Part VI - Traffic Engineering Electrical & Pavement Markings

ARTICLE 601 - GENERAL REQUIREMENTS

601.1 Description.

Traffic signal and street lighting construction shall consist of excavating the required trenches and tunnels; furnishing and laying therein the required conduit; placing cable-in-duct and/or signal cable; installing the required structures and appurtenances; backfilling the trenches; restoring the site of the work; and completing the work to the required lines and grades. All work shall be performed as shown on the plans and in accordance with the contract.

The existing signal and lighting poles, conduits, handholes, and manholes not scheduled for removal or abandonment shall be protected during construction. If the contractor believes that damage to such facilities is unavoidable, the contractor shall not damage or remove any facilities until the City Traffic Engineering electrical inspector has reviewed and approved such actions. Any damage or removal of City electrical conduit, wire, fiber, or structures, without the specific approval by the City Traffic Engineering electrical inspector shall be promptly repaired or replaced by and at the expense of the contractor. The City may elect to do repair work with City crews. The cost for any repair work done by the City will be billed to the contractor.

Any damage or removal of City street lighting, traffic signal, or communication facilities shall be repaired or replaced within 24 hours, but any resulting street light outage resulting from such damage or removal shall be confined to as few numbers of street lights as possible. The streetlight circuits shall remain operational each and every night. The City reserves the right to make temporary or permanent repairs at any time after the damage or removal, even within 24 hours of the damage or removal, with the full cost of such work, including engineering time, billed to the general contractor.

Unless a manhole (utility access structure), handhole, or structure is specifically designated for removal, it shall be saved. The contractor shall consult with the Traffic Engineering Electrical Inspector before removing or damaging any existing facilities.

601.2 Equipment.

Equipment and tools necessary for performing all parts of the work shall be satisfactory in design, capacity, and mechanical condition for the purposes intended, and any equipment which is not maintained in full working order, or which as used by the Contractor is inadequate to obtain the results prescribed, shall be repaired, improved or supplemented to obtain the progress and quality of work contemplated by the contract.

601.3 Finishing Work and Maintenance.

The Contractor shall maintain all trenches and other excavations, keeping them well filled and in a safe condition for travel, and shall deliver to the City, at the time of acceptance, a finished job with all trenches in a condition satisfactory to the Engineer.

All concrete, asphalt, and gravel pavements; stone flagging or paving; sidewalks; curbs and gutters; culverts; fences; or other structures which may have been damaged or displaced by the Contractor shall be relaid properly to the original line and grade. In areas with established and tended sod, the Contractor shall resod areas disturbed by the construction; all other areas disturbed by the construction shall be seeded. All of the above work shall be in accordance with these Specifications, or in absence of applicable specifications, to restore the original condition of the structure or area.

The Contractor shall restore and maintain all asphalt and gravel surfaces in first class condition until final acceptance of the project by the Common Council. All structures and conduit shall be cleaned of any accumulations of silt, debris or other foreign matter. Conduit shall be cleaned by use of the proper size mandrel. The area along the entire installation shall be left clean and graded in a condition satisfactory to the City of Madison Traffic Engineering Inspector. Responsibility of new installations and locating services will be transferred from the contractor once written acceptance is received from the City Traffic Engineering Inspector.

Unless otherwise provided, all costs of the work included in this Section shall be at the expense of the Contractor, and shall be included in the unit price bid for the contract items with which such work is associated. Final payment will be withheld until such work is done in a manner satisfactory to the Engineer.

601.4 Repairs and Replacement.

Contractor is responsible for repairs to damaged new and existing Traffic Engineering infrastructure, unless determined otherwise by City Inspector. When compliance with these Specifications requires repairs, such repairs shall be made by replacement of the defective section with new materials of equal quality installed in accordance with the construction specifications governing the original installation. These repairs shall include total and complete restoration of any disturbed surface to its original, or better than original, condition. Unless otherwise provided, all costs of the work included in this Section shall be at the expense of the Contractor.

601.5 Codes, Permits and Inspections.

The electrical work shall be done in strict accordance with the Wisconsin State Electrical Code and the Electrical Code of the City of Madison and shall be subject to inspection by the City Building Inspection and Rehabilitation Unit.

The Contractor shall obtain and pay for all necessary permits and certificates of inspection.

The City Traffic Engineering Inspector shall be notified at least twenty-four (24) hours in advance of beginning any underground electrical construction work, such as installing cable-in-duct, PVC conduit and concrete bases, and shall be updated frequently as to stopping and restarting underground work. All underground conduit, cable, or concrete base forms shall be inspected by the City Traffic Engineering Inspector before any trench is backfilled or concrete is poured. Any work completed without such inspection is subject to rejection as unacceptable work and shall be immediately removed and acceptably replaced or otherwise satisfactorily corrected by and at the expense of the Contractor.

601.6 Testing.

The Contractor shall furnish all equipment and appliances necessary to test all installed cable systems. The Contractor shall test and demonstrate to the satisfaction of the Traffic Engineer that the lighting circuits are properly connected and operational; continuous and free from short circuits and unspecified grounds; that they are connected in accordance with the wiring layout; and that with fuses removed the resistance to ground of nongrounded circuits between any two adjacent terminals is not less than five (5) megohms.

All cable shall be “Meggered” and the results recorded. All values shall be in accordance with standard practice for the lengths and type of cable used. All electrical circuits and equipment shall be tested and remain in operating condition.

601.7 Disposal of Excess Excavation.

The Contractor shall be responsible for the disposal of any excess excavation. In the event the Contractor encounters stones, boulders, debris, or other material which would not normally be expected when excavating for lighting units or trenching for cable placement, the Contractor shall remove and dispose of such material as may be necessary.

601.8 Tree Trimming.

All tree trimming and incidental related work shall be performed by the Contractor under the supervision of the City Streets Division. The Contractor shall schedule the work to provide reasonable notification to the Streets Division (Forestry) of the tree trimming necessary and to further provide continuity of such work.

601.9 Electrical Equipment.

All electrical equipment shall provide suitable interchangeability and durability of performance and shall require the approval of the Traffic Engineer.

601.10 Materials Furnished by the City.

All materials which are to be furnished by the City shall be picked up by the Contractor at the Traffic Engineering Shop, 1120 Sayle Street, unless otherwise specified. All costs of the work included in this Section shall be at the expense of the Contractor unless otherwise provided. The Contractor shall provide equipment and labor to load materials onto Contractor’s vehicle or trailer. Complete quantities of an item shall be picked up on one appointment unless the City agrees to a partial quantity disbursement.

ARTICLE 602 - UNDERGROUND DISTRIBUTION SYSTEMS

602.1 General.

This item consists of furnishing and installing underground traffic signal cable, fiber optic cable, loop detector lead in wire, loop detector wire and/or furnishing and installing an underground street lighting distribution system in accordance with these Specifications, the Special Provisions, and the details shown on the plans. Underground cable shall be pulled into existing and Contractor-installed conduit or installed as a cable-in-duct system as shown on the plans.

602.2 Materials.

602.2(a) Cable-in-Duct.

1. Underground Cable Conductors. Unless otherwise specified, the underground cable system shall consist of three #4 AWG, cross-linked polyethylene insulated copper conductors, Type USE, RHH, RHW, 600 volt, paralleled with a single #8 AWG ground wire, assembled in a coilable polyethylene duct (cable-in-duct) and shall comply with the requirements of IPCEA-NEMA Standard S-66-524, and insulation thickness shall be nominal 0.060 of an inch.

   Identification of the insulated conductors shall be accomplished by covering the insulation surface with a tough, strongly adherent colored coating in accordance with Method I or by surface printing in accordance with Method III of IPCEA-NEMA Standards S-19-81. White color coatings shall not be furnished or used on phase conductors.

   Conductors shall be annealed copper unless otherwise specified. Conductor sizes 14-10 AWG may be solid or Class B stranding. Sizes 8 AWG and larger shall be Class B stranding. Conductors shall comply with the requirements of IPCEA-NEMA Standard S-19-81, Part 2.

   The average insulation wall thickness shall be applied to the conductor with good concentricity. The minimum thickness of insulation at any point shall be not less than 90 percent of the specified average thickness.

2. Polyethylene Duct. The conductors shall be enclosed in a coilable polyethylene duct, suitable for direct earth burial, which shall meet the applicable requirements as defined in the Specifications for Polyethylene Molding and Extrusion Materials, ASTM D 1248, Type III, Class C.

   The duct shall have a nominal size of 1-1/4 inches, approximate I.D. of 1.42 inches and a minimum wall thickness of 0.106 of an inch.

   In addition, the duct shall meet the following requirements:

Property	Requirement	Test Method
Tensile Strength	2,800 PSI (min.)	ASTM D 638
Elongation	400% (min.)	ASTM D 638
Melt Index	0.50 (max.)	ASTM D 1238
Brittle Temperature - 80% Nonfailure	-60°C	ASTM D 746
Impact Resistance	.9 ft. #/in. of notch	ASTM D 256 Method

3. In lieu of the routine electrical tests described below, the Contractor shall furnish a manufacturer's certificate of compliance in triplicate for the insulated conductors and polyethylene duct, indicating their conformance with these Specifications.

4. The Contractor shall furnish manufacturer's certified test reports, in triplicate, to the Traffic Engineer indicating the conformance with these Specifications.

   All tests included in these Specifications shall be performed in accordance with the test procedure and frequency described in IPCEA-NEMA Standard S-19-81, Part 6.

   a. High Voltage Test: Before installation in the polyethylene duct, each reel of the completed cable shall be immersed in water for a period of not less than six hours, and while immersed shall successfully withstand the application, for a period of five minutes, of a 60 cycle test voltage of the value specified in the standard.

   b. Insulation Resistance Test: Upon completion of the above specified high voltage test, the insulation resistance of each reel of completed cable shall be measured. The insulation resistance at, or corrected to, a temperature of 60°F shall be not less than that calculated from the expression:

      $$R = 50{,}000 \log D/d$$

      Where R = Insulation resistance, megohms - 1000 feet

      D = Diameter over insulation - inches
      d = Diameter under insulation - inches

602.2(b) Electrical Conduit.

1. Rigid Steel Conduit (commonly called GS conduit)

   Rigid steel conduit (zinc coated) shall conform to the requirements of the American Standards Association Specifications for Rigid Steel Conduit, Zinc Coated, ANSI Designation: C 80.1, except with regard to identification and inspection. In addition to the manufacturer's name or trademark, as required by ANSI Designation: C 80.1, each length of conduit and nipple elbow shall have the Underwriters Laboratories, Inc. label, or an acceptable equivalent, firmly affixed.

2. Polyethylene Conduit

   The conduit shall be either a medium density or high density grade polyethylene conduit suitable for direct earth burial. Medium density polyethylene shall meet the applicable requirements for Polyethylene Molding and Extrusion Materials, ASTM D-1248, Type II, Class C. High density polyethylene shall meet the applicable requirements for Polyethylene Molding and Extrusion Materials, ASTM D 1248, Type III, Class C.

   The above materials shall also pass:

   ASTM D 638: Tests for Tensile Strength and Elongation.
   ASTM D 746: Brittle Temperature, 80% Non-failure.

ASTM D 1238: Test for Flow Rate.

The conduit shall correspond to the following dimensions:

Nominal Size	O.D.	I.D.	Min. Wall Thickness
1 in.	1.30 in.	1.05 in.	--
1-1/4	1.65	1.38	0.10 in.
1-1/2	1.90	1.61	--
2	2.37	2.06	0.15

The conduit shall be packaged on reels in accordance with industry standards.

3. Polyvinyl Chloride (PVC) Conduit (Schedule 40 and Schedule 80).

PVC conduit shall be used in accordance with the National Electrical Code and shall comply with all requirements in NEMA Specifications TC-2 (Conduit) and TC-3 (Fittings-UL-514), Federal Specification W-C-1094A, UL-651 (Standard for rigid nonmetallic conduit), and ANSI C33.91.

The conduit and fittings shall be clearly marked with a UL label. The type and manufacturer shall be identified by legible and permanent markings.

