

METROPOLITAN GOVERNMENT OF SHVILLE AND DAVIDSON COUNTY



# 730N

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## TENNESSEE DEPARTMENT OF TRANSPORTATION STANDARD SPECIFICATIONS

**Public Works**

**Rev. 6/1/2017**

Accepted by: \_\_\_\_\_

Date: \_\_\_\_\_

**TENNESSEE DEPARTMENT OF TRANSPORTATION**  
**STANDARD SPECIFICATIONS FOR**  
**ROAD AND BRIDGE CONSTRUCTION**  
June 1, 2017 (Excerpt)

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## **SECTION 730N—TRAFFIC SIGNALS**

These specifications, Section 730N, are intended as a supplement to Section 730 from the Tennessee Department of Transportation Standard Specifications for Road and Bridge Construction (March 1, 2006, or latest edition). This supplement is applicable to all traffic signal installations within Nashville and Davidson County, Tennessee. The purpose of these specifications is to provide adequate policies in the construction procedures and quality of materials that would be in the best interest of safety, convenience, and prosperity of the public. Deviation from these specifications shall be at the discretion of the Metropolitan Department of Public Works (MDPW).

**730.01—Description of Work.** The work to be done consists of furnishing and installing all necessary materials and equipment to complete in place traffic signal systems and/or modifying existing systems, all as shown on Plans, standard or special details, and as set forth in these specifications. Unless otherwise indicated on the Plans or specified in the Special Provisions, all materials shall be new.

Where existing systems are to be modified, the existing material shall be incorporated into the revised system, salvaged, or abandoned as specified or as directed by the Engineer.

All incidental parts which are not shown on the Plans, or specified herein, and which are necessary to complete the traffic signal, or other electrical systems or required for modifying existing systems, shall be furnished and installed as though such parts were shown on the Plans or specified herein. Costs of such incidentals shall be included in bid price for other items. All systems shall be complete and in operation to the satisfaction of the Engineer at the time of completion of the work. Materials used in any installations must be approved by way of a materials list submission from the Contractor to the MDPW.

### **GENERAL REQUIREMENTS**

**730.02—Regulations and Code.** Ensure that all equipment provided conforms to NEMA Standards Publication, Traffic Control Systems, latest revision, or the Radio Manufacturers Association, whichever is applicable. In addition to the requirements of these Specifications, the Plans, and the Special Provisions, all material and work shall conform to the requirements of the NEC; the Standards of ASTM, ANSI, ITE, and IMSA; the MUTCD; and other applicable local ordinances. Wherever reference is made to the NEC, or the Standards mentioned above, consider the reference to mean the code or standard that is in effect on the date of advertising the bids or authorization for force account.

**730.03—Submittal Data Requirements.** Within 30 days after the issuance of the work order, the Contractor shall submit to the MDPW, the manufacturer's descriptive literature and technical data which fully describes the types of signal equipment he proposes to use. Descriptive literature shall include the manufacturer, models, etc. and be adequate to determine if the equipment or material meets the requirements of the Plans and these specifications. These sets of submittal data shall include a list of the materials submitted along with descriptive material for, but not limited to, the following items:

- Controller
- Conflict Monitors and Malfunction Management Unit
- Cabinet and Exhaust Fan
- Detectors- Inductive, Video, Microwave, etc.
- Signal Heads including Lamp and L.E.D. Lens Information and Mounting Hardware
- Loop Wire and Loop Sealant
- Shielded Detector Cable
- Signal Cable
- Communication Cable
- Cable for Span Wire, Guys, Attachment Hardware, etc.
- Pull Boxes
- Conduit, Related Fittings, Condulets and Attachment Hardware
- Communication Equipment

The submittal sets shall also include detailed scale drawings of any non-standard or special equipment and of any proposed deviation from the Plans. If requested to do so, the Contractor shall submit for approval sample articles of any materials proposed for use. The MDPW will not be liable for any materials purchased, labor performed, or delay to the work prior to such approval.

Six prints of "Design" or "Shop" drawings indicating the proposed dimensions and material specification for each of the supports and mast arms involved shall be submitted by the Contractor to the MDPW for approval purposes within 30 days after the work order is issued. These drawings, stamped and sealed by an engineer registered in the State of Tennessee, will be reviewed by the MDPW at the earliest possible date and two prints will be returned "Approved for Fabrication", or "Returned for Revisions as Noted". Appropriate action shall be taken at this time by the Contractor to insure that the earliest possible correction of these items can be achieved so as not to delay the installation.

**730.04—Mill Test Reports and Certification.** Mill Test Reports or Certifications of Conformance to the Specifications for Materials and Design will be required for all materials incorporated into the work. The following shall be supplied by the Contractor prior to acceptance of the structures:

1. "Mill Test Reports" (M.T.R.) for MAJOR structural items only, as noted in Chart 1, shall include both physical and chemical descriptions of the material as supplied to the fabricator. When physical properties are altered during the fabrication M.T.R. covering chemical composition will be supplemented by certified test reports indicating the physical properties of this material after fabrication.
2. Certification of Conformance to the Specifications for all remaining material not covered by M.T.R. as noted in the Chart 1.
3. Certification that all welding was performed by operators qualified as follows: Steel welders to AWS and aluminum welders to ASME.
4. Certification of Conformance to the Specification for the Design of all components not completely dimensioned and detailed on the "Standard" drawing.

**CHART 1**

<b>Component Materials</b>	<b>M.T.R.</b>	<b>Certification</b>
Tubes for arms and poles	X	
Base Castings	X	
Anchor Bolts	X	
Pole tops, misc. fittings and hardware		X
Fabricated or cast-type arm connections		X
Galvanizing		X

**730.05—Working Drawings.** The Contractor shall provide within the controller cabinet and to the MDPW an electrical schematic diagram of the cabinet system wiring and one set of As-Built/Red Line drawings depicting any field modifications. Manufacturer's instructions for installation, maintenance and operation of all equipment and components shall also be submitted to the MDPW and placed within the controller cabinet. All materials placed in the cabinet shall be mounted in the cabinet inside a plastic envelope.

**730.06—Guarantee.** The Traffic Signal System(s) installed under these specifications, including all equipment, parts, and appurtenances in connection therewith shall be guaranteed to the MDPW by the Contractor against defective workmanship and materials for a period of not less than one year following the date the signal system is made operational. Except in no case shall this guarantee expire prior to three months after the final acceptance of the project. Upon completion of the project, warranties or guarantees on equipment and materials that are offered by the manufacturers as normal trade practice and have not

expired shall be turned over by the Contractor to the MDPW. At this time, the Contractor should request a written Letter of Acceptance from the MDPW for the installation.

**730.07—Training.** If requested, the Contractor shall provide to the MDPW a training session on the controller and associated cabinet equipment to be supplied on the project. The Contractor will be notified in advance if training will be required. The training session will last for a minimum two days unless the MDPW determines a lesser time is adequate. The training shall be of a level to train the user in the complete operation and programming features of all controllers. The Contractor shall provide this training at a facility agreed upon by the MDPW. The Contractor shall provide the training prior to the acceptance of the project. After the required training, the Contractor shall certify to the Engineer that training has been completed.

This training requirement shall not apply if a training program meeting these criteria has been accomplished by this vendor and/or manufacturer on the equipment being bid within 18 months previous to the date of this invitation to bid but shall apply if the bidder is proposing new, upgraded, or modified equipment not covered in such previous training program.

## **MATERIALS AND INSTALLATION**

**730.08—Excavating and Backfilling.** The excavations required for the installation of conduit, foundations and other equipment shall be performed in such a manner as to cause the least possible damage to the streets, sidewalks, and other improvements. The trenches shall not be excavated wider than necessary for the proper installation of the electrical equipment and foundations. Excavating shall not be performed until immediately before installation of conduit and other equipment. The material from the excavation shall be placed in a position where the least disruption and obstruction to vehicular and pedestrian traffic will be realized and the least interference with the surface drainage will occur. Trenches shall be graded level with suitable backfill prior to laying the conduit in the trench.

The excavations shall be backfilled and compacted to at least the density of the surrounding material. All surplus excavation material shall be removed and disposed of by the Contractor outside of the highway right-of-way, in accordance with these Specifications, or as directed by the Engineer.

Excavations, after backfilling, shall be kept well filled and maintained in a smooth and well-drained condition until permanent repairs can be made.

At the end of each day's work, and at all other times when construction operations are suspended, all equipment and other obstructions shall be removed from that portion of the roadway used by public traffic and parked a minimum of 30 ft. (9 m) from the edge of pavement unless otherwise protected by guardrail, bridge rail, or barriers installed for other purposes. Any sidewalks damaged during construction shall be traversable by pedestrians at the end of each day's work. Repair to these sidewalks will be in accordance with MDPW specifications.

Excavation in the street or highway shall be performed in such a manner that not more than one traffic lane shall be restricted in either direction at any time. Traffic shall not be obstructed during hours of peak flow unless approved otherwise by the Engineer or the MDPW Permits Office. Construction signing shall be incorporated in accordance with the Provisions of the **MUTCD**.

**730.09—Removing and Replacing Improvements.** Improvements, such as sidewalks, curbs, gutters, portland cement concrete and asphalt concrete pavement, bituminous surfacing, base material and any other improvements removed, broken or damaged by the Contractor, shall be replaced or reconstructed with the same kind of materials as found on the work. All replacement shall be in accordance with Metro standards and specifications.

The outline of all areas to be removed in portland cement concrete sidewalks and in all pavements shall be cut to a minimum depth of 2 in. (50 mm), with an abrasive type saw prior to removing the sidewalk and

pavement material. Cut for remainder of the required depth may be any method satisfactory to the Engineer. Cuts shall be neat and true with no shatter outside the removal area.

Whenever a part of a square or slab of existing concrete sidewalk or driveway is broken or damaged the entire square or slab shall be removed and the concrete reconstructed as specified above.

All work shall be done in accordance with these Specifications, or any local ordinance which may apply, whichever is of a higher standard. Cost of this removal and replacement to be included in bid price for other contract items.

**730.10—Foundations.** Foundations for posts, standards and cabinets shall be Class A, portland cement concrete. All foundations shall include a spare conduit, of a size specified on the plans, stubbed out parallel to the road.

Foundations for posts, standards and pedestals shall be poured after the post, standard, pedestal, or anchor bolts or reinforcing steel is in proper position. The exposed portions shall be formed to present a neat appearance. The bottom of concrete foundations shall rest on firm undisturbed ground. Each foundation shall include one extra 2 in. (50 mm) conduit.

Forms shall be true to line and grade. Tops of footings for posts and standards, except special foundations, shall be finished to curb or sidewalk grade or as ordered by the Engineer. Forms shall be rigid and securely braced in place. Conduit ends and anchor bolts shall be placed by means of a template until the concrete sets. Both forms and ground which will be in contact with the concrete shall be thoroughly moistened before placing concrete. Forms shall not be removed until the concrete has cured for at least twelve hours and hardened sufficiently to allow firm removal without causing damage to the concrete.

Ordinary surface finish shall be applied to exposed surfaces of concrete. Wherever the edge of a concrete foundation or sidewalk section is within 18 in. (450 mm) of any existing concrete improvement, the sidewalk section shall be extended to meet said existing improvement. Any sidewalk construction or repair shall be in accordance with MDPW standards.

Where obstructions prevent construction of planned foundations, the Contractor shall construct a foundation satisfactory to the Engineer.

**730.11—Anchor Bolts.** Anchor bolts meeting the requirements of ASTM F 1554, grade 55 or other high strength steel anchor bolts having a minimum yield strength of 55,000 p.s.i. (379 MPa) and a minimum ultimate strength of 90,000 p.s.i. (620 MPa) each fitted with one regular hex nut and one heavy-duty square nut, shall be furnished with anchor-base type poles. All nuts and not less than 10 in. (250 mm) of the threaded ends of anchor bolts shall be hot-dip galvanized in accordance with ASTM F 153. The anchor bolts shall be capable of resisting at yield strength stress the bending moment of the shaft at its yield strength stress. No exposed anchor bolts will be allowed when work is not in progress. Exposed anchor bolts could pose a hazard to pedestrians.

Plumbing of standards, posts and pedestals shall be accomplished by adjusting the nuts before the foundation is finished to final grade. Shims or similar devices for plumbing or raking will not be permitted. After plumbing or raking has been completed, anchor bolts will be cut off ¼ in. (6 mm) above the top nut and the exposed surface painted with rust protective paint.

Anchor bolts and nuts required for relocating existing standards and posts shall be furnished by the Contractor. Anchor bolts for signal poles shall meet Metro minimum diameter standards.

**730.12—Pull Boxes. Type B TRAFFIC**

Pull boxes shall have a minimum dimensions: 32 ¼ " x 19 ¼ " x 18" and be constructed and installed as shown on the Plans and standard drawings or as directed by the Engineer. Additional pull boxes may be required where conduit runs are more than 150 ft. (45 m) long. Pull boxes shall be installed wherever

practicable out of the line of traffic. Covers shall be level with the pavement, or with the curb or sidewalk grade, or with the surrounding ground as required. Each pull box shall include one extra 2 in. (50 mm) conduit.

Electrical conductors shall be placed within pull boxes in such a manner as to be clear of the frame and cover.

The bottom of the pull box shall rest firmly on a bed of crushed stone with a minimum depth of 12 in. (300 mm) below the bottom, and extending 6 in. (150 mm) beyond the outside edge of the pull box, unless otherwise specified by the Engineer.

The frame shall have a minimum weight of 42 lbs. (19 kgs). The cover shall be of the "Extra Heavy" type with a minimum weight of 54 lbs. (24.5 kgs).

1. All pull boxes shall meet Tier 22 requirements. If other than concrete, pull boxes shall be composed of reinforced plastic or epoxy mortar and be designed and tested to temperatures of -50° F (-45° C), and meet the requirements of the following: ASTM D 543, ASTM D 570, ASTM D 790, and ASTM D 635 and shall be based on Vertical Design / Test Load - 22,500lbs/33,750lbs. Loadings shall comply with ANSI 77 2002 and shall meet Tier 22 test provisions for both the cover and sidewall. The word "TRAFFIC" or the words "TRAFFIC SIGNALS" shall be inscribed on top of the covers.

### **730.13—Fiber Optic Pull Boxes.**

Fiber optic pull boxes must be properly grounded according to NEC, EIA/TIA and Bellcor (Telcordia) standards. All splice points must contain sufficient slack (50 foot minimum) to allow for future addition of communication devices, cable and splice repairs, or additional runs of "drop" cable. Sizes for fiber optic pull boxes will be determined based upon the number of cables in the system. Pull boxes will be required on each side of a street or railroad crossing.

Type A Pull Box with Cover. The pull box shall meet the following requirements:

2. Minimum dimensions: 36" x 26" x 32" exterior, Pull Box and cover shall be precast composite polymer concrete product. Pull boxes with a polymer cover but other material for the box will NOT be accepted.
3. Pull Boxes and covers shall be single-stack open-bottom assemblies configured as shown in the Plans.
4. Vertical Design / Test Load - 22,500lbs/33,750lbs. Loadings shall comply with ANSI 77 2002 and shall meet Tier 22 test provisions for both the cover and sidewall.
5. Pull Box shall meet current NEC requirements for handhole enclosures.
6. Pull Box cover shall be labeled (MPW ITS COMMUNICATIONS) with 3 inch letters.
7. Installation shall be as per guidelines of the TDOT Standard Specifications for Road and Bridge Construction, latest version. Pull boxes and covers shall be installed per the design details.
8. Pull Box will be measured in units of each and paid for at the contract price per each after the complete installation. The price bid shall include furnishing and installing the pull box and cover including excavation, gravel, restoration, and miscellaneous materials necessary for a complete and accepted installation. This price shall be full compensation for all labor, tools, materials, equipment, and incidentals necessary to complete the work.

Type B Pull Box with Cover. The pull box shall meet the following requirements:

1. Minimum dimensions: 49"W x 32" Lx 36"D exterior
2. Pull Box and cover shall be precast composite polymer concrete product. Pullboxes with a polymer cover but other material for the box will NOT be accepted. Note this is a different pull box than shown in TDOT Standard Drawings.
3. Pull Boxes and covers shall be single-stack open-bottom assemblies configured as shown in Plans.

4. Vertical Design / Test Load - 22,500lbs/33,750lbs. Loadings shall comply with ANSI 77 2002 and shall meet Tier 22 test provisions for both the cover and sidewall.
5. Pull Box shall meet current NEC requirements for handhole enclosures.
6. Pull Box cover shall be labeled (MPW ITS COMMUNICATIONS) with 3 inch letters.
7. Each Pull Box shall come equipped with four Cable Racks and twelve Rack Hooks. The Cable Racks shall be a minimum of twenty-four (24) inches and Rack Hooks shall be a minimum of seven (7) inches in length. The Cable Racks and Rack Hooks shall be hot dipped Galvanized Steel.
8. Installation shall be per guidelines of the TDOT Standard Specifications for Road and Bridge Construction, latest version. Pull boxes and covers shall be installed per the design details.
9. Cable racks and rack hooks shall be installed per the Manufacturer's recommendations.
10. Ducts shall enter the side of the pull box using a terminator and shall extend into the box no more than four (4) inches and no less than two (2) inches.
11. Pull Box will be measured in units of each and paid for at the contract price per each after the complete installation. The price bid shall include furnishing and installing the pull box and cover including excavation, gravel, restoration, cable rack rails and hooks, terminator rings, and miscellaneous materials necessary for a complete and accepted installation. This price shall be full compensation for all labor, tools, materials, equipment, and incidentals necessary to complete the work.

Terminator Ring. The terminator ring shall meet the following requirements:

1. Shall accommodate the number of ducts penetrating into the side of the Pull Box.
2. The Terminator shall mount securely to the side of the box. The Terminator shall be a minimum of one (1) inch thick and allow adequate spacing of the ducts.
3. The Terminator shall be manufactured from a composite material that will not deteriorate in any type of weather conditions.
4. Shall be installed per the Manufacturer's recommendations.
5. Shall be included in the measurement and payment of the Type A Pull Boxes, Type B Pull Boxes, and Manhole and will not be measured separately for payment.

Payment. The contract unit price shall be full compensation for all work specified in this Section. Payment will be made under:

Item No.	Description	Unit
730.03.23	Install Pull Box (Fiber Optic – Type A)	Each
730.03.24	Install Pull Box (Fiber Optic – Type B)	Each

Pull boxes will be paid per each as follows:

Stored Materials will be paid per TDOT Standard Specifications.

Final Payment will be made after complete installation and testing.

**730.14—Transformer Base.** The transformer base shall be fabricated from steel plate and sheet and designed to harmonize with the shaft. Each transformer base shall be provided with: a 7-1/2 x 9 in. (187 x 225 mm), minimum handhole with cover secured with stainless steel fastening screws; four galvanized steel bearing plates to fasten the base to the anchor bolts; four galvanized steel bolts, nuts and washers to fasten base and standard; and a 1/2 in. (13 mm) - 13 UNC grounding nut welded to the inside of the base opposite the handhole opening. The strength of the transformer base shall be comparable with that of the shaft. When transformer base is required, no handhole will be required in the shaft.

**730.15—Conduit.** Furnishing and installing plastic and steel conduit shall be in accordance with these specifications and close conformity with the lines shown on the Plans or as established by the Engineer. Threads shall be clean cut, straight and true and of sufficient length to permit proper coupling; long running threads will not be permitted on any part of the work. Threads shall be protected in transit and during



installation, and conduit shall be provided with proper supports and protection during construction to prevent injuries. All ends of pipe installed for future connections shall be properly threaded, reamed and capped to prevent water and foreign matter from entering the conduit system. Sections shall be made up with red lead, so that ends of conduit will butt together. Threaded ends shall be provided with approved conduit bushings. Conduits for fiber optic cable shall be clear of obstructions. Water based lubricants shall be used to reduce the potential for outer sheath corrosion.

Signal conduit shall be 2 in. (50 mm) in diameter, and detector conduit 1 in. (25 mm) in diameter, unless otherwise indicated. Conduit for service connections shall be 1 in. (32 mm) in diameter. Conduit for street lights shall be 2 in. (50 mm) in diameter, and conduit for communication cable shall be 2 in. (50 mm) in diameter. Conduits smaller than 1 in. (25 mm) diameter shall not be used unless otherwise specified, except grounding conductors at service points shall be enclosed in 1/2 in. (13 mm) diameter conduit. The Contractor may, at his own expense, use large size conduit, in which case it shall be for the entire length of the run with no reducing couplings permitted. There shall be one extra 2 in. (50 mm) conduit provided in each foundation and pull box.

Materials—Types of conduits and fittings used shall be as follows:

1. Steel Conduit.
  - A. Rigid conduit and fittings shall be heavy-wall, hot dipped galvanized steel conforming to Federal Specification WW-C- 581-d(3) and ANSI-C 80.1. It shall be galvanized inside and out and shall meet the requirements of ASTM A 53. Each length shall bear the label of Underwriters Laboratories, Inc.
  - B. Flexible conduit shall be galvanized flexible steel meeting Federal Specification WW-C-581-d(3), ANSI C-80.1 and UL Standard No. 6 with a minimum of 40 mils thickness of polyvinyl chloride (PVC) coating conforming to ASTM D 746.
  - C. Fiber optic conduits shall be in accordance with ASTM F 2160.
2. Plastic Conduit. Plastic conduit shall be high impact polyvinyl chloride (PVC), Schedule 80.

Installation—All bends shall be in strict compliance with the National Electric Code.

Conduits shall be laid to a depth of 6 in. (150 mm) below subgrade but not less than 24 in. (600 mm) below pavement grade except when approved by the Engineer; conduit may be laid at a depth of not less than 24 in. (600 mm) below top of curb when placed back of the curb. Conduit runs for detectors shall be parallel to existing or proposed curbs and not more than 18 in. (450 mm) behind the curb face unless other specified. Steel conduit or Schedule 80 PVC conduit shall be placed under existing pavements by approved jacking or drilling methods. Pavements shall not be disturbed without the approval of the Engineer. Where trenching is allowed in a traffic bearing area, PVC conduit (Schedule 80) encased in concrete shall be used.

All conduits shall have a Teflon pull line installed for future use and a No. 14 solid AWG locating wire installed and terminated in the controller cabinet on one eight position isolated ground bar labeled Locating Buss. Locating wire shall be capped off and identified in all hand holes and pull boxes.

After installation of the conduit is completed, all conduits installed under this contract shall be tested with a mandrel having a diameter ¼ in. (6 mm) smaller than the conduit and a length of 2 in. (50 mm). All conduits which will not allow passage of the mandrel shall be repaired to the satisfaction of the Engineer; if repairs cannot be affected the conduit shall be removed and replaced at no additional cost to the MDPW. After the mandrel test, all conduits shall be scoured with a stiff wire brush slightly larger in diameter than the conduit. The Contractor shall clear all conduits in the presence of the Engineer or his representative.

Conduits terminating in anchor base standards and pedestals shall extend approximately 2 in. (50 mm) above the foundation and shall be sloped toward the hand-hole opening. Conduits shall enter pull boxes from the bottom and shall terminate not less than 4 in. (100 mm) nor more than 6 in. (150 mm) above the bottom of the box and near the box walls to leave the major portion of the box clear.

Existing underground conduit to be incorporated into a new system shall be cleaned by blowing with compressed air, or by other means approved by the Engineer.

### **730.16—Fiber Optic Conduit.**

#### General Requirements

All continuous flexible conduit products and structure mounted multi-cell conduit shall meet the requirements specified herein. All continuous flexible conduit and structure mounted multi-cell conduit shall have been manufactured and labeled no earlier than in the sixth calendar month preceding the Metro Public Works (METRO) award date of the contract.

#### Continuous Flexible Conduit (Conduit Duct Bank)

1. Continuous Flexible Conduit shall be manufactured from virgin high-density polyethylene (HDPE) resin compound with a minimum cell classification of PE 345434C for PE 3408 materials in accordance with ASTM D-3350.
  - A. Physical and Mechanical Properties and Test Methods
    - (1) Tensile Strength @ yield - 3,000 PSI min. ASTM D-638
    - (2) Density – 0.941 g/cc min. ASTM D-4883/1505
2. Conduit shall be extruded from colored material for uniform full-thickness coloring.
3. All continuous flexible conduit shall be labeled with durable identification giving the name of the manufacturer, conduit size (inner diameter trade size and wall thickness/rating), manufacturer/date codes, the legend METRO and sequential foot marking. Labeling shall occur a maximum of every two (2) feet.
4. Conduit to be used in bends and sweeps shall have a minimum burn through time of 30 minutes when tested in accordance with Generic Requirement GR-356-CORE, Issue 1, October 1995.
5. The conduit manufacturer shall have a documented Quality Control/Assurance System.
6. All conduit used on this project shall conform to the color scheme and use described below:
  - A. Conduit Bank Type 3
    - (1) Orange (Trunk Fiber)
    - (2) Blue (Drop Fiber)
    - (3) White (Spare)
  - B. 2” Electrical Conduit
    - (1) Grey (Electrical wire)
7. 1¼ in. conduit shall conform to ASTM D-3035 and meet the following requirements:
  - A. Smoothwall SDR 11
  - B. Nominal outer diameter: 1.660 in.
  - C. Minimum inner diameter: 1.313 in.
  - D. Minimum wall thickness: 0.151 in.
8. Two (2) in. conduit shall conform to ASTM D-3035 and meet the following requirements:
  - A. Smoothwall SDR 11
  - B. Nominal outer diameter: 2.375 in.
  - C. Minimum inner diameter: 1.885 in.
  - D. Minimum wall thickness: 0.216 in.
9. Coupling
  - A. Make every effort to minimize coupling. Couplings are permitted only with the Engineer’s prior approval.
  - B. Couplings shall be airtight and watertight. All couplings shall be installed in accordance with the conduit and the coupling manufacturer’s recommendations. Only couplings of the type specified below and approved by the conduit manufacturer are permitted.
  - C. Couplings shall be accomplished only by hydraulic press-on or electro-fusion coupling methods.
    - (1) Use hydraulic press-on couplings of seamless tool-grade tubular aluminum with sealing ring barbs and center stop.
    - (2) Use hydraulic compression duct coupling tools and follow all manufacturer’s installation procedures, fully inserting both conduit sections to the coupling center stop.

- (3) Use pre-fabricated electro-fusion couplings that are field-installed using the coupling manufacturer's recommended automatic self-monitoring fusing machine and installation procedures.
- (4) Do not use any other coupling methods.

Marking Tape. The Marking Tape shall meet the following requirements:

1. The color of the tape shall be orange with "Metro PW FIBER OPTIC CABLE" printed no more than every 6.5 ft.
2. The tape shall be a dielectric, polyolefin film tape, 0.004 in. thick and 3 in. wide. The tape shall be constructed using material and ink colors which will not change when exposed to acids and other destructive substances commonly found in the soil.
3. Physical and Mechanical Properties and Test Methods
  - A. Standard Weight - 0.02 lb/ft<sup>2</sup> ASTM-D2103
  - B. Thickness-Overall - 0.004 in. ASTM-D2103
  - C. 3" Tensile Break-MD - 35 lbf ASTM-D882
  - D. 3" Tensile Strength-MD - 2900 PSI ASTM-D882
  - E. 3" Tensile Break-TD - 38 lbf ASTM-D882
  - F. 3" Tensile Strength-TD - 3160 PSI ASTM-D882
  - G. Elongation-MD - 530% ASTM-D882
  - H. Elongation-TD - 660% ASTM-D882
  - I. PPT Resistance-MD - 12 lbf ASTM-D2582
  - J. PPT Resistance-TD - 14 lbf ASTM-D2582
  - K. Tear Strength-3" x 8"-MD - 24 lbf ASTM-D2261
  - L. Tear Strength-3" x 8"-TD - 32 lbf ASTM-D2261

PPT – Puncture Propagation Tear  
MD/TD – Machine Direction/ Transverse Direction

Conduit Detection Wire. Conduit detection wire shall be #10 AWG stranded copper orange-insulated THHN-THWN conductor.

