineer's approval.
- B) Installation of the fiber optic cable shall also be in accordance with the manufacturer's specifications and recommended practices. Should the manufacturer's specifications or recommended practices appear to conflict with this special provision, the matter shall be brought to the attention of the engineer for resolution.
- C) The fiber optic interconnect cable shall be installed in continuous runs for each system, in conduit, pull boxes, splice cabinets or traffic signal controller cabinets. No splices outside of the splice cabinets or controller cabinets will be allowed.

Only those fiber tubes to be accessed in splice cabinets, controller cabinets and distribution units shall be opened, and only active fibers in that tube or tubes shall be cut and spliced. The manufacturer's recommended procedure for a mid-span access shall be followed. The continuous fiber tubes shall be neatly coiled, ensuring that the minimum bend radii are not violated, and organized in the fiber distribution unit. The continuous fibers in the fiber tube(s) that have been opened shall be coiled in the appropriate splice tray. The fibers to be spliced shall be connected by fusion splicing methods (0.06 dB loss maximum), and the splice shall be held and secured in a fusion splice organizer on the trays. The dark fibers in the 6-fiber cable shall be secured to the splice organizer on the appropriate tray but do not need to be spliced.

- D) The contractor shall document the location and termination of all fibers in the appropriate cabinet. Written documentation shall be left in the cabinet with one copy provided to the engineer.
- E) Each end of the interconnect cable shall be sealed with a manufacturer approved end cap or pulling grip for use during installation. These caps or grips shall be removed only after complete installation of the cable and for the cable acceptance testing. End caps shall be installed to remain in place where fibers are not to be terminated.
- F) The minimum bending radius and the maximum pulling force, as defined by the fiber optic cable manufacturer, of the interconnect cable shall not be exceeded during installation. The pulling of the cable shall be hand assisted at each pull box, splice cabinet and controller cabinet. The cable shall not be kinked, crushed or forced around a sharp corner. Pulling equipment may be used; however, all pulling equipment and hardware shall maintain the cable's minimum bend radius. Equipment that may contact the cable, such as sheaves, capstans, bending shoes, and quadrant blocks shall be designed for use with fiber optics. Where pulling equipment such as a winch is used, cable tension shall be continuously monitored. This may include use of a winch with a calibrated maximum tension or a dynamometer or in-line tensiometer.
- G) If a lubricant is used, it shall be of the water based type as approved by the cable manufacture and shall be compatible with the pre-lubricated polyethylene conduit. Prior to use, lubricant type and manufacturer shall be supplied to the engineer for approval.
- H) Sufficient slack shall be left at each splice cabinet and controller cabinet to allow proper termination. Each pull box shall contain a minimum of three turns of coiled cable and each signal cabinet or a splice cabinet shall contain a minimum of 10 feet (3 meters) of coiled cable. The stored cable shall be neatly coiled as per the manufacturer's minimum bending radius specification. Where the size of the box precludes the coiling of cable above the minimum bending radius, the cable shall pass straight through the pull box.

- I) The conduit containing only fiber optic interconnect cable shall be polyvinyl chloride (PVC) conduit in accordance with the standard specifications and shall be orange in color. A No. 14 AWG (2.5 mm²) Type USE stranded copper tracer wire shall be installed in the conduit in accordance with the standard specifications. The wire shall be connected with a connector at each end to a copper ground rod half an inch diameter and 8 Ft. long. Underground warning tape shall be installed in all trenches where conduit is installed. The warning tape shall be installed approximately 12 inches (0.3 meters) above the conduit. The tape shall be 4-inch (100 mm) wide polyethylene material, at least .004 inches (0.10 mm) thick. The tape shall be orange with black letters that say "Caution - Buried Fiber Optic Cable. KCMO Traffic Signals". The message shall be repeated continuously along the length of the tape. Other legends may be tendered for approval
- J) Conduit runs shall be straight between pull box to pull box, unless otherwise shown in plans or approved by the Engineer. Installation of Conduit shall meet the City specifications for lying of Conduits.
- K) At each pull box and controller cabinet, the interconnect cable shall be visibly marked "Caution - Fiber Optic Cable" by self-adhesive, weatherproof tags.

4.9.2 Cable Testing

- A) After the fiber optic cable installation, each fiber in each section shall be tested for attenuation and continuity as a minimum. The testing shall be conducted by a licensed independent testing agency, approved by the City of Kansas City, Mo. Contractor shall make all necessary arrangements to facilitate the performance of all testing. Any sections that fail the testing shall be replaced at the contractor's expense and retested. No separate payments will be made for testing, to the contractor.
- B) All testing shall be performed in an accepted manner and in accordance with the testing equipment manufacturer's recommendations. All data shall be recorded and submitted to the engineer.

4.9.3 Attenuation

- A) The end-to-end attenuation shall be measured for each link after installation by insertion loss testing.
- B) The launch cable shall be connected to the light source and the receive cable to the power meter. The two reference cables shall then be connected via a termination hub. A reference power reading (P1) shall then be taken and recorded.

- C) The system link to be tested shall then be inserted between the launch and receive cables using 2 termination hubs. A test power reading (P2) shall then be taken and recorded.
- D) The link attenuation A) in dB shall be recorded as the mathematical difference between the reference power (P1) and the test power (P2).
- E) Insertion loss testing shall be performed in both directions along the link. The direction of the test shall be recorded in the documentation. The testing shall be submitted on disk as well as a hardcopy.

4.9.4 Transmitter/Receiver Power Levels

- A) The output power levels at the network hardware transmitters and receivers shall be measured in milliwatts and recorded for system documentation.
- B) The power meter shall be connected to the transmitter side of the equipment with a system jumper. The transmit power level shall then be read and recorded. The transmitter shall then be re-connected to the cable link and the power meter connected to the receiver side of the equipment. The receive power level shall then be read and recorded.

4.9.5 Continuity

- A) Continuity tests shall be used to determine whether a test or system jumper does or does not pass light. A continuity test shall also be used to assure the fibers have not been crossed over in the jumper and to assure that the transmit fiber goes to the receiver fiber.
- B) To perform continuity test, a high-intensity flashlight shall be aimed into the connector at one end, while an observer watches for a flicker of light at the other end.

4.9.6 Optical Time Domain Reflectometer (OTDR) Testing

- A) An Optical Time Domain Reflectometer (OTDR) shall be used to evaluate the quality and length of cable reels prior to use. The fiber loss in dB/Km and the length of each reel shall be recorded in the documentation. The maximum attenuation of the cable shall be 3.5 dB/Km nominal, measured at room temperature at 850 nm [equivalent for single-mode]. This shall be submitted on disk with a copy of the software for review.
- B) A hard copy of OTDR signature traces for all system links shall be made and provided in the documentation.

4.9.7 Splice Cabinet

Splice cabinets when called for, shall be installed on a separate concrete base in accordance with Standard Plans.

4.10 System Installation

All system equipment shall be installed in accordance with the plans, the Standard Specifications and the manufacturers' recommendations, and shall result in a fully functioning system.

4.10.1 System Acceptance Tests

In addition to testing requirements outlined in the standard specifications, the contractor shall be responsible for successfully completing a four-part system acceptance test, as follows:

- a) Office Computer Acceptance Test
- b) Notebook Computer Acceptance Test
- c) System Operational Test
- d) Thirty Day System Operational Test

A) Office Computer Acceptance Test

The office computer acceptance test shall be performed after successful completion of the on-street master acceptance test and shall include at least the following tests:

- a. A simulated fault at a local controller shall be recorded in the office computer log. The user shall verify the entry by printing a log report.
- b. The user shall reschedule a timing plan change and verify that the event happens at the new time.
- c. The user shall make a timing plan change and verify that the change has been made at the local controller.
- d. The user shall print a report that shows all plan changes for the previous 24 hours.
- e. The user shall print a report showing volume and occupancy values from all system detectors for the previous 24 hours.
- f. The user shall call up a real-time intersection display.

B) Notebook Computer Acceptance Test

The notebook computer acceptance test shall consist of the same tests performed for the office computer acceptance test except all reports shall be displayed on the screen. The test shall be conducted only after the office computer acceptance test has been successfully completed. In addition, a complete local controller data base shall be uploaded from one controller and downloaded to another using only the notebook computer, the cable provided and the two controllers.

C) System Operational Test

The system operational test shall be conducted after the on-street master, office computer and notebook computer acceptance tests have been successfully completed and shall consist of a thirty day operational period during which system failures are recorded. Any failure or malfunction of equipment during the test period shall be corrected at the contractor's expense and the signal, or system, tested for an additional thirty consecutive day period. This procedure shall be repeated until the signal equipment has operated to the engineer's satisfaction for thirty consecutive days. System failures shall include, as a minimum, the following:

- a. Local controller failing to respond to the master.
- b. Master failing to respond to either the office or notebook computer.
- c. A system detector failure.

D) Thirty Day System Operational Test

The thirty day system operational test shall replace the fifteen day test period outlined in the standard specifications. Liquidated damages will only be accumulated between the end of working days and the start of the final thirty consecutive day test period.

4.11 Documentation

Complete system documentation shall be provided. Such documentation shall, as a minimum, include:

- a. Four complete system operating manuals. This includes documentation pertaining to system software.
- b. Three complete local controller operating manuals per controller.
- c. Four sets of wiring diagrams and system block diagrams.
- d. The result of all testing shall be recorded along with date of test, name of person performing test, brand name, model number, serial number of equipment used during test, and any other pertinent information and data.

SECTION 5

CONSTRUCTION REQUIREMENTS

GENERAL:

5.1 ORDER OF WORK

Within twenty (20) days following execution of a contract, the Contractor shall submit to the Engineer for approval the shop drawings as required in "MATERIALS AND EQUIPMENT" section of this specification.

A pre-construction conference shall be held with the Contractor and representatives from the department and other utilities involved or affected by this project, as directed by the Engineer.

At the earliest possible time all electrical conduit, service boxes, pole foundations and junction boxes shall be installed at the correct grade.

New traffic signal heads shall remain covered with orange bags during construction until the entire installation is placed in operation. Black bags shall not be used to cover the new signal heads during construction. Signal heads are to be covered to convey to drivers that they are not operational, as approved by the Engineer.

The Contractor is hereby advised that the work to be done shall be completed with full knowledge of the schedule made available to the Engineer. The Engineer may, at his option, cause any work completed without his knowledge or inspection, to be dismantled and inspected.