The conduit and fittings shall be produced by the same manufacturer and be homogeneous, virgin PVC C-300 compound free from visible cracks, holes or foreign inclusions. The conduit bore shall be smooth and free of blisters, nicks, or other imperfections which could mar conductors or cables.

All conduit and fittings shall be solvent welded in accordance with instructions from the manufacturer, and as directed by the Traffic Engineer. Solvent for welding PVC shall be clear, medium viscosity, with a fast set time, ASTM D 2564 or approved equal.

The Contractor shall furnish and install 10 AWG, XLP, USE rated, 600 volt AC, single conductor, stranded copper for conductors in each individual conduit installed.

4. Conduit proposed for use shall be approved in writing by the Traffic Engineer prior to beginning work on the project.

The Contractor shall furnish manufacturer's certified test reports, in triplicate, to the Traffic Engineer indicating that the conduit proposed for use conforms to the above specifications.

602.2(c) Electrical Conductors.

Electrical conductors to be furnished shall be (size) AWG insulated conductors, Type USE, RHH, RHW as more fully described in Subsection 602.2(a)(1), or other typical electrical wire as specified.

602.2(d) Traffic Signal Cable.

The contractor shall furnish and install traffic signal cable in contractor-installed and/or existing conduit as detailed on the plans. All aspects of the current edition of the Wisconsin Department of

Transportation Standard Specifications, Part 6 Section 655 as they pertain to the bid items within this section shall apply.

Furnish solid copper conductor traffic signal cables conforming to IMSA Specification Number 20-1. Provide wire size and number of conductors as the plan show.

Contractor shall furnish and install 10 AWG, XLP, USE rated, 600 volt AC, single conductor, stranded copper for conductors in each individual contractor-installed and/or existing conduit as detailed on the plans.

For wiring that extends from the terminal strip in each signal head to the mounting base, use an IMSA, 20-1 cable, 14 AWG 5, 7, 9 or 12 conductor as required.

602.2(e) Fiber Optic Cable and Fiber Optic Fusion Splicing.

The Contractor shall furnish and install fiber optic cable of count as specified and in State of Wisconsin Standard Specs 651, 655, 670 and 678 as shown on plans and as provided hereinafter.

The Contractor shall furnish single mode (SM), lt armored, loose-tube, count as specified fiber optic cable rated for outdoor use.

All fiber optic cable glass shall be supplied by the same manufacturer and shall be part of a fiber optic cable utilizing loose tube construction with the following properties:

Parameters	**Single Mode**
Type	Step Index
Core Diameter	8.3 μm (nominal)
Cladding Diameter	125 $\pm$ 1.0μm
Core to Cladding Offset	$\leq$ 0.8 μm
Coating Diameter	245 $\pm$ 10μm
Cladding Non-Circularity	$\leq$ 1.0%
Proof Tensile Test	0.7 GPa
Attenuation	@ 1310 nm $\leq$ 0.4 dB/km @1550 nm $\leq$ 0.3 db/km
Chromatic Dispersion Zero Dispersion	1310 $\pm$ nm (centered on a nominal operating wavelength of 1310)
Zero Dispersion Slope	$\leq$ 0.092 ps/nm^2/km
Maximum Dispersion	$\leq$ 2.8 ps/nm/km at 1285 - 1330 nm
Cut-Off Wavelength	1260 nm

The Contractor shall furnish tools, personnel and equipment needed to perform optical cable splicing by location. Tools and equipment furnished by the contractor include all cable, splice cases and trays for all splice protection sleeves and consumables related to outdoor cable splicing. Protect bare fibers with a heatshrink coating before placement in a sleeve or housing.

602.2(f) Loop Detector Lead In Wire.

The Contractor shall furnish 0.25 inch diameter, 4-conductor, #18 AWG, waterproof, shielded, polypropylene insulation cable, with HDPE outer jacket. Meeting IMSA specifications and according

to Wisconsin Department of Transportation Standard Spec 655. Provide loop detector lead in cable to be smooth on the outside without any ripples or ribbing from cable wires.

602.2(g) Loop Detector Wire.

The Contractor shall furnish and install loop detectors wires of dimensions as specified by placing before final paving or sawing in slots in final surface as shown in plans and sealing after installation completion.

The Contractor shall furnish moisture resistant, UF-B 14-3 wire to be used as loop detector wire.

Provide 2 feet of additional loop detector wire, considered incidental to this item, at the handhole and splice with lead-in cable.

For final surface cut in loops, the Contractor shall furnish and install a flowable polyester sealant designed for traffic loop detectors. The sealant shall be self-leveling, flowable to allow the sealant to cover the loop within the slot, shall be rated for exterior use, shall be applicable to concrete and asphalt applications, and shall be gray in color when in concrete and black in color when in asphalt.

602.3 Construction Methods.

602.3(a) Cable-in-Duct.

Cable-in-duct shall be installed in a trench and within the protection of Schedule 80 PVC conduit under all pavements and specified driveways, and in structures and in accordance with Subsection 602.3(c).

Cable-in-duct shall be installed within one (1) foot of the back of curb or as near as is practical to the back of curb as allowed by the engineer. It will, however, be the responsibility of the Contractor to locate all underground cable-in-duct in a manner to preclude damage to the cable or duct resulting from the subsequent construction. The wire part of the cable-in-duct assembly shall project at least two (2) feet above the top of each light base and the duct part shall extend 2” above the top of the raceway and be capped until the electrical connections are made within the light pole.

Under no circumstances shall cable ends be left uncovered or allowed to become submerged in water. Observations of either condition shall constitute sufficient grounds for rejection of the entire length of that cable.

The polyethylene duct which encases the wires shall be continuous to within six (6) inches of a terminal connection. Cable shall be installed in continuous lengths without splices from terminal to terminal. Splicing of cables will be permitted only in electrical handholes and electrical utility access structures, handholes in poles, and breakaway bases; or as otherwise provided in the plans.

The Contractor shall exercise care when installing the cable-in-duct to insure that the completed duct raceway is smooth and free of sharp bends and that the wires/cables inside the installed duct are “free” and capable of being easily removed and replaced.

Unless otherwise specified, all backfill shall be in accordance with the requirements of Section 502.1 of these Specifications. Native material will not be allowed for backfill if it is thirty (30) percent or more stones by volume. No rocks larger than four (4) inch diameter, stone aggregate, or any foreign

debris shall be backfilled, unless otherwise approved by the engineer. When sand backfill is required, a six (6) inch minimum sand padding shall be used below the conduit and a six (6) inch minimum sand lift shall be used above the conduit.

602.3(b) Electrical Conduit.

Electrical conduit, of size and type noted on the plans and/or in the Special Provisions, shall be installed in accordance with Subsection 602.3(c) at the locations specified, unless otherwise directed by the Traffic Engineer. In general, Schedule 80 PVC conduit shall be installed under commercial driveways and street pavements to provide protection for underground cable.

Each conduit run between access points to the wiring (e.g., handholes, electrical utility access structures, poles) shall be one size for its entire length. Electrical conduit shall be installed within one (1) foot of the back of curb or as near as practical to the back of curb, as allowed by the Engineer, when it is being placed parallel to the curb. It will, however, be the responsibility of the Contractor to locate all underground conduit in a manner to preclude damage to the duct resulting from subsequent construction. Where curb and gutter is being replaced, the new conduit to be installed parallel to the curb and gutter shall be placed according to the Typical Conduit Installation detail. When existing utilities preclude placing conduit as shown in the detail, the conduit shall be placed under the curb or as close to the curb as possible. When curb and gutter is not being replaced, the new conduit to be installed parallel to the curb and gutter shall be placed in the roadway, three feet from the edge of gutter, and as approved by the City Traffic Engineering Electrical Inspector.

For each conduit run in which cable will not be installed as part of the contract, the ends of the conduit shall be capped with standard conduit caps to preclude water and soil infiltration. If threaded caps are used, the threads shall be lubricated. Conduits terminating in a nonpaved location and not in a structure shall be turned up and end at terrace finish grade with a PVC cap securely attached, as shown on Standard Detail 6.13).

For each run of conduit, no more than 315° in bends unless approved by City Traffic Inspector. Label direction of conduits at each handhole, pole base and controller base. All splices between reels of polyethylene conduit and connections to steel or PVC conduit shall be made with approved watertight coupling assemblies. Standard conduit fittings shall be used and all costs for couplings and joints shall be included in the unit price bid for the conduit.

When connections are to be made to an existing conduit, the Contractor shall first verify that the existing conduit is fully clear and useable for its entire cross-section and length. When the existing conduit is found to be defective, the Contractor shall notify the Inspector and not proceed until the Inspector so directs. If the Contractor connects to an existing defective conduit without the express direction form the Inspector, the Contractor shall make any and all necessary repairs and replacements to all conduits, including conduit that was “existing” prior to the Contractor starting work, in accordance with Section 601.4. All costs of this work shall be at the expense of the Contractor.

Unless otherwise specified, all backfill shall be in accordance with the requirements of Section 502.1 of these Specifications. Native material will not be allowed for backfill if it is thirty (30) percent or more stones by volume. No rocks larger than four (4) inch diameter, stone aggregate, or any foreign debris shall be backfilled, unless otherwise approved by the engineer. When sand backfill is required, a six (6) inch minimum sand padding shall be used below the conduit and a six (6) inch minimum sand lift shall be used above the conduit.

With prior approval from the Traffic Engineer, the Contractor may substitute a larger size of conduit than that specified for a run; however, any resulting additional costs shall be borne by the Contractor and no adjustment in compensation will be made.

Conduit to be placed under existing pavements, sidewalks and driveways shall be installed by pushing, gophering, or boring.

Entering existing manholes shall be made by watertight methods.

The location of each conduit under pavement shall be marked on the pavement or curb as shown on Standard Detail 6.11 or as directed by the Traffic Engineer.

Upon completion of the work under the contract, including roadway finishing operations, the Contractor shall, in the presence of the Traffic Engineer or Inspector, make an inspection of each installed conduit. A mandrel at least six (6) inches in length and of the proper size shall be used during the inspection to insure that the conduit is fully open for its entire length. The Contractor shall furnish all required tools, equipment and labor necessary to make the inspections. Any conduit found crushed or damaged, or determined by the Traffic Engineer to be unsatisfactory, shall be replaced by the Contractor at the Contractor's expense before the work will be accepted.

602.3(c) Minimum Cover Requirement.

Conduit, duct, or other raceways shall be installed in accordance with the minimum cover requirements specified in the following table. Exceptions shall require the approval of the Traffic Engineer.

With prior approval, the required minimum cover may be reduced by six (6) inches for installations where a two (2) inch thick concrete pad, or equivalent in physical protection, is placed in the trench over the underground installation.

For the purposes of this subsection, "cover" is defined as the distance between the FINISHED grade and the TOP of the conduit, duct, or other raceway.

MINIMUM COVER REQUIREMENTS (0 TO 600 VOLTS)		
WIRING METHOD	**MINIMUM COVER (INCHES)**	
	IN TERRACE OR UNDER SIDEWALK	**ROADWAY**
Rigid Non-Metallic Conduit Approved for Direct-Burial without Concrete Encasement	30	24
Other Approved Raceways*	30	Not applicable
Within five feet of any handhole	40	Not applicable

*Note: Encased Raceways shall require a concrete envelope not less than two (2) inches thick.

602.3(d) Electrical Conductors.

The proper type, size and number of electrical conductors as shown on the plans shall be installed. Installation methods shall conform to that described in Subsection 602.3(a) and other appropriate Subsections of these Specifications.

602.3(e) Pull Wire.

Unless specified or directed by the Traffic Engineer, a pull wire shall be installed in each conduit run as part of the contract, including conduit connecting to existing conduit. The pull wire shall be a No. 10 AWG, or larger size, copper (insulated) TW wire approximately four (4) feet longer than the conduit run, and shall be stripped and spliced wire to wire in each access point.

The cost of pull wire shall be incidental to the cost of conduit unless specified otherwise on the plans and in the contract.

602.3(f) Traffic Signal Cable.