Pull Tape. The pull tape for cable installation shall meet the following requirements:

1. 1250 lb tensile strength
2. Flat, not round, construction
3. Printed sequential foot markings
4. Pre-lubricated for reduced pulling tension at start of cable pull
5. Low susceptibility to absorption of moisture; moisture resistant

Duct Plugs. Duct plugs shall meet the following requirements:

1. Duct plugs intended for underground telecommunications infrastructure shall be installed on conduits.
2. Duct plugs shall be sized to fit the conduits and cables with which they are used.
3. Duct plugs shall provide watertight and airtight gasketed seals by use of mechanical expansion of the duct plug body and gasket. No sealants or caulks shall be used.
4. All metallic components of duct plugs shall be stainless steel.
5. Blank duct plugs are used to seal spare conduits and shall have inner rings to which pull tape can be tied.
6. Cable duct plugs are used to seal conduits that contain a cable. The plug shall be sized to fit the conduit and cable with which it is used and shall be a split plug with a bushing assembly for sealing around the cable by mechanical compression.

Installation Requirements. All material installed shall follow the guidelines in the following sections.

1. Use blank duct plugs to seal the ends of all conduit immediately upon conduit placement. This includes, but is not limited to, intermediate/incomplete sections of conduit prior to conduit splicing or termination in pull boxes and empty conduits in pull boxes prior to cable installation.

2. Conduit shall be installed in a straight line horizontal path between pull boxes except where shown otherwise in the Plans.

#### Continuous Flexible Conduit (Conduit Duct Bank)

1. Install Conduit Duct Banks by configuring individual continuous flexible conduits into a continuous duct bank from termination point to termination point as shown in the Standard Details and other Contract Documents.
2. Continuous flexible conduit installation in earth shall be trenched, horizontal directional bored or drilled, or plowed at the Contractor's discretion, unless otherwise noted on the Plans, at a minimum depth of thirty (30) inches from the top of the conduit.
3. All continuous flexible conduit located under the paved roadway in the plan sheets shall meet the following requirements. The conduit shall be placed at a minimum depth of thirty (30) inches. Backfill shall meet Metro Standards for a paved roadway. All areas shall be completely restored daily according to the time frames set under the approved Traffic Control Plan.
4. All conduit underneath railroad tracks shall be horizontal directional bored or drilled at a minimum of ten (10) feet below the railroad bed. It is also the contractor's responsibility to determine any additional requirements from the railroad owner and shall meet those requirements in addition to those included in the plans and these specifications. Any required steel casings or other materials needed to meet the railroad authority requirements shall be included in the cost of the conduit.
5. All conduit to be installed under streams shall be horizontal directional bored or drilled. No open trenching through an area deemed to be a current or wet weather stream will be allowed. All conduit bored under streams shall be a minimum depth of five (5) feet below the stream bed.
6. Bore Logs will be required for each bore location.
7. The Contractor shall submit a proposed bore log format to the Engineer for review and approval.
8. If a drainage or utility conflict arises, the Contractor shall submit a plan for resolving the conflict to the Engineer for review and approval.
9. Make every effort to minimize coupling. Couplings are permitted only with the Engineer's prior approval.
10. Conduit shall be placed in the straightest orientation possible, reducing bends, twists, rises, and waves. Conduits shall be held in place during backfilling when necessary to keep straight and at the proper depth. Where field conditions require the trench to change direction and bends are necessary, the bends shall be formed in the trench and should be smooth and even and shall not have less than a four (4) foot radius (as measured to the inside surface of the conduit).
11. Test every conduit after the conduit is installed and before cable or pull tape is installed. Perform testing on all conduit types in these specifications, including but not limited to each cell of multi-cell conduits, each conduit in duct banks, and each conduit. All testing shall be performed using the procedures and mandrel size recommended by the conduit manufacturer. Testing shall be performed in the presence of the Engineer. Payment for all testing is included in the cost of the conduit.

#### Rigid Galvanized Steel Conduit

1. Exposed conduit runs shall be 2" rigid galvanized steel unless otherwise required by the Plans.
2. All conduit runs on structures and poles shall be properly terminated into the respective device, or a duct seal shall be installed so as to seal the conduit from moisture, insects, rodents and other foreign material. The costs of the galvanized steel conduit, and all associated fittings shall be included in the cost other items.
3. Bushings shall be installed in conduit at all exposed conduit terminations for protection of the conductors.

#### Marking Tape

1. As shown in the Plans Typical Details, install marking tape above all underground conduit installed by trenching or plowing.

2. Marking tape shall be installed in continuous manufactured lengths. No splicing or overlap is permitted.
3. Install a minimum of four (4) feet of marking tape into pull boxes where trenched conduit is terminating. Marking tape shall enter under the lower edge of the pull box.
4. Marking tape is not required when conduit is bored or plowed.

#### Conduit Detection Wire

1. Install one conduit detection wire with all conduits directly below or at the same level as the conduit. Conduit detection wire is required with all conduits installed by any installation method, including trenching, directional boring, or plowing.
2. Only one conduit detection wire is required per installed conduit segment regardless of the number of conduits installed in that segment.
3. Conduit detection wire shall be installed in conduit.
4. Conduit detection wire is not required for structure mounted conduit, except where underground segments of structure mounted conduit are greater than 20 feet in length.
5. Conduit detection wire is not required for conduit segments between pull boxes and pole/sign structure foundations, except where conduit segments are greater than 20 feet in length.
6. The conduit detection wire shall be continuous and unspliced between pull boxes and shall enter the pull boxes at the same location as the conduit with which it is installed, entering under the lower edge of the pull box.
7. Coil and secure four (4) ft of conduit detection wire in each pull box or vault.
8. Testing
  - A. Perform a continuity or tone test after installation to confirm that a continuous run of conduit detection wire was installed between pull boxes or vaults.
  - B. Prepare a test plan, supplying equipment, conducting the test and documenting the results. Submit a test plan at least 15 working days prior to the desired testing date. Testing shall not begin until the Engineer has approved the test plan, and all tests shall be conducted in the presence of the Engineer.

#### Pull Tape

1. Install pull tape into each empty conduit and empty cell within a multi-cell conduit.
2. Install the pull tape after conduit testing has been completed.
3. Install and secure five (5) feet of slacked pull tape in each empty conduit or cell at each pull box.
4. Secure the pull tape by tying it to the blank duct plug for the conduit in which it is installed.

#### Duct Plugs

1. Install blank duct plugs in each empty conduit that enters a pull box, ground-mounted cabinet, pole foundation, hub, or building entrance.
2. Install cable duct plugs in each conduit containing fiber optic or RDS communications cable that enters a pull box, ground-mounted cabinet, hub, or building entrance.
3. Do not install cable duct plugs on conduits containing power service conductors.

#### Spare Conduits in Foundations

1. A minimum of one two (2) inch spare conduit shall be installed in all pole foundations and a minimum of two (2) 2" inch conduits shall be installed in the base of all ground mounted cabinets.
2. Spare conduits shall be sealed with blank duct plugs.

Measurement. All conduit material shall be measured following the guidelines in the following sections. All conduit types shall be measured in linear feet per type to the nearest foot. All conduit types shall be measured along the conduit by the following:

1. From center of pull box to center of pull box.
2. No additional measurement will be made for vertical conduit inside the pull box or structure.

3. No additional measurement will be made for conduit between a pull box and the nearby pole or structure.

Continuous Flexible Conduit (Conduit Duct Bank)

1. Unless otherwise specified in the Plans, all costs for materials, trenching, installing, backfilling trench, plowing, directional boring, restoration, marking tape, pull tape, duct plugs, fittings, conduit detection wire, testing, bore logs and other accessories and hardware necessary for installation of the conduit system shall be included in the overall cost of the conduit or conduit duct bank.
2. Continuous flexible conduit installation in earth or shoulder, shall be trenched, horizontal directional bored or drilled, or plowed at the Contractor's discretion, unless otherwise noted on the Plans.
3. All conduit to be installed under streams shall be horizontal directional bored or drilled. No open trenching through an area deemed to be a current or wet weather stream will be allowed.
4. Continuous Flexible Conduit (Conduit Duct Bank) will be measured by the linear foot for each type of conduit bank indicated after installation and shall include the type and number of conduit indicated below.
  - A. Conduit Bank: Three - 1 ¼" Continuous Flexible Conduits
  - B. 2" Conduit: One - 2" Continuous Flexible Conduit or PVC Schedule 40 Conduit.
  - C. 2" Conduit w/Bank: One - 2" Continuous Flexible Conduit installed in the same trench as the related Conduit Bank Type as specified in the Plan Sheet.
  - D. Conduit Bank Bored: Three - 1 ¼" Continuous Flexible Conduits
  - E. 2" Conduit Bored: One - 2" Continuous Flexible Conduit

(Note: Separate encasement for borings is not required unless necessary for proper installation due to poor soil conditions. If encasement is needed in those situations the cost of the encasement shall be included in the cost of the conduit.)

Rigid Galvanized Steel Conduit. Rigid Galvanized Steel Conduit, and all related materials including but not limited to couplings, mounting straps, bonding to ground, etc., that is installed on sign structures, poles or between the pull boxes and equipment cabinets is included in the cost of other items and will not be measured separately.

Marking Tape. Marking Tape is included in the cost of the conduit and will not be measured separately.

Conduit Detection Wire. Conduit Detection Wire is included in the cost of the conduit and will not be measured separately.

Pull Tape. Pull Tape is included in the cost of the conduit and will not be measured separately.

Duct Plugs. Duct Plugs are included in the cost of the conduit and will not be measured separately.

Payment. The contract unit price shall be full compensation for all work specified in this Section. Payment will be made according to standard TDOT item numbers.

All conduit will be paid per linear foot, as applicable, as follows:

1. Stored Materials will be paid per TDOT Standard Specifications.
2. Final Payment will be made after complete installation and testing.

**730.17—Fiber Optic Infrastructure.**

All fiber optic infrastructure shall be installed per the Plans or where directed by the Engineer.

1. Furnish fiber optic infrastructure materials that meet applicable industry standards including but not limited to:
  - A. EIA/TIA
  - B. RUS

- C. IEEE
  - D. ICEA
  - E. Telcordia
  - F. ASTM
  - G. UL
  - H. NEC
  - I. NESC
2. Upon request of the Engineer, provide certification from an independent testing laboratory that certifies that the cable conforms to industry standards.
  3. Furnish fiber optic infrastructure materials recommended by the manufacturer for outside plant use and the intended application.
  4. Furnish all optical fiber, fiber optic cable, fiber optic drop cable, optical termination and connection materials, and all ancillary and incidental materials that are single-mode and/or compatible. All materials shall meet the following requirements:
    - A. Listed with and conform to RUS 7 CFR 1755.900 and associated fiber optic test procedures (FOTPs), ICEA 640, EIA/TIA-568-B.3, 598B, 758, Fiber Optic Connector Interchangeability Standard (FOCIS), and Telcordia GR-20 core requirements.
    - B. Manufacturer is currently ISO 9001 certified. This requirement applies to assemblers of manufactured components, such as patch cords and termination cabinet interconnection cables.
    - C. All cables and termination infrastructure shall be assembled from Corning SMF28e, OFS All Wave or approved equivalent single-mode optical fiber.
    - D. All fibers and buffer tubes shall follow EIA/TIA-598B identification using colors. Do not use printed legends.
    - E. All cables shall have been manufactured and labeled no earlier than in the third calendar month preceding the MPW letting date of the contract.
  5. Fiber optic installation and testing tools shall be maintained and calibrated in accordance with the tool manufacturer's recommendations. Provide tool manufacturer certified calibration documentation upon Engineer's request. Installation and testing tools include but are not limited to:
    - A. Fusion splicers
    - B. Cable pulling strain dynamometers and breakaway links
    - C. Cable air jetting/blowing systems
    - D. OTDRs
    - E. Optical attenuation testers (light sources and power meters)
  6. Fiber optic installation and testing tools shall be operated only by Contractor personnel who have been trained and certified by the tool manufacturer. Installation and testing tools requiring certified operators include but are not limited to:
    - A. Fusion splicers
    - B. Cable air jetting/blowing systems
    - C. OTDRs
    - D. Optical attenuation testers (light sources and power meters)

Fiber Optic Cable (FO Cable).

1. Provide 72-count fiber optic cable that meets the following requirements:
  - A. all-dielectric outside plant loose tube cable with central strength/anti-buckling member
  - B. dry water blocking materials and construction
  - C. reverse oscillating "SZ" stranded buffer tube construction
  - D. high tensile strength yarn
  - E. medium density polyethylene outer jacket
  - F. 72 fiber cable with 6 active buffer tubes and 12 individual stranded fibers per buffer tube
  - G. cable construction design that allows no more than 6 buffer tube positions
  - H. maximum diameter 0.48 inches
  - I. maximum weight 0.07 pounds per foot

2. Provide 12-count fiber optic cable that meets the following requirements:
  - A. all-dielectric outside plant loose tube cable with central strength/anti-buckling member
  - B. dry water blocking materials and construction
  - C. reverse oscillating "SZ" stranded buffer tube construction
  - D. high tensile strength yarn
  - E. medium density polyethylene outer jacket
  - F. 12 fiber cable with 1 active buffer tubes and 12 individual stranded fibers per buffer tube
  - G. cable construction design that allows no more than 5 buffer tube positions
  - H. maximum diameter 0.48 inches
  - I. maximum weight 0.07 pounds per foot
3. Provide Corning ALTOS All-Dielectric, Pirelli FlexLink, OFS MiDia, or approved equivalent cables.
4. Designate this cable as a trunk cable.
5. Ensure that the cable can withstand a maximum pulling tension of 600 lbf during installation and 180 lbf installed long term (at rest).
6. Provide cable with shipping, storage, and operating temperature range of -30°C to +70°C.
7. Provide cable with an installation temperature range of -30°C to +60°C.
8. Provide cable with outer jacket marking using the following template:  
Manufacturer's Name – "Optical Cable" – Month/Year of Manufacture - Telephone Handset  
Symbol – "METRO PW" – "72F SM"
9. Include in the outer jacket marking the cable sequential length in accordance with the following:
  - A. In English units every 2 feet
  - B. Within -0/+1% of the actual length of the cable
  - C. In contrasting color to the cable jacket
  - D. Marking font height no less than 0.10 inches
  - E. On any single length of cable on a reel, the sequential length markings do not run through "00000."

#### Fiber Optic Cable Indoor/Outdoor Riser Rated

1. Provide fiber optic plenum rated cable that meets the following requirements:
  - A. All-dielectric inside plant loose tube central core cable
  - B. high tensile strength yarn surrounding the central tube core
  - C. dry water blocking materials and construction
  - D. 72 fiber cable with 6 active buffer tubes and 12 individual stranded fibers per buffer tube
2. Provide Corning Freedom LST All-Dielectric, Pirelli CentralLink, or approved equivalent cables.
3. Designate this cable as building entry.
4. Ensure that the cable can withstand a maximum pulling tension of 300 lbf during installation.
5. Provide cable with shipping, storage, and operating temperature range of -30°C to +70°C and an installation temperature range of -10°C to +60°C.
6. Provide cable with outer jacket marking using the following template:  
Manufacturer's Name – "Optical Cable" – Month/Year of Manufacture - Telephone Handset  
Symbol – "METRO PW" – "72F SM"
7. Include in the outer jacket marking the cable sequential length in accordance with the following:
  - A. In English units every 2 feet
  - B. Within -0/+1% of the actual length of the cable
  - C. In contrasting color to the cable jacket
  - D. Marking font height no less than 0.10 inches
  - E. On any single length of cable on a reel, the sequential length markings do not run through "00000".

#### Fiber Optic Drop Cable (FO Drop Cable)

1. Provide fiber optic drop cable that meets the following requirements:
  - A. all-dielectric outside plant loose tube central core cable
  - B. high tensile strength yarn surrounding the central tube core



- C. dry water blocking materials and construction
- D. 4 individual stranded fibers contained within the central tube core
2. Provide Corning Freedom LST All-Dielectric, Pirelli CentraLink, or approved equivalent cables.
3. Designate this cable as drop cable.
4. Ensure that the cable can withstand a maximum pulling tension of 300 lbf during installation.
5. Provide cable with shipping, storage, and operating temperature range of -30°C to +70°C and an installation temperature range of -10°C to +60°C.
6. Provide cable with outer jacket marking using the following template:  
Manufacturer's Name – "Optical Cable" – Month/Year of Manufacture - Telephone Handset  
Symbol – "METRO PW" – "4F SM"
7. Include in the outer jacket marking the cable sequential length in accordance with the following:
  - A. In English units every 2 feet
  - B. Within -0/+1% of the actual length of the cable
  - C. In contrasting color to the cable jacket
  - D. Marking font height no less than 0.10 inches
  - E. On any single length of cable on a reel, the sequential length markings do not run through "00000".

#### Plenum Rated Nonmetallic Corrugated Raceway

1. Provide plenum rated nonmetallic corrugated raceway inside buildings when cable is not in rigid conduit.
2. Install to conform with NEC articles 770 and 800
3. Provide raceway which meets UL Standards 910 and 2024
4. Provide 2" diameter raceway

#### Fiber Optic Fusion Splice (FO Splice, Fusion)

1. Provide fusion splices for splicing of all fibers on the project. Do not provide any other type of fiber splicing.
2. Perform fusion splicing with a fully automatic portable fusion splicer that provides consistent low loss (max 0.10 dB) splices. Splicer shall provide three-axis fiber core alignment using light injection and loss measurement techniques. The fusing process shall be automatically controlled. The splicer shall provide splice loss measurements on an integral display, as well as a magnified image of the fiber alignment. The Contractor shall retain ownership of the fusion splicer.

#### Fiber Optic Connectors

1. Provide fiber optic connectors compliant with these specifications for all fiber optic infrastructure including, but not limited to, fiber optic termination cabinets, fiber optic drop panels, and fiber optic patch cords.
2. Provide only factory-installed keyed LC compatible connectors for all fiber optic infrastructure. Provide only factory-installed connectors of a type other than LC when required by the Network Switches. Do not use field-installed connectors. Do not use adapter couplers to change connector types.
3. Use ceramic ferrule connectors factory-installed with a thermal-set heat-cured epoxy and machine polished mating face. Install connectors as per Manufacturer application and recommendations, including proper termination to the outer-tubing (900 micron tubing, 3 mm fan out tubing, etc.) required for the application.
4. Use connectors rated for an operating temperature of -40°C to +75°C.
5. Provide connectors that have an installed insertion loss of less than 0.50 dB, a typical loss of 0.20 dB, and an optical return loss of greater than 45 dB.
6. Use simplex connectors for all male LC connectors. Provide latching cover for two male connectors being used in a duplex configuration. Female couplers may be duplex but must allow simplex mating connectors.
7. Label each fiber position on panels and termination cabinets containing duplex couplers with the port/position ID as shown in the Plans.

8. Provide dust caps for all exposed male connectors and female couplers at all times until permanent connector installation.

Fiber Optic Termination Cabinet (FO Termination Cabinet)

1. Provide fiber optic termination cabinets at field junctions as shown in the Plans for termination of 72-fiber outside plant (OSP) cable.
2. Use termination cabinets that are fully compatible with all components of the fiber optic infrastructure as specified, including, but not limited to, fiber optic cable, fiber optic fusion splices, and fiber optic connectors.
3. Use rack-mount termination cabinets designed to fit standard 19-inch EIA equipment racks.
4. Provide all mounting hardware and supports to mount the termination cabinets in the locations shown in the Plans.
5. Use fiber optic termination cabinets providing 72 fiber connectors and capable of storing 72 fusion splices in splice trays.
6. Use termination cabinets that integrate the splice trays and connector modules into one compartment within one cabinet, or houses the splice trays and connector modules in separate compartments integrated into one cabinet.
7. Maximum dimensions of a complete termination cabinet shall be 7 rack units high (12.25 inches) by 16 inches deep.
8. Use fiber optic termination cabinets with fully enclosed metallic construction and with a protective hinged front cover for the connector ports.
9. Provide cable access on all sides of the enclosed area behind the connector port panel.
10. Provide sufficient splice trays for storing 72 fusion splices in 12 or 24 splice increments.
11. Provide termination cabinets with fiber optic connector modules in a 12 fiber configuration of 6 rows of 1 duplex connector couplers.
12. Connector modules shall mount vertically in the termination cabinet front panel.
13. Connector modules shall include clearly legible and permanent labeling of each of the 12 fiber connector couplers, and shall be labeled and identified as shown in the Plans.
14. Provide factory-assembled 12 fiber termination interconnect cables (pigtail cables) to be fusion spliced to the outside plant cable and connected to the rear of the connector modules. Termination interconnect cables shall be all-dielectric single jacketed cable with high tensile strength yarn surrounding 12 individual 900 micron fibers following EIA/TIA-598B color identification with factory-installed connectors.
15. Provide all incidental and ancillary materials including but not limited to grommets, cable strain relief and routing hardware, blank connector panels, and labeling materials.

Fiber Optic Closure (FO Closure)

1. Provide fiber optic closures (splice closures) designed for outside plant use for splicing cables.
2. Use fiber optic splice closures that are impact-and corrosion resistant and waterproof when immersed in 10 feet of water.
3. Use fiber optic splice closures that are fully compatible with all components of the fiber optic infrastructure as specified, including but not limited to fiber optic trunk cable, fiber optic drop cable, and fiber optic fusion splices.
4. Use a cylindrical dome-type splice closure with cable entry at one end only and a sealed single-molded piece dome body of high density polyethylene or equivalent non-metallic material.
  - A. The cable entry end shall be manufactured of a similar material as the dome body and shall seal the closure with flexible thermoplastic rubber or polymer gasket seals.
  - B. The cable entry end shall include cable entrance ports that shall seal the cable and port opening with flexible thermoplastic rubber or polymer gasket seals with mechanical compression.
  - C. Closures shall be re-enterable and re-sealed without the need for specialized tools or equipment, or the use of any additional parts.
  - D. Do not use any heat shrink or caulk/encapsulate materials for sealing the assembled closure or terminated cables.

5. Provide splice closures with maximum outer dimensions of 8.0 inches diameter and 21" length unless otherwise approved by the Engineer.
  - A. Splice closures shall provide cable entrance ports for at least five fiber optic cables.
  - B. At least two cable entrance ports shall accommodate cables of at least 0.60 inches outer diameter.
  - C. The closure shall allow for the storage and express of at least 6 unopened buffer tubes.
6. Provide a splice closure with a cable entry end with pre-template cable ports and a split-plate design permitting installation of the closure in mid-span cable segments.
7. The splice closure size shown in the Plans specifies the minimum number of fusion splices to be accommodated by the closure. With the splice closure, provide all materials to accommodate the number of splices specified by the closure size, including splice tray, storage, and organizing materials.

#### Fiber Optic Drop Panel (FO Drop Panel, 4F)

1. Provide fiber optic drop panels designed for outside plant use for terminating drop cables in equipment cabinets.
2. Use fiber optic drop panels that include the fiber optic drop cable as an integral component.
3. Use fiber optic drop panels that are fully compatible with all components of the fiber optic infrastructure as specified, including, but not limited to, fiber optic trunk cable, fiber optic closures, fiber optic fusion splices, and fiber optic connectors.
4. Use fiber optic drop panels that are factory manufactured assemblies of fiber optic drop cable with factory-installed fiber connectors and integral ruggedized fiber connector enclosures.
5. Use drop panels with 4 fiber (2 duplex LC) connectors.
6. Use ruggedized fiber connector enclosures of thermally stable rigid plastic housings fully potted with a thermally stable epoxy filling that encapsulates the drop cable fan out, fibers and connector bodies.
7. Use permanent labels on the enclosure with contrasting color to identify each connector body by its associated fiber number.
8. Fiber connectors shall be arranged in rows of 1 duplex connector couplers. All fiber connectors shall be arranged on one of the long (vertical) faces of the enclosure.
9. Provide a unique serial number permanently attached on the enclosure body of each drop panel.
10. Provide an outer non-metallic cable strain-relief boot where the drop cable enters the fiber connector enclosure and that secures the cable and to the enclosure; the strain-relief boot shall fully encircle the cable for a minimum of 2 inches from the enclosure's outer surface.
11. Use fiber connector enclosures on the drop panel that are no more than 2 inches wide and deep (the maximum dimension of the enclosure plus fiber connector body) and no more than 11 inches long.
12. Provide a 0.125-inch thick aluminum mounting plate that secures to the fiber connector enclosure. The mounting plate shall have at least four mounting holes near the plate's corners that permit horizontal or vertical mounting flush to a panel, and are spaced appropriately for vertical mounting to an EIA equipment rack rail using two of the mounting holes.
13. Test all completed and assembled fiber optic drop panels at the point of manufacture and provide two copies of the manufacturer test documentation. Test each connected fiber in the drop panel to demonstrate compliance with all requirements for cables and connectors as detailed in these specifications. Include in the test documentation the location station number where the drop panel is to be installed, the serial number of the drop panel, the drop cable sequential length markings at each end of the drop cable, and the total drop cable distance.

#### Cable Labels

1. Provide cable labels that meet the following requirements:
  - A. self-coiling wrap-around type
  - B. PVC or equivalent plastic material with UV and fungus inhibitors
  - C. Base materials and graphics/printing inks/materials designed for underground outside plant use including solvent resistance, abrasion resistance and water absorption

- D. minimum size of 2.5” wide by 2.5” long
  - E. minimum thickness of 0.010”
  - F. orange label body with pre-printed text in bold black block-style font with minimum text height of 0.375”.
2. Pre-print the following text legibly on labels used for all fiber optic trunk cables (FO Cable):  
METRO PW  
OPTICAL CABLE
  3. Pre-print the following text legibly on labels used for all fiber optic drop cables (FO Drop Cable):  
METRO PW  
OPTICAL DROP CABLE
  4. On all cable labels, print the text specified above twice on the label with the text of the second image inverted. The end result shall be text which “reads correctly” when the label is coiled onto a cable.

#### Fiber Optic Patch Cords

1. Provide fiber optic patch cords consisting of a length of fiber optic cable terminated on both ends.
2. All patch cords shall be factory pre-connected assemblies adhering to all applicable cable and fiber specifications stated in these Specifications.
3. Provide patch cords of the appropriate length for the necessary connections, maintaining minimum bend radius, and with no residual strain at the connector or anywhere on the patch cord itself beyond self-support. Patch cords shall not have excess length beyond what is necessary for equipment connection and routing.
4. All patch cords shall be duplex zip-cord fiber cable with simplex LC connectors, except as otherwise allowed in section concerning fiber optic fusion splices.
  - A. The two connectors of each end of the patch cord shall be differentiated by different colors.
  - B. Provide sufficient flexibility at each end to disconnect one connector without disturbing the other, or to allow swapping of the two connectors within the same duplex coupler without disturbing the remainder of the patch cord.
  - C. Provide strain relief and reinforcement at the point where the duplex cable separates for the individual simplex connectors.
5. Fiber cable shall be 3mm jacketed cable with high tensile strength yarn protecting the inner fiber manufactured into a duplex zip-cord configuration. All Inside Plant (IP) patch cords shall meet NEC jacketing requirements.
6. Connector strain relief boots shall be fixed to the outer jacket and strength yarn.
7. Use yellow outer jackets for single mode fiber.
8. No splices of any type are allowed within a patch cord assembly.
9. Fully test each patch cord assembly at the source of manufacture and place those test results on a test tag for each mated pair of connectors. Attach the associated tag to one end of each fiber within the duplex assembly.