Any requested deviation from the "ORDER OF WORK" established herein must be approved by the Engineer or his representative.

No new fixture shall be constructed as part of this contract which is in conflict with any existing utility facility, or the code required thereby, unless approved by the Engineer.

Any malfunction of an existing signal installation resulting from the contractors operation, regardless of the nature of the work, shall be corrected at the contractor's expense in accordance with the project engineer's instructions. If any adjustments are required to the operation of an existing signal installation due to the contractor's operation, the contractor shall provide a minimum of two working days notice to the engineer.

5.2 Excavations

The Contractor shall perform all excavations for installing underground conduits, cable, boxes and pole bases in whatever substances encountered, to the depths indicated on the drawings or as otherwise approved. During excavation, material suitable for backfilling shall be piled in an orderly manner a sufficient distance from the excavation to avoid slides. Excavated materials shall be kept off sidewalks and out of the street where possible. All excavated material that is piled on sidewalks or in streets shall be removed by the end of the same working day. The Contractor shall pile excavated materials such that drivers' visibility will not be obstructed. All excavated materials not required or unsuitable for backfill shall be removed and wasted on a site obtained by the Contractor. Excavations and trenches shall not be larger or wider than necessary for the proper installation of the foundations or electrical appliance. Excavation shall not be performed until immediately before the installation of conduit, bases or other appliances. All excess excavated material shall be removed at the earliest possible time or as directed by the Engineer.

All areas excavated shall be backfilled and compacted in accordance with these Specifications. Backfill shall be deposited in not over 6 inch (150 mm) layers and tamped to 95 percent density ± 3 percent of optimum moisture. The top 6 inches (150 mm) of backfill shall be select soil suitable for sodding. All areas excavated shall be backfilled at the earliest possible time or as directed by the Engineer. After backfilling, all disturbed areas shall be kept well filled and maintained in a smooth and well drained condition until permanent repairs are made. Where trenches are excavated in established sod areas, the area shall be backfilled as above the same day excavation occurs by a method approved by the Engineer. Approved methods are intended to reduce damage to the established sod area.

The bottom of the concrete foundations shall rest on firm ground; foundations shall be poured monolithic except the top 6-inch (150 mm) pole cap. The exposed portions shall be formed to present a neat appearance. Forms shall be true to line and grade. The top of concrete foundations, except special foundations, shall be finished to either sidewalk grade or 1 inch (25 mm) above finished grade, as directed by the Engineer. Forms shall be rigid and securely braced in place. Conduit ends and anchor bolts shall be placed in proper position, to proper heights, and held in place by means of a template until the concrete sets. Each anchor bolt shall be provided with 2 hex head nuts, 2 flat washers and 1 lock washer. Both forms and ground which will contact the concrete shall be thoroughly moistened before placing concrete. All conduits shall be securely covered prior to pouring concrete. All threaded portions of anchor bolts shall be taped during the concrete pour. Any concrete splashed on poles when pouring the pole cap shall be immediately cleaned off.

5.3 CONDUITS

Trenches shall be excavated to the width and depth necessary for conduit installation. All trenches shall be backfilled as soon as practical after the installation of conduit. The bottom of the trench shall be free of Cinders; broken

concrete and other hard or objectionable material which might cause mechanical damage to the conduit, such material shall be cleared before the conduit is placed. No conduit shall be placed without approval of the trench by the engineer. All disturbed areas shall be restored to the satisfaction of the engineer.

5.3.1 Traffic Signal And Street Light Conduit

- A) Conduit shall be installed as shown in the plans and the Standard Detail sheets and in conformance with appropriate articles of the National Electric Code and the National Electrical Safety Code. In addition, wherever a conduit passes beneath a curbed street, aluminum conduit markers shall be installed in the curb immediately over the conduit location. Conduit markers shall be furnished by the Contractor as detailed on the Standard Detail sheets in the plans and shall be installed on the top of the curb by drilling the curb and epoxying the conduit marker in place.
- B) The ends of all conduits shall be well-reamed to remove burrs and rough edges. Field cuts shall be made square and true so that the ends will butt or come together for the full diameter thereof.
- C) An approved factory coupling shall be used for connection of the HDPE conduit to a 90° factory PVC elbow or between two lengths of HDPE conduit. The coupling shall be of high density polyethylene. The coupling shall have individual reverse-locking threads with a built-in center stop. The ends of the conduit shall be grooved with a grooving tool to match the reverse-locking threads of the coupling to provide for greater pull-out resistance. The coupling shall be installed with a factory recommended coupling tool to ensure an airtight and watertight lock.
- D) Conduit bends, except factory bends, shall have a radius of not less than six times the inside diameter of the conduit. Where factory bends are not used, conduit bends shall be made without crimping or flattening, using the longest radius practicable and utilizing an appropriate conduit bending tool.
- E) Conduit shall be installed under pavement sections at a depth not less than 24 inches (600 mm) below the bottom of the curb; and where laid in trenches on shoulders, conduit shall be laid to a depth of 24 to 30 inches (600 to 750 mm) below natural ground level or finish grade.
- F) The conduit shall be installed continuous from outlet to outlet or as otherwise shown on the plans. With respect to HDPE conduit, no couplings or joints will be allowed at intermediate points unless approved by the Engineer in charge of construction. The conduit may be directional bored to minimize disruption to the existing improvements or may be trenched.

- G) Conduit shall be placed under existing pavement by approved pushing or drilling methods. Pavement shall not be disturbed without the written permission of the Engineer and then only in the event insurmountable obstructions are encountered. Pushing or drilling pits shall be kept 2 feet (0.6 meters) clear of the edge of any type of pavement wherever possible. Excessive use of water such that pavement might be undermined, or sub grade softened, will not be permitted.
- H) Conduit set in concrete bases shall extend approximately 3 inches (75 mm) above the foundation vertically. Conduit entering through the bottom of a pull box / junction box shall be located near the ends to leave the major portion of the box clear. At all outlets, conduit shall enter from the direction of the run.
- I) HDPE conduit entering equipment shall be continuous into the service box, junction box and control center. A factory 90° PVC conduit elbow shall be used for installation into a control center foundation. At a traffic signal service box or junction box, the conduit shall enter and exit the sides of the box tangentially such that the cable can enter, be coiled, and exit without exceeding an 8-inch (205 mm) bending radius. For straight through connections, the conduit shall enter and exit the same side of the box. For changes in direction, the conduit shall enter tangentially and exit tangentially at a 90° angle to the entrance.
- J) Existing underground conduit to be incorporated into a new system shall be cleaned with a mandrel and blown out with compressed air.
- K) Open ends of conduits placed for future use shall be capped or plugged.
- L) Conduit runs shown on the plans are for bidding purposes only and may be changed with permission of the Engineer to avoid underground obstructions. The conduit shall generally be installed parallel to the street lighting conduit or direct-buried cable. Installation in the same trench is acceptable.
- M) Whether specifically noted on the plans or not, conduit is required in every location where the cable passes under any type of paved surface, or behind storm sewer inlets. In residential areas where future driveways and utility connections are likely to occur, conduit will be required along the entire run between poles and or pull boxes

5.3.2 Pushed Conduit:

If pushed conduit is specified, the conduit shall be installed without disturbing the existing surface. Pushed conduit may be placed by jacking, pushing, boring or other approved means.

5.3.3 External Conduit on Structure

Conduit on structure shall include conduit on bridges, retaining walls or other structures and shall be installed as shown on the plans or as directed by the engineer. The final location of all conduit and junction boxes shall be approved

by the engineer before installation is begun. Conduit shall not be attached to prestressed concrete girders or prestressed-precast concrete deck panels. The conduit shall be secured to the concrete with clamps at no more than 5 foot (1.5 m) intervals. Concrete anchors shall meet federal specification FF-S-325, Group II, Type 4, Class I and shall be galvanized in accordance with ASTM A 153, B 695-91 Class 50 or constructed of stainless steel. Minimum embedment in concrete shall be 1 3/4 inches (44 mm). The supplier shall furnish a manufacturer's certification that the concrete anchors meet the required material and galvanizing specifications. If it is necessary to anchor the conduit to steel bridge members, the attachment method shall not involve drilling, grinding or welding. Attachment method to steel members shall be approved by the engineer. Junction boxes shall be installed as shown on the plans or as directed by the engineer. Junction boxes shall be surface-mounted and installed such that covers are easily accessible. If the conduit crosses a bridge expansion joint, a conduit expansion fitting shall be used. The expansion fitting shall provide a minimum movement in either direction as shown on the plans or as specified by the engineer. Payment will be made by measurement of work completed to the satisfaction of the engineer and per itemized proposal.

5.3.4 Street Cut restoration

- A) All street cut restoration and backfill shall be in accordance with City standard SR-1. (See Appendix A For Standard Drawings). All restoration work to be done under departmental supervision and to the approval of engineer.
- B) Trenches shall be excavated to the width and depth necessary for conduit installation. All trenches shall be backfilled as soon as practical after the installation of conduit. Cinders, broken concrete and other hard or objectionable material which might cause mechanical damage to the conduit shall not be used for backfilling within 6 inches (150 mm) of the top of the conduit. Backfill material shall be deposited in the trench in layers not exceeding 6 inches (150 mm) deep and each layer shall be compacted to the approximate density of the adjacent material by an approved method before the next layer is placed. All disturbed areas shall be restored to the satisfaction of the engineer.
- C) When it is necessary to cut a street pavement, driveway, or sodded area in order to install traffic signal conduits, bases or accessories, the contractor shall repair same in accordance with the Department of Public Works standard specifications adopted herein by reference. No cuts are to be made in curbs or side-walks or placement of conduit where pushed conduit is indicated on plan sheets. Curb bases are to be bored for pushed conduit installation. When sidewalks are cut for installation of signal bases, the entire surrounding square or block of the sidewalk to the nearest expansion or scored joint, shall be replaced. In cases where the existing sidewalk is of considerable width, or extends from curb to building line and the blocks or squares are not cut into readily identifiable squares or blocks, then an opening around the cut made in the existing sidewalk shall be sawed,

instead of removing a certain block. The saw cut shall be made at least one-half the depth of the existing sidewalk it shall be outside of the cut as made in the sidewalk and there shall not be left a width of less than three feet from the edge of the saw cut to an existing identifiable construction or expansion joint in the existing sidewalk. The sidewalk, so removed, shall be replaced in compliance with applicable City standards.