Traffic Signal Cable will be furnished by the Contractor unless specified. If the City provides the Traffic Signal Cable, following receipt of the cable by the Contractor at the Traffic Engineering Shop, 1120 Sayle Street, the Contractor shall be responsible for storage and handling and placing such cables as are specified on the plans. Signal cable not used in the project shall be returned by the Contractor to the Traffic Engineering Shop with no additional compensation for this work.

The Contractor shall install Traffic Signal Cable using acceptable trade methods and practices. When pulling cable into or out of electrical utility access structures and handholes, the Contractor shall use pulleys. The Contractor shall at all times exercise caution to protect the cable and its insulation from being damaged by sharp edges. Cable shall project at least two (2) feet above bases, except at the signal controller, where it shall project at least three (3) feet above the base. Under no circumstances shall cable ends be left uncovered or allowed to become submerged in water.

Cable shall be installed in continuous lengths without splices from terminal to terminal. Splicing of cables will be permitted only in electrical handholes and electrical utility access structures, handholes in poles, pole bases, or as otherwise provided in the plans.

602.3(g) Fiber Optic Cable and Fiber Optic Fusion Splicing.

Fiber optic cable will be furnished by the Contractor. Follow all manufacturer’s recommended installation procedures. Contact the Electrical Operations Lead Worker at the City of Madison Traffic Engineering Shop, (608) 266-4767 a minimum of seven (7) working days in advance to coordinate installing equipment in contractor installed or existing Traffic Engineering conduits & handholes.

The Contractor shall provide all personnel, tools, and equipment needed to perform optical cable splicing in an environmentally controlled vehicle or trailer designed specifically for optical cable splicing. All permanent splicing will be single strand fusion type splices and paid for by the number of splices per location.

All cable strand splicing by the Contractor will be performed using a fusion splice machine that is capable of splicing within a 0.2dB loss tolerance and equipped with either live monitoring or a Local Injection Detection (LID) testing system, thus ensuring the splice quality while the splice is set up in the machine. All splices will be protected with appropriate clear heat shrink fusion splice sleeves fitted with steel-reinforcing rod(s) provided by the Contractor to protect the fiber from scoring, dirt, accumulation, moisture intrusion, and micro bending.

The Contractor shall install the fiber optic splice enclosure according to the manufacturer's recommended guidelines and perform end-to-end splicing according to the manufacturer's instructions for the supplied splice enclosure units.

The Contractor shall perform Communication System Testing according to WisDOT Standard 678.3.4 and shall label the cable with Owner – Strand Count – Start Point – End Point.

602.3(h) Loop Detector Lead In Wire.

Loop Detector Lead In Wire will be furnished by the Contractor. Install one cable for every two loops from each loop handhole to the intersection control cabinet via the most direct route, without intermediate splicing. Contractor shall install cable for new and existing loops as detailed in plans. Verify cable needs with the City of Madison Traffic Engineering Electrical Inspector before completing intersection wiring.

602.3(i) Loop Detector Wire.

The Contractor shall furnish and install the loop detector wire from the handhole at the side of the road, around the loop detection zone, and back to the handhole at the side of the road, in one continuous non-spliced length. Each conductor shall be tied at ends to create three passes with one spare pass around the detection zone.

Each loop shall be spliced to the loop detector lead in wire with connections soldered, wire capped, and connections made water tight.

If the Contractor is unable to splice to the lead-in cable the day installing the wire, the Contractor shall seal the wire ends with tar or electrical sealant to keep water out of the insulating jacket of the wire. If water does get into the insulating jacket, remove the wire and replace with new wire, this is considered incidental to the item.

For final surface cut in loops, the contractor shall saw slots into the surface to a width no larger than 0.25 inch wide, and no deeper than 2.25 inches deep. There shall be a minimum of 1.5" of depth from the top of the detection wire to the surface of the concrete pavement. Chamfers no greater than 6-inches may be allowed to ease bending at corners.

Detector slots shall be filled with flowable polyester sealant per the manufacturer's guidance and clean any excess sealant off the surface.

602.4 Measurement and Payment.

602.4(a) Cable-in-Duct.

This item, complete in place and accepted, shall be measured in linear feet in a horizontal plane, from terminal connection to terminal connection along the center line of the trench or conduit with the terminal connection being the center line of the lighting unit base, electrical utility access structure, handhole, junction box or other terminal location as required by the plans and or specifications.

Additional lengths of cable necessary for making splices and connections at lighting units, junction boxes, distribution centers and other terminal locations shall be installed by the Contractor and considered as part of the work included in this item, but will not be measured or paid for directly.

The quantity, measured as provided above, will be paid for at the contract unit price per linear foot for cable-in-duct, which price shall be payment in full for furnishing all materials, unless otherwise indicated by the plans and Special Provisions; for trench work such as excavation, bedding and backfilling, including any sand, asphalt, concrete or other required materials, unless trench and backfill are specifically noted as separate bid items; for placing cable-in-duct; for making connections and testing installed cable systems; for disposal of surplus materials; for restoration of disturbed or damaged areas including seeding and sodding, unless general terrace restoration is required and is a separate bid item; for making inspections; and for all labor, tools, equipment and incidentals necessary to complete this item of work in accordance with the contract.

602.4(b) Electrical Conduit.

This item, complete in place and accepted, shall be measured in linear feet in a horizontal plane from terminal connection to terminal connection along the centerline of the trench or conduit, with the terminal connection being the centerline of the street light or traffic signal base, electrical utility access structure, handhole, junction box or other terminal location as required by the plans and specifications. The quantity measured for payment shall be the summation of linear feet of each size and type.

Additional lengths of conduit necessary for terminating conduit at or above grade shall be installed by the Contractor and considered as part of the work included in this item, but will not be measured or paid for directly.

The quantity, measured as provided above, will be paid for at the contract unit price per linear foot of each of the specified sizes and types, which price shall be payment in full for furnishing, hauling and placing the conduit, hangers, clips, fittings, and attachments; for trench work, such as excavation, bedding and backfilling, including any sand, asphalt, concrete or other required materials, unless trench and backfill are specifically noted as separate bid items; for furnishing and installing pull wire as required by Subsection 602.3(e); for drilling holes in manholes and resealing such openings after the conduit is installed; for disposal of surplus materials; for restoration of disturbed or damaged areas including seeding and sodding, unless general terrace restoration is required and is a separate bid item; for making inspections; and for all labor, tools, equipment and incidentals necessary to complete this item of work in accordance with the contract.

The quantity of conduit installed by pushing, gophering, or boring, measured as provided above, will be paid for at the contract unit price per linear foot of each of the specified sizes, which price shall be payment in full for furnishing, hauling and placing the conduit and fittings; for securing all necessary permits; for all necessary excavation, bedding and backfilling, including any sand, concrete or other required materials; for restoration of disturbed or damaged area including seeding and sodding, unless general terrace restoration is required and is a separate bid item; for disposal of surplus materials; for making inspections; and for furnishing all labor, tools, equipment and incidentals necessary to complete the work. Item 60241, Gopher Raceway, shall include any and all work associated with determining locations of existing utilities, such as underground locates. Item 60241 shall include raceways created by pushing, gophering or boring. The measured quantity will only include distances installed directly underneath curb and gutter, roadway, and sidewalk sections that are not removed or constructed with this project. Minor alterations in conduit location may be made by the City Traffic Engineering Electrical Inspector to avoid gopher installation.

602.4(c) Electrical Conductors and Traffic Signal Cable.

This item, complete in place and accepted, shall be measured in linear feet in a horizontal plane, from terminal connection to terminal connection along the center line of the trench or conduit with the terminal connection being the center line of the signal or light base, electrical utility access structure, handhole, junction box or other terminal location as required by the plans and/or specifications.

Additional lengths of cable or conductors necessary for making splices and connections at signal bases and other terminal locations shall be installed by the Contractor and considered as part of the work included in this item, but will not be measured or paid for directly.

The quantity of cable installed, measured as provided above, will be paid for at the contract unit price per linear foot, which price shall be payment in full for furnishing, storing, handling, transporting, and installing; for furnishing all labor, tools, equipment and incidentals necessary to complete this item of work.

602.4(d) Fiber Optic Cable and Fiber Optic Fusion Splicing.

Fiber Optic Cable, complete in place and accepted, shall be measured in linear feet in a horizontal plane, from terminal connection to terminal connection along the center line of the trench or conduit with the terminal connection being the center line of the signal or light base, electrical utility access structure, handhole, junction box or other terminal location, including length of additional slack as required by the plans and/or specifications.

Additional lengths of cable or conductors necessary for making splices and connections at signal bases and other terminal locations shall be installed by the Contractor and considered as part of the work included in this item, but will not be measured or paid for directly.

The quantity of cable installed, measured as provided above, will be paid for at the contract unit price per linear foot, which price shall be payment in full for all work, materials and incidentals required to furnish and install Fiber Optic Cable with specified count.

Fiber Optic Fusion Splicing, complete in place and accepted, shall be measured as a unit, each, fused single strand.

The quantity of single strand fusion splices, will be paid for at the contract unit price, per the amount of splices per location, which price shall be payment in full for all work, materials, equipment and incidentals required to complete Fiber Optic Fusion Splicing.

602.4(e) Loop Detector Lead In Wire.

This item, complete in place and accepted, shall be measured in the linear feet in a horizontal plane, from the splice with the loop lead in wire along the centerline of the conduit to its connection with terminals in the control cabinet.

The quantity of wire installed, measured as provided above, will be paid for at the contract unit price per linear foot, which price shall be payment in full for all work, materials, equipment and incidentals required to furnish and install Loop Detector Lead In Wire.

602.4(f) Loop Detector Wire.

This item, complete in place and accepted, shall be measured in linear feet in a horizontal plane, from the handhole at the side of the road, around the loop detection zone, and back to the handhole at the side of the road.

The Contractor shall install additional lengths of wire necessary and as described. Additional lengths of wire, including the two feet of additional loop detector wire at the handhole and splice with lead-in cable, are considered part of the work included in this item and will not be measured or paid for directly.

The quantity of wire installed, measured as provided above, will be paid for at the contract unit price per linear foot, which price shall be full compensation for all work, materials, equipment and incidentals required to furnish and install Loop Detector Wires.

602.5 Electrical Trench.

602.5(a) Construction Methods.

This item consists of excavating, bedding, and backfilling a trench in roadways and terraces for electrical conduit installation. The width of the trench shall be sufficient to accommodate the conduit installations shown on the plan without stacking the conduits. The trench shall be excavated true to line and to provide a 30 inch depth for conduit, except as otherwise authorized by the Engineer in the field. Backfill shall be carefully and adequately compacted in place. In most cases, the surface restoration will be provided as a part of the general roadway contract work.

Unless otherwise specified, all backfill shall be in accordance with the requirements of Section 502.1 of these Specifications. Native material will not be allowed for backfill if it is thirty (30) percent or more stones by volume. No rocks larger than four (4) inch diameter, stone aggregate, or any foreign debris shall be backfilled, unless otherwise approved by the engineer. When sand backfill is required, a six (6) inch minimum sand padding shall be used below the conduit and a six (6) inch minimum sand lift shall be used above the conduit.

602.5(b) Method of Measurement.

Electrical trench, complete and accepted, shall be measured by length in linear feet, in a horizontal plane along the center line of the trench.

602.5(c) Basis of Payment.

The quantity of trench, measured as provided above, will be paid for at the contract unit price per linear foot, or as part of conduit or cable-in-duct installation if a separate bid item for electrical trench is not provided, which price shall be payment in full for excavating, bedding, and backfilling, including any select fill as required in Article 202 of these Specifications, including sand or other required materials; for surface restoration with topsoil and seed; for disposal of surplus materials; for making inspections; and for furnishing all materials; labor, tools, equipment, and incidentals necessary to complete the work.

ARTICLE 603 - REMOVAL OF AERIAL DISTRIBUTION SYSTEMS

603.1 General.

This item consists of removing an existing aerial electrical distribution system for street lighting in accordance with these Specifications, the Special Provisions, and the details shown on the plans.

603.2 Construction Methods.

The Contractor shall remove existing aerial cable in such a manner as to maintain service to existing street lights. The Contractor shall remove existing aerial cable and its appurtenances from existing street light standards as noted on the plans and/or in the Special Provisions. Rewiring of the street light standard, if required, shall be performed in accordance with Article 605 of these Specifications.