#### Fiber Optic Attenuator Patch Cords

1. Provide fiber optic attenuator patch cords that meet all requirements of the section concerning fiber optic patch cords.
2. Each fiber in the attenuator patch cord shall contain a passive optical attenuator with the following performance characteristics:
  - A. Dual-wavelength capability (1310 and 1550nm)
  - B. Fixed attenuation value of 6dB +/- 15%.
  - C. Minimum optical return loss 40 dB
  - D. Operating temperature range no less than -30 to +65 C

#### Project Submittal Program Requirements

1. General Requirements. The Contractor shall provide project submittals for all fiber optic infrastructure as required in the section pertaining to fiber optic termination cabinets, including scheduling requirements. The project submittals for fiber optic infrastructure shall include, but are not limited to, the additional specific requirements in this subsection.
2. Fiber Optic Installation and Testing Tools
  - A. Provide project submittals including manufacturer-recommended operations, maintenance and calibration procedures for the following equipment:
    - (1) Fusion splicers
    - (2) Cable pulling strain dynamometers and breakaway links
    - (3) Cable air jetting/blowing systems
    - (4) OTDRs
    - (5) Optical attenuation testers (light sources and power meters)
  - B. Submit documentation and proof of manufacturer-recommended operator training and certification for the following equipment:
    - (1) Fusion splicers
    - (2) Cable air jetting/blowing systems
    - (3) OTDRs
    - (4) Optical attenuation testers (light sources and power meters)

Installation Requirements. Install all fiber optic infrastructure according to the Manufacturer's recommended procedures and specifications.

#### Cable Shipping and Delivery

1. Package the cable for shipment on reels. Each package shall contain only one continuous length of cable. Construct the packaging so as to prevent damage to the cable during shipping and handling.
2. Seal both ends of the cable to prevent the ingress of moisture.
3. Include with each reel a weatherproof reel tag attached identifying the reel and cable that can be used by the manufacturer to trace the manufacturing history of the cable and the fiber. Include with each cable a cable data sheet containing the following information:
  - A. Manufacturer name
  - B. Cable part number
  - C. Factory order number
  - D. Cable length
  - E. Factory measured attenuation of each fiber
4. Cover the cable with a protective and thermal wrap.
  - A. Securely fasten the outer end of the cable to the reel head so as to prevent the cable from becoming loose in transit.
  - B. Project the inner end of the cable a minimum of 6.5 feet into a slot in the side of the reel or into a housing on the inner slot of the drum, in such a manner to make it available for testing.
  - C. Plainly mark each reel to indicate the direction in which it is to be rolled to prevent loosening of the cable on the reel.

#### Cable Handling and Installation

1. Do not exceed the maximum recommended pulling tension during installation as specified by the cable Manufacturer.
2. Continuously monitor pulling tensions with calibrated measuring devices, such as a strain dynamometer.
3. Protect all pulled installations with calibrated breakaway links.
4. Do not violate the minimum recommended bend radius during installation as specified by the cable Manufacturer. Unless the Manufacturer's recommendations are more stringent, use the following guidelines for minimum bend radius:
  - A. 20 X Cable Diameter Short Term - During Installation

- B. 10 X Cable Diameter Long Term – Installed
- 5. Before cable installation, carefully inspect the cable reels and reel stands for imperfections or faults such as nails that might cause damage to the cable as it is unreeled.
- 6. Take all necessary precautions to protect reeled cable from vandals or other sources of possible damage while unattended. Any damage to reeled cable or the reel itself shall necessitate replacement of the entire cable section at Contractor's expense.
- 7. Whenever unreeled cable is placed on the pavement or surface above a pull box, provide means of preventing vehicular or pedestrian traffic through the area in accordance with the approved Maintenance of Traffic provisions.
- 8. Keep the cable continuous throughout the pull. Cable breaks and reel end splices are permitted only as shown in the Plans.
- 9. Where a cable ends in an underground fiber optic closure, secure and store all unused fibers and buffer tubes in splice trays in preparation for future reel end splicing and continuation.

#### Cable Storage

- 1. Properly store all cable to minimize susceptibility to damage.
  - A. Maintain proper bend radius, both short and long term, during cable storage.
  - B. Storage coils shall be neat in even length coils, with no cross over or tangling.
  - C. Storage coils of different cables shall be kept completely separate except when the cables terminate in the same splice closure.
  - D. Storage coils shall be secured to cable racking hardware with tie wraps, Velcro straps, or non-metallic cable straps with locking/buckling mechanism.
  - E. Do not use adhesive or self-adhering tapes, metal wires and straps, or rope/cord.
- 2. Unless otherwise noted on the plans, the following are the requirements for cable storage for underground applications:
  - A. Trunk cable in Type A pull box – 25 feet
  - B. Trunk cable in Type B pull box – 200 feet
  - C. Drop cable in Type A pull box – 10 feet
  - D. Drop cable in Type B pull box terminated in a splice closure – 10 feet
  - E. Communications hub or Control Center (interior) – Do not store slack cable inside the communications hub building or Control Center.

#### Fiber Optic Fusion Splice (FO Splice, Fusion)

- 1. Perform fusion splicing of all fiber optic splices as shown in the Plans.
- 2. Perform fusion splicing only in enclosed spaces such as splice trailers or tents specifically intended for this operation
- 3. Completed fusion splices shall have no more than 0.10dB optical loss as measured in accordance with the section pertaining to fiber optic patch cords.
- 4. Adequately protect all fusion splices in splice trays in a splice closure or termination cabinet. Provide the splice with strain relief and protection of the stripped fiber splice in a manner recommended by the fiber and the splice tray manufacturers.
- 5. Use fusion splice protectors of a heat shrink tubing that protects the splice and extends over the fiber coating. Splice protectors shall be compatible with and as recommended by the fiber and the splice tray manufacturers.
- 6. No bare fiber may be exposed.

#### Fiber Optic Termination Cabinet (FO Termination Cabinet)

- 1. Install only one outside plant cable per termination cabinet, including within the separate splice tray storage compartment is so equipped. Install the connector modules for fibers 1 through 72 as shown in the Plans. Equip any remaining unused connector module slots with blank panels.
- 2. Install all fibers, buffer tubes, and cables following minimum internal and external bend radius, proper management, routing, fastening and protection, and with no residual strain on any connector, fiber, buffer tube or cable.

3. Install one cable buffer tube to one termination cabinet interconnect cable, matching fiber to fiber. Keep all fibers of the outside plant cable buffer tube and its corresponding termination interconnect cable complete within the same splice tray.
4. Label the front and rear of the termination cabinets with the trunk cable segment ID of the cable terminated within; use permanent clearly legible labels with minimum 0.5 inch text height.
5. Label each end of termination cabinet interconnect cables to identify the 12 trunk cable fibers/buffer tube connected; use permanent overlapping cable labels with clearly legible text.

#### Fiber Optic Closure (FO Closure)

1. Install fiber optic splice closures where and of the size shown in the Plans. Install splice closures in the center  $\pm$  3 feet of the entire length of stored cable coils, or install at the end of cables that terminate in the pull box.
2. Store FO closures and cable coils on the pull box cable rack hooks. Keep all closures and cable coils off of the bottom of the pull box. Secure closures and/or cable coils as needed to hold them in place.

#### Fiber Optic Drop Panel (FO Drop Panel, 4F)

1. Prior to factory manufacture of fiber optic drop panels, verify the final installed location of all portions of each drop cable route from the splice closure to the equipment cabinet (including, but not limited to, the cabinet location, all conduit and pull boxes, and the splice closure location) to determine the required length of drop cable, including all splice closure and storage coils, to be factory manufactured with each drop panel. Do not use the plans quantity for determining the drop cable length to be factory manufactured.
2. Using the drop panel mounting plate, install drop panels on the side panel or equipment cabinets. Mount the fiber optic drop panel with the connectors horizontal or facing downward, and route the drop cable up or down as necessary. Route and secure the drop cable such that it is fully strain-relieved, does not violate the manufacturer's recommended bending radius, and does not interfere with the operation of or access to any cabinet equipment or electrical components.
3. Place one copy of the manufacturer test documentation in the equipment cabinet, where the drop panel is installed, and submit the other copy to the Engineer.

#### Cable Labels

1. Install cable labels on all trunk and drop fiber optic cables. Clean the installed cable of all dirt and grease before applying any label.
2. Label all cables in or at every location where the cable is exposed outside of a conduit, innerduct or pole, using the cable IDs for trunk cables or the device number for drop cables. As a minimum, install cable labels in the following locations:
  - A. Within 12 inches of every cable entry to a pull box, equipment cabinet, communications hub, or the TMC.
  - B. Within 12" of the exterior entry point of every fiber optic splice closure, termination cabinet, and drop panel.
  - C. Every 30 feet for the entire length of cable in any storage coil in pull boxes.

#### Fiber Optic Patch Cords

1. Install fiber optic patch cords to connect all electronic equipment with the fiber optic infrastructure. Follow port assignments as shown in the Plans.
2. Install fiber optic patch cords to connect all active optical paths between fiber optic termination cabinets in communications hubs as shown in the Plans.
3. Neatly route and dress all patch cords to the connected devices and within cable management facilities.

Fiber Optic Attenuator Patch Cords. Provide fiber optic attenuator patch cords in accordance with the section pertaining to fiber optic drop panels.

### Project Testing

1. General Requirements
  - A. The Contractor shall conduct a project testing program for all fiber optic infrastructure as required in the section pertaining to plenum rated nonmetallic corrugated raceways. The project testing program for fiber optic infrastructure shall include but is not limited to the additional specific requirements in this subsection.
  - B. All test results shall confirm physical and performance compliance with these specifications including, but not limited to, optical fibers and fusion splices. No event in any given fiber may exceed 0.10 dB. Any event measured above 0.10 dB shall be replaced or repaired at the event point.
  - C. In addition to the notification requirements of the section pertaining to plenum rated nonmetallic corrugated raceways, provide the tentative date, time and location of fiber optic infrastructure testing no less than 7 days in advance of the test. Provide confirmed date, time and location of fiber optic infrastructure testing no less than 48 hours before conducting the test.
  - D. Provide test results documentation in electronic format (1 copy) and printed (3 copies) format. Electronic formats shall be readable in Microsoft Excel or other approved application. Printed copies shall be bound and organized by cable segment.
  - E. Provide all test results in English units of measure of length.
  - F. Submit all test results documentation to the Engineer within 14 days of completion of the tests. The Engineer will review test documentation in accordance with the Submittal Review Process in the section pertaining to fiber optic termination cabinets.
2. Pre-Installation Test (PIT)
  - A. Perform a PIT on all FO Cable prior to any cable removal from the shipping reels. Perform a PIT on each cable reel delivered to the job site.
  - B. The PIT for FO Cable shall include but is not limited to:
    - (1) A visual inspection of each cable and reel
    - (2) An OTDR Test and documentation as required in the SAT below, for three randomly selected fibers from each buffer tube.
    - (3) An Optical Attenuation Test is not required. If the contractor decides to perform one for his/her own protection, said test should be documented and provided to the Engineer.
3. Standalone Acceptance Test (SAT)
  - A. Perform an SAT on all fiber optic infrastructure on this project after field installation is complete including, but not limited to, all splicing and terminations.
  - B. An SAT for each fiber in each cable shall include OTDR Tests and Optical Attenuation Tests.
  - C. All fibers in all FO Cables and FO Drop Cables shall be tested from termination point to termination point, including:
    - (1) fibers from FO Termination Cabinet to FO Termination Cabinet
    - (2) fibers from FO Termination Cabinet to FO Drop Panel
    - (3) fibers from FO Drop Panel to FO Drop Panel
    - (4) fibers from FO Termination Cabinet to the end of the cable run in the last FO Closure.
  - D. All test results shall confirm compliance with these specifications including but not limited to optical fibers and fusion splices. No event in any given fiber may exceed 0.10 dB. Any event measured above 0.10 dB shall be replaced or repaired at the event point.
  - E. Test documentation shall include but is not limited to:
    - (1) Cable & Fiber Identification
      - a. Cable & Fiber ID and Location – Physical location (device ID and station number of FO Termination Cabinet, FO Drop Panel, or cable end FO closure), fiber number, and trunk or drop cable ID for both the beginning and end point.
      - b. Operator Name
      - c. Engineer's Representative
      - d. Date & Time
    - (2) Setup and Test Conditions Parameters
      - a. Wavelength



- b. Pulse width Optical Time Domain Reflectometer (OTDR)
- c. Refractory index (OTDR)
- d. Range (OTDR)
- e. Scale (OTDR)
- f. Ambient Temperature
- (3) Test Results for OTDR Test (each direction and averaged)
  - a. Total Fiber Trace (miles)
  - b. Splice Loss/Gain (dB)
  - c. Events > 0.05 dB
  - d. Measured Length (Cable Marking)
  - e. Total Length (OTDR Measurement)
- (4) Test Results for Attenuation Test (each direction and averaged)
  - a. Measured Cable Length (Cable Marking)
  - b. Total Length (OTDR Measurement from OTDR Test)
  - c. Number of Splices (Determined from As-Builts)
  - d. Total Link Attenuation
- F. OTDR Test
  - (1) Conduct the OTDR Test using the standard operating procedure and recommended materials as defined by the manufacturer of the test equipment.
  - (2) Use a factory patch cord (“launch cable”) of a length equal to the “dead zone” of the OTDR to connect the OTDR and the fiber under test.
  - (3) Conduct bi-directional OTDR Tests for each fiber. Calculate bi-directional averages.
  - (4) Conduct all tests at 1310 and 1550 nm for single mode cable.
- G. Optical Attenuation Test
  - (1) Conduct the Optical Attenuation Test using the standard operating procedure and recommended materials as defined by the manufacturer of the test equipment.
  - (2) Conduct bi-directional Optical Attenuation Tests for each fiber. Calculate bi-directional averages.
  - (3) Conduct all tests at 1310 and 1550 nm for single mode cable.

### Measurement

#### Fiber Optic Cable (FO Cable, 12F)

Fiber Optic Cable (FO Cable, 12F) will be measured in units of linear feet and paid for at the contract price per linear foot. The price bid shall include, the length in feet of actual cable installed as measured from the cable sequential length markings, cable labels, patch cords, ancillary and incidental materials, testing, documentation and all labor and equipment necessary to complete the work. No measurement for payment will be made for cable storage amounts in excess of that required in these specifications or the Plans. This price shall be full compensation for all labor, tools, materials, equipment and incidentals necessary to complete the work.

#### Fiber Optic Cable (FO Cable, 72F)

Fiber Optic Cable (FO Cable, 72F) will be measured in units of linear feet and paid for at the contract price per linear foot. The price bid shall include, the length in feet of actual cable installed as measured from the cable sequential length markings, cable labels, patch cords, ancillary and incidental materials, testing, documentation and all labor and equipment necessary to complete the work. No measurement for payment will be made for cable storage amounts in excess of that required in these specifications or the Plans. This price shall be full compensation for all labor, tools, materials, equipment and incidentals necessary to complete the work.

#### Fiber Optic Cable Indoor/Outdoor (FO Cable, 72F)

Fiber Optic Cable Indoor/Outdoor (FO Cable, 72F) will be measured in units of linear feet and paid for at the contract price per linear foot. The price bid shall include, the length in feet of actual cable installed as measured from the cable sequential length markings, cable labels, patch cords, ancillary and incidental

materials, testing, documentation and all labor and equipment necessary to complete the work. No measurement for payment will be made for cable storage amounts in excess of that required in these specifications or the Plans. This price shall be full compensation for all labor, tools, materials, equipment and incidentals necessary to complete the work.

Fiber Optic Drop Cable (FO Drop Cable, 4F)

Fiber Optic Drop Cable (FO Drop Cable, 4F) will be measured in units of linear feet and paid for at the contract price per linear foot. The price shall include the length in feet of actual cable installed as measured from the cable sequential length markings, fiber optic connectors, cable labels, patch cords, manufacture with the fiber optic drop panel, ancillary and incidental materials, testing, documentation and all labor and equipment necessary to complete the work. No measurement for payment will be made for cable storage amounts in excess of that required in these specifications or the Plans. This price shall be full compensation for all labor, tools, materials, equipment and incidentals necessary to complete the work.

Fiber Optic Closure (FO Closure)

Fiber Optic Closure (FO Closure) will be measured in units of each and paid for at the contract price per each. The price bid shall include but not limited to cable labels, patch cords, mounting hardware, ancillary and incidental materials, testing, documentation and all labor and equipment necessary to complete the work. This price shall be full compensation for all labor, tools, materials, equipment and incidentals necessary to complete the work.

Plenum Rated Nonmetallic Corrugated Raceway

Nonmetallic Corrugated Raceway will be measured in units of linear feet and paid for at the contract price per linear foot. The price shall include the length in feet of actual raceway installed as measured by the cable sequential length markings installed in the raceway, hangers, tape, and any ancillary and incidental materials necessary to complete the work.

Fiber Optic Connectors

Fiber Optic Connectors are included in the quantities of other pay items and will not be measured separately for payment.

Fiber Optic Splice, Fusion (FO Splice, Fusion)

Fiber Optic Splice, Fusion (FO Splice, Fusion) will be measured in units of each and paid for at the contract price per each. The price bid shall include but not limited to all ancillary and incidental materials, testing, documentation and all labor and equipment necessary to complete the work. This price shall be full compensation for all labor, tools, materials, equipment and incidentals necessary to complete the work.

Fiber Optic Termination Cabinet (FO Termination Cabinet)

Fiber Optic Termination Cabinet (FO Termination Cabinet) will be measured in units of each and paid for at the contract price per each but not limited to fiber optic connectors, cable labels, patch cords, splice tray, mounting hardware, ancillary and incidental materials, testing, documentation and all labor and equipment necessary to complete the work. This price shall be full compensation for all labor, tools, materials, equipment and incidentals necessary to complete the work.

Fiber Optic Drop Panel (FO Drop Panel, 4F)

Fiber Optic Drop Panel (FO Drop Panel, 4F) will be measured in units of each and paid for at the contract price per each. The price bid shall include but not limited to fiber optic connectors, cable labels, patch cords, manufacture with the fiber optic drop cable, mounting hardware, ancillary and incidental materials, testing, documentation and all labor and equipment necessary to complete the work. This price shall be full compensation for all labor, tools, materials, equipment and incidentals necessary to complete the work.

Cable Labels

Cable Labels are included in the quantities of other pay items and will not be measured separately for payment.

#### Fiber Optic Patch Cords

Fiber Optic Patch Cords are included in the quantities of other pay items and will not be measured separately for payment.

#### Fiber Optic Attenuator Patch Cords

Fiber Optic Attenuator Patch Cords are included in the quantities of other pay items and will not be measured separately for payment.

#### Payment

The contract unit price shall be full compensation for all work specified in this Section. Payment will be made according to standard TDOT item numbers.

Fiber optic infrastructure, except as specified below, will be paid per linear foot or per each, as applicable, as follows:

- 25% of the contract unit price upon delivery and PIT test.
- Additional 35% of the contract unit price for complete installation of cables.
- Additional 30% of the contract unit price for completion of SAT testing and documenting of all fibers in any linear foot and in each splice or termination/connection location, and submission of and acceptance of all test documentation.
- Final 10% of the contract unit price upon Final System Acceptance.

Fiber optic splices, fusion, will be paid per each as follows:

- 60% of the contract unit price upon completion of the splice.
- Additional 30% of the contract unit price for completion of SAT testing and documenting of all fibers in any linear foot and in each splice or termination/connection location, and submission of and acceptance of all test documentation.
- Final 10% of the contract unit price upon Final System Acceptance.

**730.18—Conductors.** Traffic Control Conductors shall be rated at 600 volts. All conductors, except loop conductors and cables run along messengers, shall be run in conduit except where run inside poles. Where signal conductors are run in lighting standards containing high voltage street lighting conductors, the signal conductors shall be encased in flexible or rigid metal conduit. Where telephone circuits are introduced into controller foundations, the telephone conductors shall be encased in flexible metal conduit, and shall also conform to regulations of the Code. Fiber-optic cable shall be encased in PVC Schedule 80 conduit.

Conductors for traffic loops shall be continuous AWG No. 14 (2.08 mm<sup>2</sup>) XLP stranded wire to the detector terminals or splice with shielded detector cable within a pull box or pole base.

Detector cable shall be 2 conductor twisted pair shielded AWG No. 14 (2.08 mm<sup>2</sup>) stranded meeting IMSA Specification No. 19-2.

**730.19—Cable.** All signal cable shall conform to applicable IMSA Specification No. 19 or 20. Stranded cable color-coded AWG No. 14 (2.08 mm<sup>2</sup>) shall be used for all signal and accessory circuits. All circuit runs shall retain the same color identification throughout its entire length. Communications cable shall be shielded 12 pair AWG No. 19 solid meeting IMSA Spec 20-2 unless otherwise specified by the Engineer. All communication conductors shall retain the same color code throughout its entire length.

Fiber optic cable, with the required fiber count, shall conform to RUS CFR 1755.900. Provide cable with all fibers that are useable and with a surface sufficiently free of imperfections and inclusions to meet optical, mechanical, and environmental requirements. Distinguish each fiber and buffer tube from others by means of color coding that meets EIA/TIA-598 *Color Coding of Fiber Optic Cables*.

#### **730.20—Wiring.**

1. All wiring shall be terminated to screw terminals by means of lugs.

2. All splices shall be made with solderless connectors and shall be insulated with weatherproof tape applied to a thickness equal to the original insulation.
3. Cables shall be attached to messenger by means of non-corrosive lashing rods or stainless steel wire lashings. Stainless steel lashing wire shall not be allowed on traffic signal spans.
4. All wiring within enclosed cabinets shall be neatly formed and harnessed and shall have sufficient length for access servicing.
5. Splicing of 120V signal cable shall not be allowed in conduit, pull boxes or other non-accessible locations. Splicing of any signal related cable shall be pre-approved by the Metropolitan Department of Public Works (MDPW).

**730.21—Service Connection.** Service connection details, metering, etc. shall be coordinated with the local utility as directed by the Engineer and shall conform to the MDPW requirements. The Contractor shall be responsible for obtaining the necessary service for each installation. A remote disconnect shall be installed with 50 amp, 2 pole switch in weatherproof housing.

**730.22—Sealant.** All sealant material shall be on the qualified products list maintained by the Department's Material and Test Division for sealing saw cuts. It shall resist the upward movement of loop and lead-in and shall exhibit stable dielectric characteristics, including a low permittivity and high dielectric strength. It shall bond to the roadway paving material preventing entry of moisture and shall remain flexible without melting through all anticipated temperature and weather conditions.

**730.23—Strand Cable.** Span cable for suspending signal heads between pole supports shall be 7-strand, Class A, copper-covered steel wire strand or greater, Extra High Strength (12,500 LB Minimum Breaking Strength) grade meeting the requirements of ASTM A 475, with a minimum breaking strength as noted in the Plans. An acceptable alternate is 7-strand steel wire with a Class A zinc coating meeting the requirements of ASTM A 475, with a minimum breaking strength as indicated in the Plans.

Strand cable for messenger wire use (other than span wire above) and for pole guy cable shall be of the diameter(s) indicated in the Plans and shall meet the requirements of ASTM A 475 for zinc-coated steel wire strand, 7-strand Siemens-Martin Grade with Class A zinc coating or greater, High Strength (6,500 LB Breaking Strength) grade with a class A zinc coating.

A Figure 8 cable combining the messenger cable and conductor cable in an insulated jacket is an acceptable alternate to conductor cable lashed to a messenger cable.

**730.24—Bonding and Grounding.** Metallic cable sheaths, conduit, transformer bases, anchor bolts, and metal poles and pedestals shall be made mechanically and electrically secure to form a continuous system, and shall be effectively grounded. Bonding and grounding jumpers shall be copper wire or copper strap of not less than the same cross sectional area as No. 6 AWG (13.3 mm<sup>2</sup>).

A ground electrode shall be furnished and installed at each service point. Ground electrodes shall be one-piece lengths of copperweld ground rod not less than 8 ft.(2.4 m) in length and 1/2 in. (13 mm) in diameter, installed in accordance with the Code. Grounding of conduit and neutral shall be accomplished as required under the Code except that grounding conductors shall be No. 6 AWG (13.3 mm<sup>2</sup>) or approved equal, minimum. Exposed ground conductors shall be enclosed in 1/2 in.(13 mm) diameter conduit and shall be bonded to the electrode with a copperweld ground clamp.

**730.25—Field Test.** Prior to completion of the work, the Contractor shall cause the following tests to be made on all traffic signal and lighting circuits in the presence of the Engineer:

1. Test for ground in circuit.
2. A megger test on each circuit between the circuit and ground. The insulation resistance shall be not less than the values specified in Section 119 of the Code.
3. A functional test in which it is demonstrated that each and every part of the system functions as specified or intended herein.

4. All detector loops and leads shall be tested before and after they are sealed in the pavement to be sure there are no shorts to ground in the system and to assure that the loop plus lead-in inductance is within the operating range of the detector.

Any fault in any material or in any part of the installation revealed by these tests shall be replaced or repaired by the Contractor in a manner approved by the Engineer, and the same test shall be repeated until no fault appears.

**730.26—Inspection.** After completion of the installation and before final acceptance of the project a full operational check of the system under actual traffic conditions shall be made as part of the inspection. The operational check shall cover a minimum time period of 30 calendar days. During this period the Contractor shall perform any necessary adjustments and replace any malfunctioning parts of the equipment required to place the system in an acceptable operational condition at no extra compensation. All work and materials to be performed or furnished under these specifications shall be subject to the direct supervision and inspection of the Engineer and in all respects shall meet with his approval as conforming with the provisions and requirements prescribed herein. He and his authorized representatives, shall at all times be given access to the work or any part thereof, and to any plant, yard, shop, mill or factory where, or in which, any article or material to be used or furnished in connection with such work is being prepared, fabricated or manufactured; and the Contractor will be required to provide every reasonable facility for obtaining full and sufficient information relative to the performance of the work and the character of materials, and for ascertaining that the quality of workmanship and materials is in accordance with the intent of these specifications. Warranty for the work shall begin at the time the traffic signal is activated.

The work shall be performed only in the presence of the Engineer or Inspector appointed by the Engineer, unless permission to do otherwise has first been obtained; and any thereof that is performed or constructed during the absence of Engineer or inspector, without such permission having been so granted, either expressly or by implication, will be subject to rejection.

The inspection of the work, however, shall not relieve the Contractor of any obligation to properly fulfill his contract as prescribed; and if the work or any part thereof, or any materials used in connection therewith, are found to be defective or unsuitable at any time prior to final acceptance, he will be required to forthwith make good or replace such defective or unsuitable work or material.

Application for an Engineer or Inspector in connection with work under these specifications shall be made by the Contractor at least 24 hours before the services thereof will be required.

