SP-090179
(New)

Iowa Department of Transportation

SPECIAL PROVISIONS
FOR
TRAFFIC SIGNALIZATION

Clinton County
NHSX-030-9(134)--3H-23

Effective Date
January 18, 2012

THE STANDARD SPECIFICATIONS, SERIES 2009, ARE AMENDED BY THE FOLLOWING MODIFICATIONS AND ADDITIONS. THESE ARE SPECIAL PROVISIONS AND SHALL PREVAIL OVER THOSE PUBLISHED IN THE STANDARD SPECIFICATIONS.

TABLE OF CONTENTS - TRAFFIC SIGNAL SPECIFICATIONS

PART 1 GENERAL REQUIREMENTS.

This part of the specification consists of the general requirements necessary when furnishing a traffic signal installation complete, in place and operative as described in the contract documents.

1.01 SCOPE OF WORK.

A. The work shall consist of furnishing labor, materials and performing all work necessary to install traffic control signals for the following project in the City of Clinton, Iowa: 14th St/Camanche Avenue as shown on the plans and as specified in the Contract Documents.

B. Detailed specifications, as may be embodied in the plans in the form of notes or details shall supersede and control this specification in those particulars.

1.02 EQUIPMENT AND MATERIALS.

A. Equipment and materials shall be of new stock unless the plans provide for the relocation or the use of fixtures furnished by others. New equipment and materials shall be the product of reputable manufacturers of electrical equipment, and shall meet the approval of the Engineer.

1. Equipment List.

A list of equipment and materials to be installed is included with this specification. The Contractor shall complete the list by writing in the name of the equipment manufacturer and catalog number of each item listed which they propose to install. Prior to the purchase and/or fabrication of any component equipment or material for this Project and not more than 60 calendar days after the awarding of the Contract; the Contractor shall submit to the Engineer for review five copies of the Material and Equipment List.

Review by the Engineer of shop drawings and equipment and material lists shall not relieve the Contractor of any responsibility under the Contract or the successful completion of the work in conformity with the contract documents.

2. Shop Drawings and Catalog Cuts.

Eight copies of shop drawings shall be furnished for steel mast arm poles to be furnished on the Project. Eight copies of catalog cuts and manufacturer's specifications shall be furnished for all standard off-the-shelf items.

3. Before acceptance of the work, the Contractor shall furnish the Engineer with three copies of the manufacturer's instructions for maintenance and operation of all signal equipment, wiring diagrams of the installation or system, and a parts list sufficient for the ordering of any parts.

1.03 UTILITIES.

A. Utility information on existing underground obstructions known to the Engineer are indicated on the Plans. The locations are from office records only and are generally correct, but are not guaranteed. (Service lines to individual structures or residences are not indicated, or are indicated in approximate location only.) The Contractor shall notify owning utilities of their approach to any of the facilities and conform to the requirements. The Contractor shall perform exploratory operations as necessary to verify the location, elevation, and dimensions of all known or suspected underground obstructions ahead of

any work affected thereby, and shall use care to avoid damage to them. The Contractor shall also ascertain whether any additional facilities other than those shown on the plans may be present.

1.04 STANDARD SPECIFICATIONS.

A. The installation of the traffic control signals and appurtenances shall be in conformance with the Manual on Uniform Traffic Control Devices (MUTCD), latest edition.

1.05 RIGHT OF WAY.

A. The Contractor shall confine construction operations to the right-of-way, and shall use due care in placing construction tools, equipment, excavated materials, construction materials and supplies, so as to cause the least possible damage to property. The Contractor shall promptly repair at their own expense any such damages that may occur.

1.06 PROTECTION OF WORK AND CLEAN UP.

A. The Contractor shall care for all work until final completion and acceptance by the Contracting Authority. Contractor shall repair all damage done to existing improvements caused by them. The Contractor shall remove all surplus material and rubbish from the work as it accumulates and before they make the application for the acceptance of the work.

1.07 REGULATIONS AND CODE.

A. All electrical equipment shall conform to the standards of the National Electric Manufacturers Association (NEMA). In addition to the requirement of the plans and this specification, all material and work shall conform to the requirements of the National Electrical Code, the Standards of the American Society for Testing Materials (ASTM), the American Standards Association (ASA), and local ordinances.

Wherever reference is made in this specification or in the standard provisions to the code, the safety orders, the general order, or the standards mentioned above, the reference shall be construed to mean the code, order, or standard that is in effect at the date of advertising.

1.08 CERTIFICATION OF EQUIPMENT.

A. Certification from the manufacturers of all electrical equipment, signal supports, conduit and cable shall be supplied by the Contractor stating said material complies with this specification.

1.09 REJECTED MATERIALS.

A. Rejected materials shall be immediately removed from the work site by the Contractor and shall not again be brought upon the work site. Work shall be commenced and continued at such points as may be approved by the Engineer and shall be carried out diligently and without unnecessary or unreasonable delay.

1.10 CONTRACTOR'S INVESTIGATION OF WORK.

A. It shall be the responsibility of the Contractor to examine the site of the work to determine what is required and the equipment and labor necessary for the performance of the contract. Contractor represents, by submission of a proposal for the work, that they have

investigated the character of the work and conditions which may be encountered, and the quantities and types of related work, and agrees that they will complete the contract in accordance with the contract documents for the prices specified in the proposal without making claim for any extras.

1.11 COPIES OF CONTRACT DOCUMENTS.

A. The Contractor will be furnished without cost, copies of all contract documents together with any and all addenda thereto. The Contractor shall keep one copy of all such contract documents constantly accessible on the work site.

1.12 TRAFFIC CONTROL.

A. The Contractor at all times shall conduct the operation in such a manner as to insure the safety of the motorist, the pedestrian, and their own employees. The Contractor shall perform work in such a manner and sequence as to maintain vehicular and pedestrian traffic at all times and to maintain access to adjacent private properties.

B. Where excavations occur in the sidewalks or other pedestrian-ways, the Contractor shall provide a safe and orderly pedestrian passage around the excavation area. The pedestrian passage shall not subject pedestrians to hazards from traffic or construction operations nor cause pedestrians to walk upon unsuitable or hazardous surfaces.

C. At the end of each day's work and at all other times when construction operations are suspended, all equipment and other obstructions shall be removed from that portion of the roadway or sidewalk normally open for traffic.

D. The Contractor shall furnish, install, and maintain all devices for directing, warning and rerouting traffic flow, including warning lights, barricades, and other devices necessary to adequately inform the motorist of unusual or unsafe conditions and guide them safely through the Project work area.

E. All required barricades and signs shall be in accordance with Part VI of the MUTCD and applicable Iowa DOT Supplemental Specifications and Standard Plans for traffic control. The total required barricades and signs would depend on the approved schedule of operation. A traffic control layout shall be submitted by the Contractor and approved by the Engineer prior to any field operations.

1.13 SCHEDULE OF UNIT PRICES.

A. Prior to any payment by the Contracting Authority for work completed on this project, the Contractor shall complete and forward to the Contracting Authority for approval three copies of a list of unit costs for each item listed on the Schedule of Unit Prices attached to this specification. The sum of the costs for each item shall equal the total Contract Lump Sum price for the traffic signal installation. Contracting Authority will make monthly estimates of the work performed on the project and the unit costs will be used to prepare progress payments to the Contractor. The unit costs will also be used to establish the total cost for any extra work orders related to traffic signal installation work items.

1.14 TESTING OF SIGNAL EQUIPMENT.

A. After the project is open to normal traffic, the Contractor shall notify the Engineer the date the signal or signal system will be ready for testing.

B. Upon concurrence of the Engineer, the Contractor shall place the signal or signal system in operation for a consecutive 30 day test period. The signal(s) shall not be placed into

operation without prior notification of the Engineer and concurrence by the Engineer that the signal(s) are ready to be placed into operation. Any failure or malfunction of the equipment, exclusive of minor malfunctions (such as lamp burnouts) occurring during the test period, shall be corrected at the Contractor's expense and the signal or system tested for an additional 30 consecutive day period. This procedure shall be repeated until the signal equipment has operated satisfactorily for 30 consecutive days.

1.15 SIGNAL MAINTENANCE DURING CONSTRUCTION.

A. After signal turn on and prior to final acceptance of the completed traffic signal system, the Contractor shall respond, within 24 hours, to perform maintenance or repair of any failure or malfunction reported.

1.16 GUARANTEE.

A. In addition to the warranties or guarantees on specific traffic signal equipment listed elsewhere in this specification, the Contractor shall fully guarantee the traffic control signal installation against defective equipment, materials, and quality. Should any defect develop under normal and proper operating conditions within 12 months after acceptance of the completed installation by the Contracting Authority, this malfunction shall be corrected by, and at the expense of the Contractor, including all labor, materials, and associated costs.

B. Contractor shall provide this guarantee in writing on Company or Corporation letterhead stationery to the Contracting Authority prior to final acceptance. The Contractor shall transfer all required equipment warranties on the date of final acceptance to the Contracting Authority.

1.17 METHOD OF MEASUREMENT.

A. The Traffic Signal Installation(s) as indicated on the plans, complete-in-place and accepted, will be measured as a unit lump sum quantity for all work necessary.

1.18 BASIS OF PAYMENT.

A. The Traffic Signal Installation(s) measured as provided above will be paid for at the contract lump sum price bid, which price shall be full compensation for furnishing all equipment, materials, and all other work necessary or incidental to the construction of the complete traffic control signal installation and for all equipment, tools, labor, and incidentals necessary to complete the work.

PART 2 INSTALLATION REQUIREMENTS.

This part of the specification consists of the installation details and requirements necessary during the construction of the traffic signal installation(s) complete, in place and operative as described in the Contract Documents.

2.01 HANDHOLES.

A. Handholes.

1. Handholes shall be installed at the locations shown on the plans, and at such additional points as the Contractor, at their own expense, may desire to facilitate the work.

The Contractor may furnish poured in place concrete handhole, with cast iron ring and cover, or precast concrete handhole, with cast iron ring and cover.

a. The body of the precast handhole shall meet the requirements for Class 1500D concrete pipe insofar as applicable.

b. Cast iron ring and cover may be rated light duty for non-traffic areas (145 pounds minimum); but shall be rated heavy duty for traffic areas (320 pounds minimum) where shown on plans. Deviations in weights shall not exceed plus or minus five percent.

c. The cover shall have the words TRAFFIC SIGNAL cast on the top.

d. Cable hooks – Four cable hooks shall be provided in all handholes as detailed on the plans. Cable hooks shall be galvanized steel with a minimum diameter of 3/8 inch and a minimum length of five inches and anchored in the wall of the handhold utilizing appropriate anchoring devices.

2. Type HHII shall be of pre-cast polymer concrete, polyester resin materials. The junction box shall be 30 inch by 48 inch style stackable type assembly with legend “Traffic Signal” on the lid and having the two stainless steel bolt lid, or approved equal by the Engineer. A minimum of four cable hooks shall be installed in each junction box to support the traffic signal cables.

3. Handholes shall be installed in a neat and professional manner. When the use of forms is required, they shall be set level and of sufficient thickness to prevent warping or other deflections from the specified pattern. A means shall be provided for holding conduit runs rigidly in place while the concrete is placed. All conduits shall enter the handhole at a depth of 12 inches from the top of the handhole. The Engineer shall approve any deviations from this requirement. The ends of all conduits leading into the handholes shall fit approximately two inches beyond the inside wall. An aggregate drain conforming to the dimensions shown on the plan details shall be provided. Frames and covers for handholes shall be set flush with the sidewalk or pavement surface. In unpaved areas, the top surface of the handhole shall be set with the surface of the ground.

2.02 CONDUIT SYSTEM.

A. Conduit shall be placed as shown on the plans. Change in direction of conduit shall be accomplished by bending the conduit. Bends shall be made so that the conduit will not be injured or its internal diameter changed. Bends shall be of uniform curvature and the inside radius of curvature of any bend shall not be less than six times the internal diameter of the conduit.

B. When it is necessary to cut and thread steel conduit, no exposed threads will be permitted. All couplings shall be tightened until the ends of conduits are brought together so that an electrical connection will be made throughout the entire length of the conduit run. All conduit and fittings shall be free from burrs and rough places and all conduit runs shall be cleaned, swabbed and reamed before cables are installed. Nipples shall be used to eliminate cutting and threading where short lengths of conduit are required. Where the galvanized finish on conduit has been injured in handling, such places shall be painted with zinc rich paint. All fittings used with rigid steel conduit shall be galvanized steel only.

C. Approved conduit bushings shall be installed on the exposed ends of rigid steel conduit. Bell end fittings shall be installed on the exposed ends of PVC conduit.

D. Conduit buried in open trenches shall be placed a minimum of 36 inches deep unless otherwise directed by the Engineer. Open trench methods of placing conduit will be

permitted except where the conduit is to be placed under existing pavement. Conduit in pavement areas shall be placed to a minimum depth of 24 inches below the finished pavement surface or as directed by the Engineer.

E. The backfill material from the placement of conduit in open trenches shall be deposited in the trench in layers not to exceed 6 inches in depth and each layer shall be thoroughly compacted before the next layer is placed. All cinders, broken concrete or other hard or abrasive materials shall be removed and shall not be used in the backfill material. All surplus material shall be removed from the public right-of-way.

F. Whenever excavation is made across parkways, driveways or sodded areas, the sod, topsoil, crushed stone or gravel shall be replaced or restored as nearly as possible to its original position and the whole area involved shall be left in a neat and presentable condition. Concrete sidewalks, pavements, base courses and bituminous surfaces shall be replaced with new materials.

G. When the Plans require the conduit be placed without disturbing the existing pavement the term “pushed” is used. Pushed conduit shall be placed by jacking, pushing, boring or any other means necessary to place the conduit without cutting or removing pavement. The size of a bored hole shall not exceed the outside diameter of the conduit that is to be placed. Tunneling under the pavement or water jetting will not be permitted. Pits for boring shall not be closer than two feet to the back of curb unless otherwise directed by the Engineer.