603.3 Measurement and Payment.

This item shall be measured as a lump sum, with aerial cable and its appurtenances completely removed from existing lighting standards and with all lighting systems outside of the project area remaining in operation.

This item, measured as provided above, will be paid for as a lump sum, which price shall be payment in full for disposal of surplus materials and for all labor, tools, equipment, and incidentals necessary to complete this item of work in accordance with the contract.

ARTICLE 604 - BASES FOR STREET LIGHTING UNITS AND TRAFFIC SIGNAL STANDARDS AND CONTROLLERS

604.1 General.

This item consists of constructing concrete bases with the necessary hardware for traffic signal standards, controllers, and street lighting units in accordance with these Specifications, the applicable Standard Plate for the base involved, the Special Provisions, and the details shown on the plans.

604.2 Materials.

All requirements specified in Article 301 - Concrete and Concrete Materials, regarding mix design, high-early strength concrete, testing, materials, mixing, placing, curing, and protecting the concrete, shall apply to the concrete used in the construction of said bases.

604.3 Construction Methods.

Where bases are to be installed within existing sidewalks or improved terraces, the Contractor shall remove and replace the entire stone of sidewalk or improved terrace affected by the installation unless otherwise specified or directed by the Traffic Engineer.

The general locations of the bases are shown on the plans. The exact locations and elevations shall be established in the field by the Traffic Engineer. Unless otherwise specified, bases shall be placed with one side parallel to the center line of the street and the center of the base shall be four (4) feet from the face of the curb. The elevations of the bases shall be as shown on the applicable Standard Plate unless otherwise specified.

Forms shall be placed with sufficient depth to provide a minimum of twelve (12) inches of formed base below the finished grade on the low side of the base. The top surface of the base shall be level, with a three-fourths (3/4) inch bevel on the edges, and given a float finish.

A five-eighths (5/8) inch by eight (8) foot copper-weld ground rod shall be cast into each base. The ground rod shall extend a minimum of seven (7) feet below the bottom of the base and shall be connected with a No. 4 stranded copper wire and approved connector to one anchor bolt. The No. 4 stranded copper wire shall be of sufficient length to protrude three (3) feet above the top of the base for the Contractor to connect the wire to the ground lug in the pole or metal base.

City-furnished anchor bolts shall be cast into the base. These bolts shall be placed in accordance with the base detail and other directions furnished by the City as to location and projection above the top of the base, and shall be true vertical. All anchor bolts 1” diameter and larger shall be placed in the form before concrete is poured. The bolts shall be secured by tack welding or wiring horizontal rebar to the bolts to form an anchor bolt cage. The horizontal rebar shall be placed 18” from the top and 12” from the bottom of the bolts.

The Contractor shall furnish and install a minimum of two manufactured elbows in all bases and more where specified. The contractor shall install the elbows to permit cable entrance from the street side of, or along the line of, the poles, as shown on the plans. Manufactured galvanized steel elbows with grounding bushings shall be furnished and installed in those bases where galvanized steel conduit is used, as shown on the plans. Existing conduit shall be extended into the bases. The conduit extending above the concrete base shall be centered.

Unless otherwise specified, all backfill shall be in accordance with the requirements of Section 503.2 of these Specifications.

604.4 Measurement and Payment.

These items shall be measured as units, complete in place and accepted in accordance with the contract.

These items, measured as provided above, will be paid for at the contract unit price for each of the various types of bases, which price shall be payment in full for furnishing and installing reinforcing rods, conduit elbows, clamps, ground rods, and copper wire; for picking up and installing anchor bolts; for furnishing and placing concrete masonry; for excavation, backfill, and disposal of surplus materials; and for all labor, tools, equipment and incidentals necessary to complete these items of work.

604.5 Removal of Existing Street Light Pole, Traffic Signal Poles and Cabinets, and Miscellaneous Electrical Bases and Abandoning Handholes and Electrical Utility Access Structures.

604.5(a) Description.

This work shall consist of removing, wholly or in part, street light bases, poles, arms and fixtures and concrete bases for fire alarm pedestals, traffic signal poles and traffic signal cabinets; and abandoning handholes and electrical utility access structures.

604.5(b) Construction Methods.

The Contractor shall remove those street light pole (poles, arms, metal base, and fixtures), traffic signal pole (including metal base and other attachments), traffic signal cabinet, and other miscellaneous electrical bases, and shall abandon handholes and electrical utility access structures as identified on the plan or by the Engineer. All street light poles, metal base, arms, fixtures, traffic signal poles, traffic signal cabinets, and all handhole and electrical utility access structure frames and covers removed by the Contractor, shall be delivered to the Traffic Operations Shop, 1120 Sayle Street, unless designated by the Engineer to be reinstalled in the project area or not returned to the City. The Contractor shall dispose of old concrete bases at a site provided by the Contractor.

Abandon Electrical Utility Access Structures (also known as manholes), shall consist of the following:

1. Removing the concrete roof and the top three feet of walls.
2. Breaking the floor to promote drainage; the maximum unbroken floor size shall be two-foot by two-foot.
3. Backfill and compact with sand fill.
4. Remove and return the steel frame and cover to TE Shop, 1120 Sayle Street.

604.5(c) Method of Measurement.

Removing street light pole, traffic signal pole, traffic signal cabinet, and miscellaneous electrical bases and abandoning handholes and electrical utility access structures will be measured as units. A traffic signal control cabinet base shall be considered a traffic signal base for measurement.

604.5(d) Basis of Payment.

The contract unit price for removal of street light pole shall be payment in full for removing the fixture, arm, metal base, and pole; and transporting/storing/disposing of materials as previously provided in these Specifications; and for furnishing all labor, tools, equipment, and incidentals necessary to complete the work. The Contractor shall be responsible for any damage to the street light fixtures, metal bases, and poles during removal, reinstallation and return.

The contract unit price for removal of traffic signal pole and traffic signal cabinet shall be payment in full for removing the equipment and transporting/storing/disposing of the materials as previously provided in these Specifications; and for furnishing all labor, tools, equipment, and incidentals necessary to complete the work. The Contractor shall be responsible for any damage to the existing equipment during removal, reinstallation, and return.

The contract unit price for miscellaneous electrical base removal shall be payment in full for removing and disposing of the bases as provided in the Specifications; and for furnishing all labor, tools, equipment, and incidentals necessary to complete the work.

The contract unit price for abandoning handholes and electrical utility access structures shall be payment in full for removal and return of the frame and cover, as provided in these Specifications; for backfilling the handhole or electrical utility access structure to be abandoned; and for furnishing all labor, tools, equipment, and incidentals necessary to complete the work.

604.6 Auger Street Light Base.

604.6(a) Description.

The work under this item shall consist of augering one or two holes in a concrete street light base to provide a raceway for designated duct in and out of the base.

604.6(b) Method of Measurement.

Auger Street Light Base will be measured by the number of bases so augered.

604.6(c) Basis of Payment.

The contract unit price for Auger Street Light Base shall be payment in full for providing necessary entrance and exit for designated ducts at existing street light bases and for furnishing all labor, tools, equipment and incidentals necessary to complete the work.

604.7 Base for Multi Space Parking Meters.

604.7(a) Description.

This item consists of picking up and installing city provided steel bases for multi space parking meters in accordance with these Specifications, the Special Provisions, and the Standard Detail shown on the plans.

604.7(b) Materials.

All requirements specified in Article 301 - Concrete and Concrete Materials, regarding mix design, high-early strength concrete, testing, materials, mixing, placing, curing, and protecting the concrete, shall apply to the concrete used in the construction of said concrete slab around said bases.

604.7(c) Construction Methods.

Where bases are to be installed within existing sidewalks or improved terraces, the Contractor shall remove and replace the entire stone of sidewalk or improved terrace affected by the installation unless otherwise specified or directed by the Engineer.

The general locations of the bases are shown on the plans. The exact locations and elevations shall be established in the field by the Parking Utility Maintenance Supervisor (Dan Valenza, 266-4744). Unless otherwise specified, bases shall be placed with one side parallel to the center line of the adjacent sidewalk and the center of the base shall be four (4) feet from the face of the curb. The elevations of the bases shall be as shown on the detail unless otherwise specified.

The city-furnished steel base shall be cast into the concrete sidewalk slab. The top of the steel base shall be level, with a minimum depth of two inches below the finished slab grade. Aggregate shall be compacted around the base to ensure that the base does not rock. The parking Utility will provide a reusable 13” X 20” wooden form attached to the top of the base. A representative from the Parking Utility or a designee from Traffic Engineering must approve the installation before the concrete pour. Contact the Parking Utility Maintenance Supervisor (Dan Valenza, 266-4744) 48 hours in advance prior to the concrete pour to set up a time for approval.

The concrete must be vibrated on the two open ends of the base and through the six 2.25” openings on the sides. Any bases that have insufficient compaction of aggregate or insufficient penetration of concrete into the base leading to the base rocking once a multi space meter is installed shall be removed and replaced at contractor’s expense, including replacement of the entire concrete slab.

No concrete shall be allowed to extend over the top surface of the steel base.

The contractor shall install conduit as shown in the plan. Conduit shall extend three inches above the top of the steel base plate.

Unless otherwise specified, all backfill shall be in accordance with the requirements of Section 503.2 of these Specifications.

604.7(d) Measurement and Payment.

This item shall be measured as units, complete in place and accepted in accordance with the contract.

This item, measured as provided above, will be paid for at the contract unit price for each base, which price shall be payment in full for picking up and installing the city provided steel plate in the concrete slab and placing the concrete slab; for excavation, backfill, and disposal of surplus materials; and for all labor, tools, equipment and incidentals necessary to complete these items of work.

ARTICLE 605 - INSTALLATION OF STREET LIGHTING UNITS

605.1 General.

This item consists of installing luminaires, lamps, and metal or precast concrete poles as complete street lighting units in accordance with the Plans, these Specifications and the Special Provisions.

Lighting units shall be grouped to operate from branch circuits which are energized by lighting contactors remotely controlled by photocell. Where a system is employed, no individual lighting units shall be controlled by photocells or time switches. Time switches control only the removal from service of the midnight circuit.

Each system shall be wired in a manner that presents as near as is possible a balanced load at the source of supply during midnight operation and all-night operation and all splices are located in handholes.

605.2 Construction Methods.

605.2(a) General.

Conductors to each luminaire from the bottom of the pole shall be two No. 14 solid annealed copper, UF, 600 volt, as manufactured by General Cable, Anaconda, Rome, Kaiser, or approved equal. On all systems, the phase wire at the pole handhole shall have a secondary in-line fuse assembly, Series 64, as manufactured by Elastic Stop Nut Corporation of America, Buss Tron HEB-AA fuseholder, or approved equal, with a Bussmantype FNM or FNQ fuse of the required size (refer to the following table).

REQUIRED SIZE - IN-LINE SECONDARY FUSES					
VOLTAGE	LUMINAIRE WATTAGE				
	400W	250W	200W	150W	100W or less
480V	2 amp	2 amp	2 amp	2 amp	2 amp
240V	5 amp	3.2 amp	2 amp	2 amp	2 amp
120V	6.25 amp	5 amp	5 amp	3.2 amp	2 amp

The phase wire shall not be spliced between the fuse assembly and luminaire. A sufficient length of No. 12 conductor shall be installed in the pole to permit removal of this fuse-holder through the handhole before disconnecting.