## **SIGNAL HEADS**

**730.27—Signal Heads.** Each vehicle signal head shall be of the adjustable, colored lens, vertical type with the number and type of lights detailed herein and as shown on the Plans; shall provide a light indicator in one direction only; shall be capable of adjustment (without attachments) through 360° about a vertical axis; and shall be mounted as shown on the Plans or as specified by the Engineer. The arrangement of the lenses in the signal faces shall be in accordance with the **MUTCD**. All lenses shall be glass. All circular indications shall use 12 in. (300 mm) lenses unless otherwise shown on the Plans. All arrow indications shall use 12 in. (300 mm) lenses. All new vehicle signal heads installed at any one intersection shall be of the same style and from the same manufacturer. All signal heads, signal head mountings, and outside of hoods shall have one or more coats of primer followed by two coats of high quality synthetic resin enamel of Traffic Signal Yellow or Lusterless Black Enamel (as noted on Plans) and shall meet or exceed Federal Specifications TTC-595 Gloss Yellow.

Louvers as specified, interior of signal hoods, and backplates shall have one or more coats of primer followed by two coats of Lusterless Black Enamel meeting or exceeding Master Painters Institute (MPI) Reference 94. All factory enameled equipment and materials shall be examined for damaged paint after

installation, and such damaged surfaces shall be repainted to the satisfaction of the Engineer. Factory applied enamel finish in good condition and of appropriate color will be acceptable.

Suspensions for span wire mounting of multi-faced signal heads and signal head clusters (such as a five-section signal head) shall include an approved swivel type balance adjuster for proper vertical alignment.

Signal heads shall be fabricated from die-cast bodies. Sand castings will not be acceptable.

All signal head wire entrances shall use a rubber gasket to prevent chaffing of signal cable by signal head movement.

All signal heads must meet the minimum requirements for adjustable face vehicle traffic control signal heads as specified in ITE Technical Report No. 1 (1970) and its latest revisions.

In addition to these standards the following will be applicable:

Optical Units—Signal indications shall be L.E.D. type and meet standards set forth by the I.T.E. for light output. All LED lenses shall have a minimum five-year warranty.

Signal Head Mounting and Mounting Brackets—Signal heads shall have either integral serrations or shall be equipped with positive lock rings and fittings designed to prevent heads from turning due to external forces. Lock ring and connecting fittings shall have serrated contacts. Signals shall be provided with water-tight fittings using neoprene washers. Each signal head shall be secured to the assembly with a tri-stud type connection.

Bracket mounted signal heads, as shown on the Plans, shall be supported by mounting brackets consisting of assemblies of 1-1/2 in. (38 mm) standard pipe size. All members shall be either plumb or level, symmetrically arranged, and securely assembled. Construction shall be such that all conductors are concealed within poles and mounting assembly. Each slip fitter shall be secured to the pole.

Directional Louvers—Where shown on the Plans, louvers shall be furnished and installed in the hoods of the signal head sections designated.

Directional louvers shall be so constructed as to have a snug fit in the signal hoods. The outside cylinder and vanes shall be constructed of a nonferrous metal or galvanized sheet steel. Louvers shall be painted with two coats of black enamel as specified in these specifications.

Backplates—Where shown on the Plans, backplates shall be furnished and attached to the signal heads. All backplates shall be louvered and constructed of 3,003, half-hard, 0.051 in. (1.30 mm) minimum thickness aluminum sheet. In fabricating backplates, the inside vertical edges, adjacent to the signal head, shall be bent back forming mounting brackets for attaching to the signal. Backplates are to be formed in two or more sections and bolted together, thus permitting installation after signal heads are in place. Backplates shall have a dull black appearance with a 1" minimum yellow retro reflective border around the perimeter of the backplate. The retro reflective border is to be made of a Type III prismatic material.

Wiring—Signal head leads shall be No. 18 AWG (0.82 mm<sup>2</sup>) stranded with 221° F (105° C) thermoplastic insulation. A separate white (common) lead shall be wired to each socket shell; and a colored lead, corresponding to the color code specified in the Plans, shall be wired to each socket terminal. Leads shall be of sufficient length to allow connection to the terminal block specified herein. Each complete signal head shall be provided with a minimum 4-point terminal block, properly mounted in a signal section. Stud type terminal blocks shall have not less than ¼ in. (6 mm) edge clearance to any portion of the stud. Exterior wiring shall have a 360° drip loop in advance of entering the head.

Spare conductors shall be provided for each signal head. Vehicular signal heads shall be wired with a 7-conductor cable to each signal head from the hand hole to the signal head. Cables shall be one continuous length to each head, with no splices being permitted. The individual 7-conductor cables will be spliced in the pole base with a 12-conductor cable run from the pole base to the controller. All spare conductors shall be terminated in the signal head and grounded in the controller cabinet. Pedestrian signal shall be wired using 7-conductor cable, and pedestrian pushbuttons shall be wired using 2-conductor shielded cable.

Pedestrian Signals—When shown on the Plans, pedestrian signals shall conform to the following:

1. Pedestrian indications should attract the attention of and be readable to the pedestrian both day and night and at all distances from 10 ft. (3 m) to the full width of the area to be crossed.
2. All pedestrian indications shall be rectangular in shape and shall consist of the filled symbol messages Hand and Man. For the purposes of these specifications the messages MAN and HAND shall be interpreted to be equivalent to the international symbols of a "Walking Figure" and "Upraised Hand", respectively. Countdown pedestrian heads shall be of the "self learning" type, which does not require separate programming, for the HAND indication. All new pedestrian indications shall be countdown type.
3. When illuminated, the MAN indication shall be lunar white meeting ITE standards, with an opaque material obscuring all but the letters
4. When illuminated, the HAND indication shall be Portland Orange meeting ITE standards, with an opaque material obscuring all but the letters.
5. When not illuminated, the MAN and HAND messages shall not be distinguishable by pedestrians at the far end of the crosswalk they control.
6. All pedestrian indications shall be L.E.D. type and meet ITE specifications for light output. Indications shall have a five-year minimum warranty.

Countdown pedestrian signals shall conform to the following:

1. The requirements of the **MUTCD**.
2. Applicable provisions of the current specification of the Institute of Transportation Engineers standard titled Vehicle Traffic Control Signal Heads – Part 2: L.E.D. Vehicle Traffic Signal Modules (VTCSH Part 2).
3. Current specification of the Institute of Transportation Engineers standard titled Pedestrian Traffic Control Signal Indications (PTCSI).
4. FCC Title 47, Subpart B, Section 15 on Emission of Electronic Noise.
5. Current NEMA Standard TS-2 for operational compatibility.

The manufacturer must supply certification, which includes a copy of the test report by an independent technical laboratory as to the module compliance with ITE specifications (where it applies). The report shall also indicate that the tests were performed only after the modules received a thirty (30) minute operational warm-up period immediately preceding the tests.

The housing door, door latch, and hinges shall be of aluminum, or approved equal. Hinge pins shall be stainless steel. The door shall be provided with a neoprene gasket capable of making a weather resistant, dust-proof seal when closed, and shall be clam shell design.

All pedestrian signal heads, mountings, outside of hoods, and pedestrian push button housings shall have one or more coats of primer followed by two coats of high quality synthetic resin enamel of Traffic Signal Yellow, and shall meet or exceed Federal Specifications TTC-595 Gloss Yellow. The interior of signal hoods shall have one or more coats of primer followed by two coats of Lusterless Black Enamel meeting or exceeding Federal Specifications TT-E-489. All factory enameled equipment and materials shall be examined for damaged paint after installation, and such damaged surfaces shall be repainted to the satisfaction of the Engineer. Factory applied enamel finish in good condition and of appropriate color will be acceptable.

Signal Head Installation—Signal heads shall be installed with the faces completely covered until the entire installation is ready for operation.

Audible Pedestrian Signals—When shown on the plans, audible pedestrian signal shall conform to the following:

1. Size: 5" X 3.75" X 5"
2. Weight: 3 lbs.
3. Humidity range: 5 to 95% Relative Humidity.
4. Colors: Olive Green, Federal Yellow, Flat Black, or Gloss Black Aluminum
5. Output: Cuckoo (north/south) {Duration 0.6 seconds +/- 20%, Frequency 1,100 Hz +/- 20%, and Frequency Deviation +120 Hz +/- 20% } and Peep-Peep (east/west) {Duration 0.2 seconds +/- 20%, Frequency 2,800 Hz +/- 20%, Frequency Deviation -800 Hz +/- 20% }
6. Voltage: 115 Volts AC (+/- 22%)
7. Power: 60Hz, 3 Watts
8. Temperature Range: -35F to +165F
9. Output: 90dB @ 1 watt/1 meter

## **CONTROLLERS – GENERAL**

### **730.28—Controllers: (CU)**

A controller shall consist of the complete electrical mechanism for controlling the operations of traffic control signals, including the timing mechanism and necessary auxiliary equipment, mounted in a cabinet.

The controller unit shall be Econolite® Cobalt-C Series, or approved controller compatible with Centrac<sup>TM</sup> central software. The controller shall be fully compliant with the ATC 5.2b and proposed ATC Standard 6.10. The controller shall support Linux-based software.

Control features are to include:

1. The controller unit shall meet the environmental requirements as set forth in Section 2 of the NEMA Standards Publication No. TS 2-2003 or later revision.
2. The controller shall be 10/100 Base T Ethernet ready.
3. The controller unit shall be solid state, digital based upon microprocessor design.
4. It shall utilize an input/output interface set forth in Section 3.5 of NEMA Standard Publication TS 2 – 2003 or later revision for Malfunction Management Units and Detector Racks.
5. NEMA Section 3.5.2 shall be used for input/output functions for Terminal Facilities, Detectors, and Auxiliary Devices.
6. The controller shall be capable of operating as a TS-2 type A 1 or type A 2.
7. The following interface connectors shall be accessible from the front of the controller:
  - A. Connector A shall mate with MS3116(-)-22-55S
  - B. Connector B shall mate with MS3116(-)-22-55P
  - C. Connector C shall mate with MS3116(-)-24-61P
    - (1) SDLC - 15 pin metal shell D sub-miniature (gold plated female contacts)
    - (2) RS 232 - 25 pin metal shell D sub-miniature (gold plated female contacts)
    - (3) RJ-45 10/100 Base T Ethernet Port
8. If input/output or communications functions in addition to those covered in TS 2-2003 are requested in the plans and supplied, an additional connector may be used.
9. PROGRAMMING METHODS: The methods listed below shall be available for Controller Unit programming:
  - A. Manual data entry via the front panel keyboard.
  - B. Data downloading via central system.
  - C. Data downloading from a Personal Computer.



- D. Data downloading from one Controller Unit to another using the serial port of each Controller Unit.
  - E. Data Download via USB Flash Drive
  - F. Firmware shall be flashable via computer or USB drive.
10. Controller functionality is to include:
- A. 16 phases, 8 configurable concurrent groups in 4 timing rings
  - B. 16 vehicle overlaps that can be configure as normal, green / yellow, PPLT / FYA
  - C. 16 pedestrian phases that can be configured as pedestrian overlaps
  - D. Exclusive pedestrian operation
  - E. Dynamic max operation
  - F. Extendable walk and pedestrian clearance
  - G. Advanced Walk
  - H. Bike input and green timing
  - I. Adaptive red clearance
  - J. Transit Signal Priority
  - K. Emergency and Railroad preemption
11. Coordination features are to include:
- A. 120 coordination event plans, each with its own cycle, offsets, split timing, coordinated phases, vehicle and pedestrian recall and phase omits
  - B. Offset and Split entries displayed in percent or seconds
  - C. Automatic permissive periods
  - D. Fixed or floating force-off
  - E. Crossing arterial coordination
12. The controller shall have all of the following keyboard entered values or parameters:
- (1) Phases to start in
  - (2) Phase display to be on
  - (3) Overlap display start-on condition
13. Normal start-up display shall be main street green phase(s), with concurrent overlaps green.
14. The controller shall have a backlit liquid crystal display to provide an English language menu for programming with displays for programming or reading all controller features. The dynamic displays for real-time operation shall be able to display the following values for each ring or phase(s) concurrently:
- A. Per Phase Display:
    - (1) Phase Vehicle Call
    - (2) Phase Pedestrian Call
    - (3) Phase is next in Service
    - (4) Phase is in Service
    - (5) Phase Pedestrian Intervals in Service
  - B. Per Ring Display:
    - (1) Ring Gapped Out
    - (2) Ring Maximum Green Termination
    - (3) Ring was Force off Terminated
    - (4) Ring Maximum Green II in effect
  - C. Ring Phase in Service Operating:
    - (1) Lock Call
    - (2) Non-Lock Call
    - (3) Minimum Recall
    - (4) Maximum Recall
    - (5) Pedestrian Recall
    - (6) Non-Actuated Mode
  - D. Per Ring Display of Timing Values (Real Time). The following values shall be selectable displayed and shall display the current value in a real time mode:
    - (1) Minimum Green Interval
    - (2) Passage Timer

- (3) Pedestrian Interval Timing
  - (4) Maximum Green Timer
  - (5) Time before Reduction Timer
  - (6) Time to Reduce Timer
15. It shall be possible to inspect and alter any currently programmed value while the controller is in operation without affecting the field operation. The controller shall continue to operate the intersection as values are inspected or altered. This requirement does not apply to ring structure or other programmed values which require the controller to perform a start-up sequence.
  16. All controllers firmware shall be flashable and software shall be supplied with revisions of firmware to flash into the controller. The city requires ongoing firmware support for the life cycle of the product.

All operator entered data shall be stored on a USB Flash Drive or SD Card

#### Documentation

1. A schematic wiring diagram and maintenance manual shall be provided for all equipment.
2. If a separate operations manual is published it shall also be provided. All documentation will be provided in two hard copies and in PDF electronic format.
3. The manual shall show in detail all circuits and parts. Such parts shown shall be identified by common name and part number.
4. Any manufacturer unique components will be identified as such.

Training—When four or more controller assemblies are provided under a contract, the contractor will provide a training secession for up to eight staff members. This session shall be within Davidson County and include:

1. 4 hours of classroom instruction
2. 4 hours of laboratory instruction
3. Theory of operation
4. Detailed troubleshooting techniques
5. Use of technical data including parts identification

Malfunction Management Unit (MMU)—All cabinets shall be supplied with a Malfunction Management Unit (MMU) which meets the requirements set forth in Section 4 of the NEMA Standards Publication No. TS 2-2003 or later revision. The MMU shall be the 16-channel type, and shall have the following features:

1. Liquid Crystal Display to show all data in English language format.
2. Capable of being configured to work in a NEMA TS-2 12 channel mode.
3. Shall monitor all Green/Yellow/Red/Walk field display outputs.
4. Shall be installed with Controller 24 VDC monitor not latched
5. Shall be installed with the Controller Voltage Monitor not latched.
6. Front panel mounted over-current protection (no internally mounted fuses are acceptable).
7. Front panel mounted reset switch.
8. The MMU shall log all faults as to the:
  - A. Date of fault
  - B. Time of fault
  - C. Fault condition
  - D. Power failure
9. The MMU shall store fault conditions in non-volatile memory for user retrieval.
10. The monitor shall be able to store at least 10 such faults.
11. The internal time clock shall automatically adjust for Daylight Savings Time changes.
12. Time and date shall be updated from the controller unit
13. There shall be a keyboard method for the user to display and clear the stored event log.
14. There shall be an RS-232 port on the MMU to allow the print or save to a laptop all data stored in the MMU. The laptop or printer shall interface with the MMU via a standard RS-232 cable. (Printer and laptops to be supplied by others)

15. MMU shall be equipped with a 15 pin metal shell D sub-miniature (gold plated female contacts) for SLDC communication
16. No functional field display shall be permitted unless monitored by the MMU

**730-29 Controller Cabinets**—Controller shall be housed in a rigid, weatherproof cabinet, constructed, finished and equipped as follows, and as shown on the Standard Details. All cabinets shall be wired to TS 2 Type 2 standards.

1. Material
  - A. All cabinets shall be of weather tight construction fabricated from aluminum sheet minimum 0.125 in. (3 mm) thickness or cast aluminum alloy minimum 0.25 in. (6 mm) thickness.
  - B. Painting of cabinets is not required unless required in the plans.
  - C. All pad mounted cabinets shall be 44" x 26" x 55"
  - D. Standards Publication No. TS 2-2003 or later revision unless a different size is required in the plans.
  - E. All pole mounted cabinets shall be 36" x 50" x 18" unless a different size is required in the plans or approved by Metro.
  - F. All pole mount cabinets shall be equipped with a removable bottom panel to facilitate optional pad mounting.
  - G. All shelves and panels shall mount on U-Channel type rails and be fully adjustable by loosening panel bolts.
  - H. Cabinet Main Back Panel shall be an 8 over 8 loadswitch configuration and shall be sized to fit in both 36 inch and 44 inch wide cabinets. All power, neutral and ground connections shall be labeled with color coding silkscreen or industrial smudge proof stickers. All controller input and output functions shall be grouped in logical order.
  - I. Cabinet Main Back panel shall have a hinged type device at the bottom of the panel to facilitate the lowering of the panel for inspection of the rear wiring without removal of shelving.
  - J. All feed through terminals shall be soldered. The use of spade type connectors will not be accepted
  - K. All pad foundations shall be built to Section 7, Figure 7-2 of NEMA Standards Publication No. TS 2-2003 or later revision.
2. Doors
  - A. Cabinets shall have a hinged front opening door which shall include substantially the full area of the front of the cabinet.
  - B. The door shall be equipped with a positive hold fast device to secure the door in at least two open positions; one position at approximately 90 degrees and the other at 120 degrees or more.
  - C. The holdfast device shall be easily secured and released without the use of tools.
  - D. Cabinets shall also be equipped with a switch compartment and the manual switches specified in this section and shall have a hinged front opening auxiliary door. Each door shall have a gasket to provide a weatherproof seal when closed.
  - E. The main door shall have a lock as specified in the plans or by Metro. Two keys shall be provided for each lock.
  - F. The auxiliary door shall have a standard police sub-treasury lock.
17. Cabinet Mounting – Mount cabinet as shown on the Plans or Standard Details.
18. Ventilation—Unless otherwise specified, ventilation shall be provided as follows:
  - A. All cabinets shall be ventilated through an internal baffle located in the top of the cabinet.
  - B. Inlet ventilation openings shall be filtered.
  - C. Cabinets shall be provided with two independently controlled "Exhaust Fans".
  - D. Exhaust fans shall consist of an electric fan with ball or roller bearings and a capacity of at least 100 c.f. (3 m<sup>3</sup>) per minute.
  - E. The fans shall be mounted in a rain tight housing attached to the plenum inside the top of the cabinet.

- F. Each fan shall be controlled by thermostats having a temperature differential between turn-on and turn-off of 15° F (0, +5° F) (8° C (0, + 3° C)), adjustable for turn-on through a minimum calibrated range of from 100° to 150° F (38 to 65° C).
19. Auxiliary Equipment—Except cabinets used in special applications, all cabinets shall be fitted with the following:
- A. No less than two shelves shall be provided to support controller and auxiliary equipment.
  - B. All terminal panels shall be arranged for adequate electrical clearance.
  - C. One Ground Fault Receptacle and a minimum 4 position surge type strip located on the left side of the cabinet, mounted so as not to interfere with shelf space.
  - D. L.E.D. type lighting mounted on the plenum and under lower shelf controlled by a door switch.
  - E. Wetted Mercury switches will not be acceptable, install Crydom A2475 solid state relay or equivalent.
  - F. Circuit Breakers for:
    - (1) Main Power Input to provide all power associated with normal operation. (40Amp)
    - (2) Equipment power to provide power to all associated cabinet equipment. ( 15 Amp )
    - (3) Flasher Power Input to provide all Power associated with Flash operation. (15 Amp)
    - (4) Service power to provide Power for the lamp and duplex receptacle. (10 Amp)
    - (5) Service power to provide power to street name signs
  - F. Copper Ground Buss (minimum of two 12 position bars).
  - G. The MMU sampling inputs shall be terminated at the closest tie point to the field termination of the signal displays
  - H. Where required to perform specified functions general purpose relays shall be provided.
  - I. A minimum of 24 available bare ground positions tied to AC Common Return.
  - J. Earth (driven) ground tie point to terminate a single #4 AWG (21.2 mm<sup>2</sup>) copper ground.
  - K. Tie point to tie all ground systems within the cabinet to a single reference point. All grounds (AC - return, Chassis, and Logic Ground) must be referenced to a single ground point at the electric service.
  - L. Isolate Logic Ground from AC- return and Earth ground. Provide Ped Isolation devices to protect logic ground input to the cabinet
  - M. A panel behind the auxiliary door to contain the following switches:
    - (1) An Automatic Flash switch, which shall be wired when in the Flash position, shall cause the cabinet to provide Flash Operation and Stop Time shall be applied to the controller.
    - (2) Switch to activate Manual Control Enable.
    - (3) Manual control pushbutton switch with 4 foot minimum cord. Cord shall attach to a 2 position terminal strip via fork type connectors. Terminal strip to be located on the backside of the police panel
  - N. A panel mounted inside the main door to contain the following switches:
    - (1) A technician Stop-Time switch to apply Stop Time to both controller rings.
    - (2) An Interval Advance switch, enabled only by the Stop Time switch, to be momentary pushbutton switch to apply Interval advance to the timer.
    - (3) A Signal On-Off switch which will remove the AC power applied to the signal heads for normal operation while the controller continues to operate.
    - (4) A Signal Normal/Flash switch to enable intersection flash when in the Flash position.
    - (5) 16 Individual phase vehicle and 8 pedestrian detector test switches located on the PED Isolation unit to be toggle type of the On-Off -Momentary type located on the left side of the cabinet above the detector panel or on the tech panel to place:
      - a. No Call - Call provided by detectors.
      - b. Locked detector call.
      - c. Momentary detector call.
    - (6) Switch terminals on back of main cabinet door shall be insulated or shielded so that no live parts are exposed.
    - (7) Tech panel shall have a clear fold down Lexan panel to protect the switches from accidental activation

- O. Leads to the auxiliary door switches shall be no less than No. 18 AWG (0.82 mm<sup>2</sup>) stranded.
  - P. All connections within the cabinet that have AC voltage shall be protected with a clear Lexan cover to prevent accidental shock
20. Wiring— Cabinet shall be wired to TS2 Mode “B” standard. The back-panel shall be labeled to reflect Mode “B” operation. The cabinet shall be wired according to the following:
- A. Controllers shall be wired for 8 vehicle movements, 4 pedestrian phases and 4 overlaps (sixteen phases). Sixteen NEMA input and output indicating load switches and bases shall be provided. There shall be 4 – 2 channel detection cards for each of the 8 vehicle phases.
  - B. Detector rack (8 Position) shall be wired and labeled as described in the TS-2 specification (Table 5-9, configuration 2).
  - C. Channels 1, 3, 5, and 7 green and yellow circuits shall be terminated at a load resistor. Pedestrian channels 9, 10, 11, and 12, green circuits shall be terminated at a load resistor. Load resistors shall terminate via fork type connectors.
21. Power Supply—The cabinet shall include a cabinet power supply meeting the requirements of NEMA specification TS2. The cabinet power supply shall provide all DC voltages to the cabinet and be monitored as 24v 1 & 2. The controller 24 VDC line shall not be terminated in the cabinet or be monitored. The power supply shall be completely enclosed in an aluminum housing, shall be shelf mounted, and shall provide the following voltage and current outputs:
- A. +12 VDC +/- 1 VDC, 2.0 A
  - B. +24 VDC +/- 1 VDC, 2.0 A
  - C. 12 VAC, 0.25 A
  - D. Outputs shall be fused with slow blow fuses of the ratings indicated.
  - E. AC power input shall be protected against over current with a 2 Amp slow blow fuse.
  - F. L.E.D. indicators on the front panel shall denote the presence of 12 VAC, 24 VDC and 12 VDC and the 60 Hz reference signal Test points for logic common and +24 VDC shall also be provided on the front panel.
22. Bus Interface Unit (BIU) —The cabinet shall include a Bus Interface Unit (BIU) and detector rack as defined in Section 8 of NEMA Standards Publication No. TS 2-2003 or later revision. The BIU shall be a NEMA designated BIU2 as listed in Table 8-1 of the TS-2 specification. The detector rack vehicle outputs shall be wired in parallel with the BIU to accomplish use of the detectors with or without the use of the BIU by plugging or unplugging the vehicle input suppressors.
23. Lightning Protectors and Interference Suppressors—Ample lightning protectors to provide effective defense against high transient voltages caused by lightning discharges or other sources shall be provided. Each controller cabinet must be furnished with the following surge protection devices:
- A. Main power suppressor shall be EDCO SHA-1250 or approved equal with contact wired to Alarm 1 for all but flasher or remote detector cabinets and shall have the following characteristics:
    - (1) Peak surge current: 20,000 Amperes
    - (2) Clamp Voltage: 250 Volt
    - (3) Response Time: Voltage NEVER exceeds 250 Volts
    - (4) Continuous Current: 10 AMPS at 120 VOLTS AC
    - (5) It shall be socket mounted allowing replacement in less than two minutes.
  - B. Power Protector for Controller Flasher, Flashing Beacon, and Remote Detector Cabinets:
    - (1) Peak Current: 15,000 Amperes
    - (2) Power Dissipation: 15 Watts
    - (3) Peak Voltage: 212 Volts
  - C. Controller detector input terminals (vehicle and pedestrian ) shall be terminated at a plug-in surge suppressor, EDCO PC-642C-030 or equivalent, and have the following characteristics:
    - (1) Peak Surge Current: 400 Amps Differential Mode
    - (2) Response Time: 40 Nanoseconds
    - (3) Input Capacitance: 35 pf typical
    - (4) Clamp Voltage: 30 Volts Max (either mode)
  - D. Auxiliary Relays and Fan shall be provided with a resistor/capacitor circuit to suppress generated noise.

- E. RF Filter shall be provided in controller cabinets and shall provide filtering of RF noise over the range of 60 hertz through 20 Megahertz. The RF filter may be incorporated as part of the Main Power Suppressor.
- 24. Includes a cabinet sliding storage drawer mounted under lower shelf in accordance with the following:
  - A. Approximate exterior dimensions 1.75 inches (H) x 16 inches (W) x 14 inches (D).
  - B. Telescoping drawer guides to allow full extension from the rack cage.
  - C. Opening storage compartment lid to access storage space for cabinet documentation and other items.
  - D. Supports a weight of 25 lb when extended.
  - E. Non-slip plastic laminate surface attached to the compartment lid which covers a minimum of 90% of the surface area of the lid.

Auxiliary Devices—All auxiliary Devices shall meet the requirements of Section 6 of the TS-2 specification with the following additions:

- 1. Load Switches- Each cabinet shall be provided complete, with the necessary number of **NEMA TS-2** load switches and Flash Transfer relays to fully populate the cabinet. Unused switches and relays will become spares. Load switches shall meet the following requirements:
  - A. Shall meet NEMA TS-2 Standards.
  - B. Shall have front-face mounted L.E.D. indicators to indicate the "On" condition of both the Input and Output circuits.
  - C. Shall utilize replaceable "cube" type circuitry or encapsulated discrete component construction. No unencapsulated discrete component construction shall be acceptable.

### **730-30 – Communications Equipment**

This section specifies the communications equipment needed for communication to the Public Works' network and central software. Depending on the available infrastructure, each location may require a specific configuration as specified in the Special Provisions, shown on the Plans, or directed by the Engineer.