H. All conduit openings in the controller cabinet, handholes, and bases shall be sealed with an approved sealing compound. This compound shall be readily workable soft plastic. It shall be workable at temperatures as low as 30°F, and shall not melt or run at temperatures as high as 300°F.

I. All conduit shall include one polypropylene Pull Rope with a minimum 600 pound proper tensile strength. All PVC and innerduct Conduit installed shall include a 1c No. 10 Tracer Wire with the exception of 1 inch conduit. The Contractor shall install, splice, and test the tracer wire for continuity. All conduit will be proofed upon completion to verify continuity and integrity of the duct.

2.03 WIRING.

A. Where practical, color codes shall be followed so that the red insulated conductor connects to the red indication terminal, yellow to yellow, and green to green. Circuits shall be properly labeled at the controller by durable labels, or other appropriate methods, attached to the cables.

B. All cable runs shall be continuous from connections made in the handhole compartment of signal pole bases to the terminal compartment in the controller cabinet. Splicing will not be allowed in underground handholes unless specifically called for on the plans.

C. Power lead-in cable runs shall be continuous from the Power Company service point to the meter socket and from the meter socket to the controller cabinet. The size and number of conductors shall be as shown on the plans.

D. Slack for each cable shall be provided by a 4 foot length in each handhole and a 2 foot length in each signal pole or pedestal and controller base (measured from the handhole compartment in the pole to the end of the cable).

E. Cables shall be pulled through conduit by means of a cable grip designed to provide a firm hold upon the exterior covering of the cable or cables, with a minimum of dragging

on the ground or pavement. This shall be accomplished by means of reels mounted on jacks or other suitable devices. Frame-mounted pulleys, or other suitable devices, shall be used for pulling the cables out of conduits into handholes. Only vegetable lubricants may be used to facilitate the pulling of cable.

F. Loop detectors shall be connected to the controller by a two conductor shielded cable. These cables shall be continuous from the terminal compartment in the controller cabinet to a splice made with the detector loop leads in the first handhole or pole base provided adjacent to the detector.

2.04 CONCRETE BASES.

A. Concrete bases for poles and controllers shall conform to the dimensions shown on the plans. Excavations for these bases shall be made in a neat and professional manner. The bottom of all foundations shall rest securely on firm undisturbed ground. The material for the forms shall be of sufficient thickness to prevent warping or other deflections from the specified pattern. The forms shall be set level or sloped slightly to blend with the adjacent ground level and means shall be provided for holding them rigidly in place while the concrete is being deposited. All conduits and anchor bolts shall be installed and held rigidly in place before concrete is deposited in the forms. A ground rod shall be placed at each pole and controller base as shown on the plans. Anchor bolts for the signal poles or the controller pads shall be set in place by means of a template constructed to space the anchor bolts in accordance with the manufacturer's requirements. The center of the template and the center of the concrete base shall coincide unless the Engineer shall direct otherwise. Concrete shall be consolidated by vibration during placement.

B. The top of the base shall be finished level and the top edges shall be rounded with an edger having a radius of 1/2 inch. The top 10 inches of the base shall be formed square. In sidewalk areas, adjacent to sidewalks, or in other paved areas, the top of the base shall be flush with the surrounding paved area and preformed expansion material shall be provided between the base and the other paved area. When installed in an earth shoulder away from the pavement edge, the top of the concrete base shall be approximately 2 inches above the surface of the ground. The exposed surface of the base shall have a rubbed surface finish.

C. After the foundation or base has been poured, absolutely no modification of any sort may be made. If the anchor bolts, conduit, or any part of the foundation or base is installed in an incorrect manner as determined by the Engineer, the entire foundation or base shall be removed and a new foundation or base installed at the Contractor's expense.

D. Prior to setting poles, the anchor bolts shall be covered in such a manner as to protect them against damage and to protect the public from possible injury. The foundations must be given seven days to cure before poles are erected.

2.05 BONDING AND GROUNDING.

A. All conduit, steel poles and pedestals shall be bonded to form a continuous system, and be effectively grounded. Bonding jumpers shall be No. 6 A.W.G. bare copper wire or equal connected by approved clamps.

B. Grounding of the conduit and neutral at the service point shall be accomplished as required by the National Electric Safety Code, except bonding jumpers shall be No. 6 A.W.G. or equal.

C. Ground electrodes shall be provided at each signal pole and pedestal and at the controller as detailed on the plans.

D. A No. 6 A.W.G bare copper ground wire shall be installed in all PVC conduit that carries 120 volt signal cables.

2.06 SIGNAL APPURTENANCES.

A. Signal Faces.

1. All traffic signal displays shall be installed as indicated on the plans. All overhead displays located on each mast arm shall have each red indication set at approximately the same elevation, unless otherwise directed by the Engineer.

2. During the course of construction and until the signals are placed in operation, signal faces shall be covered or turned away from approaching traffic. When ready for operation, they shall be securely fastened in position facing toward approaching traffic.

B. Controller Cabinet.

1. The controller cabinet shall be installed at the location indicated on the plans with the back of the cabinet toward the intersection such that the signal heads can be viewed while facing the controller, unless otherwise directed by the Engineer.

2. All conduit openings in the controller cabinet shall be sealed with an approved sealing compound. This compound shall be a readily workable soft plastic. It shall be workable at temperatures as low as 30°F, and shall not melt or run at temperatures as high as 300°F. The controller cabinet shall be installed on pre-placed caulking material on the concrete base. After the cabinet is installed in place, the Contractor shall also place caulking material around the base of the cabinet.

C. Pole Erection.

1. All poles shall be erected vertically, with mast arms oriented at 90 degrees to the curb line, unless otherwise specified. The bases shall be securely bolted to the cast-in-place concrete foundations. Leveling shall be accomplished by the use of metal shims and/or one nut or two nuts on each anchor bolt. One nut shall be turned on each anchor bolt and the pole placed in position on these nuts. The top nuts shall then be turned into place loosely and the pole adjusted to the vertical position by adjusting both the upper and lower nuts. After leveling the poles, mortar shall be troweled between the pole base and the foundation. Where metal shims are used for leveling, caulking material shall be placed between the pole base and foundation. If grout or caulk is placed around the pole base, a weep hole shall be left in the material to allow water to drain from inside the base.

2. Exposed edges of mortar shall be neatly finished to present a pleasing appearance. Mortar shall be of the expansive type. Each pole shall be grounded by installing a No. 6 A.W.G. bare copper ground wire between the pole and the ground rod at the foundation.

D. Painting.

1. If the painted surface of any equipment is damaged in shipping or installation, such equipment shall be retouched or repaired in a manner satisfactory to the Engineer.

2.07 REPLACING DAMAGED IMPROVEMENTS.

A. Improvements such as sidewalks, curbs, driveways, roadway pavement and any other improvements removed, broken, or damaged by the Contractor shall be replaced or reconstructed with the same kind of materials found on the work or with materials of equal quality. The new work shall be left in serviceable condition satisfactory to the Engineer. Whenever a part of a square or slab of existing concrete sidewalk, driveway, or pavement is broken or damaged, the entire square or slab shall be removed and the concrete reconstructed.

B. Surface restoration shall be considered incidental to the bid items of the project and will not be paid for separately.

2.08 LOOP DETECTOR INSTALLATION.

A. The detector loop wire shall be inserted into a flexible plastic tubing for the full length from the point of splicing and placed into the slot with the number of turns specified. The tubing shall be of a continuous length from the point of splicing of the loop wire to the lead-in cable. The field loop conductors installed in the pavement shall run continuously from the terminating handhole or base with no splices permitted. The field loop conductors shall be spliced to the lead-in cable and the lead-in cable shall run continuously from the terminating handhole or base to the detector-sensing unit except on multiple loop installations where additional loop conductors may be spliced to the lead-in cable as directed by the Engineer. At the time of placing the loop wire in the sawed slots, the ends of the tubing shall be sealed to prevent any entrance of moisture into the tubing.

B. All lengths of loop wires and tubing that are not embedded in the pavement shall be twisted with at least five turns per foot, including lengths in conduits and handholes.

C. The electrical splice between the loop lead-in cable to the controller and the loop wire shall be soldered using resin core solder and provided with a watertight protective covering for the spliced wire, the shielding on the loop lead-ins and the end of the tubing containing the loop wires. The use of open flame to heat the wire connection will not be permitted. The Contractor shall use a soldering iron, gun, or torch equipped with a soldering tip. The splice shall be made by the following method:

1. Remove all lead-in cable coverings leaving 4 inches of insulated wire exposed.

2. Remove the insulation from each conductor of a pair of lead-in cable conductors and scrape both copper conductors with knife until bright.

3. Remove the plastic tubing from the loop wires for 1 1/2 inches.

4. Remove the insulation from the loop wires and scrape both copper conductors with knife until bright.

5. Wash the exposed copper conductors with turpentine spirits to clean the conductors.

6. A soldered “Western Union” type splice, wrapped with waterproof tape and coated with a watertight protective covering shall connect the conductors.

7. Cover the exposed shielding, ground wire and end of any unused loop lead-in where the sheathing was cut, with liquid silicone rubber. Apply Butyl Rubber Polymer Tape sealant between the wires and completely cover the silicone rubber. As an acceptable alternate, the Contractor may use a 3M Company Scotchcast Kit, or approved equal, for splices.

D. The saw used to cut saw slots shall be equipped with a depth gauge and horizontal guide to assure proper depth and alignment of the slot. The blade used for the saw cut shall provide a clean, straight, well-defined 3/8 inch wide saw cut without damage to adjacent areas. The depth of the saw cut shall be 2 inches. Where the loop changes direction, the saw cuts shall be overlapped to provide full depth at all corners. Right angle or corners less than 90 degrees shall not be used.

E. Before installing the loop wire, the saw cuts shall be checked for the presence of jagged edges or protrusions. Should these exist, they must be removed. The slots must be cleaned and dried to remove cutting dust, grit, oil, moisture or other contaminants. Cleaning shall be achieved by flushing clean with a stream of water under pressure, and following this, the slots should be cleared of water and dried using oil-free compressed air.

F. Loop detector conductor shall be installed using a 3/16 inch to 1/4 inch thick wood paddle. If the wire does not lie close to the bottom of the saw cut, it shall be held down by means of a material such as tape or doubled-over pieces of the plastic tubing.

G. Each loop shall be coiled as indicated by the Engineer and the beginning conductor banded in the terminating handhole or base with a symbol “S” to denote start of conductor. Phase or function shall further identify each loop as shown on the project plans, with durable tags, or as directed by the Engineer. Loops which are physically adjacent in an individual lane or adjacent lanes shall be wound with opposite rotation (i.e. #1 CW, #2 CCW, #3 CW, etc.). Rotation reversal can be accomplished by reversing leads at the handhole.

H. Multiple loop configurations, spliced to a single lead-in loop, to be connected in series shall have the “S” conductor of one loop connected to the unbanded conductor of the adjacent loop.

I. After the installation of loops, the Contractor should meter the loops by test instruments capable of measuring electrical values of installed loop wires and lead-ins to measure inductance in microhenries and leakage resistance in megohms. The Contractor shall also provide the Engineer with a report on company letterhead indicating the inductance and leakage to ground test values for each loop. The test shall be conducted from the curbside handhole. An inductance and leakage to ground test shall also be conducted and reported for the total detector lead-in and loop system with the test being conducted at the controller cabinet. Before beginning the required test period, the Engineer may independently meter any or all loops. Should any loop be found unacceptable, the Contractor may be required to complete additional tests, as required, at their own expense. The values indicated are for tests on a single loop at curbside.

An acceptable loop installation shall be defined as follows:

<u>Inductance:</u>
The inductance reading on the loop tester is approximately the calculated value.

<u>Leakage to Ground:</u>
Deflection of the pointer to above 100 megohms.

Any unusual reading on the above shall be reported to the Engineer before sealing the loop in the pavement.

An unacceptable loop installation shall be defined as follows:

Inductance:
The inductance reading is below the calculated value.

Leakage to Ground:
Deflection of the pointer to below 100 megohms.

Any loop not meeting the requirements for an acceptable loop installation shall be repaired or replaced as directed by the Engineer. The Contractor shall bear all costs of replacing loop installations deemed unsatisfactory by the Engineer.

2.09 STREET NAME SIGNS.

A. All signs shall be handled and installed carefully to prevent any damage to the sign faces. Any sign faces which are damaged prior to or as a result of improper installation will be rejected. Undamaged replacement signs shall then be promptly sent, at no extra cost to the City of Clinton.

Sign mounting hardware shall include stainless steel bolts, washers, strapping, mounting brackets, etc.

Overhead mount:	18 inches x 48 inches - minimum of 2 places 18 inches x 60 inches - minimum of 3 places 18 inches x 72 inches - minimum of 3 places
Pole mount:	12 inches x 36 inches - mount on bracket which is banded directly to pole. Greater than 36 inches - add stiffener

PART 3 MATERIAL REQUIREMENTS.

This part of the specification consists of the material requirements necessary for the construction of a traffic signal installation complete, in place, and operative as described in the Contract Documents.

3.01 GENERAL MATERIAL REQUIREMENTS.

A. All materials used in the fabrication or assembly of the items listed below shall comply with the applicable parts of Section 2523, Highway Lighting, of the Standard Specifications with the additions as stated herein.

B. Unless otherwise noted in the contract documents, all materials furnished shall be of new stock. New materials shall be the products of reputable suppliers and manufacturers approved by the Engineer. Miscellaneous electrical equipment and materials shall be UL approved.

C. Materials delivered to the project shall be stored at a secure site and shall be protected from damage due to inclement weather prior to installation.

D. Upon request by the Engineer, appropriate quantities of materials shall be made available by the Contractor for material testing purposes.

3.02 CONCRETE.

A. Concrete for concrete bases shall be Class C structural concrete meeting the requirements of Section 2403 of the Standard Specifications.

3.03 CONDUIT.

A. General.

1. The number, type, and size of conduit shall be as shown on the plans.

2. Conduit shall meet the requirements of Articles 2523.03, N and 4185.10 of the Standard Specifications.

B. Rigid Steel Conduit.

1. Conduit shown on plans as rigid steel shall be galvanized steel meeting the requirements of ANSI Standard Specification C80.1, latest revision.