A 24” length of #12 THHN Stranded Conductor tail shall be installed to supply wires permitting easy removal of fixture wires and fuse holder through the handhole. The following color coding shall be used at all street light bases: Midnight Circuit (red), all night circuit (black), and neutral (white). Electrical splices and connections shall be electrically secure and made with pressure or compression fittings as manufactured by Thomas & Betts, Burndy, 3-M (scotch lock brand) or approved equal and used as recommended by the engineer. Taps and splices shall be protected in the following manner: all wire connections shall be coated with No-Lox Compound; taps and splices made with irregularly shaped connectors shall first be built up with insulating material, “Air Seal” #18415 manufactured by Kearney or approved equal; all sharp corners and voids shall be filled; over this, install 3 half lapped layers of rubber electrical tape, dielectric strength, 300 volts per mil - self vulcanizing tape, installed as per manufacturer’s instructions; over this, apply 3 half lapped layers Scotch Brand 33 Plus or approved equal, vinyl plastic electrical tape; then dip the entire splice 1” beyond the insulating

material in Scotch-Kote or approved equal. The constructed splice shall be allowed to air dry completely before insertion into the street light pole. All wires leaving the splice shall be in one direction. Split bolts, when used, shall be hammered and retightened three times and a spacer shall be provided between any copper and aluminum conductors. The fuse holder shall be connected to the All-Night circuit or Midnight circuit as indicated on the plans with an approved wire nut (3M or Ideal). The wire nut shall be dipped in Scotch-Kote or approved equal.

The lighting units shall be connected with the underground or overhead cable, as is applicable, and shall provide a complete, operational system when finished.

605.2(b) Metal Pole.

Metal poles shall be set and plumbed with the use of leveling nuts furnished with the anchor bolts. Luminaires shall be leveled after erecting and leveling the metal standards with bracket arms. The proper leveling method may be obtained from the manufacturer's instruction manual. Nuts on anchor and transformer bolts shall be torqued to 175-200 foot pounds or as directed by the Engineer. Rust, corrosion, and anti-seize protection shall be provided at all threaded assemblies by coating and mating surfaces with Markal (Hightemp-E-Z Break), Never-Seez (Marine Grade), LPS 100, Lubriplate, or approved equal.

The stranded copper ground wire that is installed as a part of base construction shall be attached with an approved connector (Fargo GC 202 or approved equal) to a ground nut located inside the pole and opposite the handhole.

Grout shall be troweled between the pole and concrete base and finished at an angle from the edge of the pole base to the outer edge of the foundation. A 1/2 inch slot for drainage shall be left through the grouting on the street side at the top of the concrete base. The grout shall be Patch-crete (manufactured by Ready-Crete of Milwaukee, Wisconsin) or approved equal.

605.2(c) Precast Concrete Butt-Base Pole.

The Contractor shall install the pole in an augered or hand-dug hole and shall tamp the pole securely in a plumb position using six (6) inch lifts of select salvage material. When debris is present in the salvage material to such an extent that in the Traffic Engineer's opinion good compaction cannot be obtained, material specified by the Traffic Engineer shall be used as fill.

If a bracket-arm type of installation is required, the luminaire shall be leveled after the pole has been securely tamped in a plumb position.

The Contractor is responsible for maintaining the pole in a plumb position until the project is accepted by the Common Council.

A typical detail of City-furnished precast concrete butt-base poles is shown on Standard Plate 6.05.

605.3 Measurement and Payment.

This item shall be measured as units in place, completely installed and accepted in accordance with the contract.

This item, measured as provided above, will be paid for at the contract unit price, which price shall be payment in full for picking up and installing City-furnished material including transformer or breakaway bases and devices; for furnishing and installing fuses, wire and all miscellaneous hardware necessary to integrate the components into a single unit connected to the feeder system; and for all labor, tools, equipment and incidentals necessary to complete this item of work.

ARTICLE 606 - INSTALLATION OF METERED OR UNMETERED ELECTRIC SERVICE

606.1 General.

This work consists of installing metered or unmetered electric service in accordance with the Special Provisions, these Specifications, the applicable Standard Plates, and the details shown on the plans.

606.2 Construction Methods.

The Contractor shall install a City-furnished pre-wired control cabinet on the pole or base specified and, unless specified otherwise, install a City-furnished photoelectric cell on the luminaire closest to the control cabinet.

The Contractor shall install a two (2) inch conduit or base elbow when applicable for the electric utility to install an underground service as shown on the Standard Plate.

The Contractor shall install two 5/8” x 8’ copper ground rods, with six (6) foot minimum horizontal spacing, connecting them with a No. 4 copper wire using ground clamps. Ground rods and connection wire shall have thirty (30) inch minimum ground cover. No. 4 wire shall be continuous and extend up the outside of two (2) inch G.S. conduit to control panel and connect to the ground buss on the main disconnect.

Wiring of the photoelectric cell shall be internal for a steel or precast concrete pole and within a Contractor-furnished and installed metal conduit for a wood pole installation. The wiring shall be done with 3 conductor No. 14 UF cable.

The Contractor shall obtain the electrical permits necessary for this work from the Building Inspection and Rehabilitation Unit of the City Department of Planning and Development.

606.3 Measurement and Payment.

This item shall be measured by the unit complete and operational in place and accepted in accordance with the contract.

This item, measured as provided above, will be paid for at the contract unit price, which price shall be payment in full for furnishing wire, ground rods, ground clamps, and galvanized steel conduit; for picking up and installing the City-furnished control cabinet and photoelectric cell; and for all labor, tools, equipment and incidentals necessary to complete this item of work.

ARTICLE 607 - ELECTRICAL UTILITY ACCESS STRUCTURES, ELECTRICAL HANDHOLES AND BOX-OUTS

607.1 General.

This work consists of constructing electrical utility access structures, electrical handholes and box-outs in accordance with details shown on the plans and in accordance with these Specifications and the applicable Standard Plate for the structure involved.

All materials used in construction of electrical utility access structures, electrical handholes and box-outs shall conform to the requirements for the various types of materials contained in these Specifications.

Electrical Handhole, Type I shall be gray colored polymer concrete construction. Box dimensions for Type I shall be 19” wide X 32” long X 24” deep and come with a cover rated to withstand 15,000 lbs over a 10” square with a minimum test load of 22,568 lbs. Electrical Handhole, Type III, shall be 12” x 12” x 12”. The box and cover shall be rated to withstand 20,000 lbs. Electrical Handhole, Type V, shall be gray colored polymer concrete construction. Box dimensions shall be 26” wide by 38” long by 24” deep. The box and cover shall be rated at 15,000 lbs over a 10” square with a minimum test load of 22,568 lbs. Type VII, shall be gray colored polymer concrete construction and shall have a split lid. Box dimensions shall be 30” wide by 48” long by 36” deep. The box and cover shall be rated at 15,000 lbs over a 10” square with a minimum test load of 22,568 lbs.

607.2 Construction Methods.

Unless otherwise specified, all backfill shall be in accordance with the requirements of Section 502.1 of these Specifications.

607.3 Measurement and Payment.

These items shall be measured as units complete in place and accepted in accordance with the contract.

These items, measured as provided above, will be paid for at the contract unit price for each, which price shall be payment in full for furnishing and installing all materials necessary to complete the installation, including excavation, backfill and disposal of surplus materials; and for all labor, tools, equipment and incidentals necessary to complete these items of work.

ARTICLE 608 - PAVEMENT MARKINGS

608.1 Description.

This section describes the furnishing and applying, or removing, of pavement markings.

608.2 General Requirements.

All aspects of the current edition of the Wisconsin Department of Transportation Standard Specifications, Part 6 Section 646 & Section 647 as they pertain to the bid items within this section, except for the materials, construction methods, performance requirements, method of measurement, and basis of payment described in the following sections, shall apply.

Acceptable performance of pavement markings will be evaluated during the proving period in sections. Each solid line, double line, or dotted line, measured through 600 foot length will be considered a section. Intersection markings including solid lines, groupings of diagonal lines, stop lines, crosswalks, median nose, symbols, and words or miscellaneous markings including parking stalls will be evaluated separately as a section.

608.3 Materials.

608.3(a) Skid/Slip Resistant Preformed Thermoplastic Pavement Marking.

General

Preformed thermoplastic pavement marking to be produced of the materials and by methods described below as manufactured by Ennis-Flint or approved equal.

The marking material must be produced in the United States, and the manufacturer must be ISO 9001:2008 certified for design, development and manufacturing of preformed thermoplastic pavement markings, and provide proof of current certification.

The material shall be capable of being applied on bituminous and/or Portland cement concrete pavements by the use of a handheld heat torch, and/or infrared heater without preheating the surface.

The material shall be capable of being applied in temperatures down to 45ºF (7.2ºC) without any special storage, preheating or treatment of the material before application.

The material must be a preformed thermoplastic product which contains a minimum of thirty percent (30%) intermixed anti-skid/anti-slip elements with a hardness range of 7-9 (Mohs scale), and where the top surface contains anti-skid/anti-slip elements with a hardness of 9 (Mohs scale).

Material shall be composed of an ester-modified rosin impervious to degradation by motor fuels, lubricants, etc., in conjunction with aggregates, pigments, binders, and anti-skid/anti-slip elements uniformly distributed throughout the material. The thermoplastic material shall conform to AASHTO designation M249, with the exception of the relevant differences due to the material being supplied in a preformed state, being non-reflective, and being of a color different from white or yellow.

Pigment Color

The bike lane green color shall be manufactured with appropriate pigment to ensure that the resulting colors complies with the Light Green color as specified in the FHWA Memorandum dated April 15th, 2011: Interim Approval for Optional Use of Green Colored Pavement for Bike Lanes (IA-14).

The red color shall be manufactured with appropriate pigment to ensure that the resulting colors complies with the color as specified in the FHWA Memorandum dated December 4, 2019: Interim Approval for Optional Use of Red-Colored Pavement for Transit Lanes (IA-22).

The pigment system must not contain heavy metals or any carcinogen, as defined in 29 CFR 1910.1200 in amounts exceeding permissible limits as specified in relevant Federal Regulations.

Heating Indicators

The top surface of the material shall have regularly spaced indents. The closing of these indents during application shall act as a visual cue that the material has reached a molten state, allowing for satisfactory adhesion and proper embedment of the anti-skid/anti-slip elements, and a post-application visual cue that proper application procedures have been followed.

Skid Resistance

The surface of the preformed thermoplastic material shall contain factory applied anti-skid elements with a minimum hardness of 9 (Mohs scale). Upon application, the material shall provide a minimum skid resistance value of 60 BPN when tested according to ASTM E 303.

Slip Resistance

The surface of the preformed thermoplastic material shall contain factory applied anti-skid elements with a minimum hardness of 9 (Mohs scale). Upon application the material shall provide a minimum static coefficient of friction of 0.6 when tested according to ASTM C 1028 (wet and dry), and a minimum static coefficient of friction of 0.6 when tested according to ASTM D 2047.

Thickness

The material must be supplied at a minimum thickness of 90 mils (2.29 mm) or 125 mils (3.15 mm).

Environmental Resistance

The material shall be resistant to deterioration due to exposure to sunlight, water, salt or adverse weather conditions and impervious to oil and gasoline.

608.4 Construction Methods.

608.4(a) Skid/Slip Resistant Preformed Thermoplastic Pavement Marking.

Install preformed thermoplastic pavement marking in accordance with manufactures specifications.

608.4(b) Black Epoxy.

Apply black epoxy in a grooved slot with a matte finish directly after the white marking. Apply epoxy at a wet mil thickness of 20. Apply black aggregate at a rate of 10 pounds per gallon of epoxy. Do not apply glass beads to black epoxy.

608.5 Performance Requirements.

608.5(a) Skid/Slip Resistant Preformed Thermoplastic Pavement Marking.

Preformed thermoplastic pavement marking shall be installed per plans and specification. The Engineer will notify the Contractor within 48 hours of installation regarding any pavement marking not installed to specification or to the satisfaction of the Engineer. Non-conforming preformed thermoplastic pavement marking shall be removed at no charge to the City and replaced with a conforming product.

608.6 Method of Measurement.

608.6(a) Median Nose.

Shall be measured by the square foot of material applied.

608.6(b) Double Line, 4-Inch.

Shall be measured per linear foot of two (2) 4” lines of material applied/removed.

608.6(c) Bike Lane & Straight Arrow.

Shall be combined and measured as a unit of each.

608.6(d) Removals.

Removal of lines shall be measured per linear foot and width of material removed.

608.6(e) Thermoplastic Pavement Marking 6-inch White Retroreflective Line.

Shall be measured per linear foot (LF).

608.3(f) Thermoplastic Pavement Marking, Bike Lane Green & Red Transit Lane.