5.3.5 Method Of Measurement

Unless otherwise stated in the itemized proposal, all “Conduit” shall be measured by the linear foot (linear meter) of completed and accepted work, of the type indicated on the plans.

5.3.6 Sidewalk And Wheelchair Ramps

Sidewalk and Wheelchair Ramps, new and restoration shall follow the latest revision of the City Specifications “**Section 2300 Incidental Construction**” and drawings SW 1 . (See Appendix A for Standard Drawings). Any deviations from the standards will have to be pre-approved by the Engineer in writing, prior to carrying out of said work. Unless otherwise called for, the mix used shall be as follows:

- MCIB Mix No. WA610-1-4 except for the Central Business District (CBD).
- MCIB Mix No. WA585-3/4-2 or WA634-3/4-4 with special aggregates, i.e. Trap rock, Sioux quartzite etc.

When the ambient air temperature is 90 degrees or higher, a retarder shall be used in all concrete mixes.

5.3.7 Replacement of sidewalk / ramps

A) RESIDENTIAL SIDEWALKS

Where transverse cuts are made in a standard or usual 5—foot residential sidewalk, in any area whatsoever, the entire square usually 5' x 5' shall be removed and replaced in accordance with applicable City standards.

Where a utility or other cut is made longitudinally down the sidewalk, the entire width of the sidewalk between the end blocks shall be removed and replaced for the full width of the sidewalk, in compliance with applicable City standards.

B) BUSINESS AND SIDEWALKS OTHER THAN THE USUAL 5-FOOT RESIDENTIAL WALK

In cases where a cut is made in the sidewalk where the blocks or squares are readily definable, the entire block or square shall be removed and replaced. If necessary, or if the blocks are not jointed so as to facilitate easy removal, the joint shall be sawed with a concrete saw to 1/2 of the depth of the existing sidewalk and replaced in compliance with applicable City standards.

In cases where the existing walk is of a considerable width or extends from curb to building line and the blocks or squares are not cut into readily identifiable squares or blocks, an opening around the cut made in the existing sidewalk shall be sawed instead of removing a certain block. The saw cut shall be made at least 1/2 of the depth of the existing walk. It shall be outside of the cut as made in the sidewalk and there shall not be left a width of less than 3 feet from the edge of the saw cut to an existing readily identifiable construction or expansion joint in the existing sidewalk. The sidewalk area so removed shall be replaced in compliance with applicable City standards.

5.3.8 Method Of Measurement

All sidewalk and wheelchair ramp work shall be measured and paid as stipulated in the Itemized proposal and or its amendments. However, if the damage was caused by the Contractor to facilitate the work, restoration would be carried out at the Contractor's expense.

5.4 Installation of Pull Boxes and Junction Boxes

For construction details refer to plan TCD-0-3A. (See Appendix A). All conduit openings in pull boxes and junction boxes shall be sealed with either "duct seal" or a foam type waterproofing sealer.

Pull boxes/Junction Boxes shall be installed at locations shown on the plans. Traffic rated pull boxes shall be placed in traveled ways, shoulders or where specified in plans or desired by the Engineer. Maximum distance between pull boxes should not exceed 300 Feet. For construction details see standard drawing TCD-0-3. Conduit shall enter the boxes in the side of the box and shall extend a minimum of 2 inches (50 mm) and a maximum of 4 inches (100 mm) as shown on the plans. If it is necessary to increase the excavation depth and extend the box, no direct payment will be made. The excavated opening outside the box shall be wide enough to allow compaction of the backfill material. Cinders, broken concrete, broken rock or other hard or undesirable material shall not be used for backfilling. The backfill material shall be placed in layers not to exceed 6 inches (150 mm) deep and each layer shall be thoroughly compacted before the next layer is placed. Where preformed boxes are used, the holes for the conduit shall be drilled as recommended by the manufacturer. The holes shall be round and no more than 1/2 inch (13mm) larger than the conduit. A pull box placed in a sodded area or shoulder shall have a concrete pad around the perimeter as shown on the plans. Concrete pads are not required for pull boxes installed in concrete shoulders / Sidewalks. Concrete for the pad shall meet the specifications for sidewalks. The top surface of all boxes shall be flush with surfaced areas and approximately one inch (25 mm) above earth or sodded areas.

Pull boxes/Junction Boxes shall be as called for on the plans and to specifications on the standard drawings

5.5 Bases

5.5.1 Concrete Bases

Concrete bases for posts shall conform to details shown on the plans TCD-0- 3 (See Appendix A). Excavation for bases shall be made in a neat and workman like manner. The top 12 inches of flush type bases shall be formed. Forms shall be sufficiently rigid to prevent warping or deflection. Forms shall be level, and shall be held rigidly in place while concrete is being placed. Concrete shall be Midwest Concrete Industry Standard, Air Entrained, and MCIB Mix Number A629-1/2-2. When the ambient air temperature is 90 degrees or higher, a retarder shall be used in all concrete mixes. Conduit, ground rods, and anchor bolts shall be held rigidly in place before and during concrete placement. Where called for, a 3/4 inch copper clad ground rod shall be placed in each concrete base, extending through the base into the ground as shown on the plans. Tops of all bases shall be finished level and edged to a radius of 1/2 inch. Exposed surfaces of bases shall be finished in a workmanlike manner as soon as practicable after removing forms. All conduit openings in the controller cabinet or controller cabinet base shall be sealed with an approved sealing compound after wiring is completed. This compound shall be readily workable soft plastic or watertight expanding foam.

The top of a pole base in sidewalks shall be finished flush with the existing surface and bases in sodded area or dirt shall be finished at-least one and half inch above the surrounding surface.

The top of the controller base shall be at least 4 inches above the final ground elevation. A concrete apron shall be constructed at the controller base as shown on the plans. Aprons shall be considered part of the controller base.

5.5.2 Type CS and BS Helix Core Bases

Helix core type bases, as shown on the plans, may be used as alternates for pedestal or mast arm pole foundations where conditions permit, only with the approval of the engineer. The screw anchor bases shall be installed per industry practices and shall be of steel material conforming to specifications shown on the plans. High strength bolts conforming to Section 2.1 shall be used for pole anchorage and shall be Grade 5 galvanized.

5.6 Pole Installation

All poles and pedestals are to be installed as shown in the plans and the Standard Detail sheets. All attachments are to be located in the field and all wire entrances shall be drilled or punched in the field. All drilled or punched surfaces shall be carefully reamed and/or deburred or threaded as appropriate before an application of one field coat of cold galvanizing. The Engineer shall confirm the location and mounting heights of all pole and pedestal attachments located in the field. Should

field adjustment of any attachment be necessary after the Engineer confirms the locations, the Contractor shall be responsible for plugging any holes caused by the initial installation. Hole plugging methods shall be approved by the Engineer.

Post bases shall be securely anchored to concrete bases. Pedestal posts shall be erected vertically without use of leveling nuts. Metal posts for span wire and cantilever mast arms shall be adjusted by leveling nuts. All posts for span wire and cantilever mast arms shall be raked as directed by the engineer. All signal posts shall be grounded by a No. 6 AWG bare copper wire from the ground lug inside the post to a clamp fastened to a ground rod.

All poles, arms, brackets etc should be provided with manufacturer supplied end caps and these shall be in place at the time of installation or immediately thereafter.

5.7 Signs Installed on Mast Arms

Unless otherwise specified all signs including Street name signs and Traffic regulation signs, called for in the plans, shall be provided and installed by the contractor. Said work shall be measured and paid upon completion as per the itemized proposal. The signs shall conform to the City specifications and the relevant plans.

5.8 Signal Faces

Signal faces shall be completely covered with rugged cloth material (burlap or equivalent) securely attached by wire until the time the signal is ready to be flashed or placed in normal operation. When ready for operation, they shall be securely fastened in position facing approaching traffic. Horizontally mounted lamps shall be installed by the contractor with the open segment of the filament up. Signal faces shall be aimed at the approximate center of the lane, or lanes, they control or as directed by the engineer.

5.9 Detectors

Loop Detector

Induction loop dimensions shall be as shown on the plans. Exact location of loops shall be determined by the Engineer. A slot for installation of induction loop cable three inches deep and 1/2 inch wide shall be sawed in the pavement as shown on the plans. The slot shall be brushed or blown clean. The cable shall be pushed into the slot without damaging the insulation. After the loop cable is spliced to the lead-in cable, and before the slot is sealed, the resistance of the loop and lead-in cable to ground shall be checked. After a satisfactory test, which shows resistance of not less than 10 mega ohms, the slot shall be sealed. Approved sealants are listed in Section 3.11. Additional construction details are shown on TCD-0-4.

All loop conductors shall be wound in the same direction with the start and end clearly marked on the conductors at the junction or pull box. Conductors of all

loops shall run continuous to and from the nearest junction or pull box. The loop conductors for each loop shall be spliced in the junction or pull box to a detector lead-in cable running from the box to a sensor unit mounted in the controller cabinet.

When construction of a loop is started, it shall be completed the same construction day. Should the Contractor start a loop installation and fail to satisfactorily complete it, the entire loop may be subject to replacement at the discretion of the Engineer. Construction of loops shall only be started when the ambient air temperature is 40° F. (4.5° C.) and rising.

Saw cuts for loop wires shall be made with a self-propelled, water-cooled power saw. The water is used to cool and lubricate the blade and eliminate blowing saw dust. Water shall be provided by the Contractor. All jagged edges or sharp corners and protrusions shall be removed using a small chisel and hammer. The saw cut shall be cleaned to remove cutting dust, grit, oil and other contaminants. The saw cut and entire loop area shall be flushed clean with water and dried with compressed dry air immediately after cutting. Care shall be taken during the cutting and cleaning operation to avoid blowing debris at passing pedestrians and vehicles or onto private property. All corners of loops will be drilled with 1.5 inch to 2 inch (38 mm x 50 mm) hole drill to the depth of saw cut.

Wire shall be installed so as to minimize stress at corner locations. Wire shall be kept dry when installing in the saw slot and shall be inserted by use of a blunt, preferably nonmetallic, flat paddle.

After conductors are installed in the slots cut in the pavement, the slots shall be filled with the approved sealant to within 1/8 inch (3.2 mm) of the pavement surface. The sealant shall be prepared and installed in accordance with the manufacturer's recommendations, as approved by the Engineer. The sealant shall be between 1-1/2 inches (38 mm) and 2-1/4 inches (57 mm) thick above the top conductor in the saw cut as determined by the saw cut depth and as indicated in the plans. Before setting, surplus sealant shall be removed from the adjacent road surfaces without the use of solvents. The Contractor shall allow time to let the sealant set before opening the lane(s) to traffic. Approved absorbent material shall be spread over the sealant if traffic is allowed over the loop before the sealant is completely set, as determined by the Engineer.