C. Polyvinyl Chloride Conduit.

1. Conduit shown on plans as polyvinyl chloride (PVC) shall be rigid polyvinyl chloride conduit meeting requirements of NEMA TC-2, Type 2 and applicable UL Standards.

3.04 REINFORCING STEEL.

A. Reinforcing steel shall be of the type and size as shown on the plans and shall conform to the requirements of Section 2404 of the Standard Specifications.

3.05 TRAFFIC SIGNS.

A. Traffic signs shall conform to the requirements of Section 4186 of the Standard Specifications.

B. Street name signs shall be manufactured utilizing “VIP Diamond grade” reflectorized sheeting material. The letters shall be Series B or C Caps, with a height of 8 inches. The legend and border shall be white and the background shall be blue. The border shall be 0.75 inches in width. The signs shall be single faced. The corners of the sign blank shall have a 1.5 inch radius. The street name signs shall match the signs from phase 1 of construction.

C. Traffic signs and street name signs shall be mounted on the mast arms utilizing a universally adjustable mast arm mounted street name sign bracket.

3.06 ELECTRICAL CABLE.

A. General.

1. Electrical cable for intersection signalization shall be rated 600 volts minimum.

2. The number of conductors and size of all electrical cable shall be as shown on the plans.

3. All wire shall be plainly marked on the outside of the sheath with the manufacturer's name and identification of the type of the cable.

B. Power Lead-In Cable.

1. Power lead-in cable shall be of the sizes as shown on the plans.

2. Power lead-in cable shall be 600 volt, single conductor, stranded copper, Type USE, with UL approval.

C. Signal Cable.

1. Signal cable shall be 600 volt, multi-conductor, with copper conductors of the number and size shown on the plans.

2. Signal cable shall meet requirements of the latest revision of International Municipal Signal Association (IMSA) Specification 19-1 for polyethylene insulated, polyvinyl chloride jacketed signal cable. All conductors shall be No. 14 A.W.G. unless otherwise specified on the plans.

D. Loop Detector Wire (With Plastic Tubing).

1. The loop wire shall meet the requirements of the IMSA Specifications 51-5, latest revision thereof for polyvinyl chloride insulated, nylon jacketed, loosely encased in a polyvinyl chloride or a polyethylene tube loop, detector wire. The conductor shall be No. 14 A.W.G. unless otherwise specified on the plans.

E. Detector Lead-In Cable.

1. Detector lead-in cable shall meet the requirements of the IMSA Specifications 50-2, latest revision thereof for polyethylene insulated, polyethylene jacketed loop detector lead-in cable. All conductors shall be #14 A.W.G. unless otherwise specified on the plans.

F. Video Cable.

1. The coaxial cable to be used between the video detection camera and the controller cabinet shall be a 75 ohm, precision video cable with 20 gauge solid bare copper conductor (9.9 ohms/M), solid polyethylene insulating dielectric, 98% (min.) tinned copper double-braided shield and black polyethylene outer covering. The signal attenuation shall not exceed 0.78 dB per 100 feet at 10 MHZ. This cable shall be suitable for installation in conduit or overhead with appropriate span wire and shall be Belden Coax #8281, or approved equal.

G. Luminaire Wire.

1. Cable for luminaires shall be THHN (90°C) stranded No. 8 AWG.

H. Tracer Wire.

1. A tracer wire shall be installed in all conduits with signal cables, detector cables, or communications cables.

2. The tracer wire shall be a No. 10 A.W.G. wire.

3. The tracer wire shall be a single conductor, stranded copper, Type THHN, with UL approved and an orange colored jacket.

4. Tracer wire shall be spliced in handholes to form a continuous network.

3.07 LOOP DETECTOR SAW SLOT FILLER.

A. The saw slot filler shall be a rapid cure, high viscosity, liquid epoxy, or approved equal, formulated for use in sealing inductive wire loops and leads embedded in asphaltic concrete and portland cement concrete. The saw slot filler shall be usable on grades of 15% or less without excessive flow of material, unless otherwise approved by the Engineer.

B. The epoxy sealer shall be a two component system that consists of a resin constituent identified as pourable and a hardener identified as quick setting. The sealer shall be epoxy: Bondo; Preco Gold Label Flex; or equal, as approved by the Engineer. Approval of other sealants shall be based on specifications and/or test data about their physical properties, performance properties and chemical resistance.

C. The cured sealer shall be unaffected by oils, gasoline, grease, acids and most alkalis. The mixing of components and the filling of the cut shall be in accordance with the directions of the manufacturer.

PART 4 EQUIPMENT REQUIREMENTS.

This part of the specification consists of the equipment requirements necessary for the construction of a traffic signal installation complete, in place, and operative as described in the Contract Documents.

4.01 GENERAL REQUIREMENTS.

A. All materials used in the fabrication or assembly of the items listed below shall comply with the applicable parts of Section 2523, Highway Lighting, of the Standard Specifications with the additions as stated herein.

B. Unless otherwise noted in the contract documents, all materials furnished shall be new and in so far as practicable, major items of signal control equipment should be of the same type and consist of products of the same supplier in order to secure uniformity, single responsibility and most satisfactory service. Unless specifically noted otherwise, all signalization equipment shall be similar to the best grade of this type of equipment.

C. The Contractor shall install all of the equipment and wiring necessary for intersection signalization as indicated in the Contract Documents.

D. The traffic signal system shall be complete, and the Contractor shall furnish and install all equipment necessary for the satisfactory operation of electrical apparatus and for the complete operation of the traffic signal system whether specifically mentioned or not.

4.02 ACTUATED CONTROLLER, CABINET AND AUXILIARY EQUIPMENT.

A. General.

1. The local intersection controller shall be series 820A Traffic Controller as manufactured by IDC Multisonics Corporation. The controller shall be fully compatible and interchangeable with the existing Multisonics Corporation local controllers in the City of Clinton.

2. The controller to be provided shall provide two through eight-phase operation.

3. The controller shall provide fully prompted, menu driven programmability.

4. The controller shall provide the following internal functions:
- **a.** Provision of a local time base scheduler including automatic accommodation for day light savings time.
- **b.** Provision for local coordination control.
- **c.** Provision for local preemption control with at least four programmable internal preemption sequences.
- **d.** Provide local control of remotely selected NEMA and special functions.

5. The controller shall be microprocessor type, modular, solid state providing the phasing and operation as shown on the plans. The controller shall be designed for use on nominal 120 volt, 60 Hz, single-phase alternating current.

6. The controller unit shall utilize digital timing concepts for interval settings for all phases and shall contain vehicular and pedestrian circuits and timing functions for all phases.

7. The controller equipment furnished shall be new, of the latest model, fabricated in a first-class professional manner from good quality material. The manufacturer shall replace free of charge to the Contractor and/or Contracting Authority any part that fails in any manner by reason of defective material or quality within a period of 12 months from the date that the equipment was placed into operation following installation.

B. Components.

1. The controller unit shall use modern integrated circuits and computer technology to the fullest extent feasible and incorporate digital timing techniques.

2. All component parts and terminals shall be readily accessible when the controller modules are removed from the enclosure for adjustments, testing or service.

3. The controller unit shall be designed so that the length of interval, portion, period or unit extension shall not deviate by more than plus or minus 100 milliseconds from its set value at a power source frequency of 60 Hz.

C. Chassis.

1. The controller unit shall be modular in design. Modules shall be removable and inserted without the use of any tools. Modules of unlike function shall be mechanically keyed or electrically inter-locked to prevent insertion into the wrong opening. All modules of the same function shall be interchangeable.

2. The front panel of the unit shall be permanently marked to identify the fuses, indicators, switches, controls, etc. so that the operation of the controller shall be readily apparent.

3. The control devices, indicators, fuse holders, switches, input/output connectors, and other components required for the operation and adjustment of the timer shall be mounted on the front panel.

4. Certification of a manufacturer's controller assembly by an independent testing laboratory shall be provided to the Engineer. This certification shall indicate that the manufacturer's controller assembly is in accordance with the environmental standards and meets the test procedures as specified in the NEMA Standard No. TS1-1983.

5. All components shall be amply de-rated with regard to heat dissipating capacity and rated voltage so that, with maximum ambient temperatures and maximum applied voltage, a material shortening of life or shift in values shall not occur.

6. The design life of all components under 24 hours a day operating conditions in their circuit applications shall not be less than five years.

7. Controller timing shall be set by means of a front-panel keyboard. Momentary contact pushbuttons shall be used for entering numeric data.

D. Interval Programming.

1. The controller unit shall provide for setting of the timing of each interval or period by means of keyboard pushbutton switches.

2. The controller unit shall utilize fully prompted, menu programmability to input controller data.

3. The keyboard and switches shall be on the front panel of the unit. They shall be easily identifiable. It shall not be necessary to remove or change wires or contacts or to use any tools in making interval adjustments.

4. Each phase shall have identical control parameters that may be independently set for each phase.

5. The controller unit shall be capable of providing functions with the following minimum timing ranges and timing increments:

FUNCTION	RANGE (SEC)	INCREMENTS (SEC)
Minimum Green	0-99	1.0
Passage	0-9.9	0.1
Maximum Green 1	0-99	1.0
Maximum Green 2	0-99	1.0
Yellow Clearance	3-9.9	0.1
Red Clearance	0-9.9	0.1
Red Revert	2-9.9	0.1
Walk	0-99	1.0
Pedestrian Clearance	0-99	1.0
Seconds Per Actuation	0-9.9	0.1
Time to Reduce	0-99	1.0
Time Before Reduction	0-99	1.0
Minimum Gap	0-9.9	0.1

6. Indications shall be provided and appropriately labeled to facilitate the determination of the operation of the controller unit. These indications shall consist of the following, as a minimum:

a. Phase or phases in service.
b. Phase or phases next to be serviced.
c. Presence of vehicle call, including memory and detector actuations.
d. Presence of a pedestrian call.
e. Ring status indicators, including the following: Minimum Green; Passage; Yellow Clearance; Red Clearance; Walk; Pedestrian Clearance; Reason for Termination; and Rest State.

7. The controller unit shall be capable of programming each phase to operate in the following modes through the keyboard push button switches or separate function switches.
a. Nonlocking vehicle detector memory.
b. Locking vehicle detector memory.
c. Vehicle recall.
d. Pedestrian recall.
e. Recall to maximum green.

8. All operator keyboard entered data shall be retained in a memory medium that does not require battery backup.

9. Means shall be provided to control the flashing of pedestrian signals during the pedestrian clearance interval(s).

10. The signal phasing and interval sequence shall be as shown on the plans.

E. Operational Requirements.

1. The controller shall provide multi-phase operation and shall be fully actuated with means for receiving actuation on all phases.

2. The controller shall permit a non-actuated mode of operation on any of the phases by assertion of the vehicle recall function of the desired phase.

3. The actuation of a vehicle detector during the extendible portion of an actuated traffic phase having the right-of-way shall cause the retention of right-of-way by the traffic phase for the set Passage Time from the end of the actuation but subject to the Maximum.

The actuation of any detector on a traffic phase not having the right-of-way shall cause the transfer of the right-of-way to that traffic phase at the next opportunity in the normal phase sequence.

4. The timing of the Maximum Green shall commence with one of the following:
a. With the first actuation or demand for right-of-way on a traffic phase not having the right-of-way.
b. At the beginning of the Green interval if an actuation or demand for right-of-way has been previously registered on a traffic phase not having right-of-way.

5. In the absence of detector actuations or assertion of recall switches, the right-of-way indications shall remain on the traffic phase on which the last actuation occurred.

6. The transfer of right-of-way to conflicting phases shall occur only after the display of the appropriate change clearance intervals.

7. An actuation received during a change clearance interval for a traffic phase shall cause the right-of-way to return to that phase at the next opportunity in the normal phase sequence.

8. If the right-of-way is transferred by the operation of the Maximum or extension limit, the traffic phase losing the right-of-way shall again receive it without further actuation at the next opportunity in the normal phase sequence.

9. When pedestrian actuation is received a WALK interval shall be provided concurrently with the associated Green traffic phase interval. A flashing DON'T WALK Pedestrian Clearance interval shall follow the WALK interval during which the Green traffic phase continues to be displayed. A steady DON'T WALK shall follow the flashing DON'T WALK.

10. In absence of pedestrian actuation or the assertion of pedestrian recall function, pedestrian signals shall remain in a steady DON'T WALK condition.

11. Pedestrian actuations received by a phase during steady or flashing DON'T WALK indications of that phase shall be remembered and shall cause the controller to provide pedestrian timing functions for that phase at the next opportunity in the normal phase sequence. Successive pedestrian actuations shall not cause extension of pedestrian intervals.

12. During coordination operation, if phases are placed in a pedestrian recall mode of operation to operate the controller as a pretimed controller, the WALK intervals of the non-coordinated phases shall automatically adjust with changes in the timing plans to provide the maximum amount of WALK interval possible in the phase. The adjustment of the WALK interval for the non-coordinated phases shall be similar to the adjustment in the WALK interval for the coordinated phases with timing plan changes.

F. Cabinet.

1. The controller and all associated equipment shall be furnished completely housed in a sturdy aluminum cabinet. The cabinet shall be of clean-cut design and appearance having no sharp edges, corners or projections. The size of the cabinet shall be such as to provide ample space for housing the controller and all associated electrical and auxiliary devices which are to be furnished with it as herein specified. A hinged door, with an approved doorstop assembly, shall be provided permitting complete access to the interior of the cabinet. When closed, the door shall fit closely to neoprene or other suitable gasketing material, making the cabinet weatherproof and dust-tight. The door shall be provided with a strong lock and two sets of keys. The door hinges and pins shall be of a non-corroding material.

2. In addition to the main door of the controller cabinet, there shall be an auxiliary police door provided in the main door provided with a strong lock and keys of different design than that of the main door of the cabinet. The panel behind the auxiliary police door shall contain a switch to change from normal function to flashing and vice versa. When placed in the flashing operation, the switch shall cause the signals to display the flashing indication identified in the signal sequence diagram. The signal control shall remain in full operation. A signal on-off switch shall also be provided to interrupt power to the signal heads only and continue controller operation.