- 1. Ethernet Switch
  - A. Copper – Etherwan 3575 or approved equal
    - i. Hardened managed 6-port 10/100base-tx + 2-port gigabit combo SFP switch with 2-port copper pair extender
    - ii. Fully managed switch capabilities with Layer 2 features
    - iii. 12 to 48VDC input voltage
    - Security – MAC address filtering; enable/disable port; IEEE802.1X LAN access control
    - iv. Ethernet Ports
      - 10/100BASE-TX: 6 ports
      - 10/100/1000BASE-T and 100/1000BASE-X SFP combo: 2 ports
    - v. Ethernet Extender Ports
      - RJ-11 and Terminal Block port : 2 ports
      - Cable: Telephone wire 24 AWG (Minimum 0.5mm diameter, 1-pair wire)
  - B. Fiber
    - i. Layer 2 – Cisco Industrial Ethernet 2000 series switch IE-2000-8TC-L or approved equal
      - a) Four, eight, or 16 10/100Base-T Ethernet ports (Small Form-Factor Pluggable [SFP] downlinks on selected models); fixed configurations with a compact form factor
      - b) Two gigabit combo ports: SFP (100 Mbps and 1 Gbps) or RJ45 uplink
      - c) Dual-input DC power supply, alarm relays, DIN rail mount
      - d) Industrial Power over Ethernet (PoE) solution
      - e) Conformal coating available
      - f) Swappable SD flash card and mini-USB connector
      - g) Industrial environmental compliance and certifications

- ii. Layer 3 – Cisco Industrial Ethernet 3000 series switch IE-3000-8TC-E or approved equal.
  - a) Design for Industrial Ethernet applications, including extended environmental, shock/vibration, and surge ratings; a complete set of power input options; convection cooling; and DIN-rail or 19” rack mounting
  - b) Support for Power over Ethernet (PoE) up to 15.4W per port
  - c) Support for Power over Ethernet Plus (PoE+) for the PoE+ capable devices up to 30W per port
  - d) Easy switch replacement using removable memory
  - e) Industrial design and compliance
- 2. Hardened 4G cellular modem – Connected IO LT1000 USB M2M Modem or approved equal
  - i. Provides 4G XLTE Connectivity
  - ii. Universal connectivity to host devices via micro USB Type B connector
  - iii. 5VDC power input (one mini USB Type B connector)
  - iv. One micro UICC card slot (3FF)
  - v. Two edge mounted SMA connectors for main and diversity antennas
  - vi. Ruggedized enclosure designed for surface mounted installation
- 3. 4G External Antenna – 4G MIMO LTE antenna or approved equal
- 4. VPN Firewall – Cisco Meraki Z1 or approved equal
  - i. 4 ports for printers, phones, and other devices
  - ii. 1 GbE WAN port, 4 GbE LAN ports
  - iii. 3G / 4G failover via USB modem
  - iv. 4 ports for printers, phones, and other devices
  - v. 1 GbE WAN port, 4 GbE LAN ports
  - vi. 3G / 4G failover via USB modem
  - vii. Layer 7 application

## FLASHING SCHOOL SIGNALS

**730.31—Flashing School Signals.** Flashing school signals shall conform to the following:

1. The signal shall produce two alternate flashing lights within the marginal limits of a school speed limit sign. Details of the sign construction shall be as specified on the Plans. Sign colors shall conform to the **MUTCD** and be constructed of materials complying with these specifications.
2. The two lenses shall be L.E.D., yellow in color, and a minimum of 12 in. (300 mm) in diameter.
3. The flasher unit shall be the two-circuit type to provide alternating equal on-off operation. The flashing mechanism shall produce between 50 and 60 flashes per minute through two 120-volt, 60-cycle AC, 15-ampere circuits. The flasher shall be of solid-state construction and to NEMA standards.
4. The unit shall be wired for external circuits.
5. The signal shall be actuated by a momentary key switch, (key number Chicago Lock Co. No. 2382). The timing device shall be digital (National Controls Corp. Model TMM-0999M-461, or equal) and located in a remote mounted control cabinet.
6. Where an illuminated speed limit indication is specified on the Plans, the numeral message shall be illuminated in Portland Orange in a rectangular lens and illuminated only during the period when the signal produces two alternately flashing amber lights.

## DETECTORS

**730.32—Detectors.** Detectors shall be used for actuating signal phases of traffic actuated controllers and shall be of the type specified in the Plans.

1. Lightning protection shall be EDCO SRA6LCA916 or an approved equivalent.
  - A. The lightning protection unit must withstand repeated 400 ampere surges on a 9 x 20 microsecond waveform.

- B. The unit must be 2 stage device capable of clamping a minimum of (100) 300 ampere surges to 25 volts within 40 nanoseconds. Surge applied across the 2 detector leads.
2. Inductive Loop Detectors
    - A. Loop amplifiers shall be rack mounted two channel units that meet the requirements of Section 6 of the NEMA Standards Publication No. TS 2-2003 or later revision.
    - B. The loop detector amplifier shall be Type CC as listed in Table 6-1 of the NEMA Standards Publication No. TS 2-2003 or later revision. There shall be 4 – 2 channel detection cards – for each of the 8 vehicle phases.
    - C. Detector rack shall be wired and labeled as defined in Table 5-9, Configuration 2 of NEMA Standards Publication No. TS 2-2003 or later revision.
    - D. The loop detector amplifier shall be full automatic, requiring no adjustments to effect operational ability other than setting of the operating frequency and sensitivity. The amplifier shall:
      - i. Sense any legal motor vehicle traveling at speeds up to 65 miles per hour.
      - ii. Have both a “Pulse” and “Presence” Output:
        1. Pulse output shall generate an output of 125 ±25 millisecond output for each vehicle entry.
        2. Presence output shall provide a continuous output for up to 60 minutes as long as a vehicle is within the detection zone.
      - iii. Provide at least four user selectable sensitivity ranges.
      - iv. Be supplied with at least three frequency ranges for crosstalk minimization.
      - v. Have a front-face mounted indicator to indicate active output of the internal relay. This indicator shall indicate the presence of:
        1. Normal Output
        2. Delayed Output
        3. Extended Output
      - vi. Have a front-panel mounted “Reset” switch that when pressed shall cause the unit to completely re-tune itself.
      - vii. Have Delayed or Extended timing features with the following ranges:
        1. Delayed output of 0 to 30 seconds in 1-second increments.
        2. Extended output of 0 to 10 seconds in 1/4-second increments.
      - viii. Have internal diagnostics to determine the operational ability of the loop. These diagnostics shall determine if a loop is opened or shorted, and shall provide a visible indication of such condition. Additionally, if such a condition occurs, the amplifier unit shall default to a “constant” output.
      - ix. Provide output by a mechanical relay, which shall be “off” to provide an output.
      - x. Have all delay functions wired to the associated plan phase green to inhibit that function during controller phase green.
      - xi. Be able to operate with loop lead-in lengths of at least 2,000 feet.
  3. Pedestrian Push Buttons shall be Polara Bulldog III
    - A. Where shown on the Plans, pedestrian push buttons of substantial tamper-proof construction shall be furnished and installed.
    - B. They shall consist of a direct push type button and single momentary contact switch in a cast metal housing.
    - C. Operating voltage for pedestrian push buttons shall not exceed 24 volts.
    - D. The assembly shall be weatherproof and so constructed that it will be impossible to receive an electrical shock under any weather condition.
    - E. Where a pedestrian push button is attached to a pole, the housing shall be shaped to fit the curvature of the standard or post to which it is attached to provide a rigid installation.
    - F. Unless otherwise specified, push button and sign shall be installed on the crosswalk side of the pole.
    - G. All assemblies shall meet existing A.D.A. and **MUTCD** guidelines.



**730.33—Video Detection.** This Section specifies the minimum requirements for Video Detection System (VDS) equipment furnished and installed. The work shall consist of providing all labor, materials, equipment, and incidentals necessary to furnish, install, and test Video Detection Equipment. This work consists of furnishing and installing video detection equipment complete and ready for service.

1. The video detection system shall consist of power supply, hard-wired video cameras, all necessary video and power cabling with end connectors, mounting brackets, lightning protection as recommended by the manufacturer, video detection processors/extension modules capable of processing the number of camera and phase combination video sources shown on the project plans or in the purchase order. Provide sufficient number of cameras to process vehicle presence, passage and system detection zones as shown on the project plans or listed on the purchase order.
2. Warranty
  - A. Provide a 36-month warranty or the manufacturer's standard warranty, whichever is greater on all video detection system components.
  - B. The warranty period begins on the date of installation to the project. Each system shall be marked with a permanent label or stamp indicating the date of installation.
  - C. The warranty to include, technical support shall be available from the supplier, at no cost, via telephone within 4 hours of the time a call is made 7 days a week, from factory-certified personnel or factory-certified installers.
  - D. The warranty shall include, updates to video detection processor and application software from the manufacturer without charge.
3. General Capabilities and Performance Requirements
  - A. Provide camera systems able to transmit NTSC video signals up to 1,000 feet (300 m).
  - B. Furnished video detection system configuration shall utilize video processors with 1 or more video inputs and 1 video output, responding to specific site applications, camera locations and detection zones shown on the project plans.
  - C. Provide video processors which plug directly into TS-1 and TS-2 detector racks without adapters.
  - D. Provide extension modules which allow detection zones from one camera to be routed to other card slots.
  - E. Remote programming and monitoring capability from a distant Traffic Management Center is mandatory.
  - F. Shall be Ethernet compatible with an RJ45 port.
4. Interface
  - A. Provide video inputs that accept RS170 (NTSC) signals from an external video source. Provide a BNC type interface connector located on the front of the video processing unit.
  - B. Provide a L.E.D. indicator to indicate the presence of the video signal. The L.E.D. shall illuminate upon valid video synchronization and turn off when the presence of a valid video signal is removed.
  - C. Provide one video output per processor module. The video output shall be RS170 compliant and shall pass through the input video signal. The video output shall have the capability to show text and graphical overlays to aid in system setup. The overlays shall display real-time actuation of detection zones upon vehicle detection or presence. Control of the overlays and video switching shall also be provided through the serial communications port. The video output interface connector shall be BNC or RCA type. If RCA connector is used an RCA to BNC adapter shall be provided.
  - D. Provide a serial communications port on the front panel. The serial port shall be compliant with RS-232 or RS-422 electrical interfaces and shall use a DB9 or RJ45 type connector. The serial communications interface shall allow the user to remotely configure the system and/or to extract calculated vehicle/roadway information.
  - E. Furnish interface software. The interface protocol shall support multi-drop or point-to-multipoint communications. Each video detection system shall have the capability to be individually IP addressable either built in or with third party video server units.

- F. Provide open collector contact closure outputs meeting NEMA TS2 requirements. The open collector output will be used for vehicle detection indicators as well as discrete outputs for alarm conditions.
  - G. Provide L.E.D. status indicators on the front panel. The L.E.D.'s shall illuminate when a contact closure output occurs. Provide one output L.E.D. for each contact closure output.
  - H. Provide a mouse compatible port (PS-2 or USB) on the front panel of the video processing unit. The mouse port shall be used as part of the system setup and configuration. Provide a compatible mouse with each video detection system.
5. Functionality
- A. Detection zones shall be programmed via an on-board menu displayed on a video monitor and a pointing device connected to the video detection processor. The menu shall facilitate placement of detection zones and setting of zone parameters or to view system parameters.
  - B. The video detection processor shall detect vehicles in real time as they travel across each detection zone.
  - C. The video detection processor shall have an RS-232 (DB9 or RJ45) port for communications with an external computer.
    - (1) The video detection processor port shall be multi-drop capable.
    - (2) It shall be possible to upload and save all configuration data including loop placement and save the file on a computer.
    - (3) It shall be possible to download a configuration file from a computer to the detection device.
    - (4) The video detection processor shall accept new detection patterns from an external computer through the RS-232 port when the external computer uses the correct communications protocol for downloading detection patterns.
  - D. Provide a Windows™-based software designed for local and remote connection providing video capture, real-time detection indication and detection zone modification capability.
  - E. The video detection processor shall send its detection patterns to an external computer through the RS-232 port.
  - F. The video detection processor shall default to a safe condition, such as minimum recall, fixed recall or a constant call on each active detection channel, in the event of unacceptable interference with the video signal, low visibility conditions, or power failure.
  - G. A user-selected output shall be active during the low-visibility condition that can be used to modify the controller operation if connected to the appropriate controller input modifier(s). The system shall automatically revert to normal detection mode when the low-visibility condition no longer exists.
6. Vehicle Detection
- A. A minimum of 24 detection zones per camera input shall be possible, and each detection zone shall be capable of being sized to suit the site and the desired vehicle detection area.
  - B. A single detection zone shall be able to replace multiple inductive loops and the detection zones shall be OR'ed as the default or may be AND'ed together to indicate vehicle presence on a single phase of traffic movement.
  - C. Placement of detection zones shall be done by using only a pointing device, and a graphical interface built into the video detection processor and displayed on a video monitor, to draw the detection zones on the video image from each video camera. Detection zones created in this manner shall be compatible with the PC-based software provided with the system.
  - D. The video detection processor's memory shall be non-volatile to prevent data loss during power outages.
  - E. When a vehicle is detected crossing a detection zone, the corners or entire zone of the detection zone shall flash/change color on the video overlay display to confirm the detection of the vehicle.
  - F. It shall be possible to record the operation of the unit in real time with the detection zones operating.
  - G. Detection shall be at least 98% accurate in good weather conditions, with slight degradation acceptable under adverse weather conditions (e.g. rain, snow, or fog) which reduce visibility.

- H. The video detection processor shall maintain normal operation of existing detection zones when one zone is being added or modified.
  - I. The video detection processor shall output a constant call on any detector channel corresponding to a zone being modified and shall resume normal operation upon completion.
  - J. Detection zones shall be directional to reduce false detections from objects traveling in directions other than the desired direction of travel in the detection area.
  - K. The video detection processor shall process the video input from each camera using a microprocessor at 30 frames per second at one volt peak to peak 75 ohms or EIA 170 NTSC video standard.
  - L. The video detection processor shall output minimum recall, fixed recall or constant call for each enabled detector output channel if a loss of video signal occurs. The recall behavior shall be user selectable for each output. The video detection processor shall output a constant call during the background "learning" period.
  - M. Detection zone outputs shall be configurable to allow the selection of presence, pulse, extend, and delay outputs. Timing parameters of pulse extend, and delay outputs shall be user definable between 0.1 to 25.0 seconds in increments of 0.1 seconds.
  - N. Up to six detection zones per camera view shall have the capability to count the number of vehicles detected, measure classification and speed. The data values shall be internally stored within the processor module for later retrieval through the RS-232 port. The data collection interval shall be user definable in periods of 5, 15, 30, or 60 minutes or by intersection cycle. Real-time data shall be retrieved from the PC-based software provided with the system.
7. Camera
- A. Cameras shall be completely compatible with the video detection processor and shall be certified by the manufacturer to ensure proper system operation.
  - B. The detection system shall produce accurate detector outputs under all roadway lighting conditions, regardless of time of day. The minimum range of scene luminance over which the camera shall produce a useable video image shall be the minimum range from nighttime to daytime, but not less than the range 0.009 to 930 foot-candles (0.1 lux to 10,000 lux).
  - C. The camera shall use a color CCD sensing element with resolution of not less than 470 lines horizontal and 400 lines vertical.
  - D. The camera shall include mechanisms to compensate for changing of lighting by using an electronic shutter and/or auto-iris lens.
  - E. The camera shall include a motorized variable focal length lens with factory preset focus that requires no field adjustment. Zooming of the camera lens to suit the site geometry by means of a portable interface device designed for that purpose. The horizontal field of view shall be adjustable from 8.1 to 44.3 degrees. Camera configuration shall be customized for each approach based on field site conditions and the project plans. One interface device shall be supplied at no additional cost.
  - F. The camera electronics shall include automatic gain control (AGC) to produce a satisfactory image at night.
  - G. The camera shall be housed in a weather-tight sealed enclosure. The housing shall be field rotatable to allow proper alignment between the camera and the traveled road surface.
  - H. The camera enclosure shall be equipped with a sunshield. The sunshield shall include a provision for water diversion to prevent water from flowing in the camera's field of view.
  - I. The camera enclosure shall include a thermostatically controlled heater to assure proper operation of the lens shutter at low temperatures and prevent moisture condensation on the optical faceplate of the enclosure. The heater shall directly heat the glass lens and require less than 5 watts over the temperature range.
  - J. Power consumption of the camera shall be 15 watts or less under all conditions.
  - K. The camera enclosure shall be equipped with separate, weather-tight connections for power and setup video cables at the rear of the enclosure. These connections shall allow diagnostic testing and viewing of video at the camera while the camera is installed on a mast arm or pole using a lens adjustment module furnished under this bid item.
  - L. The video signal output by the camera shall in accordance with NTSC standards.

- M. All necessary mounting brackets shall be mounted to pole shafts, mast arms, or other structures to mount cameras as indicated on the project plans. Mounting brackets shall result in a fixed-position mounting. Mounting Hardware shall be of the Astro Bracket type with a minimum of 6' height adjustment. Mounting Brackets shall be included at no additional cost.
8. Video Cable
    - A. The cable provided shall be as recommended by the manufacturer for optimal video detection performance. Coaxial cable can be used between the camera and the video detection processor in the traffic signal controller cabinet and shall be Belden 8281 or equivalent. The signal attenuation shall not exceed 0.78 dB per 100 feet (30 m) at 10 MHz.
    - B. Nominal outside diameter shall be approximately 0.305 inches (7 mm).
    - C. Coaxial cable shall be suitable for installation in conduit and in exposed sunlight environment. 75-ohm BNC plug connectors shall be used at both the camera and cabinet ends. The coaxial cable, BNC connector, and crimping tool recommended by the manufacturer of the video detection system shall be used and installed per the manufacturer's recommended instructions to ensure proper connection.
  9. Power Cable
    - A. Power cable for 120VAC cameras shall be rated for 90 C, 300 volt, 16 AWG, stranded, three-conductor cable with a nominal outside diameter of approximately 0.330 inches (8 mm). Conductor insulation color code shall be black, white and green. Outside jacket shall be black.
    - B. Power cable for 28 Volt cameras shall be the cable recommended by the manufacturer.
    - C. Camera power cable shall be suitable for installation in conduit and in exposed sunlight environment, and UL listed.
    - D. The power and video cable may be installed under the same outer jacket.
  10. Surge Protection
    - A. Provide surge protection devices for all new or added video detection devices as recommended by the manufacturer.
    - B. Coaxial cable shall be protected with an inline surge suppressor as recommended by the manufacturer or a panel mounted surge suppressor as recommended by the manufacturer or approved equal, installed and grounded per video detection manufacturer's recommendations.
  11. Physical and Environmental Specifications
    - A. Video Detection System Processor—Provide a video detection system processor that operates reliably in a typical roadside traffic cabinet environment. Provide internal cabinet equipment and a video detection system processor that meet the environmental requirements of NEMA TS2-2003 Section 2.
    - B. Video Camera Sensor
      - (1) Operating ambient temperature range: -30°F to 140°F (-34°C to 60°C). Additionally, include a heater to prevent the formation of ice and condensation in cold weather. Do not allow the heater to interfere with the operation of the video camera sensor electronics, or cause interference with the video signal.
      - (2) Vibration: Meet the requirements of TS-2 2003 section 2.1.9.
      - (3) Shock: Meet the requirements of TS-2 2003 section 2.1.10.
      - (4) Acoustic Noise: Provide a video camera sensor and enclosure that can withstand 150 dB for 30 minutes continuously, with no reduction in function or accuracy.
  12. Training
    - A. Furnish two eight hour long training sessions.
    - B. Prior to training, submit resume and references of instructor(s). The instructor shall be factory trained on the equipment and have a minimum of three years instructor experience on the VDS system. Also submit an outline of the training course in a Training Plan. Submit the Training Plan within 90 days of Contract Notice-to-Proceed. Obtain approval of the Plan from the Engineer. Explain in detail the contents of the course and the time schedule of when the training will be given.
    - C. Training shall cover the operation, setup and maintenance of the video detection system installed as part of the Contract or purchase order.

- D. Furnish all handouts, manuals and product information.
  - E. For the training, use the same models of equipment furnished for the project. Furnish all media and test equipment needed to present the training.
  - F. Training shall be conducted in the Nashville area. Training instructor(s) shall be manufacturer-certified, experienced in the skill of training others and have conducted a minimum of three two day trainings on Video Detection Systems.
13. Installation Requirements. All equipment shall be installed according to the Manufacturer's recommendations, the Plans and as follows:
- A. Materials and associated accessories/adapters shall not be applied contrary to the Manufacturer's recommendations and standard practices.
  - B. The Contractor shall furnish all tools, equipment, materials, supplies, cabling and manufactured hardware, and shall perform all operations and equipment integration necessary to provide complete, fully operational communications equipment as specified herein, within the Plan set, and/or in the Contract Documents. It is the responsibility of the Contractor to ensure that his equipment performs its required function when installed.
  - C. The Contractor shall provide the Engineer with a written inventory of items received and the condition in which they were received. Once received, the equipment becomes the Contractor's responsibility. The Contractor shall provide all labor and equipment necessary to move inventory out of the designated storage facility and to transport it to the installation location. All equipment shall be installed according to the Manufacturer's recommendations or as directed by the Engineer.
14. Testing Requirements. Testing shall include, but not be limited to, the following general requirements:
- A. The Contractor shall conduct a project testing program for all video detection equipment. The project testing program shall include but is not limited to the additional specific requirements in this subsection.
  - B. All test results shall confirm physical and performance compliance with this TSP.
  - C. Pre-installation test shall consist of an inspection of all supplied equipment for damage and completeness of parts and manuals.
  - D. Standalone Acceptance Test (SAT) shall consist of a complete check of the system after installation.
  - E. Conditional Acceptance Test shall include programming of all functions and integration to the traffic controller inputs.
  - F. On hour videos shall be made of each approach and compared to actual detection calls.
  - G. Thirty minute videos shall be made starting 15 minutes prior to sunrise and sunset for each approach and compared to actual detection calls.
  - H. All videos shall be date and time stamped.
  - I. Provide all videos to the Engineer with a summary of the results included total calls, missed calls and false calls.
  - J. All test results must meet a 98% accuracy requirement.
  - K. The Burn in period will start after successful completion of the Conditional Acceptance Test.
  - L. Submit all test results documentation to the Engineer within fourteen (14) days of completion of the tests. The Engineer will review test documentation and inform the contractor of any exceptions noted.
  - M. Any failure of the equipment including but not limited to lost calls, loss of program data or excessive false calls shall result in the Burn in period to start over.
15. Measurement. The Video Detection Systems will be measured in units of each and paid for at the contract price per each. The price bid shall include furnishing, installing warranties, full operation and configuring the VDS in accordance with applicable Standards, Specifications, and requirements. The price bid shall also include the mounting hardware, patch cords, serial port cables or connectors, power cable, user manuals, testing, warranties, and any and all other equipment required to complete installation of the unit. This price shall be full compensation for all labor, tools, materials, equipment and incidentals necessary to complete the work.

**730.34—Radar Detection.** This Section specifies the minimum requirements for Radar Detection System equipment furnished and installed. The work shall consist of providing all labor, materials, equipment, and incidentals necessary to furnish, install, and test Radar Detection System. This work consists of furnishing and installing radar detection equipment complete and ready for service.

1. Materials - The Radar Detection System shall be Wavetronix SmartSensor (Matrix for stop bar detection and Advance for advanced approach detection) and consist of power supply, hard-wired detectors, all necessary power cabling with end connectors, mounting brackets, lightning protection as recommended by the manufacturer, and detection processors / extension modules capable of processing the number of detection zones shown on the project plans. The Radar Detection System shall be designed with a matrix of 16 radars and shall support a minimum of 16 zones and a minimum of 16 channels. Provide a 24-month warranty or the manufacturer's standard warranty, whichever is greater, on all detection system components beginning on the date of installation to the project. The warranty is to include technical support available from the supplier, at no cost, via telephone within four (4) hours of the time a call is made seven (7) days a week, from factor-certified personnel or factor-certified installers. The warranty shall include updates to detection processors or application software from the manufacturer without charge.

2. Microwave Transmission - The microwave radar detector shall transmit on a frequency band of 24.0-24.25 GHz or another approved spectral band. It shall comply with the limits for a Class A digital device, pursuant to Part 15 of the FCC rules or the appropriate Spectrum Management Authority. The Radar Detection System shall not interfere with any known equipment.

3. Area of Coverage - The Radar Detection System's field of view shall cover an area defined by a beam its maximum detection range shall be as follows:

- A. Field of View - 90 degrees or more
- B. Range - 6 to 140 feet

4. Detection Zones - The minimum number of detection zones defined shall be no less than ten (10) lanes simultaneously.

5. Measurement Accuracy - The following error levels shall be achievable and demonstrated during testing:

<u>Parameter</u>	<u>Error Percentage</u>
Presence	±5%
Time Event	10 ms
Input Voltage	± 2%

6. Environmental Conditions and Protection - Except as stated otherwise herein, the equipment shall meet all its specified requirements during and after subjecting to any combination of the following:

- A. Ambient temperature range from -40°C to +74° C
- B. Relative humidity from 5 to 95 percent, non-condensing
- C. Winds up to 90 mph (sustained) with a 30% gust factor
- D. Rain and other precipitation up to 1 inch/hr
- E. Power surge of ±1kV (rise time = 1.2 μsec, hold = 50μsec) applied in differential mode to all lines, power and output, as defined by IEC 1000-4-5 and EN 61000-4-5 standards.
- F. The microwave detector shall be resistant to shock in accordance with IEC 68-2-27 (test a), NEMA TS-1 (Section 2.1.13), or approved equivalent.

7. Mechanical

- 1. The microwave radar detector shall be enclosed in a rugged weatherproof box and sealed to protect the unit from wind up to 90 mph, dust and airborne particles, and exposure to moisture (watertight by NEMA 250 standard).
- 2. Max. weight of the microwave radar detector assembly: 7 pounds
- 3. The mounting assembly shall have all coated steel, stainless steel, or aluminum construction, and shall support a load of 20 pounds or more. The mounting assembly

shall incorporate a ball-joint, or other approved mechanism that can be tilted in both axes and then locked into place, to provide the optimum area of coverage.

#### Electrical

1. The RDS unit shall be operable from 12 - 24 VDC.
2. The RDS unit shall include onboard surge protection

#### **Installation Requirements**

All equipment shall be installed according to the Manufacturer's recommendations, the Plans, and as follows:

1. Materials and associated accessories / adapters shall not be applied contrary to the Manufacturer's recommendations and standard practices.
2. The Contractor shall furnish all tools, equipment, materials, supplies, cabling, and manufactured hardware, and shall perform all operations and equipment integration necessary to provide complete, fully operational communications equipment as specified herein, within the Plan set, and/or in the Contract Documents. It is the responsibility of the Contractor to ensure that the equipment performs its required function when installed.
3. The Contractor shall provide the Engineer with a written inventory of items received and the condition in which they were received. Once received, the equipment becomes the Contractor's responsibility. The Contractor shall provide all labor and equipment necessary to move inventory out of the designated storage facility and to transport it to the installation location. All equipment shall be installed according to the Manufacturer's recommendations or as directed by the Engineer.