Mircoloop Detector

When specified microloop detector system, shall be installed in accordance with the manufacturer's specifications. Cable runs between sensor units through the pull box (or junction box) and on to the controller cabinet shall be continuous for each channel. Exact placement of sensor heads and layout of saw cuts for magnetometer detectors will be determined by the engineer.

Video Camera

All video detection shall be installed per drawings and manufacturers' recommendations. Care should be taken to cap the luminaire arm end (where it is solely used for camera mounting) and post ends (when camera is post mounted) with manufacturer supplied end caps.

5.10 Wiring

Installation of wiring shall be in accordance with the plans and specifications and appropriate articles of the National Electrical Code. In addition, allowable pulling tensions on wiring in conduits shall be as per the cable manufacturer's recommendations. Approved pulling lubricants shall be used when pulling wiring in conduits. No splicing of cables will be permitted unless shown on the plans or approved by the Engineer. Where splices are allowed, they shall be made by a method approved by the Engineer. Wire nuts shall be used in the base of any signal pole for wire connections.

Where practical, color codes shall be followed so that the red insulated conductor connects to the red indication terminal, orange to yellow, green to green and white to neutral. Circuits shall be properly labeled in all boxes and at the controller by permanent plastic or aluminum identification tags appropriately attached to the cables by an approved method. Information stamped on the tags shall identify equipment served by the conductor cable in accordance with designations used on the plans. A minimum of one (1) turn of each cable shall be left in every service or junction box for slack. In addition, slack shall be left in all poles and the controller cabinet. All slack cable shall be neatly dressed using nylon cable ties.

Bonding jumpers shall be No. 6 AWG bare copper wire or equally connected by approved clamps. Grounding of neutral at service point shall be accomplished as required by the National Electric Safety Code, except bonding jumpers shall be No. 6 AWG or equal. Ground electrodes shall be provided at each signal pole and pedestal and at the controller as detailed on the plans. The controller requires a separate service ground and equipment ground as indicated on the Standard Detail sheets in the plans.

5.10.1 Switching and Power Cable Runs

All outboard signal heads on mast arms and all pedestal mounted signals heads shall have continuous, un-spliced individual cable runs from the heads to the controller. The cable size shall be as designated in the plans.

All inboard signal heads and the side mounted head (up to a maximum of three heads), serving the same phase, can be spliced to one 7c#14 at the base of the pole and run continuous and un-spliced to the controller.

Unless otherwise stipulated, all cable runs shall be continuous without splice from the connections in the terminal block of the signal head, or disconnect hanger, to the terminal strip in the controller cabinet or to the designated pull box as shown on the plans.

Power cable runs shall be continuous without splice from the power disconnect switch located on the power supply to controller cabinet terminals. This power cable shall be encased in conduit of the size shown on the plans. Energized power cables shall run to circuit breakers. The neutral cable shall be terminated on the ground bus bar in the controller cabinet.

Where luminaires are required, a two conductor No. 10 AWG, pole and bracket cable shall be installed between the luminaire and the power source at the base of the post. Each luminaire shall be connected to its power source by a separate three conductor No. 8 AWG, source cable. A pre-molded fused connector assembly shall be installed on each conductor between the source cable and the pole and bracket cable. The assembly and cable shall be insulated with a protective rubber boot designed for the pre-molded connector.

5.10.2 Induction Loop Wiring

- A) A slot for installation of induction loop cable shall be sawed in the pavement. Each loop shall have a separate lead-in slot to the conduit. A separate conduit shall be installed between the sawed loop slot and the first pull box for each loop. The conduit opening at the end of the lead-in slot shall be at the bottom of the sawed slot. The slot shall be brushed or blown clean.
- B) The cable shall be pushed into the slot without damaging the insulation. After the loop cable is spliced to the lead-in cable, and before the slot is sealed, the resistance of the loop and lead-in cable to ground shall be checked. The resistance test shall be performed by the contractor in the presence of the engineer and documented. After a satisfactory test, showing a resistance of not less than 10 M Ω , the slot shall be sealed.
- C) The conduit opening at the end of the lead-in slot and any drilled conduit holes in the pavement shall be sealed with a pliable duct sealant prior to application of loop sealant. All sawed slots shall then be sealed with detector loop sealant. All detector cable between the loop and detector amplifier shall be twisted at least three turns per foot (10 turns per meter).
- D) The detector cable shall be two conductor No. 14 AWG (2.5 mm²) continuous from the terminal strip in controller cabinet to a splice with the detector leads in the pull box adjacent to the detector. The conductor splice shall be made with pressed sleeve connectors, or equivalent. Approved water proof splicing kits (3M or equivalent) shall be used. Ends of the case shall be sealed with plastic tape and the case poured full of insulating compound, mixed in accordance the case poured

full of insulating compound, with manufacturer's recommendation. Saw cut sealants shall be of one of the types specified or an approved substitute.

- E) Each induction loop shall be connected to its detector by a separate lead-in cable, a single-conductor No. 14 AWG (2.5 mm²) cable. If the number of turns shown on the plans or this specification is not in accordance with the manufacturer's recommendation for the sensing units furnished, then the Induction loop detector cable shall be installed in accordance with manufacturer's recommendations. The conductor splice shall be soldered without an open flame. The soldered splice shall then be capped and inserted into a direct buried splice kit.

5.10.3 Cable Identification

Where practical, color codes shall be followed so that the red insulated conductor connects to the red indication terminal, orange to yellow and green to green. Circuits shall be properly labeled in the controller cabinet, all pull boxes and junction boxes by means of round aluminum identification tags with a minimum thickness of 0.1 mils (2.5 μm) attached to the cables with a copper or aluminum wire or by using other identification tags approved by the engineer. Information stamped on the tags shall identify equipment served by the conductor cable in accordance with designations used on the plans.

5.10.4 Cable Pulling and System Grounding

Cables shall be pulled through conduit by a cable grip providing a firm hold on exterior coverings. Cable shall be pulled with a minimum of dragging on the ground or pavement. Frame mounted pulleys or other suitable devices, shall be used for pulling cables out of conduits into pull boxes. Lubricants may be used to facilitate pulling cables out of conduits into pull boxes. Slack in each cable shall be provided by a six foot loop in each pull box, five feet per controller and three foot in each junction box. All slack cable shall be neatly coiled and tied using nylon cable ties.

5.11 Turn-On, Test Period, Inspection and Acceptance Procedures

5.11.1 (A) through (D) pertains to all equipment except the Type 170 system controller.

When the contractor is certain that the installation is ready for operation and meets this specification, he shall make arrangements for inspection by the Public Works Department.

Upon completion of the inspection, the Public Works Department representative may establish the day and time for turn on of the signal installation. If deficiencies exist, a list of same will be sent to the contractor. As soon as practicable, the contractor shall correct noted deficiencies and arrange for another inspection by the Department.

The signal turn-on shall be performed by City personnel and the Engineer. The Contractor shall be present for signal turn-on and be prepared to respond to any technical difficulties that may be encountered due to construction of the traffic signal. The signal turn-on shall not occur on holidays or weekends and shall be completed between the hours of 9:00 a.m. and 2:00 p.m. unless otherwise noted in the plans or directed by the Engineer. At locations without previous traffic signal control, the new traffic signal shall flash for a period specified by the engineer prior to full signal system turn-on.

Upon receipt of written authorization, the contractor shall place the signal in operation beginning a fifteen (15) day trial period. Subsequent operational failure of all or part of, the installation may, at the discretion of the Public Works Department, be the cause for turn off for repair or revisions. Failure or operational problems occurring during the fifteen (15) day trial period may require reinstatement of the procedures described in subsections 5.11A) and B). -

When in the opinion of the Public Works Department, the signal installation has operated satisfactorily for (15) consecutive days, a final inspection by the Department will be made. A written communication, confirming final acceptance for the installation, will be sent to the contractor by the Public Works Department.

The Contractor shall be present to assist and participate in inspections of the traffic signal installation prior to final acceptance.

5.11.2 Acceptance Procedure for System Controllers And Cabinets

The 170 / 2070 System Traffic Controllers and cabinets are to be shipped directly to the City Traffic Signal Maintenance Shop by the supplier and shall undergo the following acceptance procedures:

When received, they will be checked for completeness and physical compliance with the specification.

If the controller passes test "a", then a complete electrical, electronic and software test will be run.

If the controller does not pass either test, it will be turned over to the supplier for repair or replacement.

If the controller does pass these tests, the controller is accepted at that point.

The controller and power supply will then be installed by the contractor.

The contractor shall turn-on the signals in consultation and in the presence of the engineer.

The contractor and/or the supplier is welcome to observe any part of the test procedure.

5.12 Work involving modifications to existing signals

If portions of the existing traffic installations are to be incorporated in the proposed signal installations, the following policies are to be observed during the installation of the proposed modifications and improvements:

The existing signal controls shall be kept in operation during installation of the proposed signal modifications and improvements, except for shutdowns to allow for alterations as required for installation of the proposed improvements.

Some periods of disruption to existing signal operations can be tolerated during installation of the proposed improvements. However, the Contractor shall coordinate planned disruptions of signal operations with the Engineer a reasonable time in advance of such disruption of operations. The Contractor shall be responsible for maintaining adequate traffic control during any period of disruption to the existing signal.

All existing wiring within existing controller cabinets shall be identified by the Contractor and each conductor properly labeled prior to de-energizing the existing controller to install the proposed modifications and improvements.

Planned disruptions of signal operations shall be restricted during off-peak time periods as directed by the Engineer. The signal controls shall be operable during all other periods.

Connection of a new conduit to an existing base shall be performed by intercepting the out conduit of the existing base in the nearest pull box or by installing a junction box at the convenient point of interception.

Any detector loop damaged shall be replaced in full at the contractor's expense, unless the damage and replacement is pre-approved by the Engineer. Splicing or jointing will not be acceptable.

All existing salvageable equipment (i.e. signal heads, luminaires, poles, arms, controllers and cabinets) in excess of the requirements of this project shall be completely removed from the project, and the Contractor shall deliver same equipment to the City of KCMO, in co-ordination and per instructions of the Engineer.