3. Aluminum exterior surfaces of the controller cabinet shall be unpainted.

4. The cabinet shall contain strong mounting tables, sliding ways, or other suitable supports for the controller and associated equipment.

5. All field terminals shall be suitably identified and accessible without removal of equipment contained in the cabinet.

6. A heavy-duty clear plastic envelope, securely attached to the inside wall of the cabinet or cabinet door, shall be provided for stowing cabinet electrical prints. Minimum dimensions shall be 9 inches wide by 11 inches deep.

7. The cabinet shall be furnished with all of the hardware necessary for assembly and installation. The cabinet shall be base mounted.

8. The cabinet shall contain a ventilating fan controlled by a thermostat and suitable dust filters for the capacity of the ventilating system. The filters shall be of the dry type and easily removed and replaced and be of standard dimensions commercially available.

9. The cabinet shall be provided with at least an eight position back panel when the plans call for expandability to four phases. At least a 12 position back panel shall be provided in the cabinet when the plans call for expandability to eight phases.

G. Electrical Design.

1. The distribution of the 117 VAC throughout the cabinet shall not occur until the AC+ has first passed through the power protection devices.

2. The cabinet shall be provided with power protection devices that include the main AC+ power circuit breakers, radio interference suppressors, and lightning and surge protectors. These devices shall be in addition to any protection devices furnished with the controller and auxiliary equipment. The protection devices shall be mounted on a panel that is securely fastened to an interior wall of the cabinet.

The AC+ field service shall be connected directly to a circuit breaker. This circuit breaker shall be a single pole, nonadjustable, magnetic breaker rated for 117 VAC operation with a minimum rating as shown on the plans. It shall be equipped with a solderless connector suitable for terminating the power lead-in wire. The circuit breaker shall be capable of manual operation and shall be clearly marked to indicate the “ON” and “OFF” positions.

Radio interference suppressors (RIS), adequate in number to handle the power requirements for the cabinet, shall be wired in series with and after the main AC+ circuit breaker. The RIS shall be designed to minimize interference in all broadcast, transmission and aircraft frequency bands.

The controller cabinet shall be furnished with a lightning arrestor on the AC service. The surge suppressor shall meet or exceed the following requirements:

a. Unit must be capable of withstanding repeated 20,000 ampere surges (minimum of 25).
b. Unit must have internal follow current limiters (resistive elements).
c. Unit shall contain a minimum of three active clamping stages.
d. Unit must self-extinguish within 8.3 milliseconds after trailing edge surge.
e. Parallel impedance of limiters must be less than 15 ohms.

3. External surge protection to the communications cables is required. The communications cable surge protector shall meet the following requirements:

- **a.** The unit must be a two-stage protector intended for use on data or communications pairs.
- **b.** The peak surge current for the unit shall be 10K amperes.
- **c.** The unit must be able to withstand at least 100 2,000 ampere surges.
- **d.** The response time for the unit shall be less than 5 nanoseconds.
- **e.** The unit shall be epoxy encapsulated.

4. The controller shall contain a connector enabling outgoing and incoming electrical circuits to be connected or disconnected easily without the necessity of installing or removing individual wires. The connector may be a multiple pin jack, a spring connected mounting, or approved equivalent mounting.

In the event of a power interruption, the controller shall be capable of automatic reorientation upon power resumption and shall require no manual initiation or switching.

5. Electrical connections from the controller and auxiliary devices to outgoing and incoming circuits shall be made in such a manner that the controller or auxiliary device can be replaced with a similar unit, without the necessity of disconnecting and reconnecting the individual wires. This may be accomplished by means of a multiple plug, a spring connected mounting or approved equivalent arrangement.

6. All cabinet wiring shall be neatly trained throughout the cabinet and attached to the interior panels using nonconductive clamps or tie-wraps. Bundles of cables shall be laced or tied or enclosed in a sheathing material. The cabinet wiring shall not interfere with the entrance, training, or connection of the incoming or outgoing field conductors.

Except where terminated by direct soldering, all wires shall be provided with terminal lugs for attachment to terminal blocks using screws. All wires shall be identified and labeled in accordance with the cabinet wiring prints. All wire insulation shall have a minimum rating of 600 volts.

7. A maintenance panel containing test switches shall be located on the inside of the main door. These switches shall include the following:

- **a.** Controller Power Switch.
- **b.** Detector Test Switches.
- **c.** Stop Time Switch.
- **d.** Signal Flash Switch.

8. An AC+ convenience outlet with a three wire grounding type receptacle shall be provided and be easily accessible. This receptacle and the incandescent lamp shall be separately fused from the main AC+ circuit breaker. The outlet shall be provided with ground fault protection.

9. The unit shall contain a power and flash transfer relay assembly to transfer the AC+ power and operation from the controller and load switches to the solid state flasher. Either the “AUTO-FLASH” mode switch located on the Police Panel or the conflict monitor shall control this transfer relay assembly. The flasher shall remain operational with the controller removed from the cabinet. The rate of flash shall be 50 to 60 flashes per minute with equal on and off intervals. The cabinet shall be wired to flash as shown on the plans.

The plug-in transfer relays shall be rated at a minimum of 10 amps per pole and shall be enclosed in a transparent case for protection against dust and for visual observance of operation.

10. The cabinet shall be furnished with two incandescent lamps. One lamp shall have a goose neck assembly. The lamp shall be equipped with a 25 Watt, R14 bulb. The second lamp receptacle shall be mounted on the interior wall of the cabinet and shall accommodate a standard base light bulb. Manual switches mounted on the maintenance panel shall control these lamps. The lamps shall be fused and connected with the convenience outlet as referenced above.

11. The cabinet duct fan unit shall be fused separately and wired after the main AC+ circuit breaker.

12. Molded composition barrier type terminal blocks shall be used for termination of the incoming and outgoing signals within the cabinet assembly. Each terminal block shall be of one-piece construction with a minimum of 12 terminals. Each terminal shall have a threaded contact plate with a binder head screw. The terminal blocks shall have a minimum rating of 600 volts.

All terminals shall be identified and labeled in accordance with the cabinet-wiring diagram.

The terminal block facilities shall be arranged in function groupings and mounted to either panels or brackets fastened to the interior walls of the cabinet. Each terminal block shall be retained using either machine or self-tapping screws and shall be easily removed and replaced.

The minimum terminals are as follows:

a. Terminal with circuit breaker with integral power line switch for the incoming power line.
b. Terminal unfused for the neutral side of the incoming power line.
c. Terminals and bases for each vehicle and pedestrian signal circuit. The terminals for the vehicle and pedestrian signal circuits shall be provided with lug type connectors.
d. Terminals for vehicle phase detector and pedestrian pushbutton cables. Terminals for vehicle detectors include AC+, AC neutral, relay common, relay closure, and the loops or probes from the field.
e. Terminals and bases for signal flasher and outgoing signal field circuits.
f. Terminals for all controller input and output circuits including those circuits not used on the project.
g. Terminals for all required auxiliary equipment.

Adequate electrical clearance shall be provided between terminals. The controller, auxiliary equipment, panel(s), terminals and other accessories shall be so arranged within the cabinet that they will facilitate the entrance and connection of incoming conductors.

13. The outgoing signal circuit shall be of the same polarity as the line (+) side of the power service. The incoming signal indication conductors shall be common and of the same polarity as the grounded (-) side of the power service. The neutral (-) side of the power service shall be connected to the cabinet in an approved manner to a copper ground bus located on the panel with the main AC+ circuit breaker. The cabinet shall, in turn, be connected to an earth ground through a ground rod.

14. All load switches shall conform to the triple-signal solid state type load switch as specified in the NEMA Standard No. TS1-1983. Dual-signal type load switches shall not be allowed. LED indicator lights shall be provided on the front of the load switch to designate the active circuit.

15. A Solid State conflict monitor shall be provided and located within the cabinet external to and electrically independent of the controller unit and enclosed in a finished metal case. The monitor shall detect the occurrence of conflicting Green, Yellow or Walk indications and shall cause the signals to go into predetermined flashing operation with stop timing applied simultaneously to the time should conflicts be sensed. The conflict monitor shall conform to the specifications of NEMA TS1-1983 and shall be compatible with the controller.

The conflict monitor shall utilize liquid crystal displays providing four indicators that display an active Red, Yellow, Green, and Walk input for each channel monitored.

Stop timing shall remain present during this operation. If the actual conflict has been cleared a reset switch (front mounted) on the conflict monitor shall return the controller to normal operation when depressed.

16. The cabinet shall be equipped with a separate solid state flasher to permit substitution of flashing signal indications for normal vehicle or pedestrian actuated operation. The solid state flasher shall have no contact points or moving parts and shall utilize zero-point switching. The flasher unit shall have a built-in effective radio interference filter. It shall be possible to completely remove the controller unit for inspection or maintenance when the flashing feature is energized, without disturbing the flashing feature. LED indicator lights shall be provided on the front of the flasher to indicate the active circuit.

Flashing shall be at the rate of not less than 50 or more than 60 flashes per minute with approximately 50% on and 50% off periods. Flashing rate shall not vary so long as the power source remains within the specified limits.

Flashing of vehicular signal indications shall be obtained from one or more flashers, each of which is a self-contained device designed to plug into a panel in the controller cabinet. If two flashers provide the flashing, they shall be wired to assure that the flashing of all indications on the same approach is simultaneous.

17. A detector harness shall be provided for each detector amplifier. The harness shall be tagged to indicate the detector number(s) and phase.

H. Documentation.

1. Complete system documentation shall be provided. Such documentation shall, as a minimum consist of:

- **a.** Three complete operations manuals for each controller and associated signal equipment including equipment wiring diagrams, schematics, and parts lists sufficient for ordering any parts.
- **b.** Three sets of cabinet wiring diagrams. The corresponding phase numbers for each movement shall be indicated on the intersection layout diagram on the cabinet-wiring diagram.

2. The controllers shall be provided with the most current software and documentation.

I. Guarantee.

1. The equipment furnished under this specification shall be new, of the latest model, fabricated in a first-class professional manner from good quality material.

2. The entire controller unit shall be warranted to be free from defects in quality and materials for a minimum of one year from date of acceptance. Any parts found to be defective shall, upon concurrence of the defect by the manufacturer, be replaced free of charge.

3. The Contracting Authority shall be furnished with a certification from the equipment manufacturer stating that the equipment furnished under this specification complies with all provisions of this specification. If there are any items that do not comply with this specification, then a list of those exceptions must be detailed on the certification.

4.03 INDUCTIVE LOOP VEHICLE DETECTOR.

A. General.

1. This specification contains the minimum design and operating requirements for solid state, digital inductive loop vehicle detectors capable of detecting the presence of a moving or standing vehicle.

2. A detector consists of a conductor loop or series of loops installed in the roadway, lead-in (feeder) cable, and a sensor (amplifier) unit with power supply installed in a traffic signal controller cabinet.

3. Detectors shall be dual channel units, NEMA card rack compatible, and Group 5 level operation.

B. Sensor (Amplifier) Unit.

1. The sensor unit shall be solid state, digital, providing detection channel(s) with a minimum inductance range of 50 to 1500 micro-henries. Output circuits of the sensor unit shall be provided by relays. Vehicle presence shall result in a continuous call indication.

2. The use of dual channel detector units is encouraged to minimize the number of detector units in the cabinet.

3. The sensor unit shall have the following qualities:

- **a.** Sensitivity adjustment to allow as a minimum the selection of high, medium or low sensitivity.
- **b.** Capable of providing reliable detection of licensed motor vehicles.
- **c.** Provides indicator light for visual indication of each vehicle detection.
- **d.** Will not require external equipment for tuning or adjustment.
- **e.** Provide operation in the pulse mode or presence mode. Mode to be switch selective on the front panel of the unit.
- **f.** Provides a self-tuning system that is activated automatically with each application of power. Automatic and continuous fine-tuning shall be provided to correct for environmental drift of loop impedance.
- **g.** Provide for fail-safe operation (continuous call) in the event of detector loop failure.
- **h.** Each detector channel shall respond to an absolute change (delta L) rather than as a percentage of the total inductance (delta L/L).

4. Where sensor units with delay timing are specified, the delay feature shall be selected and adjusted externally on the sensor unit housing. Timing shall be digitally derived and be selectable in 1 second increments from 0 to 30 seconds. Delay timing shall inhibit detector output until presence has been maintained for the time selected. Each new detection shall restart the delay timer. The sensor unit shall be capable of disabling delay timing by external means during that detector's associated green phase. The delay inhibit on each detector unit shall be in effect during the associated green phase unless otherwise specified on the detector summary.

5. The sensor unit shall be capable of normal operation without interference and false calls between sensor units ("crosstalk") when installed in the physical environment of the controller cabinet and the electrical environment of the associated electronic equipment installed therein, including other detectors.

6. It shall be possible to install the connecting cable in the same conduit as the signal cables, power cables and other detector cables without affecting the normal operation of the detector.

7. Loop detector sensor units shall conform to current requirements of NEMA Standard TS1-1983.

8. A documentation package shall be supplied with the sensor units that shall include two complete sets of schematic diagrams; descriptive parts lists; and instructions for maintenance and operation of the units.