#### **Testing Requirements**

Testing shall include, but not be limited to, the following general requirements:

1. The Contractor shall conduct a project testing program for all radar detection equipment. The project testing program shall include but is not limited to the additional specific requirements in this subsection.
2. All test results shall confirm physical and performance compliance with this TSP.
3. Pre-installation test shall consist of an inspection of all supplied equipment for damage and completeness of parts and manuals.
4. Standalone Acceptance Test (SAT) shall consist of a complete check of the system after installation.
5. Conditional Acceptance Test shall include programming of all functions and integration to the traffic controller inputs.
6. All test results must meet a 98% accuracy requirement.
7. The burn-in period with start after successful completion of the Conditional Acceptance Test.
8. Submit all test results documentation to the Engineer within fourteen (14) days of completion of the tests. The Engineer will review test documentation and inform the contractor of any exceptions noted.
9. Any failure of the equipment including but not limited to lost calls, loss of program data or excessive false calls shall result in the burn-in period to start over.

#### **Measurement**

The RPD will be measured in units of each and paid for at the contract price per each. The price bid shall include furnishing, installing warranties, full operation and configuring the RPD in accordance with applicable Standards, Specifications, and requirements. The price bid shall also include the mounting hardware, power cable, user manuals, testing, warranties, and any and all other equipment required to complete installation of the unit. This price shall be full compensation for all labor, tools, materials, equipment, and incidentals necessary to complete the work.

### **Payment**

The contract unit price shall be full compensation for all work specified in this section.

Payment will be made under:

#### **Item No. Description Unit**

725-01.22 VEHICLE DETECTOR EACH  
(NON-INTRUSIVE RADAR RETECTION)

## **TRAFFIC SIGNAL SUPPORTS**

**730.35—Cantilever Signal Supports.** These specifications apply to the manufacture of steel poles and mast arms for the support of traffic signals. The height of poles, shaft dimensions and wall thickness shall meet the design requirements and mounting height of traffic signals as set forth in these Specifications and in the Plans. Bracket arm lengths are indicated in the Plans. All signal supports shall meet MDPW guidelines and shall be in conformance with applicable Streetscape guidelines concerning the type of poles to be used. The Contractor shall submit shop drawings for all signal supports, stamped and sealed by an engineer registered in the State of Tennessee, to MDPW for review and approval. Designs shall be in compliance with current AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals. These standards apply to Strain pole supports, as well.

The poles shall consist of a straight or uniformly tapered shaft, cylindrical, or an approved geometric shape, in cross section, having a base welded to the lower end and complete with anchor bolts. All castings shall be clean and smooth with all details well defined and true to pattern. Steel castings shall conform to ASTM A 27, Grade 65-35. Gray iron castings shall conform to ASTM A 126, Class A. All mast arms shall be compatible with the poles in material, strength, shape, and size.

Anchor Base—An anchor base of one-piece cast steel or steel plate of adequate strength, shape and size shall be secured to the lower end of the shaft. The base shall telescope the shaft and be welded at the top and bottom faces with continuous fillet welds so that the welded connection shall develop the full strength of the adjacent shaft section to resist bending action. Each base shall be provided with a minimum of four holes to receive the anchor bolts. Cast steel bases shall be provided with removable cast iron covers for anchor bolts and tapped holes for attaching covers with hex head cap screws.

A welded frame handhole, 5 x 10 in. minimum and located 1.5 ft. above the base, shall be provided. A .5 in. - 13 UNC grounding nut shall be welded to the inside of pole at a point readily accessible for wiring.

Shaft—The shaft shall be fabricated from the best, hot rolled basic open hearth steel, and shall have only one longitudinal electrically welded joint and may have electrically welded intermediate transverse full penetration circumferential joints, at intervals of not less than 10 ft. (3 m). The shaft shall be longitudinally cold-rolled to flatten the weld and increase the physical characteristics so that the metal will have a minimum yield strength of 48,000 psi (331 Mpa). Where transverse full penetration circumferential welds are used, the fabricator of the shaft shall furnish to the Engineer certification: (1) that all such welds have been radiographed and ultrasonically tested by an independent testing laboratory using a qualified Nondestructive Testing (NDT) technician and (2) that the NDT equipment has been calibrated annually.

The shaft shall be fitted with a removable pole cap, a J-hook wire support welded inside near the top and a flange plate assembly to match that welded to the butt end of the mast arm.

Mast Arms—Mast arms shall be fabricated and certified in the same manner as the upright shafts and shall have the same physical characteristics.

The mast arms shall meet the design requirements necessary to support rigidly mounted traffic signals as designated in the Plans. All arms shall include a removable cap at the tip, grommets wire outlets and signal hanger assemblies of the type and number shown on the Plans, and a flange plate welded to the butt



end to provide a rigid connection to the mast. The assembly shall be constructed so that all wiring can be concealed internally. A 5 foot rise for the mast arm from the signal support is required per MDPW guidelines. The Contractor shall submit shop drawings for all signal supports and mast arms, stamped and sealed by an engineer registered in the State of Tennessee, to MDPW for review and approval.

Mast arms shall be connected to the upright pole at a height necessary to provide a minimum clearance of 15 ft. 0 in. (4.6 m) under the traffic signal heads or backplates and a maximum clearance of 25 ft. 7.2 in. (7.8 m) to the top of the traffic signal heads. Separate signal heads shall be installed to provide these same clearances.

Finish—Steel poles, mast arms, and hardware, shall be galvanized in accordance with ASTM A 123.

All steel and cast iron components, hardware and threaded fasteners, except anchor bolts, shall be galvanized after fabrication in accordance with ASTM A 123, or A 153 or A 385, as applicable.

**730.36—Steel Strain Poles.** Steel strain poles shall consist of a uniformly tapered or equivalent upright shaft fitted with a removable pole top, J-hook wire support and 45 deg. wire inlet near the top, a span wire clamp, a 5 x 8 in. (125 x 200 mm) handhole with reinforced frame and cover, bent anchor bolts and any other accessories to make a complete installation. The pole and all of its component parts shall be designed to support tethered traffic signals of the type and number indicated on the Plans, suspended from a span wire assembly. The poles shall be fabricated and certified in the same manner as the upright shafts in **Subsection 730.36.**

The shaft length shall be determined by the Contractor as required to meet field conditions and vertical clearances of signal heads over the roadway. The signal head clearance shall be a minimum of 15 ft. 0 in. (4.6 m) under the traffic signal heads or backplates and a maximum of 25 ft. 7.2 in. (7.8 m) to the top of the traffic signal heads. The span wire shall be fastened no closer than 1 ft. 6 in. (450 mm) from the top of the pole.

Unless otherwise specified, all strain pole traffic signal supports shall be provided with a one piece anchor type base. The base will be fabricated from drop forged or cast steel of sufficient cross section to fully develop the ultimate strength of the poles. The base shall be fastened to the pole by means of a welded connection and shall develop full strength of the pole. The base shall be provided with a minimum of four holes of sufficient size to accommodate the proper size anchor bolts that are capable of resisting at yield strength stress, the bending moment of the shaft at its yield strength stress. Removable cast iron covers for the anchor bolts shall be provided.

The shaft shall be fabricated from material providing minimum yield strength of 48,000 psi (331 MPa) after fabrication.

Finish—Steel poles and hardware, shall be galvanized in accordance with ASTM A 123.

All steel and cast iron components, hardware and threaded fasteners, except anchor bolts, shall be galvanized after fabrication in accordance with ASTM A 123, or A 153 or A 385, as applicable.

**730.37—Pedestal Support Signal Poles.** The pedestal poles shall consist of one upright pole with suitable base and any other accessories or hardware as required to make a complete installation.

All poles shall be made of one continuous piece from top of base connection for the entire height of the pole. The cross section shall be either cylindrical or octagonal and may or may not be uniformly tapered from butt to tip.

The cross section at the tip shall have a 4 ½ in. (114 mm) outside diameter.

Type "A" Pedestal (Aluminum)—Pedestals shall be of uniform octagonal or cylindrical cross section of the tubular tapered type fabricated of one full-length sheet.

Bases shall be octagonal or square in shape, of the ornamental type fabricated of cast material. A handhole shall be provided in each base.

Caps shall be of the nipple or tenon type mounting fabricated of cast material.

Bases shall be furnished with four steel anchor bolts of sufficient size and length to securely anchor the base to the concrete footing. The shaft shall be welded to the cast metal base. Refer to the AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals (current edition).

Type A pedestal shaft shall be fabricated from aluminum tubing 6063- T4 heat treated to T6 temper after fabrication, and meeting ASTM B 221.

Type A anchor base shall be made of sand-cast aluminum alloy 356-T6 meeting ASTM B 26 - SF 70A-T5 specifications.

Type "B" Pedestal (Steel)—Pedestal shall be fabricated from a 4-1/2 in. (114 mm) (outside diameter) seamless steel pipe.

Bases shall be octagonal in shape of the ornamental type fabricated of cast or malleable iron and shall have minimum height of 12 in. (300 mm). The top opening of the base shall be threaded to receive the shaft. A handhole shall be provided in each base.

Bases shall be furnished with four steel anchor bolts of sufficient length to securely anchor the base to the concrete footing.

### **730.38—Camera Poles and Structures.**

This Section specifies the minimum requirements for equipment poles furnished and installed in accordance with these specifications and the Plans. This work shall consist of furnishing, installing, and testing 50' galvanized steel camera poles with foundations in accordance with these specifications and the TDOT Standard Specifications for Road and Bridge Construction.

#### **1. Materials**

- A. Galvanized Steel Poles—Fifty foot (50') CCTV pole and foundation with lowering device, conduit, connections, clamps, anchor bolts, shoe bases and all other members shall be designed and fabricated in accordance with the Standards and requirements listed below. Design and materials documentation shall be furnished as part of the approval request submittal. Certifications will be furnished upon request by the Engineer.
  - (1) 2009 AASHTO "Standard Specifications for Structural Supports for Highway Signs, Luminaries and Traffic Signals" including all interims and updates shall be met. Design life shall be 50 years for all poles. The "Fatigue Category", "Galloping Loads" category and "Truck-Induced Gust Loads" do NOT apply to the poles.
  - (2) Shall be designed to withstand the specified forces including those produced by a 90 mph wind with a 1.14 gust effect factor.
  - (3) The Contractor shall submit manufacturer's shop drawings, layout drawings and specifications for equipment and appurtenances for the approval of the Engineer ninety (90) days after notice to proceed.
  - (4) Fabricator: The Fabricator shall be certified under Category I, "Conventional Steel Structures" as set forth by the American Institute of Steel Construction Quality Certification Program. Proof of this certification will be required.
  - (5) Welding: All welding shall be in accordance with Sections 1 through 8 of the American Welding Society (AWS) DI. 1 Structural Welding Code.

- (6) Tackers and welders shall be qualified in accordance with the American Welding Society Structural Welding code.
- (7) Tube longitudinal seam welds shall be free of cracks and excessive undercut, performed with automatic processes, and be visually inspected. Inspection records will be furnished to the Engineer.
- (8) Longitudinal welds suspected to contain defects shall be magnetic particle inspected. All circumferential butt welded pole and arm splices shall be ultrasonically and radio graphically inspected. Inspection records will be furnished to the Engineer.
- (9) Camera Pole System shall consist of a pole, anchor bolts, base plate, ground rod array, communication and power conduits to nearest pull box, grounding conduit, spare conduit and foundation as shown in plans.
- (10) Design computations for the camera poles shall be complete and shall include but not be limited to the following:
  - a. Consideration for all parts of the structure
  - b. Consideration for all possible loading combinations including wind and ice loads
  - c. Design stresses and allowable stresses for all components which comprise the proposed structure
  - d. The top of the pole deflection shall not exceed the following: 1 inch deflection from center (2 inch deflection diameter) due to 30 mph (non-gust) winds for the 50 foot poles.
  - e. All complete shop drawings and design computations shall bear the stamp of a registered Professional Engineer.
  - f. Shop drawings shall be approved prior to fabrication. Approval of the shop drawings does not relieve the Contractor of responsibility for the design, fabrication and erection of the structure.
  - g. The Engineer reserves the right to reject a pole design if the calculated deflection exceeds that specified herein.
  - h. The foundation design shall be based on actual soil conditions from soil borings conducted by the contractor. The cost of the soil borings shall be included in the cost of the pole.
- (11) The calculations shall include a pole, base plate, and anchor bolt analysis. The pole calculations shall be analyzed at the pole base, 5 foot pole intervals, and at each slip joint splice.
- (12) For each pole as shown in the plans, the following information shall be given:
  - a. The pole's diameter, thickness, section modulus, moment of inertia, and cross sectional area.
  - b. The centroid, weight, projected area, drag coefficient, velocity pressure, and wind force of each trapezoidal pole segment.
  - c. The axial force, shear force, primary moment, total moment, axial stress, bending stress, allowable axial stress, allowable bending stress, and combined stress ratio (CSR) at each elevation.
  - d. The pole's angular and linear deflection at each elevation.
- (13) Hand Holes:
  - a. The hand hole openings are reinforced with 2" wide hot rolled steel bar. The opening shall be rectangular and 5" x 8" nominal.
  - b. The cover shall be 11-gauge steel and shall be secured to a clip-on lock with a tamper-proof screw.
  - c. The reinforcing rim shall be provided with a 1/2" tapped hole and 1/2" hex head cap screw for grounding.
  - d. For poles with lowering devices two (2) hand holes shall be 18" apart, center to center and the bottom handhole shall be 18"-24" above the base of the pole.
  - e. The hand holes shall be fully compatible with the Camera Lowering Device and Portable Lowering Tool. If desired and compatible with the lowering device, one larger handhole may be provided in place of two separate hand holes.

- f. Hand holes on poles with pole mounted cabinets and transformers shall be placed toward oncoming traffic. For all other poles hand holes shall face away from traffic.
- (14) Pole Top Junction Box: All 50' camera poles shall have a pole top connector box fastened to the pole top for cable strain relief.
- (15) Cable Supports (J-Hooks & Eyelets): Top and bottom J-hooks and eyelets shall be located within the pole directly aligned with each other.
- (16) Base Plate:
  - a. Base plates shall conform to ASTM A572.
  - b. Plates shall be integrally welded to the tubes with a telescopic welded joint or a full penetration butt weld with backup bar.
  - c. Plates shall be hot dip galvanized.
- (17) Anchor Bolts:
  - a. Anchor bolts shall conform to the requirements of AASHTO M314-90 (105 ksi min. yield.) The upper 12" of the bolts shall be hot dip galvanized per ASTM A153.
  - b. Each anchor bolt shall be supplied with two (2) hex nuts and two (2) hardened washers.
  - c. The strength of the nuts shall equal or exceed the proof load of the bolts.
  - d. The top nut shall be torqued so as to produce 60% yield stress of anchor bolt.
  - e. The Contractor shall not grout between bottom of base plate and top of concrete foundation.
- B. Camera Lowering Device Requirements. All 50 foot poles shall have a Camera Lowering Device (CLD) meeting the following requirements:
  - (1) The Camera Lowering Device shall be safely operable by one technician working alone, to lower the Camera Assembly to ground level for maintenance as necessary and return the Camera Assembly to the pole top mounting and secure it in place, eliminating the need for access by a bucket truck.
  - (2) Weatherproof connectors (camera to the lowering device) shall allow for adaptation of the camera and the dome type housing for lowering and hoisting and be provided as an integral part of the design to provide a water resistant seal when the camera is raised and secured in place for surveillance operation.
  - (3) Lifting and lowering shall be done with a motorized gear box (winch).
  - (4) The CLD should be a stand-alone device mounted on a camera pole to be supplied by the Contractor and included in the cost of the 50' pole.
  - (5) An integrated CLD with pole assembly may be procured provided it meets all specifications.
  - (6) The Camera Lowering Device shall be designed to preclude the lifting cable from contacting the power or video cabling.
  - (7) The Camera Lowering Device shall support the Camera Assembly a minimum of 20" from the pole.
  - (8) The composite cable between the camera and the CCTV cabinet will be a continuous run. No pole top interconnections or splices will be permitted.
- C. Portable Camera Lowering Device Tool. The Contractor shall furnish and test one Portable Lowering Tool capable of being operated by a hand winch and an electric drill motor, which is fully compatible with the Camera Lowering Device and the Steel Camera Pole and meets the following requirements:
  - (1) The Portable Lowering Tool shall be one recommended by the manufacturer of the Camera Lowering Device.
  - (2) The Portable Lowering Tool shall have a minimum load capacity of 200 pounds with a 4 to 1 safety factor.
  - (3) The tool shall consist of a lightweight metal frame and winch assembly with cable, a quick release cable connector, an adjustable safety clutch and a variable speed industrial duty electric drill motor. The tool shall be provided with an adapter for operating the lowering device by a portable drill using a clutch mechanism. The tool shall be equipped

with a positive locking mechanism to secure the cable reel during raising and lowering operations.

- (4) This tool shall be compatible with the hand hole of the pole and the Camera Lowering Device inside the hand hole.
- (5) When attached to the hand hole, the tool will support itself and the load assuring lowering operations and provide a means to prevent freewheeling when loaded.
- (6) The Portable Lowering Tool shall be delivered to the Engineer upon project completion.
- (7) The Portable Lowering Tool shall have a reduction gear to reduce the manual effort required to operate the lifting mechanism.

D. Suspension Unit

- (1) The Contractor shall submit shop drawing to the Engineer for approval of the designed pole mounting adapters, brackets and mounting hardware.
  - (2) The Camera Lowering Device shall have a minimum load capacity of 200 pounds with a 4 to 1 safety factor.
  - (3) The enclosure receptacle and camera enclosure shall incorporate a mating device.
  - (4) The mating device shall have a minimum of 2 latching devices. These latching devices shall securely hold the camera housing and its control equipment free of vibration or motion between the enclosure receptacle and camera enclosure.
  - (5) The latching devices shall lock and unlock by alternately raising and lowering the camera enclosure.
  - (6) When the camera enclosure is latched, all weight shall be removed from the lowering cable.
  - (7) The enclosure receptacle and camera enclosure shall have a heavy-duty tracking guide.
  - (8) The tracking guide and latching devices shall lock the camera enclosure in the same position each time.
  - (9) Electrical contacts shall be provided to support all camera functions. The electrical contacts shall be brass or copper and gold coated to prevent corrosion. The contacts shall be 14 gage or larger.
  - (10) Replaceable gaskets shall be provided to seal the electrical contacts and latching devices from moisture and dust.
  - (11) The only cable permitted to move within the pole or lowering device during lowering or raising shall be the stainless steel lowering cable. All other cables shall remain stable and secure during lowering and raising.
  - (12) The Camera Lowering Device shall be designed to permit a  $\pm 3$  degree of horizontal adjustment for leveling the dome enclosure.
  - (13) The lowering cable shall be a minimum 5/32" diameter stainless steel aircraft cable with a minimum breaking strength of 2400 pounds.
  - (14) Weights and/or counterweights shall be provided to assure the alignment pin and connectors for the camera connection can be raised into position without binding and that it can be lowered properly.
2. Installation Requirements. All equipment shall be installed according to the Manufacturer's recommendations and Plans. Materials and associated accessories/adapters shall not be applied contrary to the Manufacturer's recommendations and standard practices.
- A. Poles. Standards and posts for the camera poles shall be installed as indicated on the Plans and shall conform to the following requirements:
- (1) All poles shall be installed in accordance with the National Electric Safety Code and ASSHTO.
- B. Foundations:
- (1) The Contractor shall submit a design for pole foundations that has been sealed by a registered Professional Engineer.
  - (2) The foundation design shall adhere to the prescribed loading and wind deflection as specified in TDOT Standards Specification.
  - (3) The foundations shall be constructed in accordance with the TDOT Standard Specifications and shall adhere to the approved shop drawings for the loading specified.

- (4) If soil conditions require the use of any shoring, casings, or sonotube for proper installation of the foundations, the cost of the shoring, casings or sonotube shall be included in the cost of the pole and foundation.
  - C. The dimensions and reinforcing steel shall be in accordance with the requirements of the Plans and Specifications.
  - D. Cast-in-place Concrete Pole Foundation shall cure a minimum of 28 days before any load is applied to the foundation. The Engineer may approve early installation of the pole based on the results of the 7 day test.
  - E. Conduit shall be installed in the pole foundation for access and includes conduit to the nearest pull box as shown in plans.
  - F. A minimum of one 2 inch spare conduit shall be installed in all pole foundations as shown in the Plans Typical Details. Spare conduits in pole foundations shall be sealed with blank duct plugs.
  - G. Grounding System
    - (1) The Contractor shall supply and install a grounding system with ground rod array at the base of all poles as shown on the Plans.
    - (2) The ground rod array system shall be connected to the pole through an appropriate ground clamp.
    - (3) A #6 AWG copper stranded bonding wire shall be installed between the pole and the field cabinet providing a common ground system for each site.
    - (4) All ground bonding wires shall be unspliced.
  - H. The installation method for the CCTV poles and cameras shall be such that the camera can be rotated as needed around the pole for optimum placement.
3. Measurement
- A. CCTV Pole and Foundation (50' Pole w/Lowering Device)
 

CCTV Pole and Foundation (50' Pole w/Lowering Device) will be measured in units of each and paid for at the contract price of each. The price bid shall include a 50' steel strain pole, lowering device, foundation, conduit inside foundation and to the nearest pull box, wiring between camera and field cabinet, connections to support structures, and satisfactory completion of testing and training requirements, and all work, equipment and appurtenances as required to effect the full operation including remote and local control of the CCTV site complete in place and ready for use. This price shall be full compensation for all labor, tools, materials, equipment and incidentals necessary to complete the work.
  - B. Lowering Tool for Camera Lowering Device
 

Lowering Tool for Camera Lowering Device will be measured in units of each and paid for at the contract price of each. The price bid shall include the complete operational device including all attachments. This price shall be full compensation for all labor, tools, materials, manuals, equipment and incidentals necessary to complete the work.
4. Payment. The contract unit price shall be full compensation for all work specified in this Section. Payment will be made under:

Item No.	Description	Unit
730-22.36	CCTV Pole 50' Pole Height	Each
725-07.54	Lowering Device/Lowering Tool for Camera Lowering Device	Each

The CCTV Pole will be paid per each as follows:

- 25% of the contract unit price upon complete installation of foundations.
- Additional 45% of the contract unit price upon delivery of poles or structure to the site.
- Final 30% of the contract unit price upon complete installation of poles or structure.
- Lowering Tool for Camera Lowering Device will be paid at the unit price for each device when delivered to MPW.

**730.39—Wooden Pole Signal Supports.** Wooden poles shall be class II 35' in length or as described in the Plans and shall meet the requirements of **Subsection 917.11** of the Standard Specifications. Poles shall be set to the depth shown in the Plans and fitted with all necessary hardware to make the installation complete.

The signal head clearance shall be 16 ft. 6 in. minimum to the bottom of the traffic signal heads or backplates and 25 ft. 0 in. maximum to the top of the traffic signal heads. The span wire shall be fastened no closer than 2 ft. 0 in. from the top of the pole.

Guying Components—Guy clamps shall be steel, three-bolt type, 6 in. (150 mm) length, and of the proper strand size to fit the wire used. The clamp bolts shall have upset shoulders fitting into the clamp plate. Substitution of the cable grip is subject to approval by the Engineer.

Guy wire shall be attached to the pole with a 5/8 in. (16 mm) diameter x 12 in. (300 mm) length single strand bolt with approved guy wire attachment hardware and 2 x 2 in. (50 mm) square cut washers, lock washer and square nut.

Sidewalk guy fittings shall consist of 2 in. (50 mm) I.D. standard galvanized steel pipe of required length with malleable iron pole plate and guy clamp. Pole plate to be fastened to the pole with a 5/8 diameter thru bolt and 1/2 in. (13 mm) lag screws.

All guying components and hardware shall be galvanized in accordance with ASTM A 123 or A 153.

Anchors for guys shall be of the pressed steel 4-way expanding fluke type or of the steel or malleable iron sliding plate type. The minimum unexpanded diameter shall be 8 in. (200 mm), and the minimum expanded area shall be 110 s.f. (7 cm<sup>2</sup>). Anchors shall be coated with a black asphaltic paint.

Guy anchor rods shall be drop-forged steel, 3/4 in. (19 mm) diameter and 7 ft. (2.1 m) minimum length, threaded, of the single thimble eye type, with a square anchor bolt nut.

**730.40—Pole Location.** All signal support poles shall be installed at locations shown on the Plans or where directed by the Engineer.

## MISCELLANEOUS SYSTEMS

**730.41—CCTV Camera Systems.** This Section specifies the minimum requirements for CCTV Camera Systems furnished and installed. The CCTV Camera System will provide TMC personnel with live streaming video of the roadway network via CCTV Camera Systems installed at locations shown in the Plans.

### 1. Materials

All materials furnished, assembled, fabricated or installed shall be new, corrosion resistant and in strict accordance with all of the details shown in the Plans and described in these specifications.

The CCTV Camera System shall comply with the following minimum materials specifications:

#### A. General Capabilities and Performance Requirements. Overall CCTV Camera System capabilities and performance requirements include the following:

- (1) CCTV Camera System shall be placed at fixed locations as shown on the Plans to provide coverage within the project limits including the mainline and side street travel lanes and shoulders.
- (2) The CCTV Camera System components shall be compatible with each other and be of rugged design and suitable for reliable operation when mounted in the configuration as specified in these specifications and the Plans.
- (3) The CCTV Camera System shall be capable of attended and unattended, continuous 24 hours per day operation at the sites as shown on the Plans.
- (4) Ensure that the installed equipment provides unobstructed video of the roadway, traffic, and other current conditions around a roadside CCTV field site; that it responds to camera control signals from an operator of the system; and that the video images can be transmitted to remote locations interfaced to the system for observation.
- (5) The camera shall be fully compliant with all aspects of the National Television Standards Committee (NTSC) specification, and produce NTSC compatible video.
- (6) Operate over wide dynamic light conditions ranging from low light/dusk to full sunlight having day (color)/night (monochrome) switchover and iris control, with user-selectable manual and automatic control capabilities.
- (7) Capable of being remotely controlled and programmed.
- (8) Provide a pressurized enclosure for environmental protection.
- (9) Camera shall be mounted together with the zoom lens and integrated into the pan and tilt device within the enclosure forming a totally integrated, easily removable assembly.
- (10) Camera shall include a high quality integrated camera/lens combination.
- (11) Shall be equipped with an auto-iris lens capability compatible with the zoom lens supplied.
- (12) Iris capability shall include a provision for manual override via software.
- (13) Capable of auto-focus during zoom-in or zoom-out, with provisions for override via software.
- (14) Provide overexposure protection - the camera shall not be degraded or damaged under normal reasonable operating conditions.
- (15) Provide capability for local control of pan, tilt and zoom functions at the roadside cabinet using vendor-supplied software installed on a laptop computer.
- (16) CCTV cameras shall support the NTCIP 1205 v1.08 communication protocol.

#### B. Camera Unit. The minimum Camera Unit requirements include:

- (1) The camera unit shall incorporate solid-state design and provide digital signal processing (DSP) capable of providing clear and low-bloom color video pictures during daylight hours and monochrome video at night when the roadway is illuminated with minimal roadway lighting.
- (2) The camera unit shall be equipped with a low light level sensor to automatically switch the camera to Black and White mode.