All new equipment purchased as spare parts under the requirements of this project shall be delivered new and undamaged to the City of KCMO, in co-ordination and per instructions of the Engineer.

The Contractor shall exercise care in the removal and delivery of any existing or new equipment to be delivered to the City. All non-salvaged items of existing equipment shall become the property of the Contractor.

All concrete bases removed shall be broken up and removed to a depth of twenty-four (24) inches (0.6 meters) below grade. Holes resulting from this operation shall be filled to the proper grade with suitable material approved by the Engineer. The surface shall be finished to match the surrounding area.

Unless direct buried, all abandoned and or un-used cables shall be pulled out of the conduits and disposed off per instructions of the Engineer.

Specifications regarding traffic control for signal installations can be found in the section of this specification entitled "Traffic Control".

SECTION 6

TRAFFIC CONTROL

This work shall consist of furnishing, erecting, moving, cleaning, replacing, maintaining and removing signs, barricades, lights and other traffic control devices as shown on the plans, the Traffic Control Plan, or as required by the Engineer or as proposed by the Contractor and approved by the Engineer. The Contractor shall provide, erect, remove, relocate, clean, replace and maintain at all times during the progress or temporary suspension of the work, suitable signs, barricades, fences or other necessary traffic control devices in accordance with details shown on the plans, the Traffic Control Plan, or as directed by the Engineer.

The traffic control requirements shown on the plans are minimum requirements only and do not attempt to address in depth the variety of situations that may occur once construction has begun. In no way do the requirements shown on the plans relieve the Contractor of his responsibility for selecting the proper traffic control devices and implementation procedures that will assure the safety of motorist, pedestrians and workers at all times. Any additional quantities of traffic control devices necessary to complete the contract or as ordered installed by the Engineer shall be considered subsidiary to the contract lump sum bid price. The Contractor may develop an alternate Traffic Control Plan to be submitted to the Engineer for approval prior to its use. The Contractor who develops the alternate traffic control plan shall be properly trained in developing traffic control plans and shall be certified.

The safe and satisfactory movement of traffic through the project is of paramount importance and shall be the responsibility of the Contractor. At the onset of the project, the Contractor shall provide the Engineer with the name and telephone number of an individual who shall be available on a 24-hour basis to repair, replace, remove, relocate, clean and maintain any traffic control device required or as directed by the Engineer. The Contractor shall be responsible for maintaining all traffic control devices on an around-the-clock basis, whether or not work is actively being pursued and any deficiencies noted shall be corrected immediately.

When the plans specifically provide that traffic be carried through construction, no detour will be provided for traffic during the construction of the project and the Contractor shall not route traffic on a detour without the written permission of the Engineer.

The Contractor shall furnish all necessary posts, skids, easels and supports as may be required for proper installation of traffic control devices. The size, shape, color, and

placement of all signs, barricades, mountings and devices shall comply with the details shown on the plans, and/or the Traffic Control Plan, or the current edition of the Manual on Uniform Traffic Control Devices (MUTCD). The size and layout of the message on the signs shall comply with the latest edition of Standard Highway Signs and Standard Alphabets for Highway Signs as approved by the AASHTO and the FHWA, US DOT.

Supports used for mounting signs or devices for temporary conditions shall be constructed to yield upon impact to minimize hazards to the motorists. Additional supports may be placed on the back side of signs in the form of bracing for resisting wind currents. Guy wires and tie-downs will not be allowed.

All signs, barricades, drums and markers shall be retro-reflectorized with high intensity sheeting. The message and border shall be opaque color as required for daytime use unless shown otherwise on the plans or Traffic Control Plan.

All detours signed by the Contractor shall utilize high intensity sheeting unless otherwise shown on the plans.

Traffic cones and tubular markers shall be a minimum of 28 inches (700 mm) in height with a broadened base and may be constructed of polyethylene or other material to withstand impact without damage to themselves or to vehicles. Orange shall be the predominant color on the cones and tubular markers. The Contractor shall keep them clean and bright for maximum target value. For nighttime use, tubular markers shall be reflectorized with high intensity sheeting and, in some instances, equipped with lighting devices for maximum visibility. High intensity sheeting shall have a smooth, sealed outer surface which will display the same approximate color day and night.

Reflectorization on tubular markers shall be placed as shown in the MUTCD.

Traffic cones should be used only during temporary activities where portability is advantageous and where there is adequate surveillance to see that they remain in place. Traffic cones shall not be used for nighttime operation.

All signs, barricades and traffic control devices shall comply with the current edition of the MUTCD and shall be approved by the Engineer prior to erection on the project. They shall be furnished by the Contractor and shall remain the property of the Contractor upon completion of the project, unless otherwise noted on the plans. No signs and/or traffic control devices are to be furnished or sold to the Contractor by the City.

All Type III barricades placed across a street shall be suitably distributed across the roadway and protected at night by approved yellow flashing lights unless noted otherwise on the Plans or Traffic Control Plan. The lights shall be kept burning from sunset to sunrise. Other barricades and signs shall be protected by approved yellow steady-burn or flashing lights and drums, used singly, shall be protected by flashing lights all in accordance with the details shown on the Plans or as directed by the Engineer. In cases where no details are shown, the MUTCD shall govern.

Type I or II barricades left in place at night shall be equipped with Type A or C warning lights as directed by the Engineer, unless noted otherwise on the Plans or Traffic Control Plan.

With regards to Type A or C warning lights, each brand, model and type of warning light proposed for use shall be pre-qualified. The manufacturer's name, type and model number shall be clearly shown on the outside of each unit used on the project. Warning lights shall be of the type or types shown on the plans and shall comply with the latest edition of the Institute of Traffic Engineers (ITE) Purchase Specification for Flashing and Steady-Burn Warning Lights for Type A – Low intensity flashing warning light and Type C – Steady-burn warning light. The warning lights shall be composed of an electric circuit system using a battery or batteries providing a manufacturer-rated voltage or greater for the circuit systems as follows:

- Type A – 6 volt or 12 volt
- Type C – 6 volt

When it is necessary for residents living along the road to use the road which is closed to through traffic, suitable means (including the use of temporary surfacing material) shall be provided for their entrance or exit, but the general traveling public shall be excluded.

The Contractor's responsibility for the maintenance of traffic control devices on any individual item of work included in the Contract shall extend throughout the duration of the contract unless specifically released in writing by the Engineer.

All signs and traffic control devices shall be moved ahead as the work progresses. Devices which are necessary only when work is actually being performed shall be removed from the road or completely covered with an opaque weatherproof material during periods when no work is in progress.

All appropriate permanent signs and pavement markings shall be in place as directed by the Engineer prior to opening the street. When permanent signs cannot be installed immediately, temporary signs shall be installed in their place until the permanent signs can be installed.

During non-working hours, all lanes of traffic in all directions shall be maintained. During non-peak traffic hours, the Contractor may, with the authorization of the Engineer, close traffic lanes necessary to facilitate construction. The Contractor shall not perform any work that will restrict traffic in any way between the hours of 7:00 a.m. and 8:30 a.m. or 3:30 p.m. and 6:00 p.m.

The Engineer shall approve the final location of all traffic control devices.

Existing signs in conflict with the traffic control plans or the final lane configuration shall be covered or removed and either reset or stored on the site for retrieval by the owner as directed by the Engineer.

Existing signs necessary for traffic during construction shall be adjusted (and later reset) as necessary and as directed by the Engineer to provide proper visibility.

Excavation adjacent to the roadway shall be separately delineated with Type I or II barricades and protected as directed by the Engineer. Pedestrian fencing shall be installed when excavation involves sidewalk or pedestrian areas.

Type I or II barricades shall be placed end to end to close driveways.

Type B warning lights shall be mounted on all warning signs left in place during hours of darkness. Type A or C warning lights shall be erected on all drums and barricades in place during hours of darkness, in accordance with the MUTCD.

The Contractor shall close the appropriate lane whenever working in the street including any parking, loading or unloading of equipment or materials or any related construction. Construction equipment and materials should be stored as far from the roadways as possible.

The signing of the project shall conform to the details included in the plans and/or the Traffic Control Plan. The Contractor may be permitted to erect additional informative signs, provided the signs are not contrary to standard procedure. The legend "Travel at Your Own Risk" or anything similar on any sign is prohibited.

Construction signs as well as construction vehicles parked along streets shall not restrict sight distance for vehicles exiting at streets or any drives. Reasonable access to and egress from property adjacent to the project shall be maintained at all times throughout the duration of the project.

Two-way traffic on a normal two-way street shall be provided whenever practicable and all operations shall be conducted in a sequence that will reduce the necessity for one-way traffic.

When a one-lane, two-way temporary traffic control zone is necessary, the Contractor shall provide courteous, competent flag persons to direct traffic and to provide for the satisfactory operation of one-way traffic. All flag persons shall be properly trained and certified (ATSSA is an approved certification program). Flag persons shall be equipped with STOP/SLOW hand-signaling paddles and must wear distinctive uniforms while directing or flagging through construction upon the streets. For daytime work, the flag person's vest, shirt or jacket shall be either orange, yellow, yellow-green or a fluorescent version of these colors. For nighttime work, similar outside garments shall be retro-reflective. The retro-reflective material shall be either orange, yellow, white, silver, yellow-green or a fluorescent version of these colors and shall be visible at a minimum distance of 1000 feet (300 m). The retro-reflective clothing shall be designed to clearly identify the wearer as a person. Flag person's hand-signaling signs shall be as specified in the latest edition of the MUTCD. A Contractor may use uniformed law enforcement officers as flag persons in lieu of the above uniformed flag persons. A law enforcement

officer, when used as a flag person by the Contractor, shall wear high-visibility clothing as described above. All flag persons shall understand and follow the flag person procedures outlined in the most current edition of the MUTCD. The flag person's uniforms and hand-signal signs shall be provided by the Contractor. When flag persons are required and used, they shall not be paid for separately but shall be considered subsidiary to the contract.

Pilot cars when used shall be light “pickup” trucks or other approved vehicles, preferably carrying the Contractor’s monogram or company insignia, equipped with signs reading “Pilot Car-Follow Me”. Two signs shall be mounted on the vehicle so as to be clearly visible from both directions.