Shall be measured by the square foot (SF).

608.7 Basis of Payment.

608.7(a) Thermoplastic Pavement Marking 6-inch White Retroreflective Line.

Payment for this work, measured as provided above, will be made under at the contract unit price per linear foot (LF) of 6-inch preformed thermoplastic white retroreflective line, which shall be full compensation for all work, materials, labor, and incidentals required to complete the work as specified, including any re-application or repair required under the performance requirements as provided herein.

608.7(b) Thermoplastic Pavement Marking, Bike Lane Green & Red Transit Lane.

Payment for this work, measured as provided above, will be made under at the contract unit price per each square foot (SF) of preformed thermoplastic pavement marking bike lane green and performed thermoplastic pavement marking red transit lane, which shall be full compensation for all work, materials, labor, and incidentals required to complete the work as specified, including any re-application or repair required under the performance requirements as provided herein.

ARTICLE 609 - TEMPORARY PAVEMENT MARKINGS.

609.1 Description.

This section describes the furnishing and applying, or removing, of temporary pavement markings.

609.2 General Requirements.

All aspects of the current edition of the Wisconsin Department of Transportation Standard Specifications, Part 6 Section 649 as they pertain to the bid items within this section shall apply.

ARTICLE 610 - SUPPORT STRUCTURES AND AERIAL CABLE FOR TEMPORARY STREET LIGHTS.

610.1 Description.

This section describes the furnishing, installing, maintaining, relocating and removing wood poles, guy wires, luminaries, arms, aerial cable and splice connectors required to maintain 100% of the existing lighting system. The City will remove the existing street light poles after temporary lighting has been installed (and is operational) by the Contractor.

Work for temporary wood poles and guy wires shall be according to State of Wisconsin Standard Spec 661.

The contractor shall keep streetlights in operation throughout the construction project until new lights are installed and operational.

610.2 Materials.

610.2(a) Support Structures for Temporary Street Lights.

Furnish and install Type 4 wood poles, 35’ long and 8’ arm. Luminaries shall be 150 watt LED or equivalent lumen output unless detailed otherwise in plans, full cutoff.

Protect any cable that extends from grade to 10 feet above grade by a plastic cable guard.

610.2(b) Aerial Cable for Temporary Street Lights.

Furnish aerial cable consisting of an assembly of three No. 4 XLP insulated power conductors with an ACSR messenger (grounding) wire and mounting hardware. Provide the quantity of parallel cable assemblies necessary to maintain lighting circuits within the project area.

610.3 Construction Methods.

The Contractor shall maintain existing, temporary and proposed lighting within the construction limits for the duration of the project. Also maintain existing lighting circuits which power lighting poles outside of the construction limits. Maintenance includes but is not limited to replacement of burned out lamps, replacement of knocked down poles, relocation of poles in conflict with construction and maintaining continuous lighting.

The Contractor shall keep streetlights in operation throughout the construction project until new lights are installed and operational.

Provide off-hours contact name(s) and phone number(s) for the city and police department for repair purposes and be able to respond within 2 hours to the project site for knockdowns or other work that must be completed in a timely manner. All other maintenance needs shall be completed within 24 hours of notification. It is also the Contractor’s responsibility to continuously monitor the lighting systems operation.

610.4 Measurement and Payment.

610.4(a) Support Structures for Temporary Street Lights.

This item, complete in place and accepted, shall be measured as a unit, each, installed.

The quantity of Support Structures for Temporary Street Lights, measured as provided above, will be paid for at the contract unit price, which price shall be payment in full for all work, materials, equipment and incidentals required to furnish, maintain, relocate, install and remove Support Structures for Temporary Street Lights.

610.4(b) Aerial Cable for Temporary Street Lights.

This item, complete in place and accepted, shall be measured in linear feet in a horizontal plane.

The quantity of Aerial Cable for Temporary Street Lights installed, measured as provided above, will be paid for at the contract unit price per linear foot, which price shall be payment in full for all work, materials, equipment and incidentals required to furnish, maintain, relocate, install and remove Aerial Cable for Temporary Street Lights.

ARTICLE 611 - TRAFFIC SIGNAL CONTROLLER CABINET.

611.1 Description.

This section describes furnishing a fully configured and equipped, sixteen channel (minimum), NEMA TS2 Type 1 Traffic Signal Controller Cabinet for testing by the City of Madison (1120 Sayle Street) and subsequent installation by the contractor. The traffic signal control cabinet provided shall be capable of operating the intersections as shown in the plans.

611.2 Materials.

611.2(a) Cabinet Design

Furnish a door-in-door ground mounted (without anchor bolts) aluminum cabinet of clean-cut design and appearance. Provide a cabinet of minimum size 44 inches wide, minimum 24 inches deep and minimum 52 inches to maximum 60 inches high. The size of the cabinet shall provide ample space for housing the controller, all of the associated devices which are to be furnished with the controller, all other auxiliary devices herein specified, and all equipment to be furnished and installed by others.

Provide cabinets designed for TS2 Type 1 operation. Pre-wire cabinets for a minimum of sixteen phases as specified herein. Provide a second harness ready for communication between the cabinet itself and a NEMA TS2 Type 2 Traffic Signal Controller. TS2 Type 2 harness should be easily connected without having to drop the back panel or modify the wiring on the power panel.

The cabinet shall comply with the environmental and operating standards outlined in the NEMA TS2 Standard. The cabinet shall provide reasonable vandalism protection. The cabinet shall have a NEMA 3R rating.

Construct the cabinet from type 5052-H32 aluminum with a minimum thickness of 0.125 inches. Furnish the cabinet with a natural, uncoated, aluminum finish inside and outside. Continuously weld all seams. The surface shall be smooth, free of marks and scratches. Use stainless steel for all external hardware.

On the top of the cabinet, incorporate a 1-inch slope toward the rear to prevent rain accumulation. Incorporate a rain channel into the design of the main door opening to prevent liquids from entering the enclosure.

Include an exhaust plenum with a vent screen into the roof of the cabinet. Perforations in the vent screen shall not exceed 0.125 inches in diameter. Insulate the remaining area of the roof of the cabinet with a moisture resistant rigid foam board insulation with a minimum R value of 4.0 that can be perforated for an antenna.

Equip the lower section of the cabinet door with a louvered air entrance. The air inlet shall be large enough to allow sufficient air flow per the rated fan capacity. Louvers must satisfy the NEMA rod entry test for Type 3R ventilated enclosures. Secure a washable, aluminum, removable air filter to the air entrance. The filter shall fit snugly against the cabinet door wall. Attach an aluminum, easily removable, gasketed cover over the air filter and louver.

Provide arc flash protection within the cabinet as needed to satisfy NFPA 70E and OSHA requirements.

611.2(b) Doors

The cabinet door opening shall be a minimum of 80 percent of the front surface of the cabinet. The main door and police door-in-door shall each close against a weatherproof and dust-proof, closed-cell neoprene gasket seal. The gasket material for the main door shall be a minimum of 0.188 inches thick by 1.00 inch wide. The gasket material for the police door shall be a minimum of 0.188 inches thick by 0.500 inches wide. Permanently bond the gaskets to the cabinet.

Equip the main door with a three-point latching mechanism. The upper and lower locking points of the latching mechanism shall each have a pair of nylon rollers. The handle on the main door shall utilize a shank of stainless steel 3/4 inches minimum diameter. The handle shall include a hasp for the attachment of an optional padlock. The cabinet door handle may turn either clockwise or counterclockwise to open, and shall not extend outwards past the edge of the door at any time. Position the lock assembly so the key will not cause any interference with the handle, or a person's hand on the handle, when opening the cabinet door.

Include on the main door a solid stainless steel rod stop and catch mechanism capable of rigidly holding the door open at approximately 90, 120, and 180 degrees under windy conditions. The operator must be able to engage and disengage the catch with a shoed or booted foot.

The main door hinge shall be a one-piece, continuous piano hinge with a minimum 0.25 inch stainless steel pin running the entire length of the right side of the door (right-handed). Attach the hinge in such a manner that no rivets or bolts are exposed.

Equip the main door with a brass Corbin tumbler lock No. 2, swing away dust cap. Provide two No. 2 keys. Equip the police door-in-door with a standard police lock and provide one key.

Electrically bond the door to the rest of the cabinet with a braided copper grounding conductor. The length of the grounding conductor shall allow the door to swing fully open, without using the stop bar, without stretching or breaking the grounding conductor. The grounding conductor shall not interfere with normal door operation.

Provide a door switch for the main cabinet door. When the door is opened the switch shall send a signal to the controller sufficient for the controller to log an alarm.

611.2(c) Shelves and Mountings

Mount a minimum of three vertical "C" channels on each interior side wall of the cabinet for the purpose of mounting the cabinet components. The channels shall accommodate spring mounted nuts or studs. Install three vertical "C" channels or three slotted rails on the interior back wall of the cabinet. All mounting channels and rails shall extend to within 7 inches of the top and bottom of the cabinets and shall be of sufficient strength to rigidly hold specified shelves and equipment.

Provide two full-width, 11-inch deep, fully adjustable, aluminum shelves to support the controller and other equipment. Mount the lower shelf at a height above the bottom of the cabinet such that the shelf and attached drawer does not interfere with the ability to tilt the terminal facility forward on its hinges for maintenance purposes. Mount the top shelf at least 13 inches above the surface of the lower shelf.

The controller and MMU2 will be located on the lower shelf. Locate the loop detector racks and other auxiliary equipment on the top shelf. The power supply may be mounted on either shelf.

Provide an under-shelf drawer beneath the lower shelf. The drawer shall be approximately 20 inches wide and a minimum of 12” deep. The drawer shall operate easily and smoothly, and shall have a stop to prevent inadvertently pulling the drawer out of its support. Design the stop to allow purposeful complete removal of the drawer without the use of tools. Provide a slide out shelf capable of supporting a 5 pound, 14” wide by 11” deep load. This slide out support can be the cover for the drawer, as long as it extends far enough out to support the entire 11” depth of the laptop.

Provide a fully wired receptacle on the door that is specifically designed to support the twist and lock style plug specified for the optional heater element. Locate receptacle such that when installed, heater should be mounted a minimum of 6.5” from the bottom of the door.

611.2(d) Auxiliary Cabinet Equipment

Ventilate the cabinet by means of a 120 VAC, 60HZ, tube axial compact type fan located in the top of the cabinet plenum. The fan’s free delivery airflow shall be equal to or greater than 100 cubic feet per minute. The magnetic field of the fan motor shall not affect the performance of control equipment. The fan bearings shall operate freely. The fan unit shall not crack, creep, warp, or have bearing failure within a seven year duty cycle. The maximum noise level shall be less than 40 decibels. The fan unit shall be corrosion resistant. The thermostat's turn on setting shall be adjustable from 90 to 120 degrees F. The fan shall run until the cabinet temperature decreases below the turn-on temperature setting by approximately 30 degrees F. The fan shall be fused.

Mount a single LED light strip (GESS32-13200K or approved equal) at the top of the cabinet and the appropriate power supply to support up to four (4) light strip panels. Wire the power supply to an ON/OFF toggle switch. Mount two (2) LED light strips under the lower shelf fed off the power supply on the top of the cabinet. Locate one strip on each side of the drawer.

Provide a 250-watt element heater. The heater shall be mountable on the face of the aluminum, louvered air filter cover such that feed air is supplied through the cover. Provide a protective, ventilated cover over the heater. Provide a cord and twist-off plug that will connect to the electrical receptacle on the cabinet door. Provide a thermostat with an adjustable setting from 0 to 100 degrees F. Install the thermostat on the interior ceiling of the cabinet well away from the cabinet light or any heat source. Provide a thermal limit switch to prevent the heater’s protective cover from exceeding 170 degrees F.

611.2(e) Terminal Facility

The terminal facility panel shall be constructed from 5052-H32 brushed aluminum of 0.125 inches minimum thickness and formed so as to eliminate any flexing when plug-in components are installed.