C. Detector Assignments.

Racks are assigned as follows:

Function	Rack	Slot	U/L	Special
0.1 PASSAGE	1	1	U	LOOPS 1,2,4
0.1 PASSAGE	1	1	L	LOOP 3 <COUNT>
0.1 PASSAGE	1	2	U	IF USED
0.5 PASSAGE	1	2	L	IF USED
0.5 PASSAGE	1	3	U	LOOPS 1,2,4
0.5 PASSAGE	1	3	L	LOOP 3 <COUNT>
02 STOP BAR	1	4	U	LEFT LANE
02 STOP BAR	1	4	L	RIGHT LANE
02 PASSAGE	1	5	U	IF USED
02 PASSAGE	1	5	L	IF USED
02 PASSAGE	1	6	U	SYSTEM & COUNT
02 PASSAGE	1	6	L	SYSTEM & COUNT
06 STOP BAR	1	7	U	LEFT LANE
06 STOP BAR	1	7	L	RIGHT LANE
06 PASSAGE	1	8	U	IF USED
06 PASSAGE	1	8	L	IF USED
06 PASSAGE	1	9	U	SYSTEM & COUNT
06 PASSAGE	1	9	L	SYSTEM & COUNT
03 PASSAGE	1	1	U	LOOPS 1,2,4
03 PASSAGE	2	1	L	LOOP 3 <COUNT>
03 PASSAGE	2	2	U	IF USED
07 PASSAGE	2	2	L	IF USED
07 PASSAGE	2	3	U	LOOPS 1,2,4
07 PASSAGE	2	3	L	LOOP 3 <COUNTY>

04 STOP BAR	2	4	U	LEFT LANE
04 STOP BAR	2	4	L	LEFT LANE
04 PASSAGE	2	5	U	IF USED
04 PASSAGE	2	5	L	IF USED
04 PASSAGE	2	6	U	IF USED
04 PASSAGE	2	6	L	IF USED
08 STOP BAR	2	7	U	LEFT LANE
08 STOP BAR	2	7	L	RIGHT LANE
08 PASSAGE	2	8	U	IF USED
08 PASSAGE	2	8	L	IF USED
08 PASSAGE	2	9	U	SYSTEM & COUNT
08 PASSAGE	2	9	L	SYSTEM & COUNT

System functions shall include the isolation input for phase and system detector input via the D cable. In addition, the same electronic point as the system detector shall be terminated with a connector for future adaptation as an intersection count station.

D. Guarantee.

1. The equipment furnished under this specification shall be new, of the latest model, fabricated in a first-class professional manner from good quality material.

2. The detector sensor unit shall be warranted to be free from defects in quality and materials for one year from date of shipment. Any parts found to be defective shall, upon concurrence of the defect by the manufacturer, be replaced free of charge.

3. The Contracting Authority shall be furnished with a certification from the equipment manufacturer stating that the equipment furnished under this specification complies with all provisions of this specification. If there are any items that do not comply with this specification, then a list of those exceptions must be detailed on the certification.

4.04 VIDEO TRAFFIC DETECTION SYSTEM.

A. The Video Traffic Detection System utilized on the project shall be Trafficon.

B. The video detection system shall consist of one to six video cameras, isolation amplifiers for video cabling, a control unit and pointing device.

C. 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 the video image.

D. The system shall also include a 9 inch video monitor for setting up detection zones in the field.

E. The system shall also include one-day of on-site training for City Staff on the operation, maintenance and use of the video detection system.

F. The control unit (CU) shall process video from up to six video sources simultaneously. The sources can be video cameras or video tape players. The video shall be input to the CU in RS170 format and shall be digitized and analyzed in real time.

G. The CU 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.

H. Detector zones shall be programmable via menu displayed on a uses supplied video monitor and a pointing device connected to the CU. The menu shall facilitate placement of the detection zones. A separate computer shall not be required for programming detection zones.

I. The CU shall store up to three different detector zone patterns. The CU can switch to any one of three different detector patterns within 1 second of user request via menu selection with the pointing device.

J. As an option, programming the system shall be available with a computer. Using a RS-232 communication link, the following capabilities shall be available as a minimum:

- Continuous or signal video snapshots. The user shall be able to select both the resolution and quality of the image.
- Remote detection zone setup.
- Detector File upload/download.
- Ability to store the snapshot image.
- Security Protection to prevent unauthorized remote access.

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

L. The CU shall have a RS-232 port for communications with an external computer.

M. The CU shall accept new detector patterns from an external computer through the RS-232 port when that computer uses the correct communications protocol for downloading detector patterns.

N. The CU shall send its detector patterns to an external computer through the RS-232 port when requested when that computer uses the correct communications protocol for uploading detector patterns.

O. Up to 144 detection zones shall be supported and each detection zone can be sized to suit the site and the desired vehicle detection region.

P. Detection zones shall use AND and Or logic to indicate vehicle presence on a single detector output channel.

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

R. Up to three detection zone patterns shall be saved for each camera within the CU memory and this memory shall prevent loss during power outages.

S. 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 from CU memory and have that detection zone pattern available within 1 second of activation.

T. When a vehicle is detected crossing a detection zone, the detection zone will flash a symbol on the video overlay display to confirm the detection of the vehicle.

U. Detection shall be at least 99% accurate in good weather conditions, with slight degradation possible under adverse weather conditions (eg. rain, snow, or fog) which reduce visibility. Detection accuracy is dependent upon 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.

V. The CU shall provide 32 channels of detection through either a NEMA TS1 port or a NEMA TS2 port.

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

X. Detection zones shall be directional to reduce false detections from objects traveling in directions other than the desired direction of travel in the detection area.

Y. The CU shall process the video input from each camera at 30 frames per second.

Z. The CU shall output a constant call for each enabled detector output channel if a loss of video signal occurs. The CU shall output a constant call during the background learning period.

AA. The CU shall be housed in a durable metal enclosure suitable for shelf mounting or 19 inch rack mounting in a roadside traffic equipment cabinet. The CU enclosure shall not exceed 7 inches in height, 17.75 inches in width, and 10.5 inches in depth.

BB. The CU shall operate satisfactorily in a temperature range from -34°C to +74°C and a humidity range from 0% RH to 95% RH, non-condensing as set forth in NEMA specifications.

CC. The CU shall be powered by 120 VAC 60 Hz single-phase power. Surge ratings shall be as set forth in NEMA specifications. Power consumption shall not exceed 135 watts.

DD. The CU shall include an RS-232 port for serial communications with a remote computer. This port shall be a 9 pin female “D” subminiature connector on the front of the CU.

EE. The CU shall include ports for transmitting TS1 and TS2 detections to a traffic controller. The TS1 port shall be a 37 pin female “D” connector on the front of the CU. The TS2 port shall be a 15 pin female “D” connector on the front of the CU.

FF. The front of the CU shall include up to six BNC video input connections suitable for RS-170 video inputs. Each 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 CU for vehicle detection.

GG. The front of the CU shall include one BNC video output. Any one of the six video inputs shall be switch selectable for output on this BNC connection via the pointing device at the CU, or through software and a personal computer connected through the RS-232 port via a full duplex modem link.

HH. The video inputs to the CU shall include transient voltage suppression and isolation. Amplification that shall assure the 1 volt peak to peak video signal integrity is maintained despite video cabling losses and externally induced transients. The amplifier shall have a minimum common mode rejection at 60 Hz of 90 dB.

II. The CU enclosure shall be bonded to a good earth ground.

JJ. The front face of the CU shall contain indications to enable the user to view real time detections for up to eight detector output channels at a time.

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

LL. The camera shall use a CCD sensing element and shall output monochrome video with resolution of not less than 350 lines vertical and 500 lines horizontal.

MM. The camera shall include auto-iris control based upon average scene luminance and shall be equipped with an auto-iris lens.

NN. The camera shall be housed in an environmentally sealed enclosure pressurized with dry gas to minimize the formation of condensate and extend the life of the camera and lens. The housing shall be field rotatable to allow proper alignment between camera and the traveled road surface.

OO. The camera enclosure shall be equipped with a sunshield. The sunshield shall include a provision for water diversion to prevent water from flowing in the camera's field of view. The camera enclosure with sunshield shall be less than 6 inches in diameter, less than 26 inches long, and shall weigh less than 12 pounds when the camera and lens are mounted inside the enclosure.

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

QQ. When mounted outdoors in the enclosure, the camera shall operate satisfactorily in a temperature range from -34°C to +55°C and a humidity range from 0% RH to 100% RH.

RR. The camera enclosure shall be equipped with separate, weather-tight connections for power and video cables at the rear of the enclosure to allow diagnostic testing and viewing of video at the camera while the camera is installed on a mast arm or pole. Video and power shall not be connected with the same connector.

SS. The video signal output by the camera shall be in RS170 format.

TT. The video detection system shall be warranted to be free of defects in material and quality for a period of 2 years from the 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.

UU. 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.

VV. During the warranty period, updates to CU software shall be available from the supplier without charge.

WW. 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 current pricing and terms of sale for said parts.

XX. 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.

4.05 VEHICULAR SIGNAL HEADS.

A. General.

1. This section describes the minimum acceptable design and operating requirements for vehicular signal heads with 12 inch diameter lens openings including all fittings and brackets as shown on the plans.

2. All components of the vehicular signal heads furnished under this specification shall comply with the latest version of the Institute of Transportation Engineers Standard(s) for Adjustable Face Vehicle Traffic Control Signal Heads.

B. Signal Head Assembly.

1. The housing for individual signal sections shall be made of a durable polycarbonate. It shall be clean, smooth and free of flaws, cracks, blowholes and other imperfections. It shall be designed as a self-contained unit capable of separate mounting or inclusion in a signal face containing two or more signal sections rigidly and securely fastened together. It shall be equipped with openings and positive locking devices in the top and bottom so it may be rotated between waterproof supporting brackets capable of being directed and secured at any angle in the horizontal plane. Doors and lenses shall be provided with suitable watertight gaskets and doors shall be suitably hinged and held securely to the body of the housing by simple locking devices of non-corrosive material.

2. The optical system shall be so designed as to prevent any objectionable reflection of sunrays even at times of the day when the sun may shine directly into the lens.

3. Lenses shall be 12 inches in diameter as specified on the plans. Lenses shall be polycarbonate. Glass lenses are not acceptable. Red, yellow and green LED lenses shall be used in all signal heads. LED lenses shall meet the following ITE specification:

Vehicle Traffic Control Signal Heads – Part 2: Light Emitting Diode (LED) Vehicle Traffic Control Signal Modules, An Interim Purchase Specification of the Institute of Transportation Engineers.

4. The visors for each signal section shall be durable polycarbonate not less than 0.10 inches in thickness. It shall be designed to fit tightly against the door, and shall not permit any perceptible filtration of light between it and the housing door. Visors shall be of the tunnel-type at least 8 inches long for all 12 inches rectangular pedestrian signals, at least 9 1/2 inches long for 12 inch diameter signals, shall angle slightly downward, and shall be of the type specified on the plans.

5. The reflector holder shall be designed to separately support the reflector and socket in proper relation to the lens. The reflector holder shall either be hinged to

the left-hand side of the signal body when viewed from the front with the right-hand side held in place by a spring catch or other quickly releasable means, or the reflector shall be mounted in a manner that does not require it to be removed from its normal position during bulb replacement. Both the hinge device and the spring catch, or equivalent, shall be of a flexible nature which will permit the reflector holder to be pushed inwardly for at least 1/16 inch and to align itself correctly with the lens when the door of the optical unit is closed and pressed against the rim of the reflector holder. By such means, the joint between the reflector holder and the lens shall be rendered dust-tight. It shall not be necessary to remove any screws or nuts in order to swing the reflector holder out of the body section to obtain access to the light socket. The reflector shall be Alzak treated aluminum or Lexalite© polycarbonate. Glass is not acceptable. The reflector assembly shall be interchangeable and shall be designed so that it can be easily removed without the use of tools. When polycarbonate reflectors are furnished, gaskets shall be fabricated of silicone material.

C. Specialized Options.

1. One section of each three-section signal shall be equipped with a six position terminal block for termination of field wiring. Each five-indication signal shall be equipped with an eight position terminal block.

2. The color of all polycarbonate signal heads shall be black in their entirety. The color shall be an integral part of the materials composition.

3. Signal mounting hardware for side of pole mounted signals shall consist of 1 1/2 inch pipe and appropriate fittings, each painted with one coat of primer and two coats of black enamel. Banding brackets may be aluminum or black finish.

4. Mast arm signal head assemblies shall be rigid mounted utilizing a suitable assembly consisting of both top and bottom brackets and easily adjustable in both horizontal and vertical planes. Mast arm brackets shall be aluminum.

5. Where shown on the plans, 5 inch backplates shall be furnished and attached to the signal faces to provide a dark background for signal indications. Backplates shall be construction of one-piece durable black plastic capable of withstanding a 100 M.P.H. wind.

D. Miscellaneous Requirements.

1. The signal heads shall be constructed of the highest quality materials. High-grade quality shall be used throughout. Each head shall have a smooth surface both inside and outside and shall contain no sharp fins or sharp projections of any kind.

E. Certification.

1. The Contracting Authority shall be furnished with a certification from the manufacturer of the signal head that the equipment furnished under this specification complies with all provisions of this specification. If there are any items that do no comply with this specification, a list of those exceptions must be detailed on the certification.

4.06 PEDESTRIAN SIGNAL HEADS.

A. General Requirements.

1. This section of the specifications describes minimum acceptable design and operating requirements for two-section, pedestrian traffic signal heads with LED "MAN" and "HAND" symbol messages in the top section and an LED digital countdown display in the lower section including all fittings and brackets, as specified on the plans. The pedestrian signal head shall comply with the latest version of the Institute of Transportation Engineers Standards on Pedestrian Traffic Signal Heads.

B. Signal Head Assembly.

1. The mounting, housing, and visors for pedestrian signal heads shall conform to the provisions of "Vehicle Traffic Signal Heads" section in these specifications, and as shown on the plans.

2. A 12 inch combination HAND/MAN symbol LED module will be installed in the upper section of the pedestrian signal head. A 12 inch Numeric Countdown Display LED Module shall be installed in the lower section of the pedestrian signal head.

3. The color of all polycarbonate signal heads shall be black in their entirety. The color shall be an integral part of the materials composition.

4. Signal mounting hardware shall consist of 1 1/2 inch aluminum pipe and appropriate fittings with a natural finish. Signals shall be secured to pole by using a minimum 5/8 inch wide stainless steel banding material.

C. Pedestrian Signal LED Module.

1. The upper section of the housing shall be equipped a HAND/MAN combination LED module. The LED Pedestrian module designed as retrofit for existing signal lamps shall not require special tools for installation. The LED modules shall fit into existing 12 inch traffic signal housings built to VTCSM standards without modification to the housing.