Where specified, the Contractor shall furnish, install and maintain an advance warning flashing or sequencing arrow panel. It shall be mounted on a portable chassis and shall be operated continuously when necessary to divert traffic. Operational ability of the advance warning flashing or sequencing arrow panels shall comply with the MUTCD. The lamp intensity for the advance warning flashing or sequencing arrow panel shall be adjusted to prevent an unnecessary blinding effect and to compensate for daytime and nighttime light conditions so that the arrow panel message is legible for a minimum distance of ½ mile (0.8 km). The lamp intensity, for flashing or sequencing arrow panels, shall be controlled by an automatic solar cell switch, backed by a manual switch, capable of dimming 50% from the rated lamp voltage for nighttime operation. The flashing rate of the lamps shall not be less than 25 nor more than 40 flashes per minute. Minimum lamp “on time” shall be 50% for the flashing arrow and 25% for the sequential chevron. The arrow panel lamps or lenses shall be recess-mounted or equipped with an upper hood of not less than 180°, and the color of the light emitted shall be yellow.

Fully reflectorized non-metallic drums used for channelizing traffic, lane closures and marking of specific projects shall meet the requirements of the most current edition of the MUTCD.

Type A warning lights shall be installed on drums used singly as required and directed by the Engineer, unless noted otherwise on the plans or the Traffic Control Plan.

Type A or C warning lights used on traffic control devices shall be kept lighted from sunset to sunrise and when conditions exist, as determined by the Engineer, which tend to obscure vision. All warning lights shall be used and installed in accordance with details shown on the plans, Traffic Control Plan or in accordance with the MUTCD.

On bituminous base course and/or surface course projects, and/or after milling, the Contractor shall furnish temporary striping by placing a nominal four inch (100 mm) wide by approximately four feet (1.2 meter) long retro-reflectorized stripe on the centerline of the street or lane line of multi-lane streets at approximately 50 foot (15 meter) centers, or in the case of severe curvature, approximately 25 foot (7.6 meter) centers after each lift of bituminous material has been placed unless noted otherwise on the plans and/or the Traffic Control Plan. The Contractor shall maintain this striping

until covered with the next lift or the project is accepted. Placement of striping will be as soon as practical after each lift is placed or as directed by the Engineer. The color of the striping used shall be in accordance with the most current edition of the MUTCD. Material for the striping shall be in accordance with the section of this specification titled Pavement Markings. Temporary striping is required when permanent markings cannot immediately be installed.

Temporary marking and striping tape shall be applied mechanically or manually. To assure bonding of the tape to the pavement, a truck or automobile shall be driven twice over the tape, slowly (2-3 mph)(3-5 kph), in such a manner that at least one tire rides on the tape so that the tape becomes tightly adhered. The street surface shall be clean and dry and the surface and air temperature shall be at least 40° F. (4.4° C.) and rising for Type I temporary tape and 50° F. (10° C.) and rising for Type II temporary tape.

Where temporary pavement markings are to be placed on a surface which has existing lines or markings, the incorrect lines or markings shall be removed to the fullest extent possible without damage to the pavement surface. Equipment used for the removal of the markings shall be any type that will not appreciably damage the surface or texture of the pavement. All material deposited on the pavement as a result of the removal operation, shall be removed as the work progresses. Where blast cleaning is used for the removal of pavement markings and such removal operation is being performed within 10 feet (3 m) of the traveling public, the residue, including dust, shall be removed immediately by methods approved by the Engineer.

Any appreciable damage or different appearance from the surrounding surface shall be repaired by the Contractor, at his expense, by methods approved by the Engineer. The Contractor shall treat, at his expense, the affected areas with any permanent or lasting material to blend in and match as well as practical, the appearance of the surrounding area.

During periods of inclement weather or during periods of unusually heavy traffic, the Engineer may require all operations to cease in order to adequately handle the traffic. The Engineer reserves the right to require the suspension or delay of certain operations, or the speeding up of other operations to insure a proper sequence of operations and thus aid the satisfactory movement of traffic.

The Engineer may require additional barricades, lights, flag persons, watch persons or other traffic control devices at any time or at any place that, in his opinion, are necessary for proper protection of traffic and workers. However, approval by the Engineer of the Contractor's method of operation shall not relieve the Contractor of the responsibility of protecting the traffic.

Periodic checks of traffic control devices will be made at night by the Contractor in accordance with requirements determined by the Engineer.

BASIS OF PAYMENT: Traffic Control measured as provided above will be paid for at the contract price bid.

6.1 Temporary Traffic Signals

Temporary traffic signals shall consist of furnishing and installing poles for span wire, span and tether wires, control and power cable, connection to a power source, maintenance of the installation and all other equipment and material necessary to provide the temporary installation including the controller, signal heads and mounting hardware.. If the temporary traffic signal installation is not shown on the plans, the contractor shall submit a plan to the engineer for approval prior to the installation of temporary signals. Any existing or City furnished signal equipment to be used in the temporary signal shall be shown on the temporary signal plan. Temporary signals shall have the signal heads covered until they are placed in operation. A minimum of two signal faces shall be oriented toward each street approach positioned a minimum of 8 feet (2.5 m) apart center to center and a minimum of 16 feet (5 m) above the surface of the traveled way to the bottom of the back plate. Existing signals shall not be taken out of operation until the temporary signals are ready for operation and approved by the engineer. A flashing operation shall be used during shutdown of the temporary signals.

- 6.1.1** All temporary signal equipment shall be removed by the contractor after the new installation is in operation or as directed by the engineer. Contractor furnished equipment which shall remain the property of the contractor may be new or used. Contractor furnished equipment which shall become the property of the City shall be of new stock and meet all applicable specifications. City owned equipment shall remain the property of the City and shall be disposed of as shown on the plans or as directed by the engineer.
- 6.1.2** The contractor shall pay all electrical costs incurred by operation of the temporary signals and the new signal system until the signals are accepted for maintenance. For temporary signal installations where there is no existing signal power supply, it is the responsibility of the contractor to make any necessary arrangements for providing power to the temporary signals. Portable generators shall not be used to provide power to temporary signals. No direct payment will be made for power costs. All wire and cable for temporary signals shall be suspended overhead with proper clearance or buried a minimum of 18 inches (450 mm) underground.
- 6.1.3** Temporary signal installations shall be installed to meet the construction schedule. The contractor shall be responsible for maintaining the signals in proper operating condition. Any damage to the traffic signal installation from any cause whatsoever shall be repaired at the contractor's expense.

SECTION 7

STREET LIGHTS

7.1 General

All street light installations to follow the Kansas City, Missouri Supplement to Section 2800 of the American Public Works Association, "Standard Specifications and Design criteria".

All equipment must be as shown on the drawings. Any deviations must be established by the engineer on the field.

7.2 Conduits

As specified on drawings and section 3.8.2 herein.

7.3 Anchor Bolts

Anchor bolts shall be of size, length and deformation as per the pole suppliers design and shall conform to ASTM A307. Nuts, washers and no less than the top eight inches of the bolts shall be galvanized (2.02 ounces per square foot) as specified by ASTM A 153. Nut dimensions shall conform to requirements of ANSI B18.2 for heavy semi-finished hex nuts. Washer dimensions shall conform to ASTM F436.

7.4 Breakaway Supports

Breakaway supports shall conform to "Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals," by AASHTO.

7.5 Cable

Cable in Duct/Conduit:

The cable shall be rated 600 volts, be UL listed Type RHH/RHW/USE and color-coded according to the NEC. The U.L. listing mark, cable voltage, insulation type and ratings, as well as the cable size shall be clearly printed on the cable in a color contrasting with the insulation color. Cable shall be in conformance with ICEA (Insulated Cable Engineers Association) Standard S-66- 524, NEMA Standard Publication No. WC-7 and U.L. Standard 44. Any cable used for electric service entrance run shall have a rating which includes a USE rating. Unless otherwise indicated all conductors shall be stranded. Cable insulation shall incorporate cross-linked polyethylene (XLP) and the insulation shall meet or exceed the requirements of ICEA S-66-524, NEMA Standard Publication No. WC-7, U.L. Standards 44. Size shall be 3C#* or as specified in drawings

7.5.1 Pole wiring

Cable used within poles shall be insulated with cross linked polyethylene (XLP) insulation or with ethylene propylene (EPR) insulation with a chlorosulfanated polyethylene jacket. Pole wire shall be color-coded according to the NEC, stranded, rated 600 volts, RHW/USE, and shall be U.L. listed. Unless otherwise indicated pole wire shall be 2C#10.

7.6 Pull Boxes And Junction Boxes

Pull and junction boxes shall be as specified on the plans and Standard Drawings, See section 3.10.

7.7 Poles

(For street lights other than those mounted on mast arm poles) The type and length of pole and arm will be specified on the plans. New installations shall match with existing equipment (luminaire type, pole type, etc.).

7.7.1 Hand-hole

Minimum size shall be clear 4"x6". All poles shall have ID plates with the following information:

Manufacturer's name
Date of manufacture
Part/order number

7.7.2 Aluminum Poles

The pole shaft shall be a seamless, round, tapered tube of aluminum alloy 6063-T6. The pole base flange shall be a one piece casting of aluminum alloy 356 and be attached to the shaft by a continuous circumferential weld. The pole shall be furnished with an internally mounted damper to damp wind induced harmonic vibration. The arm shall be of 6063-T6 alloy, of the length specified, and provide a two-inch NPS luminaire mount. Anchor bolt covers of aluminum alloy 356 and hex socket attachment screws of 300 series stainless steel shall be provided. The shaft, base, anchor bolt covers and arm shall have a natural color satin finish, unless otherwise specified on the plans or in the Special Provisions. A hand-hole shall be provided near the base for wiring access. The hand-hole shall be positioned 90 degrees from the luminaire mounting arm. The hand hole cover shall be secured with hex socket attachment screws of 300 series stainless steel. A ground connector capable of accepting 6 AWG wire shall be provided inside the pole, convenient to the hand-hole. The pole shall mount on the bolt circle diameter specified on the Standard Drawings, the plans or per manufacturer's recommendations. The top of the pole shall be equipped with a removable cap. The cap shall be interchangeable with a cap fitted with an ANSI standard socket for a three prong twist-lock photoelectric control. The pole and arm, when equipped with the specified luminaire and installed on a standard foundation, shall withstand an 80-MPH wind with gusts to 104 MPH while covered with one-half inch of ice.