- (3) The camera unit shall be equipped with an override capability to allow the camera to be manually switched via software to turn off the automatic low light level sensor switch feature for Color or Monochrome operation.
  - (4) Image sensor: 1/3 inch charge-coupled device (CCD) employing digital video signal processing (DSP) technology with a minimum Effective Picture Elements of 768 horizontal x 494 vertical pixels.
  - (5) Sensitivity: The camera shall maintain usable video under both day and nighttime lighting conditions. The Contractor shall provide an explanation of how their proposed camera equipment will provide usable video meeting the performance requirements specified herein. This explanation shall take into account as a minimum, the following parameters: usable video level (full video), reflectance (day and night scenarios), F-Stop, AGC and Shutter Speed.
  - (6) Video output synchronization shall be 2 to 1 interlace and will observe the NTSC (color) and EIA RS-170 (black and white) standards.
  - (7) Resolution: 470 lines horizontal and 350 TV lines vertical, NTSC equivalent.
  - (8) Signal-to-noise ratio: 48 dB, minimum with AGC off, un-weighted, and 4.5MHz filter.
  - (9) Video Signal Format: National Television Standards Committee (NTSC) composite video output of 1 Voltp-p at 75 ohms, unbalanced
- C. Camera Lens. The minimum camera lens requirements include:
- (1) The camera lens shall have a minimum F-Stop of 1.4 to 1.6.
  - (2) Optical and Digital Zoom: Provide an optical zoom of 23X and a digital zoom of 8X, minimum.
  - (3) Zoom Control: The zoom magnification shall be fully controllable via the remote PTZ mechanism. The time to pass through the full range of movement of Iris, Zoom and Focus shall in no case exceed 10 seconds.
  - (4) Iris and Focus: Support automatic iris and focus control with manual override capability. The iris shall be in a closed position when there is no power.
  - (5) White or Color Balance: Support automatic or set to yield optical results under various outdoor lighting conditions.
  - (6) Shutter Speed: Support automatic or set to yield optimal results under low lighting conditions without blooming or smearing, auto-iris on. Provide electronic shutter that is selectable in steps.
  - (7) The lens shall be equipped for continuous remote control of zoom, focus, and iris.
  - (8) Mechanical or electrical means shall be provided to protect motors from overrunning in extreme positions.
  - (9) The zoom lens shall be an integrated camera/lens combination.
  - (10) Vibration or ambient temperature changes shall not affect the automatic iris function, focus mechanism, and zoom mechanism.
  - (11) The lens shall be optically clear, impact resistant and acrylic. The acrylic lens shall not yellow, introduce appreciable light loss, or geometric distortion over a 10-year service life when exposed to the environment.
  - (12) The zoom mechanism shall be designed for maintenance-free operations. All gearing and bearings shall be self-lubricating with lubrication and gearing tolerances compatible with the environmental specifications contained herein.
- D. Character Generator. The minimum character generator requirements include:
- (1) Provide capability of generating and superimposing lines of English language text on the video image/stream.
  - (2) Provide a minimum of 20 characters per line that are between 10 and 30 horizontal TV lines in height.
  - (3) Control (enable, disable and edit) of this feature shall be available remotely and at the field site using a laptop computer.
  - (4) The text messages shall be stored in non-volatile memory.
  - (5) Characters shall be white with a black border to ensure legibility in varied scenes.

- (6) Provide the following minimum text insertion requirements with the ability to individually turn each one on or off:
  - a. Camera ID
  - b. Sector Message
  - c. Alarm Messages
  - d. Pan/Tilt Azimuth/Elevation
  - e. Compass Direction in 8 discreet zones
- E. Dome Enclosure. The minimum dome enclosure requirements include:
  - (1) Sealed, pressurized dome enclosure that provides complete protection for the camera and lens assembly from moisture and airborne contaminants.
  - (2) Environmental resistant and tamper proof meeting NEMA 4X or IP-67 rating requirements.
  - (3) The dome enclosure shall be constructed in such a way that unrestricted camera views can be obtained at all camera and lens positions.
  - (4) Dome environmental control shall be provided by nitrogen pressurization with a Schrader Valve for pressurization and purging. The enclosure shall be designed to be pressurized at 5 PSI of dry nitrogen. The notation "CAUTION – PRESSURIZED" shall be permanently printed on the rear plate of the enclosure clearly visible and readable.
  - (5) An alarm shall be displayed under low-pressure conditions and displayed on the camera video. The low-pressure alarm shall be on/off selectable by the operator at the TMC.
  - (6) The dome enclosure shall consist of a two-piece (upper and lower half) dome. The bottom half of the dome shall be attached to the upper half with a plastic-coated safety cable to prevent the lower half from falling to the ground.
  - (7) Provide a harness and cables with each enclosure to extend the video, power, and data from the CCTV Camera System to the field cabinet. No harness shall be exposed. All entry points shall have gaskets to prevent moisture entry. A sealed connector shall be at the top of the dome.
  - (8) The dome enclosure shall assist in preventing lens fogging and effectively reduce internal temperatures.
  - (9) The enclosure shall minimize glare and provide overexposure protection for the camera when pointed directly at the sun.
  - (10) The enclosure shall be equipped with a heater, a defroster and a thermostat.
  - (11) The camera equipment inside the dome enclosure shall meet all its specified requirements when operating under the following conditions:
    - a. Ambient Temperatures: -34°C to +74°C (-30°F to +165°F). A heater/blower shall be used to maintain internal dome temperatures within the manufacturer required operating temperatures for their equipment.
    - b. Relative Humidity: 5% and 95%, non-condensing
  - (12) Dome enclosure shall be secured with a mounting plate/attachment designed to withstand a 90mph sustained wind speed with a 30% gust factor.
- F. Tube Type Enclosure. The minimum enclosure requirements include:
  - (1) Sealed, pressurized enclosure that provides complete protection for the camera and lens assembly from moisture and airborne contaminants.
  - (2) Environmental resistant and tamper proof meeting NEMA 4X or IP-67 rating requirements.
  - (3) The dome enclosure shall be constructed in such a way that unrestricted camera views can be obtained at all camera and lens positions.
  - (4) Dome environmental control shall be provided by nitrogen pressurization with a Schrader Valve for pressurization and purging. The enclosure shall be designed to be pressurized at 5 PSI of dry nitrogen. The notation "CAUTION – PRESSURIZED" shall be permanently printed on the rear plate of the enclosure clearly visible and readable.
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  - (7) Provide a harness and cables with each enclosure to extend the video, power, and data from the CCTV Camera System to the field cabinet. No harness shall be exposed. All entry points shall have gaskets to prevent moisture entry.
  - (8) The enclosure shall assist in preventing lens fogging and effectively reduce internal temperatures.
  - (9) The enclosure shall minimize glare and provide overexposure protection for the camera when pointed directly at the sun.
  - (10) The enclosure shall be equipped with a heater, a defroster and a thermostat.
  - (11) The camera equipment inside the enclosure shall meet all its specified requirements when operating under the following conditions:
    - a. Ambient Temperatures: -34°C to +74°C (-30°F to +165°F). A heater/blower shall be used to maintain internal temperatures within the manufacturer required operating temperatures for their equipment.
    - b. Relative Humidity: 5% and 95%, non-condensing
  - (12) The enclosure shall be secured with a mounting plate/attachment designed to withstand a 90mph sustained wind speed with a 30% gust factor.
- G. Pan and Tilt Unit (PTU). The minimum pan and tilt unit requirements include:
- (1) Dome Enclosure:
    - a. The motorized, remotely controlled Pan/Tilt unit shall be mounted within the dome enclosure. The unit shall be integrated with the CCTV control system.
    - b. The unit shall provide continuous tilt (vertical) movement of 90 degrees from horizontal and continuous pan (horizontal) movement of 360 degrees.
    - c. Tilt speed shall be variable from zero up to 40 degrees per second, minimum, and the pan speed shall be variable from zero up to 80 degrees per second, minimum.
    - d. The unit shall be capable of simultaneous pan, tilt movements and zoom on one camera.
    - e. Drive motors shall be capable of instantaneous reversing, be corrosion resistant, not require lubrication and have overload protection.
    - f. Braking shall be provided in both pan and tilt movements to enable fast stop and reversal and to prevent drifting.
    - g. The viewing limits shall be set by a minimum of 8 discreet privacy zones that are software selectable.
  - (2) Tube Type Enclosure:
    - a. The motorized, remotely controlled Pan/Tilt unit shall be mounted within the enclosure. The unit shall be integrated with the CCTV control system.
    - b. The unit shall provide continuous tilt (vertical) movement of +33 degrees to -83 degrees from horizontal and continuous pan (horizontal) movement of 360 degrees.
    - c. Tilt speed shall be variable from zero up to 40 degrees per second, minimum, and the pan speed shall be variable from zero up to 40 degrees per second, minimum.
    - d. The unit shall be capable of simultaneous pan, tilt movements and zoom on one camera.
    - e. Drive motors shall be capable of instantaneous reversing, be corrosion resistant, not require lubrication and have overload protection.
    - f. Braking shall be provided in both pan and tilt movements to enable fast stop and reversal and to prevent drifting.
    - g. The viewing limits shall be set by a minimum of 8 discreet privacy zones that are software selectable.
- H. Camera Control Receiver – Driver. The minimum camera control receiver-driver requirements include:
- (1) The camera control receiver shall provide a single point interface for control, power, and video communications.

- (2) The camera control receiver-driver shall be included within the enclosure and control the camera, pan/tilt, and lens functions at each CCTV site.
  - (3) The unit shall provide alphanumeric generation for on-screen titles.
  - (4) The unit shall provide the ability to display diagnostic information on the screen in response to user commands.
  - (5) The diagnostic information shall include current pan, tilt, zoom and focus positions, and error codes for power, communication, position, and memory problems.
  - (6) Provide capability for programmed tours.
  - (7) The camera control receiver shall use non-volatile memory to store the required information for presets, camera ID, and sector text.
  - (8) Presets shall meet the following requirements:
    - a. A minimum of 64 presets shall be supported. Each preset shall consist of pan, tilt, zoom, and focus positions.
    - b. The Contractor shall develop and install ten (10) presets for each camera. The Contractor shall submit the preset locations to MPW for review and approval.
  - (9) Protocols: CCTV cameras shall support the NTCIP 1205 v1.08 communication protocol. No camera control receiver-driver shall use non-published protocols. Contractor shall provide protocol documentation.
  - (10) Communications Interface: The communications interface shall support communications compliant with RS-422 and/or 485 (user selectable).
  - (11) The communications interface shall be compatible with the Video Encoder serial port as defined previously.
  - (12) Connectors: Standard connectors compatible with communications and interface equipment/cables shall be provided.
  - (13) The video input and output connections shall be the BNC type.
  - (14) Connector(s) shall also be used for connecting the control outputs from the control receiver-driver unit to the camera, lens, and pan/tilt mechanisms.
- I. Electrical. The minimum electrical requirements include:
- (1) The CCTV Camera System shall be furnished with any and all equipment required for a fully functional system, including all appropriate power and communications cables as defined by the manufacturer.
  - (2) The power cables shall be sized to meet the applicable National Electrical Code (NEC) requirements.
  - (3) All devices supplied as system components shall accept, as a primary power source, 120 volts of alternating current (VAC) at an input of 60 hertz. Any device that requires source input other than 120 VAC at 60 hertz, such as cameras, PTUs, receiver/drives and enclosure heaters/blowers that operate at 24 volts or other, shall be furnished with the appropriate means of conversion.
- J. Coaxial Cabling. The minimum coaxial interconnect cable requirements include:
- (1) The coaxial cable from the CCTV Camera System to the equipment cabinet shall be Belden 1694A or approved equivalent.
  - (2) RG 6/U, 20AWG, bare copper conductor, polyethylene insulation
  - (3) 98% tinned copper, double braid shield, black polyethylene jacket
  - (4) Characteristic Impedance: 75 ohms ( $\Omega$ ), nominal
  - (5) Capacitance (conductor to shield): 21pF/ft; Inductance: 0.131uH/ft, nominal
- K. Surge Protection. All CCTV Camera System electrical interconnects shall be protected from voltage surges caused by lightning and external electromagnetic fields. The minimum surge protection requirements include:
- (1) Surge protectors shall be furnished for all non-dielectric cable and conductors (video, data/signal, and device/assembly power) between the CCTV Camera System and the equipment cabinet.
  - (2) The surge protectors shall have leads that are kept to a minimum length as recommended by the surge device manufacturer.

- (3) All surge protection devices shall be designed to meet the temperature and humidity requirements expected in this type of outdoor application.
    - (4) All Surge protectors shall be U.L. listed (UL 1449, UL 497, 497A, 497B, etc., as appropriate) and bonded to the same single-point ground point.
    - (5) Coaxial Cable Surge protectors for coaxial cable shall meet / provide the following functionality:
      - a. Attenuation: 0.1dB @10 MHz, typical
      - b. Input/Output Impedance: 75 ohms nominal
      - c. Operating Voltage of the surge protector shall match characteristics of the ITS device/assembly.
      - d. Peak Surge Current: 5,000-amperes for an 8 x 20 microsecond waveform
      - e. Response Time: 1 nanosecond or less
    - (6) Low Voltage / Signal Cable Surge protectors for data/signal/control cable shall meet /provide the following functionality:
      - a. Peak Surge Current: 10,000-amperes for an 8 x 20 microsecond waveform
      - b. Response Time: 1 nanosecond or less
      - c. Life Expectancy: Capable of surviving at a minimum of 25 occurrences at 2000-amperes
    - (7) CCTV power surge protectors for power from equipment cabinet power distribution to the CCTV Camera System shall meet/provide the following functionality:
      - a. Frequency: DC to 10MHz
      - b. Clamping Voltage: < 30VAC (rms) or 42VDC
      - c. Insertion Loss: < 0.2dB
      - d. Input/Output Impedance: 75 ohms, typical
      - e. Peak Surge Current: 3000-amperes
      - f. Response Time: 1 nanosecond or less
2. Installation Requirements. All equipment shall be installed according to the manufacturer's recommendations, the Plans and as follows:
  - A. Materials and associated accessories/adapters shall not be applied contrary to the manufacturer's recommendations and standard practices.
  - B. Shall include all materials needed to permanently mount the CCTV camera to the support structure as indicated in the plans.
  - C. Furnish and install power, video, and data cables, and any and all ancillary equipment required to provide a complete and fully operational CCTV system site.
  - D. Verify all wiring meets NEC requirements where applicable.
  - E. Cameras shall be mounted in positions which allow 360 degree continuous rotation.
3. Measurement  
CCTV Camera System will be measured in units of each and paid for at the contract price per each. The price bid shall include furnishing, installing, system integration, training, documentation, and testing of a complete CCTV Camera System including the CCTV Camera Assembly, PT unit, zoom lens, enclosure, camera controller/receiver, coaxial cable, control/signal cable, power cable, surge suppressors and conduit between the camera and the cabinet, connections to support structures, attachment hardware and brackets and all incidental items to provide and install the CCTV Camera System as intended, satisfactory completion of all testing requirements and all work, equipment and appurtenances as required for a full CCTV Camera System. The price bid shall also include all system documentation including: shop drawings, operations and maintenance manuals, wiring diagrams, block diagrams and other materials necessary to document the operation of the CCTV Camera System. This price shall be full compensation for all labor, tools, materials, equipment and incidentals necessary to complete the work.

4. Payment. The contract unit price shall be full compensation for all the work specified in this Section. Payment will be made under:

Item No.	Description	Unit
725-07.04	CCTV Camera System (Dome)	Each
N/A	CCTV Camera (Tube)	Each

N/A = There is no present TDOT Item number for this Item.

The CCTV Camera System will be paid per each as follows:

- 50% of the contract unit price upon approval of Bench Test Component, Bench Test System and Pre-Installation test results.
- Additional 20% of the contract unit price upon approval of Stand Alone Site Test results.
- Additional 20% of the contract unit price upon approval of Conditional System Acceptance Test results.
- Final 10% of the contract unit price upon Final System Acceptance.

**730.42—Video Communications Equipment**

This Section specifies the minimum requirements for video communications equipment furnished and installed. The work shall consist of providing all labor, materials, equipment, and incidentals necessary to furnish, install, and test a Video Communications System.

The Video Communications System equipment shall encode, transport over the IP-based Ethernet network, and decode digitized video signals and data communications via a full duplex serial interface for the CCTV Camera System. One encoder shall be placed in the field for each CCTV Camera. A limited number of decoders shall be provided at the TMC for general use; however, the majority of TMC components shall utilize the digital video streams.

1. Materials. The equipment and software shall comply with the following minimum material specifications:
  - A. General Capabilities and Performance Requirements. The Video Encoders and Decoders shall include the following general requirements:
    - (1) Encoders shall encode (i.e., digitize) full-motion analog video at the closed-circuit television (CCTV) remote site and then deliver the streaming video, as well as a minimum of two (2) bi-directional data channels over IP networks to the chosen remote/local network interface device (i.e., the Ethernet switch), which will transmit and receive the data streams to and from the transportation management center (TMC).
    - (2) Encoders shall be capable of streaming the video for both unicast and multicast applications with the video being transported using the User Datagram Protocol (UDP) and the data being transported using the TCP/IP through the IP-based network.
    - (3) Decoders shall convert to full-motion analog video the digitized video from an encoder, as well as transport a minimum of two bi-directional data channels over IP networks to the chosen remote encoder device.
    - (4) Encoders and decoders shall employ the compression algorithms contained in the MPEG-2 technology, according to the International Organization for Standardization (ISO) and International Electrotechnical Commission (IEC) requirements as detailed in the ISO/IEC 13818 standard.
    - (5) Encoder/decoder chassis will be located at the TMC for a combination of encoding and decoding video streams on the network and will be a rack based chassis in appropriate configuration of encoder and/or decoder cards.
    - (6) All proposed Video Encoders and Decoders provided under this Contract shall be the same model from the same manufacturer and be fully compatible and interoperable with each type provided and the network equipment.

- (7) Unless otherwise shown in the Plans, there shall be one (single) Video Encoder for each remote CCTV camera assembly and video detection site.
- (8) The Video Encoders shall fully interoperate with the Video Decoders (hardware and software) as defined in these specifications.
- (9) Mean Time Between Failure (MTBF) - The Video Encoder or Decoder shall have a minimum MTBF of 50,000 hours.
- (10) Latency: The end-to-end system latency between the Video Encoder and the Video Decoder, as defined in these specifications, shall be no more than 400msec, not including network delays. The encoders shall support various frame adjustments to minimize latency.
- (11) Video Encoders shall be remotely adjustable via a video management system so that a technician can adjust image quality controls for contrast, brightness, and hue and color levels.
- (12) The encoded digitized video signal shall be capable of being decoded by a hardware decoder module and by PC-based software applications capable of auto detecting the compression, resolution and bit rate.

B. Video and Data Requirements. The minimum video and data requirements include the following:

- (1) The Video Encoder/Decoder shall support the following video features:
  - a. Signal Format: 30 fps, NTSC color
  - b. The encoder shall provide MPEG-2 (ISO 13818-2) MP @ ML at a data rate of 128 Kbps - 12 Mbps (Aggregate Stream).
  - c. Support the following encoded resolutions (minimum):

	NTSC	PAL
Full	720 x 480	720 x 756
HHR	352 x 480	352 x 576
SIF	352 x 240	352 x 288

- (2) The Video Encoder/Decoder shall support two (2) bi-directional serial communications over Ethernet via the following methods:
    - a. Encoder serial port to Decoder serial port data stream.
    - b. IP socket to Encoder/Decoder serial port.
    - c. IP socket to Encoder TCP port where an IP based application can communicate directly to the encoder port.
    - d. The serial interface shall be transparent to the device (i.e. no additional or special protocols shall be used to communicate between the CCTV control interface).
    - e. Category 6 patch cords shall be used between video encoders/decoders and the network switch.
  - (3) The Video Encoder shall comply/support the following:
    - a. Dynamic bandwidth control: Up to 12 Mbps or greater rates (The data rate shall be defined as the maximum committed bandwidth to be utilized, which includes data bursting.)
    - b. Bandwidth increments shall be user configurable via the network.
    - c. The default bandwidth for the Video Encoder as delivered shall be set to 4 Mbps.
  - (4) The communications method shall be user selectable.
    - a. The Video Encoder/Decoder shall support a full-duplex serial interface and data rates up to 115kbps. The baud rate, stop bits, and data bits shall be user configurable.
- C. Physical and Environmental Specifications. The minimum physical and environmental requirements include:
- (1) The Video Encoder/Decoder shall have the following ports:
    - a. Network: 10/100 Mbps RJ-45
    - b. Video: Composite binary network connector (BNC)
    - c. Serial Data Interface: Two (2) DB 9 or RJ-45 ports.

- (2) The Video Encoder/Decoder Chassis will be rack based and located in the TMC Equipment room with a minimum of 3 cards that are a combination of encoder and decoder cards with the following :
    - a. Video Encoder Cards each with:
      - i. Network: 10/100 Mbps RJ-45
      - ii. Video: Two (2) Composite Bayonet Neill Concelman (BNC)
      - iii. Serial Data Interface: Two (2) DB 9 or RJ-45 ports.
    - b. Video Decoder Cards each with:
      - i. Network: 10/100 Mbps RJ-45
      - ii. Video: Two (2 ) Composite Bayonet Neill Concelman (BNC)
      - iii. Serial Data Interface: Two (2) DB 9 or RJ-45 ports.
  - (3) The video input performance measures shall comply with NTSC and EIA requirements, including the EIA-170 standard, with a composite video of 1 volt peak-to-peak (Vp-p). The equipment shall have an electrical resistance of 75 ohms ( $\Omega$ ) per 60 hertz (Hz).
  - (4) The Video Encoders used at field locations shall operate in outdoor weatherproof cabinets where the inside temperature range is -20°C to +70°C (-4°F to +158°F), and the relative humidity is between 5% and 90% non-condensing.
  - (5) The Video Decoders and Video encoder/decoder chassis shall operate in the following minimum environment: Temperature ranging from 0°C to +50°C (+32°F to +122°F), and the relative humidity is between 5% to 90% non-condensing.
  - (6) All encoders/decoders shall be PCB conformal coated to provide a level of protection from humidity, contaminants, dust, pollution, etc.
  - (7) Encoders/Decoders shall provide a local status display capability for video, data, network interfaces and power. Status indicators shall be L.E.D..
  - (8) Cable connections (Cat-6/coaxial/power) shall require no tools for installation or removal and be designed with positive locking devices such that they will not vibrate loose.
  - (9) Provide external markings -- all connectors, indicators, and replaceable components shall be permanently marked and traceable to the supplied documentation, including schematics and parts list. The external markings shall include the product function name, model number, serial number, and manufacturer's name.
  - (10) All encoders shall be shelf mountable or rack mountable. Shelf for the cabinet shall be provided if needed. Other mounting options may be submitted for review and approval by the Engineer.
  - (11) The encoder configuration shall be able to fit, including all mounting hardware, within a standard EIA 19 inch rack. The video encoder configuration shall also not exceed 13 inches in depth to accommodate the cabinet space configuration.
- D. Serial Data Interface. The minimum serial data interface requirements include:
- (1) Each Video Encoder/Decoder shall have a minimum of two (2) EIA-232/422/485 serial interface ports. These ports shall be configurable, directly or over the network, to EIA-232/422/485 mode of operation as defined by the EIA for data format, data rate, and data structure (e.g., the number of bits, parity, stop bits, etc.) via the management software provided. Each serial port shall support from 1.2 Kbps to 115 Kbps.
  - (2) Each Video Encoder shall comply/support encapsulation of the video streams in a UDP packet for network transmission.
  - (3) Each Video Encoder shall use serial interface port B to support PTZ camera control functions.
  - (4) The 2nd Video Encoder serial port shall support RS-232 data communications from a NEMA Traffic Controller. The Contractor shall be responsible for full system integration/compatibility and ensure that the RS-232 data communications signal level and integrity is sufficient for Traffic Controller data integrity and accuracy as configured in the plans. To accomplish this, the Contractor may use line drivers, isolation transformers (e.g., to address possible common mode issues, etc.), as needed. The price for these devices and materials are considered incidental and shall be included in the cost of the Encoder.



- (5) Each serial port shall support IP addressing and socket number selection.
  - (6) The equipment shall provide the capability to establish an IP connection directly from a workstation to any Encoder IP address and socket number to transport serial data, independent of whether or not the video stream for that Encoder is being viewed.
- E. Network/Video Transmission Method. The Video Encoder/Decoder shall comply/support the following:
- (1) Ethernet Interface (10/100Base-TX protocol, Full/Half-Duplex, Auto Sense (802.3), RJ-45).
  - (2) Encoder shall be specifically designed for network operation, and adhere to ISO/13818-2 Video standards (Elementary Stream/ES) and/or ISO/13818-1 Systems standards (Transport Stream/TS).
  - (3) Decoder shall be specifically designed for network operation, and adhere to ISO/13818-2 Video standards (Elementary Stream/ES) and ISO/13818-1 Systems standards (Transport Stream/TS). The decoder shall be able to auto-detect whether the incoming video stream is ES or TS.
  - (4) The Encoder/Decoder shall allow for transmission over Ethernet (wire-line or wireless) as specified in these specifications.
  - (5) The Encoder/Decoder shall connect to an Ethernet switch through Category 5e patch cords as specified in these specifications.
  - (6) Static IP Addressing (class A, B, and C).
  - (7) UDP Unicast and IP Multicast (Internet Group Multicast Protocol / IGMP V2) features for digital video transmission.
  - (8) Support Session Announcement Protocol (SAP).
- F. On Screen Text Insertion and Display. The minimum on screen text insertion and display requirements include:
- (1) The encoders shall support a comprehensive text insertion capability and shall be capable of inserting a minimum of four (4) user configurable text messages of up to 20 characters in length.
  - (2) Encoders shall be able to generate a date and time stamp in the video stream and shall be synchronized to a time-server on the network.
  - (3) Decoders shall have the option to display or not display the on-screen text.
- G. Encoder/Decoder Management System. The minimum management system requirements shall include:
- (1) The Encoder/Decoder shall be manageable through SNMP (v2), TFTP or FTP, or Telnet/CLI.
  - (2) The management system shall be provided to remotely configure and diagnose the Encoders/Decoders.
  - (3) Have capability to reset/reboot and firmware upload via the methods listed above.
  - (4) Provide a GIS map with graphical icons of devices and groups of devices, which can be accessed and provide real-time color-coded status information.
  - (5) Have the capability to change any of the device configuration settings including bit rates, image resolution and compression settings and serial interface type.
  - (6) Provide for screen text insertion of user messages.
  - (7) Provide pre-defined optimized MPEG settings for various bit rates.
  - (8) Provide update capability for the firmware in the Encoders from the central site. Ability to access the serial number, firmware number, IP address and equipment configuration. Have the capability to upload firmware to multiple units automatically.
  - (9) Provide a software video decoding capability as part of the overall hardware management software.
- H. Electrical. The minimum electrical/power requirements include:
- (1) Power: nominal input voltage of 120 VAC 60 Hz. The unit shall contain all power conversion and regulation necessary to support electronics operation.
  - (2) Power Consumption shall not exceed 60Watts.
  - (3) The Video Encoder/Decoder shall provide for automatic recovery from an over or under voltage condition when prime power has returned to the tolerance values specified herein.

All configuration parameters shall be stored in non-volatile memory and no reprogramming or manual adjustments shall be required upon power recovery.