2. The module shall have a fuse and transient suppressor incorporated for line and load protection.

3. The LED signal module shall be a single, self-containing device, not requiring on-site assembly for installation into existing traffic signal housing. The assembly of the LED module shall be designed to assure all internal components are adequately supported to withstand mechanical shock and vibration from high winds and other sources.

4. The measured chromacity coordinates for the lunar white MAN and Portland orange HAND shall conform to the chromacity requirements of Section 8.04 and Figure 1 of the VTCSH standard. The chromacity measurements shall remain unchanged over the input line voltage range of 80 VAC to 135 VAC.

5. The LED signal module shall consist of a double message overlay combining the symbols of a hand and walking man. The LED's shall be arranged in a manner to form an outline of the symbols. The shape of the outline shall conform to the standard symbols for pedestrian signals. The size HAND/MAN symbols shall comply with the Institute of Transportation Engineers Standards on Pedestrian Traffic Signal Heads. The LED's shall be distributed evenly along the message outline. The distance between each LED shall not vary more than 10%. The

individual light sources shall be interconnected so that a catastrophic failure of a single LED will result in a total loss of not more than three LED's or 5% of the total light output. There shall be no electronic components visible on the front panel of the display face. The display face shall consist solely of LED's mounted on a mat black PCB.

6. The driver board shall drive the LED's at a DC current not exceeding the maximum rating recommended by the LED manufacturer. The driver board shall regulate the LED drive current on both HAND/MAN messages to compensate for the line voltage fluctuations over the range of 80 VAC to 135 VAC. The luminous output shall not vary more than 10% over the voltage range and shall not be perceptible to the human eye. The drive circuitry shall include voltage surge protection to withstand high-resolution noise transients and low-repetition high-energy transients as stated in Section 2.16 NEMA Standard TS-2, 1992. The on-board circuitry shall meet FCC Title 47.Sub-Part 8.Section 15 regulations concerning the emissions of electronic noise. The circuitry shall ensure compatibility and proper triggering and operation of load switches and conflict monitors in signal controllers currently in use by the City.

7. The module shall conform to NEMA Moisture Resistance Standard 250-1991 for Type 4 enclosures (ITE 6.4.6.2 Moisture Resistance).

D. Pedestrian Countdown Display LED Module.

1. The lower section of the housing shall be equipped a Pedestrian Countdown Display LED module. The LED countdown module designed as retrofit for existing signal lamps shall not require special tools for installation. The LED modules shall fit into existing 12 inch traffic signal housings built to VTCSM standards without modification to the housing.

2. The LED countdown module shall be rated for use in the ambient operating temperature range of –40°F to +165°F. The module shall also be completely sealed against dust and moisture intrusion per requirements of NEMA Standard 250-1991 sections 4.7.2.1 and 4.7.3.2 for Type 4 enclosures to protect all internal components.

3. The measured chromacity coordinates for the Portland orange digits shall conform to the chromacity requirements of Section 8.04 and Figure 1 of the VTCSH standard. The chromacity measurements shall remain unchanged over the input line voltage range of 80 VAC to 135 VAC.

4. The LED signal module shall consist of two seven-segment digits. The LED's shall be distributed evenly along the message outline. The distance between each LED shall not vary more than 10%. The countdown digits shall be at least eight-inches high and shall be make of at least 88 LED's. There shall be no electronic components visible on the front panel of the display face. The display face shall consist solely of LED's mounted on a mat black PCB.

5. The driver board shall drive the LED's at a DC current not exceeding the maximum rating recommended by the LED manufacturer. The drive circuitry shall include voltage surge protection to withstand high-resolution noise transients and low-repetition high-energy transients as stated in Section 2.16 NEMA Standard TS-2, 1992. The on-board circuitry shall meet FCC Title 47.Sub-Part 8.Section 15 regulations concerning the emissions of electronic noise. The circuitry shall ensure compatibility and proper triggering and

operation of load switches and conflict monitors in signal controllers currently in use by the City.

6. The countdown module shall be compatible with all types of traffic controllers in existence. The countdown timer module shall have a micro-processor capable of setting its own time when connected to a traffic controller. When connected, the module shall continuously monitor the traffic controller for any changes to the pedestrian phase time and re-program itself automatically if needed.

The countdown module shall register the time for the walk and clearance intervals individually and shall begin counting down from the sum of both interval times.

When the walk interval is preempted, the countdown module shall also preempt and skip directly to the clearance interval and countdown to reach 0 at the same time as the solid hand. In the cycle following the preemption call, when the module completes the walk interval countdown and the clearance interval has not yet started, the module shall display the clearance time and wait for the flashing hand to resume the countdown. When the flashing hand becomes solid, the module shall display 0 for 1 second and then blank out.

The countdown module shall have an internal conflict monitor to prevent any possible conflicts between the HAND/MAN signal indications and the time display. When the HAND is solid, it shall be impossible to display any time on the display.

When the countdown module is installed in a coordinated system and the walk interval time changes at every cycle, it shall be possible to blank out the walk time and only display the clearance time.

The countdown module shall have dipswitches for the following selectable options:

1-display 0 during standby; 2-turn on all LED's for testing; 3-Coordinated mode, displays clearance time only; 4-disables dimming feature; 5-disables 30 second delay on dimming; 6-disables countdown display.

The module shall have a spare input for special applications such as extending or reducing time on demand.

E. Certification.

1. The Contracting Authority shall be furnished with a certification from the manufacturers of the signal head, pedestrian signal LED module, and the pedestrian countdown display LED module that the equipment furnished under this specification complies with all provisions of this specification. If there are any items that do not comply with this specification, a list of those exceptions must be detailed on the certification.

F. Warranty.

1. The LED signal modules shall be replaced or repaired if it fails to function as intended due to work quality or material defects within the first 60 months from date of operation.

4.07 TRAFFIC SIGNAL POLES.

A. General.

1. This section of the specification describes minimum acceptable design, material, and fabrication requirements for traffic signal poles.

2. The traffic signal mast arm and pole assemblies shall be designed to support the number of signal heads (use weight and projected areas of diecast aluminum signal heads) and signs as shown on the plans. The mast arm and pole assemblies shall be designed to support a minimum of two signal heads.

3. The mast arm and support poles shall be continuous tapered, round, steel poles of the anchor base type as shown on the plans. The poles shall be fabricated from low carbon (maximum carbon 0.30%) steel of U.S. Standard gauge.

After manufacture, they shall have a minimum yield strength of 48,000 PSI. The base and flange plates shall be of structural steel conforming to AASHTO M 183 (ASTM A 36) and cast steel conforming to ASTM A 27, Grade 65-35 or better.

It may be permissible to fabricate poles and mast arms by welding two sections together. The method used for connecting the sections shall result in a smooth joint and shall be factory welded as follows:

a. All longitudinal butt welds, except within one foot of a transverse butt-welded joint, shall have a minimum 60% penetration for plates 3/8 inch and less in thickness, and a minimum of 80% penetration for plates over 3/8 inch in thickness.

b. All longitudinal butt welds on poles and arms within one foot of a transverse butt-welded joint shall have 100% penetration.

c. All transverse butt welds for connecting sections shall have 100% penetration achieved by back-up ring or bar.

4. Pole manufacturers shall certify that only certified welding operators in accordance with AWS D1.1-80 were used and only electrodes as modified by AASHTO 1981 Standard Specifications for Welding of Structural Steel for Highway Bridges were used.

B. Mast Arm.

1. The mast arm shall be designed to support traffic signals and/or signs as shown in the Contract Documents. They shall be certified by the fabricator that the mast arms are capable of withstanding winds up to100 MPH with a 1.3 gust factor without failure. The mast arms shall be galvanized inside and out in accordance with ASTM A123, latest revision.

C. Poles.

1. The pole shall be designed to support the traffic signals and/or signs as shown on the plans. The pole shall be galvanized inside and out in accordance with the requirements of ASTM A123, latest revision. The pole shall be equipped with a nominal 5 inches by 8 inches handhole and cover located 1.5 feet above the base of the pole. Securing of the cover to the base shall be done with the use of simple tools. All hardware shall be corrosion resistant.

D. Combination Pole.

1. Where a combination street lighting/signal pole is specified on the plans, the above applies with the luminaire arm to be mounted in the same vertical plane as the signal arm unless otherwise indicated on the plans or by the Engineer.

2. The luminaire arm shall be of the truss pipe arm type.

3. The luminaire arm shall provide the spread as shown on the plans and a rise sufficient to provide for a nominal mounting height of 35 feet when attached to the pole.

E. Pole Finish.

1. The signal pole uprights shall be finish coated with smooth powder coat, color matching Lumec #BE6 Textured or Protech Color #PP311B66 Ocean Blue Textured, over galvanizing. Signal mast arm and Luminaire Arm shall only be hot dipped galvanized. Prior to the application of the powder coat, the surfaces shall be prepared by removing rolled-in mill scale, impurities, and non-metallic foreign materials. After assembly, all weld flux shall be mechanically removed. Iron or steel surfaces shall then be degreased by immersion in an agitated 4.5 - 6% concentrated caustic solution elevated to a temperature ranging from 150^{o} F - 180^{o}F. The product shall then be pickled by immersion in a heated sulfuric acid solution of 6-13% concentration, controlling the temperature at 150^{o}F. The product shall then be rinsed clean of any residual effects of the caustic or acid solutions by immersion in a circulating fresh water bath. The product shall then be immersed in a concentrated zinc ammonium chloride flux solution heated to 130^{o}F. The solution's acidity content shall be maintained between 4.5 - 5.0 pH. The product shall be air dried prior to zinc coating. Next, the product shall be hot-dip galvanized to the requirements of either ASTM A 123 or ASTM A 153 by immersion in a molten bath of prime western grade zinc maintained between 810^{o}F - 850^{o}F. Maximum aluminum content of the bath shall be 0.01% and the flux ash shall be skimmed from the bath surface prior to immersion and extraction. Galvanized exterior surfaces visually exposed shall be coated with a Urethane or Triglycidyl Isocyanurate (TGIC) Polyester Powder to a minimum dry film thickness (DFT) of 2.0 mils. The surfaces shall be mechanically etched by brush blasting and the zinc coated substrate shall be preheated to 450^{o}F for a minimum of one hour in a gas-fired convection oven. Finally, the coating shall be electrostatically applied and cured by elevating the zinc-coated substrate temperature to a minimum of 400^{o}F in a gas-fired convection oven. To prevent damage during delivery, small poles shall be wrapped in 0.188 inch thick ultraviolet-inhibiting, plastic-backed foam and larger poles shall be cradled in a 1.0 inch rubberized foam base.

2. The Contractor shall submit color proofs of the pole color before fabrication.

F. Hardware.

1. The mast arm and poles shall be equipped with all necessary hardware, shims and anchor bolts to provide for a complete installation without additional parts.

2. The anchor bolts shall meet the requirements of ASTM A 36 or better.

3. The anchor bolts shall be hot dipped galvanized for the entire length.

4. The anchor bolts shall be threaded a minimum of 6 inches at one end and have a minimum 4 inch long, 90 degree bend at the other end.

G. Shop Drawings.

1. 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. Certifications.

1. The fabricator shall certify that the mast arms are capable of withstanding winds up to 100 MPH with a 1.3 gust factor without failure; that only certified welding operators in accordance with AWS D1.1-80 or latest revisions were used; and that only electrodes as modified by AASHTO 1981 Standard Specifications for Welding of Structural Steel for Highway Bridges were used.

4.09 TRAFFIC SIGNS.

A. Traffic signs shall conform to the requirements of Section 4186 of the Standard Specifications.

B. Traffic signs shall be mounted on the mast arms utilizing a universally adjustable mast arm mounted sign bracket.

4.10 PEDESTRIAN PUSHBUTTONS.

A. Pedestrian push button detectors shall be of the direct push contact type and shall be ADA compliant.

B. The push button shall be weatherproof and of sturdy design. The entire assembly shall be weather tight, secure against electrical shock, and able to withstand continuous hard usage. The contacts shall be normally open with no current flowing except at the moment of actuation.

C. The housing shall be made of aluminum alloy and furnished with suitable mounting hardware.

D. Push button signs shall be furnished and shall conform to the requirements of the Manual On Uniform Traffic Control Devices (M.U.T.C.D.). Signs are as indicated on the plans.

E. The Contracting Authority shall be furnished with a certification from the equipment manufacturer stating that the equipment furnished under this specification complies with all provisions of this specification. If there are any items, which do not comply with this specification, then a list of those exceptions must be detailed on the certification.

4.11 FIBER OPTIC CABLE.

This work shall consist of furnishing and installing a fiber optic cable of the type, size and number of fibers specified.

A. General Requirements.

Materials and Equipment.
Materials and equipment shall be the standard products of a manufacturer regularly engaged in the manufacture of the products. All materials and equipment furnished shall be completely free from defects and poor quality. The cable shall be rated for gigabyte

data bandwidth. All fiber shall be loose tube construction for both indoor and outdoor installation. Indoor cabling shall use plenum rated conduit to within less than 50 foot of point of termination eliminating the requirement to convert to indoor cable.

Contractor Qualifications.
Trained and experienced personnel shall supervise the fiber optic cable installation. Qualified technicians shall make the cable terminations and splices. The Contractor upon request of the Engineer shall provide documentation of qualifications and experience for fiber optic equipment installations. The Engineer shall determine if the Contractor is qualified to perform this work. The Contractor shall have attended a certified fiber optic training class mandated by these specifications prior to starting work.

Codes Requirements.
The fiber optic cable installation shall be in accordance with or exceed all minimal requirements of State codes, National codes, and manufacturer codes as applicable.

Miscellaneous Equipment.
The Contractor shall furnish and install all necessary miscellaneous connectors and equipment to make a complete and operating installation in accordance with the plans, standard sheets, standard specifications, special provisions, and accepted good practice of the industry.

General Considerations.
The cable shall meet all requirements stated within this specification.
The cable shall be new, unused, and of current design and manufacture.

Fiber Characteristics.
All fibers in the cable must be usable fibers and meet required specifications.

Multi-mode Fiber
Core diameter: 62.5 +3.0um
Cladding diameter: 125.0 +2.0um
Core-to-cladding offset: <3.0um
Coating diameter 250 +15um
Graded Index
Attenuation uniformity: No point discontinuity shall be greater than 0.25 dB, except terminations or patch cords, at either 850nm or 1300nm. The coating shall be a layered UV cured acrylate applied by the fiber manufacturer. The coating shall be mechanically or chemically removable without damaging the fiber.

Factory cable rating shall be 3.5 dB/KM at 850 nM and 1.0 dB/KM at 1300 nM, or less. Installed tolerance shall be less than 3.85 dB/KM at 850 nM and less than 1.1 dB/KM at 1300 nM, testing tolerance.

All fiber cables shall be Gigabyte rated, i.e. multimode shall be 200/500 Meter for 850 and 1300 nM respectively based on a 10 dB power budget.

B. Fiber Specification Parameters.

All fibers in the cable shall meet the requirements of this specification. The testing tolerance attenuation specification shall be a maximum attenuation for each fiber over the entire operating temperature range of the cable when installed.

Optical fibers shall be placed inside a loose buffer tube, minimum six fibers per tube, normally 12 fibers per tube. Actual number of fibers per tube shall be 12 fibers per tube unless specified differently on the Plans.

Multimode – each buffer tube shall contain 12 or 6 fibers.

The buffer tubes will meet EIA/TIA-598, "Color coding of fiber optic cables."

All fiber cables shall be Gigabyte rated, i.e. multimode shall be 200/500 Meter for 850 and 1300 nM respectively and 5000 Meter for 1310 and 1550 nM.

Fiber count, tubes of fiber, shall be as specified on the plans.

Fillers shall be included in the cable core to lend symmetry to the cable cross-section where needed.

The central anti-buckling member shall consist of a glass reinforced plastic rod. The purpose of the central member is to prevent buckling of the cable.

The cable shall use a completely dry cable design without the use of gels and filling compounds. Dry water blocking material shall be used around the buffer tubes as well as internal to the tubes. Water blocking gels shall not be acceptable on this project.

Buffer tubes shall be stranded around a central member. Acceptable techniques include the use of the reverse oscillation, or "SZ", stranding process.

All dielectric cables (with no armoring) shall be sheathed with medium density polyethylene. The minimum nominal jacket thickness shall be 1.4 mm. Jacketing material shall be applied directly over the tensile strength members and flooding compound. Cable jacketing shall utilize the newer designs to provide maximum flexibility without loss or appreciable dB attenuation. Cable diameter shall not exceed 0.50 inch.

The jacket or sheath shall be marked with the manufacturer's name, the words "optical cable", the year of manufacture, number of fibers, type of fiber, and sequential feet marks. The markings shall be repeated every 3 feet. The actual length of the cable shall be within –0/+1% of the length marking. The marking shall be in a contrasting color to the cable jacket. The height of the marking shall be approximately 2.5 mm. A copy of the manufacturer fiber definition and shipping sheet identifying all tests, results and fiber indexes shall be provided to the Engineer on delivery of cable to the City or shall be included with a contractor's listing of place(s) of installation when installed by a Contractor.

The maximum pulling tension shall be 600 pounds during installation.

Where ever possible, six buffer tubes with 12 fibers each, or subsets specified, shall be provided and designated as follows:

Buffer Tube/Fiber	Tube/Fiber Color
#1, 1st tube or fiber	blue
#2, 2nd tube or fiber	orange
#3, 3rd tube or fiber	green
#4, 4th tube or fiber	brown
#5, 5th tube or fiber	slate
#6, 6th tube or fiber	white
#7, 7th tube or fiber	red
#8, 8th tube or fiber	black

#9, 9th tube or fiber	yellow
#10, 10th tube or fiber	violet
#11, 11th tube or fiber	rose
#12, 12th tube or fiber	aqua

C. Quality Assurance Provisions.

All optical fibers shall be proof tested by the fiber manufacturer at a minimum load of 100 kpsi.

All optical fibers shall be 100% attenuation tested at the manufacturer. The attenuation of each fiber shall be provided with each cable reel. The measured attenuation shall be for both 850 and 1300 frequency for multimode and 1310 or 1550 frequency for single mode. This documentation shall be provided with each spool. The Contractor shall designate on the Plans and in this documentation the location where each spool has been installed and provide this data to the Engineer.

D. Cable Installed in Ducts and Conduits.

A suitable cable feeder guide shall be used between the cable reel and the face of the duct and conduit to protect the cable and guide it into the duct off the reel. It shall be carefully inspected for jacket defects. If defects are noticed, the pulling operation shall be stopped immediately and the Engineer notified. Precautions shall be taken during installation to prevent the cable from being “kinked” or “crushed”. A pulling eye shall be attached to the cable and used to pull the cable through the duct and conduit system. A pulling swivel shall be used to eliminate twisting of the cable. As the cable is played off the reel into the cable feeder guide, it shall be sufficiently lubricated with a type of lubricant recommended by the cable manufacturer. Dynamometers or breakaway pulling swing shall be used to ensure that the pulling line tension does not exceed the installation tension value specified by the cable manufacturer. The mechanical stress placed on a cable during installation shall not be such that the cable is twisted or stretched. The pulling of cable shall be hand assisted at each controller cabinet. The cable shall not be crushed kinked or forced around a sharp corner. If a lubricant is used it shall be of water based type and approved by the cable manufacturer. Sufficient slack shall be left at each end of the cable to allow proper cable termination, MINIMUM OF 30 FEET. This slack shall be in addition to installation slack as hereinafter specified. Additional slack cable shall be left in each controller cabinet, handhole, and at the top of each conduit riser. Excess slack at controller cabinets shall be re-pulled into the nearest handhole to provide a neat and orderly installation. The minimum slack amounts shall be as follows:

Controller cabinet – 30 feet
Type 1Handhole – 20 feet
Type 2 Handhole – 100 feet

Storage of minimum slack cable in controller cabinets and additional slack at pull boxes shall be coiled. The slack coils shall be bound at a minimum of three points around the coil parameter and supported in their static storage positions. The binding material and installation shall not bind or kink the cable. Storage of additional slack cable adjacent to conduit risers and support poles shall be as visibly marked/tagged as “CAUTION – FIBER OPTIC CABLE”. Maximum length of cable pulling tensions shall not exceed the cable manufacturer’s recommendations. Along with the fiber optic cable, one (1) #10 AWG THHN, 600 volt single conductor cable (identifier conductor), orange in color, shall be pulled with 10 feet slack in each pull box. All fiber cables shall be marked with a metallic, or preapproved identifier in the handhole adjacent to the traffic signal cabinet and on the cable in the traffic signal cabinet at the point of termination. The identifier, both in the cabinet and in the handhole, shall indicate the direction the cable is going,

cable contents, and the abbreviated location for the other end destination. Fiber cabling between traffic controllers shall be outdoor rated, loose tube fiber, when not linked by a direct, continuous conduit installation.

E. Minimum Bend Radius.

For static storage, the cable shall not be bent at any location to less than ten times the diameter of the cable outside diameter or as recommended by the manufacturer. During installation, the cable shall not be bent at any location to less than twenty times the diameter of the cable outside diameter or as recommended by the manufacturer.

F. After Fiber Optic Cable Installation.

Each section of the cable shall be tested for continuity and attenuation as a minimum. If the attenuation is found not to be within the acceptable nominal values, the Contractor shall use an optical time domain reflectometer (OTDR) to locate points of localized loss caused by bends or kinks. If this is not successful the Contractor shall replace the damaged section of cable with no additional payment. Splices will not be allowed to repair the damaged section. After all fiber cable is installed between traffic controller cabinets and fiber links between fiber distribution points (FDP) complete links, all fibers, whether terminated or non-terminated, shall be tested with an OTDR. All fibers terminated shall be tested with a power meter. The Contractor may jumper termination points at controller cabinets to minimize the number of tests and run a single OTDR test between several controller cabinets, subject to the range of the OTDR. Links between FDP's shall be tested separately. Each OTDR trace, for documented test result submittal, shall be displayed individually and not be combined with other fiber traces as overlays. Multimode fiber shall be tested using 1300 nm. The results of the OTDR test shall be provided on an electronic media (disk) and paper printout. The OTDR wave, pictorial diagram of dB loss over the length of fiber tested, shall be provided along with the measured data values. The printout shall contain the manufacturer's fiber optic Index of Refraction to the third decimal point for the fiber provided. The Contractor shall provide the Engineer with a written report showing all the values measured compared to the calculated values for length and coupler/connector losses at the completion of these tests. Outdoor patch cords between FDP and controller units less than 151 feet do not need be OTDR tested.

Documentation provided to the Engineer shall include a written indication of every splice, termination, patch cord, etc. for cable being measured. Power meter measurement recordings shall indicate the exact measured distance [OTDR or field measurement with cross reference for oscillation multiplier] on the sheet showing the power meter readings. Any deviations between fiber readings in the same tube shall be notated for OTDR graphs as well as deviations greater than 5% on power meter readings. Rated values for acceptable installation shall be based on the following parameters:

Patch cords/Pigtails	.60 MM & .15 SM dB each
Terminations	1.0 dB set of 2 [In and Out]
Splices	0.08 each

1 KM = 0.3077 KF where KF is 1000 feet

Data documentation shall include for each test between cabinets or between FDP sites, the length of fiber as measured by OTDR, frequency used in test on OTDR by each fiber type, distance to each splice, termination or patch cord jumper, dB loss rating by manufacture from spool documentation, index of refraction by type of fiber in section, and the dB loss of each section as measured in the final test for each fiber. A special test shall be made on all continuous spliced fiber from start to end that includes the total dB

loss measured and the OTDR plot on electronic disk. Splice points shall be identified on the trace.

G. Cable Termination.

Terminations shall be made using the method recommended by the connector manufacturer. All fibers shall utilize a fan-out kit of the size and type recommended by the manufacturer and of the number of fibers provided in each fiber tube. All fibers terminated shall utilize a ceramic ferrule (outdoor connections), ST, mechanical termination, or be a wide temperature (-40°F to +170°F) epoxy. Heat cured or epoxy type connections meeting the full temperature ratings are acceptable for this Project, including factory manufactured pigtails. The Contractor shall be required to provide proof of purchase of sufficient quantities of ceramic terminations for outdoor terminations to verify ceramic connector usage or temperature ratings on epoxy or heat cured processes prior to terminating any fibers. The Contractor may terminate fibers by splicing factory pigtails to the fiber ends and then connecting the pigtail to the fiber coupler in the fiber tray. When splicing pigtails to terminate, all splices shall be provided with the metal reinforced shrink tube protector. The contractor may terminate fibers by the use of mechanical termination connectors.

H. Breakout Kits.

The breakout kits or termination boxes used to terminate each fiber cable in the cabinet shall provide for the separation and protection of the individual fibers with the buffer tubing and jacketing materials. The termination housing shall be installed within a wall or shelf mountable interconnect housing which shall provide for storing fibers, ample room for feed through cable, strain relief for multiple cables within unit, and accommodate ST compatible connectors. All fiber pigtails shall be terminated through ST connectors on the wall or shelf mounted interconnect panel. All terminations shall be ST type, ceramic core (outdoor connections), and plug into the provided controller unit internal fiber optic modem.. Splices to pigtail fiber, where used, shall utilize fan out kit protection to the fiber, heat shrink tubing with metal bar reinforcement and 900 micron rated pigtail insulation. Splices to factory pigtails shall use pigtails that are rated for a minimum temperature range of 0°F to +150°F. In the absence of pigtails meeting this temperature rating, fibers shall utilize loose tube fiber in fanout kit tubes and mechanical ST connectors. These splices, fiber cable to pigtails, may be external to splice trays mounted internally to the enclosure, when shown on the wiring diagrams. All other splices, not specified to be installed external to the fiber splice tray, shall be installed in splice trays and be supported with heat shrink tubing.

I. Connectors.

Connectors shall be mechanical ST (ceramic ferrule-outdoor connections) compatible, field installable, and self-aligning and centering or factory fabricated pigtails. Fiber optic equipment, used for terminating fibers, shall be rated for the type of connectors used.

J. Splices.

The fiber cable shall be installed in continuous runs between cabinets. No splices shall be allowed, unless shown on the plans or for testing. Only mechanical splices will be allowed, when specified, such as testing of non-terminated fibers. Splices, where specified, shall be by fusion splice and shall be installed using an automatic fusion splicer. Splices between two fibers leaving the cabinet shall be supported in splice trays installed in splice enclosures. All splices shall be protected by heat shrink tubing designed for fiber optic splicing applications. Fibers being terminated in two separate termination or splice enclosures shall be supported between enclosures by the use of

buffer tubing or approved equal support material or shall be pigtail patch cords. Termination / splice enclosures shall be separated by less than 12 inches unless a conduit is installed between enclosures. All splices shall be performed by an automated splicer device that verifies the final splice termination quality. All splices shall be nominally 0.03 to 0.05 dB loss but shall be less than a 0.08 dB loss.

K. Light Source.

An LED light source with a wavelength that is the system wavelength, 850 and 1300 nm for multimode and 1310 and 1550 nm for single mode, shall be used. The LED shall be stable within 0.1 dB in intensity over a time period sufficiently long to perform the measurement. The output of the LED shall overfill the input end of the launch fiber/cable in both numerical apertures (NA) and core diameter. The accuracy of the combined light source and power meter shall be less than .05 dB and be temperature compensated stabilized to 0.01 dB over the operating range of the meter(s).

L. Power Meter.

The detector in the power meter shall have an effective numerical aperture and active region that is larger than the receive reference cable and/or the fiber under test. A fiber optic source/power meter with accessories will be supplied to the city for verification testing. The power meter shall have a minimum range from +3 DBMS to –40 DBMS. The power meter shall have an accuracy of +/-0.5 dB through the operating temperature and minimum resolution of 0.1 dB.