Mount the bottom of the terminal facility a minimum of nine inches from the bottom of the cabinet. Hinge the terminal facility at the bottom to allow easy access with simple tools to all wiring on the rear of the panel. It shall not be necessary to remove the lower shelf, the shelf drawer, or any shelf-mounted equipment to hinge down the terminal facility. Provide sufficient slack in the load bay wiring to allow for dropping the load bay.

Fully wire the terminal facility with sixteen load switch sockets: eight phases of vehicular, four phases of pedestrian, and four phases of overlap operation; eight flash transfer relay sockets; one flasher socket; and two terminal facility BIU rack slots. The use of printed circuit boards is not acceptable on the terminal facility, except printed circuit boards are acceptable for the BIU interface with the load bay. Position the 16 load switch sockets in two horizontal rows of eight sockets each. Support the load switches and flasher by a bracket or shelf extending at least three inches from the terminal facility. Label all terminals, load switches, and flash transfer relay sockets. Label reference designators by silk-screening on the front and rear of the terminal facility to match drawing designations.

Provide rack mounted BIU's. Provide a dual-row, 64-pin female DIN 41612 Type B connector for each BIU rack position. Provide card guides for both edges of the BIU. Terminal and facilities BIU mounting shall be an integral part of the terminal facility.

Provide two 16-channel, 8-position, TS2 detector racks, each with an integrally mounted BIU mounting. Rack shall be addressable. Power each detector rack by the cabinet power supply. Fasten the loop detector racks towards the left side of the top shelf.

For BIU rack connectors, provide pre-wired address pins or jumper plugs corresponding to the requirements of the NEMA TS2 Standard. The address pins or jumper plugs shall control the BIU mode of operation. BIUs shall be capable of being interchanged with no additional programming.

For the terminal facility, contain all field wires within one or two rows of horizontally-mounted Marathon (or approved equal) heavy duty terminal blocks. Terminate all field output circuits on an unfused terminal block with a minimum rating of 10 amps. Use mechanical connector lugs rated for copper wire. Angle the lower section of the terminal block out from the back of the cabinet at approximately a 45 degree angle.

Identify all field input/output (I/O) terminals by permanent alphanumeric labels. All labels shall use standard nomenclature per the NEMA TS2 Standard.

All field flash sequence programming at the field terminals shall be able to be accomplished with the use of only a screwdriver.

Wire field terminal blocks to use three positions per vehicle or overlap phase (green, yellow, red).

Wire one RC network in parallel with each flash transfer relay coil.

Permanently label all logic-level, NEMA-controller and MMU2 input and output terminations on the terminal facility. Identify the function of each terminal position on the cabinet drawings.

Terminal blocks for DC signal interfacing shall have a number 6-32 x 7/32 inch screw as minimum. Functions to be terminated shall be as specified in the listing of Input/Output Terminals in Section 5 of the NEMA TS2 Standard.

Conform all terminal facility and cabinet wiring to the WSEC. The green/walk, yellow, and red/don't walk load switch outputs shall be minimum 16 gauge wire. The MMU2 (other than AC power), controller I/O, and logic ground shall be minimum 22 gauge wire. All wire colors shall be consistent in all cabinets furnished in one order.

611.2(f) Vehicle Detection Interface Panel

Provide a 32-position interface panel or two 16-position panels. Each interface panel shall allow for the connection of 32 or 16 independent field loops, respectively. One panel shall allow for 4 EVP channel inputs. The panels shall have barrier strip type terminals using 8-32 screws and be rated for 20 inch pounds of torque.

Provide a ground bus terminal between each loop pair terminal to provide a termination for the loop lead-in cable ground wire. Secure the interface panels to a mounting plate attached to the left interior side wall of the cabinet.

Provide a cable consisting of 20 AWG twisted pair wires to enable connection to and from the interface panel to a detector rack. The twisted pair wires shall be color-coded wires. Provide a cable of sufficient length to allow the detector racks to be placed on either shelf.

Provide a pathway or mechanism for securing loop lead in cables neatly next to interface panel. Identify all termination points by a unique number silk screened on the panel.

611.2(g) Lighting Control Panel

Provide an intersection lighting control panel as described. The intersection lighting control panel shall consist of an aluminum panel 0.125 inches thick and approximately 5 inches by 10 inches. Determine the actual panel size by the cabinet's mounting rail placement. Attach to the panel a 2 pole-30 amp contactor-120vac coil (Square D #8910DPA32V02 or equal), and a heavy duty six position terminal block (Marathon DJ1606 or equal). Use wire sizes 10AWG for power and load wiring, and 16AWG for control wires. Wire the terminal strip as follows:

1. Control coil
2. L1 in
3. L2 in
4. Neutral in and control coil
5. L1 out
6. L2 out

Protect each output by a MOV (V150LA20A) wired between the output and neutral. Include a photo control (Intermatic #K4021C or equal). Mount the photo control just above the cabinet door and approximately 12 inches from the right side of the cabinet. Wire the photo control to a 3 position terminal strip using 16AWG wire color coded to match the photo control wiring connected to the intersection lighting control panel.

Provide panel cover that is secured on the top and bottom of the panel with a minimum of 4 thumb screws.

Provide a switch in the cabinet that can turn intersection lighting on/off.

611.2(h) Auxiliary Surge Suppressor

Provide and mount within the cabinet an auxiliary surge suppressor unit conforming to the following minimum requirements:

- 6-NEMA 5-15R receptacles
- 2700 joule rating

Surge suppressor should be wired off a circuit breaker that is separate from the cabinet equipment such that if this circuit is faulted, the cabinet/controller and all associated equipment will still function.

611.2(i) Conductors and Cabling

All conductors in the cabinet shall be copper 22 AWG or larger. All 14 AWG and smaller wire shall conform to MIL-W-16878/1, Type B, 600V, 19-strand tinned copper. The wire shall have a minimum of 0.010 inches thick PVC insulation without clear nylon jacket and rated to 105 degrees Celsius. All 12 AWG and larger wire shall be UL or NRTL listed THHN/THWN 90 degrees Celsius, 600V, 0.020 inches thick PVC insulation, and clear nylon jacketed.

Provide controller and MMU2 cables of sufficient length to allow the units to be placed on either cabinet shelf in the operating mode. Connecting cables shall be sleeved in a braided nylon mesh. Exposed tie-wraps and interwoven cables are unacceptable.

Provide the cabinet configuration with enough SDLC RS-485 Port 1 communication cables to allow full capabilities of that cabinet. Each communication cable connector shall be a 15-pin metal shell D subminiature type. The cable shall be a shielded cable suitable for RS-485 communications. Secure all connecting cables and wire runs by mechanical clamps. Stick-on type clamps are not acceptable.

Pre-wire the terminal facility for a Type 16 MMU2.

All wiring shall be neat in appearance. Stow excess cable behind the terminal facility or below the shelves in order to allow easy access to the terminal facility and cabinet components. All cabinet wiring shall be continuous from its point of origin to its termination point. Butt type connections/splices are not acceptable.

Wire the grounding system in the cabinet into three separate circuits: AC Neutral, Earth Ground, and Logic Ground.

Isolate all pedestrian pushbutton inputs from the field to the controller through the BIU and operate at 12 VAC. Coordinate with City of Madison traffic engineering department and/or plan sheets to determine where each pedestrian push button wire is to be landed in the cabinet.

Hook or loop all wire, size 16 AWG or smaller, at solder joints around the eyelet or terminal block post prior to soldering to ensure circuit integrity. Lap joint soldering is not acceptable.

611.2(j) Cabinet Switches

Locate the following switches on a maintenance panel on the inside of the cabinet door:

a. Controller On/Off
b. Stop Time (Three Positions)

Position	Switch	Label Function
Upper	Stop Time	Place stop time on the controller
Center	Run	Remove the stop time input to the controller
Lower	Normal	Connects the MMU2 to the controller stop time input

Locate the following switches behind the police access door:

a. Signal/Off
b. Flash/Normal
c. Hand/ auto
d. Coiled hand control and cable

The above switches shall function as follows:

Off: Signals Dark
Signal: Signals On and operating as follows:

Auto	Hand
Flash: Signals Flash	Signals Flash
Normal: Signals Normal	Signals Advance by use of hand control

611.2(k) Power Panel

Power Panel Design

The power panel shall consist of a separate module, securely fastened to the interior right side wall of the cabinet. Wire the power panel to provide the necessary power to the cabinet, controller, MMU2, cabinet power supply, and all auxiliary equipment. Manufacture the power panel from 0.090-inch, 5052-H32 aluminum. Panel layout shall facilitate field inspection and maintenance accessibility without excessive disassembly or special tools.

Provide a light, tough, transparent, weather-resistant, non-yellowing, thermoplastic cover, rigidly mounted over the full power panel, with access holes for circuit breakers and other equipment, and open on the sides for ventilation.

All components of power panel shall meet or exceed the electrical requirements as laid out in section 5.4 of the NEMA TS2 Standard.

Power Panel Grounding System

On each side of the cabinet, provide a minimum 20-position neutral bus bar capable of connecting three #12 AWG wires per position.

Also on each side of the cabinet, provide a minimum 20-position equipment ground bus bar capable of connecting three #12 AWG wires per position. Install this bus bar below the neutral bus bar.

Power Panel Circuit Breakers

House in the power panel the following vertically mounted, single pole, 120 volts AC, 60 Hertz, circuit breakers, with the ON position being up:

- One 30-amp signal breaker. This breaker shall supply power for all cabinet functions not powered through one of the other breakers or fuses listed below. Streetlights will be powered from outside the cabinet in the meter breaker pedestal. This breaker shall feed a signal bus supplied through a solid state bus relay and a radio interference line filter. The bus relay, in all cases, shall be a solid state contactor and shall not be jack mounted. Breakers shall be thermal magnetic type, UL listed, with a minimum of 22,000 amp interrupting capacity.
- One 15-amp auxiliary breaker. This breaker shall supply power to the fan and heater.
- One 10-amp breaker. This breaker shall supply power for control equipment: controller, MMU, and cabinet power supply.
- One 20-amp circuit breaker for future use.

Power the cabinet light through the GFI fuse, not a circuit breaker.

Power Receptacle

Mount a two-position, 120 VAC 20 amp, NEMA 5-20R GFCl convenience outlet on the interior right side wall above or as part of the power panel. The outlet shall be fully operational and fuse protected.

611.2(l) Auxiliary Devices

Flashers

Provide one solid state flasher conforming to the requirements of section 6.3 of the NEMA TS2 Standard.

Flash Transfer Relays

Provide four flash transfer relays conforming to the requirements of section 6.4 of the NEMA TS2 Standard.

Cabinet Power Supply

Provide one power supply with each cabinet conforming to the requirements of section 5.3.5 of the NEMA TS2 Standard. Provide LED indicators for the 12 VDC, 12 VAC, and 24 VDC outputs. Provide jack plugs on the front panel for access to the +24 VDC for test purposes.

Load Switches

Provide sixteen solid state load switches conforming to the requirements of Section 6.2 of the NEMA TS2 Standard.

Bus Interface Units (BIU)

Provide four BIUs conforming to the requirements of section 8 of the NEMA TS2 Standard. Provide two BIUs with the main panel and one BIU with each of the detector racks.

Inductive Loop Detector Amplifier Card

Provide sixteen, two-channel, type C, rack mounted, inductive loop detector amplifier cards conforming to section 6.5, Inductive Loop Detector Units, of the NEMA TS2 Standard.

Install inductive loop detector amplifier cards in the rack in traffic signal control cabinet. Program the signal controller to make the inductive loop detector and signal cabinet fully operational per plan.

Time Clock

Furnish a Tork EWZ210C astronomical time clock with an 8-year lithium battery time backup, -40° F to 120° F operating range, 40-year program schedule retention, LCD type, daylight saving time, and leap year correction. Program as required by the City of Madison.

611.2(m) NEMA TS2 Type 2 Traffic Signal Controller with Special Programming Functions

General Requirements

Provide a shelf-mounted NEMA TS2 Type 2 Econolite EOS traffic signal controller programmed and ready for operation within the associated traffic signal control cabinet. The controller unit shall be fully actuated, solid state, digital microprocessor based capable of providing the number and sequence of phases, overlaps, and any special logic as described herein. The controller unit and engine board shall comply with or exceed the industry's latest Advanced Traffic Controller (ATC) standard 5.2b and proposed standard 6.10. The controller unit shall also conform to NEMA TS2 Standard, Section 3, specifications for the Type 1 Actuated configuration in the areas where the ATC standard is silent.