7.7.3 Steel Poles

The shaft shall be round, tapered, and fabricated from cold rolled open hearth, basic oxygen or electric furnace steel. The arm shall be of the same material and finish as the pole, the length specified, and shall provide a two-inch NPS luminaire mount. The shaft shall be one piece for lengths to 40 feet and may be two pieces for lengths exceeding 40 feet. The two piece shaft shall be field assembled by a slip joint, the minimum length of which is one and one half times the diameter of the shaft at the joint. The field-assembled pole must not require a weld to develop full strength. All welds in the fabrication of the shaft shall be continuous and longitudinal. The pole base flange shall be of cast steel or fabricated steel plate. It shall telescope the shaft and be secured top and bottom, by continuous circumferential welds. It shall be designed to avoid stress risers under dynamic loading. The anchor bolt covers shall be formed forged or cast and shall be attached to the base with hex socket threaded fasteners. A hand-hole shall be provided near the base for wiring access. The hand-hole shall be positioned 90 degrees away from the mounting arm. The hand-hole cover shall be secured with hex socket threaded fasteners. A ground connector capable of accepting 6 AWG wire shall be provided inside the pole convenient to the hand-hole.

The steel pole, arm, and all incidental parts shall be finished with hot dip galvanizing in accordance with ASTM A123. All fasteners shall be of 300 series stainless steel or of carbon steel galvanized in accordance with ASTM A153. The pole shall mount on the bolt circle diameter specified on the Standard Drawings, the plans, or in the Special Provisions. The top of the pole shall be equipped with a removable cap. The cap shall be interchangeable with a cap fitted with an ANSI standard socket for a three prong twist-lock photoelectric control. The pole and arm, when equipped with the specified luminaire and installed on a standard foundation, shall withstand an 80 MPH wind with gusts to 104 MPH while covered with one-half inch of ice.

7.7.4 Wood poles

New wood poles shall be preservative-treated in conformance with the American Wood Preservation Standard C4 and designated per Standard M6. Wood poles shall be fabricated in conformance with the ANSI Standard Specifications and Dimensions for Wood Poles, ANSI Publication 05.1. Poles shall be marked or have other documentation to confirm compliance with this requirement as well as the class designation as defined in the referenced standard. Poles shall be in good condition as acceptable by the Engineer and shall be in conformance with the applicable ANSI requirements for sweep, crook, defects and mechanical damage. Poles deemed unacceptable by the Engineer should be removed from the job site. Hardware shall include cable hardware as well as pole hardware including insulators, cable supports, guy anchors, guy wires and the like. Hardware shall be indicated on the drawing, or as specified herein. Hardware shall also be made available for inspection by the Engineer, and hardware deemed defective by the Engineer shall be removed from the job site. As a minimum, pole guying shall be provided where indicated on the plans and at every dead-end pole and at any pole

having non-offsetting cable support stresses, i.e. non-symmetrical cable attachments.

7.8 Luminaires

The manufacturer, type and model of approved, acceptable luminaires will be specified on the plans or in the Special Provisions. Each luminaire shall be mounted as indicated and shall be set in a plane parallel to the roadway, taking into consideration the applicable grade and super-elevation of the roadway.

7.8.1 Rectilinear Luminaire

The housing shall be aluminum or steel and shall provide a moisture proof and dust proof light chamber and weather protection for the ballast. The lens shall be a single piece of optically clear, flat, heat resistant, impact resistant glass. The lens shall be enclosed in a frame which is hinged to the underside of the luminaire housing. The frame shall be securely retained in the open or closed position and shall be readily opened, closed, or removed. The luminaire shall mount to the pole with a rectilinear mounting arm. Aluminum shall be finished with Bronze Integral Color, Aluminum Association Class I Anodizing (Duranodic or Kalcolor), unless otherwise specified on the plans or in the Special Provisions. Steel shall be electroplated with a zinc rich phosphate base, electro-coated with a zinc rich epoxy powder, and finally electro-coated surface shall be the required level and uniformity without hot spots, dark spots or striations as determined by the Engineer.

7.8.2 Cobrahead-style luminaries

Cobrahead-style luminaries shall have a housing of single piece aluminum alloy casting with integral slip fitter for a 2-inch (50 mm) bracket mounting. The mounting device shall allow the luminaire to be mounted absolutely level and shall have no more than four (4) fasteners serving both the leveling and clamping functions. It shall allow one man to install the luminaire by simultaneously holding it in position and tightening the fasteners such that the luminaire will be properly level at the first attempt. The reflector shall be natural unpainted alzak aluminum and shall be secured to the top housing.

The luminaire is to be an integral ballast type with true 90° cutoff, with shielded optical system and a heat and impact resistant flat glass lens. The Contractor shall refer to the City's most current list of approved products for luminaire manufacturer information. The ballast shall be a regulator type, high power factor, for High Pressure Sodium (HPS) at a voltage of 240 volts. The ballast shall be capable of reliably operating the lamp with a line voltage varying plus or minus 10% from normal. The lamp socket shall be preset at the factory to provide IES Type III medium cut-off light distribution.

7.8.3 Post-top luminaire

Housing shall be constructed of cast aluminum and painted black. The ballast shall be a regulator-type, high power factor, for HPS at a voltage of 240 volts. The ballast components shall be housed in a totally enclosed integral compartment, and the optical section of the unit shall be completely sealed and gasketed. The pressed prismatic refractor shall be one piece polycarbonate plastic. The refractor shall be for IES Type III distribution or Type V if specified on the plans. The Contractor shall refer to the City's most current list of approved products for luminaire manufacturer information.

7.8.4 Shoe box-style luminaire

Housing shall be aluminum and shall provide a moisture proof and dust-proof light chamber and weather protection for the ballast. The lens shall be a single piece of optically clear, flat, heat resistant, impact resistant glass. The lens shall be enclosed in a frame which is hinged to the underside of the luminaire housing. The frame shall be securely retained in the open or closed position and shall be readily opened, closed or removed. The luminaire shall mount to the pole with a rectilinear mounting arm. Aluminum shall be finished with Bronze Integral Color, Aluminum Association Class I Anodizing (Duranodic or Kalcolor), unless otherwise specified on the plans. The luminaire shall be pre-wired, requiring only connection of service wires to a terminal. The luminaire shall be equipped with a regulator-type ballast capable of operating the specified lamp. The ballast shall operate at 240 VAC, have a power factor of 0.90 or better, shall provide reliable lamp starting at -20° F. (-29° C.) or higher, and shall provide a 10% or better lamp power regulation with a 10% input voltage variation. The ballast assembly shall be separated from the lamp compartment by a metal heat barrier. The ballast shall be unitized with plug disconnects for easy removal. The luminaire shall provide IES Type III or Type V cutoff distribution as specified in the plans. The vertical angle of maximum intensity shall be between 65° and 75° in all vertical planes between the horizontal angles of 60° and 90°. The maximum permissible luminous intensity at a vertical angle of 80° and above shall be 100 candela per 1000 lumens. The illuminance on the roadway surface shall be the required level and uniformity without hot spots, dark spots or striations as determined by the Engineer. The Contractor shall refer to the City's most current list of approved products for luminaire manufacturer information.

7.8.5 ID decal

A NEMA identification decal on the outside of the ballast housing of each roadway luminaire is required. The color of the decal shall indicate the light source and the number to indicate the lamp wattage.

7.8.6 Color Coding/Light Source

Yellow - High Pressure Sodium
Red - Metal Halide

Light Blue - Mercury

Numeric Code:

- 3 = 35Watt
- 5 = 50Watt
- 10 = 100Watt
- 15 = 150Watt
- 17 = 175Watt
- 20 = 200Watt
- 25 = 250Watt
- 31 = 310Watt
- 40 = 400Watt
- 75 = 750Watt
- x1 = 1000Watt

7.8.7 Lamps

Luminaires shall be equipped with high-pressure sodium vapor lamps. Lamp life shall be not less than 24,000 hours. Burnout at 20,000 hours shall not exceed 20%. Rated initial lumen output shall be:

- 150 watt 1600 lumens
- 27,500 lumens
- 250 watt 3000 lumens
- 400 watt: 50,000 lumens
- 1000 watt: 140,000 lumens

7.9 Shop Drawings

Eight copies of complete shop drawings for manufactured equipment shall be submitted to the Engineer. Manufacturer's bulletins, leaflets and other descriptive data which contain cuts, dimensions, specifications and wiring diagrams will be acceptable for standard cataloged equipment. Such bulletins, leaflets and other descriptive data shall be clearly marked to show which item is to be used and which paragraph of the contract specification it is to satisfy. Orders for equipment shall not be placed until written approval is obtained from the Engineer.

7.10 Spare Equipment

If spare equipment is included in the contract, it shall conform to these specifications, the Standard Drawings, and the Special Provisions. All spare equipment shall be from the same manufacturer and of the same style, model, etc. as equipment installed on the project. The items shall be delivered to the jurisdictional agency at a place and time mutually agreed on by the contractor and the Engineer. The place will normally be an agency warehouse.

7.11 POLE FOUNDATION CONSTRUCTION

7.11.1 Scope

This section governs furnishing all labor, equipment, tools, materials and the performance of all work required to construct pole foundations where shown on the plans or where directed by the Engineer. Foundations shall be constructed in accordance with these specifications, the Standard Drawings and the Special Provisions.

7.11.2 Conduit Bends

Conduit bends shall be installed in concrete foundations in the quantity shown on the plans and positioned in the direction of the duct or cable run.

7.11.3 Anchor Bolts

Anchor bolts shall be installed in concrete foundations as shown on the plans and the Standard Drawing. A positioning jig shall be used to hold the bolts firmly in place during concrete placement.

7.11.4 Finishing Concrete Foundation

Finishing should be done with the anchor bolt-positioning jig in place. If the jig must be removed for finishing, it shall be re-installed immediately after finishing and left in place throughout the cure period. Safety devices shall be installed and secured firmly in place over the foundations immediately after finishing, and shall remain in place until poles are installed. Prior to pole installation, the positioning jigs shall be removed, loose concrete cleaned from around conduit ends and the conduit trimmed to provide clearance for the pole base.

7.11.5 Expansion Joints

Expansion joints shall be provided where a concrete pole foundation is adjacent to concrete. After concrete has cured a minimum of seven days, the joint shall be cleaned, filled and sealed as shown on the Standard Drawings.

7.11.6 Screw Anchor Foundations

Screw anchor foundations where specified shall be power installed using an adapter on a power digger. There shall be no pre-boring except for a depression to improve location accuracy. A spirit level shall be used to insure the foundation is plumb as it is rotated into the earth.