M. Launch Reference Attenuator.

The launch attenuator shall be utilized for all OTDR tests such that one launch cable shall be at the beginning of the fiber being tested and the second launch cable shall be on the end of the fiber being tested past the final connector. Only one launch cable shall be required when testing non-terminated fiber. The launch attenuator(s) shall be of the same fiber core size and type as the fiber under test. The attenuator shall emulate 300 foot fiber length, minimum, for multimode or as specified by the OTDR manufacturer for stabilization of the pulse generation. Launch cables shall be of identical length for incoming and outgoing light during tests. ST connectors shall be utilized with each attenuator to connect the device to the test device, OTDR. One launch cable shall be installed on the start of the fiber being tested and one launch cable shall be installed on the end of each terminated to view the dB loss of the final connector.

The OTDR shall have the Threshold Loss set at a value to show each splice or termination junction of a single fiber in each tube with out showing the extraneous noise caused by handhole coils or turns into the cabinets. This level is normally a value [Threshold Loss] between 0.3 and 0.8 on the OTDR. This trace shall be provided for one fiber in each tube tested and each “event” shall be marked as to splice, jumper or patch cord. The Threshold Loss shall then be set to a value of 0.25 for multimode fiber tests. The test of each fiber installed shall be conducted and any recorded events above this threshold shall be identified, such as jumper or patch cord. Events that are in excess the provided values shall be corrected prior to documentation submittal, such as terminations in excess of the rated value or bends in the fiber at the point of a splice entering of leaving the splice tray. For measured values recorded in excess of the above (0.25 MM) listed values. The Engineer reserves the right to spot test fiber terminations, splices, or re-testing of all fibers in a section to insure proper quality assurance both during and after installation and testing. Deviations from Engineer testing and report documentation shall be reviewed and the Contractor shall be able to retest any or all challenged measurements to verify a valid test. Inconsistent test results, in the sole opinion of the Engineer, shall be cause for the Contractor to retest the entire fiber installation.

N. Testing.

General.
The Contractor shall provide all personnel, equipment, instrumentation and supplies necessary to perform all testing. 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 Traffic Engineer as hereinbefore specified. The Contractor shall provide one copy of operating software to read and view all OTDR traces.

Attenuation.
The end-to-end attenuation shall be measured for each fiber for each link after installation and termination. A patch cord jumper cable shall be connected to both the light source and the receive cable to the power meter by the use of a connector (barrel). The two reference cables shall then be connected via a termination coupler and the power meter "zeroed" to eliminate the line loss. This process results in a reading of the actual line loss (dB) of the input connector, fiber cable, exiting connector and any other splices or jumpers installed in the measured test link. The calculated "loss" shall not include the input or departing cables in the loss calculation. The calculated fiber loss measured shall list the number of terminations, including the input and departing connectors, the number of splices and the number of patch cords used to jumper the link(s) into the measured final link. The measured values for each terminated fiber in each tube shall include the Tube number, fiber number, number of feet in the link, the number of splices, the number of patch cords and the number of connectors, if any. The length of optical cable shall be as measured by the OTDR rather than the fiber cable jacket as the fiber is a reverse oscillation process resulting in a greater optical distance than the fiber cable jacket. The value for both the OTDR length and the cable jacket shall be provided in the recorded documentation for each link distance. All distances shall be recorded in feet rather than meters for both recorded lengths.

Fibers that are not continuous from beginning of the link to the end of the link shall be noted in the documentation; otherwise, all fibers in a single tube may be listed with a single data entry for all required data listed above for all fibers in the tube. The fiber documentation for each fiber shall identify the fiber being tested by either fiber number or fiber coating color and be recorded by complete tube, Tube 1 through Tube 6, fiber 1 through fiber 12. The direction of the test shall be recorded for information purposes only to resolve discrepancies in replicating the test during inspections of the final installation. The power meter reading recordings shall log total dB loss over the length of the fiber measured, equivalent to a dB loss budget.

The output power levels at the network hardware transmitters and receivers shall be measured and recorded for system documentation. 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

Each tube of a cable shall be in the same file divider where the tube cover OTDR page shows the overview of all splices, patch cords, terminations from start to end. The second section shall include all Power Meter readings and the mandated documentation to show the calculated line loss (losses). The third section shall contain all OTDR traces, one trace per screen. The fourth section shall include the spool sheet for the fiber installed on the test section. An "explanation" sheet may be included where required to clarify an unusual reading that is valid but difficult to be explained through traditional data presentation, such as a video feed fiber that is attached to a jumper to provide continuous feed from the start to end of the tube length where other fibers in the same tube are simply spliced. The above format shall be repeated for each tube of a cable.

Continuity.
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 that the transmit fiber goes to the receiver fiber. The visible light tester shall be utilized to illuminate faulty terminations or fibers with excessive bends failing to pass light.

To perform continuity test, a high-intensity red light (Visible Fault Identifier) light source shall be aimed into the connector at one end, while an observer watches for a flicker of light at the other end. One each 650 nm red NFL light source shall be furnished to the Engineer by the Contractor on request during the testing of the fiber by the Contractor for spot testing. This device shall be made available during testing of continuity to the Engineer to assist in verifying fault locations and connector bleeding.

OTDR Testing.
An Optical Time Domain Reflectometer (OTDR) shall be used to evaluate the quality and length of cable reels prior to their use on the project. A minimum of one fiber per tube per reel shall be tested if payment for stored goods is requested. 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 as hereinbefore specified. This test does not require an electronic document; but is provided to insure that the fiber has been received in useable quality without shipment damage. The test results of the Contractor OTDR tests of received spools shall be provided to the Engineer, in a minimum of hard copy print, prior to receiving payment for stored goods.

An OTDR shall be used to evaluate the quality and length of cable installed on the project. This test shall be conducted on all fibers, terminated and not terminated, and shall be conducted after all terminations on the fibers for a link have been completed. The fiber loss in dB/km and the length of each reel shall be recorded in the documentation. The index of refraction, minimum of three decimal points, provided by the manufacturer on the spool documentation shall be used for the test on the OTDR. The maximum attenuation of the cable shall be as hereinbefore specified. A hard copy of OTDR signature traces, electronically and in printed form, for all fiber links shall be made and provided in the documentation as specified. The data provided shall be in easy to understand format and of sufficient detail to verify the results. Fiber testing shall include only one fiber trace per graph. One copy of the operating system software to view the fiber graphs shall be provided with the final documentation.

Documentation.
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. The Contractor shall be responsible to provide input to the Engineer reviewing the recorded data documentation to resolve all questions or data discrepancies. A copy of the evaluation calculation equations to be used may be obtained by the Contractor by request and by supplying a floppy disk. (The evaluation FO Calculator is an EXCEL program worksheet that calculates design dB Loss based on required inputs.) Documentation shall be considered incidental to bid items and no additional compensation shall be provided.

Schedule of Unit Prices
COMANCHE AVENUE AT 14TH STREET

No.	Item Description	Plan Quantity	Units	Unit Price	Unit Extension
1	NEMA Controller, Cabinet and Accessories	1	EA	$	$
2	Four Camera Video Detection System Inc. Controller and Acc.	1	LS	$	$
3	Uninterruptable Power Supply and Accessories	1	EA	$	$
4	5-Section, 12" RYG w/Green&Yellow Right Turn Arrow	1	EA	$	$
5	2-Section, 12" Hand/Man/Countdown pedestrian head	8	EA	$	$
6	3-Section, 12" RYG Signal Head, w/Bkpl (where noted)	12	EA	$	$
7	3-Section, 12" RYG Left Turn Arrow, w/Bkpl (where noted)	4	EA	$	$
8	Handhole, Type HHI 24" Poured or Precast, Ring and Cover	7	EA	$	$
9	Handhole, Type HHII "Tub" 30" x 48" Quazite Stackable	1	EA	$	$
10	Cable - Signal 2C #14	2344	LF	$	$
11	Cable - Signal 5C #14	3003	LF	$	$
12	Cable - Signal 7C #14	54	LF	$	$
13	Cable - Signal 12C #14	2816	LF	$	$
14	Cable - Lighting 1C #8	1722	LF	$	$
15	Cable - Ground 1C #6	730	LF	$	$
16	Cable - Tracer 1C #10	730	LF	$	$
17	Pull Rope	730	LF	$	$
18	Cable - 1c#6 Power Supply	63	LF	$	$
19	Cable - 6PR #19 for Interconnect	58	LF	$	$
20	Cable - Coax for Video Detection Cameras	1368	LF	$	$
21	Cable - Power for Video Detection Cameras	1368	LF	$	$
22	Conduit - 2" PVC Trenched	50	LF	$	$
23	Conduit - 3" PVC Trenched	146	LF	$	$
24	Conduit - 4" PVC Trenched	142	LF	$	$
25	Conduit - 3" PVC Pushed	262	LF	$	$
26	Conduit - 4" PVC Pushed	156	LF	$	$
27	Concrete Base - Controller Pad	1	EA	$	$
28	Concrete Base - 3' Dia. X 10.0' Deep Footing	2	EA	$	$
29	Concrete Base - 3' Dia. X 12.0' Deep Footing	1	EA	$	$
30	Concrete Base - 3' Dia. X 14.0' Deep Footing	1	EA	$	$
31	Concrete Base - 2' Dia X 3.0" Deep Footing	2	EA	$	$
32	Pole (Steel) - Combination Mast Arm Pole - 30' Arm	1	EA	$	$
33	Pole (Steel) - Combination Mast Arm Pole - 34' Arm	1	EA	$	$
34	Pole (Steel) - Combination Mast Arm Pole - 48' Arm	1	EA	$	$
35	Pole (Steel) - Combination Mast Arm Pole - 51' Arm	1	EA	$	$
36	Pole (Steel) - Pedestal	2	EA	$	$
37	Wye Connectors - Type L1 (20A Fuse)	2	EA	$	$
38	Wye Connectors - Type L1 (5A Fuse)	4	EA	$	$
39	Wye Connectors - Type Y1 5A FUSE	4	EA	$	$
40	Wye Connectors - Type Y3	2	EA	$	$
41	Meter Socket	1	EA	$	$
42	Traffic Sign (R3-5L) 30"x36" Mast Arm Mounting	4	EA	$	$
43	Traffic Sign (R10-12) 24"x30" Mast Arm Mounting	2	EA	$	$
44	Traffic Sign (R10-10L) 24"x30" Mast Arm Mounting	2	EA	$	$
45	Traffic Sign (R10-10R) 24"x30" Mast Arm Mounting	1	EA	$	$
46	Furnish and Install Street Name Sign "14th St"	2	EA	$	$
47	Furnish and Install Street Name Sign "Camanche Ave"	2	EA	$	$
48	Ped Pushbutton with Sign R10-3E (9"x15")	8	EA	$	$

Total Lump Sum to Furnish and Install Traffic Signals $

Approved:
City Traffic Engineer Date

Equipment and Material List
COMANCHE AVENUE AT 14TH STREET

Plan Quantity	Units	Item Description	Manufacturer	Catalog Number
1	EA	NEMA Controller, Cabinet and Accessories		
1	LS	Four Camera Video Detection System Inc. Controller and Acc.		
1	EA	Uninterruptable Power Supply and Accessories		
1	EA	5-Section, 12" RYG w/Green&Yellow Right Turn Arrow		
8	EA	2-Section, 12" Hand/Man/Countdown pedestrian head		
12	EA	3-Section, 12" RYG Signal Head, w/Bkpl (where noted)		
4	EA	3-Section, 12" RYG Left Turn Arrow, w/Bkpl (where noted)		
7	EA	Handhole, Type HHI 24" Poured or Precast Ring and Cover		
1	EA	Handhole, Type HHII "Tub" 30" x 48" Quazite Stackable		
2344	LF	Cable - Signal 2C#14		
3003	LF	Cable - Signal 5C#14		
54	LF	Cable - Signal 7C#14		
2816	LF	Cable - Signal 12C#14		
1722	LF	Cable - Lighting 1C#8		
730	LF	Cable - Ground 1C#6		
730	LF	Cable - Tracer 1C#10		
730	LF	Pull Rope		
63	LF	Cable - 1c#6 Power Supply		
58	LF	Cable - 6PR#19 for Interconnect		
1368	LF	Cable - Coax for Video Detection Cameras		
1368	LF	Cable - Power for Video Detection Cameras		
50	LF	Conduit - 2" PVC Trenched		
146	LF	Conduit - 3" PVC Trenched		
142	LF	Conduit - 4" PVC Trenched		
262	LF	Conduit - 3" PVC Pushed		
156	LF	Conduit - 4" PVC Pushed		
1	EA	Concrete Base - Controller Pad		
2	EA	Concrete Base - 3' Dia. X 10.0' Deep Footing		
1	EA	Concrete Base - 3' Dia. X 12.0' Deep Footing		
1	EA	Concrete Base - 3' Dia. X 14.0' Deep Footing		
2	EA	Concrete Base - 2' Dia X 3.0" Deep Footing		
1	EA	Pole (Steel) - Combination Mast Arm Pole - 30' Arm		
1	EA	Pole (Steel) - Combination Mast Arm Pole - 34' Arm		
1	EA	Pole (Steel) - Combination Mast Arm Pole - 48' Arm		
1	EA	Pole (Steel) - Combination Mast Arm Pole - 51' Arm		
2	EA	Pole (Steel) - Pedestal		
2	EA	Wye Connectors - Type L1 (20A Fuse)		
4	EA	Wye Connectors - Type L1 (5A Fuse)		
4	EA	Wye Connectors - Type Y1 5A FUSE		
2	EA	Wye Connectors - Type Y3		
1	EA	Meter Socket		
4	EA	Traffic Sign (R3-5L) 30"x36" Mast Arm Mounting		
2	EA	Traffic Sign (R10-12) 24"x30" Mast Arm Mounting		
2	EA	Traffic Sign (R10-10L) 24"x30" Mast Arm Mounting		
1	EA	Traffic Sign (R10-10R) 24"x30" Mast Arm Mounting		
2	EA	Furnish and Install Street Name Sign "14th St"		
2	EA	Furnish and Install Street Name Sign "Camanche Ave"		
8	EA	Ped Pushbutton with Sign R10-3E (9"x15")		

Approved:

City Traffic Engineer Date