The traffic signal controller shall have the capability to be programmed for MUTCD allowed signal sequences and non-standard operations using inputs on the front panel without requiring revisions to the operating system and the controller application software. Controller unit shall have a Linux-based operating system.

Provide intersection controller units with up to 16-phase operation plus 16 programmable overlaps regardless of whether or not preemption, coordination, or other special programming is used.

Provide a four-ring, programmable both for single and dual entry concurrent timing, nine-phase frame or equivalent. Provide volume density timing for eight phases and pedestrian timing for all phases. Provide MUTCD flash capability. All controls shall be in accordance with the NEMA TS2 Standard.

All controller timing parameters shall be fully programmable from the front panel keyboard inputs, and memory storage features shall be non-volatile under power-off conditions for at least thirty days. The locking, non-locking detection mode and per phase recall shall also be accessible on the front panel. The controller shall have the option for a security code entry before any timing parameters can be changed.

Provide a data key port and/or a USB port on the controller to load and store intersection programming.

Internally buffer all logic circuit inputs to withstand transients and noise, such as might result from normal usage, without damage to any mechanism components.

The controller shall provide a method for programming special user created logic functions. User created logic functions shall include, but not be limited to: nonstandard overlaps, special detector logic based on user selected parameters, coordination plan selection, and phase and pedestrian omits. Programming these special functions shall be accomplished through the use of the controller front panel keyboard. The need for special programming applications will not be considered acceptable; however it is acceptable to provide the programming functionality as part of a computer based controller programming application. Special user created logic functions shall be stored as intersection programming and be capable of being transferred from controller to controller through the use of a data-key or computer based controller programming application.

Front Panel Display

Provide a display panel on the front panel consisting of a backlit alphanumeric LCD display. The face of the display shall be scratch, chemical, and solvent resistant. The operator shall access the controller through a menu system. By selecting various menu options, real time operational status or stored parameter tables shall be presented to the operator.

Show on the LCD display, in addition to information required elsewhere:

a. The status of each signal phase on
b. The interval status
c. Phase termination information
d. The presence of vehicular and pedestrian calls for each phase

Timing

The passage timer shall time concurrently with the minimum green timer, such that the duration of the minimum green time is directly adjustable and is independent of the passage time setting.

In the dual-ring application, no more than two phases shall be permitted to time concurrently, and no more than one phase per ring. Provide barrier protection against concurrent timing of two conflicting phases; no phases assigned to one side of the barrier shall be permitted to time concurrently, if a conflict will occur. Service calls on a single-entry basis. Both rings shall cross the barrier simultaneously in accordance with the following logic:

a. Phases timing concurrently shall terminate simultaneously if both have a gap-out due to excessive time between actuations.
b. Phases timing concurrently shall terminate simultaneously if both have a maximum timeout.
c. Phases timing concurrently shall terminate simultaneously if one has a gap-out and the other has a maximum time-out.
d. In the event that one phase has not achieved a gap-out or maximum time-out, the other gapped-out phase shall be permitted to leave the gapped-out condition and retime an extension when an actuation is received.

Controllers shall not accept any operator input or stored timing parameters that would result in intervals shorter than the following:

- yellow clearance - 3.0 seconds
- standard minimum walk - 4.0 seconds
- preemption minimum walk = 0.0 seconds
- minimum pedestrian clearance - 6.0 seconds

At the beginning of each of the above intervals, the controller shall check the previously stored data against these minimums. If an operator attempts to load an incorrect timing parameter the controller unit shall output a unique error code on the front panel display. As an alternate to minimum timing control a coded keyboard entry security feature may be provided.

Manual (Police) Control

If manual control is used, actuation of the manual control shall permit manual advance of the Walk, Pedestrian Clearance, and Green interval terminations only. Manual termination of Yellow or All-Red clearance intervals shall not be permitted.

Coordination

The controller shall be capable of operation in progressive coordination systems and mutual coordination and shall contain, but not be limited to, the following external inputs, with all functions brought out:

- Vehicle/Pedestrian Detectors (per phase)
- Pedestrian Omit (per phase)
- Phase Omit (per phase)
- Hold (per phase)
- Omit Red Clearance (per ring)
- Internal Maximum Inhibit (per ring)
- Maximum II (per ring)
- Red Rest (per ring)
- Stop Timing (per ring)
- Force-Off (per ring)
- Select Minimum Recall (per controller)
- Manual Control (per controller)
- Semi-Modes (per controller)
- External Start (per controller)

Diagnostic Program

Provide a diagnostic program prepared by the manufacturer of the controller unit which will demonstrate the proper operation of all of the inputs, outputs, controls and indicators in the controller, and have visual confirmation on the front panel. The diagnostic program shall be resident in each controller. The controller shall continuously run a diagnostic routine in the background to assure unit integrity.

Message Logging

Provide user programmable, data logging of local events or alarm events including, but not limited to: Conflict Flash, Remote Flash, Local Flash, Controller Voltage Monitor, Detector Failure, On Line and Data Change. The time and date shall be recorded as a part of the message logged. The logging

function shall be resident in the controller unit. The logging function shall be viewed from the front panel LCD display. If the logging function cannot be viewed from the front panel LCD display, it shall be performed by supplemental auxiliary equipment supplied with this specification.

Closed Loop Operation

The controller shall be able to be used in a closed loop system using twisted pair copper, single mode fiber, multimode fiber, cellular modem, or wireless radio to connect to compatible equipment.

Firmware/Software

Provide installed in the controller current, fully operational, NTCIP compliant and active controller firmware and software sufficient for the controller to perform all functions shown on the plans, sequence of operation plan sheet, specifications, and signal timing plan for the local intersection. Provide all software licenses.

The firmware and software shall be compatible with and able to fully communicate with:

- All phase sequences used by the City, including flashing yellow for both left and right turns
- Closed loop, adaptive, Performance Measure application, and on-street control software currently utilized by the City including Centracs and Centracs Adaptive
- Both the controller and the MMU2
- City PC laptop and desktop computers with Windows 7 operating systems
- Backwards compatibility with older traffic signal controllers and software produced by the controller manufacturer and installed at City traffic signal installations since 2010
- Capable of SPaT ouput for Connected Vehicle operations

Controller Programming

Provide a controller that has been programmed to operate the associated intersection based upon the signal plan and sequence of operations sheet or as provided by the City.

611.2(n) Malfunction Management Unit (MMU)

Furnish equipment conforming to NEMA TS2 Standard, including NEMA Amendment #4-2012 for Flashing Yellow Arrow (MMU2), except where modified in this specification. Provide one shelf-mountable, 16 channel, solid-state MMU2 complete with programmed card and with Ethernet capability. The MMU2 shall meet the requirements of Section 4 of the NEMA TS2 Standard as well as Amendment #4-2012 for Flashing Yellow Arrow. The MMU2 shall be provided with Ethernet active and available for use without any further modification. The MMU2 shall come with a card that has been programmed per the sequence of operations.

The MMU2 shall be capable of the following:

- Detecting simultaneously active inputs of Green (Walk), Yellow, or Red (Don’t Walk) on the same channel.
- Determining if the field signal input states detected as active or inactive by the MMU2 correspond with the data provided by the Controller Unit.
- Monitoring an optional external watchdog output from a Controller Unit or other external cabinet device.

- Monitoring an intersection with up to four approaches using the Flashing Yellow Arrow (for protected/permissive left and right turn movements).
- Event logging for the following; AC Line log, Prior/Previous Faults log, and Monitor Reset Log. All log entries shall include a date and time stamp.
- All monitor functions shall be capable of being programmed through the front panel, without the need for computers or special program cards.
- A built-in Diagnostic Wizard shall be provided that displays detailed diagnostic information regarding the fault being analyzed. This mode shall provide a concise view of the signal states involved in the fault, pinpoint faulty signal inputs, and provide guidance on how the technician should isolate the cause of the malfunction.

The MMU2 shall have an LCD display that allows for viewing of log files and field indications, as well as the viewing and setting of date and time and configuration parameters.

Furnish test results for the MMU2 showing that it has been tested within the past 3 months. The testing should include all standard NEMA TS2 required and optional tests – including flashing yellow arrow testing for the mode appropriate for the cabinet for which it is to be installed.

611.2(o) Documentation

Cabinet Intersection Wiring Diagrams

At the time of the cabinet delivery, furnish with the cabinet two sets of printed 22x34-inch cabinet intersection wiring diagrams, one set of .dwg CAD files and one .pdf file per cabinet. After cabinet acceptance is complete, if any cabinet wiring changes were made, revise the cabinet wiring diagrams and provide two sets of printed 22x34-inch and two sets of printed cabinet intersection wiring diagrams, one set of .dwg CAD files and one .pdf file reflecting any field changes.

Manuals

At the time of the cabinet delivery, furnish the City an electronic copy of installation, operations, and maintenance manuals including each type of standard equipment in the cabinet. The manuals shall as a minimum include the following information:

a. table of contents,
b. operating procedure,
c. step-by-step maintenance and trouble-shooting information for the entire assembly,
d. schematic diagrams,
e. pictorial diagrams of parts locations,
f. itemized parts lists with parts numbers,
g. theory of operation, and
h. maintenance checklists.

The itemized parts lists shall include the manufacturer’s name and parts number for all components (such as IC, diodes, switches, relays, etc.) used. The list shall include cross references to parts numbers of other manufacturers who make the same replacement parts.

611.2(p) Cabinet Delivery

Deliver the fully wired, equipped and configured cabinet with required documentation to the City of Madison, Traffic Engineering Electrical Shop located at 1120 Sayle Street, Madison, WI, 53704. Delivery shall be on a business day between 8:00 AM and 3:00 PM. Contact the City of Madison, Traffic Engineering Electrical Shop (Ed Smith at 608-266-9034) a minimum of two business days ahead of the desired delivery time to schedule and confirm the staff availability for delivery.

611.2(q) Warranty

The Contractor shall warrant the performance and construction of the fully-configured cabinet to meet the requirements of the plan, this specification, and shall warrant all wiring parts, components, and appurtenances against defects in design, material and workmanship for a period of one year from the date of installation. In the event defects and failures become apparent during this time, the Contractor shall repair and/or replace all defective parts or appurtenances at no additional expense to the City. This specification is to construe that any part, or parts, that fail to function properly shall be replaced at no charge to the City

611.3 Construction Methods.

Furnish and install equipment and assemble the cabinet conforming to the latest revision of NEMA Standards Publication TS Version 2.06 (R2008), Traffic Controller Assemblies with NTCIP Requirements, National Electrical Manufacturers Association, hereinafter called NEMA TS2 Standard, except where modified in this specification. Conform all work to the Wisconsin State Electrical Code (WSEC).

Provide a traffic signal controller cabinet designed for TS2 Type 1 operation. Pre-wire cabinet for a minimum of sixteen phases as specified herein. Provide a second harness ready for communication between the traffic signal control cabinet itself and a NEMA TS2 Type 2 Traffic Signal Controller. TS2 Type 2 harness should be easily connected without having to drop the back panel or modify the wiring on the power panel.

Furnish and install at no extra cost any equipment and materials not specifically described but required in order to perform the intended functions in the cabinet.

The contractor shall deliver all materials to the City of Madison (1120 Sayle Street) for testing and pick up the traffic signal cabinet and components after testing to install this item as part of the construction project.

611.4 Measurement and Payment.

This item shall be measured as a unit, each, furnished, delivered, tested, accepted and installed.

The quantity of Traffic Signal Controller Cabinet installed, measured as provided above, will be paid for at the contract unit price for each traffic signal controller cabinet installed, for which price shall be payment in full for all work, materials, equipment and incidentals required to furnish, configure, deliver all materials to the City of Madison (1120 Sayle Street) for testing and subsequent installation by the contractor of each Traffic Signal Controller Cabinet.