The rotation shall continue until the bottom of the foundation base plate is at ground level. Foundation shaft diameter, base plate size, shaft length and bolt circles details shall be shown on the plans or otherwise indicated. Foundations shall be fully coordinated with the poles applicable to the project.

7.12 UNDERGROUND CABLE

7.12.1 Scope

This section governs furnishing all labor, equipment, tools, materials and the performance of all work required to install underground cable in duct or cable in conduit where shown on the plans or where directed by the Engineer. It includes pushing and or trenching, placing duct or conduit, backfilling, connecting to overhead cable, and surface restoration. The work shall be done in accordance with these specifications, the Standard Drawings, and the Special Provisions. Wires and cables shall be carefully installed to avoid damage to insulation. Wire lubricant shall be used when pulling wires into conduit. The lubricant shall be non-injurious to conduits, conductors, insulations or jackets and the lubrication shall be U.L. listed. Deviations required due to the terrain or underground obstructions shall be in accordance with the National Electric Code, ANSI C1, the National Electric Safety Code, ANSI C2, and have prior concurrence of the Engineer. All duct and conduit shall be routed to avoid root damage and the ends of the duct shall be sealed with duct sealant and mounted in the hand-hole to prevent the entrance of moisture and contaminants.

7.12.2 Conduit Marking

Contractor shall furnish and install aluminum marker, which will be placed in the top of the curb directly over the underground conduit. The marker shall be 2" in diameter and 2 ¼" long and shall be clearly identified: City of KCMO - ELECTRICAL CONDUIT.

7.12.3 Trenching

Trenches shall be sufficiently deep to assure that the top of the duct or direct buried cable is not less than 24 inches below final grade. The trench shall be no more than 6 inches in width. If the bottom of the trench is in rock or rocky soil, the duct or cable shall be placed on a 6-inch protective layer of clean, tamped backfill, meeting the City requirements Section 5:3:4 herein.

Alternate Methods:

Pushing, plowing, auguring, or boring may be used instead of trenching. Where cable duct is plowed in, it shall be done by plow feeding the cable duct and the operation shall be non-injurious to the cables or duct. The cable duct shall be round and free of kinks as it is fed into the plow to ensure unrestricted movement of the wires and cables inside the duct. Cable duct and conduit shall be installed at a minimum depth of 24 inches.

7.12.4 Duct Joints

Duct shall be joined using materials and method recommended by the manufacturer. The interior shall be sufficiently smooth to prevent cable damage during pulling.

7.12.5 Cable Splices

Splices shall be allowed only in junction boxes and light pole bases. There shall be no buried, underground or concealed splices. If the cable is cut or damaged

after installation is complete, the entire run shall be replaced and the engineer and/or inspector notified and weathering.

7.12.6 Backfilling

Backfill within six inches of the conduit or cable shall be free of rock or other solid material likely to damage the conduit or cable. The backfill shall be compacted to a density at least 90% of the maximum density for the material used as determined by ASTM Designation D698 and within.

7.12.7 Electrical Tape

Electrical tape shall be U.L. listed all weather vinyl plastic tape that is resistant to abrasion, puncture, flame, oil, alkalis etc.

7.13 Pull or Junction Boxes

Pull or junction boxes shall be installed as shown on the plans, Standard Drawings, or as directed by the Engineer. In joint use boxes, cables shall be clearly identified as street light cables with plastic or metal tags. Additional pull boxes may be installed when approved by the Engineer.

7.14 Clean Up

Poles and luminaires shall be cleaned of wrapping, shipping material, dirt, grease, etc. Scratches, abrasions or other surface damage shall be repaired to like new condition.

7.15 GROUNDING

7.15.1 Individual Ground

All electrical systems, equipment and appurtenances shall be properly grounded in strict conformance with Article 250 of the NEC. Each pole and the feed point shall be grounded. A 5/8-inch by 8-foot copper grounding rod shall be driven into the bottom of the trench adjacent to the pole or feed point foundation so that tops of the rods are 24 inches below finished grade. All connections to ground rods, structural steel, and reinforcing steel shall be made with exothermic welds. At the feed point, the grounding conductor shall connect to the neutral bus and the enclosure.

7.15.2 On a Wood Pole

The grounding conductor shall go up the pole and fasten to the luminaire or the arm. The lower eight feet of the grounding conductor on a wood pole shall be covered with standard molding. If an existing utility ground is available, the grounding conductor should connect to it instead of another ground rod.

If rock is encountered or other conditions exist which prevents the driving of the ground rod, it may be replaced, when authorized by the Engineer, with not less than 100 feet of #6 AWG BSSD copper wire fastened to the grounding conductor,

run through a conduit bend, stretched out in the trench and buried alongside the distribution duct or conduit.

7.15.3 System Ground

A 5/8 inch x 8 foot copper weld rod shall be driven into the bottom of the trench adjacent to the feed point foundation. The top three to four inches of the rod shall project above the bottom of the trench. A 6 AWG BSSD copper conductor shall be fastened to the ground rod with a thermit weld or compression clamp. The grounding conductor shall go through a conduit bend and the other end shall be connected to the neutral bus and the enclosure. A neutral conductor is required for each branch circuit. At each pole, the neutral conductor shall be connected to the ground connector inside the pole shaft.

7.16 SYSTEM TESTING

7.16.1 Cable Testing

Prior to final inspection, the contractor shall test all cables for unscheduled grounds. Each conductor shall be tested to ground with a megohmmeter at 500 volts. Readings in each case shall be infinity.

7.16.2 Operational Testing

Prior to acceptance, the entire system shall operate satisfactorily for fourteen consecutive days. Satisfactory operation is: turn on at dusk, all lights operate continuously until dawn, turn off at dawn, all lights remain off until turned on again at dusk. Any malfunction observed or recorded shall stop the test period at the time of the malfunction, and the test period shall start over when all components are satisfactorily operating.

7.17 REMOVAL

7.17.1 Removals and Relocations

All removals and/or relocations shall be as noted and identified on the plan. An itemized removal schedule and/or relocation plan shall be submitted. Any damage sustained to the lighting unit during the removal or relocation operation shall be repaired, or replaced in kind, to the satisfaction of the Engineer at contractor's own expense. Site restoration shall conform to the STANDARD SPECIFICATIONS AND DESIGN CRITERIA of the Kansas City Missouri Guidelines, see section 5:3:4 herein.

7.17.2 Removals

This item shall consist of the disconnection and removal of poles, aerial and underground cables, luminaires, all associated apparatus, connections and backfilling the pole holes and other associated work specified herein. Abandoned section of buried cable shall be de-energized at its power source, taped and labeled "abandoned".

7.17.3 Relocations

The re-use of existing poles and appurtenant items, if called for in the drawings, will be acceptable under this item, upon physical inspection and approval by the Engineer. Any additional cable splices, and other materials required to make the relocated pole operational shall be included in this item.

7.18 MEASUREMENTS AND PAYMENTS

7.18.1 Scope

This section governs the method of measurement and basis for payment of the furnishing of all labor, equipment, tools and materials and for the performance of all work necessary to complete any construction and installation covered by this section.

7.18.2 Items Not Listed in the Proposal

There shall be no measurement or separate payment for any items of work not specifically identified or listed in the Proposal and all costs pertaining thereto shall be included in the contract unit prices for other items which are listed in the Proposal.

7.18.3 Method of Measurement

The amount of completed and accepted work will be measured or determined as follows:

- **Pole Foundations:** Pole foundations will be measured per each for each type listed in the Proposal.
- **Conduit:** Conduit will be measured along the conduit from center of facility to center of facility, per linear foot (meter).
- **Underground Cable:** Underground cable will be measured along the trench line from center of facility to center of facility; per linear foot (meter) of each size of cable installed Five feet shall be added to the measured length for each entry into and for each exit from foundation, service entrance and junction box.

SECTION 8

EQUIPMENT COLOR - PAINTING AND COLOR IMPREGNATION OF MOLDED PLASTIC COMPONENTS

- A) Painting of steel supports shall conform to the "Standard Specifications for Highway Bridges", published by AASHTO. Galvanizing of steel supports shall conform to the requirements of AASHTO M111. Tubular steel poles shafts to be galvanized shall have a silicon content equal or less than 0.06 percent.
- B) Painting of any portion of molded polycarbonate signal components will not be permitted. Proper specified colors for each component shall be resin impregnated as part of the molding process in manufacture.
- C) All exterior parts of signal heads, including mounting brackets and other hardware and louvers and visors, shall be black in color. The backs, sides, framework and mounting hardware shall be gloss black. Signal section door fronts, louvers and visors shall be flat black. Aluminum or zinc plated mast arm hardware need not be painted.
- D) All exterior surfaces of controller cabinets, pedestal posts, poles, mast arms, push button frames and associated hardware except where aluminum or galvanized finish is specified shall be silver in color. Painted cabinets shall include one can of touch-up paint.
- E) Pedestals, poles and arms of spun aluminum will not be painted. Streetscape aluminum posts shall be finished with Bronze Integral Color, Aluminum Association Class I Anodizing (Duranodic, Kalcolor or equivalent).
- F) Controller cabinets shall be natural aluminum.
- G) Any change of colors for streetscape or other requirements shall be as indicated on the plans.

SECTION 9

METHOD OF MEASUREMENT AND BASIS OF PAYMENT

- A) For those items for which final payment is based on contract quantities, final measurement will not be made except for authorized changes during construction, or where appreciable errors are found in the contract quantity. The revision or correction will be computed and added to or deducted from the contract quantity.
- B) Basis of payment - Accepted traffic signal installations will be paid by measurement at the bid price for each of the pay items included in the contract. No direct payment will be made for any incidental items necessary to complete the work unless specifically provided as a pay item in the contract.

SECTION 10

CONTRACT TIME

Time of completion for all work issued as part of contract shall be the number of working days indicated in the contract and shall begin on the date indicated on the "Notice to Proceed". A working day is any weekday excluding City declared holidays that the contractor can work six (6) hours on a major item of the project.

SECTION 11

APPENDIX A

STANDARD DRAWINGS

C O N T E N T S

TCD-0-1	Traffic Control Plan
TCD-0-2	Traffic Signal Symbols
TCD-0-3	Signal Heads, Visors, Wiring Etc
TCD-0-4	Pedestals And Mast Arms
TCD-0-5	Concrete Bases
TCD-0-6	Pull Boxes Etc
SW-1	Sidewalk Ramps
C	Curbs
SR-1	Street Cut Restoration (Two Sheets)
SL-3	Street Light Foundations And Other Details