I. Installation Requirements. All equipment shall be installed according to the manufacturer's recommendations, the Plans and as follows:

- (1) The Contractor shall furnish and install any auxiliary Video Communications Equipment in support of a communications network that will transport video from CCTV cameras located along the arterials to the TMC.
- (2) Materials and associated accessories/adapters shall not be applied contrary to the manufacturer's recommendations and standard practices.
- (3) All Encoders shall be installed and configured by the contractor with the same firmware configuration. The optimum settings shall be used consistently system-wide. Any locations that require different settings for optimum performance shall be approved by the Engineer.
- (4) The Contractor shall furnish all tools, equipment, materials, supplies, and manufactured hardware, and shall perform all operations and equipment integration necessary to provide complete, fully operational video communications equipment as specified herein, within the Plan set, and/or in the Contract Documents.
- (5) The Contractor shall provide METRO with a written inventory of items received and the condition in which they were received. Once received, the equipment becomes the Contractor's responsibility. The Contractor shall provide all labor and equipment necessary to move inventory out of the designated storage facility and to transport it to the installation location. All equipment shall be installed according to the manufacturer's recommendations or as directed by the Engineer.

J. Testing Requirements. Testing shall include, but not be limited to, the following:

- (1) General Requirements:
  - a. The Contractor shall conduct a project testing program for all Video Encoders/Decoders. The project testing program for Video Encoders/Decoders shall include but is not limited to the additional specific requirements in this subsection.
  - b. All test results shall confirm physical and performance compliance with these specifications.
  - c. Submit all test results documentation to the Engineer within fourteen (14) days of completion of the tests. The Engineer will review all test documentation.
- (2) Bench Test System (BTS) and Standalone Acceptance Test (SAT)
  - a. In addition to all other required test steps for the Video Encoder/Decoder, the Contractor shall also demonstrate the ability of the Encoder to communicate with the attached Traffic Controller through the serial port.
- (3) Factory Acceptance Test (FAT)

The Contractor shall perform FAT on the Encoder and Decoder subsystem with the video subsystem to verify interoperability and compatibility. The Contractor shall provide the CCTV Camera System, VCR with ability to play a video with typical arterial traffic, proposed Encoders/Decoders, along with all devices, materials, software, test equipment, and labor to fully conduct and complete all testing for this project. The FAT shall include at a minimum the following tests:

  - a. Verify interoperability of the proposed Video Encoder with the proposed Video Decoder (hardware).

K. Measurement

The Video Encoder and Decoder will be measured in units of each and paid for at the contract price per each. The price bid shall include furnishing, installing warranties, full operation and configuring the Video Encoder and Video Decoder in accordance with applicable Standards, Specifications, and requirements. The price bid shall also include the mounting hardware, Cat-6 patch cords, power cable, user manuals, testing, warranties, serial cable/port converters as necessary, and any and all other equipment required to complete installation of the unit. This price shall be full compensation for all labor, tools, materials, equipment and incidentals necessary to complete the work.

- L. Payment. The contract unit price shall be full compensation for all work specified in this Section. Payment will be made under:

Item No.	Description	Unit
725-07.06	Video Encoder	Each

The Video Communications Equipment will be paid per each as follows:

- 50% of the contract unit price upon approval of Bench Test Component, Bench Test System and Pre-Installation Test results.
- Additional 20% of the contract unit price upon approval of Stand Alone Site Test results.
- Additional 20% of the contract unit price upon approval of Conditional System Acceptance Test results.
- Final 10% of the contract unit price upon Final System Acceptance.

### 730.43—Terminal Servers

This Section specifies the minimum requirements for Terminal Servers furnished and installed. The work shall consist of providing all labor, materials, equipment, and incidentals necessary to furnish, install, and test Terminal Servers.

The Terminal Server device, also commonly referred to as a Port Server device, will be used to communicate bi-directionally between IP-based Ethernet network systems and field devices that communicate or are controlled via a full-duplex serial interface. This includes the Modems which convert RS 232 data to 4-Wire FSK signals to communicate with existing Traffic Controllers.

1. Materials. The equipment and software shall comply with the following minimum material Specifications:
  - A. General Capabilities and Performance Requirements. The Terminal Server shall include the following general requirements:
    - (1) Provide 10/100 Base-T Ethernet Support
    - (2) RJ-45/DB9 Serial Port Connection
    - (3) RS-232/422/485 Selectable Serial Connections
    - (4) Baud rates up to 230 Kbps
    - (5) Full Modem and hardware flow control
    - (6) TCP/UDP Socket Services
    - (7) UDP Multicast
    - (8) Telnet and Reverse Telnet
    - (9) Modem emulation
    - (10)SNMP (read/Write)
    - (11)PPP
    - (12)Port buffering
    - (13)HTTP
    - (14)Remote management
    - (15)DCHP/RARP/ARP-Ping for IP address assignment
    - (16)L.E.D. status for link and power
  - B. Data Interface Requirements. The minimum video and data requirements include the following:
    - (1) The Terminal Server shall support a minimum of four (4) bi-directional serial communications over Ethernet 10/100 Base-TX.
    - (2) Each Terminal Server shall have a minimum of four (4) EIA-232/422/485 serial interface ports. These ports shall be individually and independently configurable, directly or over the network, to EIA-232/422/485 mode of operation as defined by the EIA for data format, data rate, and data structure (e.g., the number of bits, parity, stop bits, etc.). Each serial port shall support up to 230 Kbps.

- (3) Each serial port shall support IP addressing and socket number selection.
- (4) The equipment shall provide the capability to establish an IP connection directly from a workstation to any encoder IP address and socket number transport serial data.
- (5) Each Terminal Server shall have an Ethernet Interface (10/100Base-TX protocol, Full/Half-Duplex, Auto Sense (802.3), RJ-45).
- C. Physical and Environmental Specifications. The minimum physical and environmental requirements include:
  - (1) Each Terminal Server shall have the following ports:
    - a. Network Port: Minimum one (1) 10/100 Mbps RJ-45
    - b. Serial Data Interfaces: Four (4) RJ-45 ports.
  - (2) Operate in a temperature range of -35 degrees C to 74 degrees C
  - (3) Operate in relative humidity of 5% to 90% (Non-condensing)
  - (4) Approximate Dimensions—6" x 4" x 1"
  - (5) Provide external markings -- all connectors, indicators, and replaceable components shall be permanently marked and traceable to the supplied documentation, including schematics and parts list. The external markings shall include the product function name, model number, serial number, and Manufacturer's name.
  - (6) Terminal Servers shall be shelf mountable or rack mountable. Shelf for the cabinet shall be provided if needed. Other mounting options may be submitted for review and approval by the Engineer.
- D. Management Capabilities. The minimum management system requirements shall include:
  - (1) Remote Management and Port Configurable
  - (2) SNMP compatible
  - (3) Local Configuration Port
  - (4) Port Configurable via Telnet
- E. Electrical. The minimum electrical/power requirements include:
  - (1) 120 VAC
  - (2) External Power Supply is acceptable
2. Installation Requirements. All equipment shall be installed according to the Manufacturer's recommendations, the Plans and as follows:
  - A. Materials and associated accessories/adapters shall not be applied contrary to the Manufacturer's recommendations and standard practices.
  - B. The Contractor shall furnish all tools, equipment, materials, supplies, and manufactured hardware, and shall perform all operations and equipment integration necessary to provide complete, fully operational communications equipment as specified herein, within the Plan set, and/or in the Contract Documents. It is the responsibility of the Contractor to ensure DCE/DTE conflicts are addressed and that the equipment performs its required function when installed.
  - C. The Contractor shall provide the Department with a written inventory of items received and the condition in which they were received. Once received, the equipment becomes the Contractor's responsibility. The Contractor shall provide all labor and equipment necessary to move inventory out of the designated storage facility and to transport it to the installation location. All equipment shall be installed according to the Manufacturer's recommendations or as directed by the Department.
  - D. Testing Requirements. Testing shall include, but not be limited to, the following:
    - (1) General Requirements
      - a. The Contractor shall conduct a project testing program for all Terminal Servers. The project testing program shall include but is not limited to the additional specific requirements in this subsection.
      - b. All test results shall confirm physical and performance compliance with these specifications.
      - c. Submit all test results documentation to the Engineer within fourteen (14) days of completion of the tests. The Engineer will review all test documentation.
    - (2) Bench Test System (BTS) and Standalone Acceptance Test (SAT)

- a. The Contractor shall also demonstrate the ability of the Terminal Server to communicate with the attached Traffic Controllers through the Modem.
3. Measurement  
The Terminal Servers will be measured in units of each and paid for at the contract price per each. The price bid shall include furnishing, installing warranties, full operation and configuring the Terminal Server in accordance with applicable Standards, Specifications, and requirements. The price bid shall also include the mounting hardware, Cat-6 patch cords, serial port cables or connectors, power cable, user manuals, testing, warranties, and any and all other equipment required to complete installation of the unit. This price shall be full compensation for all labor, tools, materials, equipment and incidentals necessary to complete the work.
4. Payment. The contract unit price shall be full compensation for all work specified in this Section. Payment will be made under:

Item No.	Description	Unit
725-07.69	Terminal Server	Each

The Terminal Server Equipment will be paid per each as follows:

- 50% of the contract unit price upon approval of Bench Test Component, Bench Test System and Pre-Installation Test results.
- Additional 20% of the contract unit price upon approval of Stand Alone Site Test results.
- Additional 20% of the contract unit price upon approval of Conditional System Acceptance Test results.
- Final 10% of the contract unit price upon Final System Acceptance.

**730.44—L.E.D. Illuminated Street Name Sign**

1. Scope. This section describes specifications and requirements for L.E.D. Internally Illuminated street name signs (single or double faced) which will be attached to traffic signal mast arms. The sign installation details are shown in the planset.
2. General. The contractor shall provide the required signs as shown in the design plans and as per the guidelines stated in this document. The signs shall include all mounting accessories, housing, door, sign face, fasteners, L.E.D. light source, gasket and all peripherals as per the engineering plans. All signs shall be clearly legible and shall show the same shape and similar color by both day and night. The sign shall have an easy access service door that swings open and away from the sign body.
3. Hardware.
  - A. The sign shall be rigid mount directly to the signal mast arm with no moving parts. Sign bracket shall be able to be leveled to accommodate mast arms that are not level.
  - B. All external screws, nuts and locking washers shall be stainless steel. All materials furnished shall be new, first quality, and used in accordance with the highest industry practices.
4. Materials
  - A. All parts shall be made of corrosion resistant materials or shall be plated to resist corrosion. All materials used in construction shall be resistant to fungus growth and moisture-related deterioration.
  - B. The signs shall have the message as shown on the planset. The face legend shall consist of continuous piece diamond grade translucent vinyl applied over the polycarbonate sign face having the appearance of a white legend on a green background unless otherwise specified on the plans. Color and letter size and style shall be consistent with the requirements of the **MUTCD**.
  - C. Wiring shall be accomplished using 3-conductor cable.
5. Sign Body
  - A. The body of the sign shall consist of an aluminum (6000 series or approved alternative) one piece box type enclosure and separate hinged door assembly. The top of the sign body shall include drip rails to prevent water from entering the electrical housing. All seams shall be

- continuously welded, or provide alternatively approved weatherproofing, to ensure a watertight seal. A minimum of three 0.25 inch drain holes shall be located in the bottom of the sign body, a maximum of one foot from each end of the sign.
- B. The sign shall have a removable face. The door shall be one-piece frame construction. A continuous steel hinge shall mount the door to the housing.
  - C. Sign faces must be able to be removed from sign and be changed while still installed on pole. The sign face shall be 1/8" white or clear polycarbonate as designated by the Engineer.
  - D. Signs shall have airlock fasteners/thumbscrews to secure the door to the sign body.
  - E. UL listed foam gasket shall seal the sign between the door and sign body, and between the face panel and doorframe.
6. Photocell. All the internally illuminated L.E.D. signs installed at an intersection shall be controlled by one photocell. This device shall turn the unit ON during the hours of darkness. The photocell needs to be mounted so street lighting, auto headlights and other light sources won't interfere with its operation. The preferred location is inside traffic control cabinet, above the main door, just below the screened vent.
  7. Dimensions. The sign assembly shall be capable of being constructed in standard length from 4 feet up to 8 feet in length. The height of the sign shall be a minimum 12 inches and a maximum of 24 inches. The overall thickness of the sign shall be a maximum of 9.5 inches.
  8. Environmental
    - A. The sign and power supply shall be able to withstand and operate at temperature extremes of -40 deg F to +120 deg F.
    - B. The sign shall have a front panel that is UV, weather, abrasion and impact resistant.
    - C. The sign shall be designed and constructed to prevent deformation or failure due to fatigue, shock, vibration and wind loads up to 110 mph in conformance with the requirements of the AASHTO LTS-4 2001.
    - D. The sign shall be tested and certified for exclusion of water test, strain relief test.
  9. Finish
    - A. The color of the exterior of the sign assembly shall be glossy black. All exterior surfaces of the sign assembly shall be powder-coat painted in accordance with Military standard MIL-C-24712, MIL-1-45208A.
    - B. The interior of housing shall be painted white. The front panel shall be replaceable so that maintaining agencies have the option to supply their own sheeting and electrocut film for the sign faces.
  10. L.E.D. Light Engine System/Panel
    - A. The L.E.D. light engine shall be a single, self contained device, for installation in the sign housing. The L.E.D. light engine shall be mounted within the inner portion along the top, bottom of the housing.
    - B. There shall be sufficient quantity of white L.E.D.'s to uniformly illuminate the viewing area. The failure of one L.E.D. shall not reduce the light output by more than eight percent per foot of the sign face.
    - C. The L.E.D. Edge Lit Internally Illuminated Street Name Sign modules shall be composed of L.E.D.'s with a minimum viewing angle of 110 degrees mounted on rugged, secure, non-corrosive material consuming no more than 6.0 watts per linear foot. With a thermal resistance path from the L.E.D. to the most external surface of the aluminum extrusion, of no more than 20 degrees per watt at an ambient temperature of 77 degrees Fahrenheit to reduce wear and tear on the individual L.E.D.'s and to extend useable lifetime. The L.E.D. light modules shall be sufficient coupled directly to the aluminum extrusion using stainless steel mounting screws.
    - D. The L.E.D. light engine panel shall consist of a circuit board comprising an insulated aluminum substrate, with a minimum thickness of 0.125 inch. The assembly and manufacturing processes of the L.E.D. light engine shall be designed to ensure that all L.E.D. and electronic components are adequately supported to withstand mechanical shocks and vibrations in compliance with the specifications of ANSI C136.31-2001 Standards. All interconnections between L.E.D. light modules shall be hard soldered connections, or

- approved alternative, to eliminate thermal fatigue and micro cracking associated with power cycling.
- E. The manufacturer name and date of manufacture along a quality control tracking sticker shall be mounted on the inside of the L.E.D. light engine panel.
  - F. There shall be one power supply for the sign. The sign shall have an input voltage of 120 VAC. The input voltage will then be reduced and power-conditioning circuitry will be provided so that L.E.D.'s current will operate at the manufacturer's recommended specifications.
  - G. There shall be one separate 15 amp circuit breaker for all the signs at the intersection, located in Signal Control Cabinet on power panel to feed termination panel. Internally illuminated street name signs shall be wired to a separate 6 position terminal block and a separate 6 position ground bar located in the controller cabinet.
- 11. **Manufacturer.** The manufacturer agrees, upon the request of the ENGINEER, to deliver a sample of each assembly to be supplied in compliance with these specifications for inspection and test before acceptance. After completion of the test, the sample shall be returned.
  - 12. **Training**
    - A. Prior to the acceptance of the first unit, training shall be provided for the Department's engineering, maintenance and operations staff, at a facility located in Nashville. The training shall include all material and manuals required for each participant. The training shall be as follows:
    - B. The training shall be provided for a minimum of 1 hour for at least ten (10) engineering and operations personnel. The training shall include a complete demonstration of the operation and capabilities of the system including this unit. This session should include a complete review of any field adjustments or calibration of the equipment which may be necessary for optimum performance and should stress day-to-day operation and isolation of problems down to the unit level.
  - 13. **Warranty**
    - A. All components shall carry a five (5) year warranty from the date of acceptance against any imperfections in workmanship or materials.
    - B. The L.E.D. light engine shall be fully guaranteed for three (3) years from the date of acceptance. The L.E.D. light engine shall be guaranteed free of workmanship or material defects for a period of five (5) years from the date of acceptance.
  - 15. **Repairs.** Any repairs made by a manufacturer or representative shall be documented and returned with units when warranty repaired. This documentation shall include an explanation of the exact repairs made and identification of parts replaced by part number and circuit number. All warranty repairs shall be completed within thirty days of delivery of the equipment to the designated repair depot.
  - 16. **Maintenance.** All equipment shall be designed for ease of maintenance. All component parts shall be readily accessible for inspection and maintenance. The only tools and test instruments required for maintenance by Maintenance personnel shall be simple hand held tools and basic meters.
  - 17. **Documentation.** The contractor shall submit two (2) sets of complete schematics, operating manuals, and maintenance manuals for each of the device/equipment type. The maintenance manuals shall include complete sub-component parts listing and diagnostics procedures.

## COMPENSATION

**730.45—Method of Measurement.** Measurement for traffic signals will be on a per-item basis for each item to be furnished and installed, as specified herein and shown on the Plans.

With regard to items for signal head assemblies, each item to be furnished and/or installed shall be distinguished with a code number as follows:

- 1. The first digit is the number of faces per assembly.

2. The second digit will indicate the number of 12 in. (300 mm) lenses per assembly (including arrow lenses).
3. The third digit is the quantity of 8 in. (200 mm) lenses per assembly.
4. The letter "A" indicates an arrow lens and the digit following the "A" indicates the number of 12 in. (300 mm) arrow lenses per assembly.
5. The letter "H" or "V" indicates the arrangement of arrow signal lenses to be horizontal or vertical with respect to solid ball indications.

EXAMPLE:

1 5 0 A 2 H

Digits Indicate as Follows:

1 = 1 Face

5 = 5-12 in.(300 mm) Lenses

0 = 0-8 in. (200 mm) Lenses

A2 = 2-12 in.(300 mm) Arrow Lenses

H = Arrow Lenses placed horizontally with respect to circular indications.

Removal of Signal Equipment

Items of equipment or material designated or required for removal shall be measured as a lump sum for each intersection. Removal and salvage of all signal heads, poles, control equipment, cabinets, span wire, cable, etc., to be performed at an intersection shall be included as a unit cost per each intersection. This includes the cost of returning salvable equipment to the MDPW for proper disposal. Salvable items will be determined by the Engineer or his representative.

Signal Head Assembly (includes pedestrian signal heads)

Signal heads of the type indicated in the Plans shall be measured by the individual assembly complete in place, per each. This item shall include the signal heads, terminals, lamps, attachment hardware, cable connection, and testing.

Pull Box

Each pull box of the type required shall be measured as one complete unit, installed, per each. This item includes the pull box, excavation, backfilling, crushed stone base and other incidental items as called for in the Plans or Standard Drawings.

Electrical Service Connection

Electrical Service Connections shall be measured on a per each signal installation basis. This item includes the electrical service supplied to the weatherhead by the local utility, all necessary materials and labor for connection of the electrical service from the controller to the weatherhead, the wiring of the controller and detectors, and all incidentals necessary to render a complete and operable system. Each connection shall include an external disconnect. Electric service is to be obtained by the Contractor through a written request to the Nashville Electric Service. This request should include electric loads and/or the number and types of signal lenses. The request shall be submitted once the signal, including the controller cabinet, is ready for electrical inspection and shall be submitted in a timely manner so as to activate the traffic signal as scheduled.

Signal Cable

The length of signal cable of each size (number of conductors) installed shall be measured in linear feet (meter) to the nearest foot (meter) from point to point along the routing for each cable.

Horizontal measurements shall be made by center-to-center measurement from:

1. pole to pole
2. pole to signal head (when terminating in a signal head)
3. pull box to pull box
4. pull box to pole



5. pull box to pole-mounted or base-mounted controller

For cable inside mast arms, measurement shall be made from center of vertical support to signal head where cable terminates.

Vertical measurement shall be made by one of the following:

1. For cable inside poles or conduit risers, the distance from ground level to the point of attachment of the span wire.
2. For cable inside mast arm supports, the distance from ground level to the mast arm connection.
3. For cable to pole-mounted controller,
  - A. from ground level to bottom of controller.
  - B. from bottom of controller to point of attachment of span wire.
4. For cable to pole-mounted signal head or pushbutton,
  - A. from ground level to bottom of signal head or pushbutton
  - B. from bottom of signal head or pushbutton to point of attachment of span wire.

No additional allowance will be made for slack length, length inside equipment or supports (except as noted), length for the required 360° drip loop, and similar instances where additional length of cable is required.

#### Span Wire

Span wire assembly, tether wire assembly, and messenger cable by type shall be measured in linear feet (meters) to the nearest foot (meter). The measurement will be made from center to center of poles. These items include attachment hardware, strain insulators, and other hardware shown in the Plans as part of the assembly. No additional allowance will be made for slack length and other instances where additional length of wire is required.

#### Steel Conduit Riser Assembly

Conduit riser assemblies shall be measured per each for each size conduit riser installed on the outside of a pole, as required in the Plans. This item includes conduit, weatherhead, conduit, fittings, nuts, washers, banding, clamps, grounding, and other items necessary for installation.

#### Conduit

Conduit shall be measured in linear feet (meters) to the nearest foot (meter) for each size and type of conduit installed. Underground conduit will be measured along the conduit by one of the following:

1. From the face of curb to the center of a pull box, pole or controller foundation
2. From center to center of pull boxes
3. From center to center of a pull box and a pole or controller foundation
4. From center to center of pole foundations or pole foundation and controller foundation.

One ft. (1 m) will be added to the above measurements for each entry to a pull box or pole foundation and each exit of a pull box or pole foundation. Three ft. (1 m) will be added to the measurement for each capped extra entry (conduit stub) or exit to a pull box or pole foundation installed, as directed in the Plans. Three ft. (1 m) will be added to the measurement for each connection between underground conduit and above ground riser. Three ft. (1 m) will be added to the measurement for each entry or exit to a foundation for a base-mounted controller.

This item includes, unless noted otherwise on the plans, trenching, backfilling, sealing, capping, fittings, bushings, banding, grounding, and other accessories and hardware required for installation of the conduit system.

#### Vehicle Loop Detector (Amplifier)

Vehicle detector loop amplifier shall be measured per each unit and include the cable and associated hardware necessary to electrically connect the amplifier to the controller and loop lead in. Two and four

channel card rack type amplifiers shall be measured per each unit and include the cable, card rack(s), and associated hardware necessary to electrically connect the amplifiers to the controller and loop lead-ins.

#### Shielded Detector Cable

Two-conductor shielded detector cable installed between the controller cabinet and the loop detector wires shall be measured in linear feet (meters) to the nearest foot (meter). Horizontal measurements (overhead and underground) will be made by one of the following:

1. From center to center of pull boxes
2. From center to center of pull box and pole
3. From center to center of poles
4. From center to center of pull box or pole and controller foundation.

Vertical measurements will be made by one of the following:

1. From ground level to the point of attachment of span wire, inside pole or conduit riser.
2. From the bottom of controller cabinet to the point of attachment of span wire.
3. From ground level to the bottom of controller.

No additional allowance will be made for slack length, length inside equipment or supports (except as noted), splices, and similar instances where additional length of cable is required.

#### Saw Slot

Length of saw slot for installation of detection loop and lead wiring shall be measured in linear feet (meters) to the nearest foot (meter). Measurement for detection loops in the traffic lanes shall be made based on the loop size specified in the Plans, i.e., the nominal length plus the nominal width times two. No additional allowance will be made for saw overruns to obtain full depth of saw slot or diagonal cuts to prevent sharp bends in the loop wire. Measurement of saw slot for detection loop leads shall be made from the conduit entry at the face of curb or edge of pavement and along the route of the lead-in to the detection loop. For new construction or for projects where roadway resurfacing is involved, saw cuts for detection loops shall be made in the binder course.

This item includes backing rods, or polyethylene foam sealant, loop sealant, and any other incidentals necessary to render a complete and operable system.

#### Loop Wire

Length of loop wire for installation of detection loops and lead-ins shall be measured in linear feet (meters) to the nearest foot (meter). Measurement shall be made from the pull box or pole to the detection loop, around the loop the required number of turns and back to the pull box, pole, or point of splice. No additional allowance will be made for slack length, length inside equipment or supports, splices, and similar instances where additional length of wire is required.

This item includes electrical connections, testing, and any other incidentals necessary to render a complete and operable system.

#### Controller

Controllers shall be measured as one complete unit, installed, per each. This item includes all auxiliary equipment indicated in the Plans to provide signalization control as specified in the Plans, and all hardware, necessary for installation.

#### Cabinet

Cabinets shall be measured as one complete unit, installed, per each. This item includes all hardware to mount a pole mounted cabinet to the signal support pole, or the foundation required for a base mounted cabinet.

#### Wood Pole

Wood Poles, of the type and size indicated in the Plans, shall be measured per each, installed.

Guying Device

Guying Devices, of the type indicated in the Plans, shall be measured per each, installed. This item includes the guy wire, anchor, clamps, and all other components indicated in the Plans necessary for installation.

Steel Strain Pole

Steel Strain Poles of the type and size shown in the Plans, shall be measured per each, installed, unless provided for the project by MDPW. This item includes the pole, foundation, anchor bolts, grounding, and all other hardware indicated in the Plans necessary for a complete installation. In those instances where the poles are to be provided, the Contractor is responsible for providing a foundation with anchor bolts and for installing the pole on this foundation.

Cantilever Signal Support

Cantilever Signal Supports, of the type and size shown in the Plans, shall be measured per each, installed, unless provided for the project by MDPW. This item includes the vertical pole shaft, mast arm, foundation, anchor bolts, grounding, and all other hardware indicated in the Plans necessary for a complete installation. In those instances where the poles are to be provided, the Contractor is responsible for providing a foundation with anchor bolts and for installing the cantilever signal support on this foundation.

Service Cable

Two conductor power service cable of the type and size indicated in the Plans shall be measured in linear feet (meters) to the nearest foot (meter), installed. Horizontal runs will be measured center to center of poles. Vertical runs will be measured from the ground to the weatherhead inside a pole or conduit riser, or from the ground to the bottom of the controller, or from the bottom of the controller to the weatherhead. This item includes all necessary attachment hardware. No additional allowance will be made for slack length or other instances where additional length of cable is required.

Pedestrian Pushbutton with Sign

Pedestrian Pushbutton with Sign shall be measured as one complete unit, in place, per each. This item includes the pushbutton, sign, mounting hardware, wiring of pushbutton, testing, and all other incidentals necessary for a complete installation.

Pedestrian Signal Display with Pushbutton and Sign

Pedestrian Signal Display with Pushbutton and Sign shall be measured as one complete unit, in place, per each. This item includes the signal heads, terminals, lamps, cable connections, pushbutton, sign, all attachment hardware, testing, and other incidentals necessary for a complete installation.

**730.46—Basis of Payment.** The unit price to be paid shall include the cost of furnishing and installing, complete in place, each of the various types of equipment required by the Summary of Quantities which are a part of the Plans. Total payment will be payment in full for all materials, labor, equipment and incidentals necessary to produce a completely operative and finished installation of a traffic signal or traffic signal system as shown on the Plans and as herein specified, including restoration of pavements, sidewalks and appurtenances damaged or destroyed during construction and tests. This payment will be issued once a Notice of Acceptance letter has been prepared for the installation. Full compensation for all additional materials and labor not specifically shown or called for, which is necessary to complete the traffic signal installation or traffic signal system described, shall be considered and included in the total payment for the system and no additional allowance will be made therefore.

(end of TDOT 730N